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Background

This document contains the results by Poland on monitoring of radioactive contamination of bottom sediments and fish in the Southern Baltic Sea in 2014.

Action required

The Meeting is invited to take note of the information.

Monitoring of radioactive contamination of bottom sediments and fish in the Southern Baltic Sea, in 2014

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Monitoring of radioactive contamination in the Southern Baltic Sea carried out in CLOR include determination of radioactive substances in two components of marine environment: bottom sediments and biota (fish).

Bottom sediment samples were taken at six locations of Southern Baltic Sea (Fig.1). Six sediment core samples from each sampling place were divided into 12 layers, and parallel subsamples were combined. Determination of ^{137}Cs and ^{40}K was performed in all sediment samples, determinations of ^{238}Pu and $^{239.240}$Pu were done in two chosen sampling points. In 2014 the permanent monitoring had been extended to the determination of ^{90}Sr. The pooled samples corresponding to the 0-19 cm layer of sediment were analyzed.

The fish samples were taken from three sub-areas and determination of ^{137}Cs, ^{40}K and ^{226}Ra was performed. Radionuclides were analyzed in filets of cod, herring and plaice. Sprat was analyzed as whole fish without head and entrails. Additionally, ^{90}Sr was determined in fish bones from cod, herring and plaice.

Radionuclides were determined with the same methods as in previous years: ^{137}Cs, ^{40}K – gamma spectrometry, plutonium isotopes – radiochemical method and alpha spectrometry, ^{226}Ra – emanation method [1]. Determination of ^{90}Sr was performed using radiochemical method and measurement of ^{90}Y activity concentration after establishing the radioactive equilibration of ^{90}Sr -^{90}Y [2].

Bottom sediments

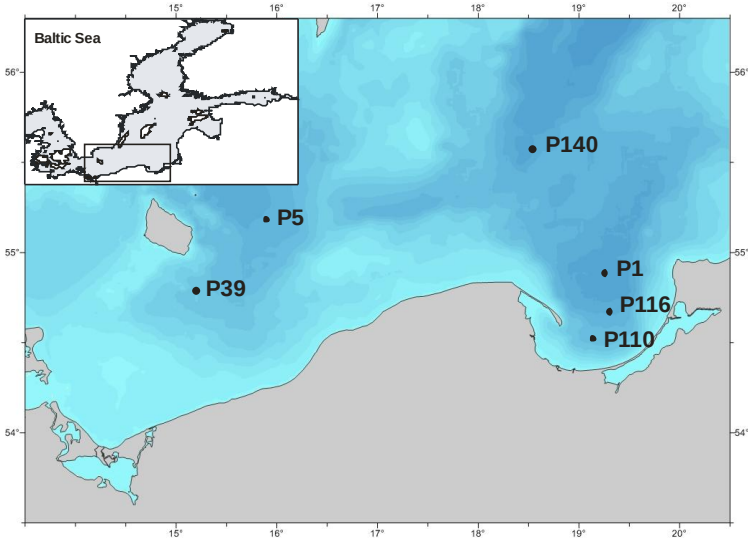

Fig.1. Bottom sediment sampling stations in 2014

In 2014 the highest ^{137}Cs activity concentrations were found in the upper sediment layers, as was observed in previous years [3,4]. In the Gulf of Gdansk (P110 and P116). the concentrations of ^{137}Cs, in the layers from 0 to 5 cm ranged from 139 Bq kg$^{-1}_{dw}$ to 227 Bq kg$^{-1}_{dw}$, and in the Bornholm Deep (P5) from 41.8 Bqkg$^{-1}_{dw}$ to 47.6 Bqkg$^{-1}_{dw}$. ^{137}Cs concentrations decrease along the sediment profiles to single Bq in the deepest layers. The vertical distribution of ^{137}Cs activity concentration in bottom sediments is shown at Fig.2.

