Mercury bio-sentinels in national parks

("the dragonfly project")

2013 update

ROMO sampling, 2013. Photo courtesy Ben Baldwin.

Sarah J. Nelson | University of Maine, Sen. George J. Mitchell Center, School of Forest Resources, and Maine RiSE Center

Colleen Flanagan | NPS-Air Resources Division

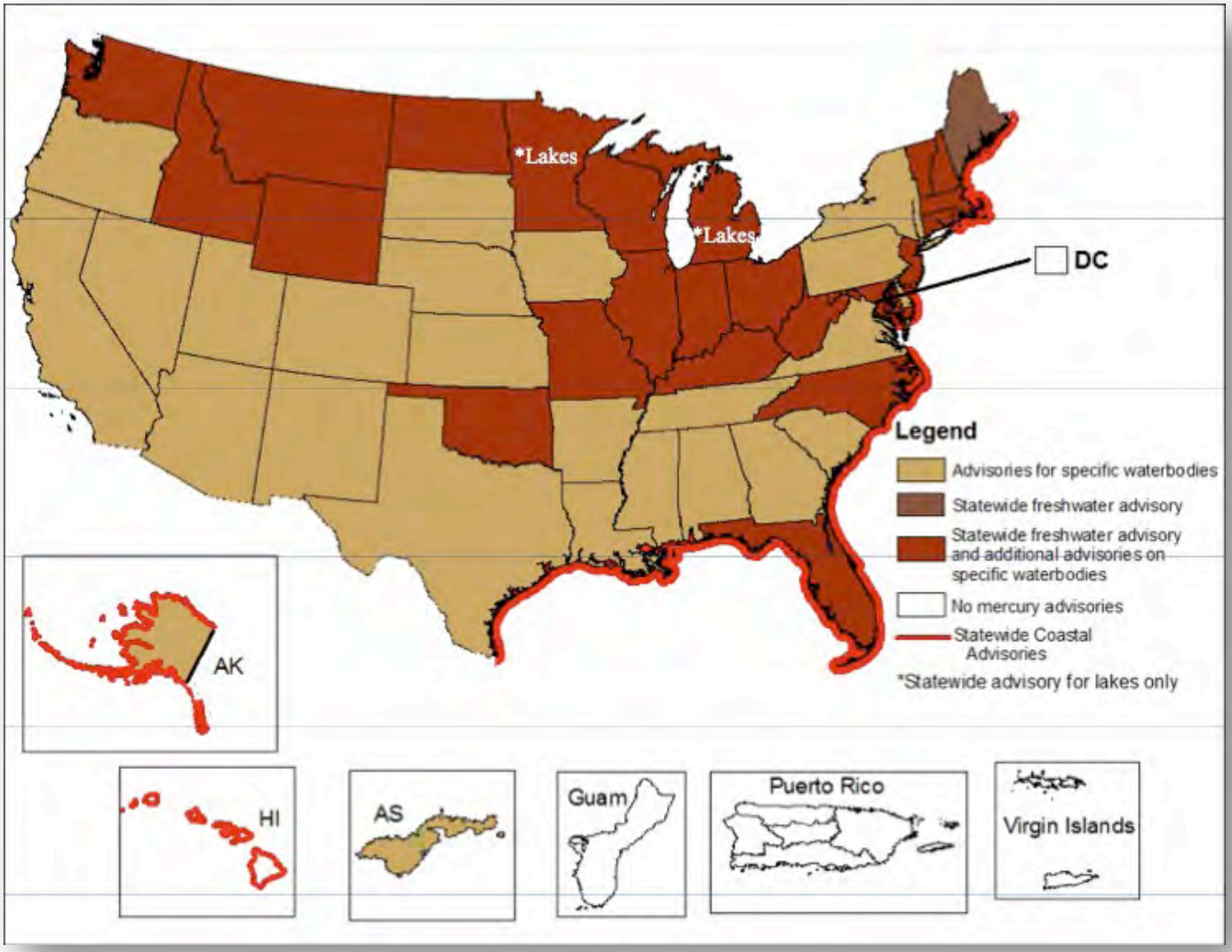
Hannah Webber | Schoodic Institute at Acadia National Park

What is mercury?

- A chemical element
  Hg
- A metal – the only metal that's liquid at room temperature
  "Quicksilver"
- Potent neurotoxin
  Mad as a hatter

How did hatters use mercury? See: http://www.cas.org/news/insights/science-connections/mad-hatter

