Waterbird Mortality Research Issues Workshop

Upper Mississippi River National Wildlife & Fish Refuge
La Crosse, WI

16 - 17 March 2010

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Final Workshop Summary

Workshop organized by: US Geological Survey (USGS); IUCN/SSC Conservation Breeding Specialist Group (CBSG).

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Executive Summary

Executive Summary

Background

Since 2002 major mortality events have been observed during spring and fall migration in several species of waterbirds, particularly the lesser scaup (*Aythya affinis*) and American coot (*Fulica americana*), in the Upper Mississippi River National Wildlife and Fish Refuge (UMR) and surrounding areas. Wildlife pathologists at the U.S. Geological Survey's (USGS) National Wildlife Health Center determined that the cause of these deaths is heavy infection with three trematode parasite species (*Cyathocotyle bushiensis*, *Leyogonimus polyoon* and *Sphaeridiotrema globulus*), leading to anemia, shock and death. Birds acquire the large number of parasites through feeding on exotic faucet snails (*Bithynia tentaculata*), which serve as the first and second intermediate host for the trematodes and, in the case of *L. polyoon*, certain infected aquatic insects. Evidence suggests that the snails, and trematodes, are expanding their distribution westward from northeastern U.S. into the Midwest states. Massive die-offs not only may have consequences for waterbird population viability, but significantly impact refuge staff time and resources (for monitoring, pickup, disposal and outreach) and raise health concerns from waterfowl hunters.

In response to this situation, USGS proposed a workshop to bring together wildlife managers and researchers involved in various aspects of the problem. At the request of USGS, this workshop was designed and facilitated by the International Union for the Conservation of Nature (IUCN) Species Survival Commission's (SSC's) Conservation Breeding Specialist Group (CBSG). The workshop was held 16-17 March 2010 at the UMR office in La Crosse, Wisconsin, gathering 21 researchers and wildlife managers from Wisconsin, Minnesota, Iowa and North Dakota to share current research efforts and findings through a series of summary presentations covering the breadth of knowledge related to this parasite-snail-bird cycle. The objectives of the workshop were to share information and ongoing research efforts, promote collaboration, and identify key research needed to move forward on developing management actions to alleviate waterbird mortality due to trematode infestation.

Workshop Process

The workshop began with a series of ten presentations, beginning with an overview of the situation across areas of Wisconsin and Minnesota, and ranging to factors governing species invasion to the genetics of snails to waterbird and system modeling. Summaries of these presentations can be found in Section 2. These presentations provided the participants with the opportunity to not only share their findings but also to increase their awareness of other sources of information and various monitoring and research efforts.

Participants were then asked to brainstorm issues and factors affecting waterbird mortality due to trematodes. These factors were placed within the system diagram for trematodes-snails-waterbirds (Figure 1). To further explore these issues, workshop participants were then divided into two working groups: 1) trematode – snail cycle; and 2) transmission to, shedding by, and mortality of waterbirds. These working groups spent the remainder of the day in expansion of their respective section of the diagram by adding additional factors and relationships based on past research, published literature, and expert opinion.

Working groups continued into the second day to identify those relationships that are substantiated vs those that are assumptions. Data gaps in the system model were identified, including both those that are being addressed by current research and those that require future research efforts. The groups also identified potential management intervention points that could reduce waterbird mortality. Comparison of these intervention points against data gaps suggested key areas for research that would inform and guide management actions. Summaries of these working group discussions were presented in plenary to allow additional input and comment from all participants.

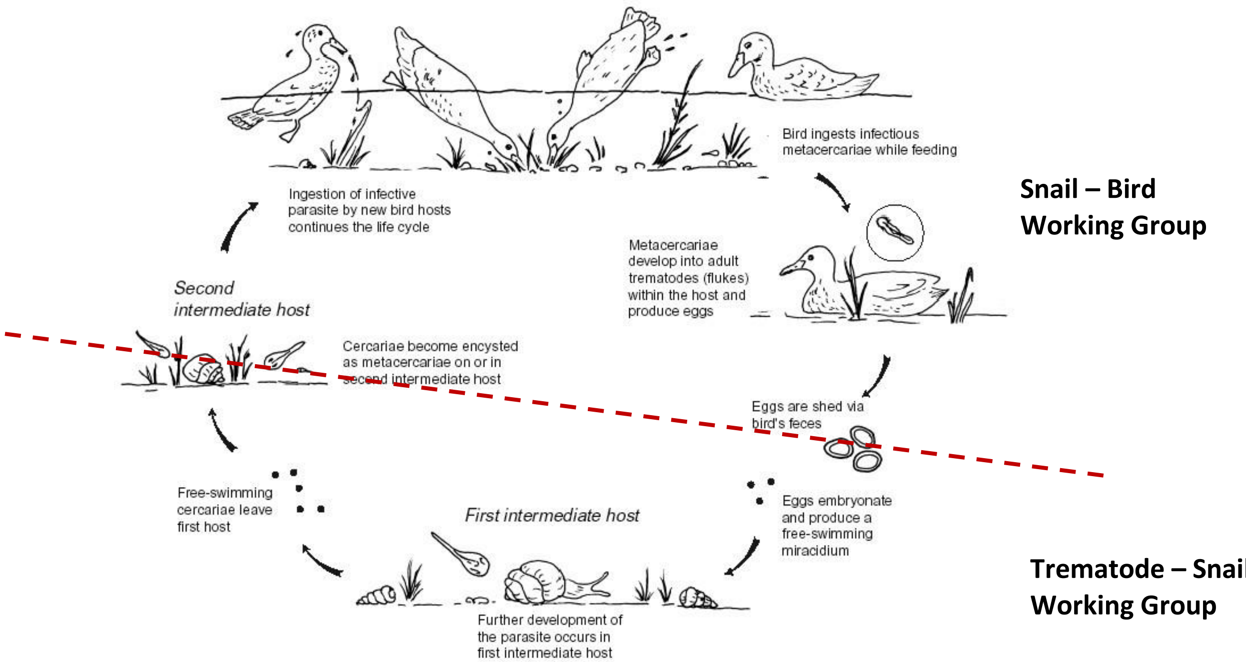

Figure 1. Primary life cycle interactions of trematodes, faucet snails and waterbirds, and basic division of topics between working groups. Diagram taken from: Friend, M. and J.C. Franson. 1999. Field manual of wildlife diseases: general field procedures and diseases of wild birds. Washington, DC: U.S. Dept. of Interior, U.S. Geological Survey.

Priority Research Needs

Using the information compiled above, each working group then developed a prioritized list of research ideas to address key questions important to developing effective management actions to reduce waterbird mortality due to parasitism by trematodes.

The *Trematode-Snail Working Group* identified the following priority research areas:

1. What are the primary drivers of *Bt* abundance and distribution?
   - Substrate type (including vegetation)
   - Hydrology: water depth, velocity, shear stress, etc.
   - Nutrition availability
   - D.O./temp./pH/turbidity and suspended solids
   - Seasonal

2. Movement and activity of *Bt* and trematodes (mark/recapture study?)
   - Between habitats
   - Seasonal (where are they in winter? In spring, how do they colonize vegetation?)
   - Hourly/daily
   - Refugia (where are they) daily or seasonally?
   - How are snails/trematodes moving to new areas/colonizing (people, birds, hydrology, other)?
   - What is the current distribution of *Bt*? – local, Midwest, nationally, Canada? – St. Lawrence.

3. *Bt* population dynamics
    - How many offspring are left with each generation (how long does it take population size to increase to given number) – in current system or entering into new systems?
    - How long do *Bt* and trematodes need to be in a system before waterbird mortality seen?

4. Beyond *Bt* what are the host species (native and invasive) of trematodes?
    - Do banded mystery and Chinese mystery snail carry trematodes?
    - What are the impacts of these parasites on their host snails (from a fitness standpoint)?

The *Snail-Waterbird Working Group* identified the following priority research areas:

1. Temporal and spatial scaup and coot distribution and foraging patterns relative to snail distribution and abundance
    a. Regional distribution of scaup (landscape level)
       Local distribution of scaup (micro scale)
    b. Describe distribution of *Bithynia* and trematodes
    c. Examine spatial and temporal overlap of above

   Aquatic system: Examine spatial and temporal distribution of:
    - Scaup
    - Coots
    - Snails – infected and non-infected--e.g. vegetation, water depth, substrate, flow, etc
    - Map suitable habitat (vegetation) for scaup-coots-snails

2. Improving mortality estimation
    - Examine carcass loss rates
    - Sample design, stratification by habitat, sample sizes, sampling frequency
    - Standardize general protocol
    - Seasonal considerations – water system type
    - Age structure of dead birds
    - Detection probability of carcasses
    - Solicit reporting of dead birds via the public in new areas (citizen science)

3. Mechanism of snail and parasite dispersal to different water bodies
    - On birds (legs, feathers)
    - Human transportation
    - Type of water body
    - Seasonal variation?

Additional research questions and topics identified by the working groups can be found in the working group summaries in Sections 3 and 4. These research ideas were shared and discussed in plenary among all workshop participants. While the primary objective of management actions is to reduce waterbird mass mortality events, it was recognized that control of invasive species such as the faucet snail is also desirable to reduce other potential ecological impacts.

Additional Outcomes and Recommendations

Other outcomes of the workshop were an increased awareness of ongoing research and enhanced opportunities for future collaboration. Workshop participants made the following additional recommendations:

1. Compile and distribute a list of relevant references on this topic to all participants (this action has been completed – see Appendix II);
2. Collaborate to develop standardized methodologies, potentially via mass collaboration tools;
3. Collaborate to develop monitoring priorities given limited resources for monitoring vs other management activities; and
4. Consider reconvening next year to revisit these issues as more information becomes available.

