^{210}Po in the Black Sea hydrobionts

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Abstract. The ^{210}Po concentrations in the Black Sea hydrobionts are reported and compared with published radioecological data on this natural radionuclide. The distribution of ^{210}Po in investigated species of the Black Sea pelagic community is the following: mesozooplankton = ctenophore < pelagic fish. ^{210}Po concentrations in the Black Sea fishes depend on their belonging to different ecological groups and decrease from pelagic species to demersal and benthic ones. ^{210}Po concentrations in the Black Sea mussels *Mytilus galloprovincialis* are as high as such determined in the Black Sea pelagic fishes. ^{210}Po concentrations in algae were the lowest among benthic hydrobionts.

1. ^{210}Po IN ALGAE, INVERTEBRATES, MOLLUSKS AND FISHES

There are numerous data of ^{210}Po concentrations, its distribution in whole body and edible tissues of marine commercial fishes and shellfishes [1,4,15-17]. The variance of ^{210}Po concentrations in marine organisms is large, extending three orders of magnitude in animals from different taxa. In each species they range widely from one tissue to another [4]. The study ^{210}Po in an ecosystem of the Ukrainian part of the Black Sea became possible after the IAEA Technical Co-operative Project RER/2003 "Marine Environmental Assessment of the Black Sea Region" was started [9-11].

The purpose of this work was to determine ^{210}Po concentrations in hydrobionts of different taxa inhabiting the Crimean coast area of the Black Sea shelf including Sevastopol Bays, to assess and to compare their range with known data for other investigated regions of the World Ocean.

For the determination of ^{210}Po in the Black Sea marine organisms the radiochemical procedure of RISOE National Laboratory was used [3]. ^{208}Po was added as a yield tracer. Polonium was spontaneously plated onto silver disks. Alpha counting of ^{208}Po and ^{210}Po was done using a silicon surface-barrier detector and alpha-spectrometer EG&G Berthold ORTEC WALLAC. The sampling places were chosen in different Bays of Sevastopol and along on the coast of Crimea on the distance from Cape Lukul to Cape Sarych (Fig.1). The investigation includes four species of algae, mesozooplankton, macrozooplankton (the ctenophore *Beroe ovata* Eschscholtz), mussels *Mytilus galloprovincialis* Lam and seventeen species of fishes. The list of investigated species of the Black Sea algae and fishes and the range of ^{210}Po concentrations in them are given in Bq.kg^{-1} dry weight (DW) or wet weight (WW) (Table 1,2). The results are reported as the mean of values and standard error (SE) of the mean for each group of data.

1.1. ^{210}Po in Phaeophyta, Rhodophyta and Chlorophyta algae

^{210}Po concentrations in the Black Sea green, brown and red algae collected in Sevastopol Bays are inside of the same order of magnitude (Table 1). For the sea lettuce *Ulva rigida* Ag. they were lower than in the brown algae *Cystoseira crinita* Bory and red one *Laurencia obtusa* (Huds) Lamour. At the same time ^{210}Po concentrations were highest in green algae *Enteromorpha intesinalis* (L.) Link (4.11 Bq.kg^{-1} DW). The similar ratio between concentrations of ^{210}Po measured in studied species of Rhodophyta, Phaeophyta and Chlorophyta from the Brazil coast was obtained by R.C.Gouvea et al. [7]. They showed that the accumulation of ^{210}Po by benthic plants depends on place of their inhabitancies. Marine plants from the Syrian coast line of the Southeastern Mediterranian area accumulate ^{210}Po up to 3.65 Bq.kg^{-1} WW [13].

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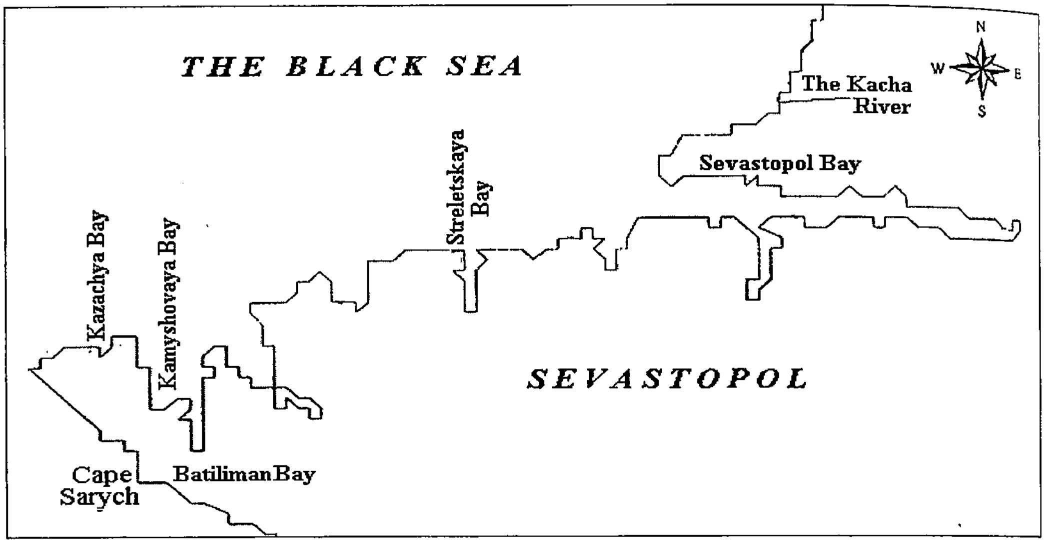

