5 Year Management Plan for Introduced Common Mudpuppies (*Necturus maculosus*) in Maine

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Executive Summary

In 1939 and 1940, 85 live specimens of common mudpuppy (*Necturus maculosus*) salamanders escaped from cages suspended in the stream running between Salmon Lake (Ellis Pond), and Great Pond in Maine. These original escapees were laboratory specimens collected in Pennsylvania by Professor Aplington of Colby college. Descendants of those common mudpuppies have since established and proliferated in the Belgrade chain of lakes. Common mudpuppies are native to the American Midwest, the Great Lakes Drainage, Manitoba, Ontario, Quebec, and New England drainages leading to Lake Champlain. Common mudpuppy ranges extend south into Louisiana to Georgia. Common mudpuppies feed on shellfish, eggs, and small fish, and are forage most actively during the winter. Ecological interactions between common mudpuppies and prey species are not understood, and common predator species remain largely unknown, although there are sparse observational reports in literature. This plan will create a monitoring system to keep track of common mudpuppy populations and where the invasive range has spread to. Consistent monitoring through trapping and observation in the immediate future, while simultaneously developing eDNA surveys to detect common mudpuppies, will create a fuller picture of the status of invasive common mudpuppies. Monitoring can inform future management decisions and pinpoint areas where efforts should be focused. Public education efforts can focus on ponds hosting common mudpuppies by posting flyers there. Research on the ecological interactions of common mudpuppies with Maine SGCN species and important game fish species such as brown trout (*Salmo trutta*) and smallmouth bass (*Micropterus dolomieu*). Once these interactions become more clear future management plans can take these into account for their goals and objectives. If successful, these efforts will increase awareness of common mudpuppies and minimize anthropogenic causes of their spread. A scientific understanding of environmental effects stemming from common mudpuppy presence will inform the dangers posed to native wildlife by common mudpuppies, if any, and what level investment is justified by their impact can be judged off the results. Ideally, common mudpuppies will no longer be existing as an unquantified factor in the ecology of Maine's lakes and streams.

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Introduction

The common mudpuppy (*Necturus maculosus*) is a fully aquatic, neotenic salamander native to the North American Midwest, parts of the American South, and ranging east to western Vermont (Bishop 1941, Green et al. 2014). Common mudpuppies were accidentally introduced to the Belgrade chain of lakes in Maine in 1939 by a biology professor who was keeping them for study when a hole was punched through a cage containing live specimens being kept in a river (Crocker 1960, Collins 2003, Sarnacki 2019). The first sightings of common mudpuppies in the Belgrade lakes following the introduction took place in 1957, and the species is still present there today (Crocker 1960, Sarnacki 2019). A lack of ecological studies focusing on predator prey interactions or competition makes predicting potential impacts of the presence of non-native common mudpuppies difficult to predict. Survivorship figures are not established, common predators are not known, there is not data on habitat suitability outside of observation by researchers (Autz 2020, Haines 2021), and much of what is known is based off studies conducted almost 100 years ago by authors such as Bishop who published a guide on salamanders in 1941 (Bishop 1941).

The environmental effects that common mudpuppies have had in the lake ecosystems has not been fully studied and is not understood (Sarnacki 2019). Anglers who fish on the Belgrade lakes have expressed concern about the potential for common mudpuppies to damage fisheries (Collins 2003). Common mudpuppies are known to eat small fish and aquatic insects which may influence survivorship of sport fish through predation and competition for food resources (Haines 2021). There are also concerns that predation by common mudpuppies

on some Maine SGCN species would increase conservation issues where common mudpuppies are present (MDIFW 2021a). There are also concerns that anglers may be using common mudpuppies as live bait and releasing live specimens afterwards (Sarnacki 2019). Mudpuppies are present in all Eastern Aquatic Ecoregions, which puts them in contact with species in their natural ranges that are also present in the Belgrade lakes (Olivero and Anderson 2008).

Given the number of unknowns around involved in managing common mudpuppies, fast action is necessary to understand the ecological, economic, and social implications of the introduced common mudpuppies in the Belgrade lakes so that any damages can be mitigated, and the spread of common mudpuppies to other lakes can be prevented. Goal 1 is to evaluate the environmental effects and spread of common mudpuppies in Maine. The first objective under goal 1 establishes monitoring systems to track common mudpuppy presence and abundance. Actions include traditional trapping (Murphy et al. 2016), eDNA surveying (Holmes 2021), and the creation of software to coordinate data and to allow for the public to report sightings (Wallace et al. 2016). Objective 2 focuses on outlining the unknown environmental effects through creel surveys (Nieman et al. 2021), and lake environment research. These actions would investigate the concerns common mudpuppies are harming ecosystems. The second goal seeks to prevent further spread of common mudpuppies through public outreach, to prevent people from spreading common mudpuppies through their own actions.

Natural History

Taxonomy

The common mudpuppy is in class Amphibia, order Caudata. The family Proteidae contains the mudpuppies and olms (Proteidae 2022). The genus *Necturus* contains the common mudpuppy as well as western waterdog (*Necturus beyeri*) and the Red River waterdog (Necturus maculosus louisianensis) (Proteidae 2022).

Species Identification

Common mudpuppies are fully aquatic, neotenic salamanders easily identified by their external gills and laterally flattened tail (Klemens 1993). Bishop (1941) found that from an average of 25 adult common mudpuppies from New York, Pennsylvania, and Kentucky, the average size from snout to tail tip was 287.4 mm, with females only slightly larger than males (average of 2mm difference), however maximum size varies throughout the range of the species, and between populations in separate water bodies (McDaniel et al. 2008). Adult males can be identified by a swollen cloaca, which will have paired papillae during the winter and spring (Chellman, Parish, and Donovan 2017). Common mudpuppies are usually a dark brown or rusty color with blue/black or black spots along the back, which may be scattered or in rows (Fig. 1)(Bishop 1926). The underside is gray with spots

Figure 1. An adult common mudpuppy (Necturus maculosus*) showing rusty brown coloration and dark spots (Bishop 1926. Photo by Trevor Persons.*

lighter than those that appear dorsally. Larvae have a dark line running mid-dorsally which is bordered by yellow (Bishop 1926). Maroon external gills are easily identified and are retained in all life stages (Bishop 1926, Klemens 1993). Mudpuppies can be differentiated from larval forms of members of the genus *Ambystoma* by their having 4 toes on all feet where *Ambystoma* have five on the rear feet (Klemens 1993).

Distribution and Home Ranges

The common mudpuppy exists throughout the Midwestern United States, in the Great Lakes Drainage, in Manitoba, Ontario, and Quebec, and in New England (Green et al. 2014).

