SCAVENGING AMPHIPODS: SENTINELS FOR PENETRATION OF HISTORIC AND NEW ORGANIC CONTAMINANTS INTO FOOD WEBS OF THE DEEP ARCTIC OCEAN

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Introduction

Few studies have investigated penetration of contaminants to the deep Arctic Ocean. Low levels in sediments present severe challenges to their use as indicators of contamination and may imply recycling in deep-ocean food webs rather than sediment burial. Marine benthic invertebrates provide another means of assessing transfer to the deep ocean. The lysianassid amphipod *Eurythenes gryllus* is a relative large (mature females up to 10-12 cm length) and long-lived (5-10 years) scavenger. *E. gryllus* has a diverse diet comprised of invertebrates and vertebrate carrion (fish and mammals) that reach the seabed (1) and is able to locate bait placed on the bottom using chemoreception. The amphipods feed rapidly to satiation to store lipids that will sustain basic metabolic processes for up to 6 months in juveniles and more than one year in mature females (2,3). Previous studies have shown that levels of POPs in *E. gryllus* collected in the central Arctic Ocean may be similar to those in seals and gulls (4). This research was conducted to determine penetration of legacy and new contaminants to the abyssal Arctic Ocean, as indicated by body burdens in *E. gryllus*. Reported here are total mercury (ΣHg), methyl mercury (MeHg), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), perfluorinated carboxylic acids (PFCAs) and perfluorooctane sulphonate (PFOS). Enantiomer composition was determined for chiral chlordanes and metabolites, and *o,p'*-DDT.

Materials and methods

E. gryllus were collected between 1983–1998 using traps with protected bait (2). Specimens were held frozen at -18°C; collection data and locations are given in Table 1 and Figure 1. Stable isotopes ($\delta^{15}N$ and $\delta^{13}C$) were determined by continuous flow ion ratio mass spectrometry after removal of carbonates. The ΣHg was determined by cold vapour atomic absorption after acid digestion. Homogenized tissue was extracted with toluene and MeHg was determined by gas chromatography-electron capture detection (GC-ECD) after derivatisation to MeHgI. Organic contaminants were determined after dichloromethane extraction of tissues and cleanup using the techniques: PCBs: GC-ECD, OCPs: GC-low resolution electron capture negative ion mass spectrometry (ECNI-LRMS), chlorobornanes (CHBs, as technical toxaphene): GC-ECNI-high resolution MS, perfluorinated chemicals: high performance liquid chromatography-MS/MS. OCP enantiomers were determined by GC-ECNI-LRMS on chiral-phase columns.

Results and discussion:

E. gryllus specimens ranged from <0.1 - 9.3 g wet weight (ww), with largest individuals from CESAR-83 and smallest from SCICEX-98 (Table 1). Length and ww were highly correlated ($r^2 = 0.956$). Trophic levels inferred from $\delta^{15}N$ (Hobson et al., 1995) were 2-5. There was no apparent relationship between percent lipid content and $\delta^{15}N$. The ΣHg ranged from 55-1130 ng g^{-1} ww, mean = 245±226, geometric mean (GM) = 177. Levels were highest on CESAR-83 and lowest on SCICEX-98. MeHg was determined in 5 samples from each expedition; results averaged 5.0% (range 1.7-20.1%) of ΣHg. (Figure 2). PFCAs (C_8-C_{12}) and PFOS were determined in 4-5 samples from each expedition. The ΣPFCAs ranged from <1.5-400 (mean=30, GM=9.0) ng g^{-1} ww. The range for PFOS was <0.06-140 (mean=19, GM=2.5) ng g^{-1} ww (Figure 2).

Legacy POPs over all expeditions spanned orders of magnitude, with GMs (ng g^{-1} lipid) ΣCHBs (4012) > ΣPCBs (2220) > ΣDDT compounds (1474) > Σchlordanes (ΣCHLs) (487) > Σmirex + photomirex (ΣMXs) (41) > Σchlorobenzenes (ΣCBZs) (14) = octachlorostyrene (OCS) (14) > Σ-hexachlorocyclohexane (Σ-HCH) (8.5) ~ pentachloroanisole (PCA) (5.2) (Figure 3). The ΣPOPs GMs differed with location: SCICEX-98 (45020) > CESAR-83 (14300) > SCICEX-96 (7764) > SHEBA-98 (4127) > SHEBA-97 (2120). Differences in PCB homologues and proportions of DDTs were found among locations. The chiral OCPs were generally nonracemic, reflecting selective metabolism in prey or in *E. gryllus* themselves. Enantiomer fractions (EFs) ranged from 0.448-0.529 (*trans*-chlordane), 0.391-0.535 (*cis*-chlordane), 0.559-0.817 (oxychlordane), 0.292-0.612 (nonachlor MC6), 0.422-0.888 (*o,p*'-DDT).

Contaminants were not significantly associated with trophic level (2-5, as inferred from stable isotopes) (5). EFs were only weakly or not significantly related to trophic level. Multidimensional Scaling (MDS) analysis was carried out using log-transformed variables. MDS separated the groups of amphipods with small, low-lipid levels individuals from SCICEX98 clearly differentiated from other samples. *E. gryllus* probably do not record the contamination of abyssal waters, but rather the vertical flux of occasional large particles (carcasses), thereby providing an independent way of viewing the time course of contaminants in the upper interior ocean – a difficult location to sample by other means.

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Figure 1. E. gryllus ollection locations.

Table 1. Collection data for E. gryllus.

Expedition	CESAR-83	SCICEX-96	SHEBA-97	SHEBA-98	SCICEX-98
Location	1	2,3,4	5	6	7
Year	1983	1996	1997	1998	1998
Depth, m	2075	3643 - 3745	3700	3500	4250
N	13	11	15	15	10[a]
Length, mm	52.8 - 75.7	21.7 - 62.7	35.4 - 54.2	41.4 - 52.8	
Dry wt., g	0.56 - 2.4	0.051 - 1.6	0.30 - 0.71	0.37 - 0.97	0.32 - 0.42[b]
Wet wt., g	2.8 -9.3	0.14 - 3.6	0.81 - 2.0	1.1 - 3.1	1.3 - 1.4[b]
Lipid %	28.8 - 62.6	34.2 - 61.7	43.7 - 62.6	53.9 - 68.2	19.8 - 30.6

a) 10 pools of 13-19 small amphipods in each; b) Range of weights and % lipid of each pool.

Figure 2. Hg, PFCAs and PFOS in E. gryllus, all expeditions. Black line: range (arrow = quantitation limit); red line: arithmetic mean; red diamond: geometric mean; box: 25-75 percentiles.

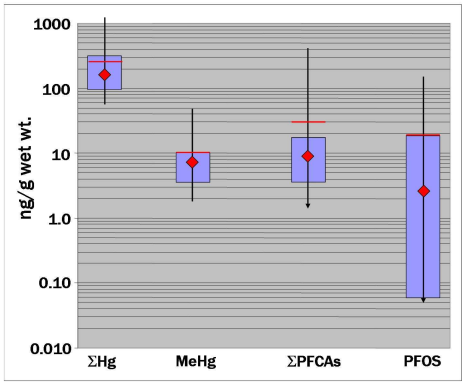

Figure 3. Organochlorines in E. gryllus, all expeditions. Symbols as in Figure 2.