

GUIDELINES FOR MONITORING OF RADIOACTIVE SUBSTANCES

to be followed when implementing HELCOM Recommendation 26/3

- 1 Environmental monitoring
 - 1.1 with reference to sub-paragraph a); routine stations
 - 1.2 with reference to sub-paragraph a); maps
 - 1.3 with reference to sub-paragraph b); radionuclides to be monitored
 - 1.4 with reference to sub-paragraph c); guidelines for reporting environmental data as Excel files

- 2 Discharge data
 - 2.1 with reference to sub-paragraph d); discharge data to be reported
 - 2.2 with reference to sub-paragraph d); form to be used for reporting discharge data

Abbreviations used for the names of the Contracting Parties:

DK	Denmark
EE	Estonia
FI	Finland
DE	Germany
LV	Latvia
LT	Lithuania
PL	Poland
RU	Russia
SE	Sweden

1 ENVIRONMENTAL MONITORING

1.1 Routine station network for regular monitoring programme is recommended as indicated in the following list and maps. Sampling frequency is once a year.

Additional stations and samples are recommended, and reporting of the results accordingly. At open sea stations both surface and near-bottom sea water samples are recommended.

A. WATER SAMPLES

1. Gulf of Bothnia

FI = 7 stations (5 open sea, 2 coastal)

Station LaV 4	65°38,08'N, 24°20,10'E
" C VI	65°14,16'N, 23°33,60'E
" BO 3	64°18,30'N, 22°21,50'E
" F 16	63°31,00'N, 21°04,00'E
" US5b	62°35,20'N, 19°58,50'E
" Olk 2	61°13,90'N, 21°24,10'E
" EB 1	61°04,00'N, 19°44,00'E

SE = 3 stations (2 open sea, 1 coastal)

Station A5	65°09,96'N, 23°13,81'E
" C14 (F26)	62°05,68'N, 18°37,39'E
" SWF135 (Örskär)	60°31,20'N, 18°21,43'E

2. Gulf of Finland

EE = 5 stations (2 open sea, 3 coastal)

Station N5	59°28,4'N, 28°00,6'E
" EE17	59°43,0'N, 25°01,0'E
" PE	59°22,8'N, 24°09,3'E
" PW	59°20,5'N, 24°02,0'E
" EE22	59°26,0'N, 23°09,0'E

FI = 5 stations (3 open sea, 2 coastal)

Station LL 3a	60°04,40'N, 26°20,50'E
" Lov 2	60°22,60'N, 26°22,10'E
" Lov R1	60°21,90'N, 26°06,20'E
" LL 7	59°50,50'N, 24°50,30'E
" JML	59°34,92'N, 23°37,79'E

RU = 9 stations

Station F10	60°05'N, 29°20'E
" F12	60°02'N, 29°03'E
" F27	59°53'N, 28°58'E
" F32	59°51'N, 28°55'E
" F28	59°52'N, 28°50'E
" F13	60°02'N, 28°45'E
" F19	60°15'N, 27°59'E

"	F5	59°57'N, 27°00'E
"	F25	59°40'N, 24°00'E

3. Gulf of Riga

LV = 3 stations

Station	LV119	57°18'N, 23°51'E
"	LV120	57°25'N, 23°46'E
"	BMP61	57°37'N, 23°37'E

4. Baltic Proper

DK = 2 stations

Station	Möen	54°57'N, 12°42'E
"	Svenskehavn	55°05'N, 15°10'E

FI = 3 stations

Station	LL17 (=BY28)	59°02,16'N, 21°04,84'E
"	BY 15	57°19,20'N, 20°03,00'E
"	BY 2	55°00,00'N, 14°05,00'E

DE = 8 stations

Station	USEDOM	54°08,00'N, 14°10,00'E
"	ARKO4	54°15,00'N, 14°05,00'E
"	RUDEN	54°11,30'N, 13°46,00'E
"	ARKO3	54°40,00'N, 13°45,00'E
"	ARKO2	54°55,00'N, 13°30,00'E
"	ARKO1	54°45,00'N, 12°48,00'E
"	DARSS2	54°35,00'N, 12°19,50'E
"	ODER	54°00,40'N, 14°12,00'E

LT = 3 stations (2 open sea, 1 coastal)

Station	LT65	55°52,9'N, 20°20,5'E
"	LT7R	55°36,65'N, 20°20,0'E
"	LT10	55°17,9'N, 21°00,8'E

PL = 16 stations (5 open sea, 11 coastal)

Station	P140	55°33,00'N, 18°24,00'E
"	P2	55°17,50'N, 18°00,00'E
"	P3	55°15,00'N, 17°04,00'E
"	P5	55°15,00'N, 15°59,00'E
"	P39	54°44,50'N, 15°08,00'E
"	P1	54°50,00'N, 19°20,00'E
"	P116	54°39,10'N, 19°17,60'E
"	P110	54°30,00'N, 19°06,80'E
"	ZN2	54°23,00'N, 18°57,50'E
"	ZN4	54°40,00'N, 18°50,00'E
"	L7	54°50,00'N, 17°32,10'E
"	P16	54°38,00'N, 16°48,00'E
"	M3	54°27,00'N, 15°59,00'E
"	K6	54°15,40'N, 15°32,00'E
"	B13	54°04,00'N, 14°15,00'E
"	B15	54°04,00'N, 14°41,50'E

"	SW3	53°56,90'N, 14°15,80'E
RU = 2 stations		
	Station BY28	59°02'N, 21°05'E
"	BY15	57°20'N, 20°03'E
SE = 1 station (coastal)		
	Station SWS36	57°25,30'N, 17°00,00'E

5. Belt Sea, Kattegat and The Sound

DK = 11 stations

Station	Gedser odde	54°28'N, 11°59'E
"	Femern baelt	54°36'N, 11°04'E
"	Langeland baelt	54°52'N, 10°50'E
"	Halskov rev	55°23'N, 11°03'E
"	Asnaes rev	55°39'N, 10°46'E
"	Kattegat SW	56°07'N, 11°10'E
"	Hesselö	56°10'N, 11°47'E
"	Kattegat-413	56°40'N, 12°00'E
"	Kullen	56°12'N, 12°23'E
"	The Sound-N A	55°48'N, 12°44'E
"	The Sound-S	55°25'N, 12°36'E

DE = 18 stations

Station	WARNEM	54°18,00'N, 12°05,00'E
"	KOTN12	54°21,70'N, 11°45,00'E
"	TROLGR	54°12,00'N, 11°40,00'E
"	MEBU1	54°07,00'N, 11°20,00'E
"	MEBU2	54°15,00'N, 11°15,00'E
"	LUEBU	54°03,00'N, 11°04,00'E
"	NEUBU	54°03,00'N, 10°51,00'E
"	FBELT 2	54°30,50'N, 11°25,00'E
"	FBELT 1	54°36,00'N, 11°13,00'E
"	KIBU2	54°35,00'N, 10°51,50'E
"	HOWABU	54°25,10'N, 10°45,00'E
"	KIBU 1	54°34,00'N, 10°34,00'E
"	LTKIEL	54°30,00'N, 10°17,50'E
"	KFOTN6	54°25,00'N, 10°12,00'E
"	STOLGR	54°33,00'N, 10°12,00'E
"	ECKFBU	54°28,00'N, 09°52,50'E
"	SCHLEI	54°40,00'N, 10°08,00'E
"	KALKGR	54°50,00'N, 09°54,00'E

SE = 3 stations (coastal)

Station	SWB38	55°43,63'N, 12°50,62'E
"	SWR36	57°13,57'N, 12°03,60'E
"	SW7 (Myrefjärden)	58°36,20'N, 11°14,70'E

B. SEDIMENT SAMPLES

1. Gulf of Bothnia

FI = 2 stations

Station C VI	65°14,16'N, 23°33,60'E
" EB 1	61°04,00'N, 19°44,00'E
SE = 5 stations	
Station A5	65°10,00'N, 23°14,00'E
" A13 (=F9)	64°42,50'N, 22°04,00'E
" C3 (=US5b)	62°39,17'N, 18°57,14'E
" C14 (=F26)	62°05,99'N, 18°32,91'E
" SWF135	60°31,20'N, 18°21,43'E

2. Gulf of Finland

EE = 1 station	
Station EE17	59°43,0'N, 25°01,0'E
FI = 2 stations	
Station LL 3a	60°04,40'N, 26°20,50'E
" JML	59°34,92'N, 23°37,79'E
RU = 4 stations	
Station F 10	60°05'N, 29°20'E
" F 12	60°02'N, 29°03'E
" F 13	60°02'N, 28°45'E
" F 5	59°57'N, 27°00'E

3. Gulf of Riga

LV = 3 stations	
Station LV119	57°18'N, 23°51'E
" LV120	57°25'N, 23°46'E
" BMP 61	57°37'N, 23°37'E

4. Baltic Proper

DK = 1 station	
Station Arkona Sea	55°00'N, 13°18'E
FI = 2 stations	
Station LL17 (=BY 28)	59°02,16'N, 21°04,84'E
" BY 15	57°19,20'N, 20°03,00'E
DE = 5 stations	
Station RUDEN	54°11,30'N, 13°46,00'E
" ARKO3	54°40,00'N, 13°45,00'E
" ARKO1	54°45,00'N, 12°48,00'E
" DARSS2	54°35,00'N, 12°19,50'E
" ODER	54°00,40'N, 14°12,00'E
LT = 3 stations	
Station LT65	55°52,9'N, 20°20,5'E
" LT10	55°17,9'N, 21°00,8'E
" LT7R	55°36,65'N, 20°20,0'E
PL = 6 stations	
Station P140	55°33,00'N, 18°24,00'E
" P5	55°15,00'N, 15°59,00'E

"	P39	54°44,50'N, 15°08,00'E
"	P1	54°50,00'N, 19°20,00'E
"	P116	54°39,10'N, 19°17,60'E
"	P110	54°30,00'N, 19°06,80'E
RU = 1 station		
	Station BY 28	59°02'N, 21°05'E
SE = 1 station		
	Station SWS36	57°25,30, 17°00,00'E

5. Belt Sea, Kattegat and The Sound

DK = 3 stations		
	Station Kattegat	56°40'N, 12°07'E
"	Great Belt	55°22,5'N, 10°59,9'E
"	The Sound	55°51'N, 12°40,1'E
DE = 9 stations		
	Station KOTN12	54°21,70'N, 11°45,00'E
"	MEBU2	54°15,00'N, 11°15,00'E
"	LUEBU	54°03,00'N, 11°04,00'E
"	NEUBU	54°03,00'N, 10°51,00'E
"	FBELT1	54°36,00'N, 11°13,00'E
"	KFOTN6	54°25,00'N, 10°12,00'E
"	STOLGR	54°33,00'N, 10°12,00'E
"	ECKFBU	54°28,00'N, 09°52,50'E
"	KALKGR	54°50,00'N, 09°54,00'E
SE = 2 stations (coastal)		
	Station SWB38	55°43,63'N, 12°50,62'E
"	SWR40	57°14,79'N, 11°56,71'E

C. FISH SAMPLES

1. Gulf of Bothnia

FI = 4 areas		
	Area Hailuoto	65°03'N, 24°30'E
"	Vaasa	63°10'N, 21°30'E
"	Olkiluoto	61°14'N, 21°20'E
"	Seili	60°14'N, 21°58'E
SE = 4 areas		
	Area SW1	65°35'N, 22°53'E
"	SW8	63°33'N, 19°54'E
"	SW2	60°44'N, 17°52'E
"	SWF22	60°26,70'N, 18°13,50'E

2. Gulf of Finland

EE = 2 areas		
	Area Sillamäe	59°28'N, 27°45'E
"	Paldiski	59°22'N, 24°10'E

FI = 2 areas
Area Tvärminne 59°50'N, 23°15'E
" Loviisa 60°22'N, 26°20'E

3. Gulf of Riga

LV = 2 areas
Area Daugavgriva 57°10'N, 24°05'E
" Central Gulf of Riga 57°25'N, 24°05'E

4. Baltic Proper

DK = 1 area (commercial catches)
Area Bornholm 55°00'N, 15°00'E
DE = 1 area
Area BARC2 54°50,00'N, 13°45,00'E
LV = 1 area
Area Lielirbe 57°40'N, 22°10'E
LT = 1 area
Area Klaipeda 56°03'N, 21°05'E
SE = 3 areas
Area SW3 58°42'N, 18°04'E
" SW5 56°53'N, 18°38'E
" SW4 55°57'N, 15°47'E

5. Belt Sea, Kattegat and The Sound

DK = 1 area (commercial catches)
Area Kattegat S 56°00'N, 11°30'E
DE = 1 area
Area BKIBU 1 54°36,00'N, 10°31,00'E
SE = 1 area
Area SW6 57°14'N, 11°50'E

