

# Biology & Management

## Brook Trout – Basic Biology

**Common Name:** Eastern Brook Trout

**Other Names:** Brook Trout, Brookie, Speckled Trout, Squaretail, Red Spot

**Scientific Name:** *Salvelinus fontinalis*

**Origin (Maine):** Native

North America is home to five species in the genus *Salvelinus*: lake trout, bull trout, Arctic char, Dolly Varden, and brook trout. All members of this genus are known as char. All members of *Salvelinus* are distinguished from all other species in the genera *Salmo* and *Oncorhynchus* by a lack of black spots on the body. In addition, *Salvelinus* species have teeth only on the anterior portion of the vomer (the narrow bone in the roof of the mouth).



**Female Brook Trout**

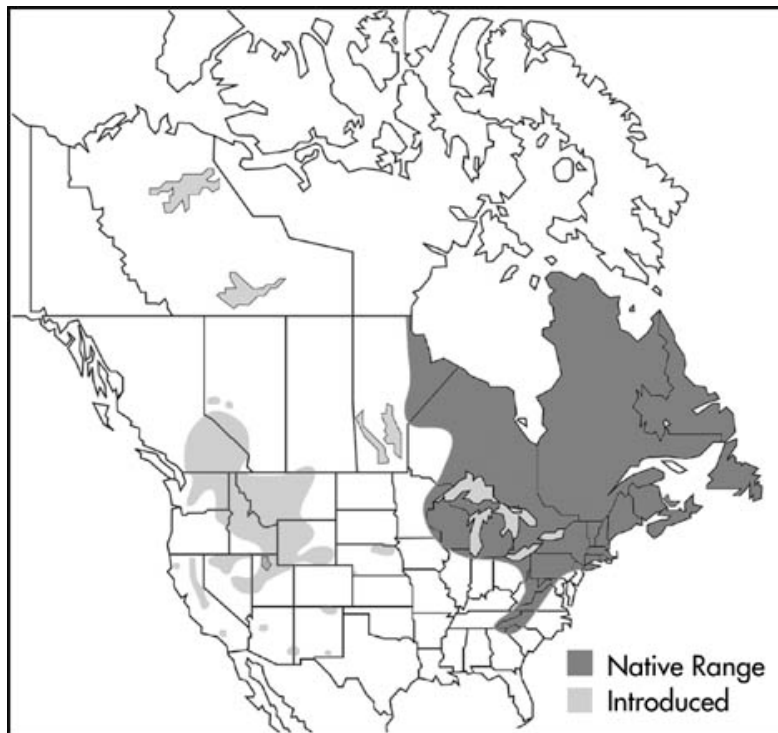


### **Male Brook Trout**

**Color/Identification:** Brook trout are one of the most beautiful salmonids in the world; the depth, range, and patterns of their colors are absolutely striking. Coloration is variable and depends on habitat. The back (dorsal) is typically olive-green to almost black with a gradual lightening of the same color on the sides. Light green to yellowish colored worm-like lines (vermiculations) occur on the top of the head and back and fade into more of a spotted pattern as it progresses downward towards the flanks. A wavy color pattern also carries into the dorsal and upper caudal fins. Towards the midline numerous orange to reddish colored spots encased in blue halos become evident. The lower fins and caudal have a distinct and discrete white band often followed by a more diffuse black band that then fades into a yellow or orange shade on the remaining portion of the fins. Their underbelly is white. Males are typically more colorful, particularly in the fall around spawning time when their lower flanks become fiery red with black pigmentation. Larger males will also have a more pointed snout and like many other male salmonids, they develop a hook jaw (kype). Brook trout can be distinguished from other members of the trout family by the white leading edges of their fins, vermiculations, and the blue haloed reddish colored spots. Illustrations above are of a female (top) and male (bottom) brook trout.