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SECTION 2

Plenary Presentations

Plenary Presentations

List of Presenters and Topics

1. Jennifer Sauer: Why do we care?
2. Calvin Gehri: Waterbird mortalities due to trematodiasis Pools 7 and 8
3. Jeff Lawrence: Scaup, coots, and trematodes in Northcentral Minnesota
4. LeAnn White: Update on trematode-associated water bird mortality cases submitted to NWHC 1989–2009
5. James Peirce & Greg Sandland: Modeling host-parasite interactions on the Mississippi River
6. Jennifer Sauer: Determining habitat characteristics of an invasive snail (*Bithynia tentaculata*) and associated trematodes as they relate to waterbird die-offs on the USFWS UMR
7. Kathryn Perez: Current status of population genetic work on *Bithynia tentaculata* using mtDNA and microsatellites
8. Sarah Whalen: Analysis of the genetic structure of *Bithynia tentaculata* snail populations in the Upper Mississippi River and the Upper Midwest
9. Doug Schnobelen: Hydrology models
10. Jane Austin: Development of a comprehensive scaup conservation action plan

Presentation #1: Why do we care?

Jennifer Sauer, USGS-Upper Midwest Environmental Sciences Center, La Crosse, WI

Meeting Notes:

- When we talk about waterbird mortality due to trematodiasis in the Midwest, we are not only talking about waterbird populations, but also invasive species.
- Major waterbird mortality events every spring and fall in Lake Onalaska (Navigation Pool 7 of the Upper Mississippi River) located near La Crosse, Wisconsin since 2002. Mortality has been primarily lesser scaup and American coots. Other waterbirds affected include blue-winged teal, ring-necked duck, ruddy duck, bufflehead, redhead, Northern shoveler, mallard, American black duck, Northern pintail, gadwall, American wigeon, canvasback, tundra swan, and herring gull.
- Part of the Upper Mississippi River National Wildlife and Fish Refuge lies within the Mississippi Flyway, through which an estimated 40% of the continent's waterfowl migrate. Recently, bird mortality has spread south to Pools 8, 9, and 11 on the Refuge—about 125 miles downstream from Pool 7.
- Potential distribution of *B. tentaculata* and associated trematodes is unknown.
- Disease events further stresses avian populations.
- American wigeon and scaup (greater and lesser) were 17% and 37% below their long-term averages, as recorded by the Waterfowl Breeding Population and Habitat Survey. Pintail 20%.
- Humane/Aesthetics/economics
- Effects of the die-offs include: (1) UMR Refuge staff time spent on monitoring waterbird reference points, clean-up, disposal, and public relations; and (2) increased difficulty of retrieval of hunter-killed birds.
- Consequences of invasive species may include: direct competition for resources with native flora and fauna, exposure to exotic diseases, predation, and general habitat degradation.
- The cost to the U.S. economy to monitor, contain, and control invasive species is estimated at $100-200 billion per year – an annual cost greater than that for all natural disasters combined.
- Latitude of *Bt* in US falls within latitude of *Bt* distribution in Europe.

Presentation #2: Waterbird mortalities due to trematodiasis Pools 7 and 8

Calvin Gehri, USFWS - La Crosse District, La Crosse, WI

Meeting Notes:

- Why and how we get estimates
- Numbers vary from year to year
- Mainly lesser scaup, coots, some BW-teal
- Monitoring Apr-May and Sept.-Dec. (ice-on)
- Weekly monitoring—ten days maximum
- Recorded: # sick, # dead, species
- Areas selected for monitoring:
  - Bird concentrations
  - Areas where birds have been found in the past
  - Current and wind
  - Known drift
  - Visibility
  - Access
  - Disturbance to other waterfowl
  - Potential conflicts with Refuge users
- Estimates based on:
  - Location of birds
  - Cover and visibility in areas checked
  - Reports from other sources (public, other agencies, hunters)
  - Aerial surveys
  - River levels, flow, and current
  - Previous experience
- Pool 7 Reference Areas are:
  - Broken Gun Island, Arrowhead Island, ABC Islands, French Island Shoreline, Lock & Dam 7
- Pool 8 Reference Area: Drive Lock & Dam 8 from Reno Boat Landing, MN, to gates
  - 26 new islands in Pool 8
- Time available to conduct searches is limited
- Disturbance to non-target species and refuge users limits search areas

Questions/comments:

- What is the actual cost of monitoring, disposal, outreach, etc.?
  - *Unknown*
- How confident are we in the estimates? Do we have detection probabilities?
  - *Believe estimates are low.*
  - *No detection probabilities, only have range now.*
- Seem to be more coot found near Broken Gun, Scaup around Arrowhead.
  - *Guess at this point, can answer with data.*
- Why do birds congregate in Lake Onalaska?
  - *Rice beds, wild celery*
  - *Calm shallow water*
  - *As birds get sick and die, current and wind push them downriver.*
- Pool 8 Islands trying to use less rock with dynamic shorelines.
- Kevin Kenow looking at how long it takes a bird to sink.
- Eagle predation on birds, birds in wild rice, birds covered with floating wild celery beds – all reasons for low estimates.

- Can estimates be done with aerial surveys, folks on bluff?
    - *Probably not – will not be able to see dead/sick birds.*
- Is age/sex recorded?
    - *Sex was for awhile; no difference seen in prevalence of mortality, therefore no longer recorded.*
    - *Age not recorded*

Presentation #3: Scaup, coots and trematodes in north-central Minnesota

Jeff Lawrence, Minnesota Department of Natural Resources, Bemidji, MN

Abstract. Major losses of waterbirds due to trematodiasas were first reported from Lake Winnibigoshish in north-central Minnesota in late October 2007. Loses were estimated at 7,000 scaup and 200 coot that year. Losses have declined each fall since then, with an estimated 2,000 and 200 scaup lost in 2008 and 2009, respectively. Coot losses have remained relatively low, an estimated 50 and 200 in 2008 and 2009, respectively. Large numbers of eagles (>100) on Lake Winnibigoshish would have consumed many sick and dead birds, which were not accounted for in the loss estimates. In addition to these losses, an estimated 200 coots died due to the trematode *Cyathocotyle bushiensis* in 2005. We sampled several sites for snails on Lake Winnibigoshish in 2008 and 2009, and also sampled sites on Bowstring Lake in 2009, a scaup staging area 15 km NE of Lake Winnibigoshish. The snail *Bithynia tenticualata*, an intermediate host of the trematodes was found on many sites on Winnibigoshish, but was not located on Bowstring. *Bithynia* snails were also located on Lower Twin Lake, about 55 miles SE of Winnibigoshish, in 2009. The snails were also in the Shell River, several miles downstream from Lower Twin Lake. The Shell River flows into the Crow Wing River which joins the Mississippi River south of Brainerd, Minnesota. Lake Winnibigoshish is also host to two other snails not native to Minnesota, the banded mystery snail and the Chinese mystery snail. The banded mystery snail is extremely abundant on Winnibigoshish, and we would like to determine if it is either a second intermediate host to the trematode or as a food resource for scaup. We are planning further investigations of scaup and snail relationships in north-central Minnesota.

Meeting Notes:

- Waterbird mortality on Lake Winnibigoshish began in fall 2007: ~7000 scaup
- Continued 2008 (~2000 scaup); 2009 (~500 scaup)
- Few coots die – did see mortality in 2005
- Scaup use is down on Lake Winnibigoshish
- >100 eagles on Winnibigoshish
- Wild rice and bulrush; ~ 90 sq. miles
- 2009 *Bt* sampling in Winnibigoshish and Bowstring
    - Near shore person/hour and incidental from walleye trawls
    - Trawls (3-12 feet water depth): sediment sand/cobble?
    - No *Bt* in Bowstring
    - Had 100-200 scaup loss in 2008 and 2009
- Twin Lakes and Shell River – *Bt* found
- Trematodes found in Canada geese near Twin Lakes
- Other invasives: Banded mystery snail (huge numbers) and Chinese mystery snail (does not seem abundant)
- Lake Winnibigoshish designated as “infested waters”: cannot transport water (i.e., empty live wells) or harvest bait.

Questions identified by Jeff Lawrence:

- Scaup/coot snail exposure depth?
- Why declining trend in losses?
- Role of banded/Chinese mystery snails?
- How are *Bithynia* spread? By birds?
- How many lakes with low level of *Bithynia*?
- How many years to increase to noticeable numbers?
- Any *Bithynia* populations without trematodes?

