USDA Northeastern Ecosystem Research Cooperative

Northeast Mercury Research Group

27-28 November, 2001 Workshop Minutes

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Northeast Mercury Research Group
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NERC (www.ecostudies.org/nerc/)

- Initiative to promote collaboration among ecosystem research scientists in NE North America.
- Increases information exchange and cooperation amongst researchers.
- Produces shared regional perspective.
- Support for long-term monitoring in region.

GEOCHEMISTRY RELATED Hg OVERVIEW

High Spatial Resolution Estimates of Hg Wet and Dry Deposition Fluxes to the Northeastern U.S. Landscape

Eric Miller, Dartmouth College

Precipitation rates vary at local scales.
Dry-deposition may be 30-60% of total Hg deposition. Dry-deposition flux highly variable at 30-1000m scales due to variant in receptor surface and microclimate.

<u>Approach</u>:

- Coarse resolution Hg concentration from network observations or emissions transport models.
- Fine resolution precipitation rate and dry-deposition velocities from HRDM
- Lindberg et al. Hg dry-deposition parameterization
- Separate Hg, RGM, Hg-particle fluxes

<u>Atmospheric. Hg Monitoring Sites</u>:

- Sites throughout Northeastern North America
- 2 types of protocols (University MI & MDN), sites run at different times
- Little variation in deposition rates from year-to-year

Combine Hg concentration w/High Resolution Hg Wet Deposition Rate to get landscape picture (e.g. S deposition in Adirondacks Park affected by cover types and microclimates).

Difficulty between Estimated Deposition and Export

- How much is storage?
- How much is emission?
- Hg fluxes in canopy = bi-directional & very large when plants are transpiring >> change in interpretation of Hg movement thru environment & modeling of Hg accumulation rate.

Hg deposition in lake and peat sediments through time in eastern North America

Steve Norton, University of Maine

Soil sediments from above treeline, ombrotrophic bogs (no drainage or input), and lakes sampled for trace metals and Hg in 1979 & in 1996. New England sedimentation rate ~1mm/year. Samples dated w/Pb 210.

Comparison between 1979 & 1996, Hg deposition and accumulation in forest floor litter had decreased substantially.

Ombrotrophic bogs – high accumulation rate of Hg in bogs. Increase starts ~1900. Rate up to 10ng.m2/year. Twice as much deposition in hummocks vs. in hollows. Spatial deposition very important in understanding Hg accumulation.

All bog samples show decline starting in ~1980.

Point sources of Hg didn't affect Hg accumulation in bogs.
Lakes w/ drainages don't accurately portray Hg deposition b/c long lag between atmospheric & what see in lakes.

- Can document Hg deposition over time in sediment cores.
- Sediment accumulation rate & concentration of Hg >> anthropogenic Hg deposition

Retention of Hg in organic soil = ~200-300 years accumulation. Large reservoir of Hg. Retention in watershed affects Hg accumulation rate.

Conclusions:

- Hg deposition started increasing in ~1890-1900.
- Max. atmospheric deposition in ME between 1970-1980. At peak, atmospheric deposition was ~2-3 x natural levels.
- Atmospheric deposition of Hg has declined by at least 50% over last few decades.
- Lake sediment may not record well the timing of decreased atmospheric deposition of Hg.
- Release of Hg stored in soils will delay the Hg levels in water, biota…

Measurement of elemental Hg flux from a tidal estuary during spring and summer conditions

Alan VanArsdale, U.S. Environmental Protection Agency

University. New Hampshire Jackson Estuary Lab.

Objective: To determine the Hg flux in a relatively undisturbed estuary. Looking at tidal mud and estuary water.

Tidal Flux Chamber: Gives ambient concentration Hg at surface of flux chamber. Ten minute average reading from chamber & 10 minute ambient reading. Compounding factors = weather, waves, tide height…

Hg flux – significant amount of Hg comes out of systems in elemental form. Hg flux high during day & low during night. Fluxes = ½ -3/4 total wet deposition in air.

Difficulty between ambient and with in chamber Hg concentration.: Flux low in night, rose in day as tide came up (possible "bubbling effect" under flux chamber) and solar radiation. Then, flux coming out of system as night comes on.

Tidal and air temperature drive Hg flux. Solar radiation may be cause of Hg flux in daylight hours?

Need to determine if periwinkles (biological activity) affect chamber & recording of Hg flux data.

Flux chamber sank into mud – need to determine effect on data recorded.

Fog may have affected changes in Hg flux.

Hg distribution along an urban gradient in New England streams

Ann Chalmers and David Krabbenhoft, U.S. Geological Survey

Highest concentration of Hg in streams were determined previously in New England.

For this study, sampled 56 sites in MA, NH, ME, and RI. Looked at sediment, water and fish tissue at sites

Objectives: Examine relationship between Hg and MeHg
Look at watershed accumulation of MeHg

Water samples: unfiltered total and MeHg, dissolved Sulfate and AVS, TOC< and LOI, DOC fractionation, and field parameters

Fish: fillet parameters; 2-3 year old sunfish
Highest concentration of total Hg in sediments and water were around Boston. No real relationship in MeHg between urban and non-urban areas. MeHg did correlate well with high organic C (DOC) and in water with TOC. High correlation of MeHg with HPOA (hydrophobic acids)

Range of methylation efficiency – lowest in urban areas, highest in southern NH & southern ME.

