Interactions between climate change, contaminants and ecosystems in the North Atlantic Landscape Conservation Cooperative

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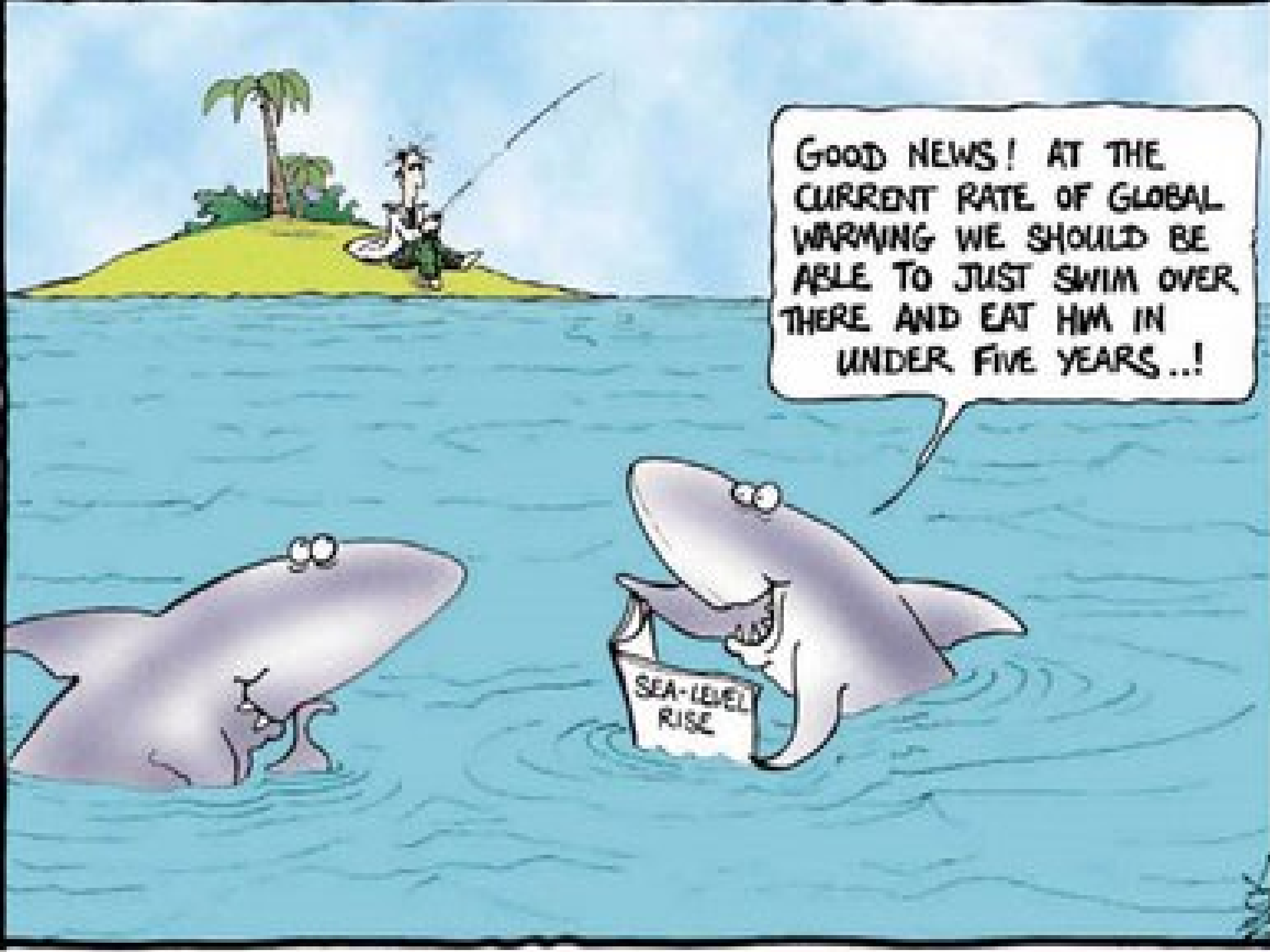
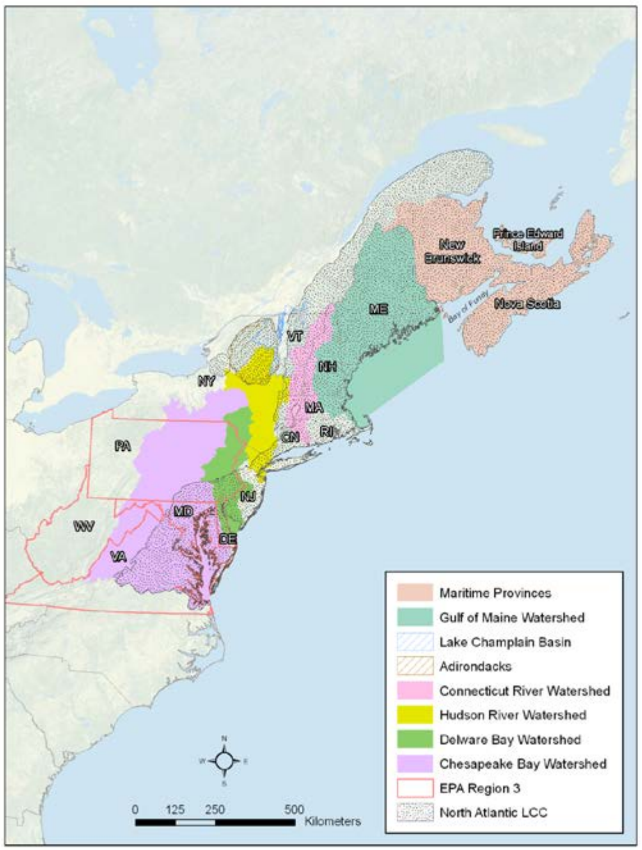
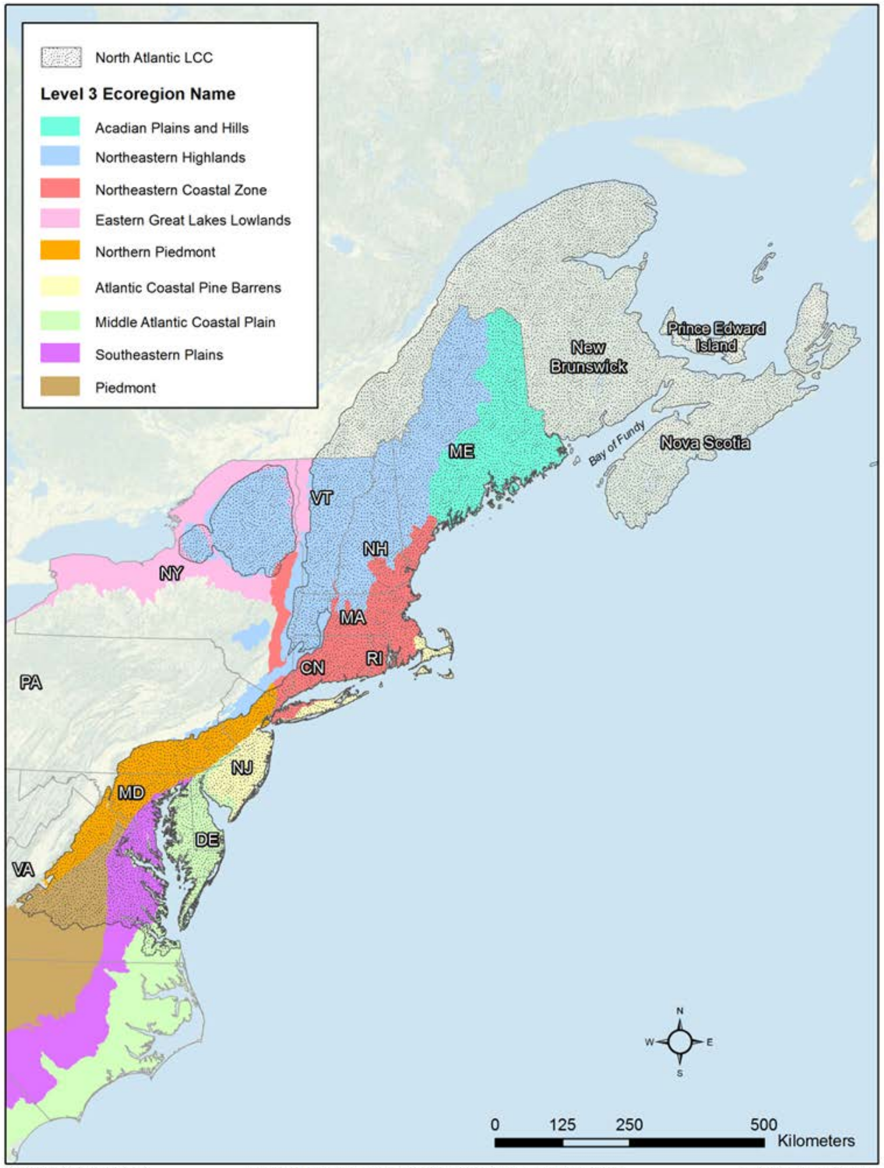
Presented to the North Atlantic LCC

