

Aquatic Nuisance Species Task Force

National Priorities List for Research on Aquatic Invasive Species

Introduction

The Aquatic Nuisance Species Task Force (ANSTF) approved the following research priorities on November 17, 2021 to capture the information, data, or tools needed to combat aquatic invasive species (AIS). Establishing AIS research priorities is an objective under the Research Goal of the ANSTF Strategic Plan for 2020-2025. To develop this list, the ANSTF Research Subcommittee surveyed ANSTF members, regional panels, and state AIS coordinators for their highest research needs in the areas of prevention, early detection and rapid response, control, restoration, outreach, and general AIS knowledge. The Subcommittee evaluated each response for its practical application, technical feasibility, national significance, and applicability to AIS policy and management. The research needs that ranked high in these areas were included in a draft list and distributed to the ANSTF for review. Comment and edits from the ANSTF were addressed by the Research Subcommittee and a final draft was prepared for ANSTF approval.

The research priorities have been grouped into management areas and, as needed, management subcategories. The order of the priorities do not represent individual importance or priority level. The ANSTF's Research Subcommittee intends to use this list to 1) inform research data calls and grants, 2) identify prospective partners and funding opportunities, and 3) track potential gaps in research needs. The priorities identified in this list were intentionally kept at a broad level, such that it would be applicable throughout the Nation. The Subcommittee recognizes research at the national level may be accomplished by working on priority species or issues at local levels, and encourages such work to support these national priorities. Lastly, the priorities identified are to be perceived as a national list reflecting the wide range of knowledge of the ANSTF and should not supersede the regulatory lists or management priorities of agencies and bureaus.

These priorities will be reviewed and updated annually to capture new or immediate threats and remove any priorities that have sufficiently progressed. The Subcommittee recognizes that the list of priorities may not change each year, but an annual review will allow the ANSTF to better document the potential changes and/or consistencies in research accomplishments and needs. The 2021 survey was the Subcommittee's first attempt to identify priority research needs from the AIS community. ANSTF comments identified some discernable areas that were not included in the survey responses, yet is uncertain if they were lacking because they are not a priority or if the survey responses did not characterize all interests within the AIS community. Accordingly, the Research Subcommittee did not incorporate suggested priorities resulting from the review period, as they were submitted outside the established process to collect and evaluate AIS priorities. However, the suggestions were recorded by the Subcommittee and will be included in the evaluation for the next revision of the National Priorities List for Research on Aquatic Invasive Species. The Research Subcommittee will also continue to encourage maximum participation in future surveys to ensure it is inclusive interests within the AIS community.

Prevention:

Preventing harmful introductions before they occur is the most effective means to avoid the risk of AIS. Success in prevention will reduce the rate of introductions, the rate of establishment, and avoid many of the long-term economic, environmental, and social costs associated with AIS. Diverse tools and methods are needed to prevent invasive species from becoming established in ecosystems where they are not native. The ANSTF has identified the following topics as priority research needs to prevent and mitigate the adverse impacts of AIS on our ecosystems, health, economies, and infrastructure:

Organism in Trade

Global markets for live plants and animals have grown over the past decade, resulting in an increased number of non-native species arriving and establishing through this pathway. Advances in global trade have also facilitated easier, faster movement of organisms. Most organisms transported for sale beyond their native range are confined, yet there is potential for some individuals to be released or escape confinement while in the care of importers, retailers, or consumers. While research examining the role of trade in biological invasion is scattered across disciplines and biological realms, existing studies suggest that global trade causes a significant invasion risk worldwide. To reduce this risk, research is needed to identify which organisms in trade can establish as new non-native populations or can serve as vectors for high risk species and increase understanding of how changes in market dynamics, supply and demand, authorities to regulate organisms in trade, and consumer behavior can influence this risk. Federal and State authorities also require evaluation within the framework of minimizing invasion risk from global trade. Priority research needs identified to mitigate the organisms in trade pathway are:

- **Increase understanding of the "organisms in trade" pathway, including potential vectors or behaviors that may facilitate introduction.**
- **Increase understanding of the effects of changing trade dynamics (e.g., rising human population, demand for foreign commodities, transport activities) on the patterns of species introductions.**
- **Evaluate Federal and State authorities, as it relates to the movement of organisms, to identify potential gaps that may result in the introduction of a non-native species.**
- **Evaluate "hitchhiker" organisms on product shipments, including identifying benign organisms in trade that may serve as a vector for high risk species.**

