Association of Fish and Wildlife Agencies

Fish and Wildlife Health Forum

Report and Recommendations

Published by the Association of Fish and Wildlife Agencies, June, 2019

Acknowledgements

We thank the following organizations for their significant financial and in-kind support for this event: BAND Foundation; U. S. Geological Survey – Ecosystems; U. S. Fish and Wildlife Service Science Applications; U. S. Forest Service Research and Development; and the Virginia Department of Game and Inland Fisheries. We particularly thank Nick Lapham of the BAND Foundation, Anne Kinsinger of USGS Ecosystems, Benjamin Tuggle of the U. S. Fish and Wildlife Service, Carl Lucero of U. S. Forest Service Research and Development, and Bob Duncan of the Virginia Department of Game and Inland Fisheries for their visionary leadership and support for the AFWA Fish and Wildlife Health Forum.

We thank the following individuals for their participation in the initial planning group for the Forum: Priya Nanjappa, Jonathan Mawdsley, Michael Adams, Jeremy Coleman, Devin DeMario, Colin Gillin, Sarah Gravem, Reid Harris, Drew Harvell, Camille Hopkins, Joseph Hoyt, Peter Jenkins, Patrice Klein, Bruce Menge, Carrie Miner, Jennifer Mock Schaeffer, and Craig Willis.

We thank the following individuals who worked collaboratively together to develop detailed plans for the Forum, beginning in July, 2018: Elsa Haubold, Jonathan Mawdsley, Meg Boera, Jeremy Coleman, Devin DeMario, Jenny Dickson, Samantha Gibbs, Colin Gillin, Camille Hopkins, Patrice Klein, and Janet Whaley. We also thank the members of the U. S. Fish and Wildlife Service's Science Applications Program's "Team Narwhal" for their assistance in designing the group discussions: Jill Cohen, Megan Cook, Laura MacLean, and Anna-Marie York.

We thank all of our speakers and presenters and we particularly thank the following individuals who led small group discussions and/or world café sessions during the Forum itself: Julie Alexander, Marilyn Blair, Devin DeMario, Cindy Driscoll, Samantha Gibbs, Mark Humpert, Maggie Johnson, Lane Kisonak, Laura MacLean, Jonathan Mawdsley, Maureen Purcell, Katherine Richgels, Jeff Trollinger, Silvana Yaroschuk, and Anna-Marie York. We also thank Meg Boera from Delaney Meeting Management for her kind and gracious assistance in helping us manage key logistical details for the Forum.

Citation of this report: Mawdsley, J. R., and Humpert, M. (eds.). 2019. Association of Fish and Wildlife Agencies Fish and Wildlife Health Forum: Report and Recommendations. Association of Fish and Wildlife Agencies, Washington, D. C., USA. 94 pp.

Executive Summary

The Association of Fish and Wildlife Agencies (AFWA) hosted the first-ever AFWA Fish and Wildlife Health Forum on November 14-16, 2018, at U. S. Geological Survey Headquarters in Reston, Virginia. The meeting was attended by slightly over 100 participants from state and federal agencies, non-governmental organizations, academia, industry, and other research institutions. This report provides a summary of the major findings and recommendations from this meeting.

Key Recommendations

Forum participants generated a long list of potential action items and recommendations for the Association of Fish and Wildlife Agencies, its members, and partners. Some of the most immediate and potentially actionable items which were proposed by participants include:

Revitalize the National Fish and Wildlife Health Initiative, with a particular focus on updating the Initiative's toolkit and briefing materials, originally developed in 2008. These materials have been provided by the Association of Fish and Wildlife Agencies to new state agency directors in order to help facilitate their responses to disease emergencies. Forum participants indicated that the most valuable portions of the toolkit included a list of contacts who can be consulted during a fish or wildlife disease crisis, as well as a position description for a state fish and wildlife agency veterinarian or health and disease specialist. The position description alone was credited with increasing the number of states with wildlife veterinarians or disease specialists from 5 to 37 between 2009 and 2019.

Improve coordination among state fish and wildlife agency staff engaged in fish and wildlife health and disease efforts, to be undertaken in collaboration with the Association's Fish and Wildlife Health Committee. Such coordination will include regular conference calls or web meetings with state agency staff, special sessions at other meetings or conferences such as the AFWA Annual Meeting, North American Wildlife and Natural Resources Conference, International Wildlife Disease Association, the U. S. Animal Health Association, American Fisheries Society, The Wildlife Society, or stand-alone meetings of relevant agency staff.

Work collaboratively with state fish and wildlife agencies to identify the highest priority needs for managing fish and wildlife diseases, including the availability of technical resources, training, staff, funding, equipment, and supplies; and work with state and federal agency partners to develop strategies to address these needs.

Advocate for additional research on the taxonomy, biology, and diseases of poorly-known fish and wildlife species, particularly those which have been identified in the State Wildlife Action Plans as Species of Greatest Conservation Need.

Improve coordination and communication among diagnostic laboratories that provide disease identification and diagnostic services to state fish and wildlife agencies and their partners. Identify gaps in capacity across the current suite of diagnostic laboratories and work with partners to address these gaps. Pursue standardization of laboratory testing protocols across laboratories in partnership with state and federal fish and wildlife managers.

Identify additional resources to support fish and wildlife health and disease research and management, particularly when such resources are aligned with major AFWA legislative priorities such as the "Recovering America's Wildlife Act."

Continued development by AFWA staff and the AFWA Fish and Wildlife Health Committee of high-value guidance documents and scientific synthesis products, such as the "Best Management Practices for the Prevention, Surveillance, and Management of Chronic Wasting Disease" and the associated technical report, which were released by AFWA in September, 2018.

Identify administrative, regulatory, and legislative opportunities to address critical "gaps" in our ability to manage and respond to fish and wildlife health and disease threats, particularly the lack of existing legal authorities for the management of many existing and new and emerging diseases of native fish and wildlife species at national and regional levels.

In addition, participants strongly endorsed the hosting by AFWA of future fish and wildlife disease meetings and events, particularly at times which would enable greater participation by state fish and wildlife agency staff. We recommend holding such a meeting on a biennial basis at minimum.

These recommendations are currently under review by the Association, its staff, and committees for possible implementation.

Contents

Casey Barton Behravesh, MS, DVM, DrPH, DACVPM, Captain in the U.S. Public Health Service, and Director of CDC's One Health Office in the National Center for Emerging and Zoonotic Infectious Diseases, gives a presentation about One Health at the inaugural AFWA Fish and Wildlife Health Forum. Photo Credit: Jonathan Mawdsley, Association of Fish and Wildlife Agencies.

Meeting Background and Purpose

The management of fish and wildlife diseases is an ever-expanding challenge for fish and wildlife conservation professionals. Major impacts have already been documented for numerous fish and wildlife species in terrestrial, freshwater, and marine ecosystems. Ongoing diseases such as Chronic Wasting Disease and Whirling Disease continue to occupy the time and efforts of fish and wildlife scientists and managers. Emerging diseases such as White-nose Syndrome in bats and amphibian chytrid fungal disease in frogs threaten populations of additional wildlife species. Most of these diseases require inter-agency coordination which is critically important in developing timely responses to disease outbreaks, in order to ensure that appropriate parties are engaged and informed at each stage of disease management. Improving our ability to manage and respond to fish and wildlife disease emergencies is an ongoing challenge, given each agency's unique jurisdictional authorities and policies for wildlife and land management, as well as the uneven distribution of resources, diagnostic laboratories and capabilities across the broader management landscape.

The AFWA Fish and Wildlife Health Forum was convened in order to provide practical recommendations to improve the ability of state and federal agencies and partners to respond to wildlife disease events in the US through the evaluation of existing systems, policies, and procedures. The forum was carefully designed to facilitate the sharing and exchanging ideas and approaches among peers who are tackling various aspects of fish and wildlife disease control. Participants explored opportunities for improved coordination, prevention, rapid response and early intervention through direct discussions with academic biologists, wildlife and fisheries managers, wildlife veterinarians, and other disease experts.

The original agenda for the Forum which was provided to attendees and a detailed description and justification for the Forum activities are provided in the Appendices.

The planning team for the Forum included Jonathan Mawdsley, Priya Nanjappa, and Devin DeMario from AFWA, Elsa Haubold, Jeremy Coleman, and Samantha Gibbs from the U. S. Fish and Wildlife Service; Janet Whaley from NOAA; Camille Hopkins from USGS; Patrice Klein from the U. S. Forest Service; Jenny Dickson from Connecticut Department of Energy and Environmental Protection; and Colin Gillin from Oregon Department of Fish and Wildlife.

Forum participants included:

Scientific experts in selected emerging and persisting diseases who:

1) address the state of the science, specifically what the latest evidence shows regarding opportunities for intervention within the epidemiology triad of host, pathogen, and environment components, and

2) provide examples of what ideal scenarios might have looked like for prevention, early detection, rapid response, early interventions or mitigation.

Management experts for selected ongoing pathogen challenges who:

1) Reflect on current systems, policies and procedures and highlight those areas that are working well, and those that could be improved, and

2) Provide examples of management approaches in the context of host, pathogen, and environment that were effective, and may have application to other diseases.

All participants were invited to learn from each other and work collaboratively together to identify:

1) Commonalities among pathogens, as well as common unmet needs and goals.

2) Unique challenges for particular pathogens, as well as specific and immediate needs for research, prevention, early detection and monitoring, rapid response, management and mitigation.

3) Communication and intervention approaches that are working well and may be replicated across taxa or systems.

4) Opportunities for increased efficiencies in coordination and communication across fish and wildlife agencies toward effective early detection, rapid response or containment, coordinated management.

5) Opportunities for improved infrastructure, outreach, information and education.

Fish and Wildlife Health Forum Process and Meeting Flow

The Fish and Wildlife Health Forum's purpose was "to improve the potential to respond to wildlife disease events in the US through the evaluation of existing systems, policies, and procedures." The meeting was designed to provide a forum that allowed sharing and exchanging ideas and approaches among peers from state and federal agencies, NGOs, and academia who are tackling various aspects of fish and wildlife disease control. Participants examined opportunities for improved coordination, prevention, rapid response and early intervention.

Participants were asked to review the 2008 National Fish and Wildlife Health Initiative Toolkit or the 2008 National Aquatic Animal Health Plan prior to attending the Forum. At the Forum, brief presentations were given by scientists and managers (see agenda) to ensure all participants had a basic understanding of the breadth of emerging issues. These presenters were asked to provide a 250-word abstract included in this meeting summary. Most of the meeting was plenary discussions and break-out sessions to identify what is working, challenges, and opportunities for moving forward. Eight volunteers served as facilitators for the small group discussions. Input was gathered using several methods including plenary discussions, the TurningPoint app where individuals could respond to questions on their phones and tablets; and small group brainstorms. A SurveyMonkey was created to gather feedback about the forum and sent out to participants by email afterwards. A detailed description of the process follows.

Opening Session

During the opening session participants heard from federal and state agencies about challenges and approaches they are taking to address challenges. The Keynote address from Becky Humphries, former Director of the Michigan Department of Natural Resources and Environment, founder of the National Fish and Wildlife Health Initiative, and former chair of the AFWA Fish and Wildlife Health Committee, reviewed the history of wildlife health and stimulated thinking for the future by posing some provocative questions through interactive dialog with the participants.

State of the Science Presentations

The first afternoon a series of lightning presentations (8 minutes or less) were given to summarize the state of the science for some emerging and epidemic diseases and pathogens. Each presentation emphasized what would be ideal in terms of prevention, early detection, rapid response, early interventions, or mitigation. Presenters were provided a slide template and asked to provide lessons learned on what is working and where there are challenges and gaps as well as potential actions.

Lessons Learned and Actions Needed Around Coordination (World Café Discussions)

The participants were then assigned to four of eight world café sessions. The purpose of the world café sessions was for participants to hear about specific cases around eight themes that can affect coordination then document lessons learned and actions needed. The Café leader started with a brief overview of the topic and then led a discussion to generate ideas around what is working, resources in place as well as

challenges, gaps, and needs around each theme. Ideas were captured on post it notes and then entered in to a google document for future analysis. These discussions were intended to assist participants in creating actions the following day and to provide some information around lessons learned.

Theme	**Case Study (leader)**
Authority	Screw worm in Florida (Sam Gibbs)
Coordination	Investigating suspected cases of novel pathogens (Jeff Trollinger)
Protocols/Standardization	AFS Blue book (Marilyn "Guppy" Blair)
Science Gaps	State of the Science (Jonathan Mawdsley)
Existing Resources	Aquatic Tools (Maureen Purcell)
Preparing for Uncertainty	Climate (Julie Alexander)
Outreach	Invasive Species Apps (Laura MacLean)
Funding	Federal Opportunities (Anna-Marie York)

Disease Management Presentations

The second morning a series of lightning presentations (8 minutes or less) were given providing the managers' perspectives regarding existing policies and procedures. They presented examples of "what worked" for specific disease events and provided recommendations on what could be improved. Presenters were provided a slide template and asked to provide lessons learned on what is working and where there are challenges and gaps as well as potential actions.

Small Group Discussions: What is Working and Challenges and Gaps for Science and Management

Participants spent most of the morning in small groups brainstorming ideas about

- What is in place and what is working for Science
- What is in place and what is working for Management
- What are challenges and gaps, needs in Science
- What are challenges and gaps, needs in Management

The groups spent 25 minutes on each of these four areas. The steering committee then generated a set of "themes" from the ideas generated.

Small Group Discussions to Develop Action Plan and Recommendations

The second afternoon was spent beginning to develop an action plan and recommendations for AFWA's Fish and Wildlife Health Committee. All participants convened in the afternoon, reviewed and provided input to the themes generated during their morning breakout discussions. They then returned to their breakout groups.

Each breakout group was assigned three of the generated themes and asked to vote on the top two actions that could be taken in the short-term and the top two actions that should be taken in the long-term. The groups were told these recommendations would be the most important part of the forum report. Groups spent the final hour of the day reporting their high priority actions to the entire forum.

One Health -- Closing Plenary Presentation

Casey Barton Behravesh, MS, DVM, DrPH, DACVPM, a Captain in the US Public Health Service, and Director of CDC's One Health Office in the National Center for Emerging and Zoonotic Infectious Diseases gave a closing plenary presentation about One Health. One Health is the collaborative effort of multiple disciplines – working locally, nationally, and globally – to attain optimal health for people, animals, and our environment.

Closing Plenary Discussion around Needs and Opportunities

Jennifer Mock Schaeffer from AFWA led the forum in a group discussion around identified needs and opportunities for better inter-agency management and coordination, resource and policy implications.

Data collected

All data collected during plenary and small group discussions were captured by the meeting facilitators in a "Google doc" in real time. A summary table was created of the science and management presentations lessons learned and recommended actions.

Forum Agenda

PARTICIPANT AGENDA

Tuesday, November 13		
1:00pm – 5:30pm	**Optional Field Trip to Smithsonian National Museum of Natural History Exhibit: "Outbreak: Epidemics in a Connected World"** Meet Jonathan Mawdsley in Sheraton lobby at 1:00 pm. Bring your DC Metro pass or plan to purchase one for $10. We will take a few Lyfts/Ubers or a shuttle to the Wiehle-Reston East Metro station and head into the District, exiting at the Federal Triangle Metro stop. For those who want to meet at the National Museum of Natural History, you can expect the group to arrive a little before 2:00 p.m. *Return to hotel on your own.*	***Offsite; start at Sheraton Reston Hotel***
Wednesday, November 14		
8:00am – 8:30am	**Registration/Check-in and Coffee**	***Foyer***
We will be using the Turning Point app extensively during the Forum. Please download the app here.		
8:30am – 9:45am	**Welcome & Opening Remarks** *Jonathan Mawdsley, AFWA (emcee) & Camille Hopkins, USGS (host) Anne Kinsinger, USGS; Ron Regan, AFWA; Nick Lapham, BAND Foundation; Benjamin Tuggle, USFWS; Carl Lucero, USFS; Bob Duncan, VA DGIF*	***Auditorium***
9:45am – 10:35am	**Keynote** Rebecca Humphries, CEO, National Wild Turkey Federation, *Imagine a Perfect Response to Future Fish and Wildlife Diseases*	***Auditorium***
10:35am – 10:50am	**Coffee Break**	***Foyer***
10:50am – 12:00pm	**Group Discussion** – led by Rebecca Humphries *If you haven't already, please log into Wi-Fi: username: AFWA; password: welcome 1234! Download the Turning Point app to your phone. Plenary discussion around the future of response to fish and wildlife diseases.*	***Auditorium***
12:00pm – 12:57pm	**Attendee Lunch**	***Cafeteria***

1:00 pm – 2:55 pm	**Presentations and Panel Discussion** ***Fish & Wildlife Health Management Approaches*** *Focus on a selection of fish & wildlife health management approaches, and what we have learned* *Ongoing Disease Management Challenges:* • *Chronic Wasting Disease (CWD): Best management practices and current efforts - Colin Gillin, DVM; Oregon Department of Fish and Wildlife* ***State of the Science*** *Syntheses on the "State of the Science"* *Focus on ideal responses and early interventions following an outbreak for select emerging or epidemic diseases and pathogens* *Contemporary Emerging Pathogens: including projects funded by the Band Foundation* • Understanding and managing white-nose syndrome in hibernating North American bats - *Craig Willis, PhD; University of Winnipeg* • Snake fungal disease - *Matt Allender, DVM, PhD; University of Illinois* • Bsal: The next potential threat to North American biodiversity - *Matt Gray, PhD; University of Tennessee-Knoxville and Molly Bletz, PhD; University of Massachusetts-Boston* • Aquatic parasites of salmonids: Problematic myxozoans - *Julie Alexander, PhD; Oregon State University* Scientific Tools and Considerations: • USGS Strategic Sciences Group case study on Bsal: Using preparatory exercises to help identify needs - *Camille Hopkins, DVM, PhD; USGS* • Diagnostic harmonization for bat white-nose syndrome - *David Blehert, PhD, USGS* • Considerations and challenges in marine vs. terrestrial ecosystems - *Sarah Gravem, PhD; Oregon State University* • Application of genomics for understanding and mitigating wildlife disease - *Anna Savage, PhD; University of Central Florida*	***Auditorium***
2:55pm – 3:14pm	Coffee	***Foyer***