D. AQUATIC PLANTS (coastal stations)

1. Gulf of Bothnia

FI = 1 site
Site Olk B 61°14,88'N, 21°23,60'E
SE = 1 site
Site SWF111 60°30,20'N, 18°22,00'E

2. Gulf of Finland

EE = 2 sites
Site Sillamäe 59°28'N, 27°45'E
" Paldiski 59°22'N, 24°10'E
FI = 1 site

Site Lov B 60°22,23'N, 26°23,35'E

3. Gulf of Riga

LV = 3 sites

Site Saulkrasti 57°15'N, 24°22'E
 " Ainazi F03 57°52'N, 24°18'E
 " Mersrags F02 57°22'N, 23°07'E

4. Baltic Proper

DK = 1 site

Site Svenskehavn 55°05'N, 15°10'E

DE = 1 site

Site BGBODD 54°13,00'N, 13°43,00'E

LV = 2 sites

Site Pape F01 56°15'N, 21°00'E
 " Pavilosta F07 56°50'N, 21°02'E

LT = 1 site

Site Klaipeda 56°03'N, 21°05'E

PL = 1 site

Site ZN2 54°23'N, 18°57'E

SE = 1 site

Site SWS15 57°15,14'N, 16°48,20'E

5. Belt Sea, Kattegat and The Sound

DK = 1 site

Site Klint 55°58'N, 11°35'E

DE = 1 site

Site BPOEL 54°05,00'N, 11°30,00'E

SE = 2 sites

Site SWB16 55°53,35'N, 12°42,60'E
 " SWR25 57°20,11'N, 12°04,45'E

E. BENTHIC ANIMALS (coastal stations)

1. Gulf of Bothnia

FI = 1 site

Station Olk 9 61°13,92'N, 21°24,20'E

SE = 2 sites

Station SWF111 60°30,20'N, 18°22,00'E
 " SWF108 60°22,40'N, 18°23,74'E

2. Gulf of Finland

FI = 1 site

Station Lov 3 60°22,17'N, 26°23,03'E

3. Baltic Proper

DE = 1 site		
Station BGBODD	54°13,00'N,	13°43,00'E
PL = 3 sites		
Station B13	54°04,00'N,	14°15,00'E
" K6	54°15,00'N,	15°32,00'E
" M3	54°27,00'N,	15°59,00'E
SE = 2 sites		
Station SWS20	57°26,97'N,	16°44,03'E
" SWS15	57°15,14'N,	16°48,20'E

4. Belt Sea, Kattegat and The Sound

DE = 1 site		
Station BPOEL	54°05,00'N,	11°30,00'E
SE = 2 sites		
Station SW6a	57°18'N,	11°54'E
" SW7	58°35'N,	11°16'E

The coordinates given for the sampling areas/sites of fish, aquatic plants and benthic animals are to be considered as centres of larger areas, where the sampling is carried out.

Locations of the stations/areas as well as division of the Baltic Sea into sub-basins are indicated in the maps attached (1-6)

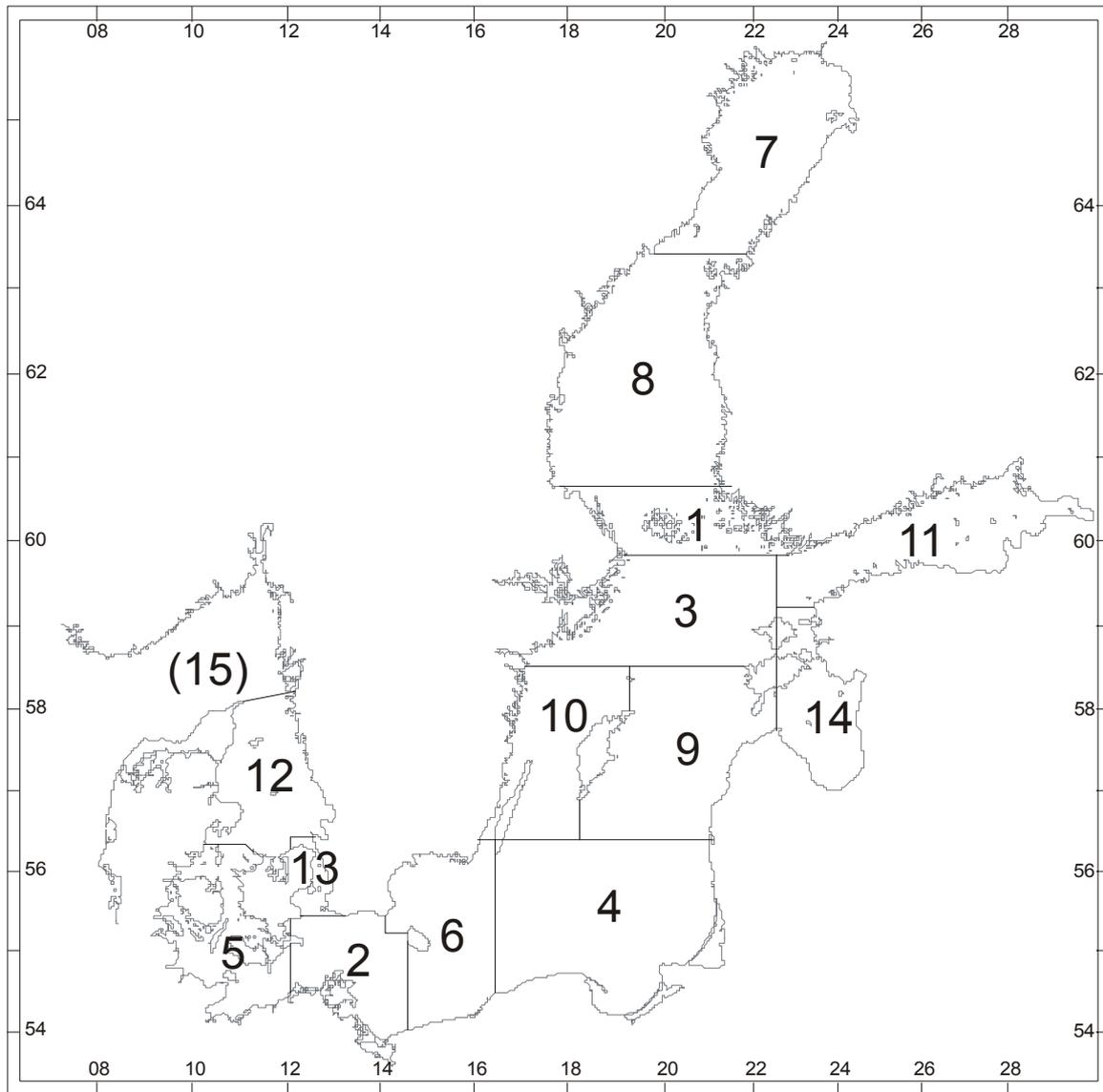
1.2 Maps

Indicating location of the sampling stations/areas:

- Map 1 Division of the Baltic Sea into sub-basins
- 1) Archipelago Sea and Åland Sea
 - 2) Arkona Sea
 - 3) Northern Baltic Proper
 - 4) Southern Baltic Proper
 - 5) Belt Sea
 - 6) Bornholm Sea
 - 7) Bothnian Bay
 - 8) Bothnian Sea
 - 9) Gotland East
 - 10) Gotland West
 - 11) Gulf of Finland
 - 12) Kattegat
 - 13) Sound
 - 14) Gulf of Riga
 - (15) Skagerrak)
- Map 2. The sampling stations of Estonia, Finland, Latvia, Lithuania, Russia and Sweden for seawater and the sites of the Nuclear Power Plants and the Research Reactors in the surroundings of the Baltic Sea.
- Map 3. The sampling stations of Denmark, Germany and Poland for seawater.
- Map 4. The sampling stations for sediment
- Map 5. The sampling areas for fish.
- Map 6. The sampling sites for aquatic plants and benthic animals.

Abbreviations used for the names of the Contracting Parties:

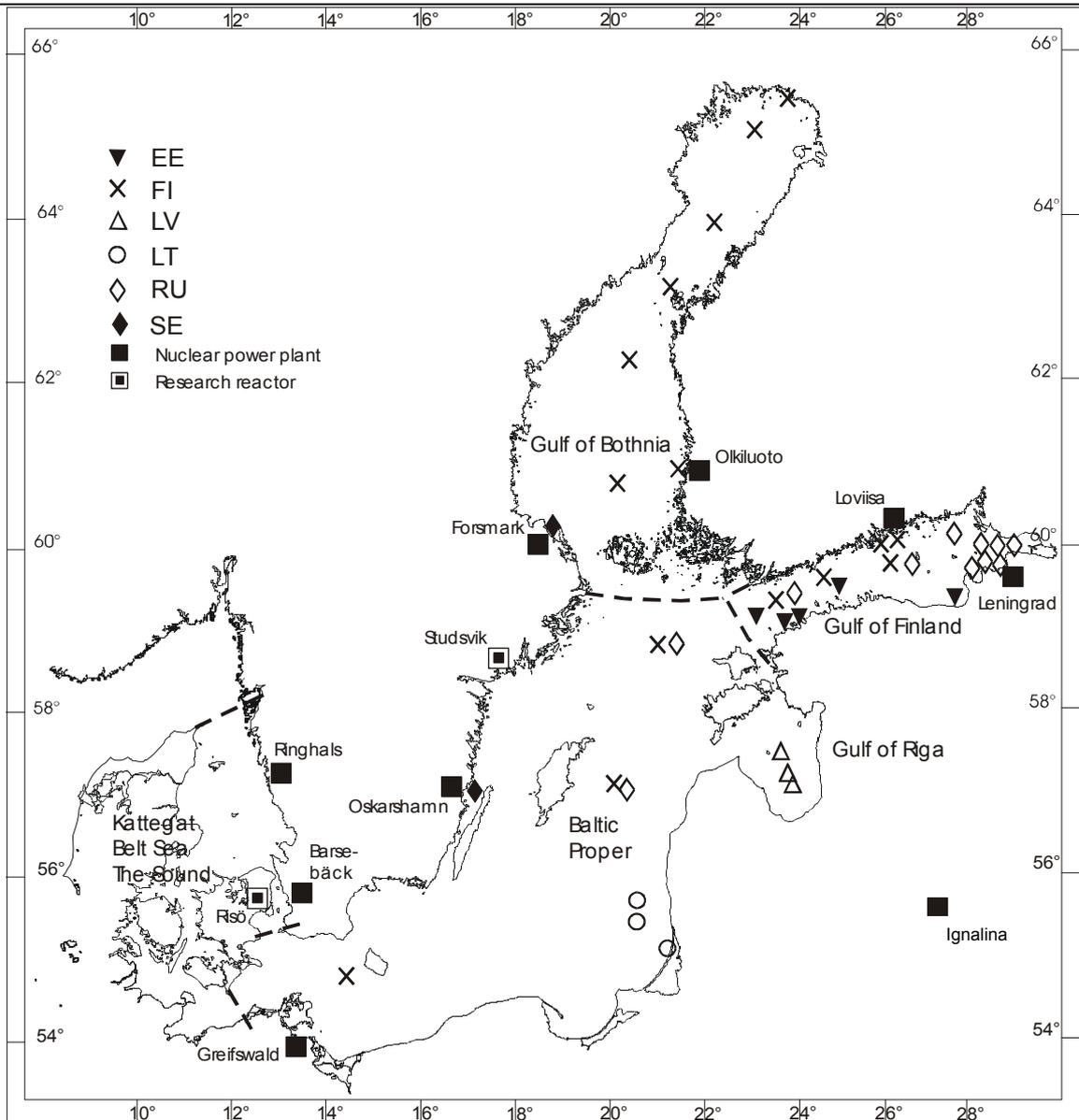
DK = Denmark
EE = Estonia
FI = Finland
DE = Germany
LV = Latvia
LT = Lithuania
PL = Poland
RU = Russia
SE = Sweden



