Maryland Aquatic Nuisance Species Management Plan







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Approved by the Aquatic Nuisance Species Task Force

This Aquatic Nuisance Species Management Plan was prepared by the Maryland Department of Natural Resources Invasive Species Matrix Team in partnership with Maryland agencies and organizations invested in invasive species management, and with input from the general public.

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MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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September 20, 2016

Susan Pasko
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Dear Dr. Pasko:

It gives us great pleasure to present Maryland's Draft State Aquatic Nuisance Species Plan. Thank you for your efforts to coordinate America's national response to the threat of aquatic invasive species.

Best regards,

State of Maryland
Larry Hogan, Governor
State of Maryland

MARYLAND

Signature 9/13/16 Date

State of Maryland
Mark J. Belton, Secretary of Maryland
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MARYLAND AQUATIC NUISANCE SPECIES MANAGEMENT PLAN

EXECUTIVE SUMMARY

An aquatic nuisance species (ANS) is a non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human health. While many aquatic species may be introduced to a water body, very few become established, and fewer are regarded as ANS. In the Chesapeake Bay watershed, there are 120 introduced and established aquatic species (mostly fishes) listed by the United States Geological Survey. Eighteen percent of these are regarded as ANS and threaten business in the State. Current initiatives to prevent future introductions and control the current spread of ANS include:

- Formation of the Maryland Department of Natural Resources Invasive Species Matrix Team;
- Passing of laws and regulations restricting the possession, use, or sale of nuisance species or gear that could result in the spread of those species;
- Development of Management Plans for targeted species by the Chesapeake Bay Program;
- Increased education awareness by working with K-12 schools and developing on-line websites; and,
- Incentives for controlling ANS with invasive species state records, raffles and contests by Maryland Department of Natural Resources.

These efforts have been successful, but there is a lack of coordination among agencies within the State to improve upon the effectiveness of these programs. Funding these initiatives and others is also not sufficient.

Purpose of Plan

- Help gain funding from private or State and Federal sources to prevent and control the spread of ANS in the State;
- Create a collaborative team of State and Federal agencies and the public to develop, cost-effective ANS population control approaches; and

- Provide tools for managers and the public to assess intentional introductions allowed by the government into Maryland and rapidly respond to unintentional or unauthorized ones.

Goal of Plan

Fully implement a coordinated strategy that minimizes risk of establishment by ANS along known pathways by 2020, stop the spread of ANS in Maryland and eradicate or control ANS to a minimal level of impact.

Objectives of Plan

- Prevent new and additional introductions of ANS to Maryland waters;

- Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species; and

- Control and slow the spread of existing ANS in Maryland.

Actions to Achieve Objectives (*selected*)

- Develop greater coordination with neighboring state agencies regarding ANS;
- Create outreach and teaching materials, as necessary, in appropriate languages for targeted stakeholder groups;
- Use NISC/ANSTF pathway analysis and ranking system to rank and determine the relative risk of ANS introduction through known vector pathways;
- Support research to identify critical control points for priority vector pathways by identifying: 1) stakeholders, including a list of wholesale and retail distributors of live animals; 2) socioeconomic and cultural barriers to interruption of vector pathways; and 3) species of greatest risk or concern;
- Assess existing laws and regulations to determine their adequacy for preventing introduction or spread of ANS;
- Conduct studies and review studies for high priority species to determine the most effective tools for removing ANS;
- Establish programs and projects for high priority ANS that can be routinely, cost-effectively, and practically lessen biomass and ecological impacts and implement strategies that engage the public or partners in those control efforts.

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GLOSSARY[1]

Aquaculture: The rearing of aquatic animals or the cultivation of aquatic plants for food.

Aquatic Nuisance Species and **Invasive Species**: Considered synonymous terms for this plan, these are non-native species whose introduction causes, or is likely to cause, economic or environmental harm or harm to human, animal, or plant health (Executive Order 13112; Beck et al. 2008). The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, authorized by United States Congress, defines an aquatic nuisance species as a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters (ANSTF 1994). The term ANS is often used interchangeably with aquatic invasive species, the preferred term of Federal and State managers.

Aquatic Species: A species that is totally or mostly dependent on aquatic ecosystems for a significant portion of their life cycle (ANSTF 1994).

Ballast: Heavy material, such as water, gravel, sand, iron or lead, placed low in a vessel to improve its stability.

Bilge: The lowest internal compartment on a ship or boat where water collects from the surrounding environment.

Control: The restriction of an activity, tendency, or phenomenon, which includes the spread of aquatic nuisance species.

Environmental Harm: Biologically significant decreases in native species populations, alterations of plant and animal communities, or changes in ecological processes that native species and other desirable plants and animals and humans depend on for survival (National Invasive Species Council, *Invasive species definition clarification and guidance white paper*, 2006).

Established: Having been in existence for enough time that the species successfully reproduces to yield viable offspring with continued survival, leading to a population that naturally persists in an environment.

Exotic: Originating in or characteristic of a distant foreign country. May be known as nonindigenous or non-native, with the latter often referencing species originating from a different watershed but within the continental United States.

[1] Unless otherwise referenced, definitions were obtained from the 2015 Oxford Dictionary, Oxford University Press.

High Priority: For the purpose of this Aquatic Nuisance Species Plan, established species or species groups for which there is a high probability of negative economic and/or ecological impact.

Indigenous: Originating or occurring naturally in a particular place; also known as native.

Introduction: The intentional or unintentional escape, release, or placement of a species into an ecosystem as a result of human activity.

Low Priority: For the purpose of this Aquatic Nuisance Species Plan, established aquatic species that occur in Maryland waters for which there are neutral or beneficial economic and/or ecological impact. Non-native species that are not established or are not considered likely to become established if introduced are also termed low priority.

Macroinvertebrate: A macroscopic invertebrate, especially one whose shortest dimension is greater than half a millimeter and large enough to be visible to the human eye.

Mollusks: An invertebrate of Phylum Mollusca including snails, clams, mussels and squid that have soft, unsegmented bodies, live in aquatic habitats, and typically possess a mantle and a shell.

Native: An animal or plant indigenous to a place, such as those that occurred pre-colonially or occurs in a particular ecosystem other than as a result of introduction.

Non-native: Originating in or characteristic of a region other than the one in question. Synonym for nonindigenous or alien, or exotic if originating from a foreign country. In Federal executive order 13112, the term *alien species* is defined as any species, including seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

Nuisance Species: A species that causes inconvenience or annoyance, synonymous with invasive species and aquatic nuisance species for the purpose of this Plan.

Pathogen: A bacterium, virus, or other microorganism that can cause disease.

Pathway: Any means that allows entry or spread of an invasive species (Campbell and Kriesch 2003), which may include a single or series of methodological steps that lead to the introduction of a non-native species.

Propagule Pressure: The number of introductions per unit time, which may include the number of individuals of a species, the number of taxa or genotypes introduced, or number of introduction events (Richardson and Pysek 2011). This encompasses variation in quantity, composition, and rate of supply of non-native organisms to a recipient region.

The release of hundreds of individuals periodically over a decade or the release of a few individuals monthly over the same period could yield the same propagule pressure.

Rapid Response: A systematic effort to identify, eradicate, or contain aquatic nuisance species while infestations are still localized (NISC 2008).

Red Alert Species: For the purpose of this Aquatic Nuisance Species Plan, aquatic nuisance species that are not established or do not yet occur in Maryland waters but may occur in the future because of human introduction or natural range extensions where it has been introduced. These species have a high probability of negative, economic and/or ecological impact and may have risk assessments or management plans for regions of their occurrence. Examples of these species include silver carp and lionfish.

Stakeholder: A person or organization with an interest or concern in something. This can include local, county, regional, state, or federal governments, along with non-governmental organizations, businesses who depend on aquatic resources for income, and the general public.

State partners: All partners within Maryland working toward the common goals noted in this Aquatic Nuisance Species Plan; listed partners are included in Appendix 2.

Taxa: The plural of taxon, which is a taxonomic group of any rank to classify organisms (e.g., kingdom, phylum, class, order, family, genus, species).

Unknown Priority: For the purpose of this Aquatic Nuisance Species Plan, aquatic species established in Maryland without any natural history information are considered 'unknown priority' so as to allow for a reasonable determination of low or high priority status. For unknown priority species, it may be prudent to consider them high priority and aquatic nuisance species until evidence states otherwise.

Vector: A type of pathway of introduction (http://www.anstaskforce.gov/ans.php, accessed December 2015), or the physical means that a species is transported into ecosystems.

Watershed: An area or ridge of land that is drained by a river, river system, or other body of water.

ACRONYMS

ANS	Aquatic Nuisance Species
ANSP	Aquatic Nuisance Species Management Plan
ANSTF	Aquatic Nuisance Species Task Force
CBP	Chesapeake Bay Program
ICTF	Invasive Catfish Task Force
ISMT	Invasive Species Matrix Team
IMO	International Maritime Organization
MAIPC	Mid-Atlantic Invasive Plant Council
MAPAIS	Mid-Atlantic Panel of Aquatic Invasive Species
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDH	Maryland Department of Health
MDDNR	Maryland Department of Natural Resources
MDSG	Maryland SeaGrant
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act
NAS	Nonindigenous Aquatic Species
NFWF	National Fish and Wildlife Foundation
NISA	National Invasive Species Act
NISC	National Invasive Species Council
NOAA	National Oceanographic and Atmospheric Administration
UM	University of Maryland
USCG	United States Coast Guard
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service

INTRODUCTION

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA), reauthorized with the passage of the National Invasive Species Act (NISA) in 1996, defines an aquatic nuisance species (ANS) as a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquaculture or recreational activities dependent on such waters. The term ANS is often used interchangeably with aquatic invasive species, which is the preferred term of Federal and State governments. The United States Department of Agriculture (USDA), Maryland Department of Agriculture (MDA), and cooperating agencies manage many terrestrial species, particularly those which threaten agriculture. While a comprehensive Maryland State Plan to manage terrestrial nuisance species may be forthcoming, the content of the current Maryland Aquatic Nuisance Species Management Plan (ANSP) focuses solely on species that spend the majority of their life cycle in aquatic habitats.

Numerous exotic species have been introduced across the globe, intentionally by government and non-government agencies using fish stocking or biological control initiatives and unintentionally from the pet trade and ballast water transfer or public release; some of these species are now regarded as ANS. In Maryland, these ANS can include: *Hydrilla verticillata*, zebra mussel, blue catfish, flathead catfish, and northern snakehead (Appendix 1).

Plan Purpose

The purpose of the ANSP is to unify stakeholders such as agencies, general public, and industries, and to more effectively coordinate activities aimed at preventing new introductions and controlling the spread of current ANS. An ANSP for Maryland will help leverage funding from private or State and Federal sources to both prevent and control the spread of ANS in Maryland by determining the pathways of introduction, identifying ANS among those pathways, and organizing a collaborative team of State and Federal agencies and the public to develop creative, cost-effective approaches toward ANS population control. It will also provide tools for natural resource managers and the public to objectively assess introductions allowed by the government into Maryland and rapidly respond to unintentional ones. The ANSP will be routinely evaluated for completion of actions in the implementation table.

Geographic Scope of Plan

Much of Maryland lies within the Chesapeake Bay watershed. The Chesapeake Bay watershed is the largest estuary in the United States (64,000 km^2) and contains major shipping routes in two of the most populous cities in the nation (Baltimore, MD and Washington, D.C.). The watershed is also interconnected with the Delaware River by the Chesapeake and Delaware (C&D) Canal and receives drainage from Washington D.C. and 6 states: Maryland, Virginia, Delaware, West Virginia, Pennsylvania, and New York.

Maryland has no natural lakes but contains several large, impounded waterways that are popular tourist destinations for out-of-state visitors. As a result of its vast drainage area and its interconnections with other watersheds, the Chesapeake Bay watershed may be colonized by ANS that naturally disperse from other state waters or which are directly introduced into Maryland waters.

While the Chesapeake Bay watershed is the largest watershed in Maryland, there are two other watersheds covered by this ANSP: the coastal bay watershed and the Youghiogheny River (Figure 1). The coastal bays watershed includes 5 coastal lagoons and tributaries that drain into them. The lagoons are generally brackish, with natural corridors to the Atlantic Ocean through the Ocean City Inlet to the north and Chincoteague Inlet (in Virginia) to the south. The Youghiogheny River drains a portion of western Maryland and is shared by West Virginia and Pennsylvania. It is a non-tidal stream that drains from Maryland into the Ohio River Basin, which drains into Mississippi River drainages.

Many of Maryland's water bodies are interconnected by canals that may increase propagule pressure and should be managed in some cases (Smith and Tibbles 1980; Daniels 2001). The hydrology of canals and dispersal corridors could change as climates and land usage change, leading to greater expansion of ANS. Increased precipitation and stream flow is expected to result from climate change in the Chesapeake Bay watershed (Najjar et al. 2010) and will serve to better connect otherwise isolated, adjacent drainages and could lead to the spread of ANS among drainages. In addition, annual averages in water temperature are more likely to increase than decrease in the Chesapeake Bay watershed (Wood et al. 2002). Increased water temperatures could also lead to natural establishment of ANS. The consideration of climate change in risk assessment is improving among state agencies (EPA 2008), but complicated because consequences of climate change are complex.

The Maryland ANSP addresses pathways and ANS for all waters in Maryland, including the three watersheds (Youghiogheny, Chesapeake, coastal bays) and shared waters with neighboring jurisdictions such as Potomac River (Maryland, Virginia, West Virginia, the District of Columbia), Nanticoke River (Maryland, Delaware), and Conowingo Reservoir (Maryland, Pennsylvania). The largest watershed that is contained by Maryland is Chesapeake Bay watershed. The coastal bay watershed is the second largest. Currently there are no data that indicate whether a particular watershed should be prioritized for action items noted within this Plan.

ANS Plans for Neighboring Jurisdictions

There are existing ANSPs for the states of Virginia, Pennsylvania, Delaware, and New York. An ANSP for West Virginia was under development - the plan went through preliminary review during the Fall of 2014, but West Virginia has not yet sought final approval from the ANS Task Force. Currently, Washington D.C. does not have an ANSP. Coordination among agencies and jurisdictions was accomplished with United

States Fish and Wildlife Services' (USFWS) leadership to restrict live possession of northern snakehead. However, many other species and pathways have not been jointly and similarly regulated (e.g., blue catfish or mandating boat cleaning before launch). There are two organizations in which these states participate to address invasive species: Mid-Atlantic Invasive Plant Council (MAIPC) and Mid-Atlantic Panel on Aquatic Invasive Species (MAPAIS). During routine meetings of these organizations, coordination of actions related to various state ANSPs is discussed. In addition to ANS plans, Maryland has several individual plans that pertain to a species or group of species. These specific plans are referenced in *HIGH PRIORITY PATHWAYS AND AQUATIC NUISANCE SPECIES* in this ANSP. Action items of those plans are similar to those included within this ANSP.

Gaps and Challenges

While a regional rapid response plan exists (Smits and Moser 2009), a comprehensive statewide plan has not been approved by the Aquatic Nuisance Species Task Force (ANSTF). A major challenge in implementing a comprehensive statewide plan is in establishing a framework for all authorities who are involved in ANS management (Appendix 2) to jointly discuss ANS issues. The MDDNR Invasive Species Matrix Team (ISMT) integrates several authorities but requires long-term stability and greater participation from other authorities. It does not include, for example, participation from university researchers and would benefit from resources provided by academia. These authorities may identify gaps in laws and regulation that could prevent ANS introduction. Recent statewide increases in fines were adopted for people violating existing ANS regulation and law. Additionally, a recent law in Maryland was passed to fine boaters who launch vessels that are fouled with organic material into public waters (State Lakes Invasive Species Act of 2015, Decontamination of Vessels). New regulations and laws may additionally become necessary as new pathways of introduction are identified. However, even existing laws and regulations to prevent bait introductions or possession of certain ANS are not easily enforced and require more education and outreach with stakeholders (e.g., bait dealers) to become effective.

Apathy regarding introduction of species may stem from a general misunderstanding of potential impacts of ANS introduction. There are gaps in existing knowledge on the impacts of many ANS within Maryland waters. In recent years, for example, gaps in understanding the ecological role of northern snakehead and blue catfish have led to widespread concern for natural resources that the State aims to protect, such as shad and largemouth bass. These gaps in knowledge have also led to a desire of some to manage the species as sport fish. Other ANS such as green crab and zebra mussel have not yet demonstratively impacted Maryland's ecosystems, though these species have caused problems for other non-indigenous regions where they thrive. To institute a control program that cost-effectively minimizes negative impacts from ANS, the negative impacts from ANS must be well-documented.

There are larger gaps in assessing risk of the establishment and invasiveness of species that are not yet in Maryland waters and some of these are red alert species. Red alert

species include silver carp and some non-native crayfishes that could enter Maryland waters through existing pathways. One of these pathways includes the sale via the World Wide Web, which is difficult to control. In addition, some species such as lionfish or water hyacinth may naturally disperse to or thrive in Maryland as water temperatures warm. In both cases there is management uncertainty and an inability to inform the general public on possible consequences.

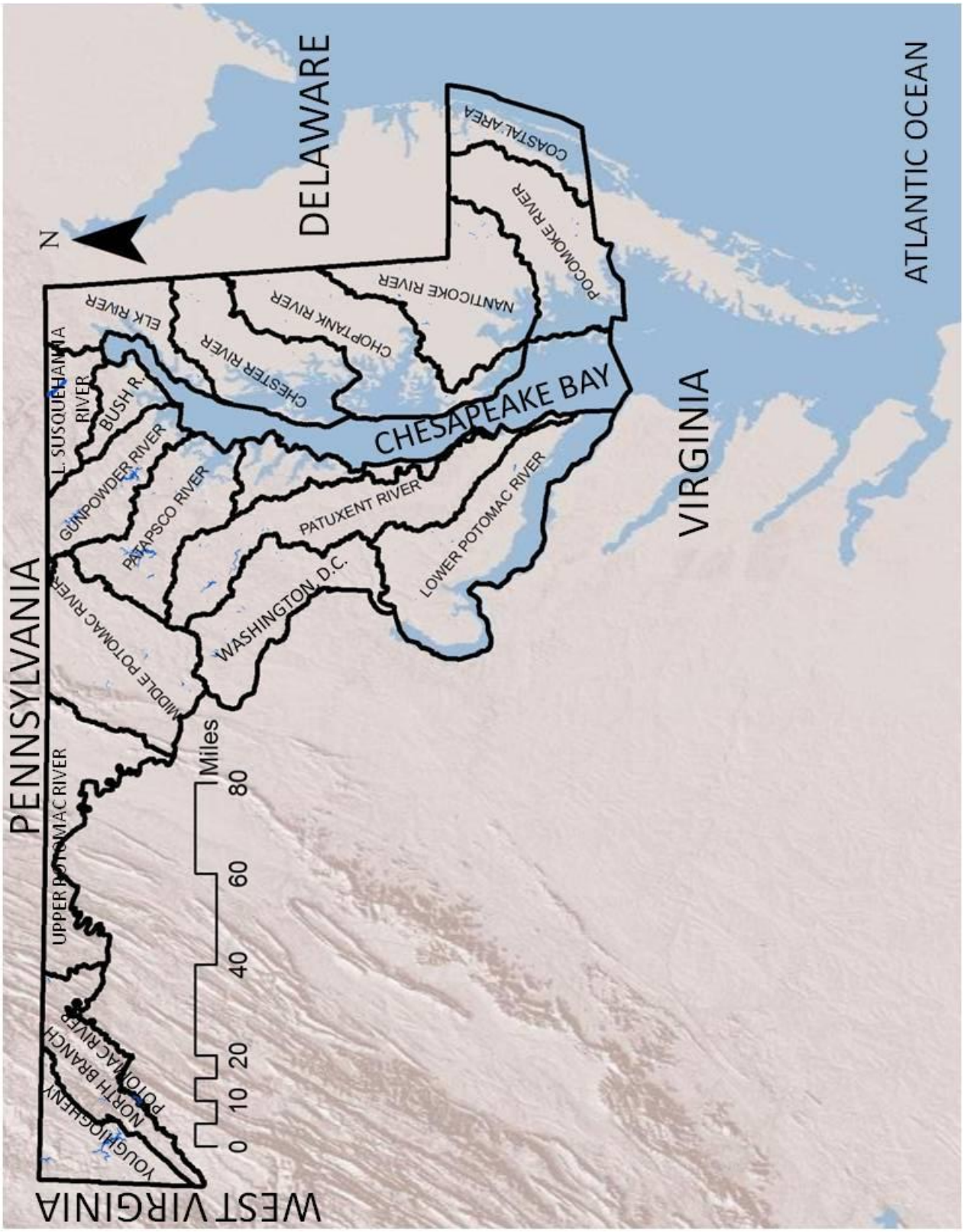

Figure 1. Map of Maryland with major basins and reservoirs.

PROBLEM DEFINITION

There are approximately 1,051 non-native aquatic animal species reported in the United States Geological Survey's Nonindigenous Aquatic Species database (Fuller and Neilson 2015). Of those, about 72% are fishes (P. Fuller, U.S. Geological Survey, pers. comm.). In the Chesapeake Bay watershed, there were 120 introduced aquatic animal species listed by USGS (2016). Some species are cryptogenic with an unknown origin, such as a Brown Pelican that was found in Maryland in 1981, either resulting from natural range expansion or introduction. Fanwort (*Cabomba caroliniana*) is another cryptogenic species in Maryland. For the purpose of this ANSP, only species that are known to be introduced from outside of Maryland will be prioritized as ANS. The probability that a non-native, introduced species' population will grow and expand its distribution depends on both the environment and natural history of the organism (Sakai et al. 2001; Kolar and Lodge 2002; Lapointe et al. 2013). The establishment of ANS requires suitable habitat (Shafland and Pestrak 1982) and may be promoted through factors such as high propagule pressure or loss of native biodiversity (Levine 2000; Duggan et al. 2006), simultaneous introduction of pathogens that affect native species (Reynolds 2013), or climate change (Rahel and Olden 2008). Introductions are considered the reason for homogenization of North American fish communities (Rahel 2000) and the primary cause of changes in biodiversity in many aquatic ecosystems (Sala et al. 2000).

The intentional introduction of non-native species is an old and worldwide practice dating back at least 1000 years when carp were widely introduced throughout Eurasia (Moyle 1986). The stocking of sport fishes throughout the United States in the late 1800's led to the establishment of nationwide fisheries for largemouth bass and have provided a stable source of food for the general public. In Louisiana, 2.5 million Florida bass (*Micropterus salmoides floridanus*) were introduced to help promote sportfishing (ABA 2014). Unfortunately, very few of these authorized introductions have had formalized risk assessments, which led to unforeseeable problems (e.g., introduction of whirling disease, Modin 1998; escape of aquaculture species, Kumar 2000; gene introgression and hybridization, Dakin et al. 2015). The unauthorized or unintentional introduction of a species may be observed serendipitously, after populations have already established; recent environmental DNA (or eDNA) techniques may help identify occurrences without direct observation (Jerde et al. 2011).

Not all species that have been introduced to Chesapeake Bay watershed are ANS (Christmas et al. 1998). Many non-native organisms may have beneficial or neutral impacts (Shafland 1996; Gozlan 2008). Those that are ANS have potential to cause or have caused negative economic and/or ecologic impacts. Some major ways ANS impact other species is through competition or predation. Competition and predation with ANS affect at least half of the threatened or endangered fishes listed by the Endangered Species Act (Wilcove et al. 1998). Extinction as a result of competition with ANS is much less likely than extinction because of predation or habitat loss (Davis 2003).

The ANS may also: 1) reduce biodiversity and simplify aquatic food webs (Tyus and Saunders 2000; Ricciardi 2005; Vitule et al. 2009); 2) dramatically change primary productivity in aquatic habitats (Nicholls et al. 1999); 3) affect water clarity; 4) spread disease (Radonski et al. 1984; Hill 2011); 5) destroy commercial fisheries (e.g., ctenophores in the Black Sea); 6) deteriorate gene pools for fishes (Philipp et al. 1983; Philipp et al. 2002; Laikre et al. 2010); and 7) increase operating costs (e.g. decontamination, gear replacement) for industry, boaters and anglers.

