Water Column Monitoring 2006

Summary report

Rolf C Sundt, Anders Ruus, Merete Grung, Daniela M Pampanin, Janina Baršienė, Halldóra Skarphéðinsdóttir

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Akvamiljø a/s, Mekjarvik 12, 4070 Randaberg, Norway
www.akvamiljo.no

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Rolf C Sundt
Project Leader

Jan Fredrik Børseth
Project Quality Assurance(IRIS)

Atle Fiskå
Manager
Akvamiljø a/s

Akvamiljø a/s, Mekjarvik 12, 4070 Randaberg, Norway
www.akvamiljo.no

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Summary

The report presents results from the Water Column Monitoring 2006, carried out in collaboration between IRIS&Akvamiljø and NIVA, with sub-contractors. The objective of the survey was to assess the extent to which discharges from Ekofisk affect organisms living in the water column. The study was designed to monitor bio-accumulation and biomarker responses in organisms held in cages in the vicinity of the platform.
The results from the survey show that caged organisms have been exposed to moderate levels of produced water components. Mussels accumulated PAHs, with levels following the expected gradient with distance from the discharge. Concentrations of PAH- and AP-metabolites in bile of caged cod were elevated suggesting moderate exposure levels. Biological responses that can be interpreted as moderate negative effects, were observed in organisms caged close to points of discharge
There was clear signal from the biological responses for several of the methods employed. As expected in animals that were kept close to the discharge, moderate negative effects were observed. The ultimate health effects on the organisms are, however, unknown at this stage. A gradient with distance from the discharge was observed for both bioaccumulation of contaminants and biological effects.

Work participants

IRIS: Rolf C Sundt, Lars Petter Myhre, Jan Fredrik Børseth, Daniela Pampanin, Kjell Birger Øysæd, Atle Nævdal, Emily Lyng.

NIVA: Merete Grung, Anders Ruus, Ketil Hylland, Eivind Farmen Finne, Christopher Harman, Kevin Thomas, Sigurd Øxnevad, Oscar Fogelberg, Anja Julie Nilsen, Tor Fredrik Holth, Åse Kristine Gudmundson Rogne, Åse Bakketun, Olav Bøyum.

List of symbols

AP	Alkylated Phenol
BaPH	benzo[a]pyrene hydroxylase
$C_1 – C_9$	referring to the number of carbons in a side chain (e.g. on a PAH or phenol)
COPSAS	ConocoPhillips
CYP1A	Cytochrome P450 1A (CYP1A) proteins
DNA	Deoxyribonucleic acid
ELISA	Enzyme Linked ImmunoSorbent Assay
FF	Fixed fluorescence
GC-MS	Gas chromatography – Mass Spectrometry
GST	Glutathion-S-Transferase
IRIS	International Research Institute of Stavanger
MN	Micronuclei
OLF	Norwegian Oil Industry Association
PW	Produced Water
rpm	Rounds per minute
VTG	Vitellogenin (precursor of egg yolk protein)
WCM	Water Column Monitoring
ZRP	Zona radiata protein (egg shell protein)

1 Introduction

The Water Column Monitoring (WCM) 2006 was carried out in collaboration between the Norwegian Institute for Water Research (NIVA) and IRIS&Akvamiljø, with several sub-contractors. The sub-contractors was Battelle (USA), the Institute of Applied Environmental Research at Stockholm University and the University of Vilnius.

Organisms living in the water column around offshore oil and gas production facilities are predominantly exposed to chemicals through discharge of production water (OLF 2000). The amount and composition of produced water (PW) varies from field to field (Røe 1998), but is generally a mixture of:

- Formation water contained naturally in the reservoir.
- Injected water used for secondary oil recovery.
- Treatment chemicals added during production.

Typically, produced water contains dissolved inorganic salts, minerals and heavy metals together with dissolved and dispersed oil components and other organic compounds. The specific chemical composition varies between reservoirs and within a reservoir as production proceeds. A target chemical characterisation of four offshore oil production platforms in the North Sea showed that the major organic components were BTEX (benzene, toluene, ethylbenzene and xylene), NPD (naphtalenes, phenanthrenes and dibenzothiophenes), PAHs (polyaromatic hydrocarbons), organic acids, alkylphenols (APs) and phenols (Røe and Johnsen 1996; Utvik 1999). As a natural consequence of well exploitation, oil content in the reservoirs will decrease and the need to inject water will increase, thus eventually leading to increase in the discharges of PW. Estimates shows that the total discharges of PW in the Norwegian sector of the North Sea will increase from approximately 130 million m^3/year in 2002 to 180 million m^3/year in 2011 followed by stabilisation and decrease in discharges (SFT 2004).

Some of the organic chemicals found in PW are relatively resistant to biodegradation, have a bioaccumulation potential and may be toxic to organisms in receiving waters (Brendehaug et al. 1992; Tollefsen et al. 1998; Taban and Børseth 2000; Aas et al. 2000a). This applies in particular to groups of chemicals such as alkylphenols (APs) and polycyclic aromatic hydrocarbons (PAHs) that are known to produce various toxic effects including reproductive disturbances, mutagenicity and carcinogenicity (Landahl et al. 1990; Bechmann 1999; Lye 2000; Meier et al. 2002). Studies from the ICES workshop "Biological effects of contaminants in the pelagic ecosystem (BECPELAG)" indicate that toxic compounds are detectable several kilometres away from a North Sea oil production platform using *in vitro* bioassays (Thomas et al. 2006; Tollefsen et al. 2006) and biomarkers (Balk et al. in press; Regoli et al. in press; Aas et al. 2006). Although there is reason to assume that many of the chemicals that are present in PW effluents may produce biological responses, the ability to assess the potential for

adverse effects are limited by the lack of sufficient *in situ* monitoring data using biological effects methods with endpoints reflecting long term (ecological) effects.

Biological indicators or markers (biomarkers) have been developed to measure the biological response related to an exposure to, or the toxic effect of, an environmental chemical (Peakall 1992). Some biomarkers are specific in terms of their ability to detect and assess the potential for effects through a specific toxic mechanism, whereas others give information about larger groups of chemicals with more diverse mechanisms of action. Common for all of the methods is the capability of performing time-integrating response assessment to complex mixtures over extended periods of time, which is often required in environmental monitoring. Since most of these methods are highly sensitive and responses occur at lower concentrations and/or prior in time to more adverse effects at a higher organisation level, the methods have become convenient early-warning tools for assessing the potential for long term (ecological) effects. The use of biomarkers in sentinel species or specific caging systems with keystone species has consequently facilitated the implementation of such methods in various environmental monitoring programs in freshwater, marine and estuarine areas. Care must be taken to avoid misuse of biomarker data in trials to extrapolate to ecologically relevant effects Forbes et al, 2006; Lam and Gray, 2003. Resent years, a combination of laboratory and field validation of the different biomarker and effects-based methods has greatly improved the knowledge of the potential and limitations of these methods and made it possible to link responses of biomarker signals to the potential for more adverse effects at the ecological level (Collier et al. 1992a; Elliot et al. 2003; Bechmann et al. in prep).

1.1 Objective

The objective of the WCM survey 2006 was to assess the extent to which discharges from an oil production platform affect organisms living in the water column. To fulfil this objective, the survey was designed as described below (chapter 1.2).

Produced water discharges, which are the most pronounced contributor to pollution of the water column, contain polycyclic aromatic hydrocarbons (PAHs), alkylphenols, decalins, organic acids and a range of inorganic chemicals (Utvik, 1999). Some of the relevant chemicals are reported to produce biological responses in controlled laboratory experiments that may ultimately cause long term (ecological) effects. Controlled caging experiments using well documented species and methods of effect have been used as the best suited monitoring system to assess the extent of influence from oil or gas production platforms (SFT, 2003).

1.2 Description of methods

This study was designed to monitor bioaccumulation and biomarker responses in organisms held in cages in the vicinity of the Ekofisk field. Six rigs were deployed along the expected current axis, from close to the discharge out to 2000 meters from the installations. Two rigs were regarded as reference, with the intention of sampling one (and have one as backup, see Figure 1). All rigs contained mussels while the two closest to the discharge and the two references also contained fish. All cages were deployed for 6 weeks.

Pre exposure samples were taken for both mussels and Atlantic cod for determination of pre-exposure levels of contaminants and biomarker responses.

Details regarding geographical positions for the deployment stations and CTD profile of the water column can be found in the cruise report (Appendix A). Distance from discharge is indicated in Table 1. The monitoring approach was based on experiences gained in previous water column monitoring surveys and from the BECPELAG workshop (Hylland et al. 2006).

Analyses of lysosomal stability and imunocompetance in mussel haemocytes were preformed of fresh material onboard the vessel. Al other analyses were performed in onshore laboratory.

Table 1. Overview of samples for biological and chemical analyses of Atlantic cod (*Gadus morhua*).

Method	Matrix	No samples
CYP1A	liver	100
GST	liver	100
VTG	blood plasma	75
ZRP	blood plasma	75
PAH-met., FF	bile	100
PAH-metabolites, GC/MS	bile	60
AP met	bile	60
DNA adducts	liver	60

Table 2. Overview of samples for biological and chemical analyses of mussels (*Mytilus edulis*).

Method	Matrix	No samples
BaPH	digestive gland	100
Lysosomal stability	haemocytes	84
Imunocompetance	haemocytes	100
Histology	digestive gland	100
PAH concentration	soft tissue	30
Lipid content	soft tissue	24
Micronucleus	haemocytes	100

1.2.1 Sea temperature and salinity

In order to collect information about stratification in the sea CTD measurements were performed from the installation. Such information is considered important because stratification affects the vertical distribution of the discharged produced water. The data may be useful for future modeling studies of plume distribution in the area.

1.2.2 Sea current

Selected cages (ST 2, 5 and REF 2) were fitted with instruments that make it possible to map the discharge dispersal in the water masses. The main purpose for this was to check and hopefully confirm that the cages were employed in the path of the discharge plume. CTD data will be useful for future modeling studies of plume distribution in the area.

1.2.3 Contamination control during transport

To check that organisms were not exposed to petrogenic contamination during the transport, sea water samples from the transportation tanks were collected and analysed for PAHs by GCMS.

1.2.4 General biological observations

General biological data as body length, weight and sex is usually recorded in environmental monitoring studies and is used in the interpretation of biomarker data. For the interpretation of biomarkers of reproductive disturbance such as vitellogenin (VTG), the information about sex is crucial for interpretation. A relationship between length and weight can be used as an estimate of the condition of the individual.

1.2.5 PAH-metabolites in fish bile

The potential adverse effects of PAHs have resulted in many years of concentration monitoring in water, sediment and biota. However, the extensive bio-transformation of PAHs by fish greatly prevents the accumulation of these compounds in extra-hepatic tissues (Stein et al. 1987). Consequently, tissue levels of parent PAH do usually not provide an adequate assessment of the PAH exposure level (Varanasi 1989). The metabolites concentrate in the gall bladder of fish following bio-transformation. Analysis of PAH metabolites in the fish bile constitutes a very sensitive method for assessment of PAH exposure in laboratory and field studies (Beyer et al. 1998; Aas et al. 2001).

Fixed wavelength fluorescence

A characteristic feature of PAH compounds is their fluorescing properties. All PAH molecules absorb ultraviolet light followed by emission of light of a longer wavelength. This UV-fluorescence phenomenon occurs because PAH molecules contain delocalised electrons. The fluorescence properties, i.e. optimal excitation and emission wavelengths and signal intensity, varies between PAH compounds and is dependent on size, structure and eventual substituents on the molecule. Generally, the optimal excitation wavelength increases with increasing size of the PAH molecule (Vo-Dinh, 1978), i.e. smaller PAHs need more energy (shorter wavelength of the excitation light) than the larger molecules. This variability can be utilised in simple detection methods for PAHs like fixed wavelength fluorescence (FF) detection and synchronous fluorescence spectrography (SFS) (Aas et al. 2000). However, this direct method is not optimal for standardisation and quantification, and should be regarded a screening method. The metabolites measured with the direct method, are mainly conjugated hydroxy PAH compounds. Standards of these compounds are impossible or difficult and expensive to obtain. With the direct method, different PAH compounds, as well as other natural constituents of the bile, may show interfering fluorescence signals. This may reduce the sensitivity of the method. This is particularly critical when levels are low.

GCMS

For a more quantitiative and qualitative analysis of PAH metabolites high performance liquid chromatography with fluorescence detection (HPLC/F) or gas chromatography with mass spectrography in single ion mode detection (GC-MS SIM) can be applied (Collier et al. 1996; Hellou and Payne 1987). The GC-MS SIM is the best suited method for detection of PAH compounds containing 2 to 3 ring structures, namely the naphthalenes and phenanthrenes (Jonsson et al. 2003; Jonsson et al. 2004). Both alkylated and non alkylated compounds are detected.

1.2.6 AP metabolites in fish bile

The alkylphenols (APs) is a group of chemicals which is relevant to discharges from the offshore oil industry. Produced water, which is released in large volumes from many platforms, includes significant levels of APs. As for PAHs the extensive bio-transformation of APs by fish greatly prevents the accumulation of these compounds in extra-hepatic tissues. Exposure studies with radiolabelled alkylphenols in fish shows that AP metabolites preferentially are excreted through the bile pathway (Sundt et al , Tollefsen et al 1998). The metabolites concentrate in the gall bladder of fish and specific metabolites of APs from bile can be quantitatively determined by GC/MS. The approach is similar to the detection of biliary PAH metabolites as a biomarker for exposure to polyaromatic hydrocarbons (Jonsson et al. in prep). For further details see Beyer and Bamber (2004).

1.2.7 Hepatic GST

Glutathione *S*-transferase (GST) is a part of the organisms detoxification system and is evolutionary developed by organisms in order to convert lipophilic compounds into more hydrophilic and thereby more easily excretable metabolites. Excretion of compounds consists of two major types of reactions: phase I, which involves hydrolysis, oxidation and reduction, and phase II, which involves conjugation. Being one of the phase II reaction enzymes, GST catalyses conjugation of glutathione to compounds with electrophilic centres. The compounds may otherwise be harmful as they may react with macromolecules controlling cell growth, such as DNA, RNA and proteins. It is therefore of great importance that the animal is capable of neutralises and excrete these compounds. Changes in the activity of GST may reflect exposure to xenobiotics, and evidence suggests that the level of expression of GST is a crucial factor in determining the sensitivity of cells to a broad spectrum of toxic chemicals. It is also probable that GST are regulated by reactive oxygen species (ROS), and that this would represent an adaptive response within the cell to oxidative stress.

1.2.8 CYP1A

The eucaryotic enzyme cytochrome P4501A (CYP1A), which belongs to the P450 gene superfamily, is a membrane-bound heme protein, located in the endoplasmic reticulum (microsomal fraction) of all examined vertebrates and carries out oxidation reactions related to xenobiotics bio-transformation. CYP1A is induced by certain xenobiotic pollutants and is therefore used as an environmental biomarker of the aquatic environment. Among the xenobiotics known to induce CYP1A are PAHs and PCBs. Immunochemical tools, Western and ELISA, have been used for estimating its relative levels in tissue preparations (Goksøyr 1991).

1.2.9 Vitellogenin

In unexposed fish, the synthesis of vitellogenin (VTG) takes place in the liver of oviparous females under the stimulation of endogenous estradiol (Tata and Smith, 1979). Male and juvenile fish of most species, which only have low levels of circulating estrogens, do not produce appreciable levels of VTG. However, these fish exhibit considerable levels of hepatic estrogen receptors and the genetic machinery required for protein synthesis, and are thus capable of producing high levels of VTG when exposed to exogenous estrogens. Induction of this female typical protein in male and juvenile fish has therefore been widely used as a sensitive biomarker for exposure to xenoestrogens (Sumpter and Jobling, 1995). The use of VTG as a biomarker for xenoestrogens in ecologically relevant fish species has since then been employed for coastal and freshwater environmental monitoring (Hylland et al., 1998; Hylland et al., 1999) and for monitoring of areas that are effected by discharged from oil production activities (Scott et al., 2006). Recent studies with freshwater species such as zebrafish and rainbow trout suggest that induction of VTG occur at concentrations of xenoestrogens that also produce alteration in sexual development when exposed during sensitive windows of embryonal and larval development (Jobling et al., 1996; Örn et al., 2003)

1.2.10 Zona radiata protein

Both the induction of vitellogenin (VTG) and zona radiata proteins (Zr-proteins) in male and juvenile oviparous vertebrates has been used as an effective and sensitive biomarker for exposure to xenoestrogens (Arukwe et al., 1997; Arukwe et al., 2000). Both VTG and Zr-proteins are synthesized in the liver in response to estrogen stimulation. They are secreted and transported in the blood to the ovary. There VTG is sequestered to form the yolk proteins that serve as nutrient reserve, while Zr-proteins form the eggshell that prevents polyspermy and provides mechanical protection for the developing embryo.

Although the measurements of VTG and Zr-protein levels in plasma have been established as rapid and sensitive assays for assessing the estrogenic potency of endocrine disruptors in both in vitro and in vivo studies (Sumpter and Jobling, 1995 and Arukwe et al., 1997), Zr-proteins have been suggested to be more sensitive than VTG at low dosage of xenoestrogens (Arukwe et al., 1997). In applying the Zr-proteins as

xenoestrogen biomarkers, it is important to minimize confounding factors, such as stress (Berg et al., 2004).

1.2.11 DNA adducts

The detoxification of genotoxicants by the inducible cytochrome P450 mixed function oxygenase systems often results in the production of reactive chemical intermediates that are highly electrophilic and can covalently bind to the bases of DNA forming adducts. Thus, the presence of DNA adducts has been taken as evidence of exposure to specific genotoxicants. DNA adduct is formed when a non-DNA chemical, e.g. a carcinogenic pollutant chemical, binds covalently to the DNA (normally to the nitrogenous base guanine). Because of the sensitive and consistent responses of hepatic DNA adduct levels to the genotoxic forms of PAH, this parameter is considered to be a reliable biomarker of PAH effect and pro-mutagenic DNA lesions in fish. However, PAHs are not the only chemicals that may form DNA adducts, a range of other pollutant chemicals also does, and even endogenous substances. But the stability of the adduct, i.e. the resistance to DNA repair mechanisms, is important. Carcinogenic PAHs form stable DNA adducts after being bio-activated in the cell. And since PAHs are common pollutants in many aquatic recipients, this pollutant class has received much attention. In addition to their use as a biomarker for (exposure and) effect of genotoxins, DNA adducts may provide information about the biological effect and potential risk of a chemical, since it has been suggested that any chemical that forms stable pro-mutagenic DNA adducts, even at very low levels, should be considered to have mutagenic and carcinogenic potential. In fish DNA adducts are most often measured in the liver, since this is the key organ for biotransformation of xenobiotics, but other tissues can also be used. In field collected fish, the DNA adduct level is indicative of a cumulative exposure to genotoxic compounds over a longer period of time (typically several months or years). For further details see Jonsson et al. (2003).

1.2.12 PAH body burden in mussel

The chemical composition of produced water is dominated by low molecular PAHs (naphthalenes, phenanthrenes, dibenzothiophenes, commonly denoted NPDs), decalins and their alkylated homologues (Utvik, 1999). High molecular PAHs such as benzopyrene, pyrene and chrysene are also present in effluents of produced water from production platforms in the North Sea, although at lower concentrations than the more low-molecular weight PAHs. Many of those chemicals have also been detected in caged organisms deployed downstream discharge points (Røe, 1998). This applies in particular to alkylated NPDs, which have been found in higher concentrations than their non-alkylated sister compounds in organisms and passive sampling devices (Røe, 1998; Ruus et al., 2006). Although the different compounds represent variable degree of health risk to the aquatic fauna, measurement of their body burden in caged animals are commonly used to assess the exposure situation in a specified area.

1.2.13 Benzo(a)pyrene hydroxylase activity

Benzo(a)pyrene hydroxylase (BaPH), commonly referred to as aryl hydrocarbon hydroxylases (AHH), represents an enzymatic activity commonly grouped as mixed function oxidases (MFOs), i.e. cytochrome P450 enzymes. These enzymes metabolise selected PAHs and consequently alter potentially harmful chemical to non-toxic and readily excretable end products. The BaPH have also an ability to convert moderately toxic chemicals to highly reactive metabolites, as seen with the conversion of benzo(a)pyrene (BaP) to quinone derivatives that may interact with DNA to form DNA-adducts, which may potentially lead to permanent cellular damage and cancer. BaPH has been shown to be induced by a variety of PAHs in mussels and consequently been proposed as a biomarker for the exposure to and the potential for adverse biological effects of certain types of PAHs (Michel et al., 1994; Sole et al., 1998). Measurement of BaPH in sentinel species such as the blue mussel has consequently been used to determine the effects of PAHs in several environmental monitoring studies including the BECPELAG workshop (Burgeot et al., 2006).

1.2.14 Imunocompetance

Haemocyte-mediated phagocytosis is the predominant form of internal defence in molluscs (Pipe and Coles, 1995), although it is generally suppressed by exposure to various contaminants (Cheng, 1988). The immune response is comprised of an integrated process of phagocytosis and lysosomal degradation and pollution-induced dysfunction of these processes may suppress immunocompetence.

Phagocytic activity of haemocytes is assessed by measuring the uptake of neutral red stained zymosan yeast cells (*Saccharomyces cerevisiae*). Phagocytic activity is regarded as a good biomarker of immune function and therefore of organism health. The more particles that are ingested by the cell in the haemolymph sample the more efficiently the immune system of the organism is functioning.

1.2.15 Lysosomal membrane stability

Membrane integrity has been found to be affected by a range of stressors, including metals and organic chemicals. One of the most well-established methods to determine changes in membrane integrity is through measurements on the lysosomal membrane stability. The method uses one of a range of available dyes, e.g. neutral red for haemocytes, which will accumulate in the lysosomal compartment of cells. A reduction in membrane integrity will cause the dye to leak back into the cytosol, an effect which can then be quantified. The method is most commonly used with circulating cells, e.g. haemocytes in blue mussels, but methods exist to use a similar method on tissues.

1.2.16 Micronucleus formation

Chromosomal rearrangements, such as micronuclei (MN), are recognised as a consequence of genome instability (Fenech et al., 1999). The MN test is among the most widely used tools in eco-genotoxicology. Micronuclei are chromatin-containing

structures that are surrounded by a membrane and have no detectable link to the cell nucleus. As an index of chromosomal damage, the micronucleus test is based on the enumeration of downstream aberrations after DNA damage and reveals a time-integrated response to complex mixtures of pollutants. The test was developed in several aquatic organisms over the last decade, including mussels (Burgeot et al, 1996, Bolognesi et al., 1996). Cytogenetic damage can result in the formation of MN-containing lagging whole chromosomes or chromosome fragments. Thus, MN assay provide the evidence of DNA breakage and spindle dysfunction caused by clastogens and aneuploidogenic poisons (Heddle et al., 1983, 1991; MacGregor, 1991; Seelbach et al., 1993; Kramer, 1998; Zoll-Moreux 1999).

1.2.17 Histology

Histopathological alterations in selected organs and tissues are conceived as histopathological or tissue-level biomarkers. By looking at the structure/morphology of digestive glands, it is possible to follow the metabolic activity. Digestive gland alterations are a reflection of disturbances at the molecular level and identification of these disturbances can aid in the understanding of whole animal impact due to pollutants and other stress factors. Histopathological characteristics of specific organs express condition and represent time-integrated endogenous and exogenous impacts on the organism stemming from alterations at lower levels of biological organisation (Stebbing 1985).

Histological biomarkers provide powerful tools to detect and characterise the biological endpoints of toxicant and carcinogen exposure (Hinton et al., 1992; Moore & Simpson, 1992). As such, the utility of histological lesions as sensitive and reliable indicators of the health of wild fish populations has been demonstrated in several European and North American studies (Kranz & Dethlefsen, 1990; Myers et al., 1998; Köhler, 1991,1992; Lang et al., 1999). Several laboratory and mesocosm studies have also demonstrated causal links between exposure to xenobiotics and the development of toxicopathic hepatic lesions (Malins et al., 1985a; Malins et al., 1985b; Moore & Myers, 1994).

In mussel, histopathological biomarkers are often analysed in the digestive gland. The digestive gland of molluscs is the main centre for metabolic regulation, participating in the mechanisms of immune defence and homeostatic regulation of the internal medium, as well as in the processes of detoxification and elimination of xenobiotics (Moore and Allen, 2002). The biomarkers selected for this study are lipofuscin and neutral lipid accumulation in mussel digestive gland. The digestive gland of bivalves is made by a complex endo-lysosomal system that is primarily in the uptake and digestion of food as well as in process of pollutant accumulation and detoxification (Cajaraville et al., 1995). The lysosomal lipid content may change due to environmental stress. In this study, lipofuscin accumulation and neutral lipid content had been chosen as histological biomarkers. Lipofuscin accumulation represents a general response (Viarengo et al., 1990; Regoli et al. 1992). Elevated lipofuscin accumulation reflects degradation of cellular membrane caused by oxidative damage following the action of different pollutants (Moore, 1988). Neutral lipid accumulation appears to be more strictly linked

to organic chemical pollution (Pipe and Moore, 1986, Lowe and Clarke, 1989, Cjaraville, 1991). Lipofilic xenobiotics in fact may alter the metabolism of neutral lipids leading to abnormal accumulation of that lipid class inside lysosomes (Moore, 1988).

2 Material and methods

Atlantic cod and blue mussel that originated from local fish and shellfish farmers were transported to the Ekofisk field and deployed in cages as described in the survey report (Appendix A). After 6 weeks of field exposure, cages with animals were retrieved, biological data on length, weight, and sex was measured and biological samples obtained.

Table 3. Locations and designation for stations.

St designations	Location
REF 1	Reference NE of discharge
REF 2	Reference E of discharge
ST 1	1600m SW
ST 2	600m SW
ST 3	Off southern flare
ST 4	Off 2/4J
ST 5	1100m NE
ST 6	2000m NE

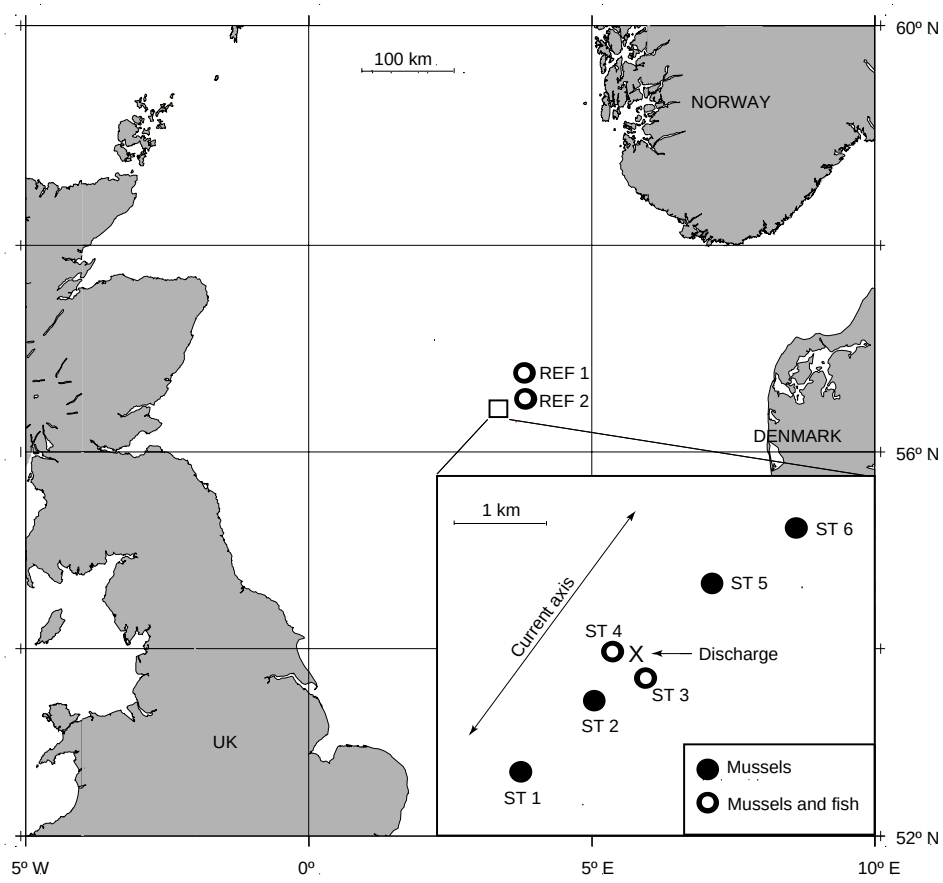

Figure 1. Positions of the caging stations at the Ekofisk field (superimposed panel) and positions of the reference stations in relation to the field.

2.1 Sea temperature and salinity

The used instrument was of the type STD/CTD – model SD204, measuring, calculating and recording sea water conductivity/salinity, temperature, depth (pressure) and sound velocity/water density. The instrument was operated by COPSAS personnel at the Ekofisk platform and lowered at 6 occasions (April 5th, May 1st, twice May 10th, May 15th and May 22nd). The instrument logged data every 2nd second.

The specifications for the instruments are as follows:

Conductivity: *Inductive cell*, range: 0-70 mS/cm, resolution: 0.01 mS/cm, accuracy: ± 0.02 mS/cm. Salinity: *Calculated from C, T and D*, range: 0-40 ppt, resolution: 0.01 ppt, accuracy: ± 0.02 ppt. Temperature: range: -2 to +40 °C, resolution: 0.001 °C, accuracy: ± 0.01 °C, response time: <0.5 sec. Pressure: ranges: 500, 1000, 2000, 6000 m, resolution: 0.01 % FS, accuracy: ± 0.02 % FS, Sound velocity: *Calculated from C, T and D*, ranges: 1300-1700 m/s, resolution: 5 cm/s, accuracy: ± 10 cm/s

2.2 Sea current

Current instruments were deployed at station 2, 5 and reference 2.

For stations 2 and 5 the instrument type Recording Current Meter RCM9 was used, measuring current velocity (range: 0 - 300 cm/s, accuracy: 2 cm/s or 2 %), current direction (accuracy/resolution: 0.35°; accuracy ±5° for 0-15° tilt), temperature (range: -2.46 – 36.04 °C, accuracy/resolution: 0.05 °C) and depth (range 0-2000 m, accuracy/resolution: 0.1 %/0.2 %). The instrument logged data every 10th minute.

The instruments were deployed in the water from 06:55 hours the 6th of April 2006 until 16:45 the 21st of May 2006 (St. 2) and from 08:25 hours the 6th of April 2006 until 09:45 the 22nd of May 2006 (St. 5). >6600 data points were collected at each station.

For the reference station 200 the used instrument were of the type Aquadopp Current Meter measuring current velocity (range: 0.5 - 500 cm/s, accuracy: 0.5 cm/s or 1 %), current direction (accuracy/resolution: 2°/0.1°), temperature (range: -4 – 40 °C, accuracy/resolution: 0.1 °C/0.01) and depth (range 0-200 m, accuracy/resolution: 0.25 % /better than 0.005 % of full scale per sample). Accuracy of current velocity is dependent on set-up parameters. During the WC monitoring the accuracy was 0.4 cm/s. The instrument measured current velocity as a 60 seconds average and logged data for every 10 minute, diagnostic data were collected every 12 hour.

The instrument was deployed in the water from 14:00 hours the 5th of April 2006 until 11:00 the 21st of May 2006. From the logged results data and diagnostics the instrument seems to work normal through the test period and a total of 6600 data points were collected. For pre-programmed set-up for Aquadopp see appendix.

2.3 Contamination control during transport

Sea water samples were collected from the fish well onboard the vessel during the transport. For each of the six samples 10 litres were used for the etyl-acetate extraction. The extracts were analysed for PAHs by GCMS (2.5.2.).

2.4 General biological observations

Fish were sexed by visual examination of gonads and liver weight was recorded. Total weight of cod was measured in the lab onboard the vessel. In order to provide best possible measurements of liver and gonads, these tissues were wrapped in aluminium foil, frozen at -20ºC and brought to Akvamiljø lab for measurements.

Condition was determined as the ratio between total weight and the cube of the fork length of the fish.

$$\text{Condition index} = [\text{Weight (g)}/\text{Length (cm)}^3)]\times 100$$

Liver somatic index (LSI, liver index) reflects the animal nourishment status. LSI at 0-samplingat the end of the exposure was calculated as:

$$\text{LSI} = [\text{Liver weight X } 100] / \text{fish weight}$$

Gonadosomatic index (GSI, gonad index) reflects the animal reproduction status. GSI at the end of the exposure was calculated as:

GSI = [Gonad weight X 100] / fish weight

2.5 PAH-metabolites in fish bile

2.5.1 Fixed fluorescence

Fixed Fluorescence (FF) is a semi-quantitative and semi-qualitative screening method for direct fluorescence detection of groups of PAH metabolites (Aas *et al*. 2000b). Bile samples were diluted 1:1600 in methanol:water (1:1). Slit widths were set at 2.5 nm for both excitation and emission wavelengths, and samples were analysed in a quartz cuvette. All bile samples were analysed by FF at the wavelength pairs 290/335, 341/383 and 380/430 nm, optimised for the detection of 2-3 ring, 4-ring and 5-ring PAH metabolites, respectively. The fluorescence signal was transformed into pyrene fluorescence equivalents through a standard curve made by pyrene (Sigma St Louis, USA). Pyrene was measured at the same fluorometer, with the same cuvette, same solvent, and with the same slit settings as the bile samples. It was, however, measured at the optimal wavelength pair of pyrene, 332/374 nm (ex/em). The concentration of PAH metabolites in bile samples was expressed as µg pyrene fluorescence equivalents (PFE) /ml bile.

2.5.2 GC/MS

Fish bile was prepared for analysis as described by Jonsson et al. (2003; 2004). Briefly, 25–30 µl of bile was weighed accurately into a micro centrifuge vial. Internal standards (2,6-dibromophenol, 3-fluorophenanthrene and 1-fluoropyrene) and β-glucuronidase (3000 units) in sodium acetate buffer (0.4 M, pH = 5) were added and the solution left at 40°C for 2 hours. The OH-PAHs were extracted with ethylacetate (4 times 0.5 ml), the combined extract dried with anhydrous sodium sulphate and concentrated to 0.5 ml. Trimethylsilyl (TMS) ethers of OH-PAHs were prepared by addition of 0.2 ml BSTFA and heating for two hours at 60°C. TPA was added as a GC-MS performance standard before transferring the prepared samples to capped vials.

Trimethylsilyl ethers of OH-PAHs (TMS-OH-PAHs) in fish bile samples were analysed by a GC-MS system consisting of a HP5890 series II Gas chromatograph, Shimudadzu QP2010 GCMS. Helium was used as carrier gas and the applied column was CP-Sil 8 CB-MS, 50 m x 0.25 mm and 0.25 µm film-thickness (Instrument Teknikk A.S., Oslo, Norway). Samples and calibration standards (1 µl) were injected on a split/splitless injector with splitless mode on for one minute. The temperatures for the injector, transfer-line and ion source were held at 250°C, 300°C and 240°C, respectively, and the GC oven temperature programme was as follows: 80°C to 120°C at 15°C min^{-1}, 120°C to 300°C at 6°C min^{-1} and held at 300°C for 30 min. Mass spectra were obtained at 70 eV in selected ion mode (SIM). Based on the fragmentation pattern of non-alkylated

TMS-O-PAHs (Jonsson et al. 2003, Krahn et al. (1992); the molecular ions were selected for determination of both alkylated and non-alkylated TMS-O-PAHs.

2.6 AP metabolites in fish bile

Fish bile was prepared for analysis as described by Jonsson et al. (2003; 2004). Briefly, 25–30 µl of bile was weighed accurately into a micro centrifuge vial. Internal standards (2,6-dibromophenol, 3-fluorophenanthrene and 1-fluoropyrene) and β-glucuronidase (3000 units) in sodium acetate buffer (0.4 M, pH = 5) were added and the solution left at 40°C for 2 hours. The OH-PAHs were extracted with ethylacetate (4 times 0.5 ml), the combined extract dried with anhydrous sodium sulphate and concentrated to 0.5 ml. Trimethylsilyl (TMS) ethers of OH-APs were prepared by addition of 0.2 ml BSTFA and heating for two hours at 60°C. TPA was added as a GC-MS performance standard before transferring the prepared samples to capped vials.

Trimethylsilyl ethers of OH-APs (TMS-OH-APs) in fish bile samples were analysed by a GC-MS system consisting of a HP5890 series II Gas chromatograph, Shimudadzu QP2010 GCMS. Helium was used as carrier gas and the applied column was CP-Sil 8 CB-MS, 50 m x 0.25 mm and 0.25 µm film-thickness (Instrument Teknikk A.S., Oslo, Norway). Samples and calibration standards (1 µl) were injected on a split/splitless injector with splitless mode on for one minute. The temperatures for the injector, transfer-line and ion source were held at 250°C, 300°C and 240°C, respectively, and the GC oven temperature programme was as follows: 80°C to 120°C at 15°C min^{-1}, 120°C to 300°C at 6°C min^{-1} and held at 300°C for 30 min. Mass spectra were obtained at 70 eV in selected ion mode (SIM). Based on the fragmentation pattern of non-alkylated TMS-O-APs (Jonsson et al. 2003); the molecular ions were selected for determination of both alkylated and non-alkylated TMS-O-APs.

2.7 Glutathion-S-transferase (GST) activity

The method used is based on Habig et al (1974), and optimised for cod tissues. Liver tissue was homogenised with a Potter-Elvehjem glass/teflon homogeniser in four volumes of ice-cold 100 mM KH_2PO_4 buffer, pH 7.8, 0.15 M KCl. The homogenate was centrifuged at 10 000 × g for 30 min. before the supernatant was centrifuget at 50 000 × g for 2 h. The cytosolic fractions were aliquoted and stored at –80^{o}C.

Cytosol samples were diluted 50 fold in ice cold phosphate buffer (100mM KH_2PO_4/K_2HPO_4, pH 7.4, 50 µL of each sample was transferred to 96 microwell plates in triplicates. Each plate additionally contained a negative and a positive control (cod sample). The microplates were stored on ice until analysis. Reagents (2 mM CDNB, 1 mM GSH) were mixed and 200 µL added to the wells (containing cytosol samples, blanks, or positive controls) using a multi channel pipette. The plate was then transferred to the microplatereader were the absorbance was measured at 340 nm during 2 minute run at 22°C. The enzyme activity can be estimated and normalised against the sample protein concentration.

The activity calculation: (well volume × (Δ Absorbance-blank))/ (sample volume × 9.6 × light-way × [Protein] $_{well}$), where 9.6 is the molar extinction coefficient (∈) for the CDNB-GSH conjugate (in $mM^{-1}cm^{-1}$). GST activities were expressed as nanomoles of substrate converted per minute per mg of protein in the cytosol.

The total protein concentrations of the samples where determined by a procedure based on the Lowry method (Lowry, 1951).

2.8 Hepatic Cytochrome P450 1A

From homogenised cod liver tissue in 100 mM KH2PO4 buffer, pH 7.8, the centrifuged cytosolic fraction was centrifuged once more at 50 000 g for a microsomal fraction of hepathocytes used in the CYP1A ELISA assay.

Total protein concentrations of the samples were determined by a procedure based on the Lowry method. Based on the total protein concentrations, the samples were diluted to10 µg/ml in carbonate-bicarbonate buffer and transferred to a 96 micro well plate, each containing 4 replicates of the sample, a blank and a positive control (cod sample). The plate was sealed with sealing tape and incubated over night in dark at 4 °C.

The second day the plate was washed three times with TTBS. 1% BSA in TTBS was added to the wells to block unspecific binding and the plate was incubated for 1 hour. The plate was washed a second time with TTBS. The primary anti body rabbit-anti-fish CYP1A (CP226) (Biosense) with dilution 1:1000 was added to all wells and the plate was sealed with sealing tape and incubated over night in dark at 4 °C. The third day the plate was washed three times with TTBS. The secondary anti body goat-anti-mouse HRP conj. (BIORAD) with dilution 1:3000 was added to all wells and incubated at 4 °C for 6 hours. The plate was washed with TTBS. TMB plus (KemEnTec) buffer was added for colour development and the reaction was stopped after 12 min. with 1 M H_2SO_4. The absorbance was read at 450 nm.

2.9 Vitellogenin

Blood samples were taken from the caudal vein by means of pre-cooled syringes containing heparin (10000 IU/ml, Sigma) and the protease inhibitor Aprotinin (5 TIU/ml, Sigma) and centrifuged at approximately 2000 g. The supernatant was carefully transferred to cryo-vials, aliquots were prepared and samples snap-frozen in liquid nitrogen. Plasma samples were stored at -80°C until analysis. Vitellogenin was determined in plasma from caged cod using a competitive ELISA with cod vitellogenin as standard and competing antigen. The analyses were performed using a kit (V01006401) from Biosense Laboratories AS (Bergen, Norway) with anti-cod antiserum and cod vitellogenin as standard, according to the instructions of the manufacturer.

Plasma samples were diluted 50 and 5000 times in Phosphate buffer saline, pH 7.2. The plasma samples were transferred to 96 well microplates, each containing duplicates of the diluted sample, a blank and a positive control (cod sample). Also two VTG standard

series were transferred to the microplates. The plates were sealed and incubated for 1 hour at 37 °C. The plates were washed three times in PBS buffer. Detecting antibody with dilution 1:500 was added to the wells and incubated for 1 hour at 37 °C. The plates were washed three times in PBS buffer. Secondary antibody with dilution 1:2000 was added to the wells and incubated for 1 hour at 37 °C. The plates were washed five times in PBS buffer and TMB substrate solution was added to the wells. The plates were incubated in the dark at room temperature for 30 min. The reaction was stopped with 0.3 M H_2SO_4 and the absorbance read at 450 nm. The VTG-concentration in the diluted samples was determined using the equation for the adjusted standard curve from the standard series. The VTG concentration was multiplied with the dilution factor and is expressed in ng/ml.

2.10 Zona Radiata Protein

Blood samples were taken from cod as described for vitellogenin. Plasma samples were stored at -80°C until analysis. Zona Radiata Protein (ZRP) was determined in plasma from caged cod using a competitive ELISA with a competing antigen.

The plasma samples were diluted 1:2000 in carbonate-bicarbonate buffer and transferred to a 96 micro well plate, each containing 4 replicates of the sample, a blank and a positive control (cod sample). The plate was sealed with sealing tape and incubated over night in the dark at 4 °C.

The second day the plate was washed three times with 20 mM Tris-buffer, pH 8.5, (TTBS). 1% BSA in TTBS was added to the wells to block unspecific binding and the plate was incubated for 1 hour. The plate was washed a second time with TTBS. The primary anti body rabbit-anti-salmon ZRP (O-146) (Biosense) with dilution 1:400 was added to all wells and the plate was sealed with sealing tape and incubated over night in dark at 4 °C. The third day the plate was washed three times with TTBS. The secondary anti body goat-anti-rabbit HRP conj. (ZYMED) with dilution 1:3000 was added to all wells and incubated at 4 °C for 6 hours. The plate was washed with TTBS. TMB plus (KemEnTec) buffer was added for colour development and the reaction was stopped after 12 min. with 1 M H2SO4. The absorbance was read at 450 nm.

2.11 DNA adducts

Deep-frozen liver tissue pieces from cod were semi-thawed. DNA was extracted and purified according to Dunn *et al*., 1987; Reichert and French 1994, with minor modifications as described by Ericson *et al*. 1998 and Ericson and Balk 2000. DNA adducts were enriched using the Nuclease P1 method, 0.8 µg Nuclease P1/µg DNA, and a 45 min incubation period (Reddy and Randerath 1986; Beach and Gupta 1992). Finally the DNA adducts were radiolabelled using 5´-[γ-^{32}P]triphosphate ([γ-^{32}P]ATP) and T_4 polynucleotide kinase (Aas *et al*. 2000a). Separation and clean up of adducts was performed by multidirectional thin-layer chromatography (TLC) on laboratory produced polyethyleneimine cellulose sheets, described as suitable for adducts formed from large hydrophobic xenobiotics, such as 4- to 6- ring, PAHs (Reichert and French 1994;

Ericson *et al*. 1999). In addition, several quality control experiments were performed parallel to the analysis of the samples. Detection limit for the method varies among samples due to individual plate background.

2.12 PAH body burden in mussel

Approximately 15 whole blue mussels were excised from their shell and transferred to solvent cleaned and high temperature treated glass containers. The mussels were frozen and transported to Batelle on dry-ice. The samples were stored at -80^{o}C until analyses.

Analysis at NIVA: (See Appendix F for a detailed description of analysis at Battelle)

The biological matter was homogenised, added internal standards (naphtalene d8, acenaphthene d8, phenanthrene d10, chrysene d12, perylene d12 and athracene d10) and saponified. The compounds were extracted with n-pentane and dried over sodium sulphate. The extraction volume was reduced and the extracts were cleaned by GPC and solvent exchanged to cyclohexane. The extracts were then analysed by GC/MS with the MS detector operating in selected ion monitoring mode (SIM) and analyte concentrations in the standard solutions were in the range 5-1000 ng/µl. The GC was equipped with a 30 m column with a stationary phase of 5% phenyl polysiloxane (0.25 mm i.d. and 0.25 µm film thickness), and an injections operated in splitless mode. The initial column temperature was 60°C, which after two minutes was raised to 250°C at a rate of 7°C/min and thereafter raised to 310°C at a rate of 15°C/min. The injector temperature was 300°C, the transfer line temperature was 280°C, the MS source temperature was 230°C and the column flow rate was 1.2 ml/min. Quantification of individual components was performed by using the internal standard method. The alkylated homologues were quantified by baseline integration of the established chromatographic pattern and the response factors were assumed equal within each group of homologues.

2.13 Benzo(a)pyrene hydroxylase activity

Benzo(a)pyrene hydroxylase activity was determined in the microsomal fraction of hepatopancreas by a method modified from Michel et al. (1994). Essentially, frozen hepatopancreas was homogenised in 5 volumes of ice-cold 0.1M potassium phosphate buffer (pH 7.8) containing 0.15 M KCl, one tablet Complete™ protease inhibitor (Boehringer-Mannheim) per 100 ml, 1mM dithiothreitol and 5% glycerol. The homogenate was centrifuged at 10 000 *g* (4 ^{o}C, 30 min.), whereupon the supernatant was removed and subjected to centrifugation at 50 000 *g* (4^{o}C, 120 min.). After centrifugation, the supernatant was removed and the pellet resuspended in ice-cold homogenisation buffer added 15% glycerol (in total 20% glycerol) and 1mM EDTA to obtain a microsomal fraction.

For analysis, 110 µl of the microsmal fraction was added to 750 µl 0.05M sodium phosphate buffer (pH 7.3) containing 2 mg/ml BSA and 40 µl of a BaP solution of 1,8 mM BaP and 80 nM (180 MBq/L) ^{14}C-BaP in acetone. The solution was divided

into two glass tubes and one tube added 80 µl sodium phosphate buffer containing 10 mM NADPH, whereas the other was added 80 µl sodium phosphate buffer. Both tubes were mixed and incubated on an orbital shaker (20^{o}C, 20 min.) before the reaction was terminated by adding 1 ml of stop solution containing 15% 1M KOH and 85 % DMSO. Non-metabolised BaP was removed by 2 sequential extraction steps with 5 ml cyclohexane for 30 min. Following extraction, 700 µL of the water phase was removed for liquid scintillation counting using a standard ^{14}C protocol.

2.14 Imunocompetance

Phagocytosis is one of the main cellular defence mechanisms in invertebrates. The phagocytosis assay measures the ingestion of zymosan yeast cells by isolated haemocytes. Decreased uptake of particles in haemolymph from experimentally treated organisms, when compared against controls, indicates inhibition of the immune function system. Phagocytic activity of haemocytes is assessed by measuring the uptake of neutral red stained zymosan yeast cells (*Saccharomyces cerevisiae*). Phagocytic activity is regarded as a good biomarker of immune function and therefore of organism health. The more particles that are ingested by the cell in the haemolymph sample the more efficiently the immune system of the organism is functioning.

Haemolymph is collected from the posterior adductor muscle (500µl) using a syringe preloaded with PBS 50µl samples of the haemolymph/PBS solution is placed into a 96 well poly-L-lysine coated multiwell plate. After an incubation period, 50µl of stock zymosan/neutral red (50 x 107 particles/ml) are added. Samples are then incubated for 30 min at +4°C. 100µl of Bakers Formal Calcium are added into all wells to fix the cells. After incubate for 10 min in the fridge, excess of zymosan is washed out using PBS solution. The neutral red dye is then re-suspended by adding Acidified Ethanol to the sample wells. This lyses the adhered cells so they release their content. The absorbance is read at 550nm with a spectrophotometer. The assay result is relative to the protein concentration of the total haemolymph sample. The protein concentration has to be measured using the Bradford method (Bradford, 1976).

2.15 Lysosomal membrane stability

The mussels from the pre-exposure group were brought to the lab in Stavanger on ice. The mussels were acclimatised in the lab in aquaria with fresh supply of sea-water for two days prior to sampling (to alleviate stress during transport). The field groups were analysed onboard the vessel directly after retrieval of cages.

Haemolymph samples were obtained from 15 individuals at each field station (23 individuals from reference station 200) and 15 individuals from the pre-exposure group.

0.4 ml haemolymph was sampled from each mussel and mixed with filtered sea water at the ratio 2:1. 40 µl haemolymph/seawater-mixture was pipetted out on microscope-slides, and incubated in a light-proof box for 20 min before 35 µl neutral red

(concentration 0.1 µg/µl) was added. All analyses were performed blind. For a detailed description of the method see Lowe (1994).

NR is selectively taken up by haemolymph cells and this adds an extra stress to the membranes. After some time, from 15 to 200 minutes, depending of the health status of the mussels, the membrane will start to burst and NR will leak out in the cytosol. This causes the form of the cells to change from irregular to round shaped. The time from NR is added the cells and until they become round and perish is observed visually with a microscope (Figure 2). The cells are observed repeatedly at 15, 30, 60, 90, 120, 150 and 180 minutes of incubation with NR. The endpoint of the analysis is when 50% of all cells become round and die. This method is perceived as a general health-parameter, and has been shown to respond to PAH/oil-exposed mussels.

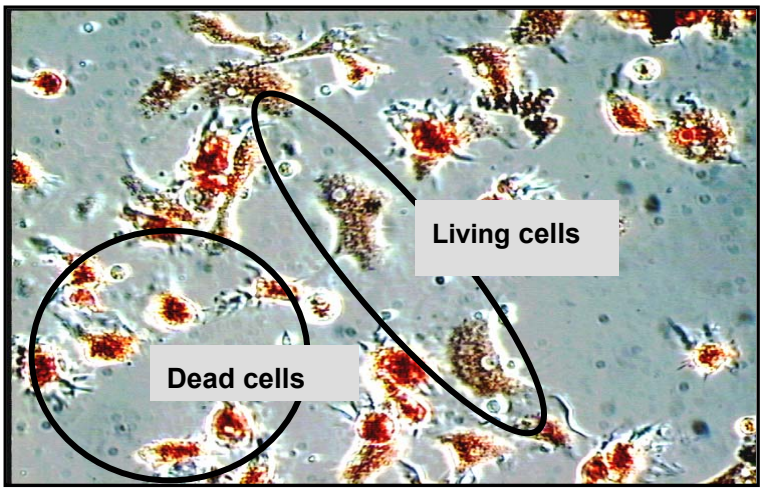

Figure 2. Microscope view (400× magnification) of living and dead mussel haemolymph cells

2.16 Micronucleus formation

Haemolymph of mussels were applied directly on slides, air-dried and fixed in methanol for 15 min. The slides were then shipped and cytogenetic analysis was done in Institute of Ecology at Vilnius University (Lithuania). Slides were stained with 5% Giemsa solution for 10-20 min. Blind scoring of micronuclei was performed on coded slides without knowledge of the exposure status of the samples to eliminate technical variability.

The frequency of micronuclei in haemocytes was determined by scoring at a 1000× magnification using Olympus BX 51 or Nikon Eclipse 50i bright-field microscope. A total of 20000-30000 cells were examined in each caged experimental group of mussel. In some mussel slides, the deficiency of appropriate cells for the micronuclei analysis

was noted. Nevertheless, 500 haemocytes was a minimum amount of cells suitable for the analysis. Therefore, in mussels micronuclei were counted in 500-2000 haemocytes from each specimen.

Only cells with intact cellular and nuclear membrane were scored. MN are scored when: i) nucleus and MN have a common cytoplasm, ii) colour intensity of MN is the same or lower than the one of the nucleus, iii) the size of the MN is equal or smaller than 1/3 of the nucleus, iv) MN must be completed separated from the nucleus, v) cells with multiple MNs are not scored.

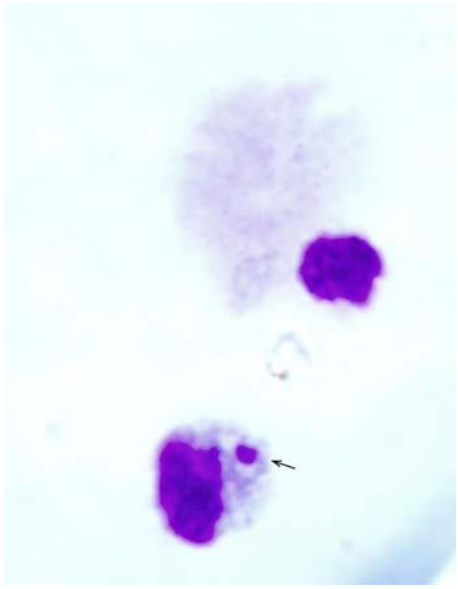

Fig. 2. Micronucleus in haemocyte (arrow) of blue mussel (1000× magnification).

2.17 Histology in mussels

For cytochemical examination small pieces (5x5x5mm) or freshly excised digestive gland tissues from animals are placed on metal cryostat chucks. Each chuck is then placed for 1 min in a small bath of n- Hexane that has been pre-cooled to -196°C (using a surrounding bath of liquid nitrogen). The metal chuck plus the quenched (super-cooled) solidified tissues are then sealed by double-wrapping in parafilm and stored at –40°C until required for sectioning.

Cryostat sections 8µm cut in a cryostat with the cabinet temperature below -25°C and the knife cooled - 20°C. The sections are transferred to “warm” slides (20°C). The section which effectively flash-dries them are (Moore 1976) and the slides can be stored in the freezer at -40 °C before use. Cryostat sections were used for analyses of lipofuscin and neutral lipid accumulation.

Lipofuscin accumulation

The lipofuscin content of lysosomes was determined using the Schomol reaction. Cryostat sections were fixed in calcium-formol for 15 min at 4°C, rinsed in distilled water and immersed in the reaction medium containing an aqueous solutionof 1% ferric chloride and 1% potassium ferrocyanide in a ratio 3:1 (v:v). Section were stained for 5 min, rinsed in acetic acid (1%) for 1 min and washed in distilled water before mounting. Slides were subjected to image analysis. Results were expressed as pixel density.

Neutral lipid accumulation

For the determination of unsaturated neutral lipids, cryostatic section were fixed in calcium-formol for 15 min at 4°C, rinsed in distilled water and transferred into 60% triethylphosphate (v/v with distilled water) for 3 min. Section were stained in 1% solution of Oil Red O in 60% triethylphosphate for 15 min. Then they were rinsed in 60% triethylphosphate for 30 s, washed in distilled water and mounted using aquous mounting medium. Neutral lipid accumulation was assessed by computer assisted image analysis. Results were expressed as pixel density.

2.18 Protein determination

Analyses at IRIS used the Bradford assay for protein normalisation, whereas analyses at NIVA used the Lowry assay to determine the concentration of protein in samples. The Bradford assay relies on the fact that protein binds to Coomassie Brilliant Blue G-250 and changes colour. Coomassie Blue exists in two colour forms, red and blue. Upon binding protein, the red form is converted to the blue form. The protein-dye complex absorbs light at 595 nm of test solution (protein solution + Coomassie) as compared to a set of standard protein solutions (bovine serum albumin, BSA).

Biomarker analyses at NIVA were normalised to protein concentration using Lowry's method adapted for plate-readers (Lowry et al., 1951) with bovine gammaglobulin as standard. The assay is based on the reaction of protein with an alkaline copper tartrate solution and Folin reagent. Amino acids reduce the Folin reagent, yielding several reduced species that have a blue colour. The colour has maximum absorbance at 750 nm and minimumm absorbance at 405 nm.

2.19 Statistical methods

Biological responses in individual mussel or fish were subjected to analysis of variance (ANOVA) to clarify whether there were differences between groups (Sokal & Rohlf, 1981). Prior to analyses, homogeneity of variances was checked using the Levene's test. Variables were transformed as appropriate to attain homodascicity. Where this was not possible, the non-parametric Kruskal-Wallis analysis was used (Sokal & Rohlf, 1981). Where the parametric ANOVA indicated significant differences, groups were compared using Tukey's post-hoc test. The level of significance for rejection of H_0: "no difference between groups" was set to 0.05.

3 Results

3.1 Sea temperature and salinity measurements at Ekofisk

The salinity was generally stable at ~35‰ through the water column (at measured depths), the whole period (April 5th to May 22nd; Figure X). A less saline surface layer (0-5 m) was encountered at some occasions. May 10th, a salinity of 28.2 was measured at ~1m depth.
The surface temperature was increasing throughout the period. It was stable through the water column (at measured depths) prior to May 10th, when a stratification became visible (Figure 3).

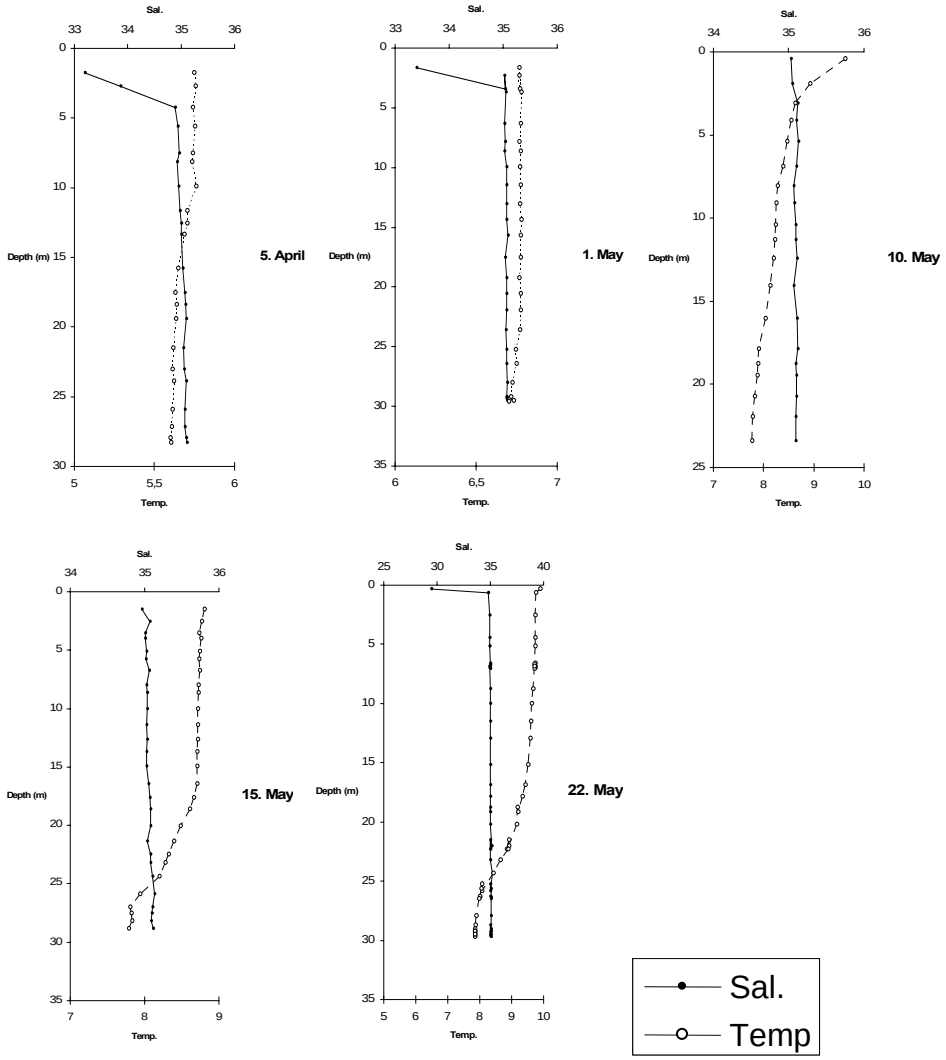

Figure 3. Salinity(‰) and temperature (°C) profiles at Ekofisk, April 5th, May 1st, May 10th, May 15th and May 22nd. Note different scales on axes.

3.2 Sea current

Station 2 and 5

Measurements indicate that the current in the area is predominantly tidal driven with an axis stretching SW-NE (Figure 4). The temperature increased from 5.5 to 9.5 °C during the deployment period for both measuring points, showing a natural spring situation. The measuring depth was 19 meters for station 2 and 17.5 meters for station 5.

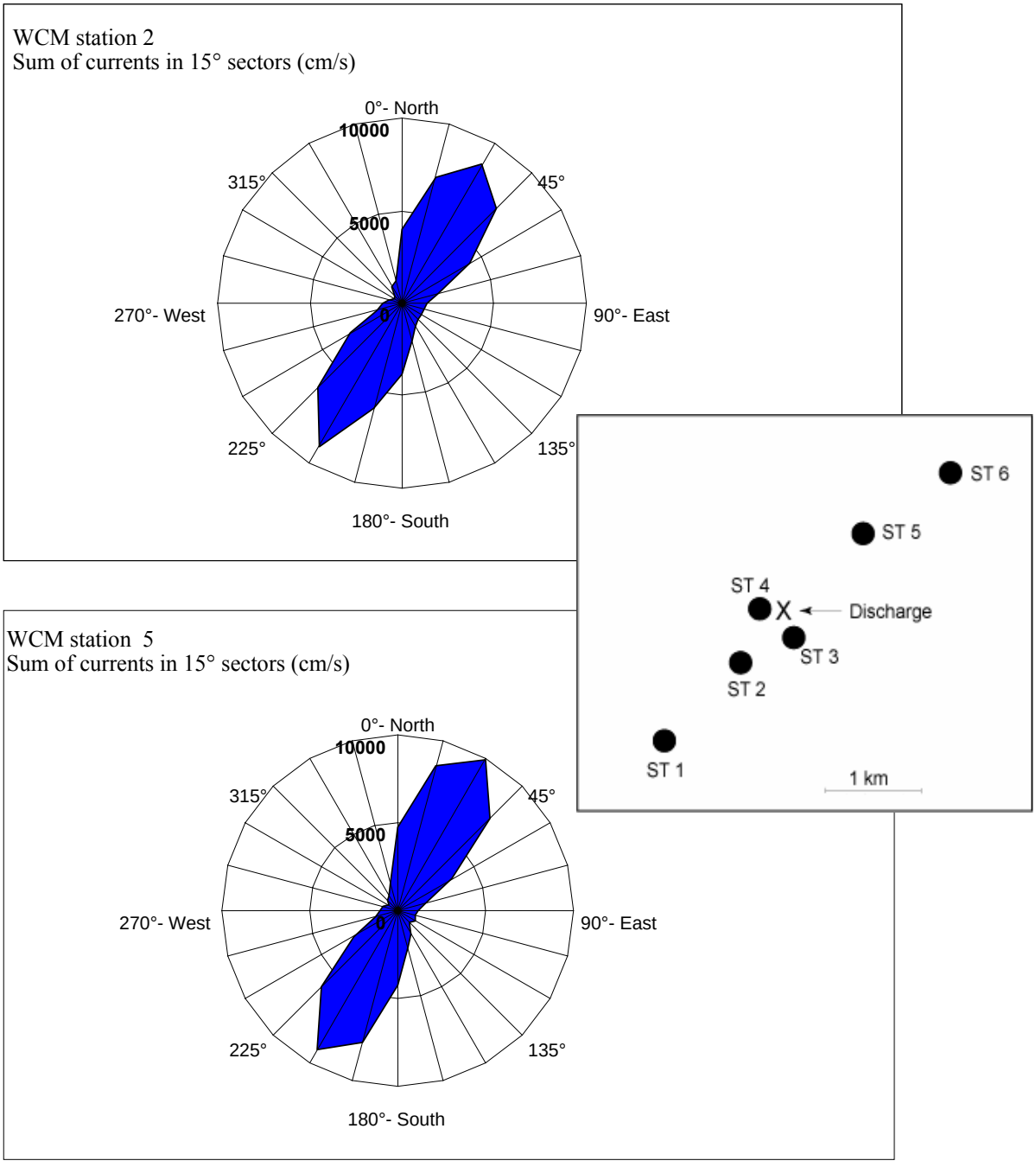

Figure 4. Sum of current measurements (in 15º sectors) at the two stations off Ekofisk. Positions of cages shown for comparison.

