To: Gabe Gries, Grants Specialist
From: Joseph W. Love, Program Manager
Date: June 30, 2021
RE: Final Report for Grant Agreement Award F20AP00210

Dear Mr. Gries,

Thank you for assisting us with achieving objectives for our funded application, "Aquatic Invasive Species Management Plan Implementation – Maryland." Below, please find our: 1) accomplishments detailed with proposed goals and objectives outlined in Award Number F20AP00210 with the U.S. Fish and Wildlife Service.

The Maryland Department of Natural Resources (hereafter, department) has made significant progress toward completing actions of its Aquatic Nuisance Species Plan. Some of this progress can be tracked online at:

https://dnr.maryland.gov/fisheries/Pages/nuisance_species.aspx.

1. Continuing support for DNR Invasive Species Outreach – 100% completed

The department periodically updates and increases signage related to invasive species in the State. Currently, the department prints signage when funds are available or in response to an invasive species outbreak. This project addressed Action 1.4.2 of Maryland's Aquatic Nuisance Species Management Plan.

The department worked on projects to promote information in Spanish when a need for such signage or pamphlets was determined necessary. As part of this project, the department translated new snakehead regulation signs to Spanish to help educate hispanic user groups of invasive species rules.

Staff purchased 25 Aquatic Hitchhiker signs, 25 signs aimed at preventing and identifying water chestnuts on Potomac River, and 160 newly designed, northern snakehead regulation signs. These signs have been posted at boat ramps throughout tidal rivers of Chesapeake Bay watershed. Additional trifold signs were earmarked for funding and aim to prevent introduction of aquatic invasive species to Deep Creek Lake. Digital images of these signs are available online:

https://dnr.maryland.gov/fisheries/Pages/signage.aspx

2. Maryland Invaders Tool – 100% completed

This project funded the aquatic portion of the Maryland Invaders Tool (MIT), a phone app for identifying and reporting invasive species occurrences. This job addressed Action 2.1.1, Identify and describe available reporting databases, of the State's ANS Plan. More importantly, it addressed Action 2.1.2, Adopt and use a reporting database that is a searchable repository for

observations of new species introductions. These were two of the ten actions that were prioritized in the State's ANS Plan.

The tool has been completed and can be found here: https://www.invasive.org/midatlantic/. It has been added to the department's Aquatic Invasive Species website, as well as the department's new reporter tool, Maryland Invasive Species Tracker (MIST).

https://dnr.maryland.gov/fisheries/Pages/nuisance_species.aspx

3. Molecular Early Detection System for Aquatic Nuisance Species in Maryland waters - year three. - 100% completed

Early detection systems for aquatic nuisance species have been improved by the advancement of polymerase chain reactions that amplify DNA sequences for decoding. The proposed work specifically addresses Action 2.3.1 of Maryland's Aquatic Nuisance Plan. The action requires the State to "assess feasibility and statistical reliability of using eDNA [or environmental DNA] detection system in Maryland waters for red alert species." Detecting aquatic nuisance species using molecular methods and eDNA is arguably more sensitive and more cost effective than using traditional biological surveys. This work is a continuation of work funded for 2018 and 2019 by assessing and reviewing the feasibility and statistical reliability of using eDNA. The objectives were to: 1) conduct a symposium and/or workshop that invites preeminent users of the technology, including the work conducted by Maryland; and 2) generate a summary report from the symposium and/or workshop for review by the department's Invasive Species Matrix Team.

A symposium entitled, Fishing for a Molecule: the practical application of eDNA for state agencies, was submitted and accepted for the American Fisheries Society's 151st conference held in Baltimore, Maryland. The symposium included ten participants, including a paper by the co-PIs of this project, Joseph Love and Jay Kilian. The paper presented by the authors conveyed information regarding the capacity building for eDNA monitoring in Maryland as well as results from a survey conducted in March 2021 to ascertain confidence and concerns with eDNA monitoring from other state agencies in the United States (abstract below). The symposium supported numerous presentations from Dr. Eric Larson (University of Illinois); Meredith Bartron (USFWS); Chris Rees (USFWS); Adam Sepulvedam (USGS); David Smith (USGS); Wes Daniel (USGS); John Darling (Senior Research Biologist; USEPA); Aaron Henning and Luanne Steffy (Susquehanna River Basin Commission); Jacob Riley (Stantec Consulting); and Joseph Love. The symposium was held in conjunction with another organized by Dr. Matt Yates (University of Quebec) who organized presentations regarding the use of eDNA in fishery management. One additional contact gained during symposia included Gregg Schumer (Director of Lab Services, Cramer Fish Sciences) who offered to assist the department in crafting a monitoring strategy using eDNA.

