

NORWEGIAN INSTITUTE FOR WATER RESEARCH

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REVIEW OF EXISTING DATA ON CADMIUM AND PCB IN MARINE  
WATERS, BIOTA AND SEDIMENTS OF NORWAY.

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By: Tor Bokn

Lars Kirkerud

Brage Rygg

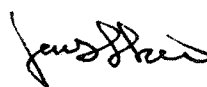
Jens Skei

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Preface.

According to the Summary Record from the 2nd meeting of the Joint Monitoring Group, Santa Maria 6-8th of March 1978 Norway was asked to deliver reports on monitoring of cadmium and PCB in fjords and coastal waters.

In a letter dated 1st of June 1978 Norwegian Institute for Water Research was asked by the State Pollution Control Authority to present a short review of existing data on cadmium and PCB in marine waters, biota and sediments of Norway.



Jens Skei, Ph.D.

Oslo,

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## Introduction.

Cadmium (Cd) is often found associated with sulfide ores (sphalerite, chalcocite, galena and pyrite). Consequently, the production of cadmium takes place in connection with zinc-lead processing. The zinc manufacturers are the main producers of metallic cadmium. By electrolytic production of cadmium a purity of 99,95% is achieved. The world production of cadmium has increased substantially since the second World War, in 1970 the production was approximately 17000 tons.

Cadmium is mainly utilized as an anticorrosion coating on iron and steel items and during production of low-melting alloys. Cadmium is also used as a moderator in atomic reactors and as an additive in the production of paint.

In 1972 87 tons of cadmium was produced in Norway, of which 90% was exported (CMI, 1975).

At the same time there was a discharge of 73 tons of cadmium, about 1/3 (23 tons) was released to the aquatic environment (CMI, 1975).

The major discharges of cadmium to the marine environment in Norway are caused by the zinc smelting industry and ferromanganese smelters. Sauda Smelteverk A/S discharged in 1974 2 tons of cadmium (NIVA, 1976a) while Norzink A/S discharged 1 ton of cadmium in 1972 (Miljøvernkomiteen i Odda, 1973). Otherwise it is assumed that the alloy industry and mines (sulfide ores) contribute with cadmium to the environment.

Polychlorinated biphenyls (PCB) belong to the group of chlorinated hydrocarbons which have drawn a lot of attention in environmental studies. PCB are artificial compounds introduced in the environment through anthropogenic activities since 1930. These compounds have been applied in the making of electric insulation materials, painting, hydraulic oils, PVC, printing ink etc..

There are no known point discharge of PCB in Norway, but it is assumed that there are several diffus discharges to the aquatic environment. Atmospheric long distance transport of PCB cannot be overlooked.

## Material and methods

The review of existing data on cadmium and PCB in the coastal waters of Norway is based on published literature, internal reports, unpublished data and personal communications. A majority of the data are little available and this review would not be possible without personal contacts at the following Universities, research institutions and other authorities:

Agder Regional College, Kristiansand.

Central Laboratory, Institute of the Directorate of Fisheries, Bergen.

Central Institute for Industrial Research, Oslo.

Department of Food and Hygiene, The Veterinary College of Norway, Oslo.

Department of Pharmacology and Toxicology, The Veterinary College of Norway, Oslo.

Marine Research Institute of the Directorate of Fisheries, Bergen.

The Official Norwegian Quality Control Institute for canned Fish Products, Stavanger.

University of Oslo, Institute of Marine Biology and Limnology, Oslo.

University of Trondheim, Institute of Marine Biochemistry, Trondheim.

University of Trondheim, The Museum, Trondheim.

Veterinary Institute of Norway, Oslo.

Vitamine Institute of the Directorate of Fisheries, Bergen.

An evaluation of the various analytical methods applied has not been carried out. Generally, cadmium has been analysed by atomic absorption spectrometry using flame or graphite oven. The PCB-analyses have been performed by gas-chromatography and electron capture detector.

The methods of decomposing the samples prior to analyses (biological material and sediments) and the difference between filtered and unfiltered water samples, have not been considered. The analysis of sediments include both surface and subsurface sediments.

Cadmium (Cd)

The data of cadmium are presented in 6 tables featuring cadmium in benthic algae (Table 1), invertebrates (Table 2), fish (wet wt.) (Table 3), fish (dry wt.) (Table 4), water (Table 5) and sediments (Table 6).

Polychlorinated biphenyls (PCB)

The available data of PCB are given in Table 7 and 8, for biological material and sediments respectively. Data of PCB in water are only available from two fjords, Oslofjorden, South East Norway (1.4 ng/l (n = 1), S.I. (1977)) and Frierfjorden, South East Norway (< 0.9- 107.5 ng/l, < 13.6 ng/l (n = 127), NIVA (1978e)).

TABLE 1. CADMIUM (Cd) IN BENTHIC ALGAE (ppm dry weight)

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Kristiansand S. S-coast	<i>Ascophyllium nodosum</i>	1977	1.6 - 6.8	3.2 (n = 14)	Solheim & Håkedal (1979)
Vågstranda, S-coast	"	Sept. 1975	0.07	0.07 (n = 1)	Julshamm og Eriksen (1978)
Sauda, W-coast	"	Sept. 1974	< 4	< 4 (n = 3)	NIVA (1976a)
Sørfjorden, Hardanger W-coast	"		8-16	10.8 (n = 11)	Haug et al. (1974a, b)
---	---				
---	---	Apr.-July 1974	6-16	10.13 (n = 8)	Melhuus et al. (1978)
---	---	May-Oct. 1974			Myklestad et al. (1978)
---	---	Sept. 1976	9-27	6.5	Myklestad et al. (in prep)
Hardangerfjord (excl. Sørfj.)	"		0.7-8	17 (n = 15)	Haug et al. (1974a, b)
Hardangerfjord (W-coast)	"	1972	1.5-7.4	3.7 (n = 30)	Stenner & Nickless (1974)
Ullvikpollen, Hardanger W-coast	"	Jun. 1976	5.4	4.1 (n = 8)	NIVA (1976b)
Borgundfjorden, Ålesund NW-coast	"	Aug. 1976	1.2	5.4 (n = 1)	NIVA (1979a)
Background, level	"			1.2 (n = 2)	Lande (1973)
Trondheimsfjord	"	Sept. 1972	< 1-1	< 2	Lande (1977)
Trondheimsfjord, NW-coast	"		< 0.7	(n = 17)	Haug et al. (1974a, b)
Trondheimsfjord, N-coast	"	May-Oct. 1974		< 0.7 (n = 33)	Myklestad et al. (1978)
Orkdalsfjorden, NW-coast	"		< 0.7-1.0	< 1	Haug et al. (1974a, b)
Ranafjord, N. Norway	"	Aug. 1975	< 3	0.8 (n = 5)	NIVA (1976c)
Skjerstadfjorden Bodø N-coast	"	1972	1.0-1.5	(n = 3)	Stenner & Nickless (1974)
Lofoten, N-coast	"		< 0.7	1.26 (n = 5)	Haug et al. (1974a, b)
Kristiansand, S-coast	<i>Ascophyllium nodosum</i> <i>Fucus vesiculosus</i>		0.09-0.55	< 0.7 (n = 6)	Julshamm og Eriksen (1978)
Oslofjorden	<i>Fucus vesiculosus</i>	Jul. 1975 Sept. 1974	< 2	0.23 (n = 6)	NIVA (1978 a)
Frierfjord-area, SE-coast	"	Nov. 1976	< 1 - 2.8	< 2 (n = 12)	NIVA (1977a, 1978e)
Kristiansand S. S-coast	"	1977	2.2-7.4	< 2 (n = 73)	Solheim & Håkedal (1979)
Stavanger, SW-coast	"	Sept. 1976	0.5(<1)-1.1	4.2 (n = 22)	NIVA (1978b)
Sauda, W-coast	"	Sept. 1974	< 4	< 1 (n = 8)	NIVA (1976)
Sørfjorden, Hardanger W-coast	"	1972	8.1-12.5	< 4 (n = 5)	Stenner & Nickless (1974)
---	---	Apr.-Jul. 1974	7-13	10.4 (n = 3)	Melhuus et al. (1978)

