EPR-dosimetry for fish

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EPR dosimetry[1]:
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Radiochemistry and beta-gamma detection[2]
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Radiobiology[2]
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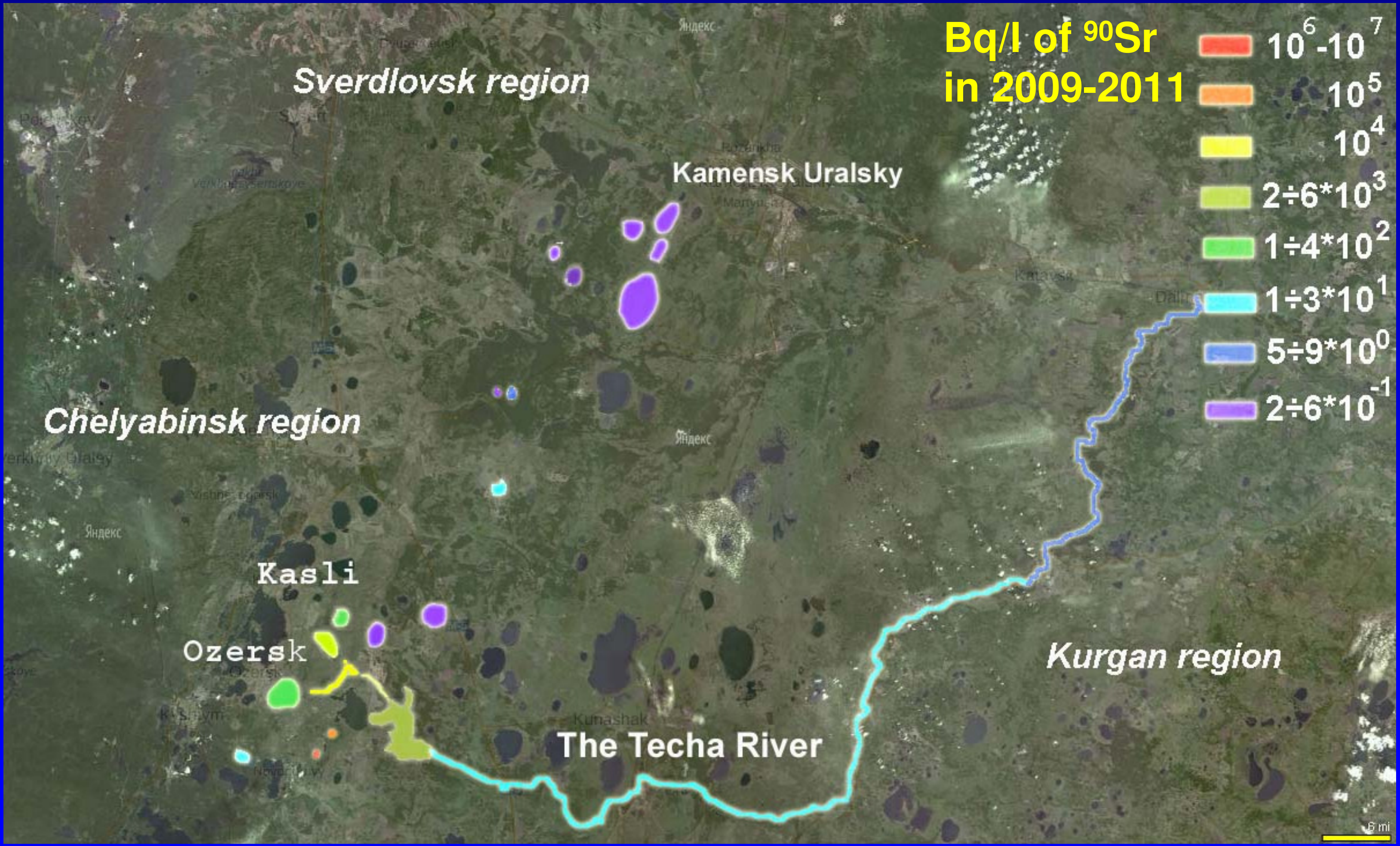
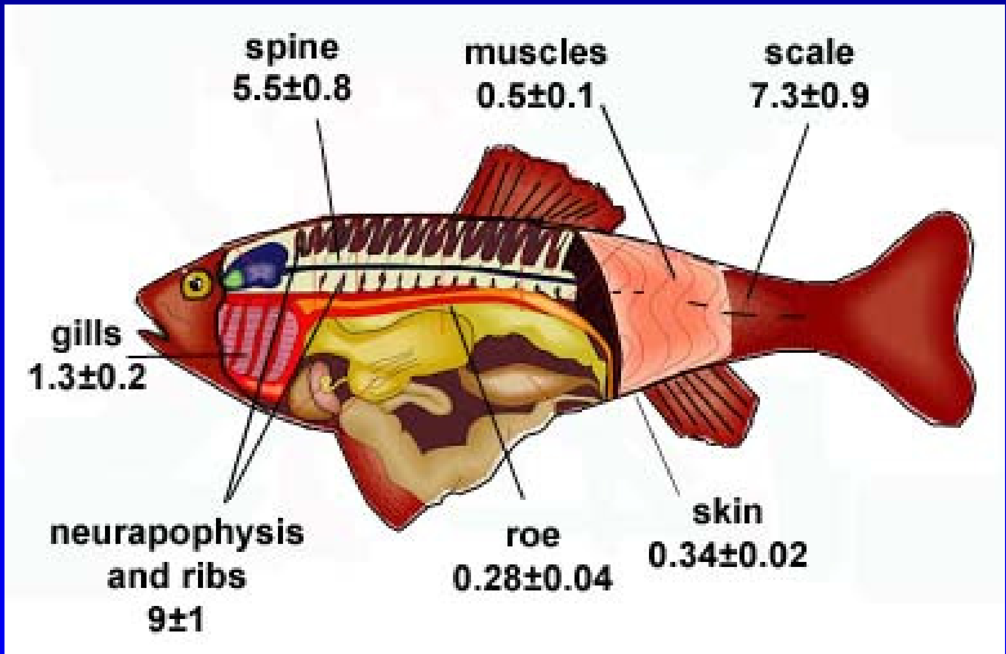
Radiation situation

