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Katharine C. Parsons, Stephanie R. Schmidt, and Jan E. Yacabucci: ***Chemical Residues in Cormorants from New York Harbor***

Wing Goodale: ***Contaminants in common loons (Gavia immer) compared to 22 other species of birds, Maine U.S.A.***

Mark Pokras: ***Learning from Loons: an example of Conservation Medicine linking animal, human & ecosystem health***

Amanda Bisol, Lisa Murphy, Erica Miller: ***Analysis of the Effects of Lead and/or Mercury Toxicity in Wild Avian Species in the Mid-Atlantic Tri-State Region***

Peter Frederick, Ashley Campbell, Rena Borkhataria, Nilmini Jayasena: ***Survival consequences of chronic exposure of White Ibises to low concentrations of dietary methylmercury.***

David Evers***: Tracking changes of environmental mercury loads through waterbirds***

Waterbirds as Indicators of Environmental Health

Session Leader: David Evers, BioDiversity Research Institute

Session Period: 9:30 to 3:40 on Friday, Nov. 6, 2009

Background: Marine and freshwater ecosystems are often under pressure from anthropogenic stressors that are challenging to evaluate. These stressors may originate from various circumstances, including reallocation of natural elements at toxic levels (e.g., mercury, sulfur and lead), environmental enhancement for naturally occurring microorganisms (e.g., avian influenza, botulism and cyanobacteria), and catastrophic (e.g., oil spills) and purposeful (e.g. emerging chemicals and organic pesticides) releases of synthetic compounds. Changing climate conditions may exacerbate many of these stressors through undescribed synergies. As an example, thawing of vast acreages of permafrost may volatilize thousands of years of mercury deposition at a time when landscape-level hydrological changes increasingly create enhanced wet-dry cycles – instrumental methylating environments for sulfur-reducing bacteria. Acidic (e.g., northeastern North American lakes) and sulfur-enriched (e.g., estuaries) environments and areas near rapidly increasing mercury emission centers (e.g., China) may be especially vulnerable to future increases in methylmercury toxicity.

This session describes the use of waterbirds as indicators of environmental health and integrity. Some species, such as the Common Loon (*Gavia immer*), are regularly used because of existing detailed information on key demographic and toxicological attributes. Loons are now formally used as monitoring endpoints for regulatory purposes (e.g., mercury emissions) and the loss of loon-years has been economized into restoration dollars (e.g., oil spills). Both are novel approaches that should be applied to other waterbirds and stressors. Invited speakers will present details of their own work, often with an overview of their target issue.

Avian influenza virus and West Nile virus illustrate how alteration of the environment can promote avian disease transmission

Samantha Gibbs
Division of Migratory Bird Management, US Fish and Wildlife Service, Arlington, Virginia

Avian influenza virus (AI) and West Nile virus (WNV) both demonstrate how the environmental impacts of land use trends and agricultural trade practices influence disease transmission in wild birds. In their historical geographic ranges, these viruses caused little to no clinical disease in wild birds, which serve as the reservoir species. Expansion from the historical ranges and establishment of the viruses in new areas, however, has brought with it unexpected morbidity and mortality in wild bird populations. This expansion, and subsequent establishment, of AI and WNV has been assisted through human alterations of the environment which benefit hosts or vectors.

Current agricultural trade practices, especially in Southeast Asia, have led to the amplification of AI viruses in the domestic bird population, increased interactions occurring between wild and domestic birds, led to the large scale movement of wild birds, and placed evolutionary pressure on the circulating viruses. In the case of WNV, amplification and transmission of the virus in North America has been increased and maintained by creating man-made improvements to habitat for the mosquito vectors while providing food and roosting resources in that same environment for wild birds. Investigation of

both diseases illustrates how wild birds can serve as sensitive indicators of environmental health by pinpointing these factors affecting patterns of disease transmission.

