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Extreme storm events increase the risk for chemical contamination of coastal waters

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Pollution Risks and Climate Change

Sea-level rise and an increase in the severity of coastal storms are probable outcomes for the Chesapeake Bay due to global climate change. A consequent ecological and economic risk for tidewater Virginia and other low-lying coastal zones is the contamination of coastal waters by industrial and agricultural chemicals released by accidental spills during severe storm events.

Easy access to the Bay and Atlantic Ocean shipping channels has made local ports and harbors a focus for industry and the military for more than 200 years. These industries, by necessity, use a variety of chemical and petroleum products in their daily operations. While current environmental regulations limit the discharge of toxic chemicals to the waterways via effluents, many of the most severe historical contamination issues in Chesapeake Bay are the result of accidental[1] and deliberate[2] spills.

The predicted increase in frequency and severity of coastal flooding makes the potential for severe contamination events very high unless proper precautions are implemented.

Hurricane Isabel approaches the mid-Atlantic coast in September 2003. Photo courtesy of NASA.

Harbors are vulnerable to flooding and are occupied by industries that use a variety of chemical and petroleum products.

Coastal flooding provides a mechanism for the release of potentially harmful chemicals.

Once organic chemicals are incorporated to bottom sediments they are persistent and costly to clean up.

The best approach for minimizing the risk of contaminant releases is to identify potential sources for chemicals of concern and evaluate their vulnerability during storm events.

A northeaster batters the ferry pier, Virginia Institute of Marine Science, Gloucester Point, Virginia.

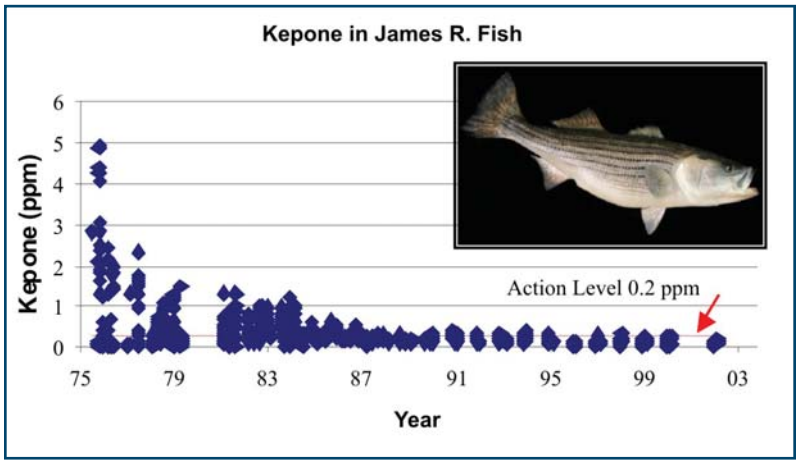
Shipping and ship repair are important industries in Virginia vulnerable to the effects from severe storms.

Oil refinery on the York River, Yorktown, Virginia.

History Lessons

The potential for accidental introduction of contaminants during storm events is real. As recently as 2005, Hurricane Katrina devastated the Gulf Coast, releasing more than 8 million gallons of oil into the Mississippi River and Gulf of Mexico.[3] For perspective, the Exxon *Valdez* spill in Prince William Sound Alaska, the largest US oil spill on record, released 11 million gallons. While Chesapeake Bay is not as large an oil production center as the New Orleans region, it sees extensive vessel traffic and is home to several major port facilities, many small refineries and oil storage facilities, and an abundance of industrial chemicals to support port and refinery activities.

