

Bsal Task Force

2022 Annual Report

May 2023



North American
Bsal Task Force
salamanderfungus.org

Background

Batrachochytrium salamandrivorans (Bsal) is a fungal pathogen of amphibians associated with the emerging infectious disease Bsal chytridiomycosis. Bsal was discovered in 2013 in Europe, following the discovery of ongoing mortality in Fire Salamanders (Martel et al. 2013). Bsal appears to be expanding in distribution (Spitzen-van der Sluijs et al. 2016). A 2014 experiment (Martel et al. 2014) revealed susceptibility of salamanders from around the world to Bsal chytridiomycosis, including some North American species. At a 2015 workshop in Colorado, researchers and managers discussed approaches to learn more about Bsal and the related emerging infectious disease caused by it and to forestall potential biodiversity losses in the Americas where it was not known to occur (Grant et al. 2016).

The North American Bsal Task Force was initiated in June 2015 and continues to meet in specialized working groups. Updates from each of the following Working Groups are highlighted below: 1) Data Management, 2) Decision Science, 3) Diagnostics, 4) Research, 5) Surveillance and Monitoring, 6) Clean Trade, 7) Response and Control, and 8) Communications and Outreach.

Working Group leads serve on the Technical Advisory Committee, which also includes representatives from concerned partner groups such as the Pet Industry Joint Advisory Council (PIJAC), Amphibian Survival Alliance, and US federal agencies. An Executive Oversight Group was envisioned for consultation. Related tasks have been taken up by the Disease Task Team founded by Partners in Amphibian and Reptile Conservation (PARC), and an independent working group in Canada, the Canadian Herpetological Health Working Group. National amphibian disease contacts in Mexico have been identified. An update from PARC is also provided below.

The PARC Disease Task Team expands the scope and capacity of the Bsal Task Force by supporting the development of disease biosecurity guidance both nationally and within regional PARC working groups (including an email disease alert system to aid rapid responses to potential Bsal chytridiomycosis in North America), and developing complementary outreach materials to the Bsal Task Force such as magazine articles, and web-posted Factsheets and Webinars.

Actions to forestall Bsal transmission have been undertaken by three key partners. In 2015, the PIJAC instituted a moratorium on Asian salamander imports. In early 2016, the US Fish and Wildlife Service implemented an Interim Rule of the Lacey Act, naming 201 salamanders as injurious. They used an evidence-based approach prohibiting importation of any salamander genus whose members were shown to be carriers or to be lethally affected by Bsal in published papers. In the summer of 2017, Canada implemented import restrictions on all salamanders (Customs Notice 17-17; <http://www.cbsa-asfc.gc.ca/publications/cn-ad/cn17-17-eng.html>).

This report compiles activities conducted by the Bsal Task Force and their partners from January 2022 to December 2022. The continuing global SARS-CoV-2 pandemic in 2022 slowed progress from the Bsal Task Force, but group members continued to meet and contribute when possible.

Key Accomplishments in 2022

- In 2022, Student Network for Amphibian Pathogen Surveillance (SNAPS) was implemented at 23 institutions from the US, Canada, and Mexico, and will expand to 28 institutions in 2023 (with all 2022 participants returning).
- SNAPS participants have sampled over 600 animals (10 species across North America)
- The first Global Amphibian and Reptile Disease Conference was held in Knoxville, TN-with Bsal task force members in attendance

Bsal Task Force Organization

The Bsal Task Force is an ad hoc group of scientists, managers, and citizens who are helping to understand and forestall the threat of Bsal in North America. Although a central focus is to coordinate strategic planning and efforts in the USA, there is participation from both Canada and Mexico, and also in partnership with European and Australian scientists. Below is a brief summary, please consult the Bsal Strategic Plan for a more detailed description of the organization (found at www.salamanderfungus.org).

Organizational Progress

Working Groups were initially formed in June 2015. Since then, they have met via conference calls on a regular basis to outline new tasks and discuss progress on existing efforts. Group membership is open and inclusive, but was initially founded with persons involved with disease research, natural resource management in state and federal agencies, environmental or conservation groups, nongovernmental organizations, and the pet industry. Each group has one to three leads, who help to coordinate personnel, manage the workload, and report to the Technical Advisory Committee. The Technical Advisory Committee (TAC) is populated by the Working Group leads and representatives from selected partner groups including federal agencies, the IUCN Amphibian Survival Alliance (ASA), and the Pet Industry Joint Advisory Council (PIJAC). The TAC meets by conference call monthly, with a focus on new items and round-robin reporting by participants. New items have included tasks to be assigned or delegated to others, opportunities for products and grant proposals, and communication-outreach and networking needs. Monthly meeting notes are routed to TAC members, then to their working group members, to ensure communication. A lead for the TAC is determined by the TAC and is rotated each year. The incoming and outgoing leads serve as co-leads. Decisions of the TAC are made by consensus.



Data Management Working Group

Leads

Michelle Koo (UC Berkeley and AmphibiaWeb)

Deanna Olson (USDA Forest Service, Pacific Northwest Research Station)

Members

Diana Lovette (website developer, UC Berkeley)

Vance Vredenburg (AmphibiaWeb steering committee, San Francisco State University)

Kathryn Ronnenberg (US Forest Service, Bd-maps data manager)

John Deck (developer, UC Berkeley).

