IP(09)07

Protection, Restoration and Enhancement of Salmon Habitat
Focus Area Report

USA

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1. Introduction

The known historic natural range of Atlantic salmon in United States (U.S.) rivers was from the Housatonic River in the south to the St. Croix River in the north (Kendall 1935, Scott and Crossman 1973). In fact, anadromous Atlantic salmon were native to nearly every major river north of the Hudson River (Atkins 1874, Kendall 1935; Figure 1).

Historically, the salmon rivers of the (U.S.) were remarkably productive. The annual historic Atlantic salmon adult population returning to U.S. rivers has been estimated to be between 300,000 (Stolte 1981) and 500,000 (Beland 1984). The largest historical salmon runs in New England were likely in the Connecticut, Merrimack, Androscoggin, Kennebec, and Penobscot Rivers (DeRoche 1967, Baum 1983). Atkins and Foster (1867) estimated that the Penobscot alone held 100,000 adults annually.

By the early 1800s, the Atlantic salmon runs in New England had been severely depleted, greatly reducing the species' distribution in the southern half of its range. The earliest impacts were from fishing, water quality degradation, and barriers to migration caused by waste disposal and waterpower development associated with the Industrial Revolution. Restoration efforts were initiated in the mid-1800s, but had little success due to the presence of dams and the inefficiency of early fishways (Stolte 1981). Natural Atlantic salmon runs had disappeared from southern New England Rivers by 1865. There was a brief period in the late 19th Century when limited runs were reestablished in the Merrimack and Connecticut Rivers by artificial propagation, but these runs were extirpated by the end of the century (USFWS 1989). Salmon runs in the large rivers south of the Kennebec River, Maine, disappeared during this same period (Atkins 1874, Kendall 1935). By the end of the 19th Century, three of the five largest salmon populations in New England (in the Connecticut, Merrimack, and Androscoggin Rivers) had been eliminated, shifting the southern extent of the species' distribution approximately 2 degrees north in latitude and 4 degrees east in longitude (Colligan et al. 1999).

The abundance of Atlantic salmon generally continued to decline in all remaining rivers with salmon populations through the last half of the 19th Century and first half of the 20th Century. By the mid-20th Century, the total adult run of Atlantic salmon to U.S. rivers had declined from hundreds of thousands of fish in the early part of the previous century to a probable range of 500 to 2,000 fish, mostly in rivers in eastern Maine (Baum and Jordan 1982, Beland et al. 1982, Fletcher et al. 1982, Fletcher and Meister 1982, Meister 1982, Baum 1983, Dube 1983).

Currently, several rivers in Maine contain Atlantic salmon populations that are protected under the federal Endangered Species Act within the Gulf of Maine distinct population segment (GOM DPS; Figure 2). The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) are also currently considering extending the protections of the Endangered Species Act to additional populations in Maine. If the

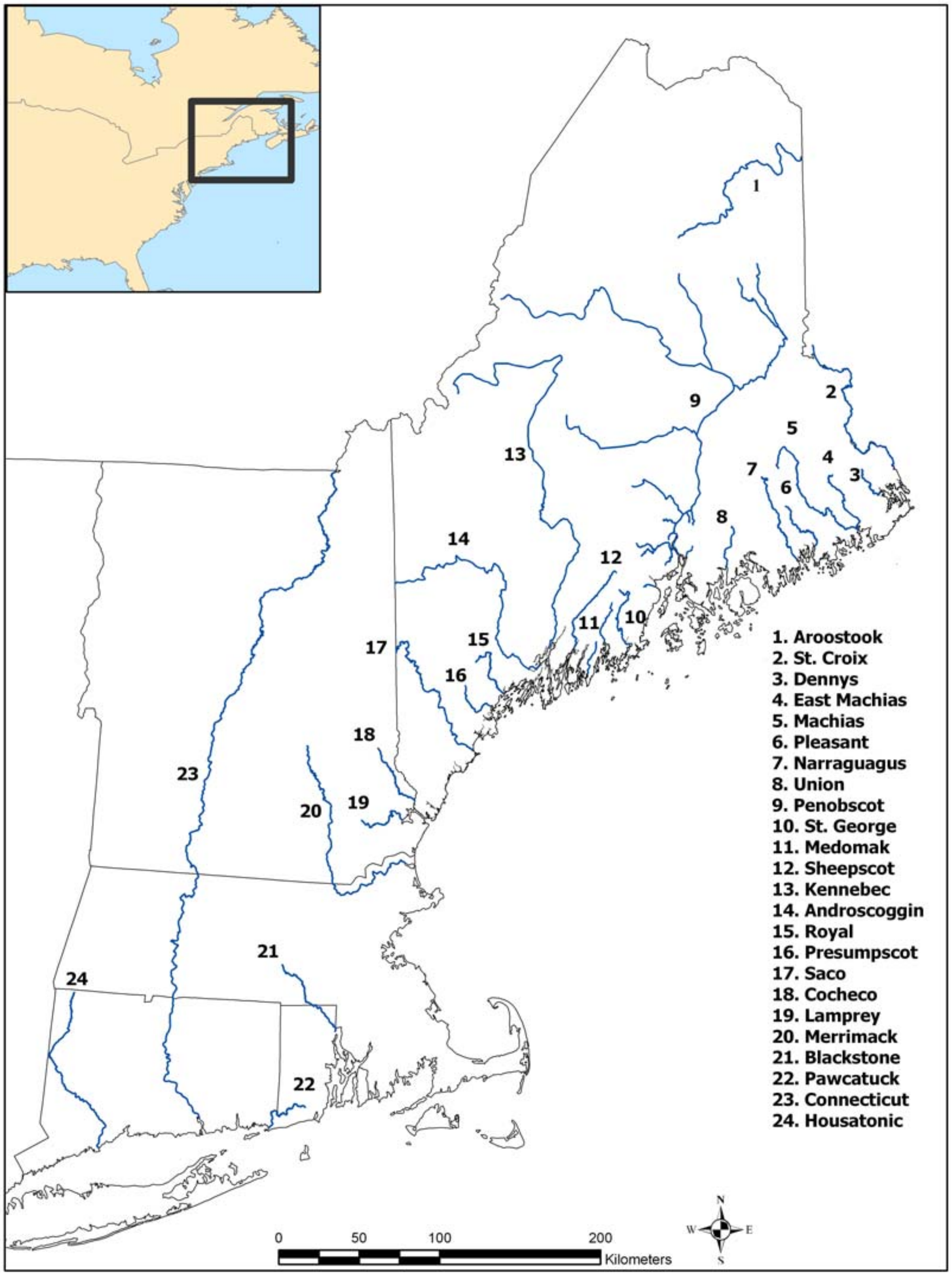

Figure 1. Selected historic Atlantic salmon rivers in the U.S.

Figure 2. Atlantic salmon management units within the U.S with major salmon rivers highlighted.

proposed rule to expand the GOM DPS is finalized, the protections of the Endangered Species Act would apply to all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin northward along the Maine coast to the Dennys, including all associated conservation hatchery populations used to supplement natural populations. Populations south of the Androscoggin River in central Maine were completely extirpated in the 1800s or early 1900s. As such, these populations do not qualify for protection under the Endangered Species Act. Many of them do, however, have ongoing restoration programs. These rivers include the Saco, Merrimack, Connecticut, and Pawcatuck. State and federal biologists have determined that the historic salmon habitat in the other non-targeted watersheds has been degraded by past human activities to the point where salmon restoration is deemed infeasible at this time. If salmon are successfully restored to targeted watersheds in the future and habitat conditions improve in the non-targeted watersheds, additional restoration programs can be considered.

As the last remnant native stock of Atlantic salmon in the US, the GOM DPS is a primary focal point of salmon management in the US. The distinction between the GOM DPS and other stocks to the south is important in understanding salmon management and salmon habitat management in the US, and this distinction is made throughout the reminder of this report.

2. Historic and Current Status of Atlantic Salmon Habitat in the US

In general, rivers in Maine containing endangered populations of Atlantic salmon are managed and researched more intensively than those populations further south. As such, the level of resolution in terms of what is known about the habitat of the rivers within the freshwater range of the GOM DPS is somewhat greater. In the following sections of this report, we will describe habitat estimates and habitat condition at the most specific and detailed level that is available. Most often, these estimates are reported as "habitat units," whereby one habitat unit equals 100 square meters of suitable rearing habitat (Elson 1975, Baum 1997).

a) Gulf Of Maine Populations

Habitat Quantity

Habitat quantity estimates for the GOM DPS have been calculated using a GIS-based habitat prediction model (see Appendix). The model was developed using data from existing habitat surveys conducted in the Machias, Sheepscot, Dennys, Sandy (a tributary to the Kennebec), Piscataquis (a tributary to the Penobscot), Mattawamkeag (a tributary to the Penobscot), and Souadabscook Rivers (a tributary to the Penobscot). A combination of reach slope, cumulative drainage area, and physiographic province were used to predict the total amount of rearing habitat within a reach. The variables included in the model explain 73 percent of the variation in rearing habitat. Although habitat surveys exist for some areas of the GOM DPS, we relied on the model to generate the habitat values for this exercise to provide consistent data across the entire GOM DPS. Existing habitat surveys were used to validate the output of the model. Habitat quantity estimates are mapped at the Hydrologic Unit Code (HUC) 10 scale (Level 5 watersheds), which are described by Seaber et al. (1994).

Within the GOM DPS there are an estimated 757,773 salmon habitat units historically available (Table 1). Approximately 52% of the historic habitat units are currently occupied by salmon. However, the presence of salmon in roughly 23% of the currently occupied habitat units is due to trap and truck operations around impassable dams. Access to historic salmon habitat varies widely by river (16.8 to 100%), with access to the largest percentage of historic habitat located in the coastal drainages (Table 2). HUC 10 watersheds with the greatest density of salmon habitat units are located higher up in the drainage and are currently inaccessible to salmon (Figure 3).

Habitat Quality

Measuring habitat quality (as defined by Hall et al. 1997) in open ecological systems is very difficult and requires tracking demographic trends in populations over time (Garshelis 2000). As such, very little is known about the true habitat quality of rivers within the freshwater range of the GOM DPS.

Indirect assessments of habitat quality have, however, been made. Within the GOM DPS, habitat quality scores have been assigned at the HUC 10 scale. This effort was based on information and input from fisheries biologists working with the State of Maine Department of Inland Fisheries and Wildlife (MDIFW), the Maine Department of Marine Resources (MDMR), NMFS, and Kleinschmidt Energy and Water Resource Consultants, who retain specific knowledge and expertise about the geographic region. Biologists with knowledge and expertise of the geographic area were asked to independently assign habitat scores, to HUC 10s using a set of scoring criteria (Figure 4) and based on the presence of, and quality of physical and biological features essential to the conservation of the species. The scoring criteria ranked qualitative features including temperature, biological communities, water quality, and substrate and cover, as being highly suitable ("3"), suitable ("2"), marginally suitable ("1") or not suitable ("0") for supporting Atlantic salmon spawning, rearing and migration activities. A habitat value of "0" indicates that one or more factors is limiting to the point that Atlantic salmon could not reasonably be expected to survive in those areas; a score of "1", "2" or "3" indicates the extent to which physical and biological features are limiting with a "1" being most limiting and a "3" being not limiting. In HUC 10s that are, and have always been inaccessible due to natural barriers, the entire HUC 10 was automatically scored as "0" and considered not occupied by the species. Emphasis was placed on identifying whether or not the physical and biological features needed for Atlantic salmon spawning and rearing are present.

Habitat quality scores for the GOM DPS were variable (Figure 5), but scores in large river systems tended to increase from the mouth of the river to headwaters. The highest habitat quality scores were located in the Penobscot and Kennebec drainages in higher elevation HUC 10s in the upper watersheds. These high quality HUC10s tend to require the longest migration distance for salmon and are often unoccupied due to dams lacking fish passage. Smaller coastal rivers, many of which are actively managed for Atlantic salmon, typically scored as medium in habitat quality. The lowest habitat quality scores were generally located in the lower Androscoggin and Kennebec drainages, however many of these HUC10s represent essential corridors for Atlantic salmon migration. Other HUC 10s that scored poorly in the Penobscot are lower gradient watersheds primarily characterized by wetlands.