Other questions:

- Is boat traffic moving snails?
  - *Unknown*
- Is decline in mortality because of decrease in scaup population size?
  - *Maybe in Lake Winnibigoshish, probably not in UMR*
- Why decline of scaup use on Lake Winnibigoshish?
  - *Unknown; decline in vegetation? Change in migration patterns?*

Presentation #4: Update on trematode-associated waterbird mortality cases submitted to NWHC 1989–2009

LeAnn White, USGS – National Wildlife Health Center, Madison, WI

Meeting Notes:

- Field signs of trematodiasis
  - Not disease specific
  - Lethargic
  - Anorexic
  - Difficulty diving or flying
- Pathology
  - Lesions in ceca: *C. bushiensis*
  - Lesions in small intestine: *S. globulus*
  - *L. polyoon* will typically have thickened intestines
- WI specimens
  - Submissions from 1996 – 2009
  - ~368 (22 species)
  - UMR, Shawano Lake, Little Lake Butte des Morts
  - Mainly coots (37%) and lesser scaup (27%)
  - Relatively equal mix of *Cb* and *Sg* infection. *Lp* only in coots.
- MN specimens
  - Submissions from 2005 – 2009
  - ~70 (10 species)
  - Lake Winnibigoshish, Rabbit Flowage, Third River Flowage, and Bowstring Lake
  - Mainly scaup (60%); coots (23%)
  - Scaup ~98% with *Sg*; 60% *Cb*
  - Coots ~69% *Cb* and *Lp*, 5% *Sg*
- Other states: CA, IA, IL, IN, MD, MT, NY, ND, OR

- Field studies: Document the presence of *B. tentaculata* and prevalence of *Cyathocotyle bushiensis, Sphaeridiotrema globulus* and *Leyogonimus polyoon* larval stages.
    - Lake Winnibigoshish, MN and Rattlesnake Reservoir & Georgetown Lake, MT
    - 1 person hour per site – hand collection/dip netting, deployed artificial substrates, samples from trawling
    - Snails back to NWHC, minimum of 60 examined for trematodes.
- Site summaries
    - Lake Winnibigoshish:
        - *Bithynia tentaculata* snails infected with *Cyathocotyle bushiensis*, *Sphaeridiotrema globulus* and *Leyogonimus polyoon*
        - Snails in deeper water (3-10 ft) also infected
    - MT:
        - Both sites with recurrent mortality events have *Bithynia tentaculata* infected with *Cyathocotyle bushiensis* and *Sphaeridiotrema globules.*
        - No *Leyogonimus polyoon* was found.
- Appears to be 80-90% infection rate in shallow water.
- Appears to be 2-13% infection rate in deeper water.

Questions:

- Is this a high infection rate compared to *Bt* in native range?
- Have there been die-offs due to trematodes in North Dakota?
    - *Jane Austin thought so*
    - *LeAnn can check NWHC records*
    - *Birds may have gone to state labs*
- Die-offs in 1960s, haven't heard anything about 1970s-80s. Were there mortalities?
- Are there die-offs in Lake Michigan?
- Did you look at shallow and deep areas?
    - *No, mainly shallow*
    - *Trawls in deeper water*

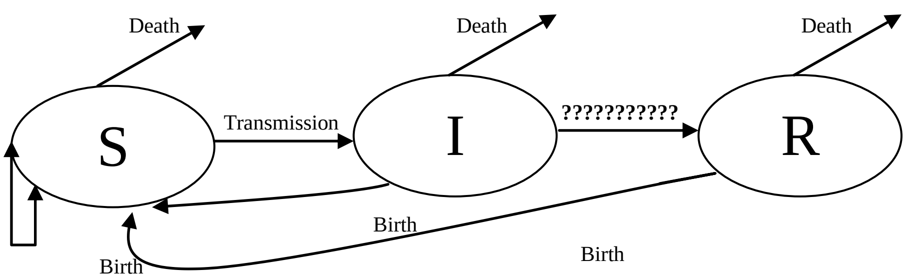
Presentation #5: Modeling host-parasite interactions on the Mississippi River

James Peirce and Greg Sandland, University of Wisconsin - La Crosse, La Crosse, WI

Abstract. *Bithynia tentaculata* is an invasive aquatic snail that was introduced into the Great Lakes in the late 1800s. In 2002, it was discovered in the upper Mississippi River (UMR) and since that time it has expanded throughout a number of the Navigation Pools. In addition to the being a threat to native benthos, the snail also harbors three exotic parasite species that are responsible for the deaths of thousands of migrating waterfowl each year. Unfortunately, little is known about the factors that are responsible for snail and parasite spread, and what the consequences of these expansions might be in the future. To address these issues, we have developed conceptual and mathematical models to: 1) identify points within the parasite life cycle that are most important for disease persistence, and 2) predict future transmission and mortality outcomes under different environmental scenarios. Parameter estimation for mathematical models has come from published reports on this system and from field collections that we have conducted over the last two summers. Preliminary results from our model suggest that parasite transmission between birds and *B. tentaculata,* and between *B. tentaculata* and other snails are key for parasite persistence within the UMR. Targeting such points in the life cycle using particular management strategies could help to curtail waterfowl mortality along the UMR.

Meeting Notes:

- Introduction to epidemiological models
- The primary reason for studying infectious disease: improve control and ultimately eradicate the infection from the population.
- Models:
  - Individual factors can be examined in isolation.
  - Optimize the use of limited resources.
  - Results can target control methods more efficiently.
- Population divided into three categories (SIR):
  - **S**usceptible - previously unexposed
  - **I**nfected - currently colonized
  - **R**ecovered - successfully cleared the infection
- Epidemiological model: combines the demographic changes of the population with the life cycle of the disease.
- Life cycle of disease
  - Rate of recovery depends on length of infection.
  - Rate of infection: transmission requires contact between infected and susceptible.
- Demographic changes
  - Natural mortality = 1/lifespan; assume mortality = birth rate to maintain constant population
- Susceptible – Infected – Recovered (SIR) equation has two equilibria:
  - Disease free
  - Endemic
- Basic reproduction number = the number of new infections resulting from an infected individual being introduced into a susceptible population.



$$\frac{dS}{dt} = \mu(S+I+R) - \beta\frac{SI}{N} - \mu S$$
$$\frac{dI}{dt} = \beta\frac{SI}{N} - \gamma I - \mu I$$
$$\frac{dR}{dt} = \gamma I - \mu R$$

- Adding parameters from river to SIR model
- Estimating parameters for model development – empirical estimates:
  - From immediate system
  - From other systems
  - Unknown parameters
- Trematode life cycle
  - Multiple waterbirds, 3 trematodes on UMR
  - Reside in intestinal tract, mature in short period of time after ingestion.
  - Trematodes reach maturity in waterbirds, then eggs are released.
  - Eggs hatch into miracidium, which actively seek first intermediate host (assumed *Bt*)
  - 5-7 weeks develop into cercariae which actively seek different species of second intermediate host (*Sg* and *Cb* use snail species; *Lp* use aquatic insects or isopods).
  - Cercariae encyst as metacercariae infective to birds at this point.
  - In birds, attach to intestinal walls causing massive amount of pathology—lesions, hemorrhaging, death.

- Model – represent complexity
    - Members and transmission rates
    - *Bt* – different infectious states
    - Susceptible waterfowl and infected waterfowl
- How to assess parameters (numbers of hosts, transmission rate)
    - Field collections
        - Standardized sampling regimes
    - Experimental assessments
        - Field patterns tested in lab
        - E.g., how well trematodes use native species as hosts
    - Model development based on findings
- Pool 7 Cormorant, Arrowhead, Broken Gun, Red Oak
    - Every 2 weeks 2008 and 2009
    - 2 sites at each island; 2 transects at each site 5 cm and 30 cm
    - All organisms sampled in "trash can"
    - ID all species, crush snails to determine parasite infection, P/A. species of parasite, stages, and numbers of parasites
    - 10 snail species found, only 1 invasive (*Bt*). Dominated by *Bt, Physa*, and *Amnicola*
    - *Bt* density highest in Broken Gun East southern transect
        - Can use as estimate of *Bt* density in model. Variance also may be used.
    - Infections in *Bt: Cb, Sg, Lp*
    - High number of snails correlated with high numbers of trematodes (*Cb* especially)
- *Cb* and *Sg* metacercariae differ between sites
    - *Sg* and *Cb* metacercariae found in *Amnicola*
    - Campeloma *Lp* cercariae
    - *Physa, Cb* and *Sg*
- Need to add native snail infection into model
- Experimental exposure of *Sg* to *Bt*, *Physa*, *Lymnaea elodes*, *Helisoma trivolvis*
    - All snails 100% infected
    - How well do they establish? No significant difference of metacercariae that encysted between snails species.
    - Therefore potential to serve as second intermediate host.
- Snail interactions
- *Bt* capacity to negatively impact native species
- Relationship between *Physa* and *Bt. Bt* increases, *Physa* increases to a point and then begins to decrease as *Bt* increases. Many factors can influence this relationship.
- Ran model using empirical estimates: some from system, some from other systems, other best guesses.
    - Initial results: most important parameter as whether or not parasite remained in population or disappeared was death rate of snails containing metacercariae. Makes sense biologically.
    - Transmission rate and death rate of infected birds also important.
- Future steps:
    - Incorporate parameter variability into the model.
    - Investigate parameters identified by the model experimentally.
    - Increase complexity of the system, i.e., additional snail and waterbird species in model.
    - Better refine certain compartments of the model i.e., completion coefficient.
    - Use this information to reduce parasite transmission.
- Strength of model is *Bt* and trematode interaction
- Weakness: Waterbird interaction. Number of species, how long persist when infected, population numbers of different species will add robustness to model.

Questions/comments:

- With experimental infection rates did you look at all life stages?
    - *No, just cercarial*
    - *Plan to replicate with both stages of parasites.*
    - *Bt not infected by native parasites.*
- Implication that you could have a widespread infection of native snails
    - *Greg: not good hosts; but possible.*
- Are there examples where they have stopped snail life cycles in nature?
    - *No, Can break for maybe short period of time.*
    - *Maybe slow down transmission rate of parasite.*

Presentation #6: Determining habitat characteristics of an invasive snail (*Bithynia tentaculata*) and associated trematodes as they relate to waterbird die-offs on the USFWS Upper Mississippi River Refuge

Jennifer Sauer, USGS-Upper Midwest Environmental Sciences Center, La Crosse, WI

Abstract. The relation between *Bithynia tentaculata* and the presence of submersed aquatic vegetation was studied in Navigation Pools 8 and 13 on the Upper Mississippi River. In spring 2002, there was a mortality event of many lesser scaup and American coot in Lake Onalaska (Navigation Pool 7) on the Mississippi River. It was found the mortality was due to parasitic flatworms (*Sphaeridiotrema globulus, Cyathocotyle bushiensis, Leyogonomus polyoon*) which uses *B. tentaculata* as an intermediate host. The invasive *Bithynia tentaculata* was introduced into the United States from Europe in the late 1800s via shipping activity. Recently, the snail has been found about 70 km south of Lake Onalaska in the Mississippi River. To gain an understanding of how many *Bithynia* snails are located in the Upper Mississippi River Navigation Pools 8 and 13, their distribution, size, infection rate, and presence-absence in relation to river environment covariates and vegetation species samples were collected in 2007. Site occupancy models were then developed to characterize habitat affinities of an "average" *Bithynia* snail. These models can also be used to predict the probability of occupancy by a *Bithynia* snail at locations where *Bithynia* snails were not detected or where surveys have not been conducted.

