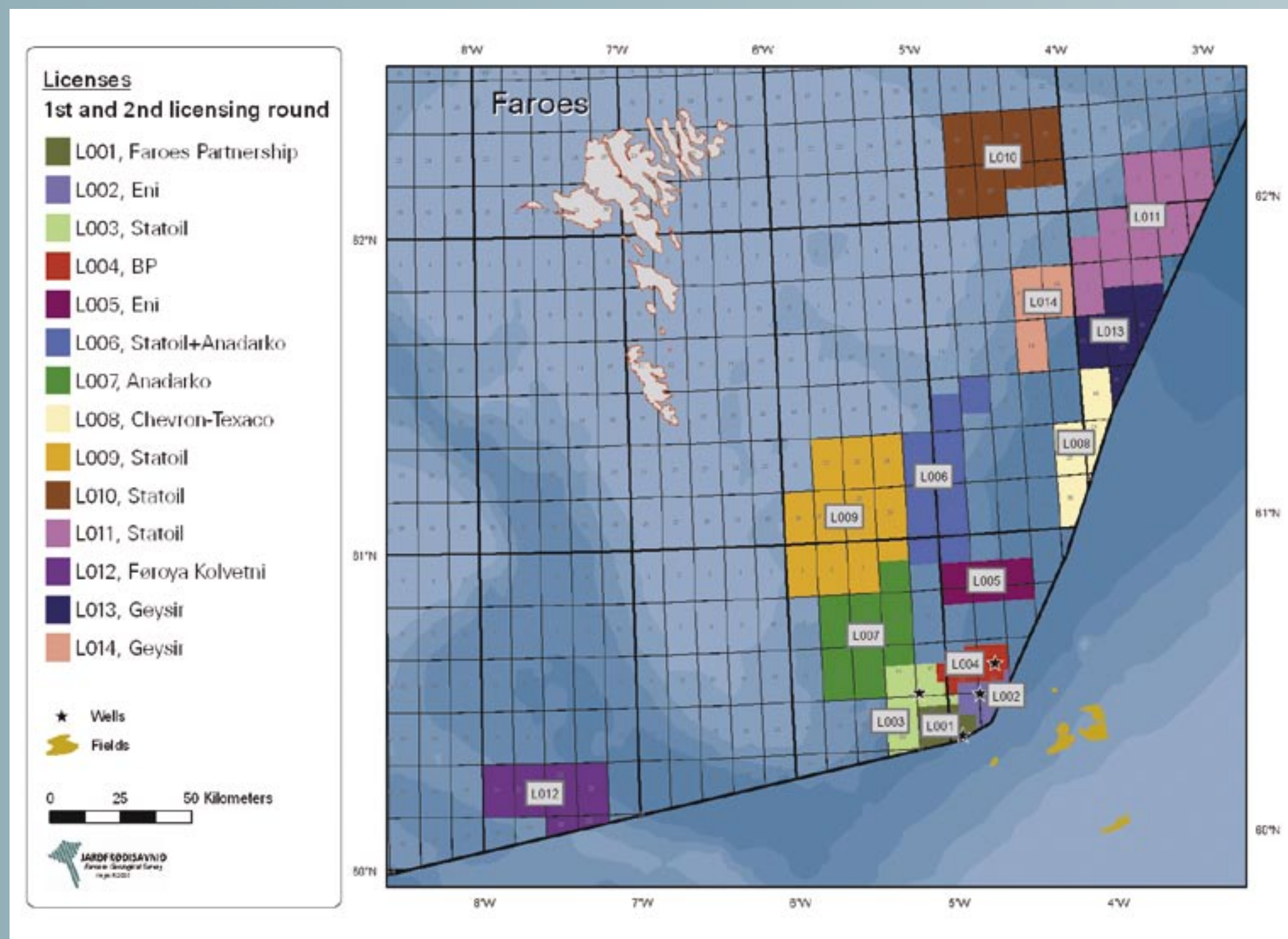


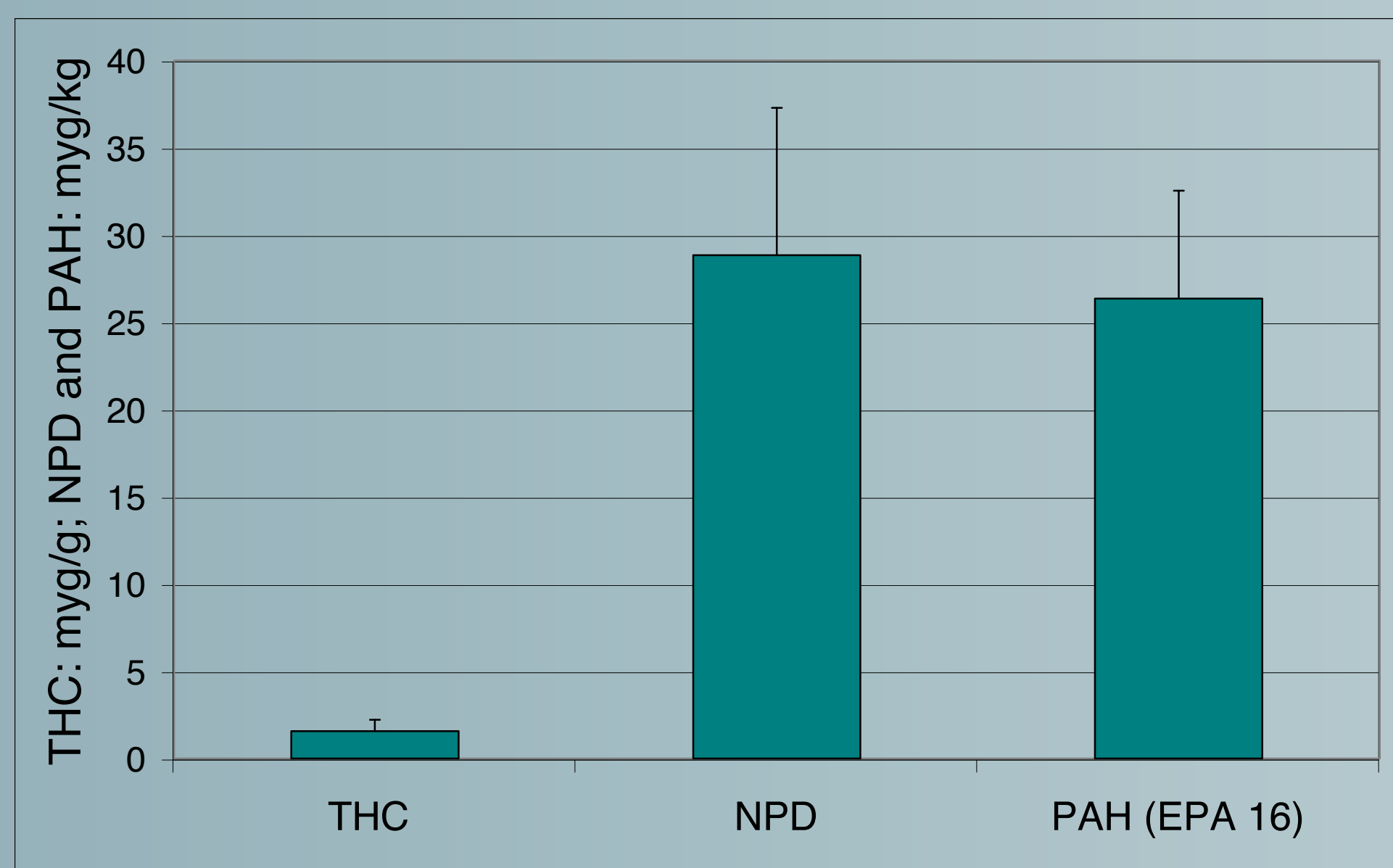


# ENVIRONMENTAL STUDIES AND MONITORING