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1993 GRANT RESEARCH SUMMARY

PROJECT TITLE: Monitoring Release of Disposed Radionuclides in the Kara Sea: Bioaccumulation of Long-Lived Radionuclides In Echinoderms and Molluscs

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OBJECTIVES The objective of the present proposal is to continue and extend our research on the trophic transfer of important radionuclides in benthic fauna of the Kara Sea. This project is assessing the extent to which select species of seastars, brittle stars, and clams typical of the Kara Sea concentrate and retain a variety of long-lived radionuclides known to be (or suspected to be) present in the disposed wastes in the Russian Arctic. The rates and routes of uptake and depuration of isotopes in the same or in closely related species are being quantified so that endemic benthic organisms can be assessed as potential bioindicators of released radionuclides in Arctic waters.

APPROACH AND ACCOMPLISHMENTS Two searches were completed for hiring manpower to help conduct the experiments for this project. Dr. David Hutchins, a postdoctoral investigator, was hired and began work in March, 1994. He recently received his PhD under the auspices of K W Bruland at the University of California, Santa Cruz. Mr. Ian Stupakoff, who has just completed his MS degree at Stony Brook under R. Aller, was also hired as of December, 1993. He is a fulltime technician in my lab, and is primarily supported off another grant, but he is working extensively on the ONR project. I have also been supervising a PhD student at Stony Brook, Mr. Wen Xiong Wang, who has helped conduct many of the *Macoma* experiments to date.

The study we are conducting is examining the extent to which clams (*Macoma balthica*) and echinoderms such as seastars (dominant asteroids in the Kara Sea include *Pontaster*, *Asterias*, and *Hymenaster)* accumulate these radioisotopes and can be used as bioindicators of released radioactive wastes. Results of experiments thus far have indicated that *M. balthica* can accumulate diverse radionuclides from a wide variety of food sources; seven different algal species have thus far been examined. The assimilation efficiency of ingested radionuclides varies greatly among the radionuclides and less among the different foods for a given radionuclide. Other factors which have been considered thus far in our experiments include food density and duration of feeding periods. Current experiments are considering the accumulation of radionuclides from the dissolved phase. By considering dissected tissues, our research clearly shows a different distribution of radionuclides in the animals obtained from dissolved and particulate (ie., food) sources. Values for assimilation efficiencies and biological half-lives for select radionuclides in *M. balthica* are presented in Table 1. The distribution of three radionuclides in the animals is given in Fig. 1, while the uptake rate of four radioisotopes from the dissolved phase is given in Fig. 2. Note that the uptake of the radionuclides from the dissolved phase conformed with Freundlich adsorption isotherms, consistent with radionuclide uptake on other marine organisms (e.g., phytoplankton).

We have begun experiments investigating the trophic transfer of radiolabeled clams (labeled by exposure to radiolabeled phytoplankton food) to starfish (*Asterias forbesii*) and have found significant transfer of ^{241}Am, some transfer of ^{57}Co, and virtually no transfer of ^{137}Cs to the starfish. These epxeriments are being conducted at 2 C to simulate Kara Sea ambient temperatures. We are in the process of conducting experiments which will quantify the depuration rate constants for each of these isotopes from the starfish. Fig. 3 displays some data on retention of these radionuclides accumulated in starfish and clams from the dissolved phase at 2 C. Results to date indicate that these organisms have unusually long biological half-lives for these radioisotopes (especially the transuranic element, americium), underscoring the likelihood that the echinoderms could be very effective bioindicators of any released radionuclides from the disposed radioactive wastes. Complementary studies by our colleague, Dr. Scott Fowler of the IAEA Marine Environmental Laboratory in Monaco, have begun to measure the uptake and retention of select radionuclides (e.g., ^{60}Co and ^{241}Am) in echinoderms. We have also planned experiments, to take place at the Monaco laboratory in conjunction with Dr. Fowler, for mid-winter using starfish and brittle stars obtained from the Russian Arctic. These experiments will be performed by Drs. Fisher and Hutchins and will employ a flowing seawater system held at 0-2 C. Gamma spectrometry will be by high purity germanium detectors rather than NaI(Tl) detectors.