Summary

The Amphibian Disease web portal (amphibiandisease.org) archives and shares aggregated Bd and Bsal data inclusive of surveillance with pathogen detections and no-detections from worldwide published-and-unpublished sources. It can communicate project plans as well as results of Bd and Bsal surveillance and research, enhancing survey efficiencies across the science-management community. In 2022, in addition to new web programming enabling expanded data visualizations, the site co-location within the AmphibiaWeb is resulting in expanding outreach and use of the portal. There was increased coordination with international and national projects to ensure smooth transitions of project planning and results to the online data archive. Expanded use of the portal was evident, for example, within the “Projects” tab there are currently 29 Bd & Bsal projects supporting a global footprint of active work. Ongoing projects are described for: Gabon, Africa, England, Germany, Norway, Europe, Asia, Mexico, Costa Rica, Peru, and several locations in the United States. Liaison with the Bsal Task Force Surveillance and Monitoring Working Group’s SNAPS (Student Network of Amphibian Population Surveillance) has been a particular emphasis area in 2022.

Key Points

- Bsal and Bd data are accessible for queries to inform science and management decisions and for metadata analyses of host-pathogen-geographic patterns and dynamics.
- Outreach is expanding awareness and use of the website for project planning and reporting of findings.
- The portal is gaining global use, with projects from Africa, Asia, Europe, and North and South America.
- The portal can now include Bd strain identification, surveillance results from captive amphibians and environmental DNA, and importantly, the finding of the disease chytridiomycosis from either Bd or Bsal infection.
- The portal can mask specific locations of amphibians with sensitive at-risk status to protect them from potential overexploitation.

Outcomes, Impacts, Products, and Manuscripts

1. Example metadata analysis from Amphibian Disease Web Portal Bd data: Rawien, J., and S. Jairaim-Doerga. 2022. Predicted *Batrachochytrium dendrobatidis* infection sites in Guyana, Suriname, and French Guiana using the species distribution model maxent. PLoS ONE 17(7):e0270134. <https://doi.org/10.1372/journal.pone.0270134>.
2. Olson, D.H., K.L. Ronnenberg, C.K. Glidden, K.R. Christiansen, and A.R. Blaustein. 2021. Corrigendum: Global patterns of the fungal pathogen *Batrachochytrium dendrobatidis* support conservation urgency. Front. Vet. Sci. 9:825058. doi: 10.3389/fvets.2022.825058. [In the original article, the word “not” was inadvertently omitted in the Results section, page 5, column 2, line 7; the correct text should read “and Bd has not been detected (J. Piovias-Scott, Washington State University, Vancouver, WA, USA; pers. Commun.)”. The online

version was updated on 8 February 2022, please download again if needed to ensure you have an accurate file.]

3. Olson, D.H., K.L Ronnenberg, C.K. Glidden, K.R. Christiansen, and A.R. Blaustein. 2021. Global *Bd* mapping project: 2021 Update. *Northwestern Naturalist* 102(2):172.

Challenges

- Outreach to raise awareness of the updated web portal and its utility, especially to early-career students and scientists who may be naïve to the portal's predecessor, Bd-maps.net or the related Global Ranavirus Reporting System.
- Maintenance of updated Bsal and Bd data which requires funding for manual data retrieval and quality assurance.
- Community adoption during project planning for broader inclusion of projects in the web portal.
- Funding to support web programming to expand functionality and cross-connections with other relevant online databases.

Interactions with other Working Groups

The Data Management Working Group works closely with the Surveillance and Monitoring Working Group.



Decision Science Working Group

Lead(s)

Evan Grant (USGS, Eastern Ecological Science Center)

Members

Robin Russell (USGS)
Riley Bernard (USGS/Penn State University)
Brittany Mosher (University of Vermont)
Alex Wright (Michigan State University)
Molly Bletz (UMass Amherst and USGS)
Graziella DiRenzo (UMass Amherst USGS Coop Unit)

Summary

The goal of the Decision Science Working Group (DSWG) of the North American *Bsal* Task Force is to support management decisions regarding *Bsal* through: (1) facilitation of decision-making processes, (2) identification and collation of information needed to make decisions, (3) development of models to predict the outcomes of different management options, and (3) evaluation of trade-offs and risk to overcome impediments to optimal decision-making.

Key Points

- Working with multiple resource managers (USFWS, New Mexico State and US Forest Service) to structure their decision making and resolve uncertainties.
- A large effort has been made to build models and parameterize them through expert elicitation to aid in the evaluation of management actions.
- Members of the group coordinated a cross pathogen system model workshop at the GARD conference to identify priority research hypotheses for *Bsal* disease systems as well as other pathogens (Bd, Ranavirus, and SFD).

Outcomes, Impacts, Products, and Manuscripts

- Bletz, MC & Grant, EHC. Cross pathogen systems model workshop. Global Amphibian and Reptile Disease Conference, Aug 2022.

Challenges

Engaging managers when immediate risk of *Bsal* infection is low (i.e., as *Bsal* has not been detected in the US) can be a major challenge. This limits the ability to identify and implement proactive management – representing a major challenge for developing management strategies for *Bsal* and other emerging infectious diseases. Engagement from managers at the *Bsal* Basics webinar which focused on the advantages of proactive management may help with this which is encouraging.

Improving integration among working groups can allow for synergies and advancement of *Bsal* management. For example, applied research guided by decision making processes with managers has a better utility to address needed and critical knowledge gaps.

Interactions with other Working Groups

The decision science group interacts most closely with the response and control working group and the research group. The expert elicitation carried out to evaluate optimal management actions engaged over 35 researchers, many of which are part of the *Bsal* Task Force.