3:15pm – 5:00pm	**Small Group Discussion: Lessons learned** *Each participant will participate in four world café case studies. See the letter on your name tag to determine the café you will begin and be at that station by 3:14.* *Case studies may include screwworm outbreak in Florida, false alarms of novel pathogens, AFS blue book, State of the Science, Aquatic tools, Climate, Invasive Species Apps, and Federal Funding Opportunities. You will write down 3 ideas of what is working and 3 ideas of challenges around the theme of each world café.* ***Starting Café Stations: Groups A&B – Station 1, Groups C&D – Station 6, Groups E&F – Station 3; Groups G&H – Station 4*** *After your fourth café case study, the meeting is adjourned for the day; please join us for the evening networking reception!*	***Auditorium Stations***
5:30pm – 7:00pm	☆ **Networking Reception at The Sheraton Reston - Cosmopolitan Lounge**	***Offsite***
Thursday, November 15		
8:00am – 8:30am	**Recap of Wednesday's Discussions –** Jonathan Mawdsley	***Auditorium***
8:30am – 9:30am	**Presentations** **Fish & Wildlife Health Management Approaches** *Focus on a selection of fish & wildlife health management approaches, and what we have learned* **Ongoing Disease Management Challenges:** • Domestic animal and wildlife interface diseases - *Patrice Klein, MS, VMD, DACPV, DACVPM; USFS* • USDA APHIS Aquatic Animal Health Program -*Kathleen Hartman, DVM, PhD; USDA APHIS* • White-nose Syndrome: Lessons learned and current challenges - *Jeremy Coleman, PhD; USFWS* • Suppressing Plague: Lessons in preventive management of introduced disease - *Mike Miller, DVM, PhD; Colorado Parks and Wildlife* **Management tools and considerations:** • Decision support processes to guide preparation and response - *Evan Grant, PhD; USGS* • West-wide, adaptive, wild sheep disease management venture– *Peregrine Wolff, DVM; Nevada Department of Wildlife*	***Auditorium***
9:30am – 9:48am	**Coffee Break**	***Foyer***

9:48am – 12:00pm	**Small Group Discussions – Lessons Learned** *Participants will break into small groups and rotate among four stations to capture:* • *What is in place and what is working for Science?* • *What is in place and what is working for Management?* • *What are challenges and gaps, needs in Science? and* • *What are challenges and gaps, needs in Management?* *You will organize collected ideas into themes. After the fourth station you will head to lunch. Return to plenary in auditorium at 12:57 for a prompt 1:00pm start!* ***Starting Stations: Group A – Station 1; Group B – Station 2; Group C – Station 3; Group D – Station 4; Group E – Station 5; Group F – Station 6; Group G – Station 7; Group H – Station 8.***	***Auditorium***
12:00pm – 12:57pm	**Lunch**	***Cafeteria***
1:00pm – 1:45pm	**Group Discussion Plenary** *Make sure you have Turning Point app and are connected to WiFi!* *Review results from morning discussion. Agree on themes surfaced during small group discussions.*	***Auditorium***
1:45pm – 4:00pm	**Small Group Discussions (*break included*) – ACTIONS** *Spend 30 minutes developing actions for each of 3 of the themes generated in previous session (will be assigned). Don't rotate, stay at the same station with the same facilitator.* *Brainstorm ideas for actions that could be taken on one theme for 30 minutes. Place post-it notes on flip chart. Each participant receives two green and two red dots to vote for each theme. Spend five minutes voting on the most important short-term actions (green dots), and the most important long-term actions (red dots). Repeat for each of the themes. Emcee will announce five minute warning for each theme (time to vote) and when it's time to change to another theme. Agree on representative to report out the top two short-term and long-term actions for each theme to the entire group. Take a break when needed.* ***Stations: Group A – Station 1; Group B – Station 2; Group C –Station 3; Group D – Station 4; Group E – Station 5; Group F – Station 6; Group G – Station 7; Group H – Station 8.***	***Auditorium stations***
4:00pm – 4:50pm	**Plenary Group Discussion** *Small groups report out top two short-term and top two long-term actions that can be taken for each of the three teams.* *Using the Turning Point app, entire group votes on the top action for each of the themes.*	***Auditorium***
4:50pm – 5:00pm	**Closing Remarks & Adjourn** – Jonathan Mawdsley	***Auditorium***
Evening	**On your own to network!**	

Friday, November 16		
8:15am – 8:30am	**Recap** – Jonathan Mawdsley	***Auditorium***
8:30am – 9:00am	**Plenary Presentation: One Health Considerations** *Casey Barton Behravesh, MS, DVM, DrPH, DACVPM; Centers for Disease Control and Prevention*	***Auditorium***
9:00am – 10:00am	**Plenary Group Discussion** – *Jennifer Mock Schaeffer; AFWA* *Make sure you have Turning Point app and are connected to WiFi!* *Summary of needs identified and opportunities for better inter-agency management and coordination, resource and policy implications*	***Auditorium***
10:00am – 10:20am	**Coffee**	***Foyer***
10:20am – 11:00am	**Plenary Group Discussion (continued)** *Summary of needs identified and opportunities for better inter-agency management and coordination, resource and policy implications*	***Auditorium***
11:00am – 12:00pm	**Summation, Closing Remarks, Next Steps** Jonathan Mawdsley (AFWA), Anne Kinsinger (USGS), Becky Humphries (NWTF), Bob Duncan (VDGIF)	***Auditorium***
Safe journeys home!		

Keynote Presentation – Becky Humphries, National Wild Turkey Federation

In 2005, the Association of Fish and Wildlife Agencies held a session on fish and wildlife health at the North American Wildlife and Natural Resources Conference. At that session, John Baughman asked if the Association should move forward with the creation of a "National Fish and Wildlife Health Initiative." Becky Humphries, Director of Michigan Department of Natural Resources at the time, was chair of the AFWA Fish and Wildlife Health Committee, and the group received a green light from AFWA leadership and directors to begin to develop a health initiative. The following set of guiding principles was developed.

Guiding Principles

- Recognize health management as a key component of any fish and wildlife conservation program
- Promote science-based management strategies
- Emphasize prevention as opposed to control or eradication as a disease management strategy
- Recognize that state fish and wildlife agencies have the responsibility for managing disease in free-ranging fish and wildlife
- Protect and support state, tribal and territorial authorities for fish and wildlife conservation
- Foster development of additional fish and wildlife health capacity, tools and training within state fish and wildlife agencies
- Recognize the wildlife/human/domestic animal disease interface
- Foster collaboration, coordination and communication among fish and wildlife health jurisdiction as well as with human and domestic animal health agencies. (speak to public in one voice)
- Recognize, articulate and integrate abilities and authorities of cooperating state and federal agencies and other partners
- Recognize the need for interstate and international coordination efforts
- Educate the public about disease issues in fish and wildlife and the flue of integrated prevention and management programs.
- The initiative will be a policy framework for interested parties to consult to minimize the negative impacts of disease issues in fish and wildlife resources

The increasing demand for fish and wildlife managers to effectively address disease issues justified development of the initiative under AFWA leadership and in cooperation with appropriate governmental and non-governmental agencies. Implementation of the initiative was supported by AFWA and USAHA resolutions. The first draft of the fish and wildlife health initiative was created in January 2006. In March, 2006, there were meetings with federal partners to obtain input and begin building a collaborative process. In April-August 2006, there were follow-up meetings with state fish and wildlife, human health, and animal health agencies. In August 2006 there was a meeting with appropriate NGOs

Goals

1. Develop and enhance capacity in state fish and wildlife management agencies to effectively address health issues

2. Minimize negative impact so health issues on fish and wildlife resources through development and implementation of science-based management strategies

Goal 1-Building capacity

- Develop state agency polices and processes
- Train state fish and wildlife health specialists and other agency personnel
- Build support through communication strategies informing personnel, policy makers, stakeholders, etc.
- Integrate abilities and authorities of cooperating agencies and other partners

Goal 2-Minimize negative impacts

- Prevent pathogen introduction/establishment
- Early detection
- Rapid response to detection
- Manage F/W health through risk assessment and adaptive management (incorporate human dimensions to maximize efficient of management efforts

First Steps

- Met with NGOs to obtain input and continue building a collaborative process
- Wildlife Disease Association and the American Association of Wildlife Veterinarians were invited to participate
- American Association of Wildlife Veterinarians solicited comments from membership.
- AFWA endorsed initiative
- Development of implementation plans
- Build public support and funding
- Coordinate with Canada and Mexico for a North American Fish and Wildlife Health Plan

Partial List of Participating Agencies/Organizations

- Multiple state fish and wildlife management, public health and animal health agencies: Universities
- Federal agencies: BLM, USGS, USFWS, NPS within USDI: APHIS-VS and -WS within USDA: HHS and DHS, etc.

So where are we today?

When Becky Humphries stepped down as Director in Michigan, Bob Duncan in Virginia took over as the Fish and Wildlife Committee Chair. Becky gave copies of the wildlife health initiative materials and particularly the toolkit to Ron Regan, Executive Director at AFWA, and asked him to give them to new

state fish and wildlife agency directors. Becky did not want new Directors to be intimidated by disease issues.

- Conducted inventory of state authorities
- Identified state and federal resources
- Discussed surveillance
- Put on workshops to provide training
- Bob Duncan decided to stand down the initiative due to lack of funding
- Decided to restart, then turned over to Scott Talbott, Director of Wyoming Game and Fish Department

Becky Humphries from the National Wild Turkey Federation addresses participants at the first-ever AFWA Fish and Wildlife Health Forum. Photo Credit: Jonathan Mawdsley, Association of Fish and Wildlife Agencies.

Presentation Abstracts

STATE OF THE SCIENCE

CONTEMPORARY EMERGING PATHOGENS

Understanding and Managing White-Nose Syndrome in Hibernating North American Bats
Craig K.R. Willis, PhD; University of Winnipeg

White-nose syndrome (WNS) was discovered near Albany New York during winter 2007 when enormous die-offs of bats were observed in several hibernacula. Since then WNS has killed millions of bats, spread across eastern North America and jumped across much of the continent and the Rockies to be detected in Washington State. WNS is caused by a multi-host, cold-tolerant fungal pathogen which has long infected hibernating bats in Eurasia and represents an invasive species to North America. The disease is defined by a simple skin infection but, via still unknown mechanisms, increases frequency of arousals from torpor during hibernation, speeding fat depletion and, presumably, causing starvation. Considerable resources have been invested testing chemical or biological treatments for application to bats and/or hibernaculum substrates and some show promise although treatments will face significant logistical and regulatory hurdles. Some bats survive WNS and the potential to manage in support of an evolutionary rescue response is an active area of research. The WNS response has benefited from several factors which improved coordination early, not least that one affected species was already federally endangered. This prompted international coordination, led by USFWS with diagnostic support from USGS and academic researchers, leading to National Plans in both the U.S. and Canada within five years. The response also benefitted from having the right people in the right positions to help guide scientists and managers and to help communicate with the public and policy makers about the importance of investing in the WNS response.

The Changing Epidemiology of Snake Fungal Disease

Matthew C. Allender, Wildlife Epidemiology Laboratory, College of Veterinary Medicine, University of Illinois, Urbana, IL. mcallend@illinois.edu

Deteriorating wildlife health threatens the sustainability and successfulness of conservation efforts. The ophidiomycosis disease syndrome (SFD) involves clinical signs ranging from minor raised and thickened scales to severe crusts or ulcers on the head and body and can cause death in severe cases. The disease has been found to affect at least 31 snake species dating back to the 1980s. While infections have been observed with great frequency in pitvipers, there are numerous reports of SFD in nonvenomous colubrid snakes. The manifestation of SFD in North American colubrids snakes is variable and has included pneumonia, ocular infections, and subcutaneous nodules. While the presence of the fungus causing infections in individuals is concerning, the role that it might play in population declines is more alarming. A timber rattlesnake population in New Hampshire consisted of 40 individuals pre- SFD; however, by the conclusion of that particular study, the entire population was reduced to 19 individuals. While many factors are affecting the conservation of this population, the occurrence of this pathogen may serve as an

additional threat to its conservation. It is clear that a multi-modal approach to disease mitigation in reptiles will help to protect captive and free-ranging species. However, a proactive approach to disease management is needed for reptiles across the globe that takes into account testing, disinfection, and appropriate quarantine.

Batrachochytrium salamandrivorans: The next potential threat to North American biodiversity
Matt Gray, PhD; University of Tennessee-Knoxville and Molly Bletz, PhD; University of Massachusetts-Boston

The recently discovered chytrid fungus, Batrachochytrium salamandrivorans (Bsal), poses a significant threat to global salamander diversity and has already decimated fire salamander populations in multiple European countries. The United States is a hotspot of salamander diversity rivaled by no other around the world, hence understanding the risk of Bsal invasion and how to respond if it emerges is essential. The North American Bsal Task Force is a collection of scientists and others that are working toward understanding the possible effects of Bsal on native host species, they have developed a Bsal response plan, which is supported by a strategic plan, and they are starting to evaluate disease intervention strategies. Initial susceptibility trials have demonstrated a broad species range of Bsal hosts in North America, and high conservation risk for approximately 30% of species tested. Understanding species susceptibility is essential to identify species and geographic regions that are at greatest threat of Bsal invasion, and can help direct surveillance and management response actions. The two best approaches to Bsal intervention are: (i) preventing or minimizing the risk of entry of the pathogen through amphibian trade, and (ii) developing management strategies that can mitigate disease emergence, reduce spread, and ideally allow animals to persist despite infection. Disease response strategies in the wild can be categorized as physical, chemical and biological, and include actions such as altering water chemistry or temperature, modifying host density, applying fungicides, vaccination, and probiotic bioaugmentation. Development and support of comprehensive national wildlife health legislation will be essential to combat significant biodiversity losses if Bsal emerges in the United States, and for addressing future wildlife diseases.

Aquatic parasites of Salmonids: Problematic myxozoans

Julie Alexander, PhD; Oregon State University

Climate related shifts in water temperatures and precipitation patterns will have significant effects on myxozoan disease dynamics, but predicting the magnitude and direction of specific responses is challenging. I present an overview of myxozoan species that are problematic in North America. *Ceratonova shasta* causes enteronecrosis and is associated with population-level declines in Klamath River salmonids. *Myxobolus cerebralis* causes whirling disease and is associated with recreational salmonid fishery collapses in the intermountain west, and has recently emerged in Canada. Transmission of myxozoan parasites occurs through waterborne stages: actinospores are released from invertebrate hosts infect salmonid fishes, and released from infected fish hosts infect invertebrate hosts. Consequently, management actions may target various life stages. Lessons learned, intervention opportunities, and scenarios are illustrated with data from managed flow events ("surface flushing" and

"dilution" flows) in the Klamath River. Recommendations consider disease dynamics in the context of future climate predictions.

SCIENTIFIC TOOLS AND CONSIDERATIONS

USGS Strategic Sciences Group case study on *Bsal*: Using preparatory exercises to help identify needs

Camille Hopkins, DVM, PhD; U.S. Geological Survey

In May 2017, a workshop was facilitated by the Department of the Interior's Strategic Sciences Group. During the workshop, a discussion-based incident response exercise focused on a hypothetical *Bsal* disease outbreak in Appalachia. Participants included representatives of the Eastern Band of the Cherokee Indians, U.S. Fish and Wildlife Service, National Park Service, U.S. Geological Survey, Appalachian Landscape Conservation Cooperative, Tennessee Wildlife Resources Agency, and U.S. Forest Service. Scenario-building was used to brainstorm cascading consequences (social, economic, and ecological) of a *Bsal* disease outbreak in the Appalachian region. This presentation will highlight lessons learned and potential actions that could be taken based on the workshop discussions.

Diagnostic Harmonization for Bat White-Nose Syndrome

David S. Blehert, PhD; U.S. Geological Survey

Coordination of laboratory diagnostics and reporting of test results is well established within the fields of human and domestic animal health, in which laboratories form networks that operate under the oversight of a national or international governing agency. This oversight ensures rapid and accurate testing, and consistent interpretation of results for ongoing disease surveillance or in the event of an outbreak. Diagnosticians specializing in wildlife diseases have lagged behind their counterparts in forming such networks or in taking other collective actions to ensure consistency of results and interpretations across laboratories. Bat white-nose syndrome is a high-impact disease with a well-established response network, and thus provides a unique opportunity to explore diagnostic harmonization – a way to achieve uniformity of results while allowing for individual differences in laboratory methodologies and equipment. Toward this end, the USFWS and USGS have hired a diagnostic harmonization coordinator, seated at the National Wildlife Health Center, to establish a voluntary laboratory network through which procedures for testing and communication of results will be collectively optimized to agreed-upon standards of reliability and reproducibility. Development of data- and consensus-based standards for diagnostic testing will help to alleviate ambiguity for resource managers who rely upon these results for decision-making and implementation of disease management strategies.