March 2013


GOOD NEWS! AT THE CURRENT RATE OF GLOBAL WARMING WE SHOULD BE ABLE TO JUST SWIM OVER THERE AND EAT HIM IN UNDER FIVE YEARS..!
SEA-LEVEL RISE

Watersheds and Ecoregions within The North Atlantic Landscape Conservation Cooperative





Map Created: April 2012 * Level 3 Ecoregions only available for continental United States Data Source: U.S. EPA

Background

- LCCs established in 2009 to address increasing land use pressures and widespread resource threats and uncertainties amplified by a rapidly changing climate
- A 2011 SETAC workshop studied global climate change (GCC)-contaminant interactions from an international perspective
- GCC-contaminant NA LCC group formed in early 2012 with the following goals
  - Define the key GCC-contaminant issues with geographic specificity
  - Prioritize research needs: coastal, estuarine, freshwater, wetland, terrestrial
  - Advise land managers, conservation decision-makers

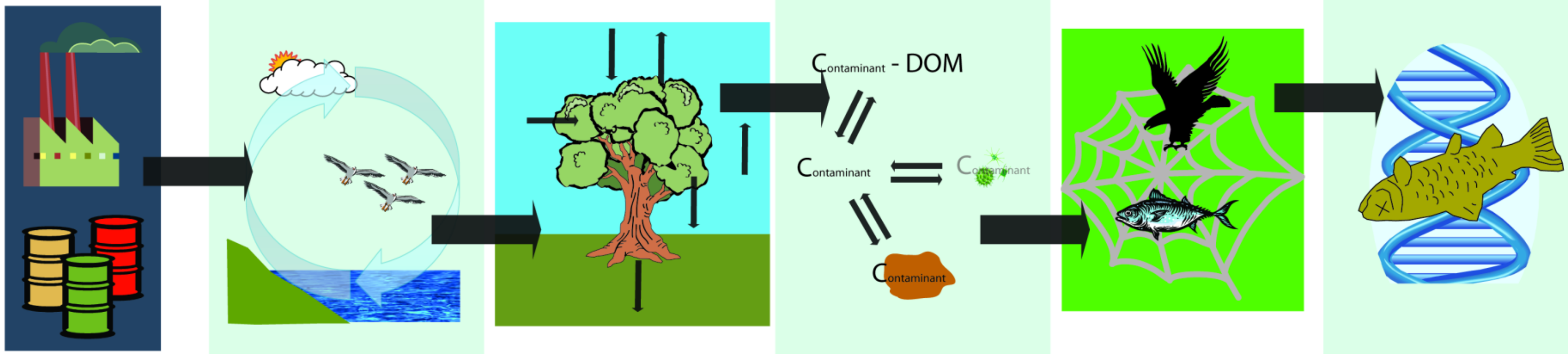
Products

- SETAC North America presentation (Nov 2012)
- Paper for submission to Integrated Environmental Assessment and Management (soon)
- Fact sheets and web materials
- Presentations to NA LCC, Regional Office, Chesapeake Bay Program
- National fact sheet and interaction with other regions and LCCs

Process

- Assembled team and held a workshop (June 2012) to select chemical classes/biogeochemical processes/taxa for case studies
- Developed conceptual model of how the interactions take place
- Selected case studies based on availability of region-specific literature
- Additional focus on taxa of special concern