**Distribution:** Brook trout are native to northeastern North America, and their distribution is limited primarily by high water temperature. Although the ideal upper temperature is frequently cited as 68° F (20°C), they inhabit waters up to 75° F (24°C). Their original distribution was affected by glaciation; distribution likely expanded with glacial contraction and retreat. The native range of brook trout is most of northeastern North America. To the North, brook trout are native to the Atlantic drainages of Newfoundland, Labrador, and Quebec, and to tributaries of James Bay and Ungava Bay. In the Hudson Bay drainage on the eastern side extends south from the Ungava Peninsula, Quebec; on the western side brook trout occur north to the Seal River of northeastern Manitoba. Southward, brook trout are native to the Great Lakes basin and in headwater tributaries of the Mississippi River of Minnesota, Wisconsin, and northeastern Iowa. Brook Trout are native to all Atlantic coastal drainages southward to Virginia and parts of

the Ohio River system. In the southern Appalachian Mountains, brook trout are native to higher-elevation streams draining to both the Atlantic Ocean and the Mississippi River. The southernmost distribution of brook trout is the headwaters of the Chattahoochee River, Georgia (see map). In addition, brook trout have been widely introduced to areas outside of their native range including western North America, South America, New Zealand, Asia, and parts of Europe.



In Maine, brook trout were originally widely distributed throughout much of the state, from coastal drainages in the south to the western mountains, and the upper reaches of many northern drainages. However, brook trout were excluded from some upland drainages by natural barriers. After the State was settled by Europeans, brook trout distribution declined in the coastal plain as a result of habitat degradation associated with development. Their range was expanded in the western mountains and in the northern portion of the state however as a result of intentional introductions into suitable, but previously inaccessible waters.

Based on 2009 data, brook trout occur in 1,503 Maine lakes (762,123 acres) and provide principal fisheries in 1,148 lakes (431,035 acres). Of these, 491 (43%) are currently stocked; these waters account for 31% of the principal-fishery acreage. Because 97% of the state's lakes have been inventoried at least once, lacustrine distribution of brook trout throughout the state is likely very accurate. However, unlike the state's lakes, few streams have been surveyed to

date. An estimated 22, 250 miles (70%) of Maine streams support principal brook trout fisheries.

**Habitat:** Brook trout have historically been the most abundant and ubiquitous coldwater game fish in Maine and remain so today despite reductions in habitat that have occurred since European settlement of the area. Basic habitat requirements include cool, clean, well-oxygenated water and suitable spawning, nursery, and adult habitat. Brook trout are the most tolerant of warm temperatures, being more comparable to rainbow and brown trout than to any other species of char. As long as water temperatures do not exceed 68° F for extended periods and oxygen levels remain at 5 ppm or greater, brook trout can usually survive and grow. Brook trout are a habitat generalist: they have lake (lacustrine), stream (fluvial), and sea-run (anadromous) populations. Brook trout are capable of spending the adult portion of their lives in marine or brackish waters, and anadromous populations are found in some of Maine's estuaries. They spend a relatively brief period of the year (40 – 90 days) in summer feeding in estuarine waters.

**Life History:** Mature brook trout, typically II+ to III+ years of age, spawn in gravelly substrate over upwelling ground water in the fall (late September – November). In Maine, the earliest spawning occurs in high-elevation waters and/or more northern latitudes. Water moving through the gravel prevents the buried eggs from freezing and provides them with oxygen. Spawning generally occurs in streams; however, shore spawning is successful in some ponds where spring-water inflows occur in gravelly or sandy shallows.



**Spawning Brook Trout.**

Prior to spawning, groups of males and females will often congregate in areas of suitable habitat. Spawning and courtship activities occur in the daytime, which is the opposite of its close relative, the lake trout (togue). The female digs a shallow pit, 4-12 inches deep called a redd, by lying on her side and rapidly beating her tail fin from side to side. This process also cleans the gravel of silt and debris. Males exhibit courting behaviors, which include circling the female and displaying highly aggressive territorial performances against other males. At the time of spawning, the female and one or two males move into the redd and simultaneously extrude their eggs and milt. The eggs are adhesive for a short period of time, which prevents them from being washed downstream. Upon completion, the female covers the fertilized eggs with gravel in a

similar manner to that used during red excavation. Brook trout lay between 500 and 5,000 eggs, depending on the size of the female. The eggs remain in the pits overwinter and absorb oxygen from the water flowing through the gravel.