States with mercury fish advisories, 2010



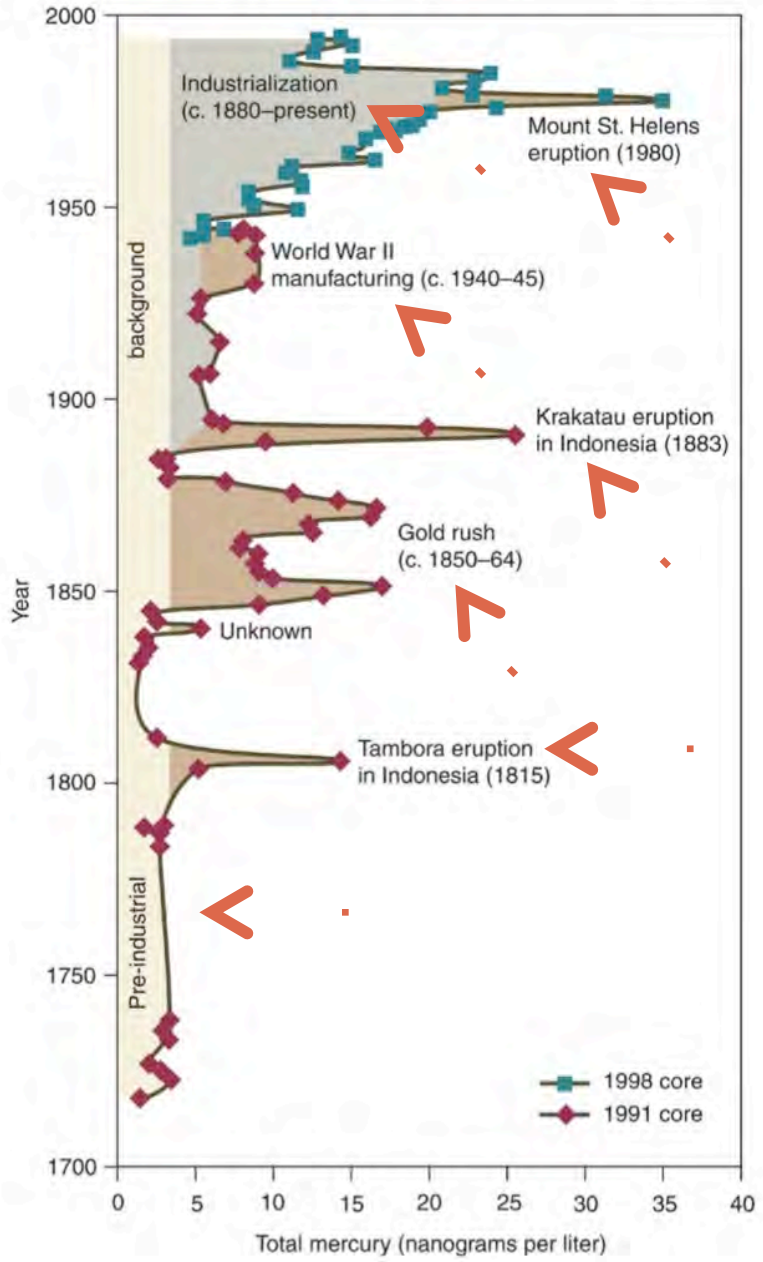
Source: 2010 National Listing of Fish and Wildlife Advisories