Conceptual Model

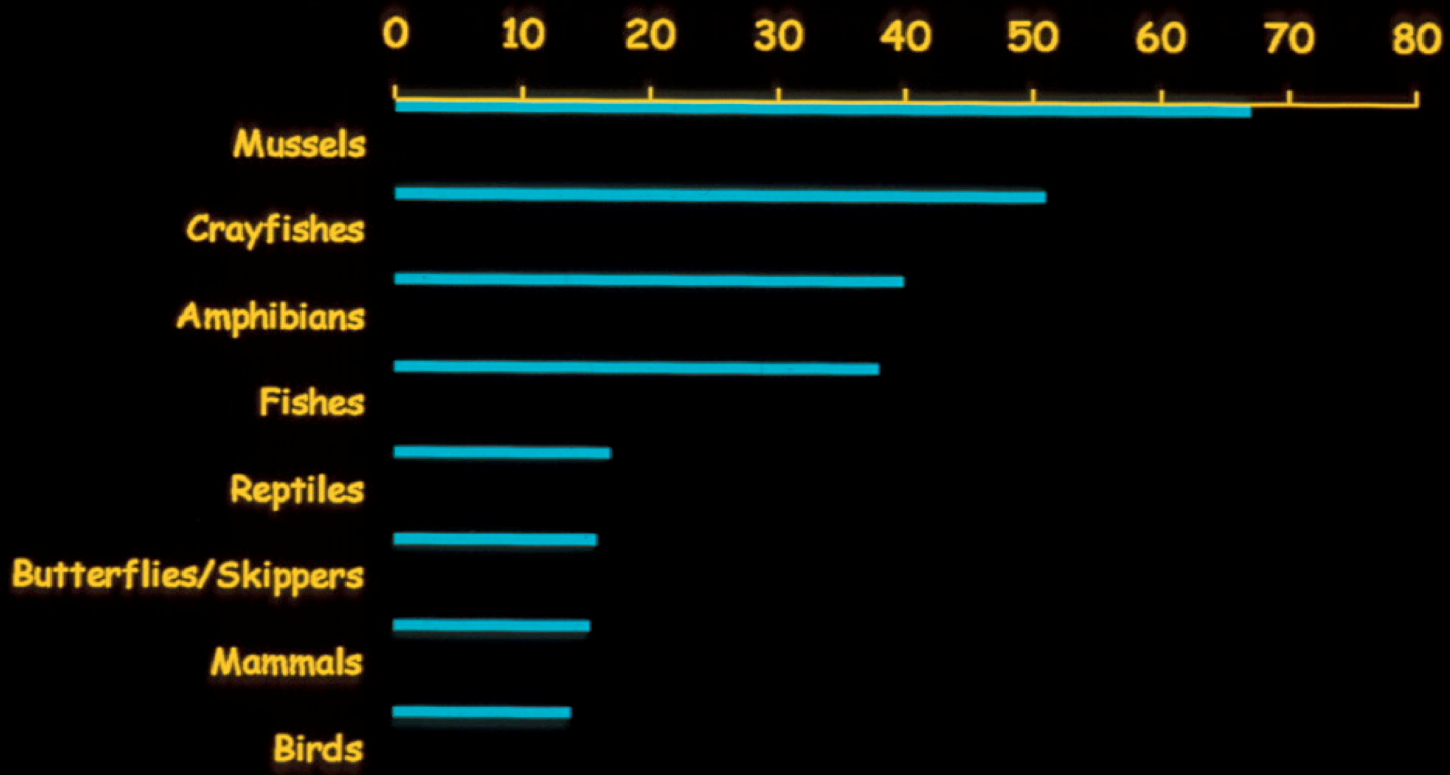


Sources	Transport	Transformations	Bioavailability	Exposure	Biological Response
Emissions Discharge Products	atmospheric transport/ deposition fluvial biota	sorption/desorption uptake/mineralization volatilization sequestration degradation methylation	binding to DOM, SPM chemical speciation pH effects redox effects	absorption distribution (bioaccumulation & bioconcentration) metabolism excretion food chain movement	toxicant-target interaction responses: organisms behavior, growth, survival, reproduction, acclimation higher levels pop, demographics, community structure function & resilience
Global Change Linkages	altered deposition patterns altered precipitation discharge quantity, timing, events	changes in land use changes due to increases in temperature, moisture, discharge legacy effects	changes in SPM, DOM faster rates more reducing conditions increased mobilization	changes in intake/uptake changes in metabolism changes in growth changes in organisms	climate-induced toxicant susceptibility toxicant-induced climate sensitivity

Case studies

- Inland acidification
- Mercury
- Eutrophication/harmful algal blooms/hypoxia
- Amphibians
- Freshwater mussels

Proportion of U.S. Species at Risk



Inland acidification: key findings

- Overall there has been a declining trend in SO_2 and NO_x emissions with slow recovery in NA LCC lakes and streams, but ongoing effects on upland forests (sugar maple, red spruce health): Adirondacks = focus area
- A recent simulation of future projections shows that anticipated increases in temperature will increase net mineralization of soil N, enhancing NO_3^- leaching and soil and surface water acidification
- Recent increases in relative abundance of nuisance colonial chrysophytes (golden algae) which is correlated with increased temperature and later ice-on date

