The mission of the Inland Fisheries Division is to use planning and science for effective management of New Hampshire's freshwater fisheries.

New Hampshire Fish and Game Department
Inland Fisheries Division
2012 Master Operational Plan

The mission of the Inland Fisheries Division is to use planning and science for effective management of New Hampshire's inland fisheries resources.

Introduction

The Inland Fisheries Division makes use of the Department's Strategic Plan (1998-2010) in conjunction with results from New Hampshire angler opinion and attitude surveys (1996 and 2004) to guide its programs. This ensures the Division is addressing the needs of the State's inland fisheries resources as well as the recreational groups who utilize these resources.

Operational planning is the process utilized by the Inland Fisheries Division to convert strategic goals and objectives into management actions. This process is comprehensive in its approach and integrates individual action plans, developed for each of the Division's five principal inland fisheries research and management programs (warmwater fisheries, coldwater fisheries, large lakes fisheries, fish conservation, and fisheries habitat), into an annual Master Operational Plan. Each action plan contains: a project objective; a description of work to be accomplished; the project's justification; and, an estimation of its costs. Central to the operational planning process is the prioritization of program projects (Appendix Table I). Each project is prioritized based on its ranking in the following areas: 1) ecological importance, 2) public interest, 3) economic importance, 4) adequacy of existing data for management purposes, 5) project feasibility, and 6) project cost to benefit ratio (Appendix Table II).

Operational planning also facilitates a process whereby each program project can be evaluated to determine its effectiveness in meeting strategic goals and objectives. These evaluations supply the information necessary to fine-tune the action plan and provide the feedback that initiates corrective action and/or revisions when necessary. It also allows the progress in each program to be measured and documented in a simple, straightforward manner.

Operational planning also assists in achieving objectives 13.1 and 13.2 in the Department's Strategic Plan (1998-2010) by implementing the actions identified in strategies 13.1.3, 13.1.4, 13.1.6, and 13.2.1 (Appendix Table III).

Warmwater Fisheries Program

Program Need:

New Hampshire's warmwater fish populations are highly utilized by anglers, with smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*M. salmoides*) ranking among the top four species fished for by anglers (Responsive Management 1996 and 2004). In 2006, 105,000 anglers fished 1.264 million days for black bass in New Hampshire (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). This level of angler participation represented 53% of New Hampshire's freshwater anglers and 46% of the total days of fishing.

Although sought by fewer anglers, yellow perch (*Perca flavescens*), pickerel (*Esox niger*) and white perch (*Morone americana*) rank in the top ten among species fished for (Responsive Management 1996 and 2004). In 2006, 33,000 anglers fished 268,000 days for northern pike and pickerel in New Hampshire (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). Sample size for anglers fishing for walleye was too small for reliable reporting of number of anglers or angler days. Thirteen percent of ice-fishing anglers preferred to fish for northern pike, and pickerel were the species most sought by ice-fishing anglers (32%) (Responsive Management 1996). Fewer open-water anglers seek walleye (*Sander vitreus*) and northern pike (*Esox lucius*), likely due to the relatively limited fishing opportunities for these species in New Hampshire. Black crappie (*Pomoxis nigromaculatus*) has recently become a popular fish with open-water and ice-fishing anglers throughout much of the state (no data available on angler preference).

Because warmwater fisheries are sustained through natural reproduction and are popular with the state's anglers, periodic assessments and/or studies are necessary to determine the status of essential population parameters so that appropriate management measures can be modified or implemented when needed. It is also imperative to collect angler data via creel surveys in order to make well-informed decisions regarding the management of these species.

On average, 439 bass tournaments are held each year in New Hampshire (2001-2005). Accordingly, it is important that tournament data are monitored and analyzed in order to recognize potential negative effects of tournaments on black bass populations.

Program Goal:

To sustain or improve warmwater fish populations, as well as provide recreational opportunities to fish for these species.

Approach:

The objectives of warmwater assessments are to determine: 1) fish condition, 2) size and population structure, 3) relative abundance (target and community species), 4) young-of-year size and abundance, 5) compare measured population parameters among populations and years, 6) age and growth, 7) population changes resulting from prior management decisions, 8) angler effort, catch and harvest rates, and opinions related to management, 9) populations that would benefit from special angling regulations, and 10) potential effects of bass tournaments on the state's black bass resources.

Warmwater fish populations will be sampled using established electrofishing, netting and angler survey techniques. Data will be collected according to established guidelines for statistical reliability, with sample designs and sample sizes being adequate in order to provide statistically valid results. Electrofishing catch-per-hour (fish/hour) will be calculated as a measure of relative abundance, based upon the equipment's "on" meter time.

Competitive bass tournament reports will be utilized to analyze trend data regarding these events and their impacts on bass populations.

Expected Results And Benefits:

Detailed knowledge of warmwater fish populations is essential for the proper management of these species. Data collected by consistent and representative methods provide information regarding fish growth, age and their overall fish health or condition. For target species, catch per unit effort provides an estimate of relative abundance while relative abundance of young fish provides information on recruitment.

The economic impact of anglers fishing for warmwater species in New Hampshire is significant as these anglers generated in excess of $56 million in fishing-related expenditures during 2006 (black bass: $37.92 million, panfish: $10.17 million, northern pike and pickerel: $8.04 million, walleye: data unavailable) (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008).

Warmwater Fisheries Program Action Plans

Project Title: Black Bass/Warmwater Fish Community Assessment

Project Objective: To determine: 1) warmwater fish condition, 2) size and population structure, 3) relative abundance, 4) black bass young-of-year (YOY) size and abundance, 5) compare measured population parameters among populations and years, 6) age and growth, 7) population changes resulting from prior management decisions, 8) angler effort, catch and harvest rates, and opinions related to management, 9) populations that would benefit from special angling regulations, and 10) maintain and update black bass database containing biological and aging data.

2012 Objectives: Ten water bodies will undergo warmwater fisheries assessments. Inclusive in this number are YOY black bass surveys at five sites on Lake Winnipesaukee, six sites on Squam Lake, two sites on the Connecticut River, five sites on Forest Lake (Dalton/Whitefield), and five sites on Spofford Lake. The black bass database will be maintained and updated. Scales collected during sampling will be aged.

Project Work Description: Black bass (*Micropterus dolomieui*, smallmouth and *M. salmoides*, largemouth) and other warmwater fish populations are primarily assessed via boat electrofishing, although these populations may also be assessed through the use of NH design fyke nets, angler surveys and/or by collecting biological data at fishing tournaments.

Electrofishing surveys are conducted after sunset using a Smith-Root electrofishing boat (SR18 or SR12). Two or three netters are used to capture fish and electrofishing equipment is adjusted according to water conductivity and observed fish behavior relative to their position in the electrode's field. The study design incorporates timed runs of 1000 seconds using the equipment's "on" meter time when sampling for target species (black bass for example) and random or community runs, which are typically 500 seconds in duration, to assess the other fish species in the lake. Black bass or other target species are captured during both target and community runs. Typically, seven to eight runs are conducted during an evening, two of which are community collections. The timed runs permit a measure of statistical precision (SD) to be estimated for relative abundance indices. All fish are placed in a live well upon capture. Fish are measured to the nearest millimeter, total length, and weighed to the nearest gram. Scale samples are taken from black bass and other target species in the region below the lateral line and slightly posterior to the pectoral fin on the left side of the fish. Fish are processed shortly after capture and then released.

Netting surveys are conducted using NH design fyke nets that are set along a water body's shoreline. Number of nets employed is dependent on the size of the water body being sampled. Fish are measured to the nearest millimeter, total length, and weighed to the nearest gram. Scale samples are taken from black bass and other target species in the region below the lateral line and slightly posterior to the pectoral fin on the left side of the fish. Fish are processed shortly after capture and then released. Before release, a small portion of a fin is excised to avoid data duplication if the fish is captured again and will allow for a population estimate to be calculated if desired.

Data collected from electrofishing and netting surveys are analyzed as follows. Relative abundance values (fish/hour) are calculated by run, water body and species, and are further partitioned into discrete length categories for black bass (see below). Proportional Stock Density (PSD) measures for bass are determined according to the length categories (based on total length) described in Gablehouse (1984) for smallmouth bass: stock 180-279 mm; quality 280-349 mm; preferred 350-429 mm; memorable 430-509 mm; and trophy > 510 mm. Largemouth bass are similarly grouped: stock 200-299 mm; quality 300-379 mm; preferred 380-509 mm; memorable 510-629 mm; and trophy > 630 mm. Relative abundance (fish/hr) measures incorporate a YOY length category and a juvenile length category, which is any fish less than stock size and greater than YOY size.

$$PSD = \frac{number\ \ of\ \ fish \geq quality}{number\ \ of\ \ fish \geq stock} \bullet 100$$

Confidence intervals are calculated for PSD estimates at the 80% confidence level using formulas based on Gustafson (1988). PSD values between 40 and 60 indicate a structurally balanced population. Values < 40 indicate too many small fish and values > 60 indicate too many large fish.

Relative weight (W_r) values are derived as a measure of condition of individual fish. Relative weight values are calculated for black bass > 150 mm (total length). This index compares the actual weight of an individual (W) with a standard weight (W_s) for a fish of the same length:

$$W_r = W/W_s \square 100$$

The standard weight equation used for smallmouth bass is $\log_{10} W_s$ (g) = - 5.329 + 3.20 x $\log_{10}$ TL(mm), proposed by Kolander et al. (1993). The equation used for largemouth bass is $\log_{10} W_s$ (g) = -5.316 + 3.191 x $\log_{10}$ TL (mm), proposed by Wege and Anderson (1978). Relative weight values > 90 may be considered good, with values > 100 considered excellent.

Linear regression is used to examine the relationship of fish total length to relative weight. When appropriate, an ANOVA, t-test, Mann-Whitney Rank Sum test, or z-test is used to test for differences between years in W_r and relative abundance values by species and length category. The level of significance for all statistical analyses is set at 0.10.

Angler surveys are conducted using established guidelines (Pollock et al. 1994), but specific details of the format will depend on the water body, questions and fishery they are meant to assess. Standard assessments will include the collection of angler effort and harvest and catch rate data as well as asking anglers specific management related questions.

Biological data are also collected at fishing tournaments (mainly black bass tournaments), primarily to gather data during a time of year when other sampling might not normally be performed. Typically, a random sample of fish is measured to the nearest millimeter, total length, and weighed to the nearest gram. Scale samples are taken from black bass and other target species in the region below the lateral line and slightly posterior to the pectoral fin on the left side of the fish.

Young-of-the-year (YOY) black bass surveys are conducted each fall at five locations on Lake Winnipesaukee. Sampling is conducted by boat electrofishing during the day using two netters. Shoreline landmarks at the five sampling locations are documented so annual surveys are consistent. Only YOY black bass are captured and one sampling run is conducted at each of the five locations. All fish are placed in a live well upon capture. Fish are measured to the nearest millimeter, total length, and weighed to the nearest gram. Scale samples are taken from black bass whose large size makes the age designation of YOY questionable. Fish are processed shortly after capture and then released. Relative abundance (fish captured/hour) values are compared among years and sites. Total length and weight are compared among years and sites by species and between species by year using a t-test or an ANOVA.

Project Justification: New Hampshire's black bass fish populations are highly utilized by anglers, with smallmouth and largemouth bass ranking among the top four species fished for by anglers (Responsive Management 1996 and 2004). Although sought by fewer anglers, yellow perch (*Perca flavescens*), pickerel (*Esox niger*) and white perch (*Morone saxitilis*) rank in the top ten among species fished for (Responsive Management 1996 and 2004). Because warmwater fisheries are sustained through natural reproduction and are popular with the state's anglers, periodic assessments and/or studies are necessary to determine the status of essential population parameters so that appropriate management measures can be modified or implemented when needed.

According to the 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation, 168,000 anglers fished 1.87 million days for warmwater species in New Hampshire (panfish: 30,000 anglers fished 339,000 days; black bass: 105,000 anglers fished 1.264 million days; northern pike and chain pickerel: 33,000 anglers fished 268,000 days) (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). The level of angler participation in black bass fishing represented 53% of New Hampshire's freshwater anglers and 46% of the total days of fishing. Since the average trip expenditure for anglers fishing in New Hampshire is $30 per day, the total expenditures by anglers fishing for warmwater species equals approximately $56.13 million.

The Black Bass/Warmwater Fish Community Assessment is a strategy that assists the Department in achieving objectives 2.1, 3.1, 6.1, 11.1, 11.3, and 16.1 within its Strategic Plan (1998-2010).

Project Costs: $44,596.00

Salary: (1) Biologist II	400 hours x $56.89/hr =	$22,756.00
(1) Biologist I	500 hours x $35.78/hr =	$17,890.00
(1) Laborer	150 hours x $10.67/hr =	$ 1,600.00
Equipment Maintenance Cost:		$ 350.00
Equipment Cost:		$ 500.00
In-State Travel Cost:		$ 1,500.00
		$44,596.00

Project Priority Score: 29 points

Ecological Importance:	High	5 points
Public Interest:	Moderate-High	4 points

Economic Importance:	High	5 points
Adequacy of Existing Data:	High	5 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Project Title: Black Bass Tournament Assessment

Project Objective: To examine number of tournaments held, tournament angler effort, bass survival to weigh-in, and trends in tournament catch rates, fish weight and initial mortality. Analysis and reporting of a calendar year's black bass tournament data should be completed within two years after data entry. Communicate management topics to tournament anglers via presentations, attendance at meetings and/or weigh-ins, or through other means. If time and staff allows, a study investigating the impacts of "fizzing" on black bass initial and delayed mortality will be conducted.

Project Work Description: Black bass (*Micropterus dolomieui*, smallmouth and *M. salmoides*, largemouth) tournaments and black bass population-related trends for waters that receive bass tournament angling pressure are monitored through a reporting requirement that is established by New Hampshire Code of Administrative Rule Fis 503.04. This regulation states that any person conducting a fishing tournament shall submit a written report (Appendix Table I) to the NHFGD within 30 days after completion of the fishing tournament. Data from written reports are entered into a Microsoft Access database and later verified for accuracy and consistency. Data are analyzed using three different approaches:

1) Analysis for all water bodies on which a permitted bass tournament was held during a given year:
a) Total number of tournaments held;
b) Number of sponsors by state that held tournaments;
c) Number of tournaments held by sponsor's State of origin;
d) Number of non-typical tournament sponsors and number of tournaments held;
e) Average number of tournaments per sponsor;
f) Total and maximum number of tournaments held by in-state and out-of-state sponsors;
h) Total and average number of participants in tournaments;
i) Number of tournaments and corresponding number of boats participating in tournaments;
j) Total angling effort in hours for tournaments;
k) Number of day, night and two-day tournaments;
l) Total number and largest weight (lbs) of largemouth and smallmouth bass entered during tournaments[1];
m) Number of tournaments per month;
n) Number of tournaments and average number of participants per tournament during the catch-and-release period;
o) Total number of water bodies that hosted tournaments and average number of tournaments per water body.

2) Analysis by water body for each water body that had three or more permitted bass tournaments per year.
a) Bass tournament effort (angler hours);
b) Bass tournament pressure (angler hours/surface acre/year);
c) Bass tournament catch rates (fish/hour) of smallmouth bass and largemouth bass entered for weigh-in[1] during the tournament;
d) Average size (weight) of smallmouth bass and largemouth bass entered for weigh-in[1] during the tournament.
e) Average number of boats per tournament (2001-2003) and number of tournaments held.

[1] Most bass tournament sponsors establish a per person limit on the number of bass that can be weighed-in and a minimum entry length, which typically is 12 inches but can range from 10 inches to 14 inches. Accordingly, bass that are caught and culled are not accounted for in this report.

Data for analysis approaches 1) and 2) (see above) are compared among years by water body to examine trends in black bass population and black bass tournament statistics. Analysis of variance (ANOVA, $\alpha = 0.05$) is used to determine if any significant differences exist within water bodies among years for angler effort, catch rates and average weight of bass.

3) Data from written reports submitted by bass tournament organizers are also examined in regards to initial mortality (i.e. mortality that occurs prior to release) of bass weighed in during bass tournaments. Initial mortality for each black bass species is calculated by month (April – October) and by year for comparative purposes. It should be noted that bass tournament reports filed for events that occur between May 15 and June 15 are excluded from analysis for the respective months because all black bass must be immediately released during this time and therefore those permitted tournaments operate under a "paper" format rather than a "weigh-in" format. Chi-square contingency analyses are used to detect significant differences ($\alpha = 0.05$) in initial mortality between smallmouth and largemouth bass; within species, among years and months; and, between large and small tournaments.

Project Justification: New Hampshire's black bass fish populations are highly utilized by anglers, with smallmouth bass and largemouth bass ranking among the top four species fished for by anglers (Responsive Management 1996 and 2004). Additionally, an average of 439 bass tournaments are held each year in New Hampshire (2001-2005). As black bass populations in the state are managed solely by natural reproduction, it is necessary to examine black bass tournament data to examine trends in tournament and black bass population statistics to ensure the continued health of these populations.

According to the 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation, 105,000 anglers fished 1.264 million days for black bass in New Hampshire (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). This level of angler participation represented 53% of New Hampshire's freshwater anglers and 46% of the total days of fishing. Since the average trip expenditure for anglers fishing in New Hampshire is $30 per day, the total expenditures by anglers fishing for black bass equals $37.92 million.

The Competitive Black Bass Tournament Assessment is a strategy that assists the Department in achieving objectives 2.1, 3.1 and 16.1 within its Strategic Plan (1998-2010).

Project Costs: $27,706.00

Salary:	(1) Biologist II	300 hours x $56.89/hr =	$17,067.00
	(1) Administrative Secretary	240 hours x $44.33/hr =	$10,639.00
			$27,706.00

Project Priority Score: 30 points

Ecological Importance:	High	5 points
Public Interest:	High	5 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	High	5 points

Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Appendix Table I.

CLUB NAME:			
CONTACT NAME AND ADDRESS:			
TOURNAMENT LOCATION:			
TOURNAMENT DATE:		←Please fill in one sheet for each date of your contest	
TOURNAMENT HOURS:	**START:**	**END:**	
TOTAL NUMBER OF PARTICIPANTS:		**TOTAL TOURNAMENT HOURS:**	
TOTAL ANGLER HOURS:		**MINIMUM BASS LENGTH:**	
TOTAL NUMBER OF LARGEMOUTH ENTERED IN TOURNAMENT:		**TOTAL NUMBER OF SMALLMOUTH ENTERED IN TOURNAMENT:**	
TOTAL NUMBER OF LARGEMOUTH RELEASED ALIVE:		**TOTAL NUMBER OF SMALLMOUTH RELEASED ALIVE:**	
TOTAL WEIGHT OF ALL LARGEMOUTH:		**TOTAL WEIGHT OF ALL SMALLMOUTH:**	
AVERAGE WEIGHT OF LARGEMOUTH:		**AVERAGE WEIGHT OF SMALLMOUTH:**	
WEIGHT OF LARGEST LARGEMOUTH:		**WEIGHT OF LARGEST SMALLMOUTH:**	
TOTAL TOURNAMENT WEIGHT:		**MAXIMUM NUMBER OF BASS ALLOWED TO BE WEIGHED IN PER ANGLER:**	
COMMENTS: Please use the comments section to give us any other relevant information, ie: weather, conditions, etc			

Project Title: Walleye Assessment

Project Objective: 1) conduct spawning population stock assessment in the Connecticut River [i.e. determine size distributions, evaluate fish condition, determine the effects of spring flow conditions on recruitment, determine relative abundance, compare these measures among years, examine population changes resulting from prior management decisions], 2) investigate opportunities to create walleye fisheries in new water bodies, and 3) evaluate young-of-the-year (YOY) production in the Connecticut River in the fall.

At a minimum, YOY walleye surveys should be conducted annually in the Connecticut River. Spring spawning stock assessment should be conducted when time and staff allows and/or when concerns are raised regarding the status of the Connecticut River population. Opportunities to create new walleye fisheries should be initiated when time and staff allows and public opinion is shown to be supportive.

Project Work Description: Walleye (*Sander vitreus*) populations are primarily assessed via boat electrofishing, although these populations may also be assessed through the use of NH design fyke nets and/or angler surveys.

Electrofishing surveys are conducted after sunset using an electrofishing boat (Smith-Root SR18). Two or three netters are used to capture fish and electrofishing equipment is adjusted according to water conductivity and observed fish behavior relative to their position in the electrode's field. The study design incorporates timed runs using the equipment's "on" meter time when sampling. The timed runs permit a measure of statistical precision (SD) to be estimated for relative abundance indices. All fish are placed in a live well upon capture. Fish are measured to the nearest millimeter, total length, and weighed to the nearest gram. Fish are processed shortly after capture and then released. Electrofishing surveys for walleye spawning stock evaluations are conducted in spring in the Connecticut River, below the Bellows Falls Dam (Walpole). Assessments of YOY walleye are conducted in the fall in the Connecticut River (Claremont to Charleston area).

Netting surveys are currently not used to sample walleye populations, but may be in the future. Netting surveys would be conducted using NH design fyke nets that are set along a water body's shoreline. Number of nets employed would depend on the size of the water body being sampled. Fish would be measured to the nearest millimeter, total length, and weighed to the nearest gram. Fish would be processed shortly after capture and then released. Before release, a small portion of a fin would be excised to avoid data duplication if the fish was captured again and would allow for a population estimate to be calculated if desired.

Data collected from electrofishing or netting surveys are analyzed as follows. Relative abundance values (fish/hour) are calculated by run and sampling location, and are further partitioned into discrete length categories described in Gablehouse (1984). Relative weight (Wr) analysis is used as a measure of fish condition. This index compares the actual weight of an individual with a standard weight for a fish of the same length:

$$W_r = W / W_s \times 100$$

The standard weight equation used for walleye is $\log_{10} W_s(g)=-5.453 + 3.180 \times \log_{10}TL(mm)$(Murphy et al. 1991). Linear regression is used to examine the relationship of fish total length to relative weight. When appropriate, an ANOVA is used to test for differences between years in W_r and relative abundance values by length category. The level of significance for all statistical analyses is set at 0.10.

Angler surveys are conducted using established guidelines (Pollock et al. 1994), but specific details of the format will depend on the water body, questions and fishery they are meant to assess. Standard assessments will include the collection of angler effort and harvest and catch rate data as well as asking anglers specific management related questions.

Project Justification: New Hampshire's walleye populations are not highly utilized by the majority of anglers, only ranking 10th in 1995 and 11th in 2003 among the species fished for by anglers (Responsive Management 1996 and 2004). This low ranking among anglers is likely because current opportunities for walleye angling are limited (there are fishable populations in approximately one pond and two large rivers state-wide). A popular fishery for them does exist in sections of the Connecticut River during the spring, fall and winter. Because walleye populations are sustained through natural reproduction, their populations are geographically limited and they are popular with a segment of the state's anglers, periodic assessments and/or studies are necessary to determine the status of essential population parameters so that appropriate management measures can be modified or implemented when needed.

According to the 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation, the sample size of anglers that fished for walleye was too small to reliably report number of walleye anglers or days fished for walleye (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). Accordingly, the total expenditure by anglers fishing for walleye could not be calculated.

The Walleye Assessment is a strategy that assists the Department in achieving objectives 2.1, 3.1, 6.1, 11.3, and 16.1 within its Strategic Plan (1998-2010).

Project Costs: $4,075.00

Salary: (1) Biologist II	37.5 hours x $56.89/hr =	$2,133.00
(1) Biologist I	37.5 hours x $35.78/hr =	$1,342.00
(1) Laborer	37.5 hours x $10.67/hr =	$ 400.00
In-State Travel Cost:		$ 200.00
		$4,075.00

Project Priority Score: 27 points

Ecological Importance:	Moderate	3 points
Public Interest:	High	5 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	Moderate-High	4 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Coldwater Fisheries Program

Program Need:

Brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*) provide important recreational fisheries in New Hampshire as demonstrated by anglers ranking these species first, third, and fifth in fishing preferences (Responsive Management 2004). Additionally, during 2006, approximately 89,000 anglers fished 1.2 million days for trout in the State's freshwaters (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). These numbers decreased when compared to the 2001 survey, 121,000 anglers and 1.3 million days, respectively. The level of angler participation also declined from 55% of New Hampshire's freshwater anglers to 45% of anglers and the total percentage of days spent fishing remained the same at 44%. New Hampshire's anglers also seek a diversity of trout fishing experiences (Responsive Management 1996). Trout fishing experiences favored by anglers include: put-and-take trout fisheries that are sustained through stocking catchable-size trout, an approach that has overwhelming (85%) angler support; quality trout fisheries, which a majority (66%) of anglers support; and, natural occurring (wild) trout fisheries that are not sustained or supplemented with stocked fish, a management strategy supported by 73% of New Hampshire's anglers.