States with mercury fish advisories, 2010

More than 1/3 of the nation's total lake acreage under advisory for Hg

Source: 2010 National Listing of Fish and Wildlife Advisories

Figure 2. A 270-year record of mercury deposition

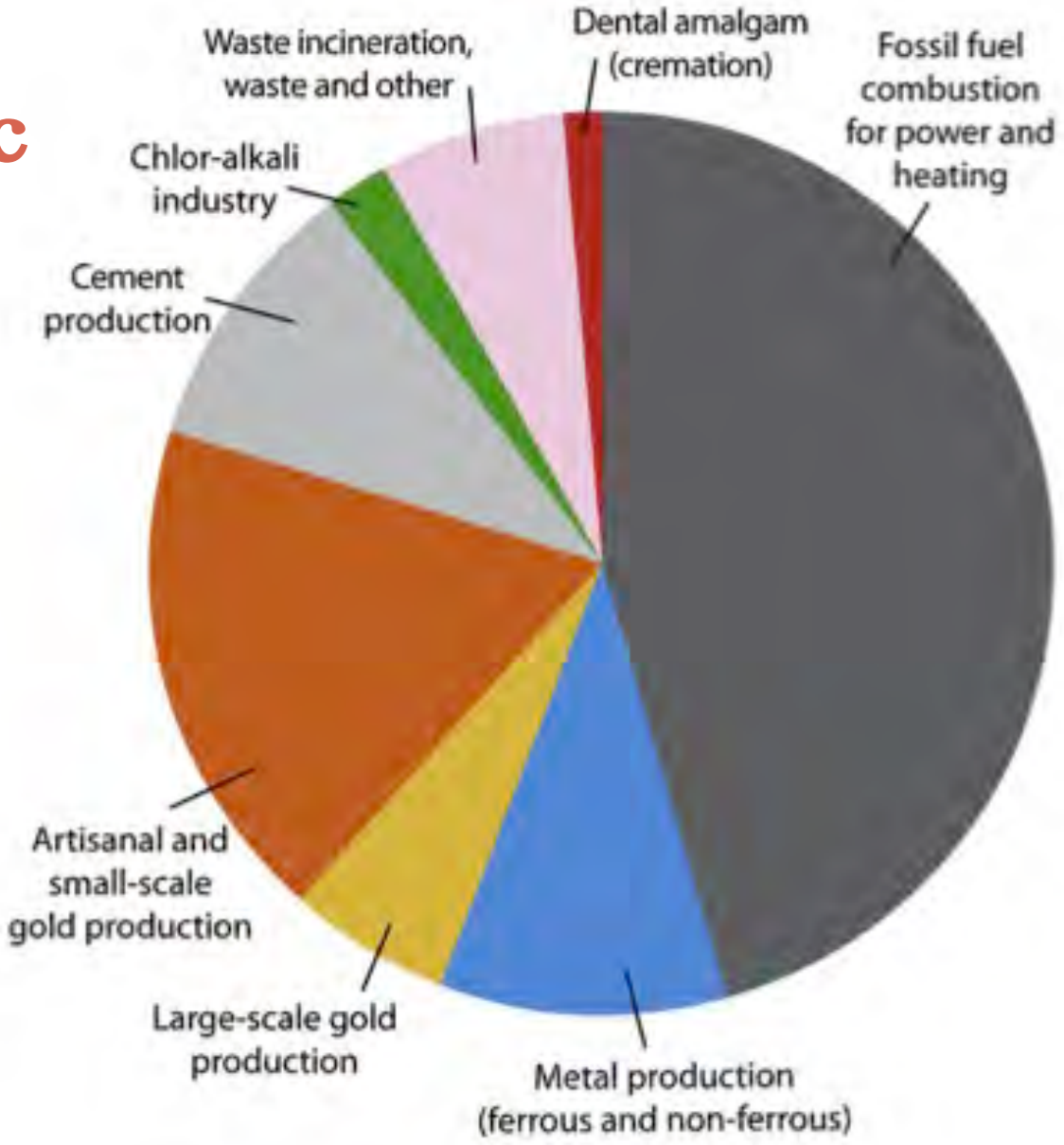


Natural sources and anthropogenic (human-caused) sources

Fremont Glacier Core

Schuster *et al.* 2002

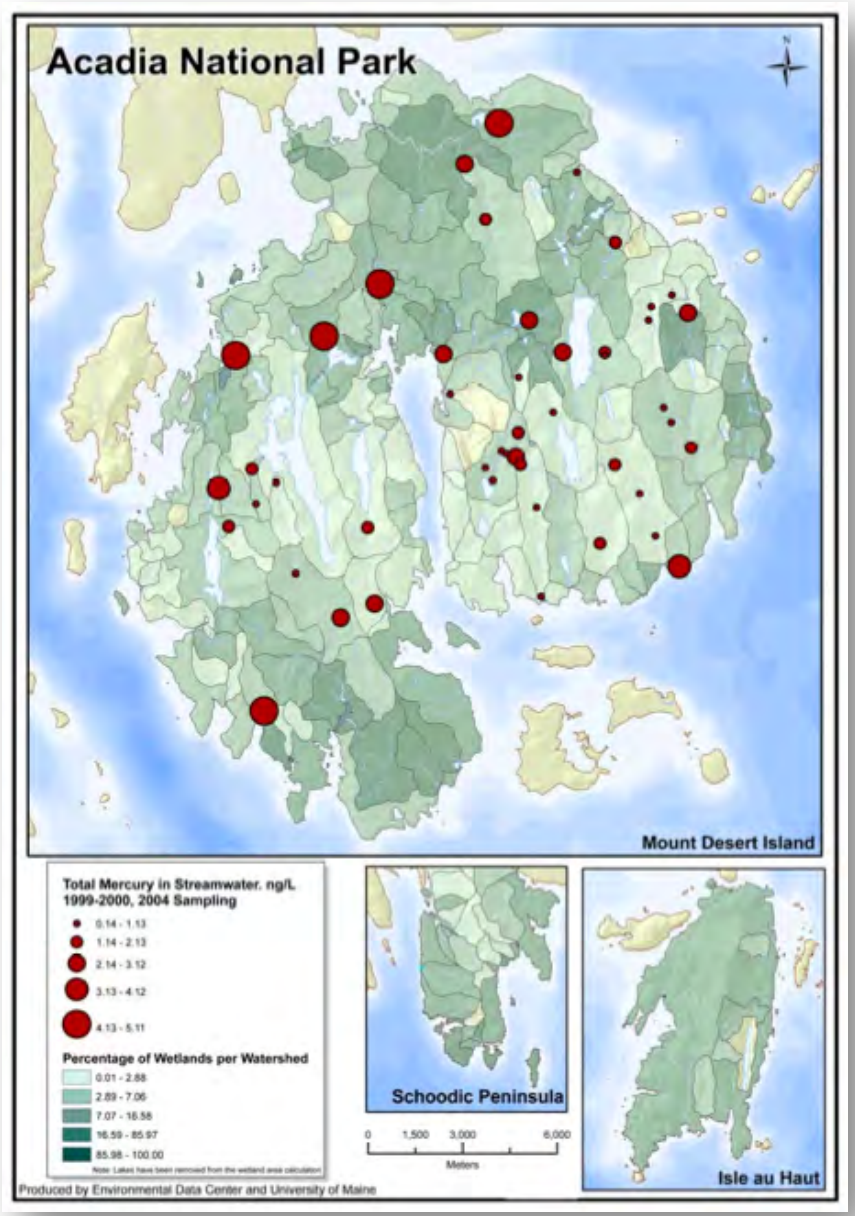
Where does **anthropogenic** mercury come from?



From Pacyna *et al.* 2010
Data: 2005 global inventories
For UNEP report

What goes up, must come down

Mercury Deposition Network: http://nadp.sws.uiuc.edu/mdn/



Mercury varies across space, sometimes surprisingly

- Watershed characteristics
- Habitat
- Foodweb structure
- Diet
- Exposure

Vaux, Nelson et al. 2009 (ACAD Condition Assessment)

Project hypothesis:

Dragonfly larvae (*Odonata: anisoptera*) **will be useful bio-sentinels** for mercury status in freshwaters because:

1. they reflect landscape influences on watershed geochemistry, and
2. their life-history characteristics are conducive to Hg accumulation

Photos: A. Anderson, Kingfisher Photography, Old Town, ME for Acadia Learning.

22 parks sampled in 2013
(6 more attempted: floods, shutdown, early winter)

Project by the numbers

- 22 parks
- 50 sites
- ~900 dragonfly larvae samples

? Larval survival…

Sampling at YELL, July 2013.
Photo courtesy of Matt Ohlen.