Diagnostics Working Group

Lead(s)

Jake Kerby (University of South Dakota)
Maria Forzan (Long Island University)

Members

Julie Ellis (University of Pennsylvania)
Dan Grear (U.S. Geological Survey)
Jeff Lorch (U.S. Geological Survey)
Robert Ossiboff (University of Florida)
Kim Hamad-Schifferli (University of Massachusetts)
Carly Muletz Wolz (Smithsonian National Zoo & Conservation Biology Institute)
Matt Allender (University of Illinois)
Heather Fenton (Northwest Territories, Canada)
An Martel (Ghent University)
Frank Passmans (Ghent University)
Laura Sprague (US Fish and Wildlife Service)
John Wood (Pisces Molecular)
Cherie Briggs (University of California)
Leon Grayfer (George Washington University)
Steven Lloyd (Zoologix, Inc.)
Deb Miller (University of Tennessee, Knoxville)
Allan Pessier (Washington State University)
LeAnn White (National Wildlife Health Center)

Summary

The Diagnostics Working Group (DxWG) promotes the development of standards for diagnosis and reporting of amphibian EIDs among the wildlife health community, with the salamander chytrid fungus, [*Batrachochytrium salamandrivorans* \(Bsal\)](#) as the primary focus. We serve as a forum to exchange ideas and work out the challenges involved in Bsal detection and to provide expert advice to the rest of the Bsal Task Force regarding the viability and pitfalls of traditional and new tools for Bsal detection and diagnosis.

The Diagnostics Working Group (DxWG) is composed of professionals with expertise in the application and interpretation of an array of diagnostic tools. Our members work in academia, diagnostic laboratories, and government agencies throughout North America and are involved in detection and reporting of amphibian diseases, including BSal.

Key Points

- This group has primarily served to provide consultations throughout the past year to answer questions.
- Several members are working on a manuscript to highlight key issues in understanding diagnostic tools and highlighting the need to understand uncertainty at many scales.

Implementation Plan Updates (New Objectives/Goals, Completed Objectives) Do not include all objectives/goals, only completions or changes from the strategic plan.

Current efforts are to investigate different approaches to diagnostic efforts. Various members have served on panels at relevant Infectious Disease related conferences to provide expertise.

Interactions with other Working Groups

Continued collaboration with relevant working groups is planned. The group primarily has provided consultation on technical questions for other groups.

Research Working Group

Lead(s)

Jonah Piovia-Scott (Washington State University)

Members*

Delia Basanta (University of Nevada, Reno)
Molly Bletz (University of Massachusetts)
Jesse Brunner (Washington State University)
Michelle Christman (US Fish and Wildlife Service)
Léa Fieschi-Méric (Laurentian University, Canada)
Maria Forzan (Long Island University)
Matt Gray (University of Tennessee)
Matt Grisnik (Tennessee State University)
Oliver Hyman (James Madison University)
Alysha Henderson (Washington State University)
Skylar Hopkins (North Carolina State University)
Brady Inman (University of Massachusetts-Boston)
Susan Jewell (US Fish and Wildlife Service)
Alexis Korotas (Notre Dame University)
Mitch Le Sage (Vanderbilt University)
David Lesbarrères (Environment and Climate Change, Canada)
Julia McCartney (University of Massachusetts-Boston)
Brittany Mosher (University of Vermont)
Alex Nelson (North Carolina State University)
Frank Pasmans (Ghent University)
Cynthia Pekarik (US Fish and Wildlife Service)
Kenzie Pereira (North Carolina State University)
Neelam Poudyal (University of Tennessee)
Kristyn Robinson (University of Massachusetts)
Louise Rollins-Smith (Vanderbilt University)
Wesley Sheley (University of Tennessee)
Laura Sprague (US Fish and Wildlife Service)
Alexa Warwick (Michigan State University)
Kerry Wixted (Association of Fish and Wildlife Agencies)
Doug Woodhams (University of Massachusetts-Boston)

**includes every person who attended a Research Working Group meeting in 2022*

Summary

The Research Working Group has advanced understanding of the threat posed by Bsal to North American amphibians and the transmission dynamics of Bsal in susceptible North American host species. The research working group has made substantial progress in understanding *Bsal* transmission and disease progression in susceptible North American salamanders such as the eastern newt (*Notophthalmus viridescens*). In addition, susceptibility trials conducted on >50 North American species have confirmed the vulnerability of many North American species to Bsal and allowed for a clearer picture of regions with the greatest potential for biodiversity loss. Finally, Bsal has been shown to inhibit immune responses in a way similar to Bd. Ongoing research focuses on understanding the potential for the introduction and spread of Bsal through the pet trade, identifying effective methods for managing Bsal, and investigating how interactions between Bsal and host immune systems influence host susceptibility and disease progression.

At least 30 scientists from the United States, Canada, and Mexico attended our monthly meetings, representing a broad array of scientific expertise, including molecular and cellular biology, immunology, ecology, mathematics, pathology, and social sciences. In addition, the Research Working Group helped organize a session on Bsal at the first Global Amphibian and Reptile Disease Conference in Knoxville Tennessee in August 2022, and many working group members presented their research at that conference.

Key Points

Research group activities

- Monthly meetings in which researchers share work in progress, followed by discussion
- Members received a major NSF grant to study the spread of amphibian pathogens (including Bsal) through live animal trade networks
- Helped organize the first Global Amphibian and Reptile Disease Conference, which featured a session on Bsal

*Recent research findings**

- North American amphibians (especially salamanders) are broadly susceptible to Bsal, and there is great potential for amphibian biodiversity loss if Bsal is introduced
 - Potential biodiversity loss is particularly high along the Pacific coast and in the Appalachian Mountains of the USA, and in the mountains of central and southern Mexico and Central America
- Bsal is highly transmissible and can spread rapidly, even at relatively low host densities and infection frequencies; carcasses may facilitate spread and extend duration of epidemics
- Bsal can inhibit immune responses and cause electrolyte imbalance in amphibian hosts
- Management strategies, such as use of plant-derived fungicides or probiotics, to reduce the impact of Bsal on amphibian hosts and the viability of Bsal in the environment have shown some promise
- Although Bsal infection of Eastern newts (*Notophthalmus viridescens*) is often fatal, newts that survive a first exposure are more likely to survive a second exposure suggesting development of a skin defense

**includes some work in progress that is not yet published*

Outcomes, Impacts, Products, and Manuscripts

2022 outcomes and impacts in the context of the [Strategic Plan](#)

- A pilot surveillance study of wholesale and retail facilities was conducted in collaboration with the Pet Advocacy Network. A larger-scale study is planned for the near future.
- At least 5 susceptibility trials have been conducted for commonly traded species, and a manuscript is in preparation. Additional susceptibility trials for commonly traded species are planned for 2023.
- A study was conducted in eastern newts showing that >90% of susceptible newts became infected across a range of host densities and initial infection prevalence treatments (Tompro et al. 2022). This study suggested frequency-dependent (rather than density-dependent) transmission.