Overview of the Impacts of Harmful Algal Blooms on Waterbirds

David M. Kidwell and Marc Suddleson
NOAA, Center for Sponsored Coastal Ocean Research, Silver Spring, Maryland

Harmful algal blooms (HABs) – algal species which cause harm to humans and the environment through toxin production and excessive growth – are a national concern affecting an increasing number of coastal ecosystems with virtually every state now reporting recurring blooms. Impacts have included the loss of coastal habitats, shellfish bed and beach closures, and illness and mortality of marine species. HAB impacts on waterbirds have been documented on both coasts for decades. Recent significant blooms of the diatom, *Pseudo-nitzschia* spp., in southern California have been linked to strandings and mortality of brown pelicans (*Pelecanus occidentalis*) and Brandt's comororants (*Phalacrocorax penicillatus*). These birds often exhibited symptoms of neurological impairment that have been associated with the toxin domoic acid. Similarly, intoxication of brevetoxins from blooms of the dinoflagellate, *Karenia brevis*, off the west coast of Flordia have led to similar incidences with double-crested cormorants (*Phalacrocorax auritus*) and other piscivorous birds. In addition to toxicological effects, HABs have been shown to impact birds through other mechanisms. For example, a 2007 a bloom of the dinoflagellate, *Akashiwo sanguine*, resulted in a sea foam that impacted the feathers and waterproofing of northern fulmars (*Fulmarus glacialis*) and other sea birds off central California. Beyond these basic correlations of avian impacts and HABs, relatively little is known about the direct and indirect effects of HABs on waterbirds, particularly at the population level. This talk will provide an overview of HABs in the US and an overview of their impacts to waterbirds through these and other examples.

Botulism in the Great Lakes: using a novel approach to track disease impacts on bird populations

Amy McMillan
Buffalo State College, Buffalo, New York

In the last decade thousands of waterbirds have died from Type E botulism poisoning in the Great Lakes. The impacts of botulism are especially severe during fall migration, when many waterbirds stage on the Great Lakes during their flight south. Common Loons are particularly hard hit; their fall migration corresponds to lake turnover, the time when botulism toxin seems to be most available in fish and invertebrates. Since it was recognized in 1999, it is estimated that botulism poisonig has killed 500 to more than 2,500 loons each year. This study was undertaken to determine which loon populations were being impacted by botulism deaths and whether we could track these impacts using population genetic assays of dead birds. Between 2001 and 2006, feather or muscle tissues from > 250 dead loons were collected along the shores of Lakes Erie and Ontario and analyzed at five polymorphic microsatellite loci. Genetic analysis indicates that loons dying from botulism on Lakes Erie and Ontario are originating from breeding sites directly north of these lakes. These birds are genetically very different from loons breeding both west and east of the Great Lakes. Over the course of the outbreak, however, genotypes have not changed in dead birds. These results will be considered as a case study in understanding disease and other environmental impacts on ecosystem health. Climate change and invasive species have played a critical role in this disease outbreak and will also be discussed.

Projected Impacts of Sea-level Rise on the Population Size of Salt-Marsh Breeding Birds within the Chesapeake Bay Region

Michael Wilson, Bryan Watts
Center for Conservation Biology, College of William and Mary & Virginia Commonwealth University, Williamsburg, Virginia

Because of their low position on the landscape, salt marshes will be one of the first habitats consumed by rising seas. Salt marshes play a critical role in the life cycle of a broad community of birds, particularly for species that rely exclusively on marsh habitats. We projected the impacts of sea-level rise on the population sizes of breeding marsh birds in the Chesapeake Bay region over a 100 yr period using available data on bird density and distribution. Sea-level rise of 0.39 m reduced marsh bird populations 35-42% for the Clapper Rail, Virginia Rail, Willet, Marsh Wren, and Seaside Sparrow, while a 1-2 m rise reduced these populations up to 80%. Sea-level rise of 0.39, 1 and 2 m reduced habitat available for Black Rails and Saltmarsh Sparrows by 51%, 90% and 99% respectively. Accelerated rises in sea level will result in significant losses in marsh habitats and catastrophic declines in many marsh-bird species including possible extirpation of species that rely on high marsh patches.

