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REGULAR ARTICLE

AQUATIC DISEASE RISK ANALYSIS: APPLICATIONS FOR THE CONSERVATION AND MANAGEMENT OF FRESHWATER MOLLUSKS

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ABSTRACT

Wildlife disease concerns are global and broad in scope and involve a wide diversity of expertise from multiple disciplines. In the realm of freshwater mollusk conservation, there is a paucity of information on pathogens of freshwater mollusks or pathogens of other species they might harbor. Consequently, it is a daunting task to manage and mitigate disease in freshwater mollusks. Disease risk analysis (DRA) is a structured, evidence-based process that aids decision making in the face of uncertainty by characterizing the potential impact of infectious and noninfectious diseases on ecosystems, wildlife, domestic animals, and people. In March 2018, as part of the 11th biennial meeting of the Freshwater Mollusk Conservation Society, a team from the University of Minnesota College of Veterinary Medicine's Risk Analysis Unit and the Conservation Planning Specialist Group (CPSG, previously the Conservation Breeding Specialist Group: http://www.cpsg.org) of the International Union of the Conservation of Nature Species Survival Commission (IUCN SSC) offered a mini-workshop series; its aim was to help conservationists, animal resource managers, and industry professionals integrate science and policy to frame, characterize, and manage health risks using international standards in DRA. Participants worked through the initial stages of DRA to examine the risks of disease introduction into aquatic systems as a result of freshwater mollusk translocation. They formulated and prioritized problems in the larger effort to (1) train the community in DRA, (2) leverage funding for further work, and (3) begin communicating with policy makers in this area. Here we report the results of this working group activity and demonstrate the utility of the DRA process in addressing concerns, real and perceived, regarding the risk of diseases associated with freshwater mollusk conservation activities.

KEY WORDS: aquatic, disease, freshwater mollusks, freshwater mussels, hazard analysis, reintroduction, risk assessment, translocation, restoration

INTRODUCTION

"Risk" is the potential of losing something of value, weighed against the potential to gain something of value (Von Neumann 1947). In the health sciences, it is defined as the probability of an adverse event occurring in a defined population over a specified time interval. At its most basic level, "risk" can be represented through the following basic equation:

$$\text{Risk} = \underline{\text{Likelihood}}\ (\text{of an outcome}) \times \underline{\text{Consequence}}\ (\text{should it occur}).$$

Risk can be characterized or measured in different ways: qualitatively (e.g., characterized as "high," "medium," or "low"), semiquantitatively (e.g., rated on a scale of 1–5), or quantitatively (assigned a probability factor or percentage). When conducting a formal "risk analysis," the outcome should be reported transparently, providing information regarding the level of uncertainty (how sure or unsure one

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is) surrounding the estimate, as well as full disclosure of the assumptions and data sources used during the process.

Disease risk analysis (DRA), particularly in the context of endangered species management, is an inherently complex process, characterized by incomplete information about the system of interest, diverse (and often competing) objectives held by different stakeholders engaged in or influenced by management activities, and insufficient mechanisms for proper collaboration and communication between the scientific community and the public (Westley and Miller 2003). Recognizing this complexity is a crucial early step in effectively applying DRA tools and processes to wildlife conservation planning. Further, applying an analysis methodology that is thorough, evidence-based, inclusive, and transparent will add significant rigor and value to the process of species conservation planning. This improved process forms at least part of the scientific foundation for generating effective disease management policy to enhance long-term species viability.

Ideally, DRA methods are implemented within a framework of structured decision making to inform species conservation planning (Gregory et al. 2012). Structured decision making (SDM) provides an organized approach to identifying multiple objectives around a given problem of interest, rigorously evaluating consequences of alternative management options, assessing trade-offs among the various alternatives, and communicating decision rationale in a clear and transparent manner. We recognize the value of incorporating SDM elements within a formal DRA process to guide freshwater mollusk conservation management, and we recommend thoughtful consideration and application of appropriate SDM tools as an extension of the DRA elements discussed in this paper.

Risk Analysis: Conducting the Process

An in-depth explanation of comparative risk analysis and assessment is beyond the scope of this discussion; a review of the references and links in Box 1 will provide the user with ample background in terms of the language and methods employed. For this report, we utilize the format supported by World Organisation for Animal Health and International Union of the Conservation of Nature (OIE and IUCN) presented in Jakob-Hoff et al. (2013) (Fig. 1):

(1) Problem formulation
(2) Hazard identification
(3) Risk assessment
(4) Risk management
(5) Implementation and review.