- Two manuscripts have been submitted (Gray et al. and Grisnik et al.) that map risk for the United States; these identify the Pacific Coast and Appalachia as regions of high biodiversity risk. Publications by Basanta et al. (2022) and García-Rodríguez et al. (2022) map risk for parts of Mexico and Central and South America; these identify mountainous regions of Central and Southern Mexico, Central America, and northern South America as areas of high biodiversity risk.

Grants

Gray, M. J., N. Poudyal, N. H. Fefferman, M. Bletz, A. Warwick, J. Lockwood, J. Brunner, J. Pioviascott. 2022. Socioeconomic and epidemiological drivers of pathogen dynamics in wildlife trade networks. Ecology and Evolution of Infectious Disease Program National Science Foundation/US Department of Agriculture. \$2.75 million. Project website: <https://www.healthyamphibiantrade.org>.

Peer-reviewed publications

Basanta, M. D., Avila-Akerberg, V., Byrne, A. Q., Castellanos-Morales, G., Martínez, T. M. G., Maldonado-López, Y., ... & Rebollar, E. A. (2022). The fungal pathogen *Batrachochytrium salamandrivorans* is not detected in wild and captive amphibians from Mexico. *PeerJ*, 10, e14117.

García-Rodríguez, A., Basanta, M. D., García-Castillo, M. G., Zumbado-Ulate, H., Neam, K., Rovito, S., ... & Parra-Olea, G. (2022). Anticipating the potential impacts of *Batrachochytrium salamandrivorans* on Neotropical salamander diversity. *Biotropica*, 54(1), 157-169.

Olson, D. H., M. J. Gray, F. Pasmans, L. Grayfer, M. Q. Wilber, E. D. Carter, and A. A. Cunningham. 2022. The rising tide of herpetological disease science and management. *Herpetological Review* 53:416-417.

Rollins-Smith, L. A., Reinert, L. K., Le Sage, M., Linney, K. N., Gillard, B. M., Umile, T. P., & Minbiole, K. P. (2022). Lymphocyte Inhibition by the Salamander-Killing Chytrid Fungus, *Batrachochytrium salamandrivorans*. *Infection and Immunity*, 90(3), e00020-22.

Tompros, A., Wilber, M. Q., Fenton, A., Carter, E. D., & Gray, M. J. (2022). Efficacy of Plant-Derived Fungicides at Inhibiting *Batrachochytrium salamandrivorans* Growth. *Journal of Fungi*, 8(10), 1025.

Conference Presentations

Lesbarreres, D, Bienentreu, J.. Amphibian disease ecology: are we just scratching the surface? Global Amphibian and Reptile Disease Conference. 5 August 2022, Knoxville, TN, USA.

Gray, M., Carter E. D., Pioviascott, J, Cusaac, J. P. W., Peterson, A. C., Whetstone, R. D., Hertz, A., Muñiz Torres, A. Y., Bletz, M. C., Woodhams, D.C., Romansic, J. M., Sutton, W.B., McCusker, C. D., Miller, D. L. *Batrachochytrium salamandrivorans*: Advances in North American research. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Grisnik, M., Gray, M.J., Pioviascott, J., Carter, E.D., Sutton, W. B. Incorporating species susceptibility and climate change into models of *Batrachochytrium salamandrivorans* risk in the United States. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Sheley, W., Cray, C., Wilber, M. Q., Carter, E. D., Gray, M. J., Miller, D. L. Imbalances and dehydration play a role in *Batrachochytrium salamandrivorans* chytridiomycosis. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Carter, D., Wilber, M. Q., Miller, D. L., Sheley, W., DeMarchi, J., Gray, M. J., From the early stages of infection to the grave: How does *Batrachochytrium salamandrivorans* transmission probability shift throughout infection? Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Peace, A., Chowdhury, M. M., Carter, E. D., Gray, M. J. Parameterizing a Multi-Stage Infection Model of the Emerging Fungal Pathogen *Batrachochytrium salamandrivorans* (Bsal). Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Burghardt, G. M., Free, A., Steele, J. M., Partin, A. P., Hartline, K. R., Wallace, S., Spatz, J. A., Cusaac, J. P. W., Sheets, C. N., Miller, D.L., Gray, M. J., Carter, E. D., standardized method for observing amphibian behavior in climate controlled chambers to assess changes with fungal disease (*Batrachochytrium salamandrivorans*) inoculation. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Tompros, A., Malagon, D., Carter, E. D., Dean, A. D., Wilber, M. Q., Fenton, A., Gray, M. J. Management strategies to reduce invasion potential of *Batrachochytrium salamandrivorans*. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Towe, A. E., Rajeev, S., Miller, D. L., Sheley, W., Carter, E. D., DeMarchi, J., Bletz, M. C., Woodhams, D. C., Gray, M. J. Risk of bacteremia associated with probiotic treatment of *Batrachochytrium salamandrivorans*. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Bletz, M. C., Whetstone, R., Rodriguez-Quijada, C., Horan, S., Woodhams, D. C., Hamad-Schifferli, K. Combination strategies boost eastern newt survival to the salamander chytrid fungus. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Whetstone, R. D., Bletz, M. C., Inman, B., Ahsan, R., Woodhams, D. C. Probiotic application delays fatal Bsal chytridiomycosis in eastern newt metamorphs (*Notophthalmus viridescens*). Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Hill, A. J., Hardman, R. H., Sutton, W. B., Grisnik, M. S., Gunderson, J. H., Walker, D. M. Surveying for Bsal in Wild Salamander Populations of Tennessee: Lessons Learned. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Yarber, C., Pearhill, R., Goldberg, C., Brunner, J. L. Evaluating environmental DNA-based detection of *Batrachochytrium salamandrivorans* in trade and captive settings. Global Amphibian and Reptile Disease Conference. 6 August 2022, Knoxville, TN, USA.