Fish: Lowest Hg concentration near Boston, highest in southern NH & ME.

Productivity of streams affects methylation of Hg.

Environmental Hg studies in northern Vermont

Jamie Shanley, U.S. Geological Survey

- Long event of wet Hg deposition, (~9ug/m2/year)
- Dry deposition of Hg up to 5x wet, may acct for up to 80% Hg deposition
- High Hg in leaf fall
- Hg 90% retained in terrestrial watershed, less than 10% exported in stream flow
- Dissolved Hg assoc/ w/ DOC, particulate with POC
- Dissolved Hg continuous, dominates stream Hg export
- Hg export episodic, with POC - Episodes drive Hg transport out of system (e.g.: snowmelt)
- Hg-DOC assoc in O-horizon soil solution
- At Sleepers River, no land use effect
- In NW VT, Hg export from agriculture. Site same as forested, but w/ 10x TSS
- MeHg – stay tuned

Input rate fairly steady.

Increased flow >> increased Hg concentration

Study: Watershed ~110sq. km.

- Water samples, snow, groundwater
- Dissolved Hg = narrow range of concentration across all sites
- Particulate Hg = concentration varied w/episodes (e.g.: snowmelt)
- Dissolved Hg related to DOC (similar to Sunday Lake…)
- Particulate Hg related to POC

Hg dynamics in soil water – dissolved less dynamic than particulate
Shows source of Hg that will can be methylated in environment

Hg:DOC ratio goes up as snowmelt progresses. At peak snowmelt, have DOC of different character

Nitrate peaks early, then declines, while Hg & DOC continue b/c have soil/.sediment source.

Strong relation across different land uses, but when look at whole Lake Champlain Basin, see less relationship. Do see strong relation between Hg and MeHg concentration in Lake Champlain Basin

Surface water Hg concentration in Canada's Atlantic Provinces

Thomas Clair, Guy Brun, and Gordon Norton, Canadian Wildlife Service

Lake sampling network (>120 lakes sampled) in Nova Scotia to Newfoundland, and in Kejimkujik National Park, Canada

Total Hg relates well w/total organic carbon (TOC)

Intensive study at Keji – soils, water geochemistry, sediments, insects…

Looked at relationship of total Hg coming out of a stream and what stream looked like. GIS landscape characteristics. Summer and winter data.

Total Hg related closely with DOC.

MeHg – summer related w/DOC, but spring did not relate w/DOC b/c methylation processes shut down during winter.

Total vs. MeHg: related well in summer, didn't relate in winter. MeHg ~10% total Hg in summer.

<u>Landscape characteristics</u>:

- Inlet vs. outlet stream
- Sunshine potential for basin (slope of basin)
- Slope – steep vs. flat (=more wetland = more complex of atmospheric Hg)
- Basin drainage – how wet soil is
- Local drainage – right around sampling site

Modeled vs. measured Hg concentration at Keji >> can predict Hg concentration well once know landscape characteristics

<u>Summary</u>:

- Regional data for Atlantic Canada is available and will be contributed
- Process and GIS oriented data from Keji will also be contributed

BIOLOGY RELATED OVERVIEW

Assessing Hg and MeHg burdens in VT and NH lake sediments, waters, and biota: A regional environmental monitoring and assessment program initiative

Neil Kamman et al., Vermont Department of Environmental Conservation

<u>Objectives</u>:

- Random sampling of lakes in VT to deter profile of lakes that have high or low Hg & use to develop good predictive model
- Understand the historical accumulation of Hg via paleolimnology

EMAP stratified random sampling program & evaluated variety of sediment and water parameters, zooplankton, prey & consumption size yellow perch, and piscivores.

Measured Hg in hypolimnion in all lakes where it was developed.

Dataset:
- 108 lakes
- 135 water quality profiles
- …

Results:
- MeHg ranges from very low to ~3ng/L
- Total Hg up to ~35ng/L
- Zooplankton range from 100-1700ng/gm

Concentration of MeHfg in epilimnetic and hypolimnetic waters related to:
- DOC
- SO4
- Temp
- DO
- Flushing (less MeHg in highly flushed lakes)
- H2S (hypolimnion only)

Fish (fillets):

Hg total ranged from very low to ~0.8ug/g. Now using age/size related fish data

MeHg in prey size fish (<10cm) = most of total Hg
Fish in acidic lakes have more Hg than less acidic lakes and have greater accumulation of Hg

NH vs VT: no different in Hg in sediments, more Hg in zooplankton, little difficulty in water, more Hg in fish

Paleolimnology: Synchrony of onset of anthropogenic Hg – increased dramatically since 1850. Compared vs. Driscoll's and Norton's results – retention estimates are small comparatively. Errors are large, but direction is clear.