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Hardangerfjorden, W.coast	<i>Fucus vesiculosus</i>	1972	4.7-6.3	5.3 (n = 6)	Stenner & Nickless (1974)
Borgundfjorden, Ålesund NW-coast	"	Aug. 1976	0.8-1.0	0.9 (n = 2)	NIVA (1979a)
W. Norway	"	Sept. 1972	1	(n = 1)	Lande (1977)
Ranafjord. N.-Norway	"	Aug. 1975	5-7	6 (n = 4)	NIVA (1976c)
Skjerstadfjorden, Bodø, N-coast	"	1972	1.8-2.8	2.16 (n = 5)	Stenner & Nickless (1974)
Oslofjorden	<i>Fucus distichus</i> ssp. <i>edentatus</i>	May 1975	<1	<1 (n = 5)	NIVA (1977c)
Kristiansand S. S-coast	<i>Fucus serratus</i>	1977	2.7-8.8	4.5 (n = 12)	Solheim & Håkedal (1979)
Stavanger SW-coast	"	Sept. 1976	<1	<1 (n = 3)	NIVA (1978b)
Sørfjorden, Hardanger W-coast	"	1972	13	13 (n = 1)	Stenner & Nickless (1974)
---- " ----	"	Apr.-Jul. 1974	22-29	25.5 (n = 2)	Melhuus et al. (1978)
Hardangerfjorden, W.coast	"	1972	3.1-7.1	5.5 (n = 6)	Stenner & Nickless (1974)
Skjerstadfjorden, Bodø N-coast	"	"	2.3-3.2	2.6 (n = 3)	---- " ----
W. Norway	<i>Palvetia canaliculata</i>	Sept. 1972	<1	(n = 1)	Lande (1977)
Kristiansand S. S-coast	Fucoids	Spring 1977	0.9-3.7	2.4 (n = 4)	Solheim et al. (1977)
Sørfjorden, Hardanger W-coast	<i>Chorda filum</i>	1972	4.7-20	12.35 (n = 2)	Stenner & Nickless (1974)
---- " ----	"	Apr.-Jul. 1974	3.0-8.0	4.95 (n = 11)	Melhuus et al. (1978)
Hardangerfjorden W.coast	"	1972	0.9-4.7	2.8 (n = 2)	Stenner & Nickless (1974)
Kristiansand S. S-coast	Kelps - <i>Laminaria</i> spp.	Spring 1977	0.3-1.3	0.6 (n = 4)	Solheim et al. (1977)
Frierfjorden, SE-coast	<i>Cladophora</i> sp.	Sept. 1974- Nov. 1976	0.4 (<2.5)-2.2	<2.5 (n = 44)	NIVA (1977a, 1978e)
Stavanger, SW-coast	<i>Codium fragile</i>	Sept. 1976	< 1-0.5	< 1 (n = 3)	NIVA (1978b)
Sørfjorden, Hardanger W-coast	<i>Enteromorpha</i> spp.	1972	3.4-13	7.28 (n = 4)	Stenner & Nickless (1974)
Sørfjorden, Hardanger W-coast	"	Apr.-Jul. 1974	7.0-13.3	10.45 (n = 8)	Melhuus et al. (1978)
Hardangerfjorden, W-coast	"	1972	2.7-4.2	3.6 (n = 3)	Stenner & Nickless (1974)
Skjerstadfjorden, Bodø N-coast	"	"	0.7-3.2	1.96 (n = 5)	---- " ----



TABLE 2. CADMIUM (Cd) IN INVERTEBRATES (ppm dry weight)

Locality	Material	Date of collection	Concentration range	Arithmetic mean n= number of samples*	References
Oslofjorden	<i>Mytilus edulis</i>	Apr. 1972	2.4-3.6	3.3 (n = 9)	Nair & Andersen (1972)
" "	"	1972-73	2.0-2.1	2.1 (n = 3)	Andersen (1973)
" "	" 17-21 mm	1973-74	1.4-2.9	2.1 (n = 5)	Berg (1977)
" "	"	Apr.-Jun. 1976	0.8-1.2	0.95 (n = 4)	Phillips (1977)
Frierfjord-area	"	Sept. 75-Nov. 76	0.9-3.9	2.12 (n = 42)	NIVA (1977a)
" "	"	Oct. 77-Jun. 78	1.9-3.5	2.87 (n = 3)	NIVA (in press.)
Kristiansand S-coast	"	?	(0.29-0.32) ****	(0.31) (n = 2)	Julshamm & Eriksen (1978)
" "	"	8. March 1975	2.2-23.1	10.5 (n = 31)	Lorentzen et al. (1975)
" "	"	12. March 1975	1.9-5.9	4.3 (n = 10)	---
" "	"	18. March 1975	2.2-5.7	4.7 (n = 14)	---
Vågstranda S-coast	"	Sept. 1975		(0.08) (n = 1)	Julshamm & Eriksen (1978)
Norw. S-W-coast	" 5.5-6 cm	Des.-71		3.0 (n = ?)	ICES (1974)
Sørfjorden, Hardanger W-coast	" (0.20-0.50g) ***	?	5.8-28.1	11.6 (n = 12)	Havre et al. (1973c)
" "	"	?	3.1-17.1	8.0 (n = 43)	---
" "	" (0.51-1.00g)	?	3.0-9.5	6.3 (n = 23)	---
" "	" (1.01-1.50g)	?	3.3-6.0	4.6 (n = 8)	---
" "	" (1.51-2.00g)	?	2.6-5.8	3.9 (n = 12)	---
" "	" (2.01-3.01g)	?			---
Hardangerfjorden W-coast	<i>Mytilus edulis</i>	1972	25.5-140	111.5 (n = 3)	Stenner & Nickless (1974)
Trondheimsfjorden S.-W-coast	"	"	6.1-23	10.75 (n = 8)	---
Norw. W-coast	" 4.5-6 cm	Sept. 1972	< 1-5	2.3 (n = 13)	Lande (1977)
Ranafjord. N-Norway	"	Jan.-72		0.9 (n = 43)	ICES (1974)
Skjerstadvjorden, Bodø N-coast	"	Aug. 1975	1.9-4.7	2 (n = 1)	NIVA (1976c)
Norwegian coast	"	1972		3.27 (n = 3)	Stenner & Nickless (1974)
Oslofjorden	<i>Modiolus modiolus</i>	1971-1972	(0.05-1.05) (0.40-0.55)	(0.37) (n = 31) (0.43) (n = 2)	Hermetikkindustriens Kontrollinstitutt (1978)
Ranafjord. N. Norway	<i>Modiolus modiolus</i>	"	6-10	15.6 (n = 1)	Andersen (1973)
Oslofjord	<i>Cardium edule</i>	Aug. 1975		8 (n = 2)	NIVA (1976c)
" "	<i>Mya arenaria</i>	1973-1974	1.1-2.0	3.8 (n = 1)	Berg (1977)
" "	<i>Macoma baltica</i>	"	0.49-0.63	1.6 (n = 3)	---
" "	<i>Corbula gibba</i>	"		0.56 (n = 2)	---
" "		"		1.4 (n = 1)	---

\*) Each sample comprises a varying number of specimens, analyzed together (e.g. NIVA 1976a, 1977b) or individually (e.g. Berg 1977, Phillips 1977).

\*\*\*) Length of specimens.

\*\*\*\*) Weight of specimens.

\*\*\*\*\*) Concentrations in brackets as wet weight.