The negative impacts or costs and positive impacts of species introductions are often considered when reaching a consensus on the urgency to address ANS. For example, *Hydrilla* is a non-native ANS plant that negatively affects boaters (Pimentel et al. 2005) and waterfront homeowners but was credited for providing habitat for fishes (Kraus and Jones 2011) after an unprecedented decline in native Chesapeake Bay grasses because of storms and poor water clarity (Orth and Moore 1983). Consequently, the level of control for *Hydrilla* is debated between anglers and recreational boaters. The release of sport fish or game fish can be similarly contentious because of the potential to lower genetic fitness of the wild population (Hill 2011), to introduce disease (Bartholomew and Reno 2002), or to negatively affect the food web (Jackson 2002). Pimentel et al. (2005) reported revenue of $69 billion per year in the United States because of introduced sport fish, but a conservative loss of $5.4 billion per year to mitigate negative effects of ANS.

Predictive models have been developed to determine whether a non-native species is likely to become ANS and negatively impact the ecosystem (Moyle and Light 1996; Kolar and Lodge 2002; Lodge et al. 2006; Hardin and Hill 2012). Quantitative and qualitative risk assessment tools have been developed to help predict consequences of introduction (e.g., McCann 1984; Kohler and Stanley 1984; Kolar and Lodge 2002; Vander Zanden and Olden 2008; Hardin and Hill 2012; Verbrugge et al. 2012). The use of these tools may inform governments and resource agencies on possible negative consequences of introduction from authorized pathways into regional waters (by State or Federal governments). These tools do little to prevent introduction through unauthorized pathways, such as bait or aquarist releases. Once an ANS is established, the options for actions are often limited to slowing its spread and controlling its biomass.

A growing number of non-native aquatic plant and animal species could adversely impact the productivity and biodiversity of Maryland's native species and alter a variety of aquatic ecosystems. Thick patches of *Hydrilla* create patchy stagnancy in tidal freshwater habitats, which can exclude hypoxia intolerant fishes and macroinvertebrates from otherwise valuable habitat refugia. As blue catfish and northern snakehead become more widely established in Chesapeake Bay, it is expected that the food webs will be influenced by these important predators. Several invasive crayfishes have been linked to dramatic declines in native crayfishes in many Maryland watersheds (Kilian et al. 2010). In addition to loss in native biodiversity, ANS have the potential to simplify aquatic food webs, alter nutrient cycling, decrease habitat value or water quality, impair angler experiences, create increases in safety concerns for swimmers or boaters, decrease property values, and negatively impact commercial fisheries and industrial infrastructure (e.g., water intakes) or power generation.

HIGH PRIORITY PATHWAYS AND AQUATIC NUISANCE SPECIES

Vectors and Priority Pathways of Introduction

The following is a list of the vectors and associated pathways that are most responsible for non-native species introductions including ANS in Maryland. These pathways are the known, prioritized pathways in Maryland. Other pathways may exist, but these were prioritized by the authors because they are known or suspected pathways of introduction for aquatic organisms in Maryland waters.

Included in the following list is information on the known species that have been introduced via each vector and a description of the current state of knowledge of the vector, including gaps that currently hinder vector management and ANS prevention. Although this list captures most of the vectors that have historically played a role in ANS introductions and will likely continue to do so in the near future, this list is not comprehensive. New vectors and pathways emerge with increasing global trade and human population (Carlton and Ruiz 2005).

Maritime Commerce Vector

Ballast Water Pathway— Oceangoing ships utilize water as ballast to provide balance and stability from port to port. Prior to a given voyage, ballast water is pumped into large, onboard holding tanks in the area of a departure port. Organisms including algae, pathogens, a variety of invertebrates, and fish can also be pumped into ballast tanks from the surrounding environment during this filling process. Ballast water, and associated aquatic organisms, are often stored in these tanks throughout the entire voyage and then released at the port of call under the authority of the captain.

Discharge of ballast water from ships can often introduce non-native ANS from distant continents to the receiving waters. However, the potential spread of ANS via ballast water discharge is not limited to transoceanic shipping. Intra-oceanic shipping can also lead to the spread of coastal marine organisms, especially among ports with similar environmental conditions. Ballast water discharge has been responsible for the establishment of over a third of marine ANS worldwide (Hewitt and Campbell 2010) and approximately 70% of ANS to the Great Lakes (Holeck et al. 2004) including zebra mussel (*Dreissena polymorpha*).

Suspected ballast water introductions have also occurred in the Chesapeake Bay. The veined rapa whelk (*Rapana venosa*), a predatory snail from Southeast Asia, is a suspected ballast water introduction first reported in the Bay in 1998. It is currently established in Virginia waters but is not known to occur in Maryland's portion of the Chesapeake Bay. An oyster disease called MSX is caused by a protozoan (*Haplosporidium nelsoni*) native to Japan and Korea and was likely introduced via the ballast water pathway, although other pathways may have been involved. In 1959 it was first documented in the

Chesapeake Bay. This ANS has caused high mortality in the eastern oyster (*Crassostrea virginica*) and has been one of several factors hindering oyster recovery efforts. Ballast water is also the suspected pathway responsible for the introduction of the Chinese mitten crab (*Eriocheir sinensis*), a catadromous ANS from eastern Asia. This species has been reported from estuaries along the Mid-Atlantic from Maryland to New York. It was first reported from the Patapsco River in 2005. There have been four crabs collected in Maryland waters since 2005, but none reported since 2007. It remains unclear if this species is currently established in the state.

In recent years, management of the ballast water pathway has involved the establishment of international and national regulations and standards aimed at reducing ANS invasions. In 2004, the International Maritime Organization (IMO) established guidelines for ballast water exchange and a ballast water discharge standard. In 2008, the USEPA finalized the Vessel General Permit which required that all vessels entering United States waters conduct saltwater exchange or meet acceptable discharge requirements and that all inter-coastal vessels conduct mandatory ballast water management practices. The USCG also regulates ballast water discharge in United States waters under the United States Final Ballast Water Rule adopted in 2012. This rule established specific discharge standards (similar to the international standard set by the IMO) and concentration limits on microorganisms in ships' ballast water. In Maryland's Chesapeake Bay, the regulatory authority and management of ballast water falls primarily under the jurisdiction of the United States Coast Guard.

While the ballast water pathway of the Maritime Commerce Vector is regulated, the Port of Baltimore ranks as the 13th largest port in the United States and third largest in the Mid-Atlantic behind Norfolk and New York in total tons of cargo imported and exported annually (MPA 2014). Maritime commerce at the port is likely to increase in coming years, possibly resulting in greater influence of the ship biofouling pathway. Recent widening of the Panama Canal will now allow Super Post-Panamax cargo ships to access East Coast ports. Baltimore is currently one of only a few such ports that have the cranes and other infrastructure to receive these large ships, which had been previously limited by their large size to the Pacific Coast.

Ship Biofouling Pathway—The accumulation of algae, plants, microorganisms, barnacles, mollusks, sponges, hydroids, tubeworms, tunicates, and other invertebrates on the superstructure of oceangoing vessels represents a significant pathway of ANS associated with the maritime commerce vector. As is the case with ballast water, biofouling organisms attached to hulls, propellers, and other ship surfaces can be transported from port to port and introduced into receiving waters.

Biofouling is the likely pathway responsible for 70% of ANS introductions in the coastal waters of North America (Fofonoff et al. 2003). Biofouling is the suspected pathway responsible for the initial introduction of the green crab (*Carcinus maenas*) on the East Coast of the United States. This ANS is now established in Maryland's Coastal Bay estuaries.

The ANS invasions resulting in dramatic changes in the function and integrity of aquatic ecosystems, declines in fisheries, human health concerns, and economic impacts associated with industry and infrastructure has prompted considerable international research on this vector since the 1980s (Davidson and Simkanin 2012). Ballast water and biofouling are among the most studied of ANS pathways and there is considerable ongoing research on ballast water treatment and antifouling systems. Management of biofouling has focused on anti-fouling paints or hull treatments to prevent the attachment of encrusting organisms.

Trade of Live Organisms Vector

Live Bait Pathway—The importation or harvest, distribution, use, and release of live bait comprise a significant pathway through which non-native potential ANS species can be introduced and spread. Live bait introductions most often result from the release of unused bait by anglers at the end of a fishing trip. These releases have been reported throughout much of the United States (Fuller et al. 1999) and may be the most important in the mid-Atlantic region (personal communication, P. Fuller, USGS/NAS). Anglers often view the practice of releasing unused bait as humane or beneficial to predatory game fishes (as prey) and the recipient ecosystem (Litvak and Mandrak 1993; Kilian et al. 2012). Regardless of the intent, releasing bait has been responsible for the introduction and spread of non-native earthworms, many species of fishes, crayfishes, and other invertebrates (USGS 2016). Concern over introducing pathogens when using nuclear worms to fish inland waters in Maryland led to consideration of an import ban (AP 2005). Bait bucket introductions of ANS have been linked to altered chemical, physical, and biological processes within aquatic ecosystems and to declines and extirpations of native species (Moyle 1976; Hobbs et al. 1989; Goodchild 2000). The threat posed by this pathway is not limited to the bait species alone. Hitchhiking species including snails, worms, algae, and other invertebrates can also be introduced via the dumping of unused bait and its associated packing material (Haska et al. 2012). Hitchhiking parasites and pathogens, such as viral hemorrhagic septicemia, a disease that has caused large fish kills in the Great Lakes region, can also be harbored on or in contaminated bait.

Release of bait by anglers is the likely pathway responsible for introductions of four non-native crayfishes including three ANS: rusty crayfish (*Oroconectes rusticus*), virile crayfish (*O. virilis*), and red swamp crawfish (*Procambarus clarkii*) in some areas of the state (Kilian et al. 2012). Red swamp crawfish was also introduced via aquaculture (see below). Bait introductions have also led to established populations of at least seven non-native fishes and this pathway is one of several sources of non-native earthworm species to Maryland (Kilian et al. 2012).

To date, management of this pathway has focused mostly on the angler. It is illegal to release live bait into Maryland waters. There are also regulations that prohibit the use of certain bait types to reduce the spread of ANS. For example, anglers are prohibited from the use of live crayfish as bait in the lower Susquehanna River, Middle Potomac River, Monocacy River, and upper Potomac River. Regulations targeting wholesale and retail distributors prohibit the import, sale, and possession of certain ANS common in the live

bait trade. The packing materials for ANS is possibly not regulated and hitchhiker species could also be introduced. Packing material for baitworms shipped from Maine, for example, is commonly brown algae, which may also have other ANS such as green crab (*Carcinus maenas*) associated with it.

Aquarium/Pet Pathway—The live trade in aquatic organisms for aquarium hobbyists and pet owners is a 25 billion dollar-per-year and growing industry (Padilla and Williams 2004) that is responsible for the movement of thousands of species of animals and plants from around the world, many of which are exotic and some are potential ANS (Strecker et al. 2011). Introductions of non-native species including ANS associated with the aquarium/pet pathway occur primarily through the intentional release of unwanted organisms by pet owners and aquarists. The organisms can be purchased from on-line sources (e.g., craigslist, www.craigslist.com), commercial suppliers (e.g., PetSmart), or other aquarium hobbyists. This pathway is responsible for hundreds of introductions nationwide and is considered an important pathway responsible for ANS introductions (Ruiz et al. 1997). A third of the world's worst ANS (as designated by the International Union for the Conservation of Nature) were introduced via the aquarium/pet pathway (Padilla and Williams 2004). As with the live bait pathway, hitchhiking organisms including pathogens and parasites also pose a threat to recipient ecosystems when released with their associated pet species.

Introductions of aquatic pets have been routinely discovered in Maryland waters and include: pacu (*Piaractus* spp.), plecostomus (catfishes of the family Loricariidae), cichlids (*Tilapia* spp.), and goldfish (*Crassius auratus*). These tropical species have low potential for establishing populations in Maryland. Other released species have become established and include: goldfish (*Carassius auratus*); red-eared (*Trachemys scripta elegans*) and yellow-bellied (*T. scripta scripta*) sliders; false map turtle (*Graptemys pseudogeographica*); and the Chinese mystery snail (*Bellamya chinensis*). There are hundreds of places to buy aquatic pets in Maryland.

Efforts to prevent ANS introductions via this pathway have focused on regulations restricting the import and sale of certain ANS (e.g., marbled crayfish) and on education/outreach to pet owners.

Water Gardening Pathway—Import and sale of live aquatic organisms for stocking outdoor water gardens is popular among hobbyists and a growing potential pathway of ANS. Introductions associated with water gardening usually occur through escape during floods or by wind and wildlife, or by improper disposal of ANS-contaminated material or water. This pathway is a significant source of known ANS as well as hitchhiking species of fungi, algae, snails, and other invertebrates (Maki and Galatowitsch 2004).

The water gardening industry is the suspected route by which *Hydrilla verticillata* was first brought to Maryland and the Mid-Atlantic region. The original introduction of this ANS plant in the Potomac River occurred after an intentional planting of what was supposed to be *Elodea* (*Anacharis*) but was actually *Hydrilla* (Fincham 2009) by National Park Service as a possible substitute for native grasses that had largely died in

the Potomac River. *Hydrilla* became abundant in the 1980's. Water gardening is also the likely pathway responsible for the introduction of water lettuce (*Pistia stratiotes*) to Mattawoman Creek in 2007. There were 5 Maryland water gardening businesses identified in Maryland in a Google search in December 2015, but many more likely occur throughout the State.

As with the aquarium/pet pathway, efforts to prevent ANS introductions via this pathway have focused on regulations restricting the import and sale of certain ANS and on education/outreach.

Live Seafood Pathway—The global seafood trade involves the importation and distribution of live aquatic species originating from distant locations and is a pathway for ANS (Chapman et al. 2003). The mechanisms of introduction associated with this pathway include the purchase of a species from a live seafood market or other vendor and the intentional release of fish and other organisms by consumers. The asiatic clam (*Corbicula fluminea*) was believed to have been introduced as a food species by immigrants a Century ago. It has now expanded its range throughout North America. Intentional introductions of live fishes, crabs, crayfish, and other seafood species may also result in the spread of associated hitchhiking species, parasites, and pathogens into recipient waters.

In Maryland, the import and release of live seafood is the likely source of Asian swamp eel (*Amphipnous cuchia*) in Lake Needwood in the Rockville, MD. Although multiple individuals have been captured in recent years, it remains unclear if Asian swamp eel is established. This pathway may have also been the source of introductions of northern snakehead (*Channa argus*) into Potomac River and Chinese mitten crab (*Eriocheir sinesis*) in Maryland. The live seafood pathway is not as widely recognized an important pathway as others (Miller et al. 2001) but was one of two suspected pathways for Chinese mitten crab into California (Cohen and Carlton 1997).

There are federal and Maryland regulations that prohibit the live import or possession of some food species, such as snakeheads. Regulations in Maryland also prohibit import, transport, purchase, live possession, propagation, sale or release of Asian swamp eel.

Biological Supply Pathway—Biological supply companies offer a variety of live organisms marketed for educational purposes. Many non-native aquatic plants, fishes, mollusks, crustaceans, and other invertebrates can be purchased from the World Wide Web. Online biological supply companies are a common source of live organisms used as teaching tools by science teachers. Introductions associated with this pathway usually occur because teachers and/or students release the organisms at the completion of their science lesson. A survey of teachers in the United States and Canada by Chan et al. (2012) found that one in four science teachers who used live organisms in their classrooms also released them into the wild. The biological supply pathway has been implicated in the introduction of three crayfishes that are ANS in the Pacific Northwest (Larson and Olden 2008, 2011).

The MDDNR has received numerous anecdotal reports of teachers releasing live aquatic species purchased from online vendors into Maryland waters. In response, MDDNR has focused education/outreach to inform teachers and school science departments to discontinue this practice.

Water Recreation Vector

Boating Gear Pathway—The use of small motorboats, sailboats, pontoons, jet skis, canoes, kayaks, and other watercraft is an increasingly common pathway associated with the spread of ANS in inland waters. Introductions associated with this pathway arise when non-native, potential ANS are inadvertently carried between water bodies in bilge water, engine cooling systems, live wells, or attached/ entangled to hulls, trailers, or other surfaces. Because recreational boats and associated gear can be transported by trailers over great distances, the use of contaminated watercraft can be a source of new ANS to Maryland. Recreational boating can also serve as a secondary pathway through which ANS originally introduced via other vectors are transferred between nearby water bodies (Kerr et al. 2005). This pathway is believed to be responsible for the spread of problematic plants (e.g., Eurasian watermilfoil, *Myriophyllum spicatum*) and animals (e.g., spiny waterflea, *Bythotrephes longimanus*). It is the most important pathway responsible for the spread of zebra mussels from the Great Lakes throughout the United States.

Maryland's coastal estuaries, Chesapeake Bay, and many large inland reservoirs are popular tourist destinations among recreational boaters, fishers, kayakers, and canoeists. Many boaters using these waters come from adjacent states. Some boaters on Maryland waters trailer their watercraft from as far west as Utah (MDDNR, Mark Lewandowski, Deep Creek Boat Inspection, 2014), which emphasizes the large geographic scope of this potential pathway. Recreational boating is the likely pathway responsible for the introduction of *Hydrilla* and Eurasian watermilfoil in Deep Creek Lake.

This pathway is regulated in Maryland by House Bill 860 that stipulates boaters must remove organic material from boats before launching in state owned impounded waters. Education/outreach efforts have also encouraged boaters to follow best management practices to minimize the spread of ANS via boating.

Angling Gear Pathway—Anglers can inadvertently transport and introduce ANS that become attached to or contained within unclean equipment including fishing rods, tackle, waders, wading boots, and other angling gear. This is one of the suspected pathways responsible for introductions of New Zealand mud snail (*Potamopyrgus antipodarum*) and spiny waterflea in many United States waters. It is also the suspected pathway by which the invasive alga didymo (*Didymosphenia geminata*) was introduced into coldwater trout streams in many countries and throughout much of the United States, including Maryland (Bothwell et al. 2009). Pathogens such as whirling disease can also be transported between water bodies on contaminated fishing gear.

In response to the introduction of didymo, the MDDNR banned the use of felt sole waders or wading boots in Maryland waters to minimize the potential transport of this and other ANS (COMAR *08.02.19.07)*. The MDDNR and partners also established wader washing stations at many popular fishing locations.

SCUBA Gear pathway—Regulators, buoyancy control devices, weight belts, wetsuits, and other gear used by recreational and commercial divers can, when not properly dried or decontaminated, serve as vectors on which ANS can be transported between water bodies. This is the suspected pathway responsible for the introduction of zebra mussels in Millbrook Quarry (VA), which is an abandoned stone quarry used for dive training (Fernald and Watson 2005). This is also the suspected pathway responsible for the introduction of invasive mussels in Hydes Quarry in Carroll County in 2018. This recreational activity is common in Chesapeake Bay watershed and on Maryland's Atlantic Coast.

Stocking Vector

Authorized Stocking Pathway—Authorized fish stocking by government agencies has long been a means by which species have been introduced outside of their native ranges to create fisheries for anglers. Fish stocking has been largely successful in enhancing the variety and numbers of game fishes available to anglers throughout the United States. There are many examples, however, where authorized introductions have also led to negative ecological impacts (Fuller 2003). For example, blue catfish (*Ictalurus furcatus*) was introduced for sport fishing in tidal rivers of Chesapeake Bay watershed Virginia Department of Game and Inland Fisheries. Largemouth bass (*Micropterus salmoides*) was intentionally introduced to Maryland shortly after the Civil War to provide local people with a year-round food source. Common carp (*Cyprinus carpio*) was also introduced as a food species throughout much of North America (Fuller 2003) and is now widespread in Maryland waters. Authorized stocking of species to support a prey base for sport or game fishes is also a pathway that has been responsible for the introductions of several non-native fishes in Maryland, including threadfin shad (*Dorosoma petenense*) and emerald shiner (*Notropis atherinoides*). Legal stocking for the purpose of biocontrol is also a common source of non-native, potential ANS. Grass carp (*Ctenopharyngodon idella*) and western mosquitofish (*Gambusia affinis*) are ANS that have been stocked in many United States waters for control of aquatic vegetation and mosquitoes, respectively.

Risk assessment methods and internal review of proposed stockings should prevent future introductions of ANS associated with the authorized stocking pathway.

Unauthorized Stocking Pathway—Unauthorized stocking for the purposes of developing a sport fishery, forage base, harvest fishery or biocontrol can result in introductions and spread of ANS and non-target, hitchhiking organisms and pathogens. Unauthorized movement and release of blue catfish by the general public has likely hastened the spread of this species throughout Chesapeake Bay watershed. This practice has also led to the introduction of Northern Snakehead to ponds in Crofton (MD), the Potomac River and the Nanticoke River.

The MDDNR Fisheries Service has regulatory authority over fish stocking in Maryland waters. Authorized stocking of private ponds requires a permit issued by MDDNR. This process involves the review of the species and sources of those species planned for stocking. However, not all members of the general public seek a permit and unauthorized introductions occur.

Management of unauthorized stocking includes a combination of regulation and education. Research is needed to better understand motives behind illegal transport and introduction of game species (e.g., blue catfish, northern snakehead) and to identify communication and outreach techniques that both highlight existing laws and convince the general public to avoid releasing species without first obtaining a permit.

Religious Release of Wildlife Pathway—Ceremonial animal release, a traditional ritual in Buddhism and other Asian religions, is the practice of releasing captive wildlife including turtles, frogs, and fishes for religious purposes (Shiu and Stokes 2009; Liu et al. 2013). This ritual, practiced among religious groups in the United States and Canada, has been linked to the spread of ANS (Shiu and Stokes 2009). This practice can involve the release of large numbers of organisms in a single event and can be performed frequently among some Buddhist groups (Shiu and Stokes 2009). This vector is a possible pathway by which northern snakehead (*Channa argus*) was first introduced to the Potomac River drainage near Washington, DC.

Aquaculture Vector

Aquaculture Pathway—The importation of aquatic organisms for the purpose of aquaculture is a major vector responsible for introductions of ANS (Naylor et al. 2001) because of escape of cultured organisms from aquaculture facilities through outflow pipes or during flooding events. Bighead carp (*Hypophthalmichthys nobilis*), silver carp (*H. molitrix*), and black carp (*Mylopharyngodon piceus*), three ANS native to Asia were originally imported to the United States for aquaculture. These species subsequently escaped aquaculture facilities and are now established throughout much of the Greater Mississippi River drainage (Fuller 2003).

This vector has played a significant role in the introduction of ANS in Maryland. Aquaculture is the known vector for the introduction of two non-native crayfishes including the southern white river crawfish (*P. zonangulus*) and the red swamp crawfish. These species, originally introduced to outdoor farm ponds for culture as food, subsequently invaded nearby streams and rivers and are firmly established in many Maryland watersheds (Kilian et al. 2009). Introductions arising from aquaculture escapes have resulted in significant biological impacts (Grosholz et al. 2015).

The MDDNR Fisheries Service issues permits to aquaculture facilities in Maryland. As part of the permitting process, species proposed for aquaculture undergo review by MDDNR biologists to assess potential ecological risk and invasion potential. Even with

this oversight, there is still considerable potential for the introduction of ANS as a result of contaminated source stocks and misidentifications of species used in aquaculture.

Canals/Dam Removal Vector

Canals/Dam Removal Pathway—The construction of canals in the late 1800's and early 1900's connected many river drainages which allowed for the free movement of aquatic organisms between systems that were previously separated by bio-geographical barriers (Fuller 2003). The construction of canals played a large role in the spread of sea lamprey (*Petromyzon marinus*) in the Great Lakes. Similarly, the Chicago Shipping and Sanitary Canal provided the corridor through which the round goby spread from the Great Lakes to the Upper Mississippi River drainage (Fuller 2003).

The Chesapeake and Ohio Canal parallels the Potomac River and can intermittently provide a low-gradient, slow water habitat through which ANS could traverse natural dispersal barriers like Great Falls on Potomac River. Several fishes, crayfishes, and amphibians native to the coastal plain of Maryland have utilized the C&O canal to expand their distributions westward across the Fall Line (Stranko et al. 2003; Kilian et al. 2010). This same corridor has also provided access to the non-tidal Potomac River by northern snakehead.

The removal of dams and the construction of fish ladders are common practices used in the restoration of diadromous fishes and riverine habitats. By restoring riverine connectivity, these techniques are often successful at providing access of migratory fishes to previously inaccessible historic habitats for spawning. However, dam removal and fish ladders can also provide free movement of ANS.