Meeting Notes:

- Looking at *Bt* and associated with submersed aquatic vegetation
- 2007 spatial distribution of *Bt* on the UMRNW&FR and Partner with the Long-Term Resource Monitoring Program (LTRMP) vegetation component
- Gain an understanding of how many *Bithynia* snails are located in the Upper Mississippi River Navigation Pools 8 and 13, their distribution, size, infection rate and presence-absence in relation to river environment covariates and vegetation species
- Methods:
    - 450 sites per pool are sampled for submersed aquatic vegetation
    - Pool 8 = 23 miles; Pool 13 = 35 miles
    - The LTRMP uses a stratified random sampling (SRS) method, with strata based on habitat
    - 6 samples are taken at each of the 450 sites
    - Vegetation is sampled using a double-headed garden rake. For *Bt* sampling, we sampled for snails at rakes 1 and 2. At each site variables such as vegetation species, water depth, and sediment type were taken.
    - Snails were then sent back to the NWHC lab for ID and examination for parasites.

- Descriptive statistics
  - *Bithynia* sp. snail presence - absence, descriptive statistics and pool – wide estimates of numbers were calculated.
  - Total numbers of snails, total number of infected *Bithynia* sp. snails and infection rate of snails
- Patch occupancy models
  - Looked at sites with and without vegetation. From presence/absence data we estimate site occupancy models that characterize habitat affinities of an “average” *Bithynia* snail.
  - Models can also be used to predict the probability of occupancy by a *Bithynia* snail at locations where *Bithynia* snails were not detected or where surveys have not been conducted.
- Results – descriptive statistics
  - Pool 8: 11632 total *Bt*; highest in impounded area
  - Total *Bt* estimated 862,278
  - Pool 13: 58 total *Bt*; in IMP area
  - Total estimates: 4986
  - Pool 8 has seen waterbird mortality; Pool 13 has not
  - Pool 8: highest number of snails in 5-6mm range
  - Pool 13: 3-4mm range
- Results – patch occupancy models (only vegetated sites)
  - Pool 8:
    - Model 1 (beta binomial) contained variables for habitat stratum impoundment, average density of submersed vegetation at the site and its quadratic term, average depth at the site and percent cover of emergent vegetation.
    - Model 2 (covariate detection); contained variables for habitat stratum impoundment, average density of submersed vegetation at the site and its quadratic term, average depth at the site and percent cover of emergent vegetation.
  - Pool 13:
    - Model 1 (beta binomial); contained a variable for the submersed aquatic vegetation species wild celery.
    - Model 2 (covariate detection); contained a variable for the submersed aquatic vegetation species wild celery.
- Future needs
  - Only looked at presence/absence data
  - *Bt* movement in spring
  - Where are the waterbirds eating the snails
  - Future abundance and distribution

Questions:

- How many *Bt* fell off of vegetation when sampling? *Unknown*
- Was there vegetation at all sites?
  - *No, Pool 8: 303 veg. sites out of 450; Pool 13: 261 sites out of 450*
- Is there a size/age relationship for *Bt*?
  - *Do not think so.*
- Did we see egg masses on vegetation?
  - *Did not look.*
- How is emergent vegetation measured?
  - *Categorical, 15-m radius around boat; also noted on rake.*
- Has anyone looked in Pool 16 for *Bt*?
  - *Not as far as I know.*
- Where and when are waterbirds eating snails?
  - *Probably at night, snails probably move from under rocks to top at night.*

Presentation #7: Current status of population genetic work on Bithynia tentaculata using mtDNA and microsatellites

Kathryn Perez, University of Wisconsin - La Crosse, La Crosse, WI

Meeting Notes:

- Genetic work, molecular markers
- Questions to answer:
  - Where did *Bt* in US originate from in native range?
  - How big was the initial introduction?
  - More than one introduction?
- Look at variation of snails here
- Looking at mitochondrial DNA – tell us where they originate from
- Future look at microsatellites
- Pool 7 snails from Russia, still looking at other *Bt* in other US locations
- Can we track historical spread in USA? Microsatellites
  - Can we predict where and how they move?
  - Look at genetic variation to get rough estimate of population size

Questions:

- How many microsatellite loci?
  - *17 total*
- Will *Bt* from New York be looked at?
  - *If we can get Bt from there.*
- Looked at St. Lawrence?
  - *No*
- Pool 13
  - *No Bt from Pool 13*

Presentation #8: Analysis of the genetic structure of *Bithynia tentaculata* snail populations in the Upper Mississippi River and the Upper Midwest

Sarah Whalen*, Minnesota State University, Mankato, MI*

Meeting Notes:

- *Bt* in Midwest: Lake Winnibigoshish, UMR, Shawano Lake, Lake Butte des Morts, Milwaukee
- How are the various geographic populations of *Bithynia tentaculata* genetically related to each other?
- Can we trace a genetic lineage of the descendant populations from their ancestral populations in the upper Midwest?
- Methods:
  - Collect snails
  - Dissect
  - Extract DNA
  - PCR to amplify microsatellites
  - Analyze PCR
  - Determine allele frequencies

- 21 locations: Lake Winnibigoshish, Shawano Lake, Milwaukee area, Pool 7—871 total *Bt* collected
- Microsatellite-rich genomic library was created using DNA from one individual collected from Lake Onalaska.
- DNA has been extracted and quantified from 249 *Bt*.
- Future plans:
  - Use primers for microsatellites to genotype collected individuals and determine genetic diversity at each location.
  - Determine whether or not genetic diversity and allele frequencies are significantly different at each location.
  - Use data to answer research questions: how are these populations related?

Questions:

- Any purpose to looking at genetics of trematodes? Assume they came over with *Bt*.
  - *Trematodes probably came over with Bt since they are needed for trematode life cycle.*
  - *However, they might not have moved over together—Bt first followed by trematode.*

Presentation #9: Hydrology models

Doug Schnobelen, *University of Iowa, Lucille A. Carter Mississippi Riverside Environmental Research Station, IA*

Meeting Notes:

- Developing hydrologic models for Pools 8 and 16; mesh model.
- Can potentially model how discharge, velocity, etc. affects snail movement.
- Mussel dynamics model developed.
- Detailed mapping of river bottom—down to cm level.
- Has multi-beam bathymetry.
- Examples: looked at bridge scour.
- Couple biologists with modeling – a tool that biologists can use.
- With model can look at different scenarios; use model as predictive scenario.
- Need monitoring to validate model.
- Other abilities
- Sediment cores
- Sediment analysis

Presentation #10: Development of a comprehensive scaup conservation action plan: dealing with mortality due to disease during spring and fall migration

***Jane Austin**, USGS, Northern Prairie Wildlife Research Center, Jamestown, ND*

Abstract. The combined breeding-season populations of greater scaup (*Aythya marila*) and lesser scaup (*A. affinis*) (hereafter, scaup) of North America have declined from population estimates of 5.7–7.6 million birds in the 1970s to a record low of 3.25 million birds in 2006. Concerns about the decline and continued low numbers have been exacerbated because there is much uncertainty about factors limiting scaup populations; therefore, appropriate management actions are unclear. We have applied the principles of structured decision-making to tackle the complex issues of scaup ecology and population dynamics to develop a comprehensive conservation action plan. This top-down, model-based approach has highlighted important gaps in our knowledge of scaup ecology and management. A fundamental objective in the draft plan is "achieve landscape conditions (continental carrying capacity capable of supporting target populations." A means objective under this fundamental objective is to minimize non-hunting mortality and health impacts. Therefore, the mortalities occurring on the upper Mississippi River basin due to trematode infections are of specific interest for the modeling of the annual life cycle of scaup. We developed a simple linear model relating scaup survival to the percentage of the scaup population exposed to the disease, with the expectation that survival would decline as infected snails spread through the flyway and more scaup would be exposed. Our preliminary model for this was based on the following assumptions and estimates: 1) an estimated 50% of the continental scaup population uses the Mississippi Flyway during spring and fall migration; 2) peak counts of 100,000-150,000 scaup occur on currently infected areas of Pools 7, 8, and 9 on the Mississippi River and several lakes in the region, with turnover rate of 2; 3) mortality is split evenly between spring and fall migrations, with ~10,000 scaup estimated to be killed annually; and 4) disease risk is higher for lesser scaup (more using Mississippi flyway) than greater scaup. Alternative management actions considered in the draft model are 1) habitat modification programs to reduce exposure of scaup to infected snails and 2) development of biocontrol of snails and/or trematodes. Costs and likelihood of success of these or other possible actions that would reduce scaup mortalities need to be improved for inclusion in the plan's decision framework. Information obtained from this workshop and from continued investigation into the disease and system ecology will be important in improving this component of the scaup life-cycle model and assessment of the most effective management approaches.