Egg incubation time varies with temperature, but wild brook trout eggs in Maine hatch out in the early spring and the newly hatched fry often remain in the gravel until their yolk sac is absorbed. At this point, fry emerge from the gravel and seek out protective cover where they can feed and grow.

**Diet:** Brook trout are opportunistic feeders and have been documented as eating an astonishing list of different food items ranging anywhere from plankton to small mammals. Worms, leeches, amphibians, crustaceans, mollusks, aquatic insects, terrestrial insects, and fish are commonly found in trout stomachs. The composition of food items consumed in their diet changes seasonally depending upon availability. However, the bulk of their diet largely consists of aquatic and terrestrial insects, as well as smaller prey fish. Studies in Maine and elsewhere suggest that fish do not become an important component of the diet until brook trout attain a size of 10-12 inches in length. On the other hand, it has also been well documented that other fish species, even small prey sized fish are often more of a detriment to trout populations than a benefit as a food resource, because they outcompete the trout for other food resources and/or even predate on juvenile trout.



**Growth and Longevity:** Brook trout are capable of extremely diverse growth rates, which are primarily dependent on such environmental factors as basic productivity, water temperature, and food abundance. In Freshwater Fishes of Canada by Scott and Crossman (1998), age 3 brook trout from four different Canadian lakes ranged from 6.8 to 15.2 inches in length. The statewide average length of 3 year-old brook trout in Maine lakes is 13.3 inches. However, same age trout from different lakes range from 7.5 to 17.5 inches in length. Stream populations are typically slower growing than lake populations. For example, age 3 wild brook trout collected from 38 streams from 1959-1962 had an average length of only 7.8 inches. Some high elevation trout populations mature and reproduce at lengths smaller than 6 inches.

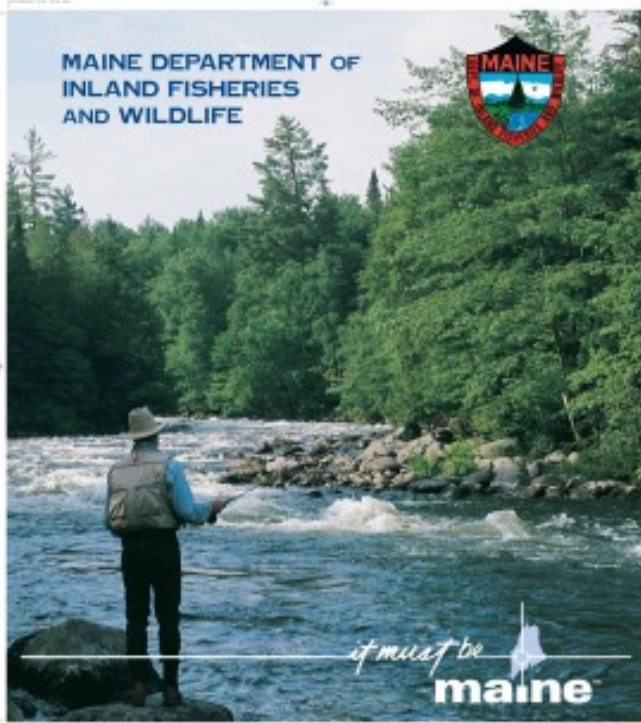


Compared to their relatives, lake trout and arctic charr, brook trout are a relatively short-lived fish with few surviving beyond 3 years of age. As a rule of thumb, the most common age of brook trout caught in Maine lakes is 3 years, while a trout caught in streams is 2 years. A few individuals may attain ages of 4 to 6 years, but rarely more. An authoritative work on freshwater fishes suggests that brook trout in Canada never live beyond 8 years. However, former Maine Regional Biologist, Roger AuClair, aged a brook trout from Moosehead Lake in 1961 that was 9 years. More recently, two 7 year old brook trout were captured in a study conducted on Chamberlain Lake, Maine. To the extreme end of the age range, biologists from California claim to have aged a brook trout from Bunny Lake in Mono County that was 20 years old and many others that were at least 15 years old.