Summary:
- Relationship between geochemistry and MeHg and total Hg in water
- Perch Hg concentration vary w/lake type
- Loon show contamination
- Hypolimnetic sediments may not be source of MeHg
- Hg fluxes are decreasing, thus leaking from watershed becoming more important factor

INVERTEBRATES

Mercury bioaccumulation, biomagnification, and biodilution in aquatic food webs

Celia Chen and Carol Folt, Dartmouth College

Study Outline
- 20 lakes in NE US – selected from EMAP lakes – with many variable characteristics
- Hg, Cd, Zn, As, and Pb analyzed
- Attempting to understand how to metals accumulation in food chain
- Collected environmental variables
- Phytoplankton & zooplankton metal, biomass, and species
- Metal concentration in fish tissue (EMAP) (= perch, trout, bass, sunfish)

- Land-use variables for lakes
- Derived variables = trophic and metal transfer variables (BCF, Zoop EF, Fish EF)

Hypotheses:
- There is a direct relationship between metal concentration in water and plankton and fish
- To determine if the concentration of Hg, Zn, & Cd, is related to levels in plankton

Hg – concentration of Hg in large zoop = good predictor for Hg level in fish, but inverse for small zoop, Water not good predictor for Hg in fish.

Hg transferred via food chain Cd & Zn: water concentration predicted fish concentration better than zoop.

Water temp related to Hg concentration. Lg zoop Hg related to small zoop.

Biodilution: Contaminant concentration decreases w/increase in biomass with in a trophic level

Trophic dilution: Contaminant concentration in consumer decreases in increased biomass of prey

Hypotheses:
- Metal concentration with in a trophic level decrease with increase abundance of org
- Metal concentration in consumers will increase with decrease in abundance of their prey
- Trophic transport of metals is more important in lass productive systems

Metal concentration in large zoop decrease with increase abundance –

Metal concentration in small and large zoop decrease with increase algal biomass – significant for large zoop & Hg

Hg concentration in fish decrease with increase abundance of large zoop

Fish metal concentration decrease w/decrease N:P ratios – more productive system >> more Hg in fish, but not in Zn.

See biodilution of Hg, Cd, Zn in trophic levels

Conclusion:
- Metal concentration in water are related to environ & land use variables
- Metals in aquatic food webs can biomagnify to fish from their food (Hg & Zn); bioconcentrate to fish from water (Cd & Zn)
- Metal concentration with in trophic level decrease with increase abundance of orgs
- Zn, Cd, and Hg concentrations in zooplankton increase with decrease abundance of their algal food
- Trophic transport of Hg may be more important in less productive systems

Using crayfish as relatively non-mobile indicators of MeHg bioavailability

Chris Pennuto and David Evers, University of Southern Maine

- Crayfish function at multiple trophic levels – predators, omnivores…
- Large, relatively common, easy to capture
- Eaten by many organisms – loons, bitterns…

- Evaluated different habitat types for same sp.: ~150 crayfish from 15 sites in NE.
- Looked at tail muscle Hg - ~98% is MeHg. Subset evaluated for Hg throughout body also, but no real difficulty between tail & viscera in Hg level. Minimal Hg in carapace
- Compared Hg levels to published record

Results:

- Tail muscle Hg differed among sites.
- Animals differed in size (length and weight), varied with site
- Thus, standardize Hg tail muscle w/length, still had Hg vary with site
- Weight explained most of variation in Hg content across sites
- No difficulty in growth rates among sites, though large size difficulty

Thus, plotted weight against length, resulting in standard growth curve >> linear relationship. Compared slopes of different populations >> growth slopes = same, thus uptake & depuration of Hg should be same.

Plot size Hg tail muscle content vs. standardize Hg content >> linear relationship that overcomes size bias between different locations.

Lower size classes, good relationship between wt & length among sites. However, at larger size classes, see less correlation between wt & length. Difficult to establish size/age relationships in crayfish.

Didn't find a good relationship between Hg content and size or habitat type.

Combined habitat types (ponds, reservoirs, brooks, rivers) >> crayfish in brooks and rivers had higher Hg/unit length than did reservoirs and ponds. Crayfish in flowing water function higher on the food web (as predators) than do animals in non-moving water – may be largest consumer, where they function more as decomposers.

FISH

Hg data collected by the Canadian Wildlife Service and our research partners in New Brunswick and Nova Scotia

Neil Burgess, Canadian Wildlife Service

Concerns:

- Hi Hg levels in loons and prey fish in eastern Canada
- Potential for adverse impacts of Hg on loons
- Potential for atmospheric Hg

Focused on 2 study areas (Keji and Lepreau): Hg in loons (blood, feathers, eggs, dead animals), in fish (yellow perch), lake chemistry, and watershed characteristics

Loon prey = primarily yellow perch in 5-20cm size range (smaller than those analyzed for human consumption)

Loons: Captured 43 adults and 20 chicks: Ad M>Ad F> chicks (adults ~10 fold higher than chicks). Keji had very high Hg levels – low pH lakes (highest pH = 5.9)

Keji Fish: Lake sizes ranged broadly. Sampled fish in all lakes that routinely had loons. Some lakes looked at variation with in lakes. Collected 9 perch in 3 size classes in each lake. Analyzed Hg by composite sampling. Fish Hg level increased as fish size increased) from 50ppb in small fish to 0.8ppm in 20cm fish. Had some very high Hg values for some small fish. Slope of Hg vs. fish length similar across most lakes (3 lakes had different slopes). Hg levels for 10cm perch vs. pH >> Hg levels highest in low pH lakes.

Lepreau Fish: Collected 10 fish from each species on 18 lakes. Diet analysis of stomach contents. Rest homogenized for analysis. Total Hg and MeHg and stable C and N isotopes analyzed

Loon blood Hg correlated with fish Hg levels (loons don't tend to go off to other lakes). Thus can estimate what loon exposure would be on lakes where have fish, but not loon, data.