APPLICATIONS The results of our experimental studies will determine the extent to which key components of the benthic fauna of the Kara Sea--particularly clams and echinoderms--are able to concentrate and retain those radionuclides most likely to contaminate the Kara Sea. The experiments employ the same species (or, for some echinoderms, genera) and environmental conditions (e.g., salinity, temperature) as in the Kara Sea benthos. If radionuclides are released from their containers in the Kara Sea, these organisms might be useful as bioindicators of released materials. Our results will provide quantitative information so that these potential sentinel organisms can help provide quantitative as well as qualitative information on ambient radionuclides. Finally, because we will provide the uptake rates, bioconcentration factors, and biological half-lives for each major radionuclide in both clams and echinoderms, in which the animals were exposed to either dissolved or particulate radionculides, the results will help determine the likelihood of food chain contamination for each radionuclide depending on its physical speciation.

Table 1. Assimilation efficiencies (AE, in %), physiological turnover rates (k, in % d^{-1}), and biological half-lives ($t_{1/2}$, in days) of six radioisotopes in *Macoma balthica*. 3H: *Thalassiosira pseudonana* (diatom); Iso: *Isochrysis galbana* (prymnesiophyte).

Isotope	Algal Food	AE (%)	k (% d^{-1})	$t_{1/2}$ (d)	r^2
^{110m}Ag	3H	53.7	4.32	16.0	0.83
	Iso	60.2	3.19	21.7	0.85
^{241}Am	3H	36.4 ± 2.7	2.1 ± 0.7	36.6 ± 12.3	0.93
	Iso	41.0 ± 10.6	1.3 ± 0.2	55.5 ± 8.9	0.75
^{109}Cd	3H	77.8	0.3	262.5	0.17
	Iso	71.7	0.3	240.6	0.24
^{57}Co	3H	35.5	3.0	22.9	0.37
	Iso	53.4	3.0	23.1	0.82
^{75}Se	3H	78.5 ± 2.8	1.9 ± 0.1	46.2 ± 1.5	0.93
	Iso	87.2 ± 1.9	1.5 ± 0.6	55.6 ± 22.4	0.85
^{65}Zn	3H	46.2 ± 1.6	1.9 ± 0.2	38.1 ± 5.0	0.90
	Iso	64.0 + 4.9	1.7 + 0.2	42.3 + 5.8	0.90

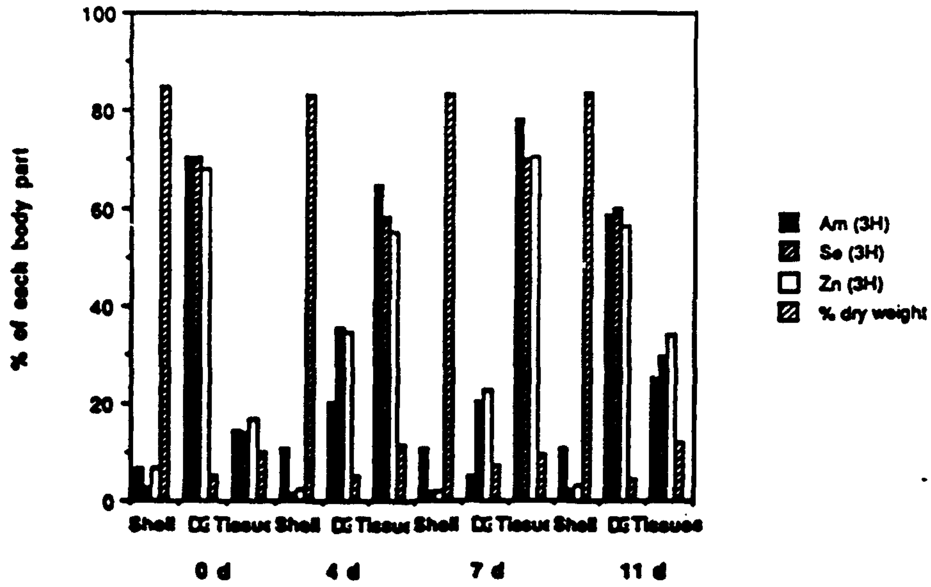

Fig. 1. Distribution of ^{241}Am, ^{75}Se and ^{65}Zn in the tissues of *Macoma balthica* after varying depuration periods (0 - 11 days). DG: digestive gland; tissue, other tissues in the soft parts.