Locality	Material	Date of collection	Concentration range	Aithmetic mean n = number of samples*	References
Trondheimsfjorden, N.-W.-coast	<i>Patella vulgata</i>	Sept. 1972	2-22	10.0 (n = 7)	Landø (1977)
Kristiansand S. S-coast	<i>Littorina littorea</i>	1977	2.3-7.8	3.8 (n = 24)	Solheim & Håkedal (1979)
---	" (shell)	"	4.8-6.3	5.7 (n = 23)	---
---	" (soft parts)	"	4.2-10.7	5.8 (n = 5)	---
---	" (shell)	"	6.4-7.3	6.7 (n = 5)	---
---	" (whole animal)	Spring 1977	0.1-1.6	0.8 (n = 8)	Solheim et al. (1977)
Hardangerfjorden W.coast	<i>Littorina littorea</i>	1972	5.4-15	9.82 (n = 6)	Stenner & Nickless (1974)
Oslofjord	<i>Nereis diversicolor</i>	1973-74	0.34-2.70	1.31 (n = 5)	Berg (1977)
"	<i>Capitella capitata</i>	"	<0.8-1.5	0.64 (n = 1)	---
"	<i>Polydora</i> spp. <i>larvae</i>	Nov.-Des. 1971	<0.3-0.7	1.1-1.2 (n = 6)	Kirkerud (1974)
"	<i>Sagitta elegans</i>	Feb. 1972	<0.3-0.6	0.6 (n = 4)	---
"	<i>Caalanus finmarchicus</i>	Okt.71-Feb.72	<0.3-0.7	0.5-0.6 (n = 6)	---
"	<i>Metridia longa</i>	Nov.-Des.-71	<0.3-0.6	<0.5 (n = 5)	---
"	<i>Oncaea borealis</i>	Nov. 1971	2.9	2.9 (n = 1)	---
"	<i>Meganyctiphanes norvegica</i>	Feb.-Mar.-72	<0.05-0.7	0.2-0.3 (n = 5)	---
"	<i>Thysanessa</i> spp.	Mar. 1972	<0.3-0.5	0.3-0.4 (n = 4)	---
"	<i>Gammarus locusta</i>	1973-1974	0.8-1.5	1.15 (n = 2)	Berg (1977)
"	<i>Praonius flexuosus</i>	1973-1974	0.27-1.54	0.76 (n = 4)	---
"	<i>Falaemon adspersus</i>	"	0.7-1.2	0.89 (n = 3)	---
"	<i>Crangon crangon</i>	"	0.3-3.6	1.5 (n = 5)	---
"	<i>Pandalus borealis</i>	Jan.-Mar.-73	0.4-1.7	0.9 (n = 6)	Neelakantan(1976)
Norwegian coast	"	1971-1972	(0.05-0.33)	(0.16) (n = 9)	Hermetikkindustriens Kontrollinstitutt (1978)
Oslofjord	<i>Carcinus maenas</i>	1973-1974	0.5-3.2	1.8 (n = 5)	Berg(1977)
Frierfjord area	"	Sep.75-Okt.76	0.32-0.99	0.67 (n = 5)	NIVA (1977a)
Norwegian coast	"	1971-1972	(0.02-0.14)	(0.07) (n = 29)	Hermetikkindustriens Kontrollinstitutt (1978)
Frierfjord area	<i>Canoe pagurus</i>	Sep.75-Nov.76	2.7-18.2	7.59 (n = 22)	NIVA (1977a)
"	" (claw)	Des.77-Jun.78	2.5-11.1	5.73 (n = 4)	NIVA (in press.)
Kristiansand S.coast	"	?		(0.77) (n = 1)	Julshamn & Eriksen(1978)
---	"	?		(0.01) (n = 1)	---
---	" (gills)	Spring 1977	1.4-3.2	1.9 (n = 4)	Solheim et al. (1977)
---	" (claws)	"	0.2-0.5	0.4 (n = 2)	---
---	" (brown meat)	"	15.8-30.1	21.6 (n = 3)	---

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples *	References
Norwegian coast	<i>Cancer pagurus</i> (dressed crab)	1977	(0.55-1.2)	(0.96) (n = 30)	Hermetikindustriens Kontrollinstitutt (1978)
-- " --	-- " -- (Liver/ Brown meat)	1971-1972	(1.6-14.2)	(6.7) (n = 33)	--- " ---
-- " --	-- " -- (White meat)	"	(<0.05-0.68)	(~0.21) (n = 25)	--- " ---
-- " --	-- " -- (Roe)	"	(0.09-1.5)	(0.48) (n = 20)	--- " ---
-- " --	-- " -- (milt)	"	(0.38-1.4)	(0.67) (n = 4)	--- " ---
Frierfjord area	<i>Ciona intestinalis</i>	May.76-Nov.76	<0.11-1.4	0.68 (n = 9)	NIVA (1977a)

TABLE 3. CADMIUM (Cd) IN FISH (ppm wet weight)

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Frierfjord area, S.E.-coast Norwegian coast	Sprat (whole)	Jan.-Aug.-77 1972-1974	<0.01-0.5 0.01-0.09	< 0.01 (n = 12) 0.025 (n = 56)	Bøe et al. (1978) Hermetikkindustriens Kontrollinstitutt (1978)
Norwegian coast, Barents Sea - North Sea	" (whole fish)		0.016-0.140	0.060 (n = 40-400 individuals)	Julshamm et al. (1978a)
Langesund, Telemark S.E.- coast	Herring	Dec.-76-Jan.-77	0.012-0.081	0.041 (n = 5)	Havre et al. (1973b)
Frierfjord area, S.E.-coast Norwegian coast	" (muscle)	Aug.-77 1972-1974	<0.01 <0.02	< 0.01 (n = 3) < 0.02 (n = 12)	Bøe et al. (1978) Hermetikkindustriens Kontrollinstitutt (1978)
Norwegian coastline, Barents Sea - North Sea	" (whole fish)		0.008-0.070	(0.041 n = 40-400 in- dividuals)	Julshamm et al. (1978a)
The Atlantic Ocean NE (Barents Sea - Lofoten, N-coast)	"	Aug.-Nov.-75	<0.07	<0.07 (n = 20)	Julshamm et al. (1978d)
Oslo, E.coast	Cod (muscle)	?	0.002-0.012	0.005 (n = 4)	Havre et al. (1973b)
Voldsfjord, Telemark SE-coast	"	Oct, 1970	0.013-0.023	0.018 (n = 5)	Havre et al. (1973b)
Frierfjord area, S.E.-coast " " " "	" (liver)	Mar.-Dec.-77 " " " "	<0.01-0.02 <0.05-0.67	<0.01 (n = 20) 0.12-0.13 (n = 14)	Bøe et al. (1978) " " " "
Kristiansand S.-coast Sørffjorden, Hardanger, W.-coast	" (muscle) " (liver)	?	0.004-0.029 0.11-2.2	0.012 (n = 12) 0.65 (n = 10)	Julshamm et al. (1978b) Havre et al. (1973b)
" " " "	" (muscle)	" " " "	0.001-0.041	0.008 (n = 24)	" " " "
Norwegian W.-coast Norwegian coast	"	Jan.-Mar.-72 1972-1974	<0.02 0.01-0.02	<0.02 (n = 5) 0.01 (n = 17)	ICES (1974) Hermetikkindustriens Kontrollinstitutt (1978)
" " " "	" (liver)	" " " "	0.07-0.20	0.14 (n = 16)	" " " "
" " " "	" (roe)	" " " "	0.01-0.01	0.009 (n = 8)	" " " "
" " " "	" (milt)	" " " "	0.01-0.05	0.02 (n = 9)	" " " "
" " " "	"	" " " "	0.02	0.02 (n = 23)	" " " "
Barents Sea, North Norway " " " "	Edible parts of Cod Non-edible parts of Cod		<0.001-0.08 0.01-0.18	~0.017 (n = 6) 0.058 (n = 8)	Julshamm et al. (1978b) " " " "