Bone-seeking ^{90}Sr in the water of Urals water-bodies



Non-uniform distribution of radionuclides in the body of an ide



Distribution of total specific activity (kBq/g)

The body-average - 1.4±0.2 kBq/g

Radionuclide fraction, %

Compart-ment	$^{90}Sr/^{90}Y$	$^{137}Cs/^{137m}Ba$	^{134}Cs	^{60}Co
Soft tissues	7,7	92	0,1	0,1
bones	96	4	<0,1	
gills	79	21	<0,1	
Body-average	79	21	<0,1	

Requirements for detectors

- **Detectors should be tissue-equivalent or small-sized (much smaller than free path of dose forming electrons) in order to fit the approach of a point detector;**
- **No fading of radiation-induced signal;**
- **Sufficient sensitivity to accumulate a detectable dose during a short exposure time (within a few months).**

Hydroxyapatite as a candidate for detecting substance

- Grains of powdered hydroxyapatite (HP) can be considered as point detectors which can be measured by Electron Paramagnetic Resonance (EPR).
- Synthetic carbonated apatite is applicable only for high dose detection (over 7-10 Gy) because of a large background signal with a strong orientation-dependent shape and amplitude.
- Detection limit for biological hydroxyapatite is 0.18Gy.

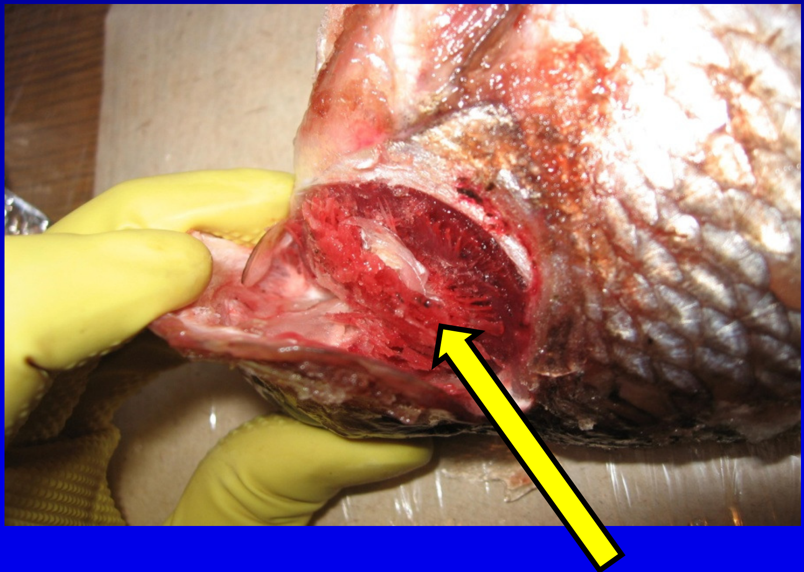
Preparation of the detectors

Hydroxyapatite-based detectors (~Ø5x3 mm)

Sodium salt of carboxymethyl cellulose (CMC) was chosen as a binding substance. Water solution of CMC represents a dense gel that is mixed with enamel grains to distribute them uniformly. Being dried at room temperature, it binds grains.