**Threats:** Brook trout abundance has declined since Maine was settled by Europeans, primarily because of habitat degradation resulting from land clearing and dam construction. Currently, the gravest threat to Maine's brook trout populations is the unauthorized introduction of competing fish species, though the long-term effects of development, global warming and atmospheric-borne pollution cannot be ignored. Nonetheless, Maine still has the greatest reserve of brook trout in the northeastern United States. Preservation of this resource will require minimizing additional loss of habitat, restoring degraded habitat, protecting water quality, preventing the introduction of competing fish species, and protecting wild populations from overharvest.

## **BROOK TROUT MANAGEMENT HISTORY IN MAINE**

Brook trout have always been harvested as a food fish, however systematic exploitation of Maine's brook trout as a sports fish increased greatly in the latter 1800's. At that time, sporting camps flourished by catering to sportsmen in search of superior fishing for brook trout and other game fish common to the state. Records of the period mention trophy trout of 2 – 6 pounds fairly regularly, and a few fish ranged upwards of 9 pounds. The state record brook trout is 12.5-pounds caught at Mooselookmeguntic Lake in 1886. It appears however, that where large fish were caught they were not abundant. The converse was also true; high numerical catches were of smaller trout. One of the earliest recorded examples is from Arnold's expedition to Quebec in 1775. Soldiers' journals recorded catching dozens of brook trout weighing a half pound each at the Carry Ponds. Angling pressure was relatively light, compared to current standards, well into the early 1900's. Early access to waters on Maine's vast private forest lands increased as they were harvested for timber, first using log drives and later private road systems to deliver their products to mills. As the number of anglers increased and more backcountry roads were constructed, angling pressure increased over the years to current levels.



## It Must Be Maine

Nearly all of the State's inland waters were originally suited for brook trout. This situation began to change as increases in human population growth, industrialization (including the construction of power-generating dams), agriculture, and timber harvesting became increasingly widespread during the 1800's. Forestry practices such as dam and road construction, river drives of raw wood (often involving stream and river channelization), and harvesting along shoreline riparian zones led to the degradation of trout habitat. Prior to the implementation of environmental laws, the indiscriminate use of large mechanized equipment to harvest timber resulted in the degradation of brook trout habitat through erosion, siltation, and the loss of stream cover and habitat. Similar habitat losses occurred early in the state's history through widespread clearing for agricultural purposes, especially in the southern and central portions of the state. Loss of habitat as a result of industrial pollution increased in the nineteenth century and continued well into the twentieth century. In summary, the state's agricultural, silvicultural, and industrial land-use history resulted in degradation of much of the State's brook trout habitat, which in turn resulted in a decline in brook trout abundance, rather than outright extirpation.

The reduction in industrial and municipal pollution in the latter half of the twentieth century following the Clean Water Act resulted in improved water quality and restoration of habitat in some of the major rivers. The imposition of environmental regulations designed to protect natural resources also provided additional protection to all brook trout habitat, including commercial woodlands. Some forestry companies have voluntarily exceeded regulatory standards in order to protect fisheries resources; in recent years some commercial landowners have partnered with the Maine Department of Inland Fisheries and Wildlife (MDIFW, Department) to restore degraded fisheries habitat.

Scientific brook trout management began with the formation of the Fisheries Research and Management Division in 1951. Prior to this date, the Department's Commissioners authorized management activities, including fish stocking that were surprisingly widespread (thanks in large part to railroad transport) but poorly documented. Dr. William C. Kendall of the Bureau of Fisheries, U.S. Dept of Commerce, conducted the earliest scientific evaluation of Maine brook trout populations in 1918. His report, specific to the Rangeley Lakes area in western Maine, discussed the physical features, species composition, and abundance of these important brook trout waters. In addition, Dr. Kendall compiled records of brook trout harvests from previous documents dating back to the mid-1800's. Dr. Gerald P. Cooper, Assistant Professor of Zoology at the University of Maine, conducted the first systematic fishery survey of statewide significance. In a series of reports published from 1940-45, Dr. Cooper and his colleagues reported findings on the fisheries of the Rangeley Chain of Lakes, the lower Androscoggin and Kennebec drainage systems, Moosehead Lake, and Haymock Lake. Of particular value for brook trout management were the age and growth data for lightly exploited populations.



