History of Trout Management in New Jersey

Overview

Trout management in New Jersey has evolved from efforts to re-establish decimated brook trout populations in the late 1800's, to protecting water quality and managing waters statewide to provide seasonal and year round trout fishing opportunities. These opportunities have been enhanced since the 1980's by the availability of trout reared at the DFW's modern fish culture facilities and implementation of a variety of angling regulations. Research conducted by the DFW lead to the development of a classification system for New Jersey's freshwaters. This classification system is recognized in state regulatory programs governing water quality and land development, which significantly aids in the protection of coldwater resources. The history of trout management in New Jersey is described below and summarized in a timeline at the end of this narrative.

1879 – 1959

Trout management in New Jersey officially dates back to the late 1800's. In response to a devastating drought in 1875, the New Jersey Fish Commission (the forerunner of the present day Fish and Game Council) planned to re-stock the state's "natural trout streams." The objective was to re-establish trout populations in streams where they had been depleted. From 1879 through 1881 the Commission stocked a total of 416,800 fingerling brook trout. By that time, trout stocking by private fishing clubs had long since been underway. In 1882 the Commission made the first recorded stocking of rainbow trout, with 7,000 fish divided between the Musconetcong, Pequest, and Paulinskill Rivers.

Frequent requests for waters to be replenished with trout ensued, causing the Commission to issue the following statement in their Annual Report of 1885:

> The wardens and interested persons have frequently requested that certain waters be replenished with trout and applications are constantly being made to the Commissioner to supply designated streams with fish, but they have seriously questioned the advisability of making further expenditures of public money for the propagation of a fish that can hardly be expected to furnish food for the masses, and which can only be looked upon as a luxury for the almost exclusive pleasure of the few who can command time and wealth to expend upon their pursuit.

However, in 1906 the Commission relented and purchased 45,000 trout from the Paradise Brook Trout Company located in Henryville, PA. Experimental stockings of brown trout, obtained from Seth Greene's hatchery in Caledonia, NY, began in 1908 in the South Branch Raritan and Millstone Rivers. In 1909, the Commission authorized contracts for the purchase of over 100,000 trout and one year later recommended construction of a state fish hatchery. The State Fish Hatchery at Hackettstown was built and production of fingerling brook trout began 1912. One year later, rainbow and brown trout were added to hatchery production. In 1914 the hatchery began rearing catchable

size brook, brown, and rainbow trout for liberation statewide. By 1932 production had risen to a little over half a million trout.
Meanwhile an extensive inventory of the state's trout resources was being conducted from 1918 –1920 under the direction of four biologists (W.T. Foster, F.N. Miller, H.E. Schradieck, and H.M. Spandau). Subsequently, as interest in trout stocking heightened with the advent of a state fish hatchery, research and inventory work was relegated to a minor role until the 1950's. In 1950 the Lake Survey Unit was assimilated into Bureau of Fisheries Laboratory which then became responsible for trout research and management activities.

At the federal level, the Federal Aid in Sport Fish Restoration (Public Law 81-6810), popularly known as the Dingell-Johnson (D-J) Act was enacted in 1950, imposing a manufacturers excise tax on recreational fishing equipment. Revenues generated by the tax provided a funding base to states for sportfish research, aquatic education, and aquatic habitat protection and restoration. In 1953, New Jersey initiated a trout stamp to help cover the costs associated with hatchery trout production. Licensed anglers were required to purchase a trout stamp ($1 annually) in order to fish for trout.

1960 – 1989

In 1962 the Bureau initiated a project, Research in Trout Management (Project F-20-R), using Federal Aid in Sport Fish Restoration funds. Project objectives initially were to determine causes of trout mortality, and to conduct investigations into the possibility of improving trout fishing by introduction of new species (or strains), and employment of new techniques and procedures. In 1964 the first water quality standards were adopted by a New Jersey State agency (Department of Health) which included a special provision for trout waters.

Over a five-year period (1968 – 1972), the Bureau of Fisheries conducted an intensive statewide stream survey under F-20-R to develop a stream classification system. In 1973 a comprehensive classification of the state's trout waters, based upon stream data collected under a five-year study, was developed. In the meantime, the Department of Environmental Protection was created (1970) and this agency's surface water quality standards began distinguishing between "trout production," "trout maintenance," and "nontrout" waters. The Bureau's classification of trout waters was refined and later formally recognized in 1981 under the newly adopted state Surface Water Quality Standards.

A new facet was added to the trout program in 1976, when lake trout eggs were brought into the Charles O. Hayford State Fish Hatchery (formerly known as the State Fish Hatchery at Hackettstown). The following year, fingerling lake trout were released into Round Valley Reservoir. The first special regulation governing angling for wild trout was adopted in 1979 when a section of Van Campens Brook was designated a Natural Trout Fishing Area.

In 1980 construction of the Pequest Trout Hatchery began. Fish production at this fish culture facility commenced in the fall of 1982 when fertilized eggs were obtained from several federal hatcheries. The production of all trout, except lake trout, shifted from the

Hackettstown Hatchery to the more modern Pequest Trout Hatchery the following year. With the improved trout production capabilities of the new hatchery it was possible to expand the traditional spring trout stocking program to include a fall stocking program that commenced in 1984. In 1983 trophy trout regulations were adopted for Round Valley Reservoir to protect the developing lake trout fishery and limit the harvest of trophy brown and rainbow trout. Another new regulation, Trout Conservation Area, was adopted for a portion of the Pequest River in 1988 to provide anglers with a quality angling experience for catchable trout. Merrill Creek Reservoir was completed in 1988 and stocked with trout (initially rainbow and lake), alewives and smallmouth bass.

1990 – 2005

Trout management took a giant leap forward in 1990 with the establishment and refinement of a variety of special trout regulations and adoption of a new allocation methodology for distributing hatchery-reared trout. The stocking allocation plan provided an equitable basis for determining trout stocking quotas on nearly 200 waters, by using measurable characteristics to determine individual allocations and frequency of stocking. To conserve naturally reproducing trout populations, Wild Trout Stream regulations were adopted for 29 streams. The Trout Conservation Area regulation was split into a seasonal and year round regulations and sections on other streams were added. Another regulation, Major Trout-Stocked Lakes (later renamed Holdover Trout Lakes), was also established for lakes that provide a fishery for holdover trout.

In 1996 the NJDFW's first trout habitat improvement project was initiated on the Musconetcong River, with the assistance of volunteers from the DFW's Wildlife Conservation Corps and Trout Unlimited. A statewide minimum size limit (7 inches) for trout was imposed in 1997 to conserve naturally reproduced trout in streams not regulated as Wild Trout Streams. In 1998 two new programs, "Hook a Winner" and the "Sea-Run Brown Trout," were initiated.

As the new millenium unfolded, many environmental, social, and economic challenges faced New Jersey's coldwater fisheries managers, who responded with new initiatives in trout research, management, and culture. The NJDFW began investigating wild brook trout genetics to determine if existing populations descended from brook trout that colonized New Jersey following deglaciation. A five-year study involving the re-inventory of trout streams that were surveyed 30 years earlier was also initiated.

In 2001 the trout-stocking program was further expanded into a "Winter Trout Program" on 24 lakes, using catchable-size rainbow trout. Responding to anglers' requests for more brown trout, beginning in 2003 the Pequest Trout Hatchery adjusted production by taking more brown trout (and less rainbow trout) eggs. The *Bonus Broodstock* program was instituted in the spring of 2004 to generate excitement and stimulate more people to try trout fishing, by stocking greater numbers of big trout in selected waters. Also that year the number of stockings on Year Round Trout Conservation Areas was increased, from two to three times following opening day.

In December 2004, in response to declining license sales, the DFW released a proposal that involved the most significant changes to its trout program since the adoption of the trout allocation methodology in 1990 (Appendix A). In this proposal the following broad scale changes were recommended: re-allocation of trout from seven large, warmwater lakes over 100 acres, to smaller waterbodies; modification of the spring stocking schedule so that all non-holdover lakes and ponds would be stocked earlier in the season; an increase in the average size of the trout stocked during the fall and winter, from 9-10" to 14-16", which would be offset by a substantial decrease in the number of trout stocked under those two programs; and the cessation of stocking on six small streams having wild brook trout populations. Following a three-month public comment period, during which over 1,000 comments were received, the proposal was modified and adopted by the Fish and Game Council. New trout-stocked waters added to program, and those discontinued required Fish Code amendments that take effect in 2006.