Locality	Material	Date of collection	Concentration Range	Arithmetic mean n = number of samples	References
The Atlantic Ocean NE (Barents Sea-Lofoten, N.-coast)	Cod (muscle)	Aug.-Nov.-1975	<0.05-0.05	≤ 0.05 (n = 54)	Juulshamm et al. (1979d)
" " " " "	" (liver)	-- " --	<0.05	< 0.05 (n = 50)	--- " ---
Norwegian coastline. Barents Sea, North Sea	Fish byproducts mainly of Cod		0.010-0.080	0.023 (n = 21)	--- " ---
Oslofjord E.-coast	Saithe	?	0.001-0.003	0.002 (n = 2)	Havre et al. (1973c)
Frierfjord area, S.E.-coast	" (muscle)	Mar.-Dec.-77	<0.01-0.01	≤ 0.01 (n = 32)	Bøe et al. (1978)
" " " " "	" (liver)	-- " --	0.02(<0.05)-0.29	0.12 (n = 37)	--- " ---
Sørfjorden, Hardanger, W.-coast	Saithe	The fall of 1971	0.001-0.003	0.002 (n = 3)	Havre et al. (1973b)
Bergen, W.-coast	"	?	0.002-0.004	0.003 (n = 4)	--- " ---
Frierfjord area, S.E.-coast	Pollack (muscle)	Mar.-Dec.-77	<0.01 - 0.03	≤ 0.01 (n = 48)	Bøe et al. (1978)
" " " " "	" (liver)	-- " --	<0.05 - 0.38	0.11-0.13(n = 47)	--- " ---
Sørfjorden, Hardanger, W.-coast	" (muscle)	The fall of 1971	0.002-0.008	0.007 (n = 9)	Havre et al. (1973b)
Frierfjord area, S.E.-coast	Haddock (muscle)	Dec.-77		< 0.01 (n = 1)	Bøe et al. (1978)
" " " " "	" (liver)	-- " --		0.15 (n = 1)	--- " ---
Sørfjorden, Hardanger, W.-coast	" (muscle)	The fall of 1971	0.003-0.014	0.008 (n = 6)	Havre et al. (1973b)
Langesund, Telemark, SE.-coast	Whiting	Dec.70/Jan.71	0.008-0.130	0.077 (n = 4)	Havre et al. (1973b)
Frierfjord area, S.E.-coast	" (muscle)	Mar.-Dec.-77	<0.01	< 0.01 (n = 63)	Bøe et al. (1978)
" " " " "	" (liver)	Jun.-Dec.-77	0.03(<0.05)-0.65	0.13-0.14(n = 44)	--- " ---
Sørfjorden, Hardanger, W.-coast	" (muscle)	The fall of 1971	0.003-0.032	0.016 (n = 3)	Havre et al. (1973b)
Frierfjord area, S.E.-coast	Eel (muscle)	Oct.-Dec.-77	<0.01-0.05	≤ 0.02 (n = 4)	Bøe et al. (1978)
" " " " "	" (liver)	-- " --	0.06-0.25	0.17 (n = 3)	--- " ---
Sørfjorden, Hardanger, W.-coast	" (muscle)	?	0.014-0.147	0.060 (n = 13)	Havre et al. (1973a)
" " " " "	" (liver)	?	1.1 -9.8	4.1 (n = 15)	--- " ---
Norwegian W.-coast	Plaice	Feb.-May.-72	<0.02	< 0.02 (n = 3)	ICES(1974)
Norwegian coast	"	1972-1974	<0.02	< 0.02 (n = 10)	Hermetikkindustriens Kontrollinstitutt (1978)
The Atlantic Ocean NE (Barents Sea-Lofoten, N.-coast)	"	Aug.-Nov.1975	<0.05	< 0.05 (n = 13)	Juulshamm et al. (1978d)
Kragerø, SE.-coast	Flounder (muscle)	?	0.001-0.011	0.006 (n = 3)	Havre et al. (1973b)
Sørfjorden, Hardanger, W.-coast	--- " ---	The fall of 1971	0.005-0.024	0.013 (n = 14)	--- " ---

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Frierfjord area, S.E.-coast	Mackrel (light muscle)	Oct.-77	<0.01	<0.01 (n = 4)	Bøe et al. (1978)
---	" (dark muscle)	"	<0.01	<0.01 (n = 4)	---
---	" (muscle)	Aug.-Dec.-77	<0.01	<0.01 (n = 12)	---
---	" (liver)	"	<0.05-1.2	0.35-0.36 (n = 15)	---
Norwegian coast, Barents Sea - North Sea	Capelin (whole fish)	"	0.037-0.076	0.052 (n = 40-400 individuals)	Julshamm et al. (1978a)
The Atlantic Ocean NE (Barents Sea-Lofoten, N-coast)	"	Aug.-Nov.-75	<0.07	<0.07 (n = 54)	Julshamm et al. (1978d)
Norwegian coastline, Barents Sea - North Sea	Great silver smelt (whole fish)	"	0.006-0.058	0.033 (n = 40-400 individuals)	Julshamm et al. (1978a)
Sørfjorden, Hardanger, W.-coast	Sea trout (muscle)	The fall of 1971	0.010-0.015	0.013 (n = 3)	Havre et al. (1973b)
Norwegian coastline, Barents Sea - North Sea	Muller's pearlsides (whole fish)	"	0.008-0.075	0.030 (n = 40-400 individuals)	Julshamm et al. (1978a)
---	Fish species mainly of the Cod family	"	0.006-0.180	0.030 (n = 20)	---
Saudafjord/Tønsberg, E.-coast	Several fish species (muscle)	?	<0.001-0.002	~0.001 (n = 7)	Havre et al. (1973c)
---	" (liver)	?	<0.01 - 0.30	~0.07 (n = 7)	---
Frierfjord-area, S.E.-coast	" (muscle)	1977	<0.1	<0.1 (n = 205)	Julshamm et al. (1978c)
---	" (liver)	"	0.07-0.41	0.16 (n = 158)	---
Kristiansand, S.-coast	"	"	<0.005-0.045	<0.018 (n = 12)	---
Sørfjorden, Hardanger, W.-coast	" (muscle)	The fall of 1971	0.001-0.023	0.007 (n = 9)	Havre et al. (1973b)
---	" (liver)	"	0.08-2.5	0.71 (n = 4)	---
Møre/Trøndelag MNW-coast	" (muscle)	?	0.001-0.004	~0.002 (n = 9)	---
---	" (liver)	"	0.04-0.07	0.06 (n = 2)	---
Norwegian coastline, Barents Sea - North Sea	"	?	0.005-0.076	0.034 (n = 40-400 individuals)	Julshamm et al. (1978a)
Norwegian Coast	"	1972-1974	0.02-0.25	0.10 (n = 5)	Hermetikkindustriens Kontrollinstitutt (1978)

TABLE 4. CADMIUM (Cd) IN FISH (ppm, dry weight)

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples:	References
Oslofjord	Spratt	Aug.-Nov. 1972	< 0.2 - 0.7	0.2-0.3 (n = 5)	Andersen et al. (1973)
Oslofjord	Herring	Aug.-Nov. 1972	< 0.2 - 0.2	≤ 0.2 (n = 5)	Andersen et al. (1973)
Trondheimsfjord	Herring	Febr. 1973		0.01 (n = 2)	Lande (1977)
Frierfjord area SE-coast	Cod	Sept. 1976	≤ 0.11	≤ 0.11 (n = 3)	NIVA (1977a)
Trondheimsfjord	Cod	Febr./January 1973		0.017 (n = 6)	Lande (1977)
Frierfjord area SE-coast	Saithe	Sept. 1976	0.11 - 0.31	0.21 (n = 3)	NIVA (1977a)
Frierfjord area SE-coast	Saithe (liver)	Sept. 1976	0.31	0.31 (n = 1)	NIVA (1977a)
Frierfjord area SE-coast	Pollack (liver)	May 1976	3.2	3.2 (n = 1)	NIVA (1977a)
Trondheimsfjord	Haddock	Febr.-June 1973		0.027 (n = 3)	Lande (1977)
Trondheimsfjord	Whiting	Feb. 1973		0.02 (n = 2)	Lande (1977)
Frierfjord area SE-coast	Eel	Sept.75/May 76	0.20 - 0.31	0.25 (n = 3)	NIVA (1977a)
Frierfjord area SE-coast	Flaice	Sept.75/May 76	0.13 - 1.11	0.46 (n = 4)	NIVA (1977a)
Oslofjord	Flounder (muscle)	1973-1974	0.03-0.67		Berg (1977)
Oslofjord	Flounder (liver)	1973-1974	0.08-2.63		Berg (1977)
Frierfjord area SE-coast	Flounder	May/Oct. 1976	0.21 - 1.05	0.63 (n = 3)	NIVA (1977a)
Trondheimsfjord	Catfish	Febr. 1973		0.02 (n = 4)	Lande (1977)
Oslofjord	Gobides (Pomatoschistus spp.)	1973-1974	0.17 - 0.29	0.24 (n = 5)	Berg (1977)
Trondheimsfjord	Other species	May/June 1973	0.01 - 0.03	0.019 (n = 13)	Lande (1977)