Rollins-Smith, L.A. Anti-Batrachochytrium immunity and chytrid immune evasion. Global Amphibian and Reptile Disease Conference. 7 August 2022, Knoxville, TN, USA.

McCartney, J. A., Le Sage, M., Rollins-Smith, L. A., Woodhams, D. C. The microbiomes of adult Eastern Newts (*Notophthalmus viridescens*) are distinct and dynamic after two exposures to

Batrachochytrium salamandrivorans. Global Amphibian and Reptile Disease Conference. 7 August 2022, Knoxville, TN, USA.

Le Sage, M., McCartney, J. A., Sheley, W. C., Stilz, R., Woodhams, D. C., Miller, D., Gray, M., Rollins-Smith, L. A. Enhanced survival in Eastern Newts after a second exposure to *Batrachochytrium salamandrivorans*. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Muñiz Torres, A. Y., Reinert, L. K., Rollins-Smith, L. A., Woodhams, D. C., Maintaining resistance to *Batrachochytrium salamandrivorans* infection despite depletion of skin defense peptides. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Cavasos, K., Poudyal, N. C., Gray, M. J., Warwick, A. R., Brunner, J. L., Piovio-Scott, J., Fefferman, N., Bletz, M., Lockwood, J., Jones, J. Awareness, attitudes and perceptions of US pet amphibian businesses and owners regarding pathogen threats, biosecurity and acquisition of certified disease-free amphibians. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Haddock, G. A., Warwick, A. R. Amphibian pet trade stakeholders' biosecurity practices, relationships, and connection to the spread of novel chytrid fungus *Batrachochytrium salamandrivorans*. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Tavarez-Jimenez, E. J., Bletz, M. C., Piovio-Scott, J., Draculan, M., Horan, S., McCartney, J.A., Woodhams, D.C. Commonly traded amphibians are susceptible to the emerging fungal pathogen *Batrachochytrium salamandrivorans*. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Arcebucho, L.B., McCartney, J.A., Woodhams, D.C. Identifying potential probiotics from Eastern Newts (*Notophthalmus viridescens*) infected with *Batrachochytrium salamandrivorans*. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Poudyal, N.C., Cavasos, K., Warwick, A., Gray, M.J. Protected area visitors' attitudes, behavior, and willingness to pay for protecting natural populations. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Urban, M.P., Merolle, C.T., Wilson, M.E., Tompros, A., Gray, M.J., Carter, E.D. Estimating the efficacy of plant-derived fungicides at inactivating *Batrachochytrium salamandrivorans* in pond water. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Pearhill, R.A., Jones, J., Gray, M.J., Brunner, J.L. Microbe surveillance in the amphibian pet trade: Results from a pilot study. Global Amphibian and Reptile Disease Conference. 8 August 2022, Knoxville, TN, USA.

Challenges

- Evaluate the potential for Bsal spillover from the pet trade
 - Integrate with Trade Working Group
- Identify and evaluate methods for managing Bsal in both field and captive environments
 - Integrate with Decision Science and Response and Control working groups
- Investigate the pathways of regional spread for Bsal
 - Learn from efforts to understand spread in Europe

- Identify needs and barriers to incorporating Bsal-related concerns into management practice and public consciousness
 - Integrate with Communications Working Group
- Determine mechanisms of disease resilience or evolutionary rescue from Bsal
- Investigate how host community structure influences the impacts of Bsal
- Learn from studies of Bsal in its native range

Interactions with other Working Groups

Brittany Mosher (Surveillance Working Group) gave a short presentation on the SNAPS working group in our meeting on 7 March 2022.

Contributed to Bsal webinar for PARC Disease Task Team on 2 December 2022.



Surveillance & Monitoring Working Group

Lead(s)

Brittany A. Mosher (University of Vermont)
Oliver Hyman (James Madison University)

Members

Michael J. Adams (U.S. Geological Survey)
Flor Breitman (Auburn University at Montgomery)
Arlene Buchholz (USDA)
Daniel A. Gear (U.S. Geological Survey)
Sasha E. Greenspan (The University of Alabama)
Aubree Hill (Tennessee Tech University)
Jessica Hua (U Wisc - Madison)
Michelle S. Koo (Museum of Vertebrate Zoology, University of California)
Olya Milenkaya (Warren Wilson College)
Eria Rebollar (Universidad Nacional Autónoma de México)
Lenny Shirose (Canadian Wildlife Health Cooperative)
Vance Vredenburg (San Francisco State University)
Jenifer B. Walke (Eastern Washington University)
Michael Yabsley (SCWDS)
Sklyar Hopkins (NC State),

Summary

The mission of the Bsal Surveillance and Monitoring Working Group is to facilitate and coordinate the surveillance and monitoring of Bsal in North America. The Working Group's primary focus for ongoing and coordinated Bsal surveillance continues to be the development of the Student Network for Amphibian Pathogen Surveillance (SNAPS) - a student-powered Bsal surveillance network that includes members in the United States, Canada, and Mexico. Here we describe the progress and future plans for SNAPS expansion and assessment.