Reference station 2

As for the Ekofisk area, measurements at the reference station 2 show predominantly tidal driven current with an axis stretching SW-NE (Figure 5). The temperature increased from 5 to 9 °C during the deployment period. The measuring depth was 12 m until the 16th of April from when it was 14 m (the rig was relocated due to work on pipeline).

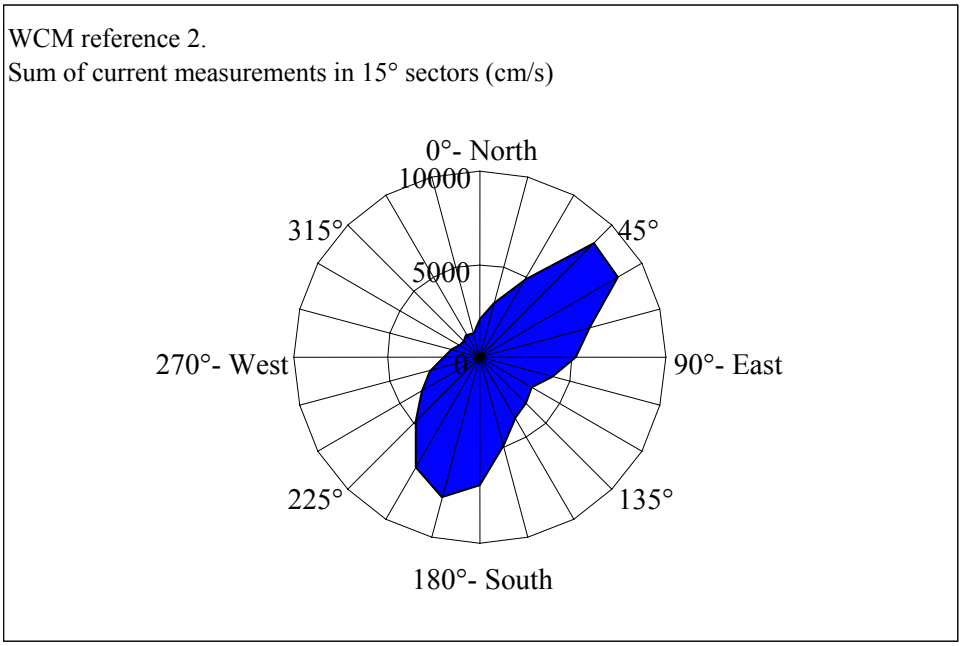

Figure 5. Sum of current measurements (in 15º sectors) at reference station 2.

3.3 Contamination control during transport

Results from GCMS analysis of PAHs in sea water from the vessels storage tanks showed only background levels. This confirms that the organisms used in the study were not contaminated by PAHs from water during the transport

Table 3. PAH (µg/L) in sea water collected in the vessels transport tanks. (n=5; quantification limit 0.005 µg/L)

Compound	Average	stdev
Naphthalene	0,011	0,010
C1-Naphthalene	0,011	0,018
C2-Naphthalene	0,009	0,013
C3-Naphthalene	<0,005	<0,005
Acenaphthylene	<0,005	<0,005
Acenaphthene	<0,005	<0,005
Fluorene	<0,005	<0,005
Phenanthrene	0,001	0,002
Anthracene	<0,005	<0,005
C1-Phen/Anthr	0,006	0,013
C2-Phen/Anthr	0,012	0,026
Dibenzothiophene	<0,005	<0,005
C1-Dibenzothiophene	<0,005	<0,005
C2-Dibenzothiophene	<0,005	<0,005
Fluoranthene	<0,005	<0,005
Pyrene	<0,005	<0,005
Benzo(a)anthracene	<0,005	<0,005

3.4 General biological observations

The body length and weight distribution in the different groups are shown in Figure 6 and Figure 7. The difference in mean values between groups is relatively small.

The experimental cod had lost some weight during deployment, as expressed by higher mean condition index in the 0-sample-group, than in all other groups (ANOVA, $P<0.0001$; Tukey HSD, $P<0,0017$). This trend is also reflected in the liver-somatic index, although the 0-samples were only significantly different from the individuals at station 400, among females (Kruskal-Wallis, multiple comparisons, $P<0.0014$)

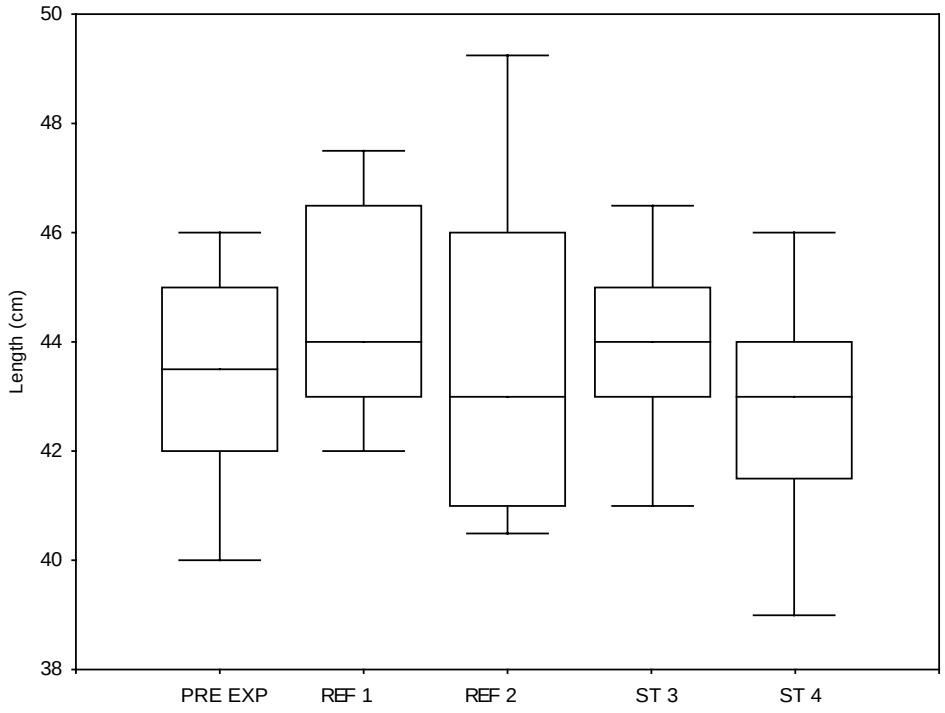

Figure 6. Length (cm) of cod in the different groups. The figure shows median, quartiles (box) and 10/90-percentiles (whiskers).

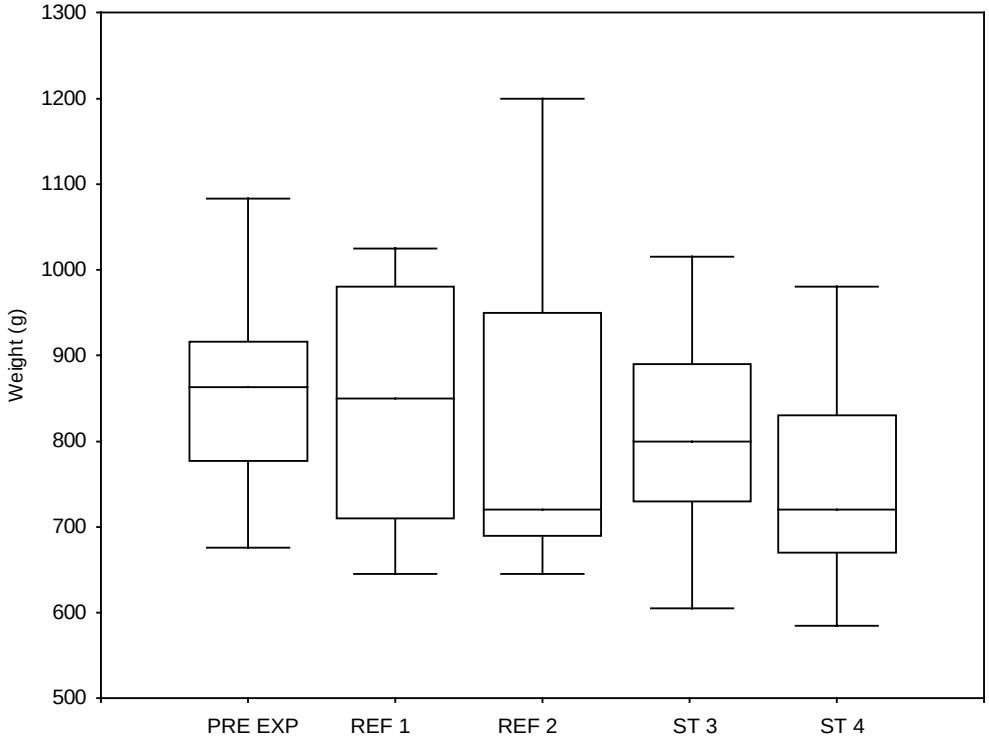

Figure 7. Weight (g) of cod in the different groups. The figure shows median, quartiles (box) and 10/90-percentiles (whiskers).

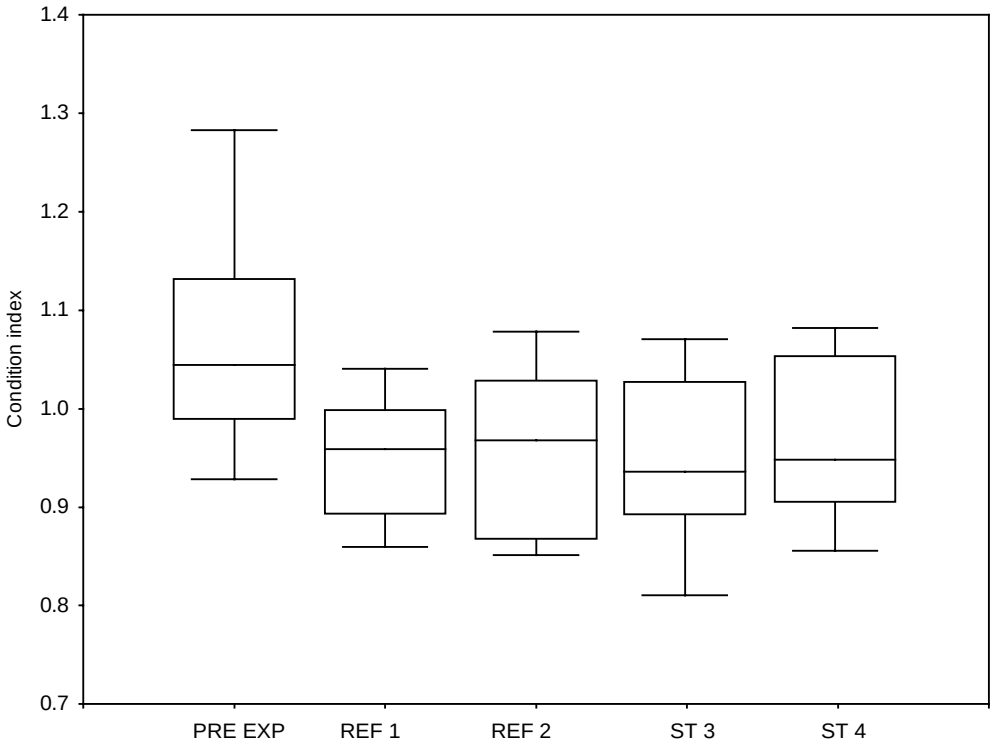

Figure 8. Condition of cod in the indicated groups. The figure shows median, quartiles (box) and 10/90-percentiles (whiskers).

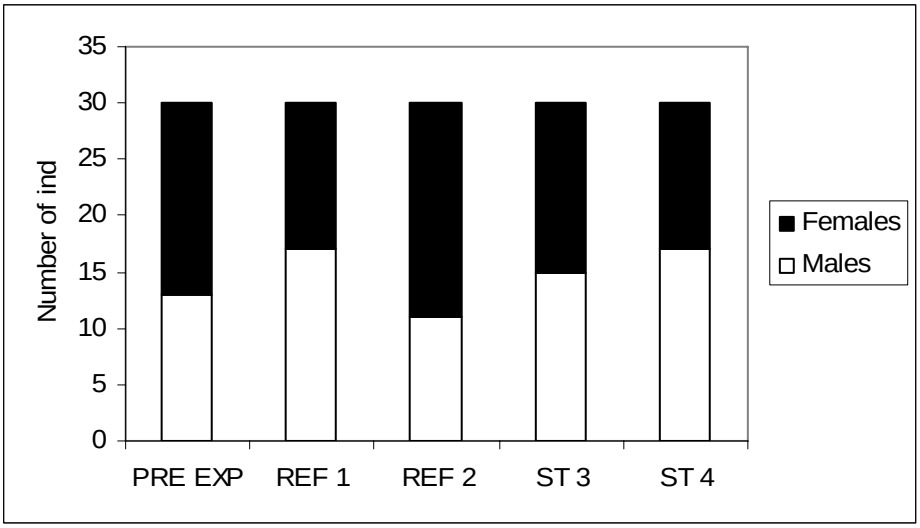

Figure 9. Sex ratios of cod in the groups indicated.

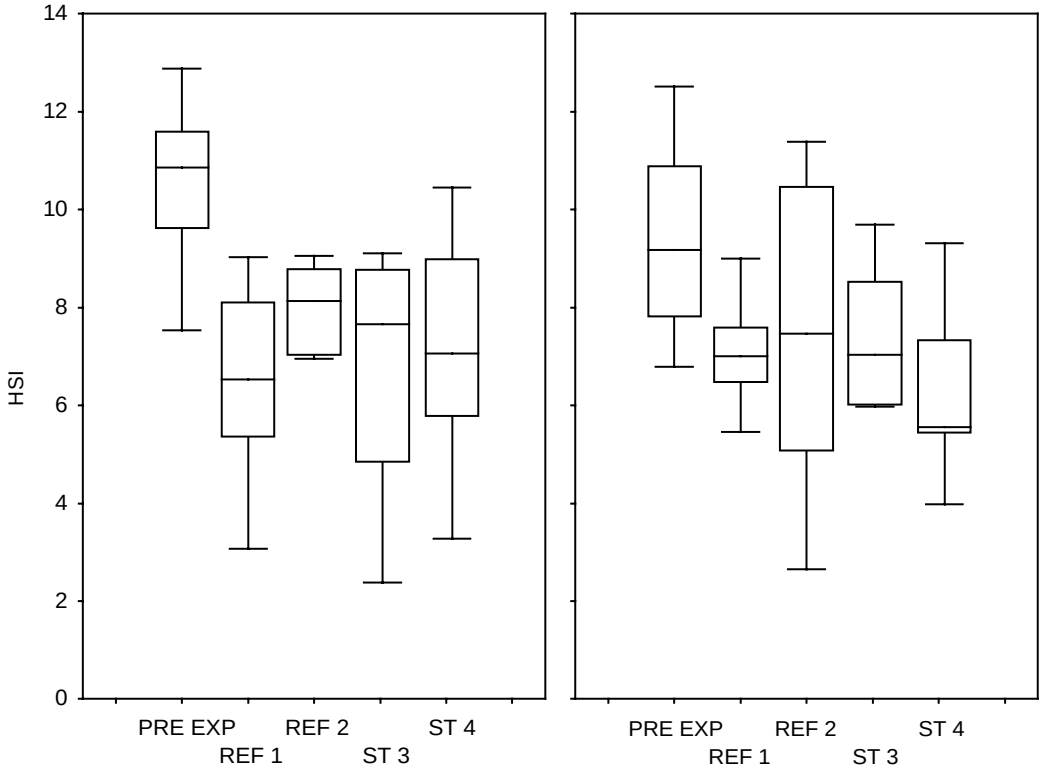

Figure 10. Liver-somatic index in cod in the indicated groups. Right: females, Left: males. The figure shows median, quartiles (box) and 10/90-percentiles (whiskers).

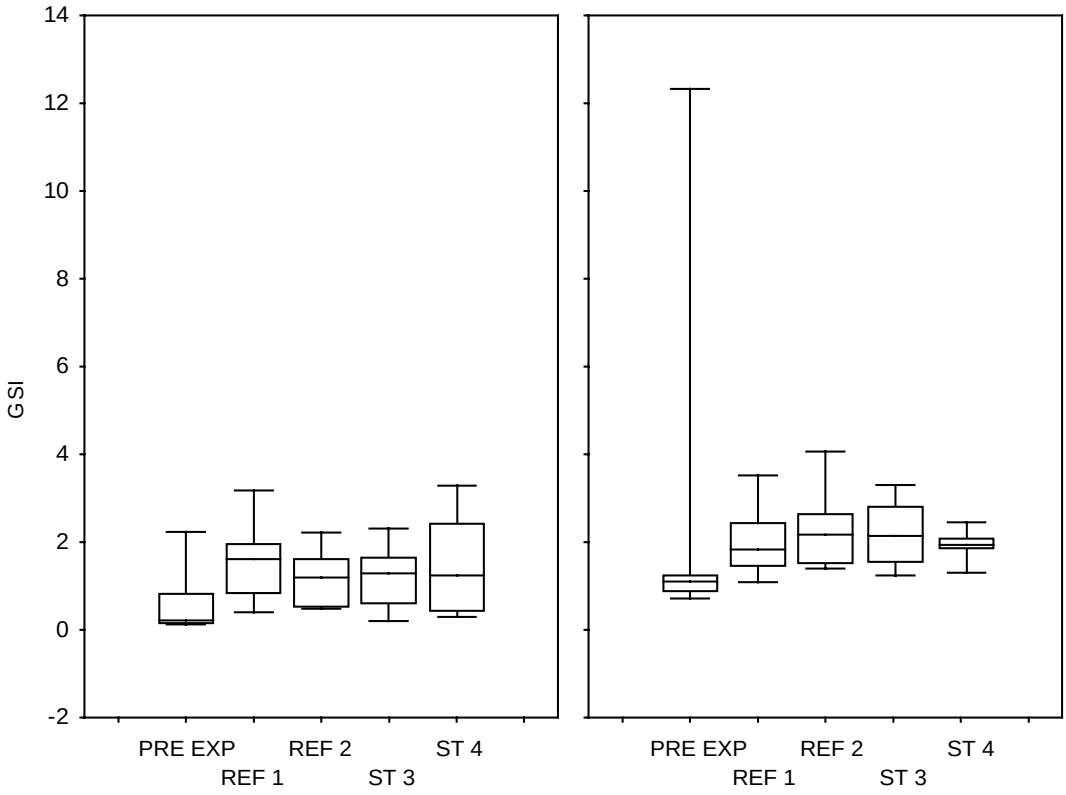

Figure 11. Gonado-somatic index in cod in the indicated groups. Right: females, Left: males. The figure shows median, quartiles (box) and 10/90-percentiles (whiskers).

3.5 Cod - PAH-metabolites in bile

3.5.1 PAH-metabolites by Fixed Fluorescence

Significant differences between groups were only found for the wavelength-pair 241/383 (identifies 4 ring structures). The reference station (100) was significantly lower than all other groups (ANOVA P<0.005; Figure 13). The signal observed for this wavelength-pair in the 0-sampling group is confirmed by a low level of pyrene detected by GCMS analysis (see 3.5.2).

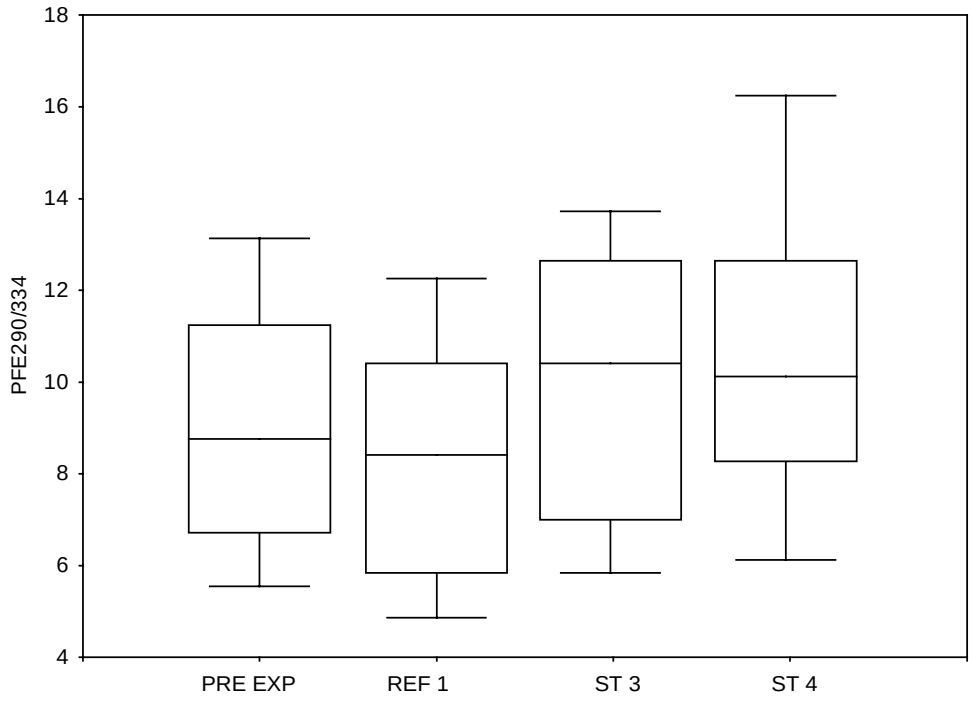

Figure 12. Fixed wavelength (290/334 nm) fluorescence levels in bile from cod in the groups indicated, expressed as pyrene fluorescence equivalents, PFE µg/g. The wavelength pair 290/334 nm identifies 2-3 ring structures. The figure shows median, quartiles and 10/90-percentiles.

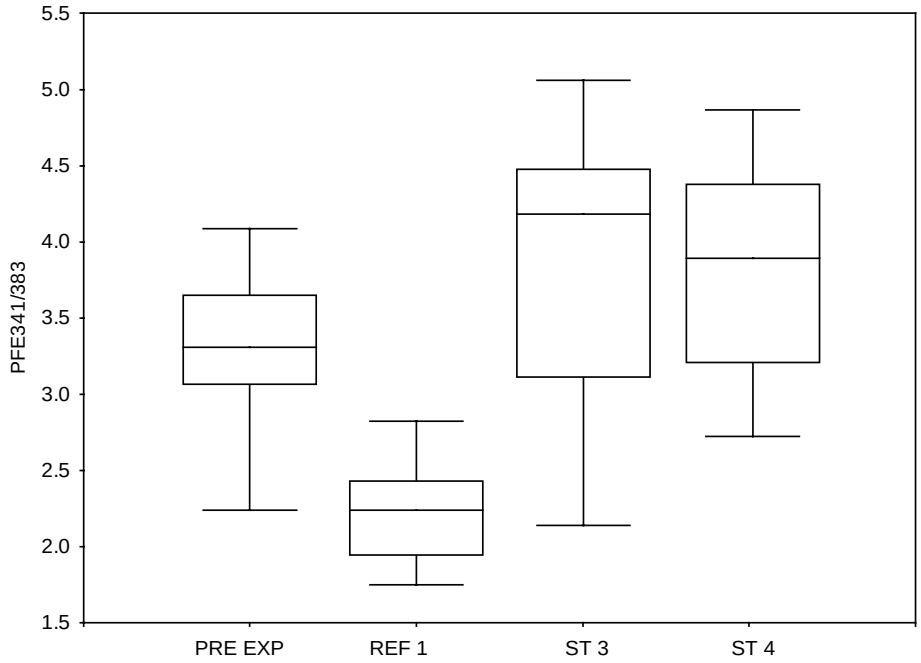

Figure 13. Fixed wavelength (341/383 nm) fluorescence levels in bile from cod in the groups indicated, expressed as pyrene fluorescence equivalents, PFE µg/g. The wavelength pair 341/383 nm identifies 4 ring structures. The figure shows median, quartiles and 10/90-percentiles.

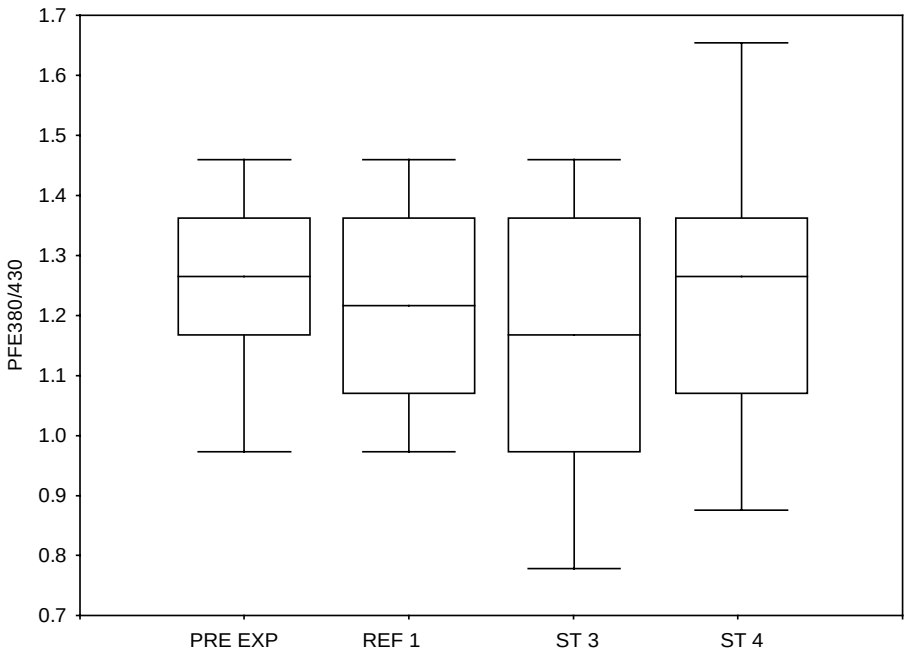

Figure 14. Fixed wavelength (380/430 nm) fluorescence levels in bile from cod in the groups indicated, expressed as pyrene fluorescence equivalents, PFE µg/g. The wavelength pair 380/430 nm identifies 5 ring structures. The figure shows median, quartiles and 10/90-percentiles.

3.5.2 PAH-metabolites by GC/MS

For all metabolite compounds, stations 400 and 300 were significantly different from the 0-sample group (ANOVA, if necessary on log-transformed concentrations; Kruskal-Wallis for C3-OH-naphthalenes; Figure 15). In most cases, the bile concentrations were also higher at station 4 and 3, than at the reference station (Ref 1; not 1-OH-naphthalene). 1-OH-naphthalene and 1-OH-pyrene were highest in the 0-sampling group. This confirms significant uptake and bio-transformation of PAHs typical for produced water to the fish from the two stations close to the discharge.

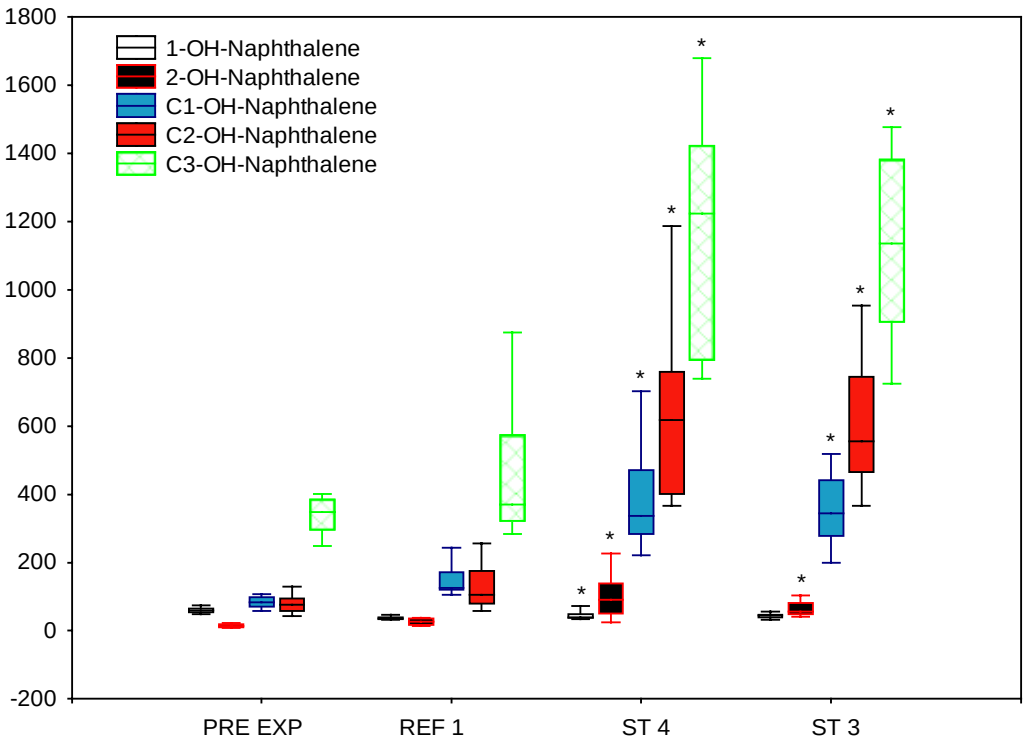

Figure 15**.** Concentrations (ng/g bile) of OH-naphthtalenes in caged cod from the groups indicated. The figure shows median, quartiles and 10/90 percentiles of five individuals from each group.

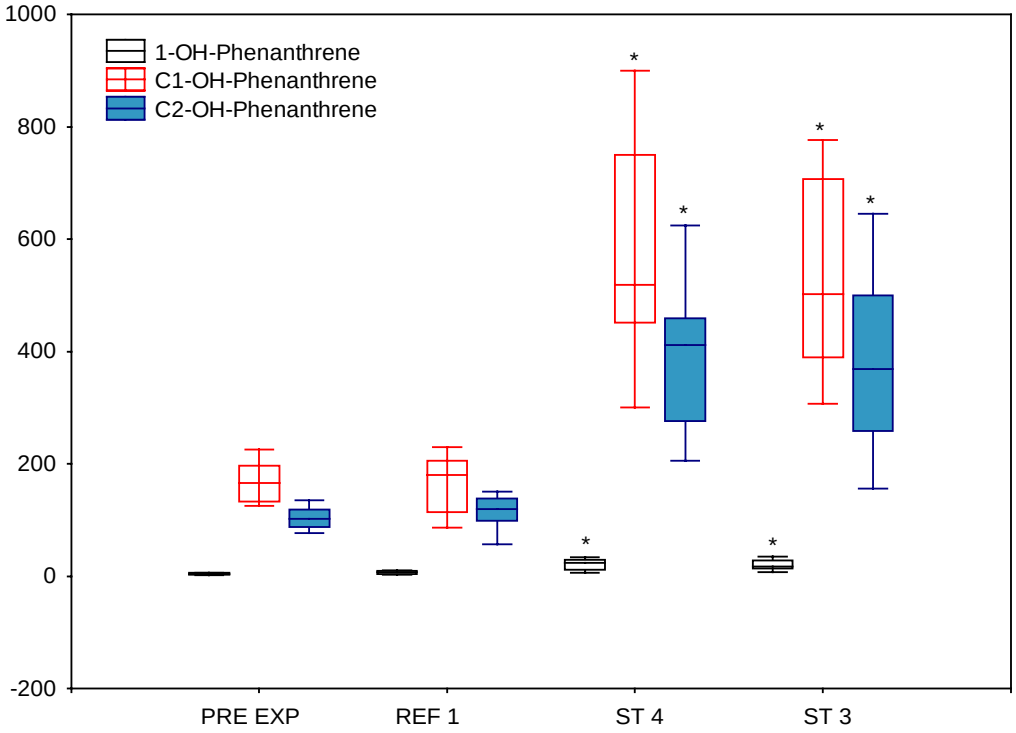

Figure 16**.** Concentrations (ng/g bile) of OH-phenanthrenes in caged cod from the groups indicated. The figure shows median, quartiles and 10/90 percentiles of five individuals from each group.

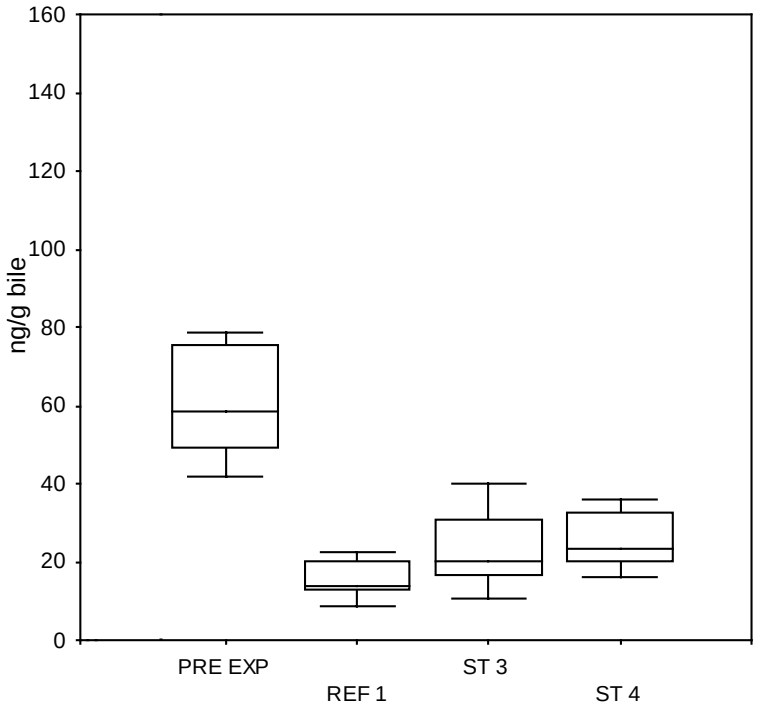

Figure 17**.** Concentrations (ng/g bile) of 1-OH-pyrene in caged cod from the groups indicated. The figure shows median, quartiles and 10/90 percentiles of five individuals from each group.

3.6 AP metabolites in cod bile

Significant differences between groups were found for all metabolite compounds (Kruskal-Wallis, $P<0.05$). This confirms significant bio-concentration and bio-transformation of APs typical for produced water to the fish from the two stations close to the discharge.

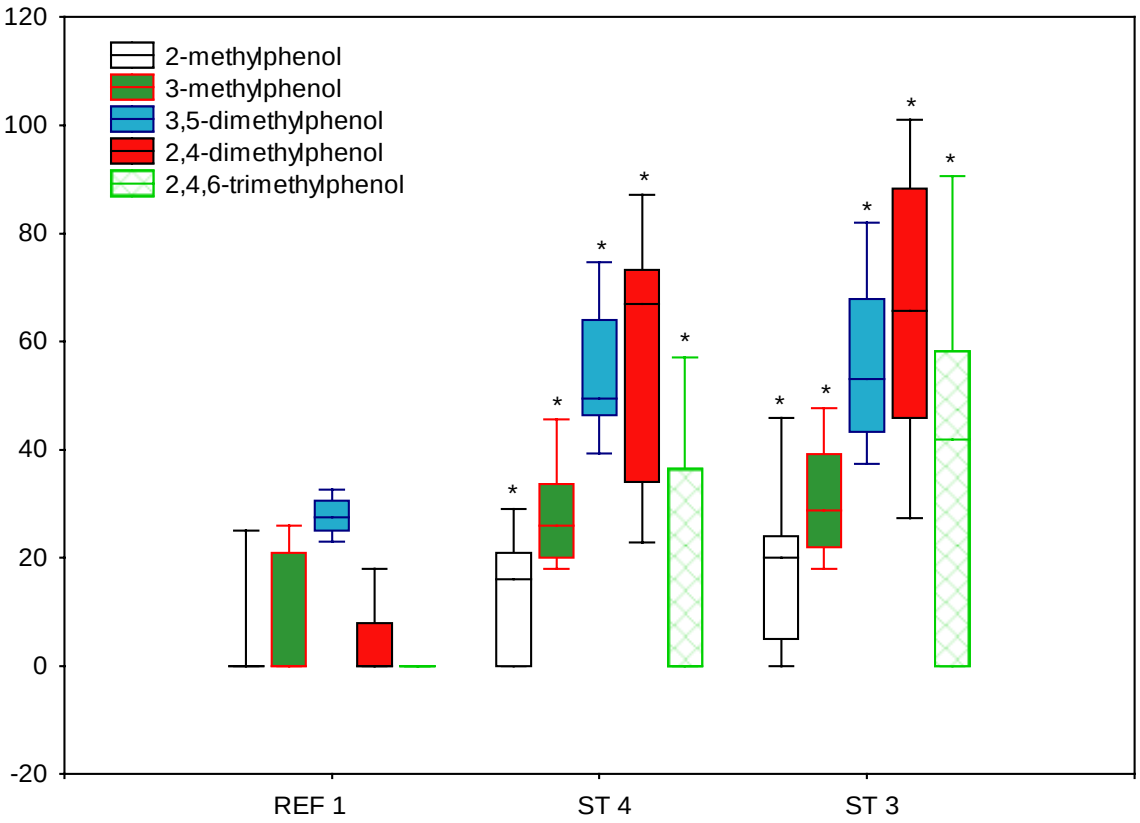

Figure 18. Concentrations (ng/g bile) of AP metabolites in caged cod from the groups indicated. The figure shows median, quartiles and 10/90 percentiles of five individuals from each group.

3.7 Hepatic GST

Generally, there were significant differences in hepatic glutathione-*S*-transferase activity between stations, but not gender related (ANOVA, P<0.0052). The 0-samples had higher GST-activity than the individuals at station 400 (females, P<0.05, Tukey HSD).

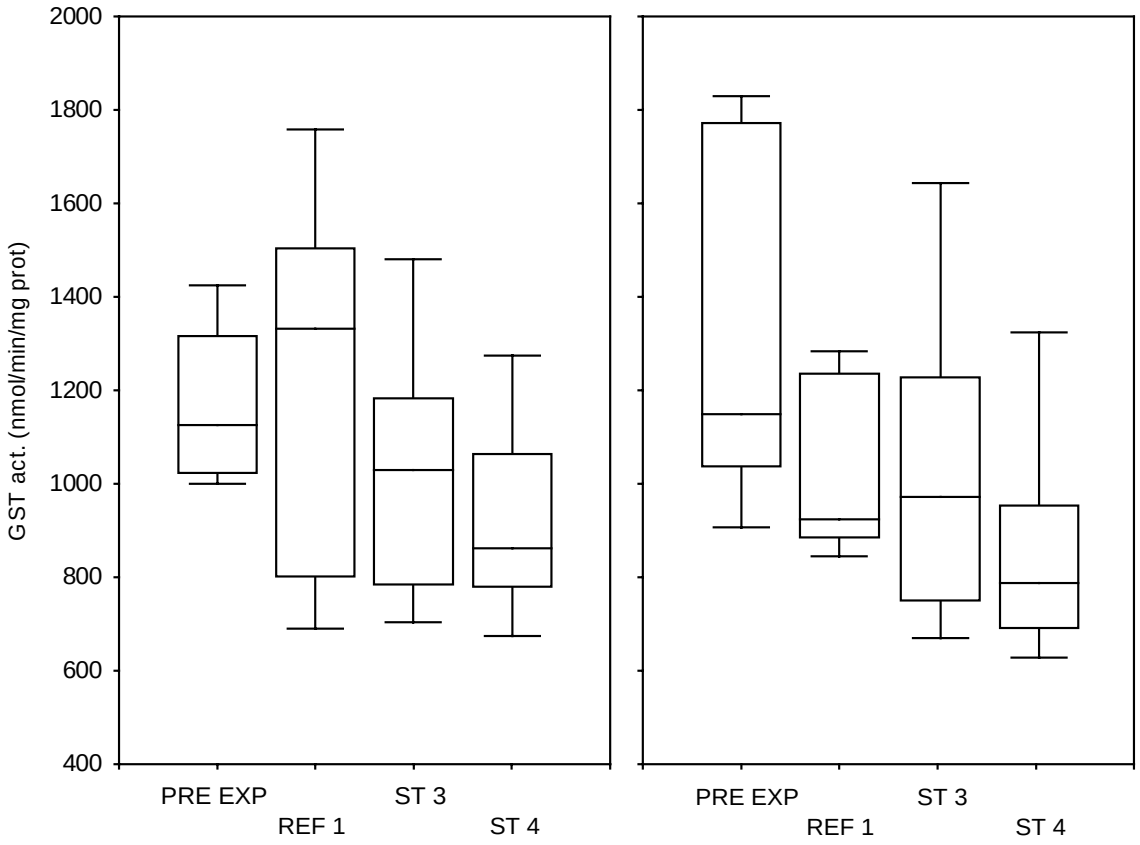

Figure 19**.** Hepatic Glutathione S-transferase, GST, (nmol/min/mg prot.) activity in cod from the indicated groups. The figure shows median, quartiles and 10/90-percentiles. Males – left panel; females – right panel.

3.8 Hepatic Cytochrome P450 1A

Differences in the amount of hepatic CYP1A protein were found between groups, for both genders. Among the males, the amount of hepatic CYP1A protein was higher at station 400 and 300, than at both reference stations (Kruskal-Wallis, multiple comparisons, P<0.027). Among the females, the amount of hepatic CYP1A protein was higher at station 4 and 3, than at reference station 1 (Kruskal-Wallis, multiple comparisons, P<0.027).

Substantial non-specific binding was found when analysing the 0-samples, causing high variability (although median CYP1A amount was lower than at stations 3 and 4 for both genders). Therefore, pre exposure data are not included in the figure, but data from two reference-stations are included.

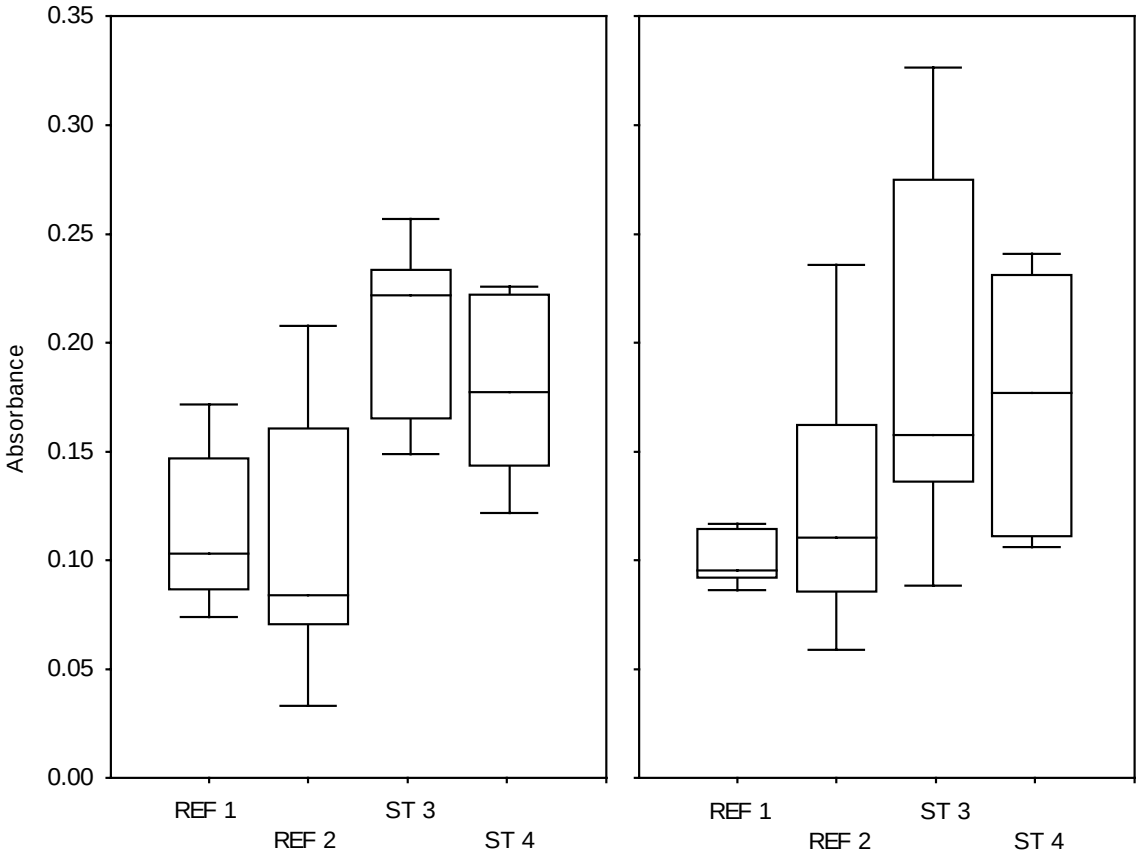

Figure 20. Hepatic Cytochrome P450 1A, activity in cod from the indicated groups. The figure shows median, quartiles and 10/90-percentiles. Females – left panel; males – right panel.

3.9 Vitellogenin

Blood samples were taken from all individuals before deployment (0-samples). The figure depicts the difference in plasma VTG-concentrations from before to after exposure ($\Delta VTG=[VTG]_{after\ exposure} - [VTG]_{before\ exposure}$). There was no increase in plasma VTG-concentrations in males at any stations. Median increase in VTG-concentrations in females were highest on station 3, however, this was not significant. A similar trend could be read from the zona radiata protein (ZRP)-results. There was some variability in the gonado-somatic index (GSI;

Figure 11), that could have some influence on the results, especially in the females, where endogenous estrogens could be an influencing factor.

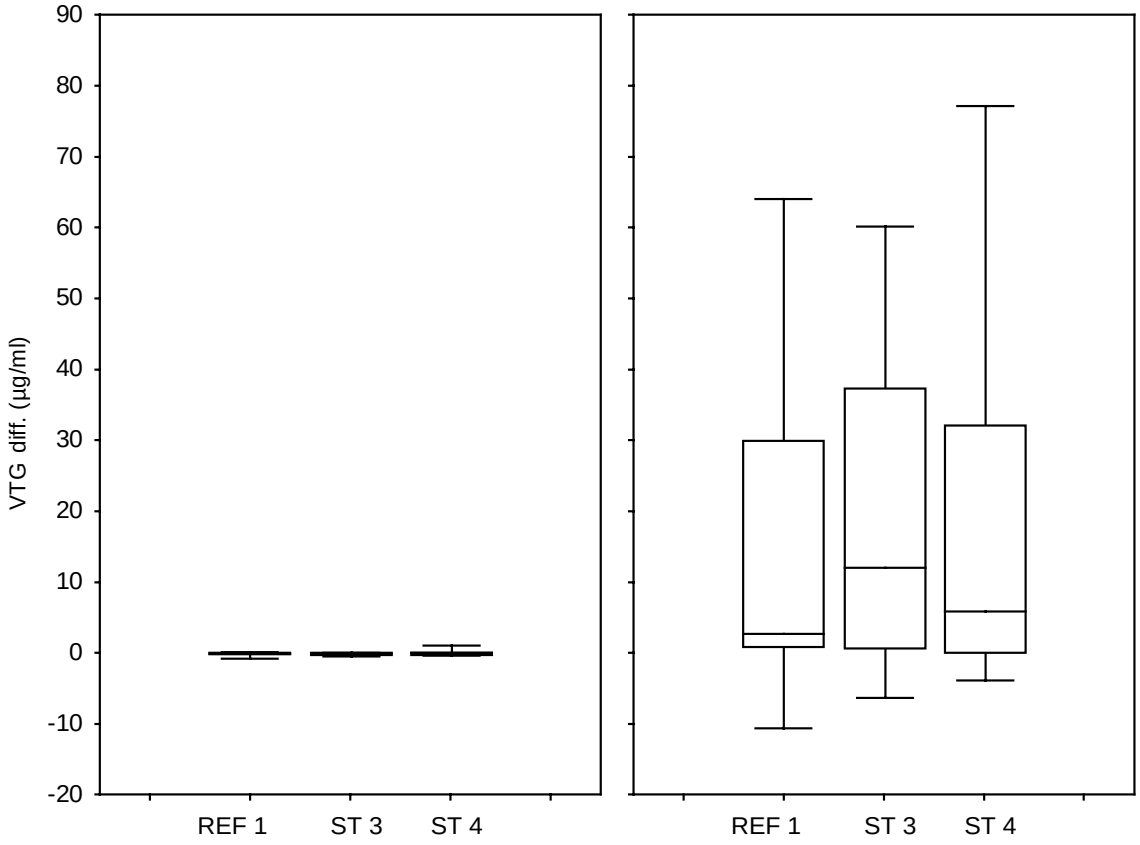

Figure 21**.** Plasma vitellogenin (ng/ml) in caged cod from the groups indicated. The figure shows median, quartiles and 10/90-percentiles. Males – left panel; females – right panel.

3.10 Zona Radiata Protein

Blood samples were taken from all individuals before deployment (0-samples). The figure depicts the difference in plasma ZRP from before to after exposure ($\Delta ZRP = ZRP_{after\ exposure} - ZRP_{before\ exposure}$; semi-quantitative). There was no increase in ZRP in males at any stations. Median increase in VTG-concentrations in females were highest on station 300, and significant differences were shown (ANOVA, P<0,048).

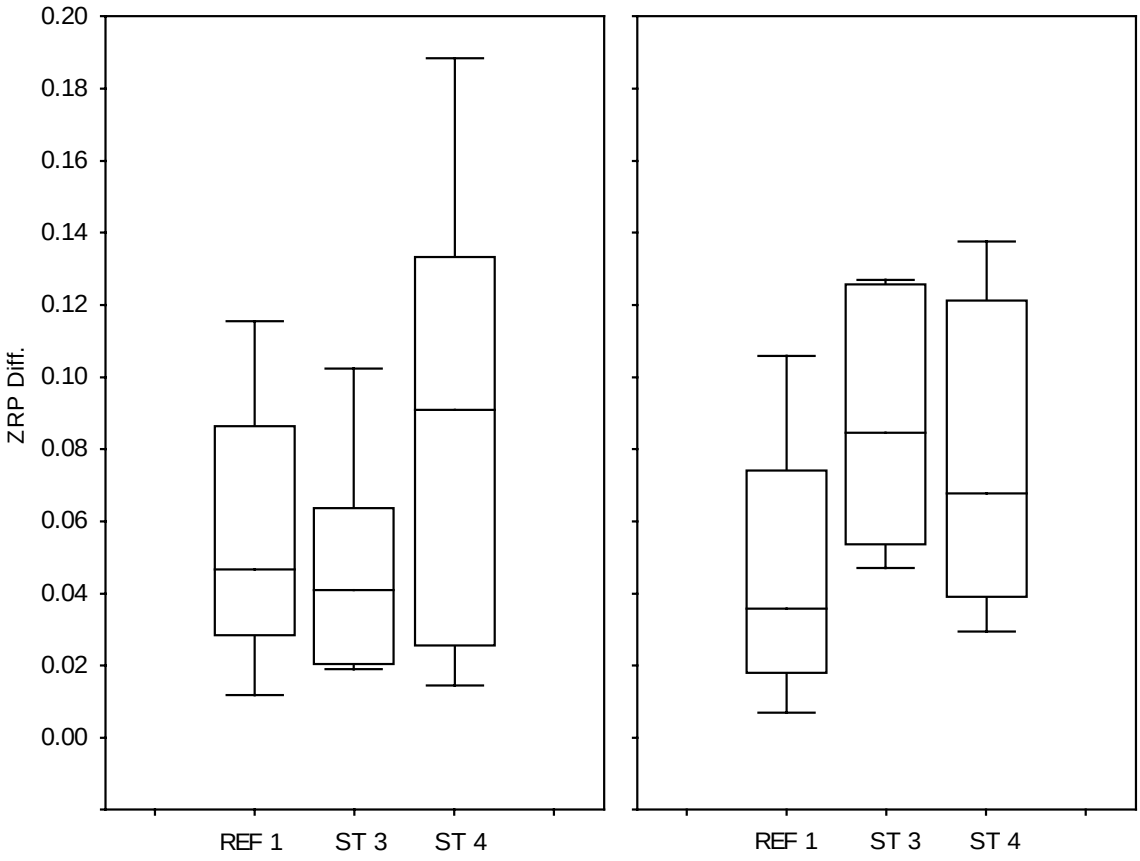

Figure 22**.** Plasma Zona radiata protein (ng/ml) in caged cod from the groups indicated. The figure shows median, quartiles and 10/90-percentiles. Males – left panel; females – right panel.

3.11 DNA adducts

The DNA adduct levels found were relatively low, but still indicate that individual fish are affected by PAH contamination. No significant differences between groups were found (P=0.7; ANOVA on log-transformed data). Average levels in cod from station 100 was 1.19 ± 0.70 nmol add/mol normal nucleotides (average ± 95% confidence level), levels from station 3 were 0.74 ± 0.27, and levels from station 4, 1.55 ± 1.10. Number of individuals that had detectable adducts were 7 (37%) from reference station 1, 3 (16%) from station 3, and 7 (37%) from station 4. Other individuals had adduct levels below the detection limits. See Appendix D for details.

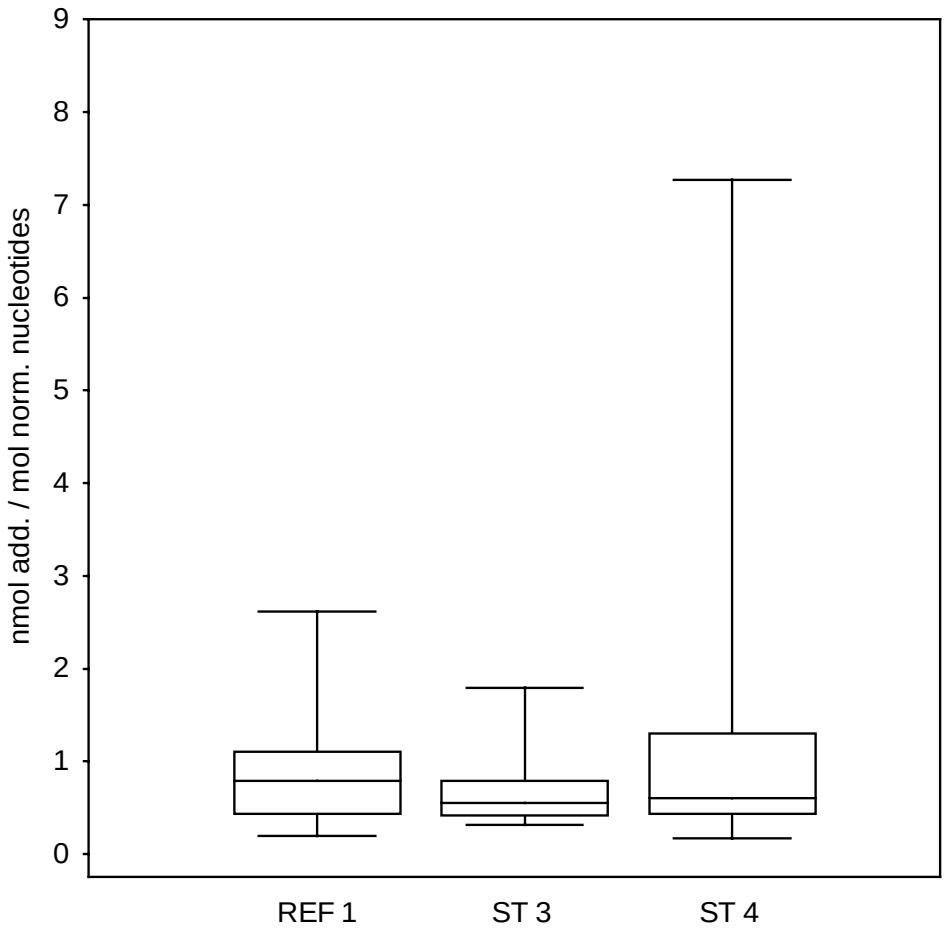

Figure 23. DNA adduct levels in liver (nmol add/mol normal nucleotides) in caged cod from the groups indicated. The figure shows median, quartiles and 10/90-percentiles.

3.12 PAH body burden in mussels

In total there were 30 pools of mussels available for PAH analyses; 3 pools from 0-time sampling, and 3 pools from 9 different stations (30 samples in total). Of these; Battelle analysed all the stations, but not the 0-time sampling. Seven of the blue mussel samples analysed for PAH content were analysed both by both NIVA and by Battelle (3 pools from reference station 1, and 2 pools from stations 3 and 4). Three of the blue mussel samples were only analysed by NIVA (zero-time sampling). NIVAs results are given in Appendix B, and the results for analyses performed by Battelle are given in Appendix F. The results in the figures in this chapter are based on the analyses by Battelle.

There were no pronounced differences in the mussel lipid content among stations (Figure 24), and data for PAHs are presented on a wet-weight basis (ng/g; Figures 25 to 30). Due to the small sample sizes (n=3 pools in each group), statistical evaluation was not performed. Groups with no overlapping values can be regarded as different. The results are shown as Sum-PAH16, Total PAH (from naphthalenes; see Appendix F), Total dibenzothiophenes, total phenanthrenes/anthracenes, total naphthalenes and total decalins, respectively.

As is evident from Figure 25, the sum PAH-16 is low for the two reference stations, higher in stations 5-6, and highest for stations 2, 3 and 4 closest to the discharge. This pattern is even more pronounced when looking at total PAHs, single PAHs, decalins and alkylated PAHs (Figures 26-30).

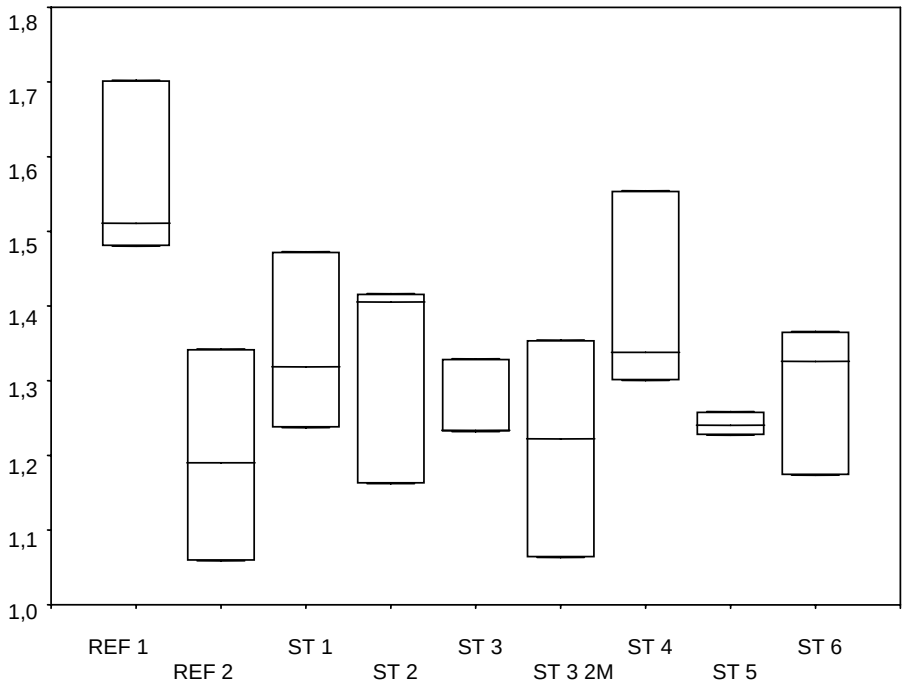

Figure 24. Lipid content (%) of mussels from the groups indicated. The figure shows median and min./max.

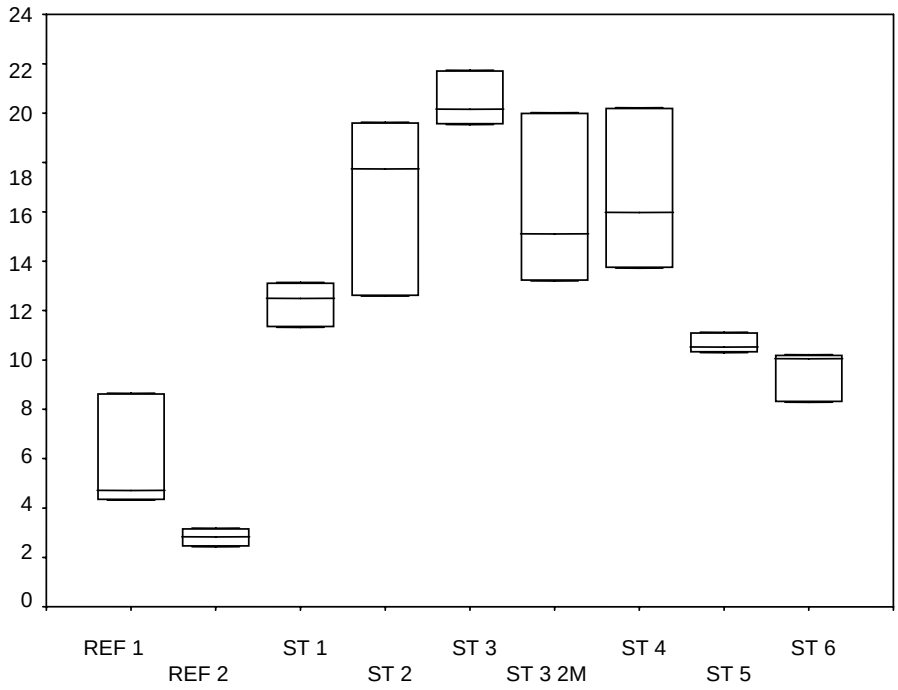

Figure 25**.** Concentrations (ng/g wet wt) shown as **Sum-PAH16** in caged mussels from the groups indicated. Boxes depict median and min-max (individual observations, since n=3).

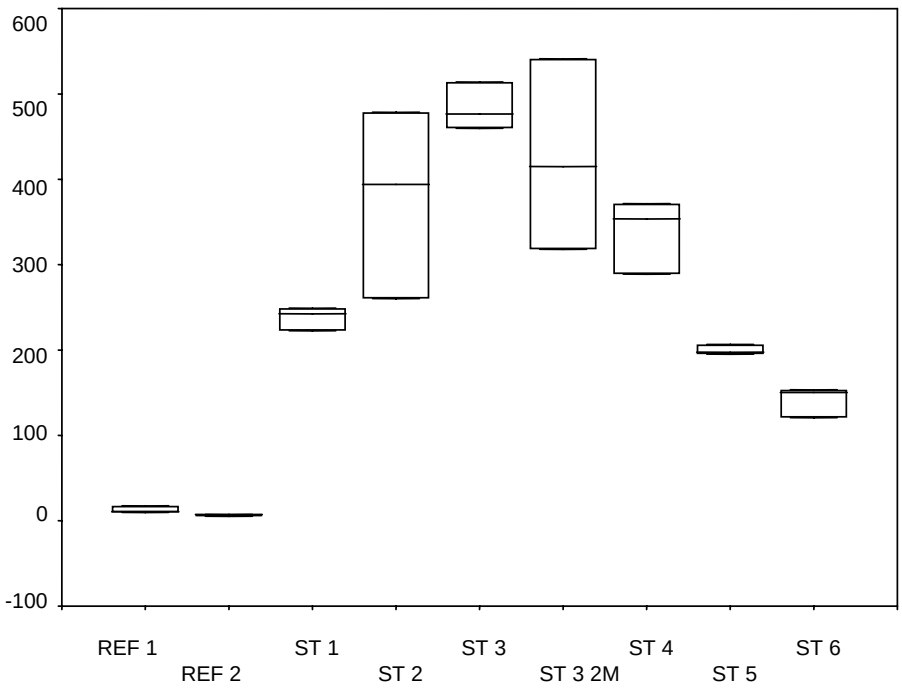

Figure 26**.** Concentrations (ng/g wet wt) shown as **total PAH** (**from naphtalene**; see Appendix F) in caged mussels from the groups indicated. Boxes depict median and min-max (individual observations, since n=3).