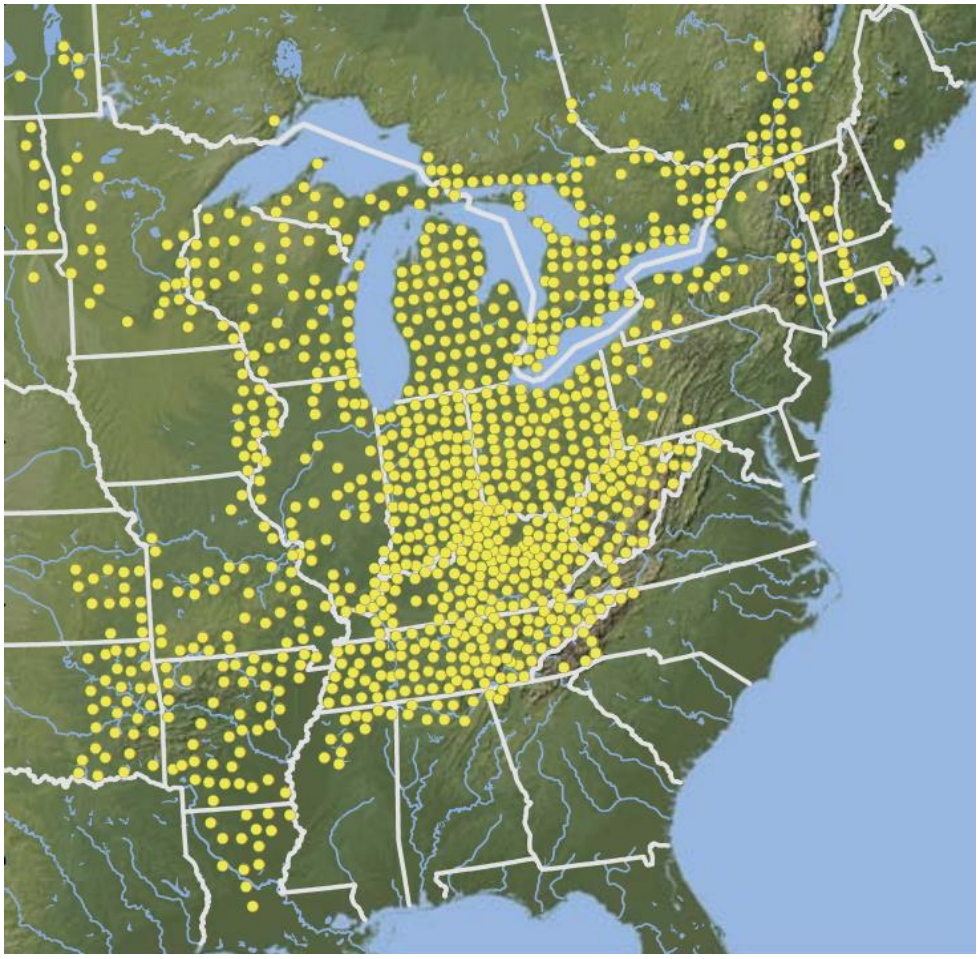

*Figure 2. Range map for the common Mudpuppy (*Necturus maculosus*) showing reported common mudpuppy populations (Green et al. 2014).*

Their range extends south to the northern parts of Louisiana, Mississippi, Alabama, and Georgia (Fig. 2)(Degraaf and Rudis 1986, Green et al. 2014).

The occurrence of common mudpuppies in Maine has been traced to the accidental release of captive specimens from a Pennsylvania population into a stream leading into Great Pond by Professor Aplington of Colby college in 1939 and again in 1940 (Crocker 1960). Aplington held specimens in cages submerged in the stream until some were torn open either by scavenging wildlife or by stones carried by the current (Crocker 1960, Collins 2003). Aplington was unable to find escaped salamanders downstream of the cage, however adult specimens were first reported by anglers as by-catch in 1957 (Crocker 1960, Collins 2003). Anglers had pulled up adult Anecdotal evidence of anglers transporting common mudpuppies for use as fishing bait may explain the radiation of the salamander out from Great Pond (Sarnacki 2019).

Members of the genus *Necturus* consistently exhibit similar home range and homing behavior. Common mudpuppies typically do not stray more than a few hundred meters from where they were first captured with an average wandering distance of 81.8 meters (Shoop and Gunning 1967, Chellman et al. 2017). Shoop and Gunning (1967) noted that caught individuals which had been released away from their capture point immediately swam off in the direction of their home range rather than seeking cover as had been predicted. The original 85 common mudpuppies which escaped into Great Ponded were collected from Pennsylvania and were noted not to have taken residence in the stream leading into the pond (Crocker 1960). If those

common mudpuppies were collected from a lake, they may attempt to find habitat most like that lake rather than taking up residence in a stream.

Habitat

The common mudpuppy inhabits both lotic and lentic aquatic environments at depths from 1-30 meters. They inhabit clear streams, rivers, and lakes to murky rivers and even drainage ditches (Bishop 1941, Shoop and Gunning 1967, Matson 2005, Craig et al. 2015, Autz 2020). In murkier water they have been observed being active throughout the day, instead of primarily at night (Bishop 1926). Nesting habitat can consist of the rooves of crayfish holes, excavated nests, or underneath submerged infrastructure (Bishop 1941, Matson 2005, Craig et al. 2015). Larvae usually leave the nest once the yolk sac is depleted and hide under detritus and rocks in the surrounding area (Matson 2005). Juveniles may inhabit depressions, uninhabited retreats, and riffles formed by the current, and may also hide in accumulated detritus (Matson 2005). Adults inhabit areas where the bottom consists of stacked rocks, logs, branches, or other submerged debris (Shoop et al. 1967, Matson 2005). Some sediment is usually required so that mudpuppies can excavate retreats, and so that nesting females can build nest cavities (Matson 2005).

Diet

Salamanders are carnivorous in all life stages (Wells 2007). Little is known about mudpuppy larval diet specifically, but across salamander clades with aquatic larvae common prey unusually consists of benthic invertebrates and zooplankton, and larger forms may eat the larvae of other amphibians (Wells 2007). Juvenile and adult diets consist of insects, fish, fish

eggs, amphibian eggs, worms, crayfish, and smaller conspecifics, with insects, fish, and crayfish accounting for the most biomass in gastric lavage samples (Bishop 1941, Shoop and Gunning 1967, Matson 2005, Haines 2021). Insects make up most of the diet in the summer and fall, while fish become the majority prey item during winter months (Haines 2021). This hunting behavior is paralleled by an increase in activity during winter months (Haines 2021). This behavior may only exist where there are harsh winters and many waterbodies freeze over, as Shoop and Gunning (1967) did not find seasonal variation in activity of the mudpuppy subspecies Red River waterdog (*Necturus maculosus louisianensis*) which inhabits states in the American South.

Influences of predation of New England native species by common mudpuppies is not well understood but could be potentially impactful on at risk species (Fig. 3)(MDIFW 2021a).

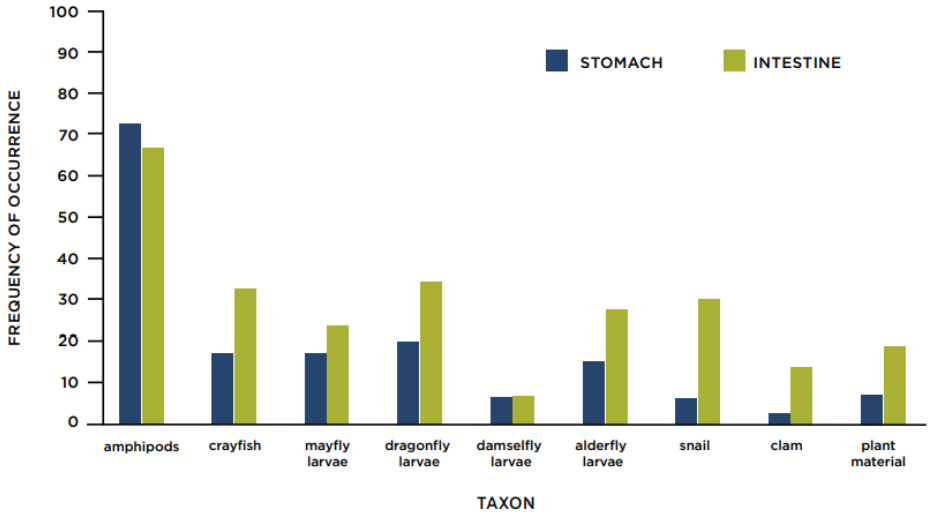

*Figure 3. The stomach and intestine contents of common mudpuppies (*Necturus maculosus*) collected in Maine. There are higher levels of amphipods than have been recorded by other sources, and no fish.*