Following the conference, a brief summary of the symposium was written and published in *Fisheries* (January 2022). Additionally, work presented during this symposium and the symposium organized by Dr. Yates, was used to develop a Q&A webpage, with a decision tree for using and reporting eDNA monitoring in Maryland. This Q&A was approved by the

department's Invasive Species Matrix Team and the department for posting. It now serves as a basis for further eDNA monitoring in the state.

https://dnr.maryland.gov/fisheries/Pages/nuisance_edna.aspx

Abstract for the 151st meeting of the American Fisheries Society (Baltimore, MD)

Agency Preferences to the Use of eDNA Monitoring for Aquatic Invasive Species

Joseph W. Love, Jay Kilian

The use of eDNA monitoring provides a new tool for improved early detection of aquatic invasive species. Barriers or caveats of its use by natural resource agencies, however, can hinder its successful use. We surveyed natural resource managers from 50 states and five jurisdictions in the United States including U.S. Pacific Islands, St. Croix, Washington D.C., Lake Champlain Interstate Region, and the Tahoe Regional Planning Agency in 2021 to identify potential barriers and caveats to eDNA monitoring. Our survey response rate was 60%, with 33 state or regional agencies providing information on the use of eDNA monitoring in their jurisdiction. For those jurisdictions that had ANS management plans, the majority of plans did not identify eDNA as a monitoring tool. However, most agencies reported a high level of familiarity with eDNA monitoring, particularly northeastern and midwestern states. Over half of the agencies had or were in the process of using eDNA as a tool. Agency representatives who were most familiar with eDNA monitoring, were also most confident in it for detecting aquatic invasive species. Agencies used the eDNA monitoring to detect 13 aquatic taxa, primarily silver and bighead carp (*Hypophthalmichthys* spp.) and zebra and quagga mussels (*Dreissena* spp.). Agencies usually performed multiple eDNA tests for confirmation and/or completed traditional macro-organism field surveys to find the species. Agencies also noted that lab processing efficiency, time, and communication were important barriers to success. If ANS plans evolve to include a robust plan for eDNA monitoring, then state agencies will need to first, establish quality relationships with DNA laboratories, and second, invest in a response plan that includes follow-up verification and public outreach.

Draft Summary Published in *Fisheries* (January 2022)

Novel advancements in detection of DNA that has been shed into aquatic environments (i.e., eDNA) have offered challenging opportunities to detect and quantify aquatic invasive species. Joe Love (MDNR) identified numerous concerns for state agencies, such as poor confidence in positive detections. Public engagement, described by Eric Larson (UI Urbana-Champaign), cost-effectively increases sampling capability and can yield a reliable source of information. Robust field sampling and lab standards, John Darling (USEPA) emphasized, improves reliability; further, uncertainty can be explicitly addressed with occupancy models and decision trees. Adam Sepulveda (USGS) described decision trees and managing positive detections within an Early Detection-Rapid Response framework. Monitoring eDNA concentrations has successfully tracked expansion and abundance of invasive round goby (*Neogobius melanostomus*), as reported by Scott George (USGS). And while Christopher Rees (USFWS) demonstrated inter-annual variability in eDNA monitoring for invasive northern snakehead (*Channa argus*) and blue catfish (*Ictalurus furcatus*), their results also reflected expectations from field observations.

Using eDNA monitoring for aquatic invasive species offers a reliable index that, when used in concert with organismal surveys, improves detection and quantification of aquatic invasive species and adds substantial return on investment.