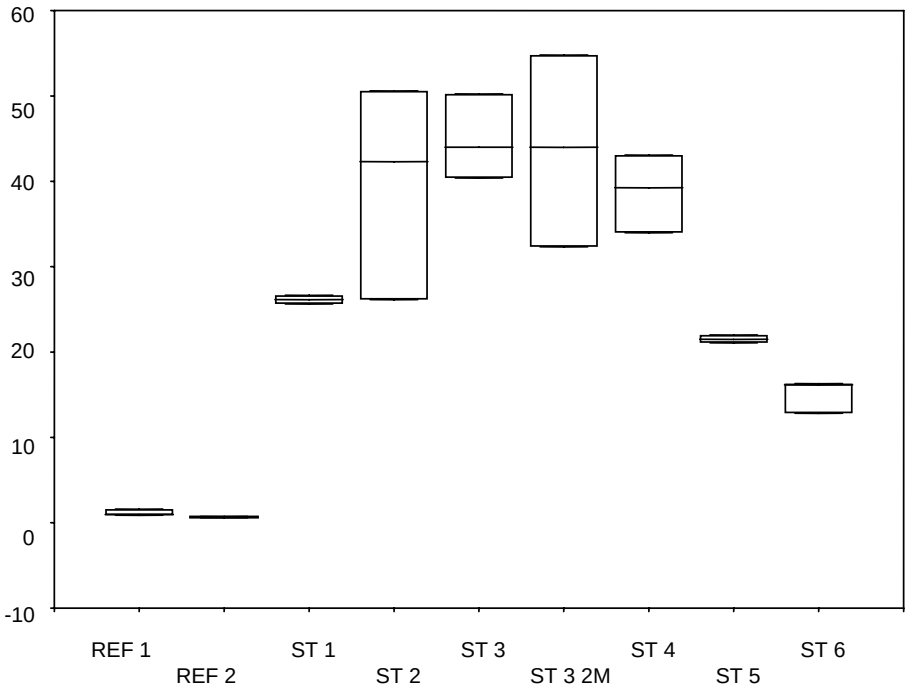

Figure 27**.** Concentrations (ng/g wet wt) shown as **total benzothiophenes** in caged mussels from the groups indicated. Boxes depict median and min-max (individual observations, since n=3).

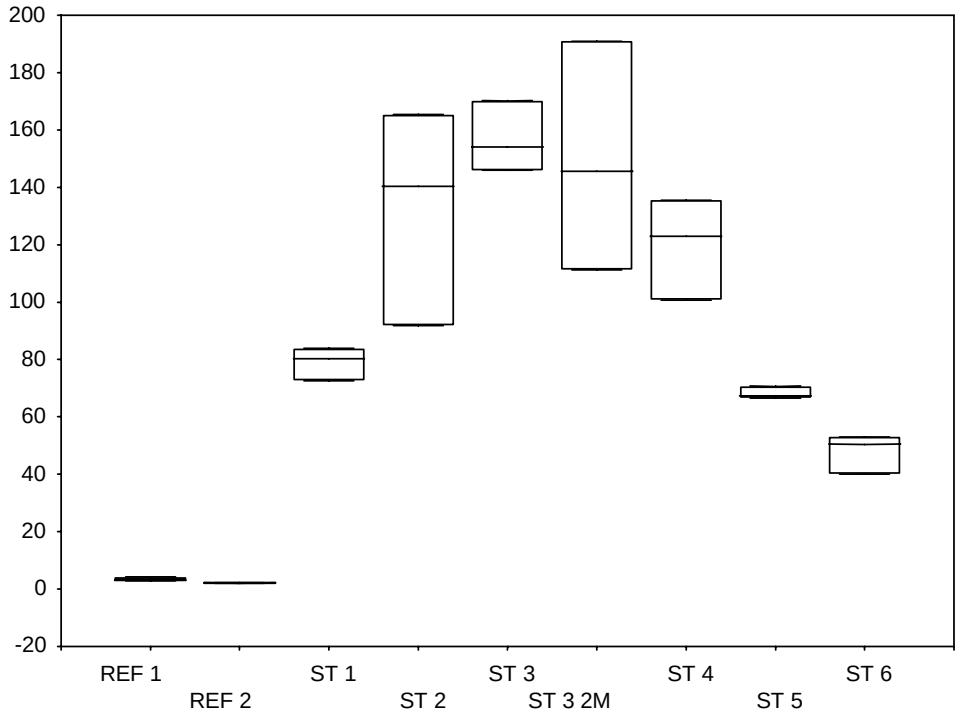

Figure 28**.** Concentrations (ng/g wet wt) shown as **total phenantrenes and anthracenes** in caged mussels from the groups indicated. Boxes depict median and min-max (individual observations, since n=3).

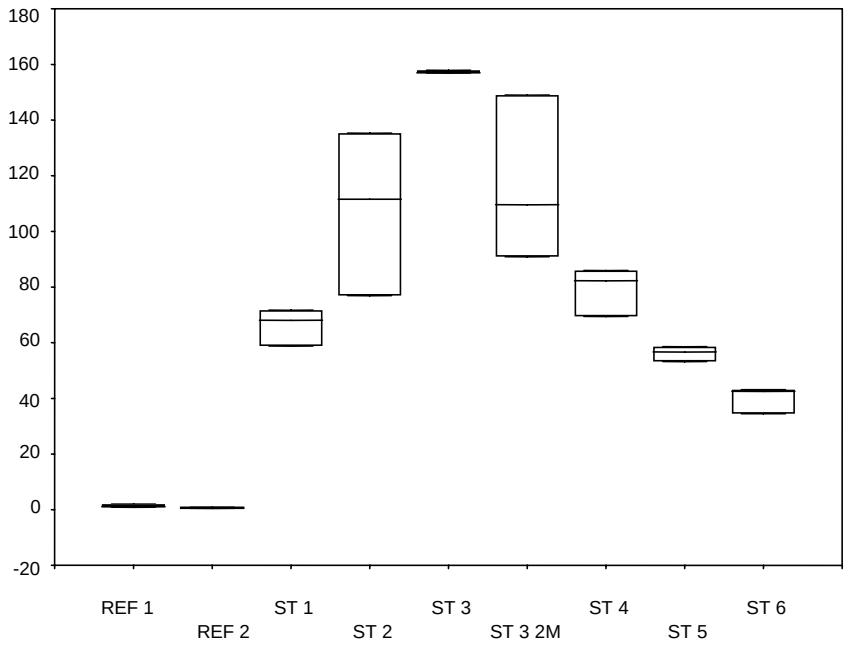

Figure 29**.** Concentrations (ng/g wet wt) shown as **total naphtalenes** in caged mussels from the groups indicated. Boxes depict median and min-max (individual observations, since n=3).

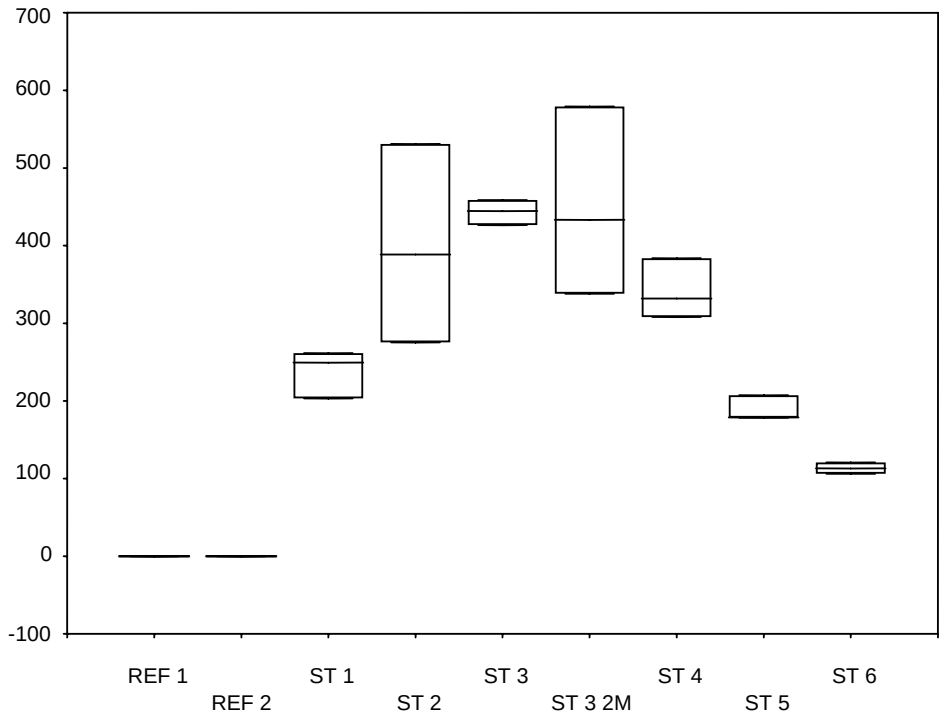

Figure 30**.** Concentrations (ng/g wet wt) shown as **total decalins** in caged mussels from the groups indicated. Boxes depict median and min-max (individual observations, since n=3).

Relative concentrations of alkylated PAHs to parent compounds:

The PAHs found in coal and petroleum often contain one or more methyl (C1), ethyl (C2), propyl (C3), butyl (C4), or (occasionally) higher alkyl substituents on one or more of the aromatic carbons. These alkyl PAHs are generally more abundant than the parent PAHs in petroleum, but are less abundant than the parent PAHs in pyrogenic PAH mixtures. It is earlier shown that mussels caged down-stream of produced water discharges from oil platforms accumulate higher concentrations of alkylnapthalenes, alkylphenanthrenes and alkyldibenzothiophenes, than their respective parent compounds (Ruus et al. 2006 Hylland et al. 2005). Figures 31-36 show this pattern, with higher alkyl-compounds:parent-compound ratios in mussels closest to the produced water discharge.

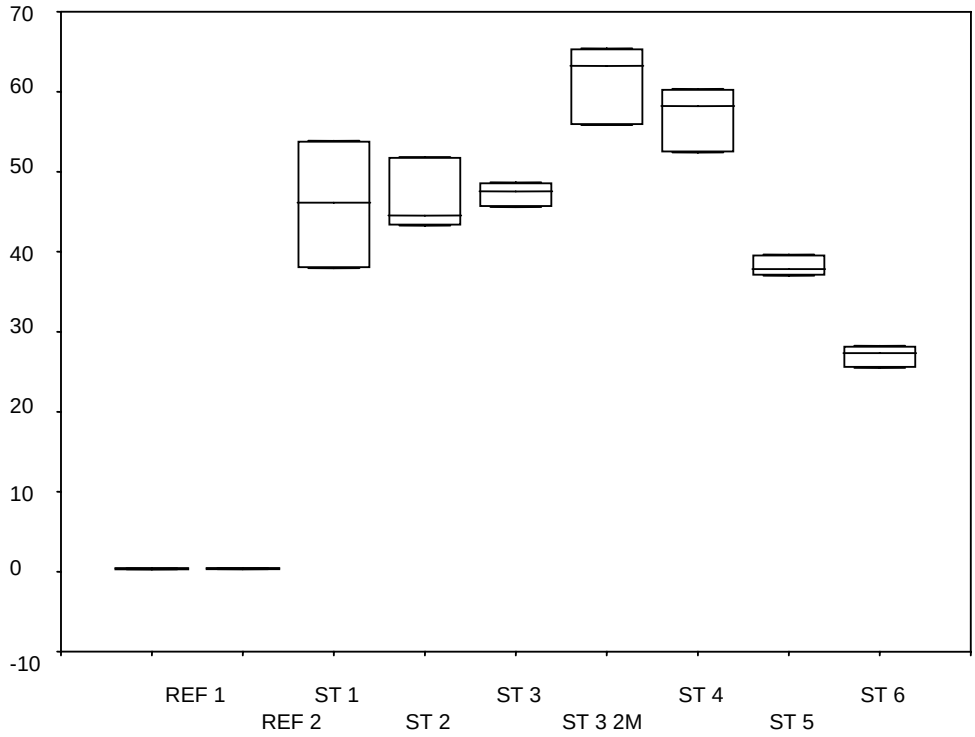

Figure 31. Ratio of alkyl-naphtalenes / naphtalenes. Boxes depict median and min-max (individual observations, since n=3).

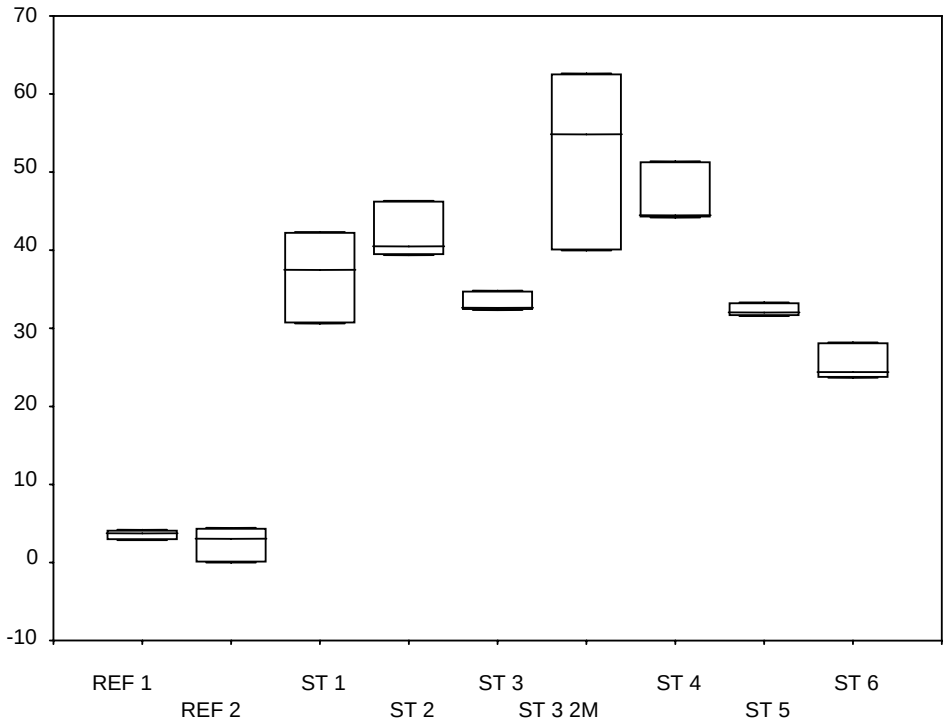

Figure 32. Ratio of alkyl-fluorenes / fluorene. Boxes depict median and min-max (individual observations, since n=3).

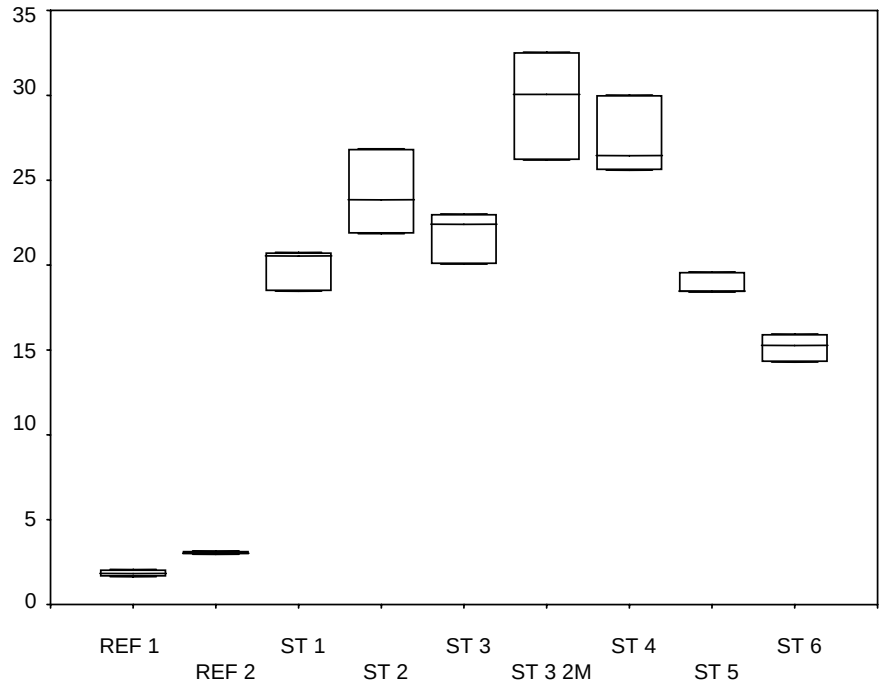

Figure 33. Ratio of alkyl-phenantrenes / phenantrenes. Boxes depict median and min-max (individual observations, since n=3).

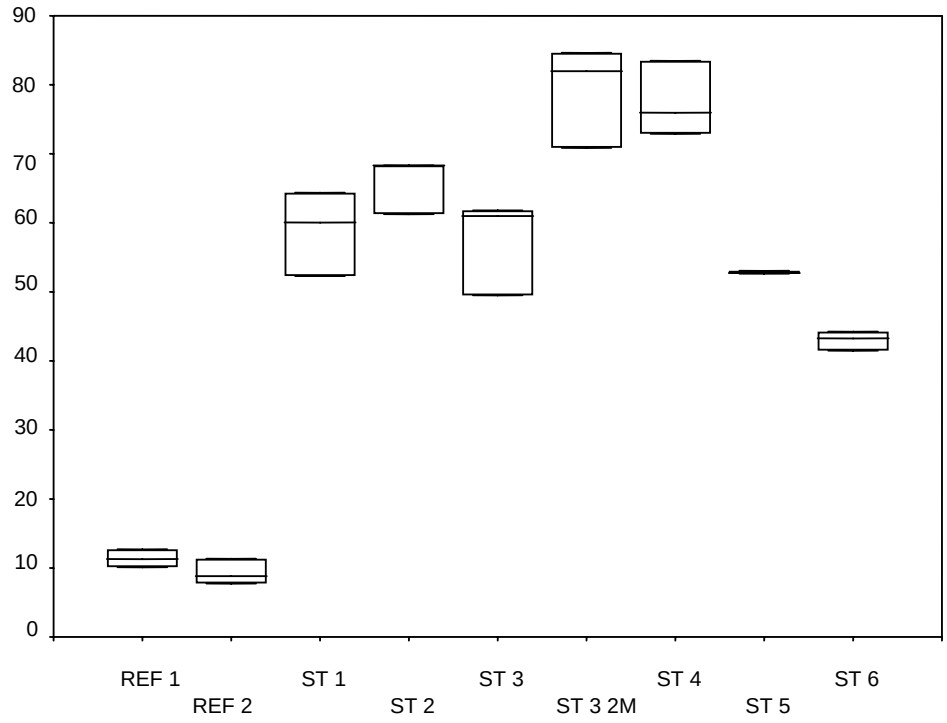

Figure 34**.** Ratio of alkyl-dibenzothiophenes / dibenzothiophenes. Boxes depict median and min-max (individual observations, since n=3).

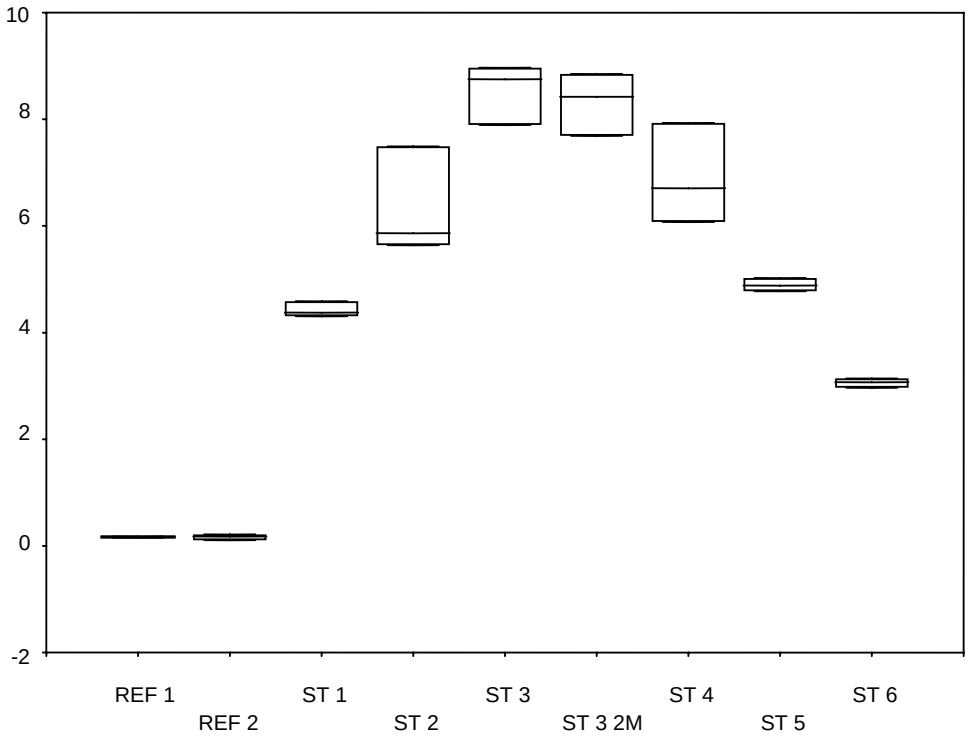

Figure 35. Ratio of alkyl-fluoroanthenes+pyrene / fluoroanthenes+pyrene. Boxes depict median and min-max (individual observations, since n=3).

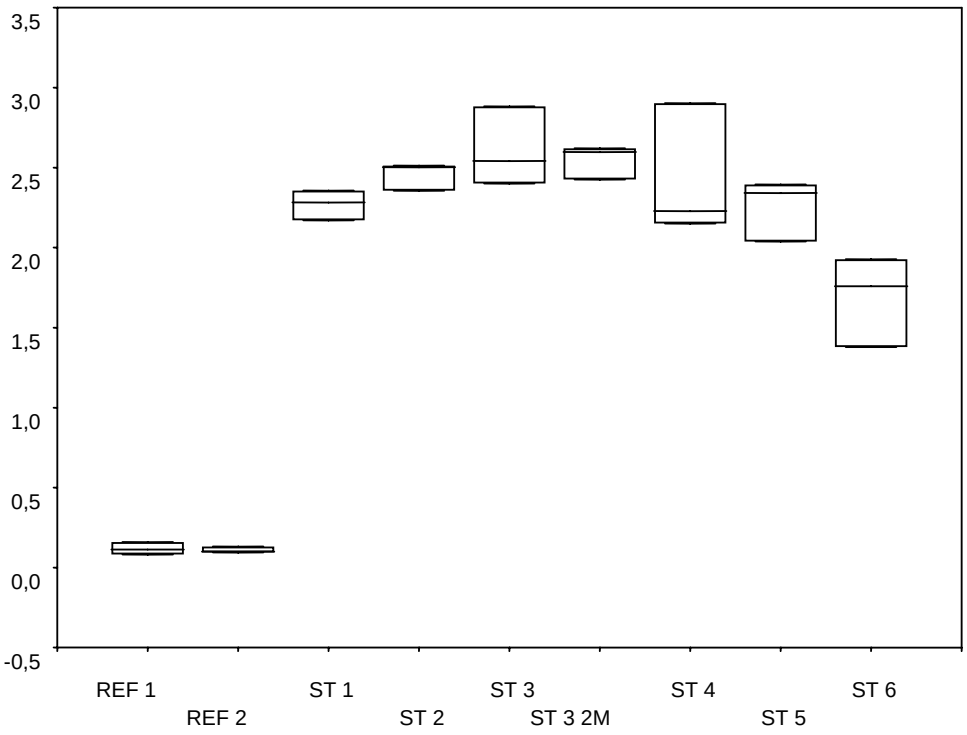

Figure 36**.** Ratio of alkyl-chrysenes / chrysenes. Boxes depict median and min-max (individual observations, since n=3).

Comparison of PAHs analysed by Battelle and NIVA

Note that the institutions have different procedures of reporting analytical results below the reporting limit. Battelle reports results below the reporting limit (the results are marked with a footnote J in the report from Battelle). Results below the reporting limit are indicated with < reporting limit in the dataset from NIVA. The institutions also have different procedures for subtracting the procedural blank sample. NIVA have subtracted the blank when the analytical result is less than 5 times the result in the procedural blank sample. This subtraction is not performed in the results from Battelle, but again a footnote indicates when the result is < 5 times the procedural blank. This complicates a direct comparison of the low values of PAHs between the institutions (i.e. reference station 100).

For the higher PAH values, the results can be directly compared. For the sum of PAH16, the analytical results are fairly in accordance. The pattern observed in the Figures 24-28 is also comparable. Interestingly, the PAH-level for the zero-time sampled blue mussels (analysed only by NIVA) are higher than the PAH-level in blue mussels from reference station (100) (see Appendix B and F). This shows that the producer of the mussels have a contamination of PAHs, and also shows the importance of analysing the mussels prior to deployment.

The results reported by NIVA regarding the alkylated NPDs are consistently somewhat higher than the results reported by Battelle, with the largest discrepancy for the C3-analogues.The largest observed discrepancy is a factor of 4 (C3-naphthalene, station 300). Neither NIVA nor Battelle are analysing a standard reference material for the alkylated PAHs. However, the difference is not discouraging, and the observed pattern is the same for both set of analyses.

3.13 Benzo(a)pyrene hydroxylase activity

For unknown reasons, no benzo(a)pyrene hydroxylase-activity could be measured in microsomes from the hepatopancreas of blue mussels from any groups. This situation was confirmed by attempts to reanalyse a subset of freshly thawed microsomes from all samples. This may be observed after insufficient removal of the stylus, but since removal of the stylus was specially taken care of during sample preparation, we do not believe this to be the cause. We can think of no specific reason for this lack of activity, but the in the Becpelag workshop (Burgeot *et al.* 2006) it was stated that BaP hydroxylase suffers from a short application in the field, and that the standardising of the measurement of BaP hydroxylase is in progress. The lack of BaP hydroxylase activity is probably not related to the exposure conditions the mussels experienced during deployment.

3.14 Immunocompetance

Phagocytosis activity increased in mussels from stations (1, 2 and 6) affected by medium pollution compare to the reference one. Only station 1 differed significantly from the reference (REF 1; $P<0.04$). On the contrary this activity was lower in the station with the highest level of organic pollutants (station 3). The activity level ranged from 3.1 to 15.1, expressed as zymosan particles x 10^7 /mg proteins.

Molluscan haemocytes play a key role in several physiological functions, such as wound and shell repair, digestion, excretion, and internal defence. In cell-mediated immune responses, phagocytosis by circulating haemocytes is the main defence against pathogens and foreign materials (Cheng 1981). Consequently, toxic effects on haemocytes potentially affect the survival of these animals. Alterations of the immuno surveillance have been reported for bivalve molluscs exposed to metals (Cheng and Sullivan 1984; Cheng 1988; Pipe et al. 1999) and xenobiotics (Fries and Tripp 1980; Alvarez and Friedl 1992; Beckmann et al. 1992; Coles et al. 1994; Cima et al. 1998).

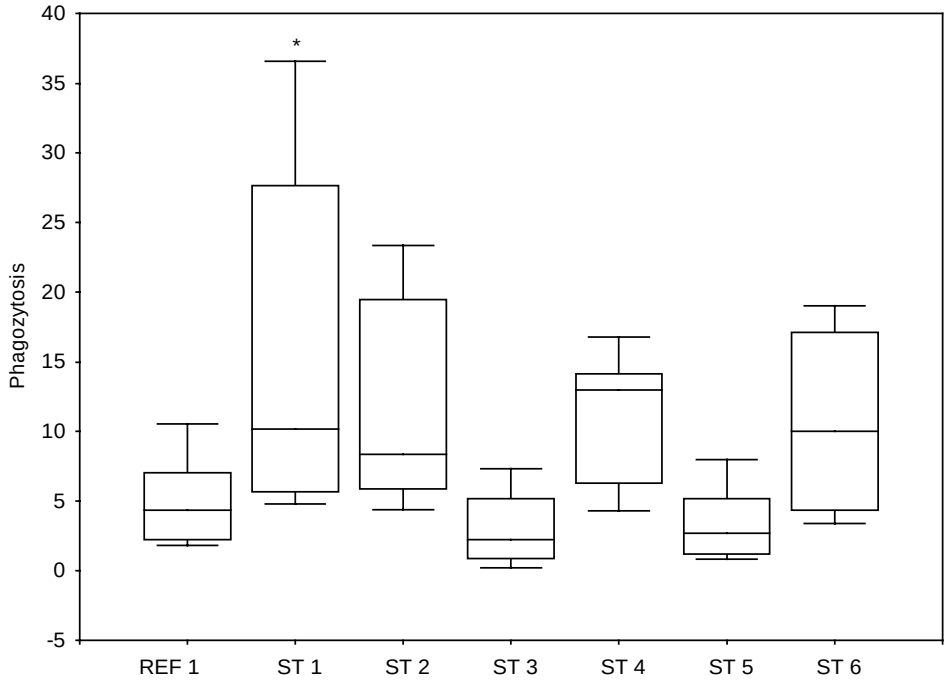

Figure 37. Phagocytosis activity levels expressed as zymosan particles x 10^{7} /mg proteins.

3.15 Lysosomal membrane stability

The observed lysosomal responses in mussel haemocytes from the 0-sampling and the reference station 200 are within the normal range of retention times usually observed for blue mussels in unexposed areas. Stations 1, 2, 3, 4 and 5 were significantly lower than the 0-samling group (ANOVA, Tukey HSD, $p<0.05$). Stations 2 and 4 were also lower than the reference (REF 2; $P<0.02$).

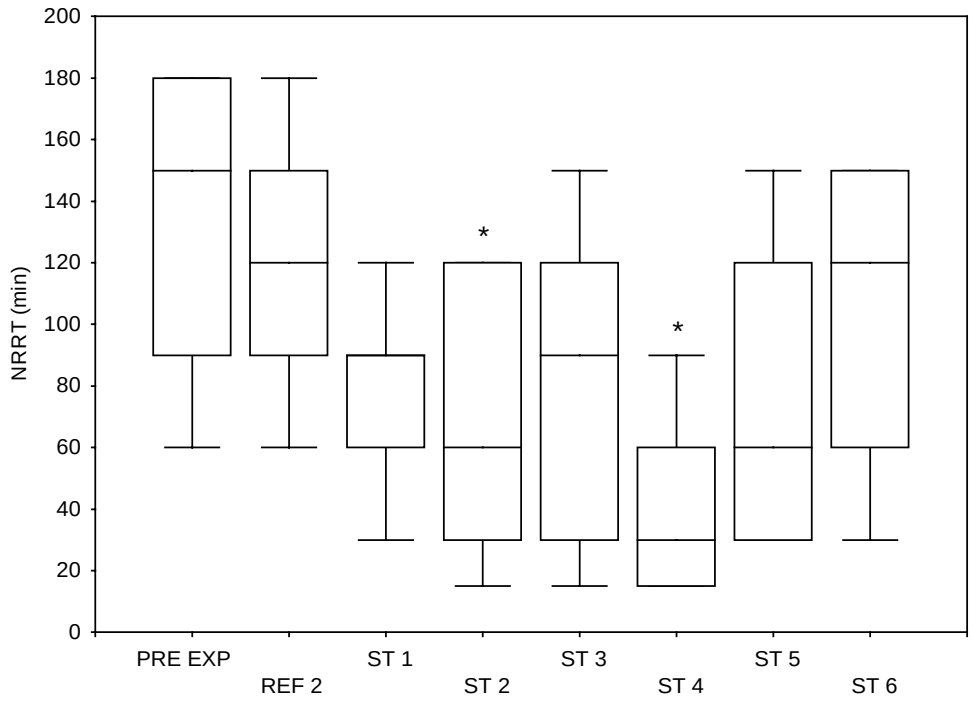

Figure 38. Labilisation period (given as Neutral Red Retention Time , NRRT; defined as the time from the addition of Neutral read to 50% of the cells are dead; min.) of lysosomal membrane in haemolymph cells from mussels from the different experimental groups. The figure shows median, quartiles and 10/90-percentiles. *: significantly lower than the reference.

3.16 Micronucleus formation

The frequency of micronuclei in the reference station 1 was equal to 1.24 MN/1000 cells. In this group, 50% of specimens did not possess micronucleated haemocytes. All groups from Ekofisk (except station 500; 1.76 MN/1000 cells) showed a more than 2-fold level compared to the reference station 1. However, only station 3 differed significantly in frequency from the reference (Kruskal-Wallis, P<0,008). In addition the two stations closest to the discharge (3 and 4) differed from other groups by their heterogeneity in responses. The frequency of micronuclei also showed a gradient with distance to the discharge similar to the levels of PAH measured.

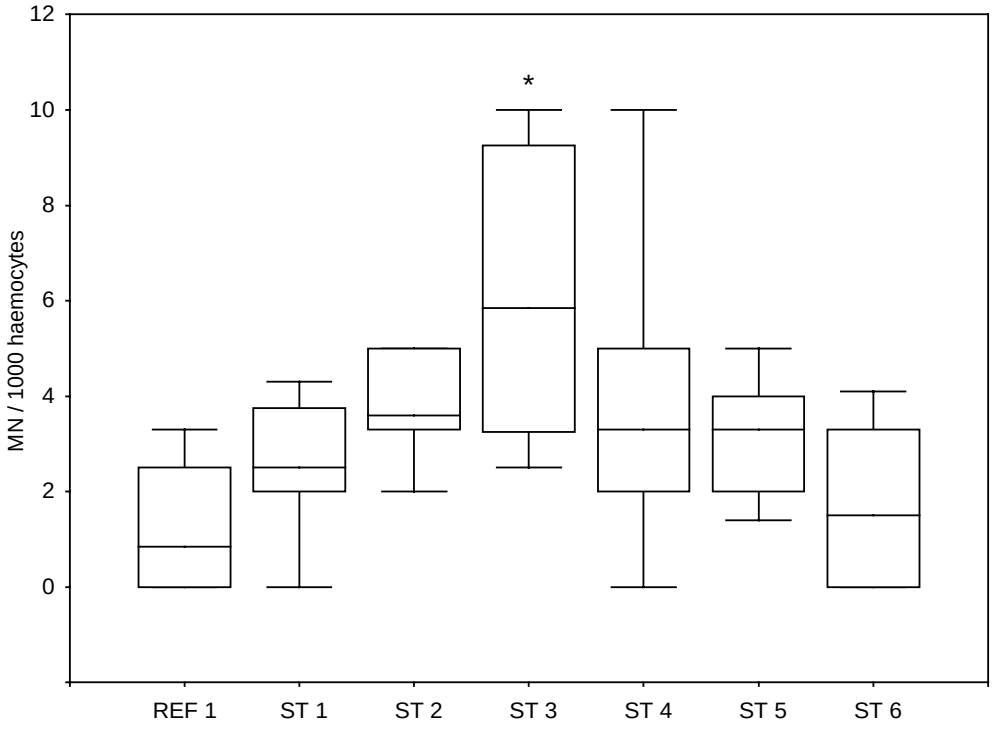

Figure 39. Frequency of micronuclei (MN/1000 haemocytes) in mussels from the groups indicated. The figure shows median, quartiles and 10/90-percentiles.

3.17 Histology in mussels

Neutral lipid accumulation

Neutral lipid accumulation was significantly lower in stations, 3 and 4 compared to the control (Ref 1; Kruskal-Wallis, multiple comparisons, P<0.03). Low values were also found in station 5 and 6, showing a general inhibition of this class of lipid accumulation in the stations around the discharge.

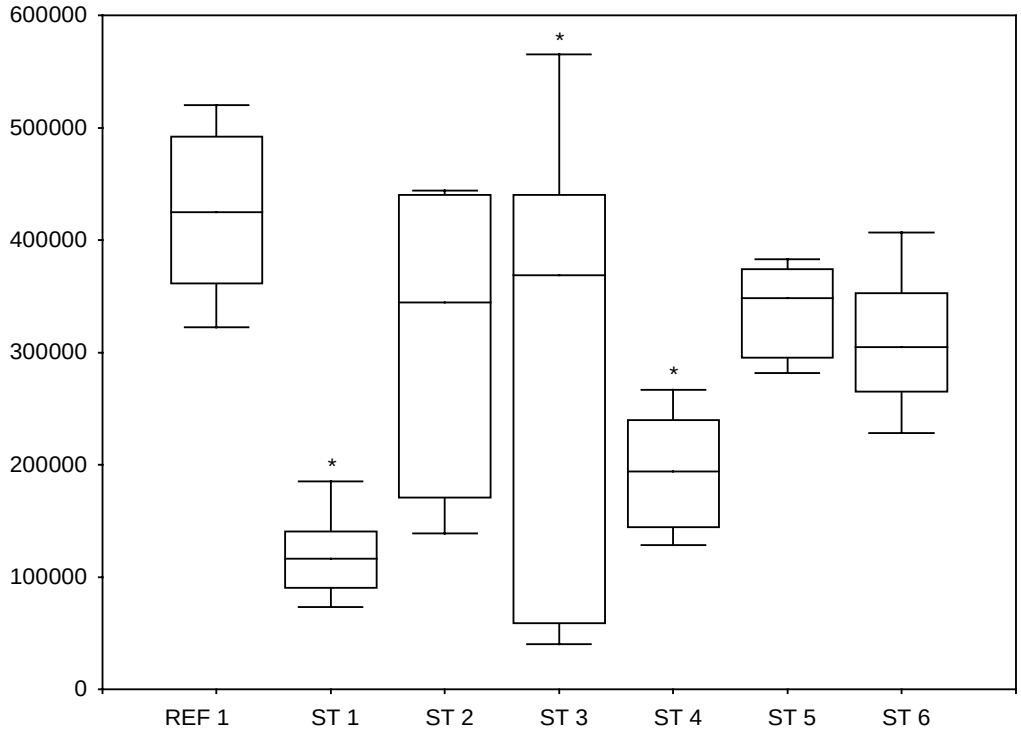

Figure 40. Neutral lipid accumulation given as optical density in mussels from the groups indicated. The figure shows median, quartiles and 10/90-percentiles.

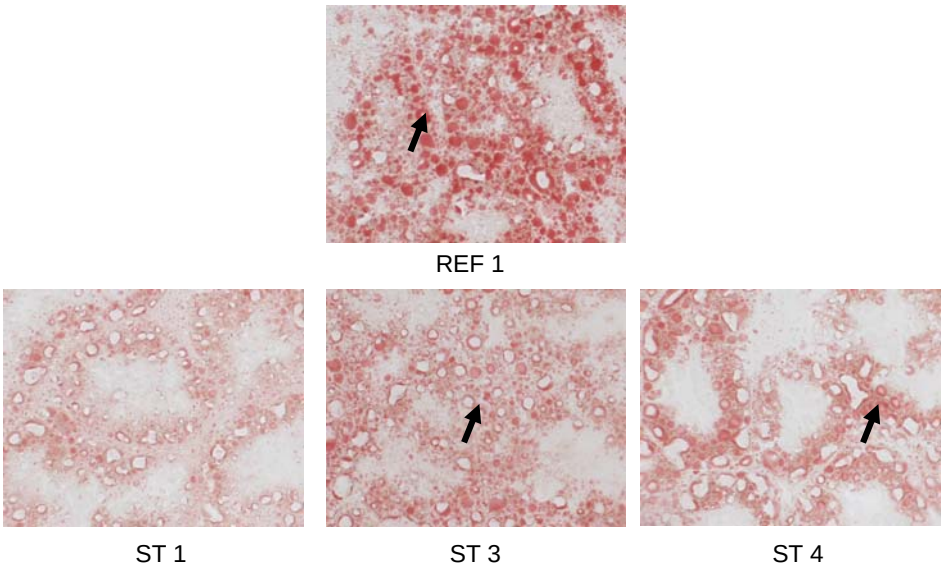

Figure 41. Histological sections (400 X magnification) showing neutral lipid accumulation (arrows) in mussel digestive gland from the groups indicated.

Lipofuscin lysosomal accumulation

Lipofuscin accumulation in lysosomes of mussel digestive gland was significantly lower in all the sites around the discharge compared to the reference site (Ref 1; Kruskal-Wallis, multiple comparisons, $P<0.0004$). Lipofuscin accumulation is the result of peroxidation of authophagocytosed proteins associated with protein aggregates and oxidatively damaged organelles. There was a significantly higher presence of vacuoles in all mussel groups caged in the proximity of the discharge compared to the reference.

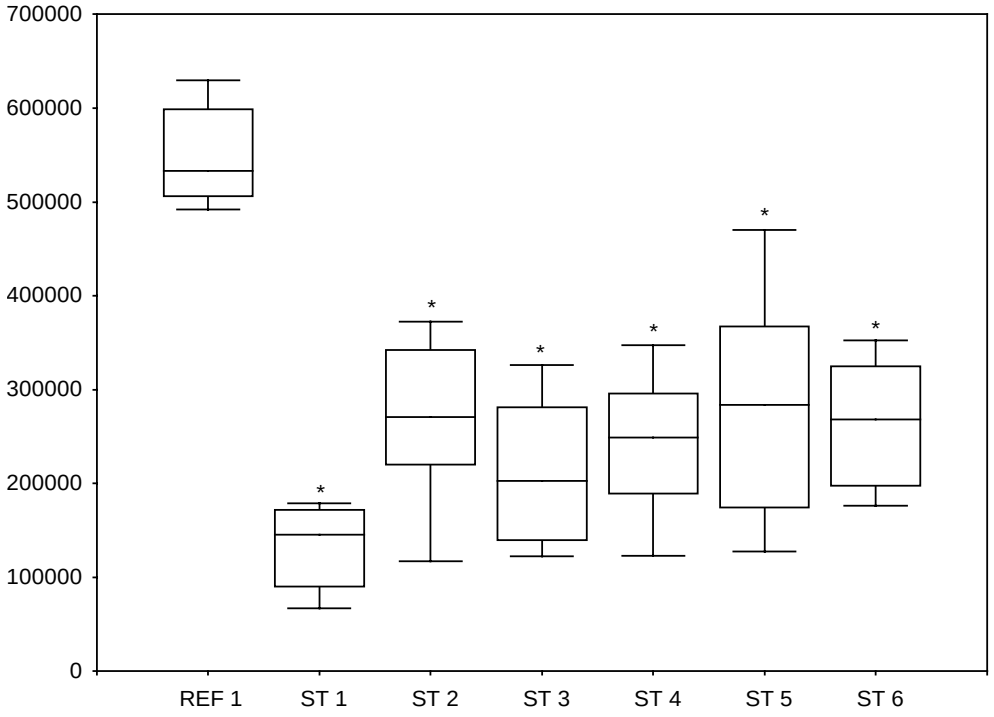

Figure 42. Lipofuscin accumulation in mussel lysosomes given as optical density from the groups indicated. The figure shows median, quartiles and 10/90-percentiles.

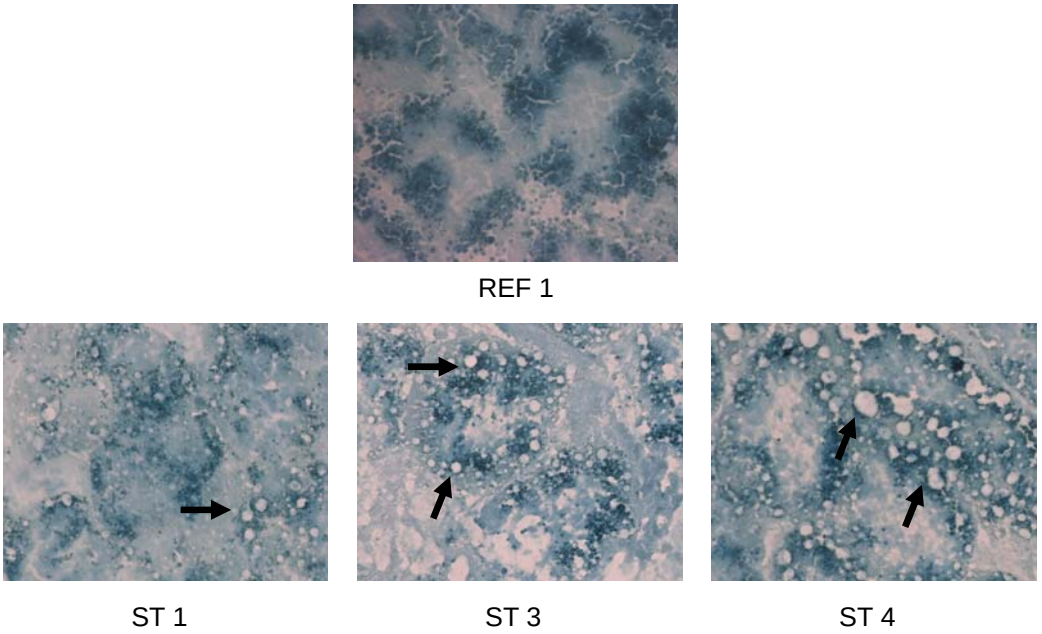

Figure 43. Histological sections (400 X magnification) showing accumulation of lipofuscin in mussels digestive gland from the groups indicated. Arrows highlight the presence of autophagy vacuoles in stations around the discharge, indicating a high stress condition.

4 Discussion

At caging depth temperature increased from 5.5 to 9.5 °C during the deployment period showing a natural spring situation. The salinity was generally stable at ~35‰ and a less saline surface layer (0-5 m) was encountered at some occasions.

Due to low availability of food in the cages the experimental cod lost weight during deployment, as expressed by higher mean condition index in the 0-sample-group, than in the other groups. In general the material was homogeneous and suitable for comparison among groups.

4.1 Tissue levels of PAHs in caged mussels

The results from the present Water Column Monitoring survey show that caged organisms from all locations in the proximity of Ekofisk have been exposed to moderate levels of produced water components. For comparison, the concentrations of ΣPAH16 accumulated in mussels closest to the produced water discharge (Station 3) were an order of magnitude higher than in mussels 500 m from the Statfjord B platform in the 2004-monitoring (Hylland et al. 2005). The concentrations were comparable with those found earlier in the vicinity of Troll (23 ng/g wet weight; Utvik et al. 1999) and 500 m from Statfjord B in 2001 (BECPELAG; 34.5 ng/g wet weight).

Analyses performed by NIVA, shows that the level of PAHs were higher in the pre exposure mussels than in the reference station 1. This shows the importance of analysing mussels prior to deployment since contamination might be present at the farm site.

4.2 Effect responses in caged mussels

Chemistry data indicated that mussels were exposed to PAHs and biological responses were also observed.

For unknown reasons, no benzo(a)pyrene hydroxylase-activity could be measured in microsomes from the hepatopancreas of blue mussels from any groups. The results were confirmed by reanalyses on a subset of freshly thawed microsomes from all samples (St 1). The background for the failing analysis is not known but quality of analysis reagents is a possible explanation.

Phagocytosis activity has been shown to increase when animals are exposed to low dose of contaminants (Pipe et al. 1999). This is in agreement with the present finding, where this activity was higher in some stations (1, 2, 4 and 6) compared to the control. On the other hand, animals exposed to higher doses of pollutants have been reported to have an inhibition of the phagocytosis activity, as might be the case for mussels from station 3. The immune system is known to be dynamic and a 6 weeks long exposure could be long enough to allow an adaptation of the animals.

The observed lysosomal responses in mussel haemocytes from the pre exposure sampling and the reference station 2 were within the normal range of retention times usually observed for mussels in unexposed areas. All stations off Ekofisk showed

shorter retention time indicating stress. The differences in this parameter followed the same gradient as for PAH body burden.

A similar gradient was seen in hemocyte micronuclei formation in mussel, although only mussels caged at station 3 had significantly increased levels compared to mussels caged at the reference location. Formation of micronuclei indicates that the PW contains genotoxic compounds in sufficient amounts to cause effects in the sea close to the discharge.

Histology:
Also the histological studies of mussels indicated that the mussels were stressed. The results showed lower levels of neutral lipids in 4 stations (1, 4, 5 and 6). Intracellular accumulation of neutral lipids in lysosomes digestive cells has been used as a complementary indication of exposure to organic pollutant (Lowe and Clarke, 1989, Cajaraville, 1991; Regoli, 1992). Moderate levels of PAH exposure normally causes increased levels of neutral lipids.

The lipofuscin accumulation assay also gave an indication of stress in animals from all the stations off Ekofisk compared to the field control. Lipofuscin accumulation is expected to increase in case of organic or metal contamination (Moore, 1988; Regoli, 1992). A possible explanation of the decrease seen in the present study could be the complexity of the xenobiotic mixture in produced water, compared to less chemically complex discharges tested elsewhere.

Nutritional deprivation is an established inducer of autophagy in mussel digestive gland, and recent data indicated that autophagy induced by stress reduces the formation of lipofuscin in oxidatively stressed mussel (Moore et al., 2006). The present results are in agreement with this and the image analysis performed in mussel digestive gland from the Ekofisk area showed a presence of vacuoles, resulting from autophagy. This clearly indicates a stress condition in mussels which is often related to oxidative stress.

4.3 PAH- and AP metabolites in cod bile

Low but quantifiable levels of pyrene metabolites in the bile of pre exposure fish indicate that the cod had been exposed to low levels of PAHs prior to deployment. The origin for the pyrene present as OH-pyrene in the cod bile is unknown. Possible sources can be the commercial fish feed, pump lubricants or exhaust from vehicles at the farm site. Presence of the observed levels is not believed to affect the quality of the material for the monitoring purposes significantly.

For all PAH and AP metabolite compounds measured, both stations at Ekofisk were significantly different from the reference station. This confirms significant uptake and bio-transformation of PAHs and APs typical for produced water to the fish from the two stations close to the discharge.

4.4 Exposure and effect responses in caged cod

The results for PAH-metabolites in the bile of cod suggest that exposure levels have been evident but moderate, at least during the last week prior to sampling (due to continuous removal by excretion). The exposure was clearly sufficient to induce elevated amounts of hepatic cytochrome P450 (CYP-1A) enzymes in the fish. Several studies have indicated that P450 induction may be the first step in a series of toxic

symptoms, such as immuno suppression, vitamin and hormonal imbalance, and reproductive failure (Reviewed by Safe, 1994).

There was no increase in plasma VTG-concentrations in males at any stations. Median increase in VTG-concentrations in females were highest on station 3, however, this was not significant. A similar (and significant) trend could be read from the zona radiata protein (ZRP)-results. Arukwe et al. (1997) have shown that ZRP-proteins are sensitive markers for low dosages of xenoestrogens, but it was surprising that the increase was observed in females, and not males.

There was a tendency towards lower GST-activities (both genders) at the stations closer to the discharge, as compared to the reference and 0-time samples (significant differences between 0-time samples and station 4 for females). This could indicate inhibition of these enzymes by produced water components. Furthermore, GSTs are affected by radicals, and the observed results could also be related to the availability of GSH, i.e. the reduced activity could be a result of oxidative stress.

The levels of DNA adducts found were in general low, however some individual fish from all stations (including the field reference station) showed elevated levels of DNA adducts. This indicates that the fish has been exposed to genotoxic pollutants beyond their short term DNA repair capacity. Variability in DNA adduct level among individuals is also recorded for cod, saithe and haddock from the Ling/Egersund bank area in the Condition Monitoring. Few studies on DNA adduct levels in wild cod from open seas in general have been published. But for comparison, Aas et al. (2003) studied DNA adduct levels in ten individuals of cod, from the Barents Sea. Six of them had detectable adduct levels with an average of 0.75 ± 0.58 (± SD) nmol add/mol normal nucleotides (average of individuals with adducts only), to be compared with 2.19, 1.55 and 3.32 for reference 1, station 3 and 4 respectively. Levels of DNA adducts in wild bottom associated fish from the Tampen area show 10-fold higher levels (Beyer et al. 2004), indicating that the bottom sediments holds more of the heavier and more adduct forming PAH compounds than what is dominating in PW. Cod collected close to the discharges from aluminium smelter industry show up to 50-fold higher DNA adducts levels compared to what is found in the present study (Aas et al. 2001). The significant uptake and bio transformation of PAHs found in the present study together with the relatively low levels of DNA adducts found, suggest low levels of adduct forming compounds in the PW discharge.

4.5 Preliminary ecological risk assessment based on lysosomal stability in mussels.

For the WCM 1999 an evaluation of environmental risk was carried out based on PAH body burden in mussels (Neff 2000). The evaluation performed by Battelle concluded that the discharge of PW at Ekofisk did not represent any environmental risk for marine life 0.5 km or further away from the discharge point. Uptake of organic compounds in mussels was compared with body burden threshold levels for acute lethality and chronic effects by dividing the threshold level for acute lethality with an application factor of 100.

The basis from WCM 2006 is better for such an evaluation because the biomarkers give a more direct measure of the organism's health status. These markers cover more types of chemical stress than critical levels based on chemical load are able to.

Acute lethality / chronic effects are related to a stress caused by a particular type of chemical compound. In cases where stress other than by PAHs influences the situation this would also be intercepted with the biomarker approach but not with the chemical based approach.

Biomarker based risk assessment is limited by the lack of connections between marker level and effect data, information that will be provided in the future. However, for lysosomal stability (NRR) levels have recently been established (OSPAR 2007). For this method, animals are considered to be healthy if NRR is >120 minutes; stressed but compensating if <120 but >50 minutes and severely stressed and probably exhibiting pathology if <50 minutes.

Based on NNR data from WCM 2006 we can conclude the same as in Battetelles report (Neff 2000) and obtain a more balanced evaluation due to more reliable data (Figure 44). Stress is indicated in mussels from all stations situated in the proximity of Ekofisk, however only Station 4 (situated close to the discharge) show NRRT levels indicating severe stress.

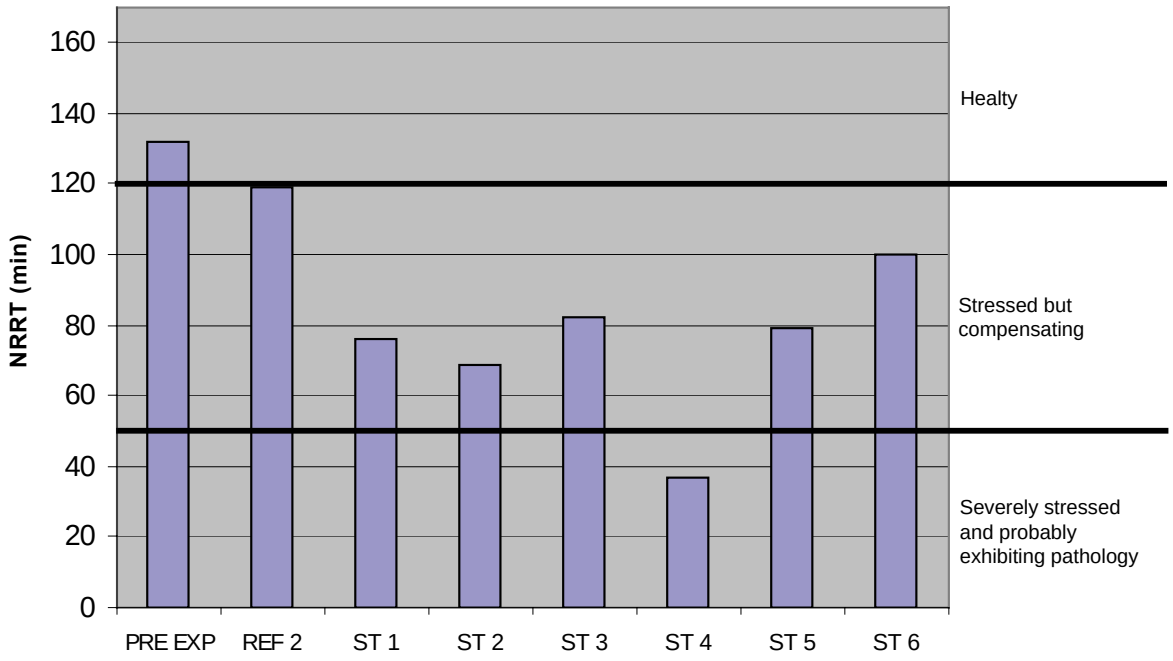

Figure 44. Lysosomal membrane stability in mussels from WCM 2006 (given as Neutral Red Retention Time, NRRT) with the stress definitions defined in OSPAR (2007)

5 Comparison of PAH body burden WCM 1999 vs. 2006

In order to give an indication of discharge development at Ekofisk from 1999 to 2006 a comparison of uptake of organic compounds was carried out. The stations that were compared are encircled in blue in Figure 1.

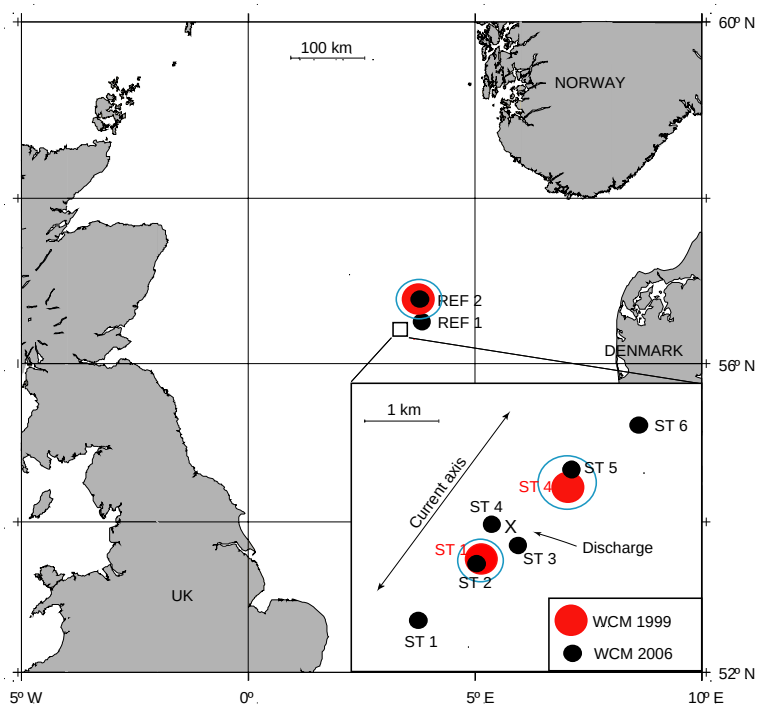

Figure 45. Map showing positions of WCM 1999 and WCM 2006 mussel stations, cages used for comparison are indicated with blue rings.

The stations closest to the discharge where data are available for comparison were Station 1-1999 and Station 4-2006 situated SW, 500 and 600 metres away respectively. Station 4-2006 had 41.4 % lower levels than Station 1 (1999).

NE of the discharge, Station 4-1999 and Station 6-2006 were used, 1000 and 1100m from the discharge respectively. A 23.3% increase in levels from 1999 to 2006 was observed.

For the reference station 2 (same position both years) a 67.6% reduction was observed, values are given in Figure 46.

A gradient with distance from the discharge was seen for both years.

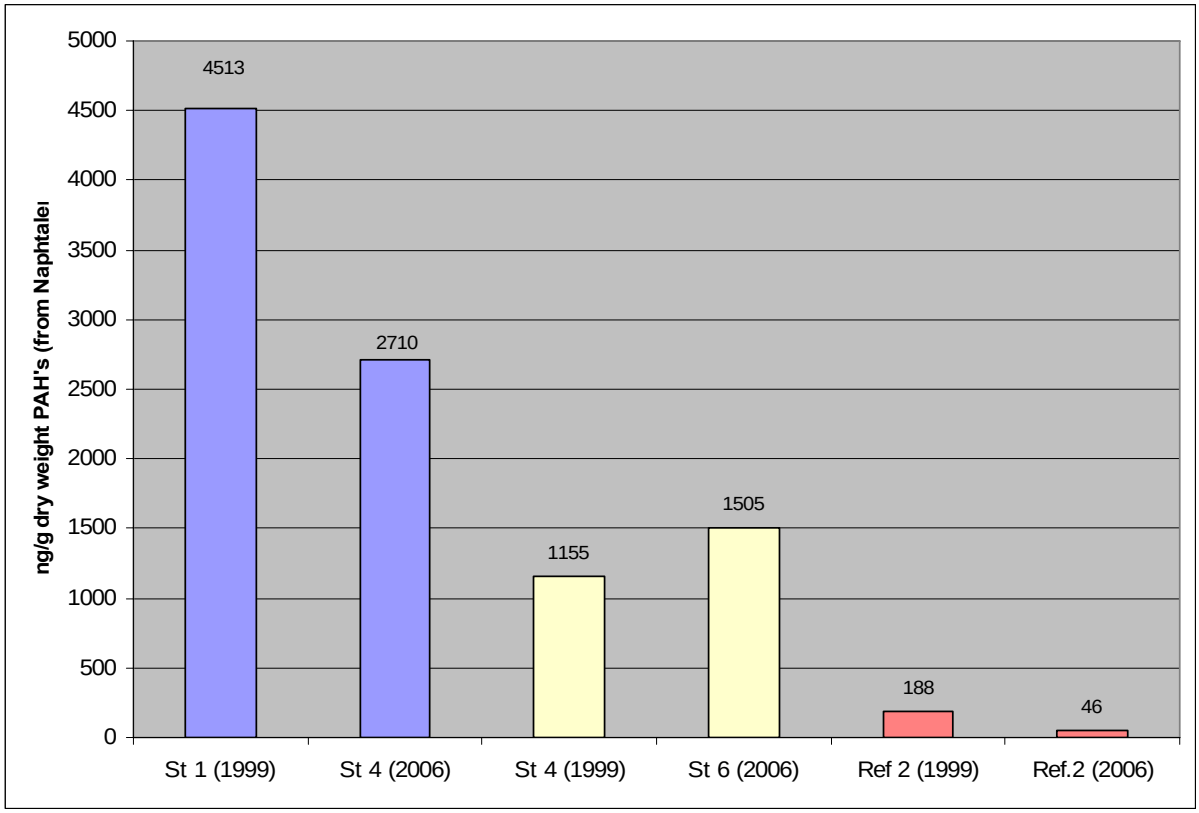

Figure 46. Comparisons of PAH body burden given in ng/g dry weight (from naphthalene). Note that levels are given in wet weight elsewhere in the report.

Results from the comparison must be interpreted with caution since samples are not optimal for comparison. The most important factors expected to influence results are listed below.

1. Locations of cages:

The stations used for comparison did not come from the exact same locations (see Figure 1).

2. Time compared to spring bloom.

WCM 1999: ~ 4 weeks, sampling 12th May

WCM 2006: ~ 6 weeks, sampling 22-22th May

Since lipophilic compounds tend to adsorb to biological surfaces like that of micro algae, differences in time compared to the spring phytoplankton bloom may affect bio availability (increased particle density will most likely increase bio availability of PAHs to filter feeding organisms such as mussels, zooplankton etc.).

3. Exposure duration

Due to lack of efficient metabolising physiology mussels accumulate PAHs over time and the 50% increase in duration from1999 to 2006 could certainly affect results.

The comparison must therefore be considered as an indication.

4. Changes in discharge volume and quality in not taken into consideration.

6 Conclusions and recommendations for future WCMs

Results show that deployed organisms from the whole investigated area contained moderate levels of hydrocarbons expected to originate from produced water. The levels were within the range found in previous years. This would likely also apply to other oil related compounds than PAH. Caged blue mussels did accumulate PAHs during the, field exposure especially 2- and 3-ring components. Bioaccumulation levels followed the expected gradient with distance to the discharge along the current axis in the area.

The lowest levels were found in 0-time mussels and in mussels held at the reference location. There was a significant increase in micronucleus formation in haemocytes of mussels caged close to the discharge with a gradient along the current axis. It is known that micronucleus formation is commonly observed as a response to PAH exposure. There were histological changes in mussels from all stations off Ekofisk although the examined tissue showed different responses than normally seen after PAH exposure. A possible explanation could be the complex chemical composition of PW compared to the more PAH dominated discharges previously tested with the methods.

For all PAH and AP metabolite compounds measured in cod bile, both stations at Ekofisk were significantly different from the reference station. This confirms significant uptake and bio-transformation of PAHs and APs typical for produced water to the fish from the two stations close to the discharge (St 3 and 4).

The exposure was sufficient to induce elevated amounts of hepatic cytochrome P450 (CYP) 1A enzymes in the fish. There was no increase in plasma VTG-concentrations in males at any stations; however significant differences between stations were seen for ZRP, however only for females.

Results on hepatic DNA adducts indicate no differences between sampling locations.

PAH body burden, lysosomal membrane stability and micronucleus formation indicate a clear gradient in the signals with distance from the discharge.

Based on experience from WCM 2006 we propose the following recommendations for future WCMs:

Current and temperature measurements at selected cages proved to be successful and of value. Future measurements of this kind will allow a better understanding of plume distribution. The measurements can also reveal to what extent stratification of the water column is present during deployment.

CTD measurements performed at the platform also proved valuable, but the following improvements should be made:

- Measurements should be performed regularly during the deployment period – e.g. twice a week to increase resolution.
- SOPs for CTD measurements should be closely followed – in 2006 the high speed of bringing up the instrument invalidated measurements (from bottom to surface)
- The CTD instruments should be lowered all the way to the bottom at each measurement
- The platform management should be involved in organising the taking of measurements

The use of a larger number of mussel cages is a good model for deployment. Cages of mussels are less resource demanding than fish, which allows greater coverage and ensures that some locations are exposed to the plume.