Reproduction and Sex Ratio

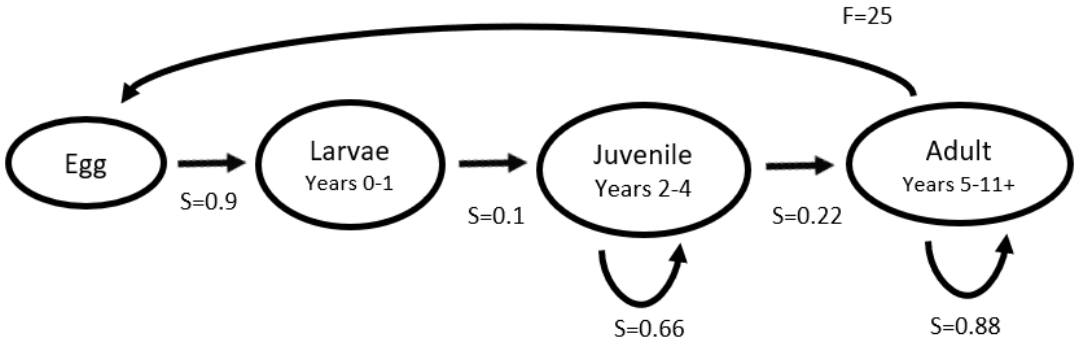

*Figure 4. Life cycle diagram for the common mudpuppy (*Necturus maculosus*). Fecundity data is taken from observations (Macedo and Holmquist 2021), figures from hellbender (*Cryptobranchus alleganiensis*) larvae, and adult survivorship is taken from greater sirens (*Siren lacterina*).*

Mating can take place from the fall into the spring. Males initiate a courtship dance and deposit a spermatophore which is taken by the female (Bishop 1941, Matson 2005). Females begin excavating nests and laying 30-100 eggs in June (Bishop 1941, Shoop 1965). Populations have been noted by Bishop (1941) to lay eggs nearly synchronously. Nests are excavated by females between 2 and 10.7 meters from the bank in water as shallow as 38 cm and as deep as 2 meters (Bishop 1941, Gendron 1999, Macedo and Holmquist 2021). The eggs are guarded by females during incubation, which may last from 30-60 days depending on temperature (Bishop 1941).

Sex ratios in the common mudpuppy are typically 1:1-5:7 with there always being higher or equivalent abundance of females in the population (Shoop 1965, McDaniel et al. 2009, Chellman et al. 2017, Autz 2020). Chellman et al. (2017) found that treatment of lampricides can reduce female abundance significantly and found more overall variation in sex ratios in the Lamoille River of Vermont, where lampricides are in use.

Mortality

Mortality/survivorship rates for the common mudpuppy and other members of *Necturus* are not known to science (McDaniel et al. 2008). Observational evidence from Haines (2021) and Macedo and Holmquist (2021) suggest that egg survivorship may be 90% or above. Haines (2021) found a collection of eggs with nearly all embryos attached, and Macedo and Holmquist (2021) found 4 nests where all but 7 eggs had successfully hatched. It is unclear whether the remaining 7 eggs represented mortalities or stragglers. Larval and adult survivorship figures are not known.

Mortality rates increase in areas being treated with the lampricide 3-trifluromethyl-4-nitrophenol (TFM). Chellman et al. (2017) found that juveniles represented 70% of TFM mortalities in the Lamoille River of Vermont, where 528 mudpuppy mortalities occurred from a single treatment. Females where much less abundant than males in traps during recapture efforts, which may be due to higher female vulnerability to TFM or a change in habitat use in the spring due to nesting (Chellman et al. 2017). Boogaard et al. (2003) suggested that mudpuppy populations would not be significantly influenced by TFM. The no observable effect concentration of TFM for mudpuppies is 1.1-1.5 times that of lampreys (Boogaard 2003), however this study did not include juveniles. The long-term vulnerability of mudpuppies to TFM is unclear.

Natural mortality of mudpuppy adults can be attributed to parasites, a variety of fish predators such as bass, trout, and pike, predaceous insects, birds, and other mudpuppies (Bishop 1941, Wells 2007, Unger et al. 2021). Mudpuppies can carry trematodes and

tapeworms (Bishop 1941, Haines 2021). Specific predators of mudpuppies are not well understood but they have been observed eaten by many species anecdotally (Haines 2021, Unger et al. 2021)

Competition

Competition with native species in Maine is not well understood (Sarnacki 2019, MDIFW 2021a). The diet of mudpuppies of aquatic macroinvertebrates and small fish overlaps with numerous fish, such as largemouth bass (*Micropterus salmoides*)(Dibble and Harrel 1997), and pumpkinseed sunfish (*Lepomis gibbosus*)(Mittelbach et al. 1991). The use of flat stones as cover for escape, hunting, and for breeding may bring them into competition with crayfish and minnows (Crocker 1960) but this has not been studied. Other salamanders in New England typically spawn in temporary vernal pools which could not support a mudpuppy population (Klemens 1993).

Population Projection

The hellbender salamander (*Cryptobranchus alleganiensis*) is another fully aquatic salamander native to the northeast which also exhibits parental care. It will be used as a surrogate species for calculating larval survival rate. Freake and DePerno (2017) reported a low larval survival rate for hellbenders at 10% average. Adult greater sirens (*Siren lacertina*) are another large aquatic salamander species with similar ecology to the common mudpuppy (Bishop 1943). Adult survivorship among pond-dwelling greater sirens in Florida is 88% (Sorensen 2003). This high survivorship is sensible for mudpuppies, as older individuals were

captured by McDaniel et al. (2008), and specimens older than 10 years were most common in two rivers samples by this study.

Observations by Macedo and Holmquist (2021) put fecundity values at ~25. Older observations by Bishop (1926) suggest much higher numbers, averaging around 50. Neither of these observations have a large sample size, and they are not from the same locations. For the sake of accuracy, both possibilities have been included in the projection.

The projection shows how effective common mudpuppies could be at colonizing new pond, lakes, and rivers based on variable fecundity and initial numbers of introduced individuals (Fig. 5). There is a wide spread of results after 25 years. The model does not figure in carrying capacity, since there are no figures for carrying capacity in common mudpuppies.

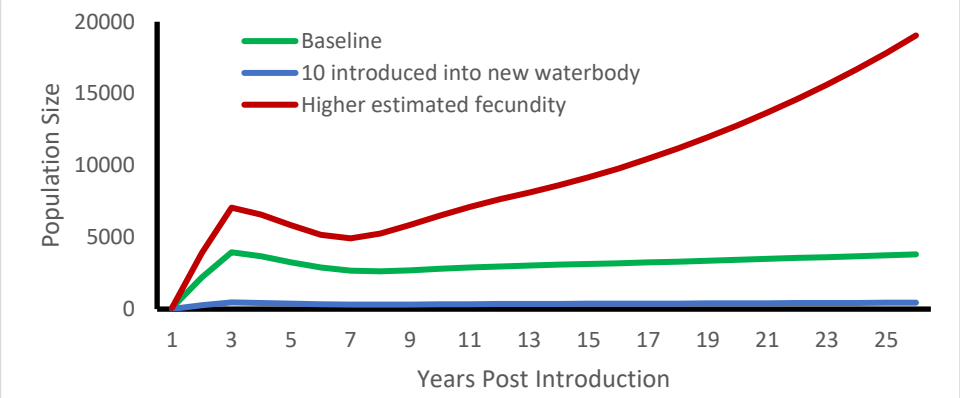

Figure 5. Projected population growth following introduction of common mudpuppies into a new waterbody. The baseline curve predicts based off the original 85 individuals which escaped upriver from Great Pond (Crocker 1960), and assumes a fecundity of 25 (Shoop 1965, Macedo and Holmquist 2021). The curve for 10 hypothetical introduced common mudpuppies operates on the same assumptions expect it assumes 10 individuals, as if a bucket of illegal live bait common mudpuppies were dumped into a waterbody. The final curve accepts the larger clutch sizes reported by Bishop (1926) of which would bring fecundity to 50.