The extensive permitting procedure associated with development of canals or removal of dams should minimize the potential for ANS introductions and spread. Construction of canals, dam removal, and construction of fish ladders are authorized via Maryland Department of Environment, Army Corps of Engineers, other agencies, and reviewed by MDDNR Environmental Review Unit. The MDDNR, USFWS, and other organizations involved in dam removal and fish passage programs consider the potential dispersal of ANS when evaluating proposed dam removal and fish passage projects. The scrutiny associated with review of such stream altering projects incorporates consideration of range expansion by ANS. To minimize the movement of ANS through the existing or new canals in Maryland, monitoring of distribution and on-the-ground population control efforts are necessary.

Research and Monitoring Vector

Research and Monitoring Pathway—Aquatic research and monitoring involves various activities (e.g., bio-assessments, fish kill investigations, restoration projects, water quality assessment, and population/status surveys) that pose a risk of transporting and introducing ANS. Many of these activities entail the use of equipment such as boats and trailers, and other gear (e.g., waders, nets) on multiple water bodies in a given day and

there is a high potential for ANS to hitchhike between waters while attached to or contained within equipment and gear. Only a fifth of surveyed fisheries programs at colleges and universities reported having a protocol in place for preventing the spread of ANS (Westhoff and Kobermann 2015). Aquatic research can also involve *in situ* experimentation where ANS could be inadvertently introduced. In 1980, National Park Service scientists conducting research to restore aquatic vegetation to the Potomac River used *in situ* experimentation in Dyke Marsh near Washington, D.C. with what they believed to be a type of Elodea. Their experiment led to the first reported invasion of *Hydrilla* in the Mid-Atlantic region (Fincham 2009). Similarly, experimental introductions of the Asian oyster (*Crassostrea gigas*) by scientists working on oyster restoration is one of two suspected vectors responsible for the introduction of the disease MSX in Chesapeake Bay (Burreson et al. 2000). Research collection activities by non-MDDNR personnel are permitted by MDDNR, which provides the opportunity to encourage cleaning of equipment.

Knowledge Gaps and other Challenges Associated with Vector/Pathway Management

The pathways of the Trade of Live Organism Vector are challenging without adequate regulation and education. In Maryland, retail bait shops frequently sell known and potential ANS and most bait sold in these shops is imported from wholesalers and sources outside of Maryland or the Mid-Atlantic region (Kilian et al. 2012). Unused bait (live fishes and crayfishes) was released by the majority of anglers in a survey of Marylanders (Kilian et al. 2012). Likewise, the large numbers of non-native aquatic species in the aquarium/pet trade and their subsequent introductions indicate that this pathway is an active route of potential ANS in Maryland. Identifying the species of highest concern within this vector may be complicated because of inconsistencies in the use of common and scientific names, misidentification and/or mislabeling of species in trade, and contamination of traded species with non-target hitchhikers (Maki and Galatowitsch 2004; Keller and Lodge 2007)

The pathways of the Water Recreation Vector require change because of behaviors of the tens of thousands of stakeholders (i.e., boaters, anglers, divers) involved in water recreation throughout the state. Encouraging stakeholders to actively and consistently decontaminate and/or dry their boats will require large scale outreach efforts and cooperation among and within Maryland state agencies.

Of the remaining vectors, the unauthorized pathway within the stocking vector remains the most challenging. Unauthorized stocking of Alabama Bass into Virginia has threatened its expansion into Maryland waters. Additionally, the release of Freshwater Drum into the Delaware River has led to its introduction to the upper Chesapeake Bay via the Chesapeake-Delaware Canal. This pathway can be interrupted with education, but requires broad behavior changing of people living within states sharing Chesapeake Bay watershed to be effective.

High Priority and Red Alert Aquatic Nuisance Species

The following sections provide ranks of high priority or red alert species for those that are considered ANS in Maryland. This list was developed by the Maryland Invasive Species Matrix Team (ISMT) based upon current concern or work with aquatic nuisance species (ANS) in Maryland, management plans for the Chesapeake Bay watershed, and information provided by Maryland Department of Natural Resources, Maryland Sea Grant, and Smithsonian Environmental Research Center (Appendix 1). High priority ranks were assigned to established species or species groups for which there is a high probability of negative economic and/or ecological impact. Red alert ranks were assigned for species that are not established, have a high potential for introduction to Maryland either by natural range expansion or unauthorized introductions, and have a high probability of negative economic and/or ecological impact. High probability of negative economic and/or ecological impact was primarily determined by experiences within the Maryland ISMT as well as whether the species was listed as injurious by the United States Fish and Wildlife Service, whether there was a State or Federal adopted management plan for the species, or whether negative impacts were indicated by a preponderance of studies in Maryland or other jurisdictions. A rank of unknown was assigned to taxa that had little information allowing for a reasonable determination of potential economic or ecological impact. Some aquatic species that have been introduced in Maryland waters do not constitute ANS and are ranked low priority or remain unranked (Appendix 1).

High Priority Freshwater Animals

Northern snakehead (*Channa argus*)—This species is native to Asia, yet has several populations in United States' waters, including Maryland, Virginia, Delaware, and Washington, D.C. The species has been listed as injurious wildlife under the Lacey Act (USFWS 2002: 67 Federal Register 62193, October 4, 2002). Since that time, it has become illegal to possess a live snakehead in Maryland, Delaware, Virginia, and Washington, DC. Thus there are federal and Maryland regulations that prohibit the live import or possession of snakeheads. While laws have likely helped reduce illegal introductions, the species has naturally spread beyond Potomac River and Nanticoke River, where it had been introduced. The species poses a threat to native fishes and crustaceans and competes with other top predators, such as largemouth bass (Saylor et al. 2012; Love and Newhard 2012). Extirpation of species has not been documented in areas invaded by snakeheads. Control efforts to prevent the spread of northern snakehead include the aforementioned ban, encouraging harvest and engaging the public in a broader dialogue to reduce propagule pressure and the release of ANS. An ANSTF approved plan for control of snakeheads nationwide is available at:

http://www.anstaskforce.gov/control.php

Blue catfish (*Ictalurus furcatus*)—Native to some parts of North America, blue catfish were intentionally introduced into tidal waters of Virginia in the early 1970's as a sport fish. Since then, the species has spread to tidal Potomac River and throughout Maryland's

waterways through unauthorized introductions and naturally. The species is tolerant of brackish water (up to 17 ppt) and are utilizing habitats in tidal estuarine portions of the Chesapeake Bay. Competition with native catfishes, and possibly predation by blue catfish on native catfishes, could lead to extirpation of native catfishes such as white catfish (*I. catus*) and bullheads (*Amerius* spp.). Blue catfish can grow to over 100 pounds and constitute a formidable predator capable of high levels of reproduction. Maryland currently has regulations to prevent release of live blue catfish from a different waterway than it was caught. There are also marketing campaigns aimed at reducing biomass of the species using harvest for human consumption and promotion of non-consumptive uses such as fertilizers. A review of the final report of the Sustainable Fisheries Goal Implementation Team Invasive Catfish Task Force (ICTF) can be accessed at:

http://www.chesapeake.org/pubs/329_Bilkovic2014.pdf

Flathead catfish (*Pylodictus olivaris*)—Native to the Mississippi River drainage of North America, this species is now found in the Potomac River, the upper Chesapeake Bay, and the Susquehanna, Elk and Sassafras Rivers. It was introduced to Occoquan Reservoir, Virginia, then spread to the Occoquan River, which is part of the Potomac River. There are individuals in the upper Potomac River, but the origin of this fish introduction is unknown. The species also spread from the Safe Harbor Dam of Susquehanna River in Pennsylvania, where it was introduced in 2002 (Smith et al. 2021), and into the upper Chesapeake Bay of Maryland. In suitable habitats, the species can quickly establish itself and amass large sizes (up to 1.4 m in length). The principal way the fish negatively impacts aquatic ecosystems is through predation. The species eats primarily fish and crustaceans. Because of predation, it can quickly decimate native catfish populations and possibly sport fish, such as sunfish (Thomas 1993). The ICTF also consider flathead catfish a potential problem and have reported on its natural history and recommendations for management at:

http://www.chesapeake.org/pubs/329_Bilkovic2014.pdf

New Zealand Mud Snail (*Potamopyrgus antipodarum*)—This species is a small euryhaline (< 15 ppt) mollusk with an elongated shell (Costil et al. 2001; Gérard et al. 2003). The species is native to lakes of New Zealand and was first discovered in Snake River (Idaho) in 1987, but was introduced to the Great Lakes of North America through ballast water releases and also to several waterways of western United States through contaminated waters shipped with game fish. The species has now become established in the Gunpowder River below Prettyboy Reservoir. The animal grazes on plant and animal detritus as well as periphytic algae. It is also ovivivparous and parthenogenic, which likely contributed to its rapid range expansion once introduced. Its range expansion may also be due to transport by fishes that ingest the snail and pass it live through its digestive tract or by anglers and boaters on contaminated gear. The species may alter primary production of streams and spread rapidly (EPA 2008). Control methods have included chemical treatment of water bodies and introduction of parasites from New Zealand. Preventing introduction has included boat and equipment decontamination.

Zebra mussel and Quagga mussel (*Dreissena polymorpha and D. bugensis*)—Introduced with ship ballast water to North America in the 1980s, the zebra mussel has caused significant negative economic and ecological impacts to the Great Lakes region and other parts of the United States (Vitousek et al. 1996). It is a filter-feeding, small bivalve that can inhabit fresh and slightly brackish waters. The species was first documented in Maryland in November 2008 at Conowingo Dam on the lower Susquehanna River when a single dead adult was found in an American shad collection basket on the upstream side of the dam. Since then, additional zebra mussels have been collected on boat hulls and other substrates in the surrounding area as well as on intake structures at two drinking water facilities. There was an established population in the lower Susquehanna River, both upstream and downstream of Conowingo Dam. As of 2014, zebra mussels had been collected in the upper Chesapeake Bay: Northeast River near Elk Neck, in the Sassafras River, and in Middle River. However, veliger numbers in lower Susquehanna River are near zero and adults below Conowingo Dam are extirpated. Propagule pressure has greatly lessened since mitigation occurred at Bainbridge Quarry in Pennsylvania. Not a single report of a zebra mussel from the upper Chesapeake Bay has been made since 2016. In 2018, an established population of zebra mussels was discovered in Hydes Quarry in Carroll County, Maryland. This population was later eradicated using potash treatments. In 2002, a workshop was held to develop species management strategies for some ANS, such as zebra mussels that had not been found in Maryland at the time (Moser 2002). One of the major strategies has included outreach.

Crayfishes—Non-native ANS in Maryland include virile crayfish (*Orconectes virilis*), rusty crayfish (*O. rusticus*), and red swamp crayfish (*Procambarus clarkii*). All three of these species have been linked to declines of native crayfishes in other regions where they have been introduced. These species currently represent the greatest threat to Maryland's native crayfish diversity. Virile crayfish, the most abundant and widespread ANS crayfish in Maryland, was first reported in the late 1950's from the Patapsco River. It is now found in 44 watersheds in Central and Western Maryland. Its spread has been followed by the concomitant, precipitous decline of the native spinycheek crayfish (*O. limosus*) and Allegheny crayfish (*O. obscurus*) in the region. These native crayfishes are now extirpated from many watersheds where virile crayfish is currently abundant. From extensive studies in other regions, these three ANS also have the capacity to adversely affect stream insects, mussels, snails, amphibians, reptiles, fishes, and sport fisheries and alter community structure and function (Hanson et al. 1990; Olsen et al. 1991; Dorn and Mittelbach 2004). Aside from observed declines to native crayfishes, the impacts of these ANS on other aspects of Maryland's aquatic ecosystems are not well understood at this time but deserve further study. Although several vectors and pathways including the pet trade, biological supply trade, and aquaculture have played a role in the introduction of crayfishes in Maryland, bait bucket introductions by anglers have been most responsible for the introduction and spread of these problematic species. Based on a survey of Maryland's freshwater anglers conducted by MDDNR in 2008, the release of live, unused bait is a common practice among Maryland anglers – especially among anglers who use live crayfish. Of those anglers who used live crayfish as bait, 69% reported releasing unused crayfish into Maryland waters (Kilian et al. 2012).

Whirling disease—This disease is caused by a freshwater myxozoan (*Myxobolus cerebralis*) and was first described in rainbow trout (*Oncorhynchus mykiss*) in Europe (Bartholomew and Reno 2002). It was subsequently introduced to North America in the 1950's and Maryland in the 1990's. Whirling disease may have been introduced by anglers or by the introduction of an intermediate host into the North Branch of the Potomac River, from where the disease was introduced to an open water hatchery that grew trout. *Myxobolus cerebralis* has a complicated life cycle and requires an intermediate host; a tubicifid oliogochaete. Intermediate stage parasites released from these worms seek out very young trout. The parasite destroys cartilage in the head and spine. Whirling disease is often fatal to juvenile fish by causing neurological damage or skeletal abnormalities. This damage causes the young trout to swim in circles, or "chase their tails", and may cause the tail to blacken as the spine is damaged. Once the damage is done, the parasite enters a final, resistant spore stage that is released once the fish dies and decomposes. The North Branch of Potomac River has two streams that continue to carry the parasite. Whirling disease is tested for, monitored and is currently under control by MDDNR.

Mute swan (*Cygnus olor*)—This ANS of the Chesapeake Bay watershed was introduced from Europe to the Atlantic coast in the late 1800's. In Maryland, the species was first observed near Ocean City in 1954. While the population was small for numerous years, after the 1980's population growth dramatically increased and resulted in a sizable increase in range. The population increased dramatically between 1986 and 1999 because control methods were not initiated. When control methods were initiated (e.g., egg addling, removal of adult swans), the population declined quickly to at least 1% of its reference size. Negative impacts from mute swans have included foraging impacts by lowering the biomass of submerged aquatic vegetation; and displacing state-threatened colonial water birds (e.g., terns). Mute swans have killed wetland birds and can be aggressive to humans. To date, efforts to reduce mute swan populations in Maryland have been largely successful. Actions to maintain low biomass of mute swan remain a high priority. A management plan to control the biomass of mute swan has been developed by the MDDNR appointed Mute Swan Task Force:

http://www.dnr.state.md.us/irc/docs/00014261.pdf

Nutria (*Myocaster coypus*)—This prolific, aquatic rodent native to South America was introduced into the United States in the early 20th century for fur farming and weed control. Individuals escaped or were intentionally released into Dorchester County in 1943, after which the population size increased to approximately 50,000 by the early 1990's. The species excavates plant roots, which leads to marsh erosion and wetland destruction. In 2002, eradication of the species from the eastern shore of Maryland began at an expense of $20 million over 5 years. The project has removed over 13,000 nutria from 150,000 acres in 5 eastern shore counties. As a result of the removals, the damaged marsh is recovering. Resulting actions from this plan have greatly reduced nutria numbers on the eastern shore of Maryland. However, this species remains a threat to Maryland through its northern expansion in Chesapeake Bay marshes in Virginia . An

interagency management plan by the Chesapeake Bay Nutria Working Group was developed in 2003:

http://www.fws.gov/chesapeakenutriaproject/PDFs/CNEP_strategic%20plan_3_2012.pdf

Red Alert Freshwater Animals

Silver carp (*Hypophthalmichthys molitrix*) and **bighead carp** (*H. nobilis*)—This freshwater fish from Asia was introduced to the Mississippi River basin in the 1970's to control algal growth in aquaculture. Carp escaped from those facilities shortly after they were brought from Asia. The species have widely spread throughout the Mississippi River and Ohio River basins in only 30 years. While the species has not yet been detected in Maryland, it is possible that it will arrive in Maryland from the Ohio River Basin by overland transport. Dams have slowed their expansion on Mississippi River and the Appalachian Mountains are barriers to dispersal to Maryland. The species causes a hazard to navigation because of their tendency to leap out of the water when startled. As silver carp leap from the water, boaters, jet skiers, and water skiers may be injured. The species may also negatively impact ecosystems by lowering the abundance of native mussels, invertebrates, and fishes. Foraging by silver carp (*Hypophthalmichthys molitrix*), an ANS in the Mississippi River and Laurentian drainages (Chen et al. 2007) will severely deplete plankton resources in otherwise plankton-rich areas (Spataru and Gophen 1985; Cooke and Hill 2010). Control programs include hydrologic separation and electric barriers to prevent spread of the species, as well as rotenone application to kill carp in some areas. Recently, control programs to market the species commercially as food have been recently attempted, though it is not clear whether these markets will lower the biomass of these species.

Alabama bass (*Micropterus hensalli*)—Alabama bass (*Micropterus henshalli*) is one of at least twelve recognized temperate black basses indigenous to the freshwater rivers and lakes of North America. It is an aggressive species that generally does not grow as big as largemouth bass, can rapidly become abundant when introduced into an ecosystem, competes with other black bass for food, and can genetically pollute populations of smallmouth bass (*M. dolomieu*) and largemouth bass (*M. salmoides*), as well as other species of black bass (e.g., Shoal Bass, Spotted Bass). Because of its fighting ability, anglers from black bass fishing clubs have illegally introduced Alabama bass to Georgia, North Carolina, and Virginia waters. It has been introduced by government agencies in Texas and California, and possibly abroad in South Africa. Where introduced, the species has not been eradicated, though harvest may be encouraged. Anglers have debated the merits of a control program dedicated to Alabama bass because some enjoy fishing for the species, while others recognize the problems it poses to other black bass species. Alabama bass has not been reported in Maryland but there is concern anglers could introduce the species into Maryland or that it could invade naturally as it currently thrives in the upper James River (Chesapeake Bay watershed). Additionally, out-of-state suppliers might unwittingly sell Alabama bass, which look similar to largemouth bass, to Marylanders.

Asian swamp eel (*Amphipnous cuchia*) **and other swamp eel species of the Family Synbranchidae**—This fish from Asia has been introduced through the commercial food fish trade or aquarium trade to Florida, Georgia, and Hawaii. In 2008 and 2012, the species was caught in Silver Lake (Gibbsboro, NJ) and the population is considered established. Because the species was collected incidentally from Lake Needwood in 2013 (MD) and because of the likelihood of establishment in Maryland if introduced, this species poses a threat to Maryland waters. The species is an opportunistic forager, but ecological impacts in North America are relatively unknown. The species spread slowly in the Everglades, consuming small fishes, crayfish and insects (Shafland et al. 2009). Control measures have been implemented in the Florida Everglades, including a combination of electrical barriers, vegetation removal, and trapping. In Maryland, it is illegal to import, transport, purchase, possess, propagate, sell or release a live Asian swamp eel.

Round goby (*Neogobius melanostomus*)—This euryhaline species is native to Europe and has become established in the Great Lakes (Charlebois et al. 2001). It was introduced by ballast water into the Great Lakes. The species has not been collected in Maryland. It consumes benthic organisms, such as worms and zebra mussels. It is considered an aggressive competitor that may outcompete native benthic fishes for prey or nesting habitats. Because it also consumes zebra mussel, the species may benefit the Great Lakes region by helping to lower abundances of zebra mussel.

High Priority Freshwater Plants/Algae

Didymo (*Didymosphenia geminata*)—This species is a freshwater diatom that uses stalks to attach to streambed material. Native to Canadian cool water streams, didymo has been reported in the United States for over 100 years; however, blooms are occurring now with increasing frequency and intensity, and in 2008 didymo was first discovered in Maryland tributaries of Gunpowder River. Subsequently, the diatom was discovered in other Maryland rivers including the Savage River in 2009, the North Branch of Potomac River in 2011, and Big Hunting Creek in 2012. Didymo can form massive blooms that smother streambeds and adversely affect freshwater fish, plant, and invertebrate species by depriving them of habitat (Root and O'Reilly 2012, and references therein). Blooms may also impact recreational opportunities and several methods of decontamination have been investigated (Root and O'Reilly 2012). This species forms blooms in fast-flowing, cold, nutrient-limited waters. After its discovery, MDDNR took action to educate the public and to prevent spread by installing wader wash stations to encourage anglers to clean their waders free of didymo. In 2011, MDDNR implemented a policy to ban felt-soled waders to help curb spread of didymo.

Brazilian elodea (*Egeria densa*)—This species was likely released from the aquarium trade. The species is native to South America, was originally imported to the United States for the aquarium trade, and has a high capacity of growth (Pistori et al. 2004). It may have spread in Maryland by boaters or naturally through fragmentation. The species can form thick and dense mats of vegetation that outcompete native aquatic plants. The mats often interfere with swimming, boating, fishing, or other recreational uses of waterbodies. Control of Brazilian elodea has been performed by mechanical and chemical means as well as biological control by triploid grass carp.

Hydrilla (*Hydrilla verticillata*)—This species is a waterweed that is native to Asia, Europe, Africa, and Australia. A common aquarium plant, it was first introduced to Florida in 1960s and is established in many areas of the United States. It is possible that *Hydrilla* was introduced to Maryland from the aquarium trade. It became abundant in the tidal Potomac River in the 1980s following massive losses of submerged vegetation (Rybicki and Landwehr 2007). Stems grow up to 1 – 2 m and leaves are arranged in whorls. The species has a high tolerance to salinity and reproduces by fragmentation and rhizomes. The density of *Hydrilla* causes problems for boat traffic and for recreational angling. Control of the plant using herbicides in Deep Creek Lake cost Maryland approximately $205,000 in 2014. Herbicides are most commonly used by MDDNR to control the biomass of the species in impoundments and ponds. In tidal rivers and impoundments, mechanical harvesters have been used; but this technique has been discontinued as it is expensive and labor intensive.

Yellow iris (*Iris pseudacorus*)— Native to Europe, Asia and Africa, this flowering perennial has been cultivated as an ornamental plant and has become established as an invasive species in some regions. The species is capable of outcompeting native iris species depending on habitat conditions (Pathikonda et al. 2009). The species creates dense, monotypic stands in waters up to a foot deep. It rapidly spreads in freshwater wetlands and riparian areas, encroaching into habitats occupied by several Maryland threatened and endangered plants including beaked spikerush (*Eleocharis rostellata*) and smallfruit beggarticks (*Bidens mitis*). The species spreads by both rhizomes and water-dispersed seeds. The rhizomes are toxic to livestock, and may be to people. It is widespread in the continental United States and stands outside cultivation have been documented in Maryland. In Maryland, the species was listed as a Tier 1 species by Maryland's Invasive Plant Advisory Committee--as of 4/11/2016. It is illegal to propagate, import, transfer, sell, purchase, transport, or introduce any living part of this species; possession is still allowed.

Purple loosestrife (*Lythum salicaria*)—This species is a wetland plant from Europe and Asia. It was transported into North America in the 1800's as seeds and plant parts by ballast water of sailing ships (Allen and Strain 2013). After its initial introduction, the plant spread naturally among canals and ditches as well as intentionally as European colonists transplanted the species believing it could be used for medicinal healing. The species competes with many native wetland plants and forms dense stands that reduce food and nesting sites for native species. The MDDNR began a biological and chemical control program in 2007 with State Highway Administration (SHA) and Maryland

Department of Agriculture (MDA) to eradicate purple loosestrife. Using citizens as scouts for locations of the plants, MDA raised and released beetles as biocontrol agents. Biological controls have been used in addition to hand-pulling and chemical treatments. Of these, chemical treatment was considered highly effective. Currently, Maryland has only a few stands of purple loosestrife. People can report purple loosestrife stands at:

http://dnrweb.dnr.state.md.us/wildlife/PurpleLoosestrife/plrform.asp

Marsh dayflower (*Murdannia keisak*)—Native to temperate and tropical parts of Asia, marsh dayflower was accidentally introduced into the United States in South Carolina around 1935. It is an annual, emergent plant that invades wetlands and forms dense mats that out-compete native vegetation. It was first reported in Maryland in 1949 from Patuxent National Wildlife Refuge (Riefner and Hill 1983) and has since become well-established in coastal areas. It is found in freshwater marshes, pond edges, ditches, streams and will likely spread into every county in Maryland over time (pers. comm. Wesley Knapp, MDDNR). Control includes hand pulling and root removal to ensure depletion of the seed source. The species readily reproduces from vegetative fragments and can spread with mechanical removal.