The tagging of fish proved to be successful for the measurements of biomarker in individual fish before and after deployment. Improvement of the statistical force of VTG and ZRP measurements were seen in the WCM 2006 when a difference (level after deployment – level before deployment) for each individual fish could be calculated. We therefore recommend that both VTG and ZRP are performed on an individual basis (pre-post exposure) in future WCMs. Other biomarkers should also be evaluated for the benefits of this possibility.

Sampling in the spring is advantageous for a number of reasons

- More stable weather simplifies operation of gear
- No interference with spawning (neither mussels nor fish)
- Colder water reduces chances of negative side effects from increased handling, due to tagging of fish.

Quantifiable levels of PAH contamination is commonly observed in farmed organisms. We therefore encourage sampling of organisms prior to deployment to establish the pre exposure level of contamination. Even though the levels are low and the observed PAH profile differs from profiles typical of oil/PW this should be take into consideration. Such anthropogenic contamination in test organisms could be reduced by selecting source and/or by allowing the organism's to depurate before deployment. Note that such a strategy would have to be planned well ahead of the deployment. The source farms utilized in WCM 2006 show lower levels of contaminations than seen in previous studies and should therefore be strong candidates in future studies.

In the WCM 2006, PAH analyses performed on the same samples by both NIVA and Battelle showed that the results were comparable. We recommend that future analyses of PAH should be performed by NIVA because it is:

- Easier access to results/chromatograms for further interpretation of the results
- Easier to extend the analytical repertoire if required
- The results can be used for publications/other purposes later
- Shipment of samples is time-consuming and should be kept to a minimum

For 2008, it is possible that the UK sector will perform a one-off monitoring study using blue mussel cages. We propose that the possibility for coordinating the WCM 2008 with the UK study is investigated and encouraged.

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8 Appendix list

8.1 Appendix A: Cruise report IRIS

8.2 Appendix B: Data report NIVA

8.3 Appendix C: Data report IRIS

8.4 Appendix D: Data report ITM, University of Stockholm

8.5 Appendix E: Data report – University of Vilnius

8.6 Appendix F: Data report – Battelle

Rolf C. Sundt

Water Column Monitoring 2006
Cruise report

Report RF – 2005 / 036

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NIVA

IRIS-Akvamiljø

Contents

1 Pre-exposure sampling

1.1 Pre-exposure sampling of cod

Pre-exposure sampling of cod was conducted 30th March on the fish farm that delivered fish to the experiment (Rygjabø, Finnøy). Sampling was carried out on the farm facility by personnel from IRIS (Rolf C Sundt and Lars Petter Myhre) and NIVA (Eivind Farmen Finne, Christopher Harman and Kevin Thomas). Samples were taken according to the list in the Appendix. Description of sampling procedure is given in 3.4.

1.2 Pre-exposure sampling of mussels

Mussels for the pre-exposure sampling arrived 28th March at the IRIS Akvamiljø facility in Mekjarvik and were kept in clean sea water taken from 80 metres depth for 6 days prior to sampling. Sampling was conducted by personnel from RF-Akvamiljø (Jan Fredrik Børseth and Daniela Pampanin). Tissue was collected according to the list in Appendix.

2 First cruise – Deployment of organisms

2.1 Research vessel and scientific personnel

The live fish carrier Seigrunn departured Stavanger 1th April and arrived back in Stavanger 5th April 2006. The scientific personnel onboard were: Rolf C. Sundt (IRIS), Bjørn Serigstad (Seamon a/s), and Dag Altin (Biotrix). The client was represented by Steinar Berntsen (ConocoPhillips).

2.2 Transfer of cod and mussels to the vessel

During fish transfer the vessel called at the quay next to the farm facility. The fish was transported from the indoor tanks to the vessel in 2000 L tanks by forklift. From the transport tanks the fish was lifted by hand in landing nets and distributed to cages submerged in the vessels fish well. To secure good water quality in the well, care was taken when choosing locality for the initial filling of the tank.

The general impression was that the fish was of good quality as delivered from the farm and that it coped well with the transport to Ekofisk, no lethality was observed. PAH contamination status was tested Fixed Fluorescent screening.

Figure 1. Fish and mussels were transported to field in cages submerged in the vessels well.

Mussels were transported on ice from the shellfish farm in the Trondheim Fjord to Sola by air and from there to Mekjarvik by car. On board the vessel the mussels were wrapped in protective nets before mounting on the cages.

Figure 2. Preparation of cage with fish and mussels prior to deployment.

2.3 Stations and rig equipment

8 rigs containing mussels were deployed, 4 of the rigs contained fish. Stations were numbered according to Table 1.

Six of the rigs were placed along a transect line in the dominating current direction from SW of the field to NE. In addition two reference stations with fish and mussels were placed at two expectedly clean locations NE of Ekofisk.

The vessels key crew had experience with deployment of the rigs used from a previous experiment (Water Column Monitoring 2004).

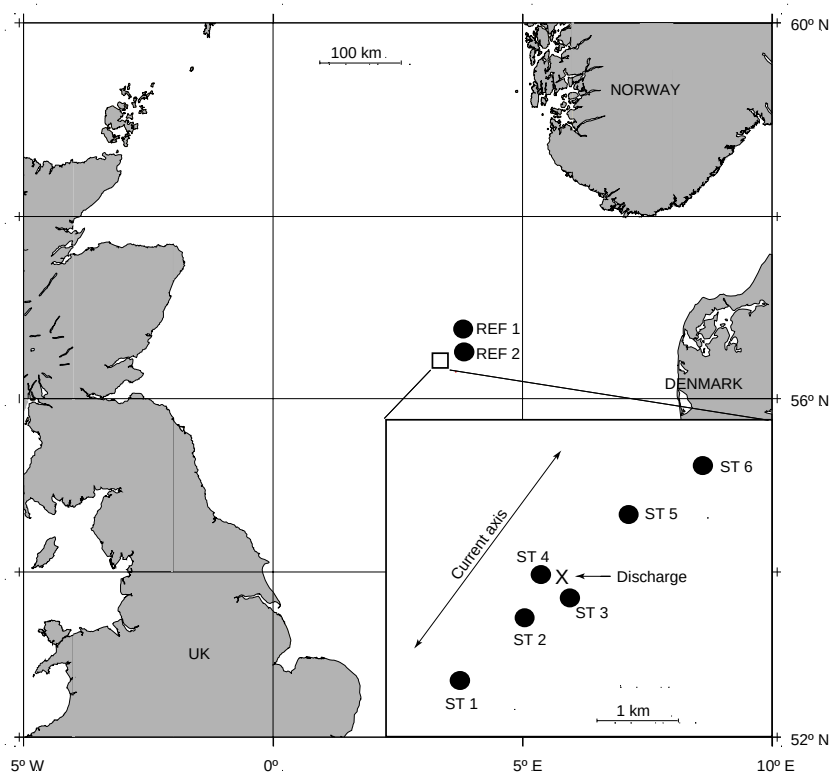


Figure 3. Positions of the caging stations at the Ekofisk field (superimposed panel) and positions of the reference stations in relation to the field.

Table 1. Locations and designation for stations. Note that the original experiment sample designations are used in appendixes.

Location	**Sample markings Mussel st.**	**Sample markings Fish st**	**Report st designations**
Reference NE of discharge	100	100	REF 1
Reference E of discharge	200	200	REF 2
1600m SW	600	-	ST 1
600m SW	400	-	ST 2
Off southern flare	300	300	ST 3
Off 2/4J	800	400	ST 4
1100m NE	700	-	ST 5
2000m NE	500	-	ST 6

Figure 4. Launching of bottom mooring weight

Figure 5. Deployment of cage containing fish and mussels off platform 2/4 J (station 4).

2.4 CTD profiles

CTD profiles were made during the rig deployment operation with a SBE "Seabird 901" probe. Temperature, conductivity, salinity, Σth, sound h. and sound m. were recorded from surface to 20 metres. Such measurements were also repeated during the exposure, see data report for results.

2.5 Monitoring of current data

Reference station 1 and mussel rigs 2 and 5 were fitted with current sensors. The rationale for this was to provide current data for confirmation of plume distribution compared to rigs. Such data can also provide input to future plume distribution modelling.

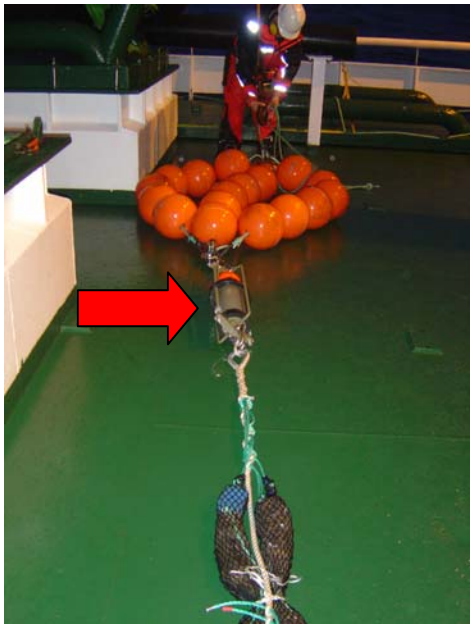


Figure 6. Current instrumentation was fitted by “in line” mounting between the mussels and the submerged flotation.

2.6 PAH contamination monitoring

In order to examine potential PAH contamination in the storage well system onboard the vessel, samples of sea water were collected. Five samples were taken from the surface of the main tank during the transport and stored in 5 litres tinted glass bottles with HCl added. The bottles were wrapped in aluminium foil and kept refrigerated until analyses.

3 Second cruise – Sampling

3.1 Objectives

The objectives were to collect cages with mussels, fish and oceanographic instruments and obtain biological samples for effect related monitoring of discharges from the Ekofisk field. (Water Column Monitoring 2006). In addition samples for analysis of AChE by Prof. Peter-Diedrik Hansen (Technische Universitaet Berlin) were collected.

The live fish carrier Seigrunn departured Stavanger 20th May (2130) and arrived back in Stavanger 23th May 2006 (0800), sampling was commenced 21th/22th May). The scientific personnel onboard were: Rolf C. Sundt, Jan Fredrik Børseth and Daniela Pampanin (IRIS-Akvamiljø), Christopher Harman, Sigurd Øxnevad and Eivind Farmen Finne (NIVA), Bjørn Serigstad (Seamon a/s), and Dag Altin (Biotrix). The client was represented by Eimund Garpestad (ConocoPhillips).

3.2 Equipment and logistics

IRIS was responsible for the accomplishment of the mussel sampling and NIVA performed the fish sampling. Equipment and chemicals were brought onboard the vessel together by the sampling personnel. Sample facilities were established in two container mounted the after-deck (mussel sampling) and on the main deck (fish sampling).

3.3 Accomplishment

All cages were picked up without any major problems. The surface float at mussel station 800 was lost during the exposure due to collision by vessel, so the rig needed ROV support for retrieval. Based on visual inspection, both mussels and fish apparently were in good shape. Some individual fish had worn fins expectedly due to contact with the net walls (see comments for individual fish in Appendix).

Most fish stomachs investigated were empty; some individuals had been eating fouling from the cages (mainly Bryozoans)

After retrieving the cages, the organisms were stored in tanks with sea water supply until sampling onboard the vessel. Cod was carried to the sampling lab in groups of five individuals. Details regarding distribution of sampling tasks are given in Appendix

Figure 7. Retrieval of cage at mussel station 800 was facilitated by ROV due to damaged surface floats.

3.4 Biological sampling

Laboratory facilities were fitted in containers mounted on the deck. Fish samples were collected by personnel from NIVA and mussel samples were collected by IRIS personnel.

The fish was sacrificed by a blow to the head and length, weight and general state was recorded. Approximately 2 ml of blood were taken and store don ice before centrifugation and freezing. The gut was opened, sex was recorded and samples were collected according to Table 2. Weight of whole fish was measured at sea. Livers and gonads were frozen and taken to Mekjarvik for measurement in order to increase weighing precision.

Table 2. Overview of samples collected from caged cod and from pre-exposure.

Matrix	**Recipient**	**Preservation**	**Method**
Liver	NIVA	Cryotubes, (l) N_2	Cyp 1a
Liver	NIVA	Cryotubes, (l) N_2	GST
Blood plasma	NIVA	Cryotubes, (l) N_2	Vitellogenin
Blood plasma	NIVA	Cryotubes, (l) N_2	Zona radiate prot.
Bile	IRIS	Cryotubes, (l) N_2	PAH met. FF
Bile	IRIS	Cryotubes, (l) N_2	PAH met. GCMS
Bile	IRIS	Cryotubes, (l) N_2	AP met. GCMS
Liver	ITM	Cryotubes, (l) N_2	DNA adducts
Liver	-	Cryotubes, (l) N_2	Bach up

For mussels haemolymphe for measurement of lysosomal stability was taken prior to the dissection of tissue. Tissue collection was done according to Table 3.

Analysis of lysosomal stability and imuno competence was commenced on fresh material onboard the vessel by means of plate reader and microscope fitted in the after deck container.

Hepatopancreas samples for histology analyses were frozen on aluminium chucks in hexane cooled with liquid nitrogen.

Table 3. Overview of samples collected from mussels.

Matrix	**Recipient**	**Preservation**	**Methode**
Hepatopancreas	NIVA	Cryotubes, (l) N_2	BaPH
Haemolymphe	IRIS	Direct analysis	Lysosomal stability
Haemocytes	IRIS	Direct analysis	Imunocompetence
Hepatopancreas	IRIS	On chuck, hexane/N_2	Histology
Soft tissue	Battelle	Heated glass/-20°C	PAH body burden
Soft tissue	NIVA	Heated glass/-20°C	Lipid content
Hemocytes	EKOI	Smear on slide	Micronucleus
Gills	TUB	Cryotubes, (l) N_2	AChE

Figure 8. After retrieval of cages, mussels and fish were stored in tanks with sea water supply until sampling.

Figure 9. Sampling of cod and mussels was conducted in lab containers mounted on the vessels deck.

3.5 Conclusion

Accomplishment of cruises was on the whole successful with respect to pick-up of cages and sampling. Sampling of both fish and mussels was commenced as planned. Loss of surface buoy on one station due to collision with vessel demanded extra effort during retrieval.

4 Appendix

Appendix 1.

Sampling data cod, pre exposure sampling

Sample no.	Length (cm)	Weight (g)	Liver weight (g)	Gonad weight (g)	Sex	Comments
1	44,0	818,0	79	0	M?	
2	40,0	878,0	128	14	F	no bile
3	42,0	727,0	70	9	M	
4	45,0	844,0	66	9	F	
5	46,0	1119,0	110	25	M	
6	41,0	916,0	84	113	F	
7	45,0	931,0	103	7	F	
8	42,0	749,0	64	9	F	
9	46,0	973,0	92	8	M	
10	43,0	900,0	98	10	F	
11	46,0	1020,0	141	2	M	
12	39,0	663,0	72	1	M	
13	43,0	901,0	77	8	F	
14	47,0	1298,0	142	12	F	
15	42,0	810,0	91	1	M	
16	45,0	916,0	69	2	M	
17	45,0	848,0	65	5	F	
18	40,0	686,0	46	6	F	
19	43,0	714,0	49	8	F	
20	46,0	1281,0	165	2	M	
21	44,0	914,0	106	7	M	
22	43,0	800,0	83	10	F	
23	44,0	887,0	111	4	M	
24	44,0	1047,0	131	12	F	
25	44,0	843,0	83	9	F	
26	40,0	639,0	44	1	M	
27	41,0	777,0	90	22	M	
28	42,0	666,0	58	12	F	
29	44,0	839,0	57	6	F	
30	43,0	883,0	84	129	F	

Sampling data cod, reference station 1.

Tag No.	Sample no.	Weight (g)	Length (cm)	Sex	Gonad (g)	Liver (g)	Comments
161	101	1020	47	M	21,4	53,5	
197	102	780	43	F	30	59	
214	103	650	42	M	20,7	16,6	
164	104	730	44	F	8	39,9	
201	105	860	44	F	21	51,3	
241	106	640	42	M	5,4	36,4	
141	107	820	44,5	F	16,8	57,5	
184	108	780	44	M	13,8	49,3	
119	109	680	44	M	2,8	20,9	
262	110	650	44	F	11,9	42,1	
255	111	1100	48,5	M	9,3	71,9	
206	112	750	42	F	26,5	67,5	
237	113	840	43	M	10,6	75,8	
162	114	860	44	F	7,4	30,9	
257	115	640	42	M	10,5	32,5	
134	116	1090	48	M	5,1	92,5	
244	117	710	43,5	M	21,3	38,1	
227	118	960	44,5	M	18,3	65,1	Burst gall bladder
217	119	910	45	F	16,5	69,1	
193	120	920	44	M	3,1	74,6	
154	121	960	46	M	11,4	74,6	
130	122	670	41	F	17,3	44,1	
199	123	530	39	M	10,4	37	
181	124	980	47	M	44,9	90,8	
251	125	900	45	F	13,1	85,4	
253	126	790	44,5	F	14,3	52,1	
232	127	980	47	M	12,9	86,7	
No Tag	128	990	47	M	16	56,9	
145	129	1000	48	F	22,5	70,1	
No Tag	130	1030	46,5	F	14,1	81,6	
No Tag	131	800	42	F			Just plasma
No Tag	132	550	39	M			Just plasma
No Tag	133	850	44,5	M			Just plasma
No Tag	134	800	43,5	M			Just plasma
No Tag	135	600	39	M			Just plasma
No Tag	136	890	44	M			Just plasma
No Tag	137	760	43,5	M			Just plasma
No Tag	138	1050	48	F			Just plasma
No Tag	139	1020	45,5	F			Just plasma
No Tag	140	940	47	?			Just plasma

Sampling data cod, reference station 2.

Tag No.	Sample no.	Weight (g)	Length (cm)	Sex	Gonad (g)	Liver (g)	Comments
125	201	1030	47	F	26	76,9	
261	202	890	44	F	23,5	63,7	
156	203	1020	46,5	F	41,5	100,5	
131	204	690	42	M	1,4	65,2	
208	205	750	41	F	17,3	43,1	
191	206	1200	50	F	22,8	110,6	
136	207	850	45,5	M	4,1	62,5	
155	208	700	40	M	3,7	49,2	
182	209	730	42,5	F	20,2	25,2	
127	210	1200	47	F	17,4	155,4	
254	211	690	43	F	10,3	18,3	
183	212	950	46	F	13,3	48,2	
192	213	700	43	M	15,5	56,9	
263	214	690	43	M	9,6	48	
221	215	1400	51	F	59,1	156,6	
132	216	920	45	F	20,7	74,3	
118	217	1300	51	F	19,9	144,6	
202	218	710	41	M	8,5	57,8	
173	219	620	41,5	F	9,6	36,8	
144	220	780	45	M	10,2	66	Burst gall bladder
160	221	960	48,5	M	9,2	86,9	
264	222	660	41	M	23	58	
215	223	650	40,5	F	10,9	13,7	
165	224	750	46	F	2,2	28,6	
189	225	680	40,5	F	15,8	69,7	
No Tag	226	650	42,5	F	11,2	36,7	
No Tag	227	710	40,5	F	23,5	74,3	
No Tag	228	710	43	M	11,5	43,4	
No Tag	229	610	39	F	13,3	69,5	Fl.1/2 incor. marked
No Tag	230	640	42	M	7	46,8	Fl.1/2 incor. marked
No Tag	231	660	43,5	F			Just Plasma
No Tag	232	680	41	M			Just Plasma
No Tag	233	710	43	M			Just Plasma
No Tag	234	530	30,5	F			Just Plasma
No Tag	235	1120	47	F			Just Plasma
No Tag	236	990	46	M			Just Plasma
No Tag	237	850	46	F			Just Plasma
No Tag	238	660	41,5	F			Just Plasma
No Tag	239	570	40	F			Just Plasma
No Tag	240	670	42	F			Just Plasma

Sampling data cod, station 3

Tag No.	Sample no.	Weight (g)	Length (cm)	Sex	Gonad (g)	Liver (g)	Comments
256	301	900	44	M	14,8	76,6	
252	302	530	39	F	6,6	15,6	
179	303	730	42	F	12,1	43,6	
133	304	890	44	M	1,8	21,2	
211	305	820	41	F	17,1	54,6	
185	306	1030	47	F	25,6	87,8	
235	307	990	45	F	27,8	59,5	
258	308	750	45	M	15,6	50,5	
167	309	850	45	M	11,5	49,2	
230	310	1200	48	F	39,8	105,4	
234	311	870	45	F	13,5	72,2	
178	312	710	43	M	1,5	54,4	
229	313	750	46	F	2,6	46,2	
203	314	1000	46	M	6,4	83,4	
122	315	900	44	F	23,4	69	
143	316	760	43,5	F	10,8	49,2	
260	317	750	43	M	2,6	30,3	
259	318	680	42	M	8,4	45	
171	319	860	44	M	6,1	75,4	Damaged fish
126	320	660	43	M	8,5	12,5	
239	321	800	44	F	17,2	60,6	
150	322	1170	48,5	F	28,8	113,4	
153	323	550	41	M	25,4	50,1	
128	324	850	45	M	13,3	73,8	
220	325	750	44	M	4,6	36,4	
No Tag	326	800	44,5	F	53,1	47,9	
No Tag	327	840	45	M	19,5	93,8	
No Tag	328	710	41	F	11,5	49,9	
No Tag	329	780	45	F	22,1	91,9	Badly damaged fish
No Tag	330	420	41	M	6	36,8	
No Tag	331	850	44	F			Plasma only
No Tag	332	840	43	M			Plasma only
No Tag	333	1100	49	M			Plasma only
No Tag	334	700	42	M			Plasma only
No Tag	335	780	45,5	M			Plasma only
No Tag	336	790	44	F			Plasma only/ Damaged fish
No Tag	337	620	42	M			Plasma only
No Tag	338	520	38	M			Plasma only
No Tag	339	680	42	F			Plasma only
No Tag	340	750	46	M			Plasma only

Sampling data cod, station 4

Tag No.	Sample no.	Weight (g)	Length (cm)	Sex	Gonad (g)	Liver (g)	Comments
210	401	1000	45	F	25,8	93,4	
222	402	720	43	M	23,7	67,6	
219	403	700	42	M	5	44,7	
228	404	670	42,5	F	12,5	49,1	
204	405	830	40	M	20,5	74,6	
146	406	720	43,5	F	13,7	30	
238	407	620	37	F	8,1	14,1	
157	408	630	39	F	15,5	40,3	
129	409	780	44	F	15,1	31	
187	410	710	43	F	13,4	39,4	
236	411	680	41,5	F	7	37	
240	412	750	43	M	10	54,8	
248	413	670	43	F	13,3	62,4	Damaged fish
246	414	910	46	M	10,6	89,9	
158	415	550	39	F	9,7	30	
186	416	960	45	M	-	31,4	
245	417	740	44	M	2	62	
266	418	720	43	M	2,4	82,2	
No Tag	419	700	41	F	15,3	38,2	
249	420	950	46	M	22,1	70,1	
231	421	660	41	M	20,9	38	
No Tag	422	520	37	M	6	30,1	
No Tag	423	1050	47	M	3,6	63,3	
No Tag	424	790	42	M	18,9	82,6	
No Tag	425	840	43	M	36,2	59,3	
No Tag	426	1000	47	F	20,7	78,7	Abnorml gall bladder
No Tag	427	550	42	M	12,9	16,9	
No Tag	428	690	44	F	14,4	39,3	
No Tag	429	790	44	M	4,2	44	
No Tag	430	810	42,5	M	2,4	55,7	
No Tag	431	640	41	F			Plasma only
No Tag	432	840	43,5	M			Plasma only
No Tag	433	720	42	F			Plasma only
No Tag	434	850	43	F			Plasma only
No Tag	435	740	43	F			Plasma only
No Tag	436	850	44	M			Plasma only
No Tag	437	820	41	F			Plasma only
No Tag	438	960	47,5	M			Plasma only
No Tag	439	690	43,5	F			Plasma only
No Tag	440	850	46	M			Plasma only

Sample information, mussels (L=length, W=width)

Site:	**REF 1**		**REF 2**	**ST 3**		**ST 2**		**ST 6**		**ST 1**	**ST 5**	**ST 4**
Sample no.	L	W	L	L	W	L	W	L	W	L	L	L
1	54	21	54	56	20	50	18	59	20	56	72	
2	62	27	59	60	21	57	25	60	21	60	61	
3	55	21	50	60	21	64	23	56	19	62	61	
4	52	20	51	56	20	58	26	58	20	53	59	
5	55	21	66	56	19	58	21	58	22	65	61	
6	64	28	60	59	21	59	22	54	19	59	60	
7	62	27	59	60	21	50	21	56	21	58	65	
8	63	26	60	55	21	56	20	50	16	65	69	
9	56	20	62	67	25	55	23	54	21	56	60	
10	55	22	59	56	20	48	18	55	21	65	57	
11	66	28	50	54	21	52	21	66	23	67	61	
12	60	21	58	61	24	60	22	64	23	60	61	
13	67	23	54	66	27	57	18	56	21	55	66	
14	57	21	55	61	20	67	22	53	18	51	60	
15	55	20	50	56	20	51	18	56	20	62	58	
16			51	68		58		64			70	58
17	61		54	64		60		55			67	69
18	57		48	61				58			69	63
19	58		53	50				57			68	58
20	68			51				61			59	57
21	59			56				53			66	65
22	63			65				54			58	62
23	52			54				55			65	56
24	57			61				61			61	56
25	62			58				58			60	60
26	65			56				65			54	55
27	51			63				50			60	55
28	60			65				52			68	57
29	57			52				50			60	55
30	57			60				54			60	

Appendix 2.

Sampling overview – cod, distribution of tasks among sampling crew.

Personell	Task / matrix	Treatment	Sample splitt	Preservation	Analysis
A*	Fish supply				
A*	Control tagging				
A	Length				
A	Weigth				
A	Fish QA				
A	Sex				
B	Blood	spinning	Plasma 1	N_2	Vtg
			Plasma 2	N_2	*Zrp*
C	Open fisk				
C	Bile	-	One tube	N_2	AP/PAH met.
C	Weight liver				
C	Liver	-	Lever 1	N_2	GST,Cyp 1a
C		-	Lever 2	N_2	DNA add.
			Lever 3	N_2	Extra
C	Weight gonades				

Appendix B.

Datareport Water Column Monitoring 2006

NIVA (Oslo)

Table 1. Body burden (µg/kg wet wt). of PAH compounds in mussels from the different groups (Analysed at NIVA).

Sample	WCM 2006 0-sampling	WCM 2006 0-sampling	WCM 2006 0-sampling
Total dry matter (g/kg)	140	160	150
Naphthalene	<0,5	<0,5	<0,5
C1-Naphthalenes	<2	<2	<2
C2-Naphthalenes	2,8	7,3	4,8
C3-Naphthalenes	5,7	7,1	<5
Acenaphthylene	<0,5	<0,5	<0,5
Acenaphthene	<0,5	<0,5	<0,5
Fluorene	<0,5	<0,5	<0,5
Anthracene	<0,5	<0,5	<0,5
Phenanthrene	0,62	0,72	0,62
C1-Phenanthrenes/Anthracenes	2,6	3,2	2,2
C2-Phenanthrenes/Anthracenes	5,9	6,8	4,8
C3-Phenanthrenes/Anthracenes	5,2	5,2	3,9
Dibenzotiophene	<0,5	<0,5	<0,5
C1-Dibenzotiophenes	<2	<2	<2
C2-Dibenzotiophenes	2,1	2,5	<2
C3-Dibenzotiophenes	3,7	3,6	2,8
Fluoranthene	1,8	1,2	1,5
Pyrene	1,3	0,98	1,2
Benzo(a)anthracene	<0,5	<0,5	<0,5
Chrysene	1,4	1,1	1,1
Benzo(b,j)fluoranthene	1,6	1,4	1,5
Benzo(k)fluoranthene	<0,5	<0,5	<0,5
Benzo(e)pyrene	1,3	1,5	1,3
Benzo(a)pyrene	<0,5	<0,5	<0,5

Perylene	0,56	<0,5	<0,5
Indeno(1,2,3-cd)pyrene	<0,5	<0,5	<0,5
Dibenz(a,c/a,h)anthracene	<0,5	<0,5	<0,5
Benzo(ghi)perylene	<0,5	<0,5	<0,5
Sum PAH	36,58	42,6	25,72
Sum PAH16	6,72	5,4	5,92
Sum NPD	28,62	36,42	19,12

Table 1. continued.

Sample	WCM 2006 st. 100 pool 1	WCM 2006 st. 100 pool 2	WCM 2006 st. 100 pool 3
Total dry matter (g/kg)	160	150	150
Naphthalene	<0,5	<0,5	<0,5
C1-Naphthalenes	<2	<2	<2
C2-Naphthalenes	2,2	<2	<2
C3-Naphthalenes	<5	<5	<5
Acenaphthylene	<0,5	<0,5	<0,5
Acenaphthene	<0,5	<0,5	<0,5
Fluorene	<0,5	<0,5	<0,5
Anthracene	<0,5	<0,5	<0,5
Phenanthrene	0,92	0,87	0,93
C1-Phenanthrenes/Anthracenes	2,3	2,7	2,6
C2-Phenanthrenes/Anthracenes	<2	<2	<2
C3-Phenanthrenes/Anthracenes	i	i	i
Dibenzotiophene	<0,5	<0,5	<0,5
C1-Dibenzotiophenes	<2	<2	<2
C2-Dibenzotiophenes	<2	<2	<2
C3-Dibenzotiophenes	<2	<2	<2
Fluoranthene	1,3	1,6	1,5
Pyrene	<0,5	<0,5	<0,5
Benzo(a)anthracene	<0,5	<0,5	<0,5
Chrysene	<0,5	<0,5	<0,5
Benzo(b,j)fluoranthene	<0,5	<0,5	<0,5
Benzo(k)fluoranthene	<0,5	<0,5	<0,5
Benzo(e)pyrene	<0,5	<0,5	<0,5
Benzo(a)pyrene	<0,5	<0,5	<0,5

Perylene	<0,5	<0,5	<0,5
Indeno(1,2,3-cd)pyrene	<0,5	<0,5	<0,5
Dibenz(a,c/a,h)anthracene	<0,5	<0,5	<0,5
Benzo(ghi)perylene	<0,5	<0,5	<0,5
Sum PAH	6,72	5,17	5,03
Sum PAH16	2,22	2,47	2,43
Sum NPD	5,42	3,57	3,53

Table 1. continued.

Sample	WCM 2006 st. 300 pool 1	WCM 2006 st. 300 pool 2
Total dry matter (g/kg)	140	130
Naphthalene	3,1	3,1
C1-Naphthalenes	18	21
C2-Naphthalenes	57	62
C3-Naphthalenes	220	230
Acenaphthylene	<0,5	<0,5
Acenaphthene	<0,5	<0,5
Fluorene	2	2,4
Anthracene	<0,5	<0,5
Phenanthrene	9	9,8
C1-Phenanthrenes/Anthracenes	56	56
C2-Phenanthrenes/Anthracenes	150	140
C3-Phenanthrenes/Anthracenes	82	78
Dibenzotiophene	0,99	1,3
C1-Dibenzotiophenes	11	12
C2-Dibenzotiophenes	37	35
C3-Dibenzotiophenes	48	43
Fluoranthene	2,4	2,3
Pyrene	0,7	0,83
Benzo(a)anthracene	0,52	<0,5
Chrysene	2,4	1,4
Benzo(b,j)fluoranthene	0,89	0,7
Benzo(k)fluoranthene	<0,5	<0,5
Benzo(e)pyrene	2,2	2,1
Benzo(a)pyrene	<0,5	<0,5
Perylene	<0,5	<0,5

Indeno(1,2,3-cd)pyrene	<0,5	<0,5
Dibenz(a,c/a,h)anthracene	<0,5	<0,5
Benzo(ghi)perylene	<0,5	<0,5
Sum PAH	703,2	700,93
Sum PAH16	21,01	20,53
Sum NPD	692,09	691,2

Table 1. continued.

Sample	WCM 2006 st. 400 pool 1	WCM 2006 st. 400 pool 2
Total dry matter (g/kg)	140	130
Naphthalene	2,7	0,61
C1-Naphthalenes	9,7	8,7
C2-Naphthalenes	29	28
C3-Naphthalenes	170	100
Acenaphthylene	<0,5	<0,5
Acenaphthene	<0,5	<0,5
Fluorene	1,2	1,2
Anthracene	<0,5	<0,5
Phenanthrene	6,2	5,1
C1-Phenanthrenes/Anthracenes	35	30
C2-Phenanthrenes/Anthracenes	85	77
C3-Phenanthrenes/Anthracenes	49	44
Dibenzotiophene	0,59	0,59
C1-Dibenzotiophenes	7	6
C2-Dibenzotiophenes	24	21
C3-Dibenzotiophenes	26	26
Fluoranthene	2,4	1,8
Pyrene	0,77	0,6
Benzo(a)anthracene	<0,5	<0,5
Chrysene	1,2	1,1
Benzo(b,j)fluoranthene	0,65	<0,5
Benzo(k)fluoranthene	<0,5	<0,5
Benzo(e)pyrene	1,5	1,2
Benzo(a)pyrene	<0,5	<0,5
Perylene	<0,5	<0,5
Indeno(1,2,3-cd)pyrene	<0,5	<0,5
Dibenz(a,c/a,h)anthracene	<0,5	<0,5
Benzo(ghi)perylene	<0,5	<0,5
Sum PAH	451,91	352,9
Sum PAH16	15,12	10,41

Sum NPD	444,19	347

Table 2. Sex, CYP1A and GST activity for individual cod from the different groups

Group	Sample-code	Sex	CYP1A (Absorbance)	GST act. (µmol/min/mg prot)
0-sampling	1	Male	0,326	1174,8
0-sampling	2	Female	0,171	1434,3
0-sampling	3	Male	0,000	791,2
0-sampling	4	Female	0,229	907,9
0-sampling	5	Male	0,019	1424,7
0-sampling	6	Female	0,000	935,9
0-sampling	7	Female	0,082	1043,0
0-sampling	8	Female	0,180	667,2
0-sampling	9	Male	0,253	1836,7
0-sampling	10	Female	0,169	1573,6
0-sampling	11	Male	0,354	1086,2
0-sampling	12	Male	0,080	1125,6
0-sampling	13	Female	0,242	1149,6
0-sampling	14	Female	0,142	1037,9
0-sampling	15	Male	0,009	1271,5
0-sampling	16	Male	0,000	1024,3
0-sampling	17	Female	0,000	1819,5
0-sampling	18	Female	0,000	1773,2
0-sampling	19	Female	0,234	1130,7
0-sampling	20	Male	0,210	1316,6
0-sampling	21	Male	0,124	1000,3
0-sampling	22	Female	0,124	1829,6
0-sampling	23	Male	0,052	1081,0
0-sampling	24	Female	0,154	1895,1
0-sampling	25	Female	0,129	

Table 2. continued.

Group	Sample-code	Sex	CYP1A (Absorbance)	GST act. (µmol/min/mg prot)
100 (REF)	101-2	Male	0,095	1464,5
100 (REF)	102-2	Female	0,092	1236,4
100 (REF)	103-2	Male	0,105	690,0
100 (REF)	105-2	Female	0,086	910,9
100 (REF)	106-2	Male	0,101	1330,1
100 (REF)	107-2	Female	0,095	1052,5
100 (REF)	108-2	Male	0,122	1986,5
100 (REF)	109-2	Male	0,156	678,8
100 (REF)	110-2	Female	0,069	1084,0
100 (REF)	111-2	Male	0,147	1334,0
100 (REF)	112-2	Female	0,097	1284,6
100 (REF)	114-2	Female	0,117	845,1
100 (REF)	115-2	Male	0,074	1117,2
100 (REF)	116-2	Male	0,114	1503,9
100 (REF)	118-2	Male	0,087	1359,5
100 (REF)	119-2	Female	0,121	907,5
100 (REF)	120-2	Male	0,072	1758,9
100 (REF)	121-2	Male	0,191	722,1
100 (REF)	122-2	Female	0,115	885,9
100 (REF)	123-2	Male	0,094	1655,1
100 (REF)	124-2	Male	0,085	1135,4
100 (REF)	125-2	Female	0,096	1669,2
100 (REF)	126-2	Female	0,092	925,1
100 (REF)	127-2	Male	0,172	802,9
100 (REF)	129-2	Female	0,105	762,5

Table 2. continued.

Group	Sample-code	Sex	CYP1A (Absorbance)	GST act. (µmol/min/mg prot)
200 (REF)	201-2	Female	0,112	
200 (REF)	202-2	Female	0,206	
200 (REF)	203-2	Female	0,097	
200 (REF)	204-2	Male	0,197	
200 (REF)	205-2	Female	0,095	
200 (REF)	206-2	Female	0,152	
200 (REF)	207-2	Male	0,084	
200 (REF)	208-2	Male	0,089	
200 (REF)	209-2	Female	0,172	
200 (REF)	211-2	Female	0,272	
200 (REF)	212-2	Female	0,109	
200 (REF)	213-2	Male	0,208	
200 (REF)	214-2	Male	0,074	
200 (REF)	215-2	Female	0,059	
200 (REF)	216-2	Female	0,064	
200 (REF)	217-2	Female	0,039	
200 (REF)	218-2	Male	0,071	
200 (REF)	219-2	Female	0,103	
200 (REF)	220-2	Male	0,033	
200 (REF)	221-2	Male	0,062	
200 (REF)	222-2	Male	0,161	
200 (REF)	223-2	Female	0,236	
200 (REF)	224-2	Female	0,115	
200 (REF)	225-2	Female	0,076	
200 (REF)	229-2	Female	0,119	

Table 2. continued.

Group	Sample-code	Sex	CYP1A (Absorbance)	GST act. (µmol/min/mg prot)
300	301-2	Male	0,223	1957,6
300	302-2	Female	0,395	750,9
300	305-3	Female	0,185	1644,2
300	306-2	Female	0,150	1774,3
300	308-2	Male	0,209	842,7
300	309-2	Male	0,228	1481,6
300	310-3	Female	0,088	1191,8
300	311-3	Female	0,261	1228,3
300	312-2	Male	0,162	878,9
300	313-2	Female	0,275	745,6
300	314-3	Male	0,235	1155,1
300	315-2	Female	0,326	670,9
300	316-2	Female	0,155	636,1
300	317-3	Male	0,257	1041,3
300	318-3	Male	0,149	726,7
300	319-3	Male	0,131	1210,5
300	320-2	Male	0,232	698,0
300	321-2	Female	0,279	1463,6
300	322-2	Female	0,136	1088,8
300	323-2	Male	0,313	1027,2
300	325-3	Male	0,221	1031,6
300	326-2	Female	0,125	972,2
300	327-2	Male	0,168	704,9
300	328-2	Female	0,158	801,7
300	329-2	Female	0,087	909,0

Table 2. continued.

Group	Sample-code	Sex	CYP1A (Absorbance)	GST act. (µmol/min/mg prot)
400	401-2	Female	0,179	1265,7
400	402-2	Male	0,203	1059,0
400	403-2	Male	0,226	870,5
400	404-2	Female	0,137	756,6
400	405-2	Male	0,183	761,5
400	406-2	Female	0,103	612,9
400	407-2	Female	0,231	645,4
400	409-2	Female	0,240	894,7
400	410-2	Female	0,175	713,3
400	414-2	Male	0,161	675,5
400	415-2	Female	0,217	820,7
400	416-2	Male	0,122	1064,6
400	417-2	Male	0,138	858,9
400	418-2	Male	0,156	801,6
400	419-2	Female	0,111	1383,6
400	421-2	Male	0,225	1129,0
400	422-2	Male	0,143	807,8
400	423-2	Male	0,222	478,4
400	424-2	Male	0,116	1729,1
400	425-2	Male	0,167	1274,8
400	426-2	Female	0,241	953,4
400	427-2	Male	0,216	780,1
400	428-2	Female	0,109	691,8
400	429-2	Male	0,282	882,9
400	430-2	Male	0,177	863,2

Table 3. Sex, plasma vitellogenin concentrations (µg/ml) before and after exposure, and the alteration in plasma vitellogenin during exposure, in cod from the different groups.

Group	Fish no	Sex	VTG pre-exposure (µg/ml)	VTG post-exposure (µg/ml)	VTG Diff. (ΔVTG)
100 (REF)	101	Male	1,76	1,26	-0,49
100 (REF)	102	Female	213,24	294,69	81,45
100 (REF)	103	Male	1,25	1,26	0,00
100 (REF)	104	Female	124,23	125,99	1,76
100 (REF)	105	Female	137,16	181,81	44,65
100 (REF)	106	Male	1,27	1,26	-0,01
100 (REF)	107	Female	176,80	143,45	-33,35
100 (REF)	108	Male	1,30	1,26	-0,04
100 (REF)	109	Male	1,28	1,26	-0,01
100 (REF)	110	Female	128,80	128,84	0,04
100 (REF)	111	Male	2,29	1,46	-0,83
100 (REF)	112	Female	147,44	211,51	64,07
100 (REF)	113	Male	1,52	1,65	0,13
100 (REF)	114	Female	124,47	126,30	1,83
100 (REF)	115	Male	1,29	1,26	-0,04
100 (REF)	116	Male	1,25	1,46	0,21
100 (REF)	117	Male	1,53	1,30	-0,23
100 (REF)	118	Male	1,56	1,33	-0,23
100 (REF)	119	Female	126,88	130,51	3,63
100 (REF)	120	Male	2,96	2,92	-0,04
100 (REF)	121	Male	1,26	1,25	-0,01
100 (REF)	122	Female	126,63	141,87	15,24
100 (REF)	123	Male	2,95	1,25	-1,69
100 (REF)	124	Male	1,24	1,25	0,01
100 (REF)	125	Female	130,85	132,52	1,67
100 (REF)	126	Female	145,51	134,89	-10,63
100 (REF)	127	Male	1,26	1,29	0,04
100 (REF)	129	Female	127,14	142,08	14,94

Table 3. continued.

Group	Fish no	Sex	VTG pre-exposure (µg/ml)	VTG post-exposure (µg/ml)	VTG Diff. (ΔVTG)
300	301	Male	2,93	2,57	-0,36
300	302	Female	126,95	127,68	0,73
300	303	Female	128,51	136,59	8,08
300	304	Male	1,25	1,25	0,00
300	305	Female	144,33	204,51	60,18
300	306	Female	134,64	165,97	31,33
300	307	Female	128,70	156,55	27,84
300	308	Male	1,31	1,29	-0,02
300	309	Male	1,49	1,27	-0,22
300	310	Female	197,07	143,21	-53,87
300	311	Female	126,68	127,50	0,82
300	312	Male	2,64	1,29	-1,35
300	313	Female	126,11	126,55	0,44
300	314	Male	1,36	1,30	-0,06
300	315	Female	153,65	238,46	84,82
300	316	Female	134,89	128,61	-6,28
300	317	Male	1,28	1,26	-0,03
300	318	Male	1,28	1,25	-0,03
300	319	Male	1,26	1,25	-0,01
300	320	Male	1,55	1,26	-0,29
300	321	Female	160,73	176,74	16,01
300	322	Female	128,12	171,48	43,36
300	323	Male	1,27	1,26	-0,01
300	324	Male	1,74	1,28	-0,46
300	325	Male	1,41	1,26	-0,15

Table 3. continued.

Group	Fish no	Sex	VTG pre-exposure (µg/ml)	VTG post-exposure (µg/ml)	VTG Diff. (ΔVTG)
400	401	Female	138,98	226,84	87,87
400	402	Male	2,11	2,35	0,24
400	403	Male	1,25	1,27	0,02
400	404	Female	128,38	135,52	7,14
400	405	Male	2,82	2,53	-0,29
400	406	Female	128,90	158,81	29,91
400	407	Female	126,48	127,19	0,71
400	408	Female	126,41	192,75	66,34
400	409	Female	129,28	161,39	32,11
400	410	Female	137,40	131,63	-5,77
400	411	Female	126,80	131,37	4,57
400	412	Male		1,91	1,91
400	413	Female	127,79	127,81	0,02
400	414	Male	1,71	1,27	-0,44
400	415	Female	130,79	128,83	-1,96
400	416	Male	1,30	1,27	-0,04
400	417	Male	1,30	1,29	-0,01
400	418	Male	1,27	1,26	-0,01
400	420	Male	1,26	1,26	0,00
400	421	Male	1,71	1,36	-0,35

Table 4. Sex, zona radiata protein (Absorbance) before and after exposure, and the alteration in plasma vitellogenin during exposure, in cod from the different groups.

Group	Fish no	Sex	ZRP (NSB corr. ABS) pre-exposure	ZRP (NSB corr. ABS) post-eksposure	ZRP Diff. (ΔZRP)
100 (REF)	101	Male	0,149	0,195	0,046
100 (REF)	102	Female	0,137	0,261	0,123
100 (REF)	103	Male	0,152	0,189	0,036
100 (REF)	104	Female	0,133	0,169	0,036
100 (REF)	105	Female	0,138	0,208	0,070
100 (REF)	106	Male	0,002	0,118	0,115
100 (REF)	107	Female	0,104	0,124	0,021
100 (REF)	108	Male	0,133	0,146	0,013
100 (REF)	109	Male	0,118	0,138	0,020
100 (REF)	110	Female	0,114	0,130	0,015
100 (REF)	111	Male	0,107	0,160	0,053
100 (REF)	112	Female	0,139	0,145	0,007
100 (REF)	113	Male	0,036	0,135	0,100
100 (REF)	114	Female	0,142	0,177	0,035
100 (REF)	115	Male	0,101	0,139	0,038
100 (REF)	116	Male	0,084	0,152	0,069
100 (REF)	117	Male	0,026	0,160	0,134
100 (REF)	118	Male	0,102	0,148	0,047
100 (REF)	119	Female	0,146	0,182	0,036
100 (REF)	120	Male	0,094	0,168	0,073
100 (REF)	121	Male	0,148	0,160	0,012
100 (REF)	122	Female	0,103	-0,004	-0,107
100 (REF)	123	Male	0,141	0,183	0,042
100 (REF)	124	Male	0,161	0,121	-0,040
100 (REF)	125	Female	0,071	0,177	0,106
100 (REF)	126	Female	0,086	0,164	0,078
100 (REF)	127	Male	0,049	0,150	0,102
100 (REF)	129	Female	0,111	0,148	0,037

Table 4. continued.

Group	Fish no	Sex	ZRP (NSB corr. ABS) pre-exposure	ZRP (NSB corr. ABS) post-eksposure	ZRP Diff. (ΔZRP)
300	301	Male	0,060	0,181	0,122
300	302	Female	0,028	0,153	0,125
300	303	Female	0,109	0,164	0,055
300	304	Male	0,130	0,150	0,021
300	305	Female	0,093	0,145	0,052
300	306	Female	0,146	0,163	0,017
300	307	Female	0,035	0,162	0,127
300	308	Male	0,097	0,123	0,026
300	309	Male	0,155	0,212	0,058
300	310	Female	0,029	0,124	0,095
300	311	Female	0,059	0,154	0,095
300	312	Male	0,141	0,127	-0,014
300	313	Female	-0,004	0,128	0,132
300	314	Male	0,155	0,173	0,019
300	315	Female	0,109	0,183	0,074
300	316	Female	0,106	0,153	0,047
300	317	Male	0,112	0,156	0,044
300	318	Male	0,110	0,175	0,064
300	319	Male	0,196	0,298	0,102
300	320	Male	0,111	0,143	0,032
300	321	Female	0,054	0,180	0,127
300	322	Female	0,122	0,194	0,071
300	323	Male	0,158	0,198	0,041
300	324	Male	0,144	0,208	0,064
300	325	Male	0,202	0,223	0,021

Table 4. continued.

Group	Fish no	Sex	ZRP (NSB corr. ABS) pre-exposure	ZRP (NSB corr. ABS) post-eksposure	ZRP Diff. (ΔZRP)
400	401	Female	0,146	0,220	0,074
400	402	Male	0,151	0,158	0,007
400	403	Male	0,131	0,153	0,022
400	404	Female	0,133	0,172	0,039
400	405	Male	0,141	0,167	0,026
400	406	Female	0,099	0,190	0,091
400	407	Female	0,028	0,175	0,147
400	408	Female	0,156	0,190	0,034
400	409	Female	0,122	0,183	0,061
400	410	Female	0,120	0,145	0,025
400	411	Female	0,041	0,170	0,128
400	412	Male	0,022	0,155	0,133
400	413	Female	0,059	0,180	0,121
400	414	Male	-0,010	0,225	0,235
400	415	Female	0,170	0,229	0,060
400	416	Male	0,119	0,190	0,071
400	417	Male	0,023	0,165	0,142
400	418	Male	0,090	0,116	0,026
400	420	Male	0,092	0,205	0,113
400	421	Male	0,043	0,153	0,111

Current measurements - details

Station 400

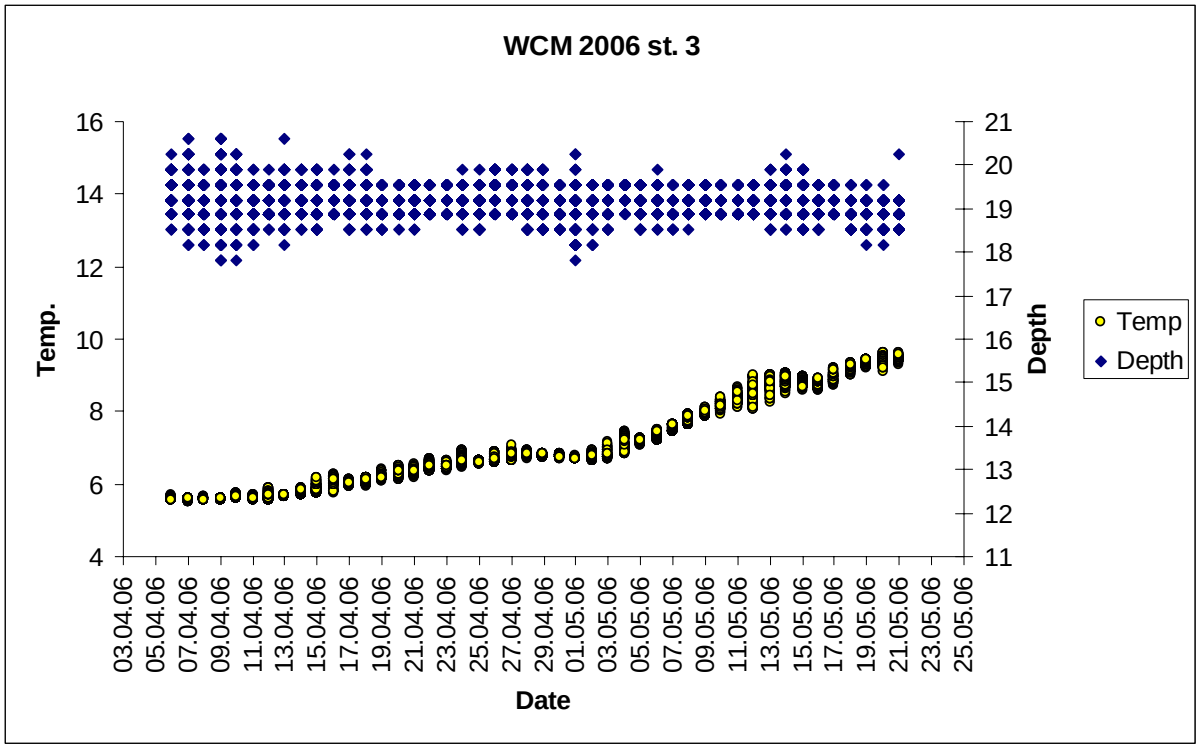
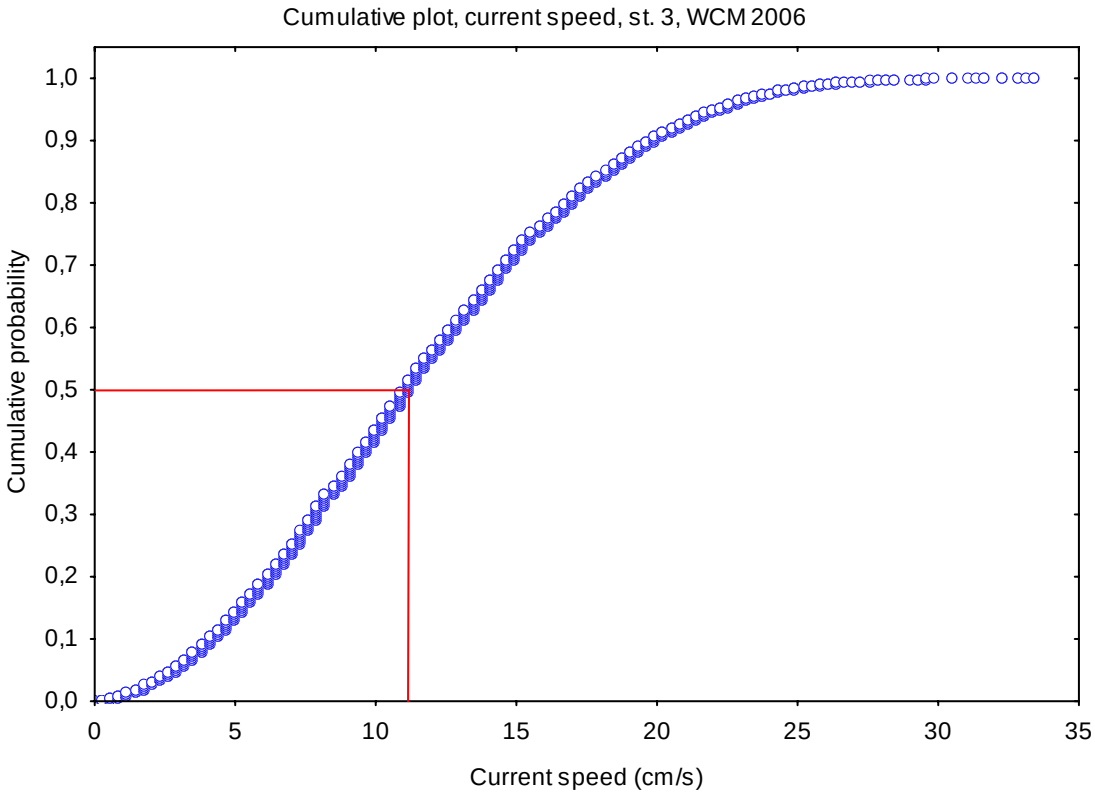


Figure 1. Water temperature (°C)and measuring depth (m) at WCM 2006 station 400. Measurements at 10 minute interval.

Table 1. Calculated parameters from current measurements from April 6th until the 21st of May, station 400.

Parameter	Velocity (cm/s)
Average	11.7
Varians	35.4
Maximum	33.4
Minimum	0.0
Median *	11.1
Measuring depth	18-20 (m)
Main directions	N-E and S-W

*See also cumulative probability plot


Cumulative plot, current speed, st. 3, WCM 2006
Cumulative probability
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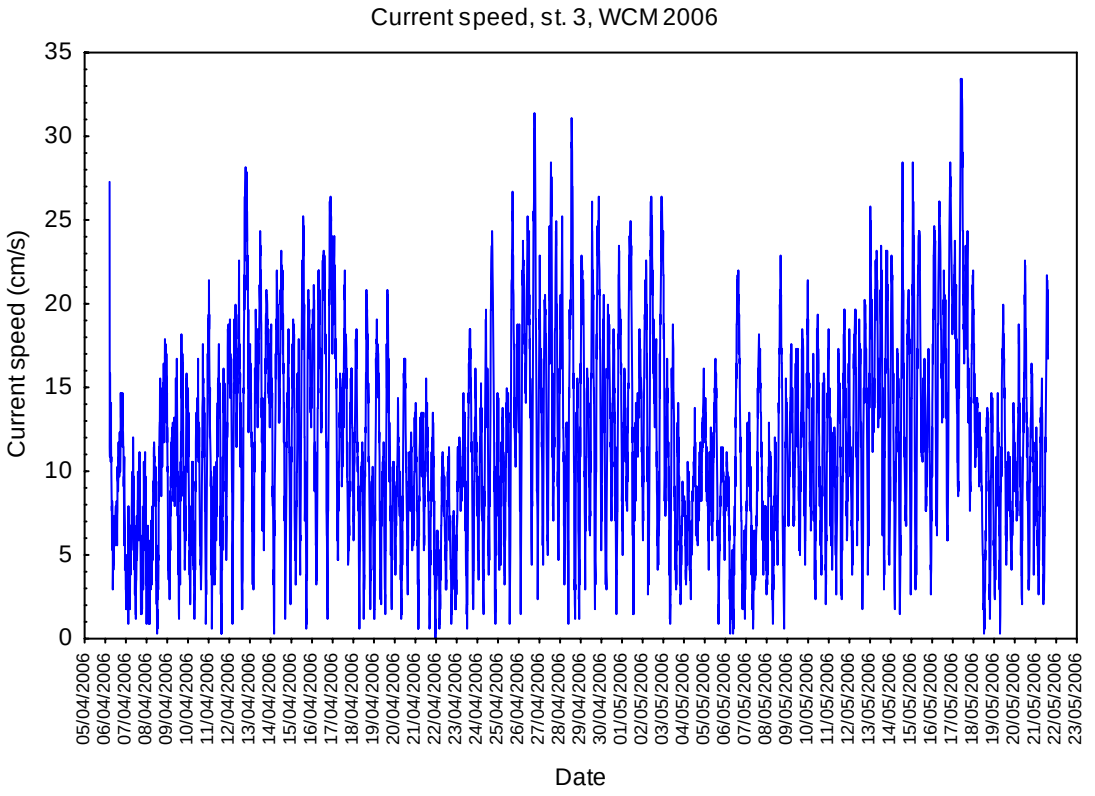
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0
5
10
15
20
25
30
35
Current speed (cm/s)


Current speed, st. 3, WCM 2006
Current speed (cm/s)
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30
25
20
15
10
5
0
05/04/2006
06/04/2006
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09/04/2006
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15/05/2006
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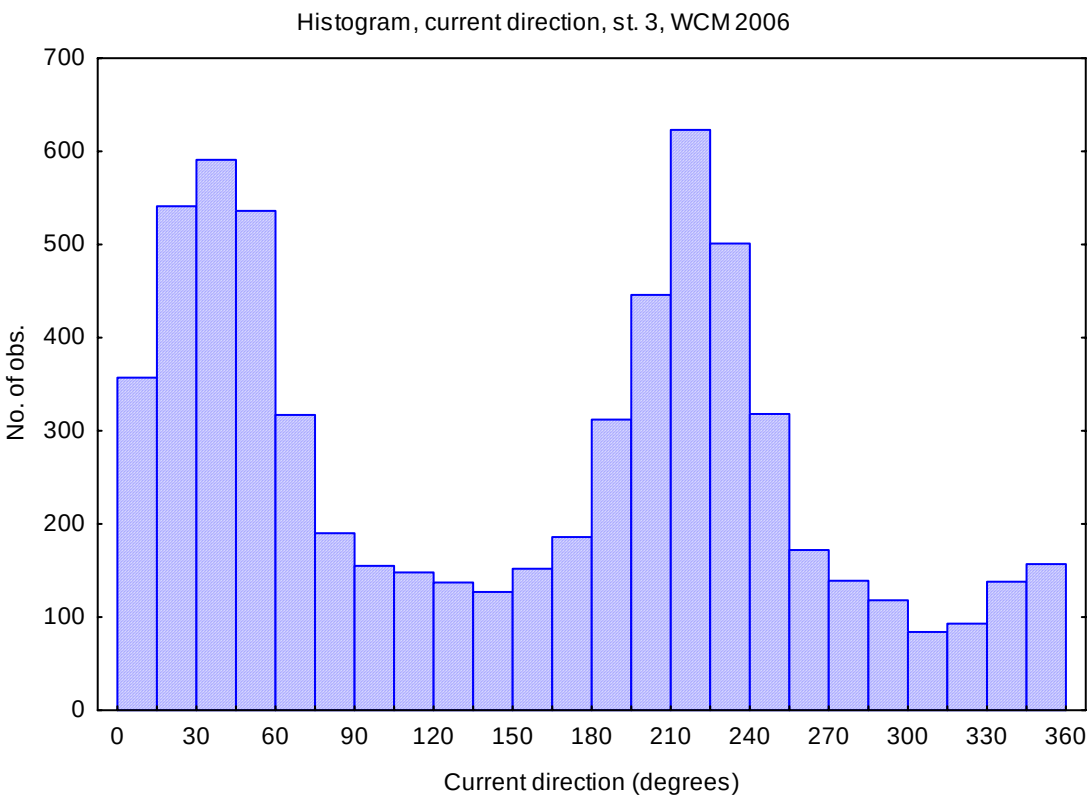
19/05/2006
20/05/2006
21/05/2006
22/05/2006
23/05/2006
Date


Histogram, current direction, st. 3, WCM 2006
No. of obs.
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600
500
400
300
200
100
0
0
30
60
90
120
150
180
210
240
270
300
330
360
Current direction (degrees)

Station 700

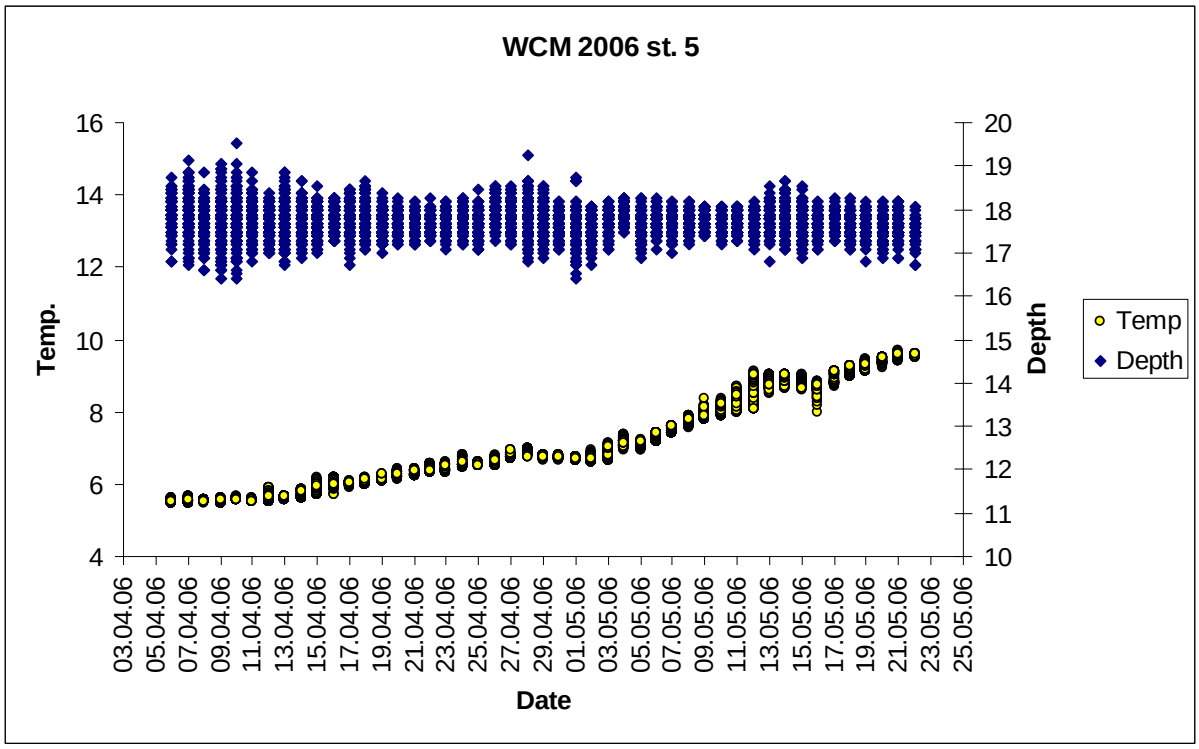
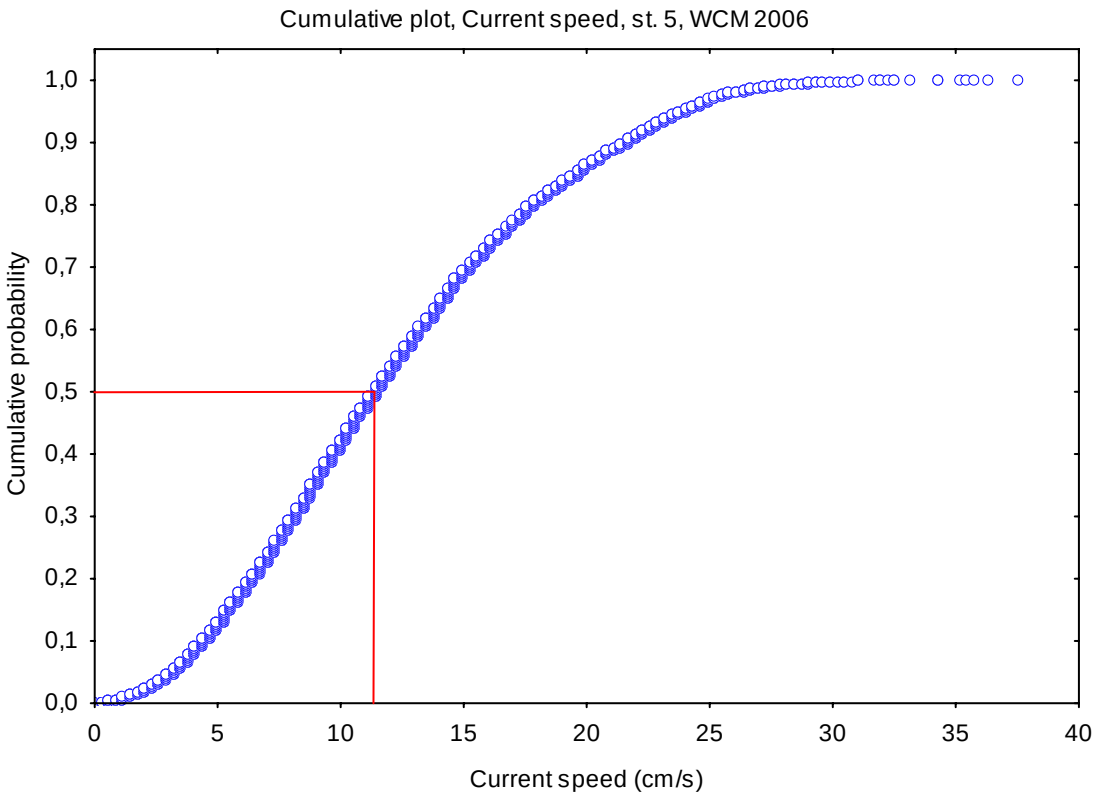


Figure X. Water temperature (°C)and measuring depth (m) at WCM 2006 station 700. Measurements at 10 minute interval.