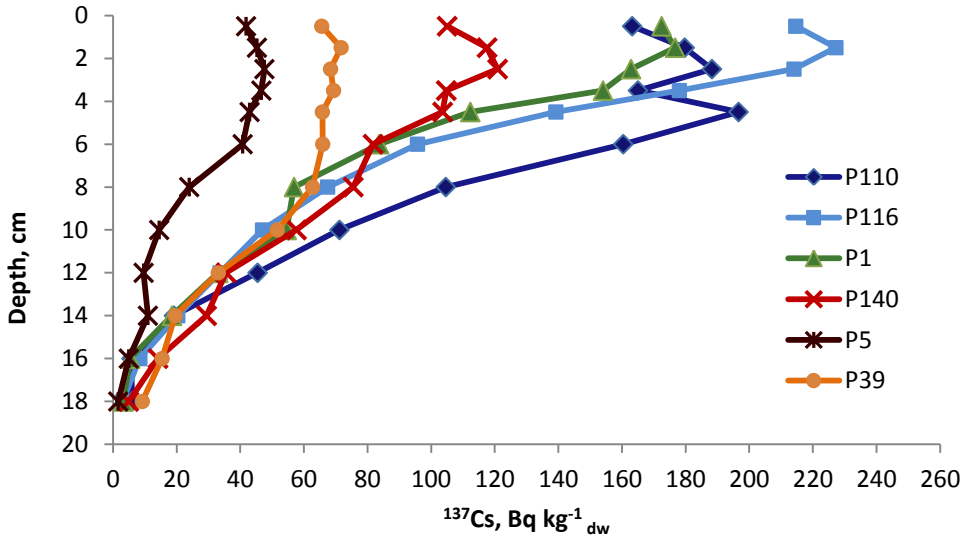

Fig.2 Vertical distribution of ^{137}Cs activity concentration in bottom sediments in the southern Baltic Sea

Determination of plutonium in bottom sediments is carried out every three years. In 2014, plutonium determination was performed in samples from stations: P110 (Gulf of Gdansk) and P1 (Gdansk Deep). Activity concentrations of plutonium were evidently higher in the Gulf of Gdansk than in the Gdansk Deep (Fig.3) what have been observed in previous years, also [3,5].

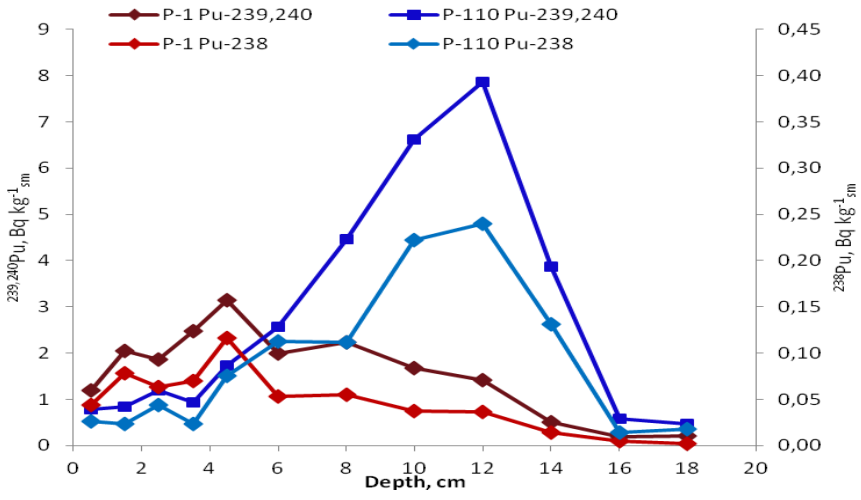

Fig.3. Activity concentrations of ^{239,240}Pu and ^{238}Pu in the bottom sediments at two selected sampling stations (P110 and P1)