Economic

The main economic concerns regarding introduced common mudpuppy in Maine are the risks to sports fishing and the cost of management. A 2014 report to the Maine Office of Tourism, and the Maine Department of Inland Fisheries and Wildlife reported $208,808,028 were spent in 2013 on goods and services related to fishing in Maine. Of the states $319.2 million GDP that year, $176 million was due to freshwater fishing related spending. Freshwater fishing accounts for over 3,300 full and part time jobs in Maine, providing over $104 million in labor income. The area around and including the Belgrade chain of lakes falls into the Kennebec Valley region, where total fishing expenditure was $31.5 million in 2013. This report included data from the cost of fishing equipment, special equipment, and trip expenditure to account for all economic activity generated by fishing trips.

The impact of invasive mudpuppies on native species is not well understood (Sarnacki 2019), which puts a multi-million dollar a year industry at risk. The most targeted fish in Maine are brook trout (*Salvelinus fontinalis*), smallmouth bass (*Micropterus dolomieu*), landlocked salmon (*Salmo salar*), lake trout (togue)(*Salvelinus namaycush*), and brown trout (*Salmo trutta*) (Maine 2014). Damage to fish stocks through competition with, or predation by, mudpuppies could jeopardize the economies of Maine and the Connecticut River Basin regions which are so reliant on the freshwater fishing industry (Maine 2014).

There are currently no efforts to manage common mudpuppy population in Maine. Much of this is due to a lack of understanding of their environmental effects (MDIFW 2021a).

Management against invasive mudpuppies may take the form of TFM lampricide treatments, which may be effective against juvenile mudpuppies, although further study is required (Matson 2005). Lampricides are used in other states to control sea lamprey (*Petromyzon marinus*) population in Lake Champlain and the Greatlakes (Matson 2005, Grunder et al. 2021). If viable, TFM treatments for mudpuppies are likely to be as expensive as those for lampreys, but possibly higher. Unlike mudpuppies, lamprey migrate upstream to spawn, where they can be treated against (Grunder et al. 2021). Mudpuppies would have to be treated where they are, which could result in a larger area needed to be treated. In 2020 the Great Lakes Fishery Commission budget for lampricide treatments was $14.8 million. The danger to native species would have to be understood and judged significant enough to warrant a multi-million dollar budget spanning multiple years. More data would have to be collected before such an intensive action could be considered, but it may only become viable if common mudpuppies are found to represent a serious threat to Maine's fisheries and ecosystem health.

Sociocultural

The existence of the mudpuppy salamander is largely unknown by the public (Collins 2003). When introduced mudpuppy populations in Great Pond, Maine became large enough to be noticed by anglers there was a strong negative reaction, including efforts by anglers to eradicate them through catching and killing large numbers of mudpuppies (Collins 2003). Interviewed anglers from around the Belgrade chain of lakes, which contains Great Pond, held largely negative views of the species, ranging from outright hostility to ambivalence about them (Collins 2003). In the Clyde River of New York there are historical records of anglers in the early

1900's cutting lines due to the false belief that common mudpuppies are poisonous, stomping the heads, and throwing the animals on the banks to die whenever common mudpuppies were caught (Bishop 1926), suggesting a long-standing dislike of them throughout their range. The source of the negativity surrounding the mudpuppies comes from a concern about risk to important fisheries, such as landlocked salmon (Collins 2003).

Recreational fishing can be deeply embedded in the culture of anglers (Lynch et al. 2016, Traver 2018). Fishing traditions may be passed down through generations, and are a source of traditional environmental knowledge, where lived experiences result in environmental learning (Lynch et al. 2016). If mudpuppies are found to be a real or perceived threat to fisheries, there could be significant backlash against their presence (Collins 2003). To preserve fishing as an industry and a cultural staple in places where mudpuppies have been introduced, it is necessary to understand how mudpuppies are interacting with local ecosystems, and to educate the public about what science knows about invasive mudpuppies. The history of contention between anglers of different backgrounds increases difficulty of navigation. The proper way to manage fisheries has never reached consensus among the public (Traver 2018). This is further complicated by the introduction of many non-native game fish species in New England (Rahel 2000). Despite being introduced, many of these species are desirable to people who don't want to see introduced mudpuppies (Collins 2005).

The sociocultural aspect of mudpuppy management in their introduced ranges in the Connecticut River Basin and in Maine ultimately comes down to what their influence will be on angler success. Public education efforts may stall if they seem to conflict with the lived

experiences of anglers. Credibility between scientists and the public will be essential for effective education. Scientists are generally considered high in competence by the public, but they are also often viewed as cold (Fiske and Dupree 2014). In to be effective communicators to the public it is important that researchers be warm, accepting, and open with the public (Fiske and Dupree 2014). People respond best to information that may challenge their views when they feel that they are being included and respected. Education and outreach efforts may be more successful with an approach including sharing, discussing, and teaching to display trustworthiness rather than relying on data alone (Fiske and Dupree 2014).

Legal/Regulatory

There are not currently any laws in Maine specifically addressing its introduced population of common mudpuppies. Until the impact of mudpuppies on local ecosystems becomes better researched and understood there may not be any further regulation (Sarnacki 2019). Speculation by Maine biologists that mudpuppies might be being spread by anglers using them as live bait (Sarnacki 2019) is addressed by a Maine law which states which species may be used as live bait, and how they should be used (Selling, using, or possessing baitfish, MRS Title 12, §12553). This law exists to prevent the same method of spreading invasive species which may be in play with mudpuppies. Better policing by the Maine Department of Inland Fisheries and Wildlife could lower incidences of mudpuppy spread by bait, while simultaneously educating the public about this issue. Increased policing of live bait use could also confirm or repute whether mudpuppies are being spread as bait at all. While the environmental effects of common mudpuppies remain unknown it would be beneficial to pass legislation to prevent

their spread. This law would take the form of a ban on the possession and distribution of common mudpuppies in Maine. This would increase the penalty for using common mudpuppies as live bait above that of existing laws restricting live bait species to a list of native minnows. Ideally this law would slow the spread of common mudpuppies into new waterways.

Game fish have been introduced purposefully to add desirable game species for better fishing opportunities across New England (Rahel 2000). Non-native game fish populations are restocked by some states to maintain fisheries for anglers (MDIFW 2021b). The practice of managing for introduced fish has created a policy of effectively permitting introduced species to exist. If common mudpuppies are found to be relatively benign in their introduced range in Maine, it may not be worth the cost of control efforts, especially if those efforts may risk unanticipated harm to native species. In such a circumstance, it may be better to include common mudpuppies in the list of managed introduced species. In this instance common mudpuppies would be managed in their current range while efforts are taken to prevent colonization of new waterbodies. The proposed law banning the possession and transport of common mudpuppies would still take effect here. Caught mudpuppies would have to be released where they were found.

The Maine Fish and Wildlife Conservation Office have the mission of restoring fish habitat and promoting healthy fish population (USFWS 2022). The same policies which the USFWS are implementing to increase fish conservation efforts will also create and improve mudpuppy habitat. As these projects are implemented the populations of mudpuppies may grow and become more of an issue. Whether there is any effect as such remains unknown,

however any mudpuppy removal efforts proposed in the future would be made more difficult if the species becomes further established.