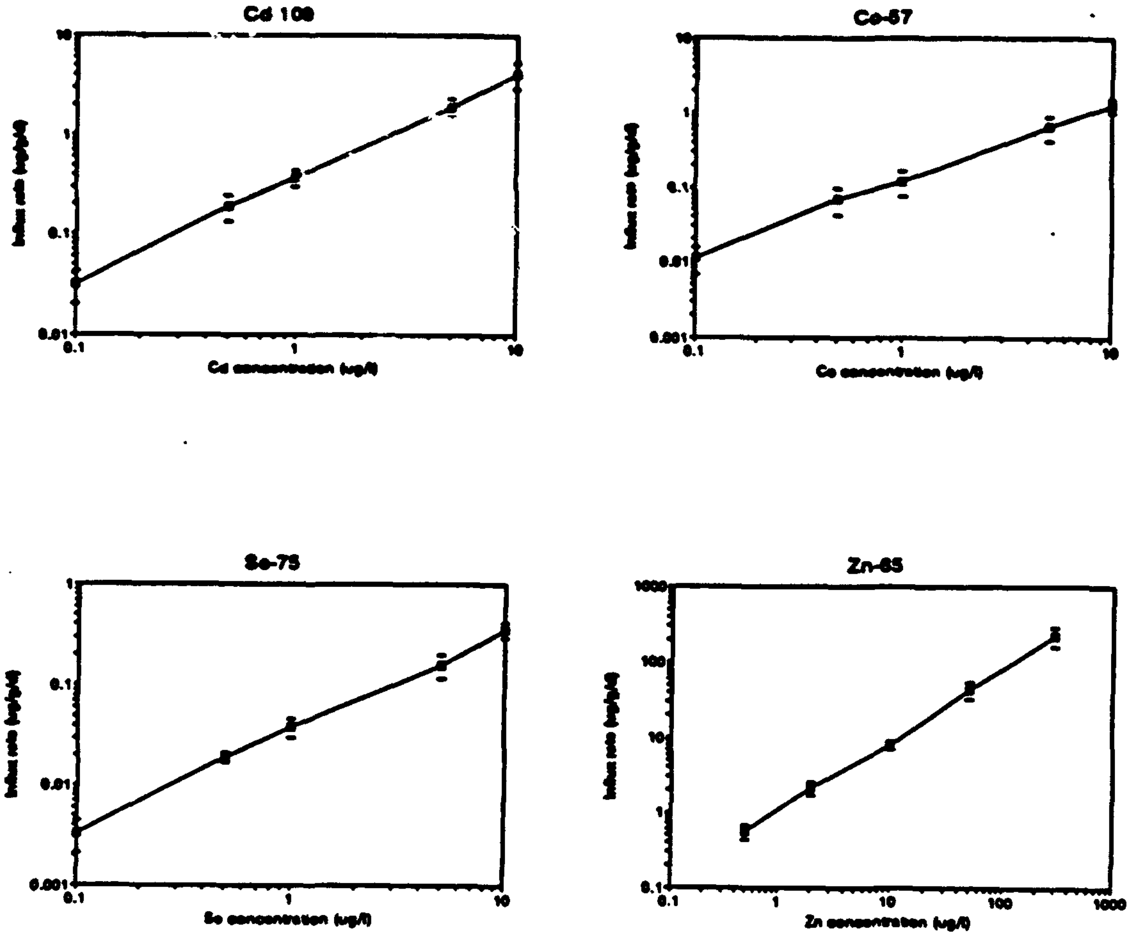

Fig. 2. Influx rates of ^{109}Cd, ^{57}Co, ^{75}Se, and ^{65}Zn in *Macoma balthica* from the dissolved phase, as a function of dissolved radioisotope concentration.

