Toxic Contaminants (SOOE Extended)

Methods and Data Sources

The methods used for detection and quantification of toxic organic chemicals and trace metals are summarized in Apeti et al. (2021) for CECs. The methods and data for toxic contaminants in sediments are from the U.S. Environmental Protection Agency. *National Aquatic Resource Surveys. National Coastal Condition Assessment 2000-2006, 2010, and 2015 (data and metadata files)*. Available from U.S. EPA website: https://archive.epa.gov/emap/archive-emap/web/html/index-124.html; https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys. The sediment data discussed in this report are included in Table 21.4. PAH, PCB, and Pesticide data are reported as sum totals. *(Note that table and figure numbers are continued from the State of Our Estuaries Report.)*

Additional Discussion

Contaminants of Emerging Concern (CECs)

There are many chemical contaminants that are rarely monitored and that are polluting US surface and drinking waters with potential impacts to both aquatic ecosystems and human health. There are many ways that exposure to these chemicals can be deleterious to health, and many of these chemicals are endocrine disruptors that can cause deleterious and altering effects on reproduction in nontarget species at low concentrations. States in the Northeast are responding by increasing efforts to determine the presence and concentrations of these chemicals in coastal ecosystems while simultaneously understanding potential health risks.

There has been an increase in research and monitoring of CECs in New Hampshire and the Gulf of Maine region over the past few years. In 2016, the NOAA Mussel Watch Program, in collaboration with the Gulf of Maine Council Gulfwatch Program, supported sampling and analysis of many of these compounds in blue mussels as part of a Gulf of Maine-wide project that covered 41 monitoring sites from Nova Scotia south to Cape Cod Bay in Massachusetts (Apeti et al. 2021). The following section of this report provides data from 8 sampling sites in the NH Seacoast area, including Clark Cove on Seavey Island (Portsmouth Naval Shipyard; MECC), and a regional context relating NH results to those in the rest of the Gulf of Maine.

The PFAS (PFOSA) found in mussels at the eight NH sample sites (Figure 21.3), can be compared to PFAS levels in mussels from around the Gulf of Maine (Apeti et al. 2021). The frequency of detection at sites in NH (62.5%) was higher than in MA (47.1%), ME (30.8%), and NS (0%). The concentrations detected in the NH samples show that the concentration (2.79 ng/g ww) at NHNM was the second highest in the Gulf of Maine, only lower than the concentration (5.46 ng/g ww) at MEPH in Portland Harbor (Figure 21.4).

Analysis of mussel tissue targeted a wide range of other CEC contaminants. Mussel samples from the eight local sampling sites were analyzed for a total of 240 to 249 individual CEC compounds, including four alkylphenols (APs), nine alternative flame retardants (AFRs), 33 current-use pesticides (CUPs), 12 per- and polyfluoralkyl substances (PFASs), 121 pharmaceuticals and personal care products (PPCPs), and 70 brominated flame retardants (BFRs). At least one CEC chemical was detected at all Gulf of Maine sites, including those in NH. Some of the contaminant types were not detected in NH (Table 21.2), including AFRs,

CUPs, and polybrominated biphenyls (PBBs; a type of BFR). The other types of CECs, including APs, PFAS, PPCPs, and PBDEs (also a type of BFR) were detected. The frequencies of detection of all targeted chemicals at the eight different sites were relatively low, ranging from 2.4% at NHLH to 5.2% at NHHS.

The detection frequencies for APs, PFAS, PPCPs, and PBDEs at NH sites were relatively high, with 75, 62.5, 100, and 100% detection of at least one individual compound from these four types of CECs at the eight NH sites (Table 21.3). The most frequently detected alkylphenol compound (AP) was NP1EO (Apeti et al. 2021). In NH, NP1EO was detected at six of the eight sampling sites, with 4-n-OP and NP2EO detected at only one site each (Table 21.2).