However, the basic process of risk analysis can be divided into conceptually similar steps, regardless of the standard used.

The first phase, *problem formulation*, consists of generally outlining the question, issue, or policies being considered, as well as a stakeholder analysis and communication plan. This

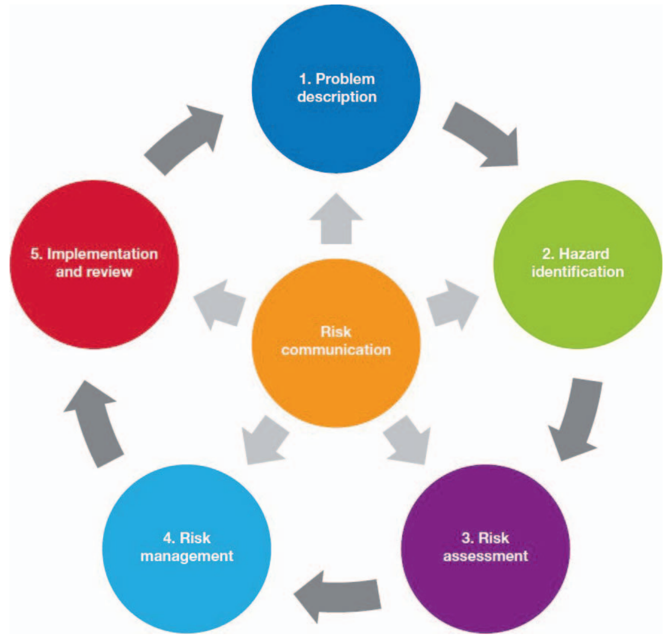

Figure 1. Phases of the disease risk analysis process as outlined by Jakob-Hoff et al. (2013).

includes outlining the general pathways and disease categories of concern. The goal of the *hazard identification* process (second phase), is to establish *specifically* which hazards (diseases) are of priority concern and the particular pathways by which they may be introduced. The result of phases 1–2 is the development of a more specific question (not unlike a scientific hypothesis) that can be modeled moving forward. This subsequent analytical model is built and tested during *risk assessment* (phase three) and results in an estimation of the probability or likelihood that each important hazard (i.e., disease) is introduced into the system as well as the associated implications (consequences). The goal of *risk management* (phase four) is to outline and test scenarios that reduce both the likelihood and implications of the risks defined during the assessment. The final phase of the process, *implementation and review*, involves the development of a clear action plan outlining a process and timeline for the evaluation and review of the established risk management plan. The involvement of all potentially affected parties in the overall stakeholder engagement process (e.g., problem formulation, pathway and hazard prioritization, data collection and evaluation, result discussion and dissemination, management option evaluation, etc.) is the goal of *risk communication*. This is an important, but often overlooked, aspect of the *risk analysis* continuum and should take place throughout the entire process.

Freshwater Mollusk Conservation and DRA

While most wildlife conservation efforts have focused on charismatic vertebrates such as mammals, birds, reptiles, and amphibians, relatively little attention has been paid to invertebrates, which represent more than 97% of extant animal

Box 1. Development of the Standards for Disease Risk Analysis in Wildlife

Several standards and processes exist today for assessing risk that may be applied to environmental, domestic animal, or free-ranging wildlife settings. The US Environmental Protection Service (EPA) has guidelines available on its website for both human health and ecological risk assessments (https://www.epa.gov/risk, accessed October 25, 2018). Of relevance, the EPA definition of ecological risk assessment is "the process for evaluating how likely it is that the environment may be impacted as a result of exposure to one or more environmental stressors such as chemicals, land change, disease, invasive species and climate change" (https://www.epa.gov/risk/ecological-risk-assessment, accessed October 25, 2018). Recognizing invasive species as one of the largest threats posed by formal and informal trade, as well as anthropogenic forces such as land use decisions and climate change, Invasive Species Specialist Group, part of the International Union for Conservation of Nature's Species Survival Commission (IUCN SSC), created a dedicated web page highlighting a myriad of risk assessment resources useful in this area (http://www.issg.org/risk_assessment_resources.htm, accessed October 25, 2018).