As a result of this proposal, the spring 2005 stocking schedule was modified so that 70 warmwater ponds and lakes were stocked during the week immediately following opening day. This change provided provide anglers with more opportunities to fish for trout earlier in the spring season when interest is still high and waterbody conditions are typically more conducive for trout. The fall 2005 trout stocking schedule was reduced from three to two weeks, because surplus fish traditionally stocked the third week had to be stocked earlier in the season to provide room in the hatchery to raise the larger fish for the 2006 season.

In 2005 more catchable-size brown trout were stocked during the spring as a result of a change in hatchery production initiated in 2003. A comprehensive Coldwater Fisheries Management Plan, which contained an information base and established goals and strategies to guide future decision making, was finalized and implemented.

Year		**Events Related to Trout Management in New Jersey**
1879	-	Fish and Game Commission began stocking brook trout in "natural trout streams" that had been severely affected by the drought of 1875.
1882	-	First recorded stocking of rainbow trout.
1908	-	First recorded stocking of brown trout First licensing of non-resident anglers.
1909	-	First licensing of resident anglers ($1.15 per person, annually). Contracts went out for the purchase of over 100,000 trout.
1910	-	Construction of a state fish hatchery recommended.
1912	-	The State Fish Hatchery at Hackettstown began propagation of brook trout.
1913	-	Brown and rainbow trout added to hatchery production.
1914	-	The state's trout stocking program shifted from fingerling to catchable-sized trout.
1918	-	Statewide survey of streams conducted for trout management purposes.

1950 - Bureau of Freshwater Fisheries Laboratory (originally the Lake Survey Unit) created and the application of its research to trout management began.

The Federal Aid in Sport Fish Restoration (Public Law 81-6810), a.k.a. the Dingell-Johnson (D-J) Act was enacted. The revenue from a 10% excise tax, imposed on recreational fishing equipment, provided a funding source for states' sportfish restoration efforts.

1953 - Initiated a special trout stamp, costing $1, to help defray rising trout propagation costs, increase hatchery trout production, and orient program costs more towards trout anglers.

1959 - State Fish Hatchery at Hackettstown renamed the Charles O. Hayford State Fish Hatchery in honor of its first supervisor who served there until 1955.

1961 - Freshwater Fisheries Lab at Lebanon was constructed.

1962 - Grant Project F-20-R, *Research in Trout Management* (funded under the D-J Act) initiated and the application of its findings to trout management began.

1963 - Pequest Trout Rearing Station along Pequest River began production.

1964 - The first water quality standards adopted by a New Jersey state agency (Department of Health) that included a special provision for trout waters.

1968 - Initiated a five-year study involving the collection of stream data under D-J Grant F-20-R, Research in Trout Management).

Round Valley Reservoir completed and opened to fishing.

1970 - New Jersey's Department of Environmental Protection was created.

1973 - First comprehensive classification of the state's trout waters, based upon stream data collected under F-20-R, Research in Trout Management).

1977 - First recorded stocking of lake trout (stocked in Round Valley Reservoir).

1979 - *Natural Trout Fishing Area* regulation established on Van Campens Brook

1980 - Construction of the Pequest Trout Hatchery and Natural Resource Education Center in Warren County commenced.

1981 - Statewide *Surface Water Quality Standards* adopted which classified the majority of the state's fresh surface waters according to their ability to support trout, and applied corresponding quality criteria.

1982 - Pequest Trout Hatchery began production of trout.

Trophy Trout Lake regulations were adopted for Round Valley Reservoir

1983 - Trout production shifted from the Charles O. Hayford State Fish Hatchery at Hackettstown to the Pequest Trout Hatchery (with the exception of lake trout) and Pequest Rearing Station closed.

NJDEP implemented comprehensive statewide stream encroachment regulations (Flood Hazard Area Control Act) governing construction activities in and adjacent to waterways were which included special provisions for the protection of trout waters.

1984 - First trout reared at the Pequest Hatchery released in New Jersey lakes and streams.

Fall Trout Stocking Program initiated.

1986 - First "Free Fishing Days" held.

1988 - *Trout Conservation Area* regulation established on a section of the Pequest River in the vicinity of the hatchery.

Merrill Creek Reservoir completed and stocked with trout, smallmouth bass and alewives.

1990 - Implemented the Trout Stocking Improvement Plan to provide an equitable basis for determining trout allocations by using measurable characteristics of all the state's trout stocked waters.

Wild Trout Stream, *Year Round Trout Conservation Area*, and *Major (Holdover) Trout-Stocked Lake* regulations adopted.

1992 - Brook trout officially designated as the NJ State Fish.

1996 - Initiated an in-stream fish habitat improvement project on a section of the Musconetcong River.

1997 - For the first time in 46 years, a minimum size limit (7 inches) on trout statewide adopted to protect small trout (wild and stocked) from being harvested by anglers.

1998 - *Hook a Winner Program* initiated (1,000 brook trout were jaw tagged).

Modified the spring trout-stocking program to include 8 small, public, urban ponds that were stocked one time (during the pre-season period).

The *Sea-Run Brown Trout Program* was initiated in the Manasquan River.

2000 - Initiated a study to characterize wild brook trout populations in New Jersey streams using molecular genetics.

A study to re-inventory and assess trout production streams previously sampled in 1968 – 1973 was initiated.

2001 - Minimum age for a fishing license and trout stamp raised from 14 to 16 years of age.

W*inter Trout Stocking Program* initiated on 24 lakes statewide to enhance trout angling opportunities in late fall and winter.

2003 - Production of brown trout at the Pequest Trout Hatchery increased by 25,000 and rainbow trout production decreased by the same amount.

Annual public fisheries forums were initiated to provide anglers with additional opportunities to comment on the DFW's research, management and culture activities.

2004 - *Bonus Broodstock Trout* program implemented for select small ponds and lakes under the spring trout stocking program.

Additional in-season stocking of brown trout (during Week 5) initiated for designated Year Trout Conservation Areas.

Proposal incorporating significant changes to the DFW's trout stocking program was released for public comment. Proposed changes included discontinuation of trout stocking at seven large, non-holdover lakes and the re-allocation of trout to new waters (small lakes and ponds); modification of the spring stocking schedule for warmwater lakes; an increase the size, and reduction in the number, of trout stocked for the fall and winter stocking seasons; and cessation of stocking in six small streams inhabited by wild brook trout.

Winter trout stocking schedule, for south Jersey lakes, was changed from early January to the third week of November.

2005 - Trout proposal modified after public comment and adopted by the Fish and Game Council, and changes to be phased in over 2005 and 2006.

Spring trout stocking schedule was modified to shift the stocking of 70 ponds and lakes statewide to one week earlier, commencing the week immediately following the opening day weekend.

More brown trout (25,000 more) released during the spring stocking program as a result of a Pequest Trout Hatchery production change, initiated in 2003.

Fall trout stocking reduced to a two-week period.

Statewide Coldwater Fisheries Management Plan finalized.

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Trout Life History and Ecology

Overview

New Jersey is inhabited by a variety of fish species that spend all or part of their life cycle in freshwater (Appendix B). The salmonid family of fishes is currently represented in New Jersey by four species: brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and lake trout (*Salvelinus namaycush*). Of these four only the brook trout is native to New Jersey. Stocking practices dating back to the late 1800's have resulted in the establishment of reproducing populations of nonnative brown and rainbow trout in a number of suitable New Jersey streams. Lake trout, another nonnative salmonid, was more recently introduced in New Jersey in 1997.

New Jersey's trout streams are generally characterized as cool, clear, waters with a coarse substrate. The majority of these streams flow through the two northern physiographic provinces, the Ridge and Valley Province and Highlands Province and a small portion of the adjacent Piedmont Province. Headwater streams in these areas are typically conducive to the survival of trout and fish species associated with trout. Cover, which can be presented in many forms, is an important habitat component for trout. Diverse in-stream habitat, represented by a mix of pool, riffle and slow moving deeper areas known as runs, are also important for various life stages.

Loss of habitat, reduced flows, sedimentation, and increased temperatures from resulting land use changes are just a few of the problems facing New Jersey's trout populations. Brook, brown, and rainbow trout, and sculpins, are intolerant of habitat and water quality impacts making them quite useful as indicators. The State's current stream classification system is based on the presence of trout and trout associated species. Although trout production streams receive additional protection through the State's Land Use Program and Surface Water Quality Standards impacts from land use changes are not prevented. The cumulative effect of these impacts is not always obvious, in that there is direct mortality, nonetheless, they have significant and long-term detrimental impacts to fish populations. Understanding the specific chemical, physical and biological needs of trout through their various life stages is essential as this information will provide the basis for the development of specific protective and/or corrective measures for damage to trout streams.