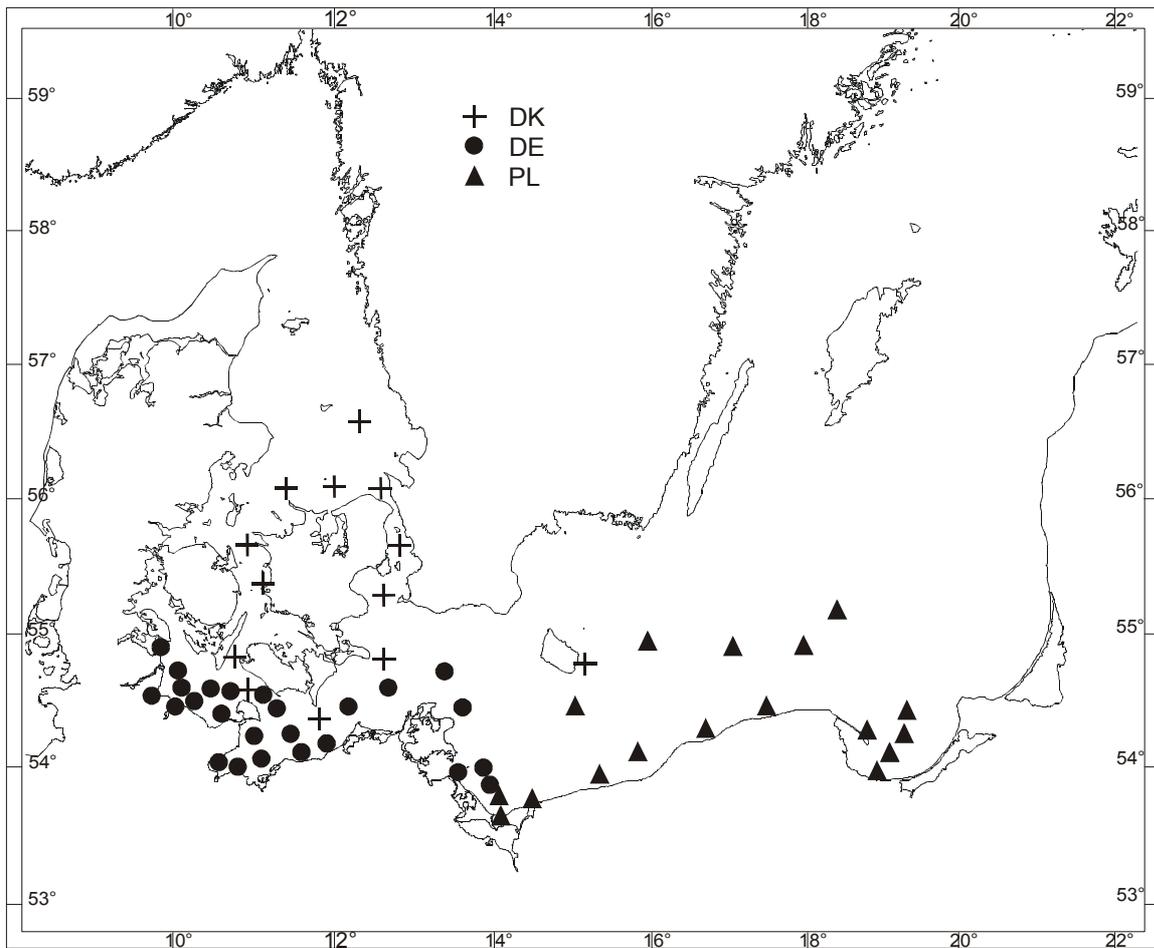
Division of the Baltic Sea into Sub-basins

- | | |
|---------------------------|---------------------|
| 1. Archipelago Sea | 8. Bothnian Sea |
| 2. Arkona Sea | 9. Gotland East |
| 3. Northern Baltic Proper | 10. Gotland West |
| 4. Southern Baltic Proper | 11. Gulf of Finland |
| 5. Belt Sea | 12. Kattegat |
| 6. Bornholm Sea | 13. Sound |
| 7. Bothnian Bay | 14. Gulf of Riga |
| | (15. Skagerak) |

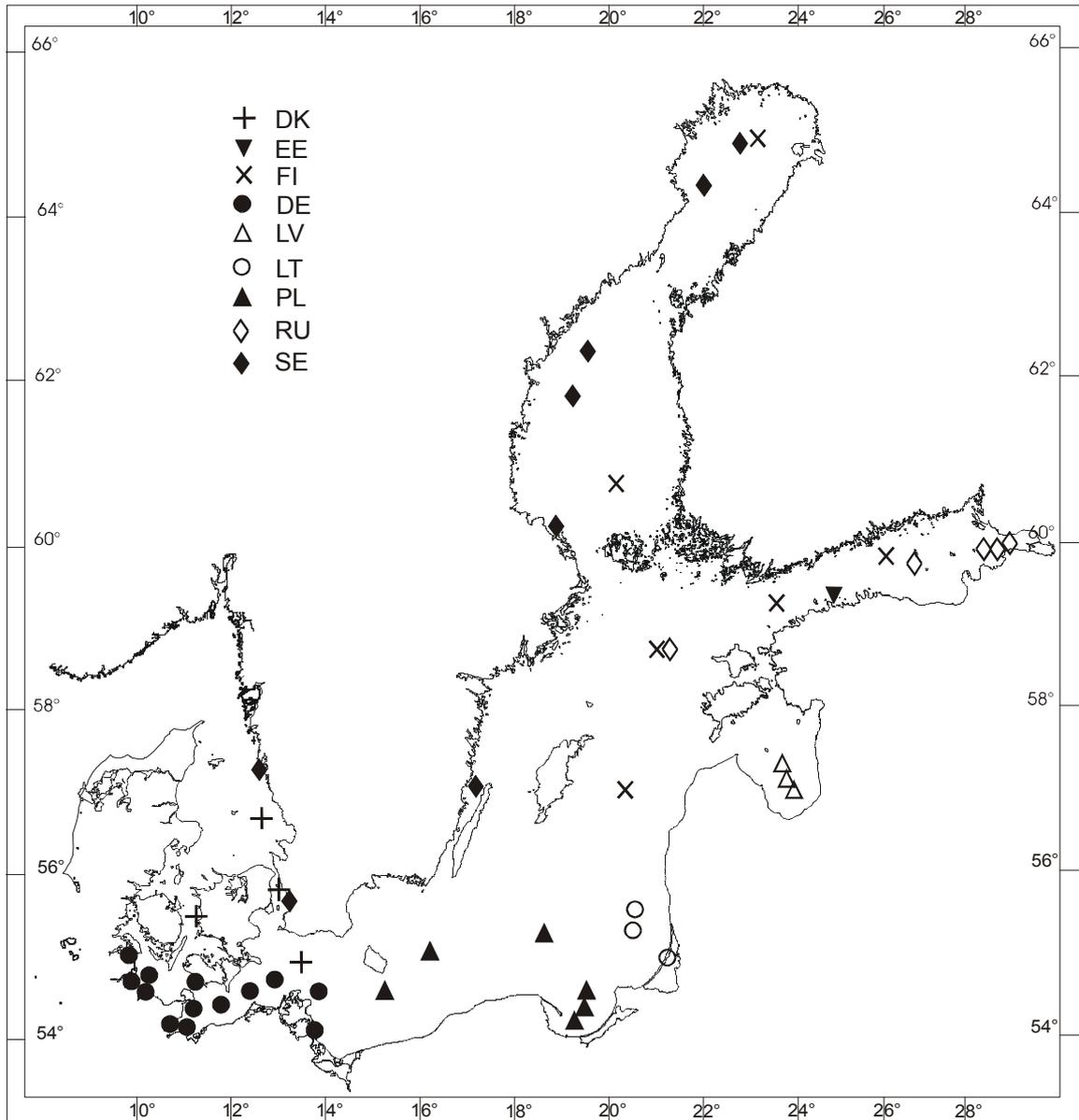
Map 1. The division of the Baltic Sea are into sub-basins.



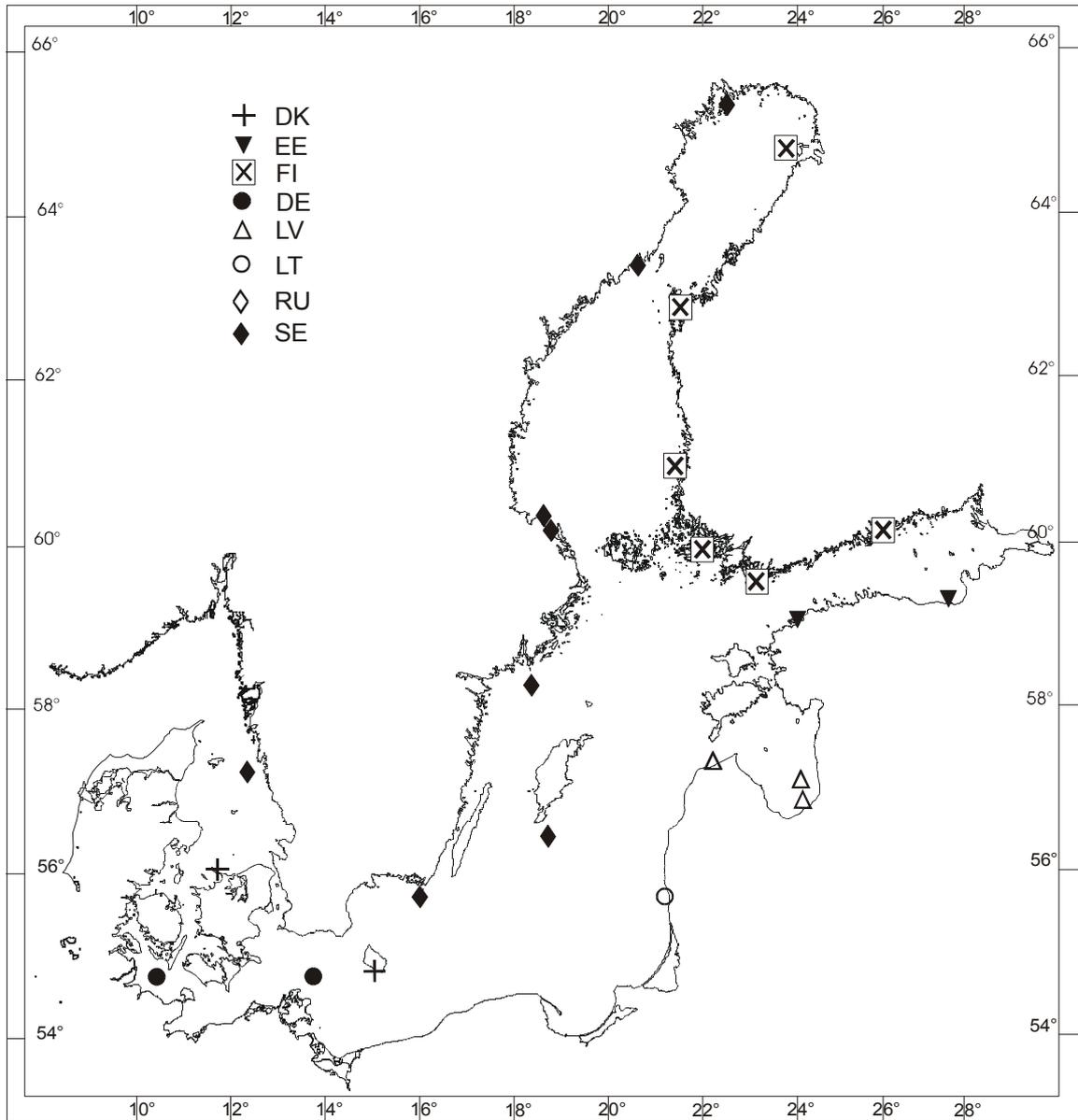
Map 2. The sampling stations of Estonia, Finland, Latvia, Lithuania, Russia and Sweden for seawater and the sites of the Nuclear Power Plants and Research Reactors in the surroundings of the Baltic Sea.