In the 1990s, the World Organisation for Animal Health (OIE) implemented a standard methodology to be applied globally when assessing infectious disease risks of animals, including those in the aquatic environment (World Organisation for Animal Health [OIE] 2018). Additionally, since 1992, IUCN's Conservation Planning Specialist Group (CPSG, formerly CBSG) has been facilitating collaboration between experts in zoo and wildlife veterinary medicine, disease ecology, and population management to develop a set of methods and tools for realistic and rigorous analysis of disease risks in wildlife and at the wildlife–domestic animal–human interface. In 2010, recognizing that the range of concerns in relation to wildlife disease had broadened well beyond those associated with animal movements, the OIE and IUCN co-sponsored the publication of the "Manual of Procedures for Wildlife Disease Risk Analysis" (Jakob-Hoff et al. 2013) and its companion, the IUCN "Guidelines for Wildlife Disease Risk Analysis" (World Organisation for Animal Health [OIE] and International Union for Conservation of Nature 2014). The intent of these publications is to support the implementation of risk assessment and management processes and tools when making decisions regarding biodiversity conservation and wildlife health at the interface of domestic animal and public health with respect to infectious diseases. In an attempt to support interdisciplinary collaboration, inform decision making, align language, and limit confusion, the IUCN adopted the terminology and framework of the OIE in regard to wildlife risk analysis. Recognizing the broad array of methods and tools available, the format supported by OIE and IUCN presented in Jakob-Hoff et al. (2013), which included input from experts encompassing all of the above, is utilized in this report.

species on the planet, play crucial roles in ecosystems and environmental stability, and seem to be just as vulnerable to external stressors (Brusca and Brusca 1990; Ponder 1999). Nonmarine mollusks (i.e., mollusks that live in terrestrial and/or freshwater environments) seem to be particularly vulnerable to population declines and extinction (Lydeard et al. 2004; Strayer and Dudgeon 2010; Lopes-Lima et al. 2017). Of the 750 recorded extinctions of animal species since the year 1500 AD, approximately 40% of these were mollusks, and the majority of these were nonmarine mollusks (www.iucnredlist.org, accessed October 24, 2018). The susceptibility of freshwater mollusks to population decline is most apparent in North America (mussels of the order Unionida, Superfamily Unionoidea), where more than 70% of the native species are considered endangered, threatened, or of special concern and 37 species are presumed or possibly extinct (Williams et al. 1993; Master et al. 2000; Lydeard et al. 2004). The reasons for these declines include environmental degradation, pollution, water-flow regulation and water extraction, fisheries overexploitation, and nonnative species introductions (Strayer and Dudgeon 2010; Lopes-Lima et al. 2017).

Conservation efforts for aquatic macroinvertebrates such as unionid mussels often start with restoring habitat and imposing harvest restrictions. In many cases, however, such changes by themselves do not restore previous species composition and population densities (Palmer et al. 2010; Jourdan et al. 2018). Supplemental strategies, such as captive propagation, augmentation, and reintroduction—practices often used in vertebrate conservation projects, in which individuals are moved to sites within current or historical distribution of the species—increasingly are being used for aquatic invertebrate groups, including unionid mussels. The differences between such approaches, as well as the considerations that should be addressed when contemplating them, have been discussed elsewhere (McMurray and Roe 2017). Given the limited data currently available on the success of unionid augmentations and reintroductions, it is difficult to evaluate the utility of these practices in the conservation of the group (Lopes-Lima et al. 2017; Jourdan et al. 2018). Although a brief search did not reveal any reports of disease resulting from unionid reintroductions or augmentations, this is a recognized risk associated with wildlife translocations, including those of mollusks (Cunningham 1996; Hoftyzer et al. 2008; Jones and Creeper 2019). If unionid translocations are going to continue to be used as a conservation tool for this group, a more thorough and prescribed analysis of the risks involved with the practice seems appropriate. Such risk assessments may not only help quantify the risks involved, but they also could help identify strategies that might reduce those risks.