Table 1. Currently occupied habitat units in the Gulf of Maine DPS.

Salmon Habitat Recovery Unit (SHRU)	Current Habitat Units Occupied	Total Habitat Units
Merrymeeting Bay	136,060	372,639
Penobscot Bay	211,064	323,740
Downeast Coastal	51,301	61,395
Total	**398,425**	**757,773**

Table 2. Major salmon rivers within the Gulf of Maine DPS.

River	Drainage Area (Sq. km)	Atlantic Salmon Habitat Units (1 unit= 100 sq.m.)		% of Historic Accessible
		Current Habitat Units Occupied	Historic Habitat Units	
Dennys	338	1,717	1,717	100
East Machias	808	6,129	6,129	100
Machias	1,291	14,964	14,964	100
Pleasant	338	3,025	3,025	100
Narraguagus	635	6,500	6,500	100
Union	1,610	2,031	12,125	17
Penobscot	22,122	207,955	314,314	66
Kennebec	15,311	100,630	254,558	40
Androscoggin	9,133	16,978	70,249	24
St. George	722	6,929	6,929	100
Sheepscot	943	5,311	7,081	75
Medomak	396	3,164	3,164	100

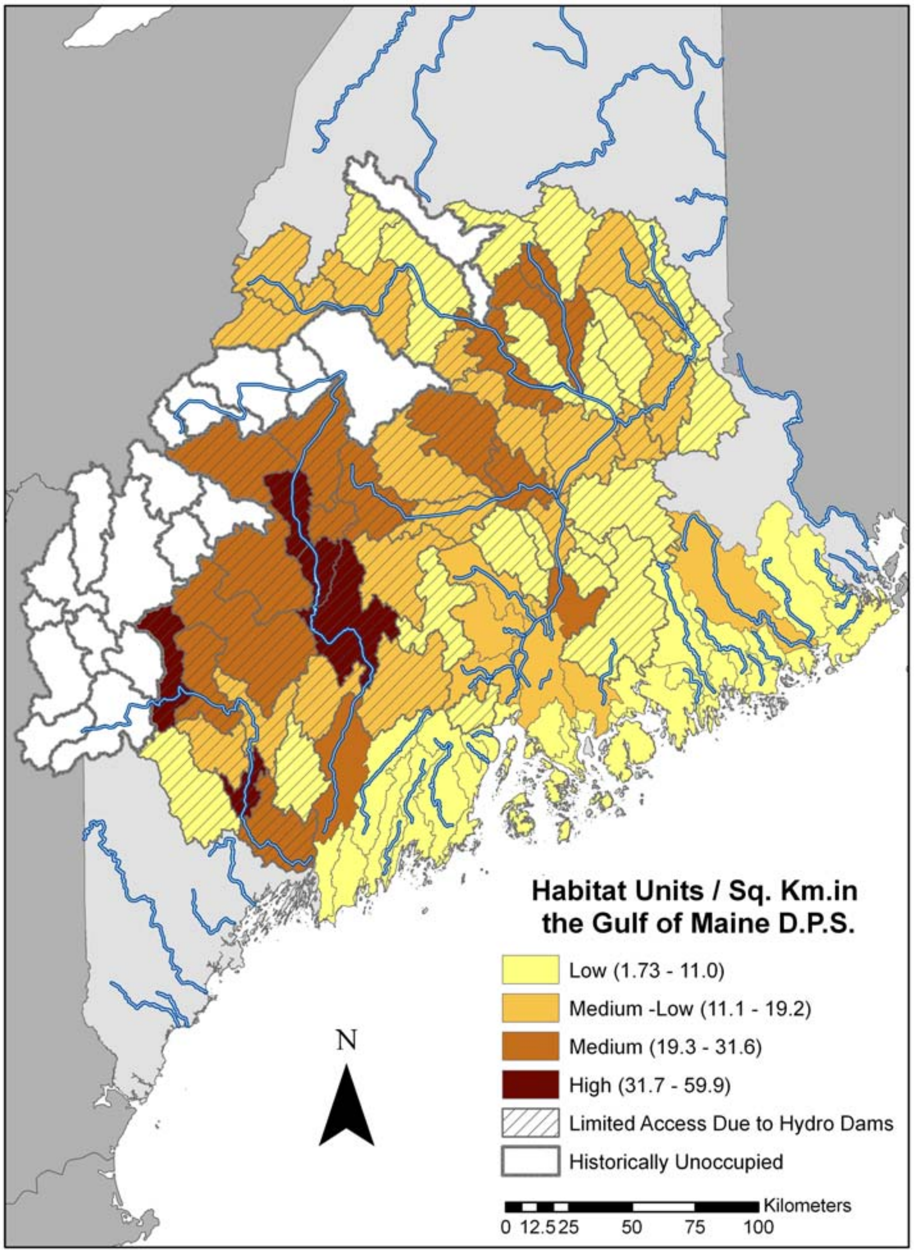

Figure 3. Atlantic salmon habitat modeled habitat units within the Gulf of Maine DPS by HUC10 watershed.

Habitat Quality Scoring Criteria

<u>**Temperature:**</u>
Highly Suitable (3) = Stream temperatures are typically below *19C with no known fluctuations above **22.5C
Suitable (2) = Stream temperatures may exceed 22.5C but are <u>not</u> known to exceed ***29C at any time
Marginally Suitable (1) = Stream temperatures may <u>not</u> exceed 29C for periods greater than 16 Hours
Not Suitable (0) = Stream temperatures are known to exceed 29C for periods greater than 16 Hours
**Upper limit for optimal foraging (Decola 1970)*
***Upper incipient temperature limit for feeding (Elliott 1991)*
****Upper incipient lethal temperature based on a 20C acclimation (Elliott 1991)*

<u>**Biological Communities:**</u>
Highly Suitable (3) = Streams are highly productive and support abundant, diverse, populations of invertebrates and fishes. Streams do not contain *non-native species.
Suitable (2) = Streams contain abundant and/or diverse populations of invertebrates and fishes. Streams contain low abundances of non-native species.
Marginally Suitable (1) = Streams contain a limited abundance and diversity of invertebrates and fishes. Streams contain a high abundances of non-native species.
Not Suitable (0) = Atlantic salmon cannot survive with current fish community structure.
**Non-native species of concern are Smallmouth Bass, Northern Pike, Chain Pickerel, Brown Trout, Rainbow Trout, and Largemouth Bass*
<u>**Water Quality:**</u>
Highly Suitable (3) = pH does not fall below *6 and dissolved oxygen content consistently remains above **8mg/L.
Suitable (2) = pH sometimes falls below 6 but always remains above ***5.5 and dissolved oxygen sometimes falls below 8mg/L but always remains above ****6mg/L
Marginally Suitable (1) = pH often falls below 6 and at times below 5.5. Dissolved oxygen sometimes falls below 6mg/L.
Not Suitable (0) = pH is chronically below 5.5 and dissolved oxygen typically remains below 6mg/L.
** Point at which egg survival becomes significantly affected (Peterson et al. 1980)*
***Oxygen requirement for alevin survival (McLaughlin and Knight 1987)*
**** Point at which pH inhibits hatching of Atlantic salmon eggs (Peterson et al. 1980)*
*****General oxygen requirement for Atlantic salmon parr (Decola 1970)*

<u>**Substrate and Cover:**</u>
Cover items, including undercut banks, diverse substrates and depths, overhanging trees and vegetation, and some types of aquatic vegetation can increase habitat suitability (Bjornn and Reiser 1991). Cover items such as these can serve as a substitute for gravel and boulders and presence of these items should be taken into consideration when scoring a HUC12.
Highly Suitable (3) = Streams contain boulders roughly *20cm diameter at abundances greater than **0.2 per sq.meter and clean (silt-free) gravel ranging in diameters from ***1.6-6.4cm is also abundant.
Suitable (2) = Streams contain sufficiently sized boulders and clean (silt-free) gravel, but boulders are present at densities sometime less than 0.2/sq.meter.
Marginally Suitable (1) = Streams contain boulders and/or gravel but neither are available in optimal sizes and/or abundances
Not Suitable (0) = Streams do not contain substrate and cover suitable for juvenile Atlantic salmon rearing.
**Mean boulder diameter used in study by Dolinsek et al. (2007)*
***Boulder density used by Dolinsek et al. (2007)*
****Preferred gravel diameter of small parr (Symons and Heland 1978)*

Figure 4. Criteria used to score biological quality within HUC 10 watersheds.

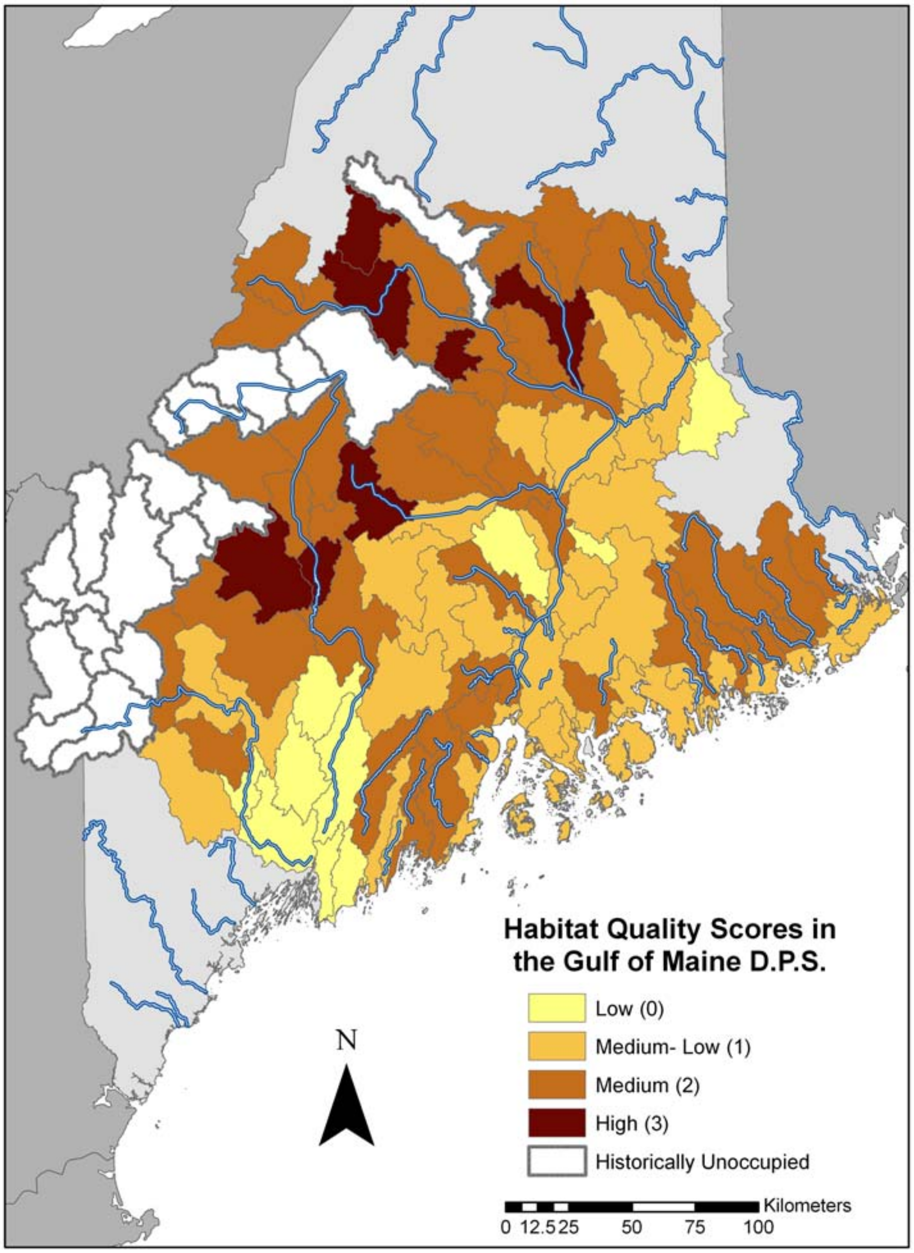

Figure 5. Atlantic salmon habitat quality scores by HUC10. Habitat quality scores are based on surveys from fisheries biologists.

b) *Salmon Rivers Outside the GOM DPS*

Extensive habitat inventories have been conducted in watersheds targeted for salmon restoration outside the GOM DPS. However, these inventories have been done mostly by the six state agencies in which the streams are located and each agency may have used slightly different methods and criteria. Furthermore, agency biologists are aware of variations in the quality of the habitat throughout the region, but to date no effort has been made to document or map different categories of habitat quality as has been done for the GOM DPS streams. Therefore, no comparable graphics such as Figures 4 and 5 above exist for these streams. In the restoration programs outside of Maine (Merrimack, Pawcatuck, and Connecticut rivers), the quality of the habitat is generally greater in the more rural and higher elevation streams and poorer in the more densely populated/urban areas closer to the ocean. In general, no effort has been made to survey the salmon habitat in watersheds not currently targeted for salmon restoration (e.g. streams that flow into Long Island Sound other than the Pawcatuck and Connecticut River). In Connecticut, a cursory effort was made to estimate the amount of historical habitat that once existed in non-targeted watersheds (e.g. Shetucket, Quinebaug, and Housatonic rivers) but this process was much less precise than the methods used to inventory streams within the Connecticut River watershed that are targeted for restoration. Table 3 includes an estimate of total units for the Housatonic River (where salmon is extinct and there are no current plans for restoration) for demonstration purposes.

