Final Report - Atlantic Salmon Restoration and Conservation In Lieu Fee Program

Compensation Rate Calculations and Fee Schedule

November 20, 2016

Background

Program Sponsor US Fish & Wildlife Service (USFWS) in conjunction with The Conservation Fund (TCF) and other project partners wish to establish the Maine Atlantic Salmon Restoration and Conservation Program (ASRCP), an In Lieu Fee (ILF) Program for compensating adverse impacts to Atlantic salmon within the State of Maine. The ASRCP will provide a compensatory mitigation option to project applicants where USFWS consultation has occurred and it has been determined there will be an adverse effect on Atlantic salmon habitat as a result of a project.

Compensation fees collected through the ILF will be placed in a fund to support compensation projects within three Salmon Habitat Recovery Units (SHRU's) in the state: Merrymeeting Bay, Penobscot Basin and Downeast Coastal.

Scope of Work

For the ILF program to function properly, a consistent, defensible and "user-friendly" mechanism for calculating program credits and debits (fees) based on project impacts to Atlantic salmon habitat is necessary. The task at hand was to develop a fee schedule and compensation rate calculation formulas for restoring, enhancing, creating, and preserving Atlantic salmon resources in the State of Maine, based on a dollar value per modeled and field-verified habitat unit. Dollar values are to include the projected costs associated with natural Atlantic salmon recovery project planning, design and construction, long-term monitoring, operations, stewardship, and maintenance.

Approach

The project was divided into four main tasks:

<u>Task 1.</u> Initial partner coordination, data gathering and literature review;

<u>Task 2.</u> Applying rapid assessment cost models to estimate the total cost of improving all potential stream crossing barriers to Atlantic salmon passage within the geographic area of the three Salmon Habitat Recovery Units;

<u>Task 3.</u> Developing quantitative and qualitative metrics to evaluate the potential impacts of individual stream crossings and other related projects within the project area;

<u>Task 4.</u> Apply metrics to cost estimates to calculate program credits and debits.

<u>Task 1.</u> Initial partner coordination, data gathering and literature review

To date, in person meetings, phone discussions and email correspondence have been conducted with more than 15 representatives of project partners, researchers and other conservation organizations and agencies. Important data key to the project was provided by MDOT and the US Fish & Wildlife Service in the form of detailed stream crossing inventory data of several thousand Maine public road crossings, and actual transportation project costs from Connecticut, New Hampshire and Maine. USFWS provided numerous GIS data layers including the locations of designated Critical Habitat, modeled Atlantic salmon rearing habitat, surveyed rearing and spawning habitat, and other pertinent data layers.

A review of published literature was conducted with its major focus being other In Lieu Fee programs around New England and the United States, a review of existing or developing decision making tools for aquatic systems restoration, and rapid cost assessment models for stream crossing and other habitat enhancement projects.

<u>Task 2.</u> Applying rapid assessment cost models to estimate the total cost of improving all potential stream crossing barriers to Atlantic salmon passage within the geographic area of the three Salmon Habitat Recovery Units

A review of available data calculating road crossing project costs aimed at providing adequate Atlantic salmon passage in Maine showed a wide range of reported costs depending on site conditions, location, materials and other factors.

Data provided by Maine DOT staff for 14 recent or in progress stream crossing structure projects in Connecticut, New Hampshire and Maine show a project cost per lineal foot ranging from $3,850 to $45,000, with a mean of $14,770.

In contrast, the installation of 39 bottomless arch culverts on forest roads in eastern Maine to improve fish passage had an average installation cost of $33,000 in 2007 dollars (Long 2010). A detailed discussion of a subset of four of the crossings yielded installation costs averaging $832/lineal foot (2007 dollars).

Outside Maine, The Nature Conservancy (Levine 2013) detailed stream crossing restoration projects in the Au sable watershed in the Adirondack region of New York. This included the installation of a 10'x5'x44' concrete box culvert in Lewis Brook at a cost of $4,956/lineal foot. Replacing an additional 174 culverts in the watershed with "fish friendly" designs was estimated to cost about $150,000 per site, with no structure lengths provided and so a lineal foot cost could not be calculated.

Similarly, data from Vermont's Green Mountain National Forest (Gillespie 2013) estimated project costs of replacing existing traditional culvert designs with those with a stream simulation design at $130,000 to $172,000 per site for five featured sites.