Presented in this section are general life history and ecology information for three salmonid species (brook, brown and rainbow trout) and conditions which should be maintained if trout are to survive. Life history charts, which summarize general information for each trout and trout-associated species found in New Jersey streams, are included at the end of this section. Technical information stated in this section, and the accompanying life history sheets regarding habitat requirements, are primarily supported by scientific literature summarized in the United States Fish and Wildlife Service habitat suitability index models developed for individual species. There is a vast array of information relating to specific habitat requirements for salmonids, which goes beyond the scope of this document.

Occurrence and Distribution

The salmonid family of fishes is represented in New Jersey by four species: brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and lake trout (*Salvelinus namaycush*). Of these four species only the brook trout is native to New Jersey. However, naturally reproducing populations of brown and rainbow trout have become established in suitable New Jersey waters where they have been historically stocked. The lake trout, a lake dwelling fish, was introduced to Round Valley Reservoir (1977) and Merrill Creek Reservoir (1988). Natural reproduction of lake trout was documented in 1985 in Round Valley Reservoir and the trophy fishery is now maintained through natural reproduction.

The distribution of the three stream-dwelling trout species can generally be related to the physiography of the state. The majority of New Jersey's trout streams flow through two northern physiographic provinces, the Ridge and Valley Province and Highlands Province and a portion of the adjacent Piedmont Province (Figure 1). Headwater streams in these areas are typically cool, clear, and high gradient in nature with rock cobble substrate conducive to trout and trout associated species. However, trout production and trout maintenance stream segments are not always in stream headwaters. As in the case of the Lamington (Black) River, sluggish upstream reaches are classified as nontrout, while trout maintenance and trout production segments are found in steep downstream gorges. Scattered trout populations are found in central and southern New Jersey (Inner and Outer Coastal Plain Provinces), but the number of trout streams in central and southern New Jersey is severely limited due to lack of suitable habitat.

Where several salmonid species co-inhabit a stream, their populations tend to be longitudinally distributed through the stream system. Brook trout typically inhabit the colder, less productive headwater areas, and overlap downstream with rainbow and brown trout. Brown trout are often found in the lower gradient downstream areas.

In addition to naturally occurring trout populations, the DFW distributes over 770,000 brook, brown and rainbow trout into over 200 waterbodies across the State, each year (Figure 2). Many of these waters are not conducive to the long-term survival of trout, however, some are able to support trout round year and have reproducing trout populations.

Life Cycle

Mature riverine trout move upstream from lakes, larger rivers and streams to spawn, seeking a bed of fine gravel in a riffle above or below a pool. Spawning gravel must be relatively free of silt and about 13 to 51 mm (1/2 to 2 inches) in diameter. Brook trout particularly favor quieter headwater streams with upwelling ground water or strong spring water flow (Greeley 1932, Kendall 1929, Ricker 1932, Webster and Eirikdottir 1976, White 1930). Brown trout pick the crest of riffles in the main channel and rainbow trout select deeper water than the other two (White and Brynildson 1967). The brook and brown trout are fall/winter spawners while the rainbow is basically a spring spawner (Table 1).

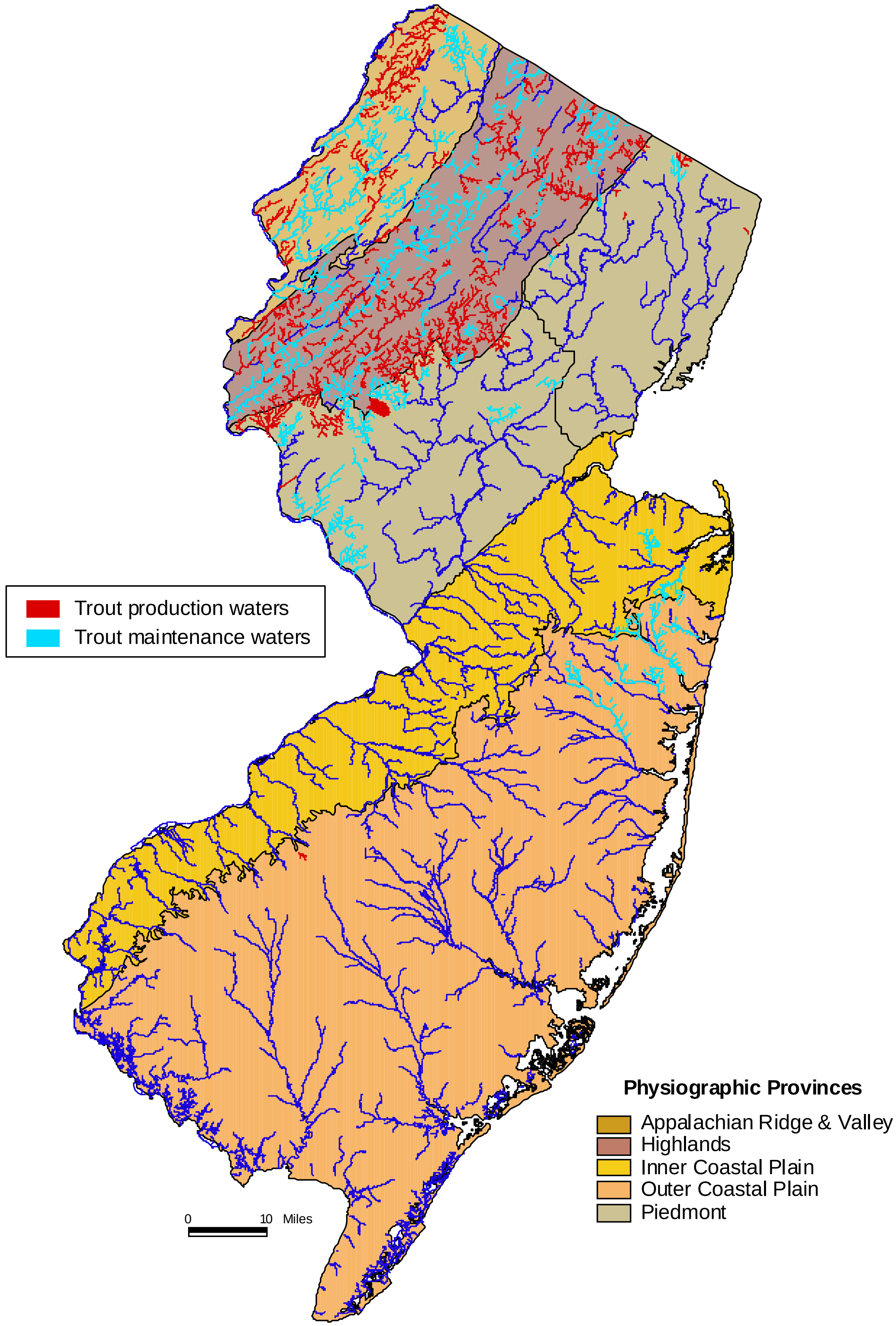


FIGURE 1.— New Jersey's trout waters (2004) shown in relation to physiographic provinces.