In this spirit, we conducted a pilot DRA stakeholder engagement workshop under the auspices of the 11th biennial Workshop of the Freshwater Mollusk Conservation Society. The workshop consisted of participants in the overall three-day conference on Freshwater Mollusk Health and Disease (Supplement 1), convened and supported by the United States Fish and Wildlife Service's (USFWS) Genoa National Fish Hatchery (Mussel Propagation Team), USFWS Midwest Fishery Resource Office and Fish Health Center, and the United States Geological Survey USGS Upper Midwest Environmental Sciences Center and designed and delivered via a collaboration of CPSG and the University of Minnesota College of Veterinary Medicine Disease Risk Analysis Unit. The audience was split into three training sessions, which included an introduction to and participation in the process. The following is a summary of these training exercises.

METHODS

The DRA training workshop was held in association with the 11th biennial Workshop of the Freshwater Mollusk Conservation Society, in La Crosse, Wisconsin, on March 13–15, 2018. Its goals were to help attendees (1) understand DRA terminology, standards, and methods, (2) introduce and practice key elements of the DRA process, and (3) understand how risk analysis can facilitate science-based management and policy. All attendees participated in one of three iterations of the DRA training workshop, each of which lasted three hours and consisted of an in-depth introduction into the DRA process, a case study that enabled participants to actively engage in the process, and a final discussion on approaches and tools available for risk assessment, implementation, and monitoring. For the case studies, participants were divided into small working groups. Here we summarize output from the case studies, which included three primary activities from the first two phases of the DRA, problem formulation and hazard identification.

Problem Formulation

Groups were asked to consider the question: What is the risk of the spread of infectious disease with mollusk translocation? We use the term translocation as "the intentional movement and release of a living organism where the primary objective is a conservation benefit," as published by IUCN in "Guidelines for Reintroductions and Other Conservation Translocations" (IUCN/SSC 2013). Groups were given approximately 10 minutes to determine if this was the "right" question to consider or if there was a more important or pressing issue on which to focus. We then instructed the groups to refine the question, giving specificity to their species or populations of concern or to the geographic location in which they were working. They also were challenged to further define the goals and scope of their DRA and to consider a more specific pathway and question if they saw the need to dig deeper (realizing that sometimes an organized discussion leads to a decision to do nothing at present).

Hazard Identification and Prioritization

We gave working groups approximately 30 minutes to list all possible hazards (diseases) of concern associated with the problem of interest and identify criteria (e.g., mortality, morbidity, transmissibility) with which to rank those hazards for further analysis. As groups considered the hazards, they had an opportunity to further refine the problem on which they were focusing, including establishing any assumptions or limitations under which they were working and the acceptable level of risk. The latter was defined as the level at which stakeholders would require management action options, given the basic premise that "zero risk" does not occur or occurs only rarely. Zero potential morbidity or likelihood of disease transmission is often not realistic.

In developing criteria for ranking hazards, groups were asked to consider the likelihood of the risk as well as the magnitude or consequences of the hazard. In other words, they were asked to consider the potential for movement of a pathogen or disease along with movement of freshwater mollusks, as well as the recognized impact of the disease on their population(s) of interest. The goal of this stage of the activity was to help groups work through and communicate clearly their criteria for prioritizing hazards for further analysis in the DRA, criteria that could be communicated easily to stakeholders and partners.

System Mapping and Identifying Critical Control Points

In the final stage of the DRA activity, we allotted 40 minutes for working groups to create a conceptual diagram of the system or pathway for freshwater mollusk translocation. They mapped the specific stages of the translocation process, from collection of mollusks at a source site to release of mollusks into a destination site. Along the pathway, groups were asked to consider what activities would increase or decrease the hazard risk and where strategies for mitigation could be implemented to reduce risk. The latter were defined as critical control points, in which specific procedures could be used to reduce the hazard to the predetermined acceptable level of risk. Specific outputs of this activity included a system map that identified critical control points (e.g., Fig. 2) and a description of the specific procedures considered for risk reduction at each point along the pathway.