Key Points

- SNAPS has established itself as a working model for Bsal surveillance and is facing the financial and logistical burden that comes with a growing membership
- In 2022, SNAPS was implemented at 23 institutions from the US, Canada, and Mexico, and will expand to 28 institutions in 2023 (with all 2022 participants returning).
- SNAPS participants have sampled over 600 animals (10 species across North America).
- We have developed free educational and training resources for SNAPS participants including a formal lesson plan, orientation handbook, and training videos.
- Assessments of SNAPS participants from 10 institutions indicated
 - SNAPS is an effective way for students to learn about amphibian pathogens.
 - High levels of instructor satisfaction
 - A lack of student participant diversity (~75% white).

Outcomes, Impacts, Products, and Manuscripts

SNAPS has successfully undergone its first stage of growth. While five universities participated in SNAPS in 2021, we had 23 participating institutions in 2022. SNAPS will expand to 28 institutions in 2023 (with all eligible 2022 participants returning). Surveys of instructors indicated high levels of satisfaction with the program and protocols further supported by the 100% return rate of instructors from 2022. Participants include institutions in the US, Mexico, and Canada who have sampled over 600 animals representing 10 species from across North America; openly-accessible at

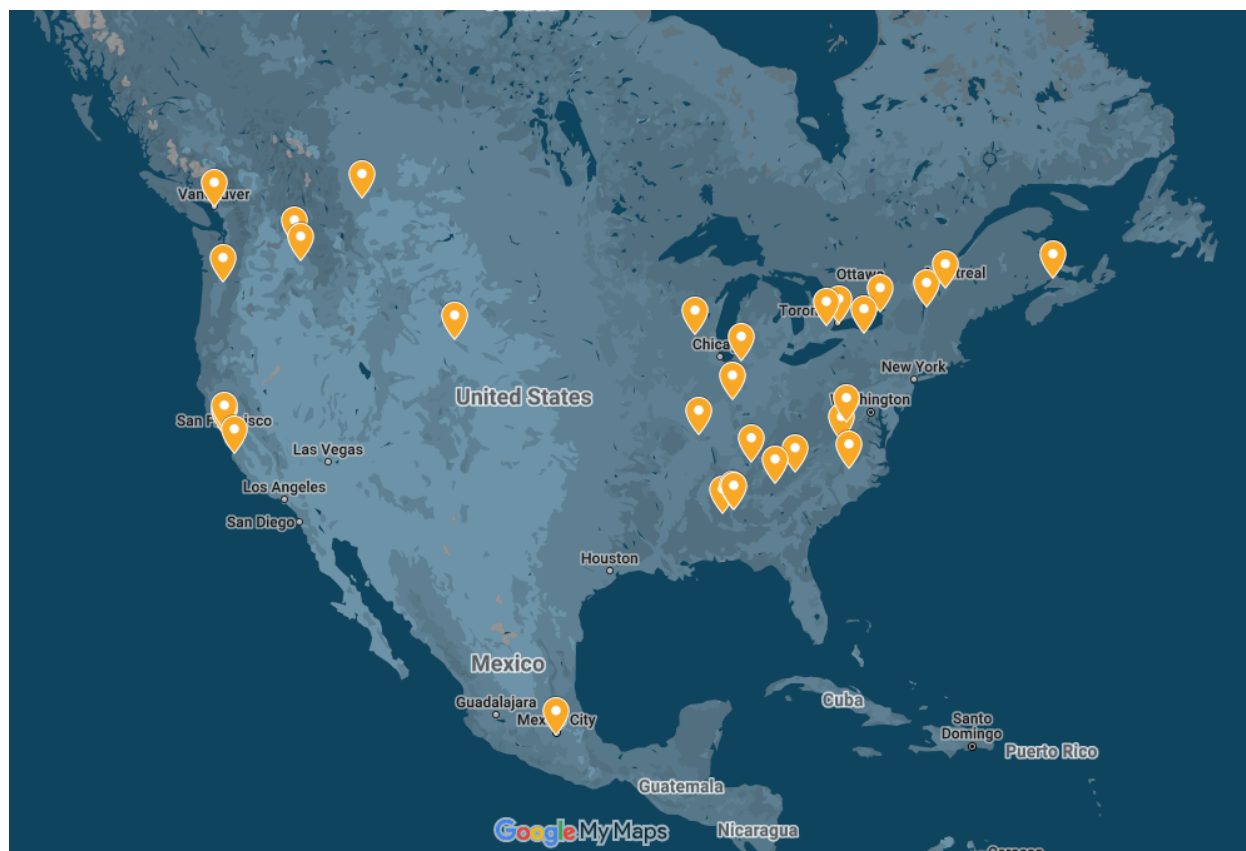


Fig. 1. Map of institutions participating in SNAPS.

SNAPS has identified one additional research lab, Southeastern Cooperative Wildlife Disease Study (SCWDS), which will fully fund and process samples from a pilot set of SNAPS classrooms in 2023. We are hopeful that the number of classes handled by SCWDS will increase from 5 to 25 classrooms over the next 5 years.

Since its inception, several hundred students have participated in SNAPS. This past year students were invited to voluntarily complete pre- and post-SNAPS surveys from all of our participating institutions to assess SNAPS effectiveness in affecting students' (1) knowledge of amphibian disease, (2) interest in the environment, and (3) self-efficacy towards conservation. Viable student assessment data collected from 10 institutions revealed that participation in SNAPS significantly increased students' knowledge and understanding of amphibian fungal pathogens. However, SNAPS participation did not lead to an increase in students' interest in the environment or their self-efficacy in contributing to conservation efforts, likely because students' scores on these elements were already quite high, nearly at the top of the 5-point scale. Survey results also indicated SNAPS lacks student participant diversity (~75% white). These results underscore the need to expand SNAPS into a broader range of course-types (Ex. introductory) and institutions (Ex. CC, HBCU).