Alkylphenols (APs) were found most prominently and at the highest concentrations at NH sites compared to the other three jurisdictions. APs are chemicals used in detergents, including household detergents, and surfactants used mostly in industrial processes and are typically transported to surface waters from wastewater treatment and on-site septic systems. They tend to persist in the environment, especially attached to particles and in sediments, and can have endocrine disrupting effects on aquatic species and humans. APs were detected at six of eight NH Seacoast area sites (Table 21.2), and the highest concentrations of each of the individual AP contaminants were detected at NH sites (Figure 21.5), including 16.6 ng NP1EO/g ww and 6.88 ng NP2EO/g ww at NHSM, and 1.44 ng 4-n-OP/g ww at NHHS.

At least one PPCP contaminant was detected in all but one site (NS) in the Gulf of Maine (Apeti et al. 2021), with higher frequencies of detection and concentrations of more than one PPCP in harbor areas and near wastewater treatment facility outfalls. The most commonly detected PPCP in the Gulf of Maine was the insect repellant DEET (87.5% detection), including detection at all eight NH sites (Table 21.3). Several other PPCPs were detected at more than one NH site, including sertraline (six sites), diphenylhydramine and triamterene (five sites), and propranolol (two sites; the only detection in the Gulf of Maine), all of which are various kinds of drugs for managing human health. Seven other PPCPs were detected at one site in NH, with all but miconazole and hydrocortisone not detected anywhere else in the Gulf of Maine.

Even though DEET was detected at all eight sites in the NH Seacoast area, the concentrations were relatively low (highest concentration = 3.47 ng/g ww at NHNM) compared to sites across Maine and at MBNR in Massachusetts where the highest concentration (31.0 ng/g ww) was recorded (Figure 21.6).

At least one individual BFR was also detected in all eight of the NH sites, with 100% detection of PBDE-47 and detection of four other PBDEs at six or more sites (Table 21.3). Only 12 of the measured 51 (23.6%) PBDE congeners were detected in Gulf of Maine mussels (Apeti et al. 2021), and of these only eight were detected at five or more sites. The maximum PBDE concentrations were measured for the congener PBDE-77 and the highest detected concentration (0.67 ng/g ww) was in mussels from NHHS.

Apeti et al. (2021) also stated that developed land-use and land with high percent impervious cover were positively correlated with AP, PFAS, and PPCP detection frequencies, and the concentrations of several individual compounds (NP1EO, PFOSA, diphenhydramine, sertraline,

PBDE-47, PBDE-71/49, and PBDE-99). Higher detection frequencies were also located at the mouths of major rivers, like the Merrimack and Kennebec rivers, and near wastewater treatment plants and combined sewer outfalls.

In summary, many CECs were present in blue mussels at sites all around the Gulf of Maine and throughout the NH Seacoast area. These results suggest widespread sources, but also questions about the toxicity of different levels of these chemicals to aquatic ecosystems and human health. More recent studies have identified many more chemicals of emerging concern, raising the alarm for more monitoring to inform management strategies for identifying and eliminating different sources of these chemicals to coastal ecosystems, and for mitigating potential health risks.

Toxic Contaminants in Sediments

Estuarine sediments are ultimately where many contaminants end up being deposited and accumulated over time. However, the ability of sediments to store various constituents is largely dependent on their chemical and physical composition. The NCCA sediment chemistry data for 2000-2015 includes 15 metals, 26 PAHs, 44 PCBs, and 30 pesticides as well as total organic carbon (TOC) and percent grain size distribution that help us understand important characteristics about sediments (e.g., the kind of hydrological environment) they were sampled from, which in turn helps provide important context for understanding the fate of contaminants in our estuaries. When we consider both TOC and grain size, we see that, as expected, finer (high % silt/clay) particles and organic rich particles are associated with higher concentrations of heavy metals (e.g., Hg, Pb and As in Figure 21.7 and 21.8). However, the same trends are not observed in more complex organic molecules such as PAHs, PCBs, and pesticides (Figures 21.7 and 21.8).