Watercraft Pathway

AIS can be spread across inland waters throughout North America by attaching to watercraft, which may include powerboats, small commercial and recreational fishing boats, sailboats, personal watercraft, canoes and kayaks, pontoon boats, and other boats that can be towed overland on trailers. For example, aquatic invasive plants can become dense mats across the water and attach to boats, most notably to trailers and engines. Zebra and quagga mussels can survive deep inside vessel systems as near-microscopic veligers and also attach to the surface area as adults. A large number of federal, state, and local agencies have enacted laws and regulations for inspections, permits, launch availability, and water access for vessels entering public waterways. Vessel decontamination programs and boat inspection stations are also commonly used throughout the western United States. Recommendations have also been made to watercraft and accessory manufacturers for new watercraft designs that may facilitate easier inspection and decontamination. Additional work is needed to evaluate current practices for

watercraft inspection and decontamination and explore new methods or technologies that may increase their efficiency while maintaining or increasing effectiveness. Priority research needs identified to mitigate the watercraft pathway are:

- **Evaluate best practices for watercraft design, particularly new or complex technology, to identify changes that could mitigate the risk of AIS introduction and spread.**
- **Evaluate the efficacy of decontamination protocols for AIS from watercraft exploring new methods or technologies to improve the efficiency and cost-effectiveness of watercraft inspection and decontamination.**
- **Increase understanding of viability of mussel veliger and other AIS in residual water from watercraft (e.g., outboard motors, I/O motors and ballast tanks) with consideration of real-world conditions.**

Ballast Water Management

Ballast water is one of the major pathways for the introduction of nonindigenous aquatic species. Ballast water is fresh or saltwater held in the ballast tanks and cargo holds of ships used to provide stability and maneuverability to offset changes in cargo or as required due to sea conditions. Ballast water taken into ballast tanks at one location is then transported and released at a future location, such as where the ship picks up more cargo. This release of ballast water may introduce diverse assemblages of organisms including non-native organisms at the location of discharge.

The U.S. Coast Guard requires the management of ballast water to prevent the introduction of AIS. Beginning in 1993, open ocean ballast water exchange was the primary management technique, which involves replacing coastal water with open ocean water during a voyage. However, ocean exchange is only partially effective and is not always possible to perform due to ship safety and operational issues. In 2012, the U.S. Coast Guard published new regulations that phase out ballast water exchange and phase in ballast water treatment to a concentration-based discharge standard using onboard or shore-based treatment systems. The International Maritime Organization is similarly phasing in required ballast water treatment globally. Accordingly, numerous ballast water treatment systems have received type approval or are in development including mechanical methods (e.g., filtration and separation), physical methods (e.g., sterilization by ultraviolet light, ozone, heat, electric current, or ultrasound), and chemical methods. The following research priorities have been identified to ensure that ballast water treatment systems are effective and meet ballast water discharge standards implemented by the U.S Coast Guard:

- **Evaluate tools and methods for rapidly determining living and viable organisms' concentration in ballast water during testing of ships' ballast water discharge under a wide variety of challenging conditions.**
- **Expand the development of ballast water treatment systems to include operationally challenging conditions, such as low hold time and extreme conditions, and streamline type approval process by establishing dose response relationships for treatment technologies.**

Microorganisms and Pathogens

Invasive pathogens are disease-causing microorganisms (such as bacteria, viruses, fungi, and protists) of plants and animals that can spread rapidly and have significant impacts across the Nation. Throughout history, epidemic diseases such as malaria, yellow fever, typhus, and bubonic plague have spread using

organisms as vectors and reservoirs. Human activities are also capable of transporting microorganisms within and between waterbodies; for example, ballast water of ships may transport waterborne pathogens as well as causative agents of harmful algal blooms. Additional study is needed to link the transport of microorganisms and pathogens to biological invasion. The following research priority was identified to help further this knowledge:

- **Improve understanding of the invasion risk posed by microorganisms and pathogens that may be disseminated by AIS or AIS pathways.**