Parrot feather (*Myriophyllum aquaticum*)—Native to South America, it is a popular plant for aquatic gardens in the United States because of its attractiveness. It was first found in Maryland in 1948 at the C&O Canal Angler's Club based on an herbarium specimen located at the Natural Museum of Natural History (#2231415). Once introduced, the species aggressively colonizes and dominates lakes, ponds, and ditches because of its ability to spread readily through fragmentation and tolerate different water levels (Hussner et al. 2009). In water bodies where the species dominates, the plant can entirely cover the surface and make it difficult for boaters, swimmers, or anglers to utilize the waterway. Control methods are often expensive and include mechanical removal.

Eurasian milfoil (*Myriophyllum spicatum*)—Native to Europe, Asia and northern Africa, this species was commonly sold as an aquarium plant in the United States. It is now found throughout much of the Nation and has been established in several eastern states since at least the 1890's based upon an herbarium specimen collected in 1895 from Carroll Island, Haw Cove. It is abundant in many Maryland waterbodies (Rybicki and Landwehr 2007) and continues to spread by boat trailers and human transport. The species forms dense mats that can shade out other plants and its thick mats can negatively affect recreation such as swimming and fishing. Clogging caused by the mats may also interfere with power generation and irrigation. Milfoil reproduces quickly through seeds and fragmentation and can infest an entire lake within two years of introduction. Once established, the species is difficult or impossible to eradicate. Control methods have included herbicides, underwater rototilling, hand pulling and triploid grass carp.

Common reed (*Phragmites australis*)—This species is a wetland plant found throughout the United States and Maryland's wetland habitats. Both native and introduced genotypes of this species currently exist in North America. The origin of the species is unclear and it natively occurs in many areas of North America. The non-native genotypes may have

been introduced in ballast material in late 1700's or early 1800's from Europe. The species is long-lived and can grow up to 6 m high. It can reproduce by seed, but more often reproduces asexually by rhizomes. The species forms dense, monotypic stands that exclude other plant species. Control methods have included herbicide, hand-pulling, and burning. A draft management plan was developed for common reed (Moser 2002). More information on controlling *Phragmites* is found at:

http://dnr2.maryland.gov/wildlife/Pages/plants_wildlife/Phragmites.aspx

Eurasian water chestnut (*Trapa natans*)—A native to Asia, water chestnut was first observed near Concord, Massachusetts in 1879 (Hummel and Kiviat 2004). This species has since become established in many states, including Maryland. It was first discovered in Maryland in the Potomac River in 1923 (Gwathmey 1945). The species can be identified and distinguished from two-horned water chestnut because of its white flowers, four-horned fruits, a prominent crown, and leaves that are green underneath. Removal of water chestnut from Potomac River cost millions of dollars in 1965. It was later discovered and removed in 2014 from the Potomac River by the Virginia Department of Wildlife Resources. In the 1990's it was also found in Bird River (near Baltimore, MD) and Sassafras River (upper Chesapeake Bay)--removal costs totaled $80,000 over a 10-year period (Moser 2002). The pathway of introduction is unknown. It is prohibited from sale in most southern states. Once established, the species forms dense floating mats that limit light and reduce dissolved oxygen levels. Its fruits have sharp spines that can cause painful puncture wounds when stepped on, even penetrating shoe leather. Manual removals by certified individuals and chemical treatments are used to remove the plants; eradication is difficult because seeds lay dormant for up to 12 years. The management plan is at:

http://www.anstaskforce.gov/Species%20plans/Water%20Chestnut%20Mgt%20Plan.pdf

Two-horned water chestnut (*Trapa bispinosa*)—Native to Asia, this species was discovered in northern Virginia in 2014 and can be distinguished from Eurasian water chestnut by having two-horned fruits rather than four horned-fruits. The range in the United States has recently expanded but has been considered by the Maryland Invasive Species Council as potentially manageable with early detection and rapid response efforts. Two-horned water chestnut can be distinguished from Eurasian water chestnut by its pink flowers, two-horned fruits, lack of a crown, and leaves that are reddish underneath. The species has been verified in Northern Virginia at 33 locations (2018). Reported occurrences in the Northeast United States had only been in Virginia within the Potomac River watershed. However, recently, the species has been collected from three ponds in Montgomery County of Maryland, in the upper watershed of Potomac River. Typically, the species is managed with hand-pulling or treatment with herbicides, particularly before fruits are produced (May - July); but such actions may need to occur annually for several years if the seeds have dropped prior to harvesting plants or if the seeds lie dormant.

Red Alert Freshwater Plants

Waterwheel (*Aldrovanda vesiculosa*)—A small carnivorous plant native to Europe, Asia, Africa and Australia, waterwheel has whorls of small leaves that help trap small arthropods and insect larvae. The species has gone extinct throughout much of its native range and only 50 known locations still have viable populations (Cross 2012). It is cultivated for sale on the World Wide Web and may be available in the aquarium or aquatic garden trade. It has been found in New Jersey, New York, coastal Virginia and Maryland. In Maryland the species has been found in Prince George's County, but it is not common. The species can be spread by movement of waterfowl and plants sticking to the feet of birds. It can also be spread by water flow and flooding.

Common water-hyacinth (*Eichhornia crassipes*)—This species is native to South America, yet it has been widely introduced to North America. In 1884 the plants were given away as gifts at an expo in New Orleans (Gettys 2014). The plants rapidly became a problem because of overgrowth in rivers that led to fish death and shipping hazards. The species has been controlled with chemicals, mechanical removal, and biological control agents. The species was found in 1998 in Fresh Pond (near the mouth of Potomac River; Scotland, Maryland), and in three counties in 2007, but apparently did not survive the winter. It was documented as overwintering in Dorchester County in 2015.

English water grass (*Glyceria maxima*)—This species is a perennial, riverbank and pond oriented grass that is native to Europe and Asia. As a flood tolerant species capable of exchanging gases using air-filled cavities within roots (Rees and Wilson 1984), it competes with native grasses and is a noxious weed outside of its native range. The species reproduces primarily by means of rhizomes. It was first introduced into North America in 1940 at the edge of Lake Ontario. Since then the species has spread to New England. It has not yet been reported in Maryland.

European frog-bit (*Hydrocharis morsus-ranae*)—Native to Europe, Asia and Africa, the species was introduced to Ottawa (Canada) as an ornamental plant in 1932. It spread to several rivers and Great Lakes shortly thereafter (O'Neill 2007). The species grows rapidly, forming dense floating mats in slow-moving waters or ponds and lakes. As it can grow quickly, large die-offs in fall lead to high levels of decomposition and reduced oxygen in the water. The species crowds native plants, hinders swimmers and boaters, clogs canals and streams, and can negatively affect fishes and other aquatic life. It has been found in New York and Vermont, but not yet Maryland.

East Indian hygrophilia (*Hygrophila polysperma*)—An herbaceous perennial from Asia, the species was introduced via the aquarium industry to Florida in the 1950's and then to Richmond (VA). It grows in waters up to 10 feet deep, along stream and lake edges, forming dense stands of stems that can shade native submersed species and clog drainage channels and pipes. It is controlled in areas where it has been introduced (Cuda and Sutton 2009). It has a minimum temperature tolerance of 39 °F, optimal growth at 71-82° F, and may not overwinter in Maryland. It is listed as a Federal Noxious Weed and has not yet been reported in Maryland.

Yellow floating heart (*Nymphoides peltata*)—A rooted perennial, waterlily-like plant native to Eastern Asia and the Mediterranean, the species grows in ponds, channels and slow-moving water. It broadly carpets water surfaces with long-stalked heart-shaped leaves, negatively affecting recreational activities, native plants and creating stagnant areas with low dissolved oxygen below the dense mats of leaves. It can reproduce through fragmentation as well as seed. It is widely sold as a water garden ornamental, yellow floating heart that has been purposefully and accidentally released outside cultivation (Countryman 1970). USGS has documented non-indigenous populations in Washington, D.C., and 29 states, but not yet in Maryland.

Giant salvinia (*Salvinia molesta*)—A floating fern from southern Brazil, this species was probably introduced to the United States through the aquarium and garden-pond trade. It can also be spread by boaters. It is one of the world's worst aquatic weeds (Thomas and Room 1986). A rapidly growing plant that can double its numbers in 2 – 10 days, it completely covers waterways and shades out native aquatic plants. As it dies, decomposition of plant tissues can cause hypoxia. It does not survive below 24° F or in water that freezes during winter. Eradication is practically impossible by hand. Small infestations can be controlled by hand, however, and should be done immediately. A weevil (*Cyrtobagous salviniae*) has been introduced into 13 countries for biocontrol. While it does not currently occur in Maryland, its impacts elsewhere and difficulty to control warrant its red alert classification.

High Priority Marine Animals and Plants

European green crab (*Carcinus maenas*)—This species is native to the Atlantic coasts of Europe and Africa. The European green crab was introduced to Massachusetts in the mid-1800's, probably through ballast water. In Maryland, the species was discovered in the coastal bays near Ocean City Inlet around 1996. It is currently found in Isle of Wight Bay. The species commonly occupies rocky jetties, bulkheads, and other structures and forages over open flats and tidal marshes. Growing to a maximum size of 3 inches, green crabs can survive in a wide range of salinity and temperatures, but have poor reproduction below 20 ppt and 10° C (Hines et al., 2004). Green crabs are legally sold as bait in Maryland, yet the state recommends that unused bait be discarded on shore and not returned to the water. The escape of live bait is currently not monitored.

Chinese mitten crab (*Eriocheir sinesis*)—This species is native to Asia. It has been reported from Chesapeake Bay. It is a small, brown crab with distinct "hairy" white-tipped claws. Only a small number of Chinese mitten crabs have been collected from Chesapeake Bay since it was confirmed in 2006 at the mouth of Patapsco River. It is tolerant of variable habitat conditions and salinities and can spread fast once established. None have been confirmed from upstream freshwater habitats where they spend most of their lives. If a Chinese mitten crab is caught, it is encouraged that the crab be kept on ice and reported to Smithsonian Environmental Research Center. A Chinese Mitten Crab Watch has been developed to help the general public report occurrences of mitten crab:

http://www.dnr.state.md.us/dnrnews/infocus/mitten_crab.asp.

Japanese shore crab (*Hemigrapsus sanguineus*)—This species is native to the western North Pacific. Japanese shore crabs have been found from Massachusetts to North Carolina in the mid to upper rocky intertidal zones (McDermott 1997). In Maryland, the species has been collected in coastal lagoons, Isle of Wight, Sinepuxent Bay and Chincoteague Bay. It was presumably released during bait discards. The small species (shell width < 50 mm) has light and dark bands on their legs and red spots on the claws. The species lives in shallow waters and oyster reefs, but impacts of the species are still unknown.

Red Alert Marine Animals and Plants

Lionfish (*Pterois volitans* and *P. miles*)—This species was introduced to the South Atlantic Bight from Florida in the 1980's or 1990's either because Hurricane Andrew destroyed an aquarium or because of intentional, illegal introductions prior to the hurricane (Schofield 2009). The species is native to the Indo-Pacific. It has quickly colonized reefs of the South Atlantic Bight and has spread to the Caribbean. In rare cases, young lionfish have traveled along the Gulf Stream and northward to the Long Island Sound (Fire Island, New York). Currently, the species is continuously distributed from Miami, Florida to Cape Hatteras, North Carolina. While the species has not been collected in Maryland waters, it is possible that changes in the direction of the Gulf Stream or warming waters will result in lionfish colonizing reefs offshore and near Assateague Island or Ocean City, Maryland. The species can negatively impact reef communities through predation (Albins and Hixon 2008) and poses a human health risk because of its venomous spines.

Asian horseshoe crab (*Tachypleus* spp.)—There are three species that have been considered for import, *T. gigas, T. tridentatus*, and *Carcinoscorpius rotundicauda*. Asian horseshoe crabs were imported by the bait industry and if introduced, they could also introduce non-native parasites and pathogens that threaten native horseshoe crab (or other species). These parasites and pathogens could also cause human health risks from neurotoxins (tetrodotoxin) that are found in *C. rotundicauda* (Kanchanapongkul 2008). For these reasons, Maryland banned the import of Asian horseshoe crabs in 2013 (Classification of Non-native Aquatic Organisms. Annotated Code of Maryland § 08.02.19.04).

MANAGEMENT PLAN

Plan Goal

The goal of the Maryland ANSP is to fully implement a coordinated strategy that minimizes risk of establishment by ANS along known pathways and when possible, stop the spread of ANS in Maryland and eradicate or control ANS to a minimal level of impact.

Plan Objectives

1) **Prevent** new and additional introductions of ANS to Maryland waters;

2) Establish an early **detection and rapid response** mechanism to find, contain, and/or eradicate newly introduced species;

3) **Control and slow the spread** of existing ANS in Maryland.

Plan Strategies, Actions and Funding

1. Prevent new and additional ANS introductions to Maryland waters

1.1 Strategy Assess relative risk of new aquatic species introductions

1.1.1 Action

Develop greater coordination with MAPAIS, ANSTF, neighboring state agencies and among Maryland universities, agencies and organizations involved with invasive species management. Use existing ANS Management Plans from neighboring states to identify lead agencies and contact information of individuals responsible for ANS management. For states without ANS Management Plans, biologists working in relevant aquatic ecosystems will be identified from collegiate contact lists and participant lists from conferences such as Northeast Association of Fish and Wildlife Agencies. Ensure representation of neighboring jurisdictions, academia, and Maryland agencies at MDDNR ISMT meetings.

1.1.2 Action

Review and update lists of red alert and high priority species listed in Appendix 1. The list can be reviewed and modified at annual meetings of MDDNR ISMT, as appropriate.

1.1.3 Action

Conduct risk assessment when new aquatic species are detected, and for red alert and high priority species listed in Appendix 1. Risk assessments include aquatic animal risk assessment, pathogen risk assessments, Science-Based Tools for Assessing Invasion Risk (STAIR), and Fish Invasiveness Scoring Kit (FISK) (see Implementation Table). Reviews may be performed during annual MDDNR ISMT meetings, with recommendations provided by the Chair.

1.1.4 Action

Rank red alert and high priority species listed in Appendix 1 according to risk and generate species-specific actions for prevention or control for species with high levels of risk. Of listed red alert and high priority species in Maryland, the percentage of species with existing risk assessments (www.fws.gov/fisheries/ANS/species_erss_reports.html; or elsewhere in literature) will be calculated and tracked across years. Risk assessments for some ANS may need to be conducted. Assessments will be provided on-line to the general public, Wetland, Fishing, Waterways, Aquaculture permitting and licensing authorities or other parties with interest within MDDNR or other cooperating agencies, when needed.

1.1.5 Action

Manage online availability of species list and support cross-use of risk assessments across state partner websites. Provide webmasters with risk assessments and rankings of species for on-line distribution.

1.2 Strategy Analyze and assess risk of vector pathways of introduction

1.2.1 Action

Use NISC/ANSTF pathway analysis and ranking system to rank and determine the relative risk of ANS introduction through known vector pathways (Orr et al. 2005). The ISMT will coordinate the use of or use procedures developed by NISC and ANSTF to rank pathways.

1.2.2 Action

As new information becomes available review and update pathway rankings. With annual meetings of ISMT and as the ANSP is reviewed (see Plan Review), the rankings of pathways may be updated based upon information learned from the NISC/ANSTF pathway analysis and ranking system.

1.2.3 Action

Develop a distribution list of State partners with ANS information websites and distribute vector pathway list and rankings to webmasters.

1.2.4 Action

Support research to identify critical control points for each known vector pathway (Whitehead and Orriss 2015) by identifying: 1) stakeholders, including a list of wholesale and retail distributors of live animals; 2) socioeconomic and cultural barriers to interruption of vector pathways; and 3) species of greatest risk or concern. The number of pathways identified in the ANS Management Plan with the necessary details (e.g., critical points) will be tallied to improve that number over time by ISMT.

1.3 Strategy

Take actions to remove or minimize risk of new species introductions or within pathways of introduction

1.3.1 Action

For some impounded waters such as Deep Creek Lake, create a watercraft inspection process that includes visual inspection, vessel movement and docking history, boat washing stations, and/or penalties for launching vessels that carry potential ANS. The creation of the watercraft inspection process will be available on-line and accompanied with education and outreach material to encourage use of the process.

1.3.2 Action

Assess existing laws and regulations to determine their adequacy for preventing introduction or spread of ANS, especially for invasive catfish, in order to provide consistent policies Bay-wide. A committee will be established to work with Maryland Sea Grant Law Clinic and University of Maryland Environmental Law Clinic and/or an intern will be hired to review proposed laws or regulation that relate to ANS and describe laws or regulation in future revisions. Meet with Natural Resources Police to ensure that existing legislation and regulation is enforceable and understandable.

1.3.3 Action

Hold stakeholder meetings to develop legislation or regulation to reduce, minimize or eliminate ANS introductions. Meet with Natural Resources Police to ensure that developing legislation and regulation is enforceable and understandable.

1.4 Strategy Identify and use existing outreach and education tools, and design and disseminate additional outreach and educational tools, as needed, to raise awareness of the consequences of ANS introduction.

1.4.1 Action

Identify or develop (when needed) education programs aimed at preventing introduction of new species using on-line materials, materials for zoos and aquariums, and guest lecturers or materials for K-12, community colleges, or 4-year universities. Where possible, the type and number of education programs identified and developed to slow spread of ANS will be determined for State partners, including programs regarding watercraft inspection. These education programs may be referenced on-line with the MDDNR ISMT website. Build relationships between MDDNR and non-profit organizations to facilitate the transfer of education or outreach materials regarding ANS.

1.4.2 Action

Create outreach and teaching materials, as necessary, in appropriate languages for targeted stakeholder groups, including fishing organizations, applicants for boating registration and fishing licenses, outdoor clubs, and corporate groups. The availability of such materials for various audiences, such as traveling exhibits, will be determined during annual MDDNR ISMT meetings to identify gaps in outreach. The distribution of these materials in the State and mid-Atlantic Region will be monitored to expand the number and distribution over time

1.4.3 Action

Develop and disseminate outreach materials for religious groups who routinely engage in "mercy releases" to educate them about the ecological and economic consequences of new species introductions and provide native alternatives. The number and diversity of products for different cultures and faith based organizations will be determined to identify existing gaps in outreach offerings.

1.5 Funding

The cost of accomplishing all proposed solutions for regulating pathways and assessing risk of introductions is estimated at $330,000/yr. Approximately 68% of these costs are associated with purchasing supplies and materials for outreach and education aimed at awareness and prevention. These supply costs could include traveling or on-loan exhibits to k-12, community colleges and 4-year universities. A smaller fraction (~ 32%) of this money is expected to be spent on staff time to implement watercraft inspection procedures, conduct research, and help establish critical control points. Most of this funding is not continuous funding, with the exception of salary for watercraft inspection personnel. There is in-kind support from the MDDNR ISMT (salary of biologists, printing costs for reports). Funding sources include the State of Maryland and ANSTF.

2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.

2.1 Strategy Compare existing databases and reporting systems to adopt a statewide database for newly introduced species.

2.1.1 Action

Identify and describe available reporting databases. At a minimum, the following databases will be reviewed by ISMT for their current and potential use: iMapInvasives (www.impainvasives.org); National Exotic Marine and Estuarine Species Information System (NEMESIS)(invasions.si.edu/nemesis); USGS Nonindigenous Aquatic Species (NAS) Database (nas.er.usgs.gov).

2.1.2 Action

Promote use of Maryland Invasive Species Tracker for observations of new species introductions. An on-line service will be identified to support statewide needs. Participation in the service will be measured as information acquired. Metrics could include number of site visits per year and number of requests (data additions, data requests) made per year.

2.1.3 Action

Periodically assess availability of new reporting databases to improve simplicity and efficacy of reporting. During review of the ANSP (see Plan Review), the availability of new reporting databases will be identified and discussed for inclusion as part of the review process.

2.1.4 Action

Develop list of taxonomic experts who will assist in identification and verification of newly discovered species, when necessary. Individuals may be added to the national ANSTF expert's database.

2.2 Strategy Engage Maryland public by establishing a citizen-science, newly introduced species detection program for targeted watersheds.

2.2.1 Action

Develop a social media platform that adheres to a high standard of professionalism to assist the public in reporting new species occurrences, responding to the public in a timely manner, and incorporating that information into national reporting databases. A social media platform such as Maryland DNR's Anglers' Log can be used to report and provide pictures of ANS (fishingreports.dnr@maryland.gov). The number of Maryland ANS reported using the social media platform can be quantified to help assess its value.

2.2.2 Action

Advertise the citizen-science program and train stewards to identify native or existing species correctly. Citizen-science programs such as the Maryland Naturalist program and Maryland's Envirothon may infuse both native species and ANS identification. Some information is available on-line via fact sheets provided on the MDDNR website. Additionally, participation in Maryland's State Fair can alsopromote awareness and identification of native species and ANS.

2.3 Strategy Establish monitoring capabilities or program within Maryland waters.

2.3.1 Action

Implement and utilize an eDNA detection system in Maryland waters for red alert or high priority species. The eDNA system will be assessed using a summary of literature reviews and results from on-going research by the University of Notre Dame.

2.3.2 Action

Develop fishery independent programs, when possible, to monitor for high priority or red alert species using aquatic surveys for plants, benthic organisms, or fishes.

2.4 Strategy Establish a Rapid Response Plan for newly introduced species, utilizing the Incident Command System structure.

2.4.1 Action

Identify relevant federal, state, regional and private organizations for an Incident Command System (see Appendix 2). The ISMT will use Appendices herein to develop a table of such organizations and the pathways for which they have responsibility. This table will be added to the ANSP.

2.4.2 Action

Utilize Rapid Response Plan for Maryland based on Smits and Moser (2009), which encourages an appropriate coordinating agency and establishes an Incident Command System team when implementing the rapid responseSeveral plans may be identified to consider responses towards specific species, habitats, or jurisdictions where the response will occur. The number of incidents within a year will be monitored over time and will be noted in future revisions of this ANSP.

2.4.3 Action

Identify funding sources for supporting rapid response activities. A list of funding sources are identified within this ANSP, but more may be identified during annual ISMT meetings. These funding sources will be amended to the Implementation Table in the

ANSP along with the action that may be addressed with the money as the ANSP is reviewed.

2.4.4 Action

Routinely train Incident Command Team members for a rapid response (see http://training/fema.gov/IS/). Positions will be identified for the rapid response plan, once adopted, by ISMT and State partners, when needed. The number of filled positions and the training of those positions will be tracked as a measure of success.

2.4.5 Action

Identify laws that require notification of ANS detection to the public, to law enforcement, and to federal authorities. A committee will be established to review proposed laws or regulations that relate to ANS, when needed.

2.5 Funding

The estimated cost for achieving these actions is $150,000/yr. Approximately 67% of this will be spent in salary. There is in-kind support by MDDNR for development of a social media platform that can be utilized by an informed public to report exotic species. This notification system could depend upon the public's knowledge of ANS, which could require funding for signs and education, or simply on the public's willingness to report an unknown species. Approximately 33% of requested funding will be spent on materials to conduct additional surveys in Maryland to monitor for high priority and red alert species. There are also numerous state and university fish/benthic surveys that may lead to detection of exotic species. Some surveys have a long history in Maryland, including: the Striped Bass Seine Survey, the Tidal Bass Survey, Maryland Biological Stream Survey, The Hart-Miller Island Exterior Monitoring Program, and Coastal Bay Program's surveys. Faculty of Maryland universities report catch results of their aquatic surveys as a condition of their scientific collection permit issued by MDDNR. There is in-kind support to initiate a Rapid Response Plan, but no funding to foster collaboration among inter-agency officials and no funding for training individuals who participate with the Incident Command Team. Potential funding sources include the State of Maryland, MAPAIS, and ANSTF.

3. Control and slow spread of existing ANS species

3.1 Strategy For high priority ANS, determine if harvest and biomass removal are effective tools to control and slow the spread of ANS.

3.1.1 Action

Conduct studies and review studies for high priority species to determine the most effective tools for removing ANS. These projects, when funded, will be evaluated by analyzing data and determining if the specific objectives of the project are met. For example, an objective may be to reduce annual biomass and the level of reduction can be determined by comparing annual estimates of biomass.

3.2 Strategy Enact statutes and regulations that criminalize, stigmatize and exact penalties for human-mediated spread of ANS.

3.2.1 Action

Implement laws that interrupt pathways of introduction that cause ANS range expansions. The Natural Resources Police report violations of laws and these violations may be categorized into those that interrupt pathways. Pathways with numerous violations may be prioritized (see also Strategy 1.2).