Program Goal:

To provide anglers with desired trout fishing experiences that result in high levels (≥50%) of satisfaction.

Approach:

To meet angler demands being placed on New Hampshire's trout fisheries approximately 1 million trout will be stocked annually into appropriate lakes, ponds, rivers and streams, with more than 75% of these waters receiving catchable-size fish. Ponds capable of supporting a put-grow-and take management strategy will receive smaller trout (~ 2 inch in length), which typically will be aerial stocked by helicopter. Selected waters will be identified and managed to provide quality or wild trout fisheries. Quality trout fisheries will offer angler's the opportunity to experience higher than average catch rates (>0.75 fish/hour) or larger than average size fish (>305 mm). Wild trout fisheries will be sustained by natural occurring populations whose biomass is ≥15 kg/ha.

Expected Results and Benefits:

Providing a diversity of trout fishing opportunities will assist in ensuring a large segment of New Hampshire's anglers desired fishing experiences are being met. Meeting these needs more effectively may also reverse the downward trend in angler satisfaction with trout fishing in New Hampshire (Responsive Management 2004, U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). When compared to the responses given to a similar question posed during a survey conducted in 1996 (Responsive Management 1996), the percent of anglers satisfied with their brook trout fishing fell from 72% to 58%; fishing satisfaction for rainbow trout declined from 75% to 62%; and for brown trout it dropped from 56% to 49%. Additionally, the economic impact of anglers fishing for trout in

New Hampshire is significant as these anglers generated $172.4 million in fishing-related expenditures during 2006 ((U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008).

Coldwater Fisheries Program Action Plans

Project Title: Cultured Trout Use and Assessment

Project Objective: To use cultured trout to sustain or supplement fisheries in suitable waters. Assessments on these waterbodies will continue to happen into the future to insure the best use of hatchery fish possible.

2012 Objectives: In 2012, assessments on Bow Lake will be initiated in order to evaluate current stocking targets and growth rates of the rainbow and brown trout that are stocked into it annually. Cohorts of fish supplemented have been marked and will continue to be for 2012. Waters will continue to be evaluated under the Fishing for the Future framework and changes to stocking will be made. In addition to the Fishing for the Future sites, evaluation of all trout lakes and ponds will continue in order to maximize the use of cultured trout in these waters. The water quality in some waterbodies has decreased due to changes in landscape or fishing pressure, negatively affecting the supplemented fish. The goal of the review is to identify waters where changes in either stocking or management will result in more angler opportunity and satisfaction.

PIT tags will continue to be utilized in Nash Stream through 2013.

Project Work Description: The New Hampshire Fish and Game Department's fish culture operations will produce approximately 460,000 (± 10%) pounds of trout and stock these fish into 614 waters annually (Table 1). Fifty-one percent (51%) of the total annual production will be stocked into 318 lakes and ponds and 49% will be released into 296 rivers and streams at prescribed rates. Waters identified as capable of supporting a put-grow-and-take trout management strategy will be stocked with fingerling-size trout, and the remaining waters will receive catchable-size trout for providing put-and-take fisheries.

Waters stocked with trout will be evaluated periodically using standardized sampling methodologies. These standardized methods will be based on the waterbody type. Remote ponds, those that are inaccessible by vehicle, will be assessed using an experimental-mesh gill net (38 m long; 2.4 m depth; five 7.6 m panels; 13, 19, 25, 32, 38 mm bar measure). The gill net set times will vary by catch rates. Stocked trout assessments in non-remote lakes and ponds will include sampling with New Hampshire style fyke nets, which consist of 1.1 x 1.3-m frames with two throats within the hoops, covered with 1.3-cm mesh (bar measure) netting, and/or gill nets consisting of multiple panels with variable mesh sizes. Trout population estimates will be determined using Schnabel and/or Shumacher methods (Ricker 1975). Assessments in rivers and streams will be performed using backpack or boat electrofishing gear, tagging, creel surveys or angling. Block seines will be used with backpack gear to enclose a 100-meter section of the stream and a multiple pass depletion method will be used for analytical purposes. Trout population estimates will be calculated using Microfish 3.0 (Van Deventer and Platts 1986). Creel surveys techniques described by Pollock et al. (1994) will be used to determine recreational catch statistics, fishing effort, and catch per unit as well as evaluate the success of management strategies. Boat electrofishing or angling will occur when the stream habitat is too large for the backpack gear. Tagging will be performed predominantly on rivers and streams to identify migration patterns and habitat preferences.

Research, involving various types of tags, has identified fish habitat preferences and migration patterns very effectively. This type of research has been performed in other New England states and habitat restoration projects have improved as a result. NHFGD personnel have utilized radio telemetry and Passive Integrated Transponder (PIT) tags to evaluate wild brook trout migration and habitat preferences and just recently tagged hatchery brook trout to assess their preferences. These two tags have been very effective at assessing both passage at potential fish barriers (i.e. culverts, falls) and tributary use in various watersheds. We plan to continue using tags to determine habitat preferences of both stocked and wild fish. The information gathered from this data will promote better resource management.

When determining migration patterns or habitat use, either PIT or radio telemetry tags will be implanted into the intraperitoneal cavity using sterile practices. PIT tagged fish will be anesthesized using clove oil and a small incision will be made on the underside of the fish slightly above the ventral fins. The tag is inserted and the fish will be released into a live well for recovery prior to being returned to the stream. Telemetry fish will be anesthetized using MS-222. A small (<2cm) incision will be made on the underside of the stomach (intraperitoneal cavity) for the radio transmitter. The tag will be inserted and the antenna of the transmitter will be fed from the inside out through a separate exit hole created by a one and a half inch, 16-gauge needle. The incision will be stitched using Ethicon© Monocryl Y923 absorbable sutures. The fish will be held in aerated recovery tubs until they resume a normal swim pattern. Tracking events will occur throughout the year by foot, boat, plane or snowmobile.

All captured trout will be measured for total length (mm), weighed (g) and sexed if necessary. Brook trout relative weight values ($W_r = W/W_s \times 100$) will be derived using the standard weight equation $\log_{10} W_s(g) = -5.085 + (3.043 \times \log_{10}$ total length (mm)), proposed by Whelan and Taylor (1984). The standard weight equation to be used for rainbow trout is $\log_{10} W_s (g) = -4.898 + (2.990 \times \log_{10}$ TL (mm)), proposed by D.G. Simpkins and W. A. Hubert, University of Wyoming, (unpublished) (Anderson and Murphy 1996). Mean relative weight values, and associated standard deviations ($\pm$SD), will be calculated for five size categories that were modified from those presented by Gablehouse (1984). These size categories are: less than stock (<160 mm TL), stock (160-289 mm TL), quality (290-359 mm TL), preferred (360-469 mm TL), and memorable (470-589 mm TL). Analysis will include determining if there are significant differences in mean W_r values among size categories and whether a significant linear relationship exists between W_r and length.

When determining growth parameters, strain performance, and survival and stock assessments, cohorts of cultured trout will be marked (typically by fin excision) prior to being released into waters under evaluation. If appropriate, scales will be removed from representative samples of various length groups for age and growth purposes.

Project Justification: Brook trout (*Salvelinus fontinalis*) are the most popular species among anglers in New Hampshire, while rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*), consistently rank in the top five species anglers prefer to fish for (Responsive Management 1996 and 2004). Since the capacity of New Hampshire's waters for natural production of trout is limited to an average of 10 pounds per acre, due to relatively infertile soil types that are unable to provide the necessary nutrients for higher production levels, the Department sustains or supplements these recreational trout fisheries by stocking cultured fish.

Use of this management strategy has overwhelming support (≥85%) from New Hampshire's anglers (Responsive Management 1996).

Cultured Trout Use and Assessment is a strategy that assists the Department in achieving objectives 2.1, 3.1, 11.1, and 11.3 within its Strategic Plan (1998-2010).

Project Costs: $2,433,232.00

Salary: (1) Biologist II	37.5 hours x $40.80/hr =	$	1,530.00
(1) Biologist I	37.5 hours x $52.32/hr =	$	1,962.00
(2) Laborer	75 hours x $10.67/hr =	$	800.00
(1) Supervisor VI	37.5 hours x $63.55/hr =	$	2,383.00
In-State Travel Cost:		$	400.00
Fish Culture Operations:		$	2,426,157.00
		$	2,433,232.00

Project Priority Score: 23 points

Ecological Importance:	Low	1 point
Public Interest:	High	5 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	Low-Moderate	2 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Table 1. New Hampshire waters sustained or supplemented with cultured trout.

Body of Water	Town	County
Abenaki Pond	Wolfeboro	Carroll
Academy Brook	Loudon	Merrimack
Airport Pond	Whitefield	Coos
Akers Pond	Errol	Coos
Ammonoosuc River	Bath,Bethlehem,Carroll,Lisbon,Littleton	Coos,Grafton
Ammonoosuc River, Upper	Berlin,Milan,Northumberland,Stark	Coos
Ammonoosuc River, Wild	Bath	Grafton
Amy Brook	Henniker	Merrimack
Andrews Brook	Newbury	Merrimack
Androscoggin River	Berlin,Cambridge,Dummer,Errol,Milan	Coos
Archery Pond	Allenstown	Merrimack
Armington Lake	Piermont	Grafton
Ashuelot River	Gilsum,Marlow,Surry,Swanzy,Winchester	Cheshire,Sullivan
Ashuelot River, South Branch	Swanzey	Cheshire
Atwood Pond	Sandwich	Carroll
Ayers Brook	Gilmanton	Belknap
Baboosic Brook	Merrimack	Hillsborough
Back Lake	Pittsburg	Coos
Bailey Brook	Nelson	Cheshire
Baker River	Rumney,Warren,Wentworth	Grafton
Baker River, South Branch	Dorchester	Grafton
Barbadoes Pond	Dover	Strafford
Basin Pond	Chatham	Carroll
Batchelder Pond	Hampton	Rockingham
Bear Brook	Allenstown	Merrimack
Bear Brook Kids Pond	Allenstown	Merrimack
Bear Brook Pond, Big	Errol	Coos
Bear Brook Pond, Little	Went. Location	Coos
Bearcamp River	Sandwich,Tamworth	Carroll
Beards Brook	Hillsborough	Hillsborough
Beaver Brook	Derry,Londonderry,Pelham,Windham	Rockingham
Beaver Brook	Alton	Belknap
Beaver Brook	Amherst	Hillsborough
Beaver Brook	Colebrook	Coos
Beaver Brook	Derry,Londonderry,Pelham,Windham	Rockingham,Hillsborough
Beaver Lake	Derry	Rockingham
Beaver Pond	Woodstock	Grafton
Beebe River	Campton,Sandwich	Carroll,Grafton
Beech Pond, Lower	Tuftonboro	Carroll

Beech River	Ossipee	Carroll
Belknap Recreation Area Pond	Gilford	Belknap
Bellamy River	Madbury	Strafford
Berry Brook	Rye	Rockingham
Bicknell Brook	Enfield	Grafton
Big Brook Bog	Pittsburg	Coos
Big Island Pond	Derry	Rockingham
Big River	Barnstead,Strafford	Belknap,Strafford
Bishop Brook	Stewartstown	Coos
Black Brook	Sanbornton	Belknap
Black Mountain Pond	Sandwich	Carroll
Black Pond	Lincoln	Grafton
Blackwater River	Andover,Salisbury,Webster	Merrimack
Blanchard Brook	Walpole	Cheshire
Blood Brook	Wilton	Hillsborough
Bloods Brook	Plainfield	Sullivan
Bog Brook	Whitefield	Coos
Bog Brook	Stratford	Coos
Boglie Brook	Peterborough	Hillsborough
Boundary Pond	Pittsburg	Coos
Bow Lake	Strafford	Strafford
Branch River	Milton,Wakefield	Carroll,Strafford
Briar Pond	Lempster	Sullivan
Brickyard Pond	Exeter	Rockingham
Brush Brook	Dublin	Cheshire
Burnham Brook	Canterbury	Merrimack
Butterfield Pond	Wilmot	Merrimack
Buzzells Run Brook	Strafford	Strafford
Caldwell Pond	Alstead	Cheshire
California Brook	Swanzey	Cheshire
Canaan Street Lake	Canaan	Grafton
Canobie Lake	Windham	Rockingham
Carlton Pond	Mont Vernon	Hillsborough
Carpenters Marsh	Hancock	Hillsborough
Carr Pond	Clarksville	Coos
Carter Ponds	Bean’s Purchase	Coos
Casalis Marsh	Peterborough	Hillsborough
Cascade Brook	Wilmot	Merrimack
Catamount Pond	Allenstown	Merrimack
Catesbane Brook	Chesterfield	Cheshire
Cedar Brook	Stewartstown	Coos
Cedar Pond	Milan	Coos
Center Pond	Nelson	Cheshire
Chandler Brook	Landaff	Grafton
Chandler Pond	Landaff	Grafton

Chapin Pond	Newport	Sullivan
Chapman Pond	Sullivan	Cheshire
Chase Brook	Litchfield	Rockingham
Cheesefactory Pond	Pittsburg	Coos
Chickwolnepy Stream	Milan	Coos
Chocorua Lake	Tamworth	Carroll
Chocorua River	Tamworth	Carroll
Christine Lake	Stark	Coos
Churchill Brook	Brookfield	Carroll
Clark Brook	Alexandria	Grafton
Clark Brook	Haverhill	Grafton
Clark Pond	Canaan	Grafton
Clarksville Pond	Clarksville	Coos
Clay Brook	Bridgewater	Grafton
Clay Brook	Lyme	Grafton
Clear Stream	Errol,Millsfield	Coos
Clough Pond	Loudon	Merrimack
Club Pond	New Durham	Strafford
Cocheco River	Dover,Farmington	Strafford
Cockermouth River	Groton,Hebron	Grafton
Coffin Brook	Alton	Belknap
Cohas Brook, Little	Londonderry	Rockingham
Cold River	Acworth,Alstead,Langdon,Walpole	Cheshire,Sullivan
Cold River	Sandwich	Carroll
Cold Spring Pond	Stoddard	Cheshire
Coldrain Pond	New Durham	Strafford
Cole Pond	Canaan	Grafton
Cole Pond	Enfield	Grafton
Connecticut Lake, First	Pittsburg	Coos
Connecticut Lake, Second	Pittsburg	Coos
Connecticut Lake, Third	Pittsburg	Coos
Connecticut River	Colebrook,Columbia,Dalton,Lancaster, Northumberland,Pittsburg,Walpole	Coos,Cheshire
Connor Pond	Ossipee	Carroll
Contoocook River	Bennington,Greenfield,Hancock,Henniker, Hillsborough,Jafferey,Peterborough	Cheshire, Hillsborough, Merrimack
Conway Lake	Eaton	Carroll
Coon Brook Bog	Pittsburg	Coos
Copps Brook	Tuftonboro	Carroll
Copps Pond	Tuftonboro	Carroll
County Farm Brook	Wilton	Hillsborough
Crawford Brook	Carroll	Coos
Crawford Notch Kids Pond	Hart's Location	Carroll
Crooked Run Brook	Barnstead	Belknap
Crystal Lake	Eaton	Carroll

Crystal Lake	Enfield	Grafton
Crystal Lake	Gilmanton	Belknap
Cummins Pond	Dorchester	Grafton
Curtis Brook	Lyndeborough	Hillsborough
Dan Hole Pond, Big	Ossipee	Carroll
Dan Hole Pond, Little	Ossipee	Carroll
Dan Hole River	Ossipee	Carroll
Danforth Brook	Bristol	Grafton
Davis Pond	Madison	Carroll
Deer Pond	New Boston	Hillsborough
Deering Reservoir	Deering	Hillsborough
Dells Pond	Littleton	Grafton
Diamond Pond, Big	Stewartstown	Coos
Diamond Pond, Little	Stewartstown	Coos
Dions Pond	Franklin	Merrimack
Dodge Brook	Lempster,Unity	Sullivan
Dolf Brook	Hopkinton	Merrimack
Dublin Lake	Dublin	Cheshire
Dudley Brook	Brentwood	Rockingham
Dummer Pond, Big	Dummer	Coos
Dummer Pond, Little	Dummer	Coos
Duncan Lake	Ossipee	Carroll
Durand Pond	Randolph	Coos
East Inlet	Pittsburg	Coos
East Kingston Pond	East Kingston	Rockingham
Eastman Brook	Grantham	Sullivan
Eastman Brook	Piermont	Grafton
Eastman Brook	Thornton	Grafton
Echo Lake	Franconia	Grafton
Ela River	New Durham	Strafford
Ellis River	Bartlett,Jackson,Pinkham's Grant	Carroll,Coos
Emerald Lake	Hillsborough	Hillsborough
Exeter Reservoir	Exeter	Rockingham
Exeter River	Brentwood,Chester,Exeter,Fremont,Sandown	Rockingham
Falls Pond	Albany	Carroll
Farrar Brook	Belmont	Belknap
Ferguson Brook	Hancock	Hillsborough
Ferrin Pond	Weare	Hillsborough
Firehouse Pond	Bow	Merrimack
Fish & Game Club Pond	Londonderry	Rockingham
Fish & Game Club Pond	Plaistow	Rockingham
Fish Pond	Columbia	Coos
Flat Mountain Pond	Waterville Valley	Grafton
Forest B Argue Pond	Pittsfield	Merrimack
Forest Brook	Madison	Carroll

Forest Lake	Winchester	Cheshire
Fowler River	Alexandria	Grafton
Fox Pond	Plymouth	Grafton
Francis Lake	Pittsburg	Coos
Franklin Pierce Lake	Hillsborough	Hillsborough
French Pond	Haverhill	Grafton
French Pond	Henniker	Merrimack
Gale River	Bethlehem,Franconia	Grafton
Garland Brook	Moultonboro	Carroll
Gilmore Pond	Jaffrey	Cheshire
Glassfactory Brook	Lyndeborough	Hillsborough
Glencliff Home Pond	Benton	Grafton
Goose Pond Brook	Canaan	Grafton
Gould Mill Brook	Brookline	Hillsborough
Gould Pond	Marlow	Cheshire
Granite Brook	Sullivan	Cheshire
Granite Lake	Stoddard	Cheshire
Grants Brook	Lyme	Grafton
Grave Brook	Springfield	Sullivan
Great Brook	Kensington	Rockingham
Great Brook	Langdon	Sullivan
Great Brook	Lebanon	Grafton
Great East Lake	Wakefield	Carroll
Greeley Pond, Upper	Livermore	Grafton
Greenfield Sports Club Pond	Greenfield	Hillsborough
Gridley River	Sharon	Hillsborough
Groveton Fish And Game Club	Northumberland	Coos
Guinea Brook	Gilmanton	Belknap
Guinea Pond	Sandwich	Carroll
Gunstock River	Gilford	Belknap
Gustin Pond	Marlow	Cheshire
Hackett Brook	Canterbury	Merrimack
Halfmile Pond	Enfield	Grafton
Hall Brook	Sandwich	Carroll
Hall Pond, Lower	Sandwich	Carroll
Hall Pond, Middle	Sandwich	Carroll
Hall Pond, Upper	Sandwich	Carroll
Halls Brook	Groton	Grafton
Hamm Branch River	Franconia	Grafton
Hancock Brook	Lincoln	Grafton
Harper Brook	New Hampton	Belknap
Harris Pond	Pittsburg	Coos
Hartford Brook	Deerfield	Rockingham
Harts Pond	Meredith	Belknap
Hatch Pond	Eaton	Carroll

Hayes Brook	Farmington,New Durham	Strafford
Hedgehog Pond	Salem	Rockingham
Hewes Brook	Lyme	Grafton
Higher Ground Pond	Wentworth	Grafton
Highland Lake	Andover	Merrimack
Hildreth Pond	Warren	Grafton
Hogback Pond	Greenfield	Hillsborough
Hood Pond	Derry	Rockingham
Hopkins Pond	Andover	Merrimack
Horace Lake	Weare	Hillsborough
Horn Pond	Wakefield	Carroll
Hosley Brook	Hancock	Hillsborough
Hothole Pond	Loudon	Merrimack
Hoyt Brook	Grafton	Grafton
Hoyt Pond	Madbury	Strafford
Hubbard Brook	Chesterfield	Cheshire
Hunkins Pond	Sanbornton	Belknap
Hunts Pond	Hancock	Hillsborough
Hurd Brook	Alton	Belknap
Hutchins Mill Pond	Effingham	Carroll
Ice Pond	New Boston	Hillsborough
Indian River	Canaan	Grafton
Indian Stream	Pittsburg	Coos
Iona Lake	Albany	Carroll
Isinglass River	Barrington,Strafford	Strafford
Island Pond	Washington	Sullivan
Israel River	Jefferson, Lancaster	Coos
Israel River, South Branch	Jefferson	Coos
Jackman Brook	Woodstock	Grafton
Jacobs Brook	Orford	Grafton
Jacquith Brook	Harrisville	Cheshire
Joe Coffin Pond	Sugar Hill	Grafton
Joe English Brook	Amherst	Hillsborough
Jones Brook	Middleton, Milton	Strafford
Judd Pond	Clarksville	Coos
Karamikas Pond	Goffstown	Hillsborough
Kelly Brook	Pittsfield	Merrimack
Kezar Lake	Sutton	Merrimack
Kiah Pond	Sandwich	Carroll
Kids Pond	Errol	Coos
Kids Pond	Gilmanton	Belknap
Kids Pond	Jackson	Carroll
Kids Pond	Jefferson	Coos
Kids Pond	Sandwich	Carroll
Kids Pond	Stark	Coos

Kimball Pond, Lower	Chatham	Carroll
Kimpton Brook	Wilmot	Merrimack
Knox Mountain Brook	Sanbornton	Belknap
Knox River	Enfield	Grafton
Kolelemook Lake	Springfield	Sullivan
Lafayette Brook	Franconia	Grafton
Lamprey River	Deerfield,Durham,Epping,Lee, Northwood,Raymond	Rockingham,Strafford
Lane River	Sutton	Merrimack
Laurel Lake	Fitzwilliam	Cheshire
Ledge Pond	Madison	Carroll
Lime Pond	Columbia	Coos
Little Bog Pond	Odell	Coos
Little Pond	Sandwich	Carroll
Little River	Barnstead	Belknap
Little River	Lee,Nottingham	Rockingham,Strafford
Little River	Exeter	Rockingham
Little River	North Hampton	Rockingham
Lonesome Lake	Lincoln	Grafton
Long Pond	Benton	Grafton
Long Pond	Croydon	Sullivan
Long Pond	Eaton	Carroll
Long Pond	Errol	Coos
Long Pond	Lempster	Sullivan
Long Pond	Millsfield	Coos
Loon Lake	Freedom	Carroll
Lost River	Woodstock	Grafton
Lougee Pond	Barnstead	Belknap
Lovejoy Brook	Enfield	Grafton
Lovell Lake	Wakefield	Carroll
Lucas Pond	Northwood	Rockingham
Lyman Brook	Columbia	Coos
Mad River	Farmington	Strafford
Mad River	Campton,Thornton,Waterville Valley	Grafton
Magoon Brook	New Hampton	Belknap
Mallego Brook	Barrington	Strafford
Manning Lake	Gilmanton	Belknap
Marshall Brook	Hanover	Grafton
Martin Brook	Richmond	Cheshire
Martin Meadow Pond	Lancaster	Coos
Mascoma Lake	Enfield	Grafton
Mascoma River	Canaan,Enfield,Lebanon	Grafton
Mason Brook	Mason	Hillsborough
Massabesic Lake	Auburn	Rockingham
Meadow Pond	Northwood	Rockingham
Melvin River	Tuftonboro	Carroll