In the Gulf of Gdansk (P110) ^{239,240}Pu activity concentrations increase from 0.79 ± 0.05 Bq kg$^{-1}_{dw}$ in the first upper layer to the maximum concentration of 7.60 ± 0.05 Bq kg$^{-1}_{dw}$ observed in the 11-13 cm layer. Activity concentration of ^{238}Pu ranged from 0.014 Bq kg$^{-1}_{dw}$ to 0.222 Bq kg$^{-1}_{dw}$. In the Gdansk Deep (P1), ^{239,240}Pu concentrations increased from 1.20 ± 0.11 Bq kg$^{-1}_{dw}$ in the first layer to 3.15 ± 0.12 Bq kg$^{-1}_{dw}$ in the layer of 4-5cm. Concentration of ^{238}Pu were in the range 0.014 – 0.116 Bq kg$^{-1}_{dw}$. The rate of ^{238}Pu to ^{239,240}Pu in both locations ranged from 0.022 to 0.044 being similar to that determined for the fallout from nuclear weapons tests.

Determination of ^{90}Sr were performed in the pooled samples (0-19 cm layer) taken at six locations. Activity concentrations of ^{90}Sr ranged from 2.15 ± 0.28 Bq kg$^{-1}_{dw}$ in P110 to 3.30 ± 0.32 Bq kg$^{-1}_{dw}$ in P 39 (Table 1), being 10-30 times lower than ^{137}Cs concentrations calculated for the same layer.

Table 1. Activity concentration of ^{90}Sr in the bottom sediments of the southern Baltic Sea (layer 0 -19 cm) compared to the activity concentrations of ^{137}Cs calculated for the same layer

Sampling station	^{90}Sr [Bq kg$^{-1}_{dw}$]	^{137}Cs [Bq kg$^{-1}_{dw}$]
P 110	2.15 ± 0.28	65.8 ± 1.5
P 116	2.39 ± 0.32	57.7 ± 3.5
P 1	3.23 ± 0.47	54.5 ± 2.7
P 140	2.31 ± 0.32	53.0 ± 2.4
P 5	2.24 ± 0.28	21.2 ± 0.9
P 39	3.30 ± 0.32	41.3 ± 2.8

The main contribution to the anthropogenic radionuclide content in Baltic Sea bottom sediments gives ^{137}Cs. Total amount of ^{137}Cs in bottom sediments differ between sub-regions, and ranged from 0.96 ± 0.03 kBq m^{-2} in the Bornholm Deep P5 to 4.23 ± 0.09 kBq m^{-2} in the Gulf of Gdansk P110 (Table 2). These differences observed for years are primarily associated with the uneven isotope contamination of the Baltic Sea environment (as a result of the Chernobyl reactor accident), different sedimentation rates and the different properties of the sediments in the various regions. In the Gdańsk Deep (P1) total amount of ^{239,240}Pu and ^{238}Pu was: 54.8 ± 1.9 Bqm^{-2} and 1.46 ± 0.12 Bqm^{-2}, respectively. At station P110 total amount of plutonium isotopes was 200 ± 9.3 Bqm^{-2} (^{239,240}Pu) and 5.98 ± 0.65 Bqm^{-2} (^{238}Pu). Total amount of ^{90}Sr in bottom sediments was in the range from 94.9 ± 13 Bq m^{-2} at station P116, to 148 ± 14 Bq m^{-2} at station P39 (Fig. 4), and less differ comparing with ^{137}Cs and plutonium isotopes. In the Baltic Sea region ^{90}Sr comes mainly from fallout after nuclear test explosions (years 1950-1980), which in this area was rather uniform.

Total amount of natural isotope - ^{40}K (in the layer 0-19cm) ranged from 31.7 ± 0.7 kBq m^{-2} at station P116 to 53.6 ± 1.0 kBq m^{-2} at station P5, being about one order higher than ^{137}Cs, and at least two orders higher than ^{239,240} Pu or ^{90}Sr.