Meeting Notes:

- Decline in continental scaup populations since the mid 1980s.
- Most of declines observed in boreal forests of Alaska and western Canada.
- The two species (greater and lesser scaup) were classified as focal species of concern by FWS in recognition of the large and widespread decline.
- Developing a framework to recover the scaup population.
- Conserve populations at levels that satisfy societal values.
- Part of model: minimize non-hunting and disease mortality.
- Potential actions:
  - Habitat programs to reduce exposure to trematode disease in non-breeding areas.
  - Develop biocontrol of trematodes and snails to reduce exposure to disease.
- Developed standard life cycle model of scaup.
- Assumptions: How trematodes fit into model
  - Estimate 50% of the continental scaup population uses the Mississippi Flyway during spring and fall migration.
  - Peak counts of 100,000-150,000 scaup occur on currently infected areas of Pools 7, 8, and 9 on the Mississippi River and several lakes in the region, with turnover rate of 2.

- Mortality is split evenly between spring and fall migrations, with ~10,000 scaup estimated to be killed annually.
- Disease risk higher for LS than GS.

- How can scaup model be improved?
  - How to appropriately model scaup survival during fall and spring migration – current scenario vs. expanded distribution of disease risk.
  - Different survival rates by season?
  - Assumptions correct? Assumptions missing?
  - What are possible alternative management actions? Costs?

Questions/discussion:

- Body condition in spring is lower—how does this relate to breeding?
  - *Maybe body condition down because of resources or disease? Not getting quality and quantity of food, disease is added stress.*
- Any other disease beyond trematodiasis?
  - *Few disease outbreaks, not large effect.*
- Does trematodiasis make birds more susceptible to other diseases?
  - *Unknown*
- Do not know if contaminants affect breeding behavior
- Where do scaup breed?
  - *60% in boreal forests in Canada and Alaska.*
- How does *Bt* distribution affect scaup distribution?
  - *Unknown; but scaup consume more animal matter (e.g., mollusks) than other diving ducks.*
- Why such a big die-off in UMR?
  - *2002 wide open niche – trematodes hit naïve population.*
- If we do not do anything, what happens?
  - *2 models*
    - *Increase exposure, increase mortality.*
    - *Bimodal, birds will adapt.*

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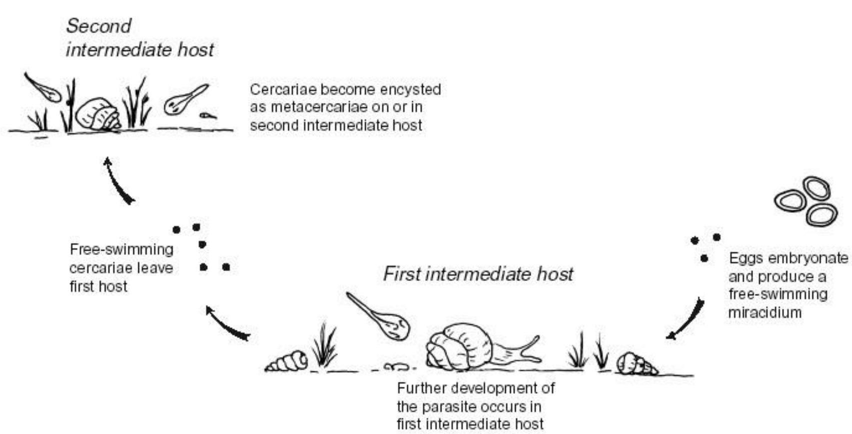

SECTION 3

Trematode – Snail Relationships Working Group Summary

Trematode – Snail Relationships Working Group Summary

Members: Jessica Larson, Jeff Lawrence, Jim Nissen, Kathryn Perez, Greg Sandland, Jennifer Sauer, Douglas Schnoebelen, Sarah Whalen, Tim Yager

This working group focused on the relationship between two trematode parasites (*Cyathocotyle bushiensis* and *Sphaeridiotrema globulus*) and their primary intermediate snail host, the faucet snail (*Bithynia tentaculata*) and other snail host species. The group began by expanding upon the system diagram generated in the plenary discussion and adding additional factors or issues potentially affecting this system and the relationships between trematodes and snails. Efforts were made to estimate the direction and relative strength of these relationships. Where possible, relationships were indicated as fact or assumption.

The group then reviewed the resulting system diagram to identify data gaps (assumptions). Participants discussed whether each gap is being addressed by current research efforts or if future research is required.

Potential invention points were identified in the system model at which management might be able to reduce waterbird mortality (indicated by **M** below). These intervention points were then compared against the data gaps to identify points of overlap that may indicate key areas for research that may inform and guide management actions.

These syntheses served to guide the group in their final task – to develop a list of prioritized research questions with the potential to contribute to the development of effective management actions for reducing waterbird mortality.

Factors and Issues Affecting Trematode – Snail Cycle

The working group identified the following factors that may influence trematodes, snails and/or their interactions. In some cases, references or potential sources of information are indicated. **MU** indicates factors or areas in which management may be possible but unlikely; **M** indicates areas with definite management options. These potential relationships are depicted in Figure 2.

- **Possible stressors on snails** (e.g., draw downs, prolonged flood, warm temperatures?)
  - Snails are not susceptible to many stressors (recent paper by Cole). Food supply and warm temperatures are not likely to be a problem. Snails are fine at 25 degrees C but are killed if at 50 C for over one minute.

- **Water depth** – how does it affect snail abundance?
  - Snails can survive at depths of at least up to 12 feet, but unsure of maximum depth. Shallower water is associated with increased snail density near islands (e.g., found more snails at 5 and 30cm than at 60cm).

- **Water chemistry** (calcium, nitrogen, phosphorous, pH, turbidity, suspended sediment, dissolved oxygen, etc.) **M**
  - Coles saw no impact of pH over short time periods, Sandland suggested that higher pH has an effect over long time periods. *Bt* density decreases in Pool 7 as pH increases over 7.8.
  - Check with B. Sorenson about turbidity effects (Emily's work).
  - Suspended sediments may not have much of an impact since *Bt* can move between two feeding modes.
  - Effect of methylmercury unknown – Sandland is thinking about studying this.

- **Vegetation density**
  - As vegetation density increases, snail density increases to a threshold at which snail density drops off; is this due to light levels and the effect of vegetation or to snail density dependent population growth?
  - Vegetation acts as a substrate – Sauer found that % cover of emergents increased occupancy (presence/absence) in a sample. **MU**
  - Vegetation as a source of nutrients (periphyton) – increases surface area for periphyton food source for snails. **MU**
  - Vegetation also increases likelihood of birds being present.
  - Therefore: mid-high vegetation density increases snail abundances and also increases probability of birds coming into contact with snails.

- **Substrate type** – what drives their preference for different habitat types? **M** (depending on the system – local, focused) trying to use less riprap, removing islands?
  - Found in a range (silty clays, rock, sand); may occupy different substrates in different systems.
  - Substrate type can affect snail density directly as well as vegetation density.
  - Maybe acting as a good food source, refuge, and higher flow for filter feeding; could also have an interaction with temperature (e.g. sand is at a deeper depth in the river).

- **Hydrology** – optimal flow? Effects of wind fetch? Effects of wave action? **M** (local)
  - Low density of *Bt* at high velocity (typically cannot colonize); when flow is lower, they will colonize formerly high flow areas – Sandland.
  - Paper available on *Bt* response to velocity and wave action.

- **Predation on snails**
  - Freshwater drum tend to be strong predators of snails, but unknown if they eat *Bt* (get drum densities from Sauer).
  - Waterbird gut contents paper by Kristin Herrmann.
  - Predation by crayfish; any species will catch them, unknown how much.

- **Snail lifespan/mortality**
  - Lifespan is 3-5 years
  - Reproductively active between 1-2 years, grow continuously throughout that time.
  - Certain age classes of snails are too small to get infected – delay snail growth somehow?
  - Growth rate may be related to food quality.
  - Too many trematodes (parasite load) could lead to mortality – based on nutrition – egg masses hard to target because they do not take in nutrients and are usually protected by rocks, etc. **M** – biocontrol? Local, probably unlikely
  - 20-30 eggs/clutch (almost 100% hatch in lab); 2 cohorts/year
  - Lay eggs covered with mucus, attached to substrate (lay on underside of substrate, low predation on egg masses).
  - Will carp rooting around and putting eggs up in the water column increase downstream dispersal? If they can float for two weeks, this could enhance dispersal.
  - Can eggs overwinter?

- **Susceptibility of certain snails to different trematodes** (at metecercarial stage)
  - Native snails also susceptible to the invasive trematodes; can get data on trematode prevalence and intensity from Sandland, Cole and Sorensen).
  - Not a lot of native parasite species found getting into *Bithynia* – has been done experimentally. Can give *Bt* an advantage over native snails.

- *Bt* is only primary intermediate host in UMR, other snails can be secondary intermediate host.
- Isopods are secondary intermediate host for *L. polyoon*.

- **Snail-snail competition**
  - *Bt* impacting native snails, but not the other way around.
  - *Bt* has some competitive advantage – reproductive rate, two feeding modes, not as parasitized as native snails because do not get the native parasites (5-6 different parasites species for *Physa*, 3-4 species for *Amnicola*, 2-3 for *Helisomus*); total of 50-60 species of trematodes cycle through snails in Mississippi river, some passing to fish, aquatic invertebrates, *Gammarus* (Sandland).
  - Invasive-invasive competition (banded mystery, Chinese mystery snails)
  - What are the parasite / stressors in the European *Bithynia* populations?

- **Temporal aspects** – how are snails moving seasonally? where do they overwinter? – aestivate
  - Study was done on the rate of movement – activity on an hourly, daily, weekly basis
  - Temporal variation;: day/night; seasonal; inter-annual variation
  - Are they more vulnerable to management intervention at certain times of year? When to use a molluscicide? Could target the islands in hotspots in the spring. In need of study.