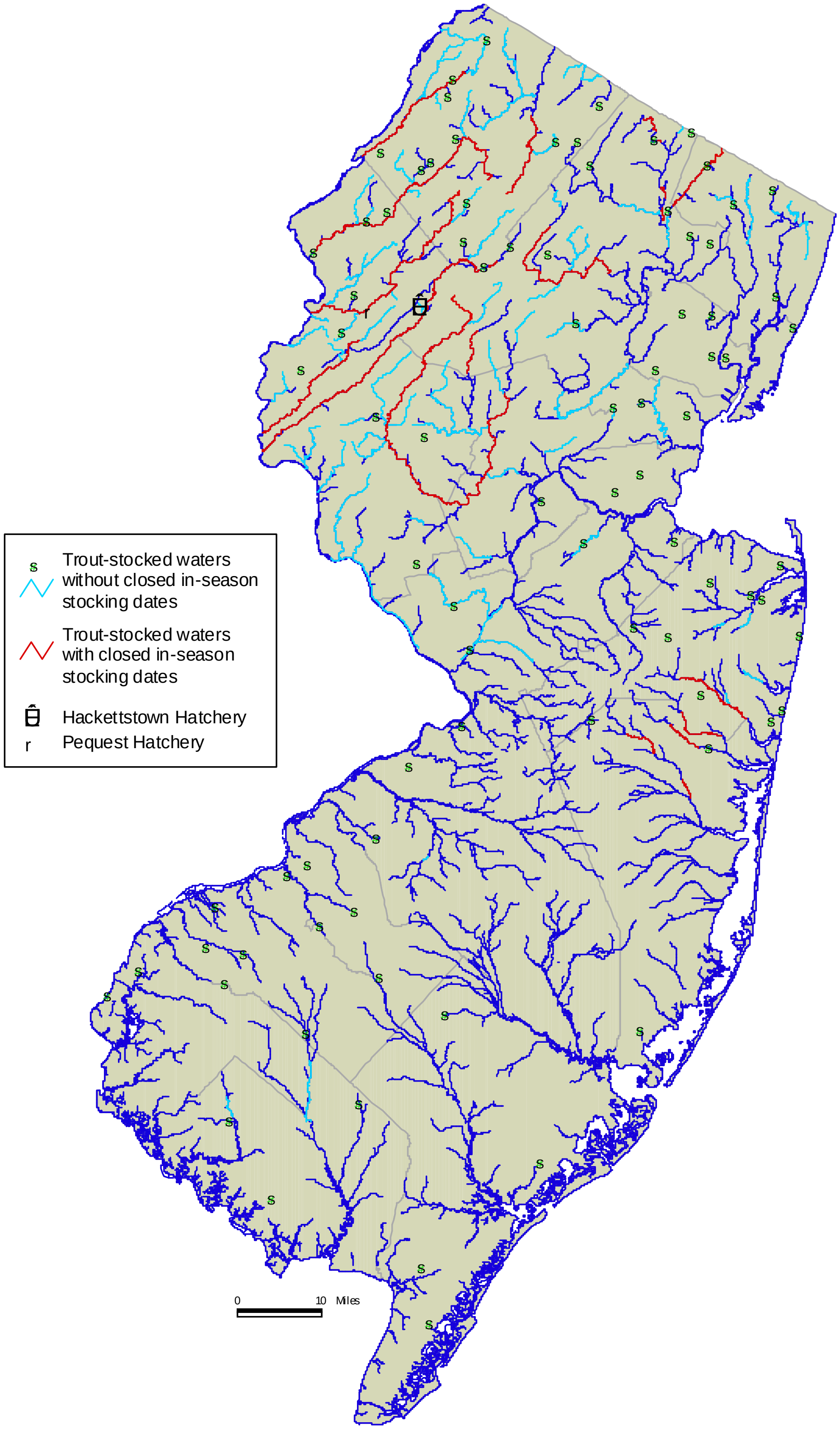


FIGURE 2.— New Jersey's trout-stocked waters (2004).

TABLE 1.— Timetable for trout spawning and egg development

Trout Species	Time of Year	Spawning Water Temperature (optimum or mean range)	Length of Egg Incubation
Brook trout	Mid-September through November	9°C	105 days at 3.9°C
			90 days at 4.5°C
			65 days at 7.8° C
			45 days at 10.0°C
			32 days at 13.4°C
			(Upper lethal limit is approx. 13°C)
Brown trout	October through December	6.7° - 8.9°C	95 days at 5°C
			66 days at 7°C
			38 days at 10.7°C
			(Normal development occurs up to 10°C)
Rainbow trout	February through March	10.0 - 15.5°C	75 days at 4.8°C
			44 days at 7.5°C
			29 days at 10.3°C
			25 days at 12.0°C
			21 days at 14.5°C
			(Normal development occurs up to 13°C)

The nest, or redd, is prepared by the female using her caudal fin (tail) to clear debris from the site and create a shallow depression. Following a courtship ritual, the male and female deposit sperm and eggs into the depression, which the female then covers with gravel. Neither parent guards the redd when spawning is completed and adults often live to spawn again in subsequent year(s). As the fertilized eggs incubate in the redd, they are sustained by the constant flow of aerated water which transports nutrients to and carries waste products away from the developing eggs as it flows through the permeable gravel. The rate of egg development is variable, depending on water temperature (Table 1). Upon hatching, the larvae (sac fry) remain buried in the gravel until the yolk sac is absorbed (3-7 days). Once the yolk is absorbed, the fry, as they are now called, emerge from the gravel and commence feeding. The events associated with the onset of spawning through fry emergence are critical, as this is the most sensitive of all life stages.

Trout are subject to predation by larger predatory fish (the fry are particularly vulnerable) and to a lesser degree by fish-eating birds and mammals. Wild trout are relatively short-lived, seldom living longer than five years in a stream. Trout may attain sexual maturity in two years with males frequently maturing a year earlier than females. If food and other factors are suitable, most mature individuals will successfully spawn each year.

Spawning activities for lake dwelling trout in New Jersey is limited to the lake trout population in Round Valley Reservoir. Stocked initially in 1977 natural reproduction was documented in 1985. Today, natural reproduction supports the entire fishery. Lake trout reach sexual maturity between 5 – 6 years of age. Spawning activity commences in the fall when mature adults begin congregating along the two dam sites in the reservoir. Males move in first, in early October, with an increasing presence of females occurring around mid to the end of the month. The exact depth of spawning is not specifically known for the Round Valley population and literature reviews indicate depth varies considerably between populations. It is noted however that gravid adults are captured 30 – 60 feet of water at the height of the spawn. Eggs are broadcast over the large boulders, which comprise the dam structures. No parental care is given. Eggs will hatch in 50 to 156 days, depending on temperature.

Food Preferences

Trout are carnivorous, feeding upon a wide variety of organisms including plankton, crustaceans, aquatic insect larvae, nymphs and adults (primarily mayfly, caddisfly, midge and blackfly), terrestrial insects, snails, worms, leeches and a wide variety of fish. Brook trout in Ontario were found to feed upon worms, leeches, crustaceans (cladocerans, amphipods, decapods), aquatic insects (over 80 genera eaten but mayfly, caddisfly, midge and blackfly larvae common), terrestrial insects (over 30 families, ants sometimes in abundance), spiders, molluscs (including clams and snails), a number of fish species including young brook trout and brook trout eggs, minnows, sticklebacks and cottids, frogs, salamanders, and a snake (Ricker 1932). The diet of brook trout consists of mostly insects and aquatic invertebrates. In general, brook trout are not particularly piscivorous (fish-eating). In streams brown trout feed mostly on bottom fauna, insects and amphipods and have been found to feed more on surface foods than brook or rainbow trout. Rainbow trout consume primarily bottom living and terrestrial insects as well as amphipods, oligochaetes (worms), crayfish and fish. The principal factors governing the types of food eaten are availability or accessibility (Neill 1938, Larkin 1956, Kalleberg 1958, Le Cren 1965, Allen 1969).

There is usually a shift in food preference as trout increase in size. Small and medium-sized trout eat large numbers of plankton, crustaceans and aquatic and terrestrial insects while larger trout will consume other fish if available. This holds true for lake trout. Large brown trout are active and feed more at night than daylight. Trout feed actively all winter, mostly on aquatic insects. Growth is highly variable, being influenced by water fertility, temperature and quantity and type of food and has been correlated to stream size.

Growth

Growth data for wild brook, brown, and rainbow trout populations in New Jersey is not available. Growth data for stocked trout following their release into open state waters is generally restricted to specific waters (impoundments).

Opportunity – Prepare and implement a research project to document the growth on naturally occurring brook, brown and rainbow trout populations throughout the entire state.

Habitat Requirements

Optimally, riverine habitat for brook, brown and rainbow trout is characterized as clear, cool to cold water streams with silt free rocky substrate in riffle-run areas. A 1:1 pool-riffle ratio is preferred with areas of slow, deep water. Stream banks are well vegetated and stable with abundant in-stream cover with a relatively stable annual water flow and temperature regime.

Shelter

Long recognized as one of the basic and essential elements of trout habitat, shelter serves as protection from predators and may provide areas of moderate current speed utilized as resting areas. Cover in streams may be provided by overhanging vegetation, under cut banks, submerged vegetation, submerged objects (stumps, logs, roots, rocks), floating debris and water turbulence. Shade patterns on the stream bottom are also utilized as a type of cover. Vegetation, along with undercut banks and other overhanging objects provide areas of shade preferred by brook, brown and rainbow trout (Newman 1956, Wickham 1967, Baldes and Vincent 1969, Chapman and Bjornn 1969, Lewis 1969). Brown trout are reported to utilize overhead cover to a greater extent than rainbow trout (Lewis 1969). Habitat improvements to increase shelter typically increase the carrying capacity of streams, especially for larger fish, has been well documented (Tarzwell 1937, 1938, Shetter et al. 1946, Saunders and Smith 1962).