When considering the spatial distribution of sediment, PAHs we can target areas for future monitoring (Figure 21.9). Most of the sites sampled in Great Bay and Hampton-Seabrook fall below the lowest effect level of 4000 ppb for freshwater sediments (Persaud et al. 1993). Levels above 22,800 ppb dry wt. are considered probable effect concentrations (MacDonald et al. 2020); the Piscataqua River and Portsmouth Harbor, notably, have the highest values.

The spatial distribution of sediment PCBs is shown in Figure 21.10 with data ranging from 2000-2010. Most of the locations sampled across the watershed were below the lowest effect level of 70 ppb (Persaud et al. 1993). The three highest levels were measured in the Piscataqua and Cocheco rivers.

These data allow us to understand the spatial distribution of contaminants of concern and to target future areas of concern for higher resolution and higher temporal frequency monitoring to better understand both the sources of the contaminants and the time scales over which they persist in the environment.

Additional Data Tables and Graphs

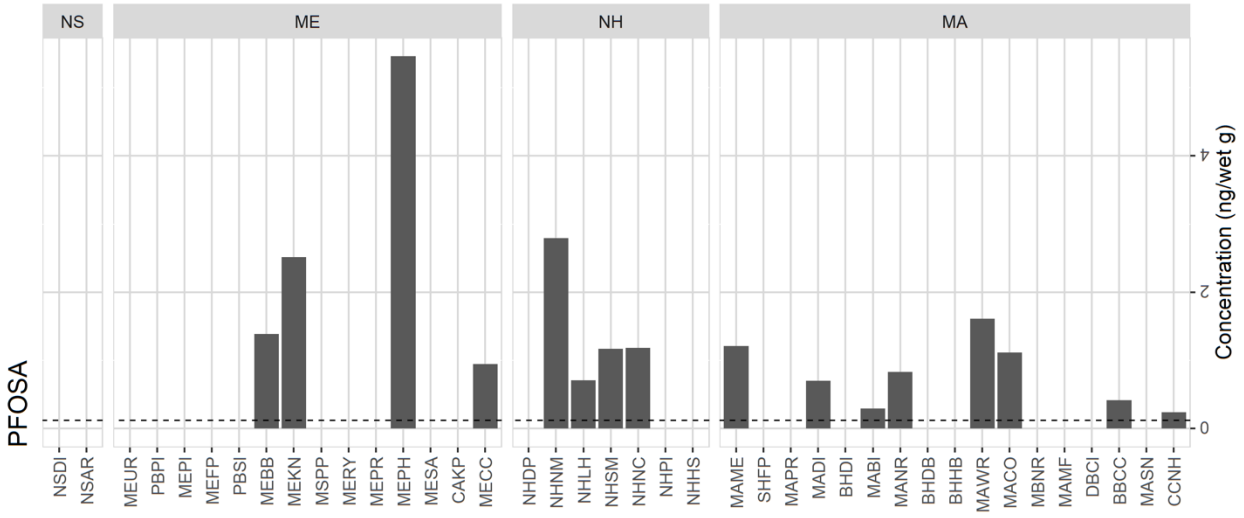

Figure 21.4. The magnitude of PFAS contaminants detected in the Gulf of Maine. The dotted line represents the minimum weight corrected detection limit. Sites are listed geographically from north to south, following the coastline. (From: Apeti et al. 2021).

Site	Number compounds analyzed	Number compounds detected	Detection frequency (%)	Alkylphenols	Alternnative flame retardants	Current use pesticides	PFAS	Pharmaceuticals & personal care products	Polybrominated biphenols	Polybrominated diphenyl ethers
NHHS	249	13	5.2	2	0	0	0	5	0	6
NHNM	240	11	4.6	1	NA	0	1	4	0	5
NHSM	249	11	4.4	2	0	0	1	5	0	3
NHDP	249	11	4.4	1	0	0	0	5	0	5
MECC	249	11	4.4	1	0	0	1	5	0	4
NHNC	248	10	4	1	0	0	1	3	0	5
NHPI	248	8	3.2	0	0	0	0	4	0	4
NHLH	248	6	2.4	0	0	0	1	1	0	4
From Apeti et al. 2021; Table 37										

Table 21.4. Total detection frequency of types of CEC contaminants in mussels from sampling sites in the NH Seacoast area.