Inland acidification: questions

- What are the effects of acidification on the availability of calcium and its influence on key forest species (e.g., sugar maple) and terrestrial food chains and how is this affected by climate change
- How will the recovery of aquatic and terrestrial organisms in ecosystems impacted by acidic deposition be altered by ongoing and future climate change

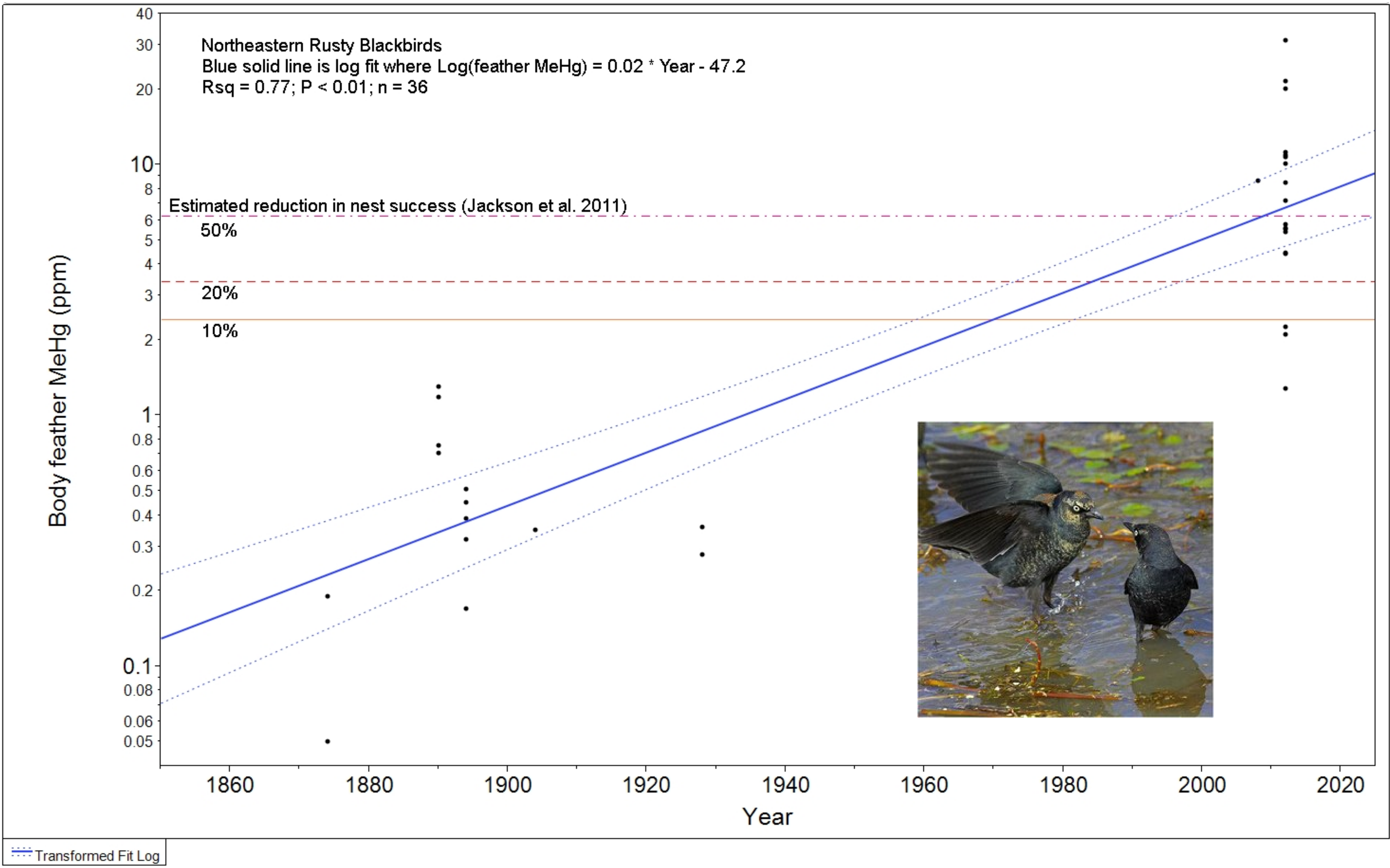
Note: because the Adirondacks is highly impacted by acidic deposition, it would be a suitable geographic area for these studies.