Merrill Park Pond	Concord	Merrimack
Merrimack River	Boscawen,Concord,Franklin,Manchester	Hillsborough,Merrimack
Merrymeeting Lake	New Durham	Strafford
Middle Pond	Pittsburg	Coos
Mill Brook	Cornish	Grafton
Mill Brook	Grafton	Grafton
Mill Brook	Jefferson	Coos
Mill Brook	Westmoreland	Cheshire
Mill Pond	Ossipee	Carroll
Millen Lake	Washington	Sullivan
Millers River	Rindge	Cheshire
Millsfield Pond, Big	Millsfield	Coos
Milton Watershed	Milton	Strafford
Mink Brook	Hanover	Grafton
Mirey Brook	Winchester	Cheshire
Mirror Lake	Canaan	Grafton
Mirror Lake	Whitefield	Coos
Mirror Lake	Woodstock	Grafton
Mohawk River	Colebrook	Coos
Mohawk River	Strafford	Strafford
Mohawk River, East Branch	Colebrook	Coos
Monfeltrag Brook	Grafton	Grafton
Moore Reservoir	Littleton	Grafton
Moose Brook	Gorham	Coos
Moose Brook	Hancock	Hillsborough
Moose Falls Flowage	Pittsburg	Coos
Moose Pond	Millsfield	Coos
Moose Pond	Pittsburg	Coos
Moose River	Randolph, Gorham	Coos
Morey Pond	Andover	Merrimack
Mountain Pond	Brookfield	Carroll
Mountain Pond	Chatham	Carroll
Mt Williams Pond	Weare	Hillsborough
Mud Pond	Easton	Grafton
Munn Pond	Errol	Coos
Nash Stream	Stratford	Coos
Nathan Pond	Dixville	Coos
Needleshop Brook	Hill	Merrimack
Nelson Brook	Gilmanton	Belknap
Nesenkeag Brook	Litchfield	Hillsborough
Newell Pond	Alstead	Cheshire
Newfound Lake	Bristol	Grafton
Newfound River	Bristol	Grafton
Nighthawk Hollow Brook	Gilmanton	Belknap
Nineteen Mile Brook	Tuftonboro	Carroll

Nippo Brook	Barrington	Strafford
Nissitissit River	Brookline	Hillsborough
North Branch River	Antrim	Hillsborough
North Pond	Langdon	Sullivan
North River	Nottingham, Lee	Rockingham, Strafford
Nubanusit Lake	Hancock	Cheshire
Nubanusit Brook	Harrisville	Cheshire
Number Seven Brook	Orange	Grafton
Ogontz Lake	Lyman	Grafton
Oliverian Pond	Benton	Grafton
Oliverian Stream	Benton	Grafton
Opechee Lake	Laconia	Belknap
Orange Pond	Orange	Grafton
Osgood Brook	Milford	Hillsborough
Ossipee Lake	Freedom	Carroll
Otter Brook	Keene,Sullivan	Cheshire
Otter Brook	Greenfield,Peterborough	Hillsborough
Owl Brook	Ashland	Grafton
Oyster River	Lee	Strafford
Partridge Brook	Westmoreland	Cheshire
Pawtuckaway River	Nottingham	Rockingham
Pea Porridge Pond, Big	Madison	Carroll
Pea Porridge Pond, Middle	Madison	Carroll
Peabody River	Gorham,Green's Grant,Martin's Location,Pinkham's Grant	Coos
Peaked Hill Pond	Thornton	Grafton
Pearl Lake	Lisbon	Grafton
Pemigewasset River	Bristol,Campton,Franklin,Lincoln, Thornton,Woodstock	Multiple
Pemigewasset River, East Branch	Lincoln	Grafton
Perch Pond	Campton	Grafton
Perch Pond	Lisbon	Grafton
Perkins Pond	Weare	Hillsborough
Perry Brook	Swanzey	Cheshire
Perry Pond, Lower	Pittsburg	Coos
Perry Stream	Pittsburg	Coos
Pettyboro Brook	Bath	Grafton
Phillips Brook	Stark	Coos
Pickard Brook	Canterbury	Merrimack
Pike Brook	Brookfield	Carroll
Pike Pond	Stark	Coos
Pine River	Ossipee	Carroll
Piscassic River	Fremont,Newfields,Newmarket	Rockingham
Piscataquog River	Goffstown	Hillsborough
Piscataquog River, Middle Branch	New Boston	Hillsborough

Piscataquog River, South Branch	New Boston	Hillsborough
Piscataquog River, West Branch	Weare	Hillsborough
Pleasant Lake	Deerfield	Rockingham
Pleasant Lake	New London	Merrimack
Pond Brook	Millsfield	Coos
Pond Brook	Sandwich	Carroll
Pond Brook	Wentworth	Grafton
Pond of Safety	Randolph	Coos
Poorfarm Brook	Gilford	Belknap
Pope Dam	Tuftonboro	Carroll
Post Office Brook	Alton	Belknap
Post Pond	Lyme	Grafton
Pout Pond	Belmont	Belknap
Priscilla Brook	Jefferson	Coos
Profile Lake	Franconia	Grafton
Province Pond	Chatham	Carroll
Punch Brook	Franklin, Salisbury	Merrimack
Purgatory Brook	Milford	Hillsborough
Purity Lake	Eaton	Carroll
Rand Brook	Francestown	Hillsborough
Rand Pond	Goshen	Sullivan
Remick Farm Pond	Tamworth	Carroll
Roaring Brook	Richmond	Cheshire
Robartwood Pond	Campton	Grafton
Robie Pond	New Boston	Hillsborough
Rocky Pond	Wentworth	Grafton
Round Pond	Errol	Coos
Round Pond	Pittsburg	Coos
Rum Brook	Canterbury	Merrimack
Russell Pond	Woodstock	Grafton
Saco Lake	Carroll	Coos
Saco River	Bartlett,Conway,Hart’s Location,	Carroll
Saco River, East Branch	Bartlett,Jackson	Carroll
Salmon Falls River	Wakefield	Carroll
Salmon Hole Brook	Lisbon	Grafton
Salmon Brook	Sanbornton	Belknap
Saltmarsh Pond	Gilford	Belknap
Sanborn Brook	Chichester	Merrimack
Sand Dam	Troy	Cheshire
Sand Pond	Marlow	Cheshire
Sawyer Pond	Livermore	Grafton
Sawyer Pond, Little	Livermore	Grafton
Scotts Bog	Pittsburg	Coos
Sessions Pond	Dummer	Coos

Shaker Brook	Troy	Cheshire
Shannon Brook	Moultonboro	Carroll
Shawtown Pond	Freedom	Carroll
Shed Brook	Hillsborough	Hillsborough
Sheehan Flowage	Clarksville	Coos
Shop Pond	Hampstead	Rockingham
Signal Pond	Errol	Coos
Silver Lake	Harrisville	Cheshire
Silver Lake	Madison	Carroll
Simmons Pond	Warner	Merrimack
Simms Stream	Columbia	Coos
Skinner Brook	Grantham	Sullivan
Sky Pond	New Hampton	Belknap
Slippery Brook	Chatham	Carroll
Smith Brook	Grafton	Grafton
Smith Pond	Washington	Sullivan
Smith River	Alexandria,Bristol,Danbury,Grafton	Grafton,Merrimack
Smith River	Wolfeboro	Carroll
Soil Conservation Pond	Wentworth	Grafton
Solitude Lake	Newbury	Merrimack
Soucook River	Loudon,Pembroke	Merrimack
Souhegan River	Amherst,Greenville,Merrimack,Milford New Ipswich,Wilton	Hillsborough
South Pond	Stark	Coos
South River	Effingham	Carroll
Spaulding Brook	Brookline	Hillsborough
Spectacle Pond	Groton	Grafton
Speedway Pond	Canterbury	Merrimack
Spickett River	Salem	Rockingham
Spofford Lake	Chesterfield	Cheshire
Spoonwood Lake	Nelson	Cheshire
Squam Lake, Big	Sandwich	Carroll
Squam Lake, Little	Holderness	Grafton
Squam River	Ashland	Grafton
Stanley Brook	Dublin	Cheshire
Stearns Brook	Milan	Coos
Stevens Brook	Sutton,Warner	Merrimack
Stinson Brook	Rumney	Grafton
Stinson Lake	Rumney	Grafton
Stirrup Iron Brook	Boscawen	Merrimack
Stirrup Iron Pond	Salisbury	Merrimack
Stocker Brook	Grantham	Sullivan
Stone Pond	Marlborough	Cheshire
Stonehouse Pond	Barrington	Strafford
Stoney Brook	Lyndeboro,Wilton	Hillsborough
Storey Brook	Lebanon	Grafton

Stratford Bog	Stratford	Coos
Streeter Pond	Sugar Hill	Grafton
Stub Hill Pond	Pittsburg	Coos
Success Pond	Success	Coos
Sucker Brook	Andover,Franklin	Merrimack
Sugar River	Croydon,Newport,Sunapee	Sullivan
Sugar River, Little	Unity	Sullivan
Sugar River, North Branch	Croydon,Grantham	Sullivan
Sugar River, South Branch	Goshen,Lempster,Newport	Sullivan
Sunapee Lake	New London,Newbury,Sunapee	Merrimack,Sullivan
Sunapee Lake, Little	New London	Merrimack
Suncook Lake	Barnstead	Belknap
Suncook River	Barnstead,Chichester,Epsom, Gilmanton,Pembroke,Pittsfield	Belknap,Merrimack
Suncook River, Little	Epsom	Merrimack
Swain Pond	Wentworth	Grafton
Swanzey Lake	Swanzey	Cheshire
Sweat Pond	Errol	Coos
Swift River	Albany,Conway,Livermore	Carroll
Swift River	Tamworth	Carroll
Tannery Brook	Boscawen	Merrimack
Tannery Brook	Wilmot	Merrimack
Tarleton Lake	Piermont,Warren	Grafton
Tates Brook	Hudson	Hillsborough
Tates Brook	Somersworth	Strafford
Taylor River	Hampton	Rockingham
Temple Brook	Temple	Hillsborough
Terrill Pond	Pittsburg	Coos
Tewksbury Pond	Grafton	Grafton
Third Lake Pond	Pittsburg	Coos
Thorne Pond	Bartlett	Carroll
Three Pond, Lower	Ellsworth	Grafton
Three Pond, Middle	Warren	Grafton
Three Pond, Upper	Warren	Grafton
Tower Hill Pond	Candia	Rockingham
Town Line Brook	Peterborough	Hillsborough
Trinith Pond	Atkinson	Rockingham
Trio Pond, Lower	Odell	Coos
Trio Pond, Upper	Odell	Coos
Trout Brook	Lyme	Grafton
Trout Pond	Freedom	Carroll
Trout Pond	Lyme	Grafton
Tucker Brook	Milford	Hillsborough
Tulley Brook	Richmond	Cheshire
Tunis Brook	Hanover	Grafton

Tunnell Brook	Benton	Grafton
Unknown Pond	Pittsburg	Coos
Village Pond	Washington	Sullivan
Wachipauka Pond	Warren	Grafton
Walker Brook	Danbury	Merrimack
Wallace Brook	Brookline	Hillsborough
Warner River	Warner	Merrimack
Warren Lake	Alstead	Cheshire
Wason Pond	Chester	Rockingham
Watson Brook	Alton	Belknap
Watts Brook	Londonderry	Rockingham
Waukeena Lake	Danbury	Merrimack
Waukewan Lake	Meredith	Belknap
Webster Lake	Franklin	Merrimack
Weeks Crossing Pond	Warren	Grafton
Wentworth Lake	Wolfeboro	Carroll
Whitcher Brook	Belmont,Northfield	Belknap,Merrimack
Whitcomb Pond	Odell	Coos
White Lake	Tamworth	Carroll
White Pond	Ossipee	Carroll
White Pond	Wilmot	Merrimack
Whiteface River	Sandwich	Carroll
Whittemore Brook	Bridgewater	Grafton
Whittemore Lake	Bennington	Hillsborough
Whitten Pond	Tuftonboro	Carroll
Wild River	Bean's Purchase	Coos
Wildcat River	Jackson	Carroll
Wiley Brook	Wolfeboro	Carroll
Willand Pond	Somersworth	Strafford
Willard Pond	Antrim	Hillsborough
Willard Pond Brook	Hancock	Hillsborough
Willow Brook	Warner	Merrimack
Winkley Brook	Hampton Falls,Seabrook	Rockingham
Winnepocket Lake	Webster	Merrimack
Winnicut River	Greenland,Stratham	Rockingham
Winnipesaukee Lake	Gilford,Moultonboro,Wolfeboro	Belknap, Carroll
Winnipesaukee River	Franklin,Northfield,Tilton	Belknap,Merrimack
Winnisquam Lake	Laconia	Belknap
Winona Lake	Center Harbor	Belknap
Wright Pond	Pittsburg	Coos
Yorks Brook	East Kingston	Rockingham
Zealand River	Bethlehem	Grafton

<u>Project Title</u>: Quality Brook Trout Assessment

<u>Project Objective</u>: To manage waters for quality trout fishing opportunities that provides anglers with higher than average catch rates (>0.75 trout/hour) and/or larger than average trout (≥ 305 mm in total length). A minimum of one waterbody a year will be assessed for quality trout management throughout the state.

2012 Objectives: We will continue to assess Lime Pond in Columbia, lower Trio Pond and Whitcomb Pond both located in Odell. Upper Hall Pond (Sandwich) will also be assessed. This waterbody may be assessed more than once to determine holdover survival in the spring prior to stocking and growth in the fall. Profile Lake will also be assessed this spring prior to stocking to determine its holdover capacity.

<u>Project Work Description</u>: Assessment objectives will be to: 1) Determine the size structure of the brook trout population; 2) Evaluate brook trout condition using relative weight (W_r) values; and, 3) Assess the growth rate of brook trout.

Waters managed for the quality fishing experience will be evaluated periodically using standardized sampling methodologies. These standardized methods will be based on the waterbody type and will occur after the close of the fishing season (October 15). Remote Ponds, those that are inaccessible by vehicle, will be assessed using an experimental-mesh gill net (38 m long; 2.4 m depth; five 7.6 m panels; 13, 19, 25, 32, 38 mm bar measure). The gill net set times will vary by catch rates. Stocked trout assessments in non-remote lakes and ponds will include sampling with New Hampshire style fyke nets, which consist of 1.1 x 1.3-m frames with two throats within the hoops, covered with 1.3-cm mesh (bar measure) netting, and/or gill nets consisting of multiple panels with variable mesh sizes. Trout population estimates will be determined using Schnabel and/or Shumacher methods (Ricker 1975). Assessments in rivers and streams will be performed using either backpack or boat electrofishing gear, tagging, creel surveys or angling. Block seines will be used with backpack gear to enclose a 100-meter section of the stream and a multiple pass depletion method will be used for analytical purposes. Trout population estimates will be calculated using Microfish 3.0 (Van Deventer and Platts 1986). Creel surveys techniques described by Pollock et al. (1994) will be used to determine recreational catch statistics, fishing effort, and catch per unit as well as evaluate the success of management strategies. Boat electrofishing or angling will occur when the stream habitat is too large for the backpack gear. Tagging will be performed predominantly on rivers and streams to identify migration patterns and habitat preferences. This information will be used to determine what the most utilized habitats are and if habitat improvement projects to the stream as a whole are necessary to improve the trout population.

Research, involving various types of tags, has identified fish habitat preferences and migration patterns very effectively. This type of research has been performed in other New England states and habitat restoration projects have improved as a result. NHFGD personnel have utilized radio telemetry and Passive Integrated Transponder (PIT) tags to evaluate wild brook trout migration and habitat preferences and just recently tagged hatchery brook trout to assess their preferences. These two tags have been very effective at assessing both passage at potential fish barriers (i.e. culverts, falls) and tributary use in various watersheds. We plan to continue using tags to determine habitat preferences of both stocked and wild fish. The information gathered from this data will promote better resource management.

When determining migration patterns or habitat use, either PIT or radio telemetry tags will be implanted into the intraperitoneal cavity using sterile practices. PIT tagged fish will be anesthetized using clove oil and a small incision will be made on the underside of the fish slightly above the ventral fins. The tag is inserted and the fish will be released into a live well for recovery prior to being returned to the stream. Telemetry fish will be anesthetized using MS-222. A small (<2cm) incision will be made on the underside of the stomach (intraperitoneal cavity) for the radio transmitter. The tag will be inserted and the antenna of the transmitter will be fed from the inside out through a separate exit hole created by a one and a half inch, appropriately sized gauge needle. The larger the width of the antenna the smaller the gauge needs to be. The incision will be stitched using Ethicon© Monocryl Y923 absorbable sutures. The fish will be held in aerated recovery tubs until they resume a normal swim pattern. Tracking events will occur throughout the year by foot, boat, plane or snowmobile.

All captured trout will be measured for total length (mm), weighed (g) and sexed if necessary. Brook trout relative weight values ($W_r = W/W_s \times 100$) will be derived using the standard weight equation $\log_{10} W_s(g) = -5.085 + (3.043 \times \log_{10}$ total length (mm)), proposed by Whelan and Taylor (1984). The standard weight equation to be used for rainbow trout is $\log_{10} W_s (g) = -4.898 + (2.990 \times \log_{10}$ TL (mm)), proposed by D.G. Simpkins and W. A. Hubert, University of Wyoming, (unpublished) (Anderson and Murphy 1996). Mean relative weight values, and associated standard deviations ($\pm$SD), will be calculated for five size categories that were modified from those presented by Gablehouse (1984). These size categories are: less than stock (<160 mm TL), stock (160-289 mm TL), quality (290-359 mm TL), preferred (360-469 mm TL), and memorable (470-589 mm TL). Analysis of variance (ANOVA) will be used to detect significant differences ($P \leq 0.05$) for size category mean relative weight values within and among waters. When ANOVA results detect significant differences, then Tukey's Honestly Significant Difference (HSD) Multiple Comparisons will be used to identify where the significant differences ($P \leq 0.05$) occur. When significant differences are found for mean relative weight values among the size categories, within the waterbody, a regression analysis will be used to detect whether a significant linear relationship exists between brook trout length and relative weight.

When determining growth parameters, strain performance, and survival and stock assessments, cohorts of cultured trout will be marked (typically by fin excision) prior to being released into waters under evaluation. If appropriate, scales will be removed from representative samples of various length groups for age and growth purposes.

When no fin clip exists, scales will be taken from representatives of various length groups for aging purposes. Population abundance estimates will be made using Schumacher and Schnabel methods described in Ricker (1975).

Once established, quality trout fisheries will be evaluated periodically to determine if sufficient trout densities and or size structures are being maintained and angler surveys will be performed to determine what level of satisfaction the fisheries are providing to the recreational anglers.

<u>Project Justification</u>: Brook trout (*Salvelinus fontinalis*) are the most popular species angled in New Hampshire (61%), followed by rainbow trout (*Oncorhynchus mykiss*) (44%) and brown trout (*Salmo trutta*), which ranked fifth (25%) in species sought by anglers (Responsive

Management 1996). In addition, a majority (66%) of anglers moderately to strongly support managing selected waters for trophy trout fishing opportunities through the use of special regulations such as catch and release (83%), special length limits (79%), gear restrictions (57%), and reduced daily bag limits (54%).

During 2006, approximately 89,000 anglers fished 1.2 million days for trout in New Hampshire's freshwaters (U.S. Department of Interior and U.S. Department of Commerce 2008). This level of angler participation ranked second only to black bass (105,000 anglers, 1.3 million days) among all types of fish angled for and represents 45% of New Hampshire's freshwater anglers and 44% of the total days of fishing. Responsive Management did a follow-up survey that indicated brook trout were still the most sought after species (2003). Establishing quality trout management areas will provide recreational fishing opportunities to a significant segment of New Hampshire's anglers who fish for trout. Currently, 27 waters (11 ponds and 18 streams) are being managed to provide quality brook trout fisheries (Table 2).

Quality Brook Trout Assessment is a strategy that assists the Department in achieving objectives 2.1, 3.1, 11.1, and 11.3 within its Strategic Plan (1998-2010).

Project Costs: $16,831.00

Salary: (2) Biologist II	150 hours x $49.36/hr =	$7,404.00
(2) Biologist I	150 hours x $51.51/hr =	$7,727.00
(1) Laborer	75 hours x $10.67/hr =	$ 800.00
In-State Travel Cost:		$ 900.00
		$16,831.00

Project Priority Score: 27 points

Ecological Importance:	Moderate	3 points
Public Interest:	High	5 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	Moderate-High	4 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Table 2. Waters managed to provide quality trout fisheries.

Name of the Water	**Location**
Archery Pond	Allenstown
Cole Pond	Enfield
Dublin Lake (Monadnock Pond)	Dublin

Hall Pond, Upper	Sandwich
Lime Pond	Columbia
Mountain Pond	Brookfield
Profile Lake	Franconia
Shaw Pond (Shawtown Pond)	Freedom
Sky Pond	New Hampton
Spofford Lake	Chesterfield
Waukewan Lake (Measley Pond)	Meredith/New Hampton
Winona Lake	Center Harbor/Meredith/New Hampton
Androscoggin River	From the Errol dam to the markers at Bragg Bay and from the Saw Mill Dam to NH/Me boundary.
Ashuelot River, South Branch	From the Iron Bridge, in East Swanzey to the Farrar Pond dam in Troy.
Cocheco River	From the Watson Road dam downstream to the head of tide.
Connecticut River	From the dam at 2nd Connecticut Lake to the upstream side of the logging bridge on Magalloway Road. From the Magalloway Road bridge to the inlet at Green Point on 1st Connecticut Lake. From 1st Connecticut Lake dam to the signs on Lake Francis. From a point 1,600 feet upstream from the bridge in North Stratford upstream to a point 250 feet below the Lyman Falls Dam in North Stratford. From the Samuel Moore Dam downstream to the Route 18 bridge.
Contoocook River	From a point 2,500 feet above the former paper mill dam in West Henniker, marked by signs and wire, upstream approximately one mile to a point marked by signs and wire.
Ellis River	From the covered bridge in Jackson to the Iron Bridge in Glen.
Isinglass River	From the Rte. 125 bridge downstream to the confluence of the Cocheco River
Lamprey River	From Wiswall dam to the first railroad trestle downstream of Packers Falls.
Mascoma River	From the Rte. 4 bridge south of the Mascoma Lake dam downstream to the covered bridge.
Merrymeeting River	From lower dam at Alton to Route 11 bridge at Alton Bay
Newfound River	The area from West Shore Road to the dam adjacent to Crescent Street in Bristol.
Pemigewasset River	From the posts 150’ below the Eastman Falls dam in Franklin to the Rte. 3 & 11 bridge in Franklin.
Perry Stream	From the Happy Corner bridge to the Connecticut River.
Piscataquog River, South Branch	From a point 300 feet upstream of the Lyndeboro Road bridge downstream to the Rte. 13 bridge in New Boston.
Saco River	From a point at Lucy Brook marked by a sign, downstream to a similar sign at the confluence with Mill Brook.
Souhegan River	From a point 300 feet upstream of the green bridge on Old Wilton Road in Greenville to a point 300 feet downstream of

	the Route 31 bridge in Wilton.
Sugar River	From the Kellyville bridge to the so-called Oak Street bridge.
Swift River	From the Rte. 113A bridge downstream to the Rte. 113 bridge.

Project Title: Wild Brook Trout Assessment

Project Objectives: To identify areas where natural reproduction of brook trout occurs and whether that area supports wild trout populations at densities ≥15 kg/ha (13 lbs/acre).

2012 Objective: PIT tags will continue to be utilized in Nash Stream through 2013. Research will continue on wild brook trout in the Diamond watershed in 2012. The Diamond watershed study is part of a long-term assessment on how wild brook trout move in an unfragmented system and what their seasonal habitat preferences are Various grant opportunities are being pursued for this purpose. A partnership between NH Fish and Game, Dartmouth College and the US Fish and Wildlife Service has resulted in one of Dartmouth's seniors performing genetic analysis on scales taken from fish within the Diamond watershed. Eastern Brook Trout Joint Venture assessments will continue throughout the summer using NH Fish and Game staff. The lower Warner River will be an area of focus this year.

Project Work Description: Statewide conservation strategies have been developed and will be used as a guide to improve the overall sustainability of brook trout in New Hampshire. These strategies include a multitude of facets including: population estimates, habitat assessments and restoration, public outreach and partnerships.

Streams will be identified and determined suitable for wild trout presence through the use of a standardized assessment protocol originating from a compilation of data from various entities. These entities include, but are not limited to, the Eastern Brook Trout Joint Venture Predictive Model (Hudy, 2006), WAP and various GIS layers (i.e. aerial photography, catchment, impervious surfaces, forest cover, water quality, brook trout presence) acquired from different agencies (i.e. USGS, USFS, DES) and conservation groups (i.e. TNC, SPNHF, NRCS). This protocol will help determine where brook trout presence should occur so NHFGD personnel can maximize their time in identifying waters for wild trout management. Water temperature data will also be collected in areas within the watershed where no data exists, as well as critical habitat.

Once brook trout presence is confirmed a more intensive assessment will occur in the watershed to estimate wild trout population abundance and determining current recreational uses. Fish population sampling is conducted using backpack electrofishing gear. Block seines are used to enclose a 100-meter section of the stream. This becomes an index site for the stream and will be shocked a minimum of two consecutive years. A multiple pass depletion method is used for analytical purposes. All trout are measured for total length (mm) and weight (g). Non-salmonids are identified and separated, a sub-sample of 25 are measured and weighed individually, and the remainder of each species is counted and weighed in aggregate. Population estimates are derived using a maximum likelihood estimation technique developed by Carle and Strub (1978) and the computer software program *Remove,* originally written by Wentworth (2003). Biomass estimates are calculated as the product of the population estimate times the mean weight of trout sampled.