Figure 1: The scheme-map of the Sevastopol Bays

Table 1. The ^{210}Po concentrations in the investigated species of algae from the Crimea coast including Sevastopol Bays, 1999

Taxonomy of algae	Latin (English) name of algae	Place and date of collection	^{210}Po concentration, Bg.kg^{-1} DW
Phaeophyta	*Cystoseira crinita Bory (*Cystoseira)	Streletskaya Bay, 23 June	1.67 ± 0.35
	Cystoseira crinita Bory (Cystoseira)	Kamyshovaya Bay, 4 July	2.09 ± 0.28
Rhodophyta	*Laurencia obtusa* (Huds*)* Lamour (Laurencia)	Kamyshovaya Bay, 4 July	2.08 ± 0.32
Chlorophyta	*Ulva rigida Ag.* (Sea lettuce)	Kamyshovaya Bay, 4 July	1.06 ± 0.14
Chlorophyta	*Enteromprpha intestinalis* (Link Enteromorpha*)*	Kamyshovaya Bay, 4 July	4.11 ± 0.56

1.2. ^{210}Po in the plankton

Among marine organisms the role of zooplankton in accumulation of ^{210}Po can be demonstrated as follows: phytoplankton < zooplankton ≤ fishes, mollusks [4]. R.D. Cherry and L.V. Shannon summarized of the published data concluded that ^{210}Po concentrations in zooplankton from different regions of the World Ocean varied widely from 2.96 to 111 Bq.kg^{-1} WW [4]. Accumulation of ^{210}Po by planktonic organisms depends on seasonal and regional factors [5].

The samples of the Black Sea mesozooplankton were collected from the depths 113-179 m of the toxic zone of the Black Sea. The dominant species in all investigated samples was *Calanus euxinus* Karavayev, 1894, (about 90%). The range of means of ^{210}Po concentrations in the Black Sea mesozooplankton collected on six different stations was 1.71 - 3.04 Bq.kg^{-1} WW [12].

The Black Sea planktonic community was significantly changed during the last two decades. The main reason was an appearance of the new resident in the Sea - the ctenophore *Mnemiopsis leidyi* (A. Agassiz*)* [18]. In last two years the new one, also ctenophore, *B. ovata,* had appeared in the Black Sea too [6]. The mentioned above species are interconnected in food pelagic chains: mesozooplankton is eaten by ctenophore *M. leidyi* and the last one is the food for *B. ovata* [6,18]. For the aim of this work predator *B. ovata* was collected in Kazachya Bay at 30 October, 2000. The determination of ^{210}Po was carried out in four groups of animals with different body lengths: 20-25 mm, 30-35 mm, 45-50 mm and 55-60 mm. In each group 5-8 animals were studied. The range of ^{210}Po concentrations in *B. ovata* from these groups was 1.18 - 2.54 Bq.kg^{-1} WW [12].

As one can see ^{210}Po concentrations in the Black Sea mesozooplankton and in the super predator *B. ovata* had comparable magnitudes. So, these data reflect food chains of some interconnected organisms representing part of the Black Sea planktonic community.

1.3. ^{210}Po in the Bivalvia (Molluscs)

^{210}Po concentrations in mussels from different regions of the World Ocean have been reported [1,4,8,15,16]. The variations of ^{210}Po concentrations in edible molluscs are connected with selected biological factors and environmental fluctuations [8,15,16].