After exposure, CMC is easily washed off with water disengaging hydroxyapatite grains for measurements

Pilot study of internal doses in the fish body

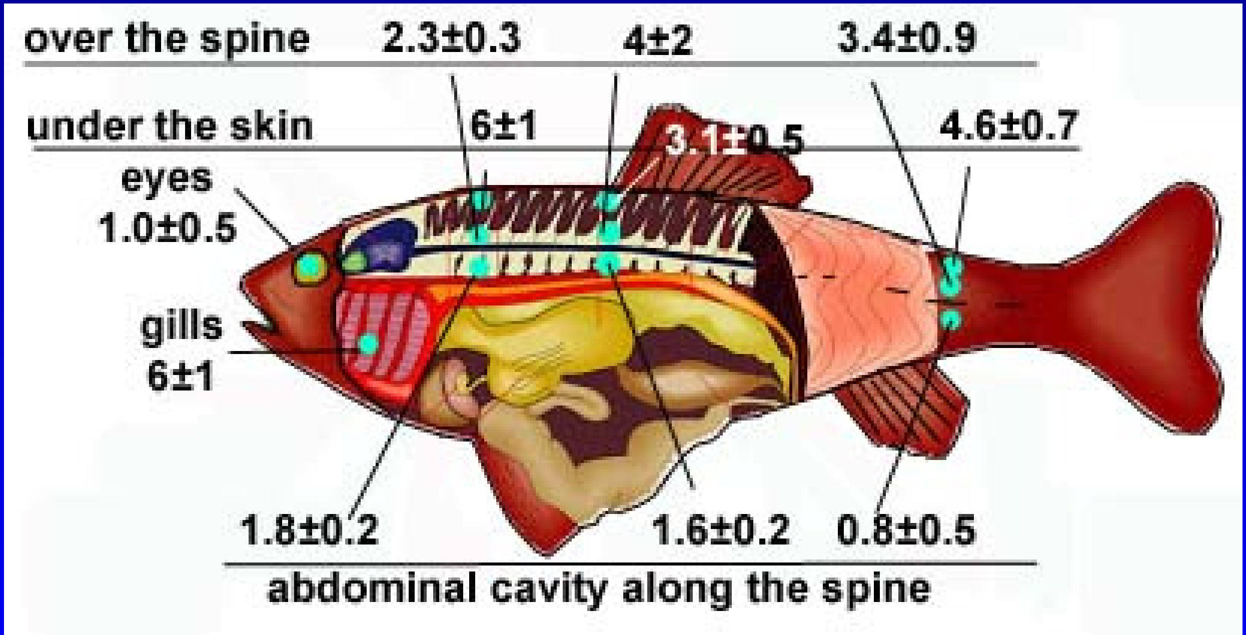


An example of detector placement into the gill *in-vitro*
Time of exposure – 4 months.

- Two detectors were placed into unexposed fish. The contribution of natural radionuclides to the accumulated dose was imperceptible;

- The doses in the detectors exposed while inside the exposed fishes were in the range from 100 to 700 mGy. The highest doses were observed in the detectors adjusted to calcified tissues.

Distribution of internal dose rates in the ide body



Dose rate distribution, mGy/day

Body-average dose rate according to the approach of uniform radionuclide distribution (Erica Tool, ResRadBiota) is ~ 9 mGy/day

Comparison of dose rates (mGy/day) in the bodies of ide and pike

Detector location		Ide	Pike
Gills		6±1	5.4±0.4
Eyes		1.0±0.5	0.4±0.3
Below spine in abdominal cavity	Near to gills	1.8±0.2	<0.4*
	In the middle of body	1.6±0.2	<0.4*
	Near to tail	0.8±0.5	0.7±0.3
Above spine and under muscle	Near to gills	2.3±0.3	3.1±0.6
	In the middle of body	4±2	2.3±0.3
	Near to tail	3.4±0.9	1.5±0.4
Under skin	Near to gills	6±1	5.3±0.3
	In the middle of body	3.1±0.5	1.4±0.5
	Near to tail	4.6±0.7	0.7±0.2
Inside skull		-	6±2

* Below the detection limit

Prospects

The proposed method is a useful tool for:

- dosimetric support for radiobiology;
- validation of doses calculated based on Monte-Carlo simulations

Problems to be solved

- The dissolving of CMC for HP extraction results in partial sample loss.
- Grains in the actual version of detectors are distributed too densely and the mass density of binding matrix (1.5 g/cm^3) is higher than that typical of soft tissues. Therefore, the measured doses can be systematically larger than the real tissue doses.
- The current procedure of pelletizing is too difficult to make detectors of a standard size and an equal mass fraction of HP.

Tasks that need to be solved

- Simplification of making and use of detectors;
- Improvement of the dosimetry accuracy (in terms of dose quantification);
- Standardization of the detector properties

The method can become an important instrument for internal dosimetry in animals, and the scope of its application can be extended (not only in fishes)

The method is described in:

Ivanov D.V. , Shishkina E.A., Osipov D.I., Razumeev R.A., Pryakhin E.A. (2014) *Internal in-vitro dosimetry for fish using hydroxyapatite-based EPR detectors.* Radiat. Environment. Biophys. (submitted)

Thank you for attention