Other data:

- lake chem.
- Watershed characteristics
- Deposition rates of Hg in precipitation
- Total & MeHg in bedrock, soil, vegetation, bogs, lake water, and sediment (Keji only) – geologic composition of Hg in environment
- Hg in yellow perch
- Provincial government Hg data on sportfish fillets

Hg studies conducted by USFWS-New England Field Office

Drew Major, U.S. Fish and Wildlife Service

- REMAP – VT
- Bob Estabrook
- Loon Mortality
- Loon sampling in NY
- River data
- BRI's loon data
- Mink from ME, NH, NY

Can compare different fish samples:

- Composite vs. individual fish samples
- Larger vs. smaller fish
- Offal vs. fillets
- Perch vs. species that are evaluated for human health concentrations

Be aware:

- Waterbodies with water level fluctuations
- River vs. lake data
- Dual basin lakes

Compilation of data for a GIS-based regression model to predict risk of Hg contamination in fish tissue in New England

Keith Robinson and Alison Simcox, U.S. Geological Survey - U.S. Environmental Protection Agency

Concepts:
Some degree of variability of Hg in fish tissue can be explained by combination of data describing watershed characteristics. Will provide tool for determining environmental factors >> Hg in fish.

Deter utility of nutrient SPARROW model for predicting Hg in environ

Build databases: fish, Hg point sources, Hg deposition patterns, watershed features, water chemistry

Develop regression models

SPARROW model: Spatially Referenced Regressions On Watershed Attributes.

- Relates observed water quality data to upstream watershed chars
- Process-oriented (preserving mass balance of nutrients)
- Incorporates only statistically significant parameters

Currently, working on 43,000 stream reaches to predict TN and TP loads, and provide data on watershed features.

The Ontario sport fish contaminant survey

Greg Mierle and Al Hayton, Ontario Ministry of the Environment

25 year dataset.
Point sources (~20 tons of Hg/year) – chlor alkali plants, contaminating Lake Erie and Lake Ontario, and areas remote from point sources of Hg contamination. Resulted in closure of commercial and sport fisheries.

Lakes across Precambrian shield contaminated Hg, assumed to be a natural contamination associated with shield. Management strategy was to limit consumption. As fish size inc, see higher levels of contamination, regardless of species (although suckers and whitefish populations low).

Survey oriented to producing "Guide to Eating Ontario Sportfish"

Database: Inland lakes, Great Lakes, rivers, reservoirs, creeks, ponds…
8 fish species = ~85% samples (~90,000 over 25 years): walleye, northern pike, lake trout, smallmouth bass, largemouth bass, yellow perch, brown bullhead, rock bass

Almost all large lakes sampled – small lakes underrepresented. Only subset of ~1600 waterbodies sampled from huge # of waterbodies.

Have analyzed trends on species specific basis.

Current focus on development of a consolidated index of Hg contamination. Use index to look at association/trends w/environ variables

Look at mass models in future

Results of analysis: Hg inc as fish size inc.

Log – log data transformation stabilizes variance, linearizes relationship. Accounts for curvature (in the arithmetic relationship if present). Assumes Hg=0 when Length =0.

<u>Data imperfections</u>:

- Data entry mistakes
- Automated outlier filtering essential
- Robust regression

Log Hg decreases as go from top predators (walleye) to herbivores (suckers & whitefish). Slope term didn't vary much across species (stat artifact?), but did vary between lakes

Can develop Hg index for Walleye Hg levels based on different fish species.

<u>Currently</u>:

- Early stages of analysis, testing data integrity.
- "Abnormal lakes"
- Other models of size dependent Hg.
- Want to look at lake specific effects on alpha and bets. Have looked at relationship to length-weight coefficients.

Fish Hg databases in New Hampshire

Bob Estabrook, New Hampshire Department of Environmental Services

Purpose of Database:

- Fish consumption advisories
- Decision makers for Hg reduction needs
- Scientists for research needs

Sources of data:

- NH Public Health Lab
- ITMP = International Toxics Monitoring Lab
- EMAP
- VT DECREASE = REMAP study
- TERL = Trace Elements Resource Lan
- ERI = Environ. Research Institute – University. of CT
- ACRES = Consulting firm for NE power…

1312 analyses from 987 lakes and reservoirs and 287 rivers and impoundments
Total Hg = 0.01-2.49

Data types:
Most = fillet, no skin; rest = fillet, skin, whole fish, and composites

Studies nested with in db:

- REMAP = 24 lakes
- Southeast lakes
- Long-term = 10 lakes

Results:

- 6-10” yellow perch – Mean Total Hg = 0.277ppm REMAP, 0.320 ppm SE lakes, 0.331 ppm all lakes
- Some yellow perch from impoundments w/fluctuating water levels, and lots from May Pond, which has high level of Hg deposition.
- Warm water fish had higher Hg levels than did cold-water fish.

Fish Consumption Advisory:

- 1 meal/month for sensitive population
- 4 meals/month for all others
- Changed to no consumption of large mouth bass, small mouth bass, and chain pickerel over 12”.

