## Emerging Contaminants in the Gulf of Maine: Parallels with the Gulf of Mexico

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> Casco Bay Estuary Partnership State of the Bay 2010 Portland, ME October 21, 2010

**Gulf of Mexico May 2010** Rig 313, east side of the Mississippi River from the BP Deepwater Horizon oil well



# **Diving In**



Op-Ed Contributor MAY 28, 2010 Swimming Through the Spil

By SUSAN D. SHAW

FOR the last few days, attention has under Blue Hill, Me.

FOR the last few days, attention use under shores of the Gulf Coast as oil has sared introdues. Fut last needs 1 lead the charact in orthor memorial test needs 1 lead in diseast intenursnes, thu has week i real me eneme f nuther perspective when I direct inte mother perspective when I dived inte Pass a Lostre wellands in southern Loui rass a coure weamous in sourcess cour surreal, sickening score beyond anythir

As the beat entered the slick. I had to As use over enteries we such a row of There were patches of oil on the gulf mixed with an orange brown puddir turned wate an orange-towned preciant call gations of a enormeal aspersant cat the attending oil. Near Rig No. 31 stopped and I (wearing a velsait, immed in

Only a few meters down, the ne jumped in.

Only a few meters down, the ne possible to make out tiny wispe enveloped in dark oily droplet the herring I could see feeding Dispersents break up the oil forming poisonous droplets

(Courtesy of: Susan D. Shaw/Marine Environmental Research Institute) Dr. Susan Shaw, director of the Marine Environmental Research Institute in Blue

Hill, took this picture recently of a patch of brown oil and dispersant in the Gulf of Mexico. Blue Hill - Dr. Susan Shaw, director of the Marine Environmental Research Institute in Blue Hill and a marine toxicologist, returned recently from the Gulf of Mexico where, accompanied by a crew

The Times, she dove in the oil slick to get a first Shaw traveled to the gulf in late May, when she

fishing boat to take them about 40 miles out to immediately hit by very strong fumes. The sur patches of viscuous brown sludge, she said. Sl the water where the oily sludge had broken up

"I'm one of few toxicologists who have gotte



"Only a few meters down, the nutrient-ri make out tiny wisps of phytoplankton, z droplets. These are essential food source gaping mouths on the oil and dispersant. Disp What will be left after the oil spill?

Thirty feet down in the Gulf of Mexico, the water suddenly goes dark. Above me, a ragged black silhouette of oil is eclipsing the sould virele that is the

sturface. I feel a familiar twinge in the back of my brain, the first warning that soon I need to get back up to breathe. With concentrated calmness,

concentrated catminess, J pouse and hang in the water, staring. Oil is above, around and benauth mer out of sight consumbane wave balance back set more dark aloude of oil. This is your to merical a work I pouse and hang in the water, starrig: On 18 above, around and henceth they out of sign somewhere way below hark yet more dark clouds of oil. This is now America's worst

somewhere way below luck yet more dark clouds of oil. This is now America's worst environmental disastar, according to the White Hottee. The beaches are clogged act only with call but with character unwhere. The context and hubititians. But is its horn. Instands has attriction answer, according to the White House. The beauties are clogged not only which all but with claureup workers, TV crews and bubblicians. But it is here, breach the state for the two for the two forms with the two for the two forms.

The silled longues of the Mississippi river don't reach this far from shore, leaving the recent clear. The familiar, envertices blue of deep water stretches below, leaving the worked be a meterino leave of emiliable due to a store of the sime back. recon clear. The familiar, eavernous blue of deep water stretches below, occasionary probed by a maveing beam of sunlight that has pieceed the amour of the slick above the stretches th process or a variable occurring occurring that has preferred the annous of the stock above for as for down as I can see, there are my speeks glinning in the shilling light, while othere link as chordraw bedure others lurk as shadows behind

Yellow-brown haloes surround the light when it appears from above, its fingues dotted as a surround to restricte measure. Tay foot halow this have 1 form more to be a surround a below-snown halces surround the light when it appears from above, its impressioned to though by a swarm of motionless insects. Terf feet below this haze, I force my eyes to be a short of the elicit-hanne in the next of the tip elicit for an other state in from the end of the elicit hanne in the next of the state of the state. though by a swarm of motionless insects. Yen feet below this haze, I force my eyes to Evens close to my mask. A shired of the slick hangs in the water in front of me, the size of