Mercury: key findings

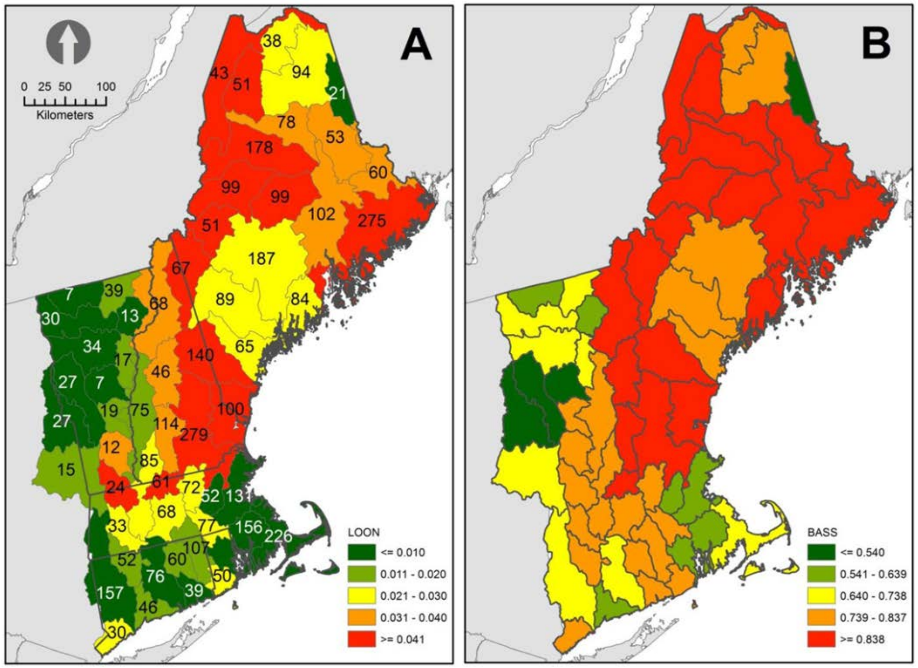
- Increased temperature will increase net rates of meHg production
- Increased precipitation → increases soil moisture → reducing conditions → increases net meHg production
- Long term increase in Rusty Blackbird feather Hg along with population decline
- Shifts in species distributions may result in some bird species moving from low to high Hg regions

Carolina wren

Rusty Blackbird breeding populations are being significantly impacted by mercury (since the 1980s). Which way will Hg trends move toward?

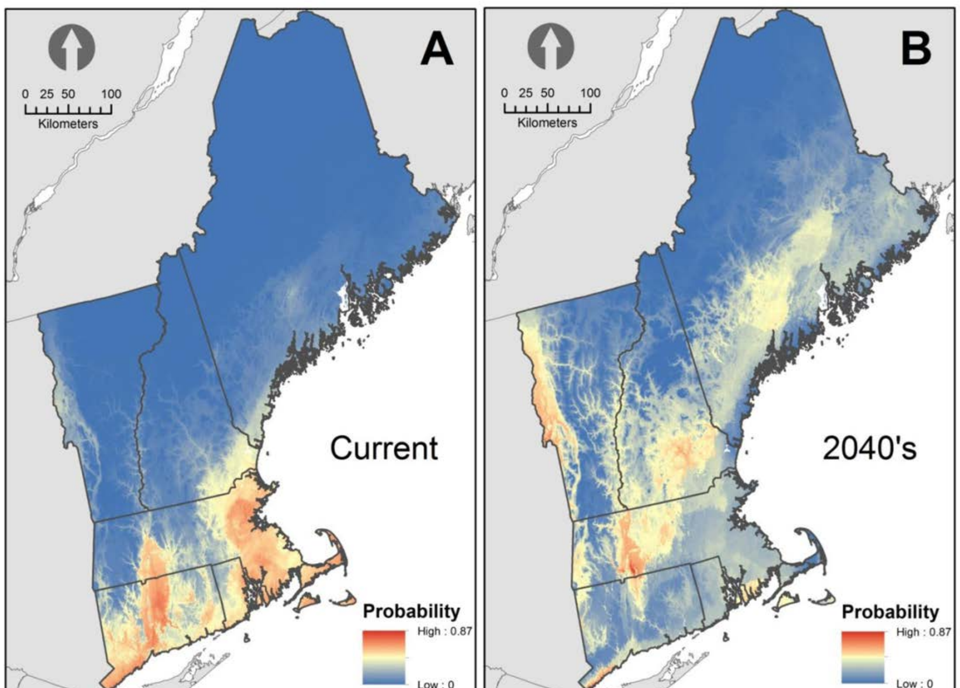


From Sam Edmonds, Biodiversity Research Institute



Predicted patterns of common loon (A) and smallmouth bass (B) concentrations in New England lakes by watershed, based on MERGANSER model. Colors represent mean model estimates under current climactic conditions. Concentrations in µg/g wet weight. Numbers=numbers of lakes within watershed

Shanley et al. 2012. Environ. Sci. Technol. 46:4641–4648).