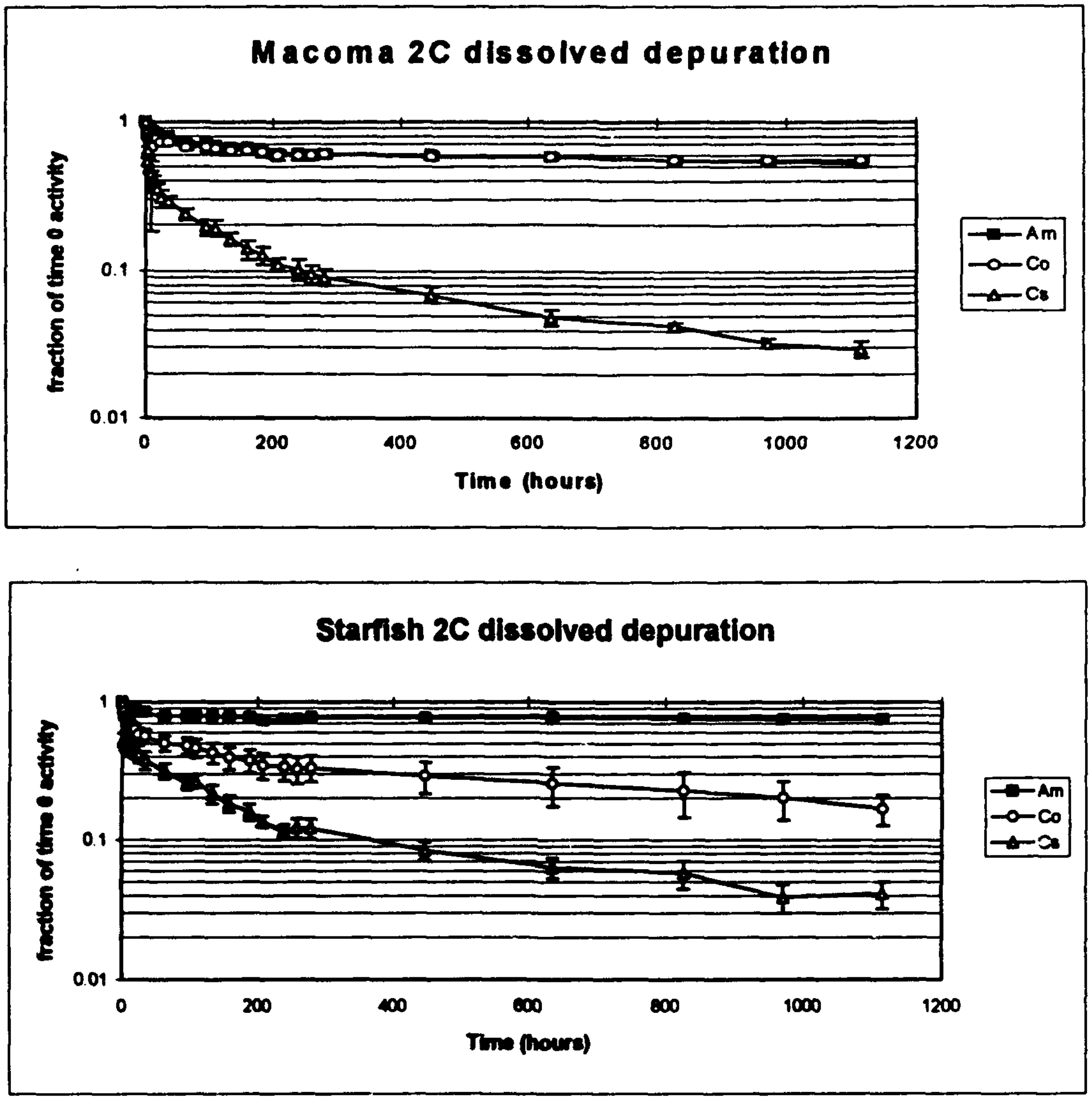

Fig. 3. Retention of ^{60}Co, ^{137}Cs, and ^{241}Am in *Macoma balthica* and *Asterias forbesii* after accumulation from the dissolved phase.