CEC type	Compound	Number of Detects	Sample Sites	Frequency (%)
AP	NP1EO	6	8	75
	4-n-OP	1	8	12.5
	NP2EO	1	8	12.5
PFAS	PFSOA	5	8	62.5
PPCP	DEET	8	8	100
	Sertaline	6	8	75
	Diphenhydramine	5	8	62.5
	Triamterene	4	8	50
	Propranolol	2	8	25
	Amitriptyline	1	8	12.5
	Atenolol	1	8	12.5
	Cocaine	1	8	12.5
	Fluoxetine	1	8	12.5
	Hydrocortisone	1	8	12.5
	Miconazole	1	8	12.5
BFR	PBDE-47	8	8	100
	PBDE-119	7	8	87.5
	PBDE-71/49	7	8	87.5
	PBDE-99	6	8	75
	PBDE-77	6	8	75
	PBDE-126	1	8	12.5
	PBDE-118	1	8	12.5

Table 21.3. The frequency of detection of CEC contaminants in mussels from sampling sites in the NH Seacoast.

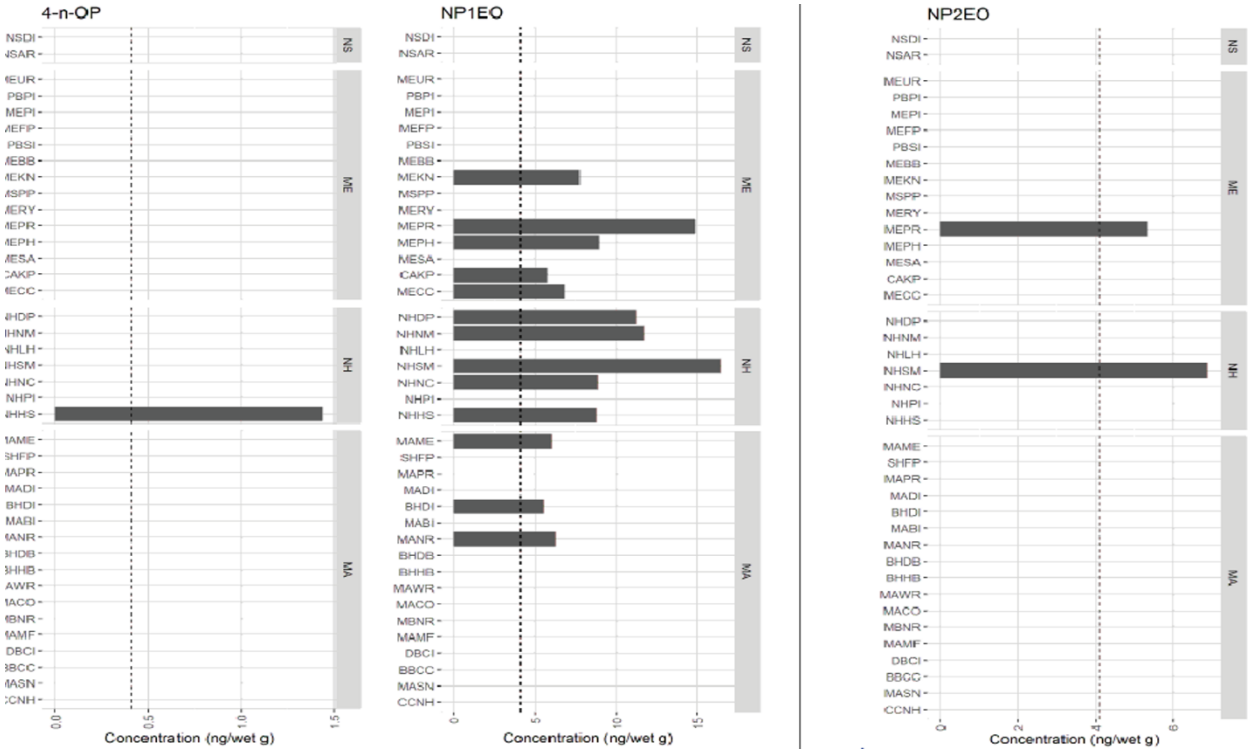

Figure 21.5. Concentrations of alkylphenols at sites in the Gulf of Maine. Sites are listed geographically from north to south, following the coastline. (From: Apeti et al. 2021).