TABLE 5 . CADMIUM (Cd) IN WATER (ppb)

Locality	Material	Date of collection	Concentration range	Arithmetic mean	References
Oslofjorden, South East Norway	water		0.20 - 0.26	0.24 (n = 5)	Lund & Larsen (1974)
Oslofjorden, South East Norway	water		1.24	1.24 (n = 1)	Lund & Solberg (1975)
Oslofjorden, South East Norway	water		0.13 - 0.74	0.25 (n = 88)	Abdullah (pers.comm.)
Oslofjorden, South East Norway	water		0 - 0.5	0.15 (n = 20)	Andersen (pers.comm.)
Drammensfjorden, South East Norway	water	1977-78	<0.01 - 0.34	0.07 (n = 150)	Schaanning (pers.comm.)
Sørfjorden, West Norway	water	1972	<0.3 - 25	<1.8 (n = 136)	Miljøvernkomiteen i Odda, (1973)
Frierfjorden, South West Norway	water	1974-75	<0.05 - 0.64	<0.12 (n = 171)	NIVA, (1978)
Borgundfjorden, West Norway	water	1976	<0.2 - 0.2	<0.2 (n = 19)	NIVA, (1979a)
Coastal water between Oslo and Larvik	water	1978	<0.1 - 0.2	<0.1 (n = 45)	NIVA, unpubl.



TABLE 6 . CADMIUM (cd) IN SEDIMENTS (ppm, dry weight)

Locality	Material	Date of collection	Concentration range	Arithmetic mean	References
Frierfjorden, South East Norway	Sediments	June 1975	< 1.5 - 26.3	< 5.3 (n = 35)	NIVA, (1978e)
Langesunds-fjorden and surrounding fjords, South East Norway	Sediments	June 1975	< 1.5 - 4.0	< 2.0 (n = 10)	NIVA, (1978e)
Voldsfjorden, South East Norway	Sediments	June 1976	0.5 - 4.0	1.3 (n = 8)	NIVA, (1978e)
Iddefjorden, South East Norway	Sediments	June 1977	0.26-14.6	4.2 (n = 39)	NIVA, (1978c)
Karmsundet, South West Norway	Sediments	June 1977	0.4 - 3.6	1.5 (n = 27)	NIVA, (1978d)
Sørfjorden, West Norway	Sediments	April 1971	16 - 850	121 (n = 16)	Skei et al., (1972)
Sørfjorden, West Norway	Sediments	April 1978	0.58-74.7	20.9 (n = 33)	NIVA, unpubl.
Kristiansand harbour, South Norway	Sediments	1978	< 0.3 - 1.17	< 0.35 (n = 48)	Hansen & Vågsholm, (1978)
Saudafjorden, South West Norway	Sediments	December 1976	0.2 - 1700	72.8 (n = 70)	NIVA, unpubl.
Borgundfjorden, West Norway	Sediments	August 1977	0.14- 1.30	0.55 (n = 21)	NIVA, unpubl.
Dalsfjorden, West Norway	Sediments	April 1978	0.19- 0.62	0.34 (n = 5)	NIVA, unpubl.
Vilnesfjorden, West Norway	Sediments	April 1978	0.36- 0.81	0.59 (n = 5)	NIVA, unpubl.
Buefjorden, West Norway	Sediments	April 1978	0.12- 0.30	0.19 (n = 7)	NIVA, unpubl.
Korssundosen, West Norway	Sediments	April 1978	< 0.1 - 0.20	< 0.12 (n = 7)	NIVA, unpubl.
Bygdevågen, West Norway	Sediments	April 1978	2.79- 3.55	3.06 (n = 10)	NIVA, unpubl.
Skifjorden, West Norway	Sediments	April 1978	0.73- 2.20	1.29 (n = 10)	NIVA, unpubl.
Åfjorden, West Norway	Sediments	April 1978	0.12- 1.30	0.34 (n = 15)	NIVA, unpubl.
Sognefjorden, West Norway	Sediments	April 1978	0.24- 1.63	0.63 (n = 10)	NIVA, unpubl.
Aurlandsfjorden, West Norway	Sediments	April 1978	0.10- 0.43	0.18 (n = 16)	NIVA, unpubl.
Trondheimsfjorden, W.-Norway	Sediments	April 1978	< 0.2 - 0.5	< 0.3 (n = 6)	Fiskum et al., (1974.)

TABLE. 7 . PCB IN BIOLOGICAL MATERIAL (ppm, wet wt.)

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
West and South coast	Sprat ( <i>Clupea sprattus</i> )	1977	0.01 - 0.21	0.074 (n = 33)	Central laboratory of the Directorate of Fisheries (1977)
Sognefjord, West coast	---	1973	0.04 - 0.07	0.05 (n = 4)	Vitamine Institute of the Directorate of Fisheries (1973)
Frierfjord, SE.-coast	---	1973		0.95 (n = 1)	---
Outer Oslofjord	---	1973	0.01 - 0.52	0.14 (n = 13)	---
Inner Oslofjord	---	1973	0.15 - 1.94	1.21 (n = 23)	---
Helgeroa, SE.-coast	---	1974		0.20 (n = 1)	Vitamine Institute of the Directorate of Fisheries (1975)
Frierfjord, SE.-coast	---	1975		0.45 (n = 1)	---
Eidangerfjord, SE.-coast	---	1974-76	0.24 - 0.9	0.42 (n = 4)	NIVA (1977a)
Frierfjord, SE.-coast	---	"	0.24 - 0.7	0.49 (n = 6)	---
Ornefjord, SE.-coast	---	1974		0.10 (n = 1)	---
Meibyfjord, SE.-coast	---	1974		0.18 (n = 1)	---
Sandefjord, SE.-coast	---	1974		0.80 (n = 1)	---
Oslofjord	---	1974		0.70 (n = 1)	---
Inner Oslofjord	---	1970	0.15 - 0.47	0.30 (n = 3)	Bjerk (1972)
Outer Oslofjord	---	1970	0.12 - 0.22	0.17 (n = 2)	---
Kragerø, S.-coast	---	1970		0.18 (n = 1)	---
Trondheimsfjord	---	1970	0 - 0.05	0.025 (n = 2)	---
Bekkelagsbassenget, Inner Oslofjord	---	1970	0.07 - 2.20	0.49 (n = 26)	---
Egersund, S.-coast	Fish-meal from sprat	1975		0.08 (n = 1)	Central Institute for Industrial Research (1975)
Norwegian coast	Cod ( <i>Gadus morhua</i> ) liver oil	1975	1.3 - 2.7	2.0 (n = 6)	Central Institute for Industrial Research (1975, 1976)
---	---	1976	3.1 - 3.2	1.3 (n = 3)	Central Institute for Industrial Research (1976)