Several other cost studies from around the country were also reviewed. A review of the available literature also revealed a recognized lack of empirical data showing the full life cycle costs of different stream crossing designs. Given a wide cost estimate range among different sources and a relatively small number of empirical data points, additional cost assessment models were sought to estimate the average costs of improving all existing stream crossing structures within the project area.

Three cost estimation models were applied to the best available dataset of surveyed stream crossings in Maine (2014), which exclude private roads. Attempts to obtain a more complete dataset have been unsuccessful due in part to confidentiality issues on private lands.

COST MODELS APPLIED

The first model applied is that developed by Thomas Neeson et al (2013) as part of the Fishwerks aquatic restoration decision making tool developed for the Great Lakes. The model estimates the total cost of each fish friendly road crossing structure in the dataset as the sum of the costs of the culvert, excavation, surfacing and miscellaneous costs, plus a 20% addition for design and construction. Separate culvert, excavation and surfacing cost sub-models were applied for each of these variables. The model was applied with small modifications from data already available in the stream crossing inventory. The additional costs of monitoring, estimated at $25,000 per project (center of range provided by Judy Gates, pers. comm. 2015) and long term maintenance ($200/yr. for 50 years), though not included in the original Neeson model, were added to the end result to create a total estimated cost to replace, monitor and maintain all crossings in the dataset that were coded as “Barrier” or “Potential Barrier” in the dataset (3,869 crossings), adjusted to 2015 dollars.

The total estimated cost was divided by the total lineal feet of crossing structure from the dataset to produce an estimate of $1,831 per lineal foot, or approximately $111,000 per crossing.

The second cost model applied is the method developed in A Primer on Habitat Project Costs prepared in the Puget Sound region by Evergreen Funding Consultants in 2003. The Evergreen model utilizes two main variables: road type and stream width, to develop a range of costs for each crossing. Road Type is split into four categories: Forest Road, Minor 2 Lane, Major 2 Lane and Highway 4+ Lanes. Stream size is broken out into widths of <10 feet, 10-20 feet and 20-30 feet. The resulting cost matrix further provides low to high cost estimate ranges for each variable pair. The necessary input data to apply this model to the project area was found by spatially joining the stream crossing inventory with a GIS coverage of DOT Public Roads. The cost ranges provided include construction, design, permitting, basic monitoring (2 years), routine maintenance (2 years), reestablishing the site to prior conditions, and project management costs that are normally associated with implementing a capital project (Evergreen 2003). More general administrative, enforcement, and long-term maintenance costs were not included. Final cost estimates were adjusted to 2015 dollars.

Low, average and high values from the cost matrix were applied to each barrier or potential barrier identified in the stream crossing inventory (3,869 crossings) to produce total costs for replacement of all such crossings. The total estimated cost was divided by the total lineal feet of crossing structure from the dataset to produce low, average and high estimates of $1,947, $2,725 and $3,504 per lineal foot, respectively. This equates to approximately $118,000 to $212,000 per crossing.

The final method utilized was developed by Barry Dikeman and others (New England Environmental Center 2010) to "provide information about what the cost impact of LD 1725 would be for typical culvert replacements in Maine". The report outlines seven cost scenarios in which existing culvert designs are upgraded to 1.2 x bankfull width designs. The seven scenarios were analyzed to determine the estimated cost contribution of the culvert material itself to the total installation cost. A related presentation by the same researchers estimated the total cost of culvert material only for upgrading all stream crossing structures in the state, estimated at 30,000. An image from the LD1725 Financial Impact Presentation is shown below:

Pipe Material Costs

Projected Total Statewide Cost Impact for Pipe Material to Achieve 1.2x Bankfull*

Structure Size Range Distribution	% of Structures Statewide	# of Structures Statewide	AVG Upsize % to Achieve 1.2BF	AVG Δ Material Cost per foot to upgrade per crossing	Total AVG Δ Material Cost to Upgrade 40' L Culvert	Total Statewide AVG Δ Material Cost to Upgrade 40' L Culvert
0" - 47"	37%	11,100	350%	$155	$6,200	$68,820,000
48" - 84"	43%	12,900	300%	$350	$14,000	$180,600,000
85" - 120"	13%	3,900	225%	$315	$12,600	$49,140,000
>120"	7%	2,100	170%	$550	$22,000	$46,200,000
			TOTAL AVG MATERIAL COST Δ			$344,760,000**

** assumes 30,000 culverts statewide with average culvert length of 40 ft.*
*** costs are expressed in 2010 dollars using current material prices obtained from regional material vendors.*