No delphins. no markes. no bluetin tune. no swordlish. no tudies. no voral beds... me elevel in the free man to dive below America's word minimum and disector bad No delphins... no whales... no bluetin tuna... no swordtish... no tuttles... no voral beds... no planklen,... The first man to dive below America's worst environmental disader looks

## Deepwater Horizon Oil Spill: Hidden Damage/ Long Term Impacts

180,000,000 gallons LA crude oil released at 5000 ft 1,800,000 gallons chemical dispersant Dispersed oil in plumes, sediments, on the sea floor

15,000 marine species in Gulf 600,000 sq mile area, 3000 mile coastline 14,383 ft at depth (average ~5300 ft)

### **DOI Strategic Sciences Working Group:** Scenarios/ Consequences/ Policy Actions to Lessen Stress, Accelerate Recovery



SSWG September 2010 New Orleans



## **Gulf to Gulf: Priority Concerns**

### **Gulf of Maine**

Area: 69,115 sq mi Pop: 10.8 million people

### **Gulf of Mexico**

Area: 615,000 sq mi Pop: 13.9 million people

## **Ecosystem Stressors**

**Population pressure/ coastal development Fisheries depletion (overfishing) Destruction/ fragmentation of critical habitat Chemical and sewage pollution Coastal dead zones Species loss, regime shifts** Oil and gas exploration, shipping, spills Lack of cohesive oceans/ toxics policy

## **Fisheries At Stake**

Gulf of Maine Total landings 530,000 mt \$900 million/ yr Lobsters: ~ \$600 million

Gulf of Mexico Total landings 1.27 billion lbs \$659 million/ yr Shrimp: 188 million lbs, \$367 million







### Gulf of Maine \$900 million/yr

### Gulf of Mexico \$659 million/yr



## **Pollution**

Chemical Contaminants (Industrial, Agricultural) Oil and Gas Coastal Dead Zones Harmful Algal Blooms





Diaz and Rosenberg 2008, Science

## Oil and Gas in the Gulf of Mexico



Source: NOAA Ocean Explorer, http://oceanexplorer.noaa.gov

## **Oil Transport in the Gulf of Maine**

Legend Oil Movements 2005 O to 10 Million Tonnes 100 to 200 Million Tonnes 200 to 300 Million Tonnes 50 to 100 Million Tonnes Greater than 300 Million Tonnes Top 100 Tanker Incidents

International Tanker Owners Pollution Federation Ltd http://www.itopf.com



## **Could This Happen Here?**

## Seals As Sentinels

Assessing Persistent Organic Pollutants in Seals and Fish in the NW Atlantic Marine Ecosystem (2000-2010)

- First extensive region-wide investigation in marine mammals and commercial fishes
- Legacy and emerging contaminants in live and stranded seals and their prey fish
- Impacting toxics policy in the US and internationally
- Funded by NOAA since 2004

Marine Environmental Research Institute (MERI) www.meriresearch.org

## **Legacy POPs** Persistent, bioaccumulative, toxic (PBT)

Legacy chemicals banned in 1970s – decreasing slowly

PCBs Dioxins Furans

Industrial chemicals/ biproducts DDT Dieldrin Chlordanes HCHs (lindane) Mirex Toxanhene

Pesticides

Cancers, endocrine disruption, immune suppression

## Halogenated Flame Retardants, Perfluorinated Chemicals

#### **Brominated flame retardants (BFRs)**

Polybrominated diphenylethers (PBDEs\*) – polyurethane foam Hexabromocyclododecane (HBCD) - building materials Tetrabromobisphenol-A (TBBPA) – plastics

### **Perfluorinated chemicals (PFCs)**

PFOS\*\*, PFOA\*\* PFSAs, PFCAs Surfactants, non-stick anti-stain fabrics fire-fighting foams

\*Phased out (PBTs, Stockholm Convention)
\*\*Human carcinogens – banned

## Flame Retardants (PBDEs)

Clothing, textiles, mattresses, upholstery, TVs, computers, plastics, electronics, house dust and food (fish)

Endocrine disruptors (thyroid), developmental neurotoxins



## **Perfluorinated Chemicals (PFCs)**

Food wrappers, stain-resistant fabrics, Scotchgard, Gortex, non-stick pans (Teflon), fire-fighting foams, drinking water **Endocrine disruptors (thyroid), P450 induction, cancer** 