3.2.2 Action

Examine existing laws for considering new or revised regulations that improve control or slow spread of existing ANS by using methods employed by Environmental Law Institute and the National Sea Grant Law Clinic. A list of existing laws aimed at controlling and slowing spread of existing ANS will be created by ISMT and provided online via the MDDNR Invasive Species website.

3.2.3 Action

Develop training materials or programs for training Natural Resource Police officers in ANS identification and law. Routine engagements with law enforcement will provide current information on status of ANS. Some training information is available as fact sheets and on-line via the MDDNR Invasive Species website. These engagements will be made annually or as needed to improve training of officers. Training will be provided by appropriate staff, such as members of ISMT.

3.3 Strategy Implement removal or containment actions to control biomass or prevent natural spread

3.3.1 Action

Identify high priority ANS that can be routinely, cost-effectively, and practically lessen controlled for biomass and ecological impacts, and implement strategies that engage the public or partners in those control efforts.This ANSP provides a listing of high priority ANS and potential control methods for those species. Strategies that can be additionally used include cooperative messaging on packaging on live seafood, in pet stores, incentives such as a bait buy-back program, or harvest incentives. The use of these strategies depends on available funding and cooperation among stakeholders.

3.3.2 Action

Restore ecosystems impacted by ANS using native species, when necessary, to help produce natural communities and reduce long-term maintenance costs. Restoration with non-ANS species may be necessary to control the impact by ANS. A review of the level to which habitats can be restored from ANS impacts should be conducted to establish management targets or expectations from restoration. Research projects aimed at restoration may then be conducted with specific objectives achieved for each study.

3.3.3 Action

Report level of biomass removed to stakeholders, along with costs. Level of biomass harvested for selected high priority ANS can be reported each year on-line or in technical reports. The MDDNR Invasive Species website provides a framework for reporting actions taken to control high priority ANS.

3.4 Funding

Requested funding for accomplishing these actions is $175,000 and this funding is requested on a continuous basis to fund staffing and control mechanisms. Approximately 43% of that is requested for salary, with $50,000 requested each year. There is no dedicated financial support for biologists to slow the spread or control biomass of aquatic nuisance and well-established species. The remaining 57% of the funding is requested for supplies and material costs. However, the cost of implementing control strategies could be in the millions, depending on the species or waterway. Funding sources may include those from ANSTF, CBP, NOAA, MDSG, MAPAIS, USFWS, National Fish and Wildlife Foundation, or State of Maryland.

Implementation Table. Possible sources of funding for implementing actions in the strategy are provided along with an estimated additional cost (in parentheses). The Lead Organization (LO) is the organization with the lead responsibility for implementing the action. The Cooperating Organizations (CO) are organizations that support or are involved in the action, along with the dollar and full time equivalent position contribution given in parentheses. In cases when additional cost is listed as $0, the implementation of the action can depend on priorities of the lead organization. Federal sources of revenue include: Aquatic Nuisance Species Task Force, Mid-Atlantic Panel of Aquatic Invasive Species, the Sea Grant Law Program, National Fish and Wildlife Foundation, NOAA Maryland SeaGrant, and dedicated congressional allocations through U.S. Fish and Wildlife Service. In 2023, a Rapid Response Fund for Aquatic Invasive Species was established through U.S. Fish and Wildlife Service to quickly fund eradications.

Objective	Strategy	Action	Program Evaluation	Priority	Funding/Staff	LO	CO
1. Prevent new and additional ANS introductions to Maryland waters.	1.1 Assess relative risk of new aquatic species introductions.	1.1.1. Develop greater coordination with MAPAIS, ANSTF, and neighboring state agencies.	Develop greater coordination with federal, regional and neighboring state agencies and among Maryland universities, agencies and organizations involved with invasive species management. Use existing ANS Management Plans from neighboring states to identify lead agencies and contact information of individuals responsible for ANS management. For states without ANS Management Plans, biologists working in relevant aquatic ecosystems will be identified from collegiate contact lists and participant lists from conferences such as Northeast Association of Fish and Wildlife Agencies. Ensure representation of neighboring jurisdictions, academia, and Maryland agencies at MDDNR ISMT meetings.	HIGH	Federal ($0); Staff (2)	MDDNR	MAPAIS ANSTF
1. Prevent new and additional ANS introductions to Maryland waters.	1.1 Assess relative risk of new aquatic species introductions	1.1.2 Review and update lists of red alert and high priority species listed in Appendix 1.	The lists can be reviewed and modified at annual meetings of MDDNR ISMT, as appropriate.	LOW	Federal ($0); Staff (5)	MDDNR	
1. Prevent new and additional ANS introductions to Maryland waters.	1.1 Assess relative risk of new aquatic species introductions	1.1.3. Conduct risk assessment when new aquatic species are detected, and for red alert and high priority species listed in Appendix 1.	Risk assessments include aquatic animal risk assessment, pathogen risk assessments, STAIR, and FISK. Reviews may be performed during annual MDDNR ISMT meetings, with recommendations provided by the Chair. Risk assessments will be provided to aquaculture permitting authorities within MDDNR, when needed.	MED	Federal ($10,000), Staff (2)	MDDNR	

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
1. Prevent new and additional ANS introductions to Maryland waters.	1.1 Assess relative risk of new aquatic species introductions	1.1.4. Rank red alert and high priority species listed in Appendix 1 according to risk and generate species-specific actions for prevention or control for species with high levels of risk.	Rank red alert and high priority species listed in Appendix 1 according to risk and generate species-specific actions for prevention or control for species with high levels of risk. Of listed red alert and high priority species in Maryland, the percentage of species with existing risk assessments (www.fws.gov/fisheries/ANS/species_erss_reports.html; or elsewhere in literature) will be calculated and tracked across years. Risk assessments for some ANS may need to be conducted. Assessments will be provided on-line to the general public, Wetland, Fishing, Waterways, Aquaculture permitting and licensing authorities or other parties with interest within MDDNR or other cooperating agencies, when needed.	LOW	Federal ANSTF ($15,000-salary); Staff (2)	MDDNR	USGS
1. Prevent new and additional ANS introductions to Maryland waters.	1.1 Assess relative risk of new aquatic species introductions	1.1.5 Manage online availability of species list, and support cross-use of risk assessments across state partner websites.	Develop a distribution list of State partners with ANS information websites. Provide webmasters with risk assessments and rankings of species for on-line distribution.	LOW	Federal ($0); Staff (1)	MDDNR	USGS NAS MPA
1. Prevent new and additional ANS introductions to Maryland waters.	1.2 Analyze and assess risk of vector pathways of introduction.	1.2.1 Use NISC/ANSTF pathway analysis and ranking system to rank and determine the relative risk of ANS introduction through known vector pathways.	The ISMT will coordinate the use of or use procedures developed by NISC and ANSTF to rank pathways (Orr et al. 2005).	HIGH	Federal ($5000); Staff (1)	MDDNR	USGS NAS

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
1. Prevent new and additional ANS introductions to Maryland waters.	1.2 Analyze and assess risk of vector pathways of introduction.	1.2.2 As new information becomes available, review and update pathway rankings.	With annual meetings of ISMT and as the ANSP is reviewed (see Plan Review), the rankings of pathways will be updated based upon information learned from the NISC/ANSTF pathway analysis and ranking system.	MED	Federal ($0); Staff (5)	MDDNR	
1. Prevent new and additional ANS introductions to Maryland waters.	1.2 Analyze and assess risk of vector pathways of introduction.	1.2.3 Establish online availability of vector pathway list and rankings.	Develop a distribution list of State partners with ANS information websites and distribute vector pathway list and rankings to webmasters.	MED	Federal ($0); Staff (2)	MDDNR	MDDNR (1 staff) MPA
1. Prevent new and additional ANS introductions to Maryland waters.	1.2 Analyze and assess risk of vector pathways of introduction.	1.2.4 Support research to identify critical control points for priority vector pathways by identifying: 1) stakeholders, including a list of wholesale and retail distributors of live animals; 2) socioeconomic and cultural barriers to interruption of vector pathways; and 3) species of greatest risk or concern.	The number of pathways identified in the ANSP with the necessary details (i.e., critical points, stakeholders, barriers, high priority or red alert species) will be tallied to improve that number over time by ISMT.	HIGH	Federal ($30,000); Staff (2)	MDDNR	
1. Prevent new and additional ANS introductions to Maryland waters.	1.3 Take actions to remove or minimize risk of new species introductions or within pathways of introduction.	1.3.1 For some impounded waters such as Deep Creek Lake, create a watercraft inspection process that includes visual inspection, vessel movement and docking history, boat washing stations, and/or penalties for launching vessels that carry potential ANS.	The creation and implementation of the watercraft inspection process will be available on-line and accompanied with on-the-ground efforts to help clean vessels.	LOW	Federal ($50,000); Staff (3)	MDDNR	

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
1. Prevent new and additional ANS introductions to Maryland waters.	1.3 Take actions to remove or minimize risk of new species introductions or within pathways of introduction.	1.3.2 Assess existing laws and regulations to determine their adequacy for preventing introduction or spread of ANS, especially for invasive catfish, in order to provide more consistent policies Bay-wide.	A committee will be established to work with Maryland Sea Grant Law Clinic and University of Maryland Environmental Law Clinic, and/or an intern will be hired to review proposed laws or regulation that relate to ANS and describe laws or regulation in future revisions. Meet with Natural Resources Police to ensure that existing legislation and regulation is enforceable and understandable.	HIGH	Federal ($5000); Staff (1)	MDDNR	ICTF MDSG UM
1. Prevent new and additional ANS introductions to Maryland waters.	1.3 Take actions to remove or minimize risk of new species introductions or within pathways of introduction.	1.3.3 Develop legislation or regulation to reduce, minimize or eliminate ANS introductions.	Meet with Natural Resources Police to ensure that developing legislation and regulation is enforceable and understandable.	MED	Federal ($0); Staff (2)	MDDNR	
1. Prevent new and additional ANS introductions to Maryland waters.	1.4 Identify and use existing outreach and education tools, and design and disseminate additional outreach and educational tools, as needed, to raise awareness of the consequences of ANS introduction.	1.4.1 Identify or develop education programs (when needed) aimed at preventing introduction of new species using on-line materials, materials for zoos and aquariums, and guest lecturers or materials for K-12, community colleges, or 4-year universities.	Where possible, the type and number of education programs identified and developed to slow spread of ANS will be determined for State partners, including programs regarding watercraft inspection. These education programs may be referenced on-line with the MDDNR ISMT website. Build relationships between MDDNR and non-profit organizations to facilitate the transfer of education or outreach materials regarding ANS.	MED	Federal ($30,000); Staff (5)	MDDNR	MDDNR (1 staff), ICTF CBP MPA

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
1. Prevent new and additional ANS introductions to Maryland waters.	1.4 Identify and use existing outreach and education tools, and design and disseminate additional outreach and educational tools, as needed, to raise awareness of the consequences of ANS introduction.	1.4.2 Create outreach and teaching materials, as necessary, in appropriate languages for targeted stakeholder groups, including fishing organizations, applicants for boating registration and fishing licenses, outdoor clubs, and corporate groups; provide materials via world wide web as, http://dnr2.maryland.gov/ccs/Pages/InvasivePlantControl.aspx or http://dnr2.maryland.gov/invasives/Pages/default.aspx.	The availability of outreach and teaching materials, such as traveling exhibits, for various audiences will be determined during annual MDDNR ISMT meetings to identify gaps in outreach. The distribution of these materials in the State and mid-Atlantic Region will be monitored to expand the number and distribution over time	HIGH	Federal ($100,000); Staff (5)	MDDNR	MDDNR (1 staff) ICTF CBP MAPAIS MPA
1. Prevent new and additional ANS introductions to Maryland waters.	1.4 Identify and use existing outreach and education tools, and design and disseminate additional outreach and educational tools, as needed, to raise awareness of the consequences of ANS introduction.	1.4.3 Develop and disseminate outreach materials for religious groups who routinely engage in "mercy releases" to educate them about the ecological and economic consequences of new species introductions and provide native alternatives.	The number and diversity of products for different cultures and faith based organizations will be determined to identify existing gaps in outreach offerings.	LOW	Federal ($25,000); staff (1)	MDDNR	MDDNR (1 staff)

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.1 Compare existing databases and reporting systems to adopt a statewide database for newly introduced species.	2.1.1 Identify and describe available reporting databases.	At a minimum, the following databases will be reviewed by ISMT for their current and potential use: iMapInvasives (www.impainvasives.org); National Exotic Marine and Estuarine Species Information System (NEMESIS)(invasions.si.edu/nemesis); USGS Nonindigenous Aquatic Species (NAS) Database (nas.er.usgs.gov).	LOW	Federal ($0); Staff (1)	MDDNR	USGS NAS
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.1 Compare existing databases and reporting systems to adopt a statewide database for newly introduced species.	2.1.2 Promote use of Maryland Invasive Species Tracker for observations of new species introductions	An on-line service will be identified to support statewide needs. Participation in the service will be measured as information acquired. Metrics could include number of site visits per year and number of requests (data additions, data requests) made per year.	MED	Federal ($0); Staff (1)	MDDNR	USGS NAS
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.1 Compare existing databases and reporting systems to adopt a statewide database for newly introduced species.	2.1.3 Periodically assess availability of new reporting databases to improve simplicity and efficacy of reporting.	During review of the ANSP (see Plan Review), the availability of new reporting databases will be identified and discussed for inclusion as part of the review process	LOW	Federal ($0); Staff (1)	MDDNR	USGS NAS

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.1 Compare existing databases and reporting systems to adopt a statewide database for newly introduced species.	2.1.4 Develop list of taxonomic experts who will assist identification of verification of newly discovered species, when necessary.	A list of taxonomic experts will be developed for the fields of freshwater plants, freshwater animals, and marine animals and plants. Individuals may be added to the national ANSTF experts database.	LOW	Federal ($0); Staff (2)	MDDNR	
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.2 Engage Maryland public by establishing a citizen-science, newly introduced species detection program for targeted watersheds.	2.2.1 Develop a social media platform that adheres to a high standard of professionalism to assist the public in reporting new species occurrences, responding to the public in a timely manner, and incorporating that information into national reporting databases.	A social media platform such as Maryland DNR's Anglers' Log can be used to report and provide pictures of ANS,fishingreports.dnr@maryland.gov. The number of Maryland ANS reported using the social media platform can be quantified to help assess its value.	LOW	Federal ($15,000); Staff (1)	MDDNR	MDE MPA
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.2 Engage Maryland public by establishing a citizen-science, newly introduced species detection program for targeted watersheds.	2.2.2 Advertise the citizen-science program and train stewards to identify native or existing species correctly.	Citizen-science programs such as the Maryland Naturalist program and Maryland's Envirothon include both native species and ANS identification. Some information is available online via fact sheets provided on the MDDNR website. Additionally, participation in Maryland's State Fair can also promote awareness and identification of native species and ANS.	LOW	Federal ($0); Staff (1)	MDDNR	MDE MPA

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.3 Establish monitoring capabilities or program within Maryland waters.	2.3.1 Implement and utilize an eDNA detection system in Maryland waters for red alert or high priority species.	The eDNA system will be assessed using a summary of literature reviews and results from on-going research by University of Notre Dame.	MED	Federal ($30,000); Staff (3)	MDDNR	MDE
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.3 Establish monitoring capabilities or program within Maryland waters.	2.3.2 Develop fishery independent programs, when possible, to monitor for high priority or red alert species using aquatic surveys for plants, benthic organisms, or fishes.	Identify existing survey programs that monitor Maryland waters and may capture high priority or red alert species; and, develop new surveys to help monitor for high priority or red alert species.	MED	Federal ($100,000-); Staff (3)	MDDNR	ICTF
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.4 Establish a Rapid Response Plan for newly introduced species, utilizing the Incident Command System structure.	2.4.1 Identify relevant federal, state, regional and private groups for Incident Command System (FEMA: www.fema.gov/national-incident-management-system/incident-command-system-resources).	The ISMT will use Appendices herein to develop a table of such organizations and the pathways for which they have responsibility. This table will be amended to the ANSP.	LOW	Federal ($0); Staff (1)	MDDNR	MDE

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.4 Establish a Rapid Response Plan for newly introduced species, utilizing the Incident Command System structure.	2.4.2 Utilize Rapid Response Plan for Maryland based on Smits and Moser (2009), which encourages an appropriate coordinating agency and establishes an Incident Command System team when implementing the rapid response.	The number of incidents within a year will be monitored over time and will be noted in future revisions of this ANSP. Several plans may be identified to consider responses towards specific species, habitats, or jurisdictions where the response will occur.	LOW	Federal ($0); Staff (1)	MDSG	MDE
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.4 Establish a Rapid Response Plan for newly introduced species, utilizing the Incident Command System structure.	2.4.3 Identify funding sources for supporting rapid response activities.	A list of potential funding sources are identified within this ANSP, but more may be identified during annual ISMT meetings. These funding sources will be amended to the Implementation Table in the ANSP along with the action that may be addressed with the money as the ANSP is reviewed.	LOW	Federal ($0); Staff (1)	MDDNR	USFWS
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.4 Establish a Rapid Response Plan for newly introduced species, utilizing the Incident Command System structure.	2.4.4 Routinely train Incident Command Team members for a rapid response .	Positions will be identified for the rapid response plan, once adopted, by ISMT and State partners, when needed. The number of filled positions and the training of those positions will be tracked as a measure of success.	MED	Federal ($15,000); Staff (5)	MDSG	MDDNR
2. Establish an early detection and rapid response mechanism to find, contain, and/or eradicate newly introduced species.	2.4 Establish a Rapid Response Plan for newly introduced species, utilizing the Incident Command System structure.	2.4.5 Identify laws that require notification of ANS detection to the public, to law enforcement, and to federal authorities.	A committee will be established to review proposed laws or regulation that relate to ANS, when needed.	LOW	Federal ($0); Staff (3)	MDDNR	

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
3. Control and slow spread of existing ANS species	3.1 For high priority ANS, determine if harvest and biomass removal are effective tools to control and slow the spread of ANS.	3.1.1 Conduct studies and review studies for high priority species to determine the most effective tools for removing ANS.	These projects, when funded, will be evaluated by analyzing data and determining if the specific objectives of the project are met. These projects may include examining basic biological processes that affect populations, such as individual growth, mortality, and recruitment, and examining basic ecological factors that contribute to natural range expansion.	HIGH	Federal ($100,000); Staff (3, min)	MDDNR	ICTF
3. Control and slow spread of existing ANS species	3.2 Enact statutes and regulations that criminalize, stigmatize and exact penalties for human-mediated spread of ANS.	3.2.1 Implement laws that interrupt pathways of introduction that cause ANS range expansions.	The Natural Resources Police report violations of laws and these violations may be categorized into those that interrupt pathways. Pathways with numerous violations may be prioritized (see also Strategy 1.2).	MED	Federal ($0); Staff (many)	MDDNR	ICTF
3. Control and slow spread of existing ANS species	3.2 Enact statutes and regulations that criminalize, stigmatize and exact penalties for human-mediated spread of ANS.	3.2.2 Examine existing laws for considering new or revised regulations that improve control or slow spread of existing ANS by using methods employed by Environmental Law Institute and National Sea Grant Law Clinic.	A list of existing laws aimed at controlling and slowing spread of existing ANS will be created by ISMT and provided online via the MDDNR Invasive Species website.	MED	Federal($5000); Staff (10)	MDDNR	ICTF

Objective	Strategy	Action	Program Evaluation	Priority	Funding	LO	CO
3. Control and slow spread of existing ANS species	3.2 Enact statutes and regulations that criminalize, stigmatize and exact penalties for human-mediated spread of ANS.	3.2.3 Develop training materials or programs for training Natural Resource Police officers in ANS identification and law.	Routine engagements with law enforcement will provide current information on status of ANS. Some training information is available as fact sheets and on-line via the MDDNR Invasive Species website. These engagements will be made annually or as needed to improve training of officers. Training will be provided by appropriate staff, such as members of ISMT.	MED	Federal ($15,000); Staff (2)	MDDNR	MDDNR
3. Control and slow spread of existing ANS species	3.3 Implement removal or containment actions to control biomass or prevent natural spread.	3.3.1 Establish programs or projects for high priority ANS that routinely, cost-effectively, and practically lessen biomass and ecological impacts, and implement strategies that engage the public or partners in those control efforts.	This ANSP provides a listing of high priority ANS and potential control methods for those species. Strategies that can be additionally used include cooperative messaging on packaging on live seafood, in pet stores, incentives such as a bait buy-back program, or harvest incentives. The use of these strategies depends on available funding and cooperation among stakeholders.	HIGH	Federal ($5,000); Staff (5)	MDDNR	ICTF
3. Control and slow spread of existing ANS species	3.3 Implement removal or containment actions to control biomass or prevent natural spread.	3.3.2 Restore ecosystems impacted by ANS using native species, when necessary, to help produce natural communities and reduce long-term maintenance costs.	Restoration with non-ANS species may be necessary to control the impact by ANS. A review of the level to which habitats can be restored from ANS impacts should be conducted to establish management targets or expectations from restoration. Research projects aimed at restoration may then be conducted with specific objectives achieved for each study.	MED	Federal ($50,000); Staff (many)	MDDNR	MPA
3. Control and slow spread of existing ANS species	3.3 Implement removal or containment actions to control biomass or prevent natural spread.	3.3.3 Report level of biomass removed to stakeholders, along with costs.	Level of biomass harvested for selected high priority ANS can be reported each year on-line or in technical reports. The MDDNR Invasive Species website provides a framework for reporting actions taken to control high priority ANS.	LOW	Federal ($0); Staff (2)	MDDNR	MPA

PRIORITIES FOR ACTION

There are 35 actions that have been identified to fully implement the ANSP. With current funding, it will not be possible to implement all of these actions within a 5-year span of reviewing this plan. Therefore 7 actions were prioritized below based upon their cost and necessity. All actions are considered to be very important and do not appear in priority order below.

1. Develop greater coordination with neighboring state agencies and Maryland agencies
2. invested in invasive species management.
3. Create outreach and teaching materials, as necessary, in appropriate languages for
4. targeted stakeholder groups.
5. Use NISC/ANSTF pathway analysis and ranking system to rank and determine the relative risk of ANS introduction through known vector pathways.
6. Support research to identify critical control points for priority vector pathways by identifying: 1) stakeholders, including a list of wholesale and retail distributors of live animals; 2) socioeconomic and cultural barriers to interruption of vector pathways; and 3) species of greatest risk or concern.
7. Assess existing laws and regulations to determine their adequacy for preventing introduction or spread of ANS.
8. Conduct studies and review studies for high priority species to determine the most effective tools for removing ANS.
9. Establish programs and projects for high priority ANS that can be routinely, cost-effectively, and practically lessen biomass and ecological impacts and implement strategies that engage the public or partners in those control efforts.

PLAN REVIEW

Periodic review of the ANSP will be the responsibility of MDDNR. The breadth and experience of MDDNR in partnership with existing authorities given in Appendix 2 will identify progress toward actions identified in the implementation table. Progress toward actions is measurable and described in the Program Evaluation section of the Implementation Table. The ANSP was last revised by ISMT and approved by ANSTF in June 2024 (APPENDIX 5). Implementing this ANSP will require progress toward all actions, though not all actions will have measurable or successful outcomes.

In most cases the implementation of actions depends on available funding and staffing. Funding from State and Federal sources depends on budgets created by legislatures whose priorities may be different than those expressed in this ANSP. In cases when additional cost is listed as $0, the implementation of the action can depend on priorities of the lead organization. While additional money may not be needed to implement the action, priorities for staff time may be different than those expressed in this ANSP. When funding and staffing is sufficiently available, the success of projects aimed at controlling biomass or impacts by ANS also depends on the habitat or environmental factors. The ability to remove biomass of ANS or to minimize impacts and spread of ANS can depend on weather, flooding, water temperatures, and access to areas by humans. While successful implementation of action items is challenging, progress over time will be noted within the framework of the ANSP review, which is a transparent evolution of work toward achieving objectives and maximizing success of reaching goals set herein.

