



Document title	Proposal for methodology for deriving threshold values for Cs-137 in fish and seawater in the Baltic Sea
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Agenda Item	3 – Development of dose-based indicator threshold values and approach for the next indicator evaluation
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Submitted by	Poland
Reference	

Background

New Baltic Sea Action Plan (BSAP) ecological objective “Minimal risk to humans and the environment from radioactivity” discussed and proposed during the 9th Meeting of HELCOM MORS EG and agreed in HELCOM 41-2020 ([Outcome](#), Annex 3 “Agreement on HELCOM objectives for the updated BSAP”) implies the need to redefine current core indicator threshold values for Cs-137 in fish and seawater which were based on the old BSAP objective “Radioactivity at pre-Chernobyl level”.

This document presents the proposal for methodology for deriving threshold values for Cs-137 in fish and seawater in the Baltic Sea for new ecological object.

The document was first presented in HELCOM MORS EG 10-2020 (Document 6-1). The meeting agreed to have extra meeting to discuss on the threshold issue. The meeting agreed to plan an extra meeting focusing only on deriving dose-based indicator threshold values and developing an appropriate approach for the next indicator evaluation.

Action

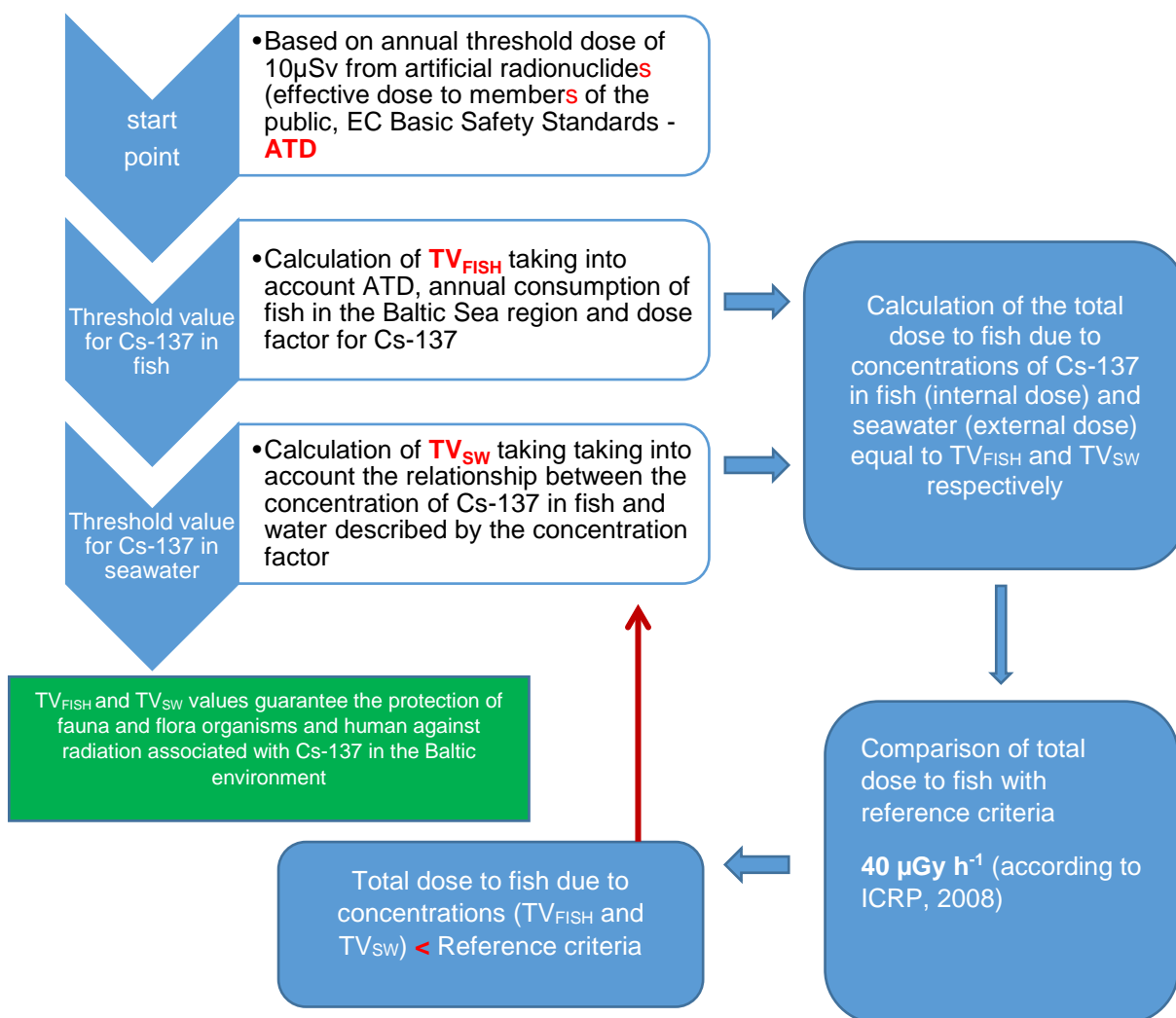
The Meeting is invited to

- discuss on the proposal for methodology for deriving threshold values.
- agree on threshold values for core indicator on radioactive substances

Proposal for methodology for deriving threshold values for Cs-137 in fish and seawater in the Baltic Sea

According to the new ecological objective “**Minimal risk to humans and the environment from radioactivity**” which were discussed during the last HELCOM MORS EG Meeting there is a need to discuss new threshold values for Cs-137 in fish and seawater.