Table X. Calculated parameters from current measurements from April 6th until the 21st of May, station 700, WCM 2006.

Parameter	Velocity (cm/s)
Average	12.3
Varians	40.9
Maximum	37.5
Minimum	0.0
Median *	11.4
Measuring depth	17-19 (m)
Main directions	N-E and S-W

*See also cumulative probability plot


Cumulative plot, Current speed, st. 5, WCM 2006
Cumulative probability
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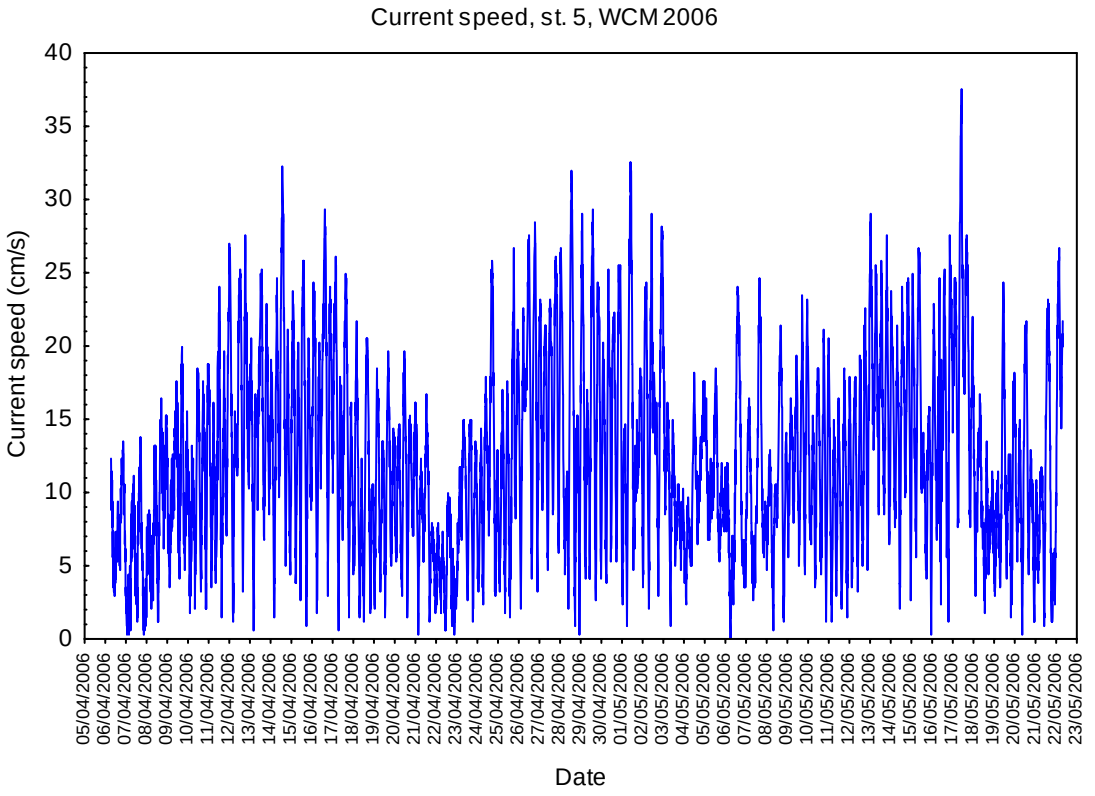
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0
5
10
15
20
25
30
35
40
Current speed (cm/s)


Current speed, st. 5, WCM 2006
Current speed (cm/s)
40
35
30
25
20
15
10
5
0
05/04/2006
06/04/2006
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08/04/2006
09/04/2006
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11/04/2006
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15/05/2006
16/05/2006
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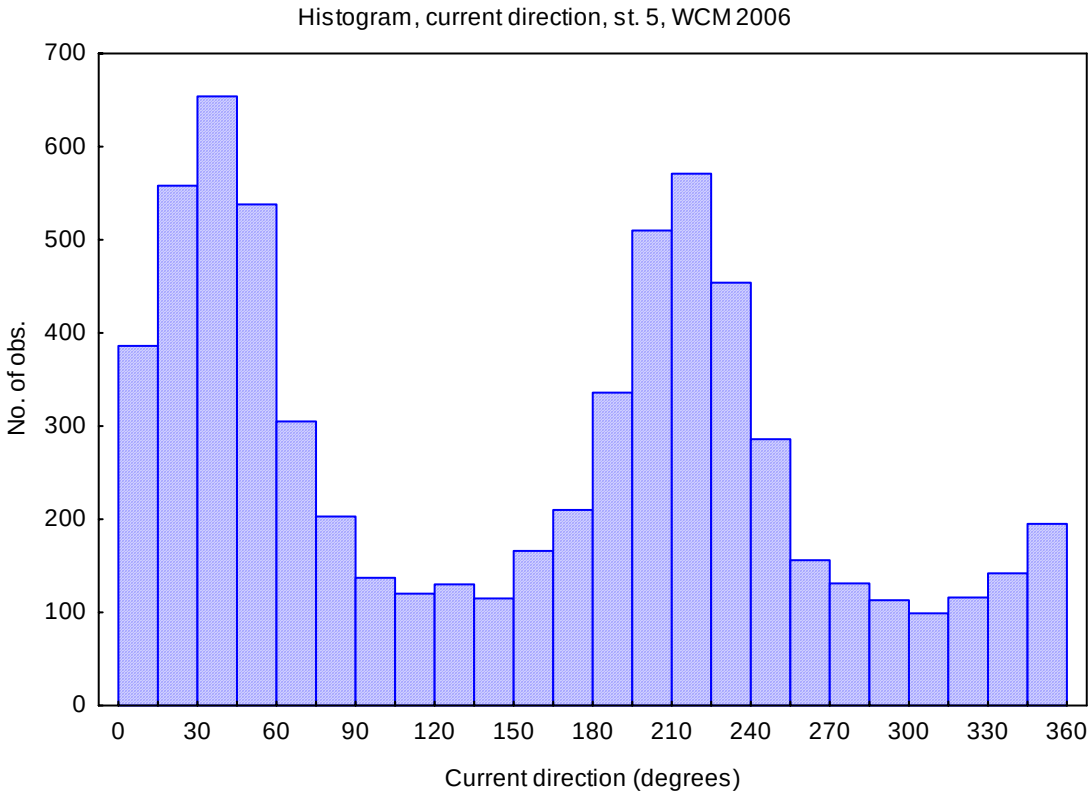
19/05/2006
20/05/2006
21/05/2006
22/05/2006
23/05/2006
Date


Histogram, current direction, st. 5, WCM 2006
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500
400
300
200
100
0
0
30
60
90
120
150
180
210
240
270
300
330
360
Current direction (degrees)

Reference station 200

Pre-programmed set-up for Aquadopp at the 200 reference station:

Deployment: WCM-06
Current time: 29.03.2006 12:47:32
Start at: 04.04.2006
Comment: Vannsøyleovervåking 2006
Measurement interval (s): 600
Average interval (s): 60
Blanking distance (m): 0.35
Diagnostics interval (min): 720
Diagnostics samples: 20
Measurement load (%): 26
Power level: LOW+
Compass upd. rate (s) : 2
Coordinate System: ENU
Speed of sound (m/s): MEASURED
Salinity (ppt): 34
File wrapping: OFF
Assumed duration (days): 60.0
Recorder size (MB): 5
Battery utilization (%): 71.0
Memory required (MB): 0.4
Velocity precision (cm/s): 0.4
Aquadopp Version 1.16a

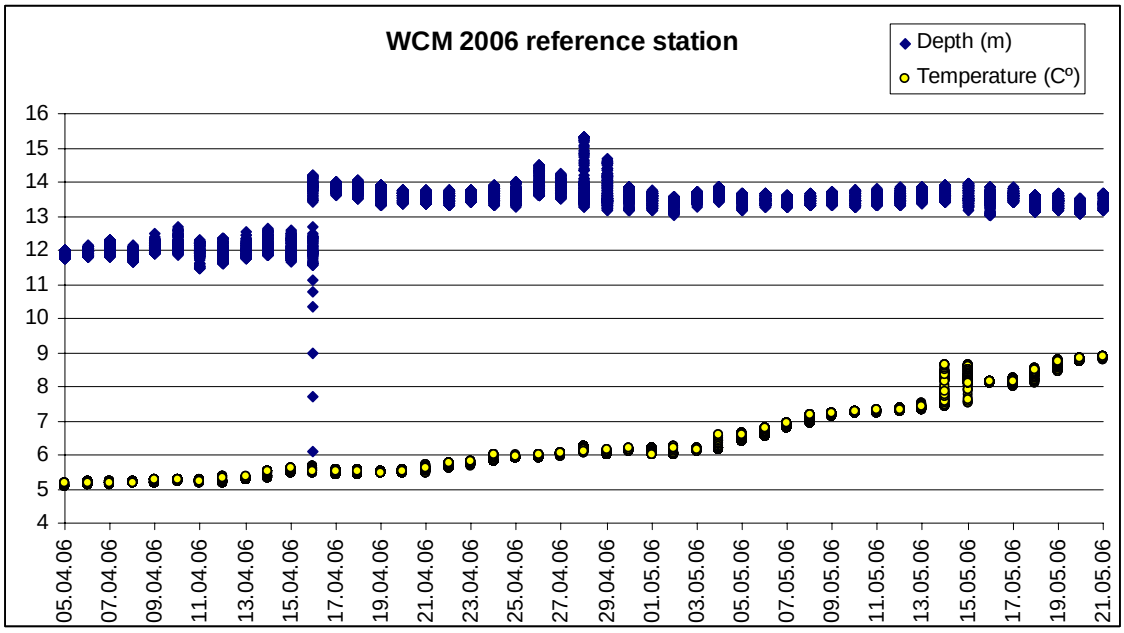
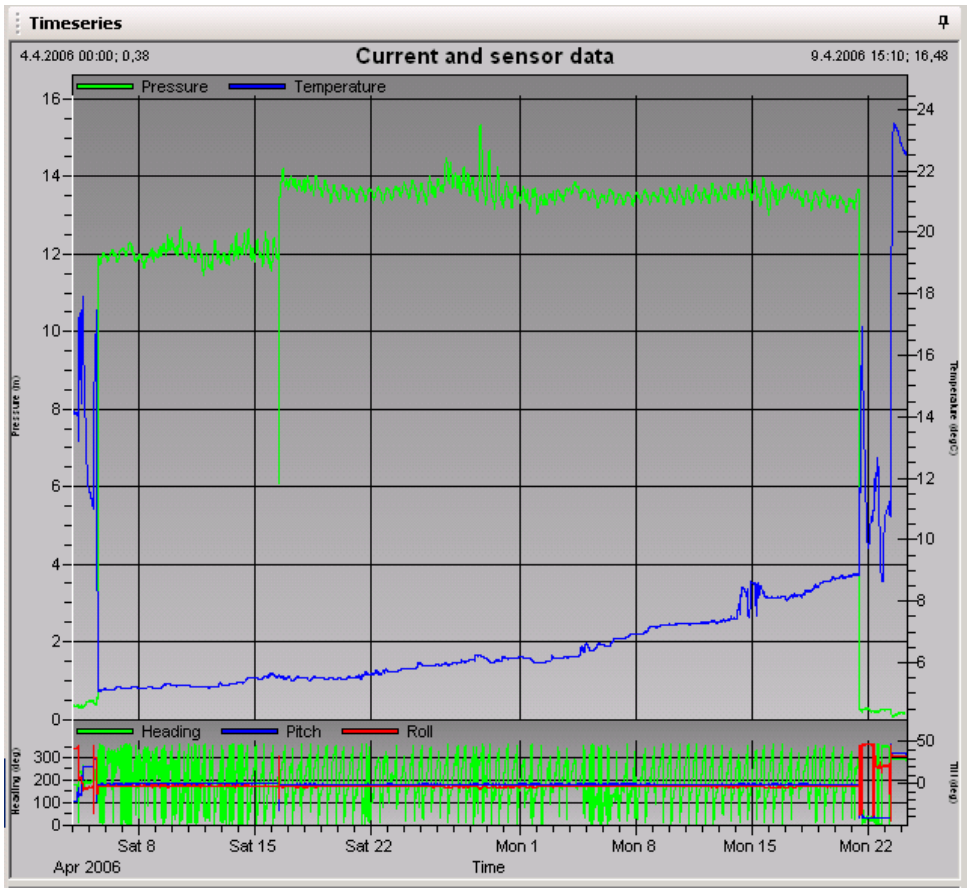
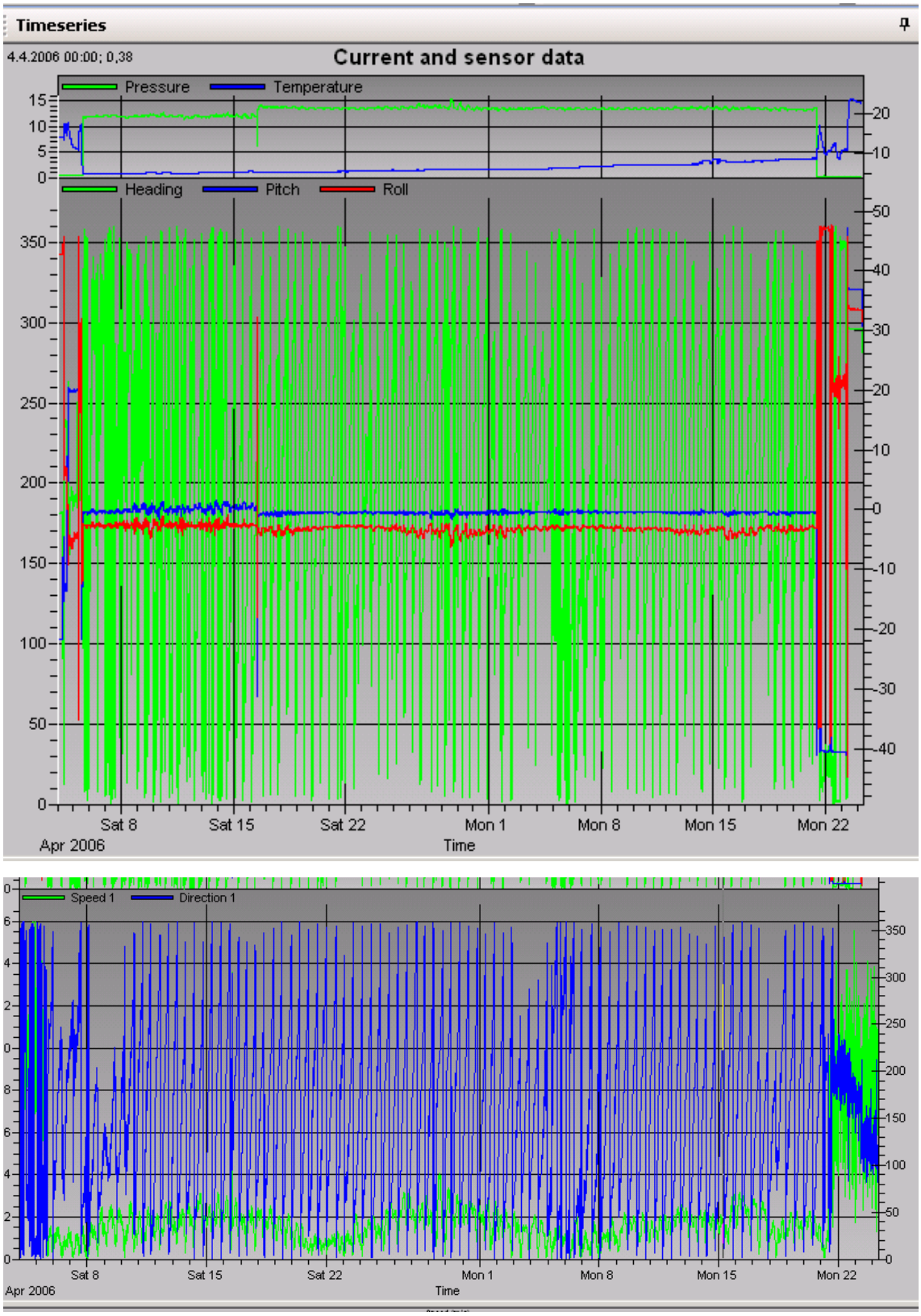


Figure X. Water temperature and measuring depth at WCM 2006 reference station. Note change in depth at the 16th of April. Measurements at 10 minute interval.

Table x. Calculated parameters from current measurements from the 5th April until the 21st of May. Some data at the 16th of April are excluded.

Parameter	Velocity (cm/s)
Average	15,0
Varians	45,4
Maximum	40,9
Minimum	0,2
Median	14,9
Measuring depth	12-14 (m)
Main directions	N-E and S-W

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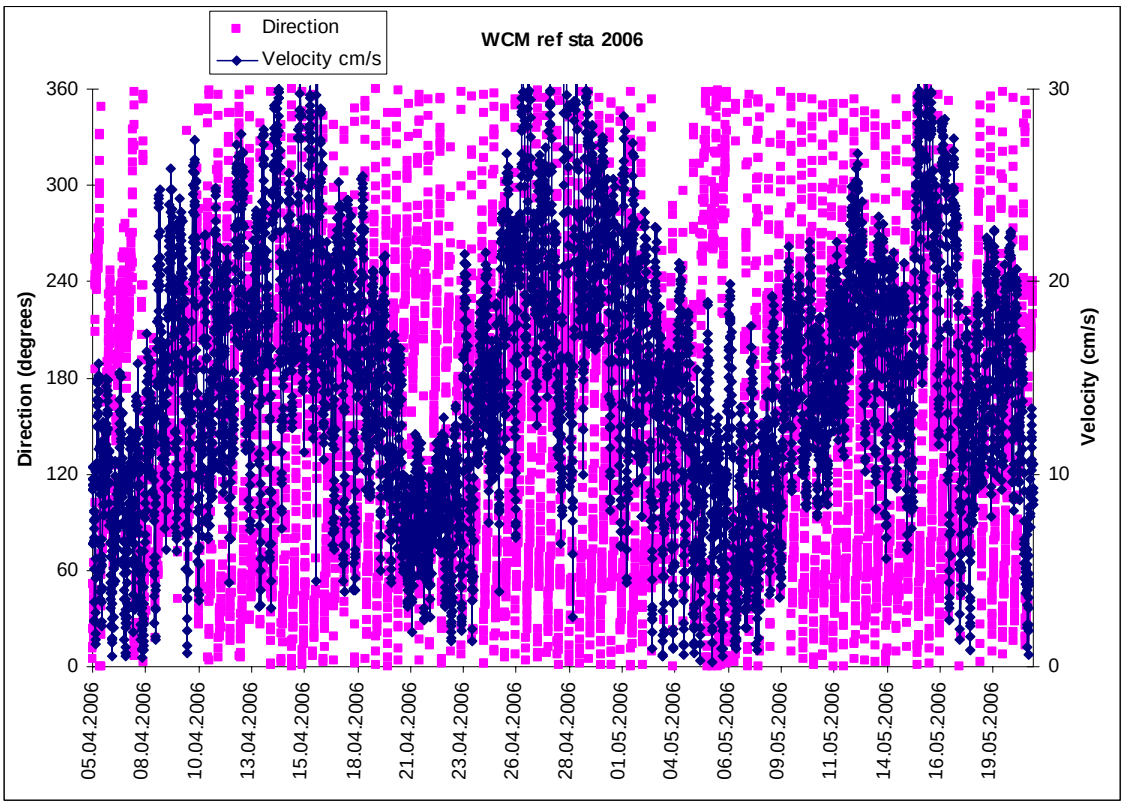
Temperature
Heading
Pitch
Roll
Sat 8
Sat 15
Sat 22
Mon 1
Mon 8
Mon 15
Mon 22
Apr 2006
Time
Speed 1
Direction 1
Sat 8
Sat 15
Sat 22
Mon 1
Mon 8
Mon 15
Mon 22
Apr 2006
Time


Direction
Velocity cm/s
WCM ref sta 2006
Direction (degrees)
Velocity (cm/s)
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30
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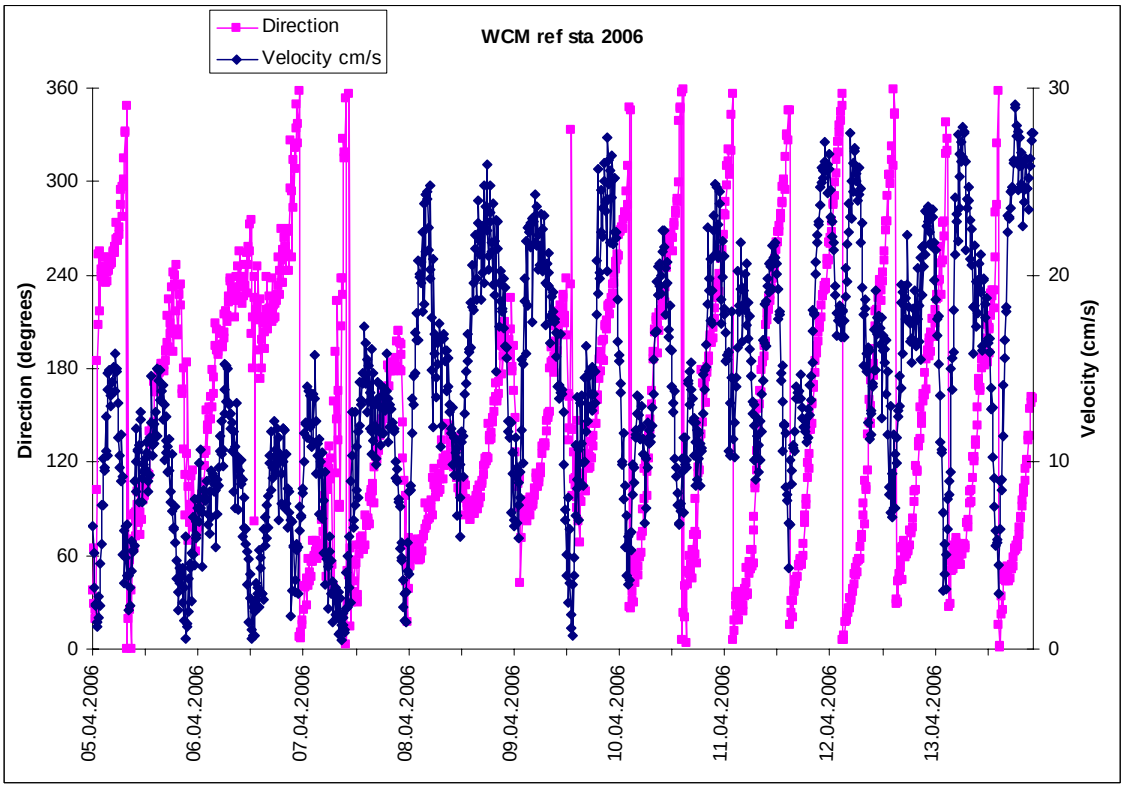
10
0
05.04.2006
08.04.2006
10.04.2006
13.04.2006
15.04.2006
18.04.2006
21.04.2006
23.04.2006
26.04.2006
28.04.2006
01.05.2006
04.05.2006
06.05.2006
09.05.2006
11.05.2006
14.05.2006
16.05.2006
19.05.2006


Direction
Velocity cm/s
WCM ref sta 2006
Direction (degrees)
Velocity (cm/s)
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300
240
180
120
60
0
30
20
10
0
05.04.2006
06.04.2006
07.04.2006
08.04.2006
09.04.2006
10.04.2006
11.04.2006
12.04.2006
13.04.2006

Appendix C

Rolf C. Sundt

Water Column Monitoring 2006
Data report

Rev.no:	01 Date: 03.09.2006
Project number:	695219
Project title:	Water Column Monitoring 2006
Project Leader:	Rolf C. Sundt
Client(s):	ConocoPhillip on behalf of OLF WCM coordination group
Research program:	
Distribution restriction:	Confidential (Open from:)

IRIS-Akvamiljø

Contents

1 Raw data – PAH metabolites by Fixed Fluorecence

Table 1. Raw data PAH metabolites by Fixed Fluorecence, 0-sampling.

Rådata, 04.03.06 0-sampling

FF + biliverdin in bile

Dilution: Biliverdin: 100 X FF: 1600X

Calculation:	B*0.057*100		D*0.6082*1600/ 1000		F*0.6082*1600/ 1000		H*0.6082*1600/ 1000	

Fish no	Biliverdin UV-abs (660)	Biliverdin mg/ml	290/335	PFE290/334 µg/ml	341/383	PFE341/383 µg/ml	380/430	PFE380/430 µg/ml	Scan
Solvent:	0,000	0,000	0,3	0,3	1,4	1,4	0,6	0,6	x
Cod 01	0,044	**0,251**	8,8	**8,6**	3,4	**3,3**	1,5	**1,5**	
Cod 03	0,119	**0,678**	10,0	**9,7**	4,2	**4,1**	1,4	**1,4**	
Cod 04	0,191	**1,089**	10,6	**10,3**	3,7	**3,6**	1,4	**1,4**	
Cod 05	0,085	**0,485**	7,6	**7,4**	4,0	**3,9**	1,2	**1,2**	
Cod 06	0,108	**0,616**	7,0	**6,8**	3,8	**3,7**	1,3	**1,3**	
Cod 07	0,046	**0,262**	15,6	**15,2**	3,6	**3,5**	1,4	**1,4**	
Cod 08	0,088	**0,502**	9,2	**9,0**	3,8	**3,7**	1,5	**1,5**	
Cod 09	0,071	**0,405**	9,5	**9,2**	3,4	**3,3**	1,4	**1,4**	
Cod 10	0,088	**0,502**	12,9	**12,6**	3,5	**3,4**	1,4	**1,4**	x
Cod 11	0,073	**0,416**	6,0	**5,8**	3,1	**3,0**	1,2	**1,2**	
Cod 12	0,049	**0,279**	8,3	**8,1**	2,9	**2,8**	1,2	**1,2**	
Cod 13	0,047	**0,268**	6,8	**6,6**	3,3	**3,2**	1,1	**1,1**	
Cod 14	0,057	**0,325**	8,4	**8,2**	3,2	**3,1**	1,3	**1,3**	
Cod 15	0,062	**0,353**	12,2	**11,9**	3,3	**3,2**	1,3	**1,3**	
Cod 16	0,085	**0,485**	8,2	**8,0**	3,4	**3,3**	1,3	**1,3**	
Cod 17	0,117	**0,667**	13,5	**13,1**	3,7	**3,6**	1,5	**1,5**	x
Cod 18	0,126	**0,718**	12,0	**11,7**	4,8	**4,7**	1,5	**1,5**	
Cod 19	0,154	**0,878**	6,4	**6,2**	3,2	**3,1**	1,3	**1,3**	
Cod 20	0,080	**0,456**	11,1	**10,8**	2,9	**2,8**	1,3	**1,3**	
Cod 21	0,021	**0,120**	4,2	**4,1**	2,3	**2,2**	1,0	**1,0**	
Cod 22	0,040	**0,228**	15,8	**15,4**	4,5	**4,4**	1,6	**1,6**	
Cod 23	0,013	**0,074**	5,7	**5,5**	1,7	**1,7**	0,7	**0,7**	
Cod 25	0,058	**0,331**	4,6	**4,5**	2,6	**2,5**	0,9	**0,9**	x
Cod 26	0,151	**0,861**	8,5	**8,3**	3,4	**3,3**	1,3	**1,3**	
Cod 27	0,095	**0,542**	12,2	**11,9**	3,5	**3,4**	1,4	**1,4**	
Cod 28	0,125	**0,713**	9,3	**9,1**	3,9	**3,8**	1,7	**1,7**	
Cod 29	0,032	**0,182**	9,8	**9,5**	2,0	**1,9**	1,0	**1,0**	x
Cod 30	0,066	**0,376**	6,0	**5,8**	3,5	**3,4**	1,4	**1,4**	

Rådata, 3/8- 06+ 4/8- 06

FF + biliverdin in bile

Dilution: Biliverdin: **100 X** FF: 1600X

Calculation:	B*0.057*100		D*0.6082*1600/ 1000		F*0.6082*1600/ 1000		H*0.6082*1600/ 1000	

Fish no	Biliverdin UV-abs (660)	Biliverdin mg/ml	290/335	PFE290/334 µg/ml	341/383	PFE341/383 µg/ml	380/430	PFE380/430 µg/ml	Scan
Solvent	0,000	0,000	0,2	0,2	1,2	1,2	0,6	0,6	
Sample 101	0,167	**0,952**	19,5	**19,0**	4,5	**4,4**	1,9	**1,8**	
102	0,077	**0,439**	5,9	**5,7**	2,7	**2,6**	1,5	**1,5**	
103	0,026	**0,148**	5,6	**5,4**	2,3	**2,2**	1,4	**1,4**	
104	0,092	**0,524**	12,6	**12,3**	1,9	**1,8**	1,1	**1,1**	x
105	0,511	**2,913**	7,1	**6,9**	1,9	**1,8**	1,1	**1,1**	x
106	0,142	**0,809**	5,1	**5,0**	2,3	**2,2**	1,2	**1,2**	
107	0,347	**1,978**	10,7	**10,4**	2,0	**1,9**	1,1	**1,1**	
108	0,064	**0,365**	6,1	**5,9**	2,3	**2,2**	1,3	**1,3**	
109	0,157	**0,895**	10,0	**9,7**	2,3	**2,2**	1,4	**1,4**	
110	0,198	**1,129**	11,0	**10,7**	2,5	**2,4**	1,3	**1,3**	x
111	0,233	**1,328**	11,8	**11,5**	2,4	**2,3**	1,4	**1,4**	x
112	0,026	**0,148**	4,8	**4,7**	1,8	**1,8**	1,0	**1,0**	
113	0,045	**0,257**	8,5	**8,3**	2,0	**1,9**	1,1	**1,1**	
114	0,132	**0,752**	9,0	**8,8**	2,1	**2,0**	1,1	**1,1**	
115	0,181	**1,032**	15,0	**14,6**	2,9	**2,8**	1,4	**1,4**	x
116	0,167	**0,952**	12,0	**11,7**	2,2	**2,1**	1,3	**1,3**	
117	0,022	**0,125**	7,5	**7,3**	1,5	**1,5**	0,8	**0,8**	
118	0,000	**0,000**	0,0	**0,0**		**0,0**	0,0	**0,0**	
119	0,210	**1,197**	8,8	**8,6**	2,3	**2,2**	1,2	**1,2**	
120	0,214	**1,220**	9,8	**9,5**	2,5	**2,4**	1,3	**1,3**	
121	0,112	**0,638**	8,8	**8,6**	2,6	**2,5**	1,5	**1,5**	
122	0,098	**0,559**	4,7	**4,6**	2,1	**2,0**	1,1	**1,1**	
123	0,057	**0,325**	6,0	**5,8**	2,2	**2,1**	1,2	**1,2**	
124	0,157	**0,895**	6,0	**5,8**	7,5	**7,3**	1,2	**1,2**	
125	0,119	**0,678**	8,3	**8,1**	2,8	**2,7**	1,4	**1,4**	
126	0,260	**1,482**	9,8	**9,5**	2,4	**2,3**	1,3	**1,3**	
127	0,011	**0,063**	5,0	**4,9**	1,4	**1,4**	0,6	**0,6**	

Rådata, 15.08.06

FF + biliverdin in bile

Dilution: Biliverdin: **100 X** FF: 1600X

Calculation:	B*0.057*100		D*0.6082*1600/ 1000		F*0.6082*1600/ 1000		H*0.6082*1600/ 1000	

Fish no	Biliverdin UV-abs (660)	Biliverdin mg/ml	290/335	PFE290/334 µg/ml	341/383	PFE341/383 µg/ml	380/430	PFE380/430 µg/ml	Scan
Solvent values->	0,000	0,000	0,2	0,2	1,2	1,2	0,6	0,6	x
301	0,143	**0,815**	12,5	**12,2**	4,3	**4,2**	1,1	**1,1**	
302	0,019	**0,108**	3,8	**3,7**	2,2	**2,1**	0,7	**0,7**	
303	0,040	**0,228**	7,7	**7,5**	3,7	**3,6**	1,2	**1,2**	
304	0,062	**0,353**	7,2	**7,0**	2,9	**2,8**	1,0	**1,0**	
305	0,102	**0,581**	12,8	**12,5**	4,3	**4,2**	1,2	**1,2**	x
306	0,177	**1,009**	16,3	**15,9**	5,2	**5,1**	1,7	**1,7**	x
307	0,167	**0,952**	13,0	**12,7**	5,0	**4,9**	1,5	**1,5**	
308	0,006	**0,034**	6,0	**5,8**	2,0	**1,9**	0,8	**0,8**	
309	0,066	**0,376**	9,0	**8,8**	4,3	**4,2**	1,3	**1,3**	
310	0,136	**0,775**	11,5	**11,2**	4,3	**4,2**	1,2	**1,2**	
311	0,025	**0,143**	7,9	**7,7**	3,3	**3,2**	1,0	**1,0**	
312	0,148	**0,844**	14,1	**13,7**	5,2	**5,1**	1,4	**1,4**	x
313	0,027	**0,154**	8,5	**8,3**	3,8	**3,7**	1,0	**1,0**	
314	0,038	**0,217**	6,8	**6,6**	3,0	**2,9**	0,9	**0,9**	
315	0,119	**0,678**	13,2	**12,8**	4,6	**4,5**	1,3	**1,3**	
316	0,086	**0,490**	12,4	**12,1**	5,2	**5,1**	1,4	**1,4**	
317	0,034	**0,194**	9,2	**9,0**	3,7	**3,6**	1,0	**1,0**	
318	0,124	**0,707**	10,7	**10,4**	4,1	**4,0**	1,3	**1,3**	
319	0,038	**0,217**	3,2	**3,1**	2,2	**2,1**	0,7	**0,7**	
320	0,082	**0,467**	11,5	**11,2**	4,4	**4,3**	1,4	**1,4**	x
321	0,042	**0,239**	7,7	**7,5**	3,2	**3,1**	1,0	**1,0**	
322	0,099	**0,564**	16,8	**16,3**	5,2	**5,1**	1,6	**1,6**	
323	0,074	**0,422**	7,0	**6,8**	3,5	**3,4**	1,0	**1,0**	
324	0,164	**0,935**	12,2	**11,9**	5,0	**4,9**	1,4	**1,4**	
325	0,141	**0,804**	13,6	**13,2**	4,6	**4,5**	1,3	**1,3**	x
326	0,070	**0,399**	13,6	**13,2**	4,6	**4,5**	1,4	**1,4**	
327	0,017	**0,097**	6,7	**6,5**	2,7	**2,6**	0,8	**0,8**	

Rådata,

FF + biliverdin in bile

Dilution: Biliverdin: **100 X** FF: 1600X

Calculation:	B*0.057*100		D*0.6082*1600/ 1000		F*0.6082*1600/ 1000		H*0.6082*1600/ 1000	

Fish no	Biliverdin UV-abs (660)	Biliverdin mg/ml	290/335	PFE290/334 µg/ml	341/383	PFE341/383 µg/ml	380/430	PFE380/430 µg/ml	Scan
Solvent	0,000	0,000	0,2	0,2	1,2	1,2	0,6	0,6	
401	0,114	**0,650**	10,4	**10,1**	3,3	**3,2**	1,1	**1,1**	
402	0,050	**0,285**	9,9	**9,6**	3,0	**2,9**	1,0	**1,0**	
403	0,122	**0,695**	10,8	**10,5**	3,7	**3,6**	1,2	**1,2**	
404	0,026	**0,148**	11,8	**11,5**	2,8	**2,7**	0,9	**0,9**	
405	0,183	**1,043**	17,0	**16,5**	4,6	**4,5**	1,5	**1,5**	x
406	0,077	**0,439**	8,8	**8,6**	2,9	**2,8**	0,9	**0,9**	
407	0,065	**0,371**	9,9	**9,6**	3,4	**3,3**	1,1	**1,1**	
408	0,487	**2,776**	11,9	**11,6**	3,9	**3,8**	1,3	**1,3**	x
409	0,038	**0,217**	5,9	**5,7**	2,5	**2,4**	0,9	**0,9**	
410	0,233	**1,328**	16,7	**16,3**	5,0	**4,9**	1,7	**1,7**	x
411	0,151	**0,861**	10,0	**9,7**	5,4	**5,3**	2,0	**1,9**	
412	0,130	**0,741**	13,8	**13,4**	4,4	**4,3**	1,4	**1,4**	
413	0,186	**1,060**	8,2	**8,0**	4,0	**3,9**	1,2	**1,2**	
414	0,105	**0,599**	6,3	**6,1**	3,5	**3,4**	1,1	**1,1**	
415	0,099	**0,564**	14,0	**13,6**	4,5	**4,4**	1,4	**1,4**	
416	0,167	**0,952**	11,5	**11,2**	4,3	**4,2**	1,3	**1,3**	
417	0,065	**0,371**	8,5	**8,3**	4,5	**4,4**	1,4	**1,4**	
418	0,117	**0,667**	8,4	**8,2**	4,0	**3,9**	1,3	**1,3**	
419	0,142	**0,809**	11,8	**11,5**	4,3	**4,2**	1,3	**1,3**	x
420	0,076	**0,433**	7,9	**7,7**	3,1	**3,0**	1,2	**1,2**	x
421	0,196	**1,117**	18,2	**17,7**	5,0	**4,9**	1,6	**1,6**	
422	0,042	**0,239**	8,8	**8,6**	3,7	**3,6**	1,3	**1,3**	
423	0,112	**0,638**	10,3	**10,0**	3,5	**3,4**	2,2	**2,1**	
424	0,108	**0,616**	13,0	**12,7**	4,8	**4,7**	1,7	**1,7**	
425	0,056	**0,319**	10,6	**10,3**	4,2	**4,1**	1,3	**1,3**	
427	0,050	**0,285**	6,0	**5,8**	2,5	**2,4**	0,8	**0,8**	
428	0,240	**1,368**	13,0	**12,7**	4,4	**4,3**	1,3	**1,3**	x

2 Raw data – PAH metabolites by GCMS

0-sampling

File name	des 11-08	des 11-09	des 11-10	des 11-11	des 11-12	des 11-13	des 11-14	des 11-15
Sample code	051206-03	051206-04	051206-05	051206-06	051206-07	051206-08	051206-09	051206-10
Sample name	Cod 1	Cod 3	Cod 4	Cod 5	Cod 6	Cod 7	Cod 8	Cod 9
Sampling date	kalib oppdatert							
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	64	56	51	67	44	59	59	62
2-OH-Naphthalene	23	10	9	8	14	10	10	12
C1-OH-Naphthalene	83	71	89	67	95	54	98	101
C2-OH-Naphthalene	77	65	98	95	18	46	57	43
C3-OH-Naphthalene	348	384	377	297	393	248	317	223
1-OH-Phenanthrene	5	6	9	5	3	3	7	5
C1-OH-Phenanthrene	161	201	249	133	197	136	179	196
C2-OH-Phenanthrene	102	96	135	77	233	67	119	106
1-OH-Pyrene	54	60	97	50	65	54	75	77

File name	des 11-16	des 11-17	des 11-18	des 11-19	des 11-20	des 11-21	des 11-22
Sample code	051206-11	051206-12	051206-13	051206-14	051206-15	051206-16	051206-17
Sample name	Cod 10	Cod 11	Cod 12	Cod 13	Cod 14	Cod 15	Cod 16
Sampling date							
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	86	48	58	54	63	65	75
2-OH-Naphthalene	61	20	20	15	20	12	14
C1-OH-Naphthalene	75	160	107	90	59	84	72
C2-OH-Naphthalene	68	158	129	66	82	85	79
C3-OH-Naphthalene	326	401	637	364	351	313	250
1-OH-Phenanthrene	7	3	2	4	2	5	6
C1-OH-Phenanthrene	225	125	129	116	166	160	185
C2-OH-Phenanthrene	103	92	134	78	95	88	112
1-OH-Pyrene	78	42	38	48	60	49	58

Station 100

File name	sept 07-06	sept 07-07	sept 07-08	sept 07-09	sept 07-10	sept 08-05	sept 08-06	sept 08-07
Sample code	240806-3	240806-4	240806-5	240806-6	240806-7	290806-3	290806-4	290806-5
Sample name	111	114	115	116	117	119	120	121
Sampling date								
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	31	37	39	46	48	36	31	37
2-OH-Naphthalene	26	36	37	37	52	18	26	26
C1-OH-Naphthalene	121	193	171	244	288	135	127	114
C2-OH-Naphthalene	121	177	176	256	351	49	103	94
C3-OH-Naphthalene	326	876	574	744	1398	300	252	545
1-OH-Phenanthrene	11	10	17	10	3	8	10	3
C1-OH-Phenanthrene	87	114	180	137	70	206	281	231
C2-OH-Phenanthrene	89	138	138	151	130	105	99	33
1-OH-Pyrene	20	9	13	11	2	16	20	18

File name	sept 08-08	sept 10-06	sept 10-07	sept 10-08	sept 10-09
Sample code	290806-6	010906-03	010906-04	010906-05	010906-06
Sample name	122	123	124	125	126
Sampling date					
Compound	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	32	36	33	34	39
2-OH-Naphthalene	18	10	13	14	29
C1-OH-Naphthalene	121	137	86	107	120
C2-OH-Naphthalene	106	120	58	65	80
C3-OH-Naphthalene	513	322	283	371	370
1-OH-Phenanthrene	8	6,3	3,5	4,6	9,1
C1-OH-Phenanthrene	203	121	111	217	192
C2-OH-Phenanthrene	100	155	57	120	147
1-OH-Pyrene	14	14	13	23	31

Station 300

File name	sept 07-11	sept 07-12	sept 07-13	sept 07-14	sept 07-15	sept 07-16	sept 07-17	sept 08-09	sept 08-10
Sample code	240806-8	240806-9	240806-10	240806-11	240806-12	240806-13	240806-14	290806-7	290806-8
Sample name	311	312	313	314	315	316	317	318	319
Sampling date									
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	56	44	45	32	38	46	40	68	46
2-OH-Naphthalene	104	56	81	41	52	85	48	147	78
C1-OH-Naphthalene	497	351	486	221	525	397	188	384	200
C2-OH-Naphthalene	753	736	968	421	954	677	397	556	189
C3-OH-Naphthalene	1333	1478	1338	945	1427	1442	724	1010	420
1-OH-Phenanthrene	18	27	30	7	18	38	16	28	5
C1-OH-Phenanthrene	378	775	403	307	484	776	369	759	283
C2-OH-Phenanthrene	217	540	394	302	349	740	157	461	104
1-OH-Pyrene	10	39	15	11	21	40	16	27	19

File name	sept 08-11	sept 08-12	sept 08-13	sept 08-14	sept 10-10	sept 10-11	sept 10-12
Sample code	290806-9	290806-10	290806-11	290806-12	010906-07	010906-08	010906-09
Sample name	320	321	322	323	324	325	326
Sampling date							
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	47	46	47	36	29	46	41
2-OH-Naphthalene	43	49	98	31	57	55	48
C1-OH-Naphthalene	289	343	520	269	317	340	344
C2-OH-Naphthalene	623	554	927	513	366	511	522
C3-OH-Naphthalene	1067	951	1546	804	867	1315	1206
1-OH-Phenanthrene	28	16	23	10	12,1	34,6	17,4
C1-OH-Phenanthrene	517	488	900	423	531	657	564
C2-OH-Phenanthrene	323	261	646	255	389	588	404
1-OH-Pyrene	20	18	42	19	31	30	31

Station 400

File name	sept 07-18	sept 07-19	sept 07-20	sept 07-21	sept 07-22	sept 07-23	sept 08-15	sept 08-16	sept 08-17
Sample code	240806-15	240806-16	240806-17	240806-18	240806-19	240806-20	290806-13	290806-14	290806-15
Sample name	411	412	413	414	415	416	417	418	419
Sampling date									
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	82	37	73	49	33	65	51	39	47
2-OH-Naphthalene	226	78	251	151	122	139	210	104	69
C1-OH-Naphthalene	767	520	703	326	472	534	472	286	354
C2-OH-Naphthalene	1329	987	1187	559	760	813	667	397	618
C3-OH-Naphthalene	1513	1797	1423	794	1679	1439	1071	757	1378
1-OH-Phenanthrene	29	30	36	10	31	25	17	12	34
C1-OH-Phenanthrene	519	751	900	301	509	573	604	403	864
C2-OH-Phenanthrene	467	445	625	269	439	387	453	276	537
1-OH-Pyrene	20	25	37	16	23	22	32	23	34

File name	sept 08-18	sept 08-19	sept 08-20	sept 08-21	sept 08-22	sept 10-13	sept 10-14	sept 10-15
Sample code	290806-16	290806-17	290806-18	290806-19	290806-20	010906-10	010906-11	010906-12
Sample name	420	421	422	423	424	425	427	428
Sampling date								
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
1-OH-Naphthalene	36	37	42	38	38	40	40	34
2-OH-Naphthalene	25	45	20	43	98	92	56	50
C1-OH-Naphthalene	222	337	229	296	408	283	186	268
C2-OH-Naphthalene	366	630	419	380	633	402	176	421
C3-OH-Naphthalene	740	1339	806	764	1224	943	623	1361
1-OH-Phenanthrene	6	27	17	16	34	9,0	4,3	27
C1-OH-Phenanthrene	452	826	453	398	641	507	169	942
C2-OH-Phenanthrene	253	459	279	206	412	308	134	974
1-OH-Pyrene	19	36	19	26	34	23	15	33

3 Raw data – AP metabolites by GCMS

File name	sept 18-06	sept 18-07	sept 18-08	sept 18-09	sept 18-10	sept 19-03	sept 19-04	sept 19-05
Sample code	080906-S3	080906-S4	080906-S5	080906-S6	080906-S7	120906-S3	120906-S4	120906-S5
Sample name	111	114	115	116	117	119	120	121
Sampling date								
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
2-methylphenol	0	0	31	0	0	0	0	0
3-methylphenol	21	0	28	0	19	0	0	0
4-methylphenol	390	0	309	50	0	818	0	386
3,5-dimethylphenol	31	33	31	23	58	26	25	28
2,4-dimethylphenol	18	0	19	0	15	0	0	8
4-ethylphenol	0	0	0	0	0	0	0	0
3-ethyl-5-methylphenol	0	62	82	52	44	35	47	26
4-n-propylphenol	0	0	0	0	0	0	0	0
2,4,6-trimethylphenol	0	0	0	0	0	0	0	0
4-tert-butylphenol	0	0	0	0	0	0	0	0
4-isopropyl-3-methylphenol	0	0	0	0	0	0	0	0
2-tert-butyl-4-methylphenol	0	0	0	0	0	0	0	0
4-tert-butyl-2-methylphenol	0	0	0	0	0	0	0	0
2,5-diisopropylphenol	0	0	0	0	0	0	0	0
4-n-butylphenol	0	0	0	0	0	0	0	0
4-n-pentylphenol	0	0	0	0	0	0	0	0
4-n-hexylphenol	0	0	0	0	0	0	0	0
4-tert-octylphenol	555	496	422	487	479	26	91	115
4,6-di-tert-butyl-2-methylphenol	25	28	26	26	29	29	28	37
4-n-heptylphenol	0	0	0	0	0	0	0	0
4-n-octylphenol	0	0	0	0	0	0	0	0
4-n-nonylphenol	0	26	25	0	31	0	0	0

File name	sept 19-06	sept 21-06	sept 21-07	sept 21-08	sept 21-09
Sample code	120906-S6	140906-S03	140906-S04	140906-S05	140906-S06
Sample name	122	123	124	125	126
Sampling date					
Compound	ng/g	ng/g	ng/g	ng/g	ng/g
2-methylphenol	0	0	24	0	25
3-methylphenol	0	0	24	0	26
4-methylphenol	0	74	78	49	66
3,5-dimethylphenol	28	25	26	21	28
2,4-dimethylphenol	7	0	0	0	0
4-ethylphenol	0	0	0	0	0
3-ethyl-5-methylphenol	40	37	55	38	55
4-n-propylphenol	0	0	0	0	0
2,4,6-trimethylphenol	0	0	0	0	0
4-tert-butylphenol	0	0	0	0	0
4-isopropyl-3-methylphenol	0	0	0	0	0
2-tert-butyl-4-methylphenol	0	0	0	0	0
4-tert-butyl-2-methylphenol	0	0	0	0	0
2,5-diisopropylphenol	0	0	0	0	0
4-n-butylphenol	0	0	0	0	0
4-n-pentylphenol	0	0	0	0	0
4-n-hexylphenol	0	0	0	0	0
4-tert-octylphenol	130	332	416	323	370
4,6-di-tert-butyl-2-methylphenol	30	27	28	33	33
4-n-heptylphenol	0	0	0	0	0
4-n-octylphenol	0	0	0	0	0
4-n-nonylphenol	0	30	0	0	0

File name	sept 18-11	sept 18-12	sept 18-13	sept 18-14	sept 18-15	sept 19-07	sept 19-08	sept 19-09
Sample code	080906-S8	080906-S9	080906-S10	080906-S11	080906-S12	120906-S7	120906-S8	120906-S9
Sample name	311	312	313	314	315	316	317	318
Sampling date								
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
2-methylphenol	56	46	20	20	0	16	0	22
3-methylphenol	44	52	38	30	0	24	22	38
4-methylphenol	91	488	355	0	0	260	292	45
3,5-dimethylphenol	54	72	73	51	44	51	40	59
2,4-dimethylphenol	97	121	65	55	60	96	27	66
4-ethylphenol	0	0	0	0	0	0	0	0
3-ethyl-5-methylphenol	41	57	65	44	0	42	49	38
4-n-propylphenol	0	0	0	0	0	0	0	0
2,4,6-trimethylphenol	52	70	50	28	34	0	0	0
4-tert-butylphenol	0	0	0	0	41	0	0	0
4-isopropyl-3-methylphenol	0	0	0	0	0	0	0	0
2-tert-butyl-4-methylphenol	0	0	0	0	49	0	0	0
4-tert-butyl-2-methylphenol	0	0	0	0	0	0	0	0
2,5-diisopropylphenol	0	0	0	0	0	0	0	0
4-n-butylphenol	0	0	0	0	0	0	0	0
4-n-pentylphenol	0	0	0	0	0	0	0	0
4-n-hexylphenol	0	0	0	0	0	0	0	21
4-tert-octylphenol	472	539	472	546	360	135	188	220
4,6-di-tert-butyl-2-methylphenol	33	30	32	36	0	28	30	31
4-n-heptylphenol	0	30	0	0	0	0	0	0
4-n-octylphenol	0	0	0	0	0	0	0	0
4-n-nonylphenol	63	56	32	32	47	0	0	0

File name	sept 19-10	sept 19-11	sept 19-12	sept 21-10	sept 21-11	sept 21-12	sept 21-13	sept 21-14
Sample code	120906-S10	120906-S11	120906-S12	140906-S07	140906-S08	140906-S09	140906-S10	140906-S11
Sample name	319	320	321	322	323	324	325	326
Sampling date								
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
2-methylphenol	0	10	20	27	0	20	20	26
3-methylphenol	22	18	28	48	20	32	28	40
4-methylphenol	40	696	2000	56	61	81	60	60
3,5-dimethylphenol	31	37	52	82	43	64	57	86
2,4-dimethylphenol	26	37	73	101	30	60	80	75
4-ethylphenol	0	0	0	0	0	0	0	0
3-ethyl-5-methylphenol	42	42	48	60	36	28	38	31
4-n-propylphenol	0	0	0	0	0	0	0	0
2,4,6-trimethylphenol	0	0	59	145	0	53	58	91
4-tert-butylphenol	38	0	0	0	0	0	0	0
4-isopropyl-3-methylphenol	0	0	0	0	0	0	0	0
2-tert-butyl-4-methylphenol	0	0	0	0	0	0	0	0
4-tert-butyl-2-methylphenol	0	0	0	0	0	0	0	0
2,5-diisopropylphenol	0	0	0	0	0	0	0	0
4-n-butylphenol	0	0	0	0	0	0	0	0
4-n-pentylphenol	0	0	0	0	0	0	0	0
4-n-hexylphenol	0	0	0	0	0	0	0	0
4-tert-octylphenol	242	278	314	384	427	352	384	444
4,6-di-tert-butyl-2-methylphenol	28	29	26	26	28	29	23	29
4-n-heptylphenol	0	0	0	21	0	0	25	0
4-n-octylphenol	0	0	0	0	0	0	0	0
4-n-nonylphenol	0	0	0	0	0	0	0	0

File name	sept 18-16	sept 18-17	sept 18-18	sept 18-19	sept 19-13	sept 19-14	sept 19-15	sept 19-16
Sample code	080906-S13	080906-S14	080906-S15	080906-S16	120906-S13	120906-S14	120906-S15	120906-S16
Sample name	411	412	413	414	415	416	417	418
Sampling date								
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
2-methylphenol	15	20	23	72	0	18	16	0
3-methylphenol	35	26	28	46	23	31	23	21
4-methylphenol	40	36	40	124	20	35	46	386
3,5-dimethylphenol	72	53	53	64	56	50	34	49
2,4-dimethylphenol	72	69	106	72	86	73	53	23
4-ethylphenol	15	0	17	0	0	0	0	0
3-ethyl-5-methylphenol	65	51	35	41	28	48	48	33
4-n-propylphenol	0	0	0	0	0	0	0	0
2,4,6-trimethylphenol	0	57	35	19	0	0	0	0
4-tert-butylphenol	0	0	0	0	0	0	0	0
4-isopropyl-3-methylphenol	0	0	0	0	0	0	0	0
2-tert-butyl-4-methylphenol	0	0	0	0	0	0	0	0
4-tert-butyl-2-methylphenol	0	0	0	0	0	0	0	0
2,5-diisopropylphenol	0	0	0	0	0	0	0	0
4-n-butylphenol	0	0	0	0	0	0	0	0
4-n-pentylphenol	0	0	0	0	0	0	0	0
4-n-hexylphenol	0	0	0	0	0	0	0	0
4-tert-octylphenol	412	448	352	432	443	570	885	388
4,6-di-tert-butyl-2-methylphenol	25	24	34	35	31	24	26	24
4-n-heptylphenol	33	32	32	24	0	0	0	0
4-n-octylphenol	0	0	0	0	0	0	0	0
4-n-nonylphenol	33	21	31	34	0	0	0	0

File name	sept 21-15 140906-	sept 21-16 140906-	sept 21-17 140906-	sept 21-18	sept 21-19 140906-	sept 21-20 140906-	sept 21-21 140906-	sept 21-22 140906-	sept 21-23 140906-
Sample code	S12	S13	S14	140906-S15	S16	S17	S18	S19	S20
Sample name	419	420	421	422	423	424	425	427	428
Sampling date									
Compound	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g	ng/g
2-methylphenol	21	0	21	18	0	0	0	0	29
3-methylphenol	34	0	36	20	19	18	18	26	46
4-methylphenol	72	99	99	96	98	51	62	68	70
3,5-dimethylphenol	75	42	65	46	47	47	42	39	85
2,4-dimethylphenol	80	33	87	34	52	43	22	23	67
4-ethylphenol	0	0	0	0	0	0	0	0	0
3-ethyl-5-methylphenol	72	36	58	36	48	29	75	47	52
4-n-propylphenol	0	0	0	0	0	0	0	0	0
2,4,6-trimethylphenol	54	0	79	29	36	42	0	0	0
4-tert-butylphenol	0	0	0	0	0	0	0	0	0
4-isopropyl-3-methylphenol	0	0	0	0	0	0	0	0	0
2-tert-butyl-4-methylphenol	0	0	0	0	0	0	0	0	0
4-tert-butyl-2-methylphenol	0	0	0	0	0	0	0	0	0
2,5-diisopropylphenol	0	0	0	0	0	0	0	0	0
4-n-butylphenol	0	0	0	0	0	0	0	0	0
4-n-pentylphenol	0	0	0	0	0	0	0	0	0
4-n-hexylphenol	0	0	0	0	0	0	0	0	0
4-tert-octylphenol	454	426	559	416	456	492	452	532	413
4,6-di-tert-butyl-2-methylphenol	27	27	29	29	29	24	27	33	26
4-n-heptylphenol	0	0	0	0	0	0	0	0	0
4-n-octylphenol	0	0	0	0	0	0	0	0	0
4-n-nonylphenol	0	0	0	0	0	0	0	0	0

4 Raw data - Lysosomal stability in mussel

Neutral Red Retention Time (min)

0-sampling	200 Ref	300	400	500	600	700	800
150	150	120	90	120	90	120	30
120	90	90	120	60	60	150	30
180	150	15	30	150	90	60	60
120	120	60	15	180	30	90	60
150	150	60	120	120	90	30	15
90	90	60	60	120	60	30	30
60	120	30	15	120	90	60	15
150	180	15	120	30	120	60	15
180	150	120	15	30	60	120	15
180	60	30	30	150	120	90	90
60	180	150	90	90	60	150	15
180	90	120	120	150	90	60	15
150	180	180	90	30	30	15	15
150	120	90	60	90	90	30	30
60	150	90	60	60	60	120	120
	30						
	15						
	60						
	120						
	180						
	90						
	180						
	90						

5 Raw data – Histology

5.1 Neutral lipid accumulation

Given as optical density

100 Ref	300	800	500	700	600	400
264023	451597	265104	305362	354228	137615	412801
334084	565412	269462	341936	374159	112970	440452
300496	600552	256414	278568	345526	88139	383761
354350	426279	267147	237749	374733	95177	344780
339361	587332	180176	207989	185714	71757	450793
520640	369096	202945	240604	281919	90678	444578
322369	332254	92961	301686	395967	120427	236875
465883	415670	185980	304982	296687	105261	215972
549232	440244	193966	392480	320685	73360	139251
458061	489264	209219	228100	291914	122571	170895
401544	437346	269289	451988	383341	271962	121720
414293	408969	233239	406832	351721	165646	
371827	392146	239838	352768	340694	185181	
443401	40489	171748	265478	294354	140431	
425476	56110	144790	344306	372669		
495076	63679	210702	297026	375600		
489807	59391	137896	367052			
424925	76605	200939				
381721	8581	104174				
369004	11408	192794				
511950	75761	128713				
570593	83252	129493				
500073	56089	163380				
439135						

5.2 Lipofuscin lysosomal accumulation

Given as optical density

100	600	400	300	800	700	500
437856	71818	176907	325914	275282	76365	184903
588231	89971	270891	358419	189229	128068	105933
509601	66849	226907	254034	278290	174318	197718
681933	46910	323303	105013	295876	89224	192602
544797	91414	372639	119481	233412	212805	202526
518624	172313	313095	122532	335450	243078	351296
532928	154083	270197	127887	159492	367439	324701
607090	154645	446757	281085	271854	251998	414819
599040	145541	248039	314171	350590	299616	407991
499807	172138	267336	260445	295785	349760	325068
492161	213096	363880	352082	398818	471988	235636
505844	133013	342100	277403	292842	476679	314389
629501	153069	277839	310436	271915	443152	226343
509835	179075	462697	235673	347580	127386	297651
536007	128275	220187	155213	204801	137107	305165
		116920	223706	240368	287602	177003
		123553	147543	215197	334042	268632
		111355	202665	302185	470301	304639
		353333	124481	249247	376809	251256
		315253	175764	235678	241221	176646
		302594	139838	154967	196383	115185
		252453	145536	173226	283627	352261
		117141	150708	96456	309689	351296
				60774		259869
				123193		337006

Appendix D

WCM 2006

DNA adducts in liver of cod (*Gadus morhua*) kept in cages in the "Ekofisk" area in the North Sea

Halldóra Skarphéðinsdóttir, Birgitta Liewenborg, Lennart Balk

Department of Applied Environmental Science
Stockholm University
Sweden

Introduction

In this study, aromatic hydrophobic PAH-DNA adducts were analysed in liver of cod (*Gadus morhua*), that had been caged for 6 weeks at three different locations in the "Ekofisk" area in the North Sea. They were analysed with the ^{32}P postlabelling assay, which is the most sensitive and frequently applied technique for detecting PAH-DNA adducts in marine organisms (Reichert *et al*., 1998).

PAHs are readily taken up and metabolised by fish, and it is during the metabolic transformation of these compounds, that they are activated to become genotoxic. It is the enzymatic phase I of the biotransformation of PAHs, that leads to the formation of reactive electrophilic metabolites which can undergo attack and bind covalently to nucleophilic centres in large molecules such as lipids, proteins, DNA, and RNA, and form adducts. Factors that affect DNA adduct levels are exposure dose, the degree of bioactivation in phase I into reactive intermediates in relation to the phase II detoxification, DNA repair efficiency, as well as cell turnover. DNA adduct levels are thus a quantifiable measure of the biologically effective dose reaching a critical target site, and they integrate multiple toxicokinetic factors such as uptake, metabolism, detoxification, excretion and covalent binding of reactive metabolites to target tissues (Reichert *et al*., 1998). DNA adducts have shown to be predecessor of both mutagenic and carcinogenic effects, and they have shown to correlate with liver lesions in fish (Baumann, 1998; Reichert *et al*., 1998). They are also widely used as, and considered to be highly relevant biomarker for PAH exposure to fish (Ericson *et al*., 1998).

Materials and Methods

Chemicals

Standard DNA (salmon sperm, D-1626), spermidin (S-2626), RNase A (R-4642), micrococcal endonuclease (N-3755) and spleen phosphodiesterase (P-9041) were obtained from Sigma Chemical Company, St. Louis, MO, USA. RNase T1 (109 193), proteinase K (1000144), α-amylase (102814), T_4-polynucleotidekinase (3´-phosphatase free, 838 292) and phenol (1814303) were purchased from Roche Diagnostics, Scandinavia AB, Bromma, Sweden. Nuclease P_1 (7160) was bought from Yamasa Corporation, Diagnostics Department, Chuo-Ku, Tokyo, Japan, and later Sigma-Aldrich Sweden AB, Stockholm, Sweden. Radiolabelled ATP ([γ-^{32}P]ATP) with specific activity 3000 Ci/mmol (110 TBq/mmol) were obtained from Amersham Biosciences, Uppsala, Sweden. The benzo[a]pyrene standard adduct, 7R, 8S, 9S-trihydroxy, 10R-(N^2-deoxyguanosyl-3´-phosphate)-7,8,9,10-tetrahydro-benzo(a)-pyrene (BaPDE-dG-3´p), was obtained from Midwest Research Institute, Kansas City, MO, USA. Cellulose (MN-301) was purchased from Machery-Nagel, Düren, Germany. Vinyl strips (PVC foil, 0.2 mm thickness), used for the groundwork of the polyethyleneimine cellulose sheets were

obtained from Andren & Söner, Stockholm, Sweden. Scintillation fluid (Ultima gold) was purchased from CIAB, Lidingö, Sweden. All other solvents and chemicals for DNA purification and adduct analysis were purchased from common commercial sources and were of analytical purity.