A stream with a mixture of pools and riffles provides a diversity of environment and helps ensure protective cover and ample production of food supplies for trout. In a study of the distribution of trout in relation to stream habitat (Saunders and Smith 1962) three stream areas were characterized – riffles, flat water and pools. Riffles are small rapids where depths are usually less than five inches; flat water has a depth less than one foot with a moderate current; pools occur in areas where logs or other obstructions deflect the flow of water resulting in scouring (depth of two feet or more encountered). Fingerlings were captured in riffle sections while older trout were found in flat-water areas, where there were hiding places, and in pools. Trout were sparse in habitats where there was an accumulation of silt on the bottom.

Lake trout habitat is described as large, clear, deep, cold lakes with high levels of dissolved oxygen. Lakers are known to make use of the entire water column provided temperatures and oxygen levels are sufficient. These habitat requirements offer only limited opportunities for expanding their presence in the state.

Temperature

Since fish are cold-blooded organisms, unable to regulate their body temperature, temperature is extremely important in determining their standard metabolic rate and hence their survival. There are optimum temperatures for feeding, general activity, growth and reproduction, as well as lethal limits. Trout are a coldwater species with optimum temperature preferences, through their various life stages, below 20°C (68°F). Upper lethal temperatures for brook trout have been reported to range from 21°C to 28.3° C (26°C can be tolerated for 24 hours and 28.3°C for one hour). Optimum temperatures for this species have been reported at 14-19°C and 7-18°C. In general, rainbow trout tolerate up to 28°C, but their optimum is below 21°C. The lethal water temperature for brown trout has been reported as 25.3°C. Lake trout prefer colder temperatures, with an optimum temperature range between 8 – 15°C.

Trout will avoid warm water areas, if possible, by retreating to areas of cooler waters commonly found in the upper reaches of streams (headwater and spring-fed areas). This reaction to high temperatures limits the amount of stream or lake area available for support of a trout population. Temperatures associated with spawning and egg incubation are identified in Table 1. Eggs are particularly sensitive to adverse temperature changes during their tender stage (first half of incubation stage – after they are water hardened and before they are eyed). Sudden increases or decreases in water temperature can cause excessive mortality. Since viable trout populations are dependent on low water temperatures, warm summer months are a critical time period.

Dissolved Oxygen

Directly related to water temperature and just as critical to survival are dissolved oxygen concentrations. Colder water is capable of holding more dissolved oxygen than warmer water (Table 2). Trout require a minimum oxygen reading of 5 mg/L, with 7 mg/L preferred, to support all life stages. Trout streams are usually well aerated as water flows through riffle sections and these streams are often saturated with oxygen. The dissolved oxygen concentration in salmonid spawning beds is especially important because the concentration in the water associated with the redds (where spawning occurs) may be very different from the concentration found in the water above the redds.

TABLE 2.— Dissolved oxygen concentration at 100% saturation for water temperatures associated with trout streams.

Water Temperature °C	Dissolved Oxygen (mg/L)
5 (41°F)	12.8
10 (50°F)	11.3
15 (59°F)	10.2
20 (68°F)	9.2
25 (77°F)	8.4

Stream Bank and Riparian Vegetation

Over the years there have been extensive reviews of literature on the importance of maintaining vegetated buffer areas along streams (Karr and Schlosser 1977, Corbett and Lynch 1978). Near stream vegetation provides shade, nutrients, bank stabilization and cover for fish and therefore its presence or absence has a significant impact on fisheries resources.

A number of studies have documented the effect of streamside vegetation on water temperature in agricultural and forestry (logging) related situations (Brown and Krygier 1970, Gray and Eddington 1969, Greene 1950, Karr and Gorman 1975). These data indicate vegetation serves as an effective buffer against temperature extremes; shaded streams are cooler in the summer and warmer during winter. Increases in summer water temperatures of 5.5-9.0°C resulted when vegetation, which shades agricultural drainages, is removed. A field and laboratory study demonstrated that temperature is an extremely important factor determining the distribution of fish species (Stauffer 1976). This study, along with other observations on shifts in species composition due to temperature (Bush 1974), indicates that removal of vegetation along small streams will result in substantial changes in fish community composition. These shifts in species composition are related to temperature changes that exceed the preferred and lethal limits for species with lower temperature optimums, and favor those with higher optimum and lethal limits.

In one study streamside vegetation that was left to shade the channel, while the rest of the woods was clear-cut, resulted in only minor changes to stream temperature (Swift and Messer 1971) This study suggests that if a minimal vegetative "buffer strip" is left (along agricultural drainages), significant decreases in stream temperature could be expected. It should be noted that the focus of this study was on temperature, and other effects on water quality and in-stream habitat, relative to minimal buffer areas, were not documented. An extensive examination of temperature in various streams with different types of buffers indicated that buffer effectiveness decreases with increasing stream size (Brown and Brazier 1972). Small streams have the greatest temperature problem, but they are also the easiest to control (due to the inverse relationship between temperature change and stream discharge for a given input of thermal radiation). Finally, if temperature control is accomplished in the upper reaches of drainages, a reduction in temperature associated problems will result both downstream and upstream areas, including small lakes and reservoirs.

Near stream vegetation can also serve as an effective nutrient and sediment filter. However, there are many variables which influence filter effectiveness (type of vegetation, filter placement, width or length of filter, duration of effectiveness, soil type, etc.) which have not been thoroughly evaluated under normal agricultural conditions and quantitatively related to each other in any predictive manner.

Headwater streams represent areas where the maximum interface between aquatic and terrestrial environment occurs. In these areas, most of the energy utilized by the aquatic invertebrates and fish is terrestrial in origin (Cummins 1975, Lotrich 1973, Chapman and Demory 1963). The coarse, particulate organic matter (leaves, twigs, etc.) is broken down, by shredders, into a fine particulate organic matter which is utilized by invertebrates. At the top of this food web are the fish predators. The implication of this web is that the removal of upstream vegetation will result in reduced invertebrate production and, in turn, fish production because of loss of allochthonous (terrestrial) energy inputs. Studies have indicated low diversity and numbers of invertebrates in streams flowing through areas lacking deciduous vegetation (Minshall 1968). Therefore, it is desirable to maintain near-stream vegetation, which can be a major source of energy on which both invertebrates and vertebrates depend.

Substrate

Stream substrate is very important in the production of fish food organisms. Many aquatic invertebrates which trout feed upon spend a large proportion of their life on or in the bottom substrate. The physical nature of the bottom is considered to be of major importance in influencing the production of bottom fauna in streams (Linduska 1942, Smith and Moyle 1944, Needham 1934, Corning 1969). Under natural stream condition "rubble" is usually considered the most productive type of substrate. Sediment deposition generally results in decreased substrate types and covers suitable sites which inevitably causes changes in species diversity and numerical abundance of benthic organisms (Tebo 1955, Wilson 1957).

For trout stream substrate is also extremely important for spawning purposes. Being broadcast spawners, eggs are dispersed all along the stream substrate. For successful hatching eggs must be well oxygenated therefore the substrate must be clear of sediment. A mix of substrate sizes is also beneficial to successful hatching in that it provides nooks and crannies, which provide protection to the eggs from predators and assures good aeration.

pH

pH is a measure of the hydrogen ion concentration in water. From a pH of 0 to- 7, solutions are acid; from pH 7 to 14, solutions are alkaline. It is important to note that the toxicity of many compounds may be markedly affected by pH. In most productive fresh waters, the pH ranges between 6.5 and 8.5. Some regions, particularly the NJ Pine Barrens, have soft waters with poor buffering capacity and naturally low pH. Results of experiments conducted in New Jersey acidotrophic (pH below 5.5) coastal streams indicate brook trout are the most acid-tolerant species, followed in order by brown trout and then rainbow trout (Pyle 1957). Rainbow trout have been found to acclimate to pH from 5.8 to 9.5 (McAfee 1966) and in New Jersey streams were found not to survive at a pH of 5.9 or less (Pyle 1957). Brown trout and brook trout were found to withstand a stream pH as low as 5.0 but the brown trout did not appear to be as healthy as the brook trout (Pyle 1957).

