Species Action Plan:
Burbot
(*Lota lota*)

Purpose: This plan provides an initial five-year blueprint for the actions needed to attain near-term and, ultimately, long-term goals for the conservation and recovery of the state endangered Burbot. This plan is a living document and will be updated as needed to reflect progress toward those goals and to incorporate new information as it becomes available.

Goals: The immediate goal is to maintain the extant populations of Burbot in Lake Erie and the upper Allegheny River drainage, and to protect its habitat in those waters. The secondary goal is to develop appropriate long-term conservation and monitoring strategies. Ultimately it is hoped the Allegheny River population will recover to the point where it can be removed from the Pennsylvania list of endangered species (58 Pa. Code §75.1), and that declines in the Lake Erie population will be arrested and reversed.

Natural History

Taxonomy: Class Actinopterygii, Order Gadiformes, Family Gadidae, Burbot (*Lota lota*, Linnaeus 1758).

Description: The genus is currently monotypic. Recent genetic work supports recognition of two subspecies, with *Lota lota maculosa* occurring in North America south of the Great Slave Lake and *L. lota lota* occurring in Eurasia and the rest of North America (Van Houdt et al. 2003, 2005, 2006). Stauffer et al. (2016) treated the Allegheny River drainage population as a distinct species – the Allegheny Burbot, based on meristic and genetic traits. However, as no formal description has been published to date, it will be considered a population of *Lota lota* for the purposes of this plan. A relict population also occurs in the upper Susquehanna River drainage in New York (Smith 1985). It may be a distinct form as well.

Figure 1. Burbot (Lota lota), Photo credit: Rob Criswell

Life History and Habitat: The Burbot is a coldwater, benthic species that primarily inhabits deep lakes and cool river systems. Burbot are crepuscular to nocturnal. They are closely associated with daytime shelter, which can influence their distribution, metabolism, and growth (Fischer 2000). In Lake Superior, Burbot have been reported to excavate trenches in clay substrate for use as cover (Boyer et al. 1989). During summer Burbot in Lake Erie are restricted primarily to the 20-cm and deeper regions of the eastern basin (Coldwater Task Group 2022).

The Allegheny River drainage Burbot prefers deep, slow pools with abundant cover in cool or cold streams. During the summers of 2002-03, this form inhabited relatively narrow (7.0 +/- 2.7 m SD) streams with deep (0.44 +/- 0.16 m SD) pools and sluggish flows (0.19 +/- 0.17 m/s SD) (Tzilkowski et al. 2004, Fischer 2008). Commonly occupied sites had ample cover in the form of boulders, rip-rap, concrete slabs, crevices in bridge abutments, large woody debris, and/or undercut banks that provided concealment. Temperatures at collection localities ranged between 13.3-23.5^{o} C (17.9 +/- 3.2^{o} C SD) and occupied streams were generally located in forested landscapes.

Spawning occurs during fall and winter, and at optimal water temperatures of 0° C -2° C (Stapanian et al. 2010). In Pennsylvania, spawning occurs on the Pennsylvania Ridge (aka Northwest Sand Bar) of Lake Erie during late fall, and a fall collection of a gravid female near McCord's Point, west of North East, suggests near-shore spawning there (Goodyear et al. 1982). Larvae have been collected off the mouth of Eighteen Mile Creek (Fish 1930). In lakes, spawning usually occurs in shallows over sand or gravel (Becker 1983). Reproductive behaviors of riverine Burbot outlined in the literature are variable, although most populations exhibit some form of migration, spawning under ice at night in slow moving water (Robins and Deubler 1955, Sorokin 1971, McPhail and Paragamian 2000). Eggs are broadcast into the water column and are semi-buoyant. The total number of eggs estimated in the ovaries of eight females from Lake Superior ranged from 268,832-1,154,014 (Bailey 1972). A large (643 mm) female from the Susquehanna River drainage, New York, contained 1,362,000 eggs (Robins and Deubler 1955). The incubation period is generally 4-5 weeks at 4^{o} C (Breder and Rosen 1966). Larvae are pelagic (Ghan and Sprules 1991) and mortality rates are likely high (McPhail and Paragamian 2000). Mean SL at age reported for the Lake Erie population are as follows: n/a at age-0, 210 mm at age-1, 322.7 mm at age-2, 376.5 mm at age-3, 424 mm age-4, 492.1 mm at age-5, 539.9 mm at age-6, 557.8 mm at age-7, 579.1 mm at age-8, 590.6 mm at age-9, and 616.0 mm at age-10 (Clemens 1951b). Mean SL at age reported for the Susquehanna River population are as follows: 79 mm at age-0, n/a at age-1, 195.3 mm at age-2, 234.7 mm at age-3, 261.1 mm at age-4, 300.0 mm at age-5, 306.1 mm at age-6, and 341.2 mm at age-7 (Robins and Deubler 1955). Maturity is attained in the third and fourth years (Clemens 1951b, Robins and Deubler 1955).