The sampling of the main commercial species of mussels in the Black Sea *M. galloprovincialis* was inside of four studied Sevastopol Bays. Three locations are natural and one is artificial situated at the maricultural farm. 293 mussels were investigated during June-July 1999. The number of individuals used in each determination depended on a size of mussel and vary from 5 to 22. Concentrations of ^{210}Po in soft tissues of mussels were determined in $Bq.kg^{-1}$ wet weight (WW). The range of the mean values was 5.3-26.7 $Bq.kg^{-1}$ WW. It was observed that was a dependency of ^{210}Po concentrations in mussels from natural population on the length of their shells, but it is not so strong and varies widely (Fig.2a). It was stronger in case of the comparison of ^{210}Po concentrations calculated in 1 kg dry weight (DW) of soft tissue with the individual dry weight of mussel (Fig.2b). In artificial population ^{210}Po concentrations in the investigated mussels with sizes 30-60 mm were on the level 20.3-21.6 $Bq.kg^{-1}$ WW. So, these values were very close. As one can see there is some difference between the natural and artificial populations.

It is known that the relation between the size of shell and mass of soft tissue in the Black Sea mussel depends on ecological factors, reproductive stage, quantity of food and it is changed via seasons [14]. The investigation of this mussel on the artificial collectors showed that the massive spawning *M.galloprovincialis* are two times in a year: in the spring and in the autumn. The animals with different size of shell take a part in the spawning. Age of the first-spawning mussels depends on season of settling. The rate of growing mussels settled in the spring is higher than in the autumn [14]. During spawning the mussel lost its mass with eggs and can lost some quantity of ^{210}Po accumulated before this stage. So, as the results summarized process of an accumulation and loss of ^{210}Po in mussel is realized via its life. In our experiments the mussels sampled on the artificial collectors were on the stage 1 (the relative quietness after spawning) and one can see that this population was synchronic. So, if one compares different data of ^{210}Po in the mussels obtained by other authors it is requested to know as more as possible information about the biological features of this subject in the time of its investigation.

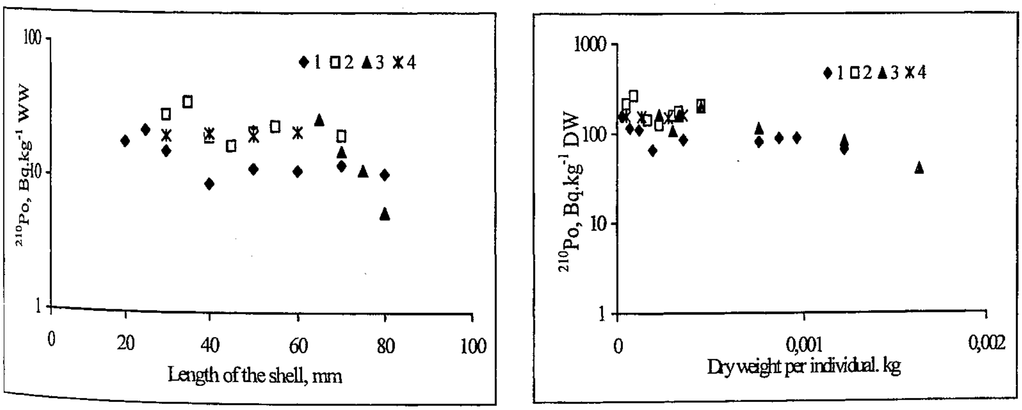

Figure 2: The dependency of ^{210}Po concentrations in soft tissue of mussel *M. galloprovincialis* on the size of shell. Investigated mussels were collected in Sevastopol Bays: 1 - Sevastopol Bay; 2 – the mouth of the Kacha River; 3 – Kazachya Bay (natural population); 4 – Kazachya Bay (the artificial population).

1.4. ^{210}Po in fishes

The ^{210}Po concentrations in the investigated species of the Black Sea fishes vary widely (Table 2). It was observed that there is a dependency between ^{210}Po concentrations in the fishes on their belonging to different ecological groups. They decrease from pelagic to demersal and benthic ones. Inside of each ecological group ^{210}Po concentration may vary widely too (Table 2). In some Black Sea fishes from different ecological groups ^{210}Po concentration was on the same level or range. Therefore the data obtained in our experiments were compared with the type of food and an inhabitancy of all stages of fishes including earlier stages of ontogenesis and it was shown that the period of life of larvas and young stages of fishes in pelagic condition is important in the accumulation of ^{210}Po [11].

Among pelagic fishes the highest concentrations of ^{210}Po were determined in the Black Sea anchovy and sprat (Table 2), which are major commercial fishes and the main marine foodstuff for population of the Crimean area including Sevastopol Region. The catching of the Black Sea sprat was reached 95-98% of total one [19]. ^{210}Po concentration in whole body of the Black Sea sprat decreases with standard length (SL) (Fig.3) [10,11]. The same trend was observed for viscera and other organs of sprat (Fig.3). The contribution of sprat organs in accumulation of ^{210}Po is the following: viscera > stomach > skeleton > gills > muscle. ^{210}Po concentration in the liver was higher in 2.5-3 times than in whole body [10,11].