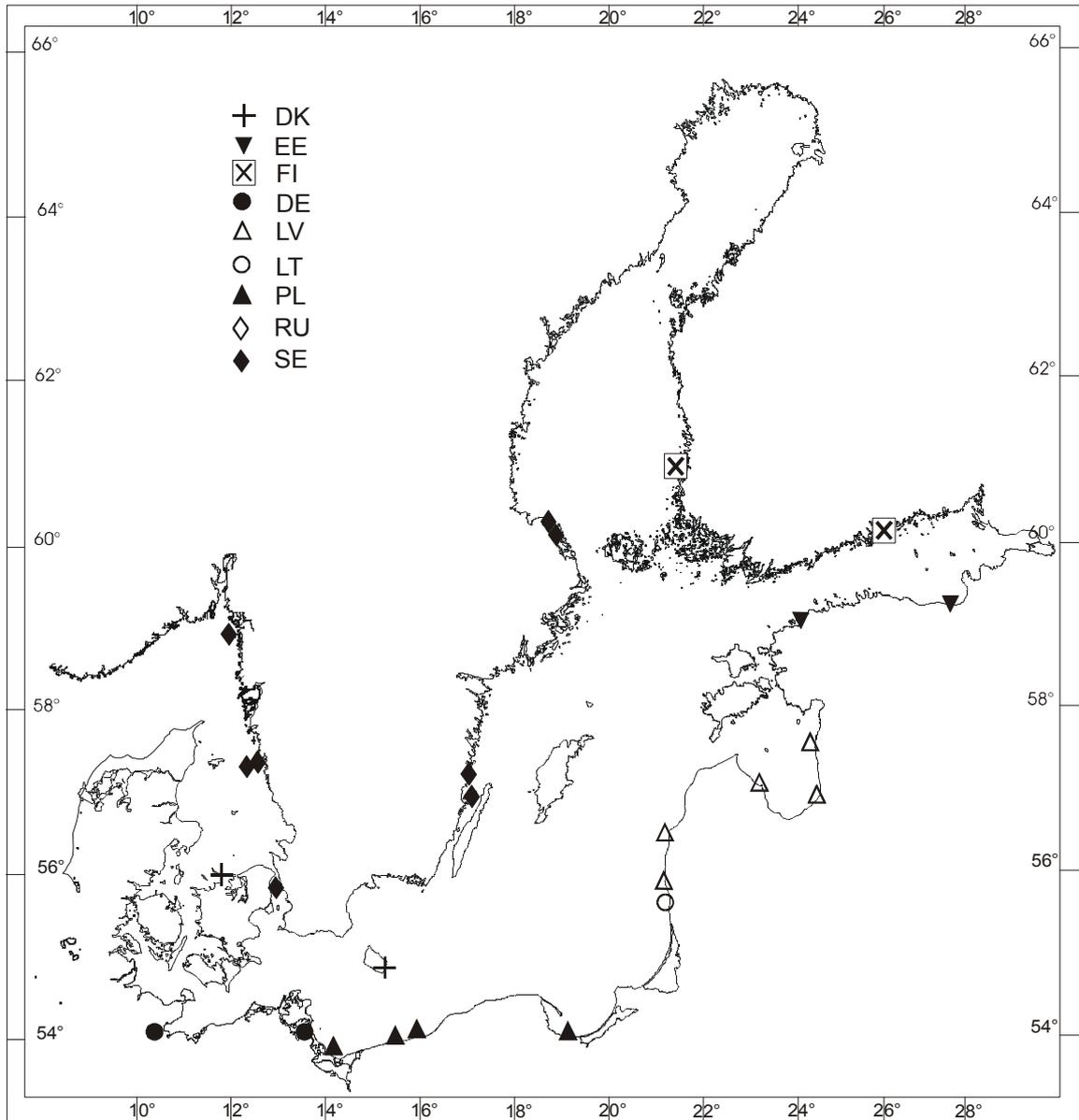
Map 3. The sampling stations of Denmark, Germany and Poland for seawater.



Map 4. The sampling stations for sediment.



Map 5. The sampling areas for fish.



Map 6. The sampling sites for aquatic plants and benthic animals.

1.3 Radionuclides to be monitored

SAMPLE	OBLIGATORY	VOLUNTARY
A. <u>Water</u> (results in Bq m ⁻³)	Radiocaesium *) Sr-90**)	H-3; Tc-99; Pu-239; 240, Am-241; γ-emitters
B. <u>Sediments</u> (results in Bq kg ⁻¹ dry wt. and Bq m ⁻²)	γ-emitters***)	Sr-90; Pu-239, 240; Am-241; natural radionuclides (e.g. Po-210)
C. <u>Fish</u> (results in Bq kg ⁻¹ fresh wt.)	γ-emitters***)	Sr-90; natural radionuclides (e.g. Po-210)
D. <u>Aquatic plants</u> (results in Bq kg ⁻¹ dry wt.)	γ-emitters***)	Sr-90; Tc-99; Pu-239, 240, Am- 241; natural radionuclides
E. <u>Benthic animals</u> (results in Bq kg ⁻¹ dry wt.)	γ-emitters***)	Sr-90; Tc-99; natural radionuclides (e.g. Po-210); Pu-239, 240; Am-241

*) Cs-137 and Cs-134, if possible

**) regularly, on a carefully selected number of samples

***) K-40, Cs-137 and other γ-emitters identifies in the γ-spectrum

1.4 Guidelines for reporting environmental data as Excel files

SEAWATER-data

File name SEAYyyy (yyyy = year of data collection e.g. 2003) should be used for seawater data

The file should consist of two sheets.

Sheet name SEA01yyyy (yyyy = year of data collection e.g. 2003) should be used for samples.

Sheet name SEA02yyyy (yyyy = year of data collection e.g. 2003) should be used for analysis data.

ATTRIBUTES FOR THE SHEET SEA01yyyy:

Attribute	Data type	Format
KEY	Text	Char(12) <u>OBLIGATORY</u>
Data type: TEXT		
Definition: Char(12)		

KEY Consists of

W = Seawater

S = Sediment

B = Biota

LABORATORY abbreviation (see below the laboratory list)

SEQUENCE NUMBER indicated as 'SAMPLING YEAR' in 4 digits and 3 digits for NUMBER

e.g. WCLOR1985002 =

Seawater, Central Laboratory for Radiological Protection, sampling year is 1985 and sample number 002, respectively.

COUNTRY		Text	Char(2)	<u>OBLIGATORY</u>
DENMARK	=	26		
ESTONIA	=	91		
FINLAND	=	34		
GERMANY	=	6	(GERMAN DEMOCRATIC REPUBLIC = 96)	
LATVIA	=	92		
LITHUANIA	=	93		
POLAND	=	67		
SWEDEN	=	77		
RUSSIA	=	90	(former SOVIET UNION)	
LABORATORY		Text	Char(4)	<u>OBLIGATORY</u>

DENMARK

RISO = Risø National Laboratory

ESTONIA

ERPC = Estonian Radiation Protection Centre

EMHI = Estonian Meteorological and Hydrological Institute

FINLAND

STUK = Radiation and Nuclear Safety Authority

GERMANY

DHIG = Federal Maritime and Hydrographic Agency (formerly Deutsches Hydrographisches Institut)

BFFG = Bundesforschungsanstalt für Fischerei

(SAAS = former National Board for Atomic Safety and Radiation Protection (Staatliches Amt für Atomsicherheit und Strahlenschutz (DD)))

LATVIA

LVEA = Latvian Environment Agency (since 01.01.2000), formerly LVDC

LVDC = Environmental data Center of Latvia (until 30.09.2000)

LREB = Lielriga Regional Environment Board

LITHUANIA

JORC = Joint Research Center (formerly)

LEPA = Environmental Protection Agency

POLAND

CLOR = Central Laboratory for Radiological Protection

IMWG = Institute of Meteorology and Water Management

RUSSIA

KRIL = V. G. Khlopin Radium Institute

SWEDEN

NCRS = Swedish University of Agricultural Sciences (former National Swedish Environmental Protection Agency)

SSSI = Swedish Radiation Protection Authority (Statens Strålskyddsinstitut)

SEQUENCE **Number** **Integer(7)** **OBLIGATORY!**
Sequence number of sampling; the sampling year and an Integer (3)

DATE **Date** **Date(dd.mm.yyyy)** **OBLIGATORY!**

YEAR **Number** **Number(yyyy)**

MONTH **Number** **Number(mm)**

DAY **Number** **Number(dd)**

STATION	Text	(Varchar (50))	<u>OBLIGATORY!</u>
	The code of the sampling station e.g., BY15 LOV2, TEILI1		
LAT (ddmmmm)	Number	Integer(ddmmmm)	<u>OBLIGATORY!</u>
	Latitude in degrees, minutes and decimal minutes		
LAT (dd.ddddd)	Number	Integer (dd.dddd)	
	Latitude in degrees and in decimal (dd.dddd)		
	-DECIMAL DEGREES = MINUTES/0.6		
LON (ddmmmm)	Number	Integer(ddmmmm)	<u>OBLIGATORY!</u>
	Longitude in degrees, minutes and decimal minutes		
LON (dd.ddddd)	Number	Integer(dd.dddd)	
	Longitude in degrees and in decimal (dd.dddd)		
	-DECIMAL DEGREES = MINUTES/0.6		
TDEPTH	Number	Integer(3.0)	
	Bottom depth at the sampling site in meters		
SDEPTH	Number	(Integer(3.0))	
	Sampling depth 125 meters as 125		
SALIN	Number	Integer(5.2)	
	Salinity of water in ‰ of sampled water		
TTEMP	Number	Integer(4.1)	
	Water temperature in Celsius (°C) degrees of sampled water		
FILT	Char	Char(1)	
	Indicates if the sample has been filtered		
	Filtered = F, Unfiltered = N		
BASIN	Number	Integer(2))	<u>OBLIGATORY!</u>
	1=ARCHIPELAGO SEA		
	2=ARKONA SEA		
	3=NORTHERN BALTIC PROPER		
	4=SOUTHERN BALTIC PROPER		
	5=BELT SEA		
	6=BORNHOLM SEA		
	7=BOTHNIAN BAY		
	8=BOTHNIAN SEA		
	9=GOTLAND EAST		
	10=GOTLAND WEST		
	11=GULF OF FINLAND		
	12=KATTEGAT		
	13= THE SOUND		
	14=GULF OF RIGA		
	(15=SKAGERRAK)		

ATTRIBUTES FOR THE SHEET SEA02yyyy:

KEY	Text	Char(12)	<u>OBLIGATORY!</u>
------------	-------------	-----------------	---------------------------

NUCLIDE	Text	Varchar(8)	<u>OBLIGATORY!</u>
----------------	-------------	-------------------	---------------------------

First the symbol of the element and then the mass number (without space)

E.g. K40 = ⁴⁰K
CS137 = ¹³⁷Cs
SR90 = ⁹⁰Sr
AG110M = ^{110m}Ag
PU239240 = ^{239,240}Pu

See List of Nuclides in Annex 1.

ANALYSIS METHOD	Text	Char(6)	<u>OBLIGATORY!</u>
------------------------	-------------	----------------	---------------------------

Insert your own code for analysis method.

Each laboratory should give their own codes for analysis methods used in the laboratory and hold a list of codes with description of methods (e.g. literature reference). The list should be revised in case of any changes. This list should be submitted to the data consultant.

Analysis method code consists of the LABORATORY code and a two digit number, e.g. STUK01, RISO03, CLOR04.

<- SIGN	Character	Char(1)
-------------------	------------------	----------------

'<' -sign indicates when the measured value is below the detection limit.

The cell should be left empty if the measured value is higher than the detection limit.

VALUE	Number	Integer(4.2E+2.0)	<u>OBLIGATORY!</u>
--------------	---------------	--------------------------	---------------------------

Measured radioactivity concentration in Bq m⁻³ in scientific format
(e.g. 123 = 1.23E+02, 0.076 = 7.6E-02)

ERROR	Number	Integer(6.2)
--------------	---------------	---------------------

Analytical uncertainties as percentage (1 sigma)

SEDIMENT – data

File name SEDyyyy (yyyy = year of data collection e.g. 2003) should be used for sediment data.

File should consist of two sheets.

Sheet name SED01yyyy (yyyy = year of data collection e.g. 2003) should be used for samples.

Sheet name SED02yyyy (yyyy = year of data collection e.g. 2003) should be used for analysis data.

ATTRIBUTES FOR THE SHEET SED01yyyy:

Attribute	Data type	Format	
KEY See above (seawater data)	Text	Char(12)	<u>OBLIGATORY!</u>
LABORATORY See above	Text	Char(4)	<u>OBLIGATORY!</u>
SEQUENCE See above	Number	Integer(7)	<u>OBLIGATORY!</u>
DATE	Date	Date(dd.mm.yyyy)	<u>OBLIGATORY!</u>
YEAR	Number	Number(yyyy)	
MONTH	Number	Number(mm)	
DAY	Number	Number(dd)	
STATION	Text	(Varchar (50))	
LAT (dd.mmmm) Latitude in degrees, minutes and decimal minutes	Number	Integer(dd.mmmm)	<u>OBLIGATORY!</u>
LAT (dd.ddddd) Latitude in degrees and in decimal (dd.dddd) -DECIMAL DEGREES = MINUTES/0.6	Number	Integer (dd.dddd)	
LON (dd.mmmm) Longitude in degrees, minutes and decimal minutes	Number	Integer(dd.mmmm)	<u>OBLIGATORY!</u>
LON (dd.dddd) Longitude in degrees and in decimal (dd.dddd) -DECIMAL DEGREES = MINUTES/0.6	Number	Integer(dd.dddd)	
DEVICE Insert your own code for sampling device. Each laboratory should give their own codes for sampling devices/methods used for sampling and hold a list of codes with description (e.g. literature reference). The list should be revised in case of any changes. This list should be submitted to the data consultant. Device code consists of the LABORATORY code and a two digit number, e.g., STUK01, RISO03, CLOR04.	Character	Char(6)	<u>OBLIGATORY!</u>
TDEPTH Bottom depth at the sampling site in meters	Number	Integer(3.0)	<u>OBLIGATORY!</u>
UPPSLI	Number	Integer(2.0)	<u>OBLIGATORY!</u>

Core slice depth from sediment surface (in cm), upper limit

LOWSLI **Number** **Integer(2.0)** **OBLIGATORY!**

Core slice depth from sediment surface (in cm), lower limit

E.g.