Candidate water's wild trout productivity will be ranked according to the categories developed by Sprankle (1996). They are as follows:

High productivity	≥ 35 kg/ha

Moderate productivity	≥ 15 kg/ha
Low productivity	< 15 kg/ha

We will be pursuing various grant opportunities in order to hire additional personnel to utilize this technique statewide. Once established as a wild trout management area, waters will have more restrictive regulations to protect the wild trout population. Evaluations will be performed periodically to determine if sufficient wild trout densities (≥ 15 kg/ha) are being maintained and angler surveys will be performed to determine whether the wild trout fisheries are providing increased satisfaction to recreational anglers.

New Hampshire has been doing genetic research for over eight years. Unfortunately, some of the projects did not break down the population structure using microsatellite DNA and were not able to differentiate among strains. Tim King, USGS, and Meredith Bartron, USFWS, have both analyzed samples from New Hampshire and determined strain status using microsatellite DNA, which can differentiate among strains. We will continue working with them as funding permits and the strains of NH's brook trout are identified. Fin clips will be made during population assessments and put into individual vials of alcohol for later analysis. The vials will be coded and samples will be sent for analysis as funding becomes available. New this year, we catalogued all of our scale samples taken in the Diamond watershed. Those scales will be aged and then processed for genetic analysis by Dartmouth College students. The students will be taught the aging process by NH Fish and Game and the genetic analysis by the Fish and Wildlife Service.

Research, involving various types of tags, has identified habitat preferences by fish very effectively. This type of research has been performed in other New England states and habitat restoration projects have improved as a result. NHFGD personnel have utilized radio telemetry to evaluate wild brook trout migration and habitat preferences in both the Dead Diamond and Nash Stream Watersheds. Passive Integrated Transponder (PIT) tags have also been utilized to assess both passage at potential fish barriers (i.e. culverts, falls) and tributary use in Nash Stream Watershed. These two tags have been very effective

<u>Project Justification</u>: Naturally reproducing brook trout (*Salvelinus fontinalis*) populations (wild brook trout) may be found in many brooks throughout New Hampshire. The factors that determine the establishment of a population include meeting physical, chemical and biological requirements of all phases of the species life history. Water temperature is considered one of the most important limiting factors for brook trout as they can only tolerate short periods of time in water > 22°C. Wild brook trout are often considered an indicator species for determining the health of an ecosystem. In New Hampshire's headwater systems they may rarely exceed a lifespan of 4 years, or attain lengths over 6-7 inches (152-178 mm).

Brook trout populations are on the decline throughout their entire east coast range. Road sediment, non-native species, and acid rain are the top three threats to their survival in New Hampshire. Two of these major threats have and continue to cause severe changes in brook trout habitat that they cannot withstand. In 1996, the New Hampshire Fish and Game Department conducted an angler survey that showed 73% of resident anglers and 79% of non-resident anglers supported managing selected waters for wild trout (Responsive Management 1996). This level of angler support has led to more intensive efforts to assess wild trout waters. Currently, 20 waters are designated as wild trout waters (3 ponds and 17 streams) (Table 3).

Wild Brook Trout Assessment is a strategy that assists the Department in achieving objectives 2.1, 3.1, 11.1, and 11.3 within its Strategic Plan (1998-2010).

Project Costs: $72,417.00

Salary: (2) Biologist II	400 hours x $46.88/hr =	$18,752.00
(2) Biologist I	300 hours x $44.18/hr =	$13,254.00
(6) Laborer	3375 hours x $10.67/hr =	$36,011.00
In-State Travel Cost:		$ 4,400.00
		$72,417.00

Project Priority Score: 30 points

Ecological Importance:	High	5 points
Public Interest:	High	5 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	High	5 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Table 3. Waters managed with regulations to provide wild trout fisheries.

Waterbody	Location
Alder Brook	Second College Grant
Androscoggin River	Berlin/Gorham/Shelburne
Carroll Stream	Carroll/Whitefield
Connecticut River	Pittsburg –Second Connecticut Lake to bridge on logging road above First Connecticut Lake
Connecticut River	Stratford
Diamond River	Second College Grant
Ethan Pond (Willey Pond)	Bethlehem
Flint’s Brook	Hollis
Greenough Pond, Little	Wentworth Location
Gulf Brook	Chesterfield
Lamb Valley Brook	Second College Grant
Long Mountain Brook	Stratford/Odell
Loomis Valley Brook	Second College Grant
Lyman Brook	Columbia
Meadow Brook	Sharon
West Branch Mohawk River	Colebrook
Pond Brook	Stratford/Odell
Sand Brook	Hillsborough
Shoal Pond	Lincoln
Witches Spring Brook	Hollis

Large Lakes Fisheries Program

<u>Program Need</u>:

Lake trout (*Salvelinus namaycush*) and landlocked salmon (*Salmo salar*) provide highly sought recreational fisheries in New Hampshire's large lakes as these two species are ranked 6th and 7th in angler preference (Responsive Management 2004). In the latest applicable survey, lake trout are ranked 2nd in ice angler preference (Responsive Management 1996). According to the most recent data, 89,000 anglers fished 1,191,000 days for trout (includes all trout species) and 13,000 anglers fished 204,000 days for salmon in New Hampshire waters during 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation). Since lake trout were not distinguished from other trout species in the above survey, the level of actual angler participation is unknown. However, for landlocked salmon, the above level of angler participation represented 6.5% of New Hampshire's freshwater anglers and 7.5% of the total days of fishing.

The economic impact of anglers fishing for trout and salmon in New Hampshire is significant as these anglers generated over $55 million and $8 million, respectively, in fishing-related expenditures during 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation). New Hampshire's large-lake fisheries are relatively specialized in nature (i.e. due to habitat requirements of the large lake coldwater fisheries, a boat and specialized equipment are required to effectively pursue desired species during much of the open water period); as such, anglers make significant economic contributions via equipment-related purchases. In New Hampshire, the economic impact of fishing is significant, as 230,000 U.S. residents (anglers) generated over $172 million in fishing-related revenues in 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation).

The New Hampshire Fish and Game Department (NHFGD) manages 23 water bodies for lake trout (Table 4). Lake trout are indigenous to six of these waters: First and Second Connecticut, Winnisquam, Winnipesaukee, Newfound, and Squam lakes, and were intentionally introduced into the other 17 waters. In 1981, NHFGD adopted a strategic plan that stated lake trout would be managed as a self-sustaining species; therefore stock assessments are necessary to determine the status of important population parameters so that management strategies can be monitored and modified as needed.

Landlocked salmon populations are maintained in 15 water bodies (Table 4) through annual plants of spring yearlings (age 1), because limited spawning and nursery habitat precludes natural reproduction from producing a suitable quantity of fish to provide acceptable fisheries (Seamans and Newell 1973). Landlocked salmon stock assessments are essential in order to monitor age and growth statistics. Data from these assessments are utilized to modify annual stocking rates so that one management objective, to have age 2 landlocked salmon attain a length of 457 mm (18 inches) by mid-November annually, can be achieved.

Rainbow smelt (*Osmerus mordax*) are essential as a source of forage for lake trout and landlocked salmon populations in New Hampshire's large lakes (NHFGD 1982); they also serve as an important prey item for other salmonids such as brown, brook, and rainbow trout, as well as a variety of other fish species found in large lake systems, including cusk, yellow and white perch, and smallmouth bass. The presence of rainbow smelt in a trout pond is acknowledged as an important factor in the department's quality trout management program. Since fluctuating populations of rainbow smelt affect the growth rates of salmonids (Seamans and Newell 1973), size characteristics, age data, and sex ratios are vital statistics that can be used to measure the status of rainbow smelt populations (Brown 1994), and allow year class strength and recruitment variations to be assessed on an annual basis (Anderson and Neumann 1996).

Program Goals:

1) To evaluate size-related (length, weight, and relative weight) statistics of spawning lake trout stocks.
2) To monitor and assess landlocked salmon growth rates and body condition on selected large lakes. To obtain annually, a sufficient supply of fertilized landlocked salmon ova to meet the requirements of our statewide salmon-stocking program.
3) To assess the species composition, size characteristics, spatial distributions of pelagic forage fish, and mean number of forage fish targets per acoustic ping (targets/ping) as an index value, on selected landlocked salmon/lake trout lakes in New Hampshire.
4) To determine size characteristics, age classes (age 1; >age 1), relative length frequency distribution, and sex ratio of rainbow smelt spawning in tributaries to selected New Hampshire lakes.

Approach:

Lake trout, landlocked salmon, rainbow smelt and other pelagic forage fish population assessments will occur annually on selected lakes. Standardized passive and active capture techniques will be used to obtain representative samples of the population under study.

Expected Results And Benefits:

Since lake trout provide an important recreational fishery and are managed as self-sustaining populations, evaluating size-related statistics of the spawning stocks allows the status of critical population parameters to be determined and tracked over time. An analysis of trend data can lead to modifying management strategies to ensure lake trout populations are sustained at desired levels and angler expectations are met.

Landlocked salmon growth assessments are an essential element in the determination of annual stocking levels for landlocked salmon (age 1), which is an important management tool for addressing growth-related issues that affect the overall success of this fishery. Additionally, using feral landlocked salmon as the source to obtain fertilized eggs sustains the annual stocking program for the fifteen lakes currently managed to provide fisheries for this species.

One of the keys to effective management of lake trout and landlocked salmon fisheries is the abundance and availability of rainbow smelt. Comparison of vital population statistics through time will provide information on the status trends and allows appropriate management strategies to be developed and implemented, such as adjusting annual landlocked salmon stocking rates to meet growth rate objectives.

Table 4. New Hampshire waterbodies managed for lake trout and/or landlocked salmon

Lake	Managed for Lake Trout	Managed for Landlocked Salmon
Connecticut Lake, First	X	X
Connecticut Lake, Second	X	X
Connecticut Lake, Third	X	
Conway Lake		X
Dan Hole Pond, Big	X	X
Diamond Pond, Big	X	
Francis Lake	X	X
Granite Lake	X	
Great East Lake	X	
Greenough Pond, Big	X	
Merrymeeting Lake	X	X
Newfound Lake	X	X
Nubanusit Lake	X	X
Ossipee Lake		X
Pleasant Lake (New London)		X
Silver Lake (Harrisville)	X	
Silver Lake (Madison)	X	
South Pond	X	
Spoonwood Pond	X	
Squam Lake, Big	X	X
Squam Lake, Little	X	X
Stinson Lake	X	
Sunapee Lake	X	X
Tarleton Lake	X	
Winnipesaukee Lake	X	X
Winnisquam Lake	X	X

Large Lake Fisheries Program Action Plans

<u>Project Title</u>: Lake Trout Population Assessment

<u>Project Objective</u>: To evaluate size-related (length, weight, and relative weight) statistics of spawning lake trout (*Salvelinus namaycush*) stocks**.** Nubanusit and Silver lakes in Region 4, and Winnipesaukee, Newfound and Sunapee lakes in Region 2 will be surveyed in fall 2012**.**

<u>Project Work Description</u>: Lake trout are captured on spawning reefs with gill nets [30 x 1.3 m, 38 mm mesh (bar measure)] tended at twenty to thirty minute intervals and/or New Hampshire-design fyke nets (four 1.1 x 1.3 m [3.6 x 4.2 ft] hoops; four throats within the hoops; 1.3 cm [0.51 in] bar-measured mesh) set overnight. When necessary, alternative methods are employed (angling) to obtain a representative sample of lake trout. Weather conditions (air temperature, cloud cover, wind speed and direction, time of sunset) and surface water temperature are recorded at the onset of sampling. All captured lake trout are measured for total length (TL) (mm), weighed (kg), and sexed. The tip of the caudal fin upper lobe is excised to identify recaptured individuals, which are not reprocessed. Sampling is non-destructive and all lake trout are released approximately 0.3 km (0.2 miles) from the net/capture site.

Relative weight values (W_r) are used to evaluate body condition/robustness. This index compares the actual weight of an individual (W) with a standard weight (W_s) for a fish of the same length:

$$W_r = W / W_s \times 100$$

The standard weight equation used for lake trout was $\log_{10} W_s$ (g) = –5.681 + (3.246 x $\log_{10}$ total length mm), proposed by Piccolo et al. (1993).

Mean W_r and associated standard deviations (SD) are calculated for lake trout length categories presented by Hubert et al. (1994). The length categories consisted of stock/quality (SQ) (300 - 499 mm), quality/preferred (QP) (500 - 649 mm), preferred/memorable (PM) (650 – 799 mm), and memorable/trophy (MT) (800 - 999 mm). Chi-square analysis with Yate's correction factor and the Fisher exact test are used to make comparisons of particular length categories as applicable. Linear regression is performed with *SigmaPlot* Version 7.101 (SPSS, Inc. 2001) to determine if significant ($P \leq 0.05$) relationships exist between male lake trout TL and W_r for the current sample year and long term means. Student's t-tests are performed with *SigmaStat* Version 2.03 (SPSS, Inc. 1997) to determine if significant ($P \leq 0.05$) differences exist between statistics from the current sample year and long-term mean for two length categories. Male and female lake trout are compared separately, since weight-related statistics for spawning female lake trout can be biased by their spawning condition (ripe vs. spent). Male W_r for two length categories (SQ, QP) is also compared between the current sample year and long-term mean.

<u>Project Justification</u>: Lake trout are indigenous to six (6) New Hampshire water bodies, First and Second Connecticut, Big Squam, Winnipesaukee, Winnisquam, and Newfound lakes (Scarola 1987); however, early management efforts expanded their range through hatchery rearing and stocking of fry, fingerling, and yearling lake trout (New Hampshire Fish and Game Department [NHFGD] 1981). In 1981, NHFGD adopted a strategic plan that stated lake trout would be

managed as a self-sustaining species; currently, twenty-three (23) water bodies are managed for lake trout fisheries in this manner (Table 4).

The largest salmonids in New Hampshire, lake trout are highly sought game fish, ranking 6th in popularity overall in a recent survey (Responsive Management 2004) and 2nd in ice-angling popularity in a previous survey (Responsive Management 1996). According to the most recent data, 89,000 anglers fished 1,191,000 days for trout (includes all trout species) in New Hampshire waters during 2006; the economic impact of these anglers is significant as they generated $55 million in fishing-related expenditures during 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation). Although angler satisfaction rates have declined for nearly all of New Hampshire's most popular game fish species, lake trout anglers were as satisfied in 2003 (49%) as in 1995 (48%), and significantly fewer anglers were dissatisfied in 2003 (16%) compared to 1995 (39%) (Responsive Management 2004). Since New Hampshire's lake trout fisheries are relatively specialized in nature (i.e. due to coldwater habitat requirements of lake trout, a boat and specialized equipment are required to effectively pursue this species during much of the open water period), anglers make significant economic contributions via equipment-related purchases. For example, although analysis of species-specific expenditures is not available, U.S. residents spent approximately $46.6 million in New Hampshire on special equipment and boating costs in 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation).

Since lake trout are indigenous, highly-sought after, and managed as self-sustaining in New Hampshire, as well as limited in distribution due to specific habitat requirements, it is critical to determine the status of essential population parameters so appropriate management measures can be modified or implemented when needed. Spawning stock evaluations are used to compare current population statistics with past data sets. Periodic lake trout spawning stock assessments have most recently been conducted at Newfound, Sunapee, Winnipesaukee, Winnisquam, Nubanusit and Spoonwood lakes.

While remaining acutely aware of the fragility of lake trout stocks, as we look toward the future, additional special regulations may be needed to ensure the availability of quality-sized lake trout desired by anglers - particularly in New Hampshire's relatively forage-limited lakes. A special 381 mm minimum length regulation enacted in 1998 at Newfound Lake has improved the size structure of the lake trout population (Viar 2002). Changing motivations for angling combined with fish consumption advisories could result in declining lake trout harvest, resulting in overabundant lake trout populations. Since lake trout are highly successful in their reproductive efforts in particular New Hampshire lakes, future regulation changes may be needed to minimize density dependent factors that negatively impact population size structure. Lake trout spawning stock evaluations, along with creel surveys, are central to the implementation of any such regulation change or monitoring such change.

Additionally, lake trout evaluations also serve as indicators of forage fish population status, since correlations between lake trout body condition (relative weight, W_r) and forage-fish abundance have been observed in Newfound and Winnipesaukee lakes. Recent high W_r values for lake trout in Newfound and Winnipesaukee lakes have been attributed to high rainbow smelt abundance (Viar 2002, 2003).

Lake Trout Population Assessment assists the Department in achieving Goal 2 and Goal 3 within its Strategic Plan (1998-2010). This project is a strategy that directly addresses Objective 2.1 and Objective 3.1 in the plan.

Project Costs: $6,939.00

Salary: (2) Biologist II	60 hours x $57.43/hr =	$3,446.00
(2) Biologist I	75 hours x $43.24/hr =	$3,243.00
In-State Travel Cost:		$ 250.00
		$6,939.00

Project Priority Score: 23 points

Ecological Importance:	High	5 points
Public Interest:	Moderate-High	4 points
Economic Importance:	Moderate	3 points
Adequacy of Existing Data:	Low	1 point
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Project Title: Landlocked Salmon Population Assessment

Project Objectives: 1) To determine the size characteristics of adult landlocked salmon in New Hampshire lakes; 2) To determine whether landlocked salmon growth meets the management plan objective that calls for age 2 fish to average $\geq$ 457mm (18 inches) in total length by mid-November each year, and; 3) To obtain sufficient numbers of fertilized landlocked salmon eggs for the maintenance of the statewide landlocked salmon-stocking program in New Hampshire. Size characteristics of adult landlocked salmon in Big Squam, Sunapee and Winnipesaukee lakes will be assessed in 2012 and approximately 100,000 landlocked salmon eggs will be collected for the maintenance of the statewide landlocked salmon-stocking program.

Project Work Description: During the fall spawning season (October/November), adult landlocked salmon are trap netted with pound and fyke nets situated near tributary inlets. The pound nets are approximately 7.3 m long x 3.7 m wide x 2.5 m deep, with 2.5 cm stretch mesh netting, and have a funnel-shaped throat that partitions the net into two compartments. The New Hampshire-design fyke nets consist of four, 1.1 m x 1.3 m hoops, up to four funnel-shaped throats within the hoops, and 2.5 cm stretch mesh netting. Nets are tended every two to three days.

Representative samples of the landlocked salmon catch are sexed, measured for total length (mm), weighed (g), and examined for excised fins to determine their age. Excising different fins from juveniles prior to release marks each landlocked salmon cohort. Any visible hook wounds on the landlocked salmon were noted in the data collection.

Fulton type condition factors (K) are calculated using the following formula:

$$K = W/L^3 \times 100{,}000;$$

where W is weight (g) and L is total length (mm).

Student’s t-test (two sample with unequal variance) is used to determine whether there is a significant difference ($P<0.05$) between the current year’s age 2 landlocked salmon mean total length and the long-term mean total length of age 2 landlocked salmon.

Landlocked salmon captured in Big Squam and/or Winnipesaukee lakes are manually spawned in early to mid-November to obtain approximately 100,000 fertilized eggs needed to sustain statewide management/stocking efforts. Prior to spawning, salmon are held in live pens within the lake and periodically checked for ripeness. Egg-taking activities are performed near the net/pen site, on the shoreline or nearby dock; a tarp is erected to minimize egg exposure to damaging UV rays. In excess of 200 landlocked salmon males and equivalent number of females are utilized in the egg-taking process. The dry method is utilized to maximize fertilization rates; a 1:1 male to female spawning ratio and random parent selection maximize genetic variability. After spawning, salmon are released alive back into the lake. Fertilized eggs are transported in coolers to Powder Mill Hatchery for disinfection and incubation; juvenile salmon are reared at this facility until stocking occurs at age 1 approximately 18 months later.

Project Justification: Lake Atlantic salmon or landlocked salmon (*Salmo salar*) were first introduced into New Hampshire waters in 1866 and many of the 15 waters (Table 4) currently managed for this species received at least token stockings within a few years of this date (Seamans and Newell 1973). This species soon attracted much interest from anglers and became a very important factor in the economics of a rapidly growing recreational industry in New Hampshire. Fishing for landlocked salmon continues to be a popular recreational pursuit, as recent surveys found this species ranked 7th in preference among New Hampshire's anglers (Responsive Management 1996 and 2004).

In 2006, approximately 13,000 resident and non-resident anglers combined for 204,000 days of landlocked salmon angling in New Hampshire; of nine popular New Hampshire sport fish, only landlocked salmon angler satisfaction was up substantially since 1995 (+20%; 36% to 56%), and dissatisfaction was down substantially (-38%; 54% to 16%) (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation). Since New Hampshire's landlocked salmon fisheries are relatively specialized in nature (i.e. due to coldwater habitat requirements, a boat and specialized equipment are required to effectively pursue this species during much of the open water period), anglers make significant economic contributions via equipment-related purchases. For example, although analysis of species-specific expenditures is not available, U.S. residents spent approximately $46.6 million in New Hampshire on special equipment and boating costs in 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation).

Landlocked salmon populations are maintained through annual stocking of age 1 fish, since limited spawning and nursery habitat precludes natural reproduction from producing a suitable quantity of fish to provide acceptable fisheries (Seamans and Newell 1973). Stocking rates are dependent upon forage fish abundance, particularly rainbow smelt (*Osmerus mordax*), a critical prey item for landlocked salmon (Seamans and Newell 1973). In conjunction with hydroacoustic and trawl net surveys, annual landlocked salmon population assessments allow for adjustments in landlocked salmon stocking rates, which help minimize variations in landlocked salmon growth and attain the management objective of age 2 salmon averaging ≥ 457mm (18 inches) in total length by mid-November each year. Sunapee, Big Squam, and Winnipesaukee lakes are surveyed on an annual basis since they are large oligotrophic lakes and provide major landlocked salmon fisheries in their respective regions of the state. Selected lakes in different regions of the state, i.e., Nubanusit and Merrymeeting lakes are surveyed when data acquisition is required for management purposes. The department will collect fertilized landlocked salmon eggs from various lakes, wherever salmon condition and egg quality is deemed best.

Additionally, landlocked salmon population assessments serve as indicators of forage fish abundance; in corresponding years (2000-2003) of high forage-fish abundance estimates (hydroacoustic surveys) in Lake Winnipesaukee, significantly higher body condition (K-factor) has been observed in male landlocked salmon compared to long-term mean values (Miller and Viar 2001, 2002, 2003, 2004).

Landlocked Salmon Population Assessment assists the Department in achieving Goal 2 and Goal 3 within its Strategic Plan (1998-2010). This project is a strategy that directly addresses Objective 2.1 and Objective 3.1 in the plan.

Project Costs: $73,613

Salary: (1) Biologist II	650 hours x $57.97/hr =	$37,681.00
(2) Biologist I	650 hours x $43.37/hr =	$28,191.00
(1) Laborer	375 hours x $10.67/hr =	$ 4,001.00
(1) Supervisor VI	22.5 hours x $64.04/hr =	$ 1,430.00
Equipment Maintenance Costs:		$ 1,100.00
In-State Travel Cost:		$ 1,210.00
		$73,613.00

Project Priority Score: 24

Ecological Importance:	Moderate	3 points
Public Interest:	Moderate	3 points
Economic Importance:	Moderate	3 points
Adequacy of Existing Data:	High	5 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

<u>Project Title</u>: Forage Fish Population Assessment

<u>Project Objective</u>: To determine the species composition, size characteristics, spatial distributions of pelagic forage fish, and mean number of forage fish targets per hydroacoustic ping (FF/P) as an index value. In 2012, hydroacoustic surveys will be undertaken on Winnipesaukee, Winnisquam, Newfound, Big and Little Squam, Nubanusit, and Sunapee lakes.