BIRDS AND MAMMALS

Assessment of Hg risk to New England’s wildlife

David Evers, BioDiversity Research Institute

- Identifying wildlife at risk
- Standardizing wildlife risk w/the Common Loon
- Development of a Wildlife Criteria Value (WCV)

Regional trends in Hg deposition and MeHg availability – West to East

Hg levels depend on

- Hydrology – water level fluctuations, flushing rates, reservoir age and origin
- Watershed and shoreline features
  - Watershed-lake surface ratio (Hg incre4ase with high ratio)
  - Watershed forestry practices (intense logging reduces vegetative/soil ability to trap Hg)
  - Wetlands produce more Hg than uplands
  - Coniferous vegetation produces 3x more Hg than deciduous
  - Mountain habitats appear to have high deposition rate

- Water Chemistry
  - Low pH, low alkalinity, high DOC, war waters create good mircohabitat for MeHg productivity
- Biology
  - Longer food chains increase MeHg levels

Species at risk from Hg exposure

- Higher trophic level freshwater piscivores
- Long-lived pelagic species feeding in off-shore waters
- Species downwind from point sources
- Inhabitants of montane habitats
- Inhabitants of urban estuaries

Examples: Bald Eagles, Common Terns, Belted Kingfishers, Black-Crowned Night-Herons, insectivorous birds (e.g.: Sharp-Tailed Sparrows, Barn Swallows, Cliff Swallows, Bicknell's Thrush).

Hot Spots – spatial analysis mapping

- Detected by USEPSA atmospheric deposition models
- Likely related to high Hg emissions from local municipal and hospital waste incinerators and coal-burning power plants

Risk Assessment:
Determine how much Hg exposure is too much

Loon = study species b/c:

- High trophic level, obligate piscivore
- Long-lived
- Documented individual and population level impacts from MeHg ingestion
- K-selected life history
- Complex and coordinated behaviors with in pair
- Mod-high sensitivity to stressors
- Logistically feasible – monitor color banded birds

Risk assessment study area in Rangeley Lakes area of ME: 43 lakes w/>180 loon territories

Hg does impact loons:

- Physiological
- Behavioral – decreased incubation time
- Increased lethargy

Population Level Impacts:

- Condition/Fitness
- Reproductive Success

Hazard assessment: NOAEL and LOAEL (Matrix risk level table)

Model: Population growth rate vs. productivity

NH = Case Study – decline in buffer population and productivity

Next step: Export the known dose of water column Hg/MeHg that impacts loons at the population level into a WCV

Summary:

- BRI fish and wildlife Hg databases total >4,000 points for the Northeast
- Establish 10-15 cm perch Hg equivalent >> basis for wildlife risk
- Construct spatially explicit WCV >> endpoint that can be used by policy makers
- Hg points are typically associated w/robust metadata sets and are relational.
- Loons as target indicator >> high resolution info on exposure and hazard assessment at a population level for much of the NERC study area

Biotic Hg information in New York

Nina Schoch, Adirondack Cooperative Loon Program

4 years loon data

lots of other information

- fisheries
- habitat
- water quality
- DECREASE
- ALCS (water quality)
- ALAP (volunteers)
- Darren Freshwater Inst.
- Citizens Lake Assessment Program

Mercury

- Charlie Driscoll
- Myearon Mitchell
- DECREASE
- NADP – MDN

Fish

- DECREASE
- SUNY ESF
- NYS DOH

Mustelids (mink, otter)

Loons

- ACLP
- McIntyre

Hg contamination in piscivorous wildlife in Quebec

Louise Champoux, Canadian Wildlife Service

Objectives:

- Document Hg levels in loons in regions of high Hg deposition and acidic deposition in Quebec

Data:

- Loon productivity
- Lake water chemistry
- Hg levels in loon blood, feathers, and eggs

Results:

- 82 loons on 24 lakes
- Repro success for 3 years for 16 lakes
- Hg levels in loons and fish
- 41% M and 15% F have blood Hg >3ppm
- 0% eggs w/elevated Hg
- Hg concentration in fish 10-15cm were primarily < 0.3ppm; species included yellow perch, pumpkinseeds…
- No real relationship between loon repro success and fish Hg levels determined yet

Georeferenced Access database

- >1000 lakes with info on water chem., taxa, Hg in fish, loons, etc.
- Canadian Lakes Loon Survey population monitoring
- Sportfish data w/subset of yellow perch data

Federal Mercury Initiative in Canada:

- numerous data sets about Hg

Common Loons: A Long-Term Mortality Dataset

Mark Pokras, Flo Tseng, Victoria Chow, and Deborah Brady, Tufts University

Causes of Loon Mortality:

- Aspergillosis – fungal respiratory disease, primarily affects immunosuppressed animals (stressed), affects ~18% loons
- Lead toxicity due to lead fishing tackle ingestion

Chicks (from hatching to fledging):

- Trauma
- Loon trauma
- Unknown
- Umbilical sac infections
- Predation

Immature (Prebreeding, have fledged, primarily on ocean)

- Aspergillosis
- …

Breeding Adult Loons:

- Lead
- Trauma
- Unknown
- Aspergillosis

Wintering Adult Loons:

- Unknown
- Infection
- …

Live Loon Project Objectives:

- Reference blood & biometric values for this species
- Understand loon demographics

Effects of Hg

- Affect many systems – subtle effects on reproduction, neuro, behavior, development
- Toxicity depends on form: metal, salts, vapor, organic

Total Hg vs. MeHg in NE Loons:

No correlation between liver wet wt total Hg and MeHg in loons.
Mean Hg levels higher than levels that see effects in other species

Aspergillosis incidence not related to Hg levels in loons

Conclusions:

- Human impacts major determinant of loon mortality in NE
- Need to determine synergistic effects of impacts on loons, e.g.: heavy metals
- In vitro testing of Hg and other impacts to deter synergistic effects (via cell cultures)

NEG-ECP Regional Mercury Action Plan

Mark Smith, Massachusetts Department of Environmental Protection

Hg Initiatives:

- Global
- Continental
- National
- Regional
- State
- Local

RMAP – Adopted in 1998
Goals:

- By 2003 – 50% reduction
- By 2010 – 75% reduction
- Long term – virtual elimination

Integrated comprehensive approach
Multimedia: air, water, land

Policy Drivers:

- Children most at risk
- Neurological endpoints
- Fish consumption advisory in all jurisdictions (large & small mouth bass, yellow perch, chain pickerel)
- Persistent in environment – intergenerational impacts
- "Cute and Cuddly" wildlife at risk
- Controllable local and distant sources that can be regulated (in-region = 60%, out of region = 40%)
    - Combustion sources (incinerators) = primary source

RMAP:

- Regional Task Force
    - Prioritize/coordinate implementation
    - Track and report on progress: biannual updates to commissioners; annual updates to Governs and Premiers
    - Share information
    - Leverage Resources
    - National/international advocacy
- Emission reductions
- Source reduction/waste management
    - Reduce/eliminate nonessential uses
    - Segregate and recycle
    - Regional models
    - Enhanced Hg collection efforts
    - Medical/dental P2 projects
- Outreach and education
    - Fish consumption advisories
    - Alternatives
- Stockpile Management
    - Safe management – retirement
    - Advocacy for Nat'l Retirement Strategy
- Research, Analysis, Strategic Monitoring
    - Support assessment of key technologies
    - Evaluation monitoring programs
    - Improve coordination of data management across region

MA Environmental Monitoring/Research Program

- Air deposition
- Emissions monitoring
- Fish, other biota, sediments
- Technology evaluations – dental amalgam separators
- Seasonal variation
- Long-term monitoring network
- Trophic level assessment

<u>Conclusions</u>

- Hg levels higher than previous studies
- No relationship to point sources with in region
- Regional Action Plan = key role in addressing regional Hg sources

New England ambient Hg monitoring network

Alan VanArsdale, U.S. Environmental Protection Agency

<u>Data Questions</u>:

- What are the seasonal patterns of Hg deposition with in the NE? Are they important from an ecosystem perspective?
- Are there significant year-to-year variations in Hg deposition with in the NE? Are there seasonal variations?
- What are the similarities and differences in the yearly and seasonal deposition patterns in the Northeast? Do these differences or similarities help explain patterns of mercury contamination in the Northeast?

- Are the seasonal, annual and spatial patterns of mercury deposition similar or different to those of other components of precipitation?
- Can differences in the concentration of atmospheric mercury explain differences in spatial and temporal patters of mercury deposition?

New England Atmospheric Hg Monitoring Network
- Coastal, inland, and mountain monitoring systems
- Urban & non-urban sites
- South to North & coastal to inland gradients

"Hg – Ozone Transport Area"
- – summertime events – see lots of Hg episodes
- – big storms

Lower wet deposition in fall, higher in summer. Urban sites rich w/Hg. More Hg deposition at Quabbin than in VT.

Dry deposition – regional events of Hg deposition in atmospheric in winter (minimal photosynthesis)

Concentration of Hg deposition affected by haze events – near coastal emissions

<u>MDM sites</u>: coastal sites - ~24% time see high Hg deposition. Deposition highest in summer, lowest in winter

Deposition at some times of year may be more biologically relevant than other times of year

Very different deposition gradients and #'s with in a site.
As move further south, amount of precipitation and amount of deposition better related, thus precipitation plays role in Hg deposition

Amount precipitation has increased over time in spring in coastal & inland sites, but at Hubbard Brook, have seen decrease in precipitation & stream flow and SO4 and NOx over time.

NHEERL Wildlife Research Demonstration Project: Methods to Assess Risks to Piscivorous Bird Populations

Diane Nacci and Peg Pelletier, U.S. Environmental Protection Agency

<u>NHEERL Wildlife Research Strategy</u>:
- Develop endpoints for risk assessments on population level
- Concentration Model evaluating impacts of multiple stressors on wildlife populations

Landscape patterns + individual responses >> population responses >> spatial context
>> predictions about populations based on landscape characteristics

<u>Loon Demonstration Project</u>:
- Addresses wildlife research objectives
- Develop methods applicable to other situations
- National interests in risks assoc w/Hg
- Availability of data

Organization of Loon Project:
- Characterize landscape
    - Develop data bases describing Hg and Wildlife distribution across environ
    - Include geo-referenced info on sp specific distributions

- Define stressors
- Estimate stressor-population effects
- Develop stressor-response models
    - Synthesize literature & on-going studies
    - Inter-species extrapolation (msr sp that can control & extrapolate to other species)
    - Habitat alteration effects (GIS analysis, spatial analysis, statistics)
- Population Projection Modeling (matrix models) to estimate population/ecological response to stressors
    - Stage-classified matrix model>> projections that describe the probability that a population will grow or decline in response to stressors or to fixed stressor over time
    - Identify what life history aspects have greatest influence on population responses (changes in reproduction have little effect on population, but change in adult survival greatly affects population, thus may want to direct management efforts to monitor adult survival
- Development of species specific genetic markers >> how some individuals come and go, what areas serve as sources and sinks
- Spatial Modeling: Patch, Meta-population models, individually based models
    - What are stressors that affects loons, and what is scale that is appropriate

Collaborative Mercury Research Network (Canada): Case study examining Hg in eastern Canada's mink and otter population

Doug Evans, Trent University

Trend in mink harvest have decreased in Ontario over last ~60 years. Possible environ impacts?