Measurable output from the Program Evaluation will be included in future reviews of the ANSP. Significant revisions will be added to the course of plan development in Appendix 3. If required, public comments regarding actions or revisions will be appended to Appendix 4. Considerations for review and revision will address:

- Updating the Implementation Table with achieved or partially achieved actions within objective.
- Noting new vector pathways
- Noting new efforts to prevent introductions using decontamination or other methods
- Noting the number of new introductions
- Updating the list of known ANS in Maryland (see Appendix 3) with total acreage of habitat occupied by the ANS in Maryland (or a specified subwatershed); and/or the relative abundance index or abundance or ranked abundance of the ANS in Maryland (or a specified subwatershed)
- Noting whether or not ANS has led to a listing of native species as a Federal and/or State species in need of conservation.
- Noting whether natural, climatic ecosystem changes have reduced effectiveness of management actions.
- Revising gaps and challenges in regional, State, or Federal regulations related to ANS management

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Maryland Aquatic Nuisance Species Management Plan

APPENDICES

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Appendix 1. AQUATIC NUISANCE SPECIES

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Table 1. Ranking Aquatic Species as ANS

Non-native species that may be or are currently distributed in Maryland because of direct or indirect introductions by humans. This list was developed by the Maryland Invasive Species Matrix Team based upon current concern or work with aquatic nuisance species (ANS) in Maryland, management plans for the Chesapeake Bay watershed, and information provided by Maryland Department of Natural Resources, Maryland Sea Grant, and Smithsonian Environmental Research Center. This is an incomplete list and will be updated with new information as it becomes available. A rank prioritizes each species for its level of concern: Red Alert (RED), High (HIGH), Low (LOW), Unknown (UNK). Species ranked as high priority or red alert are considered ANS. i = introduction, not established; e = established population; nr = not reported in Maryland. Data updated at: http://dnr.state.md.us/invasives.

Scientific Name	Common Name	Status	Rank
AQUATIC & WETLAND MACROPHYTES			
Aldrovanda vesiculosa	waterwheel	nr	RED
Butomus umbellatus	flowering rush	i	LOW
Cabomba caroliniana	fanwort	i	LOW
Callitriche stagnalis	pond water-starwort	i	LOW
Egeria densa	Brazilian elodea	e	HIGH
Eichhornia crassipes	common water-hyacinth	e	LOW
Glyceria maxima	English water grass	nr	RED
Hydrilla verticillata	Hydrilla	e	HIGH
Hydrocharis morsus-ranae	European frog-bit	nr	RED
Hygrophila polysperma	East Indian hygrophila	nr	RED
Iris pseudacorus	yellow iris	e	HIGH
Lythrum salacaria and cultivars	purple loosestrife	e	HIGH
Marsilea quadrifolia	European waterclover	i	LOW
Murdannia keisak	marsh dayflower	e	HIGH
Myriophyllum aquaticum	parrot feather	e	HIGH
Myriophyllum heterophyllum	variable milfoil	i	LOW
Myriophyllum spicatum	Eurasian milfoil	e	HIGH
Najas minor	European naiad	i	LOW
Nymphoides peltata	yellow floating-heart	nr	RED
Phragmitis australis	common reed	e	HIGH
Pistia stratiotes	water lettuce	i	LOW
Nasturtium microphylla	onerow yellowcress	i	LOW
Nasturtium officianale	watercress	i	LOW
Salvinia molesta	giant salvinia	nr	RED
Trapa natans	Eurasian water chestnut	e	HIGH
Trapa bispinosa	two-horned water chestnut	e	HIGH

ALGAE

Caulerpa taxifolia	caulerpa	n	LOW
Didymosphenia geminata	didymo	e	HIGH

FISH

Aplodinotus grunniens	*freshwater drum*	*i*	*LOW*
Astronotus ocellatus	oscar	i	LOW
Channa argus	northern snakehead	e	HIGH
Channa micropeltes	giant snakehead	i	LOW
Cichla ocellaris	butterfly peacock bass	i	LOW
Clarius batrachus	walking catfish	nr	LOW
Coregonas artedi	cisco	i	LOW
Ctenopharyngodon idella	grass carp	i	LOW
Cyprinus auratus	goldfish	e	LOW
Cyprinus carpio	common carp	e	LOW
Esox lucius x *masquinongy*	tiger muskellunge	i	LOW
Esox lucius	northern pike	e	LOW
Esox masquinongy	muskellunge	i	LOW
Ethoestoma zonale	banded darter	e	LOW
Hiodon tergisus	mooneye	i	LOW
Hypophthalmichthys molitrix	silver carp	nr	RED
Hypophthalmichthys nobilis	bighead carp	nr	RED
Ictalurus furcatus	blue catfish	e	HIGH
Ictalurus punctatus	channel catfish	e	LOW
Lepomis macrochirus	bluegill	e	LOW
Lepomis megalotis	longear sunfish	e	LOW
Lepomis microlophus	redear sunfish	e	LOW
Leuciscus idus	orfe	e	LOW
Micropterus dolomieu	smallmouth bass	e	UNK
Micropterus salmoides	largemouth bass	e	LOW
Micropterus hensalli	Alabama bass	nr	RED
Misgurnus spp.	weatherfish	e	UNK
Amphipnous albus; *A. cuchia*	Family Synbranchidae	i	RED
Morone chrysops x *saxatilis*	wiper	i	LOW
Morone chrysops	white bass	i	LOW
Mylopharyngodon piceus	black carp	i	UNK
Neogobius melanostomus	round goby	nr	RED
Notropis atherinoides	emerald shiner	e	LOW
Notropis volucellus	mimic shiner	e	LOW
Oncorhynchus clarkia behnkei	snakeriver cutthroat trout	i	LOW
Oncorhynchus clarkia	cutthroat trout	i	LOW
Oncorhynchus gorbuscha	pink salmon	i	LOW
Oncorhynchus kisutch	coho salmon	i	LOW

Oncorhynchus mykiss	rainbow trout	e	LOW
Oncorhynchus tshawytscha	chinook salmon	i	LOW
Osmerus mordax	rainbow smelt	i	LOW
Piractus brachypomus	pacu	i	LOW
Pomoxis annularis	white crappie	e	LOW
Proterothinus marmoratus	tubenose goby	i	LOW
Pterois voltans	lionfish	nr	RED
Pterois miles	lionfish	nr	RED
Pylodictus olivaris	flathead catfish	e	HIGH
Pygocentrus spp.; *Serrasalmus* spp.	piranha	i	LOW
Salmo salar	Atlantic salmon	i	LOW
Salmo trutta	brown trout	e	LOW
Salvelinus fontinalis x namaycush	splake	i	LOW
Salvelinus namacush	lake trout	i	LOW
Scardinius erythrophthalmus	rudd	i	LOW
Tinca tinca	tench	e	LOW

MOLLUSCS

Bellamya chinesis	Chinese mystery snail	e	UNK
Crassostrea gigas	Pacific oyster L**	i	UNK
Dreissena bugensis	quagga mussel	nr	UNK
Dreissena polymorpha	zebra mussel	e	HIGH
Potamophygrus antipodarum	New Zealand mud snail	nr	HIGH
Rapana venosa	veined rapa whelk	nr	UNK

CRUSTACEANS

Bythotrephes cederstoemi	spiny waterflea	nr	UNK
Cambarus thomai	little brown mudbug	e	LOW
Carcinus maenas	green crab	e	HIGH
Cercopagis pengoi	fishhook waterflea	i	UNK
Cherax spp.	Australian crayfish	nr	UNK
Daphnia lumholtzi	Daphnia	nr	UNK
Eriocheir sinensis	Chinese mitten crab	e	HIGH
Hemigrapsus sanguineus	Japanese shore crab	e	HIGH
Mysis relicta	opossum shrimp	i	LOW
Orconectes rusticus	rusty crayfish	e	HIGH
Orconectes virilis	virile crayfish	e	HIGH
Procambrus clarkii	red swamp crawfish	e	HIGH
Tachypleus spp.	Asian horseshoe crab	i	RED

FISH PATHOGENS

Bothriocephalus acheilognathi	Asian tapeworm	e	LOW
Myxobolus cerebralis	whirling disease	i	HIGH

Proteocephalus ambloplitis	bass tapeworm	e	LOW
Viral Hemorrhagic Septicemia	VHS	nr	UNK
REPTILIA			
Trachemys scrypta elegans	red eared slider turtle	e	LOW
Trachemys scripta scripta	yellow-bellied slider	e	LOW
Graptemys pseudogeographica	false map turtle	e	LOW
AVES			
Cygnus olor	mute swan	e	HIGH
MAMMALS			
Myocaster coypus	nutria	e	HIGH

Table 2. Additional Introduced Species (NEMESIS)

Invertebrate species tabled here are in addition to those of Table 1 and are established introduced species in Chesapeake Bay watershed, as listed in the National Exotic Marine and Estuarine Species Information System (NEMESIS). The database NEMESIS was developed by Smithsonian Environmental Research Center (SERC) as a national database of marine and estuarine invasions of the continental United States and Alaska. These invertebrates are not currently ranked as ANS in Maryland in Table 1 because more research is needed to reach consensus regarding their threat to aquatic resources in Maryland. In time as research is conducted and consensus reached regarding their threat in Maryland, these species may be ranked on the list of ANS in Maryland. Vectors are: A (Accidental, fisheries); B (Ballast, water or dry); C (Canal); D (Discard bait); I (Intentional, fisheries); N (Natural dispersal); S (Ship cargo or fouling); T (Trade, packing or plant shipments or pet releases).

Scientific Name	Phylum	Year Found	Vector(s)
ALGAE			
Bonnemaisonia hamifera	Rhodophycota	1967	B; S
Codium fragile	Chlorophycota	1995	S
Coscinodiscus wailesii	Bacillariophyta	1961	B
Cylindrospermopsis raciborski	Cyanophycota	2006	A; B; N; T
Gracilaria vermiculophylla	Rhodophycota	2005	B; S
Neosiphonia harveyi	Rhodophycota	1957	B; S
Odontella sinesis	Bacillariophyta	1960	B
Thalassiosira punctigera	Bacillariophyta	1988	B
MOLLUSCANS			
Bellamya japonica	Mollusca - Gastropods	2007	A; T
Bithynia tentaculata	Mollusca - Gastropods	1927	A; B; S; T
Corbicula fluminea	Mollusca - Bivalve	1971	A; C; D; I; T
Cyrenoida floridana	Mollusca - Bivalve	1952	B; C
Dreissena polymorpha	Mollusca - Bivalve	2008	A; N
Myosotella myosotis	Mollusca - Gastropods	1900	B; S
Rangea cuneata	Mollusca - Bivalve	1963	A; B; C
Rapana venosa	Mollusca - Gastropods	1998	B; S
Teredo navalis	Mollusca - Bivalve	1924	B; S
Viviparus georgianus	Mollusca - Gastropods	1901	T
CRUSTACEANS			
Amphibalanus amphitrite	Arthropoda - Barnacles	1967	A; B; S
Hourstonius spp.	Artrhopoda - Amphipods	1994	B; S
Ligia exotica	Arthorpoda - Isopods	2002	B; S

Loxothylacus panopaei	Arthropoda - Barnacles	1964	A
Microdeutopus gryllotalpa	Arthropoda - Amphipods	1994	B; S
Stenothoe gallensis	Arthropoda - Amphipods	NA	B; S
Synidotea laticauda	Arthropoda - Isopods	2002	B; S

OTHER INVERTEBRATES

Anisolabis martima	Arthropoda - Insects	1916	B; S
Anguillicoloides crassus	Nemata - Nematodes	1997	A; B
Barentsia benedeni	Entoprocta - Entoprocts	1995	S
Blackfordia virginica	Cnidaria - Hydrozoans	1904	B; S
Boccardiella ligericai	Annelida - Polychaetes	1990	B
Botrylloides violaceus	Chordata - Tunicates	2000	S
Brachydeutera longipes	Arthropoda - Insects	1983	B; S; T
Branchiura sowerbyi	Annelida - Oligochaetes	1957	A; B; T
Bugula neritina	Ectoprocta - Bryozoans	2000	S
Cambarincola pamelae	Annelida - Oligochaetes	2003	A; T
Chaetocoocus phragmitis	Arthropoda - Insects	1983	B; S; T
Cordylophora caspia	Cnidaria - Hydrozoans	1877	S
Diadumene lineata	Cnidaria - Anthozoans	1929	S
Diplosoma listerianum	Chordata - Tunicates	2001	S
Ficopomatus enigmaticus	Annelida - Polychaetes	1994	B; S
Galerucella calmariensis	Arthropoda - Insects	1992	I
Galerucella pusilla	Arthropoda - Insects	1992	I
Garveia franciscana	Cnidaria - Hydrozoans	1946	S
Gyrodactylus anguillae	Platyhelminthes - Flatworms	1999	A; B
Haplosporidium nelsoni	Protozoa - Protozoans	1959	A; B; S
Hippoporina indica	Ectoprocta - Bryozoans	2001	S
Holocranum saturejae	Arthropoda - Insects	1995	B; S; T
Lasioptera hungarica	Arthropoda - Insects	2000	B; S
Lipara rufitarsis	Arthropoda - Insects	2000	B; S; T
Lophopodella carteri	Ectoprocta - Bryozoans	1973	A; D; S
Loxosomatoides laevis	Entoprocta - Entoprocta	1995	S
Maeotias marginata	Cnidaria - Hydrozoans	1968	B; S
Moerisia lyonsi	Cnidaria - Hydrozoans	1965	B; S
Nacerdes melanura	Arthropoda - Insects	1902	S
Pseudodactylogyrus anguillae	Platyhelminthes - Flatworms	1999	A; B
Sclerocona acutella	Arthropoda - Insects	1998	B; S; T
Stylea plicata	Chordata - Tunicates	2002	S
Styela canopus	Chordata - Tunicates	2000	S
Tetramesa phragmitis	Arthropoda - Insects	2000	B; S; T

Appendix 2. EXISTING AUTHORITIES AND PROGRAMS

Maryland waters include streams and non-natural lakes and impoundments. These waterways are shared jurisdictionally with several mid-Atlantic states (Virginia, District of Columbia, Delaware, West Virginia, Pennsylvania, New York, New Jersey). Because of the importance of Maryland's waterways to several states, there are numerous federal, regional, and statewide agencies that govern use, access, and management of the waterways. The following summarizes the role of agencies, programs, and regulations.

Federal Authorities

Federal Executive Order 13112 enacted February 13, 1999, by the President of the United States, directs all federal government agencies to prevent the introduction of invasive species, to provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause. The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental impacts of their proposed actions and reasonable alternatives to those actions. Rapid response efforts for aquatic invasive species may require completion of the NEPA process if those efforts significantly impact the environment. The process consists of an evaluation of the environmental effects of a federal undertaking including its alternatives. There are three levels of analysis depending on whether or not an undertaking could significantly affect the environment. These three levels include: categorical exclusion determination; preparation of an Environmental Assessment/Finding of No Significant Impact (EA/FONSI); and preparation of an Environmental Impact Statement (EIS) (EPA 2007).

United States Coast Guard (USCG)—The USCG enforces federal law relating to invasive species and its maritime jurisdiction (i.e. Ballast Water Management, CFR, Title 46, Subpart 162, 16 U.S.C. 4711). The Marine Environmental Protection program develops and enforces regulations to avert the introduction of invasive species into the maritime environment.

National Oceanographic and Atmospheric Administration (NOAA)—The NOAA operates under most of the same invasive species Acts as USFWS (DOI). Under the Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990 (reauthorized in 1996 by the National Invasive Species Act (NISA)), the National Oceanic Atmospheric Administration (NOAA) has responsibility for prevention, monitoring, control, education, and research to prevent future introductions and the spread of aquatic invasive species.

Examples include:

- Support invasive species research in response to local, state, and regional issues that are determined by their own local and regional stakeholders through regular strategic planning.
- Provide training and technical assistance to assist natural resource managers respond to current invasions or prevent future invasions in a cost-effective way

- Provide management support through Endangered Species Act (ESA) consultations, permit reviews/evaluations, and policy development.
- Address invasive species threats to the persistence of trust resources such as threatened and endangered species, marine mammals, and fisheries.
- Support and provide technical expertise for habitat restoration projects across the nation that remove and control of invasive species.
- Sea Grant base funding supports research, outreach and education to prevent and control aquatic invasive species, including invasive tunicates on the NE and NW coasts, Asian carp threats to the Great Lakes, ballast water technology development, and zebra/quagga mussels.
- National Marine Sanctuaries perform inspections of inbound vessels and conduct monitoring and removal efforts.

NOAA provides staff support for engagement and activities related to its leadership role as the co-chair of both the National Invasive Species Council (representing Department of Commerce) and the Aquatic Nuisance Species Task Force, two interagency organizations that coordinate and ensure complementary, cost-efficient and effective Federal activities regarding invasive species.

United States Army Corps of Engineers (USACE)—The Clean Water Act Section 404 establishes a program to regulate the discharge of dredge and fill material into United States waters, including wetlands (33 U.S.C. § 1344). Responsibility for administering and enforcing Section 404 is shared by the USACE and Environmental Protection Agency (EPA). It is possible that some mechanical or physical ANS rapid response control methods, such as the mechanized clearing of riparian areas to remove ANS, or dumping of fill material to smother ANS, might require Federal or state Section 404 permits (only New Jersey and Michigan have state 404 permits). The EPA and USACE regard the use of mechanized earth-moving equipment to conduct activities in United States waters (e.g., land clearing, ditching, channelization, and in-stream mining) as regulated discharge of dredged or fill material under Section 404 unless project-specific evidence shows otherwise. Natural resource managers should consult the appropriate USACE District office when planning ANS rapid response or control action to determine if these actions require a Federal Section 404 permit.

United States Fish and Wildlife Service (USFWS)— The mission of the U.S. Fish and Wildlife Service is to work with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Because of their responsibilities, the Service is very concerned about the impacts that invasive species are having across the Nation. The U.S. Fish and Wildlife Service addresses invasive species issues through a variety of programs and partnerships. The Service's Invasive Species efforts take proactive approaches to address intentional and

unintentional introductions, combat the spread of existing invaders on and off Service lands, and maintain the Service as a leader in invasive species prevention and control.

Fisheries and Aquatic Conservation

The U.S. Fish and Wildlife Service's Aquatic Invasive Species Program is housed within the Fisheries and Habitat Conservation Program's Division of Fisheries and Aquatic Conservation. The Branch of Aquatic Invasive Species essentially houses three functions:

- The FWS Aquatic Invasive Species Program – The AIS Program seeks to prevent the introduction and spread of AIS, rapidly respond to new invasions, monitor the distribution of and control established invaders, and foster responsible conservation behaviors through its national public awareness campaigns (Stop Aquatic Hitchhikers and Habitattitude).
- Administration of Aquatic Nuisance Species Task Force – The Branch of AIS builds capacity, coordinates, and implements AIS prevention and control activities authorized under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA, as amended by the National Invasive Species Act (NISA) of 1996), including: co-chairing and administering the ANSTF, supporting Regional Panels, providing grants for State/Interstate ANS Management Plans, and implementing a National AIS program.
- Injurious Wildlife Evaluations and Listing**s** – The AIS Program supports the Injurious Wildlife Provisions of the Lacey Act through an ongoing process of evaluating species and possibly listing them as injurious through the rulemaking process.

The AIS Program has worked to prevent populations of invasive species from entering or spreading into the United States. Priority containment (boat inspection and decontamination), early detection and rapid response (snakehead eradication and Chicago Sanitary Shipping Canal), interjurisdictional coordination and planning (Quagga/Zebra Mussel Action Plan and 100th Meridian), and regulatory (injurious wildlife listing of black and silver Asian carp) and non-regulatory actions (Stop Aquatic Hitchhikers!) have occurred across many jurisdictions. Through the actions of the AIS program, a national AIS network has been built – including 42 State ANS Management Plans, 6 Regional panels, over 1,000 participants in two national public awareness campaigns and many other partners – that has planned, directed and accomplished significant regional and landscape level invasive species prevention and management resource outcomes. The AIS Program serves as the nation's front line for prevention of new aquatic invasive species by regulating imports of injurious wildlife, facilitating behavioral change and managing pathways to limit the introduction and spread of invasives (awareness campaigns and ballast water), and developing monitoring programs for invasion hotspots to facilitate early detection and rapid response.

The Service's Fisheries and Aquatic Conservation Program maintains one office in Maryland, the Maryland Fishery Resources Office, in Annapolis, MD.

National Wildlife Refuge System

The Fish and Wildlife Service also manages more than 561 refuges, encompassing more than 150 million acres of wildlife habitat, within its National Wildlife Refuge System (NWRS). According to 2013 data, more than 2.4 million acres of the Refuge System are impacted by invasive plants. In addition, there are approximately 1,715 invasive animal populations residing on refuge lands.

There are five National Wildlife Refuges in Maryland including: Blackwater, Eastern Neck, Glenn Martin, Susquehanna, and Patuxent National Wildlife Refuges.

Endangered Species

The ultimate goal of the Endangered Species Act (ESA - (16 U.S.C. § 1531 et seq.)) is the recovery (and long-term sustainability) of endangered and threatened species and the ecosystems on which they depend. Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed, and threats removed or reduced so that the species' survival in the wild can be ensured. The goal of the ESA is the recovery of listed species to levels where protection under the ESA is no longer necessary.

In many instances these threats may be caused by invasive species. They may either directly harm the species by causing mortality or may threaten a species by modifying or destroying the habitat or food source on which that species depends. A variety of methods and procedures are used to recover listed species, such as reduction of threats (including invasive species), protective measures to prevent extinction or further decline, consultation to avoid adverse impacts of Federal activities, habitat acquisition and restoration, and other on-the ground activities for managing and monitoring endangered and threatened species.

United States Geological Survey (USGS)—The USGS maintains the Nonindigenous Aquatic Species (NAS) information resource, which is a central repository for spatially referenced biogeographical accounts of introduced species in the United States. The program provides scientific reports, online/realtime queries, spatial data sets, distribution maps, and general information. The data are made available for use by biologists, interagency groups, and the general public. The USGS operates under most of the same invasive species Acts as USFWS (DOI).

United States Department of Agriculture (USDA)—Federal Noxious Weed Act (7 U.S.C. §§ 2801-2814) defines a noxious weed as any living stage (including seeds and reproductive parts) of a parasitic or other plant of a kind which is of foreign origin, is new to or not widely prevalent in the United States, and can directly or indirectly injure crops, other useful plants, livestock, poultry or other interests of agriculture, including irrigation, navigation, fish and wildlife resources, or the public health. Under the Act, the Secretary of Agriculture for USDA has the authority to prohibit the importation and interstate transportation and sale of species that the Secretary has deemed noxious through actions such as inspection and quarantine. The Secretary is allowed to seize, treat, destroy and dispose of items that have been contaminated with a noxious weed.

Environmental Protection Agency (EPA)—The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) is the principal law that authorizes EPA to regulate the manufacture, distribution, sale, and use of pesticides in the United States. The FIFRA Section 18 authorizes EPA to allow states to use a pesticide for an unregistered use for a limited time if EPA determines that emergency conditions exist. (For more information about FIFRA Section 18 emergency exemptions, see www.epa.gov/opprd001/section18. For the text of Federal regulations regarding emergency exemptions, see 40 CFR Part 166 www.access.gpo.gov/nara/cfr/waisidx_04/40cfr166_04.html. See http://www.epa.gov/owow/invasive_species/invasives_management/fifra18.html for more information on the FIFRA Section 18 exemption and Maryland's use of the statute in its response to snakeheads in ponds of Crofton, Maryland.

FIFRA Section 24(c) authorizes states to register an additional use of a federally-registered pesticide product or a new end-use product to meet a special local need, such as a rapid response or control action. For EPA guidance on FIFRA Section 24(c) registrations, see www.epa.gov/opprd001/24c.

Clean Water Act Section 402 establishes the National Pollution Discharge Elimination System (NPDES) permit program to regulate point source discharges of pollutants into waters of the United States. The EPA has authorized the Mid-Atlantic States to assume many of the permitting, administrative, and enforcement responsibilities of the NPDES permit program. A statement issued by EPA in January 2005 states that the application of a pesticide to waters of the United States consistent with all relevant requirements under the FIFRA does not require a Federal NPDES permit in the following two circumstances: 1) the application of pesticides directly to waters of the United States to control pests; or 2) the application of pesticides to control pests that are present over waters of the United States, including near such waters; that results in a portion of the pesticides being deposited to those waters.