Considerations and challenges in marine versus terrestrial ecosystems

Sarah Gravem, PhD; Oregon State University

For marine organisms, existence in a water medium and the ubiquity of waterborne larval phases present fundamentally different circumstances that have profound effects on research and management of disease. The water medium often transmits diseases readily and makes containment challenging because

pathogens can survive longer in seawater than in air, there are fewer barriers in the ocean than on land, and ocean currents can travel long distances quickly. The larval phases exhibited by most marine organisms, where larvae develop in the open ocean before returning to shore, render typical strategies like quarantine, captive breeding, vaccination, antibiotic therapy, culling, and the development of resistant transgenics challenging or unfeasible. Alternately, large numbers of traveling waterborne offspring mean that parents do not typically infect their young, that larvae can repopulate depauperate areas, and that potential for adaptive disease resistance is high. To prepare for rapid and far-ranging waterborne outbreaks, researchers and managers must preemptively form surveillance and response networks. To prepare for circumstances where many mitigation and remediation strategies aren't possible, we must concentrate resources in strategies like quarantine, captive breeding, and eventual reintroductions. These strategies require that aquaculture facilities exist before outbreaks take place. To address these issues and prepare for future outbreaks, the Sea Star Wasting Task Force and others are forming a marine disease outbreak response network and drafting a general marine disease outbreak contingency plan. The plan will include surveillance and response guidelines and identify infrastructure, such as aquaculture facilities, that will make mitigation and remediation strategies possible.

Application of genomics for understanding and mitigating wildlife disease

Anna Savage, PhD; University of Central Florida

Wildlife disease systems are diverse and idiosyncratic. Consequently, the optimal genomic tools for understanding disease drivers may vary with the specific organisms, populations and ecosystems involved. One particularly important consideration is the degree to which the causative agents behind a disease outbreak are known, suspected, or completely undetermined at the time when genomic approaches are implemented. For well-established host-pathogen systems with defined habitat characteristics linked to epidemics, narrower and deeper genomic investigations may be most appropriate and informative. In contrast, when morbidity and mortality are detected in wildlife populations but the causative agents are mysterious, genomic investigations must necessarily begin from a broader and shallower scale of inquiry. Due to the system-specific nature of how genomics tools are best applied to understanding disease, I present a series of case studies, ranging from systems with completely unknown etiological agents, to systems with well-studied and established disease drivers, to systems with established epidemiological and genomic frameworks. I highlight optimal genomics approaches used for each scenario, lessons learned from genomic studies, and whether and how genomics approaches have been instrumental in understanding and mitigating disease impacts.

FISH & WILDLIFE HEALTH MANAGEMENT APPROACHES

ONGOING DISEASE MANAGEMENT CHALLENGES

Domestic Animal and Wildlife Interface Diseases

Patrice N. Klein, MS VMD DACPV DACVPM; USDA Forest Service

There are many factors influencing the emergence or expansion of fish and wildlife diseases such as an increase in the virulence of an existing pathogen, a change in host susceptibility or a new host population, extension in the host-pathogen range, and an increase in exposure risk at the wildlife – domestic animal –

human population interface. This disease interface is described by the animal and human population boundaries and the pathogenic agents transmitted across those boundary lines; and is functionally the critical point at which cross-species transmission occurs. Interface diseases may be endemic, foreign/introduced, and/or zoonotic. Local, regional, and global expansion is promoted by climatic, environmental, and anthropogenic events. Chronic wasting disease (CWD) West Nile Virus (WNV), Monkey pox, and Avian Influenza are representative of such wildlife – domestic animal – human interface diseases to highlight the need for effective, cooperative partnerships and our abilities to respond to them.

State, federal, tribal officials and non-governmental partners recognize the need for animal and human health management systems to work together in a One Health approach to develop integrated and interdisciplinary infectious disease preparedness and response plans. Components should include integrated surveillance systems, standardized laboratory networks, defined communication channels and timely reporting mechanisms, and coordinated response infrastructures. While some of these processes are in place, others remain to be established. All are dependent on availability of resources and the ability to sustain them. Lessons learned from recent interface disease outbreaks identified the need for further research on the susceptibility of the animal and human host, the extent of pathogen range and virulence, the dynamics of inter-species transmission, the effect of seasonality on disease transmission, and diagnostic tools for early detection. Furthermore, there are needs to establish and sustain strong collaborative One Health partnerships and reinforce existing working relationships among scientists, diagnosticians, animal and public health specialists, epidemiologists, biologists, ecologists, land managers, legislators, and stakeholders to meet current and future disease challenges.

USDA APHIS Aquatic Animal Health Program

Kathleen Hartman, MS, DVM, PhD; USDA Animal and Plant Health Inspection Service

Currently the U.S. commercial aquaculture industry sectors are operating without uniform standards for the health of farm-raised aquatic animals. The aquaculture industry sectors are burdened with varying health requirements for animal movement often resulting in expensive yet meaningless testing. The National Aquaculture Association (NAA) in collaboration with the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), Veterinary Services (VS), have drafted program standards to establish a non-regulatory framework for the improvement and verification of the health of farm-raised aquatic animals produced in U.S. The standards implement the National Aquatic Animal Health Plan (NAAHP) and establishes a model approach for aquatic animal health. CAHPS outlines a series of best practices that ensure animal health, enhance farm biosecurity, and, most critically, describe methods that may assist with the safe movement and interface with farm-raised aquatic animals. The principles that make up these program standards for commercial aquaculture are: 1) aquatic animal health team; 2) risk characterization and management; 3) surveillance; 4) investigation and reporting; and 5) response. Consistent program standards provide a science-based framework to verify aquatic animal health, allow for branding, provide leverage for negotiations with trade partners, both domestic and international, and facilitate safe animal movement.

White-nose Syndrome: Lessons learned and current challenges

Jeremy T. H. Coleman, PhD: U.S. Fish and Wildlife Service

The collaborative reaction to white-nose syndrome (WNS) has been identified as a model for wildlife disease response in 21st Century North America. Considerable energy was expended to plan this multi-agency, international effort, informed by similar endeavors including colony collapse disorder, chronic wasting disease, and chytridiomycosis. The past ten years have produced many successes and several ongoing challenges. Initial challenges included a rapidly spreading novel disease of unknown etiology; unprecedented mass mortality in multiple cryptic and poorly understood host species (bats); inconsistent baseline bat population data and monitoring efforts across eastern states and provinces; and a large and diverse list of partners with no clear singular regulatory authority. We were fortunate that WNS emerged initially in states with well-established bat monitoring programs and with both adequate resources and tenacious, motivated staff (across multiple agencies). We also benefitted greatly from the close-knit professional networks of the regional bat working groups, which provided an existing framework for coordination and collaboration across the multiple states and agencies, and from the expertise of the bat and disease research community. Within this framework, a response strategy for North America was developed consisting of sister national response plans in the U.S. and Canada. Multi-agency oversight committees provide a structure for agency and tribal engagement, while task-focused working groups develop outreach and guidance materials, and identify priority research and management needs. Accomplishments include: establishing national leadership for coordination (US Fish and Wildlife Service and Canadian Wildlife Health Cooperative); significant scientific advances in understanding the dynamics WNS and a growing body of research on management tools; development of the North American Bat Monitoring Program (NABat); and the creation of a broad multi-disciplinary community of practice for WNS and bat conservation. Key continuing challenges are: maintaining critical partnerships with stakeholders; sustaining momentum and interest (internal & external); fostering scientific advances; and defining success.

Suppressing plague: Lessons in preventive management of introduced disease

Michael W. Miller, DVM, PhD; Colorado Parks and Wildlife

Controlling introduced but now enzootic wildlife diseases presents opportunities and challenges beyond those typically considered in emergency response planning. Since the introduction and spread of the bacterium *Yersinia pestis* throughout much of the western US beginning in the early 1900s, plague has become a pervasive disruptor of native grassland and shrub-steppe ecosystems, an important driver of species and ecosystem imperilment, and a key impediment to their recovery. Over the past decade attempts to blunt these impacts have focused on developing and refining tactics and tools for preventive plague suppression, especially in prairie dogs (*Cynomys* spp.). Individual agency efforts and broad interagency collaborations on both technological and regulatory fronts have advanced capacities for preemptive flea vector control and oral vaccination of susceptible hosts as tangible alternatives for preventive management. Despite ample evidence that annual field applications of these tools can modestly but measurably suppress (but not eliminate) plague, commitment to sustained landscape-scale implementation has been hampered in most jurisdictions by a paucity of dedicated (federal) funding

support and policy-level inertia. Several of the successes and shortcomings in a decade's worth of work to suppress plague at ecologically-relevant spatial and temporal scales seem worth considering in the broader context of wildlife disease management throughout the US.

Chronic Wasting Disease (CWD): Best management practices and current efforts

Colin Gillin, DVM; Oregon Department of Fish and Wildlife

Chronic wasting disease has affected North American cervids for over 50 years, leaving wildlife managers with seemingly insurmountable challenges and limited answers on mitigation of the disease spread and conservation impacts. Innovative research addressing disease transmission and interagency coordinated regulatory actions are needed to circumvent the human assisted spread of the disease. Surveillance, management, and control efforts are expensive and beyond any state agency's discretionary funding for disease outbreaks. Managers who develop a solid plan and conduct effective surveillance can limit intrastate movement, however, the most effective way to stop or slow movement of the pathogen is to not move live cervids, both within the captive cervid industry and through agency-sponsored restoration translocations. Concentrating cervids through baiting, feeding and attractants can facilitate animal to animal transmission and increase prevalence in infected populations. Once established, management of CWD becomes difficult, resource encompassing, and expensive. Landscape-scale research is needed to develop effective management techniques. State agency efforts to manage and control prevalence is best achieved through adaptive management strategies and integrated human dimensions using social science surveys, comprehensive communications plans, and increased stakeholder outreach. Research on better prion detection and new diagnostic approaches, understanding pathogenesis of the disease, disease-host ecology, and susceptible species are the focus of research questions. Other unanswered questions seek to understand the role of plants, soil and prion persistence in extending the period of contamination of environments and habitats. Best management practices based on new scientific findings are critical to successful disease management.

MANAGEMENT TOOLS AND CONSIDERATIONS

Decision support processes to guide preparation and response

Evan H. Campbell Grant, PhD; U.S. Geological Survey

Disease management decisions have elements of uncertainty, must consider multiple objectives, may not have good options for control, and often require collaboration. In short – they are just like many other complex resource management decisions. Conducting research to respond to a lack of information – who will a novel pathogen infect, where will the next outbreak occur, what control options will be effective – is a typical first response. However, research alone will not improve disease management responses. In addition to uncertainty, challenges to effective disease management responses include navigating fragmented management responsibilities, recognizing tradeoffs among competing objectives, and accommodating risk. Considering the full scope of the decision problem, including what other social and ecological management objectives are important and where there may be opportunities for creative interventions, is beneficial early on. Framing disease management decisions as soon as a problem is

recognized can help direct research, identify the scope of actions that are potentially useful, and ensure that other competing objectives are included.

West-Wide, Adaptive, Wild Sheep Disease Management Venture

Peregrine L.Wolff, DVM; Nevada Department of Wildlife and Mike Cox; Nevada Department of Wildlife

Respiratory disease-associated all-age die-offs and perennial lamb recruitment failure are the most critical threats to wild sheep in 19 of 23 Western Association of Fish and Wildlife Agency (WAFWA) jurisdictions. Despite decades of research and financial effort, there are no consistently effective methods to manage or recover affected wild sheep herds. Traditional approaches to bighorn respiratory disease have focused mainly on the role that pathogens and other factors play in the respiratory disease complex. However, we also need to understand how management actions affect disease processes. This Venture proposes to assist jurisdictions to evaluate, validate, and implement adaptive management actions that may prevent infection, clear pathogens, and improve herd performance. Such actions are vital for ensuring long-term viability of wild sheep populations on historic landscapes. In response to this challenge, the collaborative "*West-Wide Adaptive Wild Sheep Disease Management Venture*" (DMV) was created by the WAFWA Wild Sheep Working Group and Wildlife Health Committee (WHC) to achieve this purpose.

Lessons Learned

Forum participants brainstormed a lengthy list of "Lessons Learned" related to fish and wildlife disease management. The complete list can be found in the Appendix at the end of this report. Specific points which were raised repeatedly during multiple discussions and presentations at the Forum include:

Capacity

Since the organization of the National Fish and Wildlife Health Initiative in 2008, capacity at the state fish and wildlife agencies to address fish and wildlife health and disease issues has grown considerably, with at least 47 fish and wildlife health professionals now employed full-time by state agencies. Participants at the AFWA Fish and Wildlife Health Forum attributed much of this growth to materials and education provided to state fish and wildlife agency directors by the National Fish and Wildlife Health Initiative, particularly sample job descriptions for state fish and wildlife veterinarians and education materials emphasizing the importance of having in-house staff capacity for addressing fish and wildlife health and disease issues.

Collaboration

Collaborative efforts to address fish and wildlife health issues have increased greatly in recent decades. In addition to longstanding collaborative efforts such as the Southeastern Cooperative Wildlife Disease Study (SCWDS), the Northeast Wildlife Disease Cooperative (NWDC), and the National Wildlife Health Center (NWHC), the Association of Fish and Wildlife Agencies (AFWA) and its regional affiliates play an increasingly important role in fostering collaborative activities by state, federal, academic, and other non-governmental partners. Examples of these collaborative activities include the 2017-2018 development of the AFWA Best Management Practices for the Prevention, Surveillance, and Management of Chronic Wasting Disease, as well as AFWA-mediated efforts to address Bsal salamander fungus and White-nose Syndrome in bats.

Collaborative research efforts have also developed around critical fish and wildlife health needs, including the BAND Foundation's grant projects to address the salamander fungus Bsal, and the White-nose Syndrome research efforts coordinated by the U. S. Fish and Wildlife Service. Participants also mentioned the important role of the USGS Cooperative Fish and Wildlife Research Units (CRUs) in conducting research on particular wildlife disease topics. Each CRU is itself a partnership of state and federal agencies and NGO partners, an inherently collaborative model for identifying and addressing priority research needs.

Resources

Funding agencies are increasingly prioritizing fish and wildlife health topics. Recent examples include the suite of projects on disease of salamanders and bats which were funded by the BAND Foundation through AFWA, the Multi-state Conservation Grant Program's funding for the National Fish and Wildlife Health Initiative, and the National Fish and Wildlife Foundation's Bats for the Future Fund. State agencies and their partners are also exploring opportunities to obtain funding from private foundations and mitigation funds. Congressional appropriations have also been sought and obtained for particular

high-profile diseases, including Chronic Wasting Disease and White-nose Syndrome. Recognizing the limitations of individual agency budgets, many state and federal agencies are adopting collaborative approaches to fish and wildlife disease management, thereby allowing each agency to leverage its own limited funding and obtain much-needed services and expertise from outside partners.

Scientific and Technical Advances

Scientific research on fish and wildlife disease topics continues to accelerate, with increasing interest from investigators and students at laboratories and research institutions across the country and continent. New molecular and genomics approaches are revolutionizing our understanding of fish and wildlife disease biology and the causative organisms and agents. New diagnostic tools and methods are constantly being developed, improving our ability to identify fish and wildlife disease pathogens and outbreaks more rapidly than ever before. Research continues towards the development of vaccines and other treatments for individual fish and wildlife diseases, even those such as Chronic Wasting Disease where treatment options appear to be most limited. Online publication methods help to ensure that the latest research findings are published timely, and open access publication options allow researchers to obtain maximum dissemination and readership for their published results. Research programs have also focused on practical aspects of fish and wildlife disease management, including the standardization of sample collection, preservation, and testing methodologies, and the development of standardized disease surveillance methods and protocols. Finally, the advent of citizen science efforts, supported in many cases by smart phone apps and social media, have the potential to greatly increase the number and rate of reports of fish and wildlife health and disease incidents in real time.

Communications

Social media and related technologies are revolutionizing the ways in which state fish and wildlife agencies communicate with their partners and with the general public. Smart phones and associated apps have shown great promise in increasing reports of sick or incapacitated animals, supporting citizen science efforts, permitting rapid data collection and analysis in the field, and improving communications among researchers and between researchers and managers.

Successes

Participants at the AFWA Fish and Wildlife Health Forum pointed to several success stories in fish and wildlife health and disease management. These included:

- Coordinated surveillance for certain pathogens, including avian influenza
- Development, testing, and deployment of vaccines for plague and rabies
- Development of best management practices for Chronic Wasting Disease and other diseases
- National coordination for management of certain diseases (e.g. White-nose Syndrome, rabies, and Bsal)

Challenges and Gaps

Forum participants brainstormed a lengthy list of "Challenges and Gaps" related to fish and wildlife disease management. The complete list can be found in the relevant Appendix at the end of this report. Specific points which were raised repeatedly during multiple discussions and presentations at the Forum include:

Coordination and Leadership

Forum participants noted the need for increased leadership and effective coordination of fish and wildlife disease efforts. Specific recommendations included revitalizing the National Fish and Wildlife Health Initiative in order to provide information on fish and wildlife disease efforts to state and federal agency leadership, establishing a dedicated fish and wildlife health and disease coordinator position at AFWA, increased coordination through AFWA and the regional associations, and conducting regular calls and meetings of state fish and wildlife health professionals, perhaps in coordination with national meetings such as the Wildlife Disease Association or the U. S. Animal Health Association.

Collaboration

Forum participants noted a general need for improved collaboration among state and federal agency staff on fish and wildlife health and disease issues. Participants specifically mentioned the need to improve and enhance existing interagency agreements and clarify communication lines both within and across agencies in order to improve and foster collaboration across agencies on disease responses. AFWA and the regional associations, as well as entities such as SCWDS and the National Wildlife Health Center, could play a key role in fostering collaboration across agencies.

Scientific Needs

Participants noted the gap in research attention to "non-game" or "wildlife diversity" species in groups such as bats, amphibians and reptiles, sea stars, and native fishes. For many of these taxa, basic biological data is lacking and thus responses to disease outbreaks are hampered while basic biological investigations are undertaken.

Another critically important research need identified by Forum participants is the review and analysis of prior disease management interventions, in order to determine which (if any) intervention(s) are actually effective at addressing particular diseases in particular contexts.