Table 2. Total amount of radionuclides in the southern of Baltic Sea sediments in 2014

Sampling station	^{137}Cs kBq m^{-2}	^{238}Pu* Bq m^{-2}	^{239,240}Pu* Bq m^{-2}	^{90}Sr Bq m^{-2}	^{40}K kBq m^{-2}
P110	4.23 ± 0.09	5.98 ± 0,65	200 ± 9.3	138 ± 18	43.4 ± 0.9
P116	2.30 ± 0.06	2.73 ± 0,16	83.2 ± 3.0	94.9 ± 12.7	32.1 ± 0.7
P1	2.20 ± 0.06	1.46 ± 0.23	54.8 ± 3.6	137 ± 20	37.7 ± 0.8
P140	2.93 ± 0.07	3.61 ± 0.39	74.9 ± 3.4	128 ± 18	53.6 ± 1.0
P5	0.96 ± 0.03	1.55 ± 0.26	17.2 ± 1.3	102 ± 13	45.2 ± 0.8
P39	1.87 ± 0.05	2.17 ± 0.20	48.0 ± 1.7	148 ± 14	39.6 ± 0.8

*2012-2014

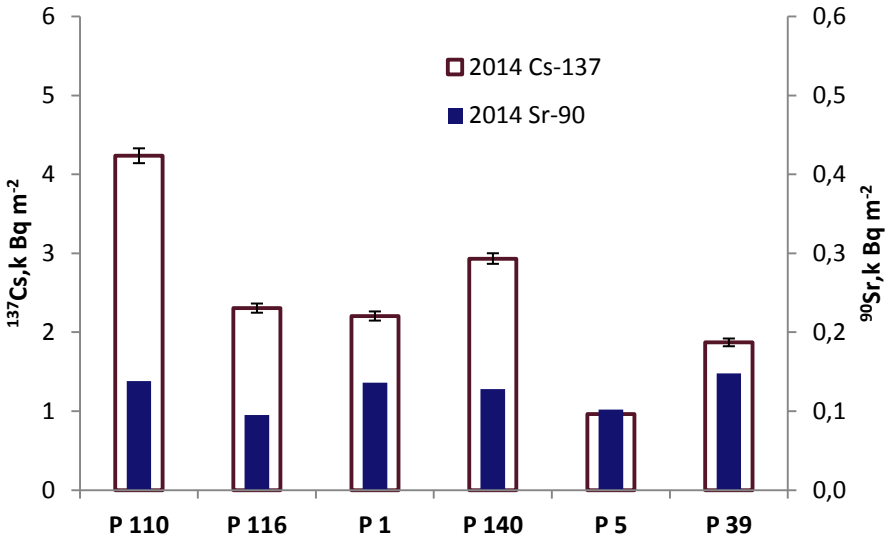

Fig. 4. Total amount of ^{137}Cs and ^{90}Sr in sub-regions of Baltic Sea

Fish

Samples of fish (herring, cod, plaice and sprat) came from commercial fishing, trapping of the known sites. Due to the limited number of individuals (5-6), differences related to the fishing place was not analyzed. The highest average activity concentration of ^{137}Cs was found in cod – 4.89 ± 0.77 Bq kg$^{-1}_{ww}$ (Table 3), which is comparable with the previous years [6,7]. In the case of the other fish species concentrations were similar (herring - 3.14 ± 0.54 Bq kg$^{-1}_{ww}$, sprat - 3.39 ± 0.26 Bq kg$^{-1}_{ww}$, plaice - 3.48 ± 0.11 Bq kg$^{-1}_{ww}$). Activity concentrations of ^{40}K

ranged from 101 ±7 Bq kg^{-1}_{ww} in plaice to 118 ± 11 Bq kg^{-1}_{ww} in cod. Activity concentrations of ^{226}Ra ranged from the lowest in herring - 27 mBq kg^{-1}_{ww} to the highest specified in cod - 91 mBq kg^{-1}_{ww}.