Statement of Need

Common mudpuppies were accidentally introduced into Maine by Colby College Professor Aplington in 1939 and 1940, and possibly spread since then by anglers for use as bait. Anglers in Maine have historically expressed concern that mudpuppies may decrease fish populations through competition and egg predation (Collins 2003). The economic and societal ramifications of the presence of invasive salamanders is not understood, but they likely hinge on their influence on sport fisheries in the region. Historic records indicate an initial fear by locals that the common mudpuppies would harm recruitment in desirable fish due to egg predation or the predation of larval fish, but this has not been proven to be happening. Some Maine Species of Greatest Conservation Need may be included in the diets of common mudpuppies creating novel conservation difficulties for these species. The inclusion of small fish in mudpuppy diets may threaten the winter baitfish industry in Maine (Matson 2005), which was worth $4.7 million in the 1990's (over $10 million adjusted for inflation) (Kircheis 1998). Conversely, mudpuppies may be acting as a food source for larger fish and other wildlife where they have spread (Wells 2007, Unger et al. 2021). Mudpuppies are most active in the winter, which is also when fish make up the largest part of their diet (Haines 2021). This increase in activity may be noticed by people ice fishing, which is a popular outdoor activity in many communities in northern New England. Nature tourism is a major industry in New England, and damage to recreational fishing could be devastating for the region.

In Maine it is illegal to use mudpuppies as live bait and to release any live bait into waterways excepting native species listed under Maine law as legal live bait (MRS Title 12, §12553., MRS Title 12, §10001., [PL 2007, c. 240, Pt. QQ, §11 (AMD).]), however this law is not well enforced or strictly adhered to (Kircheis 1998). The common mudpuppy is not listed under the Lacey Act as an example of injurious wildlife despite its success in novel territories. The current salamanders list only considers possible carriers of salamander chytrid fungus, not other criteria for injurious wildlife (50 CFR 16.14).

Currently any damage being done by mudpuppies in New England is unknown (Sarnacki 2019). Increased activity during the winter months could be putting high stresses on fish species during a stressful period. Mudpuppies could be spreading new parasites into vulnerable populations (Bishop 1941). The unknown ecological influence of mudpuppies in New England puts aquatic ecosystems at risk and could lead to having to mitigate future problems which could have been prevented by early action.

Management

Goal 1: Evaluate the environmental effects and spread of common mudpuppies in Maine.

Objective 1: In the next 5 years, establish a monitoring system in the Belgrade chain of lakes and 10 surrounding lakes in Maine to keep track of common mudpuppy presence and abundance.

Action 1.1: eDNA monitoring of waterways for presence and population size of common mudpuppies. eDNA monitoring can detect mudpuppy presence year-round and can be

calibrated to known populations to be used to estimate abundance (Chucholl et al. 2021, Holmes 2021). eDNA is a cost-effective, low effort method to check for the presence of species reliably and rapidly (Colby 2019). Lakes and streams could be tested for the presence of common mudpuppies as a preliminary before any other management effort need be expended. Lakes not known to harbor common mudpuppies could be tested to monitor for any expansion of common mudpuppy range in Maine. Challenges to eDNA surveys include difficulty of detection during the winter and in larger rivers. An assay would have to be created before testing could begin, and a known population would be needed to calibrate population estimates (Chucholl et al. 2021, Holmes 2021). Assays are currently being made by Holmes (2021) specific for the Maine common mudpuppies, but assays for other populations already exist (Sutherland 2019). eDNA can be collected from the water and from sediment (Sutherland 2019). Unlike in other studies, common mudpuppies are not native, and so there is no worry of sediment DNA from old populations giving false positives. Ten shoreline sites will be tested for common mudpuppy DNA at each lake known to contain common mudpuppies and in ten akes in the surrounding area. Then DNA will be replicated through PCR and tested. Imperfections in eDNA testing can be accounted for by occupancy modelling (Sutherland 2019). Occupancy modelling can be used to estimate detection probability and determine how many replicates need to be made for accurate results (Sutherland 2019).

Knowledge on where common mudpuppies are and what the abundances are in different areas would inform management decisions about where to allocate resources and effort. The cost effectiveness of eDNA surveying would free up more resources for other management efforts and increase the effectiveness of management.

Action 1.2: Begin physical trapping efforts to monitor common mudpuppy presence and abundance in the management area. Implement the use of modified Briggler traps to monitor for adult common mudpuppy presence. Modified Briggler traps are the most effective trapping method for passively catching common mudpuppies; deployment in the late fall, winter, and spring during the active foraging period for common mudpuppies is the most effective technique for targeting adults (Murphy et al. 2016). Modified Briggler traps can be made for ~$35 dollars each and have a success rate of 0.10 common mudpuppies caught per hour of effort, which is higher than other trapping methods historically used for common mudpuppies (Murphy et al. 2016). This method is only effective during the period of heightened common mudpuppy foraging activity from the late fall through the spring. A similar method is currently employed by the MDIFW (MDIFW 2021a), and their work would be integrated into this action.

Seining is an effective trapping technique for catching larval and juvenile common mudpuppies. It requires a worker to disturb rocks and debris ahead of a net being dragged across the bottom. This method works best with the loose debris of leaves and detritus that larval and juvenile common mudpuppies hide in before growing to the larger sizes attained by adults (Murphy et al. 2016). This method is labor intensive to deploy and requires areas where the main refugia are not large flat rocks (Murphy et al. 2016). Seining would take place in the summer months and is not reliant on baiting. Seining would target young individuals allowing for analysis of recruitment and progress of eradication of future generations. Manual surveying allows for direct observation of common mudpuppies in their habitat and has a relatively high success rate (Murphy et al. 2016). It can be conducted through wading or skin diving. Manual surveying is only effective in relatively shallow water that is clear enough to reliably sight

common mudpuppies and can only be conducted in the summer months. It also requires high enough skill to be able to catch common mudpuppies with regularity. Skin diving will be conducted in clear streams feeding into or out of waterbodies known to contain common mudpuppies twice in a summer.

Physical capture for population surveying is a more expensive and time-consuming process than eDNA surveying, however it can fill the gap until eDNA tests are fully developed and create a baseline to test eDNA sampling against. Managers would implement the different methods of physical surveying as needed and based on the survey area in question to select the most effective technique.

Action 1.3: Create a website link for members of the public to report common mudpuppies sightings, and for agencies to communicate and share data. Software could quickly, efficiently, and automatically allow for citizen scientists and researchers to make data available for all project collaborators (Wallace et al. 2016). Software would have to be developed and made available to the public with an easy-to-use user interface to encourage participation. The public would also have to be made aware of its availability. Social media posts, personal conversations with researchers, and links on public outreach materials such as fliers will spread awareness of this research tool. Involvement through citizen science would spread awareness about invasive common mudpuppies. Sightings in unexpected locations could be reported when they otherwise would not have been, and members of the public could report any instances of people transporting common mudpuppies. It would also provide opportunities for physical proof to corroborate or contest any positive eDNA tests.

No Action: Not monitoring for the presence of common mudpuppies would make management impossible. Without knowledge on where common mudpuppies are, and how abundant, any action to manage the species will be blind. Efforts could not be directed to the proper areas, and progress could not be measured.

Final Course of Action: Begin actions 1.1, 1.2, and 1.3. Use modified Briggler traps and seining. Use manual searching only for the Maine mudpuppy population. Begin work to create eDNA tests and develop software programs for data sharing and citizen science reporting. Begin the development of software to facilitate effective communication and reporting of common mudpuppy sightings.