## **Chemical Time Trends 1940-2010**





### PBDEs Increasing in North America 1970-2005



Data: Schecter et al. 2005, Ikonomou et al 2002, 2006, Rayne et al 2003, Johnson-Restrepo et al 2005, Elliott et al 2005, Lebeuf et al 2004, She et al 2002, Shaw et al 2008





## **Oceans In Crisis**

Ocean Dumping (chemicals, waste, sewage)

Runoff (pesticides, fertilizers, sewage wastes)

Plastic Debris, Release of Chemicals

Oil Spills, Release of Carcinogens

Marine Mammal, Seabird, Fish Die Offs

Dead zones Increasing Jellyfish, coral bleaching) Collapse of global fisheries by 2053

Ocean Acidification  $CO_2$ ,  $NO_2$ ,

## **Seal Stranding Locations NE Region**





Pollutant inputs from cities, farms, homes, waste treatment plants, atmospheric transport

## **Fall-Winter** Dispersal & Feeding

New York

Increasing exposure Gaining weight, blubber

Mass Bay and Long I Sound "most polluted" in North America

Mass

Maine

## Harbor Seal Food Chain



Atlantic mackerel Piscivorous, pelagic



Silver hake Piscivorous, semi-pelagic



Alewife Piscivorous, anadromous



White hake Piscivorous, bottom



Atlantic herring Planktivorous



Winter flounder Omnivorous bottom feeder



Amer. plaice Omnivorous bottom feeder (echinoderms)

## **Biomagnification**



HUMANS ??? ng/kg

#### POLAR BEARS 10,000,000 ng/kg



PLANKTON 3,000 ng/kg **COD** 300,000 ng/kg

SEAWATER 2 ng/kg (ppt)

## **Maternal Transfer to Pups**



Seal milk 50% fat - high in pollutants
Mother downloads 15-80% of her body burden

## Seals As Sentinels RESULTS

## Analyzed ~400 Chemicals in 500 Tissues 181 Seals (Live and Stranded)

- PCBs, DDTs
- Hexachlorobenzene
- Chlordanes, HCHs
- PBDEs, OH-PBDEs
- HBCDs, OH-HBCDs
- PFOS, PFOA, PFNA, PFHS (PFSAs, PFCAs)

Analytic Labs: Wadsworth Lab (Kannan), NYS Dept of Health, Albany, NY U. of Antwerp (Covaci), Belgium Eurofins-ERGO, Hamburg, Germany









## Flame Retardants (PBDEs) in Pinnipeds



Harbor seal (*Phoca vitulina*) Shaw et al. 2008, Meng et al. 2009, Law et al. 2003



**Sea lion** (*Zalophus californianus*) Meng et al. 2009, Stapleton et al. 2006



**Gray seal** (Halichoerus grypus) Ikonomou & Addison 2008



**Ringed seal** (*Pusa hispida* ) **Riget et al. 2006, Johansen et al. 2004** 



No. elephant seal (*M. angustirostris*) Meng et al. 2009



Harp seal (*P. groenlandica*) Johansen et al. 2004





## **Comparison of PBDE Levels in Pinnipeds**



![](_page_40_Figure_0.jpeg)

PBDE levels in California sea lions (mean 55 ppm lipid) highest reported in wildlife to date

## **Fireproof Harbor Seals?**

Shaw et al. 2008 Chemosphere

NW Atlantic harbor seals highly contaminated (PBDEs) First discovery of DECA flame retardant in seals Recurring disease a concern in this population

## Neurotoxic Flame Retardant Deca Banned in Furniture, Baby Products, Shipping Pallets

![](_page_42_Picture_1.jpeg)

## **Experts find traces of deca in seals**

![](_page_42_Picture_3.jpeg)

COURTESY OF THE MARINE ENVIRONMENTAL RESEARCH INSTITUTE Susan Shaw works as a marine toxicologist, director and senior scientist at the Marine **Environmental Research** Institute in Blue Hill.

#### BY KEVIN MILLER OF THE NEWS STAFF

Scientists with a Blue Hill research organization have detected traces of a controversial chemical flame retardant in harbor seals found on the northeastern coast.

The discovery by scientists at Marine Environmental the Research Institute in Blue Hill is significant because, to date, the flame retardant deca rarely appears in marine mammals at measurable levels. MERI researchers said their findings, although preliminary, lend support to calls to ban deca in Maine. "It's worrying that it's in

wildlife to this extent," said Susan Shaw, a marine toxicologist and MERI's director and senior scientist.

of chemical flame retardant used family for several years. in televisions, computers and some upholstered items.