Programs to survey brook trout habitat systematically and conduct research projects to provide guidance for the statewide management of this species were implemented soon after the Fisheries Division was established. These research projects included several investigations into the life history of lake and stream populations of both wild and stocked brook trout.

Efforts to manage the brook trout sports fishery intensively increased with angler use and with concern for the welfare of the species. Increasingly restrictive regulations – in the form of bag limits, minimum length limits, and gear restrictions – have been imposed over the years. The first fly-fishing-only restrictions were imposed on individual waters in the Rangeley and Moosehead areas near the turn of the twentieth century. However, there was no general-law bag limit on trout as late as 1910. At that time there was a 25-pound limit and a 5-inch minimum length limit. As of 1920, there was a 25-trout limit, a 15-pound limit, and a 6-inch minimum



length limit. The bag limit for brook trout in lakes has been gradually reduced from 25 fish in 1950 to the current limits of 5 fish in northern Maine and 2 fish in southern Maine. In addition, categories of standardized special regulations, including bag and length limits, were implemented in 1996 and refined effective 2007 to account for the variability in growth rates among trout waters and to standardize special brook trout regulations, thereby simplifying a confusing array of special regulations.

Hatchery-reared fish are used to provide fisheries where adult habitat is present but spawning and/or nursery habitat are lacking. Artificial propagation has played a significant role in the management of Maine's brook trout for many years. The first State fish hatchery was constructed in 1895 following a decade of private efforts to hatch and stock trout fry. With the development of additional public hatcheries and rearing stations and the improvement of transportation systems, brook trout stocking gradually increased throughout the State and reached an annual level of about 800,000 fish in the 1970's, where it has remained. Current numbers are somewhat lower, averaging 580,000 per year, due to the emphasis on stocking more waters with larger (but fewer) catchable-size brook trout, newly available due to the rebuilding of the Embden Rearing Station in 2004-05 for that express purpose. The average weight of brook trout stocked has also increased (from 1.1 oz. in the 1970's to 3.1 oz. in the 2000's) due to the trend toward stocking these older, catchable (legal-size) fish. Nonetheless, the majority of Maine's brook trout are stocked on a biological basis. The stocking of sub-legal size fish that must grow to legal size before becoming vulnerable to harvest is referred to as biological stocking. The quantity and quality of the habitat and the extent of competition from other fish species determine the size of the fish stocked. For those waters in which brook trout stocking is done on a non-biological (put-and-take) basis, catchable-size trout are typically stocked near population centers to provide immediate angling opportunity with little expectation of holdover due to habitat limitations. Brook trout stocked in marginal quality habitat during spring months will survive at least until water temperatures become prohibitively warm while those stocked in the fall provide both winter and spring fishing opportunity. This program is currently being expanded as a result of angler interest and the availability of larger numbers of catchable brook trout resulting from the upgrade of the Embden Rearing Station. Accordingly, requests for catchable brook trout increased 3% for spring yearlings and 276% for fall yearlings from 2003 to 2008. Special length and gear regulations are frequently imposed on biologically stocked brook trout waters (which are intended to attain larger size before harvest) to assure escapement to increase longevity. For put-and-take fisheries, low bag limits are more commonly imposed with the intent to distribute fish equitably among anglers. Stocking rates, determined from a policy developed by fishery managers, take into account water size, water quality, interspecific competition, and the amount of angler use.