Assessment Protocol: Monitoring efforts should be compared with the success rates found using the same methods in other studies. If the success rates are comparable or higher, then they will be considered a success. If eDNA surveying does not prove to be an effective method of monitoring for common mudpuppies compared against the more traditional methods outlined in Action 1.2, then action 1.2 will be used instead of switching to eDNA monitoring following the completion of an eDNA test for common mudpuppies. This may become necessary if the eDNA technique does not work outside of lab conditions, or if the results are greater than a single standard deviation of mean physical monitoring results. Action 1.3 will be effective if the software is made available to the public within 5 years, and public begins using the software. It will be considered highly effective if complete prior to this date, or if over half of anglers in the area use the software within 5 years of implementation. So long as monitoring efforts can find and estimate common mudpuppy abundance, the actions will be considered a

success. If the eDNA study is ready to take over for the physical monitoring methods within 5 years, the actions will be considered highly successful. If monitoring efforts are not able to effectively find common mudpuppies or estimate abundance, then the actions will be considered a failure. In this case novel methods will have to be rapidly developed and tested to monitor common mudpuppies.

Objective 2: In 5 years, outline the environmental effects of introduced common mudpuppies in Maine. Determine and significant differences in body condition and catch rate between lakes with and without common mudpuppies.

Action 2.1: Survey anglers for the abundance and size of fish caught in Maine's Belgrade chain of lakes and ten surrounding lakes using a creel survey (Nieman et al. 2021). Although angling is typically biased towards larger fish due to hook selection it would give an effective estimate of the health of game fish populations (Willis et al. 2000). The Maine Department of Inland Fish and Wildlife fishing opportunities website outlines landlocked salmon (*Salmo salar*), brown trout (*Salmo trutta*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieu*) as present in the Belgrade chain of lakes (MDIFW 2022). Creel surveys would be conducted during the ice fishing season as well as open water fishing season. The creel survey would include questions about any mudpuppies caught to add to monitoring and detection efforts. The program outlined in Goal 1, Objective 1, Action 1.3 could be modified to integrate this action into data collected for the monitoring of common mudpuppies, and create a simple, centralized system for common mudpuppy management data organization and reporting.

Action 2.2: The MDIFW is currently conducting research into the impact of common mudpuppies on native invertebrates and fish larvae (MDIFW 2021a). Data from this research will inform how significant the impact of common mudpuppies is, and if they are doing any damage. If they are not doing any harm to Maine ecosystems, it may not be necessary to take further steps to control common mudpuppy populations. If they are harmful, then steps can be taken based on the damage being done.

To add onto the already ongoing research into what effects common mudpuppies are having on Maine's aquatic ecosystems, this action proposes to monitor the body condition of fish in lakes known to contain common mudpuppies and compare them to similar lakes outside of the region. Small-mesh fyke nets and electrofishing would be used to capture fish for this purpose. Neither method can be used to effectively capture all fish species in a lake, so both small-mesh fyke netting and boat electrofishing will be used concurrently (Ruetz et al. 2007). Three fyke nets will be set along the shoreline in <1 meter of water, and they will be left out for 24 hours before being moved to the next sampling location (Ruetz et al. 2007). Boat electrofishing will take place following the fyke netting effort at the same site using 10 minute transects to be run during daylight hours (Ruetz et al. 2007). Ten sample sites will be selected per lake. In lakes where common mudpuppies are being monitored the sample sites will be the same as the common mudpuppy monitoring sites. Five lakes with and five without common mudpuppies will be sampled.

The body condition of the captured fish from the control lakes and the lakes containing common mudpuppies will be compared using quantile regression (Cade and Terrel 2008). In this

model, higher quantiles of weight with the same body length indicate better body condition (Cade and Terrel 2008). A comparison between fish living in an environment with and without common mudpuppies will reveal if competition with common mudpuppies for food is reducing body condition in fish. Data on the abundance and species can be collected concurrently to learn if any fish are being disproportionately affected or, amongst small fish, if predation is lowering abundances.

No Action: Data on ecological interactions involving common mudpuppies is sparse (MDIFW 2021a). Understanding these interactions is important to inform proper management decisions, otherwise decisions would be built on speculation, and be vulnerable to errors, false assumptions, and would not be based on solid data.

Final Course of Action: Begin Actions 2.1 and 2.2. Integrate 2.1 into Objective 1, Action 1.3 to cover both monitoring of common mudpuppies and the game species which may be impacted. It will be necessary to enact action 2.1 in both waterways both with common mudpuppies present, and without to analyze any differences. Decisions on future management options as a part of both this plan and future management plans should be built around data from these actions.

Assessment Protocol: Success in Action 2.1 is contingent on Action 1.3. If action 1.3 is a failure, then Action 2.1 will be as well. Sample sizes for angler surveys will need to be large enough for each species to run meaningful statical analyses. Action 2.2 is contingent upon capturing the spread of fish species between the small-mesh fyke net and boat electrofishing (Ruetz et al. 2007). If there are gaps in capture where a fish is not well represented in the study, then it will

be considered a failure. To be considered successful the spread of quantile values within a treatment cannot be significantly different ($P \leq 0.05$). To large of a spread could suggest factors other that common mudpuppies assuming all treatment lakes contain fully established common mudpuppy populations. In case of failure new sample sites will be selected to attempt to isolate the effect that common mudpuppies may be having on fish body condition. The results of the quantile regression will need to be statistically significant ($P \geq 0.05$) to consider the results meaningful. Any meaningful results will be considered a success. The study design will be reevaluated in the event of this failure to account for issues and be run again.

Goal 2: Prevent further spread of introduced common mudpuppies in Maine.

Objective 1: Increase awareness of common mudpuppies, their presence in Maine, and laws regarding handling of non-native species by 50% in the next 5 years.

Action 1.1: Produce educational flyers about the common mudpuppy and its introduction into the local waterways and distribute them to lake monitoring organizations (Sharp et al. 2017), such as the Lake Stewards of Maine, to pass out to the public and post them at public boat launches accessing the Belgrade chain of lakes. Flyers would contain information on the origin of Maine's common mudpuppies and the risks and laws relevant to their presence. Lake stewards would also engage in public outreach to boaters at boat launches and distribute flyers to passers-by. The placement of flyers would follow monitoring data on lakes with common mudpuppy populations and at-risk lakes with may have undetected populations or where common mudpuppies may establish in the future. Flyers would also be provided for sport shops selling fishing tackle, bait, and other supplies to post if they choose to do so.

Final Course of Action: Begin Action 1.1. Flyers will be placed at boat launches accessing waterways with common mudpuppies and that have potential to harbor undetected or future populations. They will also be made available for the public to take at Lake Stewards of Maine steward locations.

Assessment Protocol: To assess whether the flyers and corresponding outreach a survey would be available online through a link included on the flyers. Members of the public would either take the survey upon reading the flyer or be prompted to by a worker from a lake monitoring organization. The survey would ask about awareness of common mudpuppies, awareness of laws and regulations applicable to them, and about any sightings of common mudpuppies. The effectiveness of fliers can be expected to be higher after repeated exposure by the same individuals, and among people directly impacted by potential risks, such as anglers as opposed to recreational boaters (Sharp et al. 2017). A statistically significant increase ($P \geq 0.05$) in public awareness of common mudpuppies in Maine would need to be visible in survey results year-to-year to count a success. Success in preventing anthropogenic causes of common mudpuppy spread will be measured by asking if behaviors around the handling of common mudpuppies has changes. If any people had filled out the survey to indicate that they had been transporting common mudpuppies, then success will be measured by a 50% reduction in this indication on the survey. If there is no indication that anyone is transporting common mudpuppies, then success will be considered neutral. If the results do not show a statistically significant increase in awareness, then the objective will have been failed. In this case, more active public outreach options will be considered, such as supplying education materials to angler clubs, or creating

PSA's. If the fliers were the source of increased awareness in 50% or more of the survey participants, then they will be considered successful.