For fingerling brook trout, a lower lethal limit in the range of 3.2 to 3.6 was found and an upper lethal limit was estimated to be 9.8 (Daye and Garside 1975). Stocked brook trout fingerlings survived for over two years in a stream where the pH ranged as low as 4.3 (Pyle 1957) and a native population inhabited a mountain stream where pH ranged as low as 4.1 after a storm event (Powers 1929). In laboratory experiments adult brook trout were able to survive five-month exposures of pH levels down to 5.0, however, egg viability was significantly less at pH 5.0 and below (Menendez 1976). The effects of pH on salmonids and other aquatic organisms are summarized in Table 3. Based on present evidence, a pH range of 6.0 to 9.0 appears to provide complete protection for the life of trout and bottom dwelling invertebrate food organisms on which they rely.

TABLE 3.— A summary of some effects of pH on salmonids and other aquatic organisms (modified from National Academy of Sciences 1973).

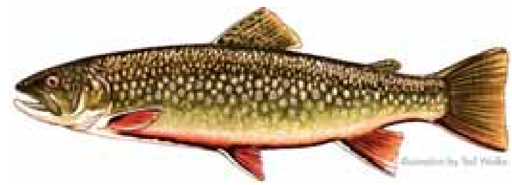
pH	Known effects
11.5-12.0	Some caddis flies (Trichoptera) survive but emergence reduced.
11.0-11.5	Rapidly lethal to all species of fish.
10.5-11.0	Rapidly lethal to salmonids. Lethal to some stoneflies (Plecoptera) and dragon flies (Odonata). Caddis fly emergence reduced.
10.0-10.5	Withstood by salmonids for short periods but eventually lethal. Some typical stoneflies and mayflies (Ephemera) survive with reduced emergence.
9.5-10.0	Lethal to salmonids over a prolonged period of time and no viable fishery for coldwater species. Causes reduced emergence of some stoneflies.
9.0-9.5	Likely to be harmful to salmonids if present for a considerable length of time and no viable fishery for coldwater species.
8.5-9.0	Approaches tolerance limit of some salmonids. No apparent effects on invertebrates.
8.0-8.5	(No effects for salmonids stated)
7.0-8.0	Full fish production. No known harmful effects on adult or immature fish, but 7.0 is near low limit for *Gammarus* reproduction and perhaps for some other crustaceans.
6.5-7.0	Not lethal to fish unless heavy metals or cyanides that are more toxic at low pH are present. Generally full fish production. Invertebrates except crustaceans relatively normal, including common occurrence of mollusks. Microorganisms, algae, and higher plants normal.
6.0-6.5	Unlikely to be toxic to fish unless free carbon dioxide is present in excess of 100 ppm. Good aquatic populations with varied species can exist with some exceptions. Reproduction of Gammarus and Daphnia prevented, perhaps other crustaceans. Aquatic plants and microorganisms relatively normal except fungi frequent.
5.5-6.0	Eastern brook trout (*Salvelinus fontinalis*) survive; rainbow trout (*Salmo gairdneri*) do not occur.
5.0-5.5	Very restricted fish populations but not lethal to any fish species unless CO^2 is high (over 25 ppm), or water contains iron salts. May be lethal to eggs and larvae of sensitive fish species. Benthic invertebrates moderately diverse, with certain black flies (Simuliidae), mayflies (Ephemerella), stoneflies, and midges (Chironomidae) present in numbers. Lethal to other invertebrates such as the mayfly. Bacterial species diversity decreased; yeasts and sulfur and iron bacteria (Thiobacillus-Ferrobacillus) common. Algae reasonably diverse and higher plants will grow.
4.5-5.0	Likely to be lethal to eggs and fry of most salmonids. Brook trout egg viability decreases significantly[1]. Brown trout (Salmo trutta) do not occur[2]. Benthic fauna restricted, mayflies reduced. Inhibits emergence of certain caddis fly, stonefly, and midge larvae. Diatoms are dominant algae.
4.0-4.5	Native brook trout populations have been documented in streams where the pH has ranged as low as 4.1[3]. Fish populations limited. Some caddis flies and dragon flies found in such habitats; certain midges dominant. Flora restricted.
3.5-4.0	Lethal to salmonids. All flora and fauna severely restricted in number of species. Cattail (*Typha*) is only common higher plant.
3.0-3.5	Unlikely that any fish can survive for more than a few hours. A few kinds of invertebrates such as certain midges and alderflies, and a few species of algae may be found at this pH.

[1] From study conducted by Menendez (1976).
[2] From study conducted by Pyle (1957)
[3] This information contradicts NAS (1973), but is supported by a study conducted by Powers (1929).

Brook Trout *(Salvelinus fontinalis)*

General Information

The only salmonid species native to New Jersey, and designated the state fish. Reproducing brook trout populations are found in streams, primarily in the northern region of the state. Brook trout are tolerant of low pH conditions. Hatchery reared “brookies” are stocked by the NJDFW throughout the state.



Native Range	Eastern Canada northward to the Arctic Circle, the new England States, and southward through Pennsylvania, along the crest of the Appalachian Mountains to northeastern Georgia. Western limits include Manitoba south through the Great Lake States (Raleigh, 1982).

Habitat Description

River: Clear, cold spring-fed water, silt free rocky substrate, 1:1 pool-riffle ratio. Tend to occupy headwater stream areas, especially when brown and rainbow trout are also present. Can tolerate lower pH than other salmonids (4.0 – 9.5). Prefer moderate flows compared to brown and rainbow trout. Base flows $\geq$ 55% of average annual daily flow is excellent, while base flows 25 – 50% is considered fair.

Lake: Clear, cold lakes that are typically oligotrophic. Presence in lakes is very temperature dependent.

Optimum Habitat Requirements

Dissolved Oxygen	$\geq$ 5 mg/l
Temperature	4.5 – 10°C
pH	6.5 – 8.0
Turbidity	0 – 30 JTU’s
Current	7 – 11 cm/sec

Diet

Fry	Terrestrial and aquatic insects
Juveniles	Terrestrial and aquatic insects
Adults	Fish, terrestrial and aquatic insects

Notes: opportunistic sight feeders, alter diet according to food availability

Reproduction

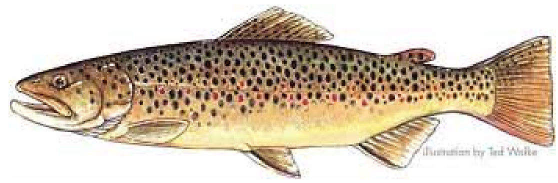
Time of Year	Mid September into November	Age Males Mature	0
Temperature Range	4.5 – 10°C	Age Females Mature	1
Water Depth		Nest	Built by female
Substrate	Gravel	Egg Type	Demersal
Time of Day	Mid-day	Parental Care	None
Critical pH		Days to Hatching	32 – 105 (temperature dependent)
Velocity Range	1 – 92 cm/sec	Oxygen Level	> 50% saturation

Notes: Spawn repeatedly throughout the fall season. Spawning success is greatly reduced in the presence of fine sediment, which reduces inter-gravel oxygen concentration. Females dig redds in gravel and fertilized eggs are then covered with substrate. Life history information taken from Raleigh, 1982.

Brown Trout *(Salmo trutta)*

General Information

Although not native to New Jersey, reproducing brown trout have become established in northern New Jersey streams through wide spread stocking. It is more tolerant to warmer temperatures than brook and rainbow trout. An anadromous (sea-run) fishery is currently being established in the Manasquan River using hatchery-reared fish.



Native Range	Throughout Europe and western Asia from Iceland, the British Isles and Scandinavia to the Aral Sea and Afghanistan. Also found in the Atlas Mountains of Northern Africa. Introduced in the United States in 1883 and is now found in many states. (Smith, 1985)

Habitat Description

River: Clear, cool to cold water, relatively silt free bottom rocky substrate. 50 to 70% pool to 30 to 50% riffle-run habitat combination with areas of slow, deep water; abundance of in-stream cover is important (Raleigh, 1984).

Lake: Clear, cool to cold, deep lakes, typically oligotrophic. Require tributary streams to spawn. Brown trout grow larger in lake environments than in streams.

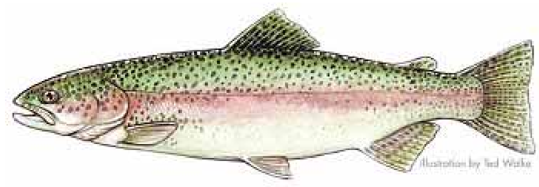
Optimum Habitat Requirements	
Dissolved Oxygen	$\geq$ 7 mg/ l
Temperature	12 – 19°C
pH	6.8 – 7.8
Turbidity	< 50 ppm
Current	02. – 5.5 ft/s (feeding) 0 to 0.7 ft/s (resting)

Diet	
Fry	Small bottom organisms, zooplankton
Juveniles	Terrestrial & aquatic insects, amphipods
Adults	Fish, crustaceans, insects
Notes: Size selective feeders – Insects are primarily Ephemeroptera, Trichoptera & Plecoptera. Active night feeders.	