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Norwegian coast	Cod ( <i>Gadus morhua</i> ) liver oil	1977	2.4 - 2.9	2.7 (n = 3)	Central Institute for Industrial Research (1977)
---	"Fish" liver oil	1975	0.36-0.70	0.51 (n = 6)	Central Institute for Industrial Research (1975)
Møre, West coast	Cod liver	1972	1.6 - 2.5	2.05 (n = 2)	Central Institute for Industrial Research (1978)
Svolvær, N.-coast	---	1972	---	1.0 (n = 1)	---
Lofoten, N.-coast	---	1969-72	1.2 - 1.2	1.2 (n = 3)	---
Frierfjord, SE.-coast	---	1975	2.0 - 50.0	20.0 (n = 18)	NIVA (1978e)
---	---	1976	3.0 - 679.0	42.0 (n = 27)	---
---	Cod muscle	1975	0.1 - 0.7	0.50 (n = 3)	---
---	---	1976	0.02- 1.1	0.32 (n = 10)	---
Eidangerfjord, Langesundsfjord, SE.-coast	Cod liver	1975	0.7 - 9.0	3.2 (n = 22)	---
---	---	1976	0.5 - 13.0	4.3 (n = 23)	---
---	Cod muscle	1975	0.02- 0.1	0.06 (n = 2)	---
---	---	1976	---	0.03 (n = 1)	---
West coast	Cod liver	1974	0.41- 2.5	1.18 (n = 28)	Kveseth & al. (1977)
---	---	1972	0.08- 10.0	1.63 (n = 195)	Kveseth & Bjerk (1976)
Norwegian Sea	---	1975	0.24- 1.52	0.96	ICES (1977)
Svalbard region	---	1975	0.20- 2.46	0.60	---
Norwegian coast	---	1974-75	0.65- 4.20	1.80	---
Svalbard region	Cod muscle	1975	N.D.- 0.57	0.30	---
Norwegian Sea	---	1975	N.D.- 0.02	0.01	---
Norwegian coast	---	1974-75	---	0.0061	---
SW.-coast	---	1972	---	<0.001	ICES (1974)
South coast	Mackerel ( <i>Scomber scombrus</i> ) oil	1962-63	1.3 - 1.8	1.55 (n = 2)	Central Institute for Industrial Research (1978)
---	---	1972	---	0.4 (n = 1)	---
Kristiansand, S.-coast	---	1973	---	1.6 (n = 1)	---
South Coast	---	1974	---	1.0 (n = 1)	---

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Kristiansand, S.-coast	Mackerel ( <i>Scomber scombrus</i> ) oil	1975		3.6 (n = 1)	Central Institute for Industrial Research (1978)
Eidangerfjord, SE.-coast	Mackerel muscle	1976	0.4 - 0.4	0.4 (n = 2)	Central Institute for Industrial Research (1976)
Kristiansand, S.-coast	Mackerel liver	1975	SD = 0.4	1.0 (n = 7)	Brevik, (1978)
" " " " " "	" " " " " "	1975		16.3 (n = 1)	" " " "
S and SW.-coast	Fish-meal from mackerel, sand eel, herring, Norway pout	1974-75	0.0007-0.99	0.058 (n = 11)	Central Institute for Industrial Research (1975)
Norwegian coast	Fish meal from spiny dogfish	1975	0.02 - 0.05	0.035 (n = 2)	Central Institute for Industrial Research (1976)
North coast	Fish meal from capelin	1974-75	0.015-0.99	0.061 (n = 9)	" " " " (1975, 1976)
Svalbard region	Capelin muscle	1975	0.12 - 0.16	0.14	ICES, (1977)
North Sea	Herring	1972	<0.001- 0.19		ICES, (1974)
" " " " " "	" " " " " "	1973-75	0.08 - 0.11	0.10 (n = 3)	Vitamine Institute of the Directorate of Fisheries (1975)
Fjord	" " " " " "	1974-75	0.12 - 0.30	0.20 (n = 4)	" " " " " "
Norwegian Sea	" " " " " "	1975	N.D. - 0.01		ICES, (1977)
Norwegian coast	" " " " " "	1970	0.48 - 1.45	1.01 (n = 8)	Bjerk, (1972)
Kristiansand, S.-coast	Herring liver	1975	SD = 0.1	0.4 (n = 3)	Brevik, (1978)
South coast	Flounder oil	1975		0.5 (n = 1)	Central Institute for Industrial Research (1978)
Kristiansand, S.-coast	Flounder liver	1975		5.1 (n = 1)	Brevik, (1978)
West coast	" " " " " "	1974	0.02 - 0.24	0.08 (n = 9)	Kveseth & al. (1977)
Frierfjord, SE.-coast	Flounder	1975-76	0.2 - 1.8	0.67 (n = 7)	NIVA (1977a)
West coast	Plaice	1972	0.01 - 0.10	0.04 (n = 3)	ICES, (1974)
Langesundsfjord, SE.-coast	" " " " " "	1976		0.07 (n = 1)	NIVA (1977a)
Abyfjord, SE.-coast	Witch	1977	0.02 - 0.06	0.044 (n = 5)	" " " " (1979b)

\*) ppm fat weight

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Frierfjord, SE.-coast	Saithe liver	1975-76	2.0 - 25.0	9.2 (n = 10)	NIVA (1977a) Frøslie & al. (1977)
---	-- " -- muscle	1975-76	0.1 - 0.2	0.1 (n = 6)	NIVA (1977a)
Eidangerfjord, SE.-coast	-- " -- liver	1975-76	1.6 - 4.3	2.95 (n = 2)	---
---	-- " -- muscle	1975-76	0.03 - 0.05	0.04 (n = 2)	---
Langesundsfjord, SE.-coast	-- " -- liver	1976		2.0 (n = 1)	---
---	-- " -- filet	1976		0.07 (n = 1)	---
Topdalsfjord, S.-coast	-- " -- liver	1975	SD = 0.5	1.7 (n = 5)	Brevik, (1978)
Frierfjord, SE.-coast	Eel	1975-76	0.5 - 1.7	0.82 (n = 5)	NIVA (1977a)
Ornefjord, Langangsfjord, SE.-coast	" *)	1975	2.56 - 2.57	2.565 (n = 2)	---
Frierfjord, SE.-coast	Pollack liver	1976	5.0 - 32.0	18.5 (n = 2)	---
---	-- " -- muscle	1976		0.1 (n = 1)	---
Eidangerfjord, SE.-coast	-- " -- liver	1976	2.7 - 7.0	4.5 (n = 2)	---
Langesundsfjord, SE.-coast	-- " -- liver	1976		5.0 (n = 1)	---
---	-- " -- muscle	1976		0.02 (n = 1)	---
---	-- " -- roe	1976		0.2 (n = 1)	---
Frierfjord, SE.-coast	Whiting liver	1976	2.5 - 15.0	8.0 (n = 3)	---
---	-- " -- muscle	1976	0.05 - 0.09	0.06 (n = 3)	---
Eidangerfjord, SE.-coast	-- " -- liver	1976		4.0 (n = 1)	---
Eidangerfjord, SE.-coast	Horse mackerel liver	1976	2.1 - 2.9	2.5 (n = 2)	Frøslie & al. (1977) NIVA (1977a)
---	-- " -- muscle	1976	0.4 - 0.4	0.4 (n = 2)	---

\*) ppm dry weight

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
West coast	Catfish liver	1974	0.15 - 0.18	0.17 (n = 3)	Kveseth & al. (1977)
---	Ballan wrasse liver	1974	N.D. - 0.13	0.03 (n = 8)	"
---	Lemon sole liver	1974	0.03 - 0.22	0.09 (n = 9)	"
---	Sea Scorpion liver	1974	0.05 - 0.36	0.18 (n = 7)	"
---	Haddock liver	1974	0.17 - 1.4	0.66 (n = 5)	"
Kristiansand, S.-coast	Cuckoo wrasse liver	1974	SD = 1.2	1.7 (n = 4)	Brevik, (1978)
Borgundfjord, W.-coast	<i>Mytilus edulis</i>	1976	0.01 - 0.05	0.03 (n = 2)	
Brevik-Langesundsfjorden, SE.-coast	---	1975	0.3 - 1.3	0.54 (n = 11)	NIVA (1977a)
---	---	1976	0.2 - 1.2	0.60 (n = 25)	" (1977, 1978e)
Brevik, SE.-coast	---	1977	0.39 - 0.54	0.47 (n = 2)	" (1979b)
---	---	1978	0.20 - 0.52	0.36 (n = 2)	" (1979c)
Bekkelagsbassenget, inner Oslofjord	---	1975	0.56 - 1.05	0.82 (n = 6)	Bokn & Rygg (1976)
Oslofjord	---	1975	0.15 - 0.15	0.15 (n = 3)	"
SW.-coast	---	1971	0.02 - 0.04	0.03 (n = 2)	ICES, (1974)
W.-coast	<i>Modiolus modiolus</i>	1974	N.D. - 0.052	0.02 (n = 9)	Kveseth & al. (1977)
Frierfjord-Abyfjord, SE.-coast	<i>Cancer pagurus</i> *)	1975	1.2 - 7.9	4.38 (n = 6)	NIVA (1977a)
---	---	1976	0.4 - 5.8	2.12 (n = 21)	"
---	---	1976	5.3 - 5.8	5.55 (n = 2)	" (1977a, 1978e)
Frierfjord, SE.-coast	<i>Carcinus maenas</i> *)	1974-77	0.2 - 3.4	1.15 (n = 8)	" (1977a, 1979b)
---	<i>Cancer pagurus</i> *)	1977-78	0.84 - 1.4	1.04 (n = 4)	" (1979c)
Abyfjorden, SE.-coast	---	1977-78	0.08 - 0.33	0.26 (n = 4)	"
Frierfjorden, SE.-coast	---	1978		0.99 (n = 1)	"
Kristiansand, S.-coast	<i>Cancer pagurus</i> , hepatopancreas	1975	SD = 9.0	7.5 (n = 8)	Brevik, (1978)
Flekkfjord, S.-coast	---	1975	SD = 0.3	2.6 (n = 5)	"