- **Colonization routes** – how are snails moving to new areas?
  - What measures are needed to slow the spread of snails to other water bodies?
  - Any direct observations of snails moving? Vegetation transfer, attached to boats, on duck hunter decoy lines, on waders, on scuba gear, on barges or construction equipment, on birds (feathers, esophagus), move with water flow?
  - Probably *Bt* has to get to the system first to act as the first intermediate host. *Campeloma* has been found with one of the trematodes as first host. Second host is any snails or isopods.

- **Bird-snail transmission** (of parasites)
  - Does snail abundance/proportion of snails infected increase transmission?
    - Increasing snail abundance means increasing #s of metacercariae
    - Higher numbers per individual
  - Waterbird movement at night?

- **Parasite-parasite competition** (invasive vs native parasites)
  - Can lead to increased virulence.

- **Trematode abundance**
  - Waterfowl decline decreased after several years? Maybe
  - Increased snail density leads to higher metacercarial intensity.
  - Increased snail density leads to higher percentage of infected snails.
  - Miricidia viable for 5-6 hours, cercariae ~ 24 hours, metacercariae can last the entire lifespan of the snail.

- **Immune systems of birds**
  - Overactive? Causing anemia – resistance/immunity? Acquired resistance?

Potential Management Strategies

- Keep birds away from snails – decoupling presence of birds and snails.
- Deworm? – population too big, birds would have to be consolidated (attempted by Blankenspool)
- Use molluscicide at very high abundance, high vegetation abundance.
- Manage vegetation to impact snail density – if we decrease vegetation density at hotspot transmission, we may decrease snails.
- Modify substrate – might be feasible in UMR but not in other systems.
- Increase snail mortality where snails aggregate certain times of the year – see below; if this could be done in high snail abundance areas, it could drop snail populations enough to make a difference.
- Place attractive substrate and get snails to aggregate; then pull them out often to kill the snails.
- Place substrate that mimics egg-laying sites that they can be pulled out and increase egg mortality.
- Place attractive substrate that is impregnated with poison to kill snails directly or transmit poison to periphyton that snails can graze and be killed.
- Draw-down (water depth adjustments) may help.
- Might be able to kill or impact them by altering water chemistry if we understood how to do this.
- Prevent movement of snails! Need to educate people to reduce spread – guidelines that limit people moving into highest snail density habitat.
- Relative snail abundance could affect transmission. If miracidium go after snails, they cannot actually infect (dilutes number of parasites that cause infection) – so, abundances of other snails could affect the life cycle by acting as decoys for the parasite.
- First intermediate host stage is vital: can release 100,000s of cercariae/day.
- Reducing viability/development of eggs (parasite eggs) or miracidia.

Waterbird Mortality Related to Trematodes

In the course of its discussions, the working group also the following information relevant to waterbird mortality related to trematodes:

- Bird-snail transmission
  - How long are birds sick before they die?
  - Habitat suitability for ducks, good foraging sites infected by snails
  - Exposure: scaup feeding patterns
  - Water depth and quality
  - Food availability: animal (scaup), vegetation (coots)
  - Migration timing & snail movements
  - Age ratios in dead birds?
- Habitat
- Residence time of the birds
  - Spring and fall mortality patterns
  - Seasonal differences in parasite stages
  - Migration phenology of birds
  - Reducing residence time
  - Practices in Europe/Russia that reduce fatalities?
- Factors affecting trematode survival
  - Bird immunology
- How do we estimate mortality?
  - Very important in mathematical modeling
  - Adult survival
  - Estimation in different habitats
  - Parasite loads in living birds? Josh Vest: parasites in hunter-shot vs. non-hunter-shot birds (Mississippi State masters student) – *Journal of Wildlife Management*

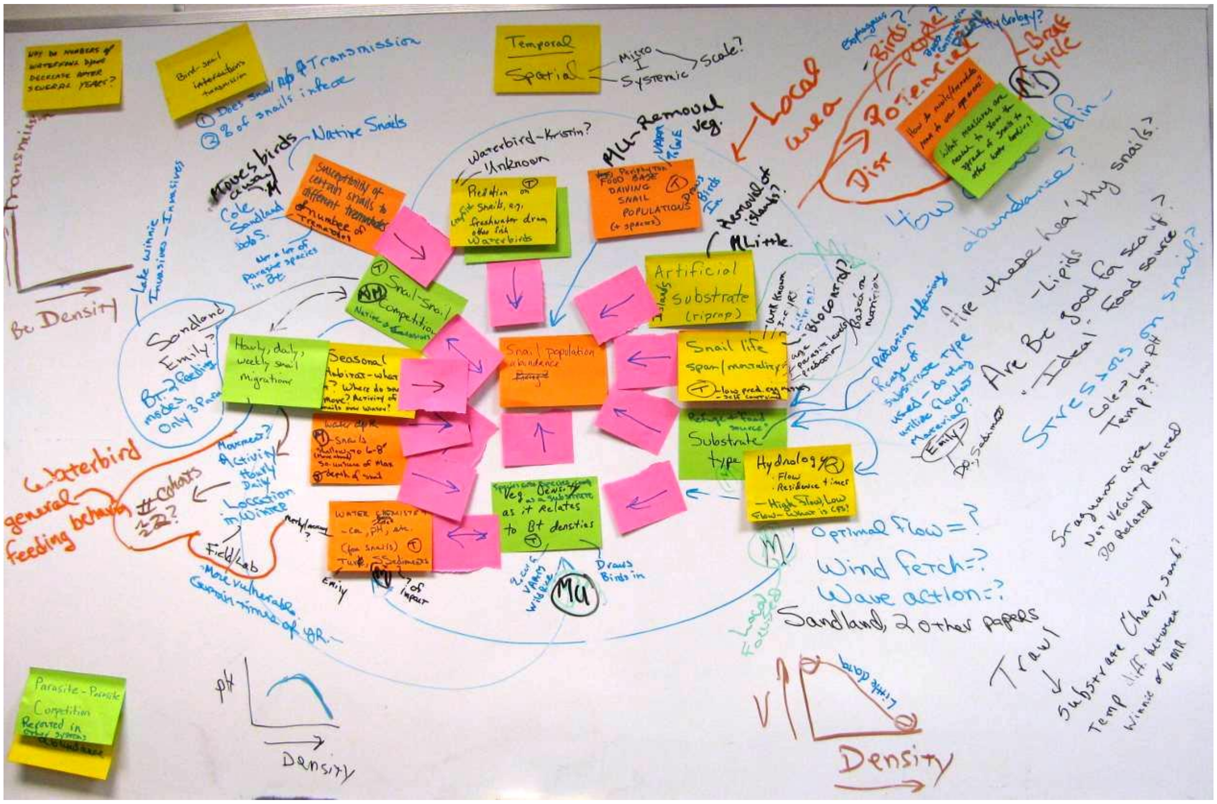

Figure 2. Working group diagram of potential factors affecting the trematode – snail cycle and interactions.

Research Questions / Ideas

The working group reviewed the important data gaps in understanding the trematode – snail system, especially in relation to potential management inventions that could reduce trematode and/or snail populations, trematode infection, and/or exposure to or impact on waterbird populations, and identified the following research questions in need of further investigation:

Key Research Questions:

1. **What are the primary drivers of *Bt* abundance and distribution?**
   - Substrate type (including vegetation)
   - Hydrology: water depth, velocity, shear stress, etc.
   - Nutrition availability
   - D.O./temp./pH/turbidity and suspended solids
   - Seasonal
   - Others

2. **Movement and activity of *Bt* and trematodes (mark/recapture study?)**
   - Between habitats
   - Seasonal (where are they in winter? In spring, how do they colonize vegetation?)
   - Hourly/daily
   - Refugia (where are they) daily or seasonally?

See http://www.aissmartprevention.wisc.edu/mappingtool.php interactive mapping tool for predicting potential zebra mussel invasion.

- How are snails/trematodes moving to new areas/colonizing (people, birds, hydrology, other)?
- What is the current distribution of *Bt*? – local, Midwest, nationally, Canada? – St. Lawrence.

3. ***Bt* population dynamics**
    - How many offspring are left with each generation (how long does it take population size to increase to given number) – in current system or entering into new systems?
    - How long do *Bt* and trematodes need to be in a system before waterbird mortality seen?

4. **Beyond *Bt* what are the host species (native and invasive) of trematodes?**
    - Do banded mystery and Chinese mystery snail carry trematodes?
    - What are the impacts of these parasites on their host snails (from a fitness standpoint)?

Additional Questions:

- Can we begin to develop best management practices? What not to do to attract *Bt*.
- In their native range, what maintains *Bt* and trematode population levels?
    - Population dynamics in Europe (density, rate of *Bt* infection, predation)
    - Literature available—task for a graduate student? Refuge biologist?
- Are there uninfected *Bt* populations?
- Are *Bt*/trematodes carrying viruses that may affect birds?
- Densities, predation and pathogens (population dynamics in Europe)
- What are the natural predators of *Bt*?
    - In literature?
    - Work with folks doing other food studies, have them look for *Bt*.
- Can we standardize sampling methods/terminology (how to define abundance)?
    - Parameters collected
    - Densities and abundance (all snails), prevalence of infection, stage, number for each trematode species.
    - Communication is the key!
- Does parasite abundance increase as snail abundance increase in all areas? (all life stages – we know it does for metacercariae)
- Are behaviors of snails affected by presence/absence of parasites? (reproduction, feeding, movement)
- What is the "health" of native snails?
- Are the snails or trematode life stages more vulnerable to management practices at certain times of the year?
- Are snails actively attracted to certain items (snail "bait")?
- Are there ways to attack trematodes (mucus/nitrogen gradients)?