4. Invasive Fish Population Biology - 100% completed

Since their establishment in Maryland's waters, three introduced and growing populations of invasive fish species have been moderately well-studied. Northern snakehead (*Channa argus*) population size structure and size, habitat use, and prey habits have been well-elucidated to the point where scientists regard them as a top predator capable of colonizing a diversity of aquatic habitats and potentially have impacts similar to other top predators, such as largemouth bass (*Micropterus salmoides*). Similarly, blue catfish (*Ictalurus furcatus*) has been well studied for its dietary habits and has become widely considered invasive because of immense population sizes in some areas of Chesapeake Bay watershed. While less studied in Maryland, flathead catfish (*Pylodictis olivaris*) tends to forage consistently at higher trophic levels than blue catfish, which elevates concerns for different prey species even though flathead catfish have maintained far smaller distribution than blue catfish. All three species have gained attention by statewide resource managers who actively encourage people to harvest them, when possible, as a mechanism of population control. In spite of the studies and management actions, these species continue to expand their range and population sizes. Such expanding ranges have prompted more studies to identify dense areas, which lowers overhead by harvesters and efficiently removes more invasive species. Unfortunately, in the notorious case of blue catfish, but more generally all three invasive fish, the consequences of encouraging harvest as a control mechanism cannot be routinely assessed because there are no dedicated population abundance censuses for these species. This multi-year project addressed Action 3.3.1, to identify high priority aquatic nuisance species that can be routinely, cost-effectively, and practically controlled for biomass and implement strategies that engage the public or partners in those control efforts.

Staff examined habitat preferences and enumerated blue catfish at overwintering and spawning grounds, where harvest would be most effective. This work was leveraged against resources provided by USGS (Leetown Science Center, Leetown, WV) and Atlantic States Marine Fisheries Commission. In combination, the current award provided by U.S. Fish and Wildlife Service allowed the department to purchase additional tags for tracking blue catfish into preferred habitats, supplies for tagging blue catfish, and additional resources for supporting a fishing derby that was held in spring 2021.

As part of this funded project, staff tagged 31 blue catfish (mean total length = 725 millimeters, mean mass = 5102 grams) during spring 2021 with radio-acoustic telemetry tags. These fish were added to fish that had been tagged during winter 2020 using funds from a different funding source. In total, 70 blue catfish were detected at least once during weekly surveys conducted between November 2020 and July 2021, and 56 moved from their detected location. To estimate abundance in tidal freshwater areas used by blue catfish, staff marked 1,472 blue catfish (≥ 200 millimeters) with either fin clips or anchor tags during summer 2021. Detections for blue catfish have been loaded and will be published online via Tagged Animal Movement Explorer:

https://usgs.gov/apps/ecosheds/tame#/projects/patuxent-blue-catfish

Habitat use measured included both tidal freshwater and oligohaline habitats (< 2.0 practical salinity units or 2400 microsiemens), but less so, mesohaline habitats. During winter, all blue catfish were detected in tidal freshwater (< 0.3 practical salinity units or 600 microsiemens) and from both shallow water within Jug Bay and deep water channels of river bends. Several blue catfish moved downstream at the onset of the spawning season and utilized a larger portion of the river, including oligohaline habitats; but, following downstream movement, many returned to tidal freshwater. Average distances traveled during winter (average = 22 kilometers) were greater than those during spawning (average 13 kilometers), with one blue catfish traveling 138 kilometers overwinter; the majority of its movement occurred in March, April, and May (Fish Number 164124). For six fish that were detected on two consecutive days, instream distance traveled averaged 4.8 kilometers per day (SE = 1.4) and ranged between 0.33 kilometers per day and 10 kilometers per day. Detection data yielded results delineating five distinct habitats (or hotspots) for blue catfish during winter and nine, during the spawning season. Some habitats were used during both overwinter and spawning seasons, including three, large hotspots shared between seasons in the river channel (mean depth = 3 meters).

Blue catfish utilized similar habitats during winter and spawning seasons, with differences observed in less shallow water use and more downriver, oligohaline habitat use during spawning. Based on their dispersal patterns and rate of movement, control efforts can be applied at the scale of a river (tidal freshwater and oligohaline habitats). Commercial or recreational harvest efforts during winter can be directed to shallow waters of bays (e.g., with haul seines) and deep channels during winter and the spawning season (e.g., with jugs). Abundance for one hotspot identified within the study reach was estimated as 29,432 fish (total length ≥ 200 millimeters) or 507 fish per hectare. Abundance within the tidal freshwater region study reach was estimated as approximately 74,743 (total length ≥ 200 millimeters).