Mink die with in few months of diet of 0.3ppm MeHg and otter with in 0.2ppm

First study:

- Collected 600 mink and 800 otter for sampling – 40 otter and 20 mink analyzed for Hg
- Initial selection designed to measure spatial variation…

Hg as function of age – no older individuals found w/high concentration of Hg for both otter and mink

Age structure of population changes when have high Hg levels in food source (die at ~5 years, instead of living to 9-12 years)
MeHg = primary component of Total Hg in mink brains, but not in otters. Freshwater otters have higher concentration of Hg than do marine otters

<u>Canadian Collaborative Mercury Research Network (COMERN)</u>:
To understand and solve the Hg threat to Canadian communities and ecosystem health

- Many components
- Including evaluation of Hg in mink and otter
    - Test hypo that age structure is a function of Hg exposure
    - Examine other indicators for possible explanation of age structure
    - Expand baseline data on Hg in Canadian mink and otter
    - Examine DNA breakage in brain and liver specimens as a function of Hg at various study sites
    - Test hypo of differences in brain demethylation between species
- Sampling Protocol
    - Collect 30 animals of each sp at each of 3 areas – high and low sites
    - Necropsies
    - Total and MeHg
    - Se analysis
    - DNA strand breakage of tissues from selected animals

- May include captive animals or capture/recapture

Hg analysis – Overview and laboratory perspectives

Robert Taylor, Texas A&M University Trace Element Research Laboratory

Develop collaboration w/lab early on

- helps w/deciding how samples should be collected
- Prevent contamination of samples (e.g.: water)

Goals:

- Accuracy
- Precision
- Minimize “less than #’s”

Strategy:

- Homogenize sample:
    - Tissue, soils, and sediments
    - Retain volatile species (total Hg, MeHg)
    - Minimize contamination
    - Retain original composition (moisture, speciation)
    - Reduce particle size

- Subsample and prepare aliquot
    - Take a representative sample
    - Do NOT take all the sample
    - Sediment and tissue digestion for “cold vapor” analysis; water
- Analytical Methods
    - Sample digestion required: cold vapor atmospheric. absorption and fluorescence, ICP-MS
    - Sample digestion not necessary: INAA and pyearolysis atomic absorption

QA/QC – labs involved w/intercalibration studies have good QA/QC

Older Hg values may not be accurate by current standards

Feathers:

- Hg levels vary within feather – e.g.: Hg level in racchus less than in barbs
- Matters where sample taken with in feather and where feather located on body
- Contour feathers similar Hg concentration throughout feather

Decision support system for managing Common Loons in New Hampshire

Mark Brennan, Space Imaging and University of New Hampshire

Remote sensing, spatial data analysis
LPC – monitoring and management of NH loon population, and education of general public
-- 25 years of data on over 200 nest sites

Biological data collected on ~150 lakes/ponds

- territorial pairs
- unmated individuals
- reproductive success

Lake data:
- Physical: # acres, elevation, lat/long, shoreline length, depth, accessibility
- Chemical: pH, turbidity, chlorophyll
- Fish: species, loon presence
- Lake polygon layer (NH state plane NAD 83)

Territory Data:
- Territories (includes nest sites) identified on USGS 1:24,000 topo & sketch maps
- Territories digitized
- Territory locations confirmed using GPS

Loon Decision Support System Concentration (Relational Database):
- GIS layers + Lake Morphology, + Loon Biology Data + Lake Fishery Data >> Loon Management Queries>> Loon Management Decisions
- Additional data sets: Banding Data, Lead Toxicity Data, Egg Mortality Data, Hg Data

How to analyze data (what to do w/it?):
- E.G.: identify potential loon territories
- Tracking analysis using Arcview GIS to evaluate change over time of loon population in NH – territory occupancy
- GIS analysis using linked tables/related data bases

Accuracy Assessment:
- Need to understand where inaccuracies are with in datasets

Contact Info:
Mark Brennan
mbrennan@spaceimaging.com

Use of spatial analyst for assessing Hg risk

Wing Goodale and David Evers, BioDiversity Research Institute

GIS and Spatial Analyst: useful tool or dangerous misinterpretation of data?