<u>Project Work Description</u>: 1) Mobile hydroacoustic and trawl net surveys are conducted in mid to late summer (late July to mid-September) when lakes are thermally stratified and rainbow smelt are restricted to pelagic waters. Surveys are conducted at night, when limnetic fish tend to be more evenly dispersed, making acoustic quantification easier (Burczynski et al. 1987). Acoustic transects are spaced at approximately 1.6 km intervals, perpendicular to the shore, and span the pelagic area of the lakes. A BioSonics Inc. DTX system, 200 kHz, split-beam digital transducer, is used to determine the number and size (dB) of targets. A 3 x 7 m rectangular mid-water trawl is used to verify fish species and size-class compositions. The net is 18 m in length and has stretched-mesh sizes of 10.2, 5.1, 1.9, and 1.3 cm. The cod end consists of 3-mm mesh knotless nylon netting. Water temperatures are recorded with two data loggers (*Stowaway Tidbit*, Onset Computer Corp.), one each affixed to the upper bar (top) and lower bar (bottom) at the head end of the trawl net. Species occurrence is determined from discrete samples of fish collected from the 0-5m, 5-10m, and 10-15m depth strata. This reduces bias in apportioning estimates among the species of fish found in the limnetic zone. Tow times vary from 0.08 – 0.50 hrs, at speeds of 1 m/s. Fish captured in the mid-water trawl are identified, enumerated, measured for total length (mm) and weighed (g).

BioSonics analysis software accomplishes preliminary analysis of hydroacoustic data files. Given standardization does not exist in how each state/natural resource agency obtains secondary results/biomass estimates (Brian Moore, BioSonics Inc., personal communication), the total number of targets identified per total transect pings will serve as the new baseline metric. This will allow for processing targets actually counted (which the split-beam transducer does directly), rather than expanding across depth strata throughout the lake, which assumes forage fish/smelt are present in similar distributions at all such depth strata - which could be the source of continued inflated biomass estimates, even with the new DTX split-beam system (Brian Moore, BioSonics Inc., personal communication).

Analysis of variance (ANOVA, $P<0.05$) will be used to determine if any significant differences exist among lakes, or within lakes among years, for mean number of targets/ping. Regression analysis will be performed to examine the relationship between mean number of targets/ping and fall trap-netted age-2 landlocked salmon body condition (K-factor) in the respective lakes and to examine the relationship between two long-term precipitation level data sets (January – May and March – May) and mean number of targets/ping in all study lakes.

<u>Project Justification</u>: Pelagic forage fish, particularly rainbow smelt, are an essential component to managing New Hampshire's large lakes for landlocked salmon (*Salmo salar)*, lake trout (*Salvelinus namaycush*), and rainbow trout (*Oncorhynchus mykiss*) populations, which provide popular fisheries in the state as demonstrated by an angler survey that showed these species ranked seventh, sixth, and third in angler preference, respectively (Responsive Management 2004). Because the growth rates and body condition of these large lake salmonids are dependent

upon sufficient pelagic forage fish abundance, assessing these populations is critical to recognizing fluctuations in abundance before salmonid growth is negatively impacted.

In 2006, approximately 13,000 resident and non-resident anglers combined for 204,000 days of landlocked salmon angling in New Hampshire; of nine (9) popular New Hampshire sport fish, only landlocked salmon angler satisfaction was up substantially since 1995 (+20%; 36% to 56%), and dissatisfaction was down substantially (-38%; 54% to 16%) (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation). Since New Hampshire's landlocked salmon fisheries are relatively specialized in nature (i.e. due to coldwater habitat requirements, a boat and specialized equipment are required to effectively pursue this species during much of the open water period), anglers make significant economic contributions via equipment-related purchases. For example, although analysis of species-specific expenditures is not available, U.S. residents spent approximately $46.6 million in New Hampshire on special equipment and boating costs in 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

The Forage Fish Assessment Project assists the Department in achieving Goal 2 and Goal 3 within its Strategic Plan (1998-2010). This project is a strategy that directly addresses Objective 2.1 in the plan and affects Objective 3.1 indirectly.

Project Costs: $28,959.00

Salary: (1) Biologist II	240 hours x $57.97/hr =	$ 13,913.00
(1) Biologist I	280 hours x $50.70/hr =	$ 14,196.00
In-State Travel Cost:		$ 350.00
Equipment Maintenance Costs:		$ 500.00
		$28,959.00

Project Priority Score: 27

Ecological Importance:	Moderate-High	4 points
Public Interest:	Moderate-High	4 points
Economic Importance:	Moderate-High	4 points
Adequacy of Existing Data:	High	5 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

<u>Project Title</u>: Tributary-Spawning Rainbow Smelt Assessment

<u>Project Objective</u>: To determine the size characteristics, age classes (age 1; >age 1), relative length-frequency distribution, and sex ratio of rainbow smelt (*Osmerus mordax*) spawning in tributaries to selected New Hampshire lakes. In the spring of 2012, spawning rainbow smelt are scheduled to be sampled in the following brooks/lakes: Region 2: Georges Brook / Newfound Lake, Tyler Brook/Winnisquam Lake, Poor Farm Brook/Winnipesaukee Lake, Red Brook/Pleasant Lake, Chandler Brook/Sunapee Lake, Mascoma River/Mascoma Lake and no-name brooks at Tarleton and Purity Lakes; Region 1: Cedar Brook/Cedar Pond, and Rowell and Camp Brooks/Christine Lake.

<u>Project Work Description</u>: The sampling of tributary spawning smelt is accomplished at night (2000-2200 hrs) from selected lakes each spring (late March to late April). Smelt are collected using a long handled (2.4-m) dip net (38-cm diameter) with 9-mm wire mesh. Total length (mm), weight (g) and sex (male/female) are recorded for each fish captured and a sub-sample of five fish for each 10 mm length interval is utilized for age determination. Scale samples are removed from individual fish and are mounted on glass slides and viewed under variable magnification (10.5x – 45x) with a Leica compound dissecting microscope. Rainbow smelt scales are examined and broken into two age groups; Age I and >Age I. Two individuals age each scale sample independently, and when agreement on age class can not be reached, that sample is not included in the analysis of age data. Age data is used to construct age-length keys (Ricker 1975) for each lake surveyed and the age-length keys are then used to partition overall length-frequency data into age-frequency data. Comparisons of these parameters through time provide information on the status of these spawning populations.

The Student's t-test (two sample with unequal variance) is used to detect significant differences ($P \leq 0.05$) in mean lengths between age 1 spawning male and female smelt (current sample year) and between the long-term mean lengths (grand means) established for age 1 spawning male and female smelt captured in tributaries to selected New Hampshire lakes.

<u>Project Justification</u>: Rainbow smelt are an essential component to managing New Hampshire’s large lakes for landlocked salmon (*Salmo salar)*, lake trout (*Salvelinus namaycush*), and rainbow trout (*Oncorhynchus mykiss*), which provide popular fisheries in the state as demonstrated by an angler survey that showed these species ranked seventh, sixth, and third in angler preference, respectively (Responsive Management 2004).

The size characteristics of age 1 rainbow smelt may be directly correlated with the overall population size in the lake, and the environmental factors that affect growth. Thus, by tracking the mean length of spawning age 1 smelt over the course of several years, a more complete understanding of smelt population dynamics can be achieved.

Stocking rates for yearling landlocked salmon are adjusted in accordance with the results of rainbow smelt spawning assessments and forage fish abundance index values. Since fluctuating populations of rainbow smelt affect salmonid growth rates, it is desirable to monitor spawning rainbow smelt populations in selected managed waters.

A total of 102,000 anglers spent 1.4 million days fishing for trout and salmon in New Hampshire waters, generating $63 million in fishing-related expenditures during 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. New Hampshire's large-lake fisheries are relatively specialized in nature (i.e. due to habitat requirements of large-lake coldwater species, a boat and specialized equipment are required to effectively pursue desired species during much of the open water period); as such, anglers make additional economic contributions via equipment-related purchases. For example, although analysis of species-specific expenditures is not available, U.S. residents spent approximately $46.6 million in New Hampshire on special equipment and boating costs in 2006 (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation).

Tributary-Spawning Rainbow Smelt Assessment assists the Department in achieving Goal 2 and Goal 3 within its Strategic Plan (1998-2010). This project is a strategy that directly addresses Objective 2.1 in the plan and affects Objective 3.1 indirectly.

Project Costs: $18,869.00

Salary: (1) Biologist II	150 hours x $57.97/hr =	$8,696.00
(1) Biologist I	150 hours x $50.70/hr =	$7,605.00
(1) Biologist I	40 hours x $52.32/hr =	$2,093.00
In-State Travel Cost:		$ 400.00
Equipment Maintenance Costs:		$ 75.00
		$18,869.00

Project Priority Score: 21 points

Ecological Importance:	Moderate-High	4 points
Public Interest:	Moderate-High	4 points
Economic Importance:	Moderate-High	4 points
Adequacy of Existing Data:	Low	1 point
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	Moderate	3 points

Fish Conservation Program

Program Need:

In pre-colonial times, Atlantic salmon (*Salmo salar*), American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American eel (*Anguilla rostrata*), sea lamprey (*Petromyzon marinus*), Atlantic sturgeon (*Acipenser oxyrinchus*), and shortnose sturgeon (*Acipenser brevirostrum*) populated the Merrimack River and Connecticut River basins. However, the spawning runs of these diadromous fish began to decline during the period of rapid industrial development that occurred in the 19th century because of pollution associated with the discharge of human and industrial waste, dam construction that served as barriers to migration, unregulated commercial fishing, and the harvest of spawning fish in freshwater (Stolte 1981). The collective impacts of these factors were so severe it became necessary to initiate an effort to restore these migratory fish to the Merrimack and Connecticut Rivers in 1864. Since the first restoration venture, a number of strategies have been implemented and though there have been varying levels of success, self-sustaining populations of these diadromous fish have not been achieved and therefore continued efforts are required.

There are at least ten indigenous species of freshwater fish potentially at risk and in need of conservation based on declining population trends, unique habitat associations, low reproductive rates, or other population and habitat characteristics that make them vulnerable to an increasingly developed landscape (Table 5). Since little is known about the current population status of these species in New Hampshire, assessments are necessary.

Program Goal:

To protect, conserve, enhance, or restore anadromous and freshwater fish species of greatest conservation need.

Approach:

Restoring self-sustaining anadromous fish populations to the Merrimack River and Connecticut River basins will be accomplished through action plans developed to implement strategies identified in *The Strategic Plan and Status Review of the Anadromous Fish Restoration Program for the Merrimack River* (1997), and *The Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River* (1998).

Assessments on the distribution, abundance and status of freshwater fish species identified as being potentially at risk and of greatest conservation need will be conducted, resulting in the development and implementation of action strategies needed to protect, enhance, or restore these populations.

Expected Results And Benefits:

Protecting, conserving, enhancing, and restoring New Hampshire's anadromous and freshwater fish populations of greatest conservation need insures that the full array of the State's fish communities remain viable.

Table 5. Species of diadromous and freshwater fish potentially at risk and in need of conservation within New Hampshire.

Common Name	**Scientific Name**
Alewife	Alosa pseudoharengus
American brook lamprey	Lampetra appendix
American eel	Anguilla rostrata
American shad	Alosa sapidissima
Atlantic salmon	Salmo salar
Atlantic sturgeon	Acipenser oxyrinchus
Banded sunfish	Enneacanthus obesus
Blueback herring	Alosa aestivalis
Bridle shiner	Notropis bifrenatus
Brook trout	Salvelinus fontinalis
Finescale dace	Phoxinus neogaeus
Lake whitefish	Coregonus clupeaformis
Northern redbelly dace	Phoxinus eos
Rainbow smelt	Osmerus mordax
Redfin pickerel	Esox americanus americanus
Round whitefish	Prosopium cylindraceum
Sea lamprey	Petromyzon marinus
Shortnose sturgeon	Acipenser brevirostrum
Swamp darter	Etheostoma fusiforme

Fish Conservation Program Action Plans

Project Title: Restoration of Atlantic Salmon to the Merrimack River

Project Objective: To restore self-sustaining Atlantic salmon spawning runs to the Merrimack River. To stock 1.0 million Atlantic salmon fry and to obtain population estimates of fall parr abundance at four index sites in the Merrimack River basin.

Project Work Description: Atlantic salmon eggs obtained from suitable stocks will be reared to the fry or smolt stage for release into the Merrimack River watershed. The production of cultured Atlantic salmon for the Merrimack River restoration effort will occur at the Nashua National Fish Hatchery, NH and North Attleboro National Fish Hatchery, MA, Green Lake National Fish Hatchery, ME and Warren State Fish Hatchery Warren, NH. Current target release numbers of Atlantic salmon fry (~1.4 million) and smolts (~50,000) will be released annually into selected Merrimack River watershed nursery streams at prescribed densities (Table 6).

Four index sites, located on the Baker, Pemigewasset, Mad, and Souhegan Rivers, will be sampled during August and September to obtain annual estimates of juvenile Atlantic salmon abundance for the watershed. The index sites will have their upstream and downstream boundaries blocked off with seines and juvenile Atlantic salmon will be captured through the use of a DC backpack electrofishing unit. Juvenile Atlantic salmon population estimates will be calculated for each index site using a BASIC program called Remove. The program uses maximum weighted likelihood estimation, based on Carle and Strub (1978), to calculate population size from a series of sequential capture efforts; associated statistics are derived using the formulas of Zippin (1956). All sampled juvenile Atlantic salmon will be measured to the nearest millimeter (mm) and weighed to the nearest gram (g).

Pre-smolt relative abundance is derived by expanding each cohort's estimated density per unit (100 m^2) to the total units identified within the watershed. This estimate is then adjusted to incorporate fish size by calculating the proportion of large parr from the index site data. This adjustment is utilized to account for the correlation of fish size and smoltification rates. A range of 35% to 65% over winter survival rate is then applied to the pre-smolt population estimates to derive estimates of smolt run size for each stream.

Atlantic salmon nursery habitat within the watershed will be inventoried and monitored according to established criteria.

The New Hampshire Technical Committee representative of the Merrimack River Anadromous Fishery Restoration Program attends regular scheduled Policy and Technical Committee Meetings annually. The representative is responsible for necessary program subcommittee activities outlined by the Policy Committee and coordinated by the U.S. Fish and Wildlife Service's program manager located at the central New England Fishery Resource complex office, Nashua, NH.

Project Justification: In 1969, formal efforts for a cooperative restoration program commenced when Massachusetts, New Hampshire, the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) mutually agreed to support such a program for the

Merrimack River watershed. The United States Forest Service (USFS) formally joined the cooperative effort in 1982.

A Strategic Plan for the restoration of Atlantic salmon to the Merrimack River was written in 1979. The most recent revision, *The Strategic Plan and Status Review of the Anadromous Fish Restoration Program for the Merrimack River* was approved in 1997 and provides a strategic plan for continued restoration of Atlantic salmon, into the 21st century. Additionally, Public Service of New Hampshire, Enel North America, Inc. and the cooperating fisheries agencies jointly developed comprehensive fish passage plans.

In order to facilitate the successful restoration of Atlantic salmon to the Merrimack River, salmon (fry, smolts) must be stocked and juvenile salmon populations must be assessed in order to evaluate the habitat capacity of various streams, and evaluate the efficacy of fry stocking density and stocking location in regards to growth and survival of juvenile salmon. Additionally, smolt estimates are used to estimate the productivity of various watershed/streams and to determine the survival rate from smolt to adult. (U.S. Atlantic Salmon Assessment Committee, 2005.)

Merrimack River Atlantic Salmon Restoration is a strategy that assists the Department in achieving objectives 2.1 and 4.1within its Strategic Plan (1998-2010) and addresses strategies 1.B.1, 1.C.1, and 1.C.4 in the Strategic Plan and Status Review of the Anadromous Fish Restoration Program for the Merrimack River (1997).

Project Costs: $31,733.00

Salary: (3) Biologist II	355 hours x $49.87/hr =	$17,704.00
(3) Biologist I	225 hours x $46.35/hr =	$10,429.00
Equipment Costs:		$ 500.00
Equipment Maintenance Costs:		$ 300.00
In-State Travel Cost:		$ 2,800.00
		$31,733.00

Project Priority Score: 20 points

Ecological Importance:	High	5 points
Public Interest:	Low	1 point
Economic Importance:	Low	1 point
Adequacy of Existing Data:	High	5 points
Project Feasibility:	Moderate	3 points
Cost-Benefit Ratio:	High	5 points

Table 6. Atlantic Salmon Fry Stocking Habitat Within The Merrimack River Watershed

	Km	**100 m² Units**	**Stocking Density**	**Fry Required**
I. E. Branch Pemigewasset River Mainstem				
a) Franconia Bk. to headwaters (1-5)	10.3	1,831	16.35	29,940
b) Franconia Bk. to confluence (6-11)	14.8	3,490	27.25	98,100
Subtotal	25.1	5,321		128,040
c) Tributaries				
1. Shoal Pond	0.8	40	16.35	660
2. Norcross	0.5	42	16.35	690
3. North Fork E. Br.	3.7	592	16.35	9,675
4. Hancock Branch	6.9	890	16.35	14,550
5. North Fork Hancock Br.	3.5	201	16.35	3,285
6. Franconia Brook	0.2	10	16.35	165
Subtotal	15.6	1,775		29,025
II. Pemigewasset River				
a) Mainstem				
1. E. Br. Confluence to Profile Lake	15.6	1,800	27.25	49,050
2. Ayers Is. Dam to E. Br. Pemi River	28.5	15,060	27.25	410,375
Subtotal	44.1	16,860		459,425
b) Tributaries				
1. Moosilaukee Bk.	5.6	619	27.25	16,875
a) Jackman Bk.	4.0	308	27.25	8,400
b) Lost River	3.7	285	27.25	7,775
2. Hubbard Bk.	2.9	217	27.25	5,900
3. Bagley Bk.	1.9	93	27.25	2,525
4. Bog Bk.	3.2	347	27.25	9,450
a) Avery Bk.	0.8	17	27.25	450
b) Campton Bog Bk. #1	1.3	44	27.25	1,200
c) Campton Bog Bk. #2	1.6	22	27.25	600
d) Campton Bog Bk. #3	1.6	17	27.25	475
5. Eastman Bk.	9.7	1,057	27.25	28,800
a) Johnson Bk.	1.6	110	27.25	3,000
b) Talford Bk.	1.6	73	27.25	2,000
6. Mill Bk.	4.8	411	27.25	11,200
a) Hazelton Bk.	1.3	183	27.25	5,000
7. Blake Bk.	2.3	72	27.25	1,975
8. Harper Bk.	1.9	90	27.25	2,450
9. Woodman Bk.	1.9	71	27.25	1,925
10. Needle Shop Bk.	4.3	185	27.25	5,050
11. Knox Bk.	1.1	49	27.25	1,325
12. West Branch Bk.**	5.0	470	27.25	12,800
13. Weeks Bk.	2.3	77	27.25	2,100
14. Reed Bk.	5.0	247	27.25	6,725
15. Glove Hollow Bk.	1.8	33	27.25	900
16. Hackett Bk.	1.3	41	27.25	1,125
17. Connor Bk. **	2.1	72	27.25	1,950
Subtotal	74.7	5,210		141,975
III. Mad River				

a) Above Campton Dam	17.6	3,100	16.35	50,685
b) Below Campton Dam	3.5	1,239	16.35	20,250
1. West Branch	5.2	332	16.35	5,430
a) Tecumseh Bk.**	1.6	94	16.35	1,530
2. Smart Bk.	1.6	94	16.35	1,530
3. Drakes Bk.	1.6	89	16.35	1,455
4. Chickenboro Bk.	1.6	36	16.35	585
5. High Bk.	1.0	15	16.35	240
6. Winter Bk.	3.2	113	16.35	1,845
7. Snow Bk.	1.6	94	16.35	1,530
8. Dry Bk.	1.3	25	16.35	405
Subtotal	39.8	5,228		85,485
IV. Beebe River	19.8	2,172	16.35	35,505
1. Ryan Bk.	1.4	33	16.35	540
2. Spenser Bk.	1.8	64	16.35	1,050
Subtotal	23.0	2,269		37,095
V. Baker River	25.9	3,555	27.25	96,875
1. East Branch	1.8	34	27.25	925
2. South Branch	4.2	484	27.25	13,200
a). Rocky Pond Branch	3.2	69	27.25	1,875
3. Clifford Bk.	1.8	78	27.25	2,125
4. Martin Bk.	1.8	35	27.25	950
5. Pond Bk.	2.6	183	27.25	5,000
6. Stinson Bk.	7.4	367	27.25	10,000
7. Halls Bk.	6.4	220	27.25	6,000
8. Groton Hollow Bk.	1.1	15	27.25	400
9. Clay Bk.	1.0	37	27.25	1,000
10. Mcloud Bk.	1.3	33	27.25	900
11. Remington Bk.	1.4	45	27.25	1,225
Subtotal	59.9	5,155		140,475
VI. Smith River	12.4	1,844	32.7	60,300
1. Mill Bk.	4.3	436	32.7	14,250
2. Hoyt Bk.	2.1	70	32.7	2,280
3. Smith Bk.	4.3	194	32.7	6,330
4. Wild Meadow Bk.	3.4	226	32.7	7,380
Subtotal	26.6	2,769		90,540
VII. Contoocook River	5.0	3,143	27.25	85,650
Contoocook River Tributaries				
1. North Branch	0.6	220	27.25	6,000
2. Beards Bk.	2.9	330	27.25	9,000
3. Blackwater River	1.9	227	27.25	6,175
4. Warner River	3.1	349	27.25	9,500
5. Lane River**	4.2	143	27.25	3,900
Subtotal	17.7	4,412		120,225
VIII. Soucook River **	3.2	616	27.25	16,775
1. Academy Bk.	3.5	285	27.25	7,775
Subtotal	6.8	901		24,550

IX. Suncook River *	2.9	433	27.25	11,800
1. Little Suncook River	2.3	143	27.25	3,900
2. Blake Bk.	0.8	18	27.25	500
3. Sanborn Bk.	1.3	49	27.25	1,325
4. Gulf Bk. **	1.6	55	27.25	1,500
5. Deer Bk.**	1.6	55	27.25	1,500
6. Bear Bk.**	1.6	55	27.25	1,500
Subtotal	12.1	808		22,025
X. Piscataquog				
1. Piscataquog, South Branch	16.7	3,591	43.6	156,560
2. Piscataquog, Middle Branch	6.3	606	27.25	16,500
3. Piscataquog, Mainstem	2.1	404	27.25	11,000
Subtotal	25.1	4600		184,060
XI. Souhegan	18.2	3,509	27.25	95,625
1. Stony Bk.	4.5	337	27.25	9,175
2. Blood Bk.**	11.3	771	27.25	21,000
3. King Bk.	1.1	18	27.25	500
Subtotal	35.1	4,635		126,300
XII. Merrimack River Tributaries				
1. Punch Bk.	1.9	110	27.25	3,000
2. Stirrup Iron Bk.	2.1	73	27.25	2,000
3. Haywood	0.8	41	27.25	1,125
4. Bryant Bk.				
a) Forest Pond Bk. **	1.6	55	27.25	1,500
b) Hazelton Bk. **	0.6	22	27.25	600
5. Burnham Bk. **	0.5	17	27.25	450
6. Black Bk.	3.1	200	27.25	5,450
Subtotal	10.6	518		14,125
GRAND TOTAL	**416.3**	60,461		**1,600,345**

** Habitat units unknown, estimates only

Atlantic salmon smolt stocking locations within the Merrimack River watershed.

Merrimack River Mainstem

a. Smolt target	200,000
b. Current stocking	50,000

<u>Project Title</u>: Atlantic Salmon Brood Stock Fishery

<u>Project Objective</u>: 1) To maintain an interim sport fishery for Atlantic salmon brood stock within the Merrimack River watershed.

<u>Project Work Description</u>: Domestic Atlantic salmon brood stock reared and spawned once at the Nashua National Fish Hatchery, are tagged and transported for release in the Merrimack River watershed for sport angling. An action strategy, developed for the program by the Technical Committee for the Merrimack Rive Anadromous Fishery Restoration Program in March of 1999, establishes a minimum annual target release number of 1,500 brood stock Atlantic salmon between the towns of Bristol, NH and Manchester, NH.

<u>Project Justification</u>: In 1969, formal efforts for a cooperative restoration program commenced when Massachusetts, New Hampshire, the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) mutually agreed to support such a program for the Merrimack River watershed. The United States Forest Service (USFS) formally joined the cooperative effort in 1982.

A Strategic Plan for the restoration of Atlantic salmon to the Merrimack River was written in 1979. The most recent revision, The Strategic Plan and Status Review of the Anadromous Fish Restoration Program for the Merrimack River was approved in 1997 and provides a strategic plan for continued restoration of Atlantic salmon, into the 21st century. Additionally, Public Service of New Hampshire, Enel North America, Inc. and the cooperating fisheries agencies jointly developed comprehensive fish passage plans.