The department supported a catfish tournament on Patuxent River on March 13, 2021. The tournament, the First Annual #DoitforRoper, was organized by anglers as a fundraiser to benefit Calvert Hospice. Over 300 people attended the tournament. The department supported the tournament by assisting with staff, providing in-kind supplies, and awarding gift cards to some participants. Staff fileted over 200 pounds of catfish that was donated to St. John's Vianney food pantry.

While Natural Resources Police were asked to attend the derby, it was determined that a better process for engaging officers with invasive fish information is in developing a training course for cadets. That course is being developed currently with a draft agenda (see below) and a planned date of August 5th, 2022. Training will be aimed at ensuring fish are treated within guidelines of regulations, which will improve training of officers who may encounter people fishing invasive fishes in the field (Action 3.2.3).

In the case of commercial harvest, abundance harvested and sold is reported to Maryland. We report the level of reported recreational and commercial harvest via online website and technical reports for these invasive fishes, in support of Action 3.3.3.

Tentative Agenda for NRP Cadet Training

Topic	Estimated Time	Supplies/Equipment
Fish Morphometrics	30 mins	Preserved Specimens, rulers, trays
Freshwater Fish ID	60 mins	Preserved Specimens and Live Specimens)
F/W Fish Mobile Quiz	30 mins	Smartphones (supplied by cadets)
Regulations - Q&A	20 mins	Fishing Guide
Contacts	10 mins	Freshwater Fisheries team structure; contact cards

5. Defining ANS Pathways and their Relative Risk in Maryland – 75% completed

The Maryland Aquatic Nuisance Species Management Plan identifies 16 pathways that have led to the introduction of the majority of aquatic invasive species now established in Maryland waters. These pathways remain a concern, but the relative risk that each pathway poses for the future introduction of invasive species has not been adequately assessed. Additionally, there are many gaps in our understanding of these pathways including a lack of information on the stakeholders involved, the geographical extent of each pathway, the potential socioeconomic and cultural barriers to pathway management, and the current species of greatest concern within each pathway. Knowledge of these factors is critically important for management of each pathway by Maryland Department of Natural Resources and other partners and for identifying critical control points where interdiction would be most effective.

In Fall 2021, Resource Assessment Service (RAS) staff initiated an examination of the live bait pathway in Maryland with the goal of identifying the suppliers involved in bait import to the state, the taxa associated with the live bait trade, and the sources (origin) of those bait taxa. The expected outcome of this investigation is to identify potential critical points along the supply chain where management (e.g., education/outreach, regulation) would be most effective at reducing ANS introductions resulting from this pathway. In November 2021, RAS developed an initial list of 71 Maryland retail bait shops via internet search. In January 2022, RAS developed a survey form of Maryland bait retailers. The intent of this survey is to obtain information from the retailers on the types and sources of live bait they sell and the names of the wholesale distributors that they use. The RAS staff also developed a survey form for live bait wholesalers. Surveys were sent to the department's Invasive Species Matrix Team for their review and comment in early March 2022. Responses from the team were incorporated into the survey form. Questions on the retailer survey include:

What is your top-selling bait(s)?
Including your top-selling baits, what types of live bait do you currently sell?

(Per bait type) – Please state the common, trade, or scientific name of the bait if known.
How do you obtain this bait?
If you obtain from a wholesaler, please provide the name of the dealer.
Is this bait wild-caught or farm-raised?
Does your supplier for this bait change periodically? If so, how often?
Where is the bait collected or grown (to the best of your knowledge)?
When did you start selling this bait at your store?
About how many individuals of this species do you keep in stock each year?
Is there a time of year when you sell this bait type the most?
When you receive this species in your store, is it in any kind of packing material? If so, what material?
Do you ever notice other animals or plants in the shipments with the bait itself?
How do you usually dispose of unsold, damaged, or dead individuals?

Reason Work Was Not Completed

Due to staffing shortages and delayed hiring, RAS was unable to complete the survey of retailers by June 2022, but the survey is planned to begin in July 2022. This survey will be sent to wholesale distributors identified during the retailer survey in July. The intent of the survey of wholesale distributors is to obtain information on the sources (e.g., aquaculture, wild-caught) and origin (e.g., state, region) of the live bait types imported into Maryland and to develop a positive working relationship with these companies. The surveys will provide important information that will be used to plan the next steps of this project that are needed to better define the live bait pathway in Maryland.