Much life history of the Allegheny Burbot is poorly understood at this time, but it is assumed to be at least in part similar to riverine populations of the Burbot. Spawning has not been observed in the Allegheny River drainage, but likely occurs in winter or early spring. Adult and young-of-year Allegheny Burbot have been observed utilizing the same small stream reaches during summer and early winter, suggesting that significant spawning migrations may not always occur. Collection

data also suggests that year class strengths vary, and may be attributed to environmental conditions, spawning cycles, or usage of unsurveyed areas (Tzilkowski et al. 2004, Fischer 2008).

Adult Burbot are primarily piscivores, but the proportion of fish in the diet is directly related to size (Bailey 1972). In Lake Erie, Clemens (1951a) found percids and crustaceans to be major prey items, with Yellow Perch, *Perca flavescens*, Walleye, *Sander vitreus*, White Bass, *Morone chrysops*, Freshwater Drum, *Aplodinotus grunniens*, Trout-perch, *Percopsis omiscomaycus*, Logperch, *Percina caprodes*, sculpins, shiners, coregonine eggs, gammarids, asellids, mysids, mayflies, and crayfish included in the diet. Diet analysis of Lake Erie Burbot in collected from New York waters in 2014 showed that four identifiable fish species occurred in stomachs at the following rates: Round Goby, *Neogobius melanostomus* (52%), Rainbow Smelt, *Osmerus mordax* (34%), Yellow Perch (3.4%), and Trout-perch (3.4%) (Coldwater Task Group 2015). Lake-wide diet information collected in 2021 showed that Round Goby was found in 46% of stomachs and Rainbow Smelt, *Osmerus mordax* in 23% of stomachs. Gizzard Shad, *Dorosoma cepedianum* were also important (Coldwater Task Group 2022). Round Gobies have become the dominant prey item, and in deep water Burbot are thought to exhibit predatory control (Madenjian et al. 2011). Larval Burbot feed on planktonic crustaceans, with a preference for cyclopoid copepods (Ghan and Sprules 1993, George et al. 2013).

Allegheny Burbot are voracious and apparently indiscriminate predators that are occasionally cannibalistic. The summer diet of young consists mainly of small aquatic dipteran and ephemeropteran insects; however, some crayfish and fishes are consumed. Fishes and crayfish, as well as a wider array of macroinvertebrates are consumed more frequently and in larger proportions as specimens attain 200 mm in length (Fischer 2008).

Distribution and Status

Global and National Distribution: The Burbot has a Holarctic distribution, commonly occurring from 40º N latitude northward on continental Eurasia and North America (Scott and Crossman 1973). The southern periphery of its range extends from Pennsylvania to Kentucky, Missouri, Wyoming, and Oregon (Page and Burr 2011) (Figure 2).

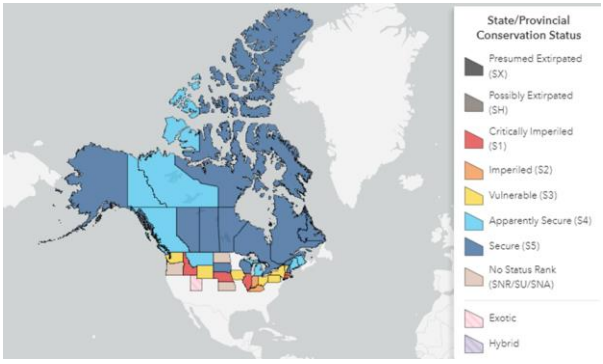

Figure 2. North American distribution of the Burbot, Lota lota (Natureserve, 2023).

Pennsylvania Distribution: The Burbot is currently known from Lake Erie and the upper Allegheny River drainage (Stauffer et al. 2016). Three older records, two from the Susquehanna River drainage, Dauphin and Lycoming counties, and one from the Delaware River basin, Bucks County were considered to be based on introductions (Fowler 1940). The Susquehanna records may represent strays from a headwaters population in that drainage that is now extant only in New York (Smith 1985, Fischer 2008).

Pennsylvania Legal Status: Endangered (58 Pa. Code §75.1)

Global Status:
Lake Erie: G5; S3
Allegheny River: G-not ranked; S2

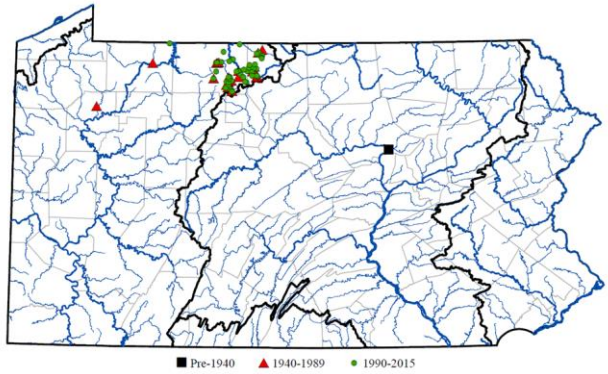

Figure 3. Pennsylvania inland populations.