Human dimensions and social science research were mentioned as priorities by a number of forum participants. In particular, human dimensions research that examines attitudes of hunters and other interest groups to specific management interventions was identified as a priority. Economic research investigating the impacts of fish and wildlife diseases on the broader society was also viewed as a priority.

Finally, the development of new management tools and refinement of existing approaches was identified as a clear priority across all fish and wildlife diseases. Predictive models of disease outbreaks and models

that help identify taxa and areas that would be vulnerable to the introduction of novel pathogens into the United States were identified as particularly helpful.

Communication

Participants identified communication as a significant area for further focus and attention. Areas for improvement include enhancing communications between researchers and managers, between technical staff and managers and leadership within agencies, and with the general public to communicate key findings and recommendations for the management of specific fish and wildlife diseases.

Resources

Resources were mentioned by virtually every forum participant as a significant need. Specific resources identified by participants include the need for additional staff, particularly at times of high testing volume or during disease outbreaks and other emergencies; additional laboratory capacity, supplies, and personnel for disease testing and diagnostics; and additional resources to permit rapid responses to novel pathogens, disease outbreaks, and other fish and wildlife health emergencies. Participants mentioned a need for dedicated funding for basic research on fish and wildlife disease, as well as dedicated resources to implement large-scale management interventions for certain widespread diseases (e.g. CWD, WNS).

Management

Several specific issues were identified by the Forum participants in regard to fish and wildlife disease management. First, participants noted the need to learn from previous management interventions, and actually implement "adaptive management" approaches rather than re-inventing the wheel with each new disease or outbreak. Second, participants noted the need for long-term thinking and long-range planning, particularly with regards to existing disease that are unlikely to be eradicated from the landscape (e.g. CWD, WNS). Third, participants noted the need to manage proactively to prevent introductions of novel pathogens such as Bsal into North America, and to conduct modeling exercises and risk assessments in order to identify pathogens likely to be introduced into North America in the foreseeable future.

Priority Recommendations and Actions

The following set of overarching recommendations was developed by the Forum participants. According to participants, the Association of Fish and Wildlife Agencies, its members, and partners should:

Revitalize the National Fish and Wildlife Health Initiative, a high-level interagency state-federal coordinating group, with a particular focus on updating the Initiative's toolkit and briefing materials which were originally developed in 2008. Since 2008, these materials have been provided by the Association of Fish and Wildlife Agencies to new state agency directors in order to help facilitate their responses to disease emergencies. Forum participants indicated that the most valuable portions of the toolkit included a list of contacts who can be consulted during a fish or wildlife disease crisis, as well as a position description for a state fish and wildlife agency veterinarian or health and disease specialist. The position description alone was credited with increasing the number of states with wildlife veterinarians or disease specialists from 5 to 37 between 2009 and 2019.

Improve coordination among state fish and wildlife agency staff engaged in fish and wildlife health and disease efforts, to be undertaken in collaboration with the Association's Fish and Wildlife Health Committee. Such coordination will include regular conference calls or web meetings with state agency staff, special sessions at other meetings or conferences such as the AFWA Annual Meeting, North American Wildlife and Natural Resources Conference, International Wildlife Disease Association, the U. S. Animal Health Association, American Fisheries Society, The Wildlife Society, or stand-alone meetings of relevant agency staff.

Work collaboratively with state fish and wildlife agencies to identify the highest priority needs for managing new and emerging fish and wildlife diseases on an ongoing basis, including the availability of technical resources, training, staff, funding, equipment, and supplies; and work with state and federal agency partners to develop strategies to address these needs.

Advocate for additional research on the taxonomy, biology, and diseases of poorly-known fish and wildlife species, particularly those which have been identified in the State Wildlife Action Plans as Species of Greatest Conservation Need.

Improve coordination and communication among diagnostic laboratories that provide disease identification and diagnostic services to state fish and wildlife agencies and their partners. Identify gaps in capacity across the current suite of diagnostic laboratories and work with partners to address these gaps. Pursue standardization of laboratory testing protocols across laboratories in partnership with state and federal fish and wildlife managers.

Identify additional resources to support fish and wildlife health and disease research and management, particularly when such resources are aligned with major AFWA legislative priorities such as the "Recovering America's Wildlife Act."

Continued development by AFWA staff and the AFWA Fish and Wildlife Health Committee of high-value guidance documents and scientific synthesis products, such as the "Best Management

Practices for the Prevention, Surveillance, and Management of Chronic Wasting Disease" and the associated technical report, which were released by AFWA in September, 2018.

Identify administrative, regulatory, and legislative opportunities to address critical "gaps" in our ability to manage and respond to fish and wildlife health and disease threats, particularly the lack of existing legal authorities for the management of many existing and new and emerging diseases of native fish and wildlife species at national and regional levels.

In addition, participants strongly endorsed the hosting by AFWA of future fish and wildlife disease meetings and events, particularly at times which would enable greater participation by state fish and wildlife agency staff. We recommend holding such a meeting on a biennial basis at minimum.

In addition to these overarching recommendations, the following specific priority actions were identified by Forum participants during the small-group discussion exercises on the second day of the Forum, and were discussed by the entire group on the third day of the Forum in order to identify potential barriers/obstacles and possible mechanisms for implementing each of these priority actions.

Short-term Priorities

Partner with industries that make products (test kits, diagnostic equipment, sampling equipment) used in fish and wildlife disease management.

Disease management considerations are better integrated into the broader management activities and priorities for fish and wildlife species.

Improved training for state fish and wildlife agency staff on the application of adaptive management principles to fish and wildlife disease management.

Identify and engage individuals/foundations with interests in conservation to provide additional support for fish and wildlife disease management.

Invite relevant stakeholders to key decision-making meetings at agencies managing fish and wildlife health and disease.

Develop talking points related to fish and wildlife health and disease management for internal agency audiences.

Develop fact sheets on individual diseases.

Compile list of state/federal/tribal disease and health regulations

Hold briefings for decision makers on fish and wildlife disease topics.

Poll the public to identify and determine knowledge and interest on fish and wildlife health issues.

Develop management systems that facilitate sampling, labs, training, QA/QC.

Identify a dedicated person possibly at AFWA to lead the charge.

Build relationships across silos and sectors through face to face meetings and social events

Review biosecurity requirements for all agency staff handling animals.

Identify private NGOs who can champion fish and wildlife disease issues with Congress.

EMAC (emergency management assistance compact) -type system for sharing information and resources for disease responses

Long-term priorities

Crisis communications planning – develop and implement an "Incident Command System" structure for fish and wildlife health and disease emergencies.

Tie emerging disease issues to ecological goods and services.

Find common goals to work towards (e.g. the health of particular wildlife populations).

Include adaptive management in fish and wildlife disease response planning.

Establish new fish and wildlife health trusts/foundations.

Invest in stand-alone human dimension expertise in each state.

Identify a centralized overarching entity to coordinate fish and wildlife health and disease responses.

Create a lead agency for fish and wildlife health and disease research for all agencies.

Develop federal legislation for fish and wildlife diseases, similar to plant phytosanitary act.

Ensure that one federal agency and one state agency is the authoritative lead in each response effort.

Hire Human Dimensions personnel and empower them to facilitate/coordinate the linkages between management and scientists.

Train fish and wildlife disease management staff in Human Dimensions and how to communicate with the public.

Improve/simplify/clarify scientific messaging points around fish and wildlife health and disease issues.

Develop national regulations or procedures to reduce the movement of pathogens and avoid accidental translocations.

Pursue funding to develop animal-side tests for wildlife diseases.

Increase public support for fish and wildlife health and disease issues through outreach/education.

Consolidate resources within agencies to create stable centers.

Interstate collaboration/task force to manage diseases.

Additional lists of potential action items which were identified by Forum participants are included in the relevant Appendix.

Jennifer Mock Schaeffer, Government Affairs Director at the Association of Fish and Wildlife Agencies, leads a group discussion of priority actions and potential policy interventions on the last day of the AFWA Fish and Wildlife Health Forum. Photo Credit: Jonathan Mawdsley, Association of Fish and Wildlife Agencies.

Post-Forum Participant Survey Results

AFWA staff developed a short eight-question survey instrument using the "Survey Monkey" website which was announced on the last day of the Forum and circulated via e-mail to all those who registered for the 2018 AFWA Fish and Wildlife Health Forum. We received 31 responses to this survey instrument. In general, responses were overwhelmingly positive, although the small group discussions were identified by respondents as an area for further refinement and additional consideration and focus in future Fish and Wildlife Health Forums

1) What is your overall evaluation of the AFWA Fish and Wildlife Health Forum?

83% reported that they were satisfied or very satisfied.

2) What is your overall evaluation of the facility and location?

94% reported that they were satisfied or very satisfied.

3) What aspects of the Fish and Wildlife Health Forum were most valuable to you?

Top 4 answers, in rank order:

Discussions

Presentations

Networking

Group Discussions

4) What aspects of the Fish and Wildlife Health Forum were least valuable to you?

Top 4 answers, in rank order:

Sessions

Discussions

Small Groups

Group Discussions

5) What is your overall rating of speakers and presentations?

90% reported that they were satisfied or very satisfied.

6) What is your overall rating of the small group discussions?

70% reported that they were satisfied or very satisfied.

7) How will the world be different as a result of the AFWA Fish and Wildlife Health Forum?

Top answers:

AFWA will focus on fish and wildlife health.

State agencies will be better able to manage fish and wildlife health and disease.

8) Would you be interested in attending a future conference hosted by AFWA on fish and wildlife health and disease?

94% reported that yes, they would be interested in attending a future conference hosted by AFWA.

Colin Gillin from the Oregon Department of Fish and Wildlife addresses participants at the AFWA Fish and Wildlife Health Forum on the subject of Chronic Wasting Disease. Photo Credit: Jonathan Mawdsley, Association of Fish and Wildlife Agencies.

Appendix 1: List of Forum Attendees

First Name	Last Name	Company	Title	Attendee Type:
A. Alonso	Aguirre	Environmental Science and Policy	Chair - ESP	Academia
Matt	Allender	Wildlife Epidemiology Lab, University of Illinois		Academia, Veterinary Expert, Wildlife Health Expert
Gray	Anderson	Virginia Department of Game and Inland Fisheries		State Agency
Douglas	Austen	American Fisheries Society	Executive Director	NGO
Joel	Bader	USFWS-Fish & Aquatic Conservation	Fish Biologist	Federal Agency
Anthony	Ballard	MDWFP		State Agency
Dean	Biggins	USGS	Research Wildlife Biologist	Federal Agency, Wildlife Health Expert
Marilyn	Blair	USFWS-Fish & Aquatic Conservation	Branch Chief, Aquatic Animal Drug Approval Partnership	Federal Agency
David	Blehert	USGS-National Wildlife Health Center	Branch Chief	Federal Agency, Wildlife Health Expert
Molly	Bletz	University of Massachusetts Boston	Post Doc	Academia
Nancy	Boedeker	Indiana Deptartment of Natural Resources	State Wildlife Veterinarian	State Agency, Academia, Veterinary Expert, Wildlife Health Expert
M. Kyle	Briggs	NC Wildlife Resources Commission	Chief Deputy Director	State Agency
Darren	Bruning	Alaska Department of Fish & Game		State Agency
Mark	Chase	U.S. Fish & Wildlife Service	Center DIrector	Federal Agency
Jeremy	Coleman	US Fish & Wildlife Service	Fish and Wildlife Biologist	Federal Agency

Merril	Cook	NC Wildlife Resources Commission	Wildlife Health Biologist	State Agency
Thomas	Deliberto	USDA APHIS WS NWRC	Assistant Director	Federal Agency, AFWA, Veterinary Expert, Wildlife Health Expert
Christine	Densmore	U.S. Geological Survey	Veterinary Medical Officer	Federal Agency, Veterinary Expert
Robert	Dittmar	Texas Parks and Wildlife Department	Wildlife Veterinarian	State Agency
Cindy	Driscoll	Maryland Dept. of Natural Resources	State Fish & Wildlife Veterinarian	State Agency, Academia, Private Consultant, Veterinary Expert, Wildlife Health Expert
Doug	Dufford	Illinois Department of Natural Resources	Wildlife Disease Program Manager	State Agency
Bob	Duncan	Virginia Dept. of Game and Inland Fisheries	Executive Director	State Agency
Julie	Ellis	University of Pennsylvania, School of Veterinary Medicine	Director, Northeast Wildlife Disease Cooperative	Academia, Wildlife Health Expert
Laurel	Field	Oregon State University	Faculty Research Assistant	Academia
Winifred	Frick	Bat Conservation International	Chief Scientist	NGO
Jarrett	Gibbons	South Carolina Dept. of Natural Resources	Hatchery Manager	State Agency
Samantha	Gibbs	U.S. Fish & Wildlife Service	Wildlife Veterinarian	Federal Agency
Colin	Gillin	Oregon Dept. of Fish and Wildlife	State Wildlife Veterinarian	State Agency
Emma	Gorenberg	US Fish and Wildlife Service	AAAS Science Policy Fellow	Federal Agency, Veterinary Expert
Evan	Grant	USGS Patuxent Wildlife Research Center, SO Conte	Research Wildlife Biologist	Federal Agency

		Anadromous Fish Research Center		
Sarah	Gravem	Oregon State University	Dr.	Academia
Matthew	Gray	University of Tennessee	Professor	Academia
Reid	Harris	Amphibian Survival Alliance	Director of International Disease Mitigation	NGO
Callie	Hartson	Arizona Game and Fish Department	Wildlife Health Biologist	State Agency
Sonia	Hernandez	Southeastern Cooperative Wildlife Disease Study	Associate Professor	Academia
M. Camille	Hopkins	US Geological Survey	Wildlife Disease Coordinator	Federal Agency
Tricia	Hosch-Hebdon	Idaho Department of Fish & Game	Wildlife Health Manager	State Agency, Manager
Becky	Humphries	National Wild Turkey Federation	CEO	NGO
Luke	Iwanowicz	US Geological Survey	Research Biologist	Federal Agency, Wildlife Health Expert
Gabe	Jenkins	Kentucky Department of Fish and Wildlife	Deer and Elk Coordinator	State Agency, Wildlife Health Expert
Susan	Jewell	USFWS-Fish & Aquatic Conservation	Fish and Wildlife Biologist	Federal Agency
Lee	Jones	US Fish and Wildlife Service	Wildlife Biologist	Federal Agency
Anne	Justice Allen	Arizona Game and Fish Department	Wildlife Veterinarian	State Agency
John	Kanter	National Wildlife Federation	Senior Wildlife Biologist	NGO
Joseph	Kath	Illinois Department of Natural Resources	Endangered Species Program Manager	State Agency, AFWA, Manager
Morgan	Kern	South Carolina Department of Natural Resources	Wildlife Biologist III/ Malacologist	State Agency, Manager

Anne	Kinsinger	US Geological Survey	Assistant Director, Ecosystems Mission Area	Federal Agency
Patrice	Klein	USDA Forest Service	Veterinary Medical Officer	Federal Agency
John	Lord	Association of Fish & Wildlife Agencies	Director of Operations	NGO
Jan	Lovy	NJ Division of Fish & Wildlife	Research Scientist	State Agency
Craig	Martin	USFWS-Fish & Aquatic Conservation	Branch Chief, Aquatic Invasive Species	Federal Agency
Martin	Mendoza	United States Department of Agriculture	Associate Deputy Administrator-WS	Federal Agency
Michael	Miller	Colorado Parks & Wildlife	Senior Wildlife Veterinarian	State Agency, Veterinary Expert, Wildlife Health Expert, Manager
Dan	Mosier II	Kansas Wildlife, Parks & Tourism		State Agency
Lisa	Murphy	University of Pennsylvania School of Veterinary Medicine	Associate Professor of Toxicology & PADLS Resident Director	Academia
Nicole	Nemeth	Southeastern Cooperative Wildlife Disease Study	Assistant Professor	Academia, Wildlife Health Expert
Steve	Olson	Association of Zoos and Aquariums	SVP, Government Affairs	NGO
Evan	Pannkuk	Georgetown University		Academia
Ken	Phillips	U.S. Fish and Wildlife Service, La Crosse Fish Health Center	Project Leader	Federal Agency
Scott	Poore	SC Department of Natural Resources	Fisheries Biologist/Hatchery Manager	State Agency, Manager
Jenny	Powers	National Park Service	Wildlife Veterinarian	Federal Agency

Maureen	Purcell	USGS	Supervisory Research Microbiologist	Federal Agency
Jonathan	Reichard	US Fish & Wildlife Service	National Assistant Coordinator for White-Nose Syndrome	Federal Agency
Brian	Reichert	US Geological Survey	NABat Coordinator	Federal Agency
Kevin	Rose	Virginia Department of Game and Inland Fisheries		
John	Rothlisberger	USDA Forest Service	National Program Leader for Aquatic Ecology Research	Federal Agency
Anna	Savage	University of Central Florida		Academia
Lisa	Shender	Florida Fish and Wildlife Conservation Commission	OPS Veterinarian II	State Agency, Veterinary Expert, Wildlife Health Expert
Amy	Silvano	Alabama Division of Wildlife and Freshwater Fisheries	Assistant Chief of Wildlife	State Agency
Patty	Stevens	U.S. Geological Survey	Branch Chief	Federal Agency
Jeff	Trollinger	VA Dept of Game and Inland Fisheries	Assistant Chief, Fish Division	State Agency
Diane	Waller	USGS Upper Midwest Environmental Sci Ctr	Research fisheries biology	Federal Agency
Nicole	Walrath	Idaho Department of Fish and Game	Fish Pathologist	State Agency, Veterinary Expert
Colby	Wells	Colorado Parks and Wildlife	Aquatic Veterinarian	State Agency
Craig	Willis	University of Winnipeg	Professor	Academia
Kelly	Winningham	Arkansas Game and Fish Commission	Fisheries Pathologist	State Agency
Peregrine	Wolff	Nevada Department of Wildife	Wildlife veterinarian	State Agency

Appendix 2: Lessons Learned, Challenges, and Recommendations from Forum Presentations

Summarized by Anna-Marie York, U. S. Fish and Wildlife Service.