Habitat Health, Ptilochronology and Waterbirds: A Tale of Two Estuaries

Charles Clarkson
University of Virginia, Charlottesville, Virginia

The use of focal species is a growing trend in conservation and management. In coastal-marine environments, bioindicators have been identified as the most ecologically relevant focal species for guiding coastal monitoring programs. Colonial waterbirds have long been used as bioindicators due to their intimate connection with the hydrologic regime and central place foraging at breeding locations. Population-level observations are frequently used for monitoring the health of near-shore habitats utilized by waterbirds, however these data are often limited to indicating that change has taken place and lend little predictive power to causality. Individual-level observation may serve as a more useful tool for identifying the proximate factors leading to population-level fluctuations. Attributes of the individual that can accurately represent the threat associated with change are useful bioindicator tools and, when coupled with population-level presence and absence data, may serve useful for ecosystem monitoring. I propose the use of ptilochronology to determine the nutritional health of nestling waterbirds at two coastal locations experiencing drastically different disturbance regimes. When coupled with nest-site observations, ptilochronology may accurately reflect local foraging habitat health and further strengthen the use of waterbirds as bioindicators.

Monitoring of Exposure to Contaminants in Two Penguin Species Using Dried Blood Spots in the DABSE Project

Alan Shlosberg[1], Wilson Rumbeiha[2], Kurunthachalam Kannan[3], Andreas Lehner[2], Tertius Gous[4], Jonas Bonnedahl[5], Olga Cuneah[1]
[1]Kimron Veterinary Institute, Bet Dagan, Israel, [2]Michigan State University, Michigan [3]Wadsworth Center, New York, [4]SANCCOB, Cape Town, South Africa, [5]Kalmar County Hospital, Kalmar, Sweden

Manifestations of ill-health, abnormal behaviour, a reduction in population or poor breeding success of a wildlife species may warrant an investigation of whether environmental exposure to contaminants may be the cause. We do such analyses using dried blood spots (DBS), which has several advantages for field work, storage and dispatch. Using DBS, we are developing a Database for Avian Blood Spot Examination (DABSE), which will detail the degree of exposure of wild birds, initially to contaminants. DABSE will allow comparison between "normal values" in healthy birds and exposure values of the same species under investigation.

The toxicant component of DABSE is quantitated at the low ppb level. As these analyses are invariably very costly, an effort has been made to lower these charges and so enable more testing, by quantitating marker compounds, which are invariably found in birds' blood at the highest concentration of all the constituents in that group. The toxicant groups that are being tested comprise:- a) Elements - As, Cd, Hg, Pb, Se, Tl; b) Chlorinated hydrocarbon insecticides, markers being βHCH, DDT, DDE, and oxychlordane; c) Polychlorinated biphenyls (PCBs), the marker being congener 153; d) Polybrominated biphenyls (PBBs), the marker being congener 153; e) Polybrominated diphenyl esters (PBDEs), the marker being congener 47; f) Perfluorinated compounds (PFCs), the markers being perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). Results will be presented from healthy African penguins (*Spheniscus demersus*) and Magellanic penguins (*Spheniscus magellanicus*), 2 of the 12 of 17 penguin species that are experiencing population declines.

Polychlorinated biphenyls, dioxins, furans, and organochlorine pesticides in belted kingfisher eggs from the upper Hudson River basin, New York, 2004.

Thomas Custer, Christine Custer, Brian Gray
USGS, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin

Nesting belted kingfishers (hereafter kingfishers, *Ceryle alcyon*) were studied on the Hudson River near Fort Edward, NY south to New Baltimore, NY and three nearby river drainages in 2004. Concentrations of 28 organic pesticides, 160 polychlorinated biphenyl(PCB) congeners, and 17 dioxin and furan (PCDD-F) congeners were quantified in kingfisher eggs. The pattern of organochlorine pesticides and PCDD-F congeners did not differ significantly between 14 eggs collected on the Hudson River and 5 eggs collected on three other nearby rivers. In contrast, the pattern of PCB congeners in eggs collected on the Hudson River differed significantly from the other rivers. The differences in patterns of PCB congeners were associated with a higher representation of lower-chlorinated congeners on the Hudson River than the other rivers. Concentrations in the sample egg collected at each nest were compared to nest survival (the probability of at least one egg hatching in a clutch) and egg success (the proportion of eggs hatching in a clutch if at least one egg hatched) of the remaining eggs in the clutch. Models that predicted nest survival and egg success as functions of contaminant levels were poorly distinguished form models that presumed no such associations. The conclusions and opinions presented here are those of the authors; they do not represent the official position of any of the funding agencies, the Hudson River Trustees, or the United States government.