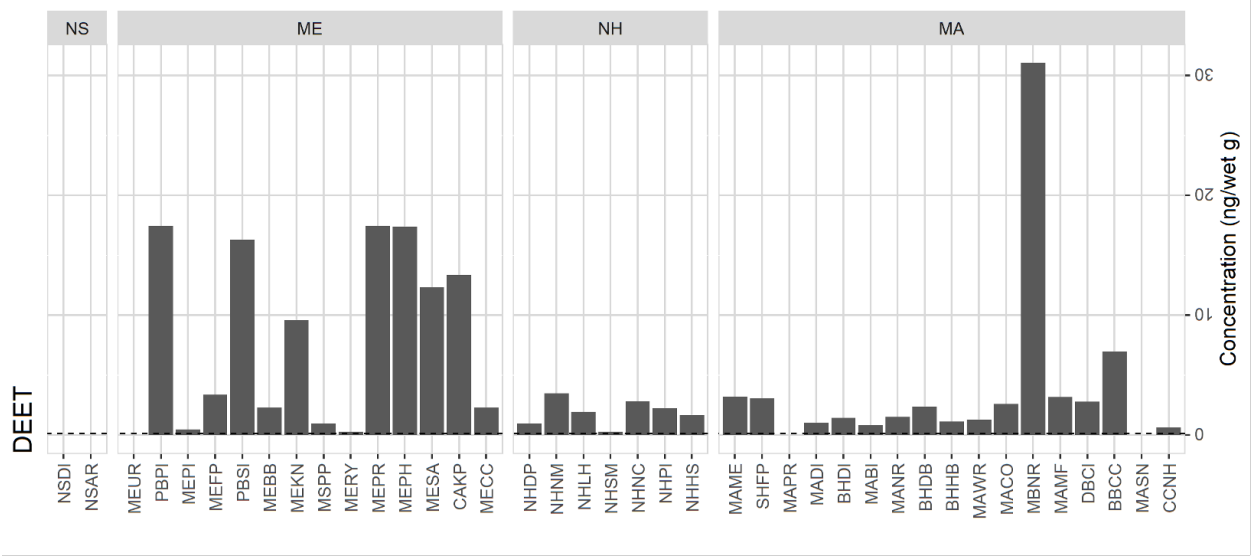

Figure 21.6. Concentrations of DEET at sites in the Gulf of Maine. Sites are listed geographically from north to south, following the coastline. (From: Apeti et al. 2021).