0-2 cm UPPSLI = 0

 LOWSLI =2

or

2-4 cm UPPSLI = 2

 LOWSLI =4

AREA **Number** **Integer(7.5)** **OBLIGATORY!**

Sampled area (m²) of bottom surface that the sample represents

e.g. 5 sub-samples with, NIEMISTÖ CORER (diameter of the core = 0.05m),

Area= δr^2 (in meters)

$\delta*(0.05/2)^2 = 0.01963 \text{ m}^2$

Total area of 5 sub-samples

= $5 * \delta*(0.05/2)^2 = 0.00981\text{m}^2$

SEDI **Number** **Integer(2)** **OBLIGATORY!**

Sediment type in the slice (see the complete List of sediment types in Annex 2)

0 = Gravel

1 = Sand

2 = Fine sand

3 = Silt

4 = Clay

5 = Mud

6 = Glacial

7 = Soft

8 = Sulphidic

9 = Fe-Mg concretions

Combination examples

12 = Sand and fine sand

45 = Clay and mud

OXIC **Text** **Char(1)**

Oxidation state of the sample

O=OXIC, A=ANOXIC

DW% **Number** **Integer(7.3)**

Dry weight as percentage (%) of fresh weight

LOI% **Number** **Integer(4.1)**

Loss of ignition as percentage (%) of dry weight

BASIN **Number** **Integer(2)** **OBLIGATORY!**

See above

ATTRIBUTES FOR THE SHEET SED02yyyy:

KEY	Text	Char(12)	<u>OBLIGATORY!</u>
------------	-------------	-----------------	---------------------------

See above

NUCLIDE	Text	Varchar(8)	<u>OBLIGATORY!</u>
----------------	-------------	-------------------	---------------------------

See above

ANALYSIS METHOD	Number	Integer(6)	<u>OBLIGATORY!</u>
------------------------	---------------	-------------------	---------------------------

Insert your own code for analytic method.

Each laboratory should give their own codes for analysis methods used in the laboratory and hold a list of codes with description of methods (literature reference). The list should be revised in case of any changes. This list should be submitted to the data consultant.

Analysis method code consists of the LABORATORY code and a two digit number, e.g. STUK01, RISO03, CLOR04.

< VALUE_Bq/kg - SIGN	Character	Char(1)
--------------------------------	------------------	----------------

'<' -sign indicates when the measured value is below the detection limit. The cell should be left empty if the measured value is higher than the detection limit.

VALUE_Bq/kg	Number	Integer(10.3)	<u>OBLIGATORY!</u>
--------------------	---------------	----------------------	---------------------------

Measured radioactivity concentration in Bq/kg dry wt. in scientific format (e.g. 123 = 1.23E+02, 0.076 = 7.6E-02)

ERROR%	Number	Integer(6.2)
---------------	---------------	---------------------

Analytical uncertainties as percentage (1 sigma)

< VALUE_Bq/m² - SIGN	Character	Char(1)
---	------------------	----------------

'<' -sign indicates when the measured value is below the detection limit. The cell should be left empty if the value is higher than the detection limit

VALUE_Bq/m²	Number	Integer(10.3)
-------------------------------	---------------	----------------------

Measured value in Bq/m² in scientific format (e.g. 12300 = 1.23E+04)

BIOTA - data

File name BIOyyyy (yyyy = year of data collection e.g. 2003) should be used for biota data.

File should consist of two sheets.

Sheet name BIO01yyyy (yyyy = year of data collection e.g. 2003) should be used for samples.

Sheet name BIO02yyyy (yyyy = year of data collection e.g. 2003) should be used for analysis data.

ATTRIBUTES FOR THE SHEET BIO01yyyy:

Attribute KEY	Data type	Format	<u>OBLIGATORY!</u>
See above (seawater data)	Text	Char(12)	<u>OBLIGATORY!</u>
LABORATORY See above	Text	Char(4)	<u>OBLIGATORY!</u>
SEQUENCE See above.	Number	Integer(7)	<u>OBLIGATORY!</u>
DATE	Date	Date(dd.mm.yyyy)	<u>OBLIGATORY!</u>
YEAR	Number	Number(yyyy)	
MONTH	Number	Number(mm)	
DAY	Number	Number(dd)	
STATION	Text	(Varchar (50))	
LAT (dd.mmmm) Latitude in degrees, minutes and decimal minutes	Number	Integer(dd.mmmm)	<u>OBLIGATORY!</u>
LAT (dd.ddddd) Latitude in degrees and in decimal (dd.dddd) -DECIMAL DEGREES = MINUTES/0.6	Number	Integer (dd.dddd)	
LON (dd.mmmm) Longitude in degrees, minutes and decimal minutes	Number	Integer(dd.mmmm)	<u>OBLIGATORY!</u>
LON (dd.dddd) Longitude in degrees and in decimal (dd.dddd) -DECIMAL DEGREES = MINUTES/0.6	Number	Integer(dd.dddd)	
SDEPTH Sampling depth in meters (e.g. 125.54)	Number	(Integer(6.2))	<u>OBLIGATORY!</u>
RUBIN Rubin code for sampled species of biota (see the list of Rubin in Annex 3)	Text	Varchar(8)	<u>OBLIGATORY!</u>
BIOTA TYPE Type of biota sampled F=FISH P=PLANT B=BENTHIC ANIMAL	Text	Char(1)	

TISSUE **Number** **Integer(2)**
 Code for the tissue or fraction from which the sample has been taken (see the List of Tissue codes in Annex 4)

NO **Number** **Integer(4)**
 Number of plant or animal specimen in the sample
 e.g. 5 fish (GADU MOR)

LENGTH **Number** **Integer(5.2)**
 Average length (in cm) of specimen in the sample

WEIGHT **Number** **Integer(5.2)**
 Average weight (in g) of specimen in the sample

DW% **Number** **Integer(7.3)**
 Dry weight as percentage (%) of fresh weight

LOI% **Number** **Integer(4.1)**
 Loss of ignition as percentage (%) of dry weight

BASIN **Number** **Integer(2)** **OBLIGATORY!**
 See above

ATTRIBUTES FOR THE SHEET BIO02yyyy:

KEY **Text** **Char(12)** **OBLIGATORY!**
 See above

NUCLIDE **Text** **Varchar(8)** **OBLIGATORY!**
 See above

METHOD **Number** **Integer(6)** **OBLIGATORY!**
 Insert your own code for analysis method.
 Each laboratory should give their own codes for analysis methods used in the laboratory and hold a list of codes with description of methods (literature reference). The list should be revised in case of any changes. This list should be submitted to the data consultant.
 Analysis method code consists of the LABORATORY code and a two digit number, e.g. STUK01, RISO03, CLOR04.

< VALUE_Bq/kg - SIGN **Character** **Char(1)**
 '<' -sign indicates when the measured value is below the detection limit. The cell should be left empty if the value is higher than the detection limit.

VALUE_Bq/kg **Number** **Integer(10.3)** **OBLIGATORY!**
 Measured radioactivity concentrations in invertebrates and aquatic plants are recommended to be reported on a DRY WEIGHT basis and those of vertebrates on

a WET WEIGHT basis. All values should be reported in scientific format (e.g. 123 = 1.23E+02, 0.076 = 7.6E-02)

BASIS	Text	Char(1)	<u>OBLIGATORY!</u>
	Code for the basis the values has been reported		
	W=WET WEIGHT		
	D=DRY WEIGHT		
	A= ASH WEIGHT (not recommended)		

ERROR%	Number	Integer(6.2)
Analytical uncertainties as percentage (1 sigma)		

Annex 1

List of Nuclides

SYMBOL	NUCLIDE	SYMBOL	NUCLIDE
AC228	Actinium-228	PB210	Lead-210
AG108M	Silver-108m	PB212	Lead-212
AG110M	Silver-110m	PB214	Lead-214
AM241	Americium-241	PO210	Polonium-210
BA140	Barium-140	PU238	Plutonium-238
BE7	Beryllium-7	PU238240	Plutonium-238,240
BI214	Bismuth-214	PU239	Plutonium-239
CE140	Cerium-140	PU239240	Plutonium-239,240
CE144	Cerium-144	PU241	Plutonium-241
CM242	Curium-242	RA224	Radium-224
CM243244	Curium-243,244	RA226	Radium-226
CM244	Curium-244	RA228	Radium-228
CO57	Cobalt-57	RU103	Ruthenium-103
CO58	Cobalt-58	RU106	Ruthenium-106
CO60	Cobalt-60	SB124	Antimony-124
CS134	Cesium-134	SB125	Antimony-125
CS134137	Cesium-134,137	SR89	Strontium-89
CS136	Cesium-136	SR90	Strontium-90
CS137	Cesium-137	TC99	Technetium-99
EU155	Europium-155	TE129M	Tellurium-129m
H3	Tritium	TH228	Thorium-228
I131	Iodine-131	U234	Uranium-234
K40	Potassium-40	U235	Uranium-235
LA140	Lanthanum-140	ZN65	Zinc-65
MN54	Manganese-54	ZR95	Zirconium-95
NB95	Niobium-95		

Annex 2

List of Sediment types

SEDI	SEDIMENT TYPE
0	GRAVEL
1	SAND
2	FINE SAND
3	SILT
4	CLAY
5	MUD
6	GLACIAL
7	SOFT
8	SULPHIDIC
9	Fe-Mg CONCRETIONS
10	SAND AND GRAVEL
11	PURE SAND
12	SAND AND FINE SAND
14	SAND AND CLAY
15	SAND AND MUD
20	FINE SAND AND GRAVEL
21	FINE SAND AND SAND
22	PURE FINE SAND
23	FINE SAND AND SILT
24	FINE SAND AND CLAY
25	FINE SAND AND MUD
30	SILT AND GRAVEL
31	SILT AND SAND
32	SILT AND FINE SAND
33	PURE SILT
34	SILT AND CLAY
35	SILT AND MUD
40	CLAY AND GRAVEL
41	CLAY AND SAND
42	CLAY AND FINE SAND
43	CLAY AND SILT
44	PURE CLAY
45	CLAY AND MUD
46	GLACIAL CLAY
47	SOFT CLAY
48	SULPHIDIC CLAY
49	CLAY AND Fe-Mg CONCRETIONS
50	MUD AND GRAVEL
51	MUD AND SAND
52	MUD AND FINE SAND
54	MUD AND CLAY
55	PURE MUD
57	SOFT MUD
58	SULPHIDIC MUD
59	MUD AND Fe-Mg CONCRETIONS

Annex 3

List of Rubin Codes

RUBIN_CODE	LATIN NAME
FUCU VES	FUCUS VESICULOSUS
CLAD GLO	CLADOPHORA GLOMERATA
MACO BAL	MACOMA BALTICA
SADU ENT	SADURIA ENTOMON
CLUP HAR	CLUPEA HARENGUS
GADU MOR	GADUS MORHUA
PLAT FLE	PLATICHTHYS FLESUS
PLEU PLA	PLEURONECTES PLATESSA
LIMA LIM	LIMANDA LIMANDA
PSET MAX	PSETTA MAXIMA
ABRA BRA	ABRAMIS BRAMA
ANGU ANG	ANGUILLA ANGUILLA
ARCT ISL	ARCTICA ISLANDICA
ASTE RUB	ASTERIAS RUBENS
CARD EDU	CARDIUM EDULE
CRAN CRA	CRANGON CRANGON
CYPR CAR	CYPRINUS CARPIO
ESOX LUC	ESOX LUCIUS
FISHLARV	FISH LARVAE
LAMI SACA	LAMINARIA SACCHARINA
MERL MER	MERLANGIUS MERLANGUS
MYA ARE	MYA ARENARIA
MYOX SCO	MYOXOCEPHALUS SCORPIUS
MYTI EDU	MYTILUS EDULIS
OSME EPE	OSMERUS EPERLANUS
PERC FLU	PERCA FLUVIATILIS
PLANKTON	PLANKTON
RUTI RUT	RUTILUS RUTILUS
SPRA SPR	SPRATTUS SPRATTUS
STIZ LUC	STIZOSTEDION LUCIOPERCA

Annex 4

List of Tissue Codes

CODE	TISSUE
1	WHOLE FISH
2	WHOLE FISH WITHOUT ENTRAILS
3	WHOLE FISH WITHOUT HEAD AND ENTRAILS
4	FLESH WITH BONES
5	FLESH WITHOUT BONES
6	HEAD
7	FINS
8	SKIN/EPIDERMIS
9	SCALES
10	BONES
11	GILLS
12	ENTRAILS
13	STOMACH
14	INTESTINE
15	STOMACH + INTESTINE
16	HEART
17	BLOOD
18	LIVER
19	KIDNEY
20	OVARY
21	TESTES
41	WHOLE ANIMALS
42	SHELLS/CARAPACE
43	SOFT PARTS
51	WHOLE HAPTOPHYTIC PLANTS
52	LOOSE-DRIFTING PLANTS
53	GROWING TIPS
54	UPPER PARTS OF PLANTS
55	LOWER PARTS OF PLANTS

2 DISCHARGE DATA

2.1 Discharge data to be reported:

- 1) Discharges into the aquatic environment from the nuclear power plants and research reactor
- on obligatory basis
- 2) Discharges into air from the nuclear power plants and research reactors and other releases, if significant
- on voluntary basis
- 3) Only nuclides with a longer half-life than one week should be reported
- 4) Other necessary monitoring is encouraged to be carried out e.g. related to airborne pollution, river discharges etc.