Species Risk Analysis

Efficient management of invasive species requires risk analysis. This early evaluation of a species' potential invasiveness allows decision makers and research managers to better understand vectors of introduction and implement proactive management actions. There are many decision-making tools that can be used to predict the likelihood of introduction, establishment, and invasiveness of known species. However, with thousands of imported species being brought into the U.S. each year, a standardized methodology is needed to anticipate which of these species have the potential to become invasive and cause future impacts. The following research priority was identified to help achieve the goal of developing national standardized risk assessment methodologies:

- **Identify and evaluate risk analysis mechanisms to prioritize species of concern based on the likelihood of invasion and potential impacts, developing new tools and parameters as needed.**

AIS Management Plans

The Nonindigenous Aquatic Nuisance Prevention and Control Act provides the Director of the U.S. Fish and Wildlife Service with the authorization to make grants available to states, tribes, and interstate organizations for the implementation of State and Interstate AIS Management Plans approved by the ANSTF. These plans help identify technical, enforcement, or financial assistance for activities needed to eliminate or reduce the environmental, public health, and safety risks associated with AIS. They focus on identifying feasible, cost-effective management practices and measures that will be undertaken by state agencies, local programs, cooperating federal agencies, and others to prevent and control AIS infestations in an environmentally sound manner. Through their AIS Plans, state efforts weave together the framework of the national AIS program by supporting prevention, early detection, rapid response, containment, and control efforts. Evaluating the progress and effectiveness of these plans allows for identification of priority activities and species, obstacles to fully implementing the AIS State management plans, and cooperative partnerships that exist among entities managing AIS. This information is critical for recognizing the amount and type of data and management methods available, which allows for an assessment of gaps, redundancies, and opportunities for collaboration among agencies that are not being realized. The following research priority was identified to facilitate assessment of ANSTF-approved State and Interstate AIS Management Plans:

- **Evaluate the effectiveness of State and Interstate AIS Management Plans for all stages and approaches of AIS management.**

Early Detection and Rapid Response

Despite the best preventive efforts, new AIS introductions into waters of the United States are expected. Unchecked, AIS can reproduce very quickly, often with significant harmful consequences. When a new species is introduced, the best strategy is early detection and rapid response. This includes monitoring habitats at greatest risk of invasion, detecting high-risk species soon after introduction, and acting quickly to keep the species from becoming established and spreading. The ANSTF has identified the following areas as priority research needs to increase the likelihood of identifying and detecting new species before they become established:

New and Existing Species Detection Tools

Rapid detection and identification of high-risk invasive animals either at the point of entry or in the environment are essential to prevent new introductions and to enable a rapid response for successful eradication. However, species can be difficult to detect as many organisms are often small-bodied, found in low densities or difficult to find either because they are camouflaged or located in area that cannot be easily accessed. Traditional approaches to assist in the early detection of invasive species have been enhanced in recent years though development for new tools such as environmental DNA (eDNA), chemical approaches, and remote sensing. Each tool has benefits, as well as challenges and limitations for the early detection of AIS. Priority research needs for the continued development and application of species detection tools include:

- **Develop and evaluate tools to quickly find and identify high risk AIS to aid inspections at airports and seaports.**
- **Evaluate the ability to accurately detect AISs infestations utilizing aerial or satellite imagery.**
- **Develop and evaluate AIS detection tools for marine and coastal species.**
- **Increase understanding of timing and probability of species establishment and sampling methods that can detect populations before they are too large to eradicate.**
- **Develop cost-efficient genetic tools (e.g., metabarcoding, eDNA) and evaluate their potential and limitations for use in early detection of new species introductions.**

Containment

The term “prevention” generally refers to prohibiting the entry of potentially invasive species into the country or new waterbody. Although this a critically important task, it represents only one aspect of AIS prevention. In many regions, AIS have established isolated populations, but have not yet spread to other waterbodies. Containing AIS to slow “secondary spread” involves a different set of goals and efforts. Increased knowledge is needed on the role of pathways for species movement, propagule pressure, factors contributing to successful establishment, and other factors to determine what waterbodies and AIS populations may be vulnerable to secondary spread. The following research priority was identified to help gather information that will allow for a better understanding of the risk from secondary spread:

- **Develop and evaluate tools and methods to more effectively track movement of organisms from established AIS populations and spread into uninfested locations.**
- **Evaluate the use of physical barriers to contain AIS, considering how use may affect native species.**