Products and Manuscripts:

- SNAPS website (<https://snaps.amphibiandisease.org>)
- SNAPS database (<https://amphibiandisease.org/projects/?id=284>)

- SNAPS resources have been updated to include a formal lesson plan, orientation handbook, and training video (Ex. <https://youtu.be/IBgkvvjcxQ>)
- Hyman et al. 2022 “SNAPS: A student network for amphibian pathogen monitoring” Oral presentation, held virtually. IRCEB annual meeting. Tempe, AZ
- Aubree Hill. 2022. “Surveying for Bsal in Wild Salamander Populations of Tennessee: Lessons Learned” Oral presentation. Global Amphibian & Reptile Disease Conference Knoxville, Tennessee, USA 4-10.
- Xavier A. Jackson & Aubree Hill. 2022. Student-led surveillance for Batrachochytrium salamandrivorans. Oral presentations at GARD and 28th meeting of the TN herp. Society. <https://blogs.tntech.edu/techtimes/2022/general/xavier-jackson-wins-2nd-place-at-gard-conference/>

Challenges

Funding and Sustainability: SNAPS has proven to be a viable model for sustainably sampling Bsal across North America. In 3 years we have expanded to 28 institutions including key locations across the United, Mexico, and Canada, with more institutions/instructors expressing interest in joining our program than we can currently support. Funding and core-member burn-out are the major factors limiting our growth and success. We currently rely on volunteers from our Working Group to develop and administer the program. This has included the development of a website, protocols, lesson plans, learning outcome assessment tools and analysis, onboarding, and data management. The growth of SNAPS means that this program will soon require dedicated (paid) personnel to manage and administer the program. The program will need to improve and professionalize various systems, including updating and maintaining the website, procuring grants and regular funding, the onboarding of new participants, accountability, data management, coordination with multiple labs, assessment of student learning outcomes, and reporting.

SNAPS website development and upkeep: Our wordpress based website (<https://snaps.amphibiandisease.org>) serves a hub for advertisement, recruitment, participant and sponsor recognition, as well as sharing lesson plans, participant data, and training materials. The website needs to be restructured to enhance sponsorship visibility, enable participant data (Ex. participant locations, # of institutions, # of students, # of samples, etc.) to update in realtime. We also need a better structure for sharing lesson plans/instructor materials and formally recruiting new participants. We currently lack a member with extensive website development experience and no members have stepped up to take the lead on this role. We need funding to pay for a web developer or identify a person to take the lead on this on a voluntary basis.

Core membership - structure, recruitment & retention: Our group currently has ~10 “core” members who semi-regularly attend 1-hour meetings each month to discuss major needs of the group. All of these members have been participating for several years now on a voluntary basis. It may be time to explore new strategies to recruit and retain new members to participate in the core steering group. New members can bring fresh energy and ideas to contribute to funding, assessment, and website initiatives. We also need to identify the key needs of our group and perhaps restructure our meetings and member activities to best meet these objectives.

Assessment & Diversifying SNAPS participants: Our pilot assessment results revealed that SNAPS is currently lacking in diversity of student race and ethnicity (90% white), grade level (97% in 3rd or higher year of undergraduate), fields of interest (already enrolled in ecology-type elective courses), and institution type (only one representative institution from small liberal arts, medium regional comprehensive, and large research). Our goals include strategically expanding and diversifying the SNAPS network to include identities that are underrepresented in STEM, lower-level students, students with broad interests (not already inclined to take conservation/ecology/field-based courses), and a variety and larger number of institution types (including field stations, Historically Black

Colleges and Universities, and Hispanic-Serving Institutions). Ideally, this expansion should also overlap with key gaps in our Bsal risk/geographic coverage and SCWDS member states.

Past and Future Objectives:

The objectives of this Working Group are to facilitate and coordinate (1) the surveillance of Bsal in North America, and (2) the monitoring of Bsal in the event of its detection in North America.

Our goals from the previous year ('21) were:

Goal 1: Facilitate and support a wide-reaching, ongoing, coordinated, and sustainable Bsal surveillance program in Canada, Mexico, and the United States.

Objective 1: Secure SNAPS funding for the upcoming spring and fall 2022 semesters

Objective 2: Secure longer-term SNAPS funding to sustain the program

Objective 3: Publish the SNAPS website

Objective 4: Recruit and onboard new participants for SNAPS, including supporting new participants and infrastructure in Mexico and Canada

Objective 5: Implement SNAPS across North America during the upcoming spring and fall 2022 semesters

Objective 6: Assess student learning outcomes from SNAPS following the spring and fall 2022 implementation

Objective 7: Streamline data processing and management to allow for additional diagnostic labs to participate

Goal 2: Identify Bsal sampling efforts that are occurring outside of efforts coordinated by the Bsal Surveillance & Monitoring Working Group.

Objective 1: Identify a new point-person to implement this goal

Goal 3: Support and facilitate sampling of amphibians in the pet trade.

Objective 1: Coordinate with the Bsal Research Working Group regarding current efforts to do pathogen surveillance and monitoring of amphibians in the pet trade

Goal 4: Develop initial plans for post-detection monitoring if Bsal were to be detected at a field or captive site in North America.

Objective 1: Identify a new point-person to implement this goal

In the timespan of this Annual Report (October 2021 - September 2022), we have continued to address all of the above goals. Goal #1 was our priority as we continued to develop our surveillance centerpiece, SNAPS. For an update on this program, see "Outcomes and Impacts" above. We also initiated implementation of Goal #2, but faced a setback when we lost the personnel needed to coordinate this effort. We made initial but limited efforts for Goals #3 and #4.

Our goals for the coming year continue to be those listed above, with our primary focus remaining the successful development, implementation, and growth of SNAPS (Goal #1). For the coming year, we have the following new objectives for each goal:

Goal 1: Facilitate and support a wide-reaching, ongoing, coordinated, and sustainable Bsal surveillance program in Canada, Mexico, and the United States.