Table 3. Major U.S. Atlantic salmon rivers outside of the GOM DPS with available salmon habitat estimates available; rivers highlighted with an asterisk (*) indicate that there are no targeted Atlantic salmon restoration activities ongoing at this time.

River	Drainage Area (Sq. km)	Atlantic Salmon Habitat Units (1 unit= 100 sq.m.)
		Surveyed Habitat Units
Aroostook	5,931	60,775
St. Croix	6,475	29,260
*Presumpscot	1,676	412
Saco	4,395	27,540
*Cocheco	479	3,070
*Lamprey	549	2,968
Merrimack	12,976	68,842
Pawcatuck	798	4,792
Connecticut	29,187	243,000
*Housatonic	5,093	56,000

3. Designation of Priority Atlantic Salmon Habitats in the US

Identifying priority habitats and key issues to be addressed is a primary focus of Atlantic salmon recovery and restoration efforts in the U.S. Prioritization of key habitats occurs at a variety of scales, ranging from the entire U.S. down to as fine as the river reach scale. We describe the prioritization of key areas as it relates to a) the GOM DPS and b) salmon rivers outside the GOM DPS.

a) The GOM DPS

These efforts are focused around implementing the Federal Endangered Species Act (ESA). Once a species is listed under the ESA, significant protections for both the species and its habitat are then implemented. The protections afforded to endangered and threatened species are often referred to as "take" prohibitions. These take prohibitions make it illegal to "take" a threatened or endangered species without an incidental take permit authorized by NMFS or USFWS. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct. Harm includes significant habitat modification or degradation when it actually kills or injures wildlife by significantly impairing essential behavioral patters including breeding, feeding or sheltering. In addition, NMFS and USFWS also designate Critical Habitat for newly listed species. Once designated, it is illegal to adversely modify Critical Habitat. These protections often have significant socioeconomic ramifications when they are implemented; thus, it is vital to ensure that the ESA is implemented at the appropriate scale. For Atlantic salmon in the U.S., this means that considerable effort is spent assessing which populations and key areas must be protected.

In 2000, NMFS and USFWS listed the GOM DPS as endangered. At that time, the GOM DPS only included all naturally reproducing remnant populations of Atlantic salmon from the Kennebec River downstream of the former Edwards Dam and from the Penobscot River downstream of the Bangor Dam, northward to the mouth of the St. Croix River. In short, salmon populations inhabiting the larger rivers such as the Penobscot, Kennebec, and Androscoggin Rivers were excluded from the GOM DPS because of the lack of genetic data at the time of listing in 2000. Since then, additional scientific information has become available in order to re-evaluate the status of populations inhabiting the larger rivers in relation to the rest of the GOM DPS. In order to make this determination, the Services convened a team of both federal and non-federal biologists to develop a Status Review that was published in 2006 (Fay et al. 2006). One of the primary recommendations of the Status Review was that the GOM DPS should be expanded to include additional populations in Maine (namely, those inhabiting the Androscoggin, Kennebec, and Penobscot Rivers). Fay et al. (2006) concluded that this is a more appropriate scale for conservation efforts over the long term because of many factors including genetic, life history, and natural selection factors for salmon populations that are similar within this range and different outside this range.

The NMFS and USFWS have recently proposed to expand the protections of the ESA to include those areas as recommended by Fay et al. (2006), including a new proposal to designate Critical Habitat in these areas as well. Considerable additional area would be included under the listing and Critical Habitat designation if the proposal is finalized as written (Figure 6). By April 30, 2009, NMFS and USFWS must make a final determination with respect to whether or not to expand protections of the ESA to these additional populations and designate Critical Habitat in these areas. If a final rule is published that does expand protections of the ESA to the additional areas as recommended by Fay et al. (2006), a longstanding question regarding the appropriate scale of conservation of Atlantic salmon in the U.S. would be largely settled.

These efforts to properly designate Atlantic salmon populations as either eligible or ineligible for protection under the ESA is a very important step in terms of identifying and designating priority and key habitat areas. The protections offered by the ESA are quite significant both in terms of take prohibitions described above and also in terms of protections offered to designated Critical Habitat; these protections are described in more detail in section five of this report.

Preventing the extinction of the last remnant Atlantic salmon populations is a high priority for the United States. As described above, there are clear and considerable differences between the management regimes within and outside of the range of the GOM DPS. The endangered status of the GOM DPS requires additional protection and intensive management of salmon habitat within the freshwater range of the GOM DPS to ensure the continued existence of the last, native stock of Atlantic salmon in the US.

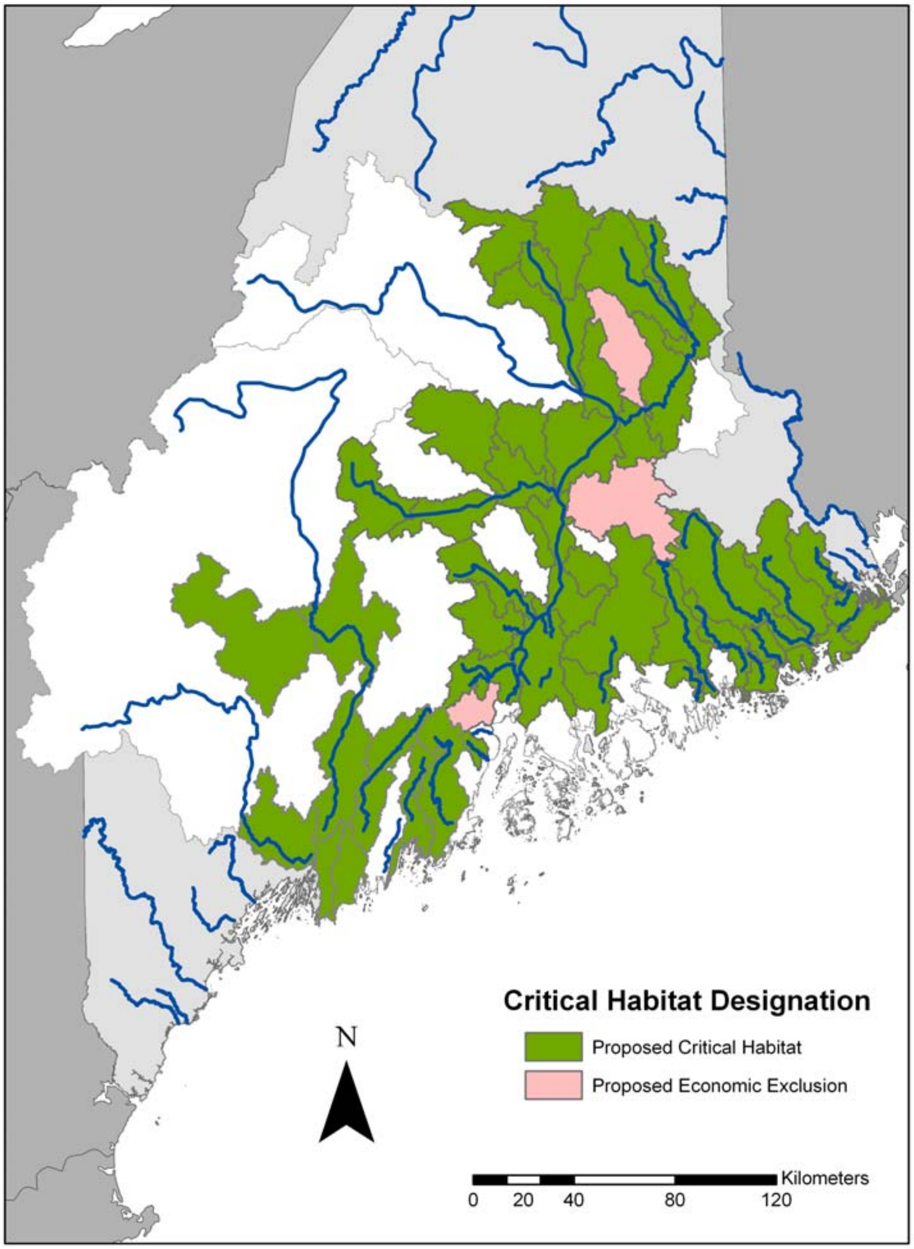

Figure 6. Areas proposed for Critical Habitat designation are highlighted in green; those proposed for exclusion because of socioeconomic issues are highlighted in pink.

b) *Salmon Rivers Outside the GOM DPS*

The restoration programs outside of Maine have recognized that in order to re-establish runs of salmon to these heavily-impacted rivers, as much habitat as possible must be stocked so that maximum smolt production is occurring. The percentage of the total available habitat stocked with fry in each program varies between watershed programs is governed by the programs ability to produce fry in hatcheries and distribute them. All programs prioritize the stocking of fry to habitat that is believed to be best able to produce smolts that can effective emigrate to the ocean. For example, in the Connecticut River program, when numbers of fry are limited, priority is placed on maximizing fry stocking in habitat in the downstream states of Connecticut and Massachusetts. During these years, only the better streams in upstream Vermont and New Hampshire will get a full stocking of fry. In years when fry are abundant, all streams receive full fry stocking. In all programs, suitable habitat that is located upstream of barrier dams (no fish passage for adult salmon) are stocked with fry to generate smolts that can get to sea even if the resultant adults are not able to return to the natal tributary. These priorities are reflected in the annual stocking plans developed by the restoration programs.

All salmon habitat is protected from degradation through the enforcement of federal and State laws (described in some detail in Section 5 of this Focus Area Report). The fact that a particular stream is of lower priority for salmon stocking than others would not permit a state to allow degradation of the habitat. Habitat restoration is greatly influenced by a prioritization of habitat, however. High quality habitat is typically not targeted for improvement and often some of the lowest quality habitat is not targeted due to the enormity of the job. Habitat that is lightly impacted is often prioritized for restoration/improvement when relatively little work is required to bring the habitat back to full production capability. Habitat connectivity is another type of habitat restoration and projects to remove dams or install a fishway are influenced by the value of the habitat upstream and downstream of the site. Dams that are below high quality spawning and nursery habitat have a higher priority for fish passage projects than dams below low quality habitat. However, the implementation of such projects is often influenced by opportunism. Projects at federally-licensed hydroelectric dams may have to wait for a re-licensing period to prescribe fishway construction, even though it is a high priority. Projects at non-hydro dams may be implemented depending upon the willingness of the dam owner and the availability of money, regardless of the quality of the upstream habitat. The prioritization of habitat in regards to stocking, protection, restoration, and fish passage is guided by habitat inventories and the Strategic Plan for each restoration program.