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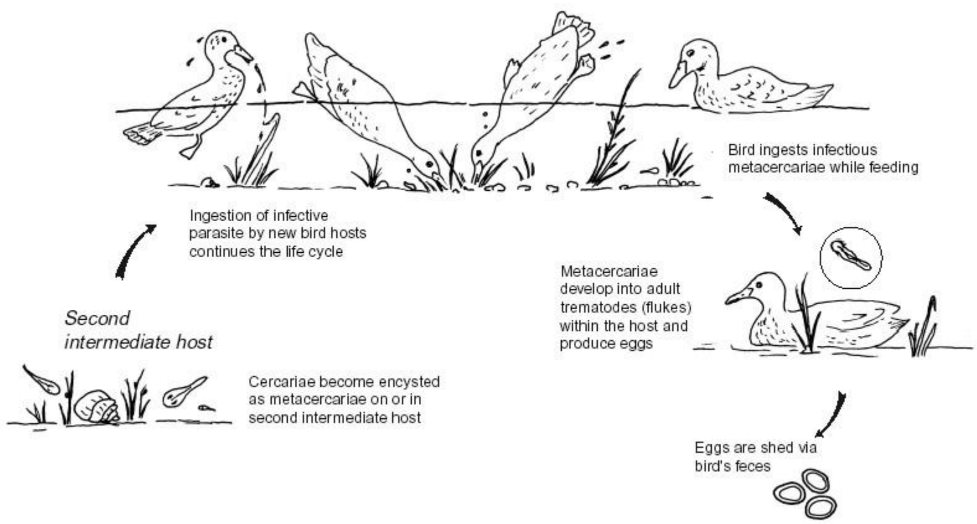

SECTION 4

Snail – Waterbird Relationships Working Group Summary

Snail – Waterbird Relationships Working Group Summary

Members: Mark Andersen, Jane Austin, Nancy Businja, Calvin Gehri, Jim Kelley, James Peirce, Charlotte Roy, Christine Sousa, Jeramie Strickland, Ben Walker, LeAnn White

This working group focused on the relationship between the faucet snail (*Bithynia tentaculata*) (and potentially other snail species serving as hosts to trematodes) and waterbird species such as the lesser scaup (*Aythya affinis*) and American coot (*Fulica americana*) that are impacted by consuming snails infested with trematodes.

The group first reviewed and expanded the system diagram generated in the plenary discussion by adding additional factors or issues potentially affecting this system and the relationships between snails and waterbirds. The direction and relative strength of each relationship was indicated where possible. The group also considered each relationship in terms of whether it was a fact or assumption.

The group then reviewed the resulting system diagram to identify data gaps (assumptions) in the understanding of this system. Participants discussed whether each gap is being addressed by current research efforts or if future research is required. Potential invention points in the system model were discussed at which management might be able to reduce waterbird mortality. These intervention points were then compared against the data gaps to identify points of overlap that may indicate key areas for research that may inform and guide management actions.

These syntheses served to guide the group in their final task – to develop a list of prioritized research questions with the potential to contribute to the development of effective management actions for reducing waterbird mortality.

Factors and Issues Affecting Snail – Waterbird Cycle

The working group identified the following factors that may influence snails and their interactions with waterbirds. These potential relationships are depicted in Figure 3.

Disturbance that forces birds into less suitable bird habitat but possibly better snail habitat. Voluntary closed areas marked by buoys, no hunting, no boats, but problem is when hotspot of infestation is in a closed area, which were originally established where good food resources occurred. Could not monitor closed areas at night. On Lake Winnibigoshish, disturbance may push infected birds into new areas.

Island restoration creates good vegetation in wind breaks but riprap also creates good snail habitat on edges of island.

Habitat suitability for ducks is in areas that have improved SAV; scaup filled with snail matter, coots filled with celery, picking up incidentally to vegetation ingestion. Habitat suitability for ducks affected by snails (scaup) and/or vegetation (coot).

How well do we understand **bird habitat use patterns**? Weekly surveys are done but not done by habitat types. Some time budget data collected for Pool 8.

Fall counts are best bird data (early September to December), spring less frequent.

Snail distribution in relation to open and closed areas:

- Can surveys be delineated to get at bird location in relation to snails?
- Majority of birds use areas where snails occur.

Residence time of birds
Best guess is up to 1-2 weeks for an individual, scaup around 10 days to 14 days, some movement between Pools 7 to 9 and back. That is enough time to become infected; longer stay increases infection rate and increases transmission rate.

Exposure affected by **feeding patterns**. Exposure of waterbirds to parasites affected by **depth and substrate**.

Scaup do not necessarily prefer amphipods, but go for the most abundant animal food (**food availability**), mollusks on winter grounds.

Species susceptibility: Has anyone analyzed data to see if some species die at greater proportions? Ruddies seem to be susceptible, bufflehead also?

Does species migration phenology affect when deaths are detected? For example, no die-offs detected during periods when no surveys done – however, however survey period is long.

Birds forage in areas that overlap with snail distribution. How is this related to infection levels of snails? Even if snail infection rate is low, **bird movement** is going to cause shedding of eggs into new areas. Local area movements affect introduction of eggs into new areas. Could sample birds with cloacal swab to see prevalence of egg presence. It can take up to 7-10 days for a bird to die after infection. Once a bird is infected and become sick, does its movements dramatically slow down?

Not seeing massive spread from Lake Winnibigoshish into Manitoba. Need *Bythnia* on those areas to cause disease. Canada may have other viable hosts.

In the lab, trematodes can **infect native snails**…can this occur in wild?

What density of infected birds are shedding eggs and what **density of snails** are required to complete cycle?

What is the **seasonal cycle of infection rates**? High at first, then taper down, drops down by August.

Spring versus fall – **seasonal mortality factors**:

- Scaup model assumes 50-50 but fall seems to be worse.
- Fall is 2-3 months, spring only one month.

Are snails doing things differently in spring and fall? Unknown

- Water temperature cues affect snail distribution? Ice out affects this in the spring.

Scaup exhibit hyperphagia in spring and fall – may pick up large amount of fat in one area and then move on. Affected by weather and food availability. Does residence time vary seasonally?

What is the percent infection rate in live birds? This affects the spreading of eggs. After a banding operation, could sample live birds for infection.

Spread of snail with trematodes to new areas. Research on fisherman and boat movements.

Confidence in estimates of mortality counts. May hire maintenance personnel that will free up biotech time to work on surveys. There are tradeoffs between short-term disturbance of sampling and getting better counts. Sinking rate of dead birds affects counts. Can you simulate the percent of birds missed through experimentation (e.g. put out a bunch of dead birds and document rate of disappearance)?

Sensitivity analysis indicated **mortality rate** determines if disease persists in the environment.

- Affected by length of infection in bird.
- Emigration removes bird from system.

Residence time and **habitat suitability** are driving the system.

Snail - bird interaction is keystone to waterbird mortality.

Percent of live birds spreading disease, bird density. What constitutes an infection? 1, 2, 10,000??

Restoration construction is a factor, as makes good snail habitat (but that did not occur at Lake Winnibigoshish).

Not found in **depths** greater than 3-5 feet, need algae on rocks.

Data Gaps

In the course of its discussions, the working group identified the following data gaps in understanding of snail - waterbird relationships:

- Foraging by scaup – location, depths, prey density? Paper in the literature in 1973 on the river, most work done on breeding grounds. Takakawa data on foraging – nocturnal, only canvasbacks?

- Snail movement patterns – they are under rocks during the day; do they come out at night? What are the mechanisms of movement, rates of movement?

- Is turbidity an issue? Scaup are tactile feeders so perhaps this may not affect them?

- How does general water quality affect snail-bird interaction?

- Are there any density effects in bird-snail interaction?

- Does bird foraging behavior change after infection? Infected birds cannot dive as deep; therefore, the food found in birds during necropsy may not reflect what they were eating when they first became infected.

- Bird immunology: Can they become adapted to parasites? Acquired resistance: if a bird becomes affected and survives, can the bird resist future infection and, if so, how? Less immune response to subsequent infection (bird condition may affect this). Mortality events may lead to selection of surviving birds that are more resistant to infections and/or birds that survive initial infection and acquire resistance.

- Fewer mortalities are observed with other bird species – are they immune to the parasites? Many parasites are host-specific. Are there differences in foraging patterns? Are scaup and coot predisposed?

- How accurate are the mortality counts?
- Can Afton's banding work be used to estimate annual survival of scaup?
- What is the age structure of dead birds? How does age affect susceptibility?
- What is the residence time of birds? Residence time/bird use influences exposure time. Good bird use data are available for fall – can these be used to calculate exposure time.
- Are the parasites native or invasive? Two of the 3 are probably invasive – are all 3?
- Are isopods intermediate hosts? Coots feeding in vegetation pick up larvae of insects that are intermediate hosts.
- What are infection rates in Europe?
- What is the distribution of trematodes continent-wide?

Potential Management Strategies

The following potential management actions or issues were identified:

- Interrupt life cycle of the parasite.
- Hazing not feasible.
- Cover rip rap.
- Flow issues
- Snails do not like finer substrates.
- Habitat modification that will affect residency time or distribution of birds.
- Bio-controls (snail predators)
- Influence competitive abilities of native snails.