DNA adduct analysis

Tissue samples were semi-thawed and the DNA extracted and purified according to Dunn *et al.* (1987); Reichert and French (1994), slightly modified as described in Ericson and Balk (2000). DNA adducts were enriched using the Nuclease P1 method, 0.41 μg Nuclease P1/μg DNA, and a 45 min incubation period (Reddy and Randerath 1986; Beach and Gupta 1992). The DNA adducts were radiolabelled using 5´-[γ-^{32}P]triphosphate([γ-^{32}P]ATP) and T_4 polynucleotide kinase. Separation and cleanup of adducts was performed by a modified multidirectional thin-layer chromatography (TLC) on laboratory produced polyethyleneimine cellulose sheets that serve as anionic exchanger support. After elution, adducts were then located on the sheets and quantified by storage phosphor imaging technology (PhosphorImager^{TMSI} and ImageQuant 5.0). In addition, several quality control experiments were performed in parallel to the analysis of the various fish tissue samples.

Controls used during the analytical work were, as always: a) Pure salmon sperm as negative control, b) the standard DNA adduct B[a]PDE-dG-3´p, and c) adducted liver tissue from B[a]P exposed perch (*Perca fluviatilis*). These were processed parallel to the samples and served as quality assurance for all the analytical steps in the ^{32}P-postlabeling method. These quality assurance experiments confirm a faultless assay for the DNA adduct measurements performed in this study.

DNA for adduct analysis was quantified on the basis of its absorption at 260 nm in a GeneQuant spectrophotometer from Pharmacia Biotech, Uppsala, Sweden. Liquid scintillation spectroscopy was performed in a Packard Tri-Carb 2100TR liquid scintillation counter from Packard Instrument Company. A Desaga spreader from Desaga Heidelberg, Germany, was used to prepare the TLC-sheets. The DNA adducts were located and the levels quantified on the TLC sheets with ImageQuant, 5.0 software, Molecular Dynamics, by the storage phosphor imaging technique using a PhosphorImager™ SI instrument (Sunnyvale, CA, USA), essential according to methodology described by Reichert *et al.* 1998.

Results

DNA adducts were analysed in liver of 20 cods from each of the three stations, except from station 300 where one sample was missing (no. 315). Autoradiograms from samples 103 and 417 had no visible DNA adducts, but very high background which gives high detection limits, they were therefore not used in average calculations. Total number of analysis for each group is thus 19.

Average DNA adduct values ± 95% confidence level are presented in Figure 1 and Table 1, and individual values can be seen in Figure 2. All individual data and averages can also be found in the appendix. Average DNA adduct levels from the different groups were similar. Average levels in cod from station 100 was 1.19 ± 0.70 nmol add/mol normal nucleotides (average ± 95% confidence level), levels from station 300 were 0.74 ± 0.27, and levels from station 400, 1.55 ± 1.10. Number of individuals that had detectable adducts were 7 (37%) from station 100, 3 (16%) from station 300, and 7 (37%) from station 400, see Table 1. Other individuals had adduct levels below the detection limits. Detection limits are calculated per

individual sample, and are dependent on the background for each autoradiogram. Autoradiograms can be seen in Figure 3, showing a few samples from each group.

The DNA adduct results from this study were relatively low, but still indicate that individual fish is affected by PAH contamination. The fact that the fish show elevated levels of DNA adducts is an abnormal condition, and confirms that the fish has been exposed to genotoxic pollutants beyond their DNA repair capacity, which suggest PAH exposure. Few studies on DNA adduct levels in fish from the North Sea or neighboring areas, or even from open seas in general have been published. But for comparison, Aas *et al*. (2003) studied DNA adduct levels in 11 fish species from the open seas of the NE Atlantic. That study showed undetectable levels of DNA adducts in the fish, or levels just above the detection limits. For Atlantic cod (*Gadus morhua*), ten individuals from the Barents Sea were analysed for DNA adducts. Six of them had detectable adduct levels with an average of 0.75 ± 0.58 (± SD) nmol add/mol norm. nucleotides (average of individuals with adducts only). To be compared with 2.19, 1.55 and 3.32 for station 100, 300 and 400 respectively.

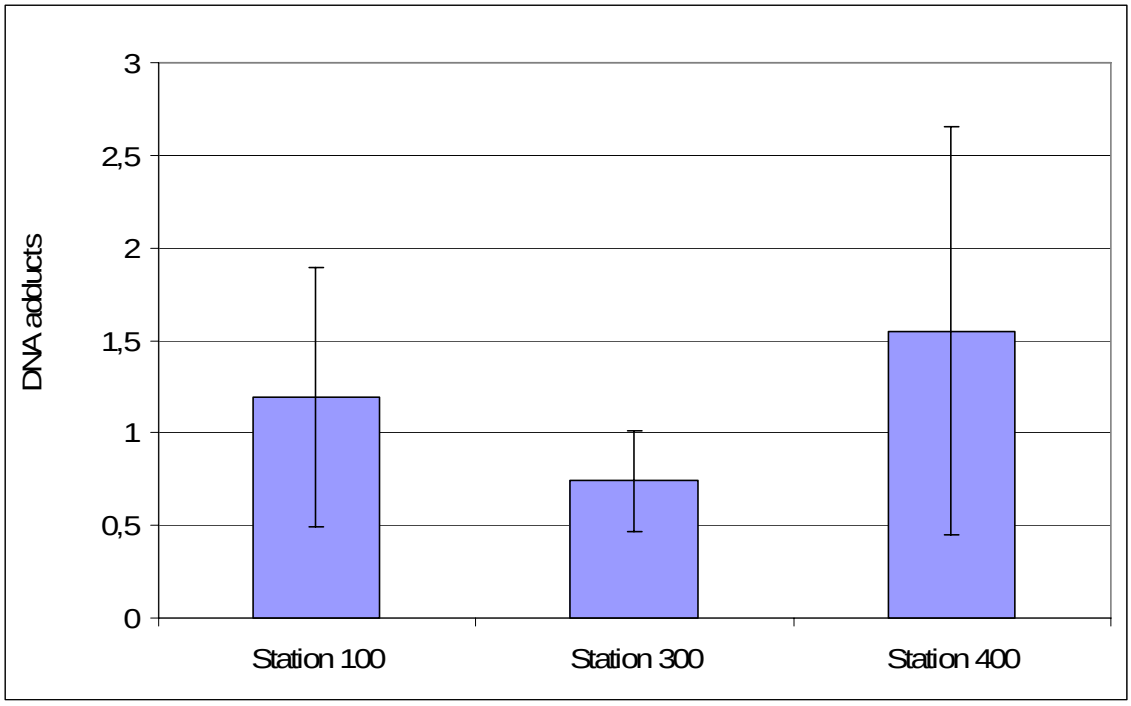
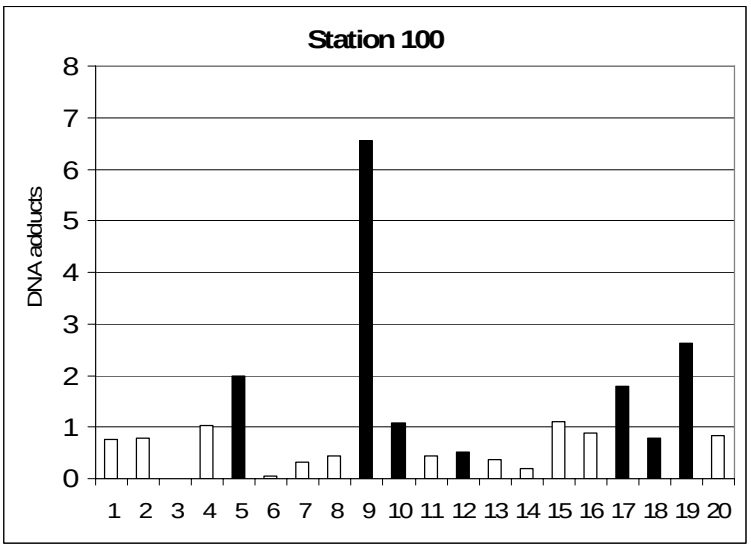
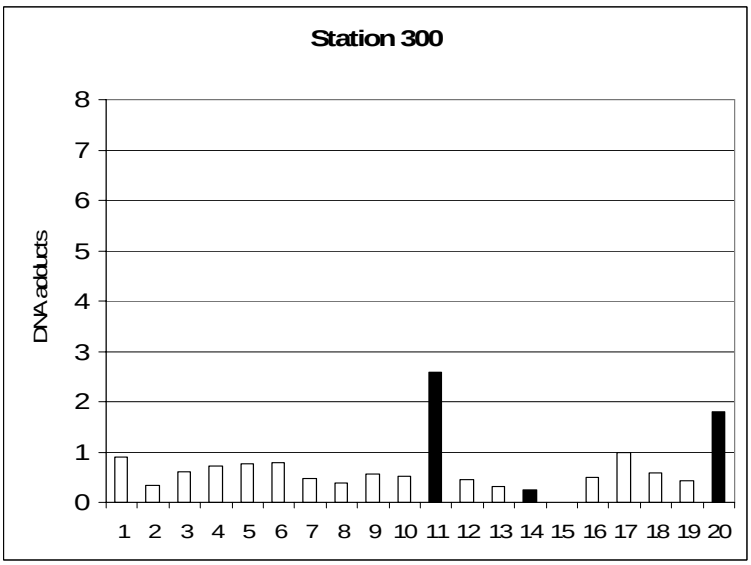


Figure 1. DNA adduct levels (nmol add/mol normal nucleotides) in liver of cod (*Gadus morhua*) caged at different locations in "Ekofisk" area in the North Sea (WCM 2006). Average ± 95% confidence level, n= 19 for all groups.





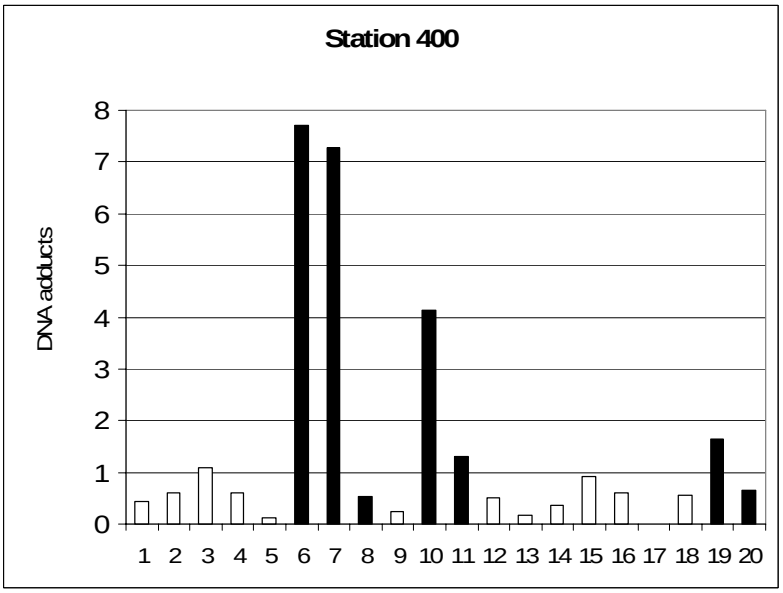
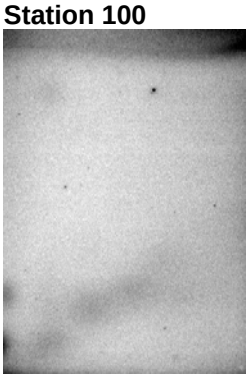


Figure 2. DNA adduct levels (nmol add/mol norm. nucleotides) in individual cod (*Gadus morhua*) from different stations. Black bars indicate individuals with adduct levels above the detection limits.

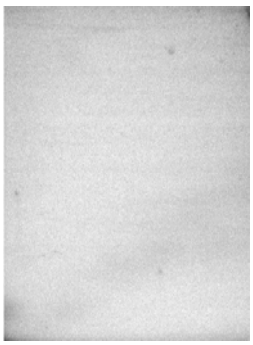
	No. of analysed individuals	No.of individuals with DNA adducts	Total average of DNA adduct levels ± 95% conf. level	Average of DNA adduct levels in individuals with DNA adducts ± 95% conf. Level	Average of detection limits for individuals without DNA adducts ± 95% conf. Level
Station 100	19	7 (37%)	1.19 ± 0.70 (n=19)	2.19 ± 1.90 (n=7)	1.20 ± 0.43 (n=12)
Station 300	19	3 (16%)	0.74 ± 0.27 (n=19)	1.55 ± 2.95 (n=3)	1.17 ± 0.21 (n=16)
Station 400	19	7 (37%)	1.55 ± 1.10 (n=19)	3.32 ± 2.86 (n=7)	1.04 ± 0.36 (n=12)

Table 1. Average DNA adduct levels and detection limits (nmol add/mol normal nucleotides) ± 95% confidence level for different groups of cod caged for 6 weeks in the "Ekofisk" area in the North Sea. Detection limits are calculated per individual sample, and are dependent on the background for each autoradiogram.

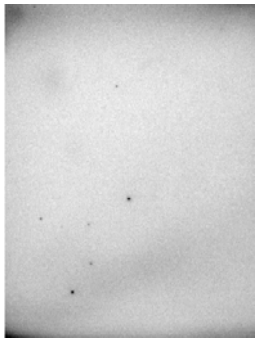
Station 100



109 6.54 nmol

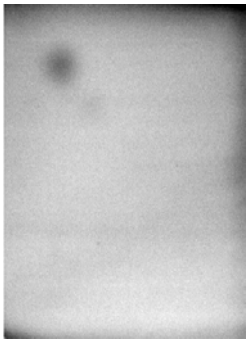


110 1.09 nmol



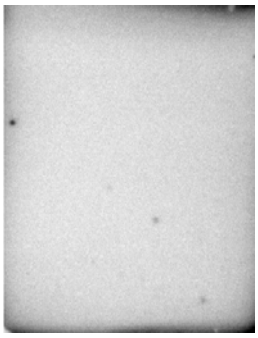
117 1.79 nmol

118 0.791 nmol

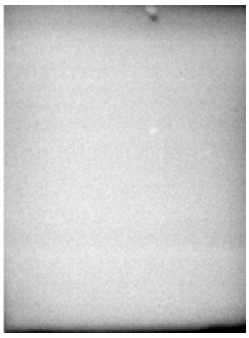


119 2.62 nmol

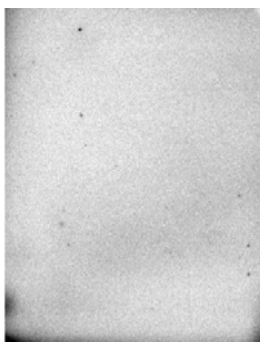
Station 300



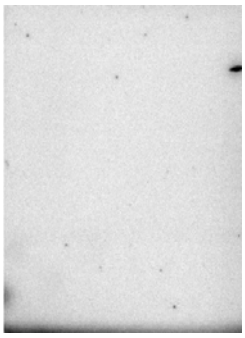
302 ≤0.672 nmol



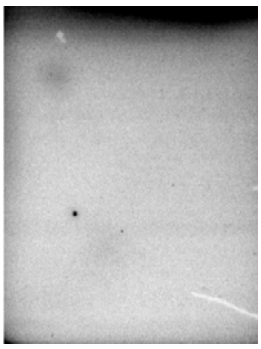
303 ≤1.22 nmol



311 2.59 nmol

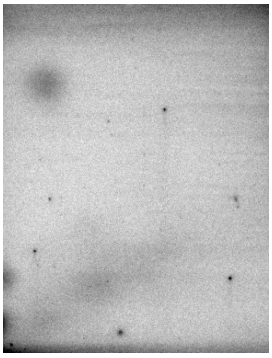


314 0.257 nmol

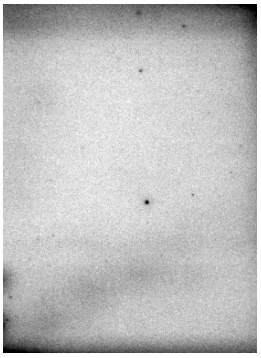


320 1.79 nmol

Station 400

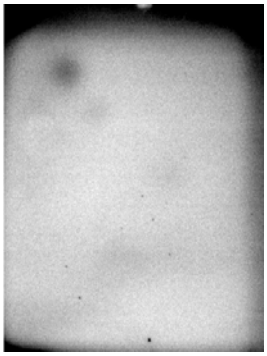


406 7.71 nmol

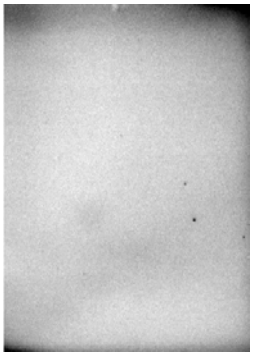


407 7.27 nmol

411 1.30 nmol



419 1.64 nmol



420 0.660 nmol

Figure 3. Autoradiograms and DNA adduct levels in liver samples of cod (*Gadus morhua*) caged at different locations in the "ekofisk" area in the North Sea (WCM 2006). Numbers under the autoradiograms represent sample number (fish) and DNA adducts (nmol add/mol normal nucleotides).

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Appendix E

(the original report contained results from additional surveys, the present version have been modified by IRIS)

Micronucleus analyses
Water Column Monitoring 2006

Reporting Period: June 2006 - October 2006

Responsible Person – Dr. habil. Janina Baršienė
Institute of Ecology of Vilnius University
Akademijos 2
08412, Vilnius
Lithuania
Tel: +370 6 8260979
Fax: +370 5 2729352
Email: janbar@ekoi.lt

Content:

1. Introduction

In spite of legislation limiting the disposal of toxic compounds, contaminants are chronically being released to the environment and pollution of environments still occurs. Since the aquatic environment is the ultimate recipient of the contaminants produced by natural and anthropogenic sources, circulation and accumulation of hazardous substances constitute biological damage. Chemicals with genotoxic and carcinogenic potential in the aquatic environment are serious concern because can bind to DNA molecules and provoke a damaging chain of biological changes, like impaired enzyme function or general metabolism, cytotoxicity, immunotoxicity, disturbances in reproduction, inhibition of growth, or carcinogenesis (Ohe et al., 2004).

Nevertheless, in nowadays an industrial technology improves, but the effluents comprising mixtures of contaminants should be monitored for the harmful effects to indigenous species. Aquatic organisms exposed to the mixtures of contaminants, and synergistic effects of different components are hardly predicted on a basis of chemical analysis. Some compounds show strong bioaccumulation without evidences to their toxicity, some other contaminants posses' very aggressive mode of action and cause harmful effects at low levels of exposure (Regoli et al., 2004).

The demonstration that industrial wastes can induce genotoxic effects point out the urgent need for sensitive assays and reliable bioindicators for the evaluation of genotoxic potential of the industrial effluents. Among current cytogenetic test systems, the assessment of micronuclei formation is commonly used for the indication of genotoxic compounds (Heddle et al., 1991). Micronuclei formation in the cells is a reflection of structural and/or numerical chromosomal disturbances arising due to action of clastogenic and aneugenic agents. Micronuclei are chromatin-containing structures that are surrounded by a membrane, are located in cytoplasm and have no detectable link to the cell nucleus. Cytogenetic damage can result in the formation of MN-containing lagging whole chromosomes or chromosome fragments. The exposure to substances with aneugenic mode of action results in damage to the mitotic spindle. The formation of MN, harboring chromosomal fragments result from direct DNA breakage and usually appear much later after treatment. Thus, MN assay provide the evidence of DNA breakage and spindle dysfunction caused by clastogens

and aneuploidogenic poisons (Heddle et al., 1991; MacGregor, 1991; Seelbach et al., 1993; Zoll-Moreux, Ferrier, 1999).

Micronucleus assay was originally developed for analysis of chemical genotoxicity in mammals (Heddle et al., 1991) and later it has been successfully adapted to species from the other groups, including aquatic organisms. Different fish species and mussels are most frequently used indicator species, which can reflect genotoxic effects in the marine environment. Invertebrates compose over 90% of species in aquatic communities and have particularly important role in ecosystem function (Dixon et al., 2002). The blue mussels are widely distributed in aquatic habitats and as many other marine species are chronically exposed to environmental contamination through via feeding and contact with polluted sediments or water.

Within the last decade, the use marine resident species as appropriate models for genetic monitoring of toxic chemicals in aquatic environment has become popular and micronuclei test was applied in both laboratory and field conditions. The micronuclei assay is one of the best biomarkers that clearly correlate with pollution load, as it has been shown in a number of studies (Al-Sabti, Hardig, 1990; Bolognesi et al., 1996, 2004, 2006; Pietrapiana et al., 2002; Baršienė et al., 2002, 2004, 2005, 2006a, 2006b, 2006c, 2006d, 2006e ; Cavas, Ergene-Gozukara, 2005);

Wastes released from oil industry are well known as representing the primary source of persistent toxicity in aquatic environment and have particular attention because of their potential mutagenic/carcinogenic/cytotoxic properties. There are some studies that described increase of environmental genotoxicity in zones affected by oil spill (Parry et al., 1997; Harvey et al., 1999; Pietrapiana et al., 2002; Frenzilli et al., 2004; Baršienė et al., 2004, 2005; 2006a, 2006b; Bolognesi et al., 2006). Nevertheless, the scarcity of test validation in laboratory designed systems remains, as well as monitoring of genotoxic effects in oil pollution zones *in situ.*.

In order to assess genotoxic impact of wastes from oil platforms, the micronuclei formation was analyzed in native and commercially important species Atlantic cod treated with Ekofisk produced water and in mussel's temporary exposed in the Ekofisk oil platform area. Fish model exposure experiment was designed as laboratory testing system of genotoxicity

in cod liver. Induction of micronuclei in cod immature erythrocytes was used as a "sentinel system" considering direct contact of contaminants and their metabolic pathway.
Mussels were caged in a gradient of suspected contamination around the Ekofisk oil platform; consider that in oil drilling areas can be differently distributed potentially genotoxic polycyclic aromatic hydrocarbons and alkylphenols. In the present study, micronuclei frequencies in haemocytes of the blue mussel were employed as the endpoint of cytogenetic damage and index of oil platform effluents genotoxicity. Haemocytes of marine mussels have been explorated in genotoxicological studies and have proved to be reliable method for the assessment of direct- and indirect-acting genotoxins (Wrisberg, Rhemrev, 1992; Bolognesi et al., 1999; Jha et al., 2005).

2. Materials and methods

The assessment of genotoxic effects of effluents from the Ekofisk oil platform was evaluated in haemocytes of mussels. Mussels were deployed to two sites close to discharge, in 600 m and 1600 m SW of discharge, as well as in 1100 m and 2000 m NE from discharge. Reference clean site was located in 20 km.
Spread on the slides and air-dried mussel hemolymph was fixed 15 min in methanol. After that the slides were stained with 5% Giemsa solution for 10-20 min. To minimize technical variation, the blind scoring of micronuclei was performed on coded slides without knowledge of the exposure status of the samples. The frequency of micronuclei in haemocytes was determined by scoring at a 1000× magnification using Olympus BX 51 or Nikon Eclipse 50i bright-field microscopes. A total of 2,000 immature erythrocytes with intact cellular and nuclear membrane were examined for each mussel specimen.
Only cells with intact cellular and nuclear membrane were scored in cod and in mussels. Round or ovoid-shaped non-refractory particles with colour and structure similar to chromatin, with a diameter 1/3-1/20 of the main nucleus and clearly detached from it were interpreted as micronuclei (Figs. 1 and 2). In general, colour intensity of MN should be the same or less than of the main nuclei. Particles with colour intensity higher than of the main nuclei were not counted as MN. The blind scoring of micronuclei was performed on coded slides without knowledge of the origin of samples. The statistical analysis was carried out using the Statistica package.

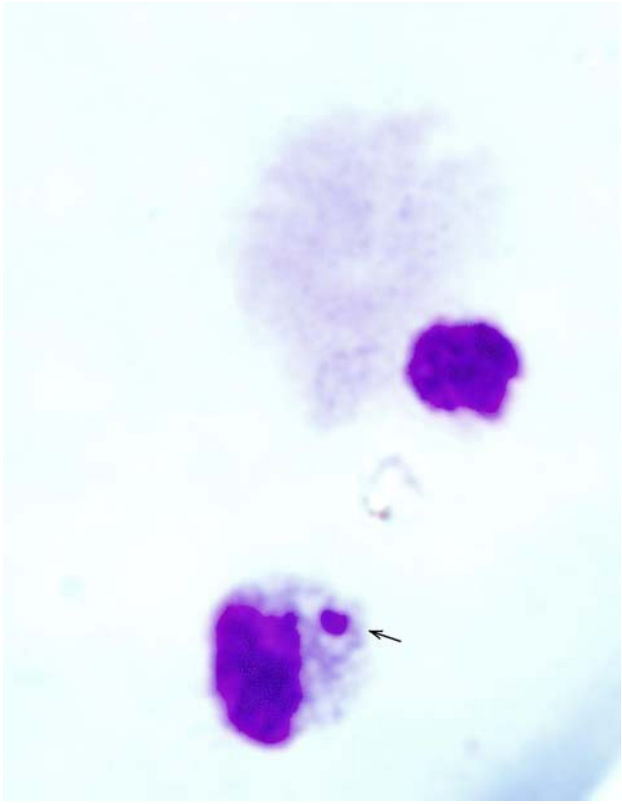

Fig. 1. Micronucleus in haemocyte (arrow) of blue mussel (1000× magnification).

3. Results

The frequency of micronuclei in the reference group of mussels was equal to 1.24 MN/1000 cells. Comparatively high induction of micronuclei (more than 2-fold level) was observed in all studied groups of mussels. The exception was only the mussels from the station 500, which is located in 2000 meters NE from the discharge. There was registered similar level of response (1.76 MN/1000 cells) as in control group of mussels (Fig. 4).
The highest induction of MN was observed in mussels caged in station 300.

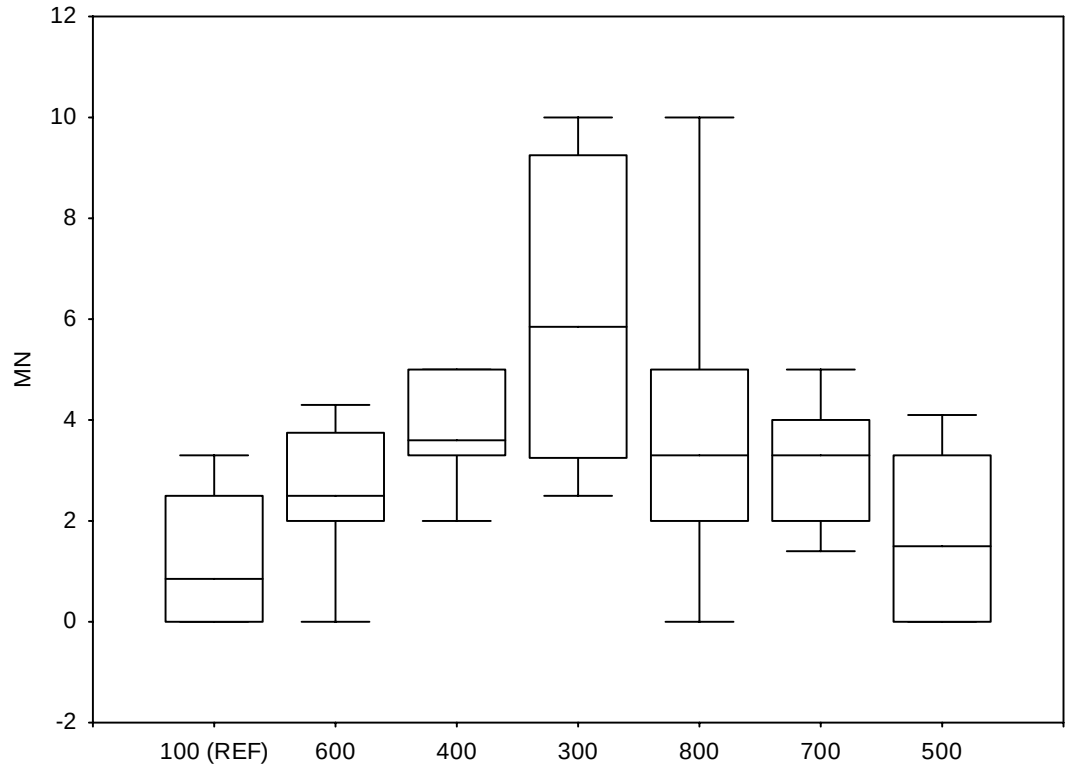

Figure 2. Frequency of micronuclei (MN/1000 haemocytes) in mussels from the groups indicated. The figure shows median, quartiles and 10/90-percentiles.

Individual analysis of MN incidences in control group of mussels showed that 50% of specimens did not possessed micronucleated haemocytes. Maximum value of 3.60 MN/1000 haemocytes was recorded in one specimen from control group. The highest response in mussels caged in the station 600 was equal to 4.40 MN/1000 haemocytes, 5.50 MN/1000 haemocytes – in the station 400, 5.00 MN/1000 haemocytes – in stations 500 and 700, 10 MN/1000 haemocytes – in the station 800. Exceptionally high levels of micronuclei, with a maximum value of 10.80 MN/1000 haemocytes, were found in mussels caged in the station 300, which is located close to the discharge. In spite, there was one specimen without formation of micronuclei in haemocytes (Table 1). In overall, mussels after caging in zones close to the discharge (stations 300 and 800) differed from other groups by their heterogeneity in responses (Table 1).

Table 1. Frequency of micronuclei in mussel caged at Ekofisk oilfield

Mussel No	Control	600	400	300	800	700	500
1	0.00	2.00	3.30	10.00	0.00	7.00	0.00
2	0.00	4.40	3.30	8.50	2,00	1.40	5.00
3	0.00	2.50	3.60	No cells*	3.30	2.20	3.30
4	3.30	4.30	5.00	10.80	5.00	No cells*	0.00
5	0.00	1.60	4.00	10.00	3.30	4.50	2.50
6	2.50	3.00	No cells*	6.00	3.30	3.30	1.60
7	0.00	2.20	5.00	5.70	0.00	2.00	2.80
8	3.60	2.50	2.00	2.50	10.00	5.00	1.40
9	0.00	4.30	4.00	2.50	5.00	3.30	0.00
10	2.50	3.75	2.00	5.00	0.00	0.00	0.00
11	1.70	0.00	5.00	No cells*	5.00	4.00	4.00
12	2.00	2.00	3.30	4.00	5.00	2.00	0.00
13	0.00	0.00	5.50	0.00	10.00	4.00	4.10
14	1.70	No cells*	0.00	6.60	3.30	3.00	0.00

* - the slides with a scarce number of cells suitable for the micronuclei analysis

4. Discussion

It is known, that petroleum industry and transport cause environmental pollution problems worldwide. Accidental oil spills from offshore oil installations, oil transportation vessels, marine oil terminals occurs in marine media and necessity of ecological control is evident. Harmful effects of crude oil and produced water could be provoked by different polyaromatic PAHs and alkylphenols, and especially those with genotoxic properties. Genotoxic effects of different PAHs can result from the oxidative biotransformation producing highly DNA-reactive metabolites that are recognized carcinogenic and mutagenic compounds (Torres-Bugarin et al., 1998; Woodhead et al., 1999; Maria et al., 2002c; Gravato, Santos, 2003). Genotoxic potency of metabolites was confirmed in various fish species (Metcalfe, 1988; Santos, 1997, 2001; Harvey et al., 1999; Maria et al., 2002a, 2002b; Brown, Steinert, 2003; Teles et al., 2003).

The objective of the present study was to estimate genotoxic potential of produced water discharges in blue mussels, widely used as bioindicator species. Mussel haemocytes were used as target cells which circulate in open vascular system and are likely to be homogenously exposed to wastes from the oil platform. Besides, it is noteworthy to stress, that our previous results have confirmed this parameter being sensitive biomarker for the assessment genotoxic effects in mussels exposed petroleum refinery plant effluents, also in mussels caged in the areas of other oil platforms (Baršienė et al., unpublished data).

The study results showed significant increase of genotoxicity in haemocytes of mussel caged at a station close to the discharge. The reference level of genotoxicity was observed only the mussels caged at reference station 100. Taking into consideration that in mussels from the Baltic and North seas, the MN baseline consists of 1-2 MN/1000 cells (Baršienė et al., 2004, 2006a), there was 3-6-fold increase of genotoxicity in the station 300.

Petroleum hydrocarbons in marine environment can seriously impact DNA of filter-feeding bivalve populations (Hamoutene et al., 2002). Significant elevation of micronuclei level in mussels 30 days post-oil spill and persistence of the cytogenetic damage up to 100 days (Parry et al., 1997) and 8 months later (Baršienė et al., 2004, 2006a) has been described. Interestingly to stress, that statistically significant increase of micronuclei levels has been found in oysters and fish caged in Haven oil spill zones 10 years after the oil spill (Bolognesi et al., 2006). Higher frequency of MN has been detected in mussels from oil terminal and marine port zones in the Baltic Sea (Baršienė, Baršytė Lovejoy, 2000; Baršienė, 2002), in Mediterranean commercial port zone (Magni et al., 2006), in polluted by aromatic hydrocarbons zones of the Venice lagoon (Venier, Zampieron, 2005). Cells with micronuclei were found to increase in the gills or hemolymph of marine molluscs treated with benzo(a)pyrene (Burgeot et al., 1995; Venier et al., 1997; Siu et al., 2004), dimethylbenz(a)antracene (Bolognesi et al., 1996), with crude oil from the North Sea (Baršienė et al., in preparation). The results of the Comet and MN assays have been presented evidences on clear dose- and time-dependent responses to benzo(a)pyrene exposure in mytiliid bivalve *Perna viridis* (Siu et al., 2004).

Summarizing the results of the current study allow to conclude that micronucleus test is sensitive tool for the determination of produced water genotoxicity. Thus, in the future the parameter could successfully be used as an early warning sign of pollution-induced genetic

damage in marine species. Taking into consideration species-specific responses and the differences in PW content, the ecologically relevant information from oil industry areas could be obtained by assessment of genotoxic effects in indigenous species both *in situ* and in caged organisms from wild populations. Additionally studies should focus on identifying environmental genotoxicity modifications by animal age, tissue, sex, season, temperature, and oxygen content in oil drilling zones.

5. Conclusions

Statistically significant increase of micronuclei levels was observed in haemocytes of mussel caged at one of the studied sites in the Ekofisk oilfield. The reference level of genotoxicity was detected only the mussels caged in reference station 100. The highest induction of MN was found in mussels exposed in station 300, close to Ekofisk platform discharge.

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Data Report

Analysis of Blue Mussels

July 2006

Prepared for:

Norwegian Institute for Water Research (NIVA)

Prepared by:

Battelle
397 Washington Street
Duxbury, Massachusetts 02332

Battelle
The Business of Innovation

Duxbury Operations
397 Washington Street
Duxbury, Massachusetts 02332
Telephone 781-934-0571
Fax: 781-934-2124

July 19, 2006

Ms. Merete Grung
Norwegian Institute for Water Research (NIVA)
Brekkeveien 19
PO Box 173, Kjelsaas
N-0411 Oslo, Norway

Re: Analysis of Blue Mussels (Battelle Reference No. N006783)

Dear Ms. Grung:

Battelle is pleased to provide you with this letter report, which serves as the analytical summary for the blue mussel samples received by Battelle on June 15, 2006. The samples were collected in support of this summer's North Sea survey. The objective of this study was to analyze the blue mussel samples for concentrations of polycyclic aromatic hydrocarbons (PAH) and other semi-volatile compounds that are often useful diagnostic parameters. This includes all the SFT-monitored N, P, D, and PAH compounds.

Sample Receipt

Twenty-seven (27) previously homogenized blue mussel samples were received at the Battelle Duxbury Operations (BDO) Laboratory on June 15, 2006 intact and in good condition. Upon receipt of samples, the temperature of the cooler was taken and the samples were logged into the laboratory. The temperature of the cooler upon receipt was within the acceptable range. No chain-of-custody documentation was received with the shipment. Battelle prepared the chain-of-custody documentation as part of the log-in procedure. The samples were stored at -20°C until processing. A summary of sample information is provided in Table 1 and the chain-of-custody documentation is presented in Attachment 1.

Table 1: Sample List

Lab ID	Field ID	Matrix	Date Received
R1757	100 POOL 1	MUSSEL	15-Jun-06
R1758	100 POOL 2	MUSSEL	15-Jun-06
R1759	100 POOL 3	MUSSEL	15-Jun-06
R1760	200 POOL 1	MUSSEL	15-Jun-06
R1761	200 POOL 2	MUSSEL	15-Jun-06
R1762	200 POOL 3	MUSSEL	15-Jun-06
R1763	300 POOL 1	MUSSEL	15-Jun-06
R1764	300 POOL 2	MUSSEL	15-Jun-06
R1765	300 POOL 3	MUSSEL	15-Jun-06
R1766	300 2M DEPTH POOL 1	MUSSEL	15-Jun-06
R1767	300 2M DEPTH POOL 2	MUSSEL	15-Jun-06
R1768	300 2M DEPTH POOL 3	MUSSEL	15-Jun-06

Lab ID	Field ID	Matrix	Date Received
R1769	400 POOL 1	MUSSEL	15-Jun-06
R1770	400 POOL 2	MUSSEL	15-Jun-06
R1771	400 POOL 3	MUSSEL	15-Jun-06
R1772	500 POOL 1	MUSSEL	15-Jun-06
R1773	500 POOL 2	MUSSEL	15-Jun-06
R1774	500 POOL 3	MUSSEL	15-Jun-06
R1775	600 POOL 1	MUSSEL	15-Jun-06
R1776	600 POOL 2	MUSSEL	15-Jun-06
R1777	600 POOL 3	MUSSEL	15-Jun-06
R1778	700 POOL 1	MUSSEL	15-Jun-06
R1779	700 POOL 2	MUSSEL	15-Jun-06
R1780	700 POOL 3	MUSSEL	15-Jun-06
R1781	800 POOL 1	MUSSEL	15-Jun-06
R1782	800 POOL 2	MUSSEL	15-Jun-06
R1783	800 POOL 3	MUSSEL	15-Jun-06

Methods

Sample Extraction: The blue mussel samples were previously homogenized. Approximately 10 - 20 g of tissue was used for analysis. A separate 5g aliquot was removed for dry weight determination. The tissue was placed in a clean 250 mL tall wide mouth glass jar with sodium sulfate for extraction. Surrogate internal standard (SIS) compounds were added and the sample was macerated with a Tissuemizer™ using methylene chloride as the extraction solvent. The Tissuemizer™ extraction was repeated once more, followed by a 1-hour solvent extraction on an orbital shaker table. The extracts were dried over sodium sulfate and concentrated by Kuderna-Danish and N2 evaporation techniques. The extracts were processed through alumina columns and further cleaned-up through HPLC equipped with a size exclusion column to isolate analytes of interest. The tissue lipid content was determined using a portion of the pre-purified extract. The final extract was spiked with internal standards (IS) and submitted for the analysis of PAH by GC/MS. The following Quality Control samples were processed along with the batch of tissue samples: two procedural blanks (PB), laboratory control sample (LCS), standard reference material (SRM), and a control oil (NSC).

Sample Analysis: Sample extracts were analyzed for PAH by gas chromatography/ mass spectrometry (GC/MS) in the selected ion monitoring (SIM) mode. Prior to sample analysis, the GC/MS was tuned with perfluorotributylamine (PFTBA) and calibrated with a 5-point calibration consisting of the target compounds to demonstrate the linear range of the analysis. The calibration was verified with a mid-level calibration check standard analysis every 10 samples.

The concentrations of the individual PAH compounds were calculated by the internal standard method. Target PAH concentrations were quantified using average response factors (RF) generated from the five-point linear calibration. Alkyl homologue PAH series concentrations were determined using the average RF for the corresponding parent compound. Well established alkyl homologue pattern recognition and integration techniques were used to determine alkyl homologues. Final concentrations were determined versus the appropriate surrogate compound.

Analytical reporting limits and estimated limits of detections were determined for each sample. The reporting limits are defined as the sample concentration equivalent to the low level standard. The estimated limits of detection are based on a sample concentration equivalent to a signal:noise

ratio of 5:1. The data were qualified with a “J” if the measured concentration was below the reporting limit. Non-detects were qualified with a “U” and null-value was reported.

Quality Assurance/Quality Control

All laboratory and data assessment and reporting activities were conducted under a Quality System defined in the Quality Assurance Manual for the BDO Laboratory. Project activities were defined in a laboratory quality assurance project plan (QAPP) that was prepared by the Project Manager and reviewed by management. The QAPP specified the work to be performed, the analytical methods to be followed, the measurement quality objectives (MQOs) to be achieved, and level of data review. All sample receipt, storage, preparation, analysis, and reporting procedures followed written Standard Operating Procedures (SOPs). Project staff members were responsible for following these procedures and ensuring that MQOs were achieved. In the event that an MQO was not met, the analytical staff documented all corrective actions taken related to that exceedance. The project manager reviewed and approved corrective actions. An independent QC Chemist reviewed all sample preparation and analytical documentation for completeness and accuracy and conducted full error checking of reported project data. The project manager was responsible for ensuring that project objectives were met and that the data were traceable and defensible.

Quality Control Issues

The QC data for the blue mussel analysis were overall good, particularly considering the complex sample matrix, low detection limits, and the variable target compound concentrations. Two procedural blanks were extracted with the large batch of samples. None of the procedural blank data indicate any notable laboratory contamination. Trace PAH was detected, but at concentrations at or below the RL and generally orders of magnitude lower than what was detected in the field samples. In cases where the sample concentration was detected at 5 times less than what was detected in the blank, the data was “B” qualified.

The surrogate recoveries for all of the field and QC samples met the MQO criteria (40 – 120%) with one exception. The surrogate recovery of naphthalene-d8 in one blank was 38%. The majority of the surrogate recoveries were in the 56 to 97% range.

The laboratory control spike (LCS) results were lower than expected. The LCS recoveries were generally in the 56 to 80% range. The tissue standard reference material (SRM) results are very good. The percent difference from target concentrations was less than 35%, with the exception of one compound. The percent difference of benzo[a]pyrene was 50%. Given the acceptable SRM results, the relatively low recoveries in the LCS appear to be an isolated incident and not a laboratory systems issue.

Ultra-trace level analytical sensitivity was obtained for all analyses. The method detection limit goals were met, and allowed for identification and quantitation of almost all target analytes in almost all samples, many at extremely low concentrations. The low detection limits, in combination with the broadly high quality procedural blank evaluations, accuracy, and precision measurements indicated that the analyses were consistently under control, that the objectives were met, and that the results can be used with confidence.

Results

The concentrations of key groups of organic compounds are summarized in Table 2. This table presents the average concentrations from the replicate mussel samples. The concentrations of the decalins were typically much higher than the other compound groups. Although the decalins may

not be an SFT requirement, they are extremely useful diagnostic parameters in this type of work; they are abundant in produced water discharge and have a much higher bioaccumulation potential than other compounds of similar abundance and similar relatively low molecular weight (decalins are quite hydrophobic). PAH are summarized in graphical format in Figure 1. Figure 1 presents the total PAH concentration for the average concentrations from the replicate mussel samples.

Table 2: Average Concentrations (ng/g,wet wt) of Key PAH Compound Groups in the Blue Mussels

Client ID	Total Decalins	Total Naphthalenes	Total Phenanthrenes/ Anthracenes	Total Dibenzothiophenes	Total PAH
100 POOL	ND	1.33	3.33	1.15	12.64
200 POOL	ND	0.66	2.13	0.68	6.62
300 POOL	443.16	157.29	156.81	44.88	483.52
300 2M DEPTH POOL	450.15	116.53	149.29	43.71	424.76
400 POOL	398.37	107.94	132.57	39.69	377.74
500 POOL	113.38	40.08	47.84	15.09	141.49
600 POOL	237.99	66.19	78.97	26.15	238.11
700 POOL	188.17	56.17	68.20	21.52	199.80
800 POOL	341.23	79.23	119.79	38.77	337.98

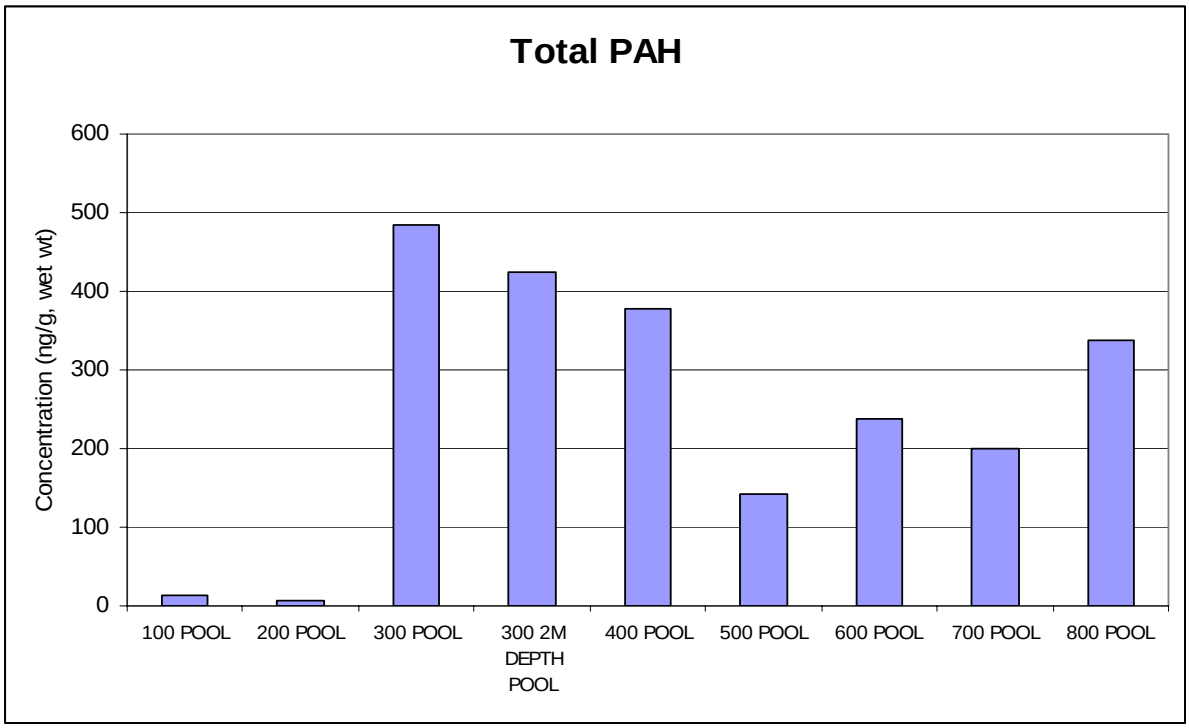


Figure 1. Total PAH Concentrations (ng/g,wet wt) in the Replicate Mussel Samples

Selected PAH data are summarized in graphical format in Attachment 2. Separate bar charts display the concentrations of key compound classes, including the SFT monitored naphthalenes,

phenanthrenes, and dibenzothiophenes compounds. Figures in Attachment 2 also present the composition of PAH in representative samples. The PAH data are summarized in more detail in tables in Attachment 3, where the results for each sample are presented.

We appreciated the opportunity to work with you on this project. Please do not hesitate to contact me at 781-952-5250 if you require additional information concerning the results.

Sincerely,

Kerylynn Krahforst
Project Manager/Research Scientist

Attachment 1: Chain-of-Custody Documentation
Attachment 2: Summary Data Graphs
Attachment 3: PAH Quality Control and Sample Data

Attachment 1
Chain-of-Custody

Sample Receipt Form

Approved: ☑ **Authorized** ☐

Project Number: | **Client:** NIVA

Received by: Carlson, Heather | **Date/Time Received:** Thursday, June 15, 2006 3:30 AM

No. of Shipping Containers: 1

SHIPMENT

Method of Delivery: Commercial Carrier | **Tracking Number:** Not Recorded

COC Forms: ☐ **Shipped with samples** ☑ **No Forms**

Cooler(s)/Box(es)

Container	Type	Sealed With	Seal Condition	Container Condition	Temp C	Total Samples
1 of 1	Cooler	Tape	Intact	Intact	5.0	27

Samples

Sample Labels:
☐ Sample labels agree with COC forms
☑ Discrepancies (see Sample Custody Corrective Action Form)

Container Seals:
☐ Tape ☐ Custody Seals ☐ Other Seals (See sample Log)
☑ Seals intact for each shipping container
☐ Seals broken (See sample log for impacted samples)

Condition of Samples:
☑ Sample containers intact
☐ Sample containers broken/leaking (See Custody Corrective Action Form)

Temperature upon receipt (°C): 5 Temperature Blank used ☐ Yes ☑ No
(Note: If temperature upon receipt differs from required conditions, see sample log comment field)

Samples Acidified: ☐ Yes ☐ No ☑ Unknown

Initial pH 5-9?: ☐ Yes ☐ No ☑ NA
If no, individual sample adjustments on the Auxiliary Sample Receipt Form

Total Residual Chlorine Present?: ☐ Yes ☐ No ☑ NA
If yes, individual sample adjustments on the Auxiliary Sample Receipt Form

Head Space <1% in samples for water VOC analysis: ☐ Yes ☐ No ☑ NA
Individual sample deviations noted on sample log

Samples Containers:
Samples returned in PC-grade jars: ☐ Yes ☐ No ☑ Unknown /Lot No.: UnKnown

Storage Location: Chem North: Freezer - F0002 (Walk-in) | **BDO IDs Assigned:** R1757 - R1783

Samples logged in by: Carlson, Heather | **Date/Time:** 06/15/2006 3:30 AM

Approved By: Abramson, Carla | **Approved On:** 6/27/2006 4:48:

Authorized By: | **Authorized On:**

Battelle
The Business of Innovation

ShpNo: SHP-060615-03

Battelle Project No: 06783-0001

Report Corrective Actions

Corrective Action No: 1 **of** 1

Authorized ☐ Approved: ☑

COC Client: NIVA
COC Project:
COC Date: 6/15/2006 3:53:00 PM

	Description of Problem:	Explanation:
Custody	Other	COC missing from shipment

Documentation of project manager notification

Sample Custodian Carlson, Heather **Date:** 6/15/2006 4:03:00 PM

Laboratory Manager: Thorn, Jonathan **Date:** 6/27/2006 7:35:00 AM

Project Manager: Krahforst, Kerylynn **Date:** 6/26/2006 4:21:00 PM

Documentation of client notification (should be completed by project manager within 24 hrs):

On 15-Jun-06 **I contacted** Grung, Merete **at** Norwegian Institute for Water Research (NIVA)

Results of communication with client (Describe any corrective action directed by the client):

Notified client. See attached e-mail. KK 6/26/06

Date this form was received back to the custodian: 6/27/2006

Reference Number:

Battelle
The Business of Innovation

ShpNo SHP-060615-03

Battelle Project No: NOP40521

Sample Receipt Form Details

Approved: ☐ Authorized ☐

Project Number: **Client:** NIVA

Received by: Carlson, Heather **Date/Time Received:** Thursday, June 15, 2006 3:30 AM

No. of Shipping Containers: 1

BDO Id:	Client Sample ID:	Collection Date:	Login Date:	Ctrs:	Matrix:	Temp:	pH:	TRC:	VOC:	Stored In:	Loc:	No:	Comments:
R1757	100 POOL 1		06/15/06 15:55		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1758	100 POOL 2		06/15/06 15:56		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1759	100 POOL 3		06/15/06 15:56		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1760	200 POOL 1		06/15/06 15:56		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1761	200 POOL 2		06/15/06 15:56		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1762	200 POOL 3		06/15/06 15:56		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1763	300 POOL 1		06/15/06 15:56		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1764	300 POOL 2		06/15/06 15:57		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1765	300 POOL 3		06/15/06 15:57		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1766	300 2M DEPTH POOL 1		06/15/06 15:57		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1767	300 2M DEPTH POOL 2		06/15/06 15:57		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1768	300 2M DEPTH POOL 3		06/15/06 15:57		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1769	400 POOL 1		06/15/06 15:58		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1770	400 POOL 2		06/15/06 15:58		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1771	400 POOL 3		06/15/06 15:58		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1772	500 POOL 1		06/15/06 15:58		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1773	500 POOL 2		06/15/06 15:58		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1774	500 POOL 3		06/15/06 15:59		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1775	600 POOL 1		06/15/06 15:59		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1776	600 POOL 2		06/15/06 15:59		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1777	600 POOL 3		06/15/06 15:59		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1778	700 POOL 1		06/15/06 15:59		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1779	700 POOL 2		06/15/06 15:59		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1780	700 POOL 3		06/15/06 16:00		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1781	800 POOL 1		06/15/06 16:00		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1782	800 POOL 2		06/15/06 16:00		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	
R1783	800 POOL 3		06/15/06 16:00		MUSSEL	5	NA	NA	NA	F0002 (Walk-in)	BIN	86	

Battelle
The Business of Innovation

ShpNo SHP-060615-03

Battelle Project No: NOP40521

Sample Receipt Form Details

Approved: ☐ Authorized ☐

Project Number: **Client:** NIVA

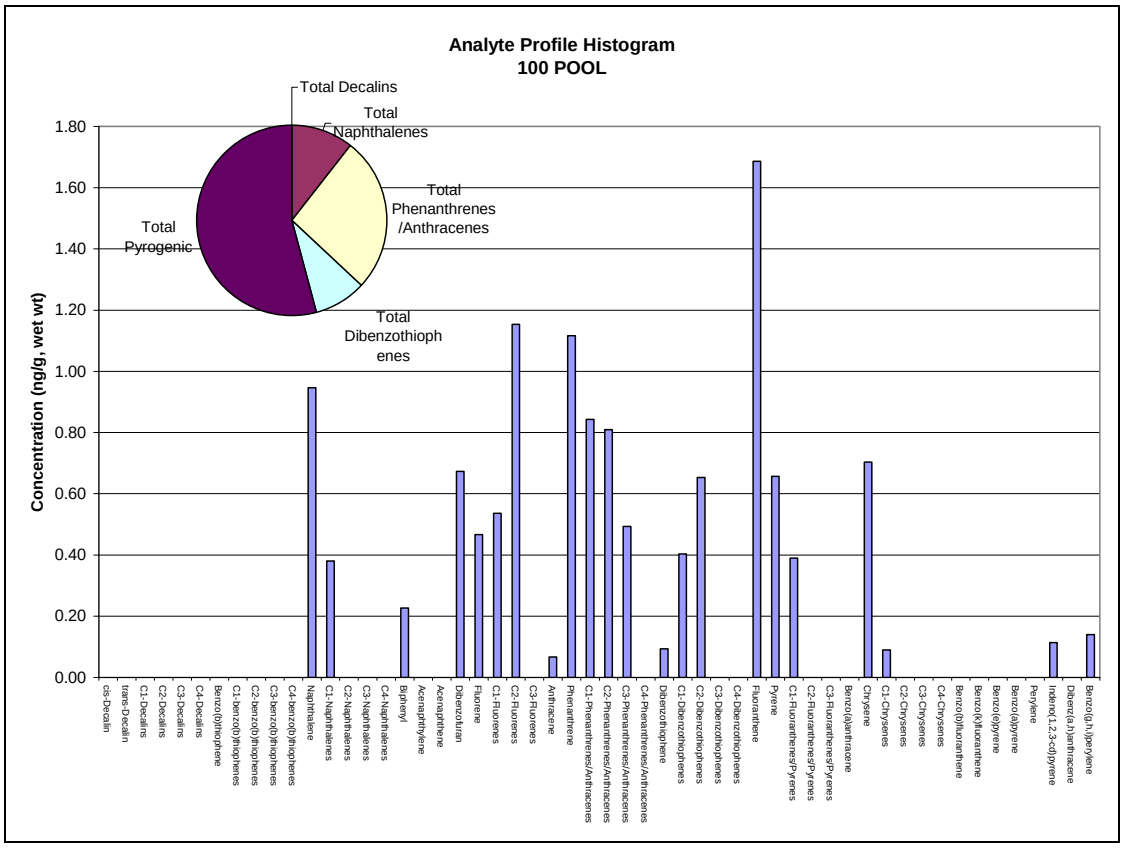
Received by: Carlson, Heather **Date/Time Received:** Thursday, June 15, 2006 3:30 AM

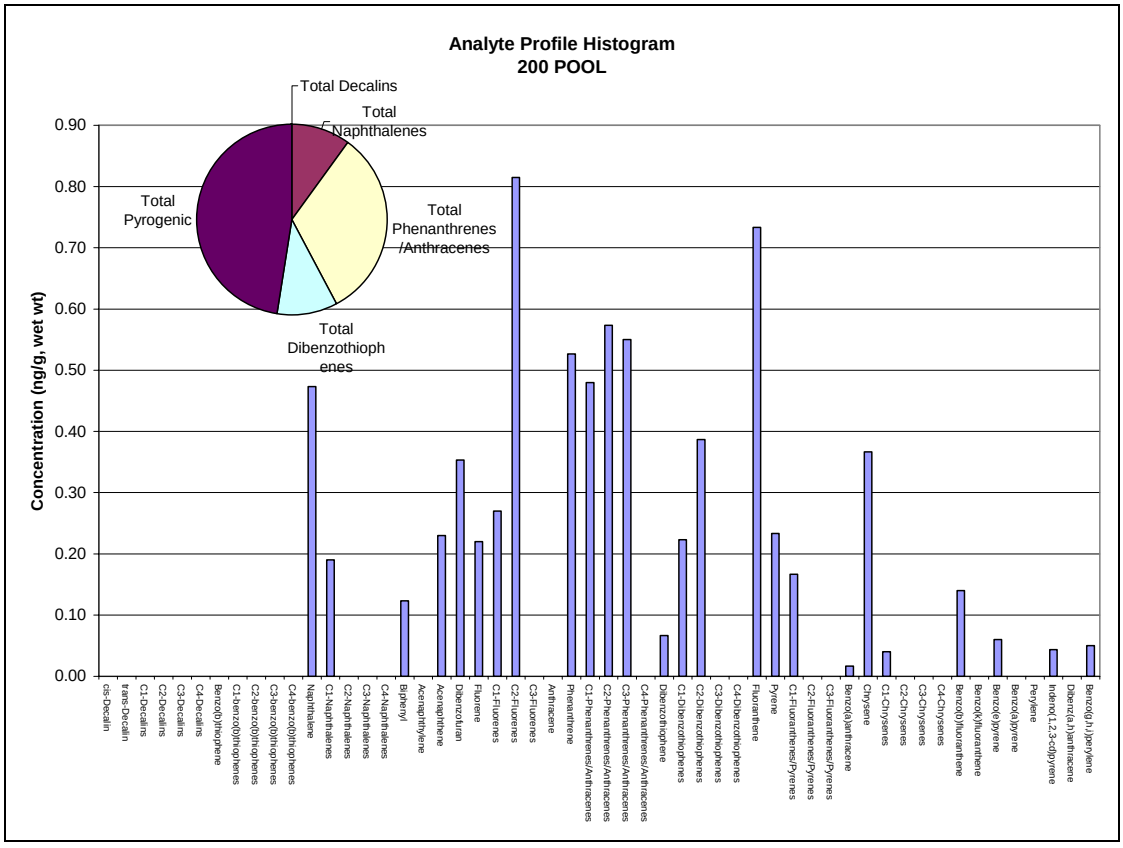
No. of Shipping Containers: 1

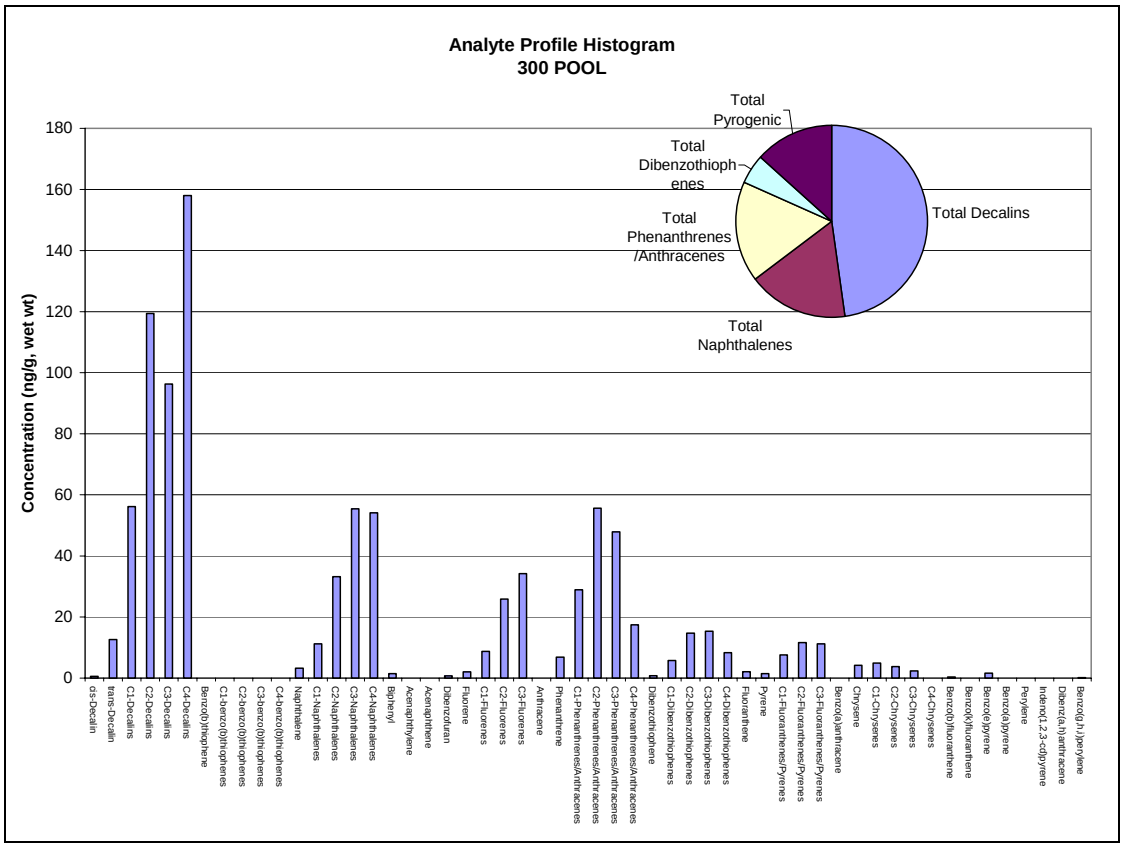
BDO Id:	Client Sample ID:	Collection Date:	Login Date:	Ctrs:	Matrix:	Temp:	pH:	TRC:	VOC:	Stored In:	Loc:	No:	Comments:

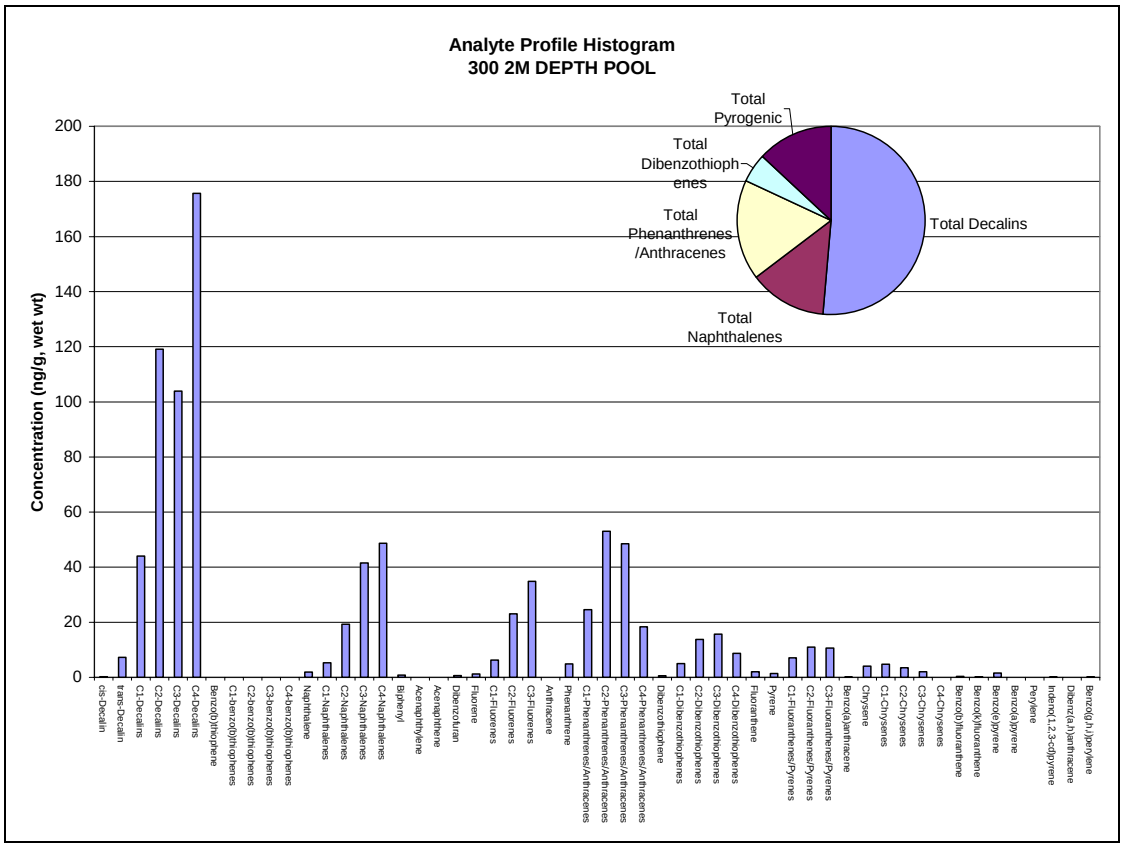
Total Samples: 27

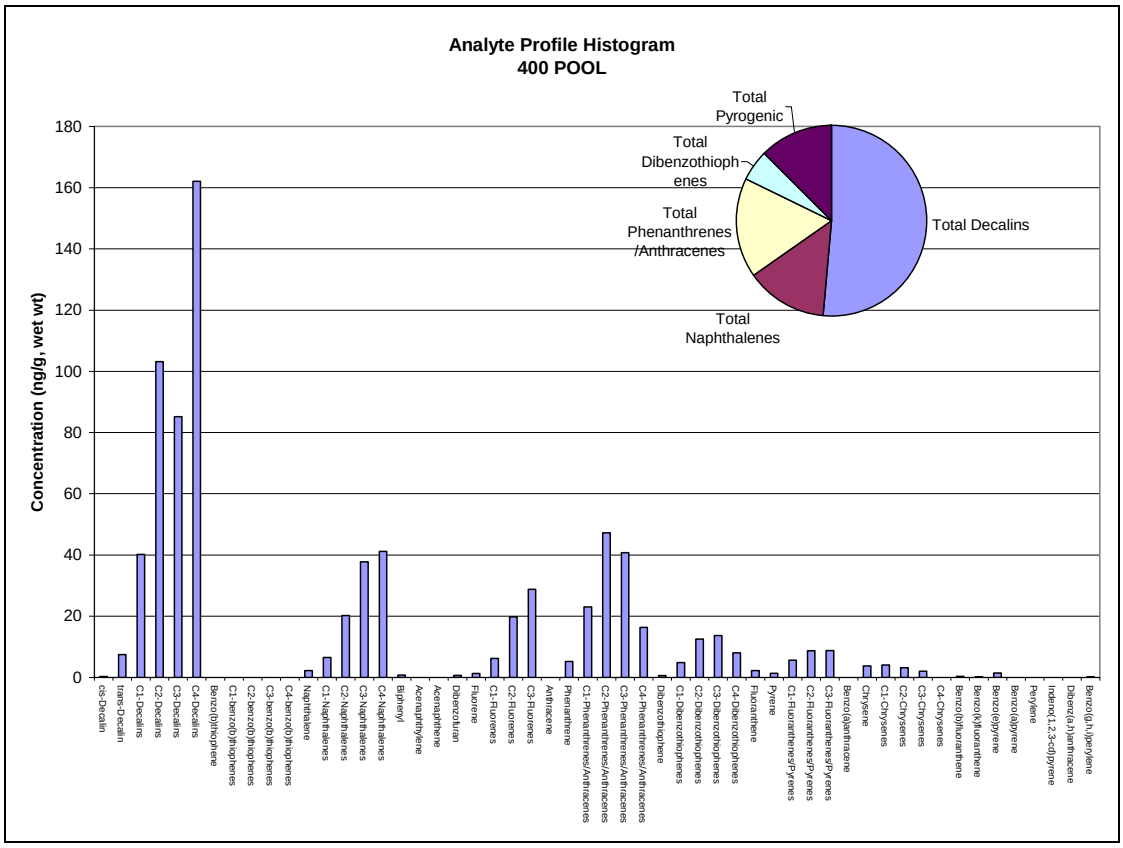
Attachment 2
Summary Data Graphs

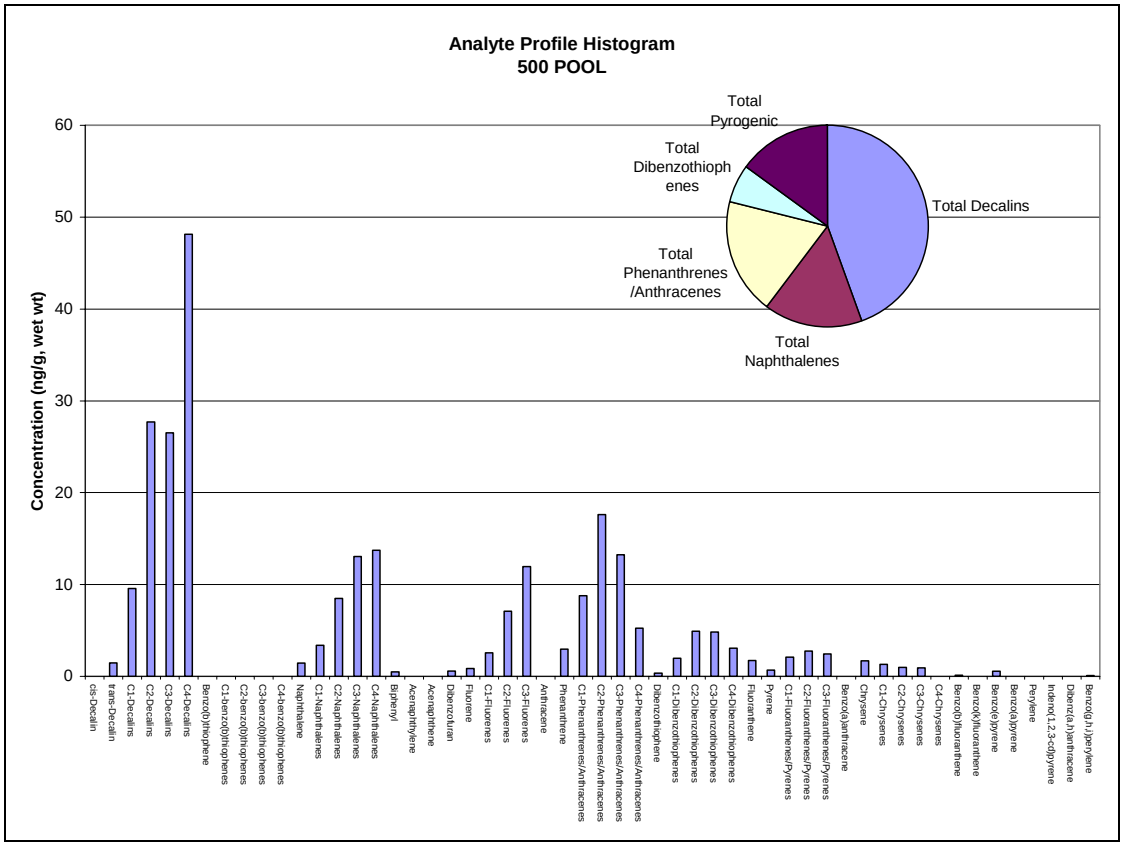

Analyte Profile Histogram
100 POOL
Total Decalins
Total Naphthalenes
Total Phenanthrenes /Anthracenes
Total Dibenzothiophenes
Total Pyrogenic
Concentration (ng/g, wet wt)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

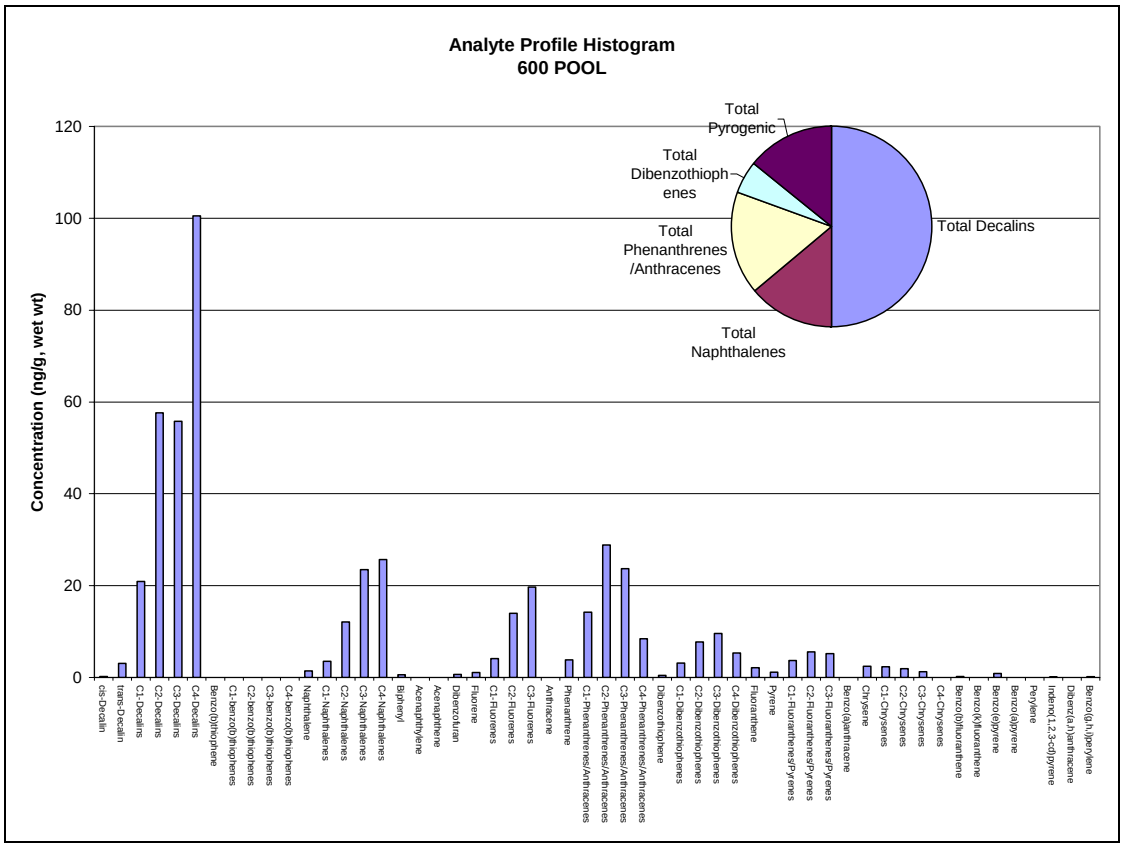

Analyte Profile Histogram
200 POOL
Total Decalins
Total Naphthalenes
Total Phenanthrenes /Anthracenes
Total Dibenzothiophenes
Total Pyrogenic
Concentration (ng/g, wet wt)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

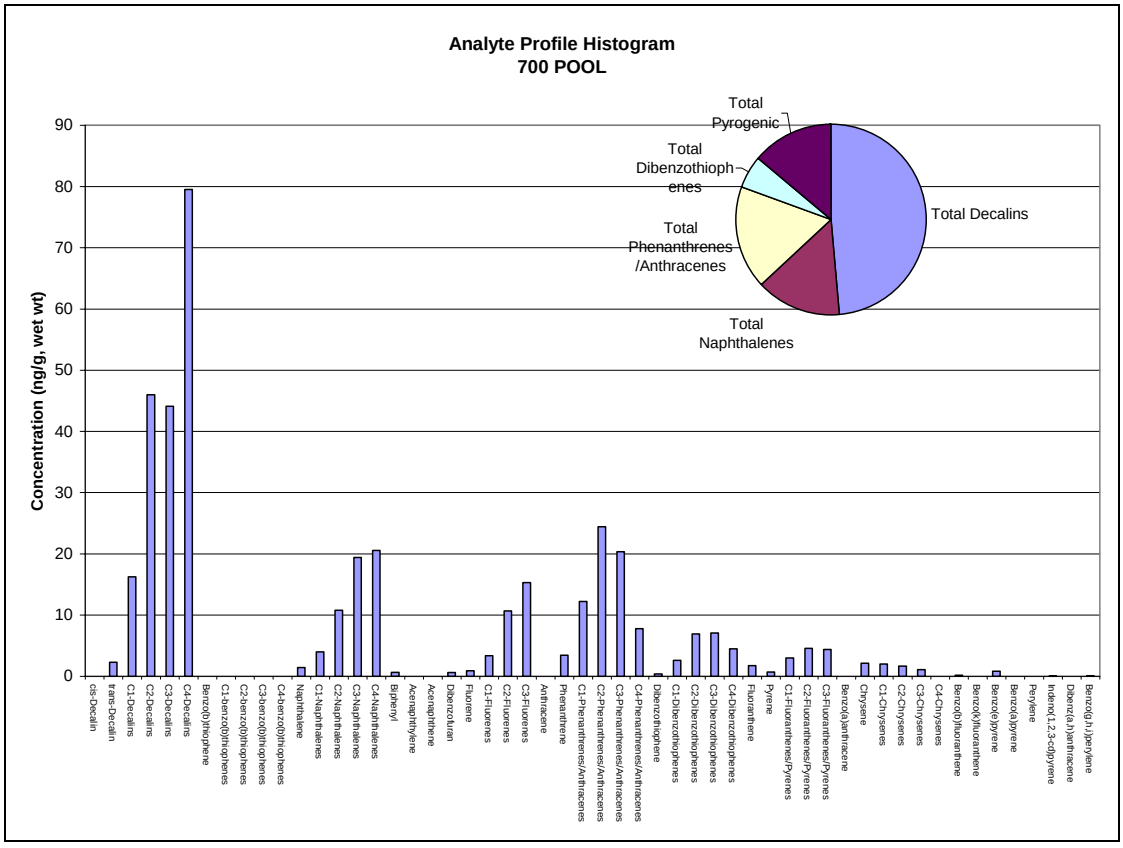

Analyte Profile Histogram
300 POOL
Concentration (ng/g, wet wt)
0
20
40
60
80
100
120
140
160
180
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene
Total Pyrogenic
Total Dibenzothiophenes
Total Phenanthrenes/Anthracenes
Total Decalins
Total Naphthalenes

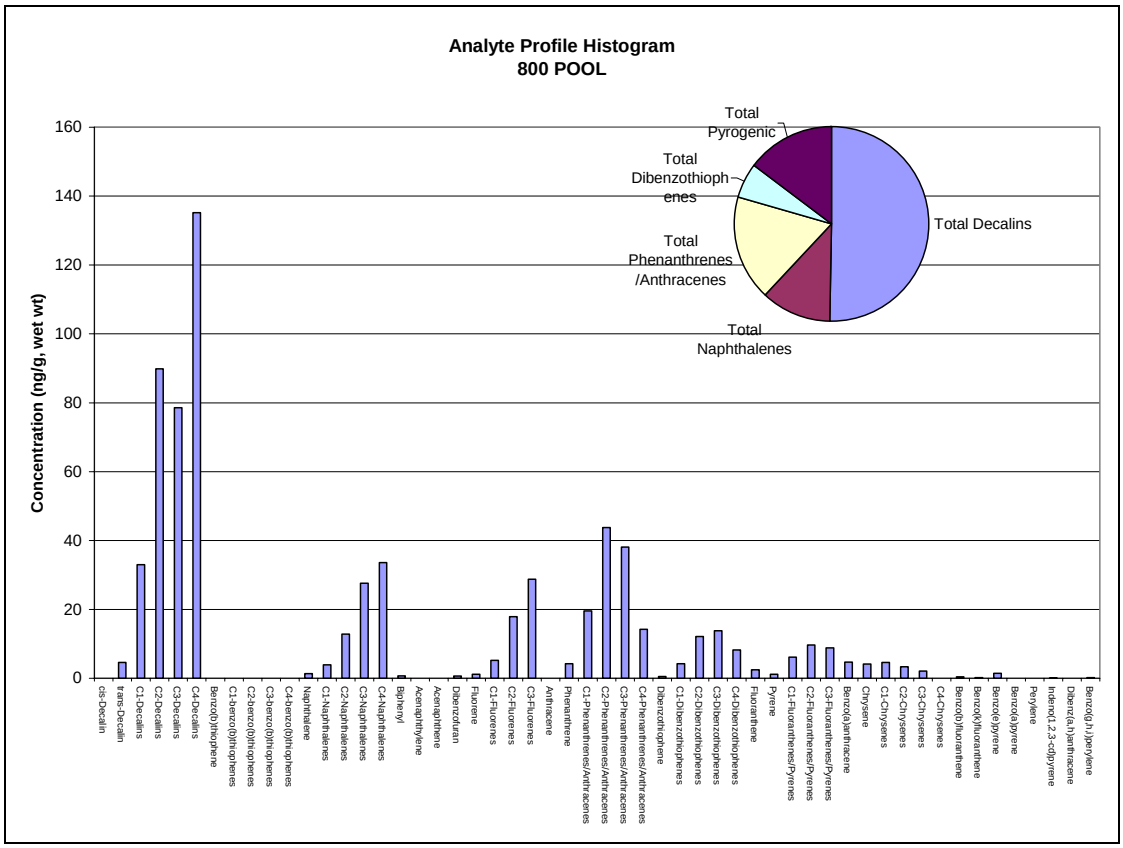

Analyte Profile Histogram
300 2M DEPTH POOL
Concentration (ng/g, wet wt)
0
20
40
60
80
100
120
140
160
180
200
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene
Total Pyrogenic
Total Dibenzothiophenes
Total Phenanthrenes/Anthracenes
Total Decalins
Total Naphthalenes


Analyte Profile Histogram
400 POOL
Concentration (ng/g, wet wt)
180
160
140
120
100
80
60
40
20
0
Total Pyrogenic
Total Dibenzothiophenes
Total Phenanthrenes/Anthracenes
Total Decalins
Total Naphthalenes
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene


Analyte Profile Histogram
500 POOL
Concentration (ng/g, wet wt)
60
50
40
30
20
10
0
Total Pyrogenic
Total Dibenzothiophenes
Total Phenanthrenes/Anthracenes
Total Decalins
Total Naphthalenes
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene


Analyte Profile Histogram
600 POOL
Concentration (ng/g, wet wt)
120
100
80
60
40
20
0
Total Pyrogenic
Total Dibenzothiophenes
Total Phenanthrenes/Anthracenes
Total Decalins
Total Naphthalenes
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene


Analyte Profile Histogram
700 POOL
Concentration (ng/g, wet wt)
90
80
70
60
50
40
30
20
10
0
Total Pyrogenic
Total Dibenzothiophenes
Total Phenanthrenes/Anthracenes
Total Decalins
Total Naphthalenes
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene


Analyte Profile Histogram
800 POOL
Concentration (ng/g, wet wt)
160
140
120
100
80
60
40
20
0
Total Pyrogenic
Total Dibenzothiophenes
Total Decalins
Total Phenanthrenes/Anthracenes
Total Naphthalenes
cis-Decalin
trans-Decalin
C1-Decalins
C2-Decalins
C3-Decalins
C4-Decalins
Benzo(b)thiophene
C1-benzo(b)thiophenes
C2-benzo(b)thiophenes
C3-benzo(b)thiophenes
C4-benzo(b)thiophenes
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Anthracene
Phenanthrene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
C4-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

Attachment 3
PAH Data

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	100 POOL 1	100 POOL 2	100 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1757-P	R1758-P	R1759-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	83.84	84.01	83.91		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.16	9.45	10.58	9.73	7.71
Sample weight (g, wet weight)	4.73	10.05	10.33	8.37	37.70
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.75		
Reporting Limit	0.927	0.436	0.424		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
cis-Decalin	U	U	U	NA	NA
trans-Decalin	U	U	U	NA	NA
C1-Decalins	U	U	U	NA	NA
C2-Decalins	U	U	U	NA	NA
C3-Decalins	U	U	U	NA	NA
C4-Decalins	U	U	U	NA	NA
Benzo(b)thiophene	U	U	U	NA	NA
C1-benzo(b)thiophenes	U	U	U	NA	NA
C2-benzo(b)thiophenes	U	U	U	NA	NA
C3-benzo(b)thiophenes	U	U	U	NA	NA
C4-benzo(b)thiophenes	U	U	U	NA	NA
Naphthalene	1.38 B	0.81 B	0.65 B	0.95	40.53
C1-Naphthalenes	0.63 J	0.24 J	0.27 J	0.38	57.11
C2-Naphthalenes	U	U	U	NA	NA
C3-Naphthalenes	U	U	U	NA	NA
C4-Naphthalenes	U	U	U	NA	NA
Biphenyl	0.34 J	0.09 J	0.25 J	0.23	55.86
Acenaphthylene	U	U	U	NA	NA
Acenaphthene	U	U	U	NA	NA
Dibenzofuran	0.71 J	0.6	0.71	0.67	9.43
Fluorene	0.52 J	0.42 J	0.46	0.47	10.79
C1-Fluorenes	0.6 J	0.52	0.49	0.54	10.60
C2-Fluorenes	1.58	1.05	0.83	1.15	33.43
C3-Fluorenes	U	U	U	NA	NA
Anthracene	0.09 J	0.04 J	0.07 J	0.07	37.75
Phenanthrene	1.49 B	0.93 B	0.93 B	1.12	28.95
C1-Phenanthrenes/Anthracenes	1.07 B	0.77 B	0.69 B	0.84	23.75
C2-Phenanthrenes/Anthracenes	0.99	0.81	0.63	0.81	22.22
C3-Phenanthrenes/Anthracenes	0.54 J	0.43 J	0.51	0.49	11.53
C4-Phenanthrenes/Anthracenes	U	U	U	NA	NA
Dibenzothiophene	0.13 J	0.07 J	0.08 J	0.09	34.44
C1-Dibenzothiophenes	0.6 J	0.35 J	0.26 J	0.40	43.68
C2-Dibenzothiophenes	0.87 J	0.54	0.55	0.65	28.73
C3-Dibenzothiophenes	U	U	U	NA	NA
C4-Dibenzothiophenes	U	U	U	NA	NA
Fluoranthene	2.24	1.49	1.33	1.69	28.80
Pyrene	1.37	0.31 J	0.29 J	0.66	94.09
C1-Fluoranthenes/Pyrenes	0.56 J	0.32 J	0.29 J	0.39	37.95
C2-Fluoranthenes/Pyrenes	U	U	U	NA	NA
C3-Fluoranthenes/Pyrenes	U	U	U	NA	NA
Benzo(a)anthracene	U	U	U	NA	NA
Chrysene	1	0.62	0.49	0.70	37.68
C1-Chrysenes	0.16 J	0.07 J	0.04 J	0.09	69.39
C2-Chrysenes	U	U	U	NA	NA
C3-Chrysenes	U	U	U	NA	NA
C4-Chrysenes	U	U	U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	100 POOL 1	100 POOL 2	100 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1757-P	R1758-P	R1759-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	83.84	84.01	83.91		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.16	9.45	10.58	9.73	7.71
Sample weight (g, wet weight)	4.73	10.05	10.33	8.37	37.70
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.75		
Reporting Limit	0.927	0.436	0.424		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	U	U	U	NA	NA
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	U	U	U	NA	NA
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.25 J	0.05 J	0.04 J	0.11	104.53
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.31 J	0.05 J	0.06 J	0.14	105.22
Total Decalins	0	0	0	0.00	NA
Total Naphthalenes	2.01	1.05	0.92	1.33	44.88
Total Phenanthrenes/Anthracenes	4.18	2.98	2.83	3.33	22.22
Total Dibenzothiophenes	1.6	0.96	0.89	1.15	34.02
Total PAH (from naphthalene)	17.43	10.58	9.92	12.64	32.89
Surrogate Recoveries (%)					
Naphthalene-d8	71	62	73		
Acenaphthene-d10	70	62	70		
Phenanthrene-d10	90	80	91		
Benzo(a)pyrene-d12	71	62	69		

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	200 POOL 1	200 POOL 2	200 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1760-P	R1761-P	R1762-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	86.35	87.38	86.76		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	8.72	8.39	10.14	9.08	10.24
Sample weight (g, wet weight)	15.08	15.19	10.51	13.59	19.65
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	0.291	0.289	0.417		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
cis-Decalin	U	U	U	NA	NA
trans-Decalin	U	U	U	NA	NA
C1-Decalins	U	U	U	NA	NA
C2-Decalins	U	U	U	NA	NA
C3-Decalins	U	U	U	NA	NA
C4-Decalins	U	U	U	NA	NA
Benzo(b)thiophene	U	U	U	NA	NA
C1-benzo(b)thiophenes	U	U	U	NA	NA
C2-benzo(b)thiophenes	U	U	U	NA	NA
C3-benzo(b)thiophenes	U	U	U	NA	NA
C4-benzo(b)thiophenes	U	U	U	NA	NA
Naphthalene	0.47 B	0.35 B	0.6 B	0.47	26.42
C1-Naphthalenes	0.15 J	0.14 J	0.28 J	0.19	41.11
C2-Naphthalenes	U	U	U	NA	NA
C3-Naphthalenes	U	U	U	NA	NA
C4-Naphthalenes	U	U	U	NA	NA
Biphenyl	0.14 J	0.11 J	0.12 J	0.12	12.39
Acenaphthylene	U	U	U	NA	NA
Acenaphthene	U	U	0.23 J	0.23	NA
Dibenzofuran	0.33	0.32	0.41 J	0.35	13.96
Fluorene	0.25 J	0.15 J	0.26 J	0.22	27.65
C1-Fluorenes	0.27 J	U	U	0.27	NA
C2-Fluorenes	0.84	U	0.79	0.82	4.34
C3-Fluorenes	U	U	U	NA	NA
Anthracene	U	U	U	NA	NA
Phenanthrene	0.56 B	0.49 B	0.53 B	0.53	6.67
C1-Phenanthrenes/Anthracenes	0.51 B	0.4 B	0.53 B	0.48	14.58
C2-Phenanthrenes/Anthracenes	0.57	0.62	0.53	0.57	7.86
C3-Phenanthrenes/Anthracenes	0.61	0.53	0.51	0.55	9.62
C4-Phenanthrenes/Anthracenes	U	U	U	NA	NA
Dibenzothiophene	0.08 J	0.06 J	0.06 J	0.07	17.32
C1-Dibenzothiophenes	0.22 J	0.18 J	0.27 J	0.22	20.19
C2-Dibenzothiophenes	0.4	0.35	0.41 J	0.39	8.31
C3-Dibenzothiophenes	U	U	U	NA	NA
C4-Dibenzothiophenes	U	U	U	NA	NA
Fluoranthene	0.83	0.61	0.76	0.73	15.33
Pyrene	0.23 J	0.22 J	0.25 J	0.23	6.55
C1-Fluoranthenes/Pyrenes	0.19 J	0.09 J	0.22 J	0.17	40.84
C2-Fluoranthenes/Pyrenes	U	U	U	NA	NA
C3-Fluoranthenes/Pyrenes	U	U	U	NA	NA
Benzo(a)anthracene	0.02 J	0.01 J	0.02 J	0.02	34.64
Chrysene	0.38	0.42	0.3 J	0.37	16.66
C1-Chrysenes	0.05 J	0.04 J	0.03 J	0.04	25.00
C2-Chrysenes	U	U	U	NA	NA
C3-Chrysenes	U	U	U	NA	NA
C4-Chrysenes	U	U	U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	200 POOL 1	200 POOL 2	200 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1760-P	R1761-P	R1762-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	86.35	87.38	86.76		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	8.72	8.39	10.14	9.08	10.24
Sample weight (g, wet weight)	15.08	15.19	10.51	13.59	19.65
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	0.291	0.289	0.417		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	U	0.09 J	0.19 J	0.14	50.51
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	0.06 J	U	U	0.06	NA
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.05 J	0.04 J	0.04 J	0.04	13.32
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.05 J	0.05 J	U	0.05	0.00
Total Decalins	0	0	0	0.00	NA
Total Naphthalenes	0.62	0.49	0.88	0.66	29.94
Total Phenanthrenes/Anthracenes	2.25	2.04	2.1	2.13	5.08
Total Dibenzothiophenes	0.7	0.59	0.74	0.68	11.48
Total PAH (from naphthalene)	7.26	5.27	7.34	6.62	17.71
Surrogate Recoveries (%)					
Naphthalene-d8	71	64	70		
Acenaphthene-d10	70	64	69		
Phenanthrene-d10	90	82	89		
Benzo(a)pyrene-d12	66	60	64		

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	300 POOL 1	300 POOL 2	300 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1763-P	R1764-P	R1765-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/30/06		
Moisture Content (%)	87.11	86.89	87.3		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.57	10.14	9.7	9.80	3.05
Sample weight (g, wet weight)	10.16	15.15	15.17	13.49	21.39
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	0.432	0.289	0.289		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
cis-Decalin	0.62	0.64	0.58	0.61	4.98
trans-Decalin	13.19	12.93	11.78	12.63	5.94
C1-Decalins	57.48	58.47	52.6	56.18	5.59
C2-Decalins	117.79	123.7	116.71	119.40	3.15
C3-Decalins	95.71	98.69	94.49	96.30	2.24
C4-Decalins	159.68	164.25	150.17	158.03	4.55
Benzo(b)thiophene	U	U	U	NA	NA
C1-benzo(b)thiophenes	U	U	U	NA	NA
C2-benzo(b)thiophenes	U	U	U	NA	NA
C3-benzo(b)thiophenes	U	U	U	NA	NA
C4-benzo(b)thiophenes	U	U	U	NA	NA
Naphthalene	3.39 B	3.23 B	3.16 B	3.26	3.62
C1-Naphthalenes	11.33	11.42	10.92	11.22	2.37
C2-Naphthalenes	34.11	33.14	32.38	33.21	2.61
C3-Naphthalenes	55.23	56.37	54.77	55.46	1.49
C4-Naphthalenes	53.9	52.74	55.79	54.14	2.84
Biphenyl	1.49	1.52	1.3	1.44	8.30
Acenaphthylene	U	U	U	NA	NA
Acenaphthene	U	U	U	NA	NA
Dibenzofuran	0.66	0.74	0.74	0.71	6.47
Fluorene	2.25	2.01	1.96	2.07	7.48
C1-Fluorenes	9.14	8.86	8.29	8.76	4.94
C2-Fluorenes	27.62	25.28	24.77	25.89	5.87
C3-Fluorenes	35.97	31.44	35.19	34.20	7.08
Anthracene	U	U	U	NA	NA
Phenanthrene	7.09	6.93	6.59	6.87	3.72
C1-Phenanthrenes/Anthracenes	30.09	28.19	28.4	28.89	3.61
C2-Phenanthrenes/Anthracenes	60.01	52.56	54.37	55.65	6.98
C3-Phenanthrenes/Anthracenes	51.95	43.64	48.14	47.91	8.68
C4-Phenanthrenes/Anthracenes	21.07	14.68	16.73	17.49	18.65
Dibenzothiophene	0.8	0.8	0.71	0.77	6.75
C1-Dibenzothiophenes	6.06	5.3	5.94	5.77	7.09
C2-Dibenzothiophenes	16.69	13.37	14.09	14.72	11.87
C3-Dibenzothiophenes	16.73	13.74	15.49	15.32	9.81
C4-Dibenzothiophenes	9.96	7.19	7.78	8.31	17.56
Fluoranthene	2.22	2	2.09	2.10	5.26
Pyrene	1.61	1.46	1.3	1.46	10.64
C1-Fluoranthenes/Pyrenes	8.5	6.88	7.5	7.63	10.72
C2-Fluoranthenes/Pyrenes	13.1	10.55	11.26	11.64	11.31
C3-Fluoranthenes/Pyrenes	12.75	9.88	10.9	11.18	13.02
Benzo(a)anthracene	U	U	U	NA	NA
Chrysene	4.61	4.09	3.97	4.22	8.06
C1-Chrysenes	5.91	4.35	4.6	4.95	16.92
C2-Chrysenes	4.46	3.37	3.44	3.76	16.24
C3-Chrysenes	2.92	2.1	2.05	2.36	20.73
C4-Chrysenes	U	U	U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	300 POOL 1	300 POOL 2	300 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1763-P	R1764-P	R1765-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/30/06		
Moisture Content (%)	87.11	86.89	87.3		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.57	10.14	9.7	9.80	3.05
Sample weight (g, wet weight)	10.16	15.15	15.17	13.49	21.39
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	0.432	0.289	0.289		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	0.42 J	0.28 J	0.32	0.34	21.21
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	1.81	1.58	1.61	1.67	7.50
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	U	U	NA	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.15 J	0.16 J	0.15 J	0.15	3.77
Total Decalins	444.47	458.68	426.33	443.16	3.66
Total Naphthalenes	157.96	156.9	157.02	157.29	0.37
Total Phenanthrenes/Anthracenes	170.21	146	154.23	156.81	7.85
Total Dibenzothiophenes	50.24	40.4	44.01	44.88	11.09
Total PAH (from naphthalene)	514	459.85	476.7	483.52	5.73
Surrogate Recoveries (%)					
Naphthalene-d8	69	68	74		
Acenaphthene-d10	70	69	74		
Phenanthrene-d10	90	88	97		
Benzo(a)pyrene-d12	74	75	82		

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N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

	300 2M DEPTH POOL		300 2M DEPTH POOL		300 2M DEPTH POOL			
Client ID	1		2		3			
Battelle Batch ID								
Battelle ID	R1766-P		R1767-P		R1768-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	06/30/06		06/30/06		06/30/06			
Moisture Content (%)	86.36		87.11		87.27			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.93		8.25		9.6		9.26	9.61
Sample weight (g, wet weight)	15.71		15.45		15.20		15.45	1.65
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.75		1.754			
Reporting Limit	0.279		0.283		0.288			
Reporting Unit	ng/g, wet weight		ng/g, wet weight		ng/g, wet weight			
cis-Decalin	0.27	J	0.21	J	0.18	J	0.22	20.83
trans-Decalin	9.83		5.73		6.02		7.19	31.81
C1-Decalins	57.66		38.69		35.64		44.00	27.12
C2-Decalins	150.43		115.68		91.33		119.15	24.93
C3-Decalins	132.43		102.5		76.8		103.91	26.79
C4-Decalins	228.55		170.43		128.08		175.69	28.71
Benzo(b)thiophene	U		U		U		NA	NA
C1-benzo(b)thiophenes	U		U		U		NA	NA
C2-benzo(b)thiophenes	U		U		U		NA	NA
C3-benzo(b)thiophenes	U		U		U		NA	NA
C4-benzo(b)thiophenes	U		U		U		NA	NA
Naphthalene	2.32	B	1.65	B	1.6	B	1.86	21.65
C1-Naphthalenes	6.74		4.4		4.69		5.28	24.17
C2-Naphthalenes	23.98		17.82		15.83		19.21	22.12
C3-Naphthalenes	52.34		39.25		32.89		41.49	23.90
C4-Naphthalenes	63.64		46.49		35.95		48.69	28.70
Biphenyl	0.92		0.82		0.68		0.81	14.94
Acenaphthylene	U		U		U		NA	NA
Acenaphthene	U		U		U		NA	NA
Dibenzofuran	0.79		0.47		0.48		0.58	31.37
Fluorene	1.33		1.17		1.12		1.21	9.09
C1-Fluorenes	8.28		6.03		4.47		6.26	30.60
C2-Fluorenes	29.05		23.8		16.18		23.01	28.12
C3-Fluorenes	45.98		34.34		24.13		34.82	31.40
Anthracene	U		U		U		NA	NA
Phenanthrene	6.15		4.34		4.09		4.86	23.13
C1-Phenanthrenes/Anthracenes	31.64		23.29		18.83		24.59	26.45
C2-Phenanthrenes/Anthracenes	67.58		51.99		39.37		52.98	26.67
C3-Phenanthrenes/Anthracenes	61.09		48.91		35.4		48.47	26.51
C4-Phenanthrenes/Anthracenes	24.57		17.06		13.55		18.39	30.61
Dibenzothiophene	0.64		0.53		0.45		0.54	17.67
C1-Dibenzothiophenes	6.47		4.62		3.92		5.00	26.33
C2-Dibenzothiophenes	16.92		13.78		10.63		13.78	22.83
C3-Dibenzothiophenes	20.16		15.8		11.06		15.67	29.04
C4-Dibenzothiophenes	10.61		9.25		6.28		8.71	25.41
Fluoranthene	2.57		1.77		1.82		2.05	21.83
Pyrene	1.65		1.57		0.89		1.37	30.48
C1-Fluoranthenes/Pyrenes	8.87		7.22		5.25		7.11	25.48
C2-Fluoranthenes/Pyrenes	13.56		11.29		8.02		10.96	25.42
C3-Fluoranthenes/Pyrenes	13.11		11.05		7.57		10.58	26.47
Benzo(a)anthracene	U		U		0.05	J	0.05	NA
Chrysene	5.09		3.88		3.13		4.03	24.52
C1-Chrysenes	5.96		4.51		3.77		4.75	23.47
C2-Chrysenes	4.3		3.52		2.56		3.46	25.19
C3-Chrysenes	2.09		2.14		1.8		2.01	9.13
C4-Chrysenes	U		U		U		NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

	300 2M DEPTH POOL	300 2M DEPTH POOL	300 2M DEPTH POOL		
Client ID	1	2	3		
Battelle Batch ID					
Battelle ID	R1766-P	R1767-P	R1768-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/30/06	06/30/06	06/30/06		
Moisture Content (%)	86.36	87.11	87.27		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.93	8.25	9.6	9.26	9.61
Sample weight (g, wet weight)	15.71	15.45	15.20	15.45	1.65
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.75	1.754		
Reporting Limit	0.279	0.283	0.288		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	0.47	0.37	0.26 J	0.37	28.65
Benzo(k)fluoranthene	0.2 J	0.15 J	0.11 J	0.15	29.41
Benzo(e)pyrene	1.89	1.51	1.17	1.52	23.64
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.08 J	0.06 J	0.04 J	0.06	33.33
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.16 J	0.15 J	0.09 J	0.13	28.39
Total Decalins	579.17	433.24	338.05	450.15	26.98
Total Naphthalenes	149.02	109.61	90.96	116.53	25.44
Total Phenanthrenes/Anthracenes	191.03	145.59	111.24	149.29	26.81
Total Dibenzothiophenes	54.8	43.98	32.34	43.71	25.70
Total PAH (from naphthalene)	541.2	415	318.08	424.76	26.34
Surrogate Recoveries (%)					
Naphthalene-d8	70	67	68		
Acenaphthene-d10	71	66	68		
Phenanthrene-d10	90	85	86		
Benzo(a)pyrene-d12	79	72	73		

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	400 POOL 1		400 POOL 2		400 POOL 3			
Battelle Batch ID								
Battelle ID	R1769-P		R1770-P		R1771-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	06/30/06		06/30/06		06/30/06			
Moisture Content (%)	86.07		86.73		85.32			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	10.09		8.76		9.65		9.50	7.13
Sample weight (g, wet weight)	10.13		15.77		10.07		11.99	27.30
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.746		1.754		1.754			
Reporting Limit	0.431		0.278		0.435			
Reporting Unit	ng/g, wet weight		ng/g, wet weight		ng/g, wet weight			
cis-Decalin	0.22	J	0.32		0.34	J	0.29	21.92
trans-Decalin	8.96		5.61		7.83		7.47	22.83
C1-Decalins	53.93		28.66		37.89		40.16	31.84
C2-Decalins	139.28		72.14		98.03		103.15	32.83
C3-Decalins	114.31		57.31		83.98		85.20	33.47
C4-Decalins	214.32		111.5		160.49		162.10	31.73
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	2.56	B	1.69	B	2.52	B	2.26	21.76
C1-Naphthalenes	7.12		5.12		7.27		6.50	18.46
C2-Naphthalenes	23.77		15.29		21.54		20.20	21.76
C3-Naphthalenes	47.43		26.74		39.16		37.78	27.57
C4-Naphthalenes	54.42		28.1		41.1		41.21	31.94
Biphenyl	0.88		0.72		0.83		0.81	10.11
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	0.81		0.51		0.63		0.65	23.23
Fluorene	1.51		0.95		1.42		1.29	23.25
C1-Fluorenes	7.78		4.58		6.19		6.18	25.88
C2-Fluorenes	24.78		13.72		20.98		19.83	28.34
C3-Fluorenes	37.4		20.18		28.75		28.78	29.92
Anthracene		U		U		U	NA	NA
Phenanthrene	5.94		4.02		5.65		5.20	19.89
C1-Phenanthrenes/Anthracenes	27.75		16.16		25.11		23.01	26.40
C2-Phenanthrenes/Anthracenes	59.43		31.38		51		47.27	30.45
C3-Phenanthrenes/Anthracenes	52.13		27.33		42.79		40.75	30.74
C4-Phenanthrenes/Anthracenes	20.19		12.99		15.85		16.34	22.18
Dibenzothiophene	0.73		0.42		0.61		0.59	26.64
C1-Dibenzothiophenes	6.21		3.51		4.88		4.87	27.74
C2-Dibenzothiophenes	16.01		8.23		13.28		12.51	31.56
C3-Dibenzothiophenes	17.49		8.74		14.86		13.70	32.78
C4-Dibenzothiophenes	10.17		5.25		8.67		8.03	31.40
Fluoranthene	2.6		1.69		2.47		2.25	21.84
Pyrene	1.49		1.03		1.49		1.34	19.87
C1-Fluoranthenes/Pyrenes	7.27		3.68		6.06		5.67	32.21
C2-Fluoranthenes/Pyrenes	11.71		5.8		8.48		8.66	34.16
C3-Fluoranthenes/Pyrenes	11.66		5.86		8.68		8.73	33.21
Benzo(a)anthracene		U		U		U	NA	NA
Chrysene	4.84		2.67		3.7		3.74	29.05
C1-Chrysenes	5.51		2.73		4.03		4.09	34.01
C2-Chrysenes	4.13		2.26		3		3.13	30.09
C3-Chrysenes	2.52		1.3		2.23		2.02	31.60
C4-Chrysenes		U		U		U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	400 POOL 1	400 POOL 2	400 POOL 3		
Battelle Batch ID					
Battelle ID	R1769-P	R1770-P	R1771-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/30/06	06/30/06	06/30/06		
Moisture Content (%)	86.07	86.73	85.32		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	10.09	8.76	9.65	9.50	7.13
Sample weight (g, wet weight)	10.13	15.77	10.07	11.99	27.30
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.746	1.754	1.754		
Reporting Limit	0.431	0.278	0.435		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	0.43	0.29	0.32 J	0.35	21.26
Benzo(k)fluoranthene	0.11 J	0.15 J	U	0.13	21.76
Benzo(e)pyrene	1.73	0.98	1.61	1.44	27.98
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	U	U	NA	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.15 J	0.1 J	0.17 J	0.14	25.75
Total Decalins	531.02	275.54	388.56	398.37	32.14
Total Naphthalenes	135.3	76.94	111.59	107.94	27.19
Total Phenanthrenes/Anthracenes	165.44	91.88	140.4	132.57	28.21
Total Dibenzothiophenes	50.61	26.15	42.3	39.69	31.34
Total PAH (from naphthalene)	478.66	260.39	394.18	377.74	29.14
Surrogate Recoveries (%)					
Naphthalene-d8	66	68	70		
Acenaphthene-d10	66	68	72		
Phenanthrene-d10	85	86	92		
Benzo(a)pyrene-d12	71	72	71		

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Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	500 POOL 1		500 POOL 2		500 POOL 3			
Battelle Batch ID								
Battelle ID	R1772-P		R1773-P		R1774-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	06/30/06		06/30/06		06/30/06			
Moisture Content (%)	85.91		86.23		86.96			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.41		9.92		9		9.44	4.88
Sample weight (g, wet weight)	10.05		11.06		15.97		12.36	25.62
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.754		1.746			
Reporting Limit	0.436		0.396		0.273			
Reporting Unit	ng/g, wet weight		ng/g, wet weight		ng/g, wet weight			
cis-Decalin	U		U		U		NA	NA
trans-Decalin	1.41		1.4		1.58		1.46	6.91
C1-Decalins	9.86		9.1		9.7		9.55	4.19
C2-Decalins	29.54		28.31		25.27		27.71	7.93
C3-Decalins	29.16		26.89		23.49		26.51	10.76
C4-Decalins	50.82		47.43		46.17		48.14	5.00
Benzo(b)thiophene	U		U		U		NA	NA
C1-benzo(b)thiophenes	U		U		U		NA	NA
C2-benzo(b)thiophenes	U		U		U		NA	NA
C3-benzo(b)thiophenes	U		U		U		NA	NA
C4-benzo(b)thiophenes	U		U		U		NA	NA
Naphthalene	1.63	B	1.5	B	1.18	B	1.44	16.12
C1-Naphthalenes	3.73		3.53		2.91		3.39	12.61
C2-Naphthalenes	8.92		9.15		7.4		8.49	11.20
C3-Naphthalenes	13.58		14.28		11.24		13.03	12.22
C4-Naphthalenes	15.32		14.06		11.8		13.73	12.99
Biphenyl	0.54		0.48		0.42		0.48	12.50
Acenaphthylene	U		U		U		NA	NA
Acenaphthene	U		U		U		NA	NA
Dibenzofuran	0.59		0.61		0.53		0.58	7.22
Fluorene	0.99		0.81		0.76		0.85	14.18
C1-Fluorenes	2.51		2.87		2.3		2.56	11.26
C2-Fluorenes	7.47		7.38		6.43		7.09	8.12
C3-Fluorenes	13.44		12.59		9.81		11.95	15.89
Anthracene	U		U		U		NA	NA
Phenanthrene	3.1		3.13		2.62		2.95	9.70
C1-Phenanthrenes/Anthracenes	8.94		9.43		7.94		8.77	8.66
C2-Phenanthrenes/Anthracenes	19.15		19.2		14.51		17.62	15.29
C3-Phenanthrenes/Anthracenes	14.13		14.66		10.97		13.25	15.05
C4-Phenanthrenes/Anthracenes	5.11		6.61		4.01		5.24	24.89
Dibenzothiophene	0.36	J	0.38	J	0.29	B	0.34	13.76
C1-Dibenzothiophenes	2.25		1.96		1.7		1.97	13.97
C2-Dibenzothiophenes	5.16		5.57		3.98		4.90	16.84
C3-Dibenzothiophenes	5.31		5.05		4.1		4.82	13.21
C4-Dibenzothiophenes	3.21		3.18		2.77		3.05	8.05
Fluoranthene	1.73		1.86		1.58		1.72	8.13
Pyrene	0.7	B	0.77		0.51	B	0.66	20.38
C1-Fluoranthenes/Pyrenes	2.29		2.25		1.72		2.09	15.25
C2-Fluoranthenes/Pyrenes	2.75		3.07		2.47		2.76	10.86
C3-Fluoranthenes/Pyrenes	2.59		2.48		2.23		2.43	7.58
Benzo(a)anthracene	U		U		U		NA	NA
Chrysene	1.69		1.93		1.45		1.69	14.20
C1-Chrysenes	1.38		1.42		1.06		1.29	15.34
C2-Chrysenes	0.95		1.3		0.68		0.98	31.83
C3-Chrysenes	U		1		0.81		0.91	14.85
C4-Chrysenes	U		U		U		NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	500 POOL 1	500 POOL 2	500 POOL 3		
Battelle Batch ID					
Battelle ID	R1772-P	R1773-P	R1774-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/30/06	06/30/06	06/30/06		
Moisture Content (%)	85.91	86.23	86.96		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.41	9.92	9	9.44	4.88
Sample weight (g, wet weight)	10.05	11.06	15.97	12.36	25.62
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.746		
Reporting Limit	0.436	0.396	0.273		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	0.13 J	0.11 J	0.11 J	0.12	9.90
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	0.53	0.67	0.45	0.55	20.25
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	U	U	NA	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.08 J	0.1 J	0.08 J	0.09	13.32
Total Decalins	120.79	113.13	106.21	113.38	6.43
Total Naphthalenes	43.18	42.52	34.53	40.08	12.01
Total Phenanthrenes/Anthracenes	50.43	53.03	40.05	47.84	14.36
Total Dibenzothiophenes	16.29	16.14	12.84	15.09	12.92
Total PAH (from naphthalene)	150.26	153.39	120.82	141.49	12.70
Surrogate Recoveries (%)					
Naphthalene-d8	62	74	74		
Acenaphthene-d10	62	73	72		
Phenanthrene-d10	81	94	92		
Benzo(a)pyrene-d12	62	70	73		

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N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	600 POOL 1		600 POOL 2		600 POOL 3			
Battelle Batch ID								
Battelle ID	R1775-P		R1776-P		R1777-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	07/01/06		07/01/06		07/01/06			
Moisture Content (%)	86.06		86.27		85.39			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.46		9.01		10.08		9.52	5.65
Sample weight (g, wet weight)	15.79		15.44		10.92		14.05	19.33
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.754		1.754			
Reporting Limit	0.278		0.284		0.402			
Reporting Unit	ng/g, wet weight		ng/g, wet weight		ng/g, wet weight			
cis-Decalin	0.15	J	0.18	J	0.23	J	0.19	21.65
trans-Decalin	2.29		3.6		3.2		3.03	22.16
C1-Decalins	17.75		22.59		22.3		20.88	13.00
C2-Decalins	51		58.94		62.92		57.62	10.53
C3-Decalins	46.31		58.31		62.66		55.76	15.19
C4-Decalins	85.77		105.6		110.17		100.51	12.90
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	1.51	B	1.24	B	1.52	B	1.42	11.16
C1-Naphthalenes	3.56		3.21		3.85		3.54	9.05
C2-Naphthalenes	10.34		12.3		13.55		12.06	13.41
C3-Naphthalenes	21.12		25.03		24.32		23.49	8.87
C4-Naphthalenes	22.32		26.27		28.44		25.68	12.08
Biphenyl	0.58		0.5		0.61		0.56	10.09
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	0.59		0.67		0.66		0.64	6.81
Fluorene	0.9		1.01		1.22		1.04	15.58
C1-Fluorenes	3.97		4.19		4.1		4.09	2.71
C2-Fluorenes	14.29		13.63		14.02		13.98	2.37
C3-Fluorenes	19.83		20.04		19.23		19.70	2.13
Anthracene		U		U		U	NA	NA
Phenanthrene	3.34		3.73		4.31		3.79	12.87
C1-Phenanthrenes/Anthracenes	12.73		14.29		15.66		14.23	10.30
C2-Phenanthrenes/Anthracenes	26.2		29.59		30.72		28.84	8.16
C3-Phenanthrenes/Anthracenes	21.41		24.58		25.05		23.68	8.36
C4-Phenanthrenes/Anthracenes	8.96		8.19		8.15		8.43	5.41
Dibenzothiophene	0.4		0.42		0.5		0.44	12.03
C1-Dibenzothiophenes	2.65		3.11		3.61		3.12	15.37
C2-Dibenzothiophenes	7.29		7.75		8.14		7.73	5.51
C3-Dibenzothiophenes	10.67		8.91		9.11		9.56	10.08
C4-Dibenzothiophenes	5.14		5.45		5.29		5.29	2.93
Fluoranthene	1.79		2.21		2.34		2.11	13.60
Pyrene	1.2		1.24		1		1.15	11.21
C1-Fluoranthenes/Pyrenes	3.61		3.82		3.58		3.67	3.56
C2-Fluoranthenes/Pyrenes	5.11		5.85		5.73		5.56	7.14
C3-Fluoranthenes/Pyrenes	5		5.43		5.07		5.17	4.47
Benzo(a)anthracene		U		U		U	NA	NA
Chrysene	2.28		2.47		2.48		2.41	4.68
C1-Chrysenes	2.08		2.53		2.33		2.31	9.75
C2-Chrysenes	1.94		1.99		1.8		1.91	5.16
C3-Chrysenes	0.93		1.3		1.53		1.25	24.15
C4-Chrysenes		U		U		U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	600 POOL 1	600 POOL 2	600 POOL 3		
Battelle Batch ID					
Battelle ID	R1775-P	R1776-P	R1777-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	07/01/06	07/01/06	07/01/06		
Moisture Content (%)	86.06	86.27	85.39		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.46	9.01	10.08	9.52	5.65
Sample weight (g, wet weight)	15.79	15.44	10.92	14.05	19.33
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	0.278	0.284	0.402		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	0.2 J	0.25 J	0.18 J	0.21	17.17
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	0.67	0.98	0.91	0.85	19.05
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	0.07 J	U	0.07	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.1 J	0.28 J	0.09 J	0.16	68.25
Total Decalins	203.27	249.22	261.48	237.99	12.89
Total Naphthalenes	58.85	68.05	71.68	66.19	9.99
Total Phenanthrenes/Anthracenes	72.64	80.38	83.89	78.97	7.29
Total Dibenzothiophenes	26.15	25.64	26.65	26.15	1.93
Total PAH (from naphthalene)	222.71	242.53	249.1	238.11	5.77
Surrogate Recoveries (%)					
Naphthalene-d8	69	58	66		
Acenaphthene-d10	69	56	67		
Phenanthrene-d10	88	72	85		
Benzo(a)pyrene-d12	77	61	70		

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	700 POOL 1		700 POOL 2		700 POOL 3			
Battelle Batch ID								
Battelle ID	R1778-P		R1779-P		R1780-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	07/01/06		07/01/06		07/06/06			
Moisture Content (%)	86.82		86.71		86.62			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.31		9.47		9.27		9.35	1.13
Sample weight (g, wet weight)	15.10		15.37		15.25		15.24	0.89
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.754		1.754			
Reporting Limit	0.290		0.285		0.288			
Reporting Unit	ng/g, wet weight		ng/g, wet weight		ng/g, wet weight			
cis-Decalin		U		U		U	NA	NA
trans-Decalin	2.09		2.83		1.89		2.27	21.81
C1-Decalins	15.28		19.5		14		16.26	17.70
C2-Decalins	43.36		52.73		41.87		45.99	12.80
C3-Decalins	42.22		47.86		42.27		44.12	7.35
C4-Decalins	75.41		84.58		78.61		79.53	5.85
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	1.46	B	1.44	B	1.4	B	1.43	2.13
C1-Naphthalenes	3.86		4.22		3.85		3.98	5.30
C2-Naphthalenes	10.78		11.12		10.42		10.77	3.25
C3-Naphthalenes	19.25		20.72		18.3		19.42	6.28
C4-Naphthalenes	21.37		21.07		19.26		20.57	5.55
Biphenyl	0.58		0.67		0.64		0.63	7.27
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	0.58		0.6		0.62		0.60	3.33
Fluorene	0.88		0.96		0.89		0.91	4.79
C1-Fluorenes	3.49		3.29		3.35		3.38	3.04
C2-Fluorenes	10.72		10.64		10.69		10.68	0.38
C3-Fluorenes	13.98		16.37		15.6		15.32	7.96
Anthracene		U		U		U	NA	NA
Phenanthrene	3.47		3.63		3.23		3.44	5.85
C1-Phenanthrenes/Anthracenes	12.11		12.69		11.84		12.21	3.56
C2-Phenanthrenes/Anthracenes	23.95		25.41		23.86		24.41	3.56
C3-Phenanthrenes/Anthracenes	20.3		21.36		19.41		20.36	4.80
C4-Phenanthrenes/Anthracenes	7.54		7.58		8.21		7.78	4.83
Dibenzothiophene	0.39		0.41		0.4		0.40	2.50
C1-Dibenzothiophenes	2.53		2.85		2.49		2.62	7.52
C2-Dibenzothiophenes	6.82		7.26		6.73		6.94	4.09
C3-Dibenzothiophenes	6.92		7.1		7.19		7.07	1.94
C4-Dibenzothiophenes	4.42		4.38		4.68		4.49	3.63
Fluoranthene	1.65		1.76		1.76		1.72	3.69
Pyrene	0.78		0.65	B	0.71	B	0.71	9.12
C1-Fluoranthenes/Pyrenes	2.96		2.98		3.04		2.99	1.39
C2-Fluoranthenes/Pyrenes	4.41		4.66		4.57		4.55	2.78
C3-Fluoranthenes/Pyrenes	4.5		4.47		4.19		4.39	3.90
Benzo(a)anthracene		U		U		U	NA	NA
Chrysene	2.02		2.35		2		2.12	9.26
C1-Chrysenes	1.95		2.02		2.05		2.01	2.56
C2-Chrysenes	1.74		1.73		1.55		1.67	6.39
C3-Chrysenes	1.04		1.04		1.19		1.09	7.95
C4-Chrysenes		U		U		U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	700 POOL 1	700 POOL 2	700 POOL 3		
Battelle Batch ID					
Battelle ID	R1778-P	R1779-P	R1780-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	07/01/06	07/01/06	07/06/06		
Moisture Content (%)	86.82	86.71	86.62		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.31	9.47	9.27	9.35	1.13
Sample weight (g, wet weight)	15.10	15.37	15.25	15.24	0.89
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	0.290	0.285	0.288		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	0.15 J	0.2 J	0.17 J	0.17	14.52
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	0.79	0.86	0.84	0.83	4.34
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.03 J	0.03 J	0.03 J	0.03	0.00
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.09 J	0.1 J	0.11 J	0.10	10.00
Total Decalins	178.36	207.5	178.64	188.17	8.90
Total Naphthalenes	56.72	58.57	53.23	56.17	4.83
Total Phenanthrenes/Anthracenes	67.37	70.67	66.55	68.20	3.20
Total Dibenzothiophenes	21.08	22	21.49	21.52	2.14
Total PAH (from naphthalene)	197.51	206.62	195.27	199.80	3.01
Surrogate Recoveries (%)					
Naphthalene-d8	68	72	68		
Acenaphthene-d10	66	71	67		
Phenanthrene-d10	87	90	90		
Benzo(a)pyrene-d12	71	73	76		

B = Result < 5 x procedural blank
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N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	800 POOL 1		800 POOL 2		800 POOL 3			
Battelle Batch ID								
Battelle ID	R1781-P		R1782-P		R1783-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	07/06/06		07/06/06		07/06/06			
Moisture Content (%)	85.75		85.14		86.58			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.39		10.46		9.69		9.85	5.61
Sample weight (g, wet weight)	15.44		15.19		15.32		15.32	0.82
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.754		1.754			
Reporting Limit	0.284		0.289		0.286			
Reporting Unit	ng/g, wet weight		ng/g, wet weight		ng/g, wet weight			
cis-Decalin		U		U		U	NA	NA
trans-Decalin	3.96		5.68		4.07		4.57	21.07
C1-Decalins	31.36		37.36		30.33		33.02	11.50
C2-Decalins	84.99		102.58		81.97		89.85	12.39
C3-Decalins	79.42		87.51		68.85		78.59	11.91
C4-Decalins	132.11		150.65		122.85		135.20	10.47
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	1.39	B	1.4	B	1.3	B	1.36	4.04
C1-Naphthalenes	3.97		4.16		3.54		3.89	8.17
C2-Naphthalenes	13.51		13.66		11.2		12.79	10.78
C3-Naphthalenes	29.06		30.24		23.55		27.62	12.93
C4-Naphthalenes	34.39		36.47		29.86		33.57	10.07
Biphenyl	0.65		0.71		0.73		0.70	5.98
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	0.62		0.71		0.59		0.64	9.76
Fluorene	1.26		1.06		1.02		1.11	11.55
C1-Fluorenes	5.27		5.65		4.71		5.21	9.08
C2-Fluorenes	19.17		19.29		15.23		17.90	12.91
C3-Fluorenes	31.25		29.52		25.42		28.73	10.42
Anthracene		U		U		U	NA	NA
Phenanthrene	4.37		4.48		3.79		4.21	8.80
C1-Phenanthrenes/Anthracenes	21.25		21.03		16.43		19.57	13.91
C2-Phenanthrenes/Anthracenes	48.96		45.05		37.13		43.71	13.79
C3-Phenanthrenes/Anthracenes	44.87		38.29		31.12		38.09	18.05
C4-Phenanthrenes/Anthracenes	16.11		14.14		12.34		14.20	13.28
Dibenzothiophene	0.51		0.51		0.46		0.49	5.85
C1-Dibenzothiophenes	4.66		4.64		3.4		4.23	17.05
C2-Dibenzothiophenes	12.74		12.48		11.09		12.10	7.33
C3-Dibenzothiophenes	16.07		13.99		11.2		13.75	17.77
C4-Dibenzothiophenes	9.1		7.63		7.84		8.19	9.71
Fluoranthene	2.48		2.45		2.3		2.41	4.00
Pyrene	1.19		1.16		1.04		1.13	7.02
C1-Fluoranthenes/Pyrenes	6.9		6.3		5.09		6.10	15.12
C2-Fluoranthenes/Pyrenes	11.74		9.28		7.95		9.66	19.91
C3-Fluoranthenes/Pyrenes	10.48		8.64		7.25		8.79	18.43
Benzo(a)anthracene		U	4.69			U	4.69	NA
Chrysene	4.33		4.3		3.64		4.09	9.54
C1-Chrysenes	5.62		4.29		3.81		4.57	20.50
C2-Chrysenes	4.19		3.2		2.66		3.35	23.16
C3-Chrysenes	2.76		2.09		1.36		2.07	33.83
C4-Chrysenes		U		U		U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	800 POOL 1	800 POOL 2	800 POOL 3		
Battelle Batch ID					
Battelle ID	R1781-P	R1782-P	R1783-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	07/06/06	07/06/06	07/06/06		
Moisture Content (%)	85.75	85.14	86.58		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.39	10.46	9.69	9.85	5.61
Sample weight (g, wet weight)	15.44	15.19	15.32	15.32	0.82
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	0.284	0.289	0.286		
Reporting Unit	ng/g, wet weight	ng/g, wet weight	ng/g, wet weight		
Benzo(b)fluoranthene	0.53	0.35	0.33	0.40	27.31
Benzo(k)fluoranthene	0.21 J	0.12 J	0.17 J	0.17	27.06
Benzo(e)pyrene	1.6	1.42	1.22	1.41	13.45
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.08 J	0.07 J	U	0.08	9.43
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.14 J	0.14 J	0.13 J	0.14	4.22
Total Decalins	331.84	383.78	308.07	341.23	11.35
Total Naphthalenes	82.32	85.93	69.45	79.23	10.93
Total Phenanthrenes/Anthracenes	135.56	122.99	100.81	119.79	14.69
Total Dibenzothiophenes	43.08	39.25	33.99	38.77	11.77
Total PAH (from naphthalene)	371.43	353.61	288.9	337.98	12.85
Surrogate Recoveries (%)					
Naphthalene-d8	66	65	65		
Acenaphthene-d10	64	64	64		
Phenanthrene-d10	83	84	84		
Benzo(a)pyrene-d12	81	83	80		