2.2 Form to be used for reporting discharge data

Page ___ of ___ pages

REPORTING FORM

Radioactive Dischargers to the Baltic Sea from Land Based Sources

1 FACILITY

1.1 Name

1.2 Country

1.3 Type of facility (e.g. reactor, fuel cycle operations, laboratory, mine, etc)

1.4 Location-Region

1.5 Year of operation commenced

2 RIVER (in case of inland based sources)

2.1 Nearest river or route for effluents to reach the Baltic Sea

2.2 Average annual river flow ($\text{m}^3 \text{s}^{-1}$)

- Minimum

- Maximum

Page ____ of ____ pages

3 RADIOACTIVE DISCHARGES YEAR _____

3.1 Total annual discharge of radionuclides in liquid effluents from the site
(half-life longer than one week)

Nuclide	Bq	Nuclide	Bq
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3.2 Airborne discharges from the site (on voluntary basis)

Nuclide	Bq	Nuclide	Bq
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

3.3 Estimate of fraction of above mentioned radionuclides reaching the Baltic Sea

4 ADDITIONAL INFORMATION

ATTACHMENT to the Guidelines for Monitoring of Radioactive Substances

Example of used methods for sample preparation and analysis

Analytical Methods Used For Biological Samples for the HELCOM/MORS Group

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Federal Research Centre for Fisheries, Institute of Fisheries Ecology, Hamburg, Germany

September 1998, updated autumn 2002, and May 2006

^s retired in spring 2004; [&] joined in Sept. 2005

1. Introduction

The analytical methods used at our Institute (Institute for Fisheries Ecology, code BFFG within MORS) have been published in Germany partly in the "Guide to methods for the monitoring of radioactivity in the environment and for registration of radioactive emissions from nuclear power installations" (BMU, 1992; updated in 1994; in German). At present, only the methods for fish and flesh of mussels and shrimps are published. However, the radiochemical procedures for invertebrates and *Fucus vesiculosus* are practically the same. Especially for the detailed description of the radiochemical procedures this work should be consulted.

In the following some general remarks concerning aspects of the sample pre-treatment as well as the measurement procedures are given.

2. Sample pre-treatment

Biota samples (fish, benthic organisms, aquatic plants) having been caught by bottom trawls (1 hour per station) are stored deep frozen (-20 °C) after pooling several specimen into one sample. Larger fishes (especially cod) are already dissected on board before freezing to obtain the fillet. From cod the livers are also taken. Mussels and aquatic plants are analysed as a whole.

For radioactivity measurements, each biota sample (fresh weight ranging from 1-10 kg, or even less in case of benthos) is dried for 2 days in the laboratory now at a temperature of 110 °C (few years earlier 130 °C). Up to the end 1995, the samples were ashed in large ovens using a 154 hour temperature programme with a maximum temperature of 460 °C (controlled by an Apple PC). Only for cod liver samples (very fatty), a more slowly and longer operating temperature programme was used with the maximum temperature reduced to 390 °C.

Two tests were made in 1991 (with North Sea fish, 12 samples) and in 1992 (with Baltic Sea cod, 8 samples) to ensure that significant losses of ¹³⁷Cs do not occur by the ashing procedure. From each fish sample (after thawing) 1 kg flesh was taken and directly measured in a 1 L Marinelli beaker. The calibration for ⁴⁰K and ¹³⁷Cs was taken from corresponding calibrations with liquid solutions without applying self-attenuation corrections. Then

each 1 kg sample was dried and ashed. The ash was then measured in a 50 mL container. The calibration was again taken from calibrations with liquid solutions, but now calculated self-attenuation corrections for ash were applied. The results for the means of the ratios "ash measurement / direct measurement" indicated that the average losses of ¹³⁷Cs were about 1%. Therefore, it was concluded that significant ashing losses of Caesium needed not to be considered.

In autumn of 1995, the complete ashing ovens' electric equipment including electronic regulators was replaced by new devices. Also, the Apple PC was replaced by a DOS PC on which a new temperature controlling programme was applied. Thereafter, in 1996, the test from 1991/1992 was repeated. Unfortunately, the result for 460 °C was, that a ¹³⁷Cs loss of some percent was found. Even at the lower temperature of 430 °C a loss of about 2.5% was found. Therefore, from 15th of October 1996 on a maximum temperature of 420 °C is being used.

After completion of the gamma spectrometric determination from the ash this sample is ashed further, now at 500 °C for the purpose of the radiochemical determination of Sr, Pu and Am.

3. Analytical methods used for MORS biota

3.1 Method BFFG01: Gamma spectrometric analysis

The detailed procedure for gammaspectrometric measurements of fish is given in the method "G- γ -SPEKT-FISCH-01" (BMU, 1992). This method can also be used for ashed material of other marine organisms.

3.1.1 Equipment

For the analysis of gamma emitting nuclides several Ge-detectors (p-type GeLi's and HPGe's and 1 n-type HPGe) are being used. Their relative efficiencies are between 20 and 48%, energy resolution values vary from 1.8 to 2.3 keV at 1.33 MeV. The detectors are placed within lead shieldings of 10 cm lead and inner layers of copper, cadmium and plexi glass. Multichannel buffer modules (stand alone modules, controlled by PC) are used for recording of the spectra (4096 channels per detector, approximate energy range 30 to 1900 keV, 0.46 keV/channel).

For the measurement of ashes of the biological material two different measurement containers are used: a small 50 mL container and a larger container of approximately 200 mL. Both containers are cylindrical plastic containers.

3.1.2 Evaluation of spectra

A self-written Fortran programme is used on a PC which is based on the principles of SAMPO80 (Koskelo et al., 1981). As it was not published some details are given below.

- automatic peak search routine from SAMPO80, modified by an additional smoothing operation;
 - list of peaks to be fitted: combined from i) the automatic peak search, ii) from user-defined characteristic peaks of those radionuclides for which detection limits have to be calculated and iii) from such user-defined peaks, which are known beforehand to be overlooked by the peak search (very weak lines near to intensive peaks, or lines within close multiplets);
 - peak fitting function: Gaussian with left side tailing, an additional left side step function and a background polynomial (2 or 3 parameters); the left wing of the step function can have an exponential decay to the left, which may be equivalent to another tailing component (important for larger peaks, also for energies less than 100 keV);
 - peak fitting is done by the method of weighted multi-linear regression (up to 15 peaks in one multiplett); in addition non-linear parameters (Fwhm, peak position, relative step height) are varied by a simple grid search: the Fwhm from calibration, however, is altered only within small limits, and only if the peak area uncertainty is less than 10% and a significant improvement of the reduced chi-square is obtained;
 - graphical package to show each multiplett together with the fitted total function, background function and, if existent, the associated peak area from the independent background measurements;
 - subtraction of background net peak count rates and propagation of uncertainties;
 - automatic energy re-calibration of each sample spectrum;
 - full energy peak efficiencies (for the water solutions) are stored for each detector as two-dimensional functions with up to 10 parameters and dependent on the variables gamma energy (keV) and filling height (cm); these allow automatic interpolation for the desired filling height of (cylindrical) volume sources; the underlying basic efficiency curve is based on a linear curve in the log-log representation (for higher energies) multiplied by a low energy-function approaching the value of 1.0 for higher energies, which is taken from Jäckel et al. (1987) and does not depend on the filling height; the up to 10 parameters have to be estimated from a laborious series of calibration measurements;
 - since the end of 1994, automatically numerically calculated self-attenuation corrections are applied for each peak down to 40 keV (see below); these are based on the geometry of the detector, the sample size (filling height of cylindrical source), the bulk sample density and on the mass-attenuation coefficients of the measured matrix;
 - radionuclide identification, calculation of activities and associated uncertainties by use of a linear equation system: a quadratic matrix (rank= number of present radionuclides) containing sums of gamma-emission probabilities and a vector containing sums of efficiency corrected net counting rates are constructed; from this vector and the matrix-inverse the radionuclide activities and their uncertainties are calculated, however, uncertainties of the emission probabilities can not be considered; this methods weights more than 1 line from a radionuclide according to their emission probabilities, in contrast to least squares methods which weights according to the peak count rate uncertainties; for each peak net count rate an U-Test is used to compare the measured count rate and its uncertainty with that calculated from the radionuclide activities and uncertainties, which clearly can indicate problems with the nuclide identification; the library contains 55 radionuclides with 527 lines (with special emphasis on the naturally-occurring decay series);
 - automatic correction for coincidence summing losses depending on the filling height, at least for ^{134}Cs , ^{60}Co ; these loss corrections are obtained from calibration measurements and are stored in a filling height dependent form in a separate file.
 - calculation of detection limits (based on quantiles $k_{\alpha}=3$ and $k_{\beta}=1.645$);
 - activity results and detection limits for the radionuclides are automatically transferred into our „data base file“;
 - at the end of 2004, a tool for self-testing of the peak evaluation was integrated according to a procedure used in a Nordic software intercomparison (Nielsen and Pálsson, 1998). Automatically, seven of the old 1977 IAEA intercalibration gamma spectra are processed and two statistical tests performed with the results, all within about 5 seconds. The spectrum evaluation programme passed the two programmed statistical tests successfully.
- To obtain self-attenuation corrections for cylindrical samples of water, ash etc. use was made of the geometry dependent numerical calculations of simplified „total efficiencies“ as they were described by Nakamura (1970), who developed a complete analytical solution for the case of cylindrical samples. The formulae (combinations of multiple integrals) are solved by numerical Gauss-Legendre integration. For the case of a cylinder diameter greater than that of the detector an extension of Nakamura's formulae was

developed. For biota ashes mass attenuation coefficients have been calculated from the approximate elemental composition of fish fillet (Atlantic cod) ash. They have been verified experimentally by transmission experiments. It was then verified that they can, at least for energies larger than 100 keV, also be used for the ash of *Fucus vesiculosus* representing ashes of aquatic plants. It turned out that the attenuation corrections of our fish ash counting geometries can amount to about 5 and more per cent for ^{137}Cs compared to the water solution calibration.

3.1.3 Background determinations

Peaks in the background are due to ^{40}K , the decay series of ^{226}Ra and ^{232}Th , interactions of cosmic rays with the material of the shielding and the detector and possible contaminations with artificial nuclides (e.g. ^{60}Co in the steel of the shielding).

To obtain good estimates of the background peaks, from some (2-4) subsequent background measurements (at least 4000 min counting time per measurement) the background net peak counting rates are calculated as weighted means. For the uncertainty of the mean net counting rates two standard deviations are calculated: an "internal" and an "external" standard deviation (see Debertin and Helmer, 1988). If the background line is under statistical control, both uncertainties are very similar. If not, the external standard deviation will be larger than the internal standard deviation; this is especially the case for the background lines of the ^{226}Ra series. The larger of both uncertainties is used as the desired standard deviation.

The background determinations are repeated nearly every half of a year, or if a contamination is suspected.

3.1.4 Efficiency calibration

In earlier years the detectors were calibrated with a laborious procedure for differing filling heights in the two measurement containers using ashes and sediments of differing densities. From the set of measured efficiencies a formula is constructed, which allows interpolation between energy, density and filling height. The nuclides normally used are: ^{210}Pb , ^{241}Am , ^{109}Cd , ^{57}Co , ^{139}Ce , ^{133}Ba , $^7\text{Be}/^{85}\text{Sr}$, ^{137}Cs , ^{54}Mn , ^{65}Zn and ^{88}Y (Physikalisch-Technische Bundesanstalt, Braunschweig). To determine losses due to coincident summing the important nuclides ^{134}Cs and ^{60}Co were added to these nuclides. The uncertainty of the efficiency is estimated to be 5%. The overall uncertainty of the calibration of a single line nuclide is assumed to be 7%.