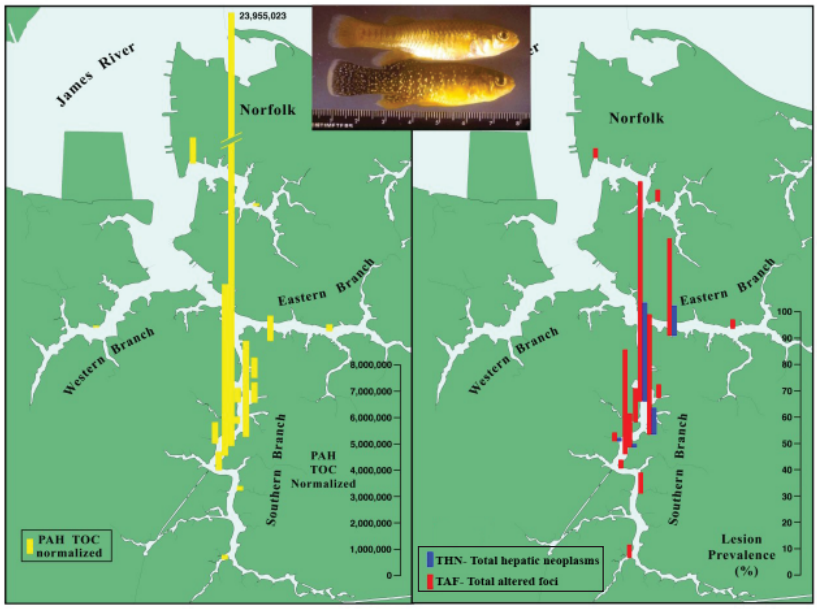
Along with oil, these other chemicals also have the capacity to damage Chesapeake Bay's complex estuarine ecosystems. Some industrial chemicals are far more persistent than those found in oil and accumulate in the food chain, causing long-term effects. Persistent organic pollutants (POPs) are one example. One POP, the synthetic pesticide Kepone,® was spilled by a manufacturing facility into the James River in the mid 1970s. Kepone® concentrates in bottom sediments and has accumulated throughout the aquatic food chain.[2] It was only through burial within the estuary's sediments over time that exposure to Kepone® was reduced. The James River was closed to all fishing in 1975 and some limited restrictions remained in effect until 1989, causing millions of dollars of economic hardship to the Commonwealth of Virginia and its citizens.



Kepone is now below the 0.2 ppm action level but is still detected in striped bass more than 30 years after Kepone was discovered in the James River.

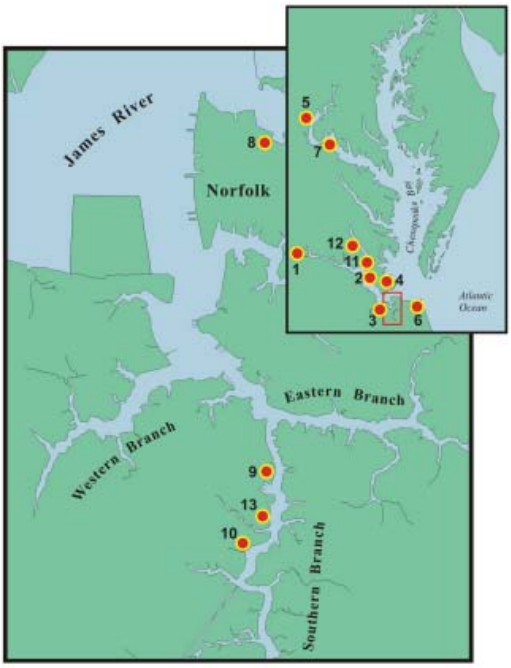
While Kepone® concentrations in fish samples have now decreased below levels for human-health concern, it is still detected in James River fish more than 30 years after the spill was first discovered. This case study demonstrates the large-scale environmental and economic impacts that can occur when a river system is contaminated by a persistent organic chemical from a localized source.

The Elizabeth River is a highly industrialized tributary to the James River near the mouth of Chesapeake Bay. It is home to the US Atlantic Fleet and has numerous shipyards and other industries on its banks. Prominent in the River's history were facilities dedicated to the treatment of wood pilings with creosote. Creosote contains organic compounds called polycyclic aromatic hydrocarbons (PAHs) that are toxic and can also cause cancer. The Elizabeth River has had many documented creosote spills due to fires, accidents, and neglect. As a result, it has some of the highest PAH concentrations reported anywhere. Atlantic Wood Industries, Inc., location of one creosote spill, is designated as an EPA Superfund clean-up site. Resident fish populations (e.g., the mummichog *Fundulus heteroclitus*) exhibit high incidences of liver cancer and are now also genetically altered from populations found in uncontaminated rivers.[4] Efforts are underway to remove the most severely contaminated sediments from the Elizabeth River but at the cost of millions of dollars and many years of effort.[1,5] Safe disposal of these contaminated bottom sediments presents another challenge.