In the 1990's the Department undertook a program to improve its brook trout hatchery brood stock. Broodstock are fish raised in a hatchery setting specifically for the production of progeny to be stocked in the state's public waters. We developed new strains from wild fish originating from the Kennebago River and Sourdnhunk Lake with the goal of producing progeny that retain wild-fish characteristics, including greater longevity. Because these strains grow and behave differently from the more domesticated strains previously stocked, stocking rates have been evaluated and adjusted as necessary. Results of comparative performance studies of the new strains indicated that the longevity of both strains exceeded that of the older, domestic strains. However, the Kennebago strain fish performed better in the hatchery/rearing-station environment and provided better returns to the angler post-stocking. Consequently, the Kennebago strain has been retained for hatchery production, though these fish are frequently crossed with the older hatchery strain to provide faster-growing (though shorter-lived) fish for specific management situations. Comparative tests of the Kennebago strain vs. F1 strain (progeny of Kennebago and Maine Hatchery Strain cross) stocked as fall fingerlings in study ponds indicated that the F1 fish had a size advantage over the Kennebago strain and therefore attained legal size at an earlier age.

The removal of introduced competing warmwater fish species from trout waters by means of chemical (rotenone) reclamation began in 1939. Since that time, about 140 trout ponds have been reclaimed, usually with good – if sometimes temporary – results. Due to the expense of this management technique and changing public sentiment, the reclamation program is currently conducted at a modest level. Reclamation remains an especially valuable tool in eradicating illegally introduced fish species. Removal of competing species by other means (i.e. netting) is generally ineffective, labor intensive, and temporary in nature in that it does not remove all of the competitors, which quickly repopulate to their former abundance.



The introduction and spread of competing fish species has had a substantial impact on the quantity and quality of Maine's brook trout resource. The chain pickerel was indigenous to only a few southern Maine waters, but by 1850 had been introduced to other parts of the State and was well established in many trout waters. More recently, northern pike and muskellunge – which are related to pickerel but grow much larger – have been illegally introduced into several drainages where they continue to expand their range. The smallmouth bass had become established in many coastal drainages by the early 1900's, but continues to be illegally introduced into new drainages, including the upper Kennebec and Androscoggin river drainages (including the Rapid River) in the 1980's; and the St. John River drainage in the 2000's (they were documented in the Meduxnekeag River drainage, a subdrainage of the St. John River, in the 1990's). Because they are present above Grand Falls, they are expected to eventually invade the upper reaches of the St. John River drainage. The rate of illegal bass introductions has also recently increased, and is a great concern for brook trout fisheries. Efforts to reduce the abundance of invasive smallmouth bass in the Rapid River in western Maine by stressing bass fry through flow manipulation have been relatively unsuccessful to date but are ongoing.

White perch and yellow perch, both severe competitors with brook trout, became widespread during the late 1800's. These species remain an active threat, as exemplified by the introduction of yellow perch into the Moosehead Lake drainage, the Rangeley Lakes, and the Fish River Chain of Lakes in the 1950's and 1960's. The often inadvertent spread of white suckers and a number of minnow species used as bait caused still further interspecific competition with brook trout, but is less of a problem today because their use as live bait is prohibited from most waters with native or wild brook trout populations. It has long been the policy of fisheries biologists to recommend the imposition of regulations restricting the use of live fish as bait on newly-surveyed waters that have brook trout populations but few if any competing species. Nonetheless, unscrupulous individuals continue to illegally introduce bait species into brook trout waters in order to harvest them for profit. Introductions of other coldwater species of

fish, including smelts, landlocked salmon and lake trout, were made into many waters that originally harbored only brook trout, but their effect on trout is fortunately less severe than that of warmwater fish.

In the 1990's the Department conducted studies to determine the abundance, longevity, rates of harvest, and genetic variability of wild trout populations. This information is being used as a reference to monitor future population changes. More recently, detailed stream surveys have been conducted in an effort to determine more accurately the relationship between stream habitat types and brook trout abundance. Thanks to funding received from the Natural Resources Conservation Service's Fish and Wildlife Conservation Grant Program, we surveyed more than 1,000 streams in 2007 and a comparable number in 2008 to document the presence and abundance of brook trout in lotic waters throughout the state. As part of this effort, stream habitat is also being systematically evaluated for symptoms of degradation and fragmentation. Wild trout populations in streams, once largely taken for granted, are now recognized for their biological, economic, and aesthetic value.