AIS Reporting

Early detection of new AIS introduction enables faster management responses and more successful outcomes. Detections may be made by agency staff, academic researchers, industry sectors, or the general public. However, once a new species is detected, it is essential that this information be reported to the appropriate personnel to determine if response action is warranted. Several Federal and State reporting platforms exist including the U.S. Geological Survey's Non-indigenous Aquatic Species database, EDDMaps, WildSpotter, and iMapInvasives. In addition to online reporting, some states have established hotlines for reporting, such as the Alaska Invasive Species Hotline or Florida's Exotic Species Reporting Hotline. Additional action is needed to encourage individuals to be vigilant for unusual or "out of place" organisms, but also to know where to report these sightings and what information to include in the report. The following research priority was identified to increase reporting of new AIS sightings:

- **Develop and evaluate reporting platforms and protocols that will identify roadblocks and mitigate barriers to encourage reporting of unusual or new species sightings.**

Control

After a species becomes established, management options include containment, control, and, if possible, eradication. Containment efforts are used to prevent further spread of the targeted AIS, while control efforts are used to suppress AIS populations so that other resource management objectives can be achieved. Methods for controlling AIS can be broadly classified into three categories: physical, chemical, or biological, as defined below:

- Physical control refers to activities such as hand-pulling, flooding, burning or use of machinery to remove or transport AIS and associated organic material from waterbodies.
- Chemical control refers to the use of specially formulated pesticides to kill or control AIS.
- Biological control refers to the intentional release of organisms to control AIS populations. Recently this category has been expanded to include genetic biocontrol, or techniques that alter the genetic material of an organism to control AIS in the environment.

Employing a combination of prevention, containment, and control measures is an effective way to manage AIS. This approach is often referred to as integrated pest management (IPM) and can include a combination of the control tools listed above. Evaluation of the effectiveness of different control methods and approaches is vital. The ANSTF has identified the following areas as priority research needs to lessen the impacts to public interests, and increase the likelihood of eradication.

Resource Management Decision Making

When AIS populations are abundant and widespread, multiple tools are often needed to remove and contain AIS populations as well as to guide management decisions. Not all control methods are practical, effective, economically feasible, or environmentally sound for every situation. Evaluation of the effectiveness of different control methods is vital for management and should include assessment of population dynamics and regional variations. For circumstances where control measures are either unavailable or impractical, resource managers also need to better understand any repercussions of not taking management action. The following research priorities were identified to help decision makers determine the most appropriate means to control an AIS population:

- **Conduct a comparative analysis of existing AIS control options, evaluating these tools for aspects such as effectiveness, cost, feasibility, environment impact, and human health impacts to inform development of control strategies and plans.**
- **Increase understanding of the importance of population dynamics and life history stages in AIS control efforts and use this information to develop population-based tools to inform eradication or population suppression**
- **Evaluate past eradication attempts of AIS (successful and unsuccessful) and long-term control efforts to determine effectiveness and lessons learned.**
- **Increase understanding of the long-term effects to waterbodies or native species from control methods used to combat aquatic invasive species.**
- **Increase understanding of the long-term environmental and economic implications to native communities when action to control or remove AIS is not taken.**

New or Existing Control Tools

Total eradication and population suppression of an AIS is a difficult task; technological innovations are playing an increasingly important role in our efforts to control and eradicate AIS, as well as increase programmatic effectiveness and cost-efficiencies. However, there remains numerous species or circumstances for which control tools are either not available or unrealistic. There are also unique challenges in AIS control. For example, the use of physical barriers may be an effective way to halt the spread of AIS, but may prevent the migration and genetic exchange of native species. The potential for Incentive programs, such as commercialized harvest or bounties, to control AIS is also uncertain as there has been limited analyses of these type of programs. The following research priorities have been identified to encourage the development of novel control tools as well as critically examine the success and shortcomings for existing tools and programs:

- **Pursue environmentally sound technologies (e.g., biocontrol, chemical, mechanical) to aid in the eradication or control of AIS.**
- **Evaluate the effectiveness of incentive programs to control AIS to inform if, and under what circumstances, this tool may be applied.**

Habitat Restoration

Solely removing AIS from an area is not enough to return the ecosystem to its pre-invaded state. Habitat restoration is often beneficial to guard against future invasions and should be conducted whenever the control or eradication of AIS is planned. Restoration activities may include activities such as stocking organisms or improving predator-prey relationships to attain food webs similar to pre-invasion conditions. However, given the substantial pressure on native biodiversity, AIS invasions may have long term consequences and conditions will likely be difficult to reverse. To be successful, limitations to traditional restoration tools and outcomes must be known. Research is needed to further enhance restoration tools and approaches to restore ecological processes as well as identify areas or situations that have a high likelihood of restoration. The following research priorities were identified to help further this knowledge:

- **Increase understanding of efforts needed to restore ecosystem function and structure to inform techniques for habitat restoration following the removal of AIS.**
- **Increase understanding of steps and methods needed to re-populate native species in areas where they have been displaced by AIS.**
- **Identify criteria to determine the likelihood of restoration, to assist in prioritization of areas for control and eradication.**

Outreach

To prevent the introduction and spread of AIS, it is critical that individuals understand why AIS are detrimental and what actions can be taken to reduce this risk. Robust public and industry awareness and outreach programs increase understanding of the impacts associated with AIS, yet there is a need to evaluate existing outreach to ensure all audiences or demographics are being reached as well as to better understand which campaigns, message and tools are the most successful in motivating individuals to change their conservation-related behaviors. The ANSTF has identified the following priority research needs to improve the effectiveness of outreach campaigns, ensure consistent messaging, and improve collaboration and innovation in message development:

- **Evaluate existing outreach campaigns to identify what messages and tools are effective at raising awareness, removing barriers, and measuring behavioral change; and what specific audiences or demographics that should be reached to increase awareness and encourage desired behaviors.**
- **Evaluate effectiveness of boat stewards and watercraft inspection and decontamination stations in their ability to increase boater awareness and encourage preventative behaviors (e.g., self-inspection)**
- **Increase understanding of public awareness of existing AIS laws and regulations, including whether awareness serves as a deterrent from performing behaviors that may result in an introduction of a non-native species.**
- **Evaluate invasive species teaching resources and activities for their ability to educate students (K-12) on the impacts of AIS and the importance of not releasing potential AIS into the environment.**

General AIS Research

Information and research can quantify and clarify the effects that AIS are having on native species and habitats as well as to socio-economics and human health. Increased knowledge of the biology, potential impacts, associated control methods, and interaction with climate change and other major drivers of change will allow for the most effective management of AIS. The following research priorities were identified by the ANSTF as informational needs to better understand the patterns and impacts of biological invasion. Strengthening knowledge in these areas will improve all areas of AIS management; accordingly, the ANSTF has identified the following as priority research needs:

AIS Impacts

AIS readily colonize and transform habitats by reducing the abundance of native species or altering ecosystem processes. In addition to harming ecosystems, AIS hinder economic development; for example, they have adverse effects on fisheries, decrease water availability, block water transport routes, decrease property values, and degrade the aesthetic quality of recreation and tourism sites. Human, animal, and plant health is also at risk from AIS, as species can facilitate disease or injuries. Increased understanding of the impacts associated with biological invasions, will help develop stronger policies and tools to prevent and mitigate the negative impacts from AIS. The following research priorities were identified to increase understanding of the impacts that result from the establishment of AIS:

- **Increase understanding of impacts from AIS to ecological systems as well as human, animal, and plant health.**
- **Increase understanding of the economic impacts of AIS, including the costs associated with different management stages (e.g., prevention vs. control) and costs to different industry sectors.**
- **Conduct a comparative analysis of existing tools that can be used to measure costs incurred from specific AIS or in localized areas to provide information to support a national AIS cost estimate.**

Climate Change

AIS management will be challenged from changes in the Earth's climate that will likely continue, or even accelerate, over the next century. Very little is known of the impacts from AIS in relation to climate change, yet models suggest that the economic, energy, social, and environmental impacts may be profound. Fast growth, rapid reproduction, and the ability to survive in a wide range of environmental conditions are among some of the life history traits shared by AIS that may allow them to capitalize on the biotic and abiotic changes generated by global climate change. Furthermore, species that have long been "in motion," but failed to establish and reproduce in hostile conditions, may soon be able to invade these once "off limit" thermal regimes. Other species will migrate to retain the temperature conditions needed for reproduction, growth, and feeding. There is a growing concern that these shifting species will begin to function as invasive species, disrupting the structure and function of their new communities. The following research priority was identified to understand how AIS will respond to climate change and help guide management of natural resources:

- **Assess how climate change, including extreme events and human adaptation, may alter invasion patterns, pathways, and probabilities of species establishment.**