Since 1994 the detectors are calibrated only with liquid solutions. Self-attenuation corrections necessary for ash samples are calculated (see 3.1.2).

The calibration procedure is not repeated every year. By regular participation in national intercalibration exercises with higher activity contents of the samples, especially of those for which true values are known, it is clearly shown whether recalibrations are necessary.

3.1.5 Checking

To control the stability of the detectors a ^{152}Eu source is counted every two weeks (on Monday) in a good reproducible geometry for 15 minutes on each detector. Net counting rates and the Fwhm of the lines at 122, 779 and 1408 keV are recorded; the relative 1s counting uncertainties do not exceed 1%.

The quality of the calibration of the 250 mL containers, which was done in the summer of 1994, was verified in detail in 1994 by measurements of standard samples and by sediment samples from a national intercalibration exercise in 1995, because from the autumn of 1994 on the new method of utilising calculated self-attenuation corrections was used and had to be checked. In the sediment intercalibration exercise of 1995 even for ^{210}Pb and ^{241}Am very good results were obtained with this method. Since 1997 three different of these multi-nuclide spiked standard sediment samples with known activities are measured each year on each detector.

Since January 2006, a special high count ^{226}Ra gamma spectrum (code MIX2NEQLONG) is available from the "2002 IAEA Intercomparison" (Arnold et al., 2005) showing about 250 gamma lines which serves as a good means to test the peak fitting evaluation of our program where peak reference values are available.

3.2 Method BFFG02 : analysis of Strontium-90

3.2.1 Radiochemical procedures

Two different versions of the method are used.

The first version is a relatively short ^{90}Y extraction method which is described in the guide "G-Sr-90-FISCH-01" (BMU, 1992). After drying the ash and addition of Y-carrier the ash is digested with slightly boiling 12 M HCl. After adjusting the acidic solution to pH 1-1.5 the ^{90}Y is extracted with HDEHP (Bis(2-ethylhexyl) hydrogen phosphate) in n-heptane. After purification of the organic phase with 1 M HCl, Y is re-extracted with 9 M HCl. The aqueous phase is then purified by extraction with Adogen-464 (Triocetyl-methylammonium chloride). Adogen-464 is used as a reagent for the group separation for the actinides and lanthanides (see Keller, 1971, chapter 10.5.3). For further purification Y is then precipitated as $\text{Y}(\text{OH})_3$ using ammonia. The $\text{Y}(\text{OH})_3$ precipitate is re-dissolved with a few drops of 7.2 M HNO_3 . Finally, Y is precipitated as Y oxalate and fixed on a disc for the measurement of ^{90}Y . After the measurement the chemical Y-yield is obtained by complexometric titration of the measured precipitate.

If Pu or Am has also to be determined from the same ash, or if ashes of benthic animals or aquatic plants have to be analysed, a second version of the method is used, which is a modified version of the classical nitric acid method. Refer to method "G-Sr-90-FISCH-02" (BMU, 1992) for a detailed description. After adding Sr-carrier and ^{85}Sr (as well as ^{242}Pu and ^{243}Am , if necessary), a Sr purification with iron

hydroxide from an acetate buffered solution is applied to reduce the influence of disturbing anions and cations. ^{90}Y and other elements (trivalent and higher) are separated by an iron hydroxide precipitation. The combined precipitates of the acetate and iron hydroxide precipitation are used for the Pu and Am determination. After addition of Y-carrier, further re-precipitation and waiting a period of up to 14 days for the ingrowth of ^{90}Y from ^{90}Sr from the cleaned Sr solution, Y is separated from Sr by extraction with HDEHP in n-heptane and precipitated as oxalate for beta measurement. The Sr-yield is determined by gamma counting of ^{85}Sr . The Y-yield is obtained by complexometric titration of the measured precipitate.

3.2.2 Measurement

The oxalate precipitates are measured with gas flow anticoincidence counters (Tracerlab, AC-1) with background counting rates between 0.25 and 0.33 cpm. The calibration of the detectors was done with a few ^{90}Y precipitates (^{90}Sr standard solution from the PTB, Braunschweig, being in equilibrium with ^{90}Y) covering a definite range around an average value of 40 mg/cm² of the oxalate precipitate. Thus, the ^{90}Y efficiency is calibrated density dependent. The calibration is repeated every few years.

Each sample is counted up to 4 times within a period of one week, with counting times of 500 min, in order to follow the decay of ^{90}Y . The measured decay curve is evaluated by weighted multi-linear regression utilising a Fortran programme developed for routine ^{90}Sr analysis. This technique enables one to detect and resolve possible interferences from following sources: 1) interference from the short-living ^{228}Ac (6.1 h) resulting in an excess of the 1. count; 2) interference from short-living precipitated radon or thoron products again resulting in an excess of the 1. count; and 3) possible interference from long-lived nuclides producing an additional quasi constant background count rate. Possible malfunctions of the counter can also be detected by this method. The analysis of the decay also gives hints, whether the used background count rate has changed significantly.

In early 2005, the beta counting system was replaced by the Risø low-level counter GM-25-5, a system with five 1-inch gas-flow detectors. The shorter distance between source and detector initially caused a thickness problem with our self-prepared ^{90}Y sources which was solved by simply applying mechanical pressure. With the Risø counter the ^{90}Y samples are counted practically continuously up to one week using a cycle time of 1200 min. The background count rates measured with cleaned disks without sample on it are quite low, around 0.1 cpm; count rates with real blank sources show slightly higher values, around 0.14 cpm. The average counting efficiency of the 5 detectors is about 0.42 for our self-prepared Y-oxalate samples. From these data, a detection limit value of slightly less than 3 mBq per sample is obtained for the ^{90}Sr (^{90}Y) measurements; thus, detection limit values of <1

mBq·kg⁻¹ ww may be achieved for fish fillet samples of more than 3 kg ww.

The corresponding Fortran evaluation program also was converted in 2005 to a Windows program. A tool was added for handling output files (simple ASCII files) of the Risø counter (e.g. graphical display of measurement series, fitting ^{90}Y decay curves) and for the transfer of the pre-aggregated counting data of the measured samples into the program's internal file format. The "traditional" multi-linear regression method for the analysis of the ^{90}Y decay curves was also replaced. As the background-subtracted measured count rates are correlated, especially at low counting rates, a matrix method is now used for calculating the least-squares solution by including the non-diagonal input covariance matrix. In addition, to minimise the bias inherent in the traditional least-squares fitting of net counting data, the fit is run three times: in the first run, the statistical weights were determined from the measured values ("Neyman Chi-square"), for the next 2 runs, however, the calculated fitting function values were used for these weights ("Pearson Chi-square").

3.2.3 Checking

The background count rate is controlled during measurement campaigns by use of a few aged blind Y-oxalate precipitates. These measurements are intensified whenever it is indicated by bad ^{90}Y decay curves or other obvious reasons. The stability of the efficiencies of the detectors are controlled monthly by the measurement of self-prepared precipitates of about 100 Bq $^{90}\text{Sr}/^{90}\text{Y}$.

The Risø beta counter was supplied with five ^{99}Tc beta sources (about 100 Bq each), which are used for the control measurements.

3.3 Method BFFG03: Analysis of Plutonium isotopes

3.3.1 Radiochemical Procedure

The radiochemical method for Pu is described in detail in the method "G- α -SPEKT-FISCH-01" (BMU, 1992).

After a 2nd ashing at 500 °C and drying the tracers ^{242}Pu (about 0.08 Bq) and, if Am has also to be determined, ^{243}Am (about 0.068 Bq) (tracer solutions obtained from EML, New York) are added to the ash. The ash is digested twice with slightly boiling 8 M HNO₃. Pu^{VI,V} is reduced with NaNO₂ to Pu^{IV} and extracted from a nitric acid solution with TOPO (Tri-n-octylphosphine oxide) in cyclohexane. The nitric acid phase is used later for the Am analysis (see below). The Pu is converted from the purified organic phase to the aqueous phase by means of a reducing extraction (reduction of Pu^{IV} to Pu^{III}) with a solution of ascorbic acid in 1 M HCl. This step is followed by a LaF₃-coprecipitation of PuF₃ and dissolution of the precipitate in a mixture of saturated boric acid and conc. HNO₃. The Pu is then reduced with NaNO₂ and adsorbed on an anion exchange resin (Dowex 1x2).

Subsequently, the Pu is eluted with a mixture of dilute HCl and dilute HF. This solution is evaporated to dryness. Finally, Pu is electrodeposited on a stainless steel plate from a solution containing ammonium oxalate and HCl. Commercial LSC counting plastic vials are used as electroplating cells, which are thrown away after the analysis. The electroplating is done for 2 hours at 300 mA.

3.3.2 Equipment

Measurements are performed with eight ORTEC 576 Alpha Spectrometer Systems. Each module contains 2 detectors. Up to 1994 16 silicon surface barrier detectors (ruggedised type, 100 μm , 8 detectors with 300 mm^2 , 8 detectors with 450 mm^2) were used. In 1994 and 1997, 6 of them were replaced by new Ultra Ion-Implanted Silicon detectors (ORTEC, 300 mm^2 , 100 μ , 19 keV Fwhm). The distance between the sample and the detector surface is about 4 mm for the older detectors, but smaller for the four newer detectors. The modules were connected to two multichannel buffer modules (MCD/PC, FAST Electronics, Munich, Germany) via two 8-input multiplexer. At the end of 1993 the old ADC's and multiplexer were replaced by new ones. At the end of 1999 the MCA system was completely replaced, consisting mainly of three Analog Multiplexers CI 8224, two Acquisition Interface Modules CI 556 AIM and a basic Genie 2000 software for driving the multichannel analysers and handling the spectra. The channel resolution (was and) is 512 channels per detector. The energy range used is from 4-8 MeV (approximately 8 keV/channel). The counting times varied earlier from 7 to 12 days, since about 1995 from 12 to 23 days.

3.3.3 Measurement and evaluation of the spectra

The tracers ^{242}Pu and ^{243}Am are used for chemical yield determination. The first ^{242}Pu tracers were donations by the US EML Laboratory, but had a ^{241}Pu impurity. Since the summer of 2004, a ^{242}Pu tracer solution from US NIST is used being free of ^{241}Pu . The ^{243}Am tracer solutions were obtained by the UK NPL via AEA Technology, the last also in 2004. By triple analyses of the IAEA-384 CRM subsamples done with the old as well as the new tracers it was confirmed for each tracer, that the results (old/new) were within about 1.2 %. For energy and efficiency calibration an older mixed standard source (^{239}Pu , ^{241}Am , ^{244}Cm ; AEA Technology) was used until the middle of 1992. Corrections for the difference between detector and sample radius, based on geometrical considerations, were obtained by a very fast Fortran program for an up to date highly sophisticated analytical method (Ruffle, 1967) or by published tables (Lindeken & Montan, 1967). The energy calibration is repeated approximately twice a year (because of a relative high activity of the Amersham mixed standard with a larger sample-detector difference).

In the middle of 1992 an alpha source self-prepared by electroplating ^{241}Am from a solution was calibrated

by the PTB (Braunschweig). Since then, the efficiency can be determined more precisely, as the estimation of a geometrical correction factor is unnecessary. This is usually done not more than once per year.

Up to 1991, alpha peak counting rates for non-overlapping Pu peaks were computed by simply integrating the channel contents for the peak regions (gross counting rates) and, for the same regions, subtracting the integrals from corresponding background spectra (average counting rates from a few subsequently measured blind samples are used). For the calculation of statistical uncertainties it was assumed that the (integrated) counting rates can be interpreted as if they were measured with a single channel counter.

Since about 1991 we have a self-written Fortran programme available ("Alkan"), which allows non-linear least squares fitting of complex alpha peak multiplets. It is based on the excellent empirical peakshape description given by Bortels and Collaers (1987). Depending on the peak shape we can work with one or two tail components for a peak. It is ideally suited for overlapping peaks in case of a bad source with larger peak width and more pronounced tailing. It also allows deconvolution in the case of a significant energy shift during the measurement (however, this now occurs very seldom). For peaks with sufficient counting statistics the smaller lines of the Pu- and Am-isotopes are also varied (positions and heights relative to the main line of the isotope) to obtain an optimal fitting result. If the counting statistics are bad, the smaller lines of the isotopes can be held fixed at pre-determined parameters during fitting. Before the fitting is done, from each sample spectrum a smoothed detector background spectrum is subtracted. Using such a programme, the precise re-calibration of the energy is no problem and can be applied to each analysed spectrum as long as a second peak besides the tracer peak exists.