Modeled New England distribution of Carolina Wren under current (A) and projected (2040s, B) climatic conditions.

Carolina wren moves from low to high Hg watersheds as range expands due to warmer temperatures

Mercury: questions

- What is the response of net methylation and trophic transfer in freshwater and estuarine wetlands to changes in temperature, precipitation, and water levels, especially on Refuges for estuarine species such as the Nelson's Sparrow, Saltmarsh Sparrow, and breeding and migrant shorebirds and in freshwater wetlands for marsh and sedge wrens, rails, and migrating shorebirds

- What are the linkages between inland acidification, calcium depletion and Hg contamination in songbirds on Refuges, especially species of conservation concern (e.g., Rusty Blackbird) and long-distance neotropical migrants (e.g., Olive-sided Flycatcher)?

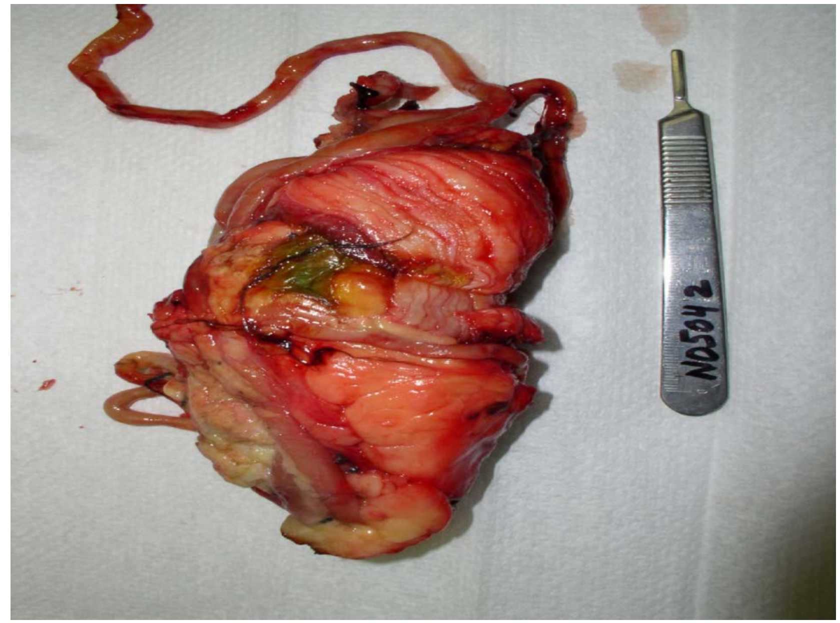
- How do MeHg concentrations in piscivorous birds vary across a range of waterbody types (e.g., managed reservoirs and pools within Refuges and under FERC licenses), in view of the likely increases in water level fluctuations due to precipitation and temperature patterns?

Poplar Island, Chesapeake Bay

July 2012 Bloom of *Microcystis* (blue green alga) and dead common tern.
Death attributed to microcystin toxin.

Steatitis: Great blue heron (2008)

Coaches and Poplar Island



Blackwater Refuge (reference)

Eutrophication/harmful algal blooms/hypoxia: key findings (1)

- Eutrophication, a major issue within estuaries (e.g., Chesapeake Bay) and lakes (e.g., Lake Champlain) is projected to increase due to greater release of nutrients from changes in precipitation patterns.
- Saltwater intrusion, sea level rise, increase in surface water temperatures, altered patterns of precipitation will favor some phytoplankton species that produce harmful algal blooms (HABs)

Eutrophication/harmful algal blooms/hypoxia: key findings (2)

- Aftermath of blooms is often accompanied by hypoxia and fish kills. 25% of MD fish kills since 1984 related to hypoxia.
- Increased temperature means less dissolved oxygen in water and higher metabolic requirements for poikilotherms.
- Hypoxia also causes sublethal effects on fish and is an endocrine disruptor.
- Wildlife dieoffs are related to HABs and it is theorized that HABs may initiate avian botulism outbreaks.