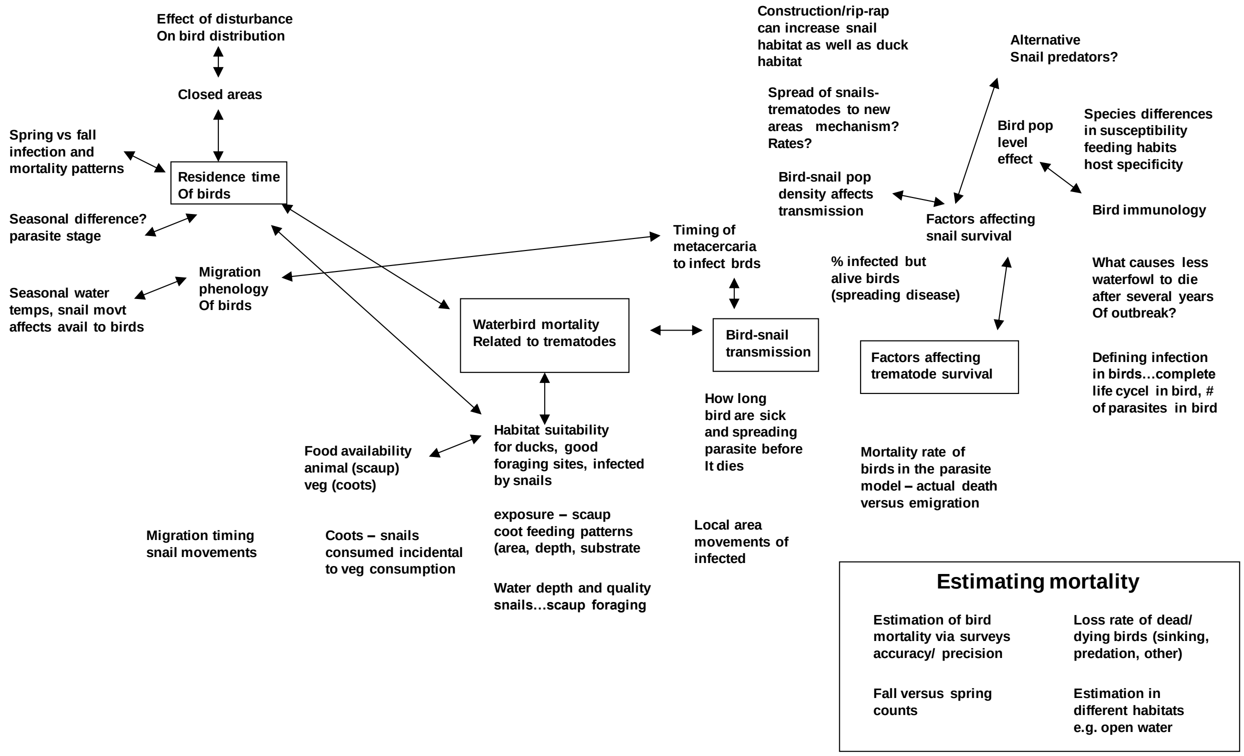

Figure 3. Working group diagram of potential factors affecting snail – waterbird cycle and interactions.

Research Questions / Ideas

The working group reviewed the important data gaps in understanding the interactions between snails and waterbirds, especially in relation to potential management inventions that could reduce snail populations, consumption of snails (and subsequent trematode infection) by waterbirds, and/or snail exposure to or impact on waterbird populations. The following research questions in need of further investigation:

Key Research Questions: *(#1 and #2 were given equal priority)*

1. **Temporal and spatial scaup and coot distribution and foraging patterns relative to snail distribution and abundance**

   a. Regional distribution of scaup (landscape level)
      Local distribution of scaup (micro scale)
   b. Describe distribution of *Bithynia* and trematodes
   c. Examine spatial and temporal overlap of above

   Aquatic system: Examine spatial and temporal distribution of:
   - Scaup
   - Coots
   - Snails (infected and non-infected) – e.g. vegetation, water depth, substrate, flow
   - Map suitable habitat (vegetation) for scaup – coots – snails

2. **Improving mortality estimation**

- Examine carcass loss rates
- Sample design, stratification by habitat, sample sizes, sampling frequency
- Standardize general protocol
- Seasonal considerations – water system type
- Age structure of dead birds
- Detection probability of carcasses
- Solicit reporting of dead birds via the public in new areas (citizen science)

3. **Mechanism of snail and parasite dispersal to different water bodies**

- On birds (legs, feathers)
- Human transportation
- Type of water body
- Seasonal variation?

Other Research Needs:

- **Factors affecting snail survival and reproduction**
  - Predators
  - Disease
  - Environmental factors

- **Factors affecting residency time of waterbirds (scaup, coots)**
  - Examine length of stay duration in individual birds for particular water body (spring vs fall)
  - Healthy bird time of stay vs time of stay for infected birds

- **Mortality timing and rate for infected birds**
  - Captive study to examine infection to shedding eggs to mortality
  - How is this related to residence time of bird in wild?
  - Effects on mobility of birds and subsequent effect on ability to spread eggs
  - Seasonal patterns?

- **Physiological response to infection (initial and subsequent infections)**
  - Captive study of dosed birds
  - Do birds acquire resistance to trematodes after initial infection?
  - Is it valid to assume that they acquire immunity?

- **Survey trematode occurrence in birds throughout the annual cycle**
  - Spatial and temporal occurrence in birds
  - Late summer/early fall versus migration and winter

- **Relationship of scaup mortality due to trematodes relative to scaup densities**
  - Linear relationship
  - Curvilinear?

Waterbird Mortality Research Issues Workshop

Upper Mississippi River National Wildlife & Fish Refuge
La Crosse, WI, US
16 – 17 March 2010

Final Workshop Summary

APPENDIX I

Workshop Participants and Agenda

Workshop Participant List

Last name	First name	E:mail	Agency
Andersen	Mark	Mark.Andersen@Wisconsin.gov	WDNR-La Crosse
Austin	Jane	jaustin@usgs.gov	USGS-Northern Prairie Wildlife Research Center
Businga	Nancy	Nancy.Businga@Wisconsin.gov	WDNR-Madison
Gehri	Calvin	Calvin_Gehri@fws.gov	USFWS-La Crosse District
Kelley	Jim	James_R_Kelley@fws.gov	USFWS-Mississippi Flyway Representative
Larson	Jessica	Jessica_Larson@fws.gov	USFWS-La Crosse District
Lawrence	Jeff	jeff.lawrence@state.mn.us	MDNR
Nissen	Jim	James_Nissen@fws.gov	USFWS-La Crosse District
Peirce	James	peirce.jame@uwlax.edu	UW-La Crosse
Perez	Kathryn	perez.kath@uwlax.edu	UW-La Crosse
Roy	Charlotte	Charlotte.Roy@state.mn.us	MDNR
Sandland	Greg	sandland.greg@uwlax.edu	UW-La Crosse
Sauer	Jennie	jsauer@usgs.gov	USGS-Upper Midwest Environmental Sci. Center
Schnoebelen	Douglas	douglas-schnoebelen @uiowa.edu	University of Iowa-Lucille A. Carver Mississippi Riverside Environmental Research Station
Sousa	Christine	Christine.Sousa@state.mn.us	MDNR
Strickland	Jeramie	jeramie_strickland@fws.gov	USFWS-Savannah District
Traylor-Holzer	Kathy	kathy@cbsg.org	IUCN/SSC Conservation Breeding Specialist Group (facilitator)
Walker	Ben	walker.benj@students.uwlax.edu	UW-La Crosse
Whalen	Sarah	sarah.whalen@mnsu.edu	Minnesota State University, Mankato
White	LeAnn	clwhite@usgs.gov	USGS-National Wildlife Health Center
Yager	Tim	Timothy_Yager@fws.gov	USFWS

Workshop Agenda and Tasks
USFWS-UMNWR, La Crosse, WI, 16 – 17 March 2010

Tuesday, 16 March: (10am – 5pm)

10:00	Welcome/introductions/workshop overview
10:30	Morning plenary presentations (Sauer, Gehri, Lawrence, White, Peirce & Sandland)
12:00	Lunch
1:00	Afternoon plenary presentations (Sauer, Perez, Whalen, Schnobelen, Austin)
3:00	System diagram development
3:30	Working groups: Diagram expansion/identification of facts and assumptions/data assembly
5:00	End of day

Wednesday, 17 March: (8:30am – 3pm)

8:30	Working groups: Identification of data gaps and potential management invention points
10:30	Plenary session: Working group summaries/discussion/diagram integration
11:30	Lunch
12:30	Working groups: Identification/prioritization of recommended research needed for effective management action to reduce waterbird mortality
2:00	Plenary session: Working group summaries/discussion
3:00	End of workshop

Working Group Tasks:

TASK 1. **Review the Issues and System Diagram Section** that is the focus of your group. Expand the list of issues/factors potentially affecting the system and incorporate these components and relationships into the diagram (based on past research, published literature, and expert opinion). Indicate the estimated direction and relative strength of these relationships. Consider geographic differences, seasonality, and both biotic and abiotic factors. Document geographic distribution of relevant factors on the map provided.

TASK 2. **Identify Facts and Assumptions** by reviewing each relationship and marking it as a fact or an assumption. Document what is known/assumed about the relationship, and provide source/citation for facts where possible.

TASK 3. **Identify data gaps** in the system model and indicate those that are being addressed by current research and those that would require future research efforts.

TASK 4. **Identify potential management invention points** in the system model that could reduce waterbird mortality. Compare these invention points against data gaps to identify key areas for research that would inform and guide management actions.

TASK 5. **List and Prioritize Research Project Ideas** with relation to the potential to contribute to the development of effective management actions for reducing waterbird mortality. Starting with the top priority projects, develop each research idea more fully by identifying the research question and any of the following to the extent possible: general description of project/methodology; relevance/potential application for management action; potential researchers/collaborators; resources needed/potential funding sources; timeline

Waterbird Mortality
Research Issues Workshop

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APPENDIX II

List of References

Bithynia Reference List

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