Liver lesions and cancer in mummichog fish are correlated to historical spills of PAH contaminants in the Elizabeth River, Virginia.[6]

Many Superfund sites in Virginia are near the shore and may be vulnerable to flooding.



Virginia Super Fund Clean-up Sites:

1. *Defense Supply Center Richmond, Chesterfield County*
2. *Fort Eustis, Newport News*
3. *Former Nansemond Ordanance Depot, Suffolk*
4. *Langley Air Force Base & NASA-Langley Research Center, Hampton*
5. *Marine Corps Combat Development Command, Quantico*
6. *Naval Amphibious Base Little Creek, Virginia Beach*
7. *Naval Surface Warfare Design, Dahlgren*
8. *Norfolk Naval Base, Norfolk*
9. *Norfolk Naval Shipyard, Norfolk*
10. *USN St. Julien's Creek Annex, Chesapeake*
11. *Yorktown Naval Weapons Station, Yorktown*
12. *Yorktown Naval Weapons Station, Cheatham Annex*
13. *Atlantic Wood Industries, Portsmouth*

References Cited

1 Atlantic Wood Industries, Inc. Superfund site, Record of Decision 2007, USEPA (http://www.epa.gov/reg3hwmd/super/sites/VAD990710410/rod/rod2007.htm)

2 Luellen, D. R., G. G, Vadas, M. A. Unger. 2006. Kepone in James River fish: 1976 -2002. *Science of the Total Environment.* 358: 286-297.

3 Louisiana Sea Grant Website (http://www.laseagrant.org/hurricane/index.htm)

4 Mulvey, M., M.C. Newman, W. Vogelbein and M.A. Unger. (2002) Genetic structure of *Fundulus heteroclitus* from PAH-contaminated and neighboring sites in the Elizabeth and York Rivers. *Aquatic Toxicology*, 61, pp. 195-209.

5 Money Point Revitalization Plan, 2006. ERP (http://www.elizabethriver.org/Non_pub%20PDFs/MP_layout_061011final.pdf)

6 Vogelbein, W. K., M. A. Unger, D. Gauthier. 2008 The Elizabeth River monitoring program 2006-2007: Association between mummichog liver histopathology and sediment chemical contamination. Final Report to the Virginia Department of Environmental Quality. 34 pp

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Recommendations

History has shown that preventing chemical spills is the best defense against the long-term ecological and economic damage that will otherwise result.

- The best approach for minimizing the risk of contaminant releases is to identify potential sources for chemicals of concern and evaluate their vulnerability during storm events. Likely sources include industrial, military, and agricultural facilities within ports. Others are vessel docking areas, on-shore containers, and previously contaminated terrestrial sites that are vulnerable to flooding. Many Virginia Superfund sites are within a short distance of the coast and are contained within the watershed.
- New modeling techniques developed at the Virginia Institute of Marine Science have the capacity to predict tidal surge and consequent flooding of low-lying areas. These techniques could be used to identify the regions at most risk for flooding during storm events.
- Model predictions can be coupled with GIS databases identifying the facilities present in the flood zone, the chemicals in use or in storage at the facilities, and plans for removing chemicals or securing the sites prior to a storm event.
- Chemical inventories should be carefully evaluated for their potential to do harm based on environmental fate, persistence, and toxicity.
- Plans should be developed to permanently relocate oil and toxic material storage facilities most at risk.
- A collaborative effort between academia, industry, and state and federal agencies should develop and administer an integrated plan to minimize the potential for long-term ecological and economic impacts from coastal contamination during storm events.

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