IN PREPARATION FOR EXPLORATION DRILLING OFFSHORE THE FAROE ISLANDS

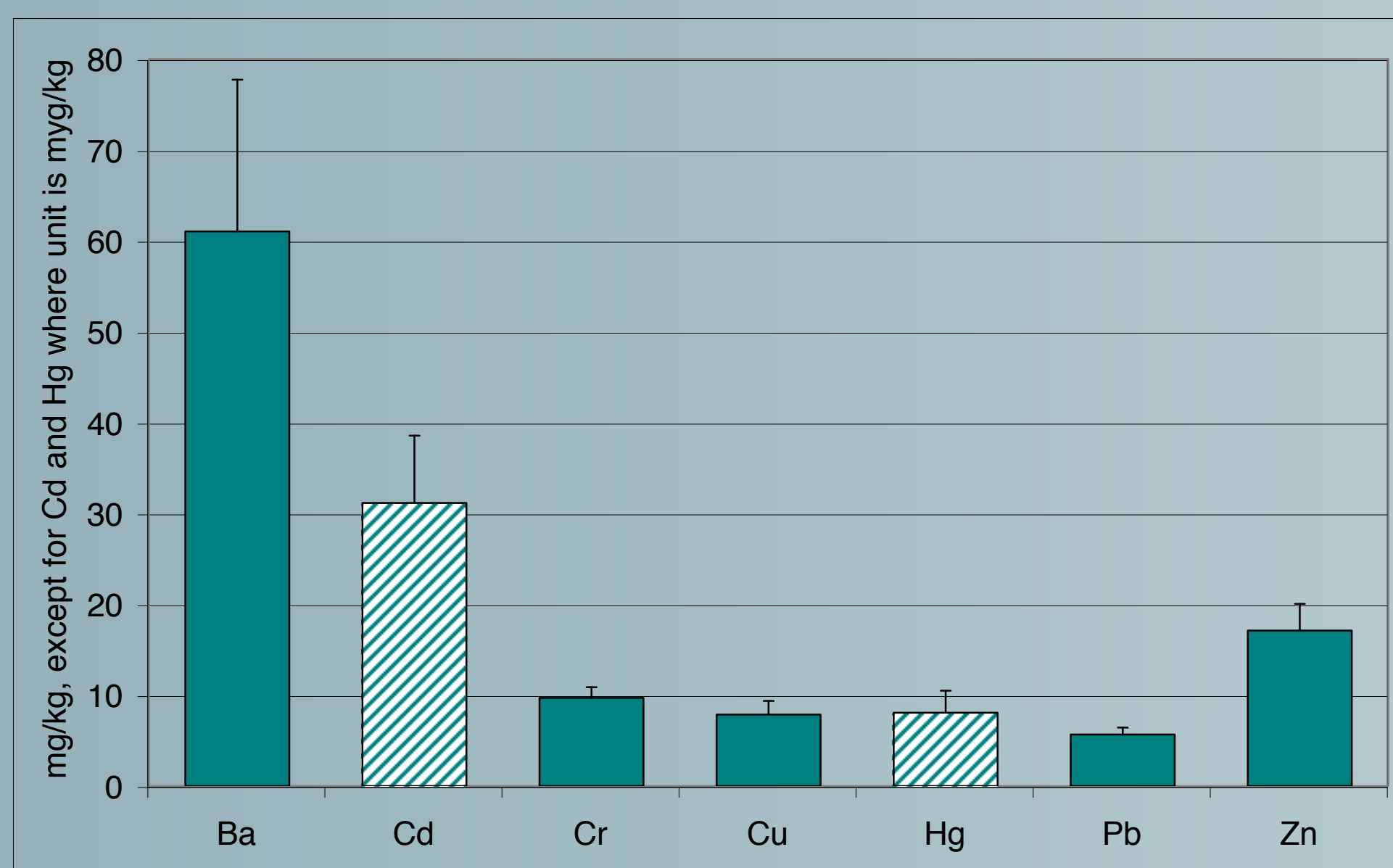
Maria Dam and Katrin Hoydal, Food-, Veterinary and Environmental Agency, Falkavegur 6, 100-Tórshavn, Faroe Islands. www.hfs.fo



