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Review

More surprises in the global greenhouse: Human health impacts from recent toxic marine aerosol formations, due to centennial alterations of world-wide coastal food webs

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ABSTRACT

Reductions of zooplankton biomasses and grazing pressures were observed during overfishing-induced trophic cascades and concurrent oil spills at global scales. Recent phytoplankton increments followed, once Fe-, P-, and N-nutrient limitations of commensal diazotrophs and dinoflagellates were also eliminated by respective human desertification, deforestation, and eutrophication during climate changes. *Si*-limitation of diatoms instead ensued during these last anthropogenic perturbations of agricultural effluents and sewage loadings. Consequently, ~15% of total world-wide annual asthma trigger responses, i.e. amounting to ~45 million adjacent humans during 2004, resulted from brevetoxin and palytoxin poisons in aerosol forms of western boundary current origins. They were denoted by greater global harmful algal bloom [HAB] abundances and breathing attacks among sea-side children during prior decadal surveys of asthma prevalence, compiled here in ten paired shelf ecosystems of western and eutrophied boundary currents. Since 1965, such inferred onshore fluxes of aerosolized DOC poisons of HABs may have served as additional wind-borne organic carriers of toxic marine MeHg, phthalate, and DDT/DDE vectors, traced by radio-iodine isotopes to potentially elicit carcinomas. During these exchanges, as much as 40% of mercury poisonings may instead have been effected by inhalation of collateral HAB-carried marine neurotoxic aerosols of MeHg, not just from eating marine fish. Health impacts in some areas were additional asthma and pneumonia episodes, as well as endocrine disruptions among the same adjacent humans, with known large local rates of thyroid cancers, physician-diagnosed pulmonary problems, and ubiquitous high indices of mercury in hair, pesticides in breast milk, and phthalates in urine.

Contents

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1. Introduction

Marine aerosols from harmful algal blooms [HABs] of *Karenia* and *Ostreopsis* spp. have been a persistent human health issue in coastal communities of the Gulf of Mexico [GOM]. Breathing difficulties during coincident fish kills had been first described off Vera Cruz, Mexico in October 1876 (Nunez Ortega, 1879; Magana et al., 2003). On the WFS [West Florida shelf], results from a complex zooplankton model, ZOOSIM [zooplankton simulations] on the top-down impacts of herbivore reductions during the last half-century demonstrated that wind-borne food web exports of aerosolized HAB asthma triggers still caused pulmonary distresses 140 years later. Yet, we had hypothesized that they were now co-transported with both other marine mercury (Walsh et al., 2015, 2016) and legacy pesticide (Stemmler and Lammel, 2009) neurotoxins, entained within sea salts and recorded as pulmonary illnesses among adjacent humans (Figs. 1–2).

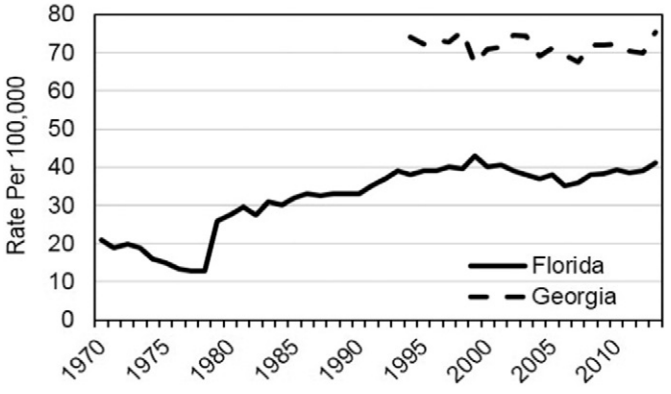

Fig. 1. Annual chronic lower respiratory disease mortalities, including asthma + pneumonia deaths = 28% in Florida during 1970–2013 (solid line) and in Georgia during 1994–2013 (dotted line), with each set of total death rates adjusted to the U.S. standard population of 100,000 residents (data courtesy of the Florida Department of Health and the Georgia Department of Public Health). Other lung fatalities were due to influenza, bronchitis, emphysema, and chronic obstructive pulmonary disease [COPD].

Sea spray, as chlorine measured in rain water, had extended ~1200 km inland from the GOM to Indiana in July–September 1955 (Junge and Gustafson, 1957), during 13 tropical cyclones that year. But, small HABs prevailed on the WFS during this decade of 1955–1965, before onset (Fig. 3) of a trophic cascade on both sides of the GOM (Walsh and Steidinger, 2001; Walsh et al., 2011). Subsequently, between 1967 and 2011, increased HAB onshore wind-borne aerosol fluxes of halides and DOC-transported organic neurotoxins amounted to ~48% of annual carbon sequestration by ungrazed WFS HABs (Walsh et al., 2016). Incremental prevalences of asthma also occurred within downstream Indiana, from 4.9% in 1966 to 11.0% in 2003 (Arbeiter, 1967; Akinbami et al., 2009).

During 2003, the GOM may still have remained a source of legacy DDE pesticide metabolites for dispersal to Indiana (Hoh and Hites, 2004), but via landfalls abetted by the dinoflagellate-dominated HAB carriers along the Florida Pandhandle, rather than past the diatom-rich Mississippi River Delta (Fig. 2). Earlier DDE maxima in Alabama air during June and September 1996 (Jantunen et al., 2000) may have also reflected seasonal onshore fluxes of HAB-modulated neurotoxins of: 1) other phthalate endocrine disruptors; 2), organic mercury poisons; and 3) asthma triggers during their usual peak summer-fall accumulations of dinoflagellate biomasses and subsequent lysed DOC carriers of lipophillic toxins.

During that two-year event, which began in September 1994 and ended by May 1996, until another HAB started in September 1997, a total of 238 manatees, ~10% of the Florida population, died from inhaling HABs. Such continued aerial imports of marine poisons were reflected in 2007 as part of recorded human asthma hospitalization rates over the SE United States, with corollary deposition of co-travelling total mercury aerosols in surface soils (Fig. 2) since 1965 (Walsh et al., 2015).

Over the past 50 years, global decimations of marine zooplankton herbivore populations (Table 1) were partly due to poisonings by petroleum (Almeda et al., 2013), DDT/DDE (Kannan and Sen Gupta, 1987), mercury (Hook and Fisher, 2001), phthalate ester (Price et al., 1986), and radionuclide (Jeffree et al., 1997) toxins. These population decrements of copepod herbivores were also the result of world-wide