4. Information Exchange Between States, Non-governmental Organizations, and the US Government

There are a variety of ways through which information on habitat issues and best management practices is exchanged between states, non-governmental organizations, and the U.S. government. These include, though are not limited to the following: the United States Atlantic Salmon Assessment Committee (USASAC); research symposia; and grants and grant reporting.

The USASAC is an important mechanism through which recent information on salmon and salmon habitat research and management flows. The role of the USASAC is tightly linked to NASCO. When the U.S. became a charter member of NASCO in 1984, the three Commissioners for the U.S. required advice and input from scientists involved in salmon research and management throughout New England and asked the New England Atlantic Salmon Committee (NEASC) to create an advisory committee. The NEASC, which is comprised of State and Federal fishery agency leaders, designated staff to serve on the "NASCO Research Committee" in 1985. The NASCO Research Committee met semiannually to prepare data for upcoming International meetings such as the International Council for the Exploration of the Sea (ICES), North Atlantic Salmon Working Group, and NASCO. In 1988, the NASCO Research Committee was restructured and renamed the U.S. Atlantic Salmon Assessment Committee (USASAC). The USASAC was charged with the following tasks: 1) to conduct annual U.S. Atlantic salmon stock assessments; 2) to evaluate ongoing U.S. Atlantic salmon research programs and develop proposals for new research; and 3) to serve as scientific advisors to the U.S. Section of NASCO. The USASAC began meeting annually to produce an annual Atlantic salmon program summary and assessment document. This report responds to Terms of Reference from NASCO to the North Atlantic Salmon Working Group. The USASAC also responds to direct requests for information from the U.S. Commissioners.

A recent example of the continued dialog between the NEASC and the USASAC is a recent request from the NEASC to the USASAC to identify the top priority fish passage projects at dams that are limiting Atlantic salmon populations. The list was to include projects that would benefit Atlantic salmon as well as other diadromous species, and the USASAC was then asked to rank these projects from a regional perspective. Before the 2007 meeting of the USASAC, representatives from state agencies in Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine were asked to provide basic information on five top priority projects in their state. The NEASC is currently using this list to leverage funds from a variety of sources, including the Federal government and non-governmental organizations, to implement these high priority projects.

In addition to the USASAC process described above, a variety of research symposia occur in the U.S. each year; these include the annual meeting of the American Fisheries Society, the Northeast Fish and Wildlife Conference, and the annual meetings of the Atlantic International Chapter and the Southern New England Chapter of the American Fisheries Society. While none of these annual meetings are specifically focused on Atlantic salmon or Atlantic salmon habitat, it is quite common for sessions in these meetings to be focused on salmon and salmon habitat and thus they offer excellent venues to share the latest scientific findings on the subject. In particular, the Atlantic International Chapter of the American Fisheries Society includes members from the U.S. as well as Canada and is therefore an excellent venue to share information not only among the research and management communities, but also across international boundaries.

In addition, there are a series or research symposia each year that focus on Atlantic salmon and other diadromous species, one with a focus on the Maine program, one with a focus on the Connecticut River Program. The Connecticut River Atlantic Salmon Commission (CRASC) sponsors a research symposium in every other year as does the NMFS for the Maine salmon program. The Maine symposium occurs on the even years (e.g., 2008) while the CRASC symposium occurs on the odd years (e.g., 2009). This arrangement of timing was recently initiated as a way to maximize efficiency and timeliness of information transfer between agencies and academia and also across programs (Connecticut to Maine and vice versa).

Several state agencies and Universities conduct research related to salmon and salmon habitat. Most often, these research and management activities are funded by grants from the federal government, state governments, or other conservation foundations such as the Fish America Foundation. As research results become available, there are typically fairly rigorous reporting requirements and may often include publication of peer-reviewed literature though these reports may also be limited to publication as gray literature. Several recent examples of these types of relationships are provided in Section 6 of this Focus Area Report.

A recent development that should significantly enhance information exchange in relation to best management practices is the Diadromous Species Restoration Research Network (DSRRN). This new program was funded by the National Science Foundation for five years and seeks to improve networking and communication among people involved in all aspects of river use and to identify overarching directions for scientific study for diadromous fish restoration. While the DSRRN is not specifically focused on salmon habitat protection and restoration, the network should enhance information exchange among groups and ultimately lead to advancement and more rapid communication of best management practices for a variety of diadromous restoration issues including salmon habitat management.

5. Habitat Protection, Restoration, and Enhancement Planning Efforts in the US

Within the U.S. there are a variety of planning mechanisms that are designed to protect salmon habitat and actively restore and enhance degraded habitats. Habitat protection, restoration and enhancement programs in the U.S. are implemented at the federal, state and local levels through a combination of regulation, consultation services, and proactive restoration and enhancement (frequently supported by federal or state funding). While there is no single plan that comprehensively addresses these needs, there are ongoing activities to advance these efforts strategically.

Below, we describe how the U.S. approaches these issues; the reader must, however, be aware that there is no single salmon habitat protection and restoration plan for the entire U.S. There are, however, a variety of salmon habitat protection and restoration plans at a variety of scales. Below we highlight several strategic plans under which the majority of current salmon programs operate in the U.S.

For the Connecticut River Program, the Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River Basin (CRASC 1998) provides six primary goals: 1) to manage Atlantic salmon production to produce sea-run Atlantic salmon returns; 2) to enhance and maintain the quantity, quality and accessibility of salmon habitat necessary to support re-established spawning populations; 3) to protect Connecticut River Atlantic salmon from exploitation; 4) to allocate adult sea-run salmon to maximize benefits to the program; 5) to assess program effectiveness by conducting monitoring, evaluation, and research, and by implementing appropriate changes; and 6) to provide the public with information and opportunities to be involved in the restoration program. The second of these goals is most germane to this Focus Area Report. Progress toward meeting this goal is accomplished by using the regulatory mechanisms already in place, described in the "Protecting Salmon Habitat" section below. There are also a variety of restoration activities implemented to meet this goal. Several of these are described in Section 6 of this Focus Area Report.

For the Merrimack River Program, the Strategic Plan for the Restoration of Anadromous Fish to the Merrimack River (USFWS 1990) provides broad direction in the sense that the Merrimack plan also includes strategic direction for the restoration of other anadromous fish to the Merrimack River. The Merrimack Plan proposes a holistic watershed approach to anadromous fish restoration. The three objectives of the Merrimack Plan are (1) an adult Atlantic salmon population that will exceed the sea-run brood stock holding capacity of the Nashua National Fish Hatchery (300) and provide some level of reproduction in the wild; (2) an annual average of 35,000 adult American shad passing the Essex fish-lift in Lawrence, Massachusetts; and (3) an annual average of 300,000 adult river herring (a term that includes both alewives and blueback herring) passing the Essex fish-lift in Lawrence, Massachusetts. Several subordinate strategies have also been articulated in order to explain how these objectives should be met. These strategies focus on holistic restoration of the anadromous suite of fish native to the Merrimack, partnership development, and education and outreach.

For the Maine Program, there are two plans of primary importance: the Final Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon (NMFS and USFWS 2005) and ATS 2015: Maine Atlantic Salmon Commission's 10-Year Strategic Plan (MASC 2005). The Final Recovery Plan for the GOM DPS was published in 2005 and will be updated after a final decision regarding the inclusion of other populations to the GOM DPS is made. The primary goal of the "ATS 2015 Plan" is to restore a viable population of Atlantic salmon with access to historical habitat that provides a public benefit. This plan also proposes a holistic ecosystem approach to salmon recovery and specifically names five elements necessary for recovery including (1) an ecosystem paradigm, (2) private and public cooperation, (3) outreach and community engagement; (4) assessment, monitoring and research; and (5) regulatory and governance roles in recovery. Similar to the Connecticut and Merrimack Plans above, the ATS 2015 Plan requires the successful implementation of the existing regulatory structure described below in the "Protecting Salmon Habitat" section of this Focus Area Report.

The effectiveness of these strategic plans is augmented through the implementation of a variety of natural resource protection laws and the implementation of a variety of habitat restoration programs. Below, we describe how salmon habitat is protected and restored through the numerous mechanisms available to resource managers in the U.S.

Protecting Salmon Habitat

In terms of comprehensive habitat protection, there are two general ways in which the U.S. approaches the issue. First from a regulatory perspective, there are a series of laws specifically designed to protect the protective capacity of salmon rivers in the U.S.

Perhaps the most important of these laws is the federal Endangered Species Act (ESA). As described in Section 3 of this Focus Area Report, the ESA prohibits individuals from unauthorized "take." Section 7 of the ESA provides for NMFS and USFWS to conduct consultations on federal projects that may affect listed species. If a project proponent seeks conduct that may affect listed salmon, the NMFS and USFWS begin a consultation process that identifies the action, describes the level of take anticipated, and (when appropriate) authorizes take through an incidental take statement. Throughout this process, NMFS and USFWS work with project proponents to minimize the level of take that is expected to occur. This often involves modifications to projects through the use of timing restrictions designed to allow work in rivers at times that are least disruptive to salmon and/or the use of best management practices. Section 10 of the ESA provides an additional (and similar) mechanism for NMFS and USFWS to authorize incidental take of listed species for activities that do not involve other federal agencies. In addition, if the recent proposal to designate Critical Habitat for the GOM DPS is finalized as written, this designation would make it illegal to adversely modify designated Critical Habitat within the freshwater range of the GOM DPS. In practice, this designation will provide protections to spawning, rearing, and migratory habitats required by the GOM DPS to complete its life history and to achieve recovery. Up until now, the GOM DPS had only received protection of individuals (i.e., the "take" prohibitions described in Section 3 of this Focus Area Report). A very rigorous and detailed planning effort was required to assess the priority areas that should receive the protections of designation. This planning effort was largely informed by the habitat quantity and quality assessments described in Section 2 of this Focus Area Report.

The protections of Critical Habitat designation only apply to the freshwater and estuarine areas within the range of the GOM DPS and do not apply to rivers south of the Androscoggin River in Maine. This is because DPSs south of the Androscoggin River were completely extirpated and thus do not qualify for protection under the federal ESA and salmon that inhabit those rivers today are derived from exogenous sources. Thus, the GOM DPS is a primary focus for salmon habitat conservation in the U.S. (as described in Section 3 of this Focus Area Report).

In addition to the protections offered to Atlantic salmon and their habitat through listing under the ESA, there are a variety of other federal laws that protect the productive capacity of salmon rivers in the U.S. Of primary importance to protecting salmon habitat in the U.S. are the Magnuson-Stevens Fishery Conservation and Management Act, the Fish and Wildlife Coordination Act, the Federal Water Pollution Control Act (Clean Water Act), and the Federal Power Act. Within the freshwater range of the GOM DPS, the effectiveness of these laws is often enhanced because of the protections of the ESA. In short, environmental reviews and permits issued through these laws are oftentimes more stringent in areas containing endangered salmon because of additional requirements that federal activities cannot jeopardize the continued existence of endangered salmon or adversely modify critical habitat. However, these other laws mentioned above do apply to most salmon rivers in the U.S. including those south of the GOM DPS (e.g., the Connecticut River). A brief description of the protective measures afforded to salmon habitat due to each law is described below.

The Magnuson-Stevens Fishery Conservation and Management Act, commonly referred to as the “Magnuson Act,” gives regional fishery management councils (Councils) the authority to prepare plans for the conservation and management of each federally managed fishery in the Exclusive Economic Zone of the U.S., including the establishment of necessary habitat conservation measures. A fishery management plan for Atlantic salmon was implemented by the New England Fishery Management Council (NEFMC) and the Assistant Administrator for Fisheries in 1987. The 1996 amendments to the Magnuson Act set forth a number of new mandates for the NMFS, regional fishery management councils, and other federal agencies to identify and protect important anadromous fish habitat. The fishery management councils, with assistance from NMFS, are required to delineate essential fish habitat (EFH) for all managed species. Federal action agencies which fund, permit or carry out activities that may adversely impact EFH are required to consult with NMFS regarding the potential effects of their actions on EFH, and respond in writing to the NMFS’ recommendations. In addition, NMFS is required to comment on any state agency activities that would impact EFH. In accordance with the 1996 amendments, the NEFMC designated EFH for Atlantic salmon in March of 1999. EFH is defined in the Magnuson-Stevens Act as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. As required by the Magnuson Act, NMFS promulgated regulations to provide guidance to the Councils for EFH designations. The regulations further clarify EFH by defining waters to include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate to include sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary to mean the habitat required to support a sustainable fishery and the managed species contribution to a healthy ecosystem; and spawning, breeding, feeding, or growth to maturity to cover a species full life cycle.