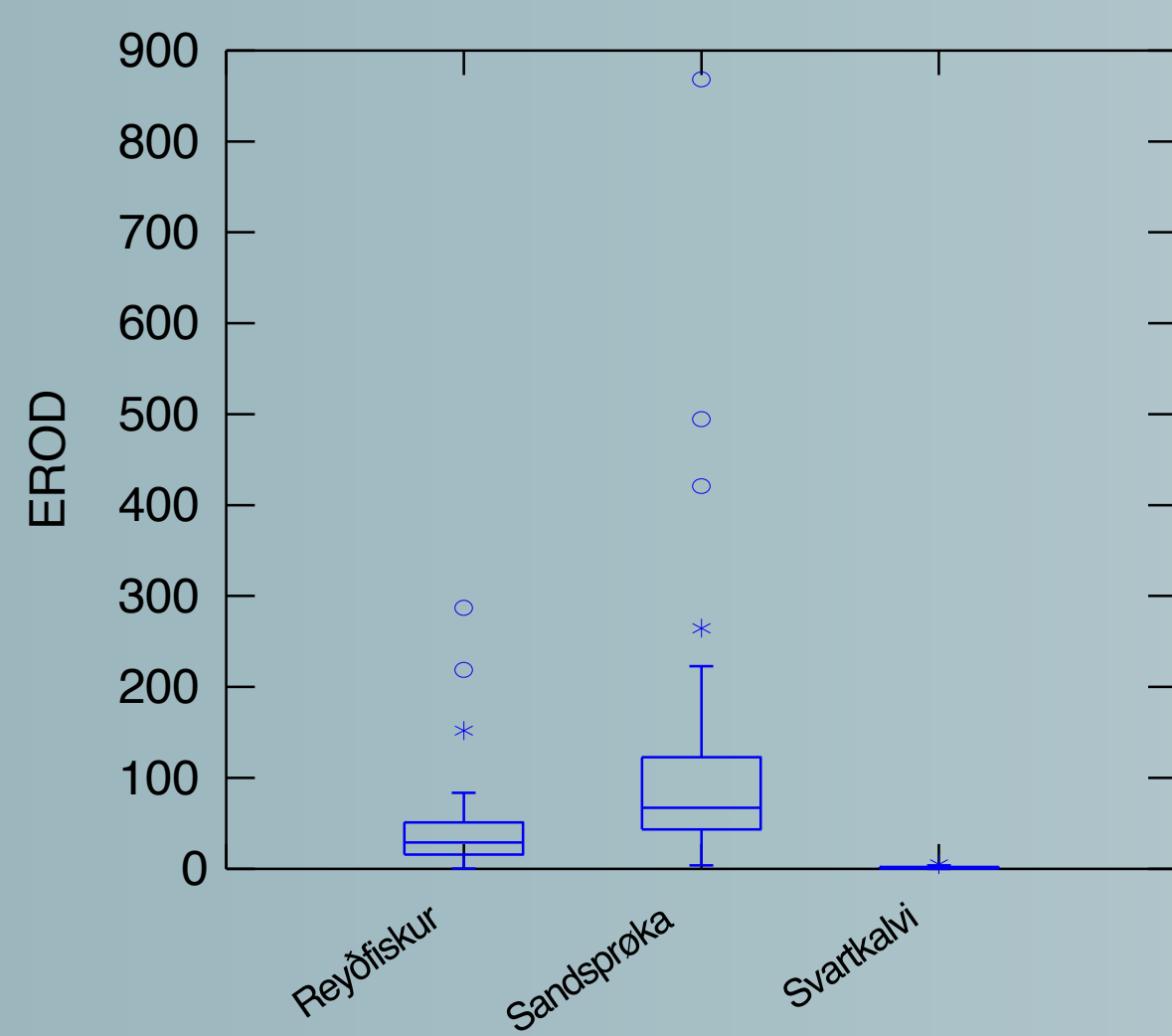
**Figure 1** The licenses given during the 1. and 2. licencing rounds for exploration drilling and seismic surveys in the Faroe Islands offshore area are shown. (Source: the Faroe Petroleum Administration, www.ofs.fo)



