BIOKINETICS OF RADIONUCLIDES AND METALS IN ADULT AND EMBRYONIC SPOTTED DOGFISH *SCYLIORHINUS CANICULA* (CHONDRICHTHYS)

Ross Jeffree *, Jean Louis Teyssie , Francois Oberhansli and Michel Warnau
IAEA Marine Environment Laboratories, 4 Quai Antoine 1er, MC 98000, Monaco - R.Jeffree@iaea.org

Abstract

Multi-radiotracer experiments have determined the dissimilar bioaccumulatory characteristics of a cartilaginous fish model, the spotted dogfish *Scyliorhinus canicula,* relative to a bony fish model, the turbot *Psetta maxima.* Encased embryos of the spotted dogfish have also been investigated for their capacity to absorb contaminants directly from water. Direct uptake of contaminants from seawater by encased embryos has demonstrated the unexpectedly high accumulatory capacities of the egg case, relative to the embryo, yolk and jelly components. This result has important implications for radiological dose to the encased embryo from the sorbed gamma-emitting nuclides.

Keywords : Bio-accumulation, Biokinetics, Trace Elements, Radionuclides, Elasmobranchii.

Introduction

This paper presents results of current experimental studies on the biokinetics in a representative Chondrichthyan, the spotted dogfish *Scyliorhinus canicula* (Chondrichthys: Scyliorhinidae) of some anthropogenic radionuclides (^{241}Am, $^{57+.60}$Co and^{134}Cs) that are typically associated with nuclear effluents to the marine environment, as well as a suite of heavy metals typically found in effluents to coastal marine systems from land-based sources. Relatively few experimental studies have been undertaken on chondrichthyans with regard to their bioaccumulation and biokinetics of radionuclides and heavy metals, although they form an important component of fisheries some of which are vulnerable due in part to their relatively slow growth rates, late sexual maturity and low fecundity [1]. However this taxon is quite distinct from the Teleost taxon in various aspects of their anatomy and physiology, as well as life history characteristics [2]. The susceptibility of the dogfish's embryonic stage to these contaminants in seawater was also investigated experimentally.

Materials and methods

The experimental protocols for the direct uptake of radioisotopes from seawater by both juvenile dogfish and their encased embryos are reported in references [3 and 4].

Results and Discussion

The uptake rates from water, measured over 14 days, varied greatly among isotopes. Concentration factors (CFs) in *S. canicula* varied by a factor of 350, with CFs for ^{51}Cr and ^{241}Am ranging from ca. 0.4 to 140, respectively. With the exception of ^{134}Cs, all radiotracers were accumulated at a faster rate in *S. canicula* than in *P. maxima* particularly for ^{241}Am and ^{65}Zn where the CFs attained during the uptake phase were, two and one order of magnitude greater in *S. canicula*, respectively. In contrast, ^{134}Cs reached a CF of about 2.5 in *P. maxima,* which is 5-fold greater than in *S. canicula*. Patterns of loss from the experimental depuration phase over 29 days showed greater similarities between species, compared to the uptake phase that highlighted the greater differences between elements.

The distributions of these seven radioisotopes among six body components indicated that the skin of the dogfish displayed a very great bioaccumulation potential, particularly its elevated levels of ^{241}Am, ^{57}Co and ^{65}Zn. However ^{65}Zn was also distinctive from ^{241}Am and ^{57}Co in its bioaccumulation, with other body components attaining concentrations of ^{65}Zn that were comparable to skin. The elevated uptake rates and higher CFs for most radioisotopes indicate that *S. canicula* is more susceptible than *P. maxima* to exposure and contamination by these metals and radionuclides in seawater.

Encased embryos of *S. canicula* absorbed six radioisotopes (^{241}Am, ^{109}Cd,^{57}Co,^{134}Cs,^{54}Mn and^{65}Zn) directly from seawater during short-term experimental exposure, demonstrating the permeability of the egg case to these contaminants. Embryo to water concentration factors (CFs) ranged from 0.14 for ^{134}Cs to 7.4 for ^{65}Zn. The ^{65}Zn and ^{57}Co CF's increased exponentially with embryo length, whereas the CF for ^{109}Cd declined with length. Among different components of the encased embryo the egg case was the major repository (69-99%) of all six radioisotopes that were evenly distributed throughout its wall. Egg case CF's were as high as 10^3 for ^{57}Co and^{65}Zn, making it a major source of gamma radiation exposure to the embryo and potentially of radioisotopes for continued absorption by the embryo, following the uptake phase of the experiment. The patterns of uptake by the egg-case approximated linearity for most isotopes and loss rates were isotope-specific; egg-case biokinetics were not greatly affected by the viability of the contained embryo. Within the embryo initial data on radio isotopic distribution show that the skin is their major site of uptake, as previously demonstrated for juveniles.

The mean (+SD) CF's for six radioisotopes in embryos and juveniles (mean wet weight 6.08 g), were also determined after 15 days of uptake under experimental conditions [4]. The CF's are very similar between embryos and juveniles for ^{54}Mn, ^{57}Co and ^{109}Cd but higher in juveniles by a factor of 3 for ^{134}Cs, a factor of about 10 for^{65}Zn, and a factor of about 30 for^{241}Am. Cadmium-109,^{57}Coand ^{54}Mn, that show comparable CF's for embryos and juveniles, have uptake patterns in juveniles that approximate to equilibrium after the 15 days of uptake. In contrast, the radioisotopes (^{134}Cs, ^{65}Zn and ^{241}Am) that show enhancement in juveniles, relative to embryos, also showed patterns of uptake in juveniles indicating that equilibrium CF's had not been reached in 15 days.

The increased CF's of ^{65}Zn in juveniles, compared to their mean CF's in embryos, are also consistent with its increasing CF in embryos as they increase in size. This phenomenon of increasing CF with increasing size indicates an expanding exchangeable pool for this radioisotope, in this species. With regard to potential chemotoxic effects the enhanced CFs for juveniles would make them more exposed to contaminant impacts, compared to embryos. However, with regard to radiation exposure from gamma-emitting isotopes the absorptive capacity of the egg-case would result in the potential for radiotoxic effects being much greater for the encased embryo. If the contaminants depurated from the egg case are also subsequently available for absorption by the embryo then their radiotoxic and chemotoxic effects may be more comparable.

References

1 - Barker M.J. & Schluessel V. (2005). Managing global shark fisheries: suggestions for prioritizing management strategies. *Aquatic Conserv: Mar Freshw Ecosyst* 15: 325-347..

2 - Bone Q, Marshall NB, Blaxter JHS. Biology of Fishes, Chapman and Hall, London, 1995, 332 pp.

3 - Jeffree R. A., Warnau M. ,Teyssie J-L. , Markich S. J. (2006).Comparison of thebioaccumulation from seawater and depuration of heavy metals and radionuclides in the spotted dogfish *Scyliorhinus canicula* (Chondrichthys) and the turbot *Psetta maxima* (Actinopterygii: Teleostei). *The Science of the Total Environment*, 368:839-852.

4 - Jeffree R. A., Warnau M, Oberhaensli, F. and. Teyssie J-L. (2006). Bioaccumulation from seawater of heavy metals and radionuclides by encased embryos of the spotted dogfish *Scyliorhinus canicula*. *Marine Pollution Bulletin*, 52: 1278-1286.