The duration of the workshop did not allow time for groups to work through additional stages of the DRA (e.g., risk assessment, development of a risk management plan, or design for implementation and monitoring), although an overview on approaches to these steps was discussed. To conclude the

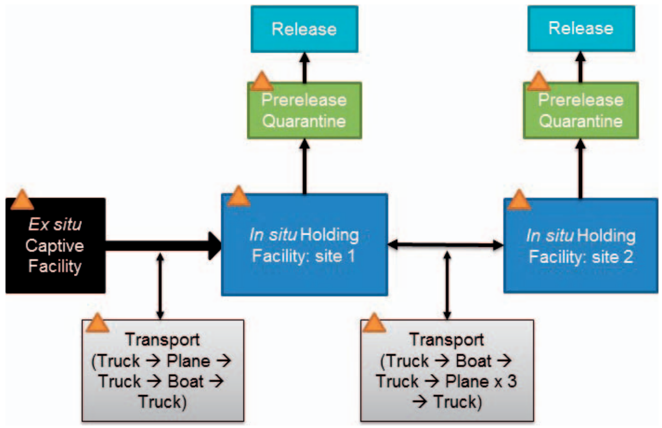

Figure 2. A generalized concept map illustrating the pathway from the captive propagation of a wildlife species to its release into the wild. This map shows how individual animals move from an ex situ captive propagation facility (black) to two separate in situ holding facilities (blue) prior to release. Transport between facilities is detailed (gray), as is an additional stage for quarantining (green) individual animals immediately prior to release (aqua). Critical control points (orange triangles) have been identified as locations along the pathway where disease risk may change and strategies for mitigation can be implemented.

DRA activity, each group reported on their problem formulation, hazard identification and prioritization, and system mapping, which are summarized below.

RESULTS

A total of 14 groups, composed of 5–10 participants each, worked through the initial DRA stages: (1) problem formulation, (2) hazard identification and prioritization, and (3) mapping the system with identification of critical control points for risk mitigation. Over the three separate iterations of the DRA workshop, approximately 110 conference attendees participated, representing national/federal ($n = 36$), state ($n = 20$), county ($n = 3$), or tribal ($n = 1$) governmental, nongovernmental ($n = 3$), university ($n = 26$), for-profit ($n = 15$), and museum and zoo ($n = 3$) organizations.

Problem Formulation

The first activity asked the working groups to refine the question, characterizing the population of interest, assumptions, scope of analysis, and acceptable level of risk. All groups felt the proposed question was important, and many maintained the question as written, while other groups refined it by incorporating greater specificity. Generally, the specificity introduced was a particular species on which the group was focused as the population at risk (e.g., *Quadrula fragosa*, *Epioblasma obliquata*) or the locations associated with mollusk translocation. Generally, particular pathogens were not identified in the question, although one group focused specifically on the risk of introducing viral hemorrhagic septicemia (VHS), a reportable viral pathogen of fish species, to the geographic region into which the mollusks were being moved (Kim and Faisal 2011). Almost all groups identified the augmented community of mollusks as the population at risk, and many included an ex situ captive propagation population as well, particularly if that population contained individuals originating from different locations. Two groups also considered native fish communities or fish species as other populations at risk. Such was the case for the group analyzing the risk of VHS introduction with mollusk translocation and for a second group that considered channel catfish an important host species for glochidial development within the region where mollusks were being introduced. Yet another group also considered humans, in addition to mollusks and fish, as a potential population at risk for disease exposure.

Assumptions outlined by the various groups demonstrated common themes. Most groups noted that source populations had some level of disease and that, subsequently, there is a risk that individual mollusks harboring viable pathogens could be unwittingly collected and translocated. One group refined this assumption further; they noted that a pathogen could remain viable through the translocation pathway such that transmission to the captive or augmented population, assumed to be free of disease currently, could occur, resulting in an observable impact of disease on the captive or augmented populations. Where a specific pathogen or pathogens were identified as the focus of the DRA, the group made a clear assumption that these were the most important pathogens to consider for analysis. Groups that considered the incorporation of quarantine, or the existence of a holding facility, as a means of disease detection and mitigation assumed that activities conducted within quarantine or holding (e.g., disease screening and surveillance) would be effective in detecting pathogens of interest, allowing for actions that could reduce disease introduction. One group that considered more than infectious pathogens as disease risks explicitly stated their assumption that copper (a hazard of concern) would be detectable in the sediment at the release site and that a population of host fish for the introduced mussels also would be present at the release site. The group that focused on VHS assumed that the pathogen was present at the source site and absent at the release site, based on the reported geographic distribution of the disease in native fish. Almost all groups noted that a major limitation to the DRA was the general lack of information on the spectrum of pathogens that mollusks might harbor, which challenged the depth at which groups could take the DRA.

