Contaminants

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Contaminants Concept paper

CONCEPTUAL

Types & intensity of sources:
Contaminants enter the marine ecosystem through a variety of mechanisms; including atmospheric deposition, direct discharges from industrial and municipal waste streams, combined sewage overflows, accidental spills, ballast water and other direct marine vessel discharges, runoff from land, especially in urbanized areas covered with impervious surfaces, and agricultural, residential and recreational (golf courses) areas, human disturbances, aquaculture facilities, etc. Historic contamination can be rendered unavailable via burial or be reintroduced as a result of dredging or resuspension of sediments associated with wind and wave action, boat motor propellers and bathing, or through the natural process of biodegradation

Transport mechanisms within marine systems
An understanding of the hydrodynamics of estuaries, bays and the systems within the region (e.g. Gulf of Maine) is essential for knowing the potential transport and fate of contaminants in the marine environment. As contaminants are introduced, either by rivers and streams, deposition from air, through stormwater runoff, or directly from waste discharges, many undergo transformation with respect to chemical speciation that may affect transport. For chemicals of environmental concern (COEC), complexation with different ligands, or sorption onto colloids or particulate matter will influence their fate and transport. Those associated with fine particles, colloids, or dissolved can be carried long distances into and within the marine environment. Contaminants that are delivered to the surface waters by dry and wet atmospheric deposition may have distributions that are fairly ubiquitous and far-reaching (e.g., mercury). Finally, transport of contaminants to the GOM marine environment may involve introduction via ballast water, boat hulls, bait and even migratory animals.

Processes affecting availability
Once in the environment, contaminants are subject to a variety of biological, physical and chemical processes that affect their availability and forms. Indigenous microorganisms can beneficially degrade organic contaminants or reduce populations of harmful microbes through predation and competition. Microorganisms and physico-chemical processes can also transform chemical contaminants into more (toxification) or less (detoxification) harmful substances, or change chemicals into more or less available forms. Microbial contaminant concentrations may decrease or increase with death and growth, and the viability and virulence may be changed by environmental conditions. Contaminants may be bound to particles, organic matter and charged inorganic surfaces, complexed with colloidal material, or have reduced solubility or bioavailablity by complexation with sulfides and other ligands. Many COEC (e.g. lead, polycyclic aromatic hydrocarbons) are particle-reactive and eventually end up buried in sediments.

Ecosystem function of contaminants
Nutrients such as nitrogen and phosphorus, are essential macro-nutrients to plants, but can have harmful ecosystem impacts at elevated concentrations. Some trace metals, considered to be toxic contaminants at high concentrations, are actually essential nutrients at low concentrations (e.g., Zn, Fe). Microbial contaminants, especially naturally occurring pathogens, also have some function in the environment, despite their deleterious effects on humans.

Exposure routes
The environmental processes that affect contaminants also dictate their availability to biota. For instance, changes in solubility of chemical contaminants can occur as a result of exposure to differing environmental conditions. Photooxidation can cause loss or changes in chemical speciation. Binding of chemical and microbial contaminants to solid surfaces renders them less available for exposure to biota, except when particles are taken up as part of the feeding activities of organisms. Metabolic processes in exposed biota can also transform contaminants in ways that result in detoxification, excretion, etc.

Multiple contaminants
In many contaminated areas, biota are exposed to multiple contaminants and thus the cummulative effect of exposure to discharged wastes or environmental conditions is more complex than what might be expected from exposure to a single contaminant. Different types of contaminants can also affect the availability and eventual exposure of biota to other types of contaminants. Thus, conceptualization of the sources, fate and effects of contaminants in the region environment is complex. Further research, monitoring, risk assessment and modeling will help to clarify these issues.

SIDE BAR ISSUE

Climate change effects and other factors
The general consensus that long-term climate change will result in warmer temperatures and more severe weather will influence the presence of contaminants in the GOM. Perhaps the most drastic changes will occur with the present mix of species. Increased temperatures are suspected to be contributing to increases in disease incidence in numerous seafood species, probably as a result of stress and more favorable conditions for microbial pathogens. Other effects on the climate, including temperature, dissolved oxygen, salinity, etc. will affect the balance of species in the ecosystem. Stormwater runoff, an important transport mechanism for contaminants in coastal areas will probably increase in the future as well. Factors affecting runoff include climate change-induced increases in severe weather and increases in impervious surface coverage with continued development within coastal watersheds.

MANAGEMENT ISSUES

The first level question managers often need to address is whether COEC are present and at what concentrations. Some guiding questions are:

- What are the concentrations of COEC in biota, sediments, air and water in the region?

- Are there new or emerging contaminants to consider?
- Where are COEC present and are there areas with high concentrations?
- Are concentrations of COEC changing with time?

Another basic consideration is the origin of the contaminants.
- What and where are the sources of contaminants?
- Are there localized source sites and do they affect surrounding areas? To what extent?

As information is being and/or has been compiled on exposure and sources, the impacts of contaminants need to be documented. The most important impacts for contaminants are typically public health effects and toxic or otherwise deleterious effects on important organisms in the region's ecosystems (NOTE: need to emphasize both human health and ecosystem level impacts).

- How many people have become infected or ill from contaminants?
- Are there effects on biota resulting from elevated levels of contaminants?
- Are there effects on biota resulting from low contaminant levels?
- Is biomagnification occurring?

Finally, as managers respond to documented effects and efforts are made to reduce or eliminate sources of contaminants, it is important to document whether actions are actually improving conditions, as intended?

- Is there evidence of improved conditions through time and space as a result of contaminant source reductions?
- Are resource harvesting and recreational uses affected?

Probably the next level entails linking available models to estimate loads and/or effects and to conduct risk analysis and management. For instance, estimates of point and non-point loading rates may be obtained by use of point source permits (NPDES, CAA) data and land use activities within the region (See Paul. J.H. et al. 2003). In addition, EPA fate and transport models can be used to link loading rates to potential biological effects on humans and biota. Another suggestion is to conduct risk analysis and characterization (i.e., application of EPA watershed-based ecological risk assessments which can be used to compare contaminants with other human stressors on valued ecosystem components) and risk management through the development of management strategies that incorporate political and socioeconomic factors.

POSSIBLE INDICATORS

- Microbial indicators of fecal contamination (e.g., fecal coliforms, enterococci, coliphage viruses, source-specific bacterial species) and other source-related indicators (brighteners, isotope ratios, rare element work in MA Bay);

- concentrations of COEC in biota;
- bio toxicity tests of media;
- biomarkers of exposure or effects from contaminant exposure
- sensitive indicator species
- biotic integrity indices
- concentrations of COEC in sediments, air and water
- loading measurements and estimates
- Number/frequency of beach closures:
- Number/frequency of seafood consumption warnings;
- acreage of shellfish closures;
- effects evidence: habitat degradation, biotic community impacts (e.g., species diversity, shifts in dominance, loss or rare species)

ONGOING INDICATOR MONITORING PROGRAMS

National Coastal Assessement, National Shellfish Sanitation Programs (NSSP)& state/provincial SSPs, beach monitoring
NOAA Mussel Watch, Benthic Surveillance and Bioeffects Study
Gulfwatch, GoMOOS
NPDES, PSP monitoring
Casco Bay and New Hampshire Estuary Project (sediment, mussel, lobster sampling)
Ongoing national air monitoring programs (MDN, NADP, IMPROVE)
Maine SWAT Program,
Other NEP and state toxics monitoring programs
Citizen volunteer monitoring groups