Essential fish habitat for Atlantic salmon is described as all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut and that meet conditions for eggs, larvae, juveniles, adults and/or spawning adults. Atlantic salmon EFH for eggs, larvae, juveniles and adults includes all aquatic habitats in the watersheds of rivers where salmon are currently present (26 rivers total), including all tributaries, to the extent that they are currently or were historically accessible for salmon migration.

The regulations also direct the Councils to consider a second, more limited habitat designation, Habitat Areas of Particular Concern (HAPCs). HAPCs are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Designated HAPCs may be but are not automatically afforded any additional regulatory protection under the Magnuson Act; however, federal projects with potential adverse impacts to HAPCs are often more carefully scrutinized during the consultation process. Considering the unique habitat associations and requirements of Atlantic salmon, the Council designated the habitat of 11 rivers in Maine as HAPCs for Atlantic salmon in March 1999. The habitat of the Dennys, Machias, East Machias, Pleasant, Narraguagus, Ducktrap, Sheepscot, Kennebec, Penobscot, St. Croix Rivers and Tunk Stream was identified as serving the following two important purposes in terms of being habitat areas of particular concern: (1) they provide a unique and important ecological function; and (2) they are sensitive to human-induced environmental degradation.

NMFS has committed to attempt to incorporate EFH consultations into interagency procedures previously established under the National Environmental Policy Act, Endangered Species Act, Clean Water Act, Fish and Wildlife Act, or other applicable statutes. Once the NMFS learns of a federal or state project that may have an adverse effect on EFH, NMFS is required to develop EFH Conservation Recommendations for the project. These recommendations may include measures to avoid, minimize, mitigate, or otherwise offset adverse effects on EFH. Federal agencies are required to respond to EFH Conservation Recommendations in writing within 30 days. Councils are also authorized to comment on federal and state projects and are required to comment on any project that may substantially impact anadromous fish habitat. Federal action agencies are required to prepare an EFH Assessment which must include the following: (1) a description of the proposed action; (2) an analysis of the effects, including cumulative effects of the actions on EFH, the managed species, and associated species by life history stage; (3) the federal agency's views regarding the effects of the action on EFH; and (4) proposed mitigation, if applicable.

The Federal Power Act, as amended, established several processes intended to protect and restore anadromous fishes impacted by hydroelectric facilities regulated by the Federal Power Commission and its successor agency, the Federal Energy Regulatory Commission (FERC). The Electric Consumers Protection Act (ECPA) of 1986 strengthened the position of the fish and wildlife agencies and Native American Tribes by requiring FERC to include conditions in FERC licenses to protect, mitigate, and enhance fish and wildlife resources. Section 18 of the Federal Power Act assigns to the Commission a responsibility to require hydroelectric licensees to construct, maintain, and operate, at their expense, fishways prescribed by the Secretaries of Interior or Commerce.

In addition, Section 4(e) of the Federal Power Act (as amended by the ECPA) establishes that FERC must give equal consideration to developmental and non-developmental values in its licensing decisions for projects located on federal reservations. Thus, FERC is responsible for assessing the power and "non-power" values associated with these different alternatives to determine which option would give the greatest benefit to the public; however, the non-power benefits of re-licensing alternatives are rarely quantified or incorporated in net benefit estimates (Black et al. 1998).

Under the Fish and Wildlife Coordination Act (FWCA), federal regulatory agencies must consider fish and wildlife resources in their project planning and in the review of applications for federal permits and licenses. These agencies must consult with state and federal fish and wildlife agencies regarding the possible impacts of proposed actions and obtain recommendations for fish and wildlife protection and enhancement measures. The USFWS and the NMFS provide recommendations to federal action agencies that include measures to protect fish and wildlife resources. The FWCA consultation requirement applies to water-related activities for which federal permits are required, the most significant of which are Section 404 and discharge permits under the Clean Water Act and Section 10 permits under the River and Harbors Act. Agency recommendations are to be given full consideration by the regulatory agency, but are not binding.

Pursuant to section 402 of the Federal Water Pollution Control Act (Clean Water Act [CWA]), the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point source discharges into water bodies within the U.S. Facilities that discharge directly into water bodies must obtain a NPDES permit. In most cases the Environmental Protection Agency (EPA) authorizes States to administer the NPDES permit program. The NPDES permits issued by the States also place limits on the amount of pollutants discharged and impose other conditions such as monitoring and best management practices in order to protect water quality and thus one aspect of the productive capacity of salmon rivers. The EPA retains oversight authority over NPDES permits issued by the States, including the authority to object to a permit where EPA finds that the permit does not ensure compliance with EPA regulations or other applicable water quality standards under the CWA. Section 404 of the CWA also provides for the U.S. Army Corps of Engineers to issue permits for the discharge of dredge or fill materials into navigable waters. In particular, the U.S. Army Corps of Engineers seeks to avoid adverse impacts and offset unavoidable adverse impacts to existing aquatic resources, and for wetlands, will strive to achieve a goal of no overall net loss of values and functions. Permit applications must be reviewed by the USFWS and the NMFS for impacts on fish and wildlife. Within the range of the GOM DPS, these reviews must ensure that issuance of the permit does not jeopardize the continued existence of the GOM DPS.

In addition to the Federal laws mentioned above, each state containing salmon populations has a variety of laws designed to protect fish habitat, water quality, and aquatic system processes. A considerable amount of variation exists from state to state; however, in general each state has laws in place that protect the productive capacity of salmon rivers from activities such as dewatering of streams, sedimentation, and water quality degradation. In Maine for example, three state regulatory processes (the Natural Resources Protection Act, the Shoreland Zoning Act, and the Water Quality Classification System) exist to prevent water quality degradation as a result of forestry activities and other land use practices. Similar regulatory mechanisms exist in other states that contain Atlantic salmon populations such as New Hampshire, Massachusetts, Vermont, Rhode Island, and Connecticut.

The second way in which priority habitats are protected is through conservation easements and direct purchase of land containing priority habitats. These efforts require careful balancing of ecological, recreational, and economic values. In general, these activities are implemented by land trusts in collaboration with state and federal funding agencies. Typically, land trusts identify important parcels in need of protection, then work with land owners to negotiate an arrangement that protects the land and water. From there, funds for the project must be raised. This often involves donations from private citizens and non-governmental organizations such as The Nature Conservancy, as well as grants from state and federal agencies. This occurs through direct purchase of parcels, and can also occur through a conservation easement whereby the landowner agrees to manage the land in ways that minimize disruption to important ecological processes in exchange for economic consideration. For example, an easement designed to protect water quality in a salmon river will often include an agreement by the landowner to reduce or eliminate timber harvest from riparian areas in order to reduce or eliminate in-stream sedimentation and simultaneously increase recruitment of large woody debris to the stream channel. Because land prices in Maine are still inexpensive relative to other parts of the U.S., conservation groups have been able to protect a fairly significant proportion of high value salmon rivers though conservation easements and direct purchase. Land prices in southern New England are much higher, and acquisitions of large tracts of land are not feasible. However, relatively small acquisitions can target areas that contain important salmon habitat and some of these have recently occurred in Southern New England as well. Several of these projects are highlighted below in Section 6 of this focus Area Report.

Restoring Salmon Habitat

Active restoration and enhancement is also an important component of the U.S. strategy to recover and restore Atlantic salmon populations. Habitat restoration projects include improved fish passage (dam removal, culvert replacement, fishways at dams), sediment removal, riverbank erosion control and repair, removal of artificial hard armoring and restoration of natural riparian features, and addition of in-stream coarse woody debris. These projects are undertaken by state and federal agencies as well as NGOs. All must obtain permits, which are reviewed by salmon biologists. Some are funded through annual government budgets while others are paid for with grants from NGOs. These projects either seek to return the salmon habitat to a more natural condition, stop an ongoing degradation, or at least mitigate for ongoing degradation that cannot be terminated.

A variety of state, federal, and non-governmental organizations are actively involved in habitat and ecosystem restoration. The NMFS, USFWS, Natural Resource Conservation Service, and U.S. Forest Service are the primary federal agencies involved in these activities. These federal agencies enhance local capacity through technical assistance in project planning as well as through direct funding.

A recent development in this area is the recent Federal Funding Opportunity (FFO) announced by the NOAA Restoration Center. This FFO is a new initiative for 2009 and is specifically targeted to support restoration of habitat connectivity and function for the benefit of Atlantic salmon within their current and historical range in New England. While priority will be given to proposals within the range of GOM DPS, projects which seek to restore or protect potential Atlantic salmon habitat in Maine outside of the range of the GOM DPS, or in three other river systems in New England (Connecticut, Wood-Pawcatuck, and Merrimack Rivers) will also be considered. The level of funding available for this FFO in 2009 has not yet been determined by Congress, so it is currently impossible to know how many projects will be funded through this mechanism.

a) Identification of impacts and potential risks to productive capacity

A variety of planning efforts, government documents, and scientific papers have examined the risks to productive capacity of Atlantic salmon habitat. Perhaps the most comprehensive is the recent Status Review for Atlantic salmon in the United States (Fay et al. 2006). Fay et al. (2006) reviewed the primary threats to Atlantic salmon and their habitat including considerations of past land use practices that no longer occur (such as log drives) and contemporary impacts (such as dams that exist on the landscape today). In short, Fay et al. (2006) concluded that a myriad of factors have led to the currently low levels of salmon and impacts to their habitats. In particular, dams (both historic and current) have been a primary factor leading to historic declines and the contemporary poor population levels.

The effects of dams are widespread. Here we briefly describe the primary effects of dams as described in detail by Fay et al. (2006). Dams directly limit access to otherwise suitable rearing and spawning habitat, thus directly reducing the productive capacity of salmon rivers. Dams also change the hydraulic characteristics of rivers. These changes, combined with reduced, non-existent, or poor fish passage, influence fish community structure. Specifically, dams create slow-moving impoundments in formerly free-flowing reaches. Not only are these altered habitats less suitable for spawning and rearing of Atlantic salmon, they may also favor non-native competitors such as smallmouth bass (*Micropterus dolomieu*) over native species such as brook trout (*Salvelinus fontinalis*) and American shad (*Alosa sapidissima*). Fish passage inefficiency also leads to direct mortality of Atlantic salmon. Upstream passage effectiveness for anadromous fish species never reaches 100 percent, and substantial mortality and migration delays occur during downstream passage events through screen impingement and turbine entrainment. The cumulative losses of smolts, in particular, incrementally diminish the productive capacity of freshwater rearing habitat above hydroelectric dams.

The loss of historical fish assemblages that were once dominated by diadromous fish is also attributed to dams, among other factors (Moring 2005). This shift in fish community structure may have lead to diminished ecosystem processes that are thought to be important to Atlantic salmon and Atlantic salmon habitat. In particular, Fay et al. (2006) and Saunders et al (2006) recently provided evidence that the co-evolved suite of diadromous fish, such as alewives (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), rainbow smelt (*Osmerus mordax*), and sea lamprey (*Petromyzon marinus*), play important roles in key life history events of Atlantic salmon in northeastern U.S. riverine ecosystems. At historic abundance levels, these diadromous fishes likely provided several important functions for Atlantic salmon such as providing alternative prey for predators of salmon (i.e., prey buffering), serving as prey for juvenile and adult salmon, nutrient cycling, and habitat conditioning (i.e., removing fine sediment from spawning gravels). Restoring the co-evolved suite of diadromous fishes to levels that sustain these functions may be required for successful recovery of the last native Atlantic salmon populations in the U.S. These findings may partially explain the low survival of smolts and post-smolts in the U.S. today.