Side note – larval survival

Photo: Ed Lindsey. News story: umaine.edu/news/blog/2013/01/07/dragonflies-as-bio-sentinels/

- Previously, best estimates from damselfly studies
  - 95% do not make it to adulthood (emergence) (*M. McPeek,Dartmouth College, pers. comm., 2012*)
- New data from summer 2013 confirm 95% mortality
  - 1600 eggs from one 12-spotted skimmer female hatched (*Libellula pulchella*)
  - ~80 hatchlings remained after 2 months

Project by the numbers

- 22 parks
- 50 sites
- ~900 dragonfly larvae samples

Citizen science participation

10 parks reported:

- 168 citizen scientists
- ~400 hours interpreter, intern, staff, scientist time
- ~1600 hours citizen scientist time

Sampling at YELL, July 2013.
Photo courtesy of Matt Ohlen.

What happens now?

- "About the site" data entered
- Family ID and lengths checked
- Notes reviewed and entered

Field Sheet – Mercury in Dragonfly Larvae from National Parks

Dragonfly Samples collected:

#	Sample ID	Family	Size (mm)	[Optional]
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

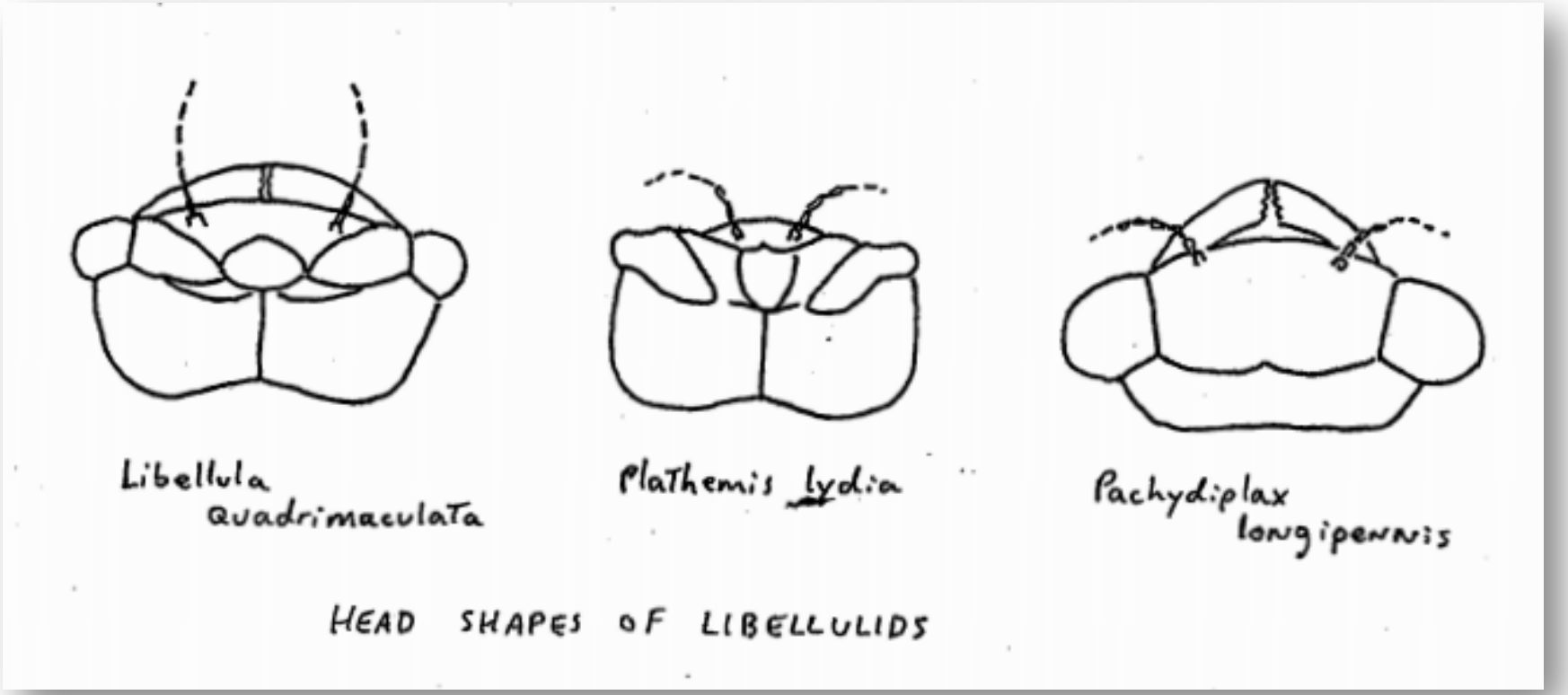
Water samples go immediately to the lab for analysis and/or preservation

Samples for Hg are freeze-dried and photographed in the lab

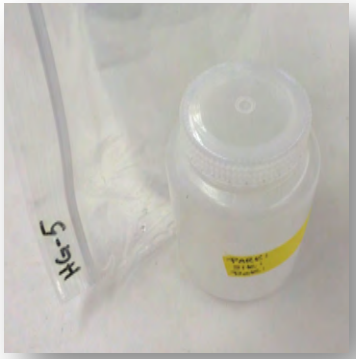
Sample analysis via DMA for Hg in larvae