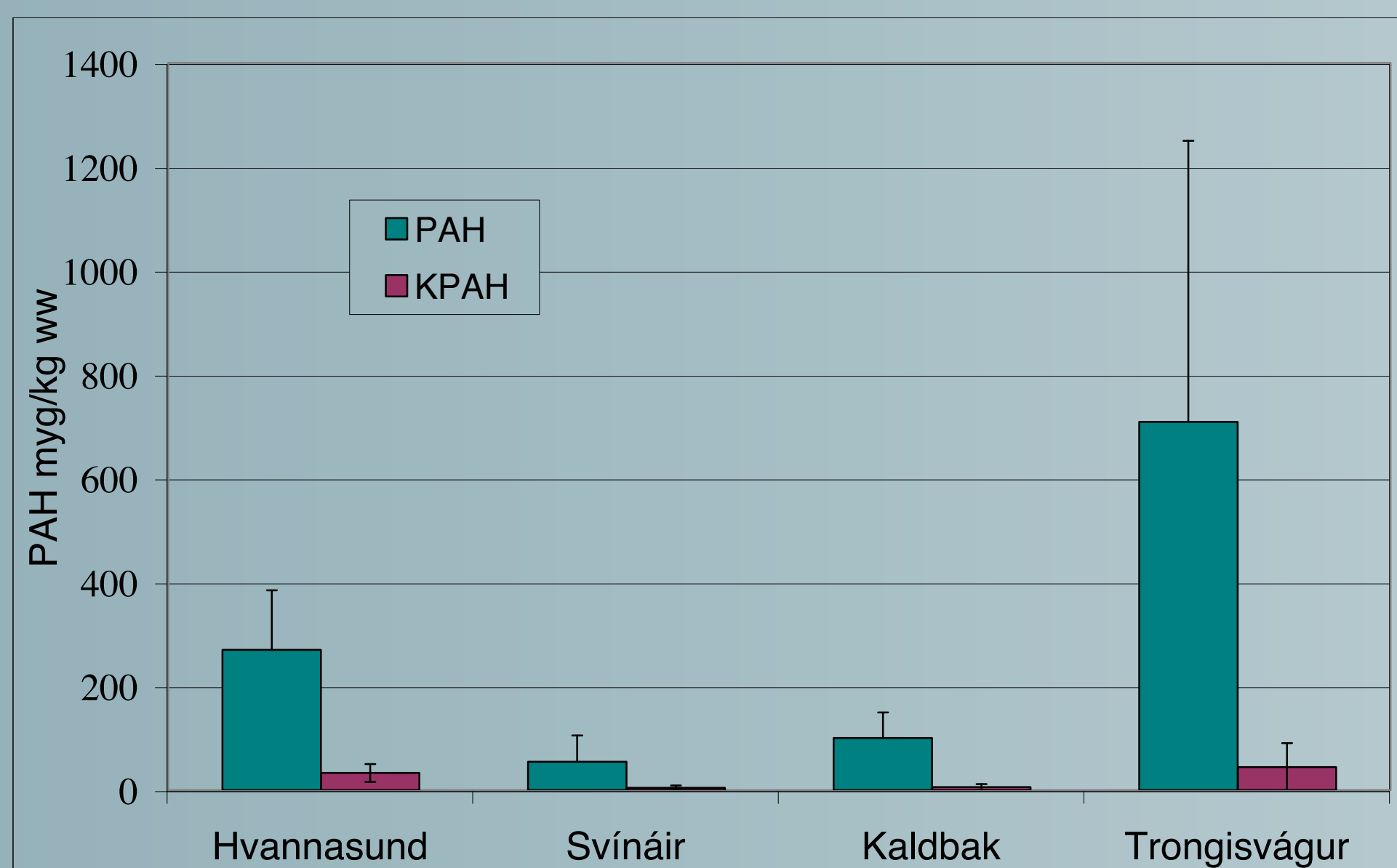
**Figure 2** The mean hydrocarbon concentration in sediments in the Faroe-Shetland Channel area included in the regional baseline survey (Mannvik et al., 2002) is shown as total hydrocarbons (THC), the sum of naphthalene, phenanthrene and dibenzothiophene (NPD) and as sum of 16 polycyclic aromatic hydrocarbons (PAH).



**Figure 3** The mean concentrations of barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb) and zinc (Zn) in sediments in the Faroe-Shetland Channel area included in the regional baseline survey (Mannvik et al., 2002) are shown. Note the different unit used for mercury and cadmium.



**Figure 4** The EROD activity as pmol/min/mg protein in cod (reyðfiskur), dab (sandsprøka) and Greenland halibut (svartkalvi) are shown (adapted from Grøsvik et al., 2000 and Hoydal, 2004).



**Figure 5** Concentrations of polycyclic aromatic hydrocarbons (PAH) in blue mussels (*Mytilus edulis*) from various locations around the Faroe Islands are given. The sum of the PAHs that are likely or potential carcinogens according to IARC, 1987, are given as KPAH. (Adapted from Hoydal, 2004).