In a recent proposal to expand the protections of the Federal ESA to include additional populations of salmon inhabiting the larger rivers of Maine (e.g., the Penobscot), the NMFS and the USFWS found that dams are a primary threat facing the GOM DPS. This finding is largely based on the Status Review conducted by Fay et al. (2006). Both Fay et al. (2006) and the recent proposal by the NMFS and USFWS found other threats to salmon to be quite pressing as well. These included past land use practices such as forestry and agriculture that led to elevated levels of fine sediments reaching rivers. Although these practices are far less destructive today because of enhanced use of best management practices, the effects from historical activities remains a threat to recovery of Atlantic salmon throughout their range in the U.S. Other threats to the productive capacity of salmon habitat identified include the diminishment of large woody debris that creates diverse habitat types in rivers; other fish passage barriers such as culverts; reduced water quality from agriculture, urbanization, and mills; pesticides, herbicides, and contaminants; among many others.

Clearly the threats to the productive capacity of Atlantic salmon habitat in the U.S. are widespread. Recent planning documents, particularly Fay et al. (2006) comprehensively evaluate these threats in a rigorous way. The Atlantic salmon recovery effort in the U.S. is moving toward addressing the threats identified by Fay et al. (2006) in a comprehensive and strategic fashion.

b) Procedures for implementation, in a timely fashion, of corrective measures

Listing of additional populations of Atlantic salmon and the designation of Critical Habitat within the range of the GOM DPS is an important step toward implementing corrective action in a timely fashion. However, even after finalization of these efforts, the pace at which corrective measures can be taken will need to be weighed against socio-economic issues and limited by agency staff availability and resources. In short, there is no clear mandate to remediate all threats to a species even after listing under the

ESA. The ESA clearly offers important protections, but these protections are limited to take prohibitions, Section 7 consultations, and Section 10 agreements described above. The ability of the federal agencies to address these threats through either regulatory or restoration activities is also ultimately limited by funding.

In regard to populations of salmon undergoing restoration outside of the GOM DPS, threats to the habitat may not be considered as jeopardizing a population as a whole but could jeopardize a local population at a stream or stream reach scale. In this case, it is unlikely that a federal agency would implement corrective measures. It is more likely that the agencies of the State in which the stream is located would seek corrective measures through legal, regulatory, or physical intervention. The timeliness of such measures may vary due to the strength of State authorities and the attention paid by the various agencies. The six states in New England that support Atlantic salmon have some of the strongest environmental regulations and interested citizenry in the nation and threats to Atlantic salmon habitat are typically detected quickly and able to be stopped effectively due to strong laws and regulations that prohibit activities that damage fish habitat.

c) The burden of proof on proponents of an activity which may have an impact on habitat

Activities that may have an effect on Atlantic salmon habitat must be reviewed for consistency with the laws and regulations described above. For federal actions within the rage of the GOM DPS, this review process most often occurs in the context of a section 7 consultation. In order for a project proponent to receive an incidental take statement that authorizes some level of take, they must: 1) thoroughly describe the activity; 2) describe the level of impact anticipated to occur as a result of the project; and 3) describe any conservation measures to be implemented that will minimize the level of impact. Depending on the level of impact of the project, the NMFS and USFWS may require impact monitoring to ensure the level of the effects is not greater than anticipated at the outset of the project. A somewhat similar consultation process also occurs within areas that are designated as EFH under the Magnuson Act; however, the EFH consultation is not necessarily binding.

Consultation is initiated when a federal agency or applicant provides a complete package which describes the project they are undertaking and contains an assessment of how that project will affect Atlantic salmon and their habitat. The federal resource agency biologists then review that package to determine if it is complete and if so if they agree with the assessment of impacts. The federal resource agency ultimately makes a determination of impact, which may or may not agree with that made by the project proponent. In general, the federal resource agency biologist is required to use best available scientific information and to err on the side of the species.

In regard to populations of salmon undergoing restoration outside of the GOM DPS, laws and regulations place the burden of proof regarding potential threats to the habitat to varying degrees, depending upon the agency that has regulatory authority. Some activities that would harm salmon habitat are clearly prohibited by State or federal law and there is no particular burden of proof needed. In some cases, a particular activity may not be prohibited, per se, but may require the Party to apply for a State or federal permit (e.g. mining gravel out of a streambed). In these cases, the regulatory agency would place the burden of proof upon the applicant. There are other instances where the activity is not prohibited, is fairly common in most places, and it is not clear whether or not it would cause harm to salmon habitat. An example might be building a shopping mall 2,000 feet away from a salmon stream when no habitat protection laws would be violated. In that case, the burden of proof may be on the conservationists in the community to demonstrate the proposed activity would damage salmon habitat.

d) Weighing the risks and the benefits to Atlantic salmon stocks with the socio-economic implications of activities

Weighing risks and benefits to Atlantic salmon stocks with the socio-economic implications is particularly difficult in the U.S. because of the severe degradation of habitat that has occurred in the past. However, the Federal ESA is quite clear in these respects. The ESA calls for the recovery of threatened and endangered species and also the ecosystems they depend on. Further, when determining whether or not a species qualifies for protection under the ESA, NMFS and USFWS are to make these determinations based solely on the best scientific and commercial data available. In short, listing determinations do not consider socio-economic issues. Thus, if a species is determined to be endangered as a result of an economic activity, the ramifications of listing that species to any industry would not be considered. Further, if a project is determined to jeopardize the continued existence of a species, NMFS and USFWS cannot authorize any take and instead must identify an alternative project that would not result in jeopardy. Thus, listing species as threatened or endangered can have significant socio-economic effects. The ESA was intended to be a strong regulatory mechanism designed to prevent extinctions even in cases with strong economic pressures.

Socio-economic issues are, however, carefully weighed when designating Critical Habitat. When designating Critical Habitat, the NMFS and USFWS must evaluate the economic costs of designation by identifying those activities that will likely need to be modified in order to avoid adverse modification of critical habitat. This analysis must also 1) assign relative economic cost to each specific area, 2) weigh the biological value against the economic cost for each specific area, and 3) consider possible exclusions.

When NMFS proposed to designate Critical Habitat for the expanded GOM DPS, it conducted this type of economic analysis. The NMFS determined that the economic costs associated with Critical Habitat designation would be quite high in many areas. For many of these areas however, the biological value was also high. In these cases, NMFS determined that the biological benefit of Critical Habitat designation should outweigh the economic costs and therefore proposed Critical Habitat designation in most areas that are currently occupied. There are only three HUC 10 watersheds that were proposed for exclusion because of socio-economic issues (Figure 6). These watersheds have a low biological value and high economic impact associated with designation. NMFS is currently examining public comments on its Critical Habitat designation and will make a final determination in April of 2009.

In regard to populations of salmon undergoing restoration outside of the GOM DPS, socio-economic issues are generally not considered by state agencies when determining the suitability of activities that might threaten salmon habitat. Generally, proposed activities are allowed or disallowed based upon their perceived impact to the habitat. Exceptions may occur in cases where very large projects with very significant social benefits are considered (e.g., a major bridge crossing or repair) and some degradation to salmon habitat is unavoidable. In that case, regulatory agencies often require the Party to mitigate for the impact—perhaps by improving salmon habitat elsewhere or removing a dam on the same salmon river.

e) Considering the effects of habitat activities on biodiversity in the areas affected

When projects are reviewed for consistency with federal law, whether it is through the ESA, Magnuson Act, FWCA, or other regulatory process, the effects to the species of concern are primary. For example, EFH for Atlantic salmon has been designated in many rivers in the Northeastern U.S. When the EFH consultation is conducted, it focuses on EFH for salmon. However, there are a variety of species that have EFH designated such as river herring and Atlantic sturgeon, and these consultations focus on those species with designated EFH. Most often these are only species of some economic importance or species that were historically important economically when they were more abundant. There is no mandate to consider biodiversity except in the case of the ESA, whereby, the NMFS and USFWS are required to recover listed species and the "ecosystems upon which they depend." If listed species requires another species to complete their life history, then the effects to that species may also be considered in a recovery context. However, there is no clear mandate to consider all aspects of biodiversity when conducting these types of environmental review.

In addition to these specific responsibilities for species and/or habitats commercially managed or protected, the USFWS and NMFS have a responsibility for the protection of all fish and wildlife and living marine resources. The mandate of these two agencies is a very broad one for the wildlife of the U.S. and therefore the agencies can provide comments and recommendations for actions necessary to protect any fish and wildlife or marine resource. In general, both agencies are also moving toward more of an ecosystem approach to management.

f) Considering other biological factors affecting the productive capacity of Atlantic salmon populations

The linkages between Atlantic salmon and the co-evolved suite of diadromous fish have received considerably more attention in recent years. As described in Section 5a of this Focus Area Report, current evidence suggests that Atlantic salmon in the Northeastern U.S. may require healthy and abundant populations of other native, diadromous species in order to complete their life history. Given these recent findings, the Atlantic salmon management program in the U.S. is beginning to shift focus toward a more holistic approach rather than a single-species focus as has been done in the past. One example of this shift in focus is a restoration prioritization process that has recently begun. This is an effort led by the NMFS in collaboration with the USFWS to evaluate a variety of restoration options and prioritize those that will have the greatest net benefit to the ecosystem in terms of restoration potential of river herring, American shad, and other species. This effort is led by staff in the salmon program in an effort to more thoroughly integrate salmon recovery with recovery of the co-evolved suite of other diadromous fish. These efforts should enhance recovery of salmon populations through the mechanisms described in detail by Fay et al. (2006) and Saunders et al. (2006).

An additional way in which other biological factors were considered to affect the productive capacity of Atlantic salmon populations was the NMFS consideration of recent trends in marine survival when designating Critical Habitat for the GOM DPS. In order to designate Critical Habitat, NMFS first had to determine the amount of habitat necessary to facilitate recovery and whether or not there was sufficient area currently occupied. If there was insufficient area occupied NMFS could have designated areas that are not currently occupied as Critical Habitat. In order to make this determination, NMFS examined recent trends in marine survival which, for U.S. populations, are at all time lows. Even with the recent declines in marine survival, NMFS was able to determine that there is sufficient habitat currently occupied and designating areas that are not currently occupied by salmon is not necessary. This determination is described in detail by Kircheis and Liebich (2007).

6. Overview of Ongoing Habitat Activities

There are a variety of ongoing activities within the U.S. that have been designed specifically to benefit Atlantic salmon populations and others that are enhancing other ecosystem processes at the same time they are benefiting Atlantic salmon and their habitat. These projects range in scale from simple tree planting in riparian areas to removal of mainstem hydro dams in the Penobscot River. Below we describe several initiatives with high potential to enhance Atlantic salmon recover and restoration efforts in the U.S.

Perhaps the most ambitious project in the U.S. currently underway is the Penobscot River Restoration Project (PRRP). If implemented, the PRRP would lead to the removal of the two lowermost main stem dams on the Penobscot River (Veazie and Great Works) and would decommission and construct a nature-like fishway around a third dam (Howland Dam). This initiative will vastly improve habitat accessibility for all diadromous species including Atlantic salmon in the basin. This is particularly important for all recovery efforts in the U.S. because the Penobscot has the largest remaining salmon population in the U.S. In fact, roughly 70% of all adult salmon in the U.S. are found in the Penobscot on an annual basis. In total, this project may ultimately cost between fifty-five and sixty 60 million dollars (USD) to complete. This would however, be the most important active restoration step toward recovery in the history of the Atlantic salmon recovery program in the U.S. To date, the dams have been purchased for 25 million dollars by the Penobscot Trust and fund raising and permitting for dam removal is ongoing.

Other dam removal efforts are currently underway or have recently been completed as well. In New Hampshire, the multi-agency New Hampshire River Restoration Task Force continued to work on identifying dams for removal in the state and pursuing strategic alterations of dams. One success story is the removal of the Merrimack Village Dam on the Souhegan River (tributary to the Merrimack River). This dam removal is also being closely monitored for effectiveness and efficacy through a thorough monitoring and assessment program. Lessons learned from this effort should significantly improve other restoration projects throughout the range of Atlantic salmon in the U.S.