Conclusion

The introduction of common mudpuppies into the Belgrade chain of lakes in Maine has led to the establishment of populations in those waterways. It has been over 70 years since those events (Crocker 1960), yet the ecological, economic, and societal ramifications of the presence of invasive salamanders is not understood (McDaniel et al. 2009). This plan will create a clear picture of where common mudpuppies are in Maine and in what abundances. When combined with new understandings of the environmental effects of common mudpuppies, range and abundance data can be used to predict how local ecosystems, economies, and social factors might have been influenced since the introduction. With this understood, and any anthropogenic spread factors being mitigated by public outreach programs, longer term management plans can be written with a solid foundation to address what is learned about the effects of common mudpuppies in Maine, whether they be harmful or benign. This foundational management plan can also be used to inform research in areas such as the Connecticut River Basin, where the status of common mudpuppies as native or introduced is contested (Klemens 1993).

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Literature Cited

Autz, J. 2020. Disribution, habitat, and seasonal activity of the mudpuppy (*Necturus maculosus*) in Eastern Kansas. Thesis, Emporia State University, Emporia, KS.

Babbit, H. 1932. Some remarks on Connecticut herpetology. Bulletin of the Boston Society of Natural History 63:23-28.

Bishop, S. C. 1926. Notes on the habits and development of the mudpuppy. New York State Museum Bulletin 268.

Bishop, S. C. 1941. The Salamanders of New York. Pages 18-37 *in*. Life History, Habits and Distribution of New York Salamanders: *Necterus maculosus maculosus* (Rafinesque)(*Siren maculosa*, Amer. Month. Mag. Crit. Rev., 1818, 4: 41) Mupuppy, Waterdog, Water lizard, Dog fish. The University of the State of New York. Albany, N.Y.Bishop, S. C. 1943. Handbook of salamanders. Cornell University Press, London, United Kingdom.

Boogaard, M. A., T. D. Bills, and D. A. Johnson. 2003. Acute toxicity of TFM and a TFM/niclosamide mixture to selected species of fish, including lake sturgeon (*Acipenser fulvescens*) and mudpuppies (*Necturus maculosus*), in laboratory and field exposures. Journal of Great Lakes Research 29:529-541.

Chellman, I. C., D. L. Parrish, and T. M. Donovan. 2017. Mudpuppy abundance in the Lamoille River, Vermont USA. Herpetological Conservation and Biology 12:422–434.

Chucholl, F., F. Fiolka, G. Segelbacher, and L. S. Epp. 2021. eDNA detection of native and invasive crayfish species allows for year-round monitoring and large-scale screening of lotic systems. Frontiers in Environmental Science 9 <https://doi.org/10.3389/fenvs.2021.639380>.

Collins, S. 2003. The Great Mudpuppy Escape (sort of). Colby Magazine 94:19-21.

Craig, J. M., D. Mifsud, J. Boase, J. C. Boase, and G. W. Kennedy. 2015. Mudpuppy (*Necturus maculosus maculosus*) spatial distribution, breeding water depth, and use of artificial spawning habitat in the Detroit River. Herpetological Conservation and Biology 10:926–934.

Crocker, D. W. 1960. Mudpuppies in Maine. Maine Field Naturalist 16:14-17.

Degraaf, R. M., and D. D. Rudis. 1983. New England wildlife: habitat, natural history, and distribution. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1986. 491 p.

Dibble, E. D., and S. L. Harrel. 1997. Largemouth bass diets in two aquatic plant communities. Journal of Aquatic Plant Management 35:74-78.

Fiske, S. T., and C. Dupree. 2014. Gaining trust as well as respect in communicating to motivated audiences about science topics. Proceedings of the National Academy of Sciences 111:13593-13597.

Freake, M. J., and C. S. DePerno. 2017. Importance of demographic surveys and public lands for the conservation of eastern hellbenders *Cryptobranchus alleganiensis alleganiensis* in southeast USA. PloS ONE 12: e0179153.

Gendron, A. D. 1999. Status report on the mudpuppy, *Necturus maculosus Rafinesque*, in Canada. Reptile and Amphibian Subcommittee, Committee on the status of Endangered Wildlife in Canada. Pp 1-84.

Green, D., L. Wier, G. Casper, and M. Lannoo. 2014. North American amphibians: distribution and diversity. University of California Press, Berkeley, CA.

Haines, A. M. 2021. Common mudpuppy (*Necturus maculosus*) distribution, diet and seasonality in western New York and morphological condition in lake and stream habitats. Thesis, Buffalo State College, Buffalo, NY.

Holmes, V. 2021. Environmental DNA monitoring of non-native mudpuppy (*Necturus maculosus*) and transient rainbow smelt (*Osmerus mordax*). The University of Maine, Orono, ME.

Kircheis, F. W. 1998. Species composition and economic value of Maine's winter baitfish industry. North American Journal of Fisheries Management 18:175-180.

Klemens, M. W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut. Hartford, CT.

Lynch, A. J., S. J. Cooke, A. M. Deines, S. D. Bower, D. B. Bunnell, I. G. Cowx, V. M. Nguyen, J. Nohner, K. Phouthavong, B. Riley, M. W. Rogers, W. W. Taylor, W. Woelmer, S. J. Youn, and T. D. Beard. 2016. The social, economic, and environmental importance of inland fish and fisheries. Environmental Reviews, 24:115–121.

Macedo, A. D., and H. Holmquist. 2021. *Necturus maculosus* (common mudpuppy) nest descriptions. Unpublished Research.

Maine Department of Inland Fisheries and Wildlife [MDIFW] a. 2021. 2019-2021 Research and Management Report. Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Maine Department of Inland Fisheries and Wildlife [MDIFW] b. 2021. Maine's 2021–2035 Statewide Fisheries and Hatcheries Management Plan. Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Maine Department of Inland Fisheries and Wildlife [MDIFW]. 2022. Fishing Opportunities in the Central Maine/Belgrade Lakes Region. <https://www.maine.gov/ifw/fishing-

boating/fishing/fishing-opportunities/maine-fishing-guide/belgrade-lakes.html>. Accessed 4 April 2022.

Maine Office of Tourism, and Maine Department of Inland Fisheries and Wildlife [MDIFW]. 2014. Fishing in Maine in 2013: A Statewide and Regional Analysis of Participation and Economic Contributions. Maine Office of Tourism, and Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Matson, T. O. 2005. *Necturus maculosus* (Rafinesque, 1818) Mudpuppy. pp. 870–871 *in*: M. J. Lannoo. Amphibian Declines: The Conservation Status of United States Species. Univ. of California Press, Berkeley, CA.

McDaniel, T. V., P. A. Martin, G. C. Barrett, K. Hughes, A. D. Gendron, L. Shirose, and C. A. Bishop. 2009. Relative abundance, age structure, and body size in mudpuppy populations in southwestern Ontario. Journal of Great Lakes Research 35:182–189.

Murphy, M. O., S. J. Price, P. H. Hime, A. N. Drayer, and D. W. Weisrock. 2016. A review of common mudpuppy (*Necturus maculosus*) capture methods and description of a revised trap design. Herpetological Review 47:575-578.

Necturus maculosus. ITIS Standard Report Page. <https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173630&print_version=PRT&source=to_print#null> Accessed 4 Feb 2022.