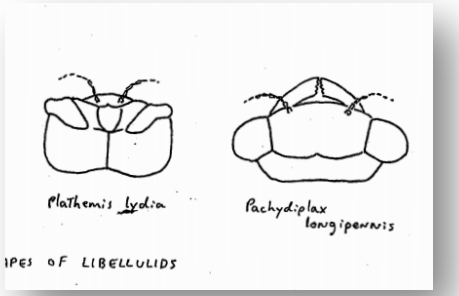
http://www.milestonesci.com/direct-mercury-analyzer.html

Representative samples go to the taxonomist for identification to species



Soltesz key, 1996; http://www.odenews.org/NEAnisopteraSpeciesKey.pdf





All samples are analyzed and data reported

Quality assurance

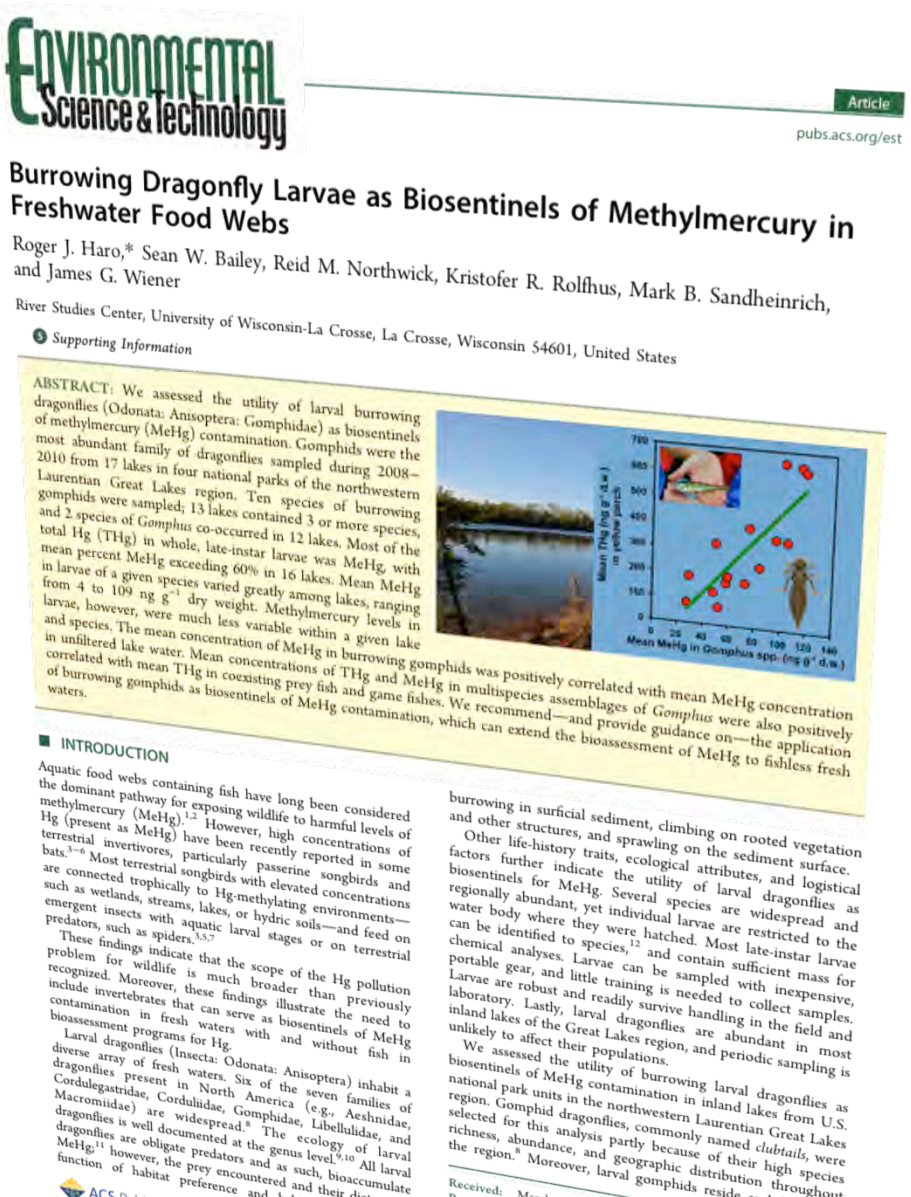
Final database coordinated

Statistical analyses

Final results summarized:
Journal article
Issue brief
Final webinar
?? Other ??

Science update: Working to resolve the issue of depuration

Haro *et al.* (2013) – larvae were "held in isolation overnight in aerated water at room temperature to allow egestion of gut contents."



ENVIRONMENTAL Science & Technology

Article

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Burrowing Dragonfly Larvae as Biosentinels of Methylmercury in Freshwater Food Webs

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Supporting Information

ABSTRACT: We assessed the utility of larval burrowing dragonflies (Odonata: Anisoptera: Gomphidae) as biosentinels of methylmercury (MeHg) contamination. Gomphids were the most abundant family of dragonflies sampled during 2008–2010 from 17 lakes in four national parks of the northwestern Laurentian Great Lakes region. Ten species of burrowing gomphids were sampled; 13 lakes contained 3 or more species, and 2 species of *Gomphus* co-occurred in 12 lakes. Most of the total Hg (THg) in whole, late-instar larvae was MeHg, with mean percent MeHg exceeding 60% in 16 lakes. Mean MeHg in larvae of a given species varied greatly among lakes, ranging from 4 to 109 ng g^{-1} dry weight. Methylmercury levels in larvae, however, were much less variable within a given lake and species. The mean concentration of MeHg in burrowing gomphids was positively correlated with mean MeHg concentration in unfiltered lake water. Mean concentrations of THg and MeHg in multispecies assemblages of *Gomphus* were also positively correlated with mean THg in coexisting prey fish and game fishes. We recommend—and provide guidance on—the application of burrowing gomphids as biosentinels of MeHg contamination, which can extend the bioassessment of MeHg to fishless fresh waters.