Objective 1: Secure SNAPS funding for the upcoming spring and fall 2024 semesters

Objective 2: Secure longer-term SNAPS funding to sustain the program

Objective 3: Publish Update and overhaul the SNAPS website

Objective 4: Recruit and onboard new participants for SNAPS, including supporting new participants and infrastructure in Mexico and Canada

Objective 5: Implement SNAPS across North America during the upcoming spring and fall 2023 semesters

Objective 6: Assess student learning outcomes and participant demographics from SNAPS following the spring and fall 2023 implementation

Objective 7: Streamline data processing and management to allow for additional diagnostic labs to participate

Goal 2: Identify Bsal sampling efforts that are occurring outside of efforts coordinated by the Bsal Surveillance & Monitoring Working Group.

Objective 1: Identify a new point-person to implement this goal

Goal 3: Support and facilitate sampling of amphibians in the pet trade.

Objective 1: Coordinate with the Trade subgroup of the Bsal Research Working Group regarding current efforts to do pathogen surveillance and monitoring of amphibians in the pet trade

Goal 4: Develop initial plans for post-detection monitoring if Bsal were to be detected at a field or captive site in North America.

Objective 1: Coordinate with the Bsal Research Working Group regarding current strategies and recommendations for post Bsal-detection monitoring

Interactions with other Working Groups

We participated in the Annual Meeting of the North American Bsal Task Force and Oliver Hyman gave the following talk: Hyman O, Milenkaya O, Mosher BA, Walke JB, Greenspan SE, Koo MS, Gear DA, Vredenburg V, MJ Adams. Feb 2022. "Surveillance & Monitoring Working Group." Oral presentation live in Zoom, Annual Meeting of the North American Bsal Task Force.

Brittany Mosher participated in a meeting of the Research Working Group in March 2022 where she gave a talk about our Working Group efforts, including SNAPS. We shared information on the SNAPS growth trajectory from 2020-present, highlighting our website, lesson plan, and onboarding session for new members. We also discussed challenges our group is facing, including funding challenges, engaging members across our network, and using our data for research questions beyond Bsal surveillance.

We presented with the rest of the North American Bsal Task Force at the Partners in Amphibian and Reptile Conservation (PARC) Disease Task Team meeting in December 2022 at their "Bsal Basics: Better Together" webinar.



Response and Control Working Group

Lead(s)

Laura Sprague (US Fish and Wildlife)

Members

Molly Bletz (UMass Amherst)

Blake Hossack (USGS)

Evan Grant (USGS)

Su Jewell (USFWS)

Matthew Gray (University Tennessee Knoxville)

Summary

The purpose of the Response and Control Group is to facilitate efficient and rapid response for managers in the event of an amphibian die off and/or if Bsal is detected. This group aims to synergize with other working groups like the Research and Decision Science Working group to allow for effective planning for and management of Bsal.

Key Points

- Rapid Response Template: Began work to revise and streamline this document by eliciting feedback from other groups
- Continued to work on DOI-Wide Categorical Exclusion (CatEx) for management of invasive species, including pathogens
- We have low membership and a lack of state representation which is challenging

Outcomes, Impacts, Products, and Manuscripts

- Rapid Response Template: Began work to revise and streamline this document by eliciting feedback from other groups, such as state and federal managers that would potentially use this, as well as people who work on rapid response exercises for the control of aquatic invasive species.
- Continued to work on DOI-Wide Categorical Exclusion (CatEx) for management of invasive species, including pathogens

Challenges

- This group is a small cohort of busy people and lacks representation for state level managers

Interactions with other Working Groups

Members from the Research Group and Decisions Group participate in the Response and Control Group calls and give updates on what the other groups are doing and how we can collaborate

Communications Working Group

Lead(s)

Alex Shepack (Florida International University)
Megan Serr (Meredith College)

Members

Mark Mandica (Amphibian Foundation)
Nina McDonnell (UMass Boston)

Summary

The Communications Task Force has a new co-lead Megan Serr. Megan has been a member of the Communications Task Force since its inception, and is now stepping up into a more prominent role. This past summer several of us discussed at the Global Amphibian and Reptile Disease Conference, the need for increased global engagement and awareness. We had a summer meeting to discuss potential engagement ideas. Engagement ideas that are at the formative stages include: Updating the Task Force Website, Engaging in PARC's Amphibian Week, Updating Museum Exhibits to include *Bsal* with *Bd*, and a Herp Review Summary on the Bsal Task Force. Currently, the one furthest along is a Story Map idea in partnership with Fish and Wildlife. This would aim to be ready by the May 2023 PARCs amphibian week.

Key Points

- Compiled, formatted, designed, and published the Annual Report
- Social Media: We continue to maintain and utilize Twitter (@salamanderfungi) and Facebook (www.facebook.com/salamanderfungus/). As of December 2022 we have 971 followers on Twitter and 333 on Facebook. Twitter followers have decreased slightly since last year, while the Facebook page has increased by 33.
- A change in top organization occurred this year and we hope to implement some fresh ideas, including a Story Map for PARC Amphibian Week 2023

Outcomes, Impacts, Products, and Manuscripts

- Nina McDonnell spearheaded the creation of promotional and educational materials that were displayed at the inaugural 2022 GARD Conference and other wildlife related meetings this year

Challenges

- Maintaining interest has flagged over the years but was reinvigorated with the Global Amphibian and Reptile Disease Conference, 2022

Interactions with other Working Groups

- The working group continues to interface with members of other groups to work on specific projects, including:
 - Dede Olson; Data Management
 - Maria Forzan; Research
 - Molly Bletz; Decision Science, Response and Management, Research