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	100 POOL 1	100 POOL 2	100 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1757-P	R1758-P	R1759-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	83.84	84.01	83.91		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.16	9.45	10.58	9.73	7.71
Sample weight (g, dry weight)	0.76	1.61	1.66	1.34	37.65
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.75		
Reporting Limit	5.770	2.724	2.636		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
cis-Decalin	U	U	U	NA	NA
trans-Decalin	U	U	U	NA	NA
C1-Decalins	U	U	U	NA	NA
C2-Decalins	U	U	U	NA	NA
C3-Decalins	U	U	U	NA	NA
C4-Decalins	U	U	U	NA	NA
Benzo(b)thiophene	U	U	U	NA	NA
C1-benzo(b)thiophenes	U	U	U	NA	NA
C2-benzo(b)thiophenes	U	U	U	NA	NA
C3-benzo(b)thiophenes	U	U	U	NA	NA
C4-benzo(b)thiophenes	U	U	U	NA	NA
Naphthalene	8.56 B	5.05 B	4.04 B	5.88	40.32
C1-Naphthalenes	3.94 J	1.47 J	1.65 J	2.35	58.51
C2-Naphthalenes	U	U	U	NA	NA
C3-Naphthalenes	U	U	U	NA	NA
C4-Naphthalenes	U	U	U	NA	NA
Biphenyl	2.09 J	0.57 J	1.57 J	1.41	54.79
Acenaphthylene	U	U	U	NA	NA
Acenaphthene	U	U	U	NA	NA
Dibenzofuran	4.4 J	3.74	4.4	4.18	9.12
Fluorene	3.23 J	2.61 J	2.86	2.90	10.76
C1-Fluorenes	3.74 J	3.22	3.02	3.33	11.17
C2-Fluorenes	9.8	6.56	5.17	7.18	33.10
C3-Fluorenes	U	U	U	NA	NA
Anthracene	0.59 J	0.27 J	0.43 J	0.43	37.21
Phenanthrene	9.26 B	5.78 B	5.8 B	6.95	28.84
C1-Phenanthrenes/Anthracenes	6.66 B	4.84 B	4.3 B	5.27	23.48
C2-Phenanthrenes/Anthracenes	6.16	5.07	3.9	5.04	22.41
C3-Phenanthrenes/Anthracenes	3.36 J	2.66 J	3.2	3.07	11.93
C4-Phenanthrenes/Anthracenes	U	U	U	NA	NA
Dibenzothiophene	0.78 J	0.43 J	0.5 J	0.57	32.49
C1-Dibenzothiophenes	3.76 J	2.18 J	1.6 J	2.51	44.48
C2-Dibenzothiophenes	5.39 J	3.38	3.42	4.06	28.28
C3-Dibenzothiophenes	U	U	U	NA	NA
C4-Dibenzothiophenes	U	U	U	NA	NA
Fluoranthene	13.95	9.32	8.25	10.51	28.84
Pyrene	8.53	1.93 J	1.78 J	4.08	94.47
C1-Fluoranthenes/Pyrenes	3.51 J	2.01 J	1.79 J	2.44	38.41
C2-Fluoranthenes/Pyrenes	U	U	U	NA	NA
C3-Fluoranthenes/Pyrenes	U	U	U	NA	NA
Benzo(a)anthracene	U	U	U	NA	NA
Chrysene	6.19	3.9	3.08	4.39	36.72
C1-Chrysenes	0.97 J	0.46 J	0.24 J	0.56	67.27
C2-Chrysenes	U	U	U	NA	NA
C3-Chrysenes	U	U	U	NA	NA
C4-Chrysenes	U	U	U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	100 POOL 1	100 POOL 2	100 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1757-P	R1758-P	R1759-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	83.84	84.01	83.91		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.16	9.45	10.58	9.73	7.71
Sample weight (g, dry weight)	0.76	1.61	1.66	1.34	37.65
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.75		
Reporting Limit	5.770	2.724	2.636		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	U	U	U	NA	NA
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	U	U	U	NA	NA
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	1.56 J	0.3 J	0.22 J	0.69	108.41
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	1.92 J	0.3 J	0.37 J	0.86	106.07
Total Decalins	0	0	0	0.00	NA
Total Naphthalenes	12.5	6.52	5.69	8.24	45.11
Total Phenanthrenes/Anthracenes	26.03	18.62	17.63	20.76	22.11
Total Dibenzothiophenes	9.93	5.99	5.52	7.15	33.89
Total PAH (from naphthalene)	108.35	66.05	61.59	78.66	32.81
Surrogate Recoveries (%)					
Naphthalene-d8	71	62	73		
Acenaphthene-d10	70	62	70		
Phenanthrene-d10	90	80	91		
Benzo(a)pyrene-d12	71	62	69		

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	200 POOL 1	200 POOL 2	200 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1760-P	R1761-P	R1762-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	86.35	87.38	86.76		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	8.72	8.39	10.14	9.08	10.24
Sample weight (g, dry weight)	2.06	1.92	1.39	1.79	19.74
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	2.129	2.284	3.155		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
cis-Decalin	U	U	U	NA	NA
trans-Decalin	U	U	U	NA	NA
C1-Decalins	U	U	U	NA	NA
C2-Decalins	U	U	U	NA	NA
C3-Decalins	U	U	U	NA	NA
C4-Decalins	U	U	U	NA	NA
Benzo(b)thiophene	U	U	U	NA	NA
C1-benzo(b)thiophenes	U	U	U	NA	NA
C2-benzo(b)thiophenes	U	U	U	NA	NA
C3-benzo(b)thiophenes	U	U	U	NA	NA
C4-benzo(b)thiophenes	U	U	U	NA	NA
Naphthalene	3.42 B	2.78 B	4.54 B	3.58	24.88
C1-Naphthalenes	1.13 J	1.1 J	2.11 J	1.45	39.72
C2-Naphthalenes	U	U	U	NA	NA
C3-Naphthalenes	U	U	U	NA	NA
C4-Naphthalenes	U	U	U	NA	NA
Biphenyl	0.99 J	0.83 J	0.89 J	0.90	8.95
Acenaphthylene	U	U	U	NA	NA
Acenaphthene	U	U	1.75 J	1.75	NA
Dibenzofuran	2.39	2.5	3.11 J	2.67	14.54
Fluorene	1.83 J	1.22 J	1.94 J	1.66	23.32
C1-Fluorenes	2.01 J	U	U	2.01	NA
C2-Fluorenes	6.16	U	6.01	6.09	1.74
C3-Fluorenes	U	U	U	NA	NA
Anthracene	U	U	U	NA	NA
Phenanthrene	4.11 B	3.87 B	4 B	3.99	3.01
C1-Phenanthrenes/Anthracenes	3.72 B	3.13 B	4.03 B	3.63	12.61
C2-Phenanthrenes/Anthracenes	4.2	4.93	3.98	4.37	11.38
C3-Phenanthrenes/Anthracenes	4.47	4.22	3.84	4.18	7.60
C4-Phenanthrenes/Anthracenes	U	U	U	NA	NA
Dibenzothiophene	0.59 J	0.47 J	0.47 J	0.51	13.58
C1-Dibenzothiophenes	1.6 J	1.42 J	2.07 J	1.70	19.78
C2-Dibenzothiophenes	2.93	2.74	3.1 J	2.92	6.16
C3-Dibenzothiophenes	U	U	U	NA	NA
C4-Dibenzothiophenes	U	U	U	NA	NA
Fluoranthene	6.07	4.84	5.71	5.54	11.41
Pyrene	1.72 J	1.78 J	1.92 J	1.81	5.68
C1-Fluoranthenes/Pyrenes	1.4 J	0.71 J	1.65 J	1.25	38.85
C2-Fluoranthenes/Pyrenes	U	U	U	NA	NA
C3-Fluoranthenes/Pyrenes	U	U	U	NA	NA
Benzo(a)anthracene	0.18 J	0.09 J	0.14 J	0.14	32.99
Chrysene	2.82	3.29	2.26 J	2.79	18.48
C1-Chrysenes	0.4 J	0.28 J	0.2 J	0.29	34.32
C2-Chrysenes	U	U	U	NA	NA
C3-Chrysenes	U	U	U	NA	NA
C4-Chrysenes	U	U	U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	200 POOL 1	200 POOL 2	200 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1760-P	R1761-P	R1762-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/29/06		
Moisture Content (%)	86.35	87.38	86.76		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	8.72	8.39	10.14	9.08	10.24
Sample weight (g, dry weight)	2.06	1.92	1.39	1.79	19.74
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	2.129	2.284	3.155		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	U	0.73 J	1.43 J	1.08	45.83
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	0.42 J	U	U	0.42	NA
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.35 J	0.3 J	0.27 J	0.31	13.18
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.38 J	0.39 J	U	0.39	1.84
Total Decalins	0	0	0	0.00	NA
Total Naphthalenes	4.55	3.88	6.65	5.03	28.75
Total Phenanthrenes/Anthracenes	16.5	16.15	15.85	16.17	2.01
Total Dibenzothiophenes	5.12	4.63	5.64	5.13	9.85
Total PAH (from naphthalene)	53.29	41.62	55.42	50.11	14.83
Surrogate Recoveries (%)					
Naphthalene-d8	71	64	70		
Acenaphthene-d10	70	64	69		
Phenanthrene-d10	90	82	89		
Benzo(a)pyrene-d12	66	60	64		

B = Result < 5 x procedural blank
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N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	300 POOL 1	300 POOL 2	300 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1763-P	R1764-P	R1765-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/30/06		
Moisture Content (%)	87.11	86.89	87.3		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.57	10.14	9.7	9.80	3.05
Sample weight (g, dry weight)	1.31	1.99	1.93	1.74	21.60
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	3.347	2.204	2.272		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
cis-Decalin	4.84	4.89	4.59	4.77	3.37
trans-Decalin	102.31	98.44	92.63	97.79	4.98
C1-Decalins	445.83	445.15	413.42	434.80	4.26
C2-Decalins	913.55	941.73	917.32	924.20	1.66
C3-Decalins	742.31	751.33	742.7	745.45	0.68
C4-Decalins	1238.46	1250.47	1180.35	1223.09	3.07
Benzo(b)thiophene	U	U	U	NA	NA
C1-benzo(b)thiophenes	U	U	U	NA	NA
C2-benzo(b)thiophenes	U	U	U	NA	NA
C3-benzo(b)thiophenes	U	U	U	NA	NA
C4-benzo(b)thiophenes	U	U	U	NA	NA
Naphthalene	26.32 B	24.6 B	24.85 B	25.26	3.68
C1-Naphthalenes	87.9	86.94	85.82	86.89	1.20
C2-Naphthalenes	264.57	252.26	254.54	257.12	2.55
C3-Naphthalenes	428.32	429.16	430.52	429.33	0.26
C4-Naphthalenes	418.03	401.49	438.54	419.35	4.43
Biphenyl	11.56	11.58	10.23	11.12	6.96
Acenaphthylene	U	U	U	NA	NA
Acenaphthene	U	U	U	NA	NA
Dibenzofuran	5.11	5.64	5.78	5.51	6.41
Fluorene	17.46	15.3	15.4	16.05	7.59
C1-Fluorenes	70.88	67.45	65.13	67.82	4.27
C2-Fluorenes	214.19	192.49	194.7	200.46	5.96
C3-Fluorenes	278.97	239.38	276.63	264.99	8.38
Anthracene	U	U	U	NA	NA
Phenanthrene	55	52.75	51.8	53.18	3.09
C1-Phenanthrenes/Anthracenes	233.37	214.58	223.24	223.73	4.20
C2-Phenanthrenes/Anthracenes	465.45	400.16	427.34	430.98	7.61
C3-Phenanthrenes/Anthracenes	402.95	332.26	378.41	371.21	9.67
C4-Phenanthrenes/Anthracenes	163.43	111.79	131.48	135.57	19.22
Dibenzothiophene	6.22	6.09	5.55	5.95	5.97
C1-Dibenzothiophenes	46.99	40.38	46.67	44.68	8.34
C2-Dibenzothiophenes	129.43	101.79	110.71	113.98	12.38
C3-Dibenzothiophenes	129.78	104.58	121.77	118.71	10.85
C4-Dibenzothiophenes	77.24	54.76	61.16	64.39	17.99
Fluoranthene	17.21	15.22	16.39	16.27	6.15
Pyrene	12.47	11.12	10.24	11.28	9.96
C1-Fluoranthenes/Pyrenes	65.91	52.41	58.96	59.09	11.42
C2-Fluoranthenes/Pyrenes	101.59	80.31	88.53	90.14	11.90
C3-Fluoranthenes/Pyrenes	98.91	75.18	85.69	86.59	13.73
Benzo(a)anthracene	U	U	U	NA	NA
Chrysene	35.75	31.12	31.22	32.70	8.09
C1-Chrysenes	45.82	33.13	36.16	38.37	17.27
C2-Chrysenes	34.57	25.68	27.02	29.09	16.48
C3-Chrysenes	22.61	15.96	16.15	18.24	20.76
C4-Chrysenes	U	U	U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	300 POOL 1	300 POOL 2	300 POOL 3		
Battelle Batch ID	06-0239	06-0239	06-0239		
Battelle ID	R1763-P	R1764-P	R1765-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/29/06	06/29/06	06/30/06		
Moisture Content (%)	87.11	86.89	87.3		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.57	10.14	9.7	9.80	3.05
Sample weight (g, dry weight)	1.31	1.99	1.93	1.74	21.60
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	3.347	2.204	2.272		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	3.24 J	2.12 J	2.53	2.63	21.55
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	14.04	12.05	12.64	12.91	7.92
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	U	U	NA	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	1.14 J	1.18 J	1.22 J	1.18	3.39
Total Decalins	3447.3	3492.01	3351.01	3430.11	2.10
Total Naphthalenes	1225.14	1194.45	1234.27	1217.95	1.71
Total Phenanthrenes/Anthracenes	1320.2	1111.54	1212.27	1214.67	8.59
Total Dibenzothiophenes	389.66	307.6	345.86	347.71	11.81
Total PAH (from naphthalene)	3986.43	3500.91	3747.02	3744.79	6.48
Surrogate Recoveries (%)					
Naphthalene-d8	69	68	74		
Acenaphthene-d10	70	69	74		
Phenanthrene-d10	90	88	97		
Benzo(a)pyrene-d12	74	75	82		

B = Result < 5 x procedural blank
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N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

	300 2M DEPTH POOL		300 2M DEPTH POOL		300 2M DEPTH POOL			
Client ID	1		2		3			
Battelle Batch ID								
Battelle ID	R1766-P		R1767-P		R1768-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	06/30/06		06/30/06		06/30/06			
Moisture Content (%)	86.36		87.11		87.27			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.93		8.25		9.6		9.26	9.61
Sample weight (g, dry weight)	2.14		1.99		1.93		2.02	5.35
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.75		1.754			
Reporting Limit	2.049		2.198		2.272			
Reporting Unit	ng/g, dry weight		ng/g, dry weight		ng/g, dry weight			
cis-Decalin	1.99	J	1.64	J	1.43	J	1.69	16.77
trans-Decalin	72.15		44.48		47.4		54.68	27.80
C1-Decalins	423.28		300.38		280.72		334.79	23.08
C2-Decalins	1104.33		898.1		719.29		907.24	21.24
C3-Decalins	972.19		795.81		604.87		790.96	23.23
C4-Decalins	1677.78		1323.19		1008.73		1336.57	25.04
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	17.03	B	12.82	B	12.61	B	14.15	17.62
C1-Naphthalenes	49.45		34.17		36.95		40.19	20.25
C2-Naphthalenes	176.04		138.39		124.64		146.36	18.18
C3-Naphthalenes	384.24		304.73		259.02		316.00	20.05
C4-Naphthalenes	467.17		360.96		283.15		370.43	24.94
Biphenyl	6.75		6.4		5.38		6.18	11.52
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	5.77		3.62		3.81		4.40	27.05
Fluorene	9.78		9.11		8.82		9.24	5.33
C1-Fluorenes	60.76		46.85		35.21		47.61	26.87
C2-Fluorenes	213.28		184.76		127.41		175.15	24.97
C3-Fluorenes	337.57		266.61		190.06		264.75	27.87
Anthracene		U		U		U	NA	NA
Phenanthrene	45.12		33.72		32.24		37.03	19.03
C1-Phenanthrenes/Anthracenes	232.28		180.81		148.31		187.13	22.63
C2-Phenanthrenes/Anthracenes	496.13		403.61		310.09		403.28	23.07
C3-Phenanthrenes/Anthracenes	448.47		379.76		278.77		369.00	23.13
C4-Phenanthrenes/Anthracenes	180.36		132.46		106.71		139.84	26.73
Dibenzothiophene	4.71		4.11		3.57		4.13	13.81
C1-Dibenzothiophenes	47.51		35.83		30.9		38.08	22.40
C2-Dibenzothiophenes	124.22		106.99		83.72		104.98	19.36
C3-Dibenzothiophenes	148.02		122.64		87.11		119.26	25.66
C4-Dibenzothiophenes	77.92		71.82		49.48		66.41	22.55
Fluoranthene	18.83		13.71		14.3		15.61	17.94
Pyrene	12.11		12.19		7.03		10.44	28.31
C1-Fluoranthenes/Pyrenes	65.09		56.06		41.34		54.16	22.13
C2-Fluoranthenes/Pyrenes	99.52		87.69		63.16		83.46	22.22
C3-Fluoranthenes/Pyrenes	96.25		85.79		59.6		80.55	23.44
Benzo(a)anthracene		U		U	0.38	J	0.38	NA
Chrysene	37.36		30.14		24.61		30.70	20.82
C1-Chrysenes	43.79		35.02		29.71		36.17	19.66
C2-Chrysenes	31.57		27.29		20.18		26.35	21.84
C3-Chrysenes	15.38		16.59		14.15		15.37	7.94
C4-Chrysenes		U		U		U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

	300 2M DEPTH POOL		300 2M DEPTH POOL		300 2M DEPTH POOL			
Client ID	1		2		3			
Battelle Batch ID								
Battelle ID	R1766-P		R1767-P		R1768-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	06/30/06		06/30/06		06/30/06			
Moisture Content (%)	86.36		87.11		87.27			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.93		8.25		9.6		9.26	9.61
Sample weight (g, dry weight)	2.14		1.99		1.93		2.02	5.35
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.75		1.754			
Reporting Limit	2.049		2.198		2.272			
Reporting Unit	ng/g, dry weight		ng/g, dry weight		ng/g, dry weight			
Benzo(b)fluoranthene	3.42		2.84		1.63	J	2.63	34.73
Benzo(k)fluoranthene	1.49	J	1.14	J	0.88	J	1.17	26.16
Benzo(e)pyrene	13.91		11.72		9.22		11.62	20.20
Benzo(a)pyrene		U		U		U	NA	NA
Perylene		U		U		U	NA	NA
Indeno(1,2,3-cd)pyrene	0.59	J	0.47	J	0.32	J	0.46	29.41
Dibenz(a,h)anthracene		U		U		U	NA	NA
Benzo(g,h,i)perylene	1.15	J	1.17	J	0.69	J	1.00	27.06
Total Decalins	4251.72		3363.6		2662.44		3425.92	23.25
Total Naphthalenes	1093.93		851.07		716.37		887.12	21.57
Total Phenanthrenes/Anthracenes	1402.36		1130.36		876.12		1136.28	23.16
Total Dibenzothiophenes	402.38		341.39		254.78		332.85	22.28
Total PAH (from naphthalene)	3973.04		3221.99		2505.16		3233.40	22.70
Surrogate Recoveries (%)								
Naphthalene-d8	70		67		68			
Acenaphthene-d10	71		66		68			
Phenanthrene-d10	90		85		86			
Benzo(a)pyrene-d12	79		72		73			

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	400 POOL 1		400 POOL 2		400 POOL 3			
Battelle Batch ID								
Battelle ID	R1769-P		R1770-P		R1771-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	06/30/06		06/30/06		06/30/06			
Moisture Content (%)	86.07		86.73		85.32			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	10.09		8.76		9.65		9.50	7.13
Sample weight (g, dry weight)	1.41		2.09		1.48		1.66	22.53
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.746		1.754		1.754			
Reporting Limit	3.096		2.098		2.963			
Reporting Unit	ng/g, dry weight		ng/g, dry weight		ng/g, dry weight			
cis-Decalin	1.56	J	2.42		2.29	J	2.09	22.18
trans-Decalin	64.39		42.35		53.28		53.34	20.66
C1-Decalins	387.44		216.28		257.82		287.18	31.09
C2-Decalins	1000.67		544.33		666.99		737.33	32.03
C3-Decalins	821.23		432.42		571.44		608.36	32.38
C4-Decalins	1539.76		841.33		1092.01		1157.70	30.56
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	18.4	B	12.76	B	17.14	B	16.10	18.39
C1-Naphthalenes	51.12		38.6		49.45		46.39	14.65
C2-Naphthalenes	170.79		115.38		146.58		144.25	19.26
C3-Naphthalenes	340.73		201.79		266.48		269.67	25.78
C4-Naphthalenes	390.96		212.05		279.65		294.22	30.71
Biphenyl	6.31		5.43		5.66		5.80	7.87
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	5.85		3.84		4.31		4.67	22.53
Fluorene	10.84		7.17		9.65		9.22	20.31
C1-Fluorenes	55.91		34.57		42.13		44.20	24.48
C2-Fluorenes	178.01		103.5		142.73		141.41	26.36
C3-Fluorenes	268.67		152.29		195.62		205.53	28.62
Anthracene		U		U		U	NA	NA
Phenanthrene	42.66		30.33		38.46		37.15	16.87
C1-Phenanthrenes/Anthracenes	199.35		121.97		170.83		164.05	23.85
C2-Phenanthrenes/Anthracenes	426.94		236.77		347.04		336.92	28.34
C3-Phenanthrenes/Anthracenes	374.5		206.2		291.17		290.62	28.96
C4-Phenanthrenes/Anthracenes	145.05		97.99		107.81		116.95	21.23
Dibenzothiophene	5.23		3.15		4.17		4.18	24.86
C1-Dibenzothiophenes	44.59		26.47		33.21		34.76	26.35
C2-Dibenzothiophenes	115.06		62.1		90.37		89.18	29.72
C3-Dibenzothiophenes	125.67		65.97		101.14		97.59	30.75
C4-Dibenzothiophenes	73.08		39.64		58.99		57.24	29.33
Fluoranthene	18.66		12.72		16.81		16.06	18.92
Pyrene	10.7		7.76		10.17		9.54	16.42
C1-Fluoranthenes/Pyrenes	52.26		27.78		41.22		40.42	30.33
C2-Fluoranthenes/Pyrenes	84.14		43.75		57.73		61.87	33.15
C3-Fluoranthenes/Pyrenes	83.76		44.19		59.03		62.33	32.07
Benzo(a)anthracene		U		U		U	NA	NA
Chrysene	34.77		20.16		25.16		26.70	27.81
C1-Chrysenes	39.57		20.61		27.39		29.19	32.91
C2-Chrysenes	29.65		17.04		20.41		22.37	29.19
C3-Chrysenes	18.12		9.83		15.17		14.37	29.23
C4-Chrysenes		U		U		U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	400 POOL 1	400 POOL 2	400 POOL 3		
Battelle Batch ID					
Battelle ID	R1769-P	R1770-P	R1771-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/30/06	06/30/06	06/30/06		
Moisture Content (%)	86.07	86.73	85.32		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	10.09	8.76	9.65	9.50	7.13
Sample weight (g, dry weight)	1.41	2.09	1.48	1.66	22.53
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.746	1.754	1.754		
Reporting Limit	3.096	2.098	2.963		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	3.06 J	2.16	2.16 J	2.46	21.12
Benzo(k)fluoranthene	0.79 J	1.14 J	U	0.97	25.65
Benzo(e)pyrene	12.43	7.36	10.93	10.24	25.43
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	U	U	NA	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	1.05 J	0.74 J	1.13 J	0.97	21.16
Total Decalins	3815.05	2079.13	2643.83	2846.00	31.11
Total Naphthalenes	972	580.58	759.3	770.63	25.43
Total Phenanthrenes/Anthracenes	1188.5	693.26	955.31	945.69	26.20
Total Dibenzothiophenes	363.63	197.33	287.88	282.95	29.43
Total PAH (from naphthalene)	3438.68	1964.74	2682.1	2695.17	27.35
Surrogate Recoveries (%)					
Naphthalene-d8	66	68	70		
Acenaphthene-d10	66	68	72		
Phenanthrene-d10	85	86	92		
Benzo(a)pyrene-d12	71	72	71		

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Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	500 POOL 1		500 POOL 2		500 POOL 3			
Battelle Batch ID								
Battelle ID	R1772-P		R1773-P		R1774-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	06/30/06		06/30/06		06/30/06			
Moisture Content (%)	85.91		86.23		86.96			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.41		9.92		9		9.44	4.88
Sample weight (g, dry weight)	1.42		1.52		2.08		1.67	21.26
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.754		1.746			
Reporting Limit	3.088		2.885		2.099			
Reporting Unit	ng/g, dry weight		ng/g, dry weight		ng/g, dry weight			
cis-Decalin		U		U		U	NA	NA
trans-Decalin	9.98		10.15		12.09		10.74	10.91
C1-Decalins	69.75		66.2		74.5		70.15	5.94
C2-Decalins	209.1		205.99		194		203.03	3.93
C3-Decalins	206.39		195.64		180.32		194.12	6.75
C4-Decalins	359.7		345.13		354.48		353.10	2.09
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	11.56	B	10.95	B	9.02	B	10.51	12.62
C1-Naphthalenes	26.37		25.72		22.31		24.80	8.79
C2-Naphthalenes	63.16		66.55		56.83		62.18	7.93
C3-Naphthalenes	96.08		103.89		86.29		95.42	9.24
C4-Naphthalenes	108.41		102.29		90.58		100.43	9.02
Biphenyl	3.85		3.46		3.23		3.51	8.92
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	4.16		4.44		4.08		4.23	4.47
Fluorene	6.99		5.87		5.8		6.22	10.74
C1-Fluorenes	17.79		20.92		17.68		18.80	9.79
C2-Fluorenes	52.87		53.7		49.35		51.97	4.44
C3-Fluorenes	95.11		91.57		75.29		87.32	12.10
Anthracene		U		U		U	NA	NA
Phenanthrene	21.91		22.76		20.09		21.59	6.32
C1-Phenanthrenes/Anthracenes	63.29		68.61		60.99		64.30	6.08
C2-Phenanthrenes/Anthracenes	135.56		139.67		111.39		128.87	11.86
C3-Phenanthrenes/Anthracenes	100.03		106.69		84.2		96.97	11.91
C4-Phenanthrenes/Anthracenes	36.19		48.06		30.79		38.35	23.04
Dibenzothiophene	2.58	J	2.76	J	2.26	B	2.53	10.00
C1-Dibenzothiophenes	15.96		14.26		13.07		14.43	10.07
C2-Dibenzothiophenes	36.49		40.53		30.56		35.86	13.98
C3-Dibenzothiophenes	37.56		36.77		31.49		35.27	9.36
C4-Dibenzothiophenes	22.7		23.14		21.25		22.36	4.42
Fluoranthene	12.27		13.57		12.16		12.67	6.19
Pyrene	4.94	B	5.63		3.93	B	4.83	17.69
C1-Fluoranthenes/Pyrenes	16.17		16.36		13.2		15.24	11.63
C2-Fluoranthenes/Pyrenes	19.47		22.35		18.93		20.25	9.08
C3-Fluoranthenes/Pyrenes	18.33		18.06		17.13		17.84	3.53
Benzo(a)anthracene		U		U		U	NA	NA
Chrysene	11.96		14.01		11.11		12.36	12.06
C1-Chrysenes	9.74		10.34		8.12		9.40	12.22
C2-Chrysenes	6.75		9.46		5.25		7.15	29.83
C3-Chrysenes		U	7.29		6.21		6.75	11.31
C4-Chrysenes		U		U		U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	500 POOL 1	500 POOL 2	500 POOL 3		
Battelle Batch ID					
Battelle ID	R1772-P	R1773-P	R1774-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	06/30/06	06/30/06	06/30/06		
Moisture Content (%)	85.91	86.23	86.96		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.41	9.92	9	9.44	4.88
Sample weight (g, dry weight)	1.42	1.52	2.08	1.67	21.26
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.746		
Reporting Limit	3.088	2.885	2.099		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	0.9 J	0.78 J	0.81 J	0.83	7.52
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	3.72	4.87	3.44	4.01	18.90
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	U	U	NA	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.57 J	0.73 J	0.58 J	0.63	14.30
Total Decalins	854.92	823.11	815.39	831.14	2.52
Total Naphthalenes	305.58	309.4	265.03	293.34	8.38
Total Phenanthrenes/Anthracenes	356.98	385.79	307.46	350.08	11.32
Total Dibenzothiophenes	115.29	117.46	98.63	110.46	9.33
Total PAH (from naphthalene)	1063.44	1116.06	927.42	1035.64	9.40
Surrogate Recoveries (%)					
Naphthalene-d8	62	74	74		
Acenaphthene-d10	62	73	72		
Phenanthrene-d10	81	94	92		
Benzo(a)pyrene-d12	62	70	73		

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J = Detected below Reporting Limit.
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Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	600 POOL 1		600 POOL 2		600 POOL 3			
Battelle Batch ID								
Battelle ID	R1775-P		R1776-P		R1777-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	07/01/06		07/01/06		07/01/06			
Moisture Content (%)	86.06		86.27		85.39			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.46		9.01		10.08		9.52	5.65
Sample weight (g, dry weight)	2.20		2.12		1.60		1.97	16.51
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.754		1.754			
Reporting Limit	1.993		2.068		2.741			
Reporting Unit	ng/g, dry weight		ng/g, dry weight		ng/g, dry weight			
cis-Decalin	1.04	J	1.32	J	1.48	J	1.28	17.40
trans-Decalin	16.4		26.23		21.86		21.50	22.91
C1-Decalins	127.36		164.5		152.21		148.02	12.78
C2-Decalins	366.05		429.22		429.41		408.23	8.95
C3-Decalins	332.38		424.67		427.66		394.90	13.72
C4-Decalins	615.6		769.05		751.91		712.19	11.81
Benzo(b)thiophene	U		U		U		NA	NA
C1-benzo(b)thiophenes	U		U		U		NA	NA
C2-benzo(b)thiophenes	U		U		U		NA	NA
C3-benzo(b)thiophenes	U		U		U		NA	NA
C4-benzo(b)thiophenes	U		U		U		NA	NA
Naphthalene	10.87	B	9.03	B	10.37	B	10.09	9.43
C1-Naphthalenes	25.58		23.36		26.25		25.06	6.04
C2-Naphthalenes	74.22		89.61		92.46		85.43	11.49
C3-Naphthalenes	151.61		182.3		165.96		166.62	9.22
C4-Naphthalenes	160.22		191.36		194.12		181.90	10.35
Biphenyl	4.19		3.62		4.17		3.99	8.10
Acenaphthylene	U		U		U		NA	NA
Acenaphthene	U		U		U		NA	NA
Dibenzofuran	4.21		4.88		4.49		4.53	7.43
Fluorene	6.46		7.35		8.33		7.38	12.67
C1-Fluorenes	28.49		30.49		27.97		28.98	4.59
C2-Fluorenes	102.54		99.24		95.69		99.16	3.45
C3-Fluorenes	142.31		145.93		131.27		139.84	5.46
Anthracene	U		U		U		NA	NA
Phenanthrene	23.97		27.14		29.4		26.84	10.16
C1-Phenanthrenes/Anthracenes	91.39		104.04		106.91		100.78	8.19
C2-Phenanthrenes/Anthracenes	188.08		215.49		209.69		204.42	7.07
C3-Phenanthrenes/Anthracenes	153.64		179.04		170.96		167.88	7.73
C4-Phenanthrenes/Anthracenes	64.29		59.63		55.61		59.84	7.26
Dibenzothiophene	2.84		3.05		3.41		3.10	9.30
C1-Dibenzothiophenes	19.05		22.67		24.63		22.12	12.80
C2-Dibenzothiophenes	52.33		56.45		55.54		54.77	3.95
C3-Dibenzothiophenes	76.57		64.93		62.16		67.89	11.26
C4-Dibenzothiophenes	36.9		39.69		36.07		37.55	5.05
Fluoranthene	12.85		16.11		15.96		14.97	12.29
Pyrene	8.59		9.06		6.84		8.16	14.33
C1-Fluoranthenes/Pyrenes	25.89		27.81		24.46		26.05	6.45
C2-Fluoranthenes/Pyrenes	36.67		42.6		39.09		39.45	7.56
C3-Fluoranthenes/Pyrenes	35.88		39.57		34.61		36.69	7.02
Benzo(a)anthracene	U		U		U		NA	NA
Chrysene	16.36		18		16.93		17.10	4.87
C1-Chrysenes	14.92		18.44		15.9		16.42	11.06
C2-Chrysenes	13.92		14.52		12.3		13.58	8.46
C3-Chrysenes	6.65		9.44		10.47		8.85	22.32
C4-Chrysenes	U		U		U		NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	600 POOL 1	600 POOL 2	600 POOL 3		
Battelle Batch ID					
Battelle ID	R1775-P	R1776-P	R1777-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	07/01/06	07/01/06	07/01/06		
Moisture Content (%)	86.06	86.27	85.39		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.46	9.01	10.08	9.52	5.65
Sample weight (g, dry weight)	2.20	2.12	1.60	1.97	16.51
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	1.993	2.068	2.741		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	1.44 J	1.83 J	1.22 J	1.50	20.64
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	4.83	7.16	6.2	6.06	19.31
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	U	0.53 J	U	0.53	NA
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.7 J	2.05 J	0.64 J	1.13	70.56
Total Decalins	1458.83	1814.99	1784.53	1686.12	11.71
Total Naphthalenes	422.5	495.66	489.16	469.11	8.63
Total Phenanthrenes/Anthracenes	521.37	585.34	572.57	559.76	6.05
Total Dibenzothiophenes	187.69	186.79	181.81	185.43	1.71
Total PAH (from naphthalene)	1598.46	1766.42	1700.08	1688.32	5.01
Surrogate Recoveries (%)					
Naphthalene-d8	69	58	66		
Acenaphthene-d10	69	56	67		
Phenanthrene-d10	88	72	85		
Benzo(a)pyrene-d12	77	61	70		

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Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	700 POOL 1	700 POOL 2	700 POOL 3		
Battelle Batch ID					
Battelle ID	R1778-P	R1779-P	R1780-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	07/01/06	07/01/06	07/06/06		
Moisture Content (%)	86.82	86.71	86.62		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.31	9.47	9.27	9.35	1.13
Sample weight (g, dry weight)	1.99	2.04	2.04	2.02	1.43
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	2.204	2.150	2.150		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
cis-Decalin	U	U	U	NA	NA
trans-Decalin	15.86	21.29	14.11	17.09	21.91
C1-Decalins	115.94	146.9	104.65	122.50	17.86
C2-Decalins	329	397.25	313.03	346.43	12.91
C3-Decalins	320.34	360.59	316.03	332.32	7.40
C4-Decalins	572.21	637.25	587.64	599.03	5.67
Benzo(b)thiophene	U	U	U	NA	NA
C1-benzo(b)thiophenes	U	U	U	NA	NA
C2-benzo(b)thiophenes	U	U	U	NA	NA
C3-benzo(b)thiophenes	U	U	U	NA	NA
C4-benzo(b)thiophenes	U	U	U	NA	NA
Naphthalene	11.09 B	10.84 B	10.47 B	10.80	2.89
C1-Naphthalenes	29.28	31.78	28.77	29.94	5.38
C2-Naphthalenes	81.76	83.79	77.9	81.15	3.69
C3-Naphthalenes	146.05	156.09	136.78	146.31	6.60
C4-Naphthalenes	162.14	158.74	144	154.96	6.22
Biphenyl	4.37	5.07	4.81	4.75	7.45
Acenaphthylene	U	U	U	NA	NA
Acenaphthene	U	U	U	NA	NA
Dibenzofuran	4.43	4.51	4.63	4.52	2.23
Fluorene	6.7	7.2	6.63	6.84	4.54
C1-Fluorenes	26.49	24.76	25.07	25.44	3.63
C2-Fluorenes	81.33	80.2	79.93	80.49	0.92
C3-Fluorenes	106.1	123.33	116.62	115.35	7.53
Anthracene	U	U	U	NA	NA
Phenanthrene	26.34	27.35	24.15	25.95	6.30
C1-Phenanthrenes/Anthracenes	91.9	95.58	88.53	92.00	3.83
C2-Phenanthrenes/Anthracenes	181.76	191.45	178.36	183.86	3.69
C3-Phenanthrenes/Anthracenes	154.05	160.97	145.11	153.38	5.18
C4-Phenanthrenes/Anthracenes	57.19	57.08	61.4	58.56	4.21
Dibenzothiophene	2.93	3.1	3.02	3.02	2.82
C1-Dibenzothiophenes	19.17	21.45	18.61	19.74	7.62
C2-Dibenzothiophenes	51.73	54.67	50.33	52.24	4.24
C3-Dibenzothiophenes	52.53	53.49	53.78	53.27	1.23
C4-Dibenzothiophenes	33.56	33	34.97	33.84	3.00
Fluoranthene	12.51	13.27	13.18	12.99	3.20
Pyrene	5.93	4.9 B	5.29 B	5.37	9.68
C1-Fluoranthenes/Pyrenes	22.43	22.47	22.71	22.54	0.67
C2-Fluoranthenes/Pyrenes	33.46	35.11	34.15	34.24	2.42
C3-Fluoranthenes/Pyrenes	34.11	33.68	31.35	33.05	4.49
Benzo(a)anthracene	U	U	U	NA	NA
Chrysene	15.35	17.68	14.96	16.00	9.19
C1-Chrysenes	14.8	15.24	15.31	15.12	1.83
C2-Chrysenes	13.19	13.01	11.59	12.60	6.96
C3-Chrysenes	7.86	7.81	8.9	8.19	7.51
C4-Chrysenes	U	U	U	NA	NA

Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	700 POOL 1	700 POOL 2	700 POOL 3		
Battelle Batch ID					
Battelle ID	R1778-P	R1779-P	R1780-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	07/01/06	07/01/06	07/06/06		
Moisture Content (%)	86.82	86.71	86.62		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.31	9.47	9.27	9.35	1.13
Sample weight (g, dry weight)	1.99	2.04	2.04	2.02	1.43
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	2.204	2.150	2.150		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	1.13 J	1.51 J	1.3 J	1.31	14.49
Benzo(k)fluoranthene	U	U	U	NA	NA
Benzo(e)pyrene	5.99	6.46	6.28	6.24	3.80
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.24 J	0.24 J	0.21 J	0.23	7.53
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.66 J	0.79 J	0.81 J	0.75	10.81
Total Decalins	1353.35	1563.28	1335.46	1417.36	8.94
Total Naphthalenes	430.32	441.24	397.92	423.16	5.32
Total Phenanthrenes/Anthracenes	511.24	532.43	497.55	513.74	3.42
Total Dibenzothiophenes	159.92	165.71	160.71	162.11	1.94
Total PAH (from naphthalene)	1498.56	1556.62	1459.91	1505.03	3.23
Surrogate Recoveries (%)					
Naphthalene-d8	68	72	68		
Acenaphthene-d10	66	71	67		
Phenanthrene-d10	87	90	90		
Benzo(a)pyrene-d12	71	73	76		

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
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N = QC value outside QC criteria.
NA = Not Applicable

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The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	800 POOL 1		800 POOL 2		800 POOL 3			
Battelle Batch ID								
Battelle ID	R1781-P		R1782-P		R1783-P			
Collection Date	06/23/06		06/23/06		06/23/06			
Extraction Date	06/23/06		06/23/06		06/23/06			
Analysis Date	07/06/06		07/06/06		07/06/06			
Moisture Content (%)	85.75		85.14		86.58			
Matrix	MUSSEL		MUSSEL		MUSSEL		***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.39		10.46		9.69		9.85	5.61
Sample weight (g, dry weight)	2.20		2.26		2.06		2.17	4.72
Pre-injection Volume (uL)	500		500		500			
Dilution Factor	1.754		1.754		1.754			
Reporting Limit	1.993		1.940		2.129			
Reporting Unit	ng/g, dry weight		ng/g, dry weight		ng/g, dry weight			
cis-Decalin		U		U		U	NA	NA
trans-Decalin	27.82		38.2		30.26		32.09	16.91
C1-Decalins	220.08		251.12		225.57		232.26	7.13
C2-Decalins	596.49		689.49		609.62		631.87	7.97
C3-Decalins	557.4		588.19		512		552.53	6.94
C4-Decalins	927.17		1012.55		913.64		951.12	5.64
Benzo(b)thiophene		U		U		U	NA	NA
C1-benzo(b)thiophenes		U		U		U	NA	NA
C2-benzo(b)thiophenes		U		U		U	NA	NA
C3-benzo(b)thiophenes		U		U		U	NA	NA
C4-benzo(b)thiophenes		U		U		U	NA	NA
Naphthalene	9.75	B	9.4	B	9.63	B	9.59	1.85
C1-Naphthalenes	27.88		27.98		26.33		27.40	3.38
C2-Naphthalenes	94.81		91.81		83.28		89.97	6.65
C3-Naphthalenes	203.93		203.25		175.11		194.10	8.47
C4-Naphthalenes	241.35		245.11		222.09		236.18	5.23
Biphenyl	4.56		4.77		5.41		4.91	9.01
Acenaphthylene		U		U		U	NA	NA
Acenaphthene		U		U		U	NA	NA
Dibenzofuran	4.32		4.77		4.38		4.49	5.44
Fluorene	8.84		7.12		7.6		7.85	11.30
C1-Fluorenes	36.96		37.94		35.04		36.65	4.03
C2-Fluorenes	134.57		129.64		113.25		125.82	8.87
C3-Fluorenes	219.31		198.4		189.02		202.24	7.67
Anthracene		U		U		U	NA	NA
Phenanthrene	30.67		30.11		28.22		29.67	4.33
C1-Phenanthrenes/Anthracenes	149.14		141.34		122.21		137.56	10.07
C2-Phenanthrenes/Anthracenes	343.61		302.77		276.1		307.49	11.06
C3-Phenanthrenes/Anthracenes	314.88		257.36		231.42		267.89	15.94
C4-Phenanthrenes/Anthracenes	113.04		95.03		91.81		99.96	11.45
Dibenzothiophene	3.56		3.4		3.45		3.47	2.36
C1-Dibenzothiophenes	32.72		31.21		25.29		29.74	13.20
C2-Dibenzothiophenes	89.43		83.91		82.44		85.26	4.32
C3-Dibenzothiophenes	112.77		94.05		83.28		96.70	15.43
C4-Dibenzothiophenes	63.88		51.3		58.32		57.83	10.90
Fluoranthene	17.43		16.49		17.08		17.00	2.79
Pyrene	8.37		7.79		7.77		7.98	4.27
C1-Fluoranthenes/Pyrenes	48.45		42.37		37.89		42.90	12.35
C2-Fluoranthenes/Pyrenes	82.42		62.39		59.16		67.99	18.53
C3-Fluoranthenes/Pyrenes	73.58		58.1		53.95		61.88	16.72
Benzo(a)anthracene		U	31.51			U	31.51	NA
Chrysene	30.36		28.91		27.08		28.78	5.71
C1-Chrysenes	39.43		28.81		28.31		32.18	19.52
C2-Chrysenes	29.42		21.51		19.75		23.56	21.86
C3-Chrysenes	19.35		14.02		10.09		14.49	32.08
C4-Chrysenes		U		U		U	NA	NA

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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	800 POOL 1	800 POOL 2	800 POOL 3		
Battelle Batch ID					
Battelle ID	R1781-P	R1782-P	R1783-P		
Collection Date	06/23/06	06/23/06	06/23/06		
Extraction Date	06/23/06	06/23/06	06/23/06		
Analysis Date	07/06/06	07/06/06	07/06/06		
Moisture Content (%)	85.75	85.14	86.58		
Matrix	MUSSEL	MUSSEL	MUSSEL	***AVERAGE***	***%RSD***
Lipid Content (%, dry weight)	9.39	10.46	9.69	9.85	5.61
Sample weight (g, dry weight)	2.20	2.26	2.06	2.17	4.72
Pre-injection Volume (uL)	500	500	500		
Dilution Factor	1.754	1.754	1.754		
Reporting Limit	1.993	1.940	2.129		
Reporting Unit	ng/g, dry weight	ng/g, dry weight	ng/g, dry weight		
Benzo(b)fluoranthene	3.73	2.35	2.49	2.86	26.59
Benzo(k)fluoranthene	1.46 J	0.83 J	1.3 J	1.20	27.36
Benzo(e)pyrene	11.22	9.55	9.09	9.95	11.26
Benzo(a)pyrene	U	U	U	NA	NA
Perylene	U	U	U	NA	NA
Indeno(1,2,3-cd)pyrene	0.56 J	0.46 J	U	0.51	13.86
Dibenz(a,h)anthracene	U	U	U	NA	NA
Benzo(g,h,i)perylene	0.96 J	0.95 J	0.98 J	0.96	1.59
Total Decalins	2328.96	2579.55	2291.09	2399.87	6.53
Total Naphthalenes	577.72	577.55	516.44	557.24	6.34
Total Phenanthrenes/Anthracenes	951.34	826.61	749.76	842.57	12.07
Total Dibenzothiophenes	302.36	263.87	252.78	273.00	9.53
Total PAH (from naphthalene)	2606.72	2376.71	2148.62	2377.35	9.63
Surrogate Recoveries (%)					
Naphthalene-d8	66	65	65		
Acenaphthene-d10	64	64	64		
Phenanthrene-d10	83	84	84		
Benzo(a)pyrene-d12	81	83	80		

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Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	Procedural Blank		Procedural Blank	
Battelle Batch ID	06-0239		06-0239	
Battelle ID	BJ094PB-P		BJ095PB-P	
Collection Date	06/23/06		6/23/2006	
Extraction Date	06/23/06		6/23/2006	
Analysis Date	06/29/06		6/29/2006	
Moisture Content (%)	86.18		86.18	
Matrix	MUSSEL		MUSSEL	
Lipid Content (%, dry weight)	NA		NA	
Sample weight (g, wet weight)	13.32		13.32	
Pre-injection Volume (uL)	500		500	
Dilution Factor	1.667		1.667	
Reporting Limit	0.313		0.313	
Reporting Unit	ng/g, wet weight		ng/g, wet weight	
cis-Decalin		U		U
trans-Decalin		U		U
C1-Decalins		U		U
C2-Decalins		U		U
C3-Decalins		U		U
C4-Decalins		U		U
Benzo(b)thiophene		U		U
C1-benzo(b)thiophenes		U		U
C2-benzo(b)thiophenes		U		U
C3-benzo(b)thiophenes		U		U
C4-benzo(b)thiophenes		U		U
Naphthalene	0.78		0.91	
C1-Naphthalenes	0.22	J	0.24	J
C2-Naphthalenes		U		U
C3-Naphthalenes		U		U
C4-Naphthalenes		U		U
Biphenyl		U		U
Acenaphthylene		U		U
Acenaphthene		U		U
Dibenzofuran		U	0.14	J
Fluorene		U	0.11	J
C1-Fluorenes		U	0.59	
C2-Fluorenes		U	1.01	N
C3-Fluorenes		U		U
Anthracene		U		U
Phenanthrene	0.38		0.92	
C1-Phenanthrenes/Anthracenes	0.42		1.82	N
C2-Phenanthrenes/Anthracenes		U	0.72	
C3-Phenanthrenes/Anthracenes		U		U
C4-Phenanthrenes/Anthracenes		U		U
Dibenzothiophene	0.07	J	0.16	J
C1-Dibenzothiophenes	0.23	J	0.81	N
C2-Dibenzothiophenes		U	0.52	N
C3-Dibenzothiophenes		U		U
C4-Dibenzothiophenes		U		U
Fluoranthene	0.09	J	0.2	J
Pyrene	0.15	J	0.36	
C1-Fluoranthenes/Pyrenes		U		U
C2-Fluoranthenes/Pyrenes		U		U
C3-Fluoranthenes/Pyrenes		U		U
Benzo(a)anthracene		U		U
Chrysene		U		U
C1-Chrysenes		U		U
C2-Chrysenes		U		U
C3-Chrysenes		U		U
C4-Chrysenes		U		U
Benzo(b)fluoranthene		U		U

Battelle
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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	Procedural Blank		Procedural Blank	
Battelle Batch ID	06-0239		06-0239	
Battelle ID	BJ094PB-P		BJ095PB-P	
Collection Date	06/23/06		6/23/2006	
Extraction Date	06/23/06		6/23/2006	
Analysis Date	06/29/06		6/29/2006	
Moisture Content (%)	86.18		86.18	
Matrix	MUSSEL		MUSSEL	
Lipid Content (%, dry weight)	NA		NA	
Sample weight (g, wet weight)	13.32		13.32	
Pre-injection Volume (uL)	500		500	
Dilution Factor	1.667		1.667	
Reporting Limit	0.313		0.313	
Reporting Unit	ng/g, wet weight		ng/g, wet weight	
Benzo(k)fluoranthene		U		U
Benzo(e)pyrene		U		U
Benzo(a)pyrene		U		U
Perylene		U		U
Indeno(1,2,3-cd)pyrene		U		U
Dibenz(a,h)anthracene		U		U
Benzo(g,h,i)perylene		U		U
Total PAH	2.34		8.51	
Surrogate Recoveries (%)				
Naphthalene-d8	46		38	N
Acenaphthene-d10	58		51	
Phenanthrene-d10	80		72	
Benzo(a)pyrene-d12	71		63	

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Battelle
The Business of Innovation

Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	Procedural Blank		Procedural Blank	
Battelle Batch ID	06-0239		06-0239	
Battelle ID	BJ094PB-P		BJ095PB-P	
Collection Date	06/23/06		6/23/2006	
Extraction Date	06/23/06		6/23/2006	
Analysis Date	06/29/06		6/29/2006	
Moisture Content (%)	86.18		86.18	
Matrix	MUSSEL		MUSSEL	
Lipid Content (%, dry weight)	NA		NA	
Sample weight (g, dry weight)	1.84		1.84	
Pre-injection Volume (uL)	500		500	
Dilution Factor	1.667		1.667	
Reporting Limit	2.265		2.265	
Reporting Unit	ng/g, dry weight		ng/g, dry weight	
cis-Decalin		U		U
trans-Decalin		U		U
C1-Decalins		U		U
C2-Decalins		U		U
C3-Decalins		U		U
C4-Decalins		U		U
Benzo(b)thiophene		U		U
C1-benzo(b)thiophenes		U		U
C2-benzo(b)thiophenes		U		U
C3-benzo(b)thiophenes		U		U
C4-benzo(b)thiophenes		U		U
Naphthalene	5.66		6.6	
C1-Naphthalenes	1.58	J	1.76	J
C2-Naphthalenes		U		U
C3-Naphthalenes		U		U
C4-Naphthalenes		U		U
Biphenyl		U		U
Acenaphthylene		U		U
Acenaphthene		U		U
Dibenzofuran		U	1.01	J
Fluorene		U	0.81	J
C1-Fluorenes		U	4.31	
C2-Fluorenes		U	7.34	N
C3-Fluorenes		U		U
Anthracene		U		U
Phenanthrene	2.73		6.68	
C1-Phenanthrenes/Anthracenes	3.05		13.2	N
C2-Phenanthrenes/Anthracenes		U	5.22	
C3-Phenanthrenes/Anthracenes		U		U
C4-Phenanthrenes/Anthracenes		U		U
Dibenzothiophene	0.5	J	1.15	J
C1-Dibenzothiophenes	1.69	J	5.88	N
C2-Dibenzothiophenes		U	3.77	N
C3-Dibenzothiophenes		U		U
C4-Dibenzothiophenes		U		U
Fluoranthene	0.62	J	1.45	J
Pyrene	1.12	J	2.62	
C1-Fluoranthenes/Pyrenes		U		U
C2-Fluoranthenes/Pyrenes		U		U
C3-Fluoranthenes/Pyrenes		U		U
Benzo(a)anthracene		U		U
Chrysene		U		U
C1-Chrysenes		U		U
C2-Chrysenes		U		U
C3-Chrysenes		U		U
C4-Chrysenes		U		U
Benzo(b)fluoranthene		U		U

Battelle
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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	Procedural Blank	Procedural Blank
Battelle Batch ID	06-0239	06-0239
Battelle ID	BJ094PB-P	BJ095PB-P
Collection Date	06/23/06	6/23/2006
Extraction Date	06/23/06	6/23/2006
Analysis Date	06/29/06	6/29/2006
Moisture Content (%)	86.18	86.18
Matrix	MUSSEL	MUSSEL
Lipid Content (%, dry weight)	NA	NA
Sample weight (g, dry weight)	1.84	1.84
Pre-injection Volume (uL)	500	500
Dilution Factor	1.667	1.667
Reporting Limit	2.265	2.265
Reporting Unit	ng/g, dry weight	ng/g, dry weight
Benzo(k)fluoranthene	U	U
Benzo(e)pyrene	U	U
Benzo(a)pyrene	U	U
Perylene	U	U
Indeno(1,2,3-cd)pyrene	U	U
Dibenz(a,h)anthracene	U	U
Benzo(g,h,i)perylene	U	U
Total PAH	16.95 J	61.8 J

Surrogate Recoveries (%)

Naphthalene-d8	46	38 N
Acenaphthene-d10	58	51
Phenanthrene-d10	80	72
Benzo(a)pyrene-d12	71	63

B = Result < 5 x procedural blank
J = Detected below Reporting Limit.
U = Not Detected.
N = QC value outside QC criteria.
NA = Not Applicable

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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

	Laboratory Control				
Client ID	Sample				
Battelle Batch ID	06-0239				
Battelle ID	BJ096LCS-P				
Collection Date	06/23/06				
Extraction Date	06/23/06				
Analysis Date	06/29/06				
Moisture Content (%)	79.14				
Matrix	MUSSEL				
Lipid Content (%, dry weight)	6.09				
Sample weight (g, wet weight)	20.16				
Pre-injection Volume (uL)	500				
Dilution Factor	1.754				
Reporting Limit	0.218				
Reporting Unit	ng/g, wet weight		Target	% Recovery	Qualifier
cis-Decalin	31.59		53.39	59	N
trans-Decalin	30.19		51.79	58	N
C1-Decalins		U			
C2-Decalins		U			
C3-Decalins		U			
C4-Decalins		U			
Benzo(b)thiophene	36.13		49.64	73	
C1-benzo(b)thiophenes		U			
C2-benzo(b)thiophenes		U			
C3-benzo(b)thiophenes		U			
C4-benzo(b)thiophenes		U			
Naphthalene	33.77		49.61	68	N
C1-Naphthalenes		U			
C2-Naphthalenes		U			
C3-Naphthalenes		U			
C4-Naphthalenes		U			
Biphenyl	37.79		49.69	76	
Acenaphthylene	36.41		49.65	73	
Acenaphthene	37.12		49.64	75	
Dibenzofuran	39.82		49.70	80	
Fluorene	36.93		49.63	74	
C1-Fluorenes		U			
C2-Fluorenes		U			
C3-Fluorenes		U			
Anthracene	36.15		49.61	73	
Phenanthrene	33.89		49.63	68	N
C1-Phenanthrenes/Anthracenes		U			
C2-Phenanthrenes/Anthracenes		U			
C3-Phenanthrenes/Anthracenes		U			
C4-Phenanthrenes/Anthracenes		U			
Dibenzothiophene	32.65		49.83	66	N
C1-Dibenzothiophenes		U			
C2-Dibenzothiophenes		U			
C3-Dibenzothiophenes		U			
C4-Dibenzothiophenes		U			
Fluoranthene	33.77		49.63	68	N
Pyrene	34.53		49.62	70	
C1-Fluoranthenes/Pyrenes		U			
C2-Fluoranthenes/Pyrenes		U			
C3-Fluoranthenes/Pyrenes		U			
Benzo(a)anthracene	27.75		49.62	56	N
Chrysene	27.77		49.62	56	N
C1-Chrysenes		U			
C2-Chrysenes		U			
C3-Chrysenes		U			
C4-Chrysenes		U			

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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

	Laboratory Control			
Client ID	Sample			
Battelle Batch ID	06-0239			
Battelle ID	BJ096LCS-P			
Collection Date	06/23/06			
Extraction Date	06/23/06			
Analysis Date	06/29/06			
Moisture Content (%)	79.14			
Matrix	MUSSEL			
Lipid Content (%, dry weight)	6.09			
Sample weight (g, wet weight)	20.16			
Pre-injection Volume (uL)	500			
Dilution Factor	1.754			
Reporting Limit	0.218			
Reporting Unit	ng/g, wet weight	Target	% Recovery	Qualifier
Benzo(b)fluoranthene	32.5	49.65	65	N
Benzo(k)fluoranthene	38.17	49.63	77	
Benzo(e)pyrene	34.1	49.73	69	N
Benzo(a)pyrene	35.29	49.64	71	
Perylene	38.52	49.70	78	
Indeno(1,2,3-cd)pyrene	34.25	49.63	69	N
Dibenz(a,h)anthracene	35.8	49.63	72	
Benzo(g,h,i)perylene	33.48	49.62	67	N
Total PAH	730.46			

Surrogate Recoveries (%)

Naphthalene-d8	68
Acenaphthene-d10	64
Phenanthrene-d10	79
Benzo(a)pyrene-d12	64

B = Result < 5 x procedural blank
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NA = Not Applicable

Battelle
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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	SRM2977				
Battelle Batch ID	06-0239				
Battelle ID	BJ097SRM-P				
Collection Date	06/23/06				
Extraction Date	06/23/06				
Analysis Date	06/29/06				
Moisture Content (%)	NA				
Matrix	MUSSEL				
Lipid Content (%, dry weight)	NA				
Sample weight (g, wet weight)	3.12				
Pre-injection Volume (uL)	500				
Dilution Factor	1.667				
Reporting Limit	1.336				
Reporting Unit	ng/g, wet weight		Value	%Difference	Qualifier
cis-Decalin	2.54				
trans-Decalin	25.25				
C1-Decalins	92.51				
C2-Decalins	161.74				
C3-Decalins	56.33				
C4-Decalins	111.79				
Benzo(b)thiophene		U			
C1-benzo(b)thiophenes	14.65				
C2-benzo(b)thiophenes	23.39				
C3-benzo(b)thiophenes	67.6				
C4-benzo(b)thiophenes	114.93				
Naphthalene	8.27				
C1-Naphthalenes	7.99				
C2-Naphthalenes	56.59				
C3-Naphthalenes	262.42				
C4-Naphthalenes	324.46				
Biphenyl	1.78				
Acenaphthylene	1.98				
Acenaphthene		U			
Dibenzofuran	5.1				
Fluorene	8.58		10.24	16.2	
C1-Fluorenes	40.08				
C2-Fluorenes	177.91				
C3-Fluorenes	350.75				
Anthracene	2.73				
Phenanthrene	27.92		35.1	20.5	
C1-Phenanthrenes/Anthracenes	121.56				
C2-Phenanthrenes/Anthracenes	380.31				
C3-Phenanthrenes/Anthracenes	455.08				
C4-Phenanthrenes/Anthracenes	201.88				
Dibenzothiophene	19.88				
C1-Dibenzothiophenes	167.27				
C2-Dibenzothiophenes	544.7				
C3-Dibenzothiophenes	686.89				
C4-Dibenzothiophenes	416.42				
Fluoranthene	28.86		38.7	25.4	
Pyrene	62.61		78.9	20.6	
C1-Fluoranthenes/Pyrenes	78.19				
C2-Fluoranthenes/Pyrenes	104.13				
C3-Fluoranthenes/Pyrenes	90.23				
Benzo(a)anthracene	13.63		20.34	33	
Chrysene	55.58				
C1-Chrysenes	48.73				
C2-Chrysenes	46.96				
C3-Chrysenes	22.72				
C4-Chrysenes		U			
Benzo(b)fluoranthene	8.65		11.01	21.4	

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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	SRM2977			
Battelle Batch ID	06-0239			
Battelle ID	BJ097SRM-P			
Collection Date	06/23/06			
Extraction Date	06/23/06			
Analysis Date	06/29/06			
Moisture Content (%)	NA			
Matrix	MUSSEL			
Lipid Content (%, dry weight)	NA			
Sample weight (g, wet weight)	3.12			
Pre-injection Volume (uL)	500			
Dilution Factor	1.667			
Reporting Limit	1.336			
Reporting Unit	ng/g, wet weight	Value	%Difference	Qualifier
Benzo(k)fluoranthene	8.03			
Benzo(e)pyrene	12.49	13.1	4.7	
Benzo(a)pyrene	4.15	8.35	50.3	N
Perylene	2.35	3.5	32.9	
Indeno(1,2,3-cd)pyrene	3.16	4.84	34.7	
Dibenz(a,h)anthracene	1.04 J	1.41	26.2	
Benzo(g,h,i)perylene	6.95	9.53	27.1	
Total PAH	4869.01			

Surrogate Recoveries (%)

Naphthalene-d8	62
Acenaphthene-d10	60
Phenanthrene-d10	76
Benzo(a)pyrene-d12	70

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NA = Not Applicable

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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	North Slope Crude			
Battelle Batch ID	06-0239			
Battelle ID	BJ111NSC-P			
Collection Date	06/28/06			
Extraction Date	06/28/06			
Analysis Date	06/29/06			
Moisture Content (%)	NA			
Matrix	OIL			
Lipid Content (%, dry weight)	NA			
Sample weight (g, wet weight)	5.01			
Pre-injection Volume (uL)	1200			
Dilution Factor	1			
Reporting Limit	1.198			
Reporting Unit	mg/Kg, oil weight		Target	% Difference	Qualifier
cis-Decalin	21.21			
trans-Decalin	432.87			
C1-Decalins	908.2		903.62	0.5
C2-Decalins	973.97		869.20	12.1
C3-Decalins	503.63		444.65	13.3
C4-Decalins	519.43		443.92	17.0
Benzo(b)thiophene	11.98			
C1-benzo(b)thiophenes	40.62			
C2-benzo(b)thiophenes	110.23		95.74	15.1
C3-benzo(b)thiophenes	163.04		132.67	22.9
C4-benzo(b)thiophenes	120.03		96.72	24.1
Naphthalene	633.15		714.43	11.4
C1-Naphthalenes	1413.56		1534.53	7.9
C2-Naphthalenes	2029.34		1897.27	7.0
C3-Naphthalenes	1725.49		1436.53	20.1
C4-Naphthalenes	985.85		773.42	27.5
Biphenyl	207.67		216.49	4.1
Acenaphthylene		U		
Acenaphthene	11.37			
Dibenzofuran	68.04		71.98	5.5
Fluorene	73.5		87.56	16.1
C1-Fluorenes	213.81		219.89	2.8
C2-Fluorenes	386.81		341.20	13.4
C3-Fluorenes	356.25		299.61	18.9
Anthracene		U		
Phenanthrene	229.89		272.58	15.7
C1-Phenanthrenes/Anthracenes	543.71		564.81	3.7
C2-Phenanthrenes/Anthracenes	716.23		660.43	8.4
C3-Phenanthrenes/Anthracenes	522.64		448.76	16.5
C4-Phenanthrenes/Anthracenes	213.68		176.00	21.4
Dibenzothiophene	206.53		218.80	5.6
C1-Dibenzothiophenes	410.88		434.54	5.4
C2-Dibenzothiophenes	598.51		551.44	8.5
C3-Dibenzothiophenes	542.53		460.96	17.7
C4-Dibenzothiophenes	278.12		236.77	17.5
Fluoranthene	3.38			
Pyrene	13.15			
C1-Fluoranthenes/Pyrenes	74.19		78.43	5.4
C2-Fluoranthenes/Pyrenes	129.87		132.93	2.3
C3-Fluoranthenes/Pyrenes	149.16		151.73	1.7
Benzo(a)anthracene	1.27			
Chrysene	40.07		50.99	21.4
C1-Chrysenes	65.72		81.69	19.6
C2-Chrysenes	78.71		95.93	18.0
C3-Chrysenes	74.81		89.87	16.8
C4-Chrysenes	55.37		76.33	27.5
Benzo(b)fluoranthene	3.99			

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Project Client: Norwegian Institute for Water Research (NIVA)
Project Name: NIVA - Analysis of Blue Mussels
Project Number: N006783-0001

Client ID	North Slope Crude			
Battelle Batch ID	06-0239			
Battelle ID	BJ111NSC-P			
Collection Date	06/28/06			
Extraction Date	06/28/06			
Analysis Date	06/29/06			
Moisture Content (%)	NA			
Matrix	OIL			
Lipid Content (%, dry weight)	NA			
Sample weight (g, wet weight)	5.01			
Pre-injection Volume (uL)	1200			
Dilution Factor	1			
Reporting Limit	1.198			
Reporting Unit	mg/Kg, oil weight	Target	% Difference	Qualifier
Benzo(k)fluoranthene		U		
Benzo(e)pyrene	9.92			
Benzo(a)pyrene		U		
Perylene		U		
Indeno(1,2,3-cd)pyrene		U		
Dibenz(a,h)anthracene	0.9	J		
Benzo(g,h,i)perylene	2.67			
Total PAH	13070.74			

Surrogate Recoveries (%)

Naphthalene-d8	105
Acenaphthene-d10	102
Phenanthrene-d10	104
Benzo(a)pyrene-d12	112

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