Presentation	**1. CWD: BMP & current efforts; Gillin, Mawdsley, Schaeffer, Fischer**	**2. Understanding & Managing WNS in Hibernating N.A. Bats; Willis**	**3. Changing Epidemiology of Snake Fungal Disease; Allender**
Lessons Learned	-Stop moving the prion -Stop moving infected carcasses and parts -Stop baiting, feeding, artificially congregating animals -Limit movement of Cervid products	-We were "lucky" in that an endangered species was among the first threatened with WNS, leading to early coordination. -The right leadership and folks with the ability to communicate clearly with both scientists and policy makers.	-Ophidiomycosis reports increasing since 2006 -Causative agent is Ophidiomyces ophiodiicola -Historic occurrence since the 1980s -Significant threat to biodiversity, species dependent -Ophidiomycosis affecting over 40 species of snakes in North America and Europe
Challenges	Gaps -Coordinated national effort to stop moving the prion -Adaptive Management -Specific & sensitive live animal test -Approach to environmental contamination -Public health, Regulatory coordination, Communication HD	-Multi-host fungal disease of bats -11 species confirmed with WNS -6 more carrying P. destructans -Environmental reservoir in hibernacula -Invasive species from Eurasia -in western NA we don't: 1) know where bats are in winter, 2) have regulatory approval for treatments; and 3) we don't know downsides of treatment – e.g., Attenuate evolutionary response in host? Favor evolution of	-Diagnosis remains frustrating (lack of validated assay; no case definition) -Route of transmission & environmental characteristics leading to proliferation still unknown -Ophidiomycosis is widespread in nearly every N.A. habitat -All species should be considered susceptible -Severity of infection is species-specific -Route of transmission & environmental characteristics leading to proliferation remain unknown

		treatment resistance in pathogen?	-Population level effects still unknown
Recommendations	-Stop moving CWD prion -Stop facilitating transmission & high prevalence -Research needed: Detection & diagnostics; Disease Epi; Human Dimensions -AFWA Directors & Wildlife Chiefs national leadership role -Communicate AFWA CWD BMP -Standardize messaging -Coordinate State approaches -Develop model regulations -Increase public/hunter/stakeholder adoption	-Spray "stuff on bats" (SOB) or substrates in hibernacula -Biological/chemical treatments including vaccine and UV -'Natural history challenges' and regulatory challenges -Modify hibernaculum environment (for sites we know about) -Protect/enhance summer habitat to help survivors -Do we even need detection? -Modify hibernaculum to balance "great for bats" against "bad for fungus" -List species and enforce critical habitat protection -Habitat features that support evolutionary rescue	-Strict biosecurity for field programs -Surveillance to characterize disease impacts -Treat critically endangered species in appropriate situations

Presentation	**4. Bsal:Next Potential Threat to N.A. Biodiversity; Gray, Bletz, Nanjappa, Harris**	**5. Aquatic Parasites of Salmonids: Problematic Myxozoans; Alexander**	**6. DOI Strategic Sciences Group Bsal Case Study: Using Preparatory Exercises to Identify Needs; Hopkins**
Lessons Learned	-Transmission via contact if efficient -Transmission via water is concentration dependent -Environmental persistence is short -Humans & wildlife can translocate Bsal	-Myxozoan parasites have comples life cycles -Temperature influences all phases of life cycle -Discharge drives invertebrate host density -Severe disease effects observed in hot/dry years	- DOI Strategic Sciences Group gives DOI capacity to assemble crisis science teams and provide results to leadership as usable knowledge, to construct chain of consequences scenarios that identify the potential short- and long-term

	-Coordination of N.A. Bsal Task Force: Technical Advisory Committee; Working Groups	-Break life cycle doesn't equal disease risk -Whirling disease in fish culture: remove invertebrate habitat, treat water -Prevention is best in natural systems -Dams and water management are opportunities for treatment	environmental, social, and economic cascading consequences of the crisis, and determine intervention points. -Establish communication networks among experts. -USGS Amphibian Research & Monitoring Initiative -Bsal Task Force & local partnerships -Wildlife Disease Incident Command System -Amphibian Disease Laboratory Network
Challenges	-Lacey Act only applies to host, not pathogen -DOI needs authority to: Stop, inspect and quarantine commercial trade shipments; Treat or cull infected shipments; Manage pathogens and vectors; Enable declaration and fund release for wildlife disease emergencies	-Limitations on surveillance in natural systems: Funding; Logistics; eDNA under development -Pathogen intervention is limited in the wild	-Improve our knowledge of the fine-scale distribution of key amphibian species (State and Federal threatened and endangered [T&E] species; Bsal-susceptible species) -Develop an interorganizational online data visualization tool so that we can quickly know what species of interest may be at risk for a given outbreak. -Dynamic Decision Model of Potential Treatment Methods -Research needs relevant to intervention decisions
Recommendations	-Prevent entry & facilitate rapid response through comprehensive wildlife health legislation	-Complex life cycles provide opportunities for control and balance: -Consider water year and legacy context -Water allocation and storage -Time water release to capitalize on natural accretion events	-Regulatory preparation (FIFRA Section 18, NEPA) -Interventions with cultural sensitivity (historical or religious resources) -Field research on interventions in Bsal-affected areas (Europe, Asia) -Public information campaign -Outbreak communications plan

		-Hatchery production and timing of release -Water quality -Evaluate impacts and fund monitoring	-Broad stakeholder engagement --Research gaps: containment options; lotic environment; temperature control; fungicidal environmental treatments; tests to confirm decontamination; dispersal through susceptible and carrier species; influence of environmental condition on disease outcomes

Presentation	**7. Diagnostic Harmonization for WNS; Alger, Richgels, Blehert**	**8. Considerations and Challenges in Marine vs Terrestrial Ecosystems; Gravem & Sea Star Wasting Task Force**	**9. Utility of Genomics for Understanding & Mitigating Wildlife Disease; Savage**
Lessons Learned	-Diagnostic standardization ensures accuracy and consistent interpretation -Rapid ID of WNS causal fungal pathogen -Establishment of criteria for disease -Sensitive & robust real-time PCR test -Case definition for interpreting results -Management-focused research	-Sea Star Wasting Strategic Action Plan: -ID knowledge gaps & action items -Response plan if SSWS re-emerges -Consider rehabilitation -ID policy options	Genomics provides tools to: -Detect & characterize pathogens -Uncover routes of disease transmission & spread -ID extent disease susceptibility is influenced by host & pathogen attributes -Elucidate impacts of disease on wildlife populations
Challenges	-Diagnostic procedures for wildlife disease are not regulated or standardized -Resource managers need reliable results and consistent reporting to support management decisions -Harmonization needed to ensure quality standards while allowing flexibility in methods & platforms -Building consensus for interpretation of results	Marine disease outcomes: longer pathogen residency; direct contact less important; transport by currents; few barriers to dispersal Marine management challenges: rapid widespread transmission; containment challenging; typical transmission models less applicable; vaccination, antibiotic therapy, culling are futile in the wild	-Without definitively knowing the pathogen(s), the appropriate experimental design to pair with host genomic analyses is lacking. -Lack of historical samples for genomic analysis has limited identification of pathogen origins. -Genome size and complexity still presents a challenge for robust and high-quality genome sequencing.
Recommendations	-Use existing WNS response network to	-Form surveillance & response networks	-Unless the appropriate samples exist to use genomics

	develop diagnostic harmonization model -USGS & FWS co-funding Diagnostic Harmonization Coordinator -Create network that is self-sustaining and will serve as a model for other wildlife diseases -Facilitate dialogue between labs and resource managers -Best Practices Handbook	-Contingency plan -Precautionary measures during outbreaks -Integrate disease & ocean current models -Pre-emptively build aquaculture facilities for quarantine & captive breeding	for identifying the pathogen, its origin, and spread, "omics" studies should come **after** fundamental epidemiology and fulfillment of Koch's postulates -Whenever possible and regardless of a known disease outbreak, biological samples should be collected from wildlife, preserved and archived for potential genomic analysis. -If overall surveillance of wildlife and sample collection improves, genomics will become an increasingly important and useful technique for rapidly identifying and eliminating pathogen threats

Presentation	**10. Domestic Animal & Wildlife Interface Diseases; Klein**	**11. USDA APHIS VS Aquatic Animal Health Program; Hartman**	**12. White-nose Syndrome: Lessons Learned and Current Challenges; Coleman, Reichard et al**
Lessons Learned	-Using a 'One Health' collaborative approach to develop integrated and interdisciplinary disease preparedness and response plans. -Coordinated animal and human health surveillance systems. -Standardized laboratory test methods and networks. -Defined internal and external communication channels with timely reporting mechanisms. -Consistent messaging.	-APHIS is lead authority for commercial aquaculture -Prioritizing pathogens of concern for domestic industry -Development of Commercial Aquaculture Program Standards (CAHPS)	-NY had strong bat program and resources; -NYSDOH Northeast Bat Working Group and existing relationships -Bat research community -Central leadership in US and Canada -Communication: calls, webcast, meetings -NEAFWA request to FWS helped define roles -Centralized diagnostics -Partnership between agencies, researchers, and stakeholders; Meetings created community -National Plans: US & Canada -Agency and public support (communication) -Champions within and outside gov't -Funding secured for research and state response -Research has produced -Follow a "do everything" policy (Basic and applied research, short and long-term objectives) -Progress is possible with best available information
Challenges	-Identify gaps in agencies' roles and authorities.	-Unrealized national aquatic animal health plan. -Inconsistent state health	-Mass mortality and rapid spread -Etiology unknown

	-Create effective, cooperative partnerships to respond to interface diseases. -Advances in scientific information -Susceptibility of the animal and human hosts -Extent of pathogen range and virulence -Dynamics of inter-species transmission -Effect of the environment on disease transmission -Diagnostic tools for early detection and intervention -Communication plans -Legislated resources & funding for disease control and response	requirements for movement. -Commercial aquaculture forced into natural resource paradigm. -Surveillance and testing with meaningless results. -Communication and collaboration. -Availability of veterinarians. -CAHPS "Be-In". -Data management and sharing. -Diagnostic laboratory and assay standards. -Wildlife surveillance.	-Multiple cryptic host species with unusual life stages -Considerable data gaps/research needs -Large and diverse list of partners -No clear Federal role in US (ESA) -No dedicated funding or resources -Communications (neg. public opinion) -Stakeholder engagement/trust -No standing model or guidance -Few successful examples of managing wildlife disease or invasive species -Difficulty engaging experts and state agency leadership -Failures of imagination -Reliable early detection -Competition, external and internal -Clear differences in risk tolerance -Different agency values and missions (Decision Analysis) -Overcoming inertia and tribalism -Uncertainty of resources/agency support -Regulatory framework for rapid response -Regulatory considerations: navigating bureaucracy, differing authorities within state boundaries -Adapting to stay nimble

Recommendations	-Recognize key roles & authorities of respective agencies – bridge gaps. -Build collaborative inter-agency "One Health" partnerships for an integrated disease response. -Engage scientists, diagnosticians, animal & public health specialists, epidemiologists, biologists, ecologists, land managers, legislators, and stakeholders to meet current and future disease challenges. -Promote public-private partnerships.	-Transparency and communication -Risk based approaches for surveillance and testing -Consistent standards with uniform implementation	-Communications: Engage stakeholders early and often: inreach and outreach -Establish core messaging and SOPs -Response planning must be scalable and adaptive -Beware analysis paralysis -Bold field experiments can have value -Goals or guidelines for managing disease, especially where a nexus with invasive species, ESA, other regulations -Balancing Conservation with agency objectives and limitations -Can we determine realistic long-term goals? -Threat from disease can be compounded – we cannot afford myopia -Courting innovation: we need 21st Century tools for modern problems -Broad partnerships across disciplines -Regulatory framework must adapt

Presentation	**13. Suppressing Plague; Miller**	**14. Decision support processes to guide preparation and response; Grant**	**15. Disease Management Joint Venture; Wolff et al**
Lessons Learned	-Tool choices (vector control, vaccination). -Relatively seamless lab to field transition. -State – private ± federal partnerships. -Accessible "low-tech" approaches. -Regulatory innovation.	-Decision framing (transparently structure the problem to find solutions) -Conceptual diagram (formalize thinking about how the system works) -Models (making predictions even when lacking of data)	-Baseline health data - guidelines / training -Active and passive surveillance -Defining herd status Pre-translocation testing of both source/recipient herds -Trying novel management strategies (targeted removal of chronic shedders, population reduction, depopulation)
Challenges	-Introduced pathogen, profound & pervasive effects. -Reactive management inadequate for conservation. -Demands sustained, large-scale effort. -Limited sociopolitical interest & support. -Nebulous excuse for postponing action (aka "NEPA"). -Funding -Reconciling expectations with reality -Forever is a long, long time... (sustained & sustainable commitments)	-Jurisdiction (Collaborative management, Enforcement) -Laws & mandates Are sometimes unclear -Cost (Time, personnel, money, ecosystem) -Information gap between science and management -	-Don't understand all factors associated with variability in herd response to infection -Few management options to deal with infected herds -Highly Political -Domestic sheep industry denies the science is valid -Jurisdictions deny that they had or have a problem -Managing across borders -Infected herds with no negative population response (few options for translocation, aversion to ewe hunts, aversion to predators)
Recommendations	-Please send money. -Fix NEPA. Broadly. Proactively. -Secure long-term commitments. -Tweak tech.	- Frame decisions, rationally and transparently -Managers & researchers work together -Identify who is responsible for a response,	-Assessing efforts from different jurisdictions -Sharing results

		what choices may be available, potential constraints, and what uncertainties may impede a decision. -Identify all the relevant management objectives (including parts of the ecosystem that are not under threat from disease), choices for management actions, legal or policy impediments, and an analysis that identifies tradeoffs among the objectives. -Influence diagrams aid in estimating the effects of management actions, generating creative and complementary management actions, improving collaboration across disciplines, evaluating important uncertainties, and prioritizing future research and funding to meet shared objectives. -Synthesis: Are there common decision problems -Conduct research for all important objectives (not just treatment) -Be creative in finding alternatives -Confront challenges to proactive management (not always scientific uncertainty)	-Continued movement of sheep without proper pre-testing

Appendix 3: Draft Actions, Identified by Forum Participants in Small Groups

	ADAPTIVE MANAGEMENT **Laura**	Collaboration Mark	FUNDING Devin	COLLABORATION Silvana
Top 2 Short Term Actions	Training on adaptive management (develop, provide, require?) Make sure we all agree on what is Adaptive Management, the "recipe" and use it consistently	1=Dedicated person, someone to lead the charge (i.e. AFWA fish and wildlife committee 2=Build relationships through face-to-face meetings, social events	1= Identify and Engage individuals/foundations w/interests in conservation to provide additional support/ ID public/private partnership opps 2= Evaluate/compile current funding initiatives and develop collaborative initiatives	1st disease discussions integrated into species/taxa management meetings 2nd Inter agency MOUs before joint projects
Top 2 Long Term Actions	Include Adaptive Management in Response Planning Hire a consultant or create a team to provide science support to conduct adaptive management	1=Work at regional population level instead of state 2=Shift the culture with grant requirements (collaboration, communication required)	1= Establish new F&W Health trusts/foundations 2= Identify champions in congress to increase funding	1st Find Common Goals to work towards (maybe healthy wildlife POPs) – 6 votes 2nd Funding – 3 votes Overachieving wildlife disease group - 3 votes
All Actions	Hire a subject matter expert to consult Apply the precautionary principle	Greater use of communication technology	Market a donation program nationally (e.g. WWF/TNC) Identify specific funding needs (clear needs)	Simpler citizen science reporting systems Engage museums aquariums and zoos

	Regional Animal Health networks for consultations and review AFWA create a team (or Regional team) that you could go to for consultation or to conduct adaptive management Create a matrix for measurement - so you can see where adaptive management is working/not working Ensure adaptive management is recognized as best management path Identify/inventory to know what the resources are in your agency/state for adaptive management Get it so that supervisors say that you must do this/use this to staff Integrate into agency thought process Create a staff "exchange" program (like a detail) to get hands on experience with adaptive management --	(video conferencing of AFWA committee meetings) Educate Directors-importance of collaboration, disease issues and impact on the mission, prioritization, include wildlife health	Advocate for RAWA and other national state/local legislation Get RAWA introduced and passed continued outreach to public who then will support more funds for wildlife/ecosystems Drive RFP's at NIFA, NIH, NSF, etc. identify key congress members on appropriations committees to support initiatives dedicated congressional appropriation (e.g. wildlife health trust) private industry sources expand stakeholders to include other industries Pool funds across states/regions to obtain economies of scale identify potential NGO supporters Engage NGO's look to non-traditional funding sources (e.g. ASPIRE Grants) GOFUNDME page for wildlife health Set up donation kiosks @ key wildlife viewing areas or an app that pings at location to file Increase awareness of economic impacts of wildlife disease Identify congressional leaders that will move an initiative forward	More transparent hierarchy available for outsiders (e.g. academics) Model surveillance strategies integrated at regional level to bring together different groups Academic and agencies ties to support graduate students Stronger ties w academics especially flexible grad students – e.g. fellowships Agency/university workshops Transparency and communication Flexibility Scenario-based workshops bringing together different disciplines Agency leadership provide time for staff to spend time visiting (ride-along/story telling/updates/presentations) other agencies/entities Face to face meetings Funding agencies encouraging collaborative projects between states+federal+academic+agencies Seek to understand underlying values and motivations rather than stating positions Know what resources you bring to the group

	state to state or agency/state opportunities		champions in congress identify key stakeholders to support funding initiatives	Acknowledge and value everyone's expertise Open minded idea sharing Active attentive listening Clear lines of communications Mutually beneficial Acknowledge differing outcome priorities for collaborators – academics want to publish - NGOs want conservation outcomes Clear agreements Disease specific working groups Inter-jurisdictional meetings (including tribes) Establish data sharing protocols before collaboration
	FUNDING Laura	Tools/Advancements Mark	HUMAN DIMENSIONS & COMMUNICATIONS PUBLIC & EXTERNAL	Human dimension Silvana
Top 2 Short Term Actions	1 = Partner with industry who has treatment products - cost share - they get tax deductions and good public perception. Already good examples of this happening (peanut butter)	1= Fact Sheets of diseases and appropriate tests and labs that conduct them 2=Public mortality event reporting App. tht "completes the circuit" and alerts the agency with	1 = Poll public knowledge & interest of fish and wildlife health issues 2 = Human dimensions research to develop engagement strategies for public/stakeholders	<u>Human Dimensions</u> 1st Invite stakeholders to decision - making meetings 2nd engaging diverse local and national public to fund what's important to them about healthy wildlife population <u>Inter-agency communication</u> ● 1st Talking points