\*) ppm dry weight

Locality	Material	Date of collection	Concentration range	Arithmetic mean n = number of samples	References
Oslofjord SW.-coast	Pandalid shrimp -- " --	1972		0.05	ICES, (1974)
Frierfjord-Abyfjord, SE.-coast	Sea squirts (Ascidataea, several species) <i>Strongylocentrotus</i> *) <i>dreobachiensis</i>	1972 1976	0.01 - 0.7	0.06 0.16 (n = 5)	--- " --- NIVA (1977a, 1978e)
Frierfjord, SE.-coast	<i>Asterias rubens</i> <i>Ophiotromus flemmosus</i> *)	1975		0.2 (n = 1)	--- " --- (1977a)
West coast		1974	1.0 - 10.0	5.0 (n = 10)	Kveseth & al. (1977)
Frierfjord, SE.-coast	<i>Cladophora</i> sp. *)	1975		0.1 (n = 1)	NIVA (1977a)
--- " ---	<i>Fucus vesiculosus</i> *)	1974		0.26 (n = 1)	--- " ---
Brevik-Langesundsford, SE.-coast		1974	0.06 - 0.09	0.075 (n = 2)	--- " ---

\*) ppm dry weight

n.d = not detected

S.D = Standard Deviation

TABLE 8 . PCB IN SEDIMENTS (ppm dry weight)

Locality	Material	Date of collection	Concentration range	Arithmetic mean	References
Karmsundet, South West Norway	Sediments	June 1977	0.34 - 0.47	0.41 (n = 2)	NIVA, (1978d)
Gandsfjorden, South West Norway	Sediments	September 1976	0.06	0.06 (n = 1)	NIVA, (1978b)
Armøyfjorden, South West Norway	Sediments	September 1976	0.01	0.01 (n = 1)	NIVA, (1978b)
Hafsfjorden, South West Norway	Sediments	September 1976	0.25	0.25 (n = 1)	NIVA, (1978b)
Bekkelagsbassenget, South East Norway	Sediments	January 1977	0.17 - 0.30	0.22 (n = 4)	NIVA, (1977b)
Voldsfjorden, South East Norway	Sediments	June 1976	0.2 - 0.7	0.4 (n = 4)	NIVA, unpubl.



References

Andersen, A.T., Dommasnes, A., & Hesthagen, I.H., 1973:

Some heavy metals in sprat (*Sprattus sprattus*) and herring (*Crupea harengus*) from the inner Oslofjord.

Aquaculture, 2, 17-22

Andersen, A.T., 1973:

Tungmetaller og andre forurensninger i Oslofjorden og kystfarvann-  
innvirkning av disse på marine organismer.

Vann, 2, 1-5

Berg, S.K., 1977:

Skrubba, *Platichthys flesus* (L.), I Oslofjorden og dens forhold til  
forurensing.

Innholdet av tungmetallene (Fe, Cu, Zn, Cd, Hg og Pb) i skrubbe,  
*Platichthys flesus* (L.), fra Oslofjorden, sett i forhold til tung-  
metallkonsentrasjonene i vann og næringsdyr fra samme område.

Hovedfagsoppgave, Universitetet i Oslo 124 s. + tab.

Bjerk, J.E., 1972:

Residues of DDT and PCB in Norwegian sprat (*Clupea sprattus*) and  
herring (*Clupea harengus*)

Nord.Vet.-Med., 24, 451-457

Bokn, T., & Rygg, B., 1976:

Polyklorerte bifenyler i transplanterte blåskjell. Organiska miljø-  
gifter i vatten. Tolfte nordiska Symposiet om vattenforskning, Visby  
11-13 Maj 1976.

Miljøvårdssekretariatet, publikation 1972: 2, 395-400

Brevik, E.M., 1978:

Organochlorins in fish and crabs from the Kristiansand fjord in  
Norway.

Nord.Vet.-Med., 30, 375-379

Bøe, B., Egaas, E., & Julshamn, K., 1978:

Nr. 6/78. Analyse av klorerte hydrokarboner og sporelementer i fisk fra Grenlandsfjordene 1977.

Fiskeridirektoratet, Bergen.

C.M.I. (Chr. Michelsens Institutt), 1975:

Materialstrømanalyse av kadmium.

En skisse.

NTNF-prosjekt B. 1540.4316-26 34 pp.

Fiskum, A., Aakhus, B., Borchsenius, H., Scheldrup, A., Jørgensen, L., Hegset, E., & Os, B., 1974:

Orkdalsfjorden - forurensningskilder - skadevirkninger - mulige forbedringer. Trondheim, The University of Trondheim.

Committee of Environmental studies.

Frøslie, A., Norheim, G., Hoff, H., & Underdal, B., 1977:

Persistente klorerte hydrokarboner i fisk fra Grenlandsområdet innsamlet ved årsskiftet 1975-76 og 1976-77. Stensilert rapport.

Hansen, B., & Vågsholm, K.R., 1978:

Analyse av sedimentprøver fra Kristiansands havn.

Seminaroppgave, 56 pp.

Haug, A., Melsom, S., Omang, S., 1974a:

Tungmetallforurensninger i Trondheimsfjorden og Hardangerfjorden undersøkt ved analyser av grisetang.

Kjemi. 1 (3453). 1-3.

Haug, A., Melsom, S., & Omang, S., 1974b:

Estimation of heavy metal pollution in two norwegian fjord areas by analysis of the brown alga *Ascophyllum nodosum*.

Environ. Pollut. 7. 179-192.

Havre, G.N., Underdal, B., & Christiansen, C., 1973a:

Cadmium concentrations in some fish species from a coastal area in southern Norway. - Oikos, 24. 155-157.

Havre, G.N., Underdal, B., & Christiansen, C., 1973b:

The content of lead and some other heavy elements in different fish species from a fjord in western Norway. - From the proceedings of the International symposium: Environmental Health Aspects of Lead. Amsterdam (Nederland), October 2-6. 1972.

Havre, G.N., Underdal, B., & Trosdal, C., 1973c:

Analyse av elementene Hg, Cd, Pb, Zn i marint, animalsk materiale fra Sjørfjorden i Hardanger. Stensilert. 7 s. + tabs.

Hermetikkindustriens Kontrollinstitutt, 1978:

Cd i biologisk materiale. Brev av 22. november 1978. (B. Uppstad). 3 s.

ICES, 1974:

Report of working group for the international study of the pollution of the North Sea and its effects on living resources and their exploitation. Cooperative research report No. 39. Int. Council Explor. Mer. Charlottenlund, 191 pp.

ICES, 1977:

A baseline study of the level of contaminating substances in living resources of the North Atlantic Cooperative research report No. 69. Int. Council Explor. Mer. Charlottenlund, 82 pp.

Julshamn, K., & Eriksen, J., 1978:

Sporelementer i fisk, skaldyr og tang i og utenfor Kristiansand havn. Rapport nr. 5 (1978). Fiskeridirektoratets Vitamininstitutt. Stensilert 16 s. + tabs.

Julshamn, K., Haugsnes, J., & Utne, F., 1978a:

The contents of 14 major and minor elements (minerals) in norwegian fish species and fish byproducts, determined by atomic absorption spectrophotometry. - Fisk.Dir.Skr., Ser. Ernæring. 1 (4), 117-135.