Reproduction			
Time of Year	October – December	Age Males Mature	0 +
Temperature Range	7 – 9°C	Age Females Mature	1 +
Water Depth	24.4 – 45.7 cm	Nest	Bury in gravel
Substrate	Gravel (0.6 – 0.7 cm)	Egg Type	Demersal
Time of Day		Parental Care	None
Critical pH	5.0	Days to Hatching	38 – 95 (temp dependent)
Velocity Range		Oxygen Level	
Notes: Cover is essential to brown trout fry survival (Raleigh, 1984).			

Rainbow Trout *(Oncorhynchus mykiss)*

General Information
Like the brown trout, rainbow trout are a non-native salmonid species and are distributed annually throughout the state through the FW's trout stocking program. These stockings, however, have not resulted in wide spread reproducing populations as seen with brown trout. The number of reproducing populations within the state is minimal.



Native Range	Pacific drainages from Northwestern Mexico to the Kushowin River in Alaska. In Canada, found in the Peace and Athabasca Rivers in the Mackenzie drainage (Smith 1985).

Habitat Description
River: Clear, cold stream systems with a 1:1 pool – riffle ration with areas of slow deep water; abundant in-stream cover and stable water flow, Base flow ≥ 50% of average annual daily flow is considered excellent, 25 – 50% of annual daily flow is only considered fair. (Raleigh, 1984).
Lake: Clear, cold, deep lakes, typically oligotrophic. Require tributary streams with a gravel substrate to reproduce (Raleigh, 1984).

Optimum Habitat Requirements	
Dissolved Oxygen	≥ 7 mg/l
Temperature	12 – 19°C
pH	6.5 – 8.0
Turbidity	0 – 30 JTU's
Current	

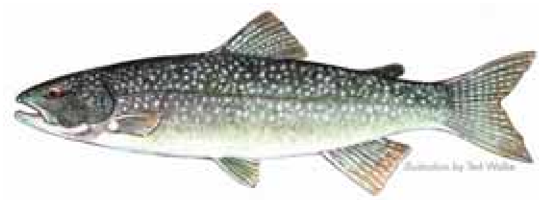
Diet	
Fry	Insects
Juveniles	Aquatic and terrestrial insects
Adults	Fish, aquatic and terrestrial insects
Notes: Opportunistic feeders	

Reproduction			
Time of Year	February – March	Age Males Mature	2 - 3
Temperature Range	10 – 15.5°C	Age Females Mature	3
Water Depth		Nest	Built by female
Substrate	Gravel, size dependent on size of individual	Egg Type	Demersal
Time of Day	Day / Night	Parental Care	None
Critical pH		Days to Hatching	28 – 40 (temp. dependent)
Velocity Range		Oxygen Level	
Notes: Almost exclusively stream spawners; streams with no inlet or outlet generally do not have a reproducing population of rainbow trout.			

Lake Trout *(Salvelinus namaycush)*

General Information

This non-native salmonid is found primarily in two NJ reservoirs (Round Valley and Merrill Creek). The lake trout is the state's largest salmonid species with the current state record weighing in at 32 lbs., 8 oz. Round Valley Reservoir supports a reproducing lake trout population and may represent the most southern range of this species in the U.S.



Native Range	Widely distributed only in the northern reaches of North America but has been introduced elsewhere. In the United States, occurs in the New England States, the Great Lake states of New York, Pennsylvania, Michigan, Wisconsin and Minnesota. In the west, Montana, Idaho and Alaska. In Canada, native lake trout occur in all provinces and territories, except Prince Edward Island, insular Newfoundland, portions of the prairie provinces, and coastal British Columbia.

Habitat Description
River: Occurs in some river systems in the northern half of its range, low tolerance of salinity (11- 13% upper limit).
Lake: Large, deep, clear, cold lakes with high levels of dissolved oxygen throughout. Lake trout will make use of entire water column provided temperature and oxygen levels are sufficient. Highly mobile throughout the water column.

Optimum Habitat Requirements	
Dissolved Oxygen	$\geq$ 6 mg/ l
Temperature	8 – 15°C
pH	
Turbidity	
Current	

Diet	
Fry	Zooplankton
Juveniles	Zooplankton, insects
Adults	Fish, zooplankton, insects
Notes: Feed on the most abundant food available	

Reproduction			
Time of Year	September – December	Age Males Mature	5
Temperature Range	12-13°C	Age Females Mature	6 - 8
Water Depth	15 cm – 55 m	Nest	None
Substrate	Rubble/ Large rock	Egg Type	Broadcast
Time of Day	Dusk-midnight	Parental Care	None
Critical pH		Days to Hatching	50 – 156 (temp. dependent)
Velocity Range		Oxygen Level	
Notes: May spawn intermittently after reaching sexual maturity. Spawn in lakes, rarely in stream environments.			

Landlocked (Atlantic) Salmon *(Salmo salar)*

General Information
The hard fighting Atlantic salmon may soon be making a re-appearance in NJ, having been stocked in the 1950's in a then privately owned lake. It is anticipated that in May 2006, several thousand 8-inch salmon, from Massachusetts, will be stocked into one of New Jersey's regulated Holdover Trout Lakes. These newly stocked fish are expected to reach the legal minimum size of 12 inches the following year.

Native Range	Naturally found in the basin of the North Atlantic Ocean compromising the entire water region of Greenland, Portugal, Iceland, Southern Greenland, the Ungava region of North Quebec and south to Connecticut River. Landlocked forms were introduced to the New England States and parts of Canada with success. (Scott and Crossman 1973)

Habitat Description
River: Utilizes rivers only for spawning and nursery purpose, juveniles migrate out to open water after spending considerable time in the river. Preferable habitat for successful spawning is rapid moving water with a good gravel substrate, although may occur under a variety of water flow conditions with different substrate. Salmon will not spawn in still water with a muddy substrate. (Leim and Scott,1966)
Lake: Prefers Oligotrophic lakes that are deep, low in organic matter, chemically infertile with good dissolved oxygen levels with a maximum temperature of 23°C, however can tolerate marginal and homothermous Lakes that have less stringent water quality condition. Requires tributaries flowing into the lake in order to have successful reproduction. (Havey and Warner 1970)

Optimum Habitat Requirements	
Dissolved Oxygen	≥ 5 mg/ l
Temperature	≤ 23°C
pH	≥ 6.0
Turbidity	
Current	

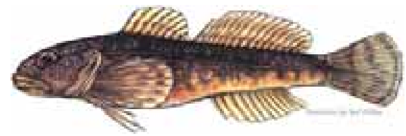
Diet	
Fry	Plankton
Juveniles	Aquatic and Terrestrial Insects
Adults	Smelt and Alewife
Note: Diet for adult landlocked salmon only.	

Reproduction			
Time of Year	October – November	Age Males Mature	1 - 2
Temperature Range	0-3°C	Age Females Mature	1 - 2
Water Depth	12.7 – 25.4 cm	Nest	Bury in gravel
Substrate	Gravel/Sand	Egg Type	Benthic
Time of Day		Parental Care	None
Critical pH	≥ 6.0	Days to Hatching	99 – 161 (temp. dependent)
Velocity Range		Oxygen Level	≥ 5 mg/ l
Notes: Salmon spawn only in rivers after spending 1 to 2 years in open water.			

Slimy Sculpin *(Cottus cognatus)*

General Information

Sciulpins prefer high gradient waters with rock, gravel substrate, which limits their distribution to the northern waters of the state. They are intolerant of impaired water qualities.



Native Range	Northern North America to extreme northeastern Siberia. In North America, it occurs from Virginia, Labrador and Ungava on the east, westward through most of northern North America to Alaska, and on St. Lawrence Island in the Bering Sea. (Scott and Crossman 1973).

Habitat Description
River: Cool, rock/gravel; headwater streams.
Lake: Occurs in lakes outside the state but in New Jersey it is essentially limited to stream environments.

Optimum Habitat Requirements	
Dissolved Oxygen	
Temperature	4 – 16°C
pH	
Turbidity	
Current	

Diet	
Fry	Insects
Juveniles	Insects
Adults	Insects
Notes: Activity mostly nocturnal	

Reproduction			
Time of Year	May	Age Males Mature	
Temperature Range	5 – 8°C	Age Females Mature	
Water Depth	< 1.5 m	Nest	Under a ledge, rock or root
Substrate	Rocks, submerged tree roots	Egg Type	Adhesive
Time of Day		Parental Care	Male
Critical pH		Days to Hatching	28
Velocity Range		Oxygen Level	
Notes: Eggs deposited on the ceiling of the nest, nests usually contain eggs from more than 1 female.			