INTRODUCTION

Aquatic food webs containing fish have long been considered the dominant pathway for exposing wildlife to harmful levels of methylmercury (MeHg).[1,2] However, high concentrations of Hg (present as MeHg) have been recently reported in some terrestrial invertivores, particularly passerine songbirds and bats.[3−6] Most terrestrial songbirds with elevated concentrations are connected trophically to Hg-methylating environments—such as wetlands, streams, lakes, or hydric soils—and feed on emergent insects with aquatic larval stages or on terrestrial predators, such as spiders.[3,5,7]

These findings indicate that the scope of the Hg pollution problem for wildlife is much broader than previously recognized. Moreover, these findings illustrate the need to include invertebrates that can serve as biosentinels of MeHg contamination in fresh waters with and without fish in bioassessment programs for Hg.

Larval dragonflies (Insecta: Odonata: Anisoptera) inhabit a diverse array of fresh waters. Six of the seven families of dragonflies present in North America (e.g., Aeshnidae, Cordulegastridae, Corduliidae, Gomphidae, Libellulidae, and Macromiidae) are widespread.[8] The ecology of larval dragonflies is well documented at the genus level.[9,10] All larval dragonflies are obligate predators and as such, bioaccumulate MeHg;[11] however, the prey encountered and their diet function of habitat preference and

burrowing in surficial sediment, climbing on rooted vegetation and other structures, and sprawling on the sediment surface.

Other life-history traits, ecological attributes, and logistical factors further indicate the utility of larval dragonflies as biosentinels for MeHg. Several species are widespread and regionally abundant, yet individual larvae are restricted to the water body where they were hatched. Most late-instar larvae can be identified to species,[12] and contain sufficient mass for chemical analyses. Larvae can be sampled with inexpensive, portable gear, and little training is needed to collect samples. Larvae are robust and readily survive handling in the field and laboratory. Lastly, larval dragonflies are abundant in most inland lakes of the Great Lakes region, and periodic sampling is unlikely to affect their populations.

We assessed the utility of burrowing larval dragonflies as biosentinels of MeHg contamination in inland lakes from U.S. national park units in the northwestern Laurentian Great Lakes region. Gomphid dragonflies, commonly named *clubtails*, were selected for this analysis partly because of their high species richness, abundance, and geographic distribution throughout the region.[8] Moreover, larval gomphids reside

Received:

Science update: Working to resolve the issue of depuration

We did not ask you to set up individual mercury-free tanks of aerated water to hold your larvae overnight!

Early results from Maine study are promising (more soon…)