The calculation of the final activity results including uncertainties and detection limits earlier was done with a separate small BASIC programme. This required average net blank count rates (detector background already subtracted) with uncertainties for each measured radionuclide. These are obtained from the analyses of a certain number of blank samples, which are performed routinely at a rate of about 10% of all analysed routine samples.

In the autumn of 2000, this programme was replaced by a completely new program version developed with Lahey Fortran 90/95 and Winteracter GUI which is now running under MS Windows. The formula for calculating the sample activity concentration values depends now on more than 20 parameters, which nearly all may have an attributed uncertainty. In the case of ^{241}Am determination, possible additional background contributions are considered now: i) ^{241}Am impurity in the ^{243}Am tracer solution, and ii) ^{241}Am impurity from the ^{242}Pu tracer solution which may have built up ^{241}Am from the ^{241}Pu impurity. The task of calculating the complete uncertainty propagation has been drastically simplified by making use of calculating the partial derivatives by

a very simple numerical method; thus, it is no longer necessary to develop “huge” analytical formulae for the complete description of the measurand’s uncertainty. As a result, a complete uncertainty budget can be obtained showing for each of the over 20 parameters its relative “per cent” contribution to the combined variance. This numerical method makes it also very simple by an additional numerical iterative algorithm to derive values for the decision and the detection limit, which now depend on all uncertainties considered in the calculation of the combined uncertainty.

Since the autumn of 2001, a new version of the alpha peak fitting programme (“AlkanW”) was developed, also with Lahey Fortran 90/95 and Winteracter GUI, which is now running under MS Windows. Additionally, the above mentioned source code for calculating the complete analytical result including the uncertainty estimation was integrated in AlkanW. The peak fitting algorithm was slightly modified to take now Pearson’s Chi-square for minimisation by using the fitting function itself for defining statistical weights, which shows an improved peak area preservation. In the early 2002, this was again changed by implementing the ultimate method, from the statistical point of view, for fitting Poisson distributed counting data: the Poisson Maximum Likelihood Estimation. This method was recently demonstrated to be unbiased with respect to the fitted peak area regardless the size of the area (Hauschild and Jentschel, 2001). All other methods, including Pearson’s Chi-square and, even more, the commonly used Neyman’s Chi-Square, are known to give biased peak areas, especially in the case of low counting statistics spectra.

3.3.4 Checking

The detector background is controlled approximately once per year by long-term measurement (23 days or more) of specially cleaned stainless steel plates. These (smoothed) background spectra are subtracted from the sample spectra. The quality of the energy calibration is controlled by recording from each sample spectrum the fitted channel positions of ^{242}Pu , $^{239,240}\text{Pu}$ and ^{238}Pu , as far as they can be fitted. Our experience is that these positions, which are determined quite precisely by the fitting programme (and recorded since 1993), were very stable (unless there were electronic malfunctions): average variations for the ^{242}Pu peak were about one channel, i.e. about 8 keV.

Approximately once per year it is controlled how much the activity concentration of the tracer solutions could have changed over the time. For this purpose 6 or more „100% standards“ from the tracer solutions are prepared and measured. This had also to be done in June 1995, because we had to separate radiochemically the ^{241}Am having been built up from the ^{241}Pu in our ^{242}Pu solution, because we then started with our Am analysis. The „100% standards“ of ^{242}Pu are prepared by giving the amount of ^{242}Pu tracer (0.25 mL) directly into the ammonium oxalate and HCl solution in the

electrodeposition cell just before starting with the electrodeposition.

3.4 Method BFFG04: Analysis of Americium-241

3.4.1 Radiochemical Procedure

Our method for Am is used since the autumn of 1995 and is not described elsewhere. A short description is given here.

After adjusting the Am containing nitric acid phase obtained from the Pu extraction (see text for the Pu method) to pH 1, the Am is extracted with TOPO in cyclohexane. From the organic phase the Am is re-extracted with 8 M HNO_3 . The Am is then converted to a 9 M HCl solution. This solution is passed through a mixed-bed ion exchanger (cation exchanger (Dowex 50x8), upper layer; anion exchanger (Dowex 1x8), lower layer). Subsequently, the 9 M HCl eluate is converted to a 12 M HNO_3 solution and the Am extracted by DDCP (di-n-butyl N,N-diethylcarbamoyl phosphate) in n-heptane. The next step is the re-extraction of Am with 2 M HNO_3 . From this phase, the Am is then converted to a methanol/nitric acid solution. This solution is passed through an anion exchanger (Dowex 1x4). Then the Am containing ion exchanger is washed with a $\text{CH}_3\text{OH} / \text{NH}_4\text{SCN} / \text{HCl}$ -solution. Am is eluted from the exchanger by a mixture of $\text{CH}_3\text{OH} / \text{HCl}$. Finally, Am is electrodeposited in the same way as Pu.

Details about the equipment, measurement and evaluation of spectra and checking are the same as outlined for the Pu procedure.

4. Intercalibration

Table 1 shows for some radionuclides the normalised results of our measurements on international intercalibration samples from the IAEA. The samples are taken from that time period in which data have been produced for MORS. ^{241}Am was measured by gamma-ray spectrometry in earlier years, but by alpha-spectrometry since the end of 1994. The radionuclides averages over all IAEA samples and the corresponding standard deviations are also given in Table 1. It has to be noted, that the deviations from the reference values are greater for ^{40}K and ^{137}Cs (approximately 8%), than for ^{134}Cs and ^{241}Am (< 2%). This is not understood, because the determination of the two nuclides ^{134}Cs and ^{241}Am is more complicated. In the case of ^{134}Cs , losses by coincident summing have always been corrected automatically by our programme. Our very low ^{137}Cs value for IAEA-384 looks dramatically, however, the activity concentration was very low with large uncertainty.

The relative standard deviations quoted in Table 1 reflect very well our assumed overall calibration uncertainty of 7% for single line gamma emitters. The standard deviations for the Pu isotopes are slightly higher.

Our ^{90}Sr results are most often lower than the reference values, the latter could be established in only

a few cases. They are at the lower end, especially in those cases where only few measured values spanning a large range were delivered to IAEA. Our “feeling” is that the lower ^{90}Sr values are the more realistic ones. However, our value for IAEA-315 might have suffered from an undetected loss of Sr.

Our results of the DHI intercomparison on Baltic Sea sediment are also included in Table 1. Here, the deviations from the reference values are low for ^{40}K , ^{134}Cs and ^{137}Cs .

From the national intercalibration exercises, those organised by the Bundesanstalt für Gewässerkunde (in Koblenz) with sediments from the river Rhine, which were spiked with many gamma emitting radionuclides as well as $^{89}\text{Sr}/^{90}\text{Sr}$ with levels significantly above environmental levels, are of special interest for the judgement of our measurements. Their “true” activity reference values are known precisely from spiking and in most cases confirmed by the means from all laboratories. These exercises are repeated about every three years. Two spiked samples, S2 and S3, were distributed: S3 had the higher activity values, S2 the lower ones, but still much more than natural river sediments usually contain.

Table 2 shows for the years 1983 to 2000 our normalised results for selected radionuclides including ^{90}Sr , which was measured by our combined $^{89}\text{Sr}/^{90}\text{Sr}$ method (not having been used for MORS samples). Since 1992, ^{90}Sr was no longer analysed to avoid cross contaminations from the higher ^{241}Am activities. Except for ^{90}Sr and ^{241}Am , the deviations from unity are smaller than those presented in Table 1. The reason for the bias of the ^{60}Co and ^{137}Cs values in the 2000 exercise is not yet clear.

5. Laboratory movement

In 2002, the laboratory was moved to another place in Hamburg. Radiochemical work was thereby delayed at least until spring of 2003. Working of the alpha spectrometry system was not delayed, however, the gamma spectrometry had to be reduced to only 3 of the original 8 Ge detectors, which re-started working in spring 2004. Beta counting re-started with the new Risø counter in spring 2005.

6. Literature

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Table 1: International intercalibration exercises (IAEA) (IAEA-326,327 updated June 10, 2001)
 Activity concentration ratios (our mean/reference value) (IAEA-414 updated Oct. 12, 2004)
²⁴¹Am was measured by gamma spectrometry, since 1994 by alpha spectrometry

Sample	year	⁹⁰ Sr	⁴⁰ K	⁶⁰ Co	¹³⁴ Cs	¹³⁷ Cs	²³⁸ Pu	^{239,40} Pu	²⁴¹ Am γ
MA-B-3 (fish)	1986	-	0.989	-	-	1.0	-	-	-
IAEA-306 (sediment)	1989	0.729	0.893	-	0.962	0.891	0.824	1.00	1.05
IAEA-307 (seaplant)	1989	-	0.877	-	0.925	0.861	1.08	1.10	-
IAEA-308 (seaweed)	1989	0.750	0.911	-	1.063	0.911	-	1.00	-
IAEA-352 (fish)	1989	-	0.962	-	-	0.963	-	-	-
IAEA-367 (sediment)	1991	-	-	0.630	-	0.897	-	0.903	0.898
IAEA-368 (sediment)	1991	-	-	0.833	-	-	0.965	0.913	1.00
IAEA-134 (cockles)	1992	1.417	0.939	0.911	-	0.940	1.000	1.040	1.26
IAEA-135 (sediment)	1992	0.980	0.905	0.833	0.962	0.932	1.074	1.094	0.934
IAEA-375 % (soil)	1992	1.058	0.969	-	1.105	1.016	1.437	1.147	-
IAEA-300 (sediment)	1993	0.954	0.949	0.493	1.096	0.987	0.933	0.969	-
IAEA-315 (sediment)	1993	0.237*	0.902	1.118	1.050	0.954	1.008	1.010	0.970
IAEA-326 (soil)	1994	0.965	0.942	-	0.906 A	0.870A	0.754	0.951	1.012 (α)
IAEA-327 (soil)	1994	1.084	0.926	-	-	0.961	0.820	0.981	0.973 (α)
IAEA-134 #	1997	0.854	0.915	0.887	-	0.944	1.023	1.053	1.025 (α)
IAEA-307 #	1997	0.694	0.873	-	-	0.839	1.080	1.075	-
IAEA-384 (sediment)	1998	-	0.928	0.996	-	0.440*	1.136	1.102	1.111 (α)
IAEA-414 (fishfl.)	2000	-	0.944	-	-	1.014	0.957	1.008	0.990 (α)
Mean:		0.898	0.927	0.838	1.023	0.941	1.007	1.021	1.020
Median:		0.954	0.927	0.860	1.050	0.944	1.004	1.009	1.000
Standard deviation		0.264	0.033	0.198	0.072	0.053	0.166	0.070	0.098
DHI sediment	1989	-	0.981	-	0.978	1.008	0.862	0.947	1.092

%: final values not available until now

#: these two samples were again analysed in 1997 during the international Mururoa project.

*: not used for summary statistics

A: no definite Cs reference values due to sample inhomogeneity

Table 2: National riverine sediment intercalibration exercises, organised by the Bundesanstalt für Gewässerkunde, Koblenz

Activity concentration ratios (our mean/reference ratio); ²⁴¹Am always measured by gamma spectrometry. For values in parentheses the mean of all laboratories was used, as no true reference values existed. ⁹⁰Sr was here measured by a combined ⁸⁹Sr/⁹⁰Sr method.

Year	sample	⁹⁰ Sr	⁴⁰ K	⁵⁷ Co	⁶⁰ Co	⁶⁵ Zn	¹³⁴ Cs	¹³⁷ Cs	²⁴¹ Am
1983	S2	0.895	(1.095)	0.965	0.983	0.982	0.959	0.985	0.916
	S3	-	(1.130)	0.972	1.001	1.026	0.974	0.997	0.920
1986	S2	1.017	(0.963)	0.990	1.028	1.052	1.011	1.017	0.967
	S3	-	(1.016)	0.997	1.035	1.049	1.016	1.040	0.986
1989	S2	0.934	(0.919)	1.004	1.000	1.016	(0.996)	(0.993)	0.972
	S3	-	(1.023)	0.998	0.977	1.004	(1.086)	(1.006)	0.950
1992	S3	-	(1.017)	0.951	0.967	-	(1.087)	(0.953)	0.976
1995	S2	-	(0.985)	1.016	1.000	1.007	-	(0.972)	0.994
	S3	-	(0.981)	1.036	1.012	1.024	-	(0.974)	1.015
2000 (*)	S2	-	(0.952)	0.974	1.059	0.963	0.962	1.076	0.967
	S3	-	(0.952)	0.987	1.077	0.994	0.991	(0.974)	1.004
Mean:		0.949	1.003	0.990	1.013	1.012	1.009	0.999	0.970
Median:		0.934	0.985	0.990	1.001	1.012	0.996	0.993	0.972
Standard dev.		0.062	0.063	0.024	0.034	0.028	0.048	0.035	0.031

*) preliminary values