	2 = Organize NGOs/pubic to raise awareness of elected officials or agencies >> redirected priorities	jurisdiction for that species/location		● 2nd Communication to agency leadership on wildlife disease issues
Top 2 Long Term Actions	1 = Tie emerging disease issues to ecological goods and services 2 = Court Congressionals / legislators by organizing briefings, visits, field trips, and events	1=Pursue a funding source to develop an animal-side test for high priority diseases 2=Overcome the mortality data sharing hurdle between agencies so that a one-stop shop website can be built with real time mapping	1 = Improve/simplify science messaging 2 = market value of healthy wildlife populations/ecosystem health	<u>Human Dimensions</u> 1st Incorporate human dimension data into all wildlife disease plan 2nd invest in stand -alone human dimensions experts in each state <u>Inter-agency communication</u> Centralized overarching entity , like a foundation or center for wildlife disease 2nd Hire collaborative managers who value employee input
All Actions	Increase wildlife value to local economy Identify the economic impact of wildlife disease Shaming Create relevancy -- human health & economics Create passion Go Fund Me Sites Creative alternative to $ Allocate a % of license sales to animal health	Fact-check current USDA import requirements to lessen impacts on scientific exchange Proficiency testing for fee-for service labs outside the NAHLN Network	national advertising/education campaign market 'trust fund" protocols to develop communications plans develop strategies of communication that maintains public interest & engagement with wildlife health continue to foster collaborations among researchers & managers identify communication strategies for directors & commissioners	<u>Human Dimensions</u> increase human dimension staffing in state agencies public attended workshops to poll on issues non-game wildlife disease related surveys to gauge public interest and reactions to potential management actions use surveys and information campaign outreach that delivers messages and information that meets different

	portion of license plate sales goes to fund disease research Donations through multisources -- ex. license buyers can donate money directly to animal health Fund-raising Print more money :) Link animal health for wildlife, human health, and ag health for legislation when funding is occurring Political science - understand how it works Create a funding task force within the agency to have funding discussions Increase administration prioritization and/or importance Raise awareness education/awareness Raise awareness within agency to make the issue a higher priority Court private philanthropy Private/public partnerships Cost sharing Emergency disaster response (have a disaster :/)		(internal communications re wildlife health) survey legislators to learn about knowledge of impacts of wildlife disease identify public perceptions re various management activities assess public & constituent expectations (tolerances) for management actions survey partners/NGO's for knowledge/interest, capacity for disease capitalize on affection for animals to engage (use images of diseased animals) use social media explore non traditional communication channels engage public with a celebrity spokesperson use marketing firms to develop outreach materials on wildlife health & disease issues/management actions generate economic impacts analyses of non-game/commercial spp looking at indirect effects of disease (i.e. ecosystem) Expand/communicate issues to engage citizen scientists for added capacity	cultural needs , traditions, communication methods must do them as much as possible <u>Inter-agency communication</u> Interagency regional and national wildlife disease regular communications (calls, meetings) (include tribes) Communications plans for agencies pertaining to disease Dedicated time for staff meetings to disseminate information about topics and issues Establish a wildlife disease network Dedicated wildlife disease website on each agency website (internal/external) communication to non-disease staff on wildlife disease issues Overarching wildlife disease group development

			engage citizen scientists as a way to increase awareness & general public engagement develop wildlife health curriculum for primary/secondary schools Regional/park workshops on recognizing disease and importance get stakeholders in same room develop concise consistent messaging for disease issues develop consistent key messages	
	INTERNAL COMMUNICATIONS Laura	Wildlife Disease Scientific Processes Mark	REGULATIONS & AUTHORITIES	Underrepresented Taxa
Top 2 Short Term Actions	1 = Hold regular briefing with decision makers (not just when a crisis) 2 = Broaden the communications and participation with AFWA's Wildlife Health Committee. Info isn't getting out there as broadly as it could. Seems to depend on one person forwarding on valuable info	1=Biosecurity requirements for any agency staff or researchers handling animals T2-Institutional care and use committee review of state and federal animal handling activities (research, education, display) T2-Publications with management implications	1= compile list of state/federal/tribal disease and health regulations 2= draft model wildlife health legislation/regulations	● 1st Define criteria for prioritization of resources toward underrepresented taxa ● 2nd EDucate public on importance of underrepresented taxa in ecosystems

		are rewarded by the authors' agency(s)		
Top 2 Long Term Actions	1 = Crisis communications plan / Incident Command System Structure for FWHD -- make sure you have a system in place Establish a communications team as part of your Response Plan -- bring in your Communications staff	1=Increase public support for wildlife disease issues through outreach and education campaigns 2=List of recommended applied science projects for wildlife health graduate students	1= Develop national regulations that effectively reduce movement of pathogens through translocation of domestic & wild animals 2= extend authorities to cover pathogens not necessarily important to human or domestic species health	● 1st capacity building for underrepresented taxa (including invertebrates and aquatic, marine and freshwater 2nd Research on underrepresented taxa training in the health of underrepresented taxa
All Actions	Establish ground rules for communications (how and what) Have clear/transparent channels established for communications Avoid communication overload Provide/require routine training on …	Identify funds for highly actionable projects in reptile and amphibian disease	enact a national regulation for 50 state regulating/prohibiting the movement of intact cervid carcasses and raw trophies authority for health certificate for interstate travel address gaps in animal import regulations regarding health and disease testing for animals not destined for zoo work toward a non-game wildlife health bill with similar authority given to regulators as ag and human health joint wildlife health workshops with ag have a regulatory framework that can quickly incorporate new science	Interdisciplinary training for grad students in wildlife disease Training workshops for aquatic invertebrate diagnoses and response for health specialists Training for invertebrate wildlife disease sampling (antemortem and postmortem) Training DVMs in invert health Training in health of agriculturally important insects Capacity building for invertebrate wildlife disease surveillance and management (freshwater and marine)

	Define strategic communication needs to Administration Hire/employ a scientific communicator Endorse peer-to-peer science engagement Hold routine meetings with stakeholders Develop disease fact sheets Make sure there's info on your employee/intranet channels		regulate/clarify regulations on shipping infected animals/infectious tissues across state lines collaborate/coordinate with USDA-APHIS to establish meaningful disease management objectives for wildlife/livestock diseases avenue for expedited permitting process for field activities sampling in event of outbreak reach out to ag agencies foster development of regional health committees (include state, federal and tribal agencies)	Diagnostic lab capacity for invertebrates (freshwater and marine) Allocate funding for underrepresented taxa Staffing to work on underrepresented taxa Start freshwater bivalve and crustaceans initiative Interagency (including AFWA) prioritization of freshwater bivalve and crustaceans Research on amphibians Research on coral Gallinaceous birds health surveillance Research on plants Research on reptiles Prioritize research on insects, especially since disease could control pests Research on foundation species (e.g. trees, kelps, grasses, seagrass) Prioritize research on marine animals /plants that aren't fish or mammals (invertebrates) Historical data on invertebrate populations Regional and national invertebrate population monitoring to support

				disease surveillance and impact studies (like marine) Public education on ecosystem services underrepresented taxa – why are they relevant to the public Communicate who/what they are Outreach on invertebrates and their health issues (public and congress) Designated annual days or weeks focused on underrepresented taxa (like bat weeks) Marketing to raise awareness of health issues and relevance of underrepresented taxa – including aquatics Citizen science engagement on invertebrate healthy surveillance projects (freshwater and marine) Ecosystem services and economic studies on invertebrate benefits Seek public input on priority species (underrepresented taxa) Define the issues Decision science/ structured decision making to ID priorities Assessing species priorities for ecosystem health

	HUMAN DIMENSIONS + COMMUNICATIONS, PUBLIC / EXTERNAL Lane	HUMAN DIMENSIONS + COMMUNICATIONS, PUBLIC / INTERNAL Cindy	**Tools & Advancements** Jeff	Regulation and Authorities Katherine
Top 2 Short Term Actions	● Prioritize messaging ● Expand and build a social media presence (state and federal agencies, AFWA, AFS, etc.)	<u>Human Dimensions</u> ● Identify relevant human dimensions case studies and understand them ● Define the human dimensions component of needs or perceptions with the agencies <u>Communication</u> ● Educate scientists on how to message to the public	● Develop a Management System that shares Sampling, Labs, training and quality of data with support for diagnostic procedures and new technologies ● Field side testing equipment that is portable	● Develop standard NEPA templates/boiler plates for disease response and facilitate application of categorical exclusions (6 votes) ● TIE: Find and eliminate overlap in authorities (2 votes) ● TIE: AFWA led effort to nationally (USDA) regulate movement of captive cervids around the country (2 votes)
Top 2 Long Term Actions	● Train state and federal wildlife agency staff on human dimensions and how to communicate with the public and break down complex topics ● Tie for 2nd: Involve HD biologist in any public survey to ensure results are valid and surveys are designed	<u>Human Dimensions</u> ● Hire Human Dimensions personnel and empower them to facilitate coordination between science and management and human dimensions ● Define the human dimensions component of needs or perceptions within the agencies	**<u>Tools & Advancements</u>** ● Consolidate resources within agencies to create stable centers of excellence to address critical needs ● More point-of-care diagnostic testing implemented with QMS/e-Nose/eDNA environmental sampling ● Genomic tools to predict S/B to diseases	● Federal legislation similar to the plant phytosanitary act to prevent import of possible wildlife disease vectors (4 votes) ● TIE: Ensure that one federal agency and one state agency is designated the authoritative lead for emergency response and disease outbreaks (2 votes) ● TIE: Identify or create a way to regulate industries that move

	appropriately AND encourage fish and wildlife health curriculum in schools at elementary, high school, and graduate levels	<u>Communication</u> ● Similarly to how science informs management, HD should inform communicators and educators to meet the needs within and among agencies ● Agency communications components need to communicate with each other		wildlife to prevent spread (2 votes) ● TIE: Authority to regulate pathogens directly (2 votes)
All Actions	● HD survey to help ID keywords / tactics to persuade the public to care / be engaged ● Emerging infectious disease video game ● Including as many stakeholders as possible in messaging ● Interactive meeting with public (forum), also meeting between scientists and managers ● Consistent messaging among agencies ● Effectively counter misinformation with	● Communication: less emphasis on social media and move on to 'talking' to the public		● Develop standard NEPA templates/boiler plates for disease response and facilitate application of categorical exclusions (6 votes) ● TIE: Find and eliminate overlap in authorities (2 votes) ● TIE: AFWA led effort to nationally (USDA) regulate movement of captive cervids around the country (2 votes) ● Strengthen disease monitoring programs/regulations pertaining to captive cervids (USDA)- 1 vote, ST ● AFWA designate regional liaison to educate policy makers across jurisdictional boundaries - LT

	clear and unbiased science ● Learn which outreach method works with which demographic groups ● Engage the art-science community to create "pathogen artwork" like the "Mucinex Monster" ● More public surveys to help understand their knowledge of disease and what factor contribute to their belief, rather than focus groups			● Establish provisions to ensure that states take steps to limit disease within its boundaries (e.g. CWD expansion from states not addressing the problem) - ST ● AFWA led effort to nationally (USDA) align captive cervid "rules" with those of other livestock (cattle) - ST ● State agencies educate/outreach to legislative personnel the ramifications of FW health concerns on local level - 1 vote, ST ● Fix NEPA - LT ● Federal legislation similar to the plant phytosanitary act to prevent import of possible wildlife disease vectors (4 votes) ● TIE: Ensure that one federal agency and one state agency is designated the authoritative lead for emergency response and disease outbreaks (2 votes) ● TIE: Identify or create a way to regulate industries that move wildlife to prevent spread (2 votes) ● TIE: Authority to regulate pathogens directly (2 votes)

	TOOLS / ADVANCEMENTS	FUNDING	Collaboration	Bureaucracy, Impediments, Policy, and Planning
Top 2 Short Term Actions	● Dynamic fish and wildlife health toolkit / essentials guide for higher management / directors ● Congress expands authority under Lacey Act to list pathogens and parasites as injurious (short + long)	● Improve marketing including: (1) Figuring out how to market conservation values effectively to increase public support; (2) engage economists to determine money generated by wildlife and publicize the economic advantage of wildlife; (3) unite consumer advocacy groups for effective PSAs ● Crowdsource funding: (1) develop more private public partnerships; (2) find a commercial/industry partner such as Dawn detergent for oil cleanup or bighorn friendly wool or bat-friendly tequila;	● Private NGOs championing wildlife and fish causes with Congress ● Professionals need to maintain an inclusive attitude in conversations - Beer, chocolate and discussions over meals are great additions	1. Identify regional (multi-state) objectives that articulates "success" in managing a disease and have these goals delineated at multiple and interacting scales (local - state - region) - 3 votes 2. TIE: Public outreach campaigns that relate human health and well-being to fish and wildlife health 3. TIE: Define and identify in which dimensions policy is elastic and in which it is fixed/rigid (e.g. where is our flexibility to address wildlife disease)
Top 2 Long Term Actions	● Research to better predict consequences of pathogen introductions (e.g., similar to Bsal efforts) ● Congress expands authority under Lacey	● Support large-scale funding such as "Recovering America's Wildlife Legislation" ● Seek global initiatives such as tapping into international	● Interstate collaboration regionally to manage disease issues (Regional/National/International Task Force(s)) ● Create OneHealth equality among wildlife, domestic	1. Include wildlife disease in FEMA's definition of an emergency (or have congress grant declaration of emergency authority to an agency to address wildlife disease) 2. Collaborate with states and agencies to develop objectives and

	Act to list pathogens and parasites as injurious (short + long)	disease control funds OIE/FAO/UN	animal and public health experts ● Research entities meeting management needs (e.g. APHIS-ARS, FS-NFS and RD)	goals for wildlife disease. Communicate these with policy holders.
All Actions	● Online Q&A forum for public to ask questions or share observations managed by FWA or state/federal biologists ● System to create BMP for emerging issues ● National surveillance program for aquatic pathogens of high concern, incl. harmonization of state testing requirements ● Assemble reference material to help with regulatory burdens like NEPA ● Leadership to develop risk assessments for high concern pathogens and development of emergency / contingency plans	● Identify mult-disease needs and efficiencies ● Evaluate success and ● Use innovation to increase efficiency such as: citizen scientists and crowd-sourcing (e.g., 'Ideation", "hack-a-thon") ● Evaluate successes and failures to identify and prioritize efforts to seek funding (lessons learned) ● Multi-state (largescale) resource pooling ● Request emergency funding to change the reality on the ground ● AFWA - lobby Congress for us! ● Allow agencies to co-mingle funding to deal with diseases		1. Define/identify in which divisions is policy elastic (and which are rixed/rigid) - ST 2. Fix NEPA - LT 3. Collaborate with states and agencies to develop objectives and goals. Communicate these with policy holders - LT 4. Develop multi-state disease management/contigency plans with specific objectives, monitoring protocols, and triggers for management interventions - LT 5. Identify regional (multi-state) objectives that articulates "success" in managing a disease (e.g. < 7% occurrence, eradicate in 5 years, etc) - ST 6. Include wildlife disease in FEMA's definition of an emergency/natural disaster

	● Form interdisciplinary idea incubator to develop new tools and approaches ● Free online training for fish and wildlife health BMPs for professionals provided by AFWA ● AFWA health update on webpage that is accessible to both professionals and the public ● Validated diagnostic tests, ring testing and harmonization for aquatic pathogens ● General database to help collect and share data between agencies ● Regional or national database for diagnostic testing by public agencies			7. Create national trust fund to accumulate dollars available to respond to disease 8. Public outreach campaigns that relate human health and well-being to fish and wildlife health 9. Regular outreach from stakeholders to state and federal legislatures about the impacts of fish and wildlife disease ("Disease Week on the Hill")
	TIME	REGULATIONS and AUTHORITIES	Human Resources/Capacity	Data Sharing