Chemical Residues in Cormorants from New York Harbor

Katharine C. Parsons, Stephanie R. Schmidt, and Jan E. Yacabucci
Manomet Center for Conservation Sciences, Manomet Massachusetts

Double-crested Cormorant (*Phalacrocorax auritus*) recolonized New York Harbor in the mid-1980s following persecution and local extirpation occurring during the 19th and 20th centuries. Reproductive success in the 1990s was 30% less than highest levels recorded in North America. We investigated toxicological causes of sub-optimum reproductive success and developed benchmark information on exposure and effects to position the species as a potential bioindicator for toxics management efforts in the NY-NJ Harbor Estuary. We assessed productivity endpoints in marked nests at three study sites in coastal New York including inner and outer harbor sites, and a reference site in eastern Long Island. Tissues sampled for evaluation of residue levels included eggs, and blood and feathers of nestlings. Laboratory analytes included metals, polycyclic aromatic hydrocarbons (PAHs), chlorinated pesticides, polychlorinated biphenyls (PCBs), dioxins and furans. Nestling survival was lowest at the inner harbor site. Cormorant offspring at the inner harbor site had significantly higher levels of cadmium, PAHs (eggs), DDT, dieldrin and other chlorinated pesticides, PCB congeners, dioxins (including 2,3,7,8-tetrachlorodibenzo-p-dioxin TCDD) and furans than the reference site. Levels detected in New York Harbor cormorants were above toxic effects thresholds for PAHs, DDT, PCBs, and TCDD.

Contaminants in common loons (Gavia immer) compared to 22 other species of birds, Maine U.S.A.

Wing Goodale
BioDiversity Research Institute, Gorham, Maine

In 2007 and 2008 we measured 192 contaminants in common loon (Gavia immer) eggs collected from 11 locations in Maine, spanning the entire state. We compared these results to contaminant levels in 61 egg-composites of 22 other species of Maine birds, representing seabirds, shorebirds, wading birds, raptors, and passerines. We analyzed the egg composites for mercury (Hg), polychlorinated biphenyls (PCB), polybrominated diphenyl ethers (PBDE), perfluorinated compounds (PFCs), and organochlorine pesticides (OCs). We detected all of these contaminants in our loon samples. Out of the 23 species tested, common loon eggs ranked seventh highest in contaminant load, with Atlantic puffin (Fratercula arctica), piping plover (Charadrius melodus), belted kingfisher (Ceryle alcyon), great black-backed gull (Larus marinus), peregrine falcon (Falco peregrines), and bald eagle (Haliaeetus leucocephalus) having higher contaminant levels; Virginia rail (Rallus limicola) and willet (Catoptrophorus semipalmatus) had the lowest levels. Out of all species tested, loons had the highest Hg levels and six of the eggs had PFC levels above an adverse affects threshold in chickens. These results demonstrate that historical and emerging chemicals of concern are both persistent and pervasive in Maine.

Learning from Loons: an example of Conservation Medicine linking animal, human & ecosystem health

Mark A. Pokras
Wildlife Clinic & Center for Conservation Medicine, Tufts University, Cummings School of Veterinary Medicine, N. Grafton, Massachusetts

Conservation medicine examines the linkages among the health of people, animals and the environment. Few issues illustrate this approach better than an examination of lead (Pb) toxicity. Since 1987, over 1000 common loons found dead or moribund have been examined as part of a New England wide study. Results confirm that much summer loon mortality is due directly or indirectly to human activities on breeding lakes. Heavy metal (lead) toxicosis from ingested sinkers and jigs has been shown to be the major cause of mortality in adult birds during the breeding season. Angling and shooting sports continue to deposit thousands of tons of Pb into aquatic environments each year. The magnitude of these problems, efforts to protect loons and other wildlife and the availability of non-toxic alternatives will be addressed.