The proposal is based on calculations of the threshold concentration value for fish and on the Agreement on a Methodology for Deriving Environmental Assessment Criteria and their application (OSPAR Agreement: 2016-07). The diagram below shows the algorithm for dealing with threshold values for Cs-137 in fish and seawater and how to verify them.



- The starting point is the adoption of the value for radiological reference criteria for protection of the public and the environment, which result from current legislation. According to the IAEA recommendation, two values of radiological reference criteria for human are considered within a process:
 - the established annual dose limit (1 mSv) for members of the public in planned exposure situations

- the individual annual dose level (of the order of 10 μSv) used to grant exemption to activities and facilities

The present calculations adopted a more restrictive approach and used the annual threshold dose of 10 μSv from artificial radionuclides, which is effective dose to members of the public for calculations (EC Basic Safety Standards, 2013).

2. Based on the adopted dose value, the Cs-137 concentration in fish is calculated, assuming consumption at an above-average level in Scandinavian countries. The calculated concentration will correspond to the threshold value for good environmental status guaranteeing safety for fish and man. This concentration is calculated based on the equation:

$$TV_{FISH} = \frac{ATD}{H * DF}$$

Where:

ATD – annual threshold dose (10 μSv)

H – above-average annual fish consumption (25 kg)

DF – dose factor (for Cs-137 it is $1.3 \cdot 10^{-8} \text{ Sv Bq}^{-1}$, ICRP 72, 1996)

Based on selected parameters, determined threshold value for Cs-137 in fish **TV_{FISH}** is equal to **31 Bq kg⁻¹ ww**

3. Based on the determined TV_{FISH} value, the threshold value for Cs-137 in seawater is calculated using the relationship between the concentrations of this isotope in fish and seawater expressed by the concentration factor (CR) values:

$$CR = \frac{C_{FISH}}{C_{SW}}$$

Where

C_{FISH} - Cs-137 concentration in fish

C_{SW} – Cs-137 concentration in seawater

Threshold value for Cs-137 in seawater is calculated with equation:

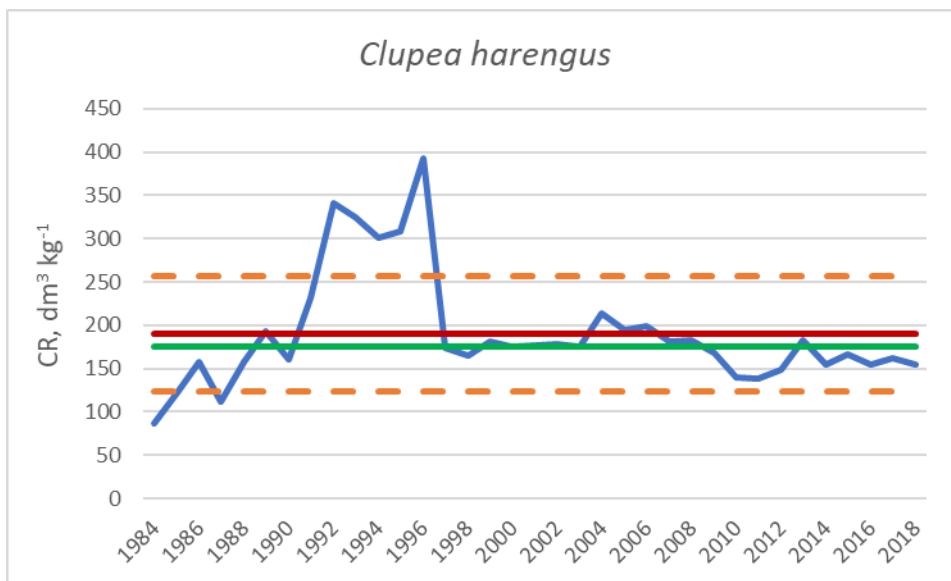
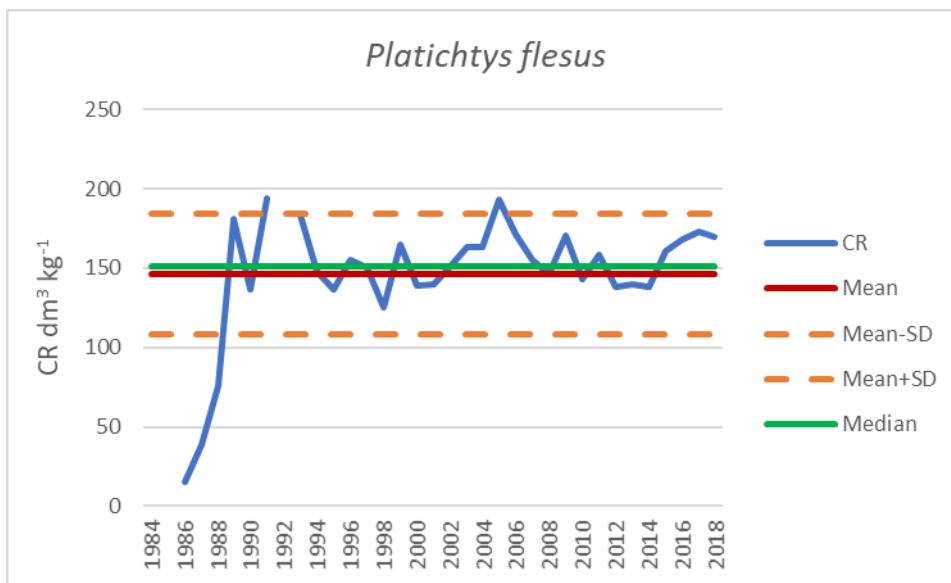
$$TV_{SW} = \frac{TV_{FISH}}{CR}$$

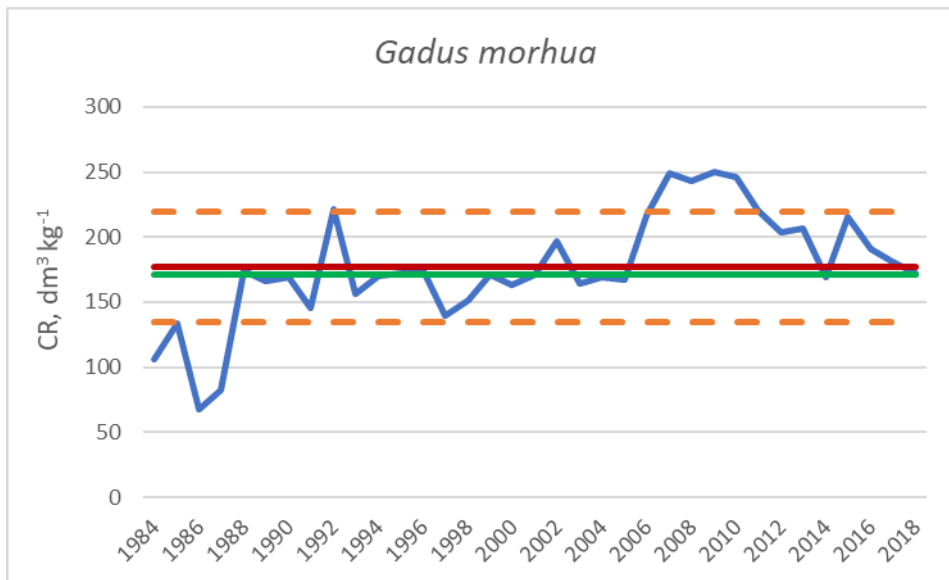
The average concentration ratio determined for flatfish and herring (135) was used in the calculations:

Species	Concentration ratio (CR)		
	Erica tool	southern Baltic	References
Pelagic fish	60	-	HOSSEINI, A., THØRRING, H., BROWN, J.E., SAXÉN, R., ILUS E., Transfer of radionuclides in aquatic ecosystems – Default concentration ratios for aquatic biota in the Erica Tool, Journal of Environmental Radioactivity, Volume 99, Issue 9 (2008) 1408–1429.
Flatfish	40	-	
Cod	-	170 (140-194)	
Flatfish	-	135 (116-153)	

Herring	-	135 (120-152)	Tamara Zalewska, Maria Suplińska, Fish pollution with anthropogenic ¹³⁷ Cs in the southern Baltic Sea, Chemosphere 90 (2013) 1760–1766
Cod		Mean: 177 Median: 171	Baltic monitoring data 1984 - 2018
Flatfish		Mean: 146 Median: 151	
Herring		Mean: 190 Median: 175	

In order to determine the CR based on the monitoring data, the mean values of the concentration of Cs-137 in fish (separately for each species: herring, cod, flatfish) and the average concentration of Cs-137 in the seawater for each year were calculated. On this basis, the CR values for each year were calculated (see figure below). For further calculations, the median value for herring was proposed (175 dm³ kg⁻¹).





Assuming the median value for herring ($175 \text{ dm}^3 \text{ kg}^{-1}$), the calculated threshold value for seawater **TV_{sw}** is **0.18 Bq l^{-1}** (180 Bq m^{-3}). (reference concentration applied in OSPAR is 4.5 Bq l^{-1})

- The last step is to check whether the dose derived from the threshold values meets the criteria for protection for fauna and flora, which according to ICRP (2008) is equal to the lower value of the 'derived consideration reference levels' (DCRL), which is equal to $40 \mu\text{Gy h}^{-1}$.

As described in Agreement on a Methodology for Deriving Environmental Assessment Criteria and their application (OSPAR Agreement: 2016-07):

The ICRP defines DCRLs as dose rates for chronic exposures derived for a set of conceptual 'reference animals and plants' (RAPs) representative of different environments (e.g., terrestrial, aquatic) that serve as markers at which one should pause in order for the known radiation effects data to be considered alongside other relevant factors when considering managerial options. The DCRLs are grouped into bands, which span an order of magnitude, corresponding to different RAPs and considering a range of possible effects at the level of individuals which may have impact at the level of populations (from cytogenetic and mutation effects to loss of reproductive capacity, morbidity and mortality). The bands are expressed in terms of absorbed dose rates in $\mu\text{Gy/h}$ units.

Because this range includes values from 40 to $400 \mu\text{Gy h}^{-1}$, it can be assumed that the impact of radiation below $40 \mu\text{Gy h}^{-1}$ is negligible.

In order to calculate the total dose to fish due to concentrations of Cs-137 in fish (internal dose) and seawater (external dose) equal to TV_{FISH} and TV_{SW} , respectively, the following equations were used:

for external dose:

$$D_{\text{ext}} = \text{DCF}_{\text{ext}} * \text{TV}_{\text{SW}}$$

Where:

D_{ext} – external dose due to the Cs-137 concentration in seawater equal to TV_{SW}

DCF_{ext} – dose coefficients for non-human biota (for external exposure in aquatic environment for flatfish - $3.0 \cdot 10^{-4} \mu\text{Gy h}^{-1} \text{ Bq}^{-1} \text{ l}$ (ICRP 136, 2017))

The determined dose from external source is equal to $0.5 \cdot 10^{-4} \mu\text{Gy h}^{-1}$

for internal dose:

$$D_{\text{INT}} = \text{DCF}_{\text{INT}} * \text{TV}_{\text{FISH}}$$

D_{int} – internal dose due to the Cs-137 concentration in fish equal to TV_{FISH}

DCF_{int} – dose coefficients for non-human biota (for internal exposure for flatfish – $1.7 \cdot 10^{-4} \mu\text{Gy h}^{-1}$

$\text{Bq}^{-1} \text{kg}$ (ICRP 136, 2017))

The determined dose from internal source is equal to $52 \cdot 10^{-4} \mu\text{Gy h}^{-1}$

The total dose to fish is $53 \cdot 10^{-4} \mu\text{Gy h}^{-1}$ and is lower than the lower value of the 'derived consideration reference levels' (DCRL), which is equal to $40 \mu\text{Gy h}^{-1}$, which means that the adopted threshold values for fish and seawater meet the requirements for the protection of fish in the Baltic Sea environment.