Top 2 Short Term Actions	• Hire more staff (permanent, temporary, interns) to assist in disease efforts; funding + staff + time devoted to issues / need more dedicated staff toward specific wildlife issues and problems / explore alternative sources of funding to hire additional staff (top short and long) Four-way tie for second between: • Sabbatical or detail funding to allow scientists time to focus on key issue • Create strategic and logistic plans in advance of surveillance / invest in planning • Invest in tech (ipads and apps) + create or purchase tools that will help decrease amount	• Work as a group to thoroughly identify authority needs and requirements that limit action; frameworks and plans for state, federal tribal coordination - given that there are aspects of this need that are short term and longterm, this is our top action for both categories • Programmatic permits that are more blanket and for general use would allow for efficiencies and help in emergencies - programmatic permits and assessments	• EMAC system-type resource sharing for disease response, IMTs (Incident Mgmt Teams) for short-term disease response • Increase staff (field staff, programmers/data managers, population monitoring, research, epidemiologists)	1. Establish data sharing MOUs to facilitate the population of national databases 2. Fund database development and upkeep management

	of time particular tasks consume • Develop more strategic risk-based surveillance plans to get more value for effort			
Top 2 Long Term Actions	● Hire more staff (permanent, temporary, interns) to assist in disease efforts; funding + staff + time devoted to issues / need more dedicated staff toward specific wildlife issues and problems / explore alternative sources of funding to hire additional staff (top short and long) ● Encourage wildlife health component in all field staff EWPs	● Work as a group to thoroughly identify authority needs and requirements that limit action; frameworks and plans for state, federal tribal coordination - given that there are aspects of this need that are short term and longterm, this is our top action for both categories ● Streamline, clarify, and fill gaps in regulations. Ensure that regulations are detailed, specific and simple	● Create a lead agency for fish and wildlife health research which supports all agencies ● AFWA asks for a dedicated wildlife/aquatic lab for every state ● Recruitment programs for next generation disease managers	1. Nationally supported wildlife disease database that includes geographic location and incidents through time. 2. Require funded research and monitoring projects to report data specific database/repository within specific timeframe (i.e. link funding to timely reporting)
All Actions	● Reprioritize tasks ● AFWA position paper on wildlife health programs ● Expand work week...or not	● Elevate the urgency of establishing effective legislation and regulation ● Engage regulated community and ret. comm		1. Establish data sharing MOUs to facilitate the population of national databases 2. Fund database development and upkeep management

	● Time machine ● "Shared" positions that are funded by two groups and have split time ● Funding for scientists to conduct post-implementation reviews to develop BMPs and clarify what worked or didn't work ● Citizen scientist and public engagement projects ● AFWA draft/supply model justification for hiring wildlife health positions ● AFWA draft / supply model EWP / position description for wildlife health positions	● Find a champion - legislator interest (eg. cute child advocate) ● Authorize one federal agency to deal with diseases (agriculture and wildlife combined - because of complications currently)		3. Nationally supported wildlife disease database that includes geographic location and incidents through time. 4. Require funded research and monitoring projects to report data specific database/repository within specific timeframe (i.e. link funding to timely reporting) 5. Establish data sharing templates and clear guidance for data ownership and use 6. Review existing disease databases to identify common fields and opportunities to integrate 7. Develop and use shared information management systems where appropriate 8. Create and maintain a national database for each known disease - include geographic locations of incidents through time

Appendix 4: Complete List of Lessons Learned, as Identified by Forum Participants in Small Groups

Thurs. morning – Lessons Learned		
Topic	Theme	Lessons learned
Science What's working	Collaboration	Understanding means both ways
		We all impact each other
		Recognition of need to interface (EG US and wildlife)
		· major leap
		· want to work together
		· be transparent
		· change in our approach
		· desire for working collaboratively
		· efforts to collaborate on specific disease issues across institutions to disease treatment and sometimes control
		· the right people at the right time
	Broader look at science	Integrated research
		· work smarter
		· taking a broader look at science if the disease impacts is happening
		· solutions with human health implications
		· solutions with financial implications eg CWD
		· development of real-time molecular based tools
		· enhanced horizon scanning processes
		· new disease techniques available better science and management
	Increased access to technical capacity	· increase in number of labs available for testing
		· techniques are harmonized
		· sensitive and specific diagnostics
		· research
		· multiple universities and researchers working on animal health issues
	Time scale is faster	· faster publication times and increased access to publications
		· time scales
		· can go from zero to 1,000 miles an hour, rapid
		· people willing to be champions now

	Identifying champions for science	· champion influx with funding - more available information
Science what's working (group 2)	Balance of Basic Science/	· transitioning research into management strategies
	Applied Science	· using date to inform decisions
		· wide-sweeping research approach -- basic biology to applied research
		· research having direct application to management
		· funders "rewarding"/recognizing knowledge translation & impact
		· research driven by needs of management agency (e.g. FWS-USGS-partner research)
		· learning about species interactions that provides new paths toward management options
		· white papers translated into applied management strategies
		· Info exchange with managers and agencies to direct research objectives
	Collaboration	· funding agencies placing emphasis on collaborative work
		● managers helping collect data samples
		● research teams combining expertise
		● collaborative efforts and better communication between agencies
		● data sharing
		● increased collaboration and greater access to experts
		● research working groups that facilitate info exchange & collaboration
		● multi-disciplinary research - using expertise from universities, agencies, etc.
	Advances in tools	· advancement in molecular and genomic tools and reduction in cost in utilizing those techniques
		· talking about doing test harmonization
		· advances in technology
		· laboratory techniques continue to improve rapidly
		· development of new treatments/methods for disease mitigation
	Knowledge mobilization	· publications ahead of print allow for faster communication of results

		· Increased opportunities to share results in novel ways and engaging
	Training	● funding agencies pushing science into better directions
		Co-op units are working (to deliver science and foster next generation of scientists)
		Great students coming up, bright minds, better at communications
		Training next generation of scientists
C Laura (group 3)	Collaboration	●collaborative research
		collaborative mapping of disease occurrences
		Regional/national coordination for mortality event investigation
		collaborative efforts with external partners
		data sharing
		development of BMPs
		Interdisciplinary efforts to address disease
		Partnering with citizen scientists to broaden observation/response networks
		USGS Cooperative research stations/centers
		Idea sharing (an not worrying about getting "scooped" by someone
	Diagnostics & Epidemiological Tools	● Identification of transmission pathways, including environmental reservoirs
		Identification of susceptible, tolerant, resistant species
		Elucidation of pathogen biology
		Genomic studies of host/pathogen
		Application of molecular techniques
		Development of novel diagnostic assays
		Using the tools identified by basic research have been successfully applied - e.g., development of SVP vaccine
		Technology transfer
		Testing
	Expanding uses of funding	● Flexibility in funding and its uses\
		Effective use of limited resources
		Grant opportunities
		Funding requires science-based objectives
		Look at game and non-game proportionately
		● Procedures for the validation of new detection methods
		Identification of disease and causative agents

	Increasing collective knowledge	Understanding of "disease basics" (for many established nof emerging agents)
		Improved and more accessible technology
	● Theme G	● Establishment of a lab network with SOP & Q/A has been beneficial to wildlife management
		● State of the science
		● translation to management or regulatory action
		● timeliness is better (improved)
		● (relatively) rapid communication of key finding
		● communication of research results to regulators (and they acted)
	● Theme F	● Engagement of scientific community
		● interest in important problems
		● Scientific community wants to work on these issues
		● landscape scale better allows looking at game and nongame
		● implementation of tools
	● Theme H	● Science Based implementation
		● establishment of sample collection, preservation and testing protocols
		● Development of surveillance methods and protocols for some diseases in some species
D Laura	● Theme A	● Coordination of WNS research
		● Bsal task force - standardizing testing protocols
		● collaborations/partnerships
		● standardized testing protocols
		● Bsal task force
		● herp scientists quite inclusive, tight knit and collaborative
		● States and local diagnostic labs collaborating on research projects
		● greater collaboration between states in research
		● harmonization
		● state wildlife agencies partnering with universities or research
		● coordinating research
		● greater collaboration in research
		● WNS and other wildlife disease communities
		● researchers

		● ability for collaboration due to advancement in communication technology
		● artificial intelligence, machine-learning (starting to apply to diseases)
		● SDM/Decision science focused on wildlife diseases
	● Theme B	● Paradigm shift
		● increased awareness
		● perceived need for wildlife health research
		● independent thought (not hindered by agency agenda sometimes)
		● field of wildlife health and disease
		● one health is expanding rapidly
		● research is leading to outcomes (applied)
		● ever growing body of wildlife health/ disease related knowledge
		● but now money applied science not there
		● not just one pathogen but multi-factored
		● shift to genomics
		● Citizen science
	● Tools	● diagnostic tools
		● genomic tools
		● epidemiology tools
		● increased understanding of immune function
		● increasing expertise in laboratory analyses
		● new diagnostic modalities are rapidly emerging
		● wildlife disease vaccine research
		● epidemiology tools
		● improved diagnostic capability with application to management (WGS)
		● advances in identification of pathogens at genomic level
		● molecular diagnostics high throughput ability
		● advances in diagnostic tools - PCR, multiplex PCR
		● new testing techniques/capability e.g. genomics
		● micobiome
		● ability to detect evolutionary adaptation to disease
		● ability to test for genetic response to disease
		● traceback of disease outbreaks (Genomics)
		● use of DNA for detection

		● population monitoring
		● population monitoring of large charismatic animals and game/fished species
		● ecosystem level surveillance allows detection of change
		● NABat standardized continental-scale population monitoring
		● modeling
		● data visualization
		● data visualization tools relevant to disease (whispers, Marine, FWS fish diseases tool)
	● Theme D Funding	● more money in a diverse amount
		● multiple species
		● not 1 thing at a time
E Lane	● Networks in advance of a problem	● Common goals in terms of science in understanding disease
		● Importance of research
		● Importance of surveillance
		Efforts to share data (not always successful)
		Personal networks across diverse orgs
		Numerous multi agency collaborative efforts
		Tackling wildlife disease problems through knowledge and research
	`Infrastructure	● For aquatic pathogens, a solid nationwide diagnostic infrastructure at fed, state, tribes, university
		Bluebook inspection manuals
		Funding, admin support and communication is key to success
		One hearth (?)
		Transparency with ongoing research
		Require scientists to share unpublished results
	● Advancements	● Advances in epidemiology (risk based surveillance)
		eDNA testing
		High throughput / cost effective
		More open access research papers than long ago, more open databases
		Advances in understanding of disease and techniques in research
		Applications of new methods in research
	● Subject matter experts	● Efficiency of using students to create much of the science
		Ability to specialize

		Many key pathogens have good knowledge base
		Advances in transmission models for aquatic pathogens that can be expanded on
	● Engaged scientific and public communities	● Engaged public that cares about (?)
		Engaged scientific community with multidisciplinary and overlapping interests and expertise
		Connecting opinion with pathogen research and management (human dimensions)
		Passionate community willing to engage w/ each other to achieve common goals
F Lane	● Collaboration / communications	● Multidisciplinary engagement / need involvement of diverse expertise
		Consistent goals to benefit resource
		Open communication to share important info w/o delay
		Cooperative forums for multiagency info flow
	● Collaborative science	● SCWDS / coop research
		Many labs working on same pathogens / many good ideas
		Research-management collaboration
		Collaborative research is the norm and very effective
		Interdisciplinary science works
	● Prioritization of scientific needs	● Early efforts to understand variation in vulnerability (prioritize focus of action)
		Brainstorming and IDing needs and priorities (disease or species specific)
	● Translating / transparency	● Improving at communicating science to the public
		Science communication external
	● Scientific / technological innovation	● Molecular methods (PCR + gPCR)
		Many tech advances and rapidly growing
		Lab testing, research diagnosis of pathogens
		Regional labs
		SCWDHC
		USGS WHC
G Lane	● Funding	● Increasing funding interest from private foundations
		Mitigation funds used for science
		Some opportunities to address high priority problems through grant based funding
	● Communications /	● Better science communication to non scientists
		Online science publications
		Better communication from researcher to researcher to public

	outreach / info access	Better databases for storing / retrieving data
	● Knowledge / talent base	● Talented and engaged pool of contributing scientists
		Good researchers in places and working on the issues
		Basic epidemiology is well understood
		Improved baseline knowledge with research
	● Technological developments	● New / novel detection methods being developed
		Application of new tech to wildlife-disease research
		Improved tech for testing methods
		New tech being developed and coming online
		Just in time sci/tech development
	● Cross-disciplinary collaboration	● Cross-disciplinary expertise collaboration
		Multidisciplinary and interagency research approaches are being better supported and recognized
		Improved understanding that diseases do not necessarily affect only wildlife or domestic species
H Lane	● Collaboration	● Coordinating research and minimizing duplication
		Collaboration across disciplines
		Scientists and managers working together, i.e., coproduction of science
		Information sharing among the community of practice
		Creating opportunities for collaboration between agencies within states and among states and with NGOs
		Integration of disciplines, e.g., biology, HD, phys. science, tec.
		Integrated research programs that address host-agent-environment together
	● Reliability	Long-standing established credibility
		Scientific method results in credible results
	● Funding	Collaboratively funding highest science priorities
	● Relevance to management	● Useful predictive models that can be updated with new research and surveillance data
		Increasing production of structured decision making tools to inform management
		Scientists motivated to research topics relevant to management
		Adaptation strategies for treatments of pathogens where possible
	● Useful tools	● Standardized diagnostic protocols
		Risk assessments (+ maps)

		Diagnostic services
		Health programs (AAHP) to assist resource managers
Lessons Learned – What do we have in place that is effective and what is working in MANAGEMENT (Anna-Marie and Cindy)		
Group (A-H)	Theme	Post it
A Mark (Group 1)	● Management	● increase in number of disease and health specialists in agency
		● increase in diversity has led to loss "voices - always done it this way"
		● continued focus on one health approach
		● in field management after decisions have been made
		● not reinventing the wheel (i.e. emerging disease responses seem to be adopting some aspects of WNS response
	● Collaboration - stakeholders, communication with agencies	● integration of NGOs into response
		● international communication/collaboration
		● communication within agencies/bureaus
		● multi-agency collaboration
		● communication among management entities
		● communication between scientists and managers
		● multi-agency task force or team efforts toward common objectives
		● better communication across agencies
		● informal networks of experts
	● communication with public aka social media	● outreach to the public through social media
		● public opinion reaches decision makers more quickly demanding action through social media
		● public outreach tie management action to things public cares about
		● smart phones with reporting apps, cameras
	● research and technology	● scientific/academic research on disease management
		● more tools in the toolbox
		● many laboratory support options available
		● speed of diagnostics has increased
		● rapid assessment of genetic diversity within populations
		● genomic technologies allowing us to identify at-risk populations

Appendix 5: Complete List of Challenges and Gaps, as Identified by Forum Participants in Small Groups

Lessons Learned – What are the Challenges and Gaps and resources needed in Science (Devin and Earl)		
Group	Theme	Lessons learned
Challenges and Gaps in Science	Proactive	● Current hot topic issues consuming all resources
		● knowledge of emerging and potential issues
	Underrepresented taxa needs	● How fish amphibians and reptiles influence ranavirus dynamics in a shared environment
		● How community structure affects disease occurrence for ophidiomycosis
		● Persistence of ophidiomyces in the environment
		Effects of ophidiomyces on snake populations and individual fitness
		Relationships of fungal organisms to each other
		Role of co-pathogens in well-known diseases
	● Communication and Collaboration	● Communication - interagency, intragency, across all outside
		● Identification of management goals and consistent movement across agencies towards obtaining objectives
		● Clear, accessible communication of key findings
		Development of research priorities collaboratively and pragmatically
		Research directed by management agencies multiple cooperators and universities
		Prioritization of questions (within a problem area)
		Development of management tools
		Translation to management actions
		Better integration of research and management
	● Management	● Disease detection technologies
	● Detection - Disease dynamics and modeling	●
	● Funding	● lots of cards saying funding
	● Epidemiology	● Validated/harmonized methods for pathogen detection
		Validated tests
		Predictive models
		Identification of critical control points

		Risk Assessments
Challenges and Gaps in Science	● Communicating science to public	● ability to use science/data to change behavior
		Ability to counteract pseudoscience
	Baseline data collection and surveillance	● Surveillance for pathogens
		· Utilize public for surveillance
		· national level disease surveillance tools
		· Better understanding of immune system of affected wildlife and ways to boost it
		· Quantifying ecological consequences
		· Need "before" data
		· Baseline data on very long-term "normals" (geological time) for distribution and presence of pathogens
		· Lack of baseline disease/health data
		· Baseline wildlife health
	Tools	● Utilize technology for better surveillance
		· Standardized research/testing protocols (QA/QC) among labs
	Management	● Disease management strategies
		Management interventions for environmentally persistent pathogens
	Surveillance	● Environmental factors
		Specifics about climate change
	Risk assessment and quantification	● Ability to predict outbreaks
		Data needed to help prioritize disease threats (population impacts, public health impacts, etc.)
		Ability to forecast/predict high-risk times for wildlife diseases
		More vigorous disease modeling
		Population level impacts in target species
		Realistic metrics to evaluate efficiency of management actions
		Quantifying economic consequences of disease
	● Inter-organizational collaboration and communication	● Territoriality
		Differing needs and pressure to publish
		Driving science relevant to management with collaboration
		Coordination
	● Under-represented taxa	● Marine Science Gap
	● Data sharing	● Accessibility of data (pre-publication)
		Data and information sharing

		Location privacy issues - e.g. geographic locations at county vs. GPS coordinates
	● Human and financial resources	● Funding capacity
	Scientific method takes time	Research takes too long (not quick enough for management)
		Speed with which science happens
Challenges and Gaps in Science	● Standardization of science (methods, interpretation, etc.)	● Validated testing methods
		Better tests for pathogens
		Data interpretation
		Uniformity in tests and sampling procedures
	● Funding	● Human health has the largest piece of funding
		More funding for fish and wildlife conservation and health
	● Data Sharing	● Databases don't talk to each other
		Lack of databases and information sharing
	● Collaboration	● Asking/identifying the right questions
		Do we agree on our desired outcomes/outputs?
		Improved collaboration and communication
		How to manage scientists to collaborate and share information while respecting competitive scientific processes for publication, etc.
		Transdisciplinary needs to be implemented
	● Publication Process	● The flashy race to publish (results in junk science)
		Impact of science
		Quality control and validity of published information - Junk science
	● Impediments to progress (agency operations)	● Tying agency researchers to same publication standards for advancement as academics. Affects interest in applied science needs.
	● Barriers to proactive management	● Reactive vs. proactive
		Science to inform pathway risk management focused on prevention
		Increased understanding of how environmental factors, pathways, and vectors contribute to emerging disease issues
	● Communicating with non-science audience/public	● Education of public about diseases, impacts, and long-term goals
		Change of public attitude perception of wildlife as the villain of disease transmission
	Funding	· Commitment to long term research issues