Only three groups reported the intended scope of the DRA. One group discussed the scope of the problem, where unknown die-off events of host fish were occurring in the propagation facility. They assumed that mussels collected as broodstock were harboring fish pathogens. Consequently, they also were considering any shared, potentially contaminated equipment and fish or water released from the facility as a component of the DRA. A second group considered the DRA a cost-benefit analysis, intending to determine if successful translocation and reestablishment of a thriving mollusk population was worth the risk of introducing disease, based on the recognized consequence to the existing aquatic populations within the destination location. The third group identified the scope of their DRA based on the taxonomic groups of interest and locations of the translocation activities.

Often, the acceptable level of risk and the perceived risk of introducing disease with mollusk translocation were reported as the same thing and considered to be high. For example, even in these early stages of the DRA process, which required groups to reflect on the process of translocation, most recognized a general lack of existing standards for biosecurity in preventing disease transmission in the community. This deficiency seemed to be partly due to a large amount of uncertainty surrounding important aquatic or mussel pathogens, the role of mollusks in their transmission, and the role of disease in the decline of aquatic, and more specifically mollusk, populations. Thus, the general consensus among groups was that, despite these unknowns, a higher level of risk would be tolerated where survival and reestablishment of mollusk populations is highly dependent on translocation activities.

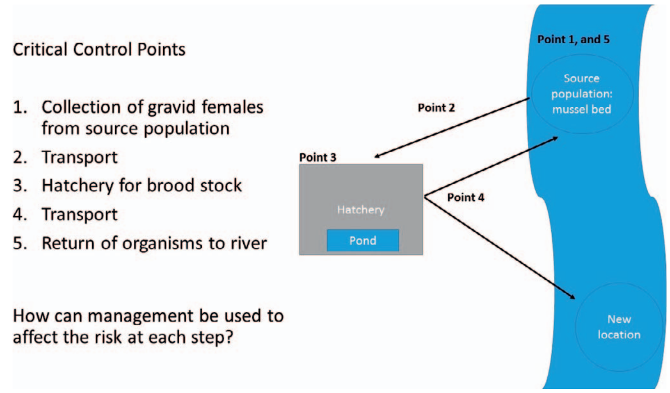

Figure 3. Representative conceptual map of the steps involved in the translocation and augmentation of freshwater mollusk populations. The diagram is one of several systems maps produced by the working groups during the DRA workshop and represents the general steps of the translocation process that were considered by most groups. Each critical control point identified by the working group is a place along the process where disease risk may increase or decrease as a result of activities at that location along the pathway.

Hazard Identification and Prioritization

Working groups identified a number of infectious and noninfectious hazards to consider with freshwater mollusk translocation. Infectious hazards, the primary focus of most groups, often were classified at a broad level—viruses, parasites, bacteria, and fungi, for example—although in a few cases, specific pathogens or pathogen groups were the focus (e.g., *Tetrahymena glochidiophila*, digenean trematodes, ciliated protozoans). Several groups also identified as hazards fish or other aquatic pathogens—in particular, VHS and *Aeromonas salmonicida*— that mollusks might harbor. Noninfectious hazards included the unintended transport of native and nonnative, nontarget species; copper contamination; genetically linked diseases; and/or habitat differences that might influence health and survival.

Criteria for prioritizing hazards are generally based on (1) the likelihood of risk, which in the case of an infectious hazard would be the likelihood that infectious mollusks were translocated, thus potentially introducing pathogens to a new site or augmented site, and (2) the consequence or magnitude of pathogen introduction. Commonly listed criteria for prioritization included hazard presence in source and augmented populations, presence of susceptible species in captive facilities or at release sites, capacity to detect and/or control hazards along the pathway, the transmission route, virulence, and infectious and latent periods of pathogens, the interaction of translocation activities and infection outcomes (e.g., stress on susceptibility or infectiousness), and potential for pathogen dispersal in contaminated water (from source or captive facilities). As groups weighed the consequence of disease introduction, they considered primarily pathogen characteristics such as species specificity and morbidity and mortality impacts on mollusk and other aquatic species populations in both captive facilities and in situ populations. Similar considerations were given to the risk of translocating nontarget native and nonnative species, particularly the presence of species in either source or destination sites and the ability to detect and mitigate nontarget species transfers within the translocation pathway.