Nieman C. L., C. Iwicki , A. J. Lynch , G. G. Sass , C. T. Solomon , A. Trudeau, and B. van Poorten. 2021. Creel surveys for social-ecological-systems focused fisheries management. Reviews in Fisheries Science and Aquaculture, https://doi.org/10.1080/23308249.2020.1869696.

Olivero, A. P., and M. G. Anderson. 2008. Northeast aquatic habitat classification system. The Nature Conservancy. Eastern Regional Office Boston, MA.

Proteidae. ITIS Standard Report Page. <https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=1094180#null> Accessed 4 Feb 2022.

Rahel, F. J. 2000. Homogenization of fish faunas across the United States. Science 288:854-856.

Reiling, S. and H. Cheng. 2013. Outdoor recreation trends in Maine. Maine Agricultural and forest Experiment Station Publication No. 3346.

Ruetz, C., D. Uzarski, D. M. Kruegar, and E. S. Rutherford. 2007. Sampling a littoral fish assemblage: comparison of small-mesh fyke netting and boat electrofishing. North American Journal of Fisheries Management 27:825-831.

Sarnacki, A. 2019. The largest amphibians in Maine have invaded its lakes and ponds. Bangor Daily News 16 October 2019. <https://bangordailynews.com/2019/10/16/outdoors/the-largest-amphibians-in-maine-have-invaded-its-lakes-and-ponds/#:~:text=What%27s%20a%20mudpuppy%3F,of%20lakes%2C%20streams%20and%20rivers.>. Accessed 1 Feb 2022.

Sorensen, K. 2003. Population characteristics of *Siren lacertina* and *Amphiuma means* in North Florida. Southeastern Naturalist 3:249-258.

Sharp, R. L., L. B. Cleckner, and S. DePillo. 2017. The impact of on-site educational outreach on recreational users' perceptions of aquatic invasive species and their management. Environmental Education Research 23:1200-1210.

Shoop R. C. and G. E. Gunning. 1967. Seasonal Activity and Movements of *Necturus* in Louisiana. Copeia 1967:732-737.

Shoop R. C. 1965. Aspects of Reproduction in Louisiana *Necturus* Populations. The American Midland Naturalist 74:357-367.

Traver, J. 2018. Trout fishing on the cultural divide. Northern Woodlands 13 July 2018.

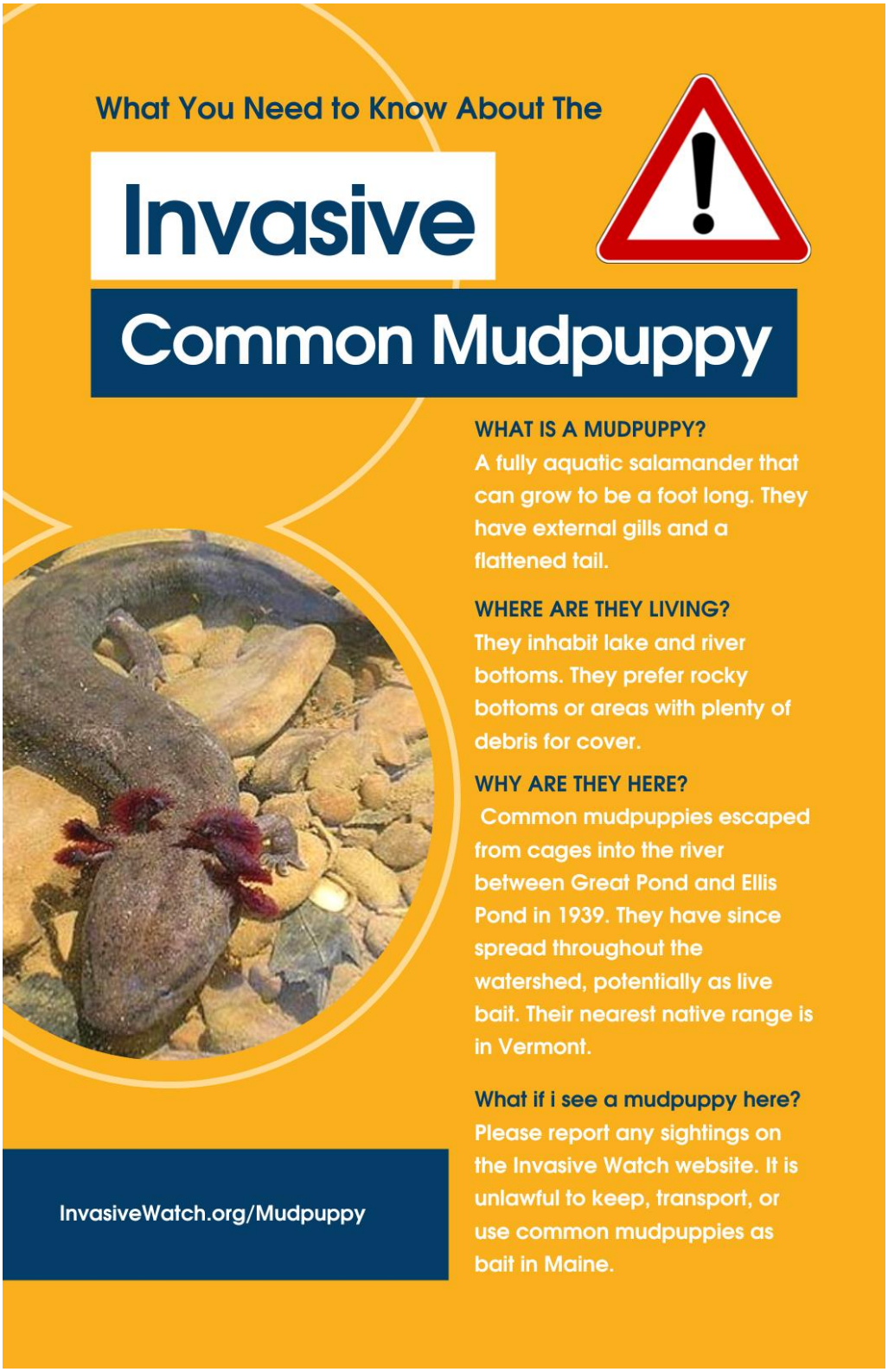
Unger, S., L. Williams, and J. D. Groves. 2021. *Necturus maculosus* (mudpuppy): predation. Herpetological Review 52:818-818.

U.S. Fish and Wildlife Service [USFWS]. 2022. Maine fish and wildlife conservation office. <https://www.fws.gov/office/maine-fish-and-wildlife-conservation>. Accessed 14 Mar 2022.

Wallace, R. D., C. T. Bargeron, D. J. Moorhead, and J. H. LaForest. 2016. IveGot1: reporting and tracking invasive species in Florida. Southeastern Naturalist 15:51-62.

Wells. K. D. 2007. The ecology and behavior of amphibians. The University of Chicago Press, Chicago, Illinois, USA.

Appendix


What You Need to Know About The
Invasive
Common Mudpuppy
WHAT IS A MUDPUPPY?
A fully aquatic salamander that can grow to be a foot long. They have external gills and a flattened tail.
WHERE ARE THEY LIVING?
They inhabit lake and river bottoms. They prefer rocky bottoms or areas with plenty of debris for cover.
WHY ARE THEY HERE?
Common mudpuppies escaped from cages into the river between Great Pond and Ellis Pond in 1939. They have since spread throughout the watershed, potentially as live bait. Their nearest native range is in Vermont.
What if i see a mudpuppy here?
Please report any sightings on the Invasive Watch website. It is unlawful to keep, transport, or use common mudpuppies as bait in Maine.
InvasiveWatch.org/Mudpuppy