Spatial Analyst = modeling method that interpolates between points to create a continuous gradient map

Three model types: inverse distance weighted, spline, kriging>>grid of "pixels"

Inverse Distance Weighted: Creates a surface that gradually changes between pts. Most appropriate for data that decrease w/influence as changes
- Low power: moderate values have more influence
- High Power: Each individual value has more influence
- Simple, doesn't mask outliers
- Appropriate on large scale

Search Radius:
- Variable
- Fixed: goes a certain distance out – doesn't interpolate if don't have data
- Complex and uses math function – potential to change output

Spline: uses a mathematical function that minimizes overall surface curvature >> general trends

Kriging:

- uses statistical relationship to create a surface instead of using value of each pt.
- Assumes that direction and distance of data important.
- 5 types of kriging
- appropriate when data is directional

Density of data important – more data >> better model
Scale important – make sure appropriate for analysis, management decisions…
Visualization tool, not data analysis tool

Data Standard: Georeferenced

- Decimal degrees for lat/longs (convert from degrees/minutes/seconds)
- GIS = Alberts equal area North America

Environment Canada's Acid Precipitation Monitoring Networks in Atlantic Canada

Tom Clair, Canadian Wildlife Service

Demonstration of CD-rom – map based approach
Good way to coordinate data – include pictures, maps, references, scan in old reports & make available for downloading…

Could also base it on type of data – e.g.: Hg, birds, mammals…

Mark Bernier = contact point/link for coordinating CD

Need to make policy decision re: how CD should be distributed…

Geographic extent: NYS to Newfoundland

BREAK-OUT GROUPS

DATABASES/COVERAGES

- Discuss how to best bring the databases together and their associated metadata that will be used for a map-based database that will be logically accessible (i.e., CD);
  - i. Consider CD w/metadata or description of data +/- different CD w/raw data.
  - ii. Include contact information w/metadata so people can request more data if needed
  - iii. Can group raw data into categories, so can still be interpreted even if raw data not included.
  - iv. Links to other programs (e.g.: mussels)

  -- May want to have more than one point of entry into CD – map based, species based…

Contributors should provide data to level that comfortable with. Need to decide if CD will be fully public. May need caveat on CD if data not yet published.

GIS COVERAGES NEEDED FOR RELATING TO HG DATABASE & "GROUP LEADERS" (Identify mercury databases and projects)**:**

DATABASES

- Air, deposition – Alan Vanarsdale & Steve Beauchamps
- Water & watershed – Tom Clair & Jamie Shanley
- Sediments & soils - Steve Norton, Andy Rencz & Neil Kamman
- Algae – Celia Chen
- Invertebrates – Celia Chen & Chris Pennuto
- Fish – Neil Kamman, Neil Burgess & Greg Mierle
- Birds/Herps - Dave Evers & Louise Champoux
- Mammals – Doug Evans &Drew Major

COVERAGES

- geology
- paleohistory
- terrestrial - soils
- lake characteristics
- watershed/shoreline habitat

Working Group Goals:

- Identify needs
- Identify obstacles
- Identify objectives for each group
- What resources needed to crunch data & # people to hire to help w/database development

DATABASE:

1. Description of project (why data collected) – provides "comfort level" that researcher willing to contribute. Summary of dataset
2. Description of database (QA/QC, etc): how parameters chosen and identified
3. Database – georeferenced, waterbody id #
   - Ideally standardized, but will probably need to standardize later – database will help standardize future research and datasets

Group leaders should coordinate w/Peg Pelletier – EPA!

DEADLINES:

- "Flyer" done by Dave and Tom by **Decrease 15, 2001** – provides objectives of NERC db, long-term goals, data use statement/policy…
- Template design done and example of how to submit data by end of **December, 2001**
- Submit Description of project and description of database by end of **Feb, 2002**
- Submit Database by end of **April, 2002**
- First draft of CD by end of **August, 2002**

FIRST YEAR OBJECTIVE: freshwater systems. Later can add other systems (marine).
However, Alan Vanarsdale would like to include information on estuaries & marine interactions with freshwater sources. But, scope too big for time and budget limits of current framework

PROPOSAL FOR 2002

- Hire someone to coordinate fish and other databases
- Neil Burgess, Neil Kammon, Drew Major, Greg Mierle, and Bob Estabrook will prepare proposal

- Person could be housed at USFWS – space available
- Person should be an employee of a NGO, not a government agency

Relational DB QC/Mapping logistics:
  - Coordinate and proof datasets – will need help from local level to proof data
  - Points and polygon analysis? Through GIS, DeLorme plots
  - Problems matching US & Canadian topos – standard sizes different (1:25,000 vs. 1:24,000)
  - EPA NHEERL may be able to help & coordinate **** define scope of need and send to Diane Nacci ASAP!**
  - Go to federal mapping agency (USGS, Canadian GS) and get overview maps first

Waterbody table:
  - Develop a common/standardized waterbody table that has "official" lake characteristics for everything.
  - Lat/longs based on centroid of waterbody.
  - Need to decide what coordinates to locate waterbody with – lat/longs, UTMs…
  - Each group provides list of waterbodies that working on & tie them to already established GIS layers
  - Scale issues (e.g.: 1:100,000), coordinate issues…
  - Need to decide extent of area to use & coordinate data from – how far up into Canada to go

Phase 2 –NERC Proposal:
- Data assimilation, crunching, and producing maps
- Identify hypotheses and projected synthesis papers
  - Hg pathways
  - Landscape patterns
  - Standardizing biotic Hg levels into a common currency
  - Watersheds – links across region
  - "Super paper" – across all media describing where connections and disconnections are (similar to Bioscience paper for acid rain)
- Data interpretation and analysis

Phase 3 – NERC Proposal:
- Manuscript preparation and submission of synthesis papers

NERC Budget ~$100,000/year
- ~35K for workshop
- ~$65 for staff support

NEW REFERENCE:

Mercury In The Aquatic Environment: A Review Of Factors Affecting Methylation. *Critical Reviews in Science and Technology*. 31(3): 241-293. 2001