System Mapping and Identifying Critical Control Points

The translocation pathway mapped by most groups included collection of freshwater mollusks from a source population, transport to one or more holding or propagation facilities, followed by transport to either an augmented population or a new location (e.g., Fig. 3). In most cases, the destination location was different from the source location, although one group that considered a hatchery facility where aquatic species or mollusks from other locations were maintained as a potential source for disease introduction augmented the population from which the captive broodstock originated. Generally, locations for disease to originate along the pathway were considered to be the collection site and rearing facility, particularly in cases where the water source for the rearing facility differs from that of the collection site.

Most groups identified holding or propagation facilities as an optimal place to integrate quarantine for disease screening and/or mitigation (although these facilities were not necessarily functioning in this capacity). Some groups maintained that quarantine with disease screening should occur when new mollusks enter the facility, to reduce the risk of disease entering the captive facility, and again before transporting mollusks to their destination location, to reduce risk to the augmented population. Another option for disease screening is prior to collection, in which a sample of the population might be screened for the hazards of concern. Groups also identified quarantine of host fish used in rearing facilities as an important measure for reducing the risk of fish pathogens entering the propagation facility and impacting the broodstock or being transported with mollusks to new locations upon release. Good biosecurity, which includes the decontamination of water leaving the captive facility, was identified as an important factor in reducing disease risk within these sites.

Groups also identified transportation events as critical control points, where additional measures can be implemented to mitigate disease: equipment cleaning and disinfection, water changes and decontamination, examination and/or testing of mollusks for evidence of disease, minimization of transport stress through water quality and temperature regulation, and removal of nontarget species. These measures were deemed particularly important for disease mitigation in cases where a captive facility, which might provide a quarantine mechanism, is not part of the translocation pathway. Groups also recommended that, where seasonal pathogens are of concern, transport activities might be limited to times of the year when pathogen risk is lowest. Groups agreed that the key to identifying changes in disease risks and responding to those changes with measures that mitigate risks and protect all aquatic populations is to carefully monitor source, captive, and augmented/reintroduced populations for disease.

DISCUSSION

The March 2018 DRA workshop, although limited in time and scope, successfully introduced mollusk conservation biologists and population managers to an internationally accepted, structured approach to considering disease risks in conservation planning. While weighing risks of adverse outcomes in population management was not a novel concept, considering the risk of disease in this context generally was. Overall, feedback on the workshop was positive, and many participants thought that a structured approach to problem formulation and hazard ranking was useful. This process highlighted a number of commonalities:

- There are differing approaches to outlining very similar problems, depending upon the "lens" of the person addressing the problem. A multidisciplinary, workshop approach to problem definition can resolve differences in language and methodology to create a collaborative problem definition and/or picture that can be used by the community to move forward.
- As is common when addressing almost all problems associated with wildlife diseases, the paucity of data available on mollusks, or on their role as disease vectors, limits the amount of "data-driven" decisions that can be made, increasing reliance upon qualitative data and expert opinion. However, despite the large amount of uncertainty in regard to the unknowns, most participants recognized the need to consider disease and its impacts in association with conservation activities.
- The systems mapping revealed multiple conceptually similar opportunities for disease mitigation (e.g., quarantine of new arrivals or prerelease, biosecurity of facility and equipment, decontamination of discharged water, etc.) that can be implemented even without a priori knowledge of a specific pathogen of concern.

At the very least, this process is a useful tool for addressing an identified problem with an eye toward developing evidence-based, scientifically rigorous solutions. A representative group of experts in this community now possess first-pass answers to the following:

- Are there cases or scenarios where the risk of infectious disease is perceived to be important enough to be assessed formally?
  - If so, what are those scenarios?
- Who are the stakeholders and does the stakeholder community collectively want to engage in this process?
- What are the potential pathways and consequences of concern?
- What are the criteria for prioritizing pathways and potential pathogens?
- Moving forward, is there a list of priority problems for this community to address using the process outlined above?

Most importantly, the question initially posed to all participants, "What is the risk of the spread of infectious disease with mollusk translocation?," was considered important for the mollusk conservation community to continue to discuss. We encourage the community to continue to identify and define specific situations where science can contribute to examining and mitigating disease risks for wildlife management.

ACKNOWLEDGMENTS

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