Table 3. The average concentrations of ^{137}Cs and ^{226}Ra in Baltic Sea fish in 2014

Species (number of samples)	Number of fish, total	Fish lenght cm	^{137}Cs [Bq kg^{-1}_{ww}]	^{40}K [Bq kg^{-1}_{ww}]	^{226}Ra [Bq kg^{-1}_{ww}]
Cod (6)	23	25-38	4.89 ± 0.77*	118 ± 11	0.091 ± 0.007
Herring (6)	122	16-25	3.14 ± 0.54	110 ± 16	0.027 ± 0.002
Sprat ** (5)	243	7-13	3.39 ± 0.26	108 ± 3	0.062 ± 0.003
Plaice (5)	38	22-28	3.48 ± 0.11	101 ± 7	0.053 ± 0.006

* standard deviation ** whole fish without a head

The average concentrations of ^{137}Cs calculated for the four species of the Baltic Sea in 2014 was 3.73 ± 0.79 Bq kg^{-1}_{ww}. Activity concentration of ^{137}Cs in the Baltic Sea fish decreased continuously (Fig.5), but it is still almost two times higher than before the Chernobyl accident [8]. The effective half-life ($T_{1/2\ eff}$) of ^{137}Cs depends on the fish species being equal to about 12.4 years for herring (planktonophagous) and 15.4 years for cod (predator).

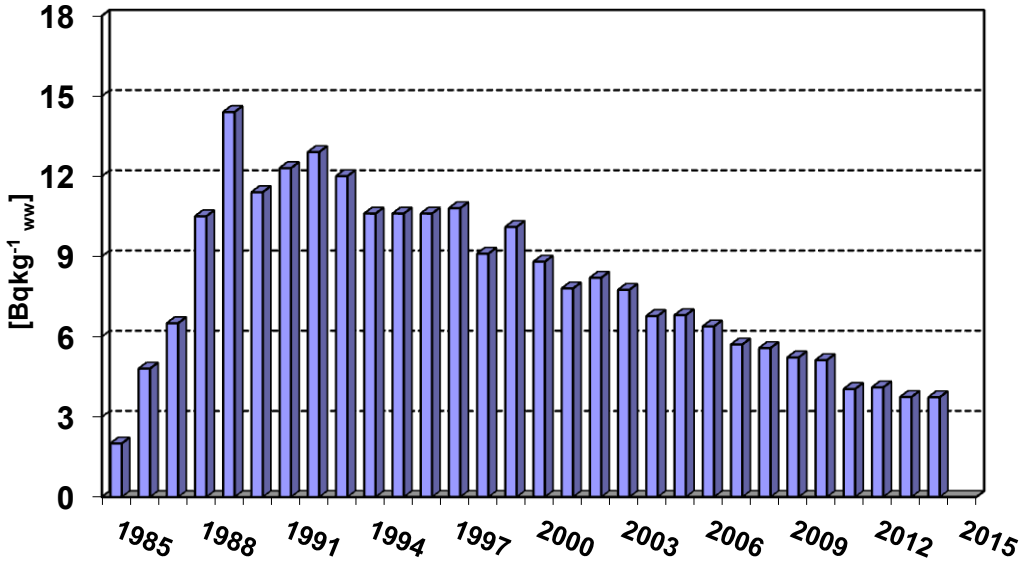

Fig.5. The average activity concentration of ^{137}Cs in Baltic Sea fish in years 1985-2014

Last year, the determinations of ^{90}Sr in fish bones were also carried out. Activity concentrations of ^{90}Sr in herring bones was 0.389 ± 0.022 Bq kg^{-1}_{ww}, in cod – 0.481 ± 0.038 Bq kg^{-1}_{ww} and in plaice – 0.540 ± 0.031 Bq kg^{-1}_{ww}. These concentrations determined in years 1982-1983 (before the Chernobyl accident), were: 0.750 Bq kg^{-1}_{ww}, 0.805 Bq kg^{-1}_{ww} and 0.850 Bq kg^{-1}_{ww}, respectively [9]. Because strontium is mostly bioaccumulated in bones, ^{90}Sr concentration in bones is at least three times to about one order of magnitude higher than concentration found in the whole fish [10] (0.023±0.003 Bq kg^{-1}_{ww} in herring to 0.155±0.011 Bq kg^{-1}_{ww} in plaice).

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