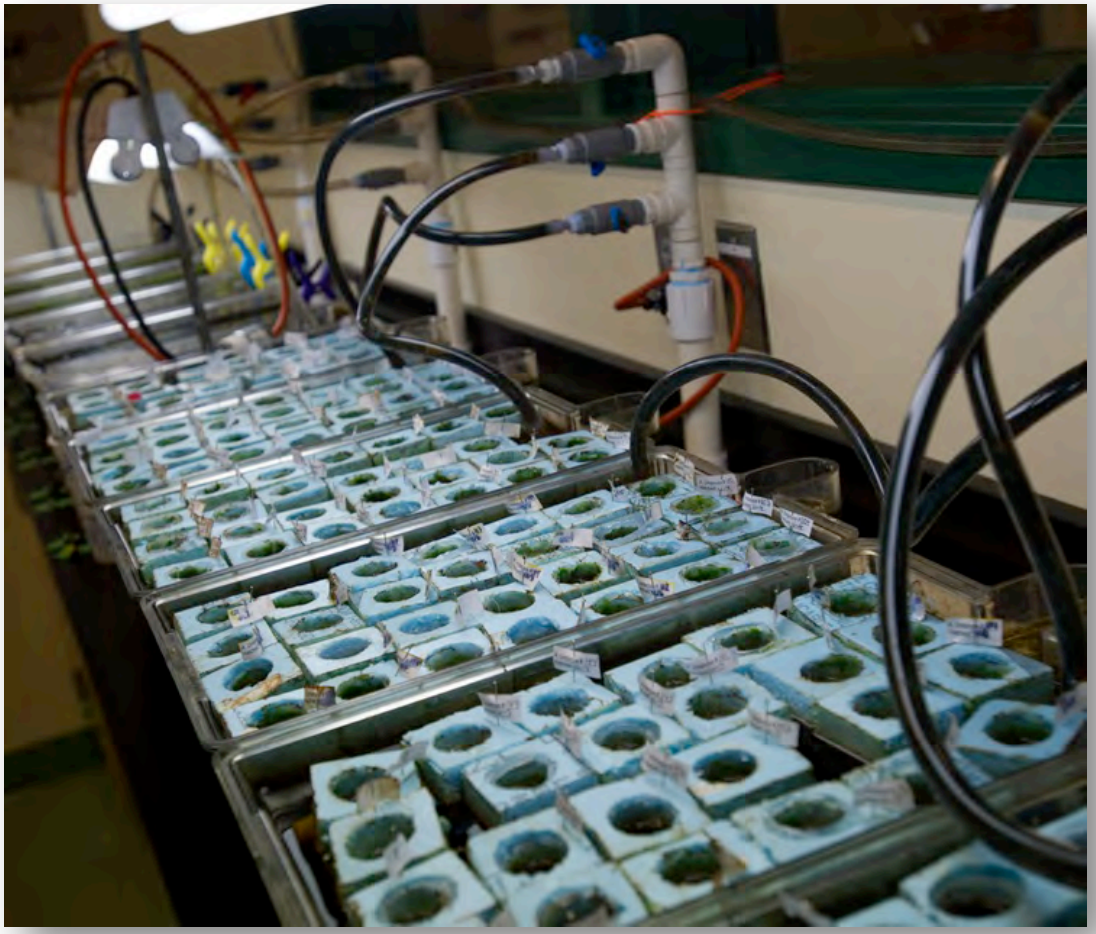
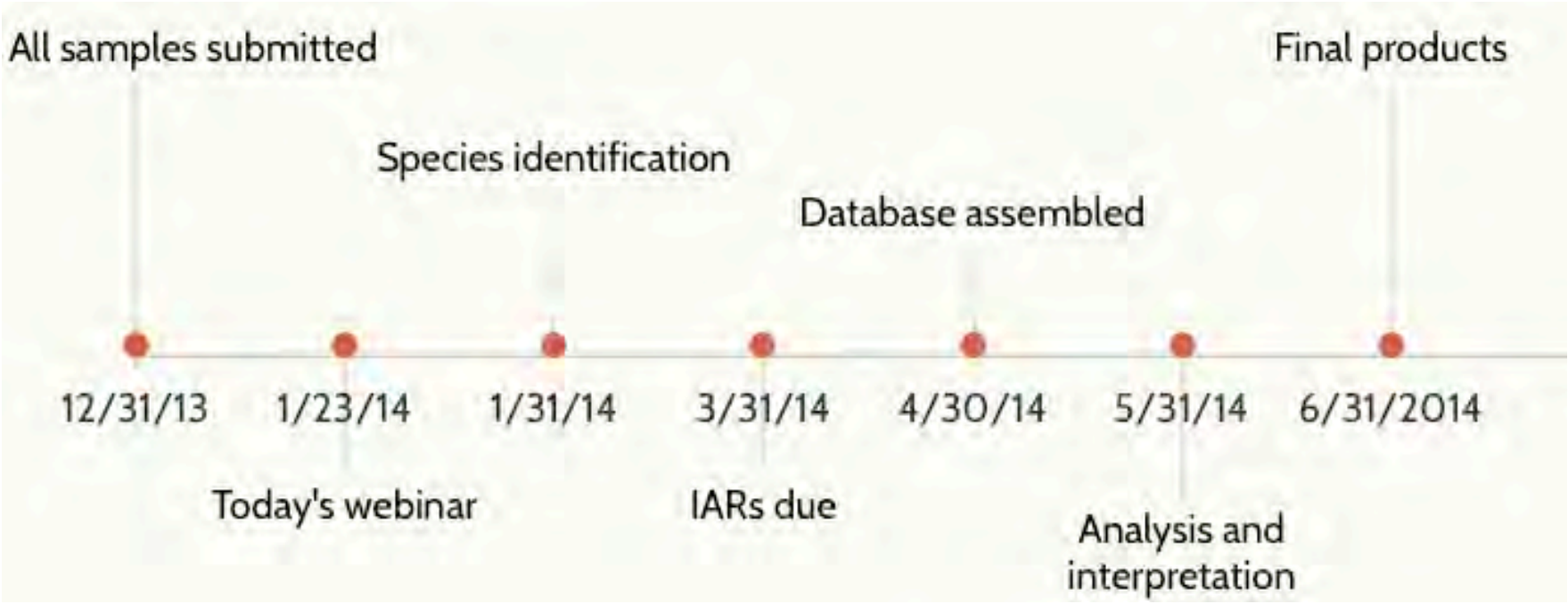


Photo: UMaine

Timeline and next steps



Where to look for updates

- e-mail blasts
- Project Web site: http://www2.nature.nps.gov/air/Studies/air_toxics/dragonfly/index.cfm

National Park Service

National Park Service
U.S. Department of the Interior

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- Air Quality in Parks
- Basics
- Laws & Policy
- Monitoring & Data
- Permit Applications
- Photos & Multimedia
- Planning
- Publications
- Studies
  - Ecological Assessments