Challenges and Gaps in Science		· funding short term
		· disease du jour approach to funding and capacity
		· basic research not getting funded
		· funding
		· funding
		· lack of funding
		· lack of funding designated for applied research
		· lack of adequate funding
		· lack of funding
	Interagency Communication	● communication of research results in accessible language and accessible platforms
		● communication of complex ideas
		● constant communication between management agencies and research institutions
		● gap between researchers/scientists and managers
		● communicating results to decision makers
		● communicating science to management agencies
	● Harmful/wrong incentives	● academic "shenanigans" embargoes, competitive culture
	Cultural Inertia	
		● pressure to publish in high importance journals that leads to less specificity that is useful for management
		● lack of incentives for academics to do more than publish results in scientific outlets
	● Communication - non scientific public	● bad science communicators (i.e. people who can't/won't talk to the public)
		● sharing of research results with agencies and public
		● communicating science to public
		● better dissemination of information to public
	● Data Sharing	● sharing of data
	● Lack of Long-term Thinking	● thinking innovatively isn't rewarded
		● results need to be evaluated in context of time
		● data collection sustained over long term in rapidly changing world
	● Adaptive Management	● agencies remembering "science based management"
		● actively doing adaptive management
		● use of adaptive management isn't widespread
	● Science Translation into	● research-driven by management objectives or problems
		● agencies needs to drive more need based science
		● public trust in expertise

	Policy & Management	● laying groundwork for emerging issues to legislators/public
		● policy makers understanding and embracing science
		● robust science can take longer than decision makers want
Challenges and Gaps in Science	● Funding	● Need more trained personnel, this includes challenge to budget
		● more available wildlife-focused funds
		● funding
	● Adaptive Management Process	Publishing results of effectiveness of control actions
	● Diagnostics	●Practical, accessible effective diagnostics
	● Applied Science	●Ability to apply research in natural environments
		more applied
		Approaches and strategies and tools to mitigate and manage disease in natural populations
		Disconnection between science and management logistics
		linking hypothesis w/real risk to help management
	● Host Physiology	● How does environment affect immune function
		Info. on host immune responses, factors that affect it and vaccine development
	● Developing a Systems Approach	● Info. on dominant transmission routes and factors that affect those routes
		Info. on genetic variation of pathogens, isolates, and implications
		population demographic information
		better models and understanding what drives disease emergence and submergence
		basic research to facilitate risk assessments and disease models
	● Information availability	· ● more interdisciplinary efforts to solve complex wildlife health issues
		· education and outreach to vet community and recruitment
		· user friendly ways to accumulate and share data easily and effectively
		· publishing results of effectiveness of control actions
		· make publications more accessible
		· delay sharing data and results of studies
		· more interdisciplinary efforts to solve complex wildlife health issues
		· more efficient exchange of scientific data
		·
	● Public Outreach	●Public Perceptions/Human Dimensions surveys

		Interpreting scientific needs to Congress in their "language" so they can pass helpful legislation
		Improve scientific data and communication in a way that the public can understand
		better communication of what the complex science actually means to the rest of us
Challenges and Gaps in Science	● Funding	· ● Need money and resources - people included
		· Funding to develop new techniques
		· Funding and resources
	● Translate into Management	· ●Implementation of science outcomes into policy, regs. and or actions
		· Distinction between science and management makes it difficult to realistically bridge gaps in both directions
		· Risk assessments and management implications
		· Communication and collaboration between agencies, states, NGOs and all groups
		· appreciation of value of science by public and decision-makers
	● Disparate/Competing Organizational Goasl	● Publish or perish versus rapid response due to competition
		strategic use of available funds
		prioritization of available funding to benefit resources
	● Logistics	●Lack of research in some areas of science
		lack of coordination between people sampling animals and researchers working on pathogens
		Standardization
		central, organized repository for science information data, collaborations and management actions
		recognition that "species" difference matters
		effective delivery mechanisms
Challenges and Gaps in Science	● Funding	● Financial support for training programs and students
		● Adequate funding opportunities for both basic and applied research
		● Funding
		● Money
		● Funding for wildlife disease support infrastructure for center of excellence to support state needs
	● Strategic Planning/Prioritization	● Internal competition for limited resources
		● Funding agencies may choose to fund a shiny object instead of building needed infrustructure to elevate quality of basic capabilities

		● Research interest in non-game populations
		● limited focus on proactive measures/what is most effective
		● more focus on prevention rather than reaction to problem/disease outbreak
	● 3 C's - Communication, Collaboration, Cooperation	● Collaborative databases to capture current knowledge
		● Coordination each time a new disease emerges in a new species there is a tendency to reinvent the wheel
		● Communication between agencies
		● non-regulatory disease reporting accountability
		● Management listening to science and vice versa
	● Professional Diagnostic Infrastructure	● Standardized lab
		● Consistency w/testing methods
		● Updates to testing methods-keeping up with new technology
		● Fish and wildlife test standards and network
		● Non-regulatory disease reporting accountability
		● lack of widely available validated diagnostic testing that can be utilized for both surveillance and response
	● Disease Baseline Knowledge Gaps	● Interface disease transmission critical points
		● Long-term monitoring
		● Environmental persistence
		● Basic data
		● Reference genomes for inverts.
Challenges and Gaps in Science	●Study Design	● Unified probabilistic sample design surveillance
		Standardized laboratory testing
		Robust accounting of uncertainty from lab to field
		Ability to test lab verified treatment in the field
		Understanding variability of progression in species and individuals
		Which uncertainty most important to address
	● Disease Biology	● Establishment of historical or baseline data
		Transmission thresholds
		Population impacts of disease
		contribution of environmental to disease dynamics
		population level inferences of disease
		Field test development/live test development
		Forecasts of diseases that are likely to emerge in N.A. in the future particularly non-indigenous pathogens

		research in human social aspects of disease spread
	● Funding	● Funding for innovative pilot projects that may be viewed as out of the mainstream
		Secure funding for long-term, established research programs
	● Disease Impacts to Humans	● Zoonotic potentials of disease
		Research into economic impacts of disease
		Research into human social aspects of disease spread
	● Human Dimensions	● Overall acceptance to discredit science if you don't like the answer
		science sometimes competitive environment vs. collaboration among bureaus and/or PIs
Topic	Theme	Lessons learned
Challenges/ Gaps in Manage-ment	● Funding	● Lack of funding
		● Competing needs for funding
		● Money
		● Large scale funding for direct management research
		● No support for preventive medicine
	● Politics	● Politics over science
		● Shifts in management towards public use and away from conservation
		● Education of legislators/policy-makers
		● Political power from stakeholders w/opposing views
		● Political and public resistance to appropriate mgm't actions
	● Bureaucratic Impediments "red tape"	● Authority ; who is the point person/team role of agencies permitting obstacles to management actions
		● Ability to respond rapidly; lots of approvals for management actions
		● Entrenched ideas and beliefs
	● Public buy-in and education about wildlife health issues	● Communicating effectively with the public
		● Public buy-in
	● Cultural Inertia	● Stuck to old
		● Lack of risk tolerance
		● Need more
		● Collaboration discussion w/ researchers and managers
		● Apprehensiveness to share data
		● Proactive instead of reactive thinking

		● Need innovative out of box thinking
		● Low profile species – no support or money
	● Lack of capacity for quick response	● Enforcement
		● Human power to accomplish objectives
		● Changing environmental conditions –changing faster than we can keep up
		● Greater capacity to address issues
	● Animal Welfare	● Lack of access to IACUC committees outside of academia
		● Inconsistent use of ICUC to ensure animal welfare
		● Inappropriate activities with live animals by untrained professionals
		● Lack of enforcement
		● Push-back against improved welfare
		● Lack of awareness about animal welfare issues
Challenges/ Gaps in Manage-ment	● Funding	● Lack of funding
		● Competing needs for funding
		● Money
		● Large scale funding for direct management research
		● No support for preventive medicine
	● Politics	● Politics over science
		● Shifts in management towards public use and away from conservation
		● Education of legislators/policy-makers
		● Political power from stakeholders w/opposing views
		● Political and public resistance to appropriate mgt. actions
	Bureaucratic Impediments “red tape”	● Authority ; who is the point person/team role of agencies permitting obstacles to management actions
		● Ability to respond rapidly; lots of approvals for management actions
		● Entrenched ideas and beliefs
	Public buy-in and education about wildlife health issues	● Communicating effectively with the public
		● Public buy-in
	Cultural Inertia	● Stuck to old
		● Lack of risk tolerance
		● Need more
		● Collaboration discussion w/ researchers and managers
		● Apprehensiveness to share data
		● Proactive instead of reactive thinking

		● Need innovative out of box thinking
		● Low profile species – no support or money
	Lack of capacity for quick response	● Enforcement
		● Human power to accomplish objectives
		● Changing environmental conditions –changing faster than we can keep up
		● Greater capacity to address issues
	Animal Welfare	● Lack of access to IACUC committees outside of academia
		● Inconsistent use of ICUC to ensure animal welfare
		● Inappropriate activities with live animals by untrained professionals
		● Lack of enforcement
		● Push-back against improved welfare
		● Lack of awareness about animal welfare issues
Challenges/ Gaps in Manage-ment group 3	Intervention tools	● Biosecurity practices
		● Environmental clean up disinfection
		● vaccines
	Funding	● Funding
		● More grants that can be used for marine studies
	People / technical resources	● More aquatic/marine facilities (e.g quarantine capabilities)
		● Lab capacities
		● Capacity
		● Personnel
	Lack of Management by system approach	● Management of marine disease
		● How disease should affect management decisions (when do we know when to react)
		● Management of aquatic disease
		● Managing multiple taxa in presence of pathogen that only affects one taxa
	Internal/external politics influencing management	● Different philosophies between agencies
		● Authority
		● Lack of political will to implement management actions
		● Lack of political will to support actions
	● Effective public engagement	● Public education
		● Managing expectations
		● Public expectations and politics
	● Informed management	● Directed applied research
		● Better communication /collaboration w/academia
		● Identification of the questions

Challenges/ Gaps in Manage-ment	● Funding	● Inadequate agency time and money
		● Funding
	Planning	● Assigning priorities to problem in context of program
		● Long term planning
		● Need well defined, realistic goals, objectives
		● Need more proactive planning surveillance
	Political Issues/Conflicting Responsibilities	● Unrealistic "feasible" management options
		● Agency responsibilities/priorities can restrict resources (including time) needed for addressing health issues
		● Political barriers to measurement actions
		● More Authority to address nongame non listed species disease
	Knowledge	● Scientific knowledge gap
		● More management options
		● State of the science
	Capacity Building	● Capacity in parks
		● Diagnostic capacity and interpretation
		● Staff for wildlife disease surveillance efforts
		● Training for agency staff
		● Staffing priority
		● Climate change ability to adapt
		● Assigning new staff responsibility to respond to disease lack of "boots on the ground" (staffing shortage/priorities)
	Communication	● Differing perceptions of the magnitude of the problem
		● Public fatigue
		● Public support for some management actions
		● Public health
		● More emphasis on public outreach needed
		● Inadequate public support
	● Intergroup Relationship	● Lack of clear roles
		● Diverse values
		● FOIA data sharing
		● Coordination of surveillance / management strategies among states and agencies
		● Challenges of managing disease that cross jurisdictions jurisdictional cooperation/coordination
		● Relationships
		● Collaboration/coordination

Challenges and Gaps in Manage-ment	● Prevention	● More focus on preventative strategies than reactionary (contingency and response plans, etc.)
	Prevention	Need for risk assessment with aquatic resource management activities
	Prevention	More management tools
	● Regulatory	● Identifying regulatory jurisdiction
	Regulatory	Identifying regulatory gaps, how to bridge them
	● Capacity Building	● Baseline data for pathogens - in animals and on landscape
	Capacity Building	Diagnostic capacity to assess efficacy of management
	Capacity Building	Need for researchers and diagnostic labs to provide meaningful data and information to managers and biologists
	Capacity Building	Standardization of diagnostic testing for management decisions
	Capacity Building	Training for field personnel
	Capacity Building	Communication to field personnel about what and why they are managing for disease
	● Stakeholder communication	● Gaining public support for management action
	Stakeholder communication	● Being able to give an "end time" answer to stakeholders on management decisions (measuring success)
	Science and management communication	● Need for better internal communication between researchers/scientists and managers
	Science and management communication	● Need for better collaboration and communication in management and between agencies
	Science and management communication	Better understanding of manager's needs/capacities
	Implementation	· Understanding of willingness to enact management actions
		· Prioritizing actions
		· Need for better prioritization for funding/attention
		· Inertia in initiating actions
Challenges and Gaps in Manage-ment group 5	Outreach	Scientist and managers do a poor job of getting the public (or policy makers) to care
	● Outreach	● Make congressmen care
	● Outreach	● As publicly (or at least partially) funded agencies, the public is fickle and easily distracted
	● Outreach	● effective and relevant communication
		● Tribalism

	● Lack of collaboration	· Myopic focus
		● Jurisdictions are hard to manage across, lack of flexibility
	● Funding	● Funding to research and implement large-scale management
		● We need more resources
	● Inertia (fear of loss)	● Fear of loss
	Inertia (fear of loss)	Denial - failure to engage before the problem arrives
	Inertia (fear of loss)	Inertia - uncertainty can lead to inaction
	Guidance (required and optional)	Translating management needs into policy
	Guidance (required and optional)	In absence of regulations, how do we manage effectively (implement best management practice)
	Guidance (required and optional)	Robust infrastructure (similar to climate science centers, national leader with regional centers).
	Guidance (required and optional)	Standardized management approaches
	Guidance (required and optional)	Standardized surveillance protocols
	Communication and coordination	communication within and among agencies
	Communication and coordination	communication and coordination between agencies, states, research and NGOs
	Communication and coordination	Translating science to the decision makers
	Communication and coordination	translation of science into management
	Inertia (fear of loss)	Uncertainty of outcome is not well embraced outside pure science. We need to better define expect actions to garner support for trying something.
	Inertia (fear of loss)	Although adaptive management is often our need, it is counter-intuitive to those who don't feel comfortable with change
Challenges and gaps in manage-ment	Regulatory	● Regulations can be a barrier
	● Regulatory	● Enforcement of regulations
	● Leadership	● Lack of support from political figures and certain groups
	● Leadership	● Lack of emphasis from leadership
	● Leadership	● Need rapid response actions worked out and approved before needed
	Leadership	ability to make more rapid (real-time) management decisions that are better able to contain rapidly emerging disease issues (such as pathogen spread)

	● Coordination and communication	● Coordination between agencies with similar interests; need better/more open communication
	● Coordination and communication	● confusion over jurisdiction and authority
	● Coordination and communication	● continued improvement in communication channels between agencies, diagnostic laboratories, and those in the field
	● Coordination and communication	● connecting knowledge from the field/lab with upper levels where management decisions are made
	● Coordination and communication	competing interests of natural resource management and commercial agriculture. Overlapping authorities /ill fitting policies.
	Coordination and communication	easy for managers to neglect population health needs
	Toolbox	information on host-parasite epidemiology for many systems and difficulty acquiring that information
	Toolbox	Effective treatments
	Toolbox	Lack of robust models, we need more mathematicians
	Toolbox	expanding the toolbox; open to new ideas, innovation and outside perspectives
	Personnel resources (human capital)	low staff to apply effective management
	Personnel resources (human capital)	more dedicated wildlife health staff
	Personnel resources (human capital)	Time
	Personnel resources (human capital)	readily available material on wildlife health management practices for directores/higher management
	Personnel resources (human capital)	limited training opportunities for population health topics especially for non-health related positions
	Outreach	public engagement
	Outreach	constituents don't understand the need
	Outreach	lack of social and political will to invest in more resources to aid in proactive management of wildlife diseases
	Surveillance	Early detection
	Surveillance	lack of surveillance
	Funding	Funding and support to maintain infrastructure/biosurveillance after emergency or initial outbreak is over; conversely proactive surveillance or risk analysis before a problem occurs
	Funding	lack of funding to apply effective management
	Funding	competition for funds with traditional projects, values, practices

	Funding	research funding for diseases impacting natural resources. Particular research that addresses management-related questions
H Katherine	● Communication	● Effective messaging strategies
	● Communication	● Limited public awareness, understanding and support for wildlife disease management
	Communication	● communication interagency (local, state, federal)
	Communication	● outreach to stakeholders and beyond into community
	● Communication	● sharing learning among agencies/populations
	● Communication	● public and internal knowledge base
	● Communication	● guidelines and strategies for identifying stakeholder groups
	● Communication	● effective strategies for reaching constituency groups
	● Funding	● Lack of funding to implement management
		● reliable funding stream
		· collaboration - sharing resources
	Measuring success	well-defined thresholds for taking action
	Measuring success	not quantifying the economic costs of disease
	Measuring success	unrealistic expectations regarding “solving” the problem, e.g. eradication vs. management
	Regulatory	Economic incentive exists for unregulated species movement
	Regulatory	Regulatory requirements that impede rapid response
	Regulatory	Can’t control some sectors (e.g. pet trade)
	Coordination needs	on/off leadership commitment
	Coordination needs	lack of integration and shared vision/mission of different agencies
	Information needs	Uncertainty in net benefit of multiple treatments