## Introduction

Before the oil exploration offshore the Faroe Islands began in 2001, the oil companies with interest to be actively exploring the Faroe underground commissioned studies on the environment in the area where the drilling was to be done, and in areas likely to be influenced in any way by the exploration activity. The content and scope of the studies were to a certain extent defined by the industry and local authorities, research institutes and other stakeholders in common. The studies done were inspired by similar work previously done in the neighbouring areas with oil exploration activities, especially the Norwegian sector of the North Sea, but with special emphasis on the gaps of knowledge that existed for the Faroe environment and with an aim to support the building of local scientific and regulatory capacity.

## Studies of the Environment and the Environmental Vulnerability

The areas laid out to exploration activities, both drilling and seismic surveys, in the 1. and 2. license rounds are shown in Figure 1. The water column in the areas where drilling licenses were given are approx. 1000 m deep. The licenced areas are overall "off the beaten path" what biological and environmental investigations are regarded, but the aim of the studies launched (Table 1) was to fill the gaps that emerged when the available knowledge was examined. Together with other material (Table 2), as for instance assessments of risk for oil-spills, this knowledge was combined into an "Environmental Statement" (Anon. 2001) for the license area, as part fulfillment of the legal obligations laid on the oil industry in the hydrocarbon act.

## The chemical pollution focussed environmental studies

Studies aimed at defining the ambient level of pollutants normally associated with oil exploration and extraction activity were undertaken. The studies comprised measurements of pollutants as heavy metals and polycyclic aromatic hydrocarbons, PAHs, both in sediments and in fish and invertebrates.

In the Faroe-Shetland Channel area, a study with 16 sediment sampling stations laid out in a grid was performed, see photo in lower right corner, using the method adapted by the Norwegian environmental authority for offshore environmental monitoring (Nilssen and Nordby, 1999). The analytical work comprised analyses of chemical pollutants and benthic biota species composition, density and diversity (Larsen, 2001; Mannvik et al., 2002). The chemical analyses included hydrocarbon parameters like total hydrocarbon (THC), PAHs and the sum of naphthalenes, phenanthrenes and dibenzothiophenes (NPD), (Figure 2). The parameters also included a selection of metals normally analysed in monitoring of offshore activity (barium, cadmium, chrome, copper, lead, mercury and zinc, Figure 3) and in a subset of the samples also PCB and sedimentation rate. The results indicated that the area was non-depositional, with no detectable short-term sedimentation (analysed using isotopes of 210Pb and 137Cs) at three of sampling stations and a 0.26 mm/yr sedimentation rate at the fourth. PCB, as the individual congeners CBs 28, 52, 101, 118, 153 and 180, could not be detected at 0.05 µg/kg dw except in two samples, where CB 28 was quantified to 0.07 and 0.19 µg/kg dw (Mannvik et al., 2002).

The studies were not strictly focussed on the area of the exploration licenses but covered also parts of the shelf and slope area and the coastal zone. Greenland halibut (*Reinhardtius hippoglossoides*) from the south-eastern part of Faroe Island slope was analysed for PAH and heavy metals as well as for the biomarkers of PAH and estrogen mimics exposure. The biomarkers quantified were EROD activity and DNA adducts in liver, PAH metabolites in gall, and vitellogenin and zona radiata protein in blood (Grøsvik et al., 2000). From the coastal area juvenile cod (*Gadus morhua*), dab (*Limanda limanda*) and sculpin (*Myoxocephalus scorpius*) were analysed for the concentration of CYP1A protein in liver in addition to the set of biomarkers analysed in the Greenland halibut (Hoydal, 2004). Overall, the level of biomarkers was low and indicative of an unpolluted state. The biomarkers in the coastal species were however, higher than in the Greenland halibut from the slope area, but not outside what is regarded as a natural background level (Figure 4).

The analyses of pollutants in the coastal fish species were complemented by analyses on coastal zone invertebrates (Hoydal, 2004). The invertebrates analysed were blue mussel (*Mytilus edulis*), horse mussel (*Modiolus modiolus*), dogwhelk (*Nucella lapillus*), periwinkles (*Littorina obtusata*) and limpets (*Patella vulgata*). The sampling locations were chosen so as to represent both sheltered bays and more exposed coastal areas. The concentration of PAH in blue mussels were approx. 10 times the level measured in the other invertebrates, and if classified according to the system of Molvær et al., 1997, the environmental state of these coastal sampling sites would be described as moderately to markedly polluted with regard to PAH (Figure 5).