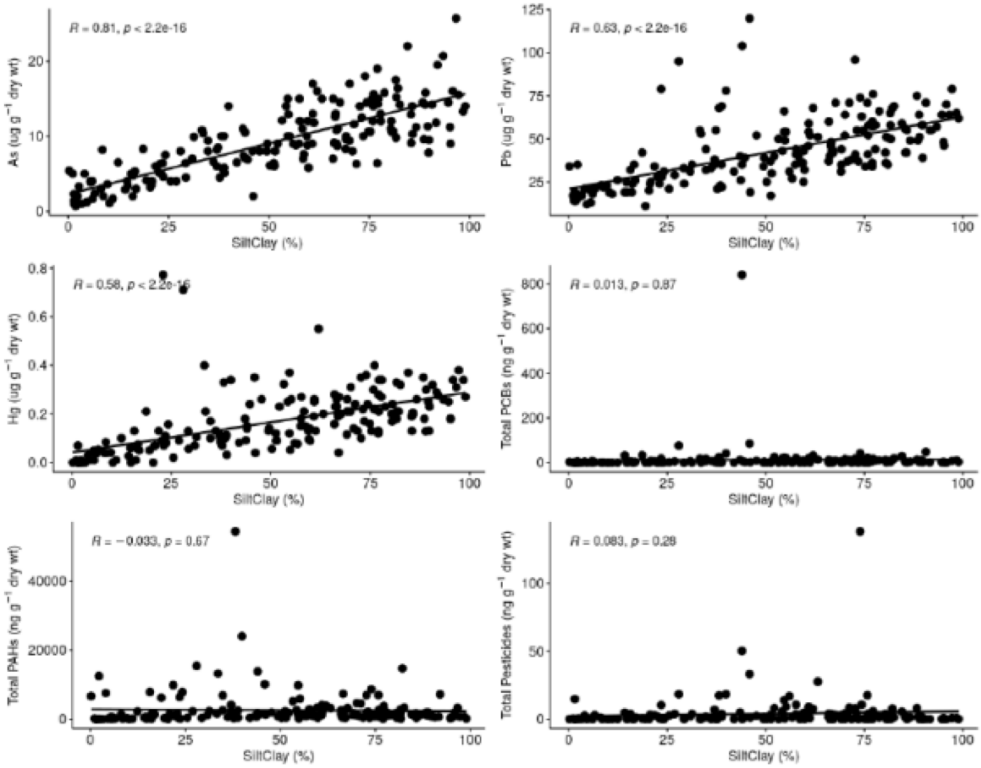

Figure 21.7 Contaminants of concern (As, Pb, Hg, PAHs, PCBs, and pesticides) vs. percent silt/clay grain size fraction.