But deca is coming under intense scrutiny from environmental and health advocates who

claim the chemi-Inside cal is a potential Washington neurotoxin that leads fight is showing up in humans and against deca Page B4 wildlife.

The Maine Legislature's Natural Resources Committee will hold a workshop this Tuesday on a bill, LD 1658, that would phase out the sale of many products containing deca.

Shaw and her team of researchers have been testing harbor seals for the presence of chemicals in the poly-Deca is the most common form brominated diphenyl ether seals proves that the chemical other PBDEs.

Until recently the MERI team other electronics as well as in has tested for the presence of other PBDEs, including two known as octa and penta that were mals break the chemical down banned several years ago.

Shaw said researchers have found high levels of penta and octa penta. in the seals' blubber. But they were alarmed recently to find traces of deca in four out of eight seals tested.

They plan to test blubber taken from more than 30 other seals that were found stranded from Maine to New York in recent years.

Representatives of the chemical industry defend deca by pointing out that the chemical, unlike its relatives octa and penta, rarely appears in mammals' fatty tissues. But Shaw said deca's presence in the four test fish that seals eat for deca and

does accumulate in marine mammals.

Shaw argued that deca is often difficult to detect because maminto lower - and more dangerous - forms associated with octa and

"It suggests that they are exposed to pretty high levels of deca, but they are breaking it down to these other congeners," said Shaw, who is presenting her findings at an international conference on brominated flame retardants in Amsterdam later this week.

MERI researchers believe the harbor seals likely are being exposed to deca through the food chain. They are working with several other international groups to

# **Toxic Effects of PBDEs**

## **Human Health Effects**

#### Cryptorchidism

– Main et al, 2007

#### **Hormone Effects**

- Meeker et al., 2009 –
   Decrease in Androgens and LH; Increase in FSH and Inhibin
- Meijer et al, 2008
   Decrease in Testosterone

#### **Reproductive Effects**

- -- Eskenazi et al., 2009 Low Birth Weight; Altered Behaviors
- -- Harley et al, 2010

#### Increased time to pregnancy

#### **Neurological Effects**

Herbstman et al, 2010
 Decreased IQ

### **Decreased Sperm Quality**

- Akutse et al, 2008

#### Diabetes

- Lim et al, 2008
- Turyk et al, 2009 (only in
- hypothyroid subjects)

### **Thyroid Homeostasis**

- Herbstman et al, 2008 decrease in TT4
- Turyk et al, 2007 elevated T4
- Meeker et al, 2009 elevated T4, TBG
- Dallaire et al, 2009 Elevated T3 ~ BDE47
- Eskenzai et al, 2009 Low TSH

## Health Effects in Animals & Wildlife

- Reproductive toxicity: Abnormal gonadal development, reduced ovarian follicles, reduced sperm count
- Neurotoxicity: Decreased memory, learning deficits, altered motor behavior, hyperactivity
- Endocrine disruption: contributing to obesity & diabetes
- Thyroid hormone alterations
- Cancers

## "Emerging Contaminants" - Replacements for Banned Chemicals

## **Replacements for Banned Flame Retardants**

Chemical	Primary Uses
Hexabromocyclododecane (HBCD)	insulation, textiles, thermoplastics
Tetrabromobisphenol-A (TBBPA)	printed circuit boards, thermoplastics
Decabromodiphenylethane (DBDPE)	thermoplastics
1,2-Bis(2,4,6 tribromophenoxy) ethane (BTBPE)	thermoplastics
Pentabromoethylbenzene (PBEB)	textiles, adhesives, coatings, polyurethane foam
Hexabromobenzene (HBB)	thermoplastics?
Dechlorane Plus®	electrical wires/cables, computer connectors, plastic roofing materials
Firemaster 550 <sup>®</sup>	polyurethane foam

## New MERI Study:

Emerging Contaminants in the Northwest Atlantic Marine Food Web

Novel chemicals marketed as replacements for banned flame retardants (PBDEs)

■ Analysis: tissues of ≥40 harbor seals from the northwest Atlantic and their major prey fish

Contamination status, trends

NOAA 2010-2011

### Summary

PBDEs, PFCs reaching the oceans; North American PBDE levels rivalling PCBs

NW Atlantic harbor seals are highly contaminated by PBDEs and other POPs

Biomagnification from prey fishes

Replacement chemicals need further study to determine health and environmental risks

## **Publications**

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![](_page_51_Picture_2.jpeg)

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