Clean Water Act Section 404 establishes a program to regulate the discharge of dredge and fill material into waters of the United States, including wetlands. Responsibility for administering and enforcing Section 404 is shared by the US. Army Corps of Engineers (USACE) and EPA. It is possible that some mechanical/physical ANS rapid response control methods, such as the mechanized clearing of riparian areas to remove ANS, or dumping of fill material to smother ANS, might require Federal or state Section 404 permits (only New Jersey and Michigan have state 404 permits). EPA and USACE regard the use of mechanized earth-moving equipment to conduct activities in waters of the United States (e.g., land clearing, ditching, channelization, and in-stream mining) as regulated discharge of dredged or fill material under Section 404 unless project-specific evidence shows otherwise. Natural resource managers should consult the appropriate USACE District office when planning ANS rapid response or control action to determine if these actions require a Federal Section 404 permit.

Aquatic Nuisance Species Task Force (ANSTF)— The Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA), reauthorized as the National Invasive Species Act (NISA) in 1996, was primarily created in response to the zebra mussel invasion of the Great Lakes, where ballast water introduction had caused serious ecological and socio-economic impacts. Although the zebra mussel invasion of the Great Lakes has played a central role in prompting passage of the federal legislation, NANPCA has been established to prevent the occurrence of all new ANS introductions and to limit the dispersal of all ANS already in U.S. waters.

The act, established for the prevention and control of the unintentional introduction of nonindigenous aquatic nuisance species, is based on the following five objectives as listed in Section 1002 of NANPCA:

- To prevent further unintentional introductions of nonindigenous aquatic nuisance species;
- To coordinate federally funded research, control efforts and information dissemination;
- To develop and carry out environmentally sound control methods to prevent, monitor and control unintentional introductions;
- To understand and minimize economic and ecological damage; and
- To establish a program of research and technology development to assist state governments.

The primary components of the Act:

- Required vessels entering ports on the Great Lakes to exchange ballast water and meet other requirements, with voluntary guidelines for similar actions on other waters of the U.S.
- Authorized a number of studies and monitoring programs to assess the spread of AIS and develop methods for controlling them.
- Required the development of Armed Services ballast water programs as well as the establishment of the Ballast water Management Demonstration Program.
- Authorized the establishment of the Aquatic Nuisance Species Task Force
- Established a mechanism for regional collaboration and coordination through the establishment of the ANSTF Regional Panels
- Authorized the development of an AIS Program to be housed within the U.S. Fish and Wildlife Service; and
- Established the State\Interstate ANS Management Plan Grant program managed by the U.S. Fish and Wildlife Service, through which States can develop and implement a comprehensive state management plan for the prevention and control of aquatic nuisance species.

NISA amended NANPCA "To provide for ballast water management to prevent the introduction and spread of nonindigenous species into the waters of the United States, and for other purposes." NISA authorized:

- The production of guidelines for how to guard against the introduction and dispersal of invasive species
- Regulations for vessel operations and crew safety, and education and training programs to promote compliance.
- Funding for research on environmentally sound methods to control the spread of invasive species,
- Ecological surveys for certain environmentally sensitive regions of the country; and,
- The establishment of the National Ballast Information Clearinghouse to provide data about ballasting practices and compliance with guidelines.

State Authorities

Maryland's aquatic invasive species laws are implemented primarily through the Department of Natural Resources (MDDNR). The MDDNR has unified authority to address all invasion pathways and all types of organisms, with the exception of the horticulture industry, which is regulated by the Maryland Department of Agriculture (MDA) under the state noxious weed law. The MDA may list banned species to address noxious weeds but has not listed any aquatic plants to date. The MDDNR has created lists of banned and approved wildlife and fish and limits the uses of listed species according to their threats to the environment or public health and safety.

Maryland Department of Agriculture (MDA)—The MDA has the authority to regulate the plant nursery trade. Until recently the agency worked with MDDNR to treat *Phragmites*. That work will now be the responsibility of counties. The ANS that MDA continues to maintain an active interest include: parrot feather, *Elodea*, common water hyacinth, water lettuce, purple loosestrife, *Iris pseudacorus*, *Hydrilla*, and giant salvinia.

Maryland Department of the Environment (MDE)—The MDE has the authority under the Federal Clean Water Act to list waters that are not meeting their designated uses as impaired. This can include waters where ANS interfere with designated uses.

Maryland Department of Transportation Port Administration (MPA)—The mission of the Maryland Port Administration is to stimulate the flow of waterborne commerce through Maryland in a manner that provides economic benefit to the citizens of the State, and is dedicated to doing so in a manner that is protective of the environment by our commitment to environmental compliance, continuous improvement of environmental performance, pollution preventions, and effective interaction/outreach. The MPA monitors for ANS at their terminals and dredged material containment facilities and assists in the efforts to establish Maryland's native aquatic populations through invasive species control, funding other state or federal agencies, and conducting monitoring programs defined to support the health of the Chesapeake Bay. In addition, the MPA,

along with other stakeholders provide support to the Maryland Environmental Resources Center (MERC) that was created in 2008. Their mission is to test the efficacy of proposed ballast water treatment systems to prevent the transport and introduction of invasive species by maritime shipping vessels into bodies of water such as the Chesapeake Bay and explore the tolerance of fouling organisms to conditions found during common ocean voyages to identify high risk species and develop methods for surveying vessels for biofouling and quantify the effectiveness of ship biofouling management guidelines.

Maryland Sea Grant—Maryland Sea Grant has produced several fact sheets for ANS in Maryland as well as conducted a workshop in 2002 to develop regional invasive species management strategies (http://www.mdsg.umd.edu/topics/aquatic-invasive-species/aquatic-invasive-species). With the Mid-Atlantic Panel on Aquatic Invasive Species, Maryland Sea Grant developed a rapid response plan for agencies and jurisdictions within the Mid-Atlantic region. The template response plan is referenced within action items of this ANSP.

Maryland Department of Natural Resources (MDDNR)—The MDDNR manages and regulates land and resources. The Secretary of MDDNR was granted wide authority to implement invasive species measures in 2003, as described in Maryland Annotated Subsection 4-205.1. Invasive species activities are performed by MDDNR biologists and resource managers from appropriate units within the organization. Coordination is provided through the interdisciplinary Invasive Species Matrix Team (ISMT) which has no dedicated staff but functions as a professional clearing house. The ISMT also performs tasks on an ad-hoc basis including addressing specific management actions, regulatory changes, and addressing research needs.

As manager of over 480,000 acres of public lands, MDDNR is involved in the control and prevention of invasive species on a daily basis. MDDNR has implemented species plans for nutria, common reed (*Phragmites*), mute swan, northern snakehead, Asian water chestnut, zebra mussel, didymo, and purple loosestrife. Most MDDNR land managers engage with invasive species on a regular basis, primarily terrestrial plants.

Because of its broad role in managing fish, wildlife, land, and water in the state MDDNR is the usual recipient of unusual or exotic species discovered in the wild. In this capacity, the agency is able to monitor the status and rate of discovery of incidental aquatic invasive species that are regularly captured on Maryland waters. There is currently no formal record of these captures, discoveries, and seizures, but that function has been considered as a possible future role for the MDDNR ISMT if and when additional resources become available.

The MDDNR Fisheries Service regulates the aquaculture industry and numerous proposals for the use of exotic species in contained systems or for rerelease into the wild have been brought forward for consideration by the agency. The most notable of these proposals was the potential introduction of the Asian oyster (*Crassostrea ariakensis*), a species that was ultimately rejected after years of scientific and legislative debate.

The MDDNR Chesapeake and Coastal Services guide restoration of ecosystems that are impacted by aquatic nuisance species. They encourage development of Hazard Analysis and Critical Control Point (HACCP) plans for all federally funded or authorized restoration projects.

The MDDNR has limited authority over the pet trade. In general, authority is restricted to invasive species prohibited under specific regulation, native species protected by wildlife laws, and prohibitions on harmful (dangerous/venomous) species.

Maryland's aquatic invasive species laws are implemented primarily through the MDDNR. The MDDNR has unified authority to address all invasion pathways and all types of organisms, with the exception of the horticulture industry, which is regulated by the Maryland Department of Agriculture (MDA) under the state noxious weed law. The MDA may list banned species to address noxious weeds but has not listed any aquatic plants to date. The MDDNR has created lists of banned and approved wildlife and fish and limits the uses of listed species according to their threats to the environment or public health and safety.

As part of its authority over most aquatic and some terrestrial exotic (non-native) species, MDDNR regulates captive wildlife — that is, mammals, birds, reptiles, and amphibians — to prevent the introduction of pests that could harm or compete with native species (Md. Code Ann., Nat. Res. §§ 10-901, 10-903). It is illegal to import, possess, breed, sell, or release any non-native wildlife species without a permit from MDDNR (MD. Regs. Code tit. 8, § 08.03.09.04). Permits are available only if the animal to be imported is both free of disease and will not be "inimical" to native species.

The legislature has also mandated specific requirements for nutria (requiring eradication plan pursuant to Md. Code Ann., Nat. Res. § 10-202.1), mute swans (requiring population management pursuant to MD. Code Ann., Nat. Res. § 10-211), and non-native reptiles and amphibians (prohibiting release only pursuant to Md. Regs. Code tit. 8, § 08.03.11.10).

In addition to wildlife, MDDNR also regulates "aquatic organisms," including fish, shellfish, and aquatic plants (Md. Code Ann., Nat. Res. § 4-202, 4-205.1). State law gives the Department authority to ban the importation, possession, or introduction of non-native aquatic species into state waters (Md. Code Ann., Nat. Res. § 4-205.1).

Maryland was the first state in the nation to prohibit the use of felt-soled waders in fishing because of their capacity to transport aquatic invasive species (COMAR *08.02.19.07*). The MDDNR regulations also contain unique provisions to further guard against the accidental transport and release of ANS. Specifically, the use of watercraft containing prohibited species is not allowed in state waters, and water from ANS-infected locations may not be diverted or transported (Md. Regs. Code tit. 8, §08.02.19.05).

Regional Authorities

The Chesapeake Bay watershed is shared by 6 state jurisdictions and the District of Columbia. The tidal basin of the Potomac River is shared by Maryland, Virginia, and the District of Columbia. The tidal basin of the Nanticoke River is shared by Delaware and Maryland. Stretches of the non-tidal Potomac River in western Maryland are shared with West Virginia. Conowingo Reservoir is shared between Maryland and Pennsylvania. State partnerships have been developed in some cases to share management of the resources in the shared waterbodies. While Virginia, West Virginia, and Pennsylvania have or are developing statewide ANS Plans, jurisdictions do not have joint plans for the Chesapeake Bay watershed.

Mid-Atlantic Panel—Formed in 2003 through the efforts of the Chesapeake Bay Program's Invasive Species Workgroup, the Mid-Atlantic Panel on Aquatic Invasive Species (MAPAIS) works to prevent the introduction and spread of aquatic invasive species through science and management, policy, and education and outreach activities and initiatives. The MAPAIS helps state, federal, and local agencies, non-profits, and private landowners in the Mid-Atlantic states tackle ANS issues by identifying and prioritizing regional issues, coordinating local ANS programs, and assisting the ANSTF in coordinating federal programs that promote effective methods of preventing and managing ANS introductions. In addition, MAPAIS also produced a Rapid Response Plan to foster a timely, thorough response to unauthorized, intentional or unintentional introductions of aquatic nuisance species (Smits and Moser 2009).

Chesapeake Bay Program (CBP)—The CBP adopted the "Chesapeake Bay Policy for the Introduction of Non-Indigenous Aquatic Species" in 1993. This Policy requires jurisdictions to notify the CBP if they are planning to introduce a non-native, aquatic species to the Chesapeake Bay. A panel to evaluate the introduction is convened by CBP and to make voluntary recommendations to the jurisdiction. The Policy develops guidelines for assessing risk of introduction and for education and control or eradication of ANS. In the Chesapeake 2000 Agreement, the CPB identified two primary goals regarding ANS: 1) identify and rank non-native, aquatic and terrestrial species that cause or potentially cause negative impact to the Bay's aquatic ecosystem by 2001; and 2) develop and implement management plans for problematic species by 2003.

Potomac River Fisheries Commission (PRFC)—The PRFC is the Maryland-Virginia bi-state regulatory authority for fishery matters in the mainstem tidal Potomac River from Washington, D.C. to the Chesapeake Bay. The Commission is comprised of eight members, four appointed by Governor of Maryland and four appointed by Governor of Virginia. The PRFC adopts rules, regulations and licenses for recreational and commercial fishing, catching or attempting to catch fish, crabs, oysters and clams. The regulations carry the full force and effect of law and are jointly enforced by Maryland and Virginia.

Appendix 3. HISTORY OF ANSP DEVELOPMENT

History of Plan Development

This plan was initially prepared in 2014 and 2015 by a subcommittee of the MDDNR Invasive Species Matrix Team (with *) and later reviewed with comment by other members. In addition to the Team members listed below, an initial draft was also reviewed by Clarence Fullard (NOAA) and Susan Pasko (NOAA).

Matt Ashton (Natural Resources Biologist)
Email: matthew.ashton@maryland.gov
Phone: 410-260-8604

Rich Bohn (Permit Coordinator)
Email: richard.bohn@maryland.gov
Phone: 410-260-8317

Nancy Butowski (Program Manager, Fishery Management Plans & Fish Passage)*
Email: nancy.butowski@maryland.gov
Phone: 410-260-8268

Jay Kilian (Natural Resources Biologist)*
Email: jay.kilian@maryland.gov
Phone: 410-260-8617

Kerrie Kyde (Invasive Plant Ecologist)*
Email: kerrie.kyde@maryland.gov
Phone: 301-948-8243

Mark Lewandowski (Natural Resources Biologist)*
Email: mark.lewandowski@maryland.gov
Phone: 410-260-8634

Dr. Joseph Love (Tidal Bass Program Manager, MDDNR Fisheries)*
Email: joseph.love@maryland.gov
Phone: 410-260-8257

Jonathan McKnight (MDDNR Invasive Species Matrix Team, Chair; Associate Director of Wildlife and Heritage Service)*
Email: jonathan.mcknight@maryland.gov
Phone: 410-260-8539

Susan Rivers (Natural Resources Biologist)*
Email: susan.rivers@maryland.gov
Phone: 301-791-4736

Sarah Widman (Regulations Officer)
Email: sarah.widman@maryland.gov
Phone: 410-260-8266

Once ISMT had produced a draft, it was sent out to the following Unit Directors for dissemination and internal review:

Christine Conn (Integrated Policy and Review)

Oct 20 2015

Christine Conn -DNR-

Thanks Mike and Roland. I have copied Joe Love on this to ensure that your review comments go directly to him.

Christine

Roland and I met this morning and talked through the MD ANS Management Plan. We both think the document is thorough and thoughtful with a good mix of specific suggestions and overviews of the issues. Very well cited too, its obvious a lot of work went into it as is reflected in our lack of suggestions for additional work. We only have a few relatively minor comments.

The document should detail how other agencies like MDE and MHT will be involved up front for rapid response. Without the help of other agencies this document will have limited usefulness as permit issues may preclude work.

The terms ANS and AIS are used irregularly thoughout. We suggest picking one acronym and sticking with it through the whole document.

An experienced editor should be used before this document moves forward. Capitalization and punctuation are erratic throughout, with major section headings not capitalized, some words capitalized inconsistently, a mixture of italicized and bold words distracting and making the transitions between sections confusing.

Suggest moving the Executive Summary towards the front of the document, rather than having the first meaningful text not begin until page 11.

That's it, thanks for the opportunity to review.

Mike

Charles C. Deegan (Critical Area Commission) - NO COMMENT

Matt Fleming (Chesapeake and Coastal Service) -

Claudia Donegan -DNR-

I left you a voice mail regarding the ANSP for MD -- and I am coordinator any comments from the Chesapeake and Coastal Service -- I would like to hear from our CBNEER folks - but they are all out at a week long conference. In addition this goal of the ANSP task force maybe be quite pertinent to our work here in Habitat Restoration and Conservation in CCS - so we may have a few comments on this goal -- not sure its in the MD plan -- but will look closer

Goal 5: Restoration – Protect and rehabilitate native species and ecosystems by conducting habitat restoration efforts on multiple scales Habitat restoration is an essential part of the control and management efforts used to guard against future invasions or to minimize harm to native ecological communities and other public interests. Restoration of the natural habitat should be addressed whenever the control or eradication of ANS is planned since habitat rehabilitation is often necessary to avoid the replacement of one invasive species with another, control flooding, or avoid other problems associated with the absence of biological organisms. Restoration activities may also include planting or stocking organisms or improving predator-prey relationships to attain food webs more similar to pre-invasion conditions. ANS can be transported by materials, equipment, vehicles, or personnel used to conduct restoration activities; accordingly all habitat restorations, even those not focused on ANS control, should call attention to actions that prevent establishment of invaders not yet present within the project site. Restoration efforts should make use of plant and animal species that are native to the particular habitat. One of the benefits of using native species includes their ability to thrive under the local conditions while being less likely to invade new habitats. Consequently, native species reduce maintenance costs and produce healthy natural communities, thus providing a practical and ecologically valuable option for restoration projects. The actions suggested below focus on ANS concerns during habitat restoration efforts by targeting consideration of potential ANS during planning and implementation of restoration activities and encouraging post-restoration monitoring to ensure that any ANS introduced as a result of restoration are responded to in a rapid and efficient manner. Objective 5.1: Restore impacted ecosystems a. Identify

and support agencies or programs that can assist in restoring areas impacted by ANS b. Provide technical assistance on the species and methods to use in restoring native species, including means to enhance resilience against re-invasion, climate change, and other drivers of change c. Compile, highlight, and share lessons learned for both restoration successes and failures within the United States Objective 5.2: Address and provide technical assistance for invasive species management before, during, and after habitat restoration projects a. Ensure that Federal land and water management field and guidance manuals consider ANS issues during the planning and development of habitat restoration projects b. Review and make accessible existing restoration project standards to mitigate impacts of ANS during restoration activities. Develop new guidelines when warranted c. Encourage application of adaptive management principles and assessment of treatment regimes to improve and sustain restoration efforts over time d. Encourage the development of Hazard Analysis and Critical Control Point (HACCP) plans for all federally funded or authorized restoration projects e. Support the development and expansion of markets that supply native plants and certified weed-free materials; encourage use of these materials by agencies and other organizations Encourage post-restoration monitoring for ANS by agencies and other organizations conducting habitat restoration or landscaping projects. Encourage restoration of areas following ANS eradication or control efforts

Adding something similar for Action Item in Implementation Table http://dnr2.maryland.gov/ccs/Pages/InvasivePlantControl.aspx

Among several editorial changes, add Marsh Dayflower to list (Chris Snow, CB NEER), give Figure 1 its own page or orient differently.

RESPONSE: All suggested changes were made. The concept of including restoration of native organisms was added to Action 3.3.2.

Dr. Dave Goshorn (Aquatic Resources) - NO COMMENT

Jordan Loran (Engineering and Construction) - NO COMMENT

Bruce Michael (Resource Assessment Service) - NO COMMENT

Mark O'Malley (Boating Services) - NO COMMENT

Paul Peditto (Wildlife & Heritage Service) - NO COMMENT

Nita Settina (Park Service) - NO COMMENT

John Turgeon (Maryland Environmental Trust) - NO COMMENT

Don VanHassent (Forest Service) - NO COMMENT

Emily Wilson (Land Acquisition & Planning) - NO COMMENT

Daryl Anthony (Land Resources) - NO COMMENT

Dave Blazer (Fisheries) - NO COMMENT

Comments received from Unit Directors were incorporated into the ANSP by 11/20/2015. The ANSP was then preliminarily reviewed by Don MacClean.

Donald MacLean (Branch of Aquatic Invasive Species, United States Fish and Wildlife Service, Acting Executive Secretary of the ANS Task Force).

General Comments provided:

I think the draft MD ANS Plan (MDANSP) is off to a great start. It has most of the components required in the State Plan Guidance and is a fine foundation for Maryland to start to more formally address its aquatic invasive species issues. I especially like the section on High Priority Pathways and Aquatic Nuisance Species. You have done a good job of keeping the topics succinct while still giving a decent overview and including pertinent information from Maryland (which many states fail to do well).

I do, however, have some comments that I feel will improve the MDANSP. My comments are organized as follows:

1) *First I outline one specific concern I have with the MDANSP,*
2) *Then I go through the MDANSP section by section, outlining missing content, and providing other comments where necessary,*
3) *Then I provide a suggestion for one section that seems to be completely missing (Priorities for Action);*
4) *And finally I provide some alternative text for the U.S. Fish and Wildlife Service summary (breaking it out into an FWS section and an ANSTF section).*

In addition, I have also provided some specific comments on various parts of the document in track changes within your original Word document as well).

Important Notes:

- *The comments below are based on the <u>ANSTF Guidance for State and Interstate Aquatic Nuisance Species Management Plans</u>, which is available on the ANSTF web site (http://www.anstaskforce.gov/State%20Plans/Guidance_for_State_%20Interstate_ANS_Plans_2005.pdf). In the comments below, the term "Guidance" refers to this document.*
- *Where I indicate that some content is missing, I am <u>NOT</u> looking for huge volumes of information – just one or several paragraphs to address the topic is all that is needed in most cases.*

RESPONSE: All edits suggested were included in the ANSP. Notable changes included: 1) a rewording of the Plan Goal; 2) Objectives were clarified and re-organized as suggested, and matched between Executive Summary and within the text of the document;

3) the Plan Purpose was clarified and a Justification was included; 4) Action material from the Implementation Table was added to the bulleted outline; 5) funding sources and amounts were edited in the Implementation Table for consistency with the text; 6) additional context for action items were added to the text with a detail similar to that of the Lake Tahoe plan; 7) definitions were cited and re-written (when appropriate) from the Oxford Dictionary; 8) specific Maryland plans for managing aquatic nuisance species were cited with hyperlinks in the species description section; 9) a new paragraph on geographic scope of the plan was written; 10) the map was replaced as suggested; 11) cryptogenic species included several plants and Brown Pelican - a sentence addressing these species was added but these are not prioritized within the ANS (to our knowledge, there are no cryptogenic species of concern); 12) a table legend for program evaluation was added in the Implementation table; 13) acronyms were used in the funding source column for the Implementation Table and those acronyms are referenced in the ANSP; 14) additional columns added to the Implementation Table included, "Lead Organization" and "Cooperating Organization;" 15) a paragraph was added in the Plan Review section to address why factors that may inhibit implementation of the plan; 16) a Priorities for Action section was added and the New York Plan was used as a template, with a prioritization of the least costly and most important actions over the next 5 years; and 17) replacement sections for Appendix 2 were added, as suggested.

The ANSP was then submitted for public comment and to external reviewers listed below. External reviewers were given 30 days and additionally asked to complete relevant sections of Appendix 2, Existing Authorities and Programs. Final comments were received by 2/22/2016. Reviewers were asked to address how ANS will or are being addressed and where their role is within the ANSP. The documented was linked to the webpage for ISMT for a period of 30 days and comments were sent directly to ISMT (see Appendix 4). The announcement of its posting was advertised to Sport Fish Commissioners and Tidal Fish Commissioners, Office of Communications, and via Fisheries Services' Constant Contact or email list serve.

Carol Holko (Maryland Department of Agriculture) -

> *Hi Joe,*
> *Yes three of us here are at PPWM were able to review your plan, they included Gaye Williams, Entomologist/Taxonomist; Bob Trumbule, Nursery Inspection Supervisor and myself. We all agree that from our program perspective we don't think the species listed will be of any consequence to the the industries we work with/regulate; mainly the nursery trade. There are a few exceptions that our nursery inspector supervisor mentioned and they include, Parrot feather, Elodea (not spp. densa, generally), Common water hyacinth, Water Lettuce and purple loosestrife that are sometimes sold in the aquatic/nursery trade. Iris pseudacorus (yellow iris) has been listed as a Tier 1 plant in the new Invasive Plant Regulations, which are scheduled to be put into regulation this year. As a Tier 1 plant, it will prevent the nursery trade from selling this plant.*
>
> *MDA is also concerned about Hydrilla and giant salvinia. MDA Weed Control works with DNR to treat phragmites, however the recent cut of this program in the FY17 budget will move all weed treatments to the counties.*
>
> *Again we appreciate you giving us the time to review and comment on this document. We look forward to seeing the final product.*
>
> *Regards, Kim*
> *Kimberly*
> *A. Rice, Program Manager, Plant Protection & Weed Management*
> *Maryland Department of Agriculture, 50 Harry S. Truman Parkway, Annapolis, MD 21401*
> *Phone: 4108415920*
> *Cell: 2402747641*
> *Fax: 4108415835*
> *email: kimberly.rice@maryland.gov*

RESPONSE: In response to some of these comments, the role of MDA in regulating plant nursery trade and their interest in specific species was noted in Appendix 2.

