

# Endocrine-related effects in wildlife from the Chesapeake Bay watershed: a review

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# Objectives

- Provide an updated summary of available data/studies related to endocrine disruption in wildlife species in the Chesapeake Bay watershed
- Identify monitoring and research gaps

# Background

- Past 10 years, two major reviews of data and literature related to the levels and the effects of contaminants in Chesapeake Bay wildlife
  - Rattner, B. A., and McGowan, P. C. (2007). Potential Hazards of Environmental Contaminants to Avifauna Residing in the Chesapeake Bay Estuary. *Waterbirds* 30(sp1), 63-81
  - US EPA, USGS, and USFWS (2012). Toxic Contaminants in the Chesapeake Bay and its Watershed: Extent and Severity of Occurrence and Potential Biological Effects



# Rattner and McGowan 2007

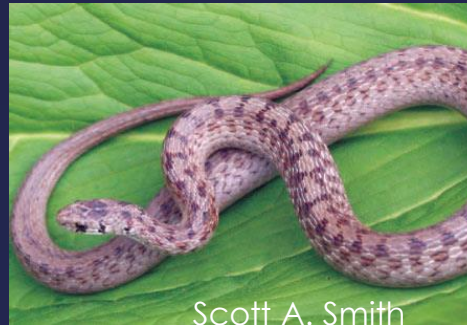
- Reviewed research published 1988 - 2006
- Birds residing in Chesapeake estuary and nearby coastal barrier islands
- Data on contaminant levels and effects focused on most industrialized parts
- Other regions, particularly the more agricultural areas, lack sufficient studies
- Very limited information is available on emerging contaminants and on biomarker or bioindicator responses in birds from CB watershed

# US EPA, USGS, and USFWS (2012)

- Summarized information on the extent and severity of occurrence of toxic contamination in the Bay and watershed
- Only limited data available on residue levels in wildlife for many classes of contaminants
- Even less information published on possible sub-lethal effects, particularly ED-related
- Large data gaps in understanding extent and/or severity of effects of multiple groups of contaminants with known or suspected endocrine effects
  - dioxins and furans, current use pesticides, pharmaceuticals, household and PC products, flame retardants, and biogenic hormones
- Limited available data concentrated primarily on the estuary and major tributaries

# Targets

- Birds
- Amphibians
- Reptiles
- Mammals



# Databases

- Google, Pubmed, et al.
- Contaminant Exposure and Effects-Terrestrial Vertebrates database (CEE-TV-USGS)
- Non-profit, university reports
- Theses/Dissertations
- Government reports
- Field and controlled studies\*





# ED vs. not ED

## ED

- Hormone levels
- Steroidogenesis-related endpoints
- Reproductive parameters
- Egg Shell thickness
- Behavior
- Fecundity
- Sex ratio
- Histology (gonads, thyroid, adrenal)
- Secondary sexual characteristics
- Sexual development & metamorphosis
- Immune endpoints
- Factors along the HPG, HPT and HPA feedback pathways
- Growth or somatic indices

## Not ED

- Only chemical residues
- Clinical observations of toxicity
- Only oxidative stress
- Only CYP450-*monooxygenase activities (EROD et al.)*
- Other non endocrine-related biomarkers
- Only population counts



# Birds



- Since 1973, 21 studies examined endocrine-related endpoints
  - 6/21 from the South River, VA Hg site
  - 12/21 examined OCs and other POPs
  - 2/21 examined effects of Pb
  - 1/21 examined acidification



USGS

# Birds - Mercury

- Female tree swallows (TS) in contaminated areas produced fewer fledglings (Brasso et al. 2008)
- No effect on hatching success (TS) (Taylor & Cristol 2015)
- Nestling sex ratios shifted towards female – TS, belted kingfisher, and eastern bluebird (Bouland et al. 2012)
- Female TS from the Hg-contaminated sites had a weaker PHA response (Hawley et al. 2009)
- Adrenocortical responses, plasma T3 and T4 suppressed in TS nestlings (Wada et al. 2009)



Hagley Museum/DuPont Product Collection

# Birds - POPs



- No apparent large-scale effects of OC pesticides or BFRs on osprey productivity (Lazarus, 2015)
- No effects on egg laying or hatching success on TS from Anacostia (Lohnes, 2006)
- Bald eagle productivity at NSF Indian Head, MD = VA side of Potomac (Mojica and Watts 2011)
- DE, DDT, and Total PCBs negatively correlated with eggshell thickness in peregrine falcons (Clark et al. 2009)
- NS relationships between OCs in eggs and hatching, fledging, or overall reproductive success of black-crowned night herons in Baltimore Harbor (Rattner et al, 2001)



# ED in Birds

- Multiple field studies on PCB contamination – varied results, possibly because of differences in susceptibility, congener profiles etc.
- Eurasian dippers at urban sites had poorer nestling body condition, changes in nestling thyroid hormone homeostasis, and altered brood sex ratios, with no overt effects on nest productivity (Morrissey et al. 2014).
- Wild European starling nestlings exposed to prey from percolating sewage treatment beds had impaired growth and immunological function (Markman et al. 2011)

# Avian Research Gaps

- Location – no systematic investigation of specific endocrine-related endpoints across multiple locations and land uses
- Limited endpoints have been examined – productivity and hatching success most common
  - explicit effects on egg laying, hatching, and successful fledging are only rarely altered substantially in response to contaminant exposure (Morrissey et al. 2014)
- Species differences