Julshamn, K., Haugsnes, J., & Eriksen, J., 1978b:

Major and minor element (mineral) levels in products and offal from the fishing industries. - Fisk.Dir.Skr., Ser. Ernæring. 1 (4), 137-144.

Julshamn, K., Haugsnes, J., & Secher, K., 1978c:

Sporelementer i fisk fra Grenlandsfjordene i 1977.

Rapport nr. 1 (1978).

Fiskeridirektoratets Vitamininstitutt. Stensilert 21 s. + tabs.

Julshamn, K., Haugsnes, J., & Eriksen, J., 1978d:

Sporelementer i torsk, sild, rødspette og lodde fra det nordøstlige Atlanterhav. Rapport nr. 6 (1978) Fiskeridirektoratets Vitamininstitutt. Stensilert. 13 s. + tabs.

Kirkerud, L.A., 1974:

Konsentrasjonen av kopper, sink, bly og kadmium (delvis også jern) målt i zooplankton-arter fra Oslofjorden og Skagerak.

Hovedfagsoppgave, Universitetet i Oslo. 63 s + vedlegg.

Kveseth, N.J., & Bjerk, J.E., 1976:

Torsk fra Vestlandsfjorder analysert med henblikk på klorinsektisider og PCB.

Nord. Vet.-Med., 28, 170-176

Kveseth, N.J., Bjerk, J.E., Fimreite, N., & Stenersen, J., 1977:

Rester av DDT og PCB i omgivelsene i et norsk fruktdistrikt fire år etter forbudet mot bruk av DDT.

Forskning og forsøk i landbruket, 28, 317-330

Lande, E., 1973:

Resipientundersøkelsen av Trondheimsfjorden. 2. Tungmetallundersøkelsene - preliminærrapport 20. mars 1973.  
Det kongelige norske videnskabers selskab, Museet. Trondheim.

Lande, E., 1977:

Heavy metal pollution in Trondheimsfjorden, Norway, and the recorded effects on the fauna and flora.  
Environ.Pollut. 12, 187-198.

Lorentzen, I., Noraas, S., & Sørboten, B., 1975:

Blåskjell (*Mytilus edulis*) benyttet som indikator organisme for studier av tungmetallfordeling i en sjøvannsresipient. -  
Seminaroppgave Agder Distriktshøgskole 1975. Stensilert.

Lund, W., & Larsen, B.W., 1974:

The application of electrodeposition techniques to flameless atomic absorption spectrometry.  
Anal.Chim. Acta., 72, 57-62.

Lund, W., & Salberg, M., 1975:

Anodic stripping voltametry with the florence mercury film electrode. Determination of copper, lead and cadmium in sea water.  
Anal.Chim. Acta, 76, 131-141.

Melhuus, A., Seip, K.L., Seip, H.M., & Myklestad, S., 1978:

A preliminary study of the use of benthic algae as biological indicators of heavy metal pollution in Sørffjorden, Norway. -  
Environ. Pollut. 15, 101-107.

Miljøvernkomiteen i Odda, 1973:

Resipientundersøkelser i Sørffjorden 1972.  
Odda, Norway, 250 pp.

Myklestad, S., Eide, I., & Melsom, S., 1976:

Flytting av *Ascophyllum nodosum* fra lokalitet med høy - til lokalitet med reeltivt normal tungmetallbelastning. - Foreløpig rapport.

Myklestad, S., Eide, I., & Melsom, S., 1977:

Opptak av tungmetaller i brunalgen *Ascophyllum nodosum* in situ.  
Halvårsrapport. (I. Eide) juli 1977. Stensilert.

Myklestad, S., Eide, I. & Melsom, S., 1978:

Exchange of Heavy Metals in *Ascophyllum nodosum* (L.) Le Sol. In Situ  
by Means of Transplanting Experiments. - Environ. Pollut. 16,  
277-284.

Nair, K.V.K., & Andersen, A.T., 1972:

The distribution of copper, zinc, cadmium and lead in *Mytilus edulis*  
from Oslofjord.  
C.M./E:20. Fisheries Improvement Committee ICES.

Neelakantan, B., 1976:

Distribution of heavy metals in the northern shrimp *Pandalus borealis*  
from the Oslofjord.  
Fish. Technol. 13, 20-25.

NIVA (Norwegian Inst. for Water Res.), 1976a:

0-51/74. Resipientundersøkelse av Saudafjorden. Observasjoner av  
hydrografi, sedimenter og biologiske forhold 10-13/9 1974. 142 pp.

NIVA, 1976b:

0-55/76. Orienterende resipientundersøkelse av Ulvikpollen,  
Hardanger 22-23.6.1976. 33 pp.

NIVA, 1976c:

0-31/75. Resipientundersøkelse i Ranafjorden. Rapport nr. 2.  
Innledende hydrografiske, geokjemiske og biologiske undersøkelser.  
141 pp.

NIVA, 1977a:

0-111/70. Resipientundersøkelse av nedre Skienselva, Frierfjorden  
og tilliggende fjordområder. Rapport nr. 6. Fremdriftsrapport fra  
de biologiske undersøkelsene mars 1974 - mai 1976. 234 pp.

NIVA, 1977b:

0-34/76. Sedimentundersøkelse i Bekkelagsbassenget. Januar 1977.  
45 pp.

NIVA, 1977c:

O-160/71. Undersøkelse av hydrografiske og biologiske forhold i indre Oslofjord. Overvåkningsprogram. Årsrapport 1975-76. 119 pp.

NIVA, 1978a:

O-95/74. Resipientundersøkelser ved Vallø i Sem og Vårnes i Stokke. Rapport nr. 1. Biologiske undersøkelser i juli-august 1975. 65 pp.

NIVA, 1978b:

O-82/76. Kjemisk/biologiske undersøkelser i fjordene omkring Stavangerhalvøya. September 1976. 66 pp.

NIVA, 1978c:

O-38/75. Nasjonalt program for overvåkning av vannressurser. Pilotprosjekt. Iddefjorden 1977. 74 pp.

NIVA, 1978d:

O-147/76. Orienterende undersøkelser i Karmsundet Hydrokjemiske, sedimentgeokjemiske og biologiske undersøkelser i juni 1977. 58 pp.

NIVA, 1978e:

O-111/70. Resipientundersøkelse av Nedre Skienselva, Frierfjorden og tilliggende fjordområder. Rapport 8. (in press.)

NIVA, 1979a:

O-88/74. Resipientundersøkelse av Borgundfjorden i Ålesund (in prep.)

NIVA, 1979b:

O-129/76. Overvåking av forurensninger i Grenlandsfjordene og Skienselva. Årsrapport 1977. (in prep.)

NIVA, 1979c:

O-129/76. Overvåking av forurensninger i Grenlandsfjordene og Skienselva. Årsrapport 1978. (in prep.)

Phillips, D.J.H., 1977:

The common mussel *Mytilus edulis* as an indicator of trace metals in Scandinavian waters. 1. Zinc and Cadmium.

Mar.Biol., 46, 147-156.

S.I. (Norwegian Central Inst. for Ind. Res.), 1977:

Tilførsel av tungmetaller og klorerte forbindelser. En vurdering av de ulike kilders relative betydning. 61 pp.

Skei, J.M., Price, N.B., Calvert, S.E., & H. Høltedahl, 1972:

The distribution of heavy metals in sediments of Sørfjord, West Norway.

Water, Air and Soil Poll., 1, 452-461.

Solheim, H., & Håkedal, J., 1979:

Trace elements in some marine organisms in Kristiansand Fjord - 1977. - Agder Distriktshøgskoles skriftserie (in prep.)

Solheim, H., Håkedal, J., Bjønnes, P., & Brakstad, D., 1977:

Undersøkelse av tungmetaller i biologisk materiale fra Kristiansandsfjordene. Seminaroppgave våren 1977.

Agder Distriktshøgskole. Stensilert.

Stenner, R.D., Nickless, G., 1974:

Distribution of some heavy metals in organisms in Hardangerfjord and Skjerstadvfjord, Norway.

Water, Air and Soil. Poll. 3, 279-291.