The USFWS Gulf of Maine program in collaboration with the Maine Forest Service has spearheaded a Maine fish passage barrier inventory. The inventory is an evolving initiative designed to conduct a comprehensive inventory of bridges and culverts at road-crossings, dams and natural obstructions that may limit fish passage. Surveyed watersheds to date include the lower and middle Penobscot with future plans to expand into the Piscataquis and Mattawamkeag drainages. These surveys will provide a baseline for prioritizing passage restoration projects. Partners include Gulf of Maine Coastal Program office, Maine Forest Service, Maine Atlantic Salmon Commission, Project SHARE, NMFS, and the Atlantic Salmon Federation.

Project SHARE (Salmon Habitat and River Enhancement) is non-profit habitat restoration group located in Washington County, Maine, which focuses on fish passage implementation for endangered Atlantic salmon in Downeast Rivers in Maine. Existing undersized, hung and damaged culverts in streams are replaced with open-bottom arch culverts of removable crossing structures. Outreach and conservation efforts are primarily funded through the Natural Resources Conservation Service (NRCS) Wildlife Habitat Incentives Program (WHIP). In 2007, Project SHARE completed 13 stream habitat connectivity projects in four Downeast Rivers using funds from USDA-WHIP, USFWS, MASC-SCEP, Project SHARE, Washington County Soil and Water Conservation District, and private landowners. One culvert was completely removed in the Machias River watershed. The remaining 12 projects replaced undersized or failing structures with open bottom arches that spanned 1.2 times bankfull stream width. Although the majority of these restoration projects were located above mapped juvenile Atlantic salmon habitat, the Harmon Brook site, in the East Machias watershed, was within mapped habitat. This location is routinely stocked with fry, although stocking was not conducted in 2007 in anticipation of culvert replacement. Pre-construction electrofishing collected 40 salmon parr just above and below the road in Harmon Brook. One restoration site, located 50 meters above the West Branch Machias River, contained both young-of-the-year and parr Atlantic salmon during the pre-construction fish removal efforts.

In recent years there have been a variety of conservation easements and land purchases designed to permanently protect salmon rivers as well. For example, one of the largest nature preserves in Connecticut is the Burnham Brook Nature Preserve owned by The Nature Conservancy. It was acquired (and continues to be added to) for a variety of reasons including the protection of high value salmon habitat on the Eightmile River, a tributary to the Connecticut River. The money for this project was raised mostly by private donations outside of government activities but in consultation with state and federal biologists who understood the value of the habitat to salmon and other species.

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GIS-Based Atlantic Salmon Habitat Model

DRAFT
2008

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Appendix

GIS-Based Atlantic Salmon Habitat Model

Jed Wright [1], John Sweka [2], Alex Abbott [1], Tara Trinko[3]

Introduction

Fisheries management agencies have traditionally utilized field surveys to develop estimates of Atlantic salmon habitat in Maine rivers. While providing detailed information, field surveys are expensive to conduct and to-date cover only a small portion of the range of historic habitat of Atlantic salmon. A GIS-based habitat model was developed to predict the amount of Atlantic salmon rearing habitat in un-surveyed salmon rivers. The model was developed using data from habitat surveys conducted in the Machias, Sheepscot, Dennys, Sandy, Piscataquis, Mattawmkeag, and Soudabscook Rivers. The model uses reach slope derived from contour and digital elevation model (DEM) datasets, cumulative drainage area, and physiographic province to predict the total amount of rearing habitat within a reach. The variables included in the model explain 73% of the variation in rearing habitat. Maps and data from the model will help inform the proposed listing of critical habitats. This GIS based model will also be used for a variety of management activities including stocking, removing barriers, and prioritizing in-stream habitat restoration projects. The maps below show the extent of the area modeled by the project and detailed GIS output that is available from the model.

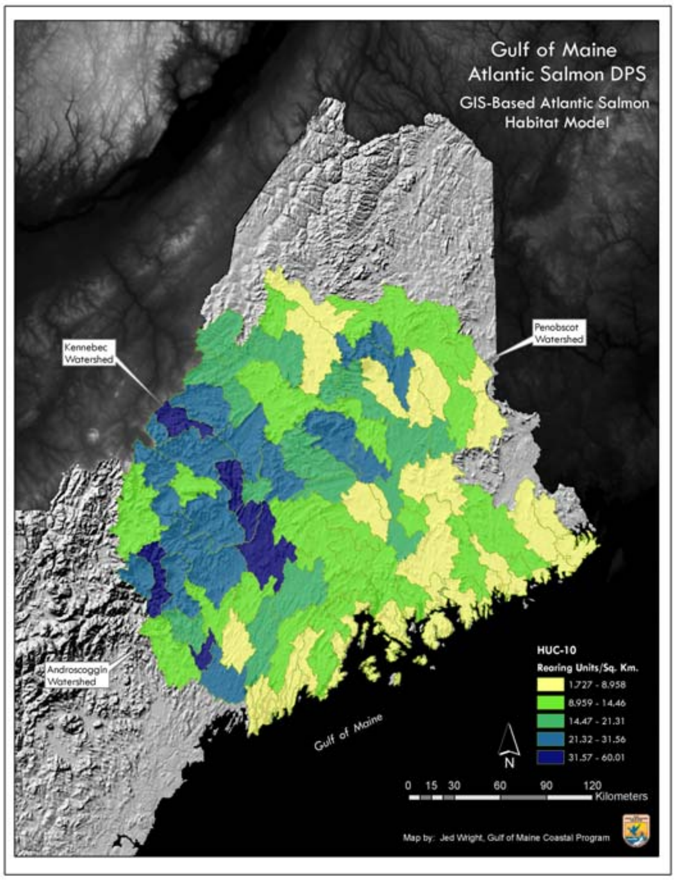

Figure 1: Extent of area included in GIS model.

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[1] U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program
[2] U.S. Fish and Wildlife Service, Northeast Fishery Center
[3] NOAA Fisheries Service, Maine Field Station

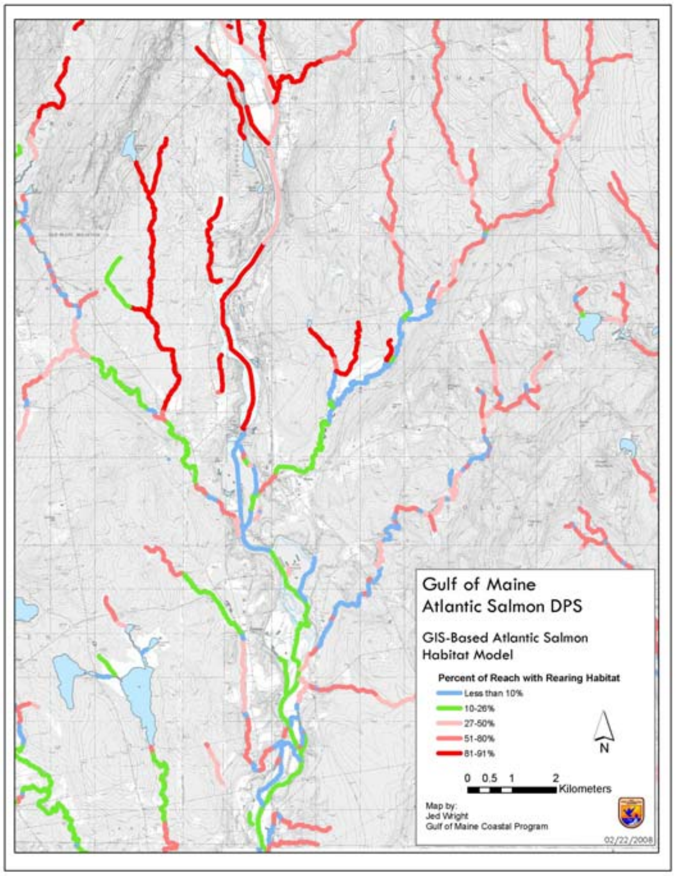

Figure 2: The GIS model predicts the amount of habitat within each stream reach.

Methods

<u>Stream Segment Selection Methods</u>

ArcGIS software version 9.2 (Environmental Systems Research Institute 2006) was used to process datasets used in the analysis. The National Hydrography High Resolution Dataset (NHDH) was used to identify potential habitat within the expanded Atlantic Salmon Gulf of Maine Distinct Population Segment (GOM-DPS). NHDH flowlines that were either perennial streams/rivers or that were located within 1:24,000 double line river segments were selected for use in the model. Selected stream and river reaches were then dissolved by GNIS-ID using the dissolve command in ArcTool Box. XTools Pro Version 5.0 was used to convert multipart selected stream segments to single parts and editing was conducted to remove short artificial path segments.

<u>Stream Segment Slope Determination</u>

Using the selected stream segments, XTools Pro was used to split the selected set of NHDH polylines with a 1:24,000 contour coverage. X Tools Pro was then used to create To and FROM endpoints from the newly split line segments. A spatial join was used to obtain an elevation value for the TO and FROM points from contour lines. In addition, a distance to the nearest contour line was calculated for each point. Hawth's Tools Version 3.27 was then used to obtain digital elevation model (DEM) elevation values to each TO and FROM point. DEM values were obtained from both 10 and 30 meter DEM datasets as a 10 meter DEM was not available for the entire study area. After values had been obtained from contour and DEM datasets, a final elevation was calculated for each point.

A point located within 1 meter of the nearest contour line was given a final elevation based on contour values. All remaining points were then coded with a final elevation of the corresponding DEM value, 10 meter values were used if available otherwise 30 meter DEM dataset values were used. Final elevations were calculated in meters.

TO and FROM points were joined by attribute back to corresponding selected NHDH stream segments based on either From ID or To ID and Object ID. The NHDH line was then coded with the FROM and TO elevation of the points. A field was added to NHD lines called "vertical" and a value was calculated as FROM elevation- TO Elevation. All lines were then examined for negative slopes and edited for errors. In addition, segments that intersected contour lines multiple times or segments that intersected contour lines and identical FROM and TO values were dissolved. Finally, a "slope" field was added to the selected NHD stream segments and calculated as (Vertical/ ShapeLength)*100 to give the percent slope. All data sets were edited to contain less than 5% negative or zero slopes as calculated by total stream length. All negative and zero slope values were removed from the data set for later regression analyses. A final processing step involved identifying reaches that were located in tidal river reaches. National Wetlands Inventory (NWI) datasets were used to select and delete reaches that were located in either in estuarine or riverine tidal areas. The final reach dataset included over 148,010 reaches.

<u>Cumulative Drainage Area</u>

The original dataset used to develop the habitat model used Arc Hydro for ArcGIS 9 (version 1.1) and both 10 and 30 meter DEMs to obtain a cumulative drainage area for the downstream end of each reach. Unfortunately, there was not enough processing time to create cumulative drainage areas for almost 150,000 points representing the downstream end of each potential habitat line segment. Instead, cumulative drainage area was calculated where possible for all segments using NHDPlus datasets (http://www.horizon-systems.com/nhdplus/index.php). NHDPlus provides a cumulative drainage area (as well as other attributes such as flow and Strahler stream order) for each reach through a tabular join (through the ComID field) to the flowlineattributesflow.dbf table.

Cumulative drainage area was calculated (in the CumDrnSqKM field) for each potential habitat segment where its original NHDH ReachCode matched the ReachCode of the NHDPlus lines. Each of the matching lines received a MatchCode of 1 for ease of identification throughout processing. All line segments were run through the FLoWs (Colorado State University; v. 9.2) Snap Points to Landscape Network Edges Pre-Processing tool using ArcGIS 9.2 software to assign a reach identifier (rid) and a distance ratio value (ratio) to the centroids of each potential habitat segment. FLoWs snaps each input point within a specified distance to the NHDPlus lines ("Network Edges"), and gives the ratio of the distance that point sits along the NHDPlus reach line from downstream to upstream. To avoid the large number of errors that can occur when the tool snaps points to the lines the downstream TO points were not used as inputs to the tool. Instead, the segments' centroids were substituted. There is a difference in distance between the TO points and the centroids of the same line segments and this process provides only the approximate ratio of the distance of each TO point along the original reach line. Yet, as there are normally several potential habitat line segments within each NHDPlus reach, this process provides a reasonable ratio of the distance for use in calculating cumulative drainage areas.