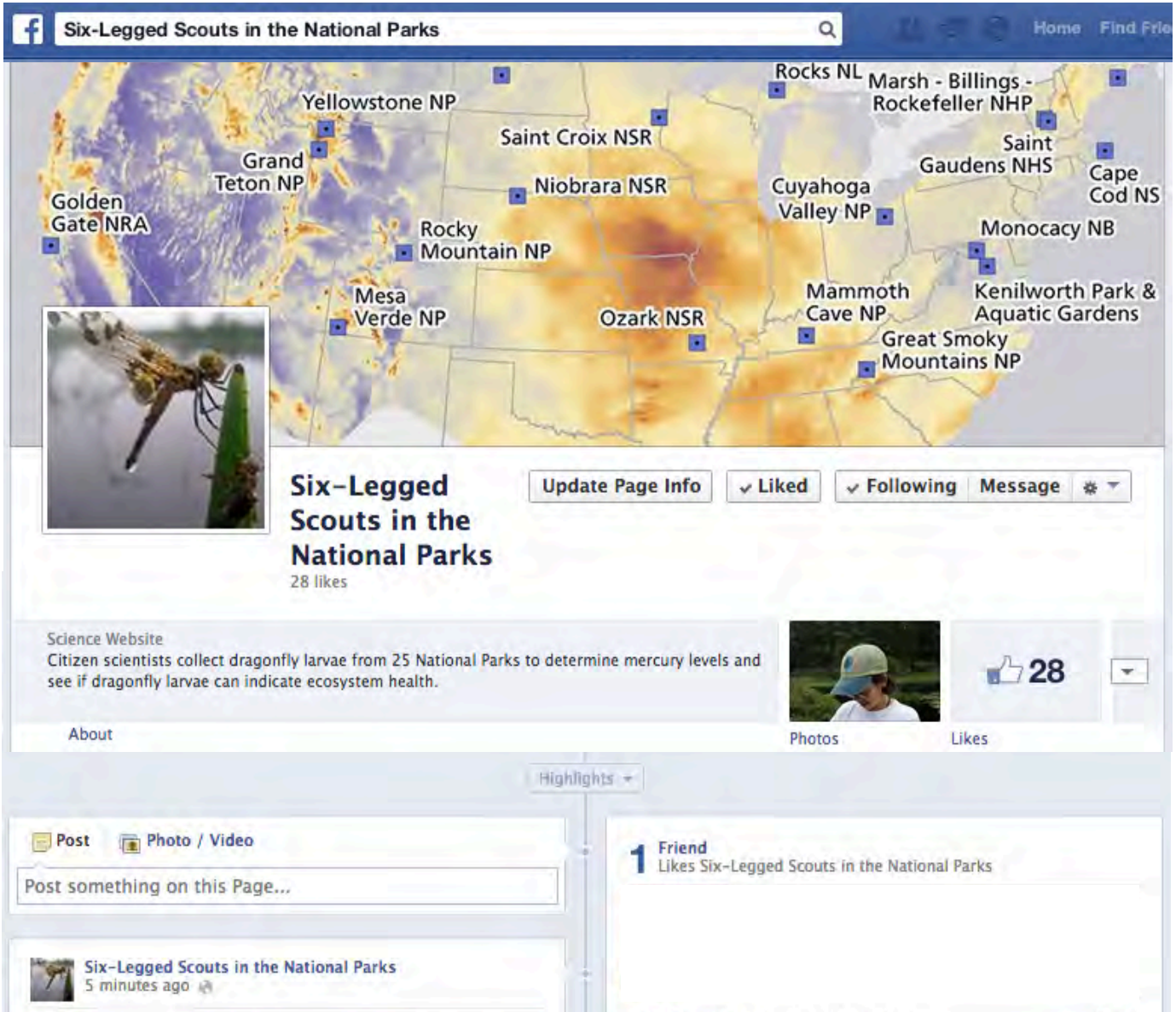
Citizen Scientists Study Mercury in Dragonfly Larvae

Dragonfly larvae are currently being sampled for mercury levels in national parks. Mercury is a toxic pollutant that can harm human and wildlife health, threatening the natural resources the NPS is charged with protecting.The main source of human-caused mercury in remote national park environments is atmospheric deposition from coal-burning power plants.

The larval stage of the dragonfly lives in the water, and individuals are collected from river or lake bottoms with nets.

Find us on: facebook

Six-Legged Scouts in the National Parks



Plans for 2014

USGS-NPS Water Quality Partnership proposal was selected for funding

Linking freshwater mercury concentrations in parks to risk factors and bio-sentinels: a national-scale research and citizen science partnership

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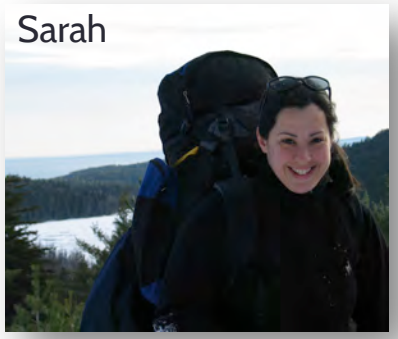
In collaboration with: Roger Haro[4] and Celia Chen[5]
[4]University of Wisconsin – La Crosse, La Crosse, WI; [5]Dartmouth College, Hanover, NH



Expanding on this year's design and investigating additional sample types and mechanisms

- Dragonfly larvae Hg and MeHg (methylmercury)

+Habitat, feeding guild, developmental stage

- Water chemistry including Hg and MeHg

+Sediment Hg

- Site characteristics

+Temporal patterns (intensive parks, ACAD and OLYM)

Sampling at ACAD, Aug. 2013. Photo: Marissa Giroux.

2014 sampling – planning in progress

- More standardization across sites would help strengthen the science
  - Sampling in a similar timeframe – for example, late summer into fall
  - Sampling in more permanent waterbodies?
- Always looking for good coverage across all regions

Sampling at CUVA, 2013. Photo courtesy of Pam Barnes.

Acknowledgements

National Park Service

USGS-NPS Water Quality Partnership

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Ed Lindsey, Old Town High School

Acadia Learning Program, including Bill Zoellick and Molly Schauffler, and **Maine Sea Grant**

Marissa Giroux, UMaine research assistant and skilled cat-herder

Bronco Quick, taxonomist

Sampling at GRSM, November 2011. Photo: Emily Darling.

Special thanks to Ami Riscassi for volunteering in year one (& beyond)!