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ScienceDirect

Marine Environmental Research 65 (2008) 101–127

MARINE ENVIRONMENTAL RESEARCH

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Relationship of parasites and pathologies to contaminant body burden in sentinel bivalves: NOAA Status and Trends 'Mussel Watch' Program

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Received 17 January 2007; received in revised form 11 September 2007; accepted 13 September 2007

Abstract

The 1995–1998 database from NOAA's National Status and Trends 'Mussel Watch' Program was used to compare the distributional patterns of parasites and pathologies with contaminant body burdens. Principal components analysis (PCA) resolved five groups of contaminants in both mussels and oysters: one dominated by polycyclic aromatic hydrocarbons (PAHs), one dominated by pesticides, and three dominated by metals. Metals produced a much more complex picture of spatial trends in body burden than did either the pesticides or PAHs. Contrasted to the relative simplicity of the contaminant groupings, PCA exposed a suite of parasite/pathology groups with few similarities between the sentinel bivalve taxa. Thus, the relationship between parasites/pathologies and contaminants differs significantly between taxa despite the similarity in contaminant pattern. Moreover, the combined effects of many contaminants and parasites may be important, leading to complex biological-contaminant interactions with synergies both of biological and chemical origin.

Overall, correlations between parasites/pathologies and contaminants were more frequent with metals, frequent with pesticides, and less frequent with PAHs in mussels. In oysters, correlations with pesticides and metals were about equally frequent, but correlations with PAHs were still rare. In mytilids, correlations with metals predominated. Negative and positive correlations with metals occurred with about the same frequency in both taxa. The majority of correlations with pesticides were negative in oysters; not so for mytilids. Of the many significant correlations involving parasites, few involved single-celled eukaryotes or prokaryotes. The vast majority involved multi-cellular eukaryotes and nearly all of them either cestodes, trematode sporocysts, or trematode metacercariae. The few correlations for single-celled parasites all involved proliferating protozoa or protozoa reaching high body burdens through transmission. The tendency for the larger or more numerous parasites to be involved suggests that unequal sequestration of contaminates between host and parasite tissue is a potential mediator. An alternative is that contaminants differentially affect parasites and their hosts by varying host susceptibility or parasite survival.

Keywords: Bivalve; Mussel; Oyster; Mussel watch; Parasite; Pathology; Contaminant; Body burden; Metal; PAH; PCB; Pesticide

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doi:10.1016/j.marenvres.2007.09.003

1. Introduction

Bivalve mollusks, such as mussels or oysters, are often used as sentinel organisms in contaminant monitoring programs (Phillips, 1977; Farrington et al., 1983; Green et al., 1989; Oliver and Fisher, 1999; Peterson, 2001). Bivalves are preferentially chosen as sentinel organisms for their ability to concentrate both metals and organic contaminants, their immobility, their limited ability to metabolize accumulated contaminants, their relatively wide distribution among habitats including those relatively heavily polluted, their abundance, their persistence, and their ease of collection, all of which make them good long-term integrators of the surrounding environment (Phillips, 1977; O'Connor, 2002).

The National Status and Trends 'Mussel Watch' Program has been monitoring contaminants of environmental concern since 1986 using bivalves as sentinel organisms (O'Connor, 2002). As Mussel Watch was designed to document the geographic distribution and temporal trends of contamination on a national scale, most sites were placed away from known point sources of contamination, poorly flushed industrial waterways, and pilings or metal buoys (O'Connor and Beliaeff, 1995; O'Connor, 1996). Sampling sites of an earlier Mussel Watch program (Goldberg et al., 1978, 1983) were, when possible, incorporated into the current Mussel Watch program (O'Connor, 1994).

Bivalves are presently collected every other year at a network of over 250 estuarine, lakeshore, and coastal locations along the US Great Lakes, East, West, and Gulf coasts, with approximately half being visited during each annual sampling. Bivalve samples are analyzed for a variety of contaminants, including polycyclic aromatic hydrocarbons (PAHs), chlorinated pesticides, polychlorinated biphenyl (PCB) congeners, and major and trace elements. The Mussel Watch program also monitors the health of bivalve populations through the measurement of a variety of biological indices, including the prevalence and infection intensity of parasites, diseases, and tissue pathologies. The database thus obtained provides an opportunity to examine the relationships between parasites and pathologies on the one hand and contaminants on the other over a large geographic scale. The question of the relationship of contaminant body burden to parasites and pathologies is a complex one. Extrapolating from laboratory and field experimentation comparing parasites/pathologies with contaminant body burden to inferences at geographic scales has been difficult, due to the multiplicity of contaminants and parasites present in most environments and the limited geographic scale of most present-day databases inclusive of both variables.

Certain contaminants may increase parasite body burden favoring the propagation of parasites by excluding their natural predators, by reducing the resistance of their hosts, or by providing improved living conditions for their intermediate hosts (Möller, 1987). Contaminants may also interfere with parasite transmission or proliferation within hosts and thus reduce parasite burden (Lafferty and Kuris, 1999). The interaction of parasite and pathology with contaminant body burden is known primarily from controlled experiments. Barszcz et al. (1978) showed that host oysters exposed to crude oil had an increase in prevalence and intensity of infection by parasites, for example. Experimental studies by Pascoe and Cram (1977) and Boyce and Yamada (1977) showed that parasitized host fishes were more sensitive to Cd and Zn, respectively. Ciliate epibionts increased host mortality in copepods exposed to PAHs (Puckett and Carman, 2002). In contrast, Khan and Kiceniuk (1983) found reduced infections of endoparasites in host fish exposed to crude oil. Whether the influence of the contaminant is directly on the parasite or mediated through the host is often unclear. The immune systems of host animals can be affected by contaminants (Sindermann, 1979; Rohde, 1993), lowering the resistance of a host to a variety of parasites and increasing susceptibility to parasitic invasion and disease (Barszcz et al., 1978; Galli et al., 2001). Thulin (1989) pointed out that ectoparasites may be particularly sensitive to contaminants because they are in intimate contact with the external environment. Such parasites may be useful indicator organisms for early detection of adverse environmental effects (Thulin, 1989; MacKenzie et al., 1995; Galli et al., 2001).

The cause and effect explanation is most often the inference from observed correlations between parasite body burden and contaminant body burden. More recently, however, research has begun documenting an alternative explanation; the differential in body burden between parasites and their hosts may accrue from differential affinities for contaminant accumulation. Zimmerman et al. (1999), Sures et al. (1999) and Heinonen et al. (2001) provide salient examples. Although this potential is not yet included in models of contaminant body burden (e.g., Fraysse et al., 2002; Lee et al., 2002; Yamamoto et al., 2003), this realization leaves the