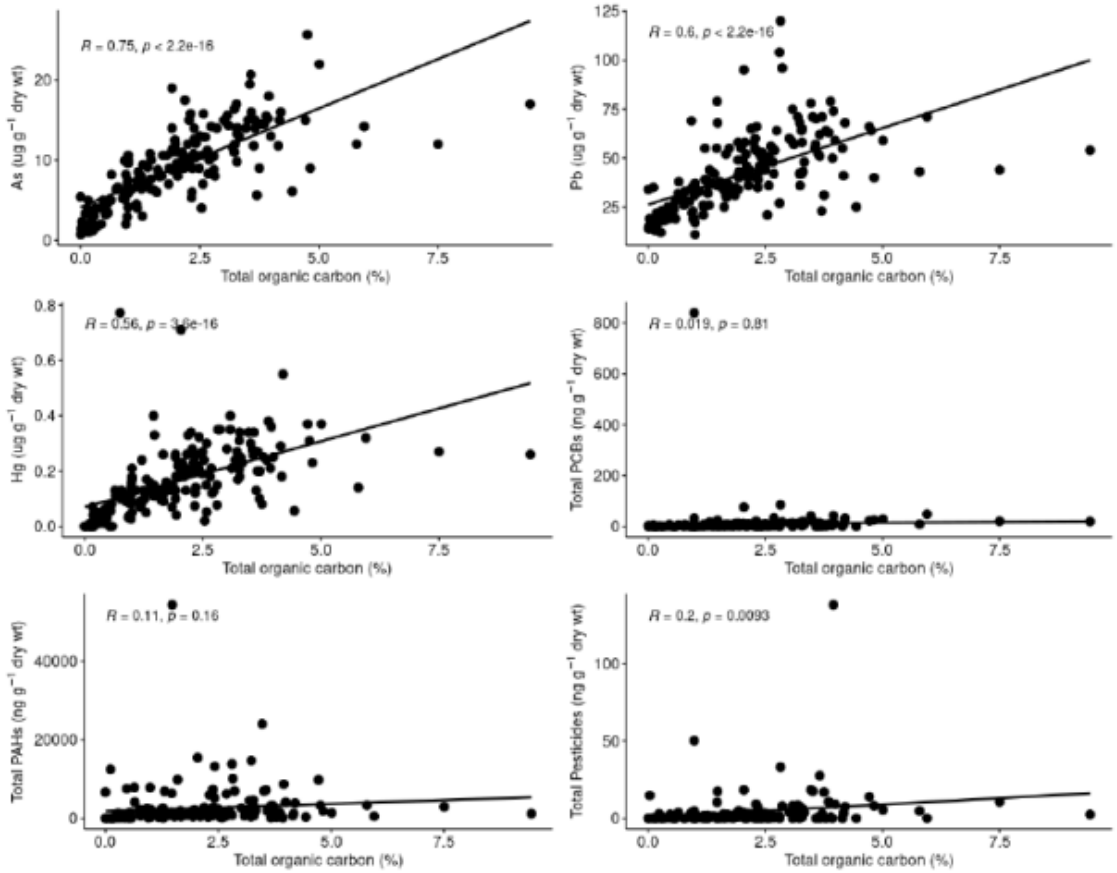

Figure 21.8 Contaminants of concern (As, Pb, Hg, PAHs, PCBs and Pesticides) vs. percent total organic carbon (TOC).

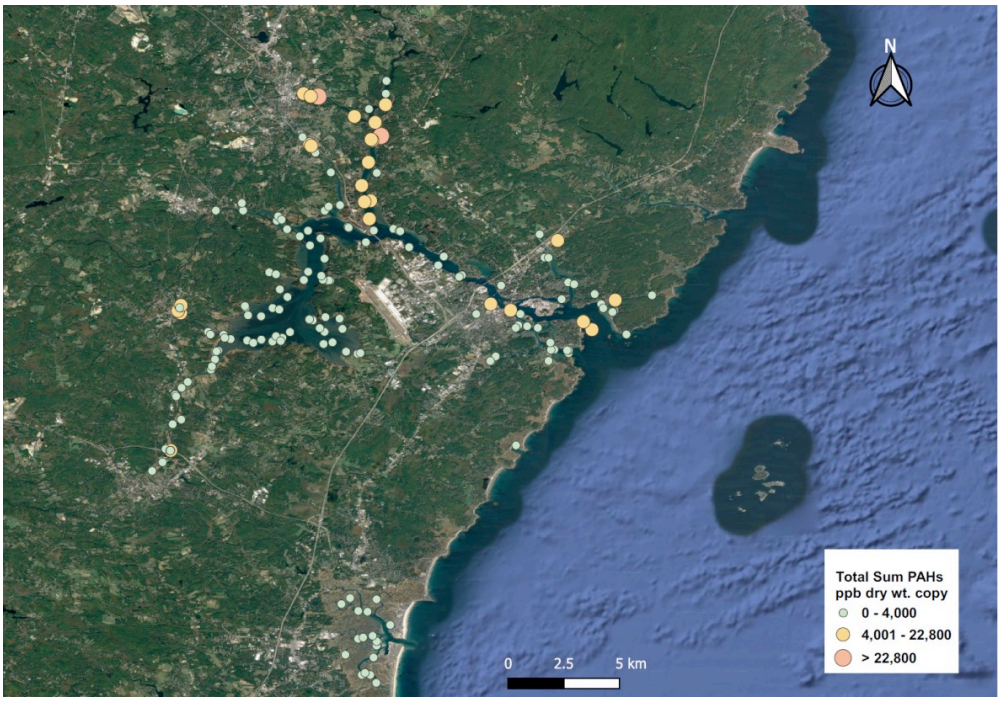

Figure 21.9 Distribution of sediment total sum PAH concentrations in Piscataqua Region Watershed Estuaries and tributaries from NCCA surveys 2000-2006, 2010, and 2015. Concentrations greater than 22,800 ppb (red) are considered probable effect concentrations (MacDonald et al. 2020). At concentrations < 4,000 ppb (green), effects are not expected. Intermediate concentrations with less defined risk are shown in orange. ***Data source: National Coastal Condition Assessment, EPA.***