In some fishes from different ecological groups an accumulative ability of liver and gonads was compared. ^{210}Po concentration in liver of the pelagic flat needlefish was higher in 6.5 times than in gonads (17.6 and 2.7 Bq.kg^{-1} WW). For the Black Sea turbot as benthic one such ratio was 7.7 (1.15 and 0.15 Bq.kg^{-1} WW) [10]. It is very important to underline that the role of reproductive organ of the Black Sea fishes in ^{210}Po accumulation is low.

Table 2. The ^{210}Po concentration in the main species of the Black Sea fishes from Sevastopol Bays, May-June 1999.

English name of fish	Latin name of fish	^{210}Po concentration, Bq.kg^{-1} WW
Benthic species		
Small scaled scorpion fish	*Scorpaena porcus Linne*	0.67 ± 0.08
Common stargazer	*Uranoscorpus scaber Linne*	0.37 ± 0.04
Grass goby	*Zosterisessor ophiocephalus (Pallas)*	0.97 ± 0.11
Round goby	*Neogobius melanostomus (Pallas)*	1.73 ± 0.22
Black goby	*Gobius niger Linne*	2.09 ± 0.28
Toad goby	*Mesogobius batrachocephalus (Pallas)*	0.58 ± 0.07
Blunt-snouted mullet	*Mullus barbatus ponticus Essipov*	4.70 ± 0.49
Demersal fishes:		
Ocellated wrasse	*Crenilabrus ocellatus (Forsäl)*	2.00 ± 0.28
Long-striped wrasse	*Symphodus tinca (Linne)*	6.60 ± 0.87
Whiting	*Merlangius merlangus euxinus (Nordmann)*	10.72 ± 1.14
Pelagic species:		
Mediterranean sand smelt	*Atherina hepsetus Linne*	1.70 ± 0.21
Flat needlefish	*Belone belone euxini (Günther)*	7.37 ± 0.79
High-body pickerel	*Spicara smaris (Linne)*	13.60 ± 1.41
Black Sea scad	*Trachurus mediterraneus ponticus Aleev*	5.22 ± 0.49
Black Sea sprat	*Sprattus sprattus phalericus (Risso)*	32.03 ± 3.21
Black Sea anchovy	*Engraulis encrasicolus ponticus Aleksandrov*	40.72 ± 4.34

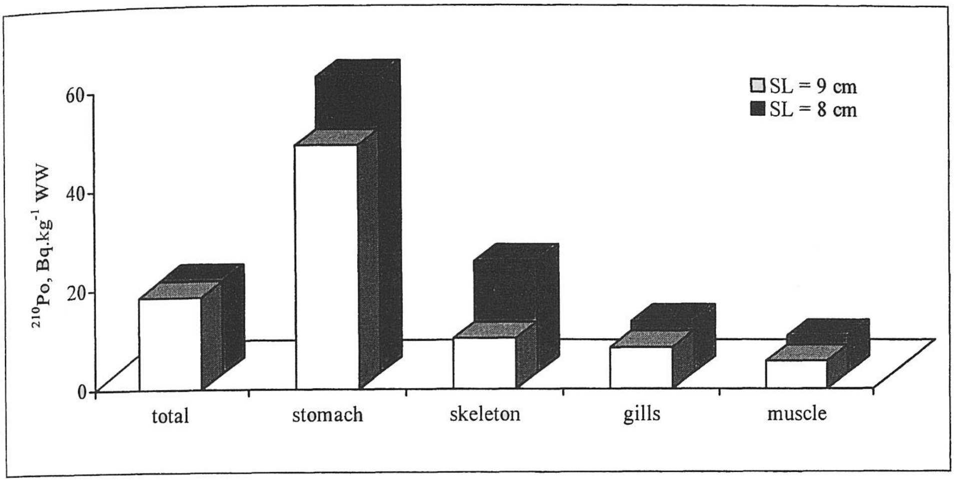

Figure 3: ^{210}Po concentration in whole body and the main organs of sprat with its different standard length (SL).

The main results of this work:

1. The ability of marine organisms inhabited on the shelf of Crimea area including Sevastopol Bays is demonstrated as follows: benthic algae and benthic fishes ≤ zooplankton < demersal fishes < pelagic fishes, mussels. The highest concentration of ^{210}Po was determined in the Black Sea anchovy and sprat.
2. In the Black Sea sprat, which is the main commercial fish in the investigated area, the concentration of ^{210}Po in its organs is: muscle < gills < skeleton < stomach < viscera.
3. ^{210}Po concentrations in the commercial species of the Black Sea mussels *M. galloprovincialis* were on the levels of the data from others regions of the World Ocean.

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