Eutrophication/harmful algal blooms/hypoxia: questions

- Is there a need for more intensive and extensive monitoring of phytoplankton species in estuaries, lakes, and rivers and how could a reliable network be established?
- Is there a need for the systematic maintenance of a regional fish kill and wildlife die-off data base across the region?
- Is there a need for establishing protocols and funding for rapid responses to investigate the factors responsible for fish/wildlife kills?
- What would be needed to be able to better predict the factors that lead to HABs and prevent them?
- What is the relationship between HABs and wildlife disease within the NA LCC?
- How important is hypoxia as an endocrine disruptor within the NA LCC?

Amphibians: key findings (1)

- Higher evaporation rates, higher stream and wetland temperatures, altered precipitation patterns, and increased seasonal water deficits could alter hydrology of vernal wetlands and low order streams. Salamanders are at particular risk.
- Changes in pesticide use due to shifts in cropland will affect amphibians but this is difficult to predict

Amphibians: key findings (2)

- Uncertainty due to complex interactions between precipitation/evaporation/development time
- Interplay between temperature and toxicity:
  - Organochlorine pesticides Incr. temp= incr. toxicity
  - Pyrethroids: incr. temp. = decr. toxicity

Increased temp. = quicker development = less exposure

But also: Increased drought = less dilution = more exposure

Amphibians: question

- How will the recovery of amphibians in ecosystems impacted by acidic deposition be altered by ongoing and future climate change.

Note: Because of the impacts of inland acidification, the Adirondacks would be a suitable area for such a study.

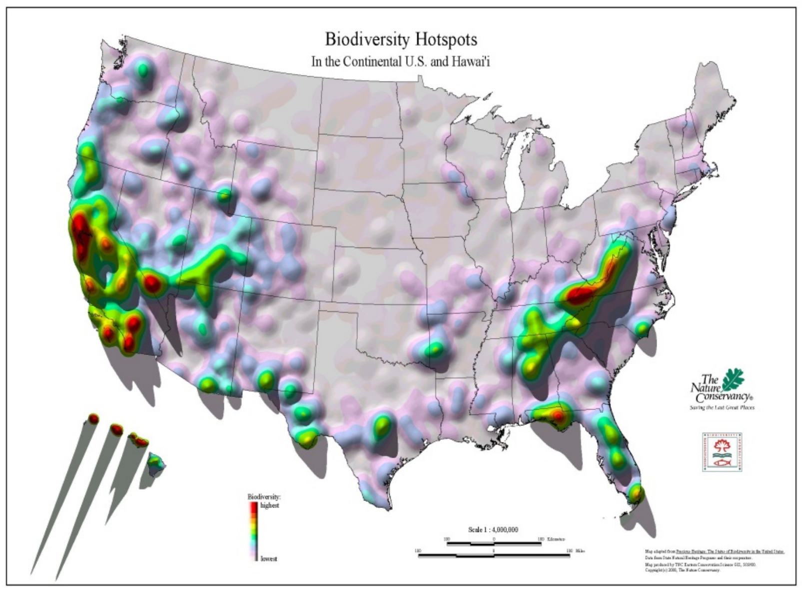
Freshwater Mussels, Ammonia Toxicity and Climate Change

- 300 mussel species in North America
  - 35 extinct
  - 70% of species imperiled
  - 32 species in NALCC, two endangered
  - Most endangered faunal group in U.S.

- Ammonia sources in streams from agriculture, sewage treatment plants, various industries.

- All mussel life stages, glochidia, juveniles and adults are very sensitive to ammonia
  - Toxicity at <0.5 mgNH_3-N/L

Ammonia toxicity is pH and temperature dependent
  - global temperature increase a concern
  - drought, low flows a concern



Freshwater mussels: key findings

- NA LCC rivers support 32 species including 2 endangered (Dwarf wedgemussel and James spinymussel)
- Juvenile mussels are particularly sensitive to ammonia
- Increased stream temperature leads to:
  - 1) decreased oxygen conc., increased metabolic requirements
  - 2) increased ammonia toxicity (increased concentrations of un-ionized ammonia)
- Increased drought=less dilution=increased concentrations
- Dwarf wedgemussel requires clear coolwater streams

Freshwater mussels: questions

- Field monitoring to determine differences in surface water and benthic interstitial pore water ammonia concentrations
- What are synergistic relationships between temperature, ammonia, road salts, and other pollutants?
- Determining what makes a mussel population "healthy"—needed to help determine which populations are most vulnerable and which appear to be resilient in the face of these stressors

Next steps

- Finish paper and submit to Integrated Environmental Assessment and Management
  - Includes prioritized areas for further investigation
- Prepare fact sheets and web materials
- Interact with other LCCs
- *Funding proposals to NA LCC and other interested groups?*

Questions?????

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