# Amphibians



- 7 studies examining endocrine-related effects in CB
  - 4 studies at Hg contaminated South River, VA
  - 3 studies of acidified ponds and streams in PA, MD, WV





# Amphibians - Results



- American toads maternally transferred Hg to eggs – negative relationship between Hg and % viable hatchlings but 21% greater metamorphic success in larvae from Hg-exposed mothers (Bergeron, 2011a)
- Maternal exposure to Hg caused ↓ growth, ↑ duration of metamorphic climax, and ↓ swimming performance in American toad larvae (Bergeron, 2011b)
- Significant negative effect of Hg on speed, responsiveness and prey capture ability of two-lined salamanders (Burke 2010)
- American toads from Hg-exposed mothers weighed 14% less than those from reference mothers, took 6% longer to complete metamorphosis and had 2.5 times the prevalence of spinal malformations (Todd et al. 2011)

# Amphibians - Results

- No significant effect of environmental pH on baseline CORT or handling-induced CORT levels in dusky salamanders (Woodley et al. 2014)
- Acidification (pH 4.2) affected wood frogs (↑ time to metamorphosis), Jefferson salamanders (mortality), but not spotted salamanders (Rowe et al, 1992)
- Baseline and stress-induced corticosterone concentrations were negatively related to pH and positively related to nitrate in Jefferson's salamander (Chambers 2013)





# ED in Amphibians

- Gonadal intersex, feminization of secondary sexual characteristics and altered sex hormone concentrations have been observed in wild amphibians at sites contaminated by agricultural pesticides across Italy, South Africa and the mid-western USA, parts of Florida, Ontario and Michigan, but exact chemical causality remains uncertain (European Environment Agency 2012).
- Murphy et al. (2006) found no consistent relationship between agricultural contaminants (including atrazine) and the incidence of hermaphroditism or testicular oocytes
- The number of abnormalities and frequency of intersex gonads increased with agriculture dose-dependently (McCoy et al. 2008)

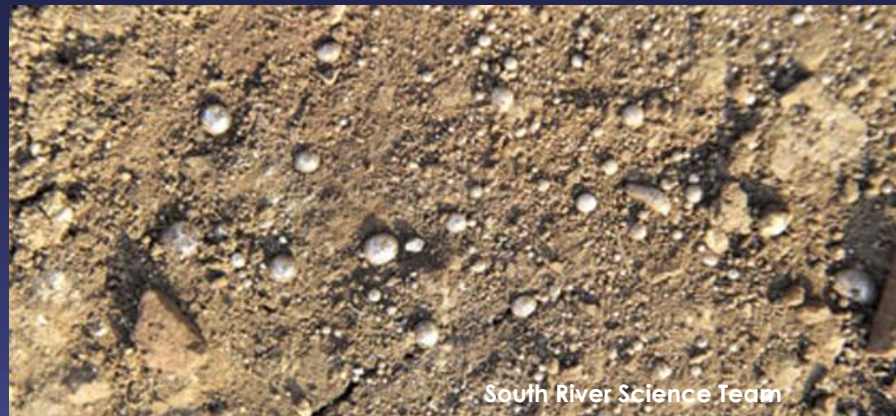
# Gaps?

- Location – no systematic investigation of specific endocrine-related endpoints across multiple locations and land uses
- Limited endpoints
- Species differences

# Reptiles



- 3 studies identified in Chesapeake Bay watershed
- All conducted along the South River, VA



# Reptiles- Results

- Significant effect of maternally transferred Hg on foraging- decreased motivation to feed with increasing Hg and negative effects on strike efficiency in northern watersnakes (Chin et al. 2013a)
- Little evidence of adverse effects of Hg on reproductive output and embryonic survival of northern watersnakes (Chin et al. 2013b)
- Hg in snapping turtle eggs was negatively correlated with hatching success, due to increased egg infertility and embryonic mortality (Hopkins et al. 2013)





# Non-CB studies



- Cape Cod, MA (Kitna et al 2006) – male painted turtle from organic and inorganic waste contaminated pond had ↓ sperm counts, testicular weights
- Pendleton, SC (Irwin et al. 2009) – female painted turtles from ag ponds had ↑ plasma VTG than controls
- CA (Meyer et al. 2014) – Hg exposure in turtles was negatively correlated with plasma T3 and positively correlated with T4



# Gaps?

- Location – no systematic investigation of specific endocrine-related endpoints across multiple locations and land uses
- Limited endpoints
- Species differences

# Mammals

- 3 studies identified in Chesapeake Bay watershed
- 2 from the South River



# Mammals-Results



- Muskrats near lower Elizabeth River had lower body weights, lower mean fat indices, increased adrenal weights, and increased parasitism and disease (Holbrook et al. 1993)
- Higher Hg in blood and fur in big brown bats but no differences in adrenocortical response (Wada et al. 2010)
- No significant differences in neurochemical biomarker responses between little brown bats from contaminated and un-contaminated sites (Nam et al. 2012)

# Mammals

- There are surprisingly few documented examples of ED in wild mammals. It is unclear whether this reflects the fact that ED is rare in wild mammals, or whether it is simply a reflection of how far and few between these studies are. (EEA, 2012)

# Gaps?

- Location – no systematic investigation of specific endocrine-related endpoints across multiple locations and land uses
- Endpoints
- Species differences

# Questions/Discussion

- Missing studies?