The next step was to assign catchment areas to each NHDPlus reach through a join to the NHDPlus catchment shapefile via the ComID field. The ratio calculated above was then used to calculate the segments' approximate catchment area, take its inverse, and subtract that from the CumDrnSqKM value for each segment with a MatchCode = 1, but not including any headwater stream segments with a ratio > 0.1 (these segments are generally in smaller catchments that receive the default cumulative drainage area value applied to other segments without matching NHDPlus reaches). A selection was made of all segments of MatchCode = 1 AND CumDrnSqKM = Catchment AND Ratio > 0.1, and all selected records had a new cumulative drainage area field, CumDrain2, calculated = -99 (No Data). The selection was then switched to its reciprocal, and values calculated using the formula:

CumDrain2 = CumDrnSqKM - (Ratio * Catchment)

Next, all records of MatchCode not equal to 1 were selected and calculated = -99. Finally, a new field, DA, was calculated to hold the value of cumulative drainage area in square miles.

Cumulative drainage area for all streams without matching NHDP ReachCodes (MatchCode = -99) were set at a fixed value of one square mile after calculation of sample drainage areas from various watersheds within the SHRUs.

<u>Reach Width</u>

A width for each stream reach was calculated using regional hydraulic geometry curves for Maine rivers based on Dudley (2004) and the cumulative drainage area obtained from the steps outlined above.

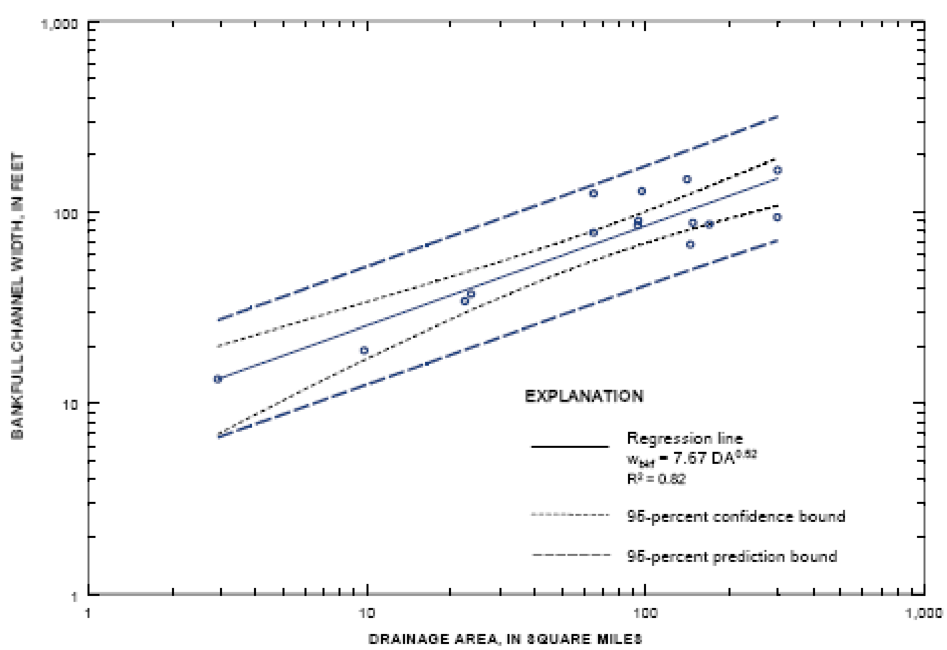

Figure 3: Regional relation of bankfull channel width to drainage area for rivers in coastal and central Maine. [wbkf, channel width associated with the bankfull streamflow; DA, drainage area; R2, fraction of variance explained by regression] (Dudley 2004).

A cursory analysis was undertaken to examine the relationship between predicted bankfull widths and widths measured in the field during habitat surveys. This examination showed that habitat widths were approximately 80% of predicted bankfull widths.

Physiographic Provinces

Maine Atlantic salmon rivers span a diverse set of geologies, climates and elevations. In order to account for these differences we incorporated a physiographic variable into the model. Each river reach was classified by physiographic divisions based on Fenneman, N.M., and Johnson, D.W. (1946).

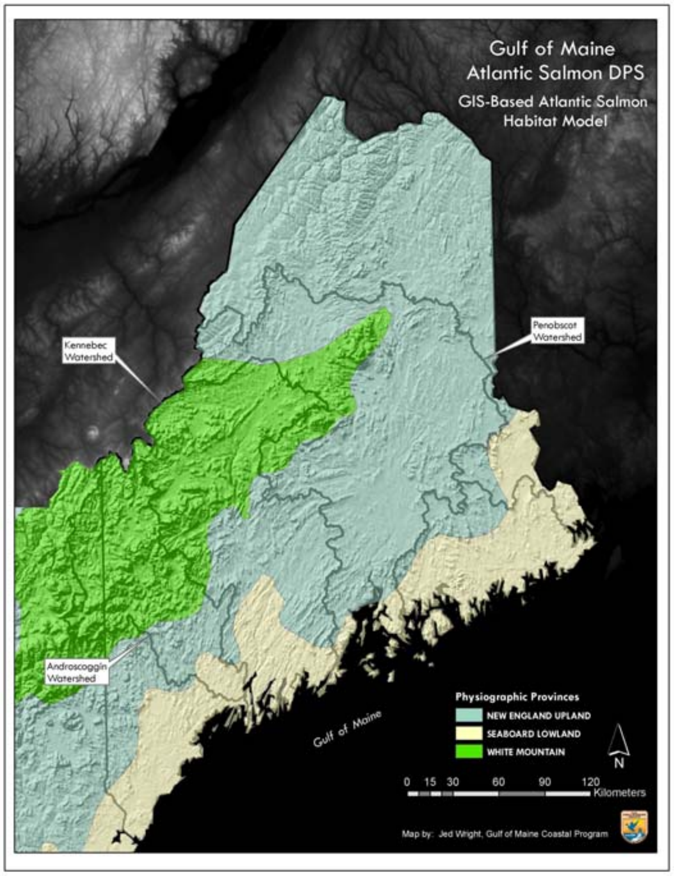

Figure 4: Physiographic provinces included in GIS model.

Final Dataset

The final dataset included the following variables:

Variable	Definition
Unique ID	A unique ID for each stream reach in the SHRU
Source	Elevation source (DEM or contour)
Physiographic Province	Physiographic province from Fenneman
HUC10_Code	USGS HUC 10 code
Length	Length of each reach in meter
Reach Slope	Slope calculated from vertical elevation and reach length
Cumulative Drainage Area	Drainage area in square meters at downstream end of reach
Width	80% of width calculated using regional hydraulic

	geometry curves and cumulative drainage area
Access	N if the reach was not historically accessible to salmon

Regression Tree Analysis

Regression tree analysis is a modern statistical technique that has advantages over classical multiple regression techniques in that there are no assumptions about the error structure of the data and is robust to highly correlated predictor variables (De' Atth and Fabricius 2000). The regression tree is constructed by repeatedly splitting the data into two mutually exclusive groups which are as homogeneous as possible. A group of data is referred to as a node and nodes are further split into additional nodes creating a graphical tree explaining the variability in the data. For numeric predictor variables, the values of a predictor are ranked and trial splits are made moving across all possible division points. The variance of the resulting nodes is calculated and the splitting point which results in the most homogeneous groups (minimized variance) is retained. This process is then repeated for each of the other predictor variables and the best split for any predictor variable is used to perform the actual split on the node. Thus, the optimal split on any given node may be performed by any one of the predictor variables. The regression tree process can result in an overly complex tree as resulting nodes are split further and further. Breiman et al. (1984) recommended *V*-fold cross-validation as a means to find the best single tree for description and predictive purposes.

The computer software DTREG® (Sherrod 2006) was used to build the regression tree describing the variation in percent rearing habitat within a stream reach. A total of 332 stream reaches were used in the analysis. Predictor variables included valley width cumulative drainage, reach slope, and physiographic province. An initial split based on physiographic province was specified in the model because of the apparent differences between streams of different physiographic provinces.

The optimal tree based on *V*-fold cross validation contained predictor variables of physiographic province, cumulative drainage area, and reach slope and explained 73% of the variation in percent rearing habitat (Figure 5). Valley width was dropped from the set of predictors because it provided little additional explanatory power. The final tree contained 12 terminal nodes. In general, there was a tendency for percent rearing habitat to increase with greater slope, but there was also an apparent interaction between reach slope and cumulative drainage area (Figure 5).

This model was then used to predict the percent rearing habitat and absolute amount of rearing habitat in 148,010 reaches throughout Maine rivers. Predictions of percent rearing habitat were made by running the data through the DTREG® software and assigning each reach to one of the terminal nodes of the regression tree. The absolute amount of habitat in a reach was estimated by multiplying the area (length x mean width) of the stream reach by the mean percent rearing habitat of the terminal node. The variance associated with the estimate of rearing habitat equaled the variance of the terminal node (Standard Deviation in Figure 5 squared) multiplied by the $area^2$ of the reach. The total rearing habitat within river basins was estimated by summing estimates of reach habitat and associated variances.

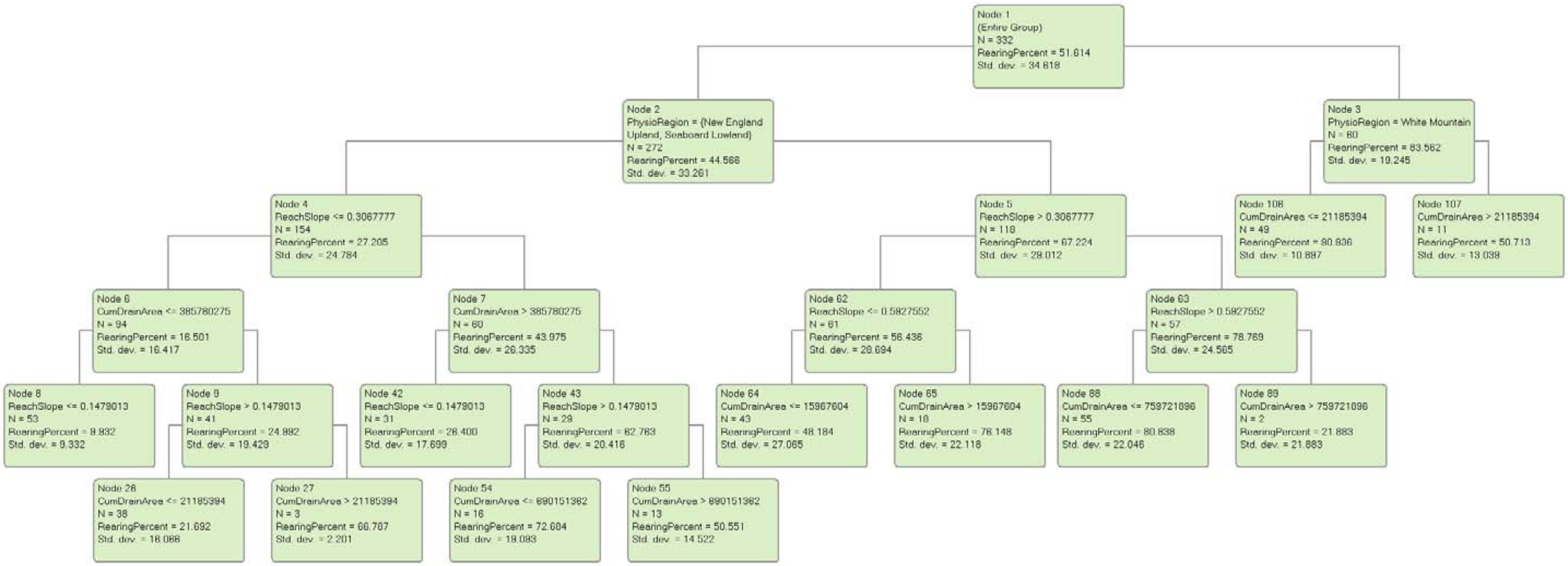

Figure 5: Regression tree model to predict the percent rearing habitat in a steam reach. The model explained 73% of the variation in percent rearing habitat from the 332 reaches used to create the model.

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