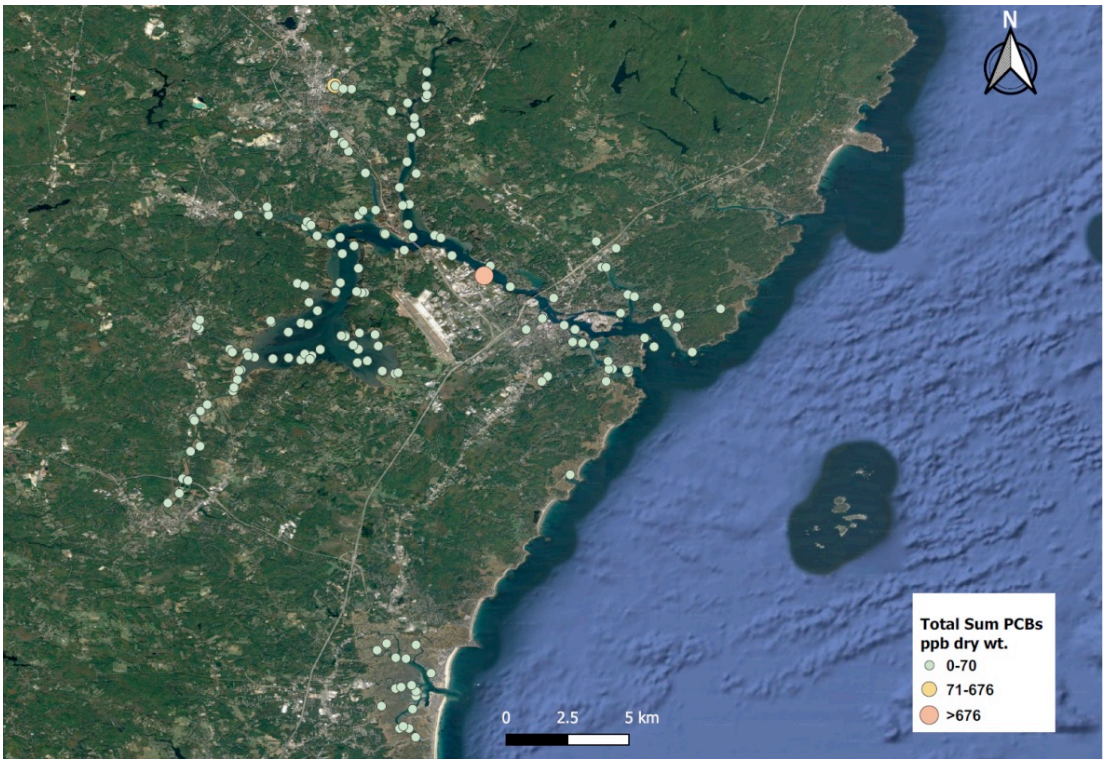

Figure 21.10 Distribution of sediment total sum PCB concentrations in Piscataqua Region Watershed Estuaries and tributaries from NCCA surveys 2000-2006 and 2010. Concentrations greater than 676 ppb (red) are considered probable effect concentrations (MacDonald et al. 2020). At concentrations < 70 ppb (green), effects are not expected. Intermediate concentrations with less defined risk are shown in orange. *Data source: National Coastal Condition Assessment, EPA.*

Acknowledgements and Credit

Stephen Jones (UNH/NH Sea Grant Program), Maria Florencia Fahnestock (UNH) and NOAA Mussel Watch Program. The New Hampshire NCCA 2000-2015 data were a result of the collective efforts of dedicated field crews working out of the UNH Jackson Estuarine Lab, plus laboratory staff, data management and quality control staff, analysts and many others from EPA, states, tribes, federal agencies, universities, and other organizations. Please contact nars-hq@epa.gov with any questions.

References

Apeti, D.A., Rider, M., Jones, S., Wirth, E. and Regan, S., 2021. An Assessment of Contaminants of Emerging Concern in the Gulf of Maine. NOAA Technical Memorandum NOS NCCOS 291. Silver Spring, MD. 118 pp. DOI 10.25923/c2z4-k112

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