Longnose Dace *(Rhinichthys cataractae)*

General Information

A species associated with trout due to its similar affinity for swift moving, steep gradient headwater streams. A bottom dwelling species, relatively short lived, with few individuals five years or older. Longnose dace are found in the northern and central regions of New Jersey.

Native Range	Occurs from coast to coast across North America, as far south as the Rocky Mountains in Mexico and as far north as the Mackenzie River system near the Arctic Circle. In the east, it extends south through the Appalachians to Georgia, in the west, along the Rocky Mountains, and along the Pacific Coast from Oregon north through British Columbia. (Edwards, 1983).

Habitat Description

River: Steep gradient, swift flowing, and typically headwater streams with a rock and gravel substrate. Benthic species residing just above the substrate. Shallow water species typically reside in water 0.3 meters deep or less. Over hanging cover orientated species. In swift flowing streams species requires areas of cover to protect from current.

Lake: Literature citations identify wave-swept areas of lakeshores, in New Jersey their presence is essentially limited to streams.

Optimum Habitat Requirements	
Dissolved Oxygen	
Temperature	14 – 18°C
pH	
Turbidity	
Current	> 45 cm/sec

Diet	
Fry	Algae
Juveniles	Mayflies, chironomids; aquatic insects
Adults	Aquatic/terrestrial insects and larvae

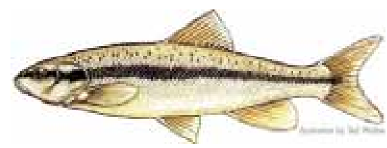
Notes: Will eat whatever is in abundance.

Reproduction			
Time of Year	June – July	Age Males Mature	2
Temperature Range	14 – 19°C	Age Females Mature	2
Water Depth		Nest	None
Substrate	Gravel/rock	Egg Type	Demersal, adhesive
Time of Day		Parental Care	
Critical pH		Days to Hatching	
Velocity Range	45 – 60 cm/sec	Oxygen Level	

Notes: Life history information taken from Edwards 1983.

Blacknose Dace *(Rhinichthys atratulus)*

General Information
Blacknose dace are commonly found in New Jersey trout waters. They appear to be somewhat adaptable to low-gradient waters since they have also been documented in a few locations within the Lower Delaware Drainage. Like its cousin, the longnose, blacknose dace are relatively short lived, reaching age 3 or 4 years of age at most.



Native Range	Atlantic Coast west through the Great Lakes region to North and South Dakota. Southward it is found on both sides of the Appalachian Mountains to Georgia, Alabama, and Mississippi. In Canada it inhabits clear, cold streams from Nova Scotia to Manitoba.

Habitat Description
River: Small, clear swift flowing streams with gravel, rock substrate. Although known to prefer high gradient waters blacknose dace within the state have also been documented in low gradient waters of Southern New Jersey.
Lake: A stream dwelling species but may be found in some lakes near the mouths of tributaries.

Optimum Habitat Requirements	
Dissolved Oxygen	
Temperature	
pH	
Turbidity	
Current	

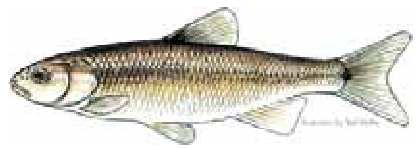
Diet	
Fry	Aquatic insect larvae
Juveniles	Aquatic insect larvae
Adults	Aquatic insect larvae
Notes: Prey on their own eggs.	

Reproduction			
Time of Year	May – June	Age Males Mature	2
Temperature Range	15.5 – 18°C	Age Females Mature	2
Water Depth	Shallow	Nest	None
Substrate	Gravel	Egg Type	
Time of Day		Parental Care	Male
Critical pH		Days to Hatching	
Velocity Range		Oxygen Level	
Notes: Spawn in shallow riffle areas. Prey on their own eggs during spawning. Life history information taken from Scott and Crossman 1973.			

Creek Chub *(Semotilus atromaculatus)*

General Information

Creek chubs are found in streams throughout the state. Individuals reaching 10 inches in length are not uncommon. Although sometimes found in lakes they prefer clear, small streams abundant in cover.



Native Range	Widely distributed from the Rocky Mountains to the Atlantic Coast and from the Gulf of Mexico to southern Manitoba and Quebec. (McMahon, 1982).

Habitat Description

Rivers: Small, clear, cool streams with moderate to high gradients. Prefer shallow streams (<1m depth) with a gravel substrate for spawning but are found across a variety of substrates. Found in the pool and run areas of streams with abundant cover and forage.

Lakes: May occasionally be encountered in ponds and lakes but essentially is a stream dwelling species.

Optimum Habitat Requirements	
Dissolved Oxygen	
Temperature	12 – 21°C
pH	6.0 – 9.0
Turbidity	
Current	< 60 cm /sec

Diet	
Fry	Terrestrial and aquatic insects
Juveniles	Terrestrial and aquatic insects, mollusks, and fish
Adults	Terrestrial and aquatic insects, mollusks, and fish
Notes:	

Reproduction

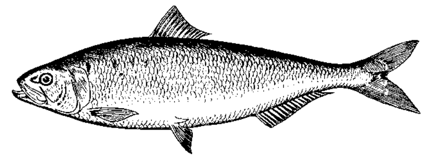
Time of Year	April – July	Age Males Mature	2 - 5
Temperature Range	14°C	Age Females Mature	2 - 5
Water Depth	Shallow	Nest	Male
Substrate	Gravel	Egg Type	
Time of Day		Parental Care	
Critical pH		Days to Hatching	10
Velocity Range		Oxygen Level	

Notes: Successful reproduction is adversely affected by water temperatures < 11°C. Life history information taken from McMahon 1982.

Alewife (*Alosa pseudoharengus*)

General Information

A schooling fish, primarily anadromous, inhabiting the ocean and many coastal/tidal river systems in NJ. Freshwater land-locked populations have been established in many lakes throughout the state and are often an important prey species for a variety of game fish. They are also commercially harvested and used as baitfish.



Native Range	Land-locked forms are located mostly in the NE United States. Their range extends from Nova Scotia to North Carolina and into the Great Lakes. (Bochenek 1981, Pardue 1983)

Habitat Description

Rivers: River populations are anadromous. Found in river systems during the spring spawning migration (April-June). Will utilize smaller streams for spawning than the closely related American shad.

Lakes: May occupy all strata of a land-locked waterbody during the course of the year. Primarily pelagic (open water), however, will move into littoral areas in late spring and summer to spawn and then return to deeper water. Have a preference for the warmer waters. Also move into shallow areas at night and return to deeper waters during the day. Move in large schools. Attracted to light.

Optimum Habitat Requirements	
Dissolved Oxygen	
Temperature	11-19°C (adults) 17-19°C (young)
pH	
Turbidity	
Current	

Diet	
Fry	zooplankton
Juveniles	insect larvae, zooplankton, some fish larvae
Adults	insect larvae, zooplankton,
Notes: Planktivores become more omnivorous with increase in size. Mainly filter feeders.	

Growth

Age	1	2	3
Male (total length in mm)	95	127	135
Female (total length in mm)	102	128	142

Notes: Growth data from Lake Hopatcong, 1979-1980 (Bochenek 1981). Landlocked alewives have a shorter life expectancy and poorer growth rate than its anadromous counterparts. Females grow faster. Growth slows significantly after the onset of sexual maturity.

Reproduction

Time of Year	June	Age Males Mature	2 - 3
Temperature Range	10° - 26.7°C	Age Females Mature	2 - 3
Water Depth	150 - 300 mm	Nest	None
Substrate	Veg, sand, gravel	Egg Type	Non-adhesive
Time of Day	Night	Parental Care	None
Critical pH		Days to Hatching	4 - 6
Velocity Range	Not critical	Oxygen Level	critical

Notes: Females move into spawning areas (tributaries and shallow littoral zones) first. Will spawn in moderate currents if a more adequate spawning area is unavailable. Spawn in groups of two or three - each female deposits 60,000-100,000 eggs. Diet, growth and reproduction information taken from Brown 1972;Janssen 1976; Crowder 1983; Janssen 1978; Nigro 1982 and Bochenek 1981.

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