As outlined in the Strategic Plan, the domestic Atlantic salmon brood stock program was initiated in order to develop the egg production necessary to meet the fry-stocking target for the Merrimack River Anadromous Fish Restoration Program. Once mature brood stock have been spawned at the Nashua National Fish Hatchery they become surplus since supplemental year-classes are being produced annually. The Merrimack River Technical Committee proposed the brood stock Atlantic salmon sport fishery in 1989 and after public hearings and informational meetings were held the program was approved by the Merrimack River Policy Committee in 1991. Following subsequent approval by the New Hampshire Fish and Game Commission in 1992 and the program was officially initiated in 1993.

The Atlantic salmon brood stock fishery, which is managed cooperatively between the New Hampshire Fish and Game Department and the US Fish and Wildlife Service, is intended to be an interim sport fishery, as described under the Sport Fishery Development section of the Strategic Plan. The plan describes how the stocking of domestic Atlantic salmon would be phased out as the numbers of sea run Atlantic salmon returns to the Merrimack River increase.

The Atlantic Salmon Brood Stock Fishery is a strategy that assists the Department in achieving objectives 3.1, 7.2, 11.1 and 11.3 within its Strategic Plan (1998-2010) and addresses strategies 1.C.3, and 3.A.1 in the Strategic Plan and Status Review of the Anadromous Fish Restoration Program for the Merrimack River (1997).

<u>Project Costs</u>: $9,615.00

Salary: (1) Biologist II	75 hours x $50.83/hr =	$3,812.00
(1) Biologist I	75 hours x $36.04/hr =	$2,703.00
Equipment Costs:		$2,500.00
Equipment Maintenance Costs:		$ 100.00
In-State Travel Cost:		$ 500.00
		$9,615.00

Project Priority Score: 14 points

Ecological Importance:	Low	1 point
Public Interest:	Low	1 point
Economic Importance:	Low	1 point
Adequacy of Existing Data:	Low	1 point
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

<u>Project Title</u>: Restoration of Clupeids to the Merrimack River

<u>Project Objective</u>: 1) To restore self-sustaining American shad (*Alosa sapidissima*) and river herring (*Alosa psuedoharengus* and *Alosa aestivalis*) populations to the Merrimack River; and, 2) To monitor diadromous and resident fish passage at fishways within New Hampshire's waters of the Merrimack River.

<u>Project Work Description</u>: Available adult American shad and river herring captured at fishways at the Essex Dam on the Merrimack River and from coastal Massachusetts and New Hampshire rivers will be transported to suitable release locations within the Merrimack River watershed. Project personnel will continue to meet with representatives of the utility companies to discuss the efficiencies of fish passage facilities and to recommend modifications, if necessary, to improve upstream and downstream fish passage.

<u>Project Justification</u>: In 1969, formal efforts for a cooperative restoration program commenced when Massachusetts, New Hampshire, the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) mutually agreed to support such a program for the Merrimack River watershed. The United States Forest Service (USFS) formally joined the cooperative effort in 1982.

The recent relicensing of the Merrimack River Hydrolectric Project, which includes Amoskeag, Hooksett and Garvins Falls dams, by the Federal Energy Regulatory Commission has resulted in a new prescription for fish passage requirement. Based on estimates of potential shad production upstream of each dam, the prescription requires fishway construction at Hooksett Dam after the passage of 9,500 shad at Amoskeag and fishway construction at Garvins Falls after the passage of 9,800 shad at Hooksett. If nature-like or rock-ramp type fishways, which would not allow for the enumeration of shad, are constructed at the Hooksett dam, then an alternative trigger of 19,300 shad passed at Amoskeag will require fish passage to be built at Garvins Falls.

The Technical Committee for the Merrimack River Anadromous Fishery Restoration Program finalized an action plan for the program in March of 2000. Revisions to the plan are currently underway, with separate plans under development for each target species. The American shad strategic plan was finalized in 2010. The plan identifies the need to annually capture between 2,000 and 4,000 adults from the Essex Dam Fishway (Lawrence, MA) for transport and release at spawning sites in the watershed. A minimum target of 1,000,000 shad fry, spawned from adults captured at the Essex fish lift, will be stocked into New Hampshire reaches of the Merrimack River from the NNFH. The fry will have their otoliths marked with tetracycline, so that fish resulting from hatchery operations can be distinguished from wild fish for monitoring purposes (Lorson and Mudrak 1987).

Targets for river herring transfers from sources in Maine and the New Hampshire seacoast will be set during the revision of the river herring strategic plan. Stocking locations for river herring in the Merrimack River watershed have been identified by the USFWS and are currently being prioritized by the River Herring Subcommittee of the Merrimack River Technical Committee. Juvenile shad and river herring, resulting from stocked adults or hatchery released fry, will be monitored by barge electrofishing, visual observations at dams, or by beach seine, depending on the location.

Benefits from clupeid restoration initiative include: increasing population levels for these ecologically important species, providing an important forage base, mitigating predation on salmon smolt, enhancing recreational angling, and providing greater public awareness and support for the diadromous fish restoration program

Merrimack River Clupeid Restoration is a strategy that assists the Department in achieving objectives 2.1 and 4.1within its Strategic Plan (1998-2010) and addresses strategies 1.B and 1.C.5 in the Strategic Plan and Status Review of the Anadromous Fish Restoration Program for the Merrimack River (1997).

Project Costs: $16,661.00

Salary: (1) Biologist II	250 hours x $50.83/hr =	$12,708.00
(1) Biologist I	75 hours x $36.04/hr =	$ 2,703.00
Equipment Maintenance Costs:		$ 500.00
In-State Travel Cost:		$ 750.00
		$16,661.00

Project Priority Score: 19 points

Ecological Importance:	High	5 points
Public Interest:	Low-Moderate	2 points
Economic Importance:	Low	1 point
Adequacy of Existing Data:	High	5 points
Project Feasibility:	Low	1 point
Cost-Benefit Ratio:	High	5 points

Project Title: Restoration of Atlantic Salmon to the Connecticut River

Project Objective: To restore self–sustaining Atlantic salmon spawning runs to the Connecticut River. To stock approximately 60,000 Atlantic salmon fry and to obtain populations estimates of fall parr abundance at 15 index sites in the Connecticut River basin.

Project Work Description: Atlantic salmon eggs obtained from suitable stocks will be reared to the fry or smolt stage for release into the Connecticut River watershed. Due to flood damage during Hurricane Irene, the production of cultured Atlantic salmon for the Connecticut River Program will no longer occur at the White River National Fish Hatchery. Fry production will continue to occur, at reduced capacity, at Kensington State Fish Hatchery (KSFH) in Connecticut, Roger Reed State Fish Hatchery (RRSFH) in Massachusetts, and Roxbury State Fish Hatchery (RSFH) in Vermont.

Atlantic salmon fry (up to 3 million) and smolts (~100,000) will be released annually into selected Connecticut River watershed nursery streams at prescribed densities (CRASC 1998). Of this total, ~250,000 fry will be stocked in the Connecticut River's main stem and tributaries within New Hampshire's boundaries.

Juvenile Atlantic salmon are sampled at pre-determined index sites with a pulse DC backpack electrofishing unit during the months of August and September. The upstream and downstream boundaries of the index sites are blocked off with seines and a multiple pass depletion method is utilized at all index sites for analytical purposes. Fish are measured for total length (L) to the nearest millimeter (mm) and weighed (W) to the nearest gram (g). Fish condition values (K) are derived for >0+ parr using the formula: $K = (W/L^3)10^5$.

Pre-smolt production estimates are derived by expanding each cohort's estimated density per unit (100 yd^2) to the total units identified within the system. This estimate is then adjusted to incorporate fish size by calculating the proportion of individuals greater than 112 mm (4.5 inches) total length from the index site data. This adjustment is utilized to account for the correlation of fish size and smoltification rates. An over winter survival rate of 0.65 is applied to the pre-smolt population estimates to derive estimates of smolt run size for each stream (Sprankle 2000). The northernmost tributaries have estimates for age specific densities. Population estimates of fish at each index site are now derived using a BASIC program called Remove. The program uses maximum weighted likelihood estimation, based on Carle and Strub (1978), to calculate population size from a series of sequential capture efforts; associated statistics are derived using the formulas of Zippin (1956).

Atlantic salmon nursery habitat within the watershed will also be inventoried and monitored according to established criteria.

The New Hampshire Technical Committee representative of the Connecticut River Atlantic Salmon Commission attends regular scheduled Policy and Technical committee meetings annually. The representative is responsible for necessary program subcommittee activities outlined by the Policy Committee and coordinated by the U.S. Fish and Wildlife Service's program manager located at the Coordinators Office, Sunderland, MA.

Project Justification: The current Connecticut River Atlantic salmon restoration program began in 1967, when Connecticut, Massachusetts, New Hampshire, Vermont, USFWS, and NMFS signed a statement of intent to restore anadromous fish to the Connecticut River. The USFS formally joined the cooperative effort in 1979. In 1983, Congress passed the Connecticut River Basin Atlantic Salmon Compact, which formalized the state/federal agreements. This legislation has parallel legislation in each of the four basin states and spells out the responsibilities of the membership. The legislation authorizing the Commission was re-established by Congress in 2002. The *Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River Basin 1982* was revised in 1998 and provides the foundation for continued restoration of Atlantic salmon, into the 21st century.

The Atlantic Salmon Restoration Program for the Connecticut River Basin relies primarily on fry stocking to increase adult salmon returns to the river (although smolt stocking occurs). However, using this management strategy means the majority of smolt production is dependent on the quality and quantity of habitat available to juvenile Atlantic salmon (*Salmo salar*).

Since the amount of juvenile Atlantic salmon habitat has not been surveyed for all New Hampshire tributaries to the Connecticut River, a quantitative analysis of these streams may result in increased units being identified as suitable for stocking fry. Stocking additional habitat units with Atlantic salmon fry could increase smolt production in the watershed and theoretically increase adult returns.

In addition to determining the proper number of Atlantic salmon fry to stock within the Connecticut River basin, an assessment program enables annual evaluations and projections of smolt production to occur, which allows comparisons to be made among systems and years.

Connecticut River Atlantic Salmon Restoration is a strategy that assists the Department in achieving objectives 2.1and 4.1 within its Strategic Plan (1998-2010) and addresses objectives 1.A, 1.B, 1.C, 2.A, 3.A, 5.A, and 5.B in the Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River (1998).

Project Costs: $23,703.00

Salary:	(3) Biologist II	225 hours x $49.51/hr =	$11,139.00
	(3) Biologist I	225 hours x $41.38/hr =	$ 9,311.00
	Supervisor VI	15 hours x $63.55/hr =	$ 953.00
Equipment Costs:			$ 500.00
Equipment Maintenance Costs:			$ 300.00
In-State Travel Cost:			$ 1,500.00
			$23,703.00

Project Priority Score: 20 points

Ecological Importance:	High	5 points
Public Interest:	Low	1 point
Economic Importance:	Low	1 point
Adequacy of Existing Data:	High	5 points
Project Feasibility:	Moderate	3 points
Cost-Benefit Ratio:	High	5 points

Project Title: Restoration of Clupeids to the Connecticut River

Project Objective: 1) To restore and maintain self-sustaining American shad and river herring populations to their historic range in the Connecticut River, including the Ashuelot River; and, 2) To monitor diadromous and resident fish passage at fishways within New Hampshire's portion of the Connecticut River.

Project Work Description: Available pre-spawn adult American shad and river herring captured at and around fishways at the Holyoke Dam on the Connecticut River will be transported to suitable release locations within the Connecticut River watershed and the Ashuelot River.

Juvenile production will be documented and assessed, using visual surveys, in late summer/early fall in the Ashuelot River. When feasible, boat or backpack electrofishing and seining will be used to calculate catch per unit effort. Total length and weight of fish will be recorded.

The Vernon and Bellows Falls fishways will be monitored each spring (either live or video counts), given financial and staffing constraints. Project personnel will continue to meet with representatives of the utility companies to discuss the efficiencies of fish passage facilities and to recommend modifications, if necessary, to improve upstream and downstream fish passage.

Project Justification: Formal efforts to create a cooperative fishery restoration program in the Connecticut River Basin began in 1967 when the states of Massachusetts, New Hampshire, Vermont, and Connecticut, and the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) mutually agreed to support such a program. The United States Forest Service (USFS) formally joined the cooperative effort in 1982.

A management plan for American shad in the Connecticut River basin was written in 1982 by the Shad Studies Subcommittee (sub group of the Connecticut River Atlantic Salmon Commission's Technical Committee) and endorsed by the Connecticut River Atlantic Salmon Commission (CRASC 1992). The goal of this management plan is to "restore and maintain a spawning shad population to its historic range in the Connecticut River basin and to provide and maintain sport and the traditional in-river commercial fisheries for the species." A NH Fish and Game Department management plan for the restoration of migratory fish to the Ashuelot River basin (Sprankle 1998) calls for annual transfers to the Ashuelot River of 750 pre-spawn adult American shad and river herring.

In order to help facilitate the successful restoration of American shad and river herring to the Connecticut River, pre-spawn adult American shad and river herring should be captured, transported and stocked in the New Hampshire section of the Connecticut River and in the Ashuelot River. Additionally, fishway monitoring should be conducted to assess adult returns of these species and juvenile production should be assessed.

Connecticut River Clupeid Restoration is a strategy that assists the Department in achieving objectives 2.1 and 4.1within the Strategic Plan (1998-2010) and addresses objectives outlined in both the Management Plan for American Shad in the Connecticut River Basin (1991) and The Plan for the Restoration of Migratory Fishes to the Ashuelot River Basin, NH (1998).

Project Costs: $6,539.00

Salary: (2) Biologist II	88 hours x $53.86/hr =	$4,740.00
(1) Biologist I	23 hours x $35.78/hr =	$ 823.00
Equipment Costs:		$ 100.00
Equipment Maintenance Costs:		$ 100.00
In-State Travel Cost:		$ 776.00
		$6,539.00

Project Priority Score: 19 points

Ecological Importance:	High	5 points
Public Interest:	Low-Moderate	2 points
Economic Importance:	Low	1 point
Adequacy of Existing Data:	High	5 points
Project Feasibility:	Low	1 point
Cost-Benefit Ratio:	High	5 points

Project Title: Implementation of New Hampshire's Wildlife Action Plan

Project Objectives: 1) To assess the distribution, abundance, and status of fish species identified as being in greatest need of conservation because of declining population trends, unique habitat associations, low reproductive rates or other population and habitat characteristics that make them vulnerable to an increasingly developed landscape; 2) To assess key aquatic habitats essential to the conservation of the identified fish species; 3) To implement strategies to conserve the identified fisheries resources; and, 4) To monitor the effectiveness of conservation strategies and make adjustments in response to new information or changing conditions.

2012 Objectives:

1) To create distribution maps of New Hampshire's Fish Species of Concern accurate to a scale that will be useful to conservation organizations, town planners, government agencies, and the public.

Project Work Description:

Freshwater fish are among the most threatened fauna in the world (Richter et al. 1997). Eighteen fish species of concern were identified in New Hampshire's Wildlife Action Plan. Before the completion of the Wildlife Action Plan, there was very limited information on the current status of 9 of these 18 species (American brook lamprey, banded sunfish, bridle shiner, finescale dace, lake whitefish, northern redbelly dace, redfin pickerel, round whitefish, and swamp darter). Regional population declines, habitat loss, and limited dispersal abilities are common themes among several of these fish species. New Hampshire has undergone extensive land conversion since the presence of most of these species was recorded in the late 1930s.

Using historical species location records, a preliminary presence/absence investigation of these 9 fish species of concern was initiated in 2005. Comparisons of fish species records from these surveys with historical occurrences have yielded valuable information on the status of these species. Data collected from this survey, completed in 2008, resulted in the addition of the bridle shiner and the American brook lamprey to New Hampshire's state Threatened and Endangered Species List. This presence absence survey also provided valuable baseline data on the current distribution and status of the remaining 7 fish species of concern (along with other more common species).

Surveys of sites with historical fish records have been essential for setting management priorities, yet there is a need for more quantitative information on the distributions, habitat requirements, and status of New Hampshire's fish species of concern. Future measures will include the expansion of distribution surveys beyond the sites with historical records to create accurate distribution maps for each species. These maps will be used to identify potential threats on a scale that is meaningful for conservation work and environmental impact permit reviews. They will be used to identify and prioritize opportunities for protection or restoration.

The value of expanded distribution surveys has been demonstrated by recent work in the Oyster River Watershed. The American Brook Lamprey habitat mapping project (T7 Project I / Job 1.06), has proven to be an effective model for the use of distribution surveys and habitat mapping in the conservation of fish species of concern. The Oyster River Watershed contains the only documented population of American brook lampreys in New Hampshire. Until recently, the distribution and status of brook lamprey habitat in the watershed was unknown. Surveys conducted in 2007 and 2008 identified and mapped the occupied American brook lamprey habitat above the second dam upstream from the Great Bay estuary. An ongoing effort to communicate the results of this project has increased awareness of the American brook lamprey among local officials. Since the surveys were begun, the American brook lamprey has been the focus of conservation easement applications and stream crossing design. This model of collecting detailed information on the distribution of a species of concern, and then distributing that information to help guide conservation decisions, will be applied to species with wider distributions in the state. Expected results and benefits include:

- Detailed information on the distribution of fish species of concern and the habitats which support them. This information is valuable for guiding protection and restoration projects at the local scale on which most decisions are made. It is also important as baseline data for monitoring the status of the species over time and for evaluating the impacts of threats on multiple scales.
- The data collected will be entered into the Wildlife Sightings database, maintained by the Natural Heritage Bureau. This database is used during the permitting process to help reduce the impacts of development on species of concern.
- The data will also add to a growing fish database, which has a variety of applications, including:
    - Informing regional and state efforts to develop an aquatic habitat classification system based on aquatic species assemblages.
    - Providing the raw data for predictive models designed to fill in gaps in the database and better understand the factors that influence fish communities and their habitats. This modeling effort is important for tracking the success of broad scale conservation projects such as the Eastern Brook Trout Joint Venture.
    - Supporting a collaborative effort between NHFGD and NHDES to understand the influence of human activities on fish communities. By identifying the fish species in reference watersheds vs. impaired watersheds, patterns in fish distribution may be used to enforce water quality standards.

At least 30 sites will be surveyed annually. Sites will be selected based on the location and habitat conditions of sites with confirmed records of each species. Topographical maps, aerial photos, and GIS data will be used to identify the closest suitable habitat within the same watershed as sites with known records of fish species of concern. Priority will be given to surveys for American brook lamprey, bridle shiner, and round whitefish. The results of presence/absence surveys at sites with historical records found these three species to be at a higher level of risk than the 6 other fish species that were targeted.

Stream sampling techniques described in Barbour et al (1999) will be followed as closely as possible. Some deviation from these techniques (e.g. sample area lengths) may be needed based on sites and species found. A ¼" mesh bag seine will be used to sample fish in muddy habitats with thick vegetation. In shallow areas with firmer substrate, backpack electro-shockers will be the primary sampling method. NHFGD design fyke nets, gill nets, and a boat electro-shocker will be used in lakes and deep river habitats. A species is considered present at a site if one or more individuals are captured. Distribution maps will be created using GIS software. Suitable habitat adjacent to survey sites with confirmed records of a species will be assumed to be occupied to the nearest significant barrier to dispersal or change in habitat. Maps and technical assistance will be distributed to the appropriate town planners, watershed associations, and conservation organizations to create awareness and promote conservation of fish species of concern and the habitats that support them.

Attempts will be made to ensure impacts to fish and other aquatic biota are minimized. Fish species will be handled as little as possible and monitored periodically for stress while in captivity. All work will be conducted by NHFG Fisheries Division staff. This job does not directly involve any federally listed plants or animals, or significant disturbance of ground or habitats. Inland fisheries staff will seek guidance from the USFWS to avoid impacts to the federally listed dwarf wedge mussel when working in the Connecticut River watershed.

Project Justification: In 1997 the Office of State Planning (NHOSP) projected the human population residing in New Hampshire would be 1,206,000 by 2003. The 2003 census revealed the population had actually reached 1,288,000 and it will continue to grow, as the NHOSP projection for 2010 is 1,385,000. This level of population growth, along with the associated residential and commercial development that occurs, has resulted in adverse impacts to aquatic habitats and the fish populations it supports. As suburban fringes and rural lands are developed for homes, commerce, and transportation, the natural vegetative cover and soils are replaced with constructed artificial landscapes and impervious surfaces. When urbanization and the accompanying increase in watershed imperviousness occurs in areas that were once forests and fields, aquatic systems are affected by water quality-related problems such as non-point source pollution, increased water temperatures and sedimentation, which can cause the decline or loss of fish populations (USEPA 1997). Risk assessment and implementing and evaluating the resulting action strategies is an essential element in the long-term protection of New Hampshire's fish species and habitats identified as being in greatest need of conservation.

Implementation of New Hampshire's Comprehensive Wildlife Plan is a strategy that directly assists the Department in achieving objectives 1.1, 1.3, 2.1 and 4.1 within its Strategic Plan (1998-2010).

Project Costs: $13,272.00

Salary: (1) Biologist II	112.5 hours x $50.83/hr =	$5,718.00
(1) Biologist I	112.5 hours x $36.04/hr =	$4,054.00
Equipment Costs:		$1,500.00
In-State Travel Cost:		$2,000.00
		$13,272.00

Project Priority Score: 24 points

Ecological Importance:	High	5 points
Public Interest:	Moderate	3 points
Economic Importance:	Low	1 point
Adequacy of Existing Data:	High	5 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Project Title: Fish Species Database and Predictive Model Development

Project Objectives: To compile existing and future fish data into a single spatially linked database to be used for a variety of applications including species distribution mapping, aquatic habitat classification, and predictive model development.

2012 Objectives:

1) Gather all existing fish data and compile it into a single database that is compatible with Arcmap 9 GIS software.
2) Conduct fish surveys at selected sites to fill in gaps in the database.

Project Work Description: Fish data from a variety of projects will be carefully screened and compiled into a single database. The database will be structured for use with GIS mapping software. Single pass electrofishing surveys will be conducted at sites throughout the state, with the goal of adding fish data from habitats and regions that are under represented in the current database.

Project Justification: Mapping software and predictive models are increasingly powerful tools for use in fisheries conservation. Projects such as the Eastern Brook Trout Joint Venture, the New Hampshire Wildlife Action Plan, and the NHDES Biomonitoring Program have relied heavily on GIS analysis to guide conservation strategies. The reliability of species and habitat distribution maps and predictive models depends on the quality of data that are used in their development. Inaccuracies or biases in the dataset can have a major influence on the final product. Examples of ongoing projects that rely on biological data from field surveys include an ongoing effort to classify and map aquatic habitat types in the northeast, a coldwater habitat model to be used in water quality regulations, and the refinement of eastern brook trout status and distribution maps in New Hampshire. Confidence in the underlying dataset is critical if mapping and modeling tools are to be relied upon for decision making. This project will address the flaws in our current dataset and build a strong foundation for future conservation work.

Developing a fish species database and predictive model is a strategy that assists the Department in achieving objectives 1.1, 1.3, 2.1, and 4.1 within its Strategic Plan (1998-2010).

Project Costs: $30,061.00

Salary: (1) Biologist II	300 hours x $50.83/hr =	$15,249.00
(1) Biologist I	300 hours x $36.04/hr =	$10,812.00
Equipment Costs:		$ 1,000.00
In-State Travel Cost:		$ 3,000.00
		$30,061.00

Project Priority Score: 20 points

Ecological Importance:	High	5 points
Public Interest:	Moderate	1 point
Economic Importance:	Low	1 point
Adequacy of Existing Data:	Moderate	3 points

Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Fisheries Habitat Program

Program Need:

Fish abundance, as well as species composition, is affected by the quality of their aquatic habitat (Hubert and Bergersen 1998). Riparian and aquatic ecosystems are currently being altered, impacted or destroyed at a greater rate than any time in history (National Research Council 1992). Two primary anthropogenic causes of aquatic ecosystem dysfunction are land and water use practices (Kauffman et al. 1997). Land use practices that can have a detrimental affect on watersheds include sand and gravel mining, logging, road construction, landscape fragmentation, and agriculture. Water use practices that can degrade aquatic habitat include physical alteration of watercourses, flood control structures and practices, water flow diversion and consumption, and destruction or modification of wetlands.

Degradation of riparian zones and streams diminishes their capacity to provide critical ecosystem functions, including the cycling and chemical transformation of nutrients, purification of water, attenuation of floods, maintenance of stream flows and stream temperatures, recharging of groundwater, and establishment and maintenance of fish habitat (Kauffman et al. 1997). Recent scientific reviews of aquatic biological diversity and riverine health have urged a watershed approach as the most appropriate methodology to resolve fisheries declines (Naiman 1992; Doppelt et al. 1993; Williams et al. 1997). The watershed approach seeks to correct the underlying causes of habitat degradation rather than treat site-specific symptoms (Frissell 1997). Inherent in the watershed approach is the active involvement of those responsible for and concerned about managing land and water throughout the watershed, including various government agencies, private landowners, civic groups, industry, anglers, and conservation interests (Dombeck et al. 1997).