## References

Anonymous 2001. Environmental Impact Assessment. 2001. Alpha Environmental Consultants.\*  
 Anonymous. 2001b. Oil spill sensitivity maps and coastal protection plans for the Faroe Islands. 2001. Cordah Limited.\*  
 Bett, B.J., Pearson, T.H. and Sørensen, J. 2001. Expert Review of Seabed Fauna and Chemistry. Southampton Oceanography Centre, SEAS/ Akvaplan-niva, Kaldbak Lab.\*  
 Bloch, D., Mikkelsen, B. and Ofstad, L.H. 2000. Marine Mammals in Faroese Waters. Faroese Natural History Museum / Fisheries Laboratory.\*  
 Bruntse, G., Lein, T.E. and Nielsen, R. 1999. Marine benthic algae and invertebrate communities from the shallow waters of the Faroe Islands. A baseline study. Kaldbak Marine Biological Laboratory.  
 Bruntse, G. and Tendal, O.S. (Ed). 2001. Marine biological investigations and assemblages of benthic invertebrates from the Faroe Islands. Kaldbak Marine Biological Laboratory.\*  
 Dam, M. and Danielsen, J. 2003. Faroe Islands Coastal Resources and Prioritisation Maps. The Food, Veterinary and Environmental Agency.  
 Debes, H.H. 2003. Macrozooplankton in the Faroe-Shetland Channel. The Faroese Fisheries Laboratory.\*  
 Det Norske Veritas, 2005. Fishing Data and Seismic Activity for the Faroes (electronic GIS maps). Available in electronic version at www.foib.fo, under "Reports".  
 Grøsvik, B.E., Bjørnstad, A., Nævdal, A., Westerlund, S. and Aas, E. 2000. A Baseline Study of Greenland Halibut off the Faroe Islands. RF - Rogaland Research.\*  
 Hoydal, K. 2004. Background levels of oil-derived pollution in fish and invertebrates from the coastal zone around the Faroe Islands - Biomarker analyses in fish and analyses of PAH and metals in invertebrates. Master thesis, University of Copenhagen, March 2004.  
 Jákupsstovu, S.H. i., Olsen, D. and Zachariassen, K. 1999. Effects of seismic activity on the fisheries at the Faroe Islands. Faroese Fisheries Laboratory.\*  
 Jákupsstovu, S.H. i., 1999b. Fisheries in Faroese Waters. Faroese Fisheries Laboratory.\*  
 Jødestøl, K.A. 2001. Environmental Risk Assessment. Det Norske Veritas.\*  
 Larsen, L.H. 2001. Field report: Benthic Baseline Survey of the Faroes offshore license areas 001-004 April-June 2001. Akvaplan-Niva, Polar-miljøenteret, Tromsø.\*  
 Long, E.R. and Morgan, L.G. 1990. The potential for biological effects of sediment-associated contaminants tested in the national status trends program. NOAA Techn. memorandum, NOS OMA 52, pp. 175.  
 Mannvik, H.P., Pettersen, A. and Jøllynn, C. 2002. Environmental baseline survey of the Faroe offshore license areas 001 - 004 in the Faroe - Shetland Channel, 2001. Akvaplan-niva.\*  
 Molvær, J., Knutzen, J., Magnússon, J., Rygg, B., Skei, J. and Sørensen, J. 1997. Klassifisering av miljøværdier i fjorder og kystfarvann. State Pollution Control Authority, Norway. Guideline no. 97-03.  
 Nilssen, I. and Nordby, M., 1999. Miljøovervåking av petroleumsvirksomheten på norsk sektor. State Pollution Control Authority, Norway, report no. 1999-01.  
 Olsen, B., Jensen, J.-K. and Reinert, A. 2000. Populations of Guillemots, Razorbills and Puffins in Faroese Waters as Documented by Ringed Birds. Faroese Fishery Laboratory.\*  
 Perry, F., Perry, R. and Park, I. 2001. Coastal Protection Plans Faroe Islands. Cordah Limited.\*  
 Skov, H., Upton, A.J., Reid, J.B., Webb, A., Taylor, S.J. and Durink, 2002. Dispersion and vulnerability of marine birds and cetaceans in Faroese waters. Joint Nature Conservation Committee, Peterborough.\*  
 Skognes, K. 2001. Oil Drift Simulations Faroe Islands [GEM License 003]. Sintef.\*  
 Taylor, S.J. and Reid, J.B. 2001. The Distribution of Seabirds and Cetaceans around the Faroe Islands. Joint Nature Conservation Committee.\*  
 Thomsen, B. 2002. An Experiment on how seismic shooting affects caged fish. Faroese Fisheries Laboratory.\*