Charlie Poukish (Maryland Department of Environment) -

RESPONSE: Reviewed plan and provided edits. Significant edits included: 1) adding a bullet to the list of current initiatives in the Executive Summary (Passing of laws and regulations restricting the possession, use, or sale of nuisance species or gear that could result in the spread of those species); 2) inclusion of agencies to include in dissemination of risk assessments; 3) addition of new action 2.1.4 to identify taxonomic experts; 4) addition of funding source, Hart-Miller Island Exterior Monitoring Program; 5) downgrading of common water-hyacinth from High Priority to Low Priority because of its poor tolerance to winter temperatures; and 6) description of the role of MDE in invasive species management. Other edits to the text were also noted on the draft and incorporated into the ANSP. It was suggested to consider inclusion of rainbow darter in Appendix 1. This species was not added to Appendix 1 because according to the Atlas of North American Freshwater Fishes, rainbow darter was collected from the Atlantic Slope in the upper Potomac River. It is not common in Maryland.

Dr. Fredrika Moser (Maryland Sea Grant) -

RESPONSE: Reviewed plan and provided numerous edits. Most editorial edits were made to improve clarity. Significant edits included: 1) definitions were clarified as suggested and example species were deleted from low priority and high priority definitions; 2) the introduction of species in packing material in the bait trade was added in the Live Bait vector discussion, with reference to transit from Maine; 3) the evidence to support seafood trade as a vector is not extensive, but Miller et al. was cited along with Carlton and Cohen's work - this pathway is not as widely recognized for importance as others and that point was noted; 4) the statement regarding negative impacts from authorized stocking was deleted rather than referenced because the impacts from ANS are well-described elsewhere in the plan; 5) the ANSTF and MAPAIS were added to Action 1.1.1, as suggested, to specify the need to coordinate with those groups as well as neighboring states; 6) Sea Grant Law Clinic and Environmental Law Clinic were added to the program evaluation in Action 1.3.2, with specific reference to cooperating agency MDSG; 7) MAPAIS was identified as a cooperating agency for Action 1.4.2, as suggested; 8) National Sea Grant Law Clinic was added to Action 3.2.2 as suggested; and 9) the suggested funding sources were added to Implementation Table.

Bruce Vogt (National Oceanographic and Atmospheric Administration) and
Nicholas DiPasquale (Environmental Protection Agency, Chesapeake Bay Program) -

> *DiPasquale, Nicholas <dipasquale.nicholas@epa.gov> Thu, Jan 21, 2016 at 1:13 PM*
> *To: Joseph W Love DNR <joseph.love@maryland.gov>*

Cc: "jennifer_greiner@fws.gov" <jennifer_greiner@fws.gov>, Bruce Vogt NOAA Federal <bruce.vogt@noaa.gov>, Kara Skipper NOAA Affiliate <kara.skipper@noaa.gov>

Joe, thanks for reaching out to me for comments on Maryland's draft ANS plan. Per your request, please find attached comments from the Chesapeake Bay Program's Sustainable Fisheries and Vital Habitats Goal Teams. I applaud Maryland's commitment to addressing ANS issues and competing for national funding to support it. The Chesapeake Bay Program shares Maryland's concern regarding the serious regional impacts ANS have on both economies and ecosystems. Back in 2003, the partnership's Invasive Species Workgroup helped form the Mid-Atlantic Panel on Aquatic Invasive Species (MAPAIS) under ANSTF (referenced on page 86 of the draft). Since then, the Chesapeake Bay Program has provided support for MAPAIS in the form of staff time through the Habitat Goal Implementation Team. We look forward to continuing this mutually supportive relationship between the CBP partnership and the regional panel in terms of communication on emerging issues and working with all of the jurisdictions to combat ANS most efficiently across the watershed.

Thanks again for allowing CBP the opportunity to review and comment on this draft. Best, Nick

Attached Comments on Behalf of Vital Habitat and Sustainable Fisheries Goal Implementation Teams modified the ANSP as: 1) a link to the final report of the Sustainable Fisheries Goal Implementation Team Invasive Catfish Task Force was added to species descriptions for both blue catfish and flathead catfish; 2) it was noted that not all resident populations of Canada Goose require management, just large ones that adversely impact the environment; 3) an action to improve monitoring was added by editing Strategy 2.3 and have it broadly address monitoring - Action 2.3.2 was added to specifically identify the need for monitoring for high priority and red alert species; 4) edits to the description of MAPAIS were made as requested; 5) the description of blue catfish was edited to include its salinity tolerance; and 6) the program evaluation for Action 3.1.1 was edited to stress a need for basic biological and ecological studies that elucidate recruitment, mortality, and population growth, as well as ecological factors that influence natural spread of the species.

Pam Fuller (United States Geological Survey) -

On Fri, Jan 29, 2016 at 11:34 AM, Fuller, Pam <pfuller@usgs.gov> wrote:

Hi Joe,

I have attached my comments. Feel free to call with questions!

Pam Fuller
USGS
Nonindigenous Aquatic Species Program
Wetlands and Aquatic Research Center
7920 NW 71st Street
Gainesville, FL 32653

President, Introduced Fish Section
American Fisheries Society

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RESPONSE: Several comments on the ANSP were made and incorporated into the current version of the ANSP. Notable additions included: 1) several edits to confirm the recorded history of ANS; 2) Action 1.1.4 was edited to include the website of about 2000 risk assessments conducted by the U.S. Fish and Wildlife Service; 3) the USGS/NAS was added as a cooperative organization for Actions 1.2.1, 1.5.1, 2.1.1, and 2.1.2 and the concept of creating a new database for reporting ANS was removed; 4) Strategy 1.4 was edited to include a need to identify existing outreach tools; and 5) EDDMaps was removed from the list of possible databases because of their inclusion of non-aquatic organisms.

Steve Minkkinen (United States Fish and Wildlife Service, Maryland Fishery Resources Office) -

Minkkinen, Steve <steve_minkkinen@fws.gov>
To: Joseph W. Love - DNR- <joseph.love@maryland.gov>
Thu, Feb 11, 2016 at 3:55 PM

I didn't have a chance to talk to you after the snakehead meeting since I had another meeting to go to. I did read the management plan. It is well written. My only comment is on knowledge gaps and challenges on page 28. It may be worth noting that invasive species can be purchased on the internet pretty easily making that a potentially dangerous vector.

RESPONSE: The World Wide Web as a dangerous vector was added to Gaps and Challenges as well as in the pathway section.

Andrew Wilds, APHIS (United States Department of Agriculture) - NO SUGGESTIONS

Tom Toplisek (United States Army Corps of Engineers) - NO COMMENT

LT Scott McBride (United States Coast Guard) - NO COMMENT

Holly Miller (Maryland Department of Transportation Port Administration) -

> *Holly Miller <hmiller2@marylandports.com> Fri, Feb 26, 2016 at 4:06 PM*
> *To: Joseph W Love DNR< joseph.love@maryland.gov>*
> *Hi Joe-*
> *I sincerely apologize for my delay in providing input on the ANS Plan... Here is a suggested paragraph for the MPA portion of Appendix 2 (page 84)...In reviewing the action plans, I feel that MPA could become a cooperating agency in some of the outreach aspects,distributing the ANS plans to our citizens groups or other Dredged Material Management Program committees as some of the watermen and other stakeholders may be interested in this topic. We could also assist in web based outreach through the Healthy Harbors and Greenports websites posting the links to ANS information and the importance of notifying MDDNR of ANS sightings, etc. We could also provide more information to the ANSTF and/ or the ISMT on the MERC efforts as both ballast water and biofouling are identified as pathways. Locations for listing MPA as a potential CO are: pg.50 1.1.5, 1.2.3, pg.52 1.4.1 – 1.4.2, pg.54 2.2, pg.58 3.3.2, and 3.3.3.*
> *We feel that the issues of ANS is very important and are interested in how the goals of the plan are achieved, and would like the opportunity to be part of the continued discussions. Please let me know if you have any questions or need any additional information. Again, I sincerely apologize for the delayed response on the plan.*
> *Thanks,*
> *Holly L. Miller*
> *Maryland Port Administration*
> *World Trade Center*
> *401 E. Pratt Street Suite 1900*
> *Baltimore, MD 21202*
> *Phone: 4103854748*
> *EMail: hmiller2@marylandports.com*

RESPONSE: The suggested paragraph was added to Appendix 2. Maryland Port Administration was added as a cooperating organization for the identified actions.

Marty Gary (Potomac River Fisheries Commission) - NO COMMENT

The ANSP then underwent a preliminary review by the Aquatic Nuisance Species Task Force. Reviews were received from Don MacLean (U.S. Fish and Wildlife Service), Susan Pasko (U.S. Fish and Wildlife Service), Dr. Ian Davidson (Smithsonian Environmental Research Center), and Dr. Alexis Rudd (NOAA Fisheries Office of Policy). These edits and comments were included into the draft of the ANSP. Significant edits included a suggestion by SERC to add several lower trophic level aquatic nuisance species that should be researched to address whether they are or will become problematic. These species were added as a new table to Appendix 1 and will be considered in the future as potential aquatic nuisance species. The budget was also better clarified to specifically address possible funding for salary and for materials or supplies.

Appendix 4. PUBLIC COMMENTS ON THE ANSP

Public comments were received on the ANSP during winter and spring of 2016. It was opened on 12/24/2015. A notice was sent out using Constant Contact to the general public who had signed up to receive notices from Maryland Department of Natural Resources. It was also posted on the Department's Invasive Species Matrix Page. A copy was supplied to commissioners of the Sport Fish Advisory Commission and the Tidal Fish Advisory Commission, which represent commercial and recreational angler interests in Maryland. The date and initials of commenter are provided along with the unaltered comment.

12/28/2015

I'm a Maryland recreational angler. I'm retired, but during my working life, I acquired an environmental background. Very good plan. Well done. My comments are below.

Comments on Maryland Aquatic Nuisance Species Management Plan - draft dated December 2015

Page 5. In the Executive Summary, consider qualifying or in some way quantifying the term "Chesapeake Bay watershed" so that it better defines the scope of the plan, otherwise begin the sentence with, "For example, in the Chesapeake Bay watershed . . . ." To the casual reader or layperson quickly reading the executive summary, it seems that the plan may only be addressing the Bay and nearby waters/adjacent tributaries.

Page 6. The Objectives, and the Actions to Achieve Objections are very good. They appear to be both comprehensive and executable.

Page 10. In the Glossary, consider adding the term, "Non-native non-nuisance" or Non-indigenous non-nuisance in order to define those species that although not native to the state, have been long established, are naturally reproducing in such a way that wild populations of the species exist, and have become in many ways a beneficial part of the current ecosystem.

Page 12. In the Acronyms, you may want to include NOAA.

Page 19, second paragraph. The period needs to be removed at the end of the sentence that reads, "The USCG also regulates ballast water discharge in United States waters under the United States.", or the following needs to be added, ". . . Code of Federal Regulations, Title 46, Shipping." or something to that effect.

Page 24, Angler Gear Pathway. I would like to comment, and it may be noteworthy to add that the ban on the use of felt soled wading boots in Maryland waters comes at an increased fall risk to the angler. Pennsylvania has not yet instituted this ban, at least not to my knowledge. It may be worthwhile to find out how their plan addresses the angler gear pathway with respect to wading boots, and if adequate, adopt it for Maryland waters?

Page 46. General comment related to Plan Strategies 3. I am in favor of the plan, as long as an attempt is not made to eradicate "non-native non-nuisance" species in order to better establish or re-establish "genetically pure" native species. As explained in the plan, many non-native species were introduced with good intention, only to discover their negative impacts after the fact. I know it's unlikely to happen given current requirements to conduct environmental assessments prior to taking action, but please avoid the pitfall of committing two wrongs in order to make a right especially at taxpayer expense.

Good luck to the working group/committee, keep up the good work, and thank you for the opportunity to comment.

RESPONSE: Edits to references of pages 5, 12 and 19 were included in the re-draft of the plan.

12/26/2015

1) The statement on page 25 that "…Blue Catfish and Flathead Catfish were introduced for sport fishing in the Potomac River in the 1960s by VDGIF" is false and should be removed or edited. VDGIF has NEVER stocked blue catfish in the Potomac River for any purpose. We stocked several Virginia rivers in the 1970s, and as I think you know; the origin of BCF in the tidal Potomac is unknown. To deliberately indict VDGIF for this introduction is grossly misleading and disingenuous. Flatheads were stocked in the Occoquan in the 1960s. This misrepresentation is repeated on page 29 and should be changed.

2) I am uncertain how you (or others) determined that Northern Snakehead have a "high probability of negative economic and/or ecological impacts". As I thought you knew, there are no published accounts of anything of the sort. The two studies cited in the draft merely show dietary overlap (not competition as claimed) and the fact that snakeheads will eat bass fingerlings when starved in hatchery raceways. I think one could actually argue that at this point there have been economic benefits of this fish, although I would not advertise it.

3) The Flathead Catfish section appears to suggest these fish colonized the Susquehanna system by dispersing from the Occoquan. This should be revised to reflect reality including the very low abundance of this fish in the tidal Potomac system and the near impossibility that they seeded other bay populations. That this fish was such a nuisance, DNR requested to sample Virginia waters (unsuccessfully) just to find one to display at the state fair. Don't really see that problem…

RESPONSE: All suggested edits were made to the catfish descriptions. Additionally, the reference to "snakeheads having a high probability of negative economic and/or ecological impacts" was re-written completely and re-stated as, "could impact."

1/29/2016

Mr. Love,

I would like to provide feedback on Maryland's draft Aquatic Nuisance Species Plan. Kindly send me an email acknowledging that you have read my comments and confirming that they will be factored into the State's decision-making processes going forward.

I proudly lead a growing group of concerned catfish anglers known as Bay Catfish Advocates (BCA). Over 1,400 individuals have formally supported BCA (see our Facebook page at https://www.facebook.com/baycatfish), as have many groups. Our supporters are located not only in Maryland, Virginia, and Pennsylvania – but throughout North America.

Below are several relevant excerpts from our BCA statement of objective/purpose:

- BCA seeks "game fish" status for both trophy blue and trophy flathead catfish. The game fish status that we desire should be fostered through the implementation of a **realistic, balanced management approach** that supports the current and future needs of the nascent commercial blue catfish fishery, through the harvesting of appropriate numbers of smaller fish, while at the same time preserving ample numbers of larger blue and flathead catfish for current and future recreational anglers.

- BCA also advocates existing and future regulations that prohibit the transportation/subsequent introduction of live trophy blue and flathead catfish from the Chesapeake Bay watershed to waters other than where they were originally caught.

- Chesapeake Bay Catfish Advocates also request that policy makers recognize the fact that a significant number of advocates have - for many years prior to these fish being labeled "invasive" - invested considerable resources in the recreational pursuit of their preferred quarry.

Referencing page 15 of the State's draft plan, then, BCA strongly believes that both trophy blue and trophy flathead catfish are, in fact, "important gamefish." Like shad and largemouth bass, which the State clearly values, trophy blue and trophy flathead catfish belong on the list of "natural resources that the State aims to protect."

I have developed very good working relationships with key individuals within the Maryland Department of Natural Resources, the Potomac River Fisheries Commission, and the Virginia Department of Game and Inland Fisheries. I am willing to work with any individual or organization to change what I perceive to be a stigma (fueled more by over-sensationalism, I believe, than credible scientific evidence) associated with blue and flathead catfish. BCA would like for trophy blue and trophy flathead catfish to be formally recognized as important game fish, a status that we believe they have rightfully earned.

P.S. – Be sure to read the passionate comments of BCA supporters on our website: http://baycatfish.com/comments.html

RESPONSE: The inclusion of statements regarding the importance of blue catfish and flathead catfish to the angling community as both food and recreation was included in the descriptions of these two species.

2/9/16

Tue, Feb 9, 2016 at 8:44 AM

To: joseph.love@maryland.gov

Mr. Love,

I do not have time to thoroughly read ANS (Aquatic Nuisance Species) Management Plan. I do notice that in the executive summary, it is stated that you intend to create "increased educational awareness by working with K-12 schools."

I served as an educator in the Baltimore City Public School System for 16 years. During my career, I obtained grants from the Chesapeake Bay Foundation, supervised the growing of underwater grasses in science classes, and led field trips for their planting by the children. I highly recommend that any such programs that you create do not rely too heavily on the internet. Rather they should involve hands-on and direct visual experiences as far as possible. I would recommend the creation of a traveling aquarium(s) that could be meshed with Maryland's science curriculum for the various grades, and then be available to travel from school to school upon request. In the best of all possible worlds, some of the tanks (or other exhibits) would have objects that children could touch or handle. As a veteran of numerous trips to the National Aquarium, I assure you that children find live fish absolutely fascinating.

In a conservation effort such as this, an educated public is your greatest asset. Lessons brought home in school by real life experience (i.e., not just book/blackboard/internet learning) last a lifetime. If you can get into Maryland's classrooms, ANS will cease as a problem at some point in the future.

RESPONSE: The concept of a traveling aquarium was specifically included as an outreach tool in Action 1.4.2.

Appendix 5. REVISION HISTORY

Susan Pasko
Executive Secretary, ANS Task Force
U.S. Fish and Wildlife Service

703-358-2466
Susan_pasko@fws.gov

Dear Susan Pasko:

Please review our revisions to the Maryland Aquatic Nuisance Species Management Plan. These revisions were recommended by members of the Maryland Department of Natural Resources' Invasive Species Matrix Team. This letter follows our preliminary review letter sent April 1 and the response sent by Dr. MacLean on April 17. Please see a brief summary of changes (below) along with the plan revised using Microsoft Word's track changes. If you have any questions, please do not hesitate to contact me.

Sincerely,

Joseph W. Love, Ph.D.
Statewide Operations Manager
Freshwater Fisheries and Hatcheries Division

410-260-8297
Joseph.love@maryland.gov

Summary of Revisions

Summary of Revision

The framework of the Maryland Aquatic Nuisance Species (ANS) Management Plan remains the same. The following content changes will be incorporated.

Nonindigenous ANS Background:

Minor grammatical corrections will be made throughout. Where appropriate, information will be updated to reflect the current knowledge of ANS in Maryland.

Additions of High Priority and Red Alert Aquatic Nuisance Species:

Since plan adoption, a new red alert species (Alabama Bass) could threaten the state's natural resources and was added to the plan. Additionally, four new ANS have been discovered with populations in Maryland. New Zealand Mud Snail will be moved from a red alert animal to a high priority animal because this species is now established n the Gunpowder River downstream of Prettyboy Reservoir. Two-horned Water Chestnut will be described as a high priority freshwater plants/algae. Accordingly, "Water Chestnut (*Trapa natans*)" will be specified as "Eurasian Water Chestnut." Quagga mussel (*Dreissena bugensis*) that has been found in Maryland will be added to the plan. The section regarding zebra mussel has been revised to reflect successful eradication efforts and more limited range than in 2016 when the ANS plan was adopted. Freshwater Drum has been discovered in Maryland; but as its risk assessment indicated a low risk to natural resources currently, it will be listed in Table 1 as a low priority ANS. The sections referencing Asian swamp eel will be revised to reference all species within its family of Synbranchidae as red alert, rather than simply the Asian swamp eel.

Management Actions:

The actions to achieve objectives will be revised according to what already has been done and what still needs to be done. There will be an addition of new actions that have become necessary since the plan's inception. The implementation table will be updated with more accurate estimates of federal costs for each action and staff needed (full time equivalent) to achieve the actions. It will also be modified with a new column to identify each objective as a high priority, medium priority, or low priority.

All other changes will extend from the modifications made to the body of the document. The glossary, literature citations, and appendices will be updated accordingly.

Justification:

As the framework and content core remain the same, this update was considered a major technical revision that requires approval by the Aquatic Nuisance Species Task Force. The plan adds new species, and the Implementation Table of the plan is updated with new information. Actions will be updated with ongoing progress and may be reprioritized based upon that progress. These revisions will not undergo public comment but have undergone internal review by members of the state's Invasive Species Matrix Team.

Maryland Aquatic Nuisance Species Management Plan
Review of Revisions (05/2024)

OVERALL DOCUMENT
Minor grammatical and spelling errors will be made throughout the document. We will revise action lists to reflect accomplishments and new priorities; five actions will be revised to reflect progress in accomplishment and the need for continued management. Species lists will be updated with new information. Additionally, new species will be added because of their establishment, or suspected introduction in Maryland.

TABLE OF CONTENTS
1) Executive Summary
Made minor grammatical and spelling changes. Revised to reflect new listing of prioritized actions. A newly prioritized action related to control and slowing spread of existing ANS was added.
2) Glossary
Made minor grammatical changes.
3) Acronyms
The Maryland Department of Health (MDH) was added.
4) Introduction
Plan Purpose
Made minor grammatical changes.
Geographic Scope of Plan
Made minor grammatical changes.
ANS Plans for Neighboring Jurisdictions
Made minor grammatical changes, added Delaware in list of states with approved ANSPs.
Gaps and Challenges
Made minor grammatical changes.
Figure 1: Map of Maryland
5) Problem Definition
Minor grammatical changes.
6) High Priority Pathways and ANS
Vectors and Priority Pathways of Introduction
Made minor grammatical and spelling changes. Updated with new information.
Knowledge Gaps and other challenges Associated with Vector/Pathway Management
Updated with new information.
High Priority and Red Alert ANS
Made minor grammatical and spelling changes. Updated with new information, moved 1 species from red alert to high priority, added 1 red alert species, revised 1 red alert species to include other species within the same family, and added three new high priority species.
7) Management Plan
Plan Goal
Minor grammatical changes.
Plan Objectives
Plan Strategies, Actions and Funding
Prevent new and additional ANS introductions in Maryland

Made minor grammatical and spelling changes. Revised two actions to reflect completion of development, but continued management.

Establish an early detection and rapid response mechanism

Made minor grammatical and spelling changes. Revised three actions to reflect completion of development, but continued management.

Control and slow spread of existing ANS

Made minor grammatical and spelling changes.

8) Implementation Table

Made changes as necessitated by revisions to actions (noted above). Added a column to highlight priority for accomplishment (High, Medium, Low). Priorities stemmed from section 9 (below). Revised federal costs in funding, where necessary, to illustrate more accurate figures based upon revision of actions. Identified the number of necessary full time equivalent staff expected to accomplish the action.

9) Priorities for Action

Revised based upon accomplishments and new priorities.

10) Plan Review

Made minor grammatical changes.

11) Literature Cited

Added one citation.

12) Appendices

Appendix 1: Aquatic Nuisance Species

Made minor grammatical and spelling errors. Updated the list based upon revisions to red alert and high priority ANS species (noted above).

Appendix 2: Existing Authorities and Programs

No changes.

Appendix 3: History of ANSP Development

No changes.

Appendix 4: Public Comments of the ANSP

No changes.

Maryland

Joseph W Love -DNR- <joseph.love@mary[illegible]d.gov>

MD ANS Plan for Review - Major Revision

Maclean, Don <don_maclean@fws.gov> Mon, [illegible] 17, 2024 at [illegible]:21 PM
To: Joseph W Love -DNR- <joseph.love@maryland.gov>
Cc: "Pasko, Susan R" <susan_pasko@fws.gov>

Hi Joe,

Hope your summer is going well! ... and maybe this will make it a little better.

Regarding the changes that you wish to make to the Maryland ANS Management Plan, I have discussed them with Executive Secretary, Susan Pasko, and we feel that they fall right into the [illegible] middle of the middle category.

As such, after my detailed review, we do NOT feel these changes need to be approved by the ANS Task Force. .... You may go ahead and make the changes that you outlined to me in the summary documents. But please note that if you wish to make additional changes we may need to talk more.

Please keep a copy of this email for your records. (and maybe consider a more detailed revision of the Maryland Plan in the near future).

Thanks so much.

Don MacLean

Donald R. MacLean (*he/him*)
U.S. Fish and Wildlife Service
Division of Fish and Aquatic Conservation
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