Program Goal:

To preserve, enhance, and restore New Hampshire's fisheries habitats at a watershed-scale so that viable fish communities can be supported for their intrinsic value and long-term benefits to the state.

Approach:

Fisheries habitat preservation, enhancement, and/or restoration will entail an initial resource analysis to evaluate the status of existing riparian and aquatic habitat within a watershed. Preserving intact and functional riparian and aquatic habitat will be the first priority in any watershed reclamation plan. To facilitate planning for the restoration of riparian and/or aquatic habitat within a watershed, habitats will be partitioned into one of three categories, those capable of rapid recovery, those with a slow rate of natural recovery, and those with little or no resilience capacity (Kauffman et al. 1997). Only after those riparian and aquatic habitats with high resilience capacity are improving or restored, will restoration efforts shift its focus to the other types.

A *passive* or *natural* approach will be undertaken first whenever riparian and aquatic habitat restoration activities are deemed feasible. This will be accomplished primarily by implementing strategies that will halt land and water use practices that are degrading the habitat or preventing its recovery. This natural recovery process will be monitored or assessed for a sufficient length of time in order to ascertain whether *active* restoration is necessary. *Active* restoration may include constructing instream structures, road removal or modification, stabilization of sediment sources, riparian planting, culvert replacements, etc. (Doppelt et al. 1993; William et al., 1997). The objective of *active* restoration will be to move the watershed toward the structure, function, or composition of the historic ecosystem based on an examination of local disturbance regimes and at several spatial scales (Roper et al. 1997). Monitoring of passive or active restoration activities recommended by Kershner (1998) will be conducted, at a minimum, using methods described by Bain and Stevenson (1999).

Expected Results And Benefits:

A watershed-scale approach to preserving, enhancing, and restoring New Hampshire's fisheries habitats will result in functional ecosystems that exhibit self-sustaining natural processes and linkages among its terrestrial, riparian, and aquatic components. This in turn will lead to long-term maintenance of instream fish habitat, fish community structure and fish population abundance.

Fisheries Habitat Program Action Plans

Project Title: Aquatic Habitat Restoration Support

Project Objective: To provide technical support to aquatic habitat restoration and protection activities in New Hampshire.

For 2012, the specific objectives are to provide technical expertise on:

1. dam removal projects,
2. aquatic habitat restoration projects (including the Nash Stream Restoration Project and lake habitat enhancement projects),
3. NHDES wetland and water quality rules through coordination with NHDES (specifically, serving as a technical expert on stream crossing design relative to fish passage and fluvial geomorphology, which will include making presentations on this subject to interested groups), and
4. reviews of environmental impacts relative to NHDES wetlands applications and NPDES permitting process.
5. Serve on various interagency committees including the Rivers Management Advisory Committee and the Technical Review Committees for the Souhegan and Lamprey Rivers Pilot Instream Flow Studies

Project Work Description: Stakeholder groups involved in river restoration and protection activities will be provided technical support and field activities will be conducted as needed. River restoration activities may include dam removals, restoration of instream and/or riparian habitat, restoration of geomorphology, or other restoration activities. Assessments of habitat and the use of habitat by fish prior to and after restoration activities will also be conducted in order to evaluate the effectiveness of each restoration activity. Technical reviews of environmental impacts, specifically during the wetland permitting process, which is done through the U.S. Army Corps of Engineers and NHDES, will include reviewing overall plans, engineering designs and site visits. Technical advice and the agency's position on issues affecting fish and wildlife will be communicated while on various interagency committees, including the Rivers Management Advisory Committee and the Technical Review Committees for the Souhegan and Lamprey Rivers Pilot Instream Flow Studies.

Project Justification: Many aquatic habitats in New Hampshire have been severely degraded leading to the subsequent negative impacts on fisheries resources they support.

Aquatic Habitat Restoration Support is a strategy that directly assists the Department in achieving objectives 1.1, 1.2, 2.1, and 3.1 within its Strategic Plan (1998-2010), and Strategies 3.2.3, 3.2.6, , and Objective 3.2 in the Action Plan, Adapting to Changing Times.

Project Costs: $52,960.00

Salary: (1) Biologist II	1000 hours x $52.96/hr =	$52,960.00

Project Priority Score: 28 points

Ecological Importance:	High	5 points
Public Interest:	Moderate-High	4 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	Moderate	4 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Project Title: Warmwater Habitat Improvement

Project Objective: To improve warmwater fish habitat and opportunities to fish for these species in selected lakes. Structures will be added to Harrisville Pond in 2012.

Project Work Description: A water body's need for installation of habitat structures will be based on a number of criteria, which may include a lack of existing structure, low abundance of sport or prey species, and/or poor growth or recruitment of sport or prey species. Initial assessments of existing structure will be made using visual observations, underwater cameras, and GPS/mapping software (completed in 2006). Assessments of fish populations will primarily be made via boat electrofishing, although NH design fyke nets may also be used (completed in 2006). Biological data collected will include relative abundance, relative weight, total length, weight, age, and growth (Gries and Racine 2005).

Small conifer trees (Christmas trees) were chosen for this project because they are a natural material and readily available. The trees were collected in winter 2006 from the Keene Transfer Station, but due to concerns raised by NHDES and the time needed to develop a fact sheet on the topic, we discarded the trees. Trees were again collected in winter 2009-2010 from the Keene Transfer Station. It is intended that several trees will be combined into one structure and for trees to sit vertically in the water column by anchoring the base to cement filled buckets or cinder blocks. Further specifics of what type of structure(s) to use, depth of placement and number of structures were determined on a water body specific basis taking into account particular project objectives (i.e. increase habitat for spawning, adult fish, species of interest, etc.) and reviewing available relevant literature.

Type, number, and depth of structures cannot be determined prior to assessments of each specific water body for a number of reasons. Use of structures by fish is variable and can depend on proximity and density of existing natural structure (Wilbur 1978; Rogers and Bergersen 1999; Hunt and Annett 2002; Hunt et al. 2002; Wills et al. 2004), depth of structure placement (Walters et al. 1991; Johnson and Lynch 1992), presence of other fish species (Johnson et al. 1988), water clarity (Johnson et al. 1988), season (Johnson and Lynch 1992; Moring and Nicholson 1994; Rogers and Bergersen 1999; Barwick et al. 2004), fish life stage or size (Johnson and Lynch 1992; Moring and Nicholson 1994), fish species (Johnson et al. 1988; Walters et al. 1991; Moring and Nicholson 1994; Richards 1997; Barwick et al. 2004; Wills et al. 2004), and type of structure used (Johnson and Lynch 1992; Moring and Nicholson 1994; Richards 1997; Rogers and Bergersen 1999; Wills et al. 2004). Additionally, density of natural littoral structure can depend on level of residential lakeshore development (Christensen et al. 1996).

Post-habitat assessments will be conducted after structures have been added and may include sampling of fish populations (see above; conducted at least one year after structure deployment), video observations during summer and winter to document fish use, and angling surveys (conducted at least one month after structure deployment). Angling data may be compared between control and treatment areas (Richards 1997). Comparisons may be made for biological data collected before and after habitat structures have been placed, although fish population responses to habitat enhancement can be difficult to detect (Tugend et al. 2002; Allen et al. 2003), especially at a large scale such as an entire water body (Barwick et al. 2004). Additionally, replication of habitat structure studies through use of multiple lakes is often needed to increase statistical power enough to detect significant differences (Carpenter et al. 1995).

Project Justification: Improving fish habitat by installing habitat structures is a common and successful strategy used by State management agencies across the United States. Frequent objectives of habitat improvement projects include increasing angler catch rates, creating nursery habitat for juvenile fish, and creating adult fish and spawning habitat (Tugend et al. 2002).

Habitat structures can improve warmwater fish habitat and opportunities to fish for these species through a number of mechanisms. Structures have been suggested to increase recruitment by providing spawning cover (Vogele and Rainwater 1975; Hunt et al. 2002) and can also act to increase nest success (Hunt and Annett 2002; Wills et al. 2004), quality of spawning habitat (Hunt and Annett 2002), spawning nest density (Wills et al. 2004), and juvenile habitat (Jackson et al. 2000; Allen et al. 2003; Barwick et al. 2004). Studies have also shown that fish abundance often increases or becomes concentrated in areas modified with structures (Johnson et al. 1988; Johnson and Lynch 1992; Moring and Nicholson 1994; Richards 1997; Rogers and Bergersen 1999; Barwick et al. 2004) and that angler catch rates are often higher in modified areas (Wickham et al. 1973; Wilbur 1978; Richards 1997; Johnson and Lynch 1992; Rogers and Bergersen 1999). Additionally, habitat improvements provide additional structure for aquatic invertebrates to colonize (Angermeier and Karr 1984; Moring and Nicholson 1994)

New Hampshire's black bass fish populations are highly utilized by anglers, with smallmouth (*Micropterus dolomieui*) and largemouth bass (*M. salmoides*) ranking among the top four species fished for by anglers (Responsive Management 1996 and 2004). Although sought by fewer anglers, yellow perch (*Perca flavescens*), pickerel (*Esox niger*) and white perch (*Morone saxitilis*) rank in the top ten among species fished for (Responsive Management 1996 and 2004). Because warmwater fisheries are sustained through natural reproduction and are popular with the state's anglers, the addition of habitat structures to improve warmwater fish habitat and angling opportunities is warranted.

According to the 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation, 168,000 anglers fished 1.87 million days for warmwater species in New Hampshire (panfish: 30,000 anglers fished 339,000 days; black bass: 105,000 anglers fished 1.264 million days; northern pike and chain pickerel: 33,000 anglers fished 268,000 days) (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau 2008). The level of angler participation in black bass fishing represented 53% of New Hampshire's freshwater anglers and 46% of the total days of fishing. Since the average trip expenditure for anglers fishing in New Hampshire is $30 per day, the total expenditures by anglers fishing for warmwater species equals approximately $56.13 million.

Installation of habitat structures will allow the Department to improve fish habitat for warmwater fish in New Hampshire. Additionally, involving anglers and bass tournament organizations in this process presents an excellent opportunity for the Department and anglers to work together towards the common goal of improving and sustaining New Hampshire's fisheries resources for current and future generations.

The Warmwater Habitat Improvement Project is a strategy that assists the Department in achieving objectives 2.1, 3.1, 6.1 and 16.1 within its Strategic Plan (1998-2010), and Strategy 3.2.3 and Objective 3.2 in the Action Plan, Adapting to Changing Times.

Project Costs: $4,583.00

Salary: (2) Biologist II	37.5 hours x $54.93/hr =	$2,060.00
(1) Biologist I	30.0 hours x $35.78/hr =	$1,073.00
Equipment Cost:		$ 500.00
Equipment Maintenance Costs:		$ 350.00
In-State Travel Cost:		$ 400.00
Construction Cost:		$ 200.00
		$4,583.00

Project Priority Score: 29 points

Ecological Importance:	High	5 points
Public Interest:	Moderate-High	4 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	High	5 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Project Title: Lake Horace Marsh Restoration

Project Objective: To restore a natural water level regime to Lake Horace Marsh to improve and protect the ecological integrity of the marsh for fish and wildlife habitat. Construction for the project was completed in late December 2008.

For 2012, the specific objective is to conduct at annual site visits and photodocument the conditions during these visits.

Project Work Description: Work on this project will consist primarily of providing technical expertise in the conceptual, design and construction phases of a water level control structure, and if needed, a fish passage structure. Technical considerations of the project include the habitat requirements, life history, behavior, and fish passage requirements of fish species of concern (chain pickerel, largemouth bass, yellow perch, white sucker, golden shiner, and common shiner).

An assessment of the fish using the marsh both before and after the water level structure is constructed will be needed. It is anticipated that the structure will be built in fall 2008. Fish were sampled using fyke nets and seines in the marsh in May and October 2005. These data provide a baseline of the use of the marsh by fish prior to the water level control structure being constructed. To assess the effectiveness of the project, fish sampling will also occur one, three, and five years after the structure is built.

The Fish and Game Commission approved the use of up to $35,000 from the Fisheries Habitat Fund to secure matching funds through a watershed grant from New Hampshire Department of Environmental Services (NHDES). The Piscataquog Watershed Association (now Piscataquog Land Conservancy) is the sponsor of the watershed grant. The total project cost is $187,267.

Project Justification: Lake Horace Marsh is at the upstream end of Lake Horace in the Town of Weare. The marsh is designated by NHDES as a "Prime" wetland. The marsh and lake are part of the North Branch Piscataquog River, one of the fourteen "Designated Rivers". The marsh is in a section of the river classified as a "Natural River". RSA 483:7-a defines natural rivers as the following:

"…(a) Natural rivers are free-flowing rivers or segments characterized by the high quality of natural and scenic resources. River shorelines are in primarily natural vegetation and river corridors are generally undeveloped. Development, if any, is limited to forest management and scattered housing. For natural rivers, the following criteria and management objectives shall apply:

(1) The minimum length of any segment shall be 5 miles.
(2) Existing water quality shall be not lower than Class B level pursuant to the water quality standards established under RSA 485-A:8.
(3) The minimum distance from the river shoreline to a paved road open to the public for motor vehicle use shall be 250 feet, except where a vegetative or other natural barrier exists which effectively screens the sight and sound of motor vehicles for a majority of the length of the river or segment.
(4) Management of natural rivers and segments shall perpetuate their natural condition as defined in this chapter and shall consider, protect, and ensure the rights of riparian owners to use the river for forest management, agricultural, public water supply, and other purposes which are compatible with instream public uses of the river and the management and protection of the resources for which the river or segment is designated."

The dam at the outlet of Lake Horace controlled the water elevation of both Lake Horace and Lake Horace Marsh. The dam is owned and operated by NHDES. The water elevation of Lake Horace is lowered approximately five feet, starting in mid-October, and raised approximately five feet starting in early to mid-May. Consequently, prior to the project's completion, much of the marsh is dewatered during the winter, and much of the substrate becomes frozen. The aquatic habitat in the marsh was impacted such that the emergent vegetation is primarily monotypic, and submerged aquatic vegetation is spatially limited to a relatively narrow area occupied by the river channel. Little or no submerged vegetation occurred in the dewatered areas.

The recreational fishery in Lake Horace is primarily for yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), panfish (including the recently introduced black crappie, *Poxomis nigromaculatus*), brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). Brown trout and rainbow trout are stocked by NHFGD. Yellow perch and chain pickerel spawn in shallow water very soon after ice-out, which typically occurs in mid-April. Yellow perch spawn at water temperatures of ~6°C to 13°C over submerged aquatic vegetation and brush at water depths of ~1.5 to 3 feet (Scott and Crossman 1973, Kreiger et al. 1983); chain pickerel spawn over submerged and emergent aquatic vegetation at water depths of 3 to 10 feet (Scott and Crossman 1973). Submerged aquatic vegetation is limited to a relatively narrow area of the river channel in water generally <3 feet deep, and emergent aquatic vegetation is generally above the water level in mid-April. Therefore, the spawning habitat for these two species was very limited in Lake Horace Marsh because of the winter drawdown. Additionally, largemouth bass typically move into shallow water areas to feed heavily (prior to spawning) and to locate spawning sites in the early spring, often before ice-out (Mayhew 1987, J. Magee personal observation). Because the water elevation in the marsh was not increased until early to mid-May, the operation of the dam at Lake Horace likely negatively impacted the ability of largemouth bass to feed and to locate spawning sites in the early spring.

Additionally, the water elevation of Lake Horace Marsh was decreased approximately five feet every fall at a time after which many reptiles and amphibians have prepared for winter by burrowing into the substrates in shallow water areas. Much of these shallow water areas were dewatered when the water level is decreased at the dam. These reptiles and amphibians cannot survive freezing temperatures. Strandings of amphibian larvae have been documented in 2004 immediately after the drawdown. Strandings of young-of-the-year brown bullhead (*Ameiurus nebulosus*) have been documented during the October drawdown prior to project completion. Providing a natural water level regime in Lake Horace Marsh (by eliminating the winter drawdown) will protect submerged and emergent aquatic vegetation, reptiles and amphibians. The submerged and emergent aquatic vegetation provide habitat and reptiles and amphibian provide a food source for fish species in the marsh and lake.

Lake Horace Marsh Restoration is a strategy that directly assists the Department in achieving objectives 1.1 and 2.1within its Strategic Plan (1998-2010), and Strategies 3.2.3 and 3.2.6, and Objective 3.2 in the Action Plan, Adapting to Changing Times.

<u>Project Costs</u>: $1,120.00

Salary: (1) Biologist II 15 hours x $52.96/hr = $794.00

(1) Biologist I	7.5 hours x $36.04/hr =	$270.00
In-State Travel Cost:		$ 56.00
		$1120.00

Project Priority Score: 28 points

Ecological Importance:	High	5 points
Public Interest:	Moderate-High	4 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	Moderate-High	4 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Project Title: Nash Stream Restoration

Project Objectives: 1) Assess the aquatic and riparian habitat, fish community, and water quality of Nash Stream, its tributaries, and lakes/ponds; 2) Identify potential stream restoration projects that would improve the physical habitat and ecological integrity of Nash Stream, its tributaries, and lakes/ponds; 3) Evaluate the feasibility of implementing each stream restoration project; and, 4) Conduct stream restoration projects with the greatest opportunity and likelihood of success.

Project Work Description: Work on this project will consist primarily of providing technical expertise and fieldwork in the assessment and restoration of aquatic and riparian habitat of Nash Stream, its tributaries, and lakes/ponds relative to fish. This will include, at a minimum, the following (#1-6 were completed in 2005-2007, and will be done again after restoration activities, and #7 will occur in 2006-2012):

1. Collecting and summarizing background data on the habitat and fish in Nash Stream, its tributaries and lakes/ponds.
2. Collecting additional data on the physical instream and riparian habitat including:
    a. Rosgen Level I, II, and III assessments in several sites in Nash Stream. These sites will likely be sites at which restoration activities are conducted and Rosgen assessments are made before and after restoration.
    b. Water temperature monitoring of at least three sites in Nash Stream and one site in each of the eight tributaries.
    c. Air temperature monitoring in the watershed at an intermediate elevation.
    d. Flow measurements at the same sites water temperature is monitored.
3. Identification, description, and assessment of stream crossings relative to fish passage and geomorphology.
4. Collecting data on the fish populations and macroinvertebrates.
5. Identify areas and causes of degradation and possible restorative actions to improve or correct the ecological conditions.
6. Identify potential negative impacts of restorative actions.
7. Conduct restoration activities (2006-2012).

Project Justification: The Nash Stream watershed is nearly wholly contained within the Nash Stream Forest, which is owned by the State of New Hampshire; therefore it offers a unique opportunity to restore the ecological integrity of a significant watershed. Based on recent (1990 – present) fish surveys, the wild brook trout population in Nash Stream is low in comparison to other New Hampshire streams and the survival of Atlantic salmon stocked as fry in Nash Stream is minimal (generally about 1% from fry to age 1 parr; the survival of most Atlantic salmon stocked as fry in northern New Hampshire is >1% - 9%). It is possible, however that age 0 and/or age 1 Atlantic salmon move downstream into the Ammonoosuc River in search of more preferred habitat (i.e., more cobble and small boulder and deeper water) because the habitat in Nash Stream is limited, as it consists almost entirely of shallow riffles (less suitable habitat).

Habitat surveys conducted in the early 1990s, indicates there is very little pool habitat in Nash Stream, a condition that has been attributed to a dam break and subsequent flood that occurred in 1969. The flood scoured most of the streambed of its medium-sized substrate and filled the pools that once existed in the stream. The lack of pool habitat may be limiting the growth and survival and ultimately the population of brook trout in Nash Stream and its tributaries, though anecdotal evidence suggests the physical habitat has changed since the 1990 surveys.

The United States Forest Service (USFS) owns the conservation easement on Nash Stream Forest. The USFS has conducted several stream restorations in northern New Hampshire and western Maine, and is interested in conducting similar restorations in the Nash Stream Forest. Additionally, Trout Unlimited (TU) has already received some funding for assessment activities in 2005 through the New Hampshire Charitable Foundation, and is interested in collaborating with, at a minimum, the USFS and New Hampshire Fish and Game Department.

Nash Stream Restoration is a strategy that directly assists the Department in achieving objectives 1.1, 1.3, and 2.1 within its Strategic Plan (1998-2010); and, objectives 1, 2, 4, and 5 for Fisheries Resources in the Nash Stream Forest Management Plan (NHDRED 2002), and Strategies 3.2.3 and 3.2.6, and Objective 3.2 in the Action Plan, Adapting to Changing Times.

Project Costs: $29,023.00

Salary: (1) Biologist II	500.0 hours x $52.96/hr =	$26,480.00
(1) Biologist I	37.5 hours x $52.32/hr =	$ 1,962.00
In-State Travel Cost:		$ 581.00
		$29,023.00

Project Priority Score: 30 points

Ecological Importance:	High	5 points
Public Interest:	High	5 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	High	5 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

<u>Project Title</u>: Water Temperature Metrics Analysis

<u>Project Objective</u>: To determine the water temperature metrics most useful to the management of individual fish species and entire fish communities within lotic systems.

For 2011-2012, the specific objectives are to (#1 was completed on a subset of data in 2006, #2-#4 will be completed in 2011-2012):

1. Determine the relationship between two temperature metrics (mean July water temperature and mean daily water temperature fluctuation) and young-of-year (YOY) brook trout (*Salvelinus fontinalis*) density and biomass,
2. Determine the relationship between two temperature metrics (mean July water temperature and mean daily water temperature fluctuation) and yearling and older (YAO) brook trout density and biomass,
3. Determine the values for the above temperature metrics at which brook trout are and are not present using presence/absence data, and
4. Determine the values for #3 at which all other species of fish are and are not present using presence/absence data.
5. Collaborate with other entities (specifically UNH, USEPA, Massachusetts Fish and Wildlife and NHDES, who are working on independent analyses of similar data)

<u>Project Work Description</u>: The work will be conducted in two phases, and the primary species of interest is brook trout. All aspects of the work will be coordinated with NHDES, specifically the Biomonitoring Program. For Phase I, the work on this project was conducted in 2005 and consisted of determining the type of data needed and planning required to analyze water temperature and fish data to meet the project objectives. Phase II work was nearly completed in 2006 and entailed the actual calculations of water temperature metrics and the relationship of those metrics to fish species presence and/or abundance. Objectives #1, 2, and 4 have been completed on the dataset that was available as of December 2006. Because data at approximately 5000 additional sites was collected in 2007-2010, the work in 2011-2012 will focus on analyzing this larger dataset.

<u>Project Justification</u>: Although much work has been conducted to determine the temperature tolerances of many fish species, most has been done in the laboratory. Additionally, most of those studies have used constant temperatures or changing temperatures that are not environmentally relevant (i.e., change at a rate faster than occurs in the natural environment). Thus, although the general temperature tolerances of fish species that inhabit New Hampshire waters are known, little empirical data collected in New Hampshire is available to justify management decisions based on water temperature and fish data collected at a given site. Currently, NHFGD biologists use specific metrics (e.g., the number of days in which the mean water temperature exceeded 70°F) and but also rely on professional judgment to identify cold water streams suitable for several management options. It is important to strengthen the quantitative metrics while retaining some ability to use professional judgment in making management decisions.

NHDES is responsible for regulating water quality standards in the state. Recently, NHDES has become interested in strengthening its ability to protect the water quality of first order streams, specifically as it relates to water temperature. Much of the brook trout habitat (based on water temperature) is in the first order streams of New Hampshire, but NHDES does not currently have empirical data to understand the link between water quality (i.e., water temperature) and biology (specifically, brook trout presence, abundance, and biomass per area) in first order streams. If NHDES had this type of quantitative information, NHDES would be able to more fully protect small lotic systems, and in turn, the fish communities that depend on them (specifically brook trout). It is essential that these small streams be protected as the water quality in them affects the water quality of all the streams into which they flow. For example, increasing the summer water temperature of a small stream that happens to offer the only summer refugia (from high water temperatures) for brook trout that seasonally inhabit areas downstream could effectively destroy the brook trout population in the system. In 2009, UNH received a grant from the USEPA to conduct similar analyses on water temperature metric relationships to wild brook trout in both New Hampshire and Massachusetts. NHFGD will work collaboratively with UNH, USEPA, Massachusetts Fish and Wildlife and NHDES on this work.