\* Available at www.foib.fo/Reports



Tórshavn, the capital of the Faroe Islands (M. Dam)

Theme	Environmental study title	Reference
The seabed and benthic fauna	Expert Review of Seabed Fauna and Chemistry	Bett et al., 2001
	Marine benthic algae and invertebrate communities from the shallow waters of the Faroe Islands. A baseline study. Marine biological investigations and assemblages of benthic invertebrates from the Faroe Islands	Bruntse et al., 1999 Bruntse et al., 2001
Plancton	Macrozooplankton in the Faroe-Shetland Channel	Debes, 2003
Fish and fishery	Effects of seismic activity on the fisheries at the Faroe Islands	Jákupsstovu et al., 1999
	Fisheries in Faroese Waters	Jákupsstovu et al., 1999b Thomsen, 2002
Marine mammals and seabirds	An Experiment on how seismic shooting affects caged fish	Det Norske Veritas, 2005
	Fishing Data and Seismic Activity for the Faroes (electronic GIS maps)	Det Norske Veritas, 2005
Marine mammals and seabirds	Marine mammals in Faroese Waters	Bloch et al., 2000
	The Distribution of Seabirds and Cetaceans around the Faroe Islands	Taylor and Reid, 2001
	Dispersion and vulnerability of marine birds and cetaceans in Faroese waters. Populations of Guillemots, Razorbills and Puffins in Faroese Waters as Documented by Ringed Birds	Skov et al., 2002 Olsen et al., 2000

**Table 1** The environmental and environmental vulnerability studies done in preparation for the oil and gas exploration offshore the Faroe Islands are listed. All reports are available at the web-site www.foib.fo at "Reports".

Theme	Environmental study title	Reference
Environmental risk assessment	Environmental Risk Assessment	Jødestøl, 2001
Oil spill drift modelling	Oil Drift Simulations Faroe Islands [GEM License 003]	Skognes, 2001
Coastal protection	Coastal Protection Plans Faroe Islands	Perry et al., 2001
	Oil spill sensitivity maps and coastal protection plans for the Faroe Islands	Anon., 2001b
	Faroe Islands Coastal Resources and Prioritisation Maps	Dam and Danielsen, 2003

**Table 2** Emergency planning and prevention related studies done in preparation for the oil and gas exploration offshore the Faroe Islands are listed. All reports are available at the web-site www.foib.fo at "Reports".

Theme	Environmental study title	Reference
Regional baseline in Faroe-Shetland Channel	Field report: Benthic Baseline Survey of the Faroes offshore license areas 001-004 April-June 2001.	Larsen, 2001
	Environmental baseline survey of the Faroe offshore license areas 001 - 004 in the Faroe - Shetland Channel, 2001	Mannvik et al., 2002
Baseline study on slope and outer shelf area	A Baseline Study of Greenland Halibut off the Faroe Islands	Grøsvik et al., 2000
Baseline study in the coastal area	Background levels of oil-derived pollution in fish and invertebrates from the coastal zone around the Faroe Islands - Biomarker analyses in fish and analyses of PAH and metals in invertebrates.	Hoydal, 2004

**Table 3** Environmental studies focussed on the potential chemical pollution of an oil and gas exploration activity.

## Conclusion

At the time of the first exploration drillings offshore the Faroe Islands, in the area bordering UK around 61°N and 5°W in 2001, an environmental impact assessment had been done. The environmental impact assessment contained descriptions of the environment in and around the licensed area and risk assessments of the coming activities. The assessments were based on studies undertaken for the purpose as a cooperation between the oil industry and the scientific institutions in the Faroe Islands and abroad.



Sediment sampling in the Faroe-Shetland Channel (L.-H. Larsen)