Maine's wild brook trout populations are recognized for their genetic and aesthetic values and efforts to protect these traits through the imposition of special regulations have been expanded. To help protect Maine's lake and pond brook trout populations, the Maine legislature enacted in 2005 LD 1131 "*An Act to Recognize and Protect the Native Eastern Brook Trout as Maine's Heritage Fish*". This bill named the eastern brook trout as the State's heritage fish. This legislation protects Maine's native (i.e. never been stocked "A-list" waters) brook trout in two ways: the statute 1) prohibits the stocking of interspecific or intraspecific predator, prey, or competitor fish species from any hatchery or wild source without legislative approval, and 2) prohibits the use and possession of live baitfish on those waters. LD 1131 was later amended and directed the MDIFW to review wild (i.e. historically stocked and now self-sustaining) brook trout waters for possible inclusion on the A-list. The MDIFW reported that wild brook trout waters had not been entirely isolated from the impacts of stocking, but concluded nonetheless that wild brook trout populations were an important resource. These waters were organized under a "B-list" and defined as waters that 1) have not been directly stocked with brook trout in at least 25 years, 2) have self-sustaining brook trout populations, and 3) brook trout are sufficiently abundant to be considered a principal brook trout fishery.

Currently, Fisheries Division biologists have been reviewing the current A and B lists for new waters to add or waters to change on each list; over 600 hours of staff time have been dedicated to this effort between Fall 2012 and Spring 2013. The Division has evaluated waters to add to the A and B lists based on new surveys conducted by staff biologists since 2010, and based on remote pond surveys conducted in 2011 and 2012 through a partnership with Trout Unlimited and Maine Audubon. The Division has also proposed waters to change or remove from the lists based on new assessment information. Potential changes to the lists may result from historic stocking records (e.g., federal records) that were obtained after LD 1131 was enacted, a careful field review of brook trout habitat quality and population size, or from recent surveys that indicate waters no longer exist (e.g., old driving dam or beaver dam failure). MDIFW Administration and a public working group will review proposed changes to the A and B lists during the coming months.

Over the past 50 years, significant advances in knowledge and management expertise have been made relating to Maine's brook trout resource, enabling sound and rational management programs for this species. However, increased demand for brook trout, coupled with habitat threats and stagnant or decreasing funding levels for management and research, are necessitating innovative approaches to brook trout management. For example, the recently developed standardized regulations imposed on waters according to biological principles are not only resulting in a simplified law book, but – more importantly – are preventing overharvest, protecting genetically important older-age fish, and increasing carry-over to meet angler demands for larger fish.

Recognizing the economic importance of Maine's brook trout, we have increased promotional advertising of the sport fishery to both in state and out of state anglers. This advertising includes the following initiatives that are promoted through the media and at sportsman's shows that the Department attends annually throughout the northeast:

- **Brook trout fishing is promoted at seminars**
- **Brook trout photos are featured prominently at sportsman show displays**
- **Promotional literature, posters, and stickers are handed out at these events**
- **Maine brook trout are promoted in national fishing magazines and web sites**
- **Brook trout are featured prominently in the Department's merchandise line**
- **The species author completed two books (technical and non-technical versions) on brook trout biology and management**
- **A brook trout initiative is currently being developed to inform the public of Maine's wild brook trout resources and to facilitate angling through the development of a dedicated website.**

**These initiatives are put forth under the premise that promotion and protection of Maine's brook trout resource need not be mutually exclusive if they are adequately protected by appropriate regulations.**

In the absence of pure research, brook trout data have been consolidated onto computerized statewide databases, which are being used to monitor trends in the fishery. Grants are increasingly being used as funding sources to accomplish specific fisheries projects, notably resource inventory and stream restoration projects. Finally, the Department recognizes and supports the evolving angler ethic regarding the voluntary release of legal-size fish. These changing attitudes, together with the preservation of habitat through reasonable environmental regulations and intensive management efforts, demonstrate the Department's and the public's commitment to protecting and preserving our brook trout fishery. Despite this commitment, however, habitat degradation from past land use practices and the illegal introduction of predatory and competing fish species remain dire threats to brook trout populations.

## **Additional Reading**

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Karas, Nick. 1997. Brook Trout. The Lyons Press, New York, New York. 371 pp.