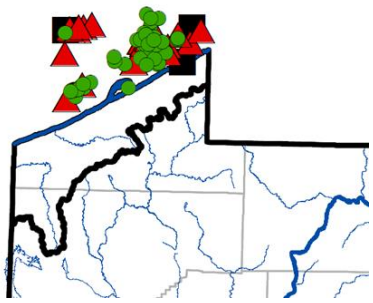

Figure 4. Pennsylvania Lake Erie Population.

Management Status

The Allegheny River population of the Burbot is currently on Pennsylvania's list of endangered fishes. Therefore, it receives the protection afforded by Chapter 75 of the Title 58 PA Code and it is reviewed in the Environmental Review permitting program administered by the Pennsylvania Natural Heritage Program. In addition, any physical take or intentional disturbance of individuals in unlawful.

The Lake Erie population does not enjoy the protection of a threatened/endangered listing. It may be taken during the period June 1 – September 30 by hook-and-line, or by spear/gig (at a minimum depth of sixty feet). The daily limit is five individuals (58 Pa. Code §69.12).

Population trends:
1) Lake Erie:
The Lake Erie Burbot population has experienced drastic changes since the mid-twentieth century. Clemens (1951a) stated that Burbot often recruited to fishermen's nets in quantities considered to be of nuisance. Subsequently, a population

collapse occurred during the 1950s and 1960s due to poor water quality, habitat degradation, and overexploitation. Improved water quality in the 1970s and Sea Lamprey, *Petromyzon marinus* control beginning in 1986 allowed a Burbot recovery in the 1990s until approximately 2003 (Stapanian et al. 2008). Since the early 2000s, fisheries data indicate that the Burbot population has continually declined. In Pennsylvania, CPE declined from 5 individuals per net left in 1999 to less than 1/lift during 2012-2021. The commercial catch in Pennsylvania (incidental in nets targeting other fishes) was only 68 lb in 2021 (Coldwater Task Group 2022).

2) Allegheny River:
The population is relatively small, but currently appears to be stable in Pennsylvania based on observations over the last 20 years. Fischer (2008) considered Cole Creek, McKean County, to contain the best population, with estimates at three sample sites of 255 burbot / hectare (95% CI: 162, 485) at the uppermost site, 266 burbot / hectare (95% CI: 238, 313) at the middle site, and 318 burbot/hectare (95% CI: 257, 405) at the most downstream site.

Threats

1) Water Quality and Habitat Loss:

Lake Erie Population: Excessive nutrient enrichment from a variety of sources (primarily phosphorus loading) during the 1950s and 1960s (Burns and Ross 1972) shifted the central basin from mesotrophic to eutrophic, and the eastern basin from oligotrophic to mesotrophic (Ryan et al. 2003).

Allegheny River Population: Elevated water temperatures, water quality degradation, and habitat destruction have been noted as potential threats (Tzilkowski et al. 2004, Fischer 2008).

2) Direct Mortality:

Lake Erie Population: As noted, it is legal to take Burbot in the Pennsylvania waters of Lake Erie. The level of take is unknown, but likely insignificant to the overall status of the population.

Allegheny River Population: Direct mortality is considered to be minimal, with no significant impact to the population.

3) Introduced Species:

Lake Erie Population: Madenjian et al. (2011) reported that Burbot exerted significant predatory control over the invasive Round Goby *Neogobius melanostomus* in eastern Lake Erie. During 2007-2008 Burbot fed on gobies at an annual rate equal to 61% of standing goby stock. How this relationship may affect future status and conservation of the Burbot population in unknown. Sea Lamprey *Petromyzon marinus* parasitism is an ongoing threat. Sea Lamprey control efforts beginning in 1986 aided in the Burbot population recovery in the 1990s (Stampanian et al. 2008). Invasive crayfish have been documented to negatively impact young-

of-year Burbot elsewhere (Hirch and Fisher 2008), although no such problem has yet been identified in Lake Erie.

Allegheny River Population: No significant impacts from introduced species have been identified in this population.

Conservation and Recovery

Conservation and Recovery Goal: The goal of this plan is to implement actions that maintain, augment, protect, and enhance extant populations of Burbot in the Commonwealth and ensure sufficient distribution to adequately secure the species and allow its removal from the Pennsylvania list of endangered species (58 Pa. Code §75.1).

Conservation Actions:

1) Work towards the protection, conservation and enhancement of extant populations.
   a. Continue to review appropriate permits through the Environmental Review Program for Burbot conservation; continue to work with federal and state government agencies to minimize pollution and habitat destruction.
   b. Encourage the development of regulations and policies that would reduce the introduction and spread of aquatic invasive species.

2) Conduct research projects to describe life history and ecology attributes needed to develop management strategies including the following:
   a. Age structure
   b. Growth
   c. Health
   d. Spawning
   e. Population genetics
   f. Influence of anthropogenic perturbations on populations
   g. Characterize interactions between the Burbot and introduced species including stocked gamefishes

3) Monitoring
   a. Develop a monitoring strategy for Allegheny River population based on previous surveys and information gathered from research efforts and initiate monitoring of existing populations at reference stations.
   b. Continue monitoring efforts in cooperation with the Lake Erie Coldwater Task Group.

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