Additionally, NHFGD will be responsible for the implementation of New Hampshire's Wildlife Action Plan. Because many fish species are included in the plan, it is a requirement that NHFGD fully understand the habitat (in this case, water temperature) requirements of each of the species. Information on water temperature requirements may be available from the literature for some species, but it may no be applicable to fish in New Hampshire. Therefore, it is essential to determine the water temperature requirements for fish populations occurring in New Hampshire.

Water Temperature Metrics Analysis is a strategy that directly assists the Department in achieving objectives 1.1, 1.2, 1.3, 2.1, and 4.1within its Strategic Plan (1998-2010), and Strategy 3.2.3 and Objective 3.2 in the Action Plan, Adapting to Changing Times.

Project Costs: $1,986.00

Salary: (1) Biologist II	37.5 hours x $52.96/hr =	$1,986.00

Project Priority Score: 26 points

Ecological Importance:	High	5 points
Public Interest:	High	5 points
Economic Importance:	High	5 points
Adequacy of Existing Data:	Low	1 point
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Project Title: Instream Flow

Project Objective: To provide technical expertise on instream flow policies for the State of New Hampshire and to assist in developing policies for instream flow.

For 2012, the specific objectives are to:

1. Provide technical expertise to the Pilot Instream Flow Study and resultant legislation for the Lamprey River, and
2. Contribute to the development of New Hampshire Instream Flow Rules by participating in meetings on this subject.

Project Work Description: Work on this project will consist primarily of providing technical expertise on habitat requirements of fish and the amount of habitat needed relative to instream flow rules. This will be accomplished by coordinating the development of instream flows policies in New Hampshire with NHDES, the USFWS, other state and federal agencies, and other stakeholders to the instream flow rules.

Project Justification: Aquatic habitat is affected by many factors. Water withdrawals for agriculture, water supply, municipal and commercial purposes, and operations of dams at hydroelectric projects and for flood management directly affect the amount of water, and thus the amount and type of aquatic habitat in a given body of water. Additionally, development can have indirect effects on aquatic habitat by causing alterations in the hydrology of a watershed and by serving as a source and conduit for pollutants that enter a waterbody. Protecting instream flows is essential because of the direct role it plays in determining the amount and quality of aquatic habitat in streams, especially given the rapid rate of development that is occurring in New Hampshire.

Instream flow is one of the key protection measures provided for under the Rivers Management and Protection Act (RSA 483). The Act gives the NHDES the authority and responsibility to maintain flow to support instream public uses in rivers that have been designated by the Legislature for special protection under RSA 483.

In 2002, a broad coalition of New Hampshire business and conservation interests joined together to enact compromise legislation which became Chapter 278, Laws of 2002 (from House Bill 1449-A) that calls for a pilot program for instream flow protection on two of the fourteen designated rivers - the Lamprey River in the coastal watershed and the Souhegan River in the Merrimack watershed. With the advice and input of the statewide Rivers Management Advisory Committee (RMAC), NHDES adopted Instream Flow Rules (Env-Ws 1900) effective May 29, 2003 that apply to the Souhegan and Lamprey Rivers. The rules describe the process for conducting a Protected Instream Flow study and developing a Water Management Plan to implement the study results. If the pilot program were successful, the rules would be amended before they could be applied to other Designated Rivers.

Instream Flow is a strategy that directly assists the Department in achieving objectives 1.1, 1.2, 1.3, 2.1, and 4.1 within its Strategic Plan (1998-2010), and Strategy 3.2.3 and Objective 3.2 in the Action Plan, Adapting to Changing Times.

Project Costs: $1,986.00

Salary: (1) Biologist II	37.5 hours x $52.96/hr =	$1,986.00

Project Priority Score: 27 points

Ecological Importance:	High	5 points
Public Interest:	Low-High	4 points
Economic Importance:	Low-High	4 points
Adequacy of Existing Data:	Moderate-High	4 points
Project Feasibility:	High	5 points
Cost-Benefit Ratio:	High	5 points

Appendix Table I. Project costs and priority scores.

Project Title	Project Cost	Project Priority Score
Black Bass Tournament Assessment	$27,706.00	30
Wild Brook Trout Assessment	$72,417.00	30
Nash Stream Restoration	$29,023.00	30
Black Bass/Warmwater Fish Community Assessment	$44,596.00	29
Warmwater Habitat Improvement	$4,583.00	29
Lake Horace Marsh Restoration	$1,120.00	28
Instream Flow	$1,986.00	27
Quality Brook Trout Assessment	$16,831.00	27
Forage Fish Assessment	$28,959.00	27
Aquatic Habitat Restoration Support	$52,960.00	27
Water Temperature Metrics Analysis	$1,986.00	26
Landlocked Salmon Population Assessment	$73,613.00	24
Implementation of NH's Wildlife Action Plan	$13,272.00	24
Cultured Trout Use and Assessment	$2,433,232.00	23
Lake Trout Population Assessment	$6,939.00	23
Tributary Spawning Rainbow Smelt Assessment	$18,869.00	21
Merrimack River Atlantic Salmon Restoration	$31,733.00	20
Connecticut River Atlantic Salmon Restoration	$23,703.00	20
Fish Species Database and Predictive Model Development	$30,061.00	20
Merrimack River Clupeid Restoration	$16,661.00	19
Connecticut River Clupeid Restoration	$6,539.00	19
Walleye Assessment	$4,075.00	18
Atlantic Salmon Brood Stock Fishery	$9,615.00	14
Total Costs	$2,950,479.00	

Appendix Table II. Project Priority Rating Criteria.

Ecological Importance:

Self-Sustaining Fishery or Restoration of a Fish Population	High = 5 points
Put-Grow-and-Take Fishery	Moderate = 3 points
Put-and-Take Fishery	Low = 1 point

Public Interest:

Angler Preference Rank 1-5 or Public Support is ≥ 75%	High = 5 points
Angler Preference Rank 6-10 or Public Support is 50-75%	Moderate = 3 points
Angler Preference Rank >10 or Public Support is <50%	Low = 1 point

Economic Importance:

Days of fishing > 1,000,000	High = 5 points
Days of fishing = 100,000-1,000,000	Moderate = 3 points
Days of fishing <100,000	Low = 1 point

Note: Days of fishing data should be obtained from the most recent (currently 2006) National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Adequacy of Existing Data:

No data exists or needs to be collected annually	High = 5 points
Existing data is inadequate	Moderate = 3 points
Existing data needs to be updated	Low = 1 point

Project Feasibility:

Required personnel & financial resources are available	High = 5 point
Requires additional personnel <u>or</u> financial resources	Moderate = 3 points
Requires additional personnel <u>and</u> financial resources	Low = 1 point

Cost-Benefit Ratio:

Benefit(s) exceeds cost(s)	High = 5 points
Benefit(s) equals cost(s)	Moderate = 3 points
Cost(s) exceeds benefit(s)	Low = 1 point

Appendix Table III. Referenced strategic plan objectives and strategies.

<u>New Hampshire Fish and Game Department Strategic Plan (1998-2010)</u>

Objective 1.1: By 2010, sustain critical and essential habitats by implementing appropriate conservation measures.

Objective 1.2: Maintain and/or enhance overall wildlife values of other significant lands and waters while providing appropriate access.

Objective 1.3: Manage and protect habitat for specific species as indicated by species management plans.

Objective 2.1: Achieve species population goals using the best scientific methods and management practices available.

Objective 3.1: Maintain an overall high satisfaction rate among the various users of New Hampshire's fish, wildlife, and marine resources.

Objective 4.1: Monitor large-scale land and water use activities affecting fish, wildlife, and marine resources and recreational opportunities.

Objective 6.1: By July 1, 1999, implement an ongoing process for gathering and utilizing information from the public to help guide the Department's planning and decision making.

Objective 7.2: By 2010, increase by 50 percent (from 12,000 to 18,000) the number of New Hampshire residents and visitors who participate annually in one or more of the Department-sponsored outdoor recreation-related educational activities.

Objective 8.1: Effectively communicate to the public about the mission, goals, and activities of the Fish and Game Department.

Objective 11.1: Create a 75% participation level in fish, wildlife, and marine resource-related recreation (based on the U.S. Fish and Wildlife Survey).

Objective 13.1: The Fish and Game Department is guided and managed according to a comprehensive management plan.

Strategy/action 13.1.3: By July 1, 1998, complete operational plans based on the strategic plan.

Strategy/action 13.1.4: Evaluate and review priorities and strategic and operational plans every 2 years, congruent with the budget biennium.

Strategy/action 13.1.6: Continually assess and evaluate the impact of Department actions on fish, wildlife and marine resources and their habitats.

Objective 13.2: Department decision-making is based on the best technical and professional information available, consideration of public opinion, and a broad range of input from Department staff.

Strategy/action 13.2.1: The Department and each division will annually assess the long and short-term information needed to make decisions and develop strategies to obtain it.

Objective 16.1: By March 1, 1998, implement a standard process for handling historical and current data and information.

Strategic Plan and Status Review of the Anadromous Fish Restoration Program for the Merrimack River (1997)

Strategy 1.B. Identify and implement initiatives to restore stocks of target species.

Strategy 1.B.1. Produce Atlantic salmon fry and smolts to meet program needs.

Strategy 1.C.1. Develop and implement an evaluation and monitoring plan to (1) continue basin wide estimates of fall parr abundance (tributary specific preferred), (2) obtain an annual basin wide smolt production index (tributary specific preferred), (3) determine timing of smolt migration within the Merrimack River watershed and (4) identify and quantify the sources of smolt mortality that occurs in the river and estuary.

Strategy 1.C.3. Continue to provide for evaluation of the domestic broodstock releases (sport fishery, natural reproduction, fish movement, etc.) to maximize their benefit to the Merrimack River program.

Strategy 1.C.4. Refine instream habitat evaluation to best use hatchery Atlantic salmon products (eggs, unfed fry, fry, parr, and smolts).

Strategy 1.C.5. Monitor existing upstream and downstream fish passage facilities and modifications for efficiency in passing American shad, river herring, and Atlantic salmon.

Strategy 3.A.1. Continue to utilize domestic broodstock for the Domestic Broodstock Sport Fishery such that harvest of 1,000 fish (includes fish caught and released) can be achieved.

Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River (1998)

Objective 1.A. Produce 15 million Atlantic salmon eggs annually from Connecticut River strain of fish to fully support the Restoration and Management Program.

Objective 1.B. Produce and stock 10 million Atlantic salmon fry annually.

Objective 1.C. Produce and stock a minimum of 100,000 hatchery Atlantic salmon smolts annually.

Objective 2.A. Protect, maintain and restore existing Atlantic salmon habitat in 38 selected tributaries.

Objective 3.A. Support scientific management of sea-run Atlantic salmon populations.

Objective 5.A. Conduct monitoring, evaluation, and research to improve effectiveness of the Program.

Objective 5.B. Identify information gaps, problems, and management issues.

Adapting to Changing Times Action Plan

Objective 3.2 Grow the number of partnerships the Department is actively involved with.

Strategy 3.2.3 Establish stronger relationships among other state and federal natural resource agencies.

Strategy 3.2.6 Improve the Department's coordination and use of volunteers and implement processes that recognize volunteer efforts.

Literature Cited

Allen, M. S., Tugend, K. I., and Mann, M. J. 2003. Largemouth bass abundance and angler catch rates following a habitat enhancement project at Lake Kissimmee, Florida. North American Journal of Fisheries Management 23: 845-855.

Anderson, R.O. and R.M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 *in* B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd Edition. American Fisheries Society, Bethesda, Maryland.

Angermeier, P. L. and Karr, J. R. 1984. Relationship between woody debris and fish habitat in a small warmwater stream. Transactions of the American Fisheries Society 113: 716-726.

Argyle, R.L. 1992. Acoustics as a tool for the assessment of Great Lakes forage fishes. Fisheries Research, 14:179-196.

Bain, M.B., and N.J. Stevenson, editors. 1999. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, Maryland.

Barwick, R. D., Kwak, T. J., Noble, R. L., and Barwick, D. H. 2004. Fish populations associated with habitat-modified piers and natural woody debris in Piedmont Carolina reservoirs. North American Journal of Fisheries Management 24: 1120-1133.

Brown, R.W. 1994. Reproduction, early life history, and recruitment of rainbow smelt in St. Martin Bay, Lake Huron. Doctoral dissertation. Michigan State University, East Lansing. 176p.

Carle, F.L., and M.R. Strub. 1978. A new method for estimating population size from removal data. Biometrics 43:621-630.

Carpenter, S. R., Cunningham, P., Gafny, S., Munoz-Del-Rio, A., Nibbleink, N., Olson, M., Pellett, T., Storlie, C., and Trebitz, A. 1995. Response of bluegill to habitat manipulations: power to detect effects. North American Journal of Fisheries Management 15: 519-527.

Christensen, D. L., Herwig, B. R., Schindler, D. E., and Carpenter, S. R. 1996. Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. Ecological Applications 6: 1143-1149.

Connecticut River Atlantic Salmon Commission. 1998. The strategic plan for the restoration of Atlantic salmon to the Connecticut River. Connecticut River Atlantic Salmon Commission. Sunderland, Massachusetts.

Dolloff, C.A., D.G. Hankin, and G.H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. Gen. Tech. Rep. SE-83. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 25 pp.

Dombeck, M.P., J.E. Williams, and C.A. Wood. 1997. Watershed restoration: social and scientific challenges for fish biologists. Fisheries Vol. 22 (5): 26-27.

Doppelt, B., M. Scurlock, C. Frissel, and J. Karr. 1993. Entering the watershed: a new approach to save America's river ecosystems. Island Press, Washington, DC.

Frissell, C. A. 1997. Ecological principles. *In* J.E. Williams et al., eds. Watershed restoration: principles and practices. American Fisheries Society, Bethesda, MD.

Gablehouse, D. W. 1984. A length categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Gries, G., and M. Racine. 2005. Warmwater population assessments in New Hampshire (2004). F-50-R-21 Project Segment Report. New Hampshire Fish and Game Department. Concord, NH. 42 pp.

Gustafson, K. A. 1988. Approximating confidence intervals for indices of fish population size structure. North American Journal of Fisheries Management 8:139-141.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. and Aqua. Sci. 45(5): 834-844.

Hubert, W.A., R.D. Gibson, and R.A. Whaley. 1994. Interpreting relative weights of lake trout stocks. North American Journal of Fisheries Management. 14: 212-215.

Hubert, W.A. and E.P. Bergersen. 1998. Define the purpose of habitat analysis and avoid the activity trap. Fisheries Vol. 23 (5): 20-21.

Hunt, J. and Annett, C. A. 2002. Effects of habitat manipulation on reproductive success of individual largemouth bass in an Ozark reservoir. North American Journal of Fisheries Management 22: 1201-1208.

Hunt, J., N. Bacheler, E. Videan, D. Wilson, and C. Annett. 2002. Enhancing largemouth bass spawning: behavioral and habitat considerations. Pages 277-290 *in* D.P. Phillips and M.S. Ridgway, editors. Black bass: ecology, conservation, and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Jackson, J. R., Noble, R. L., Irwin, E. R., and Van Horn, S. L. 2000. Response of juvenile largemouth bass to habitat enhancement through addition of artificial substrates. Proc. Annual Conf. Southeast. Assoc. Fish and Wildl.Agencies 13 pp.

Johnson, D. L., Beaumier, R. A., and Lynch, W. E., Jr. 1988. Selection of habitat structure interstice size by bluegills and largemouth bass in ponds. Transactions of the American Fisheries Society 117: 171-179.

Johnson, D. L. and Lynch, W. E., Jr. 1992. Panfish use of and angler success at evergreen tree, brush, and stake-bed structures. North American Journal of Fisheries Management 12: 222-229.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries Vol. 22 (5): 12-24.

Kershner, J.L. 1997. Monitoring and adaptive management. Pages 116-131 in J.E. Williams, C.A. Wood, and M.P. Dombeck, editors. Watershed restoration: principles and practices. American Fisheries Society, Bethesda, Maryland.

Kolander, T. D., D. W. Willis, and B. R. Murphy. 1993. Proposed revision of the standard weight equation for smallmouth bass. North American Journal of Fisheries Management 13: 398-400.

Kwak, T.J. and T.F. Waters. 1997. Trout production dynamics and water quality in Minnesota streams. Transactions of the American Fisheries Society Vol. 126 (1): 35-48.

Mayhew, J. (editor). 1987. Iowa Fish and Fishing. Iowa Department of Natural Resources, Des Moines, Iowa. 323 pp.

Merrimack River Policy Committee. 1988. Merrimack River basin fish passage action plan for anadromous fish. Revised 1997. Merrimack River Coordinators Office. Nashua, New Hampshire.

______ 1997. The strategic plan and status review of the anadromous fish restoration program for the Merrimack River. Merrimack River Policy Committee. Nashua, New Hampshire.

Miller, D.R. and J.A. Viar. 2001. A comparison of landlocked salmon size statistics for three New Hampshire lakes, 2000. NHFGD. F-50-R-17. Concord, NH. 23 p.

Miller, D.R. and J.A. Viar. 2002. A comparison of landlocked salmon size statistics for three New Hampshire lakes, 2001. NHFGD. F-50-R-18. Concord, NH. 23 p.

Miller, D.R. and J.A. Viar. 2003. A comparison of landlocked salmon size statistics for three New Hampshire lakes, 2002. NHFGD. F-50-R-19. Concord, NH. 27 p.

Miller, D.R. and J.A. Viar. 2004. A comparison of landlocked salmon size statistics for three New Hampshire lakes, 2003. NHFGD. F-50-R-20. Concord, NH. 26 p.

Moring, J. R. and Nicholson, P. H. 1994. Evaluation of three types of artificial habitats for fishes in a freshwater pond in Maine, USA. Bulletin of Marine Science 55: 1149-1159.

Mundahl, N.D. and R.A. Sagan. 2005. Spawning ecology of the American brook lamprey, *Lampetra appendix*. Environmental Biology of Fishes 73:283-292.

Murphy B.R., D.W. Willis, and T.A. Springer. 1991. The relative weight index in fisheries management: status and needs. Fisheries (16) #2. American Fisheries Society. Bethesda, MD.

Naiman, R.J., ed. 1992. Watershed management: balancing sustainability and environmental change. Springer-Verlag, New York.

National Research Council. (U.S.) Committee on restoration of aquatic ecosystems-science, technology and public policy. 1992. Restoration of aquatic ecosystems. National Academy Press, Washington, DC.

New Hampshire Department of Resources and Economic Development. 2002. Nash Stream Forest Management Plan.

New Hampshire Fish and Game Department. 1981. Strategic plan for the management of lake trout in New Hampshire, Part One. Concord, NH. 51 p.

______ 1982. Fisheries management plan for rainbow smelt (*Osmerus mordax*). New Hampshire Fish and Game Department, Concord. 11p.

______ 1999. Stream sampling manual. 17 pp.

Normandeau, D. 1963. The Life History of the Round Whitefish *Prosopium cylindraceum* Pallas, of Newfound Lake, N.H. 115p.

Perry, S.G. 1998. Interpreting relative weights of New Hampshire lake trout stocks. A Final Report. New Hampshire Fish and Game Department. Concord, NH. 13 pp.

Piccolo, J.J., W.A. Hubert, and R.A. Whaley. 1993. Standard weight equation for lake trout. North American Journal of Fisheries Management. 13:401-404.

Pollock, K.H., C.M. Jones, and T.L. Brown. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society Special Publication 25.

Responsive Management. 1996. New Hampshire freshwater angler survey. Responsive Management, Harrisonburg, VA.

______ 2004. New Hampshire angler survey: resident anglers' participation in and satisfaction with fishing and their opinions on fishing issues. Responsive Management, Harrisonburg, VA.

Richards, T. 1997. Placement and monitoring of synthetic and evergreen tree fish attracting devices. Massachusetts Division of Fisheries and Wildlife. Westborough, MA. 20 pp.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board Of Canada 191:382p.

Rogers, K. B. and Bergersen, E. P. 1999. Utility of Synthetic Structures for Concentrating Adult Northern Pike and Largemouth Bass. North American Journal of Fisheries Management 19: 1054-1065.

Roper, B.B., J.J. Dose, and J.E. Williams. 1997. Stream restoration: is fisheries biology enough? Fisheries Vol. 22 (5): 6-11.

Rosgen, D. 1996. Applied River Morphology, Wildland Hydrology, Pagosa Springs Colorado.

Scarola, J.F. 1987. Freshwater fishes of New Hampshire. NHFGD. Concord, NH. 132 p.

Scott, W. B., Crossman, E. J., 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada - Bulletin 184.

Seamans, R.G. and A.E. Newell. 1973. Management of lake Atlantic salmon (*Salmo salar*) in New Hampshire. New Hampshire Fish and Game Department, Concord. 92p.

Simonson, T. D., J. Lyons, and P. D. Kanehl. 1993. Guidelines for evaluating fish habitat in Wisconsin streams. Gen. Tech. Rep. NC-164. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 36 pp.

Stolte, Lawrence W. 1981. The forgotten salmon of the Merrimack. U.S. Government Printing Office, Washington, D.C. 214 pages.

Sprankle, K. 1998. Plan for the restoration of migratory fishes to the Ashuelot River basin, New Hampshire. F62R Project Segment Report. New Hampshire Fish and Game Department. Concord, NH.

______ 2000. Wild brook trout population assessments in southwest New Hampshire. F-50-R-16 Project Segment Report. NH Fish and Game Department, Concord, NH.

______ 2000. Atlantic salmon index site summary for the Connecticut River Basin (1999). F-50-R-16 Project Segment Report. NH Fish and Game Department, Concord, NH.

Tugend, K. I., Allen, M. S., and Webb, M. 2002. Use of artificial habitat structures in U.S. lakes and reservoirs: a survey from the southern division AFS reservoir committee. Fisheries 27: 22-27.

U.S. Atlantic Salmon Assessment Committee. 2004. Annual Report of the U.S. Atlantic Salmon Assessment Committee. Report No. 16. Woodshole, MA.

U. S. Environmental Protection Agency. 1994. EMAP Surface waters field operations manual for lakes. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

______ 1997. Urbanization and streams: studies of hydrologic impacts. EPA-841-R-87-009. Washington, D.C.

U. S. Department of Interior, Fish and Wildlife Service, and U. S. Department of Commerce, U.S. Bureau of the Census. 2008. 2006 National survey of fishing, hunting, and wildlife associated recreation.

Van Deventer, J.S. and W.S. Platts. 1985. A computer software system for entering, managing, and analyzing fish recapture data from streams. U.S. Forest Research Note INT-352.

Viar, J.A. 2002. Lake trout spawning stock assessment, Newfound Lake. New Hampshire Fish and Game Department. F-50-R-18, Job 3, Concord, NH. 20 p.

Viar, J.A. 2003. Lake trout spawning stock assessment, Lake Winnipesaukee. NHFGD. F-50-R-19, Job 3, Concord, NH. 18 p.

Vogele, L.E., and W.C. Rainwater. 1975. Use of brush shelters as cover by spawning black basses (*Micropterus*) in Bull Shoals Reservoir. Transactions of the American Fisheries Society 104: 264-269.

Walters, D.A., W.E. Lynch, Jr., and D.L. Johnson. 1991. How depth and interstice size of artificial structures influence fish attraction. North American Journal of Fisheries Management 11: 319-329.

Wege, G. J. and R. O. Anderson. 1978. Relative weight: a new index of condition for largemouth bass. *In* New approaches to the management of small impoundments. Special publication 5., North Central Division, American Fisheries Society. Washington, D.C.

Wentworth,R. 1993. Estimating population size using the removal method. Vermont Department of Fish and Wildlife. Waterbury, VT.

Whelan, G.E. and W. W. Taylor . 1984. Fisheries Report. ELF Communications Systems Monitoring Program. Annual report for ecosystem tasks 5.8, 5.9, 5.10 for ITT Research Institute, Chicago, IL. U.S. Navy Electronics System Command, Technical Report EO6548-8,Washington, D.C.

Wickham, D.A., J.W. Watson, Jr., and L.H. Ogren. 1973. The efficacy of midwater artificial structures for attracting pelagic sport fish. Transactions of the American Fisheries Society 102: 563-572.

Wilbur, R.L. 1978. Two types of fish attractors compared in Lake Tohopekaliga, Florida. Transactions of the American Fisheries Society 107: 689-695.

Williams, J.E., C.A. Woods, and M.P. Dombeck. 1997. Watershed restoration: principles and practices. American Fisheries Society, Bethesda, MD.

Wills, T. C., Bremigan, M. T., and Hayes, D. B. 2004. Variable effects of habitat enhancement structures across species and habitats in Michigan reservoirs. Transactions of the American Fisheries Society 133: 399-411.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.