Analysis of the Effects of Lead and/or Mercury Toxicity in Wild Avian Species in the Mid-Atlantic Tri-State Region

Amanda Bisol[1], Lisa Murphy[1], Erica Miller[2]
[1]University of Pennsylvania School of Veterinary Medicine, Philadelphia, PA, United States, [2]Tri State Bird Rescue and Research, Inc., Newark,, Delaware

Lead (Pb) and mercury (Hg) are heavy metals known to be major pollutants in the environment and to have negative effects on wildlife ecosystems. This study provides a retrospective analysis of the Pb and Hg test results of wild bird patients from the mid-Atlantic region by evaluating species tested, entry dates, outcomes, and threshold levels. These test results were generated at the New Bolton Center Toxicology Laboratory from whole blood samples from patients at Tri-State Bird Rescue and Research, Inc. in Delaware using atomic absorption spectrometry. The records analyzed date from January, 1997 through December, 2007. During that time period 562 patients were tested for Pb, and 218 of these birds were tested for Hg. This encompasses 41 species from 12 orders. The birds came from locations within 6 states: MD, PA, NJ, DE, VA, and NY. ArcGIS® was used to analyze data geographically and to look for potential locations of heavy metal environmental contamination. Specific regions were noted as having high Pb contamination. Of the birds tested, 23.5% had >0.20ppm Pb blood wet weight levels, requiring treatment. The Hg positive value used was >0.30ppm blood wet weight and 56% of the birds tested had

levels greater than this. One main finding of this study showed that 69% of birds with >0.20ppm Pb blood wet weight concentration entered the clinic from November through March. These dates are significant as they denote the start of hunting season where more Pb shot is available for consumption in the environment.

Survival consequences of chronic exposure of White Ibises to low concentrations of dietary methylmercury.

Peter Frederick[1], Ashley Campbell[2], Rena Borkhataria[1], Nilmini Jayasena[1]
[1]University of Florida, Gainesville, Florida, [2]Florida Atlantic University, Boca Raton, Florida

Methylmercury (MeHg) is known to cause neurotoxic effects, reproductive impairment, immune function impairment, and endocrine disruption. However, it is unclear how cumulative effects of MeHg affect survival, and few experimental studies exist. We experimentally exposed White Ibises (Eudocimus albus) to chronic, low concentrations of dietary MeHg from 90 d of age to 3 – 4 yrs of age in a large free-flight aviary. Dietary levels were 0, 0.01, 0.05 and 0.3 ppm MeHg ww. At an age of 3 – 4 yr, adults were fed food not containing MeHg for a period of 3 months, and then soft-released to the wild using a release site where abundant food and safe roosting was provided, within 5 km of prime breeding habitat. Individually marked birds were then resighted at the release site and at large communal roosts nearby over a period of 3 months (140 birds, 25 recapture intervals). We used recapture analysis (Program Mark) to examine the effects of time, sex, age, and MeHg treatment group on survival. Models balancing fit and parsimoniousness indicated time explained survival well. An interactive effect of MeHg treatment group and time on resight probability was indicated in one of the less parsimonious models. These results suggest that effects of chronic exposure at these levels do not result in permanent impairment severe enough to affect survival. However, since these birds had been depurated for 3 months prior to release, we have not tested whether animals exposed currently to MeHg at these levels would show impaired survival.

Tracking changes of environmental mercury loads through waterbirds

David Evers
BioDiversity Research Institute, Gorham, Maine

Global cycling of available environmental mercury (Hg) loads is in flux. The remobilization of Hg through human activities is responsible for much of this change. In response, regulatory policies for Hg emissions and effluents at multiple geographic scales are happening or are imminent. Because the relationship of Hg deposition and ecological response is challenging to predict through traditional regulatory metrics such as air, sediment and water, high trophic level biotic indicators are needed to directly measure changes in environmental loading. Waterbirds, particularly the Common Loon, are increasingly acknowledged as suitable indicators for measuring environmental health. The Common Loon is one of the few bird species to be used for regulatory monitoring needs. The use of this species reflects an in-depth knowledge of Hg exposure profiles across North America, known adverse effect levels using reproductive endpoints, and the compilation of demographic information based on >4,000 uniquely marked individuals over the past 20 years that provides key variables for modeling such as site fidelity, population age structure, and migration connectivity. National Hg monitoring programs that include the Common Loon are happening in Canada and are proposed for the United States.