- **Assumes 30,000 replacements**
- **Assumes 40 foot average length**
  - **Increasing the estimate for average length will increase total cost:**
    - **50 foot average = $430,950,000**
    - **60 foot average = $517,140,000**
    - **75 foot average = $646,425,000**
- **An unknown percentage of the crossings in the >120" range may be bridge structures.**

Cost figures were adjusted to 2015 dollars. Culvert-to-total-installation ratios from the 2010 report were applied to the presentation data to estimate a lineal foot cost average per structure. The table below shows the relative cost contribution of culvert material to total construction costs from New England Environmental Center 2010 report:

Scenario	1.2 BFW ft	Replacement culvert type	Culvert Cost	Total Cost	Culvert as %
1C	12	CMP arch	12500	47760	26.2%
1D	12	Concrete box	35000	73635	47.5%
2B	12	CMP arch	15000	86935	17.3%
2C	12	Concrete box	42000	115075	36.5%
3B	9	CMP galv arch pipe	7000	39060	17.9%
3C	9	CMP arch	11250	58010	19.4%
3D	9	Concrete box	25000	73050	34.2%
4B	8	CMP galv arch pipe	7200	48475	14.9%
4C	8	CMP arch	9750	42865	22.7%
5C	16	CMP arch	20000	63925	31.3%
5D	16	Concrete box	38750	85575	45.3%
6C	18	CMP arch	22500	89550	25.1%
6D	18	Concrete box	52500	118625	44.3%
7C	20	CMP arch	28750	99325	28.9%
7D	20	Concrete box	60000	128800	46.6%
Low %	14.9%				
High %	47.5%				
Mean %	30.5%				
Median %	28.9%				

For the purposes of applying this estimation method to crossings in the project area, the mean value of 30.5% was chosen. Additional estimates for preliminary engineering (10%) and monitoring ($25,000 per project) were added (Judy Gates, pers. comm. 2015), in addition to a $200 per year estimate for long term maintenance over a 50 year life cycle.

Using the average crossing structure length in the stream crossing inventory dataset of 60.5 feet, the analysis produced an average lineal foot cost of $1,713 per foot, or approximately $103,000 per crossing.

While the methods of estimation may not be robust enough to accurately predict costs for a single project, spread out over several thousand records they produced relatively similar results, especially among the Neeson and Dikeman methods, and with both varying less than 15% from the low end of the range of the Evergreen model. Of the three models, the Dikeman model, produced in Maine for the DOT, seems most relevant and its results were chosen to apply in Task 4, which is to relate the potential costs of providing upgrades to problematic stream crossings in the project area to the amount of Atlantic salmon habitat that is currently being impeded by them.

<u>Task 3.</u> Developing quantitative and qualitative metrics to easily evaluate the potential impacts of individual stream crossings and other related projects within the project area

According to a GIS-Based predictive model developed by Wright, et al (2008), there are a total of approximately 757,000 units (defined as 100 sq. m) of Atlantic salmon rearing habitat within the Merrymeeting Bay, Penobscot Basin and Downeast Coastal Salmon Habitat Recovery Units.

Of these, a far smaller percentage are suitable to provide salmon the needed characteristics to sustain them, and provide a functional equivalent of only about 135,000 units (NMFS 2009). Of these, an optimistic estimate is that only about 39,000 units are “likely accessible” to fish (Maine DMR 2011). The National Marine Fisheries Service believes 30,000 accessible units of habitat within each SHRU is necessary for self-sustaining populations of Atlantic salmon to recover and persist (NMFS 2009).

QUANTITATIVE HABITAT MEASURES

Metrics were investigated to measure the quantity and quality of salmon habitat, for inclusion in compensation rate calculation formulas for ILF credits and debits. For quantitative measures, three categories were considered for inclusion: total rearing habitat units within each SHRU, total functional units, and total units blocked from fish.

Of the three, only total blocked habitat units can be combined at this time with the above cost models in an “apples to apples” calculation. The available dataset of road crossings is not and likely will not be fully complete and available for some time to come. The crossing dataset is the source for both information about each structure and the sum of blocked rearing habitat units for each inventoried crossing. Because the dataset is incomplete, the sum of blocked units in the inventory data is much smaller than the actual total. However, the number of stream crossings is also lower and is directly linked record by record to the sum of blocked habitat units, allowing for a quantitative judgment for each inventoried crossing.

Incorporating Spawning Habitat Impacts

In addition to blocked rearing units, the impact on blocked spawning habitat was also incorporated into the compensation rate calculation formulas. When attempting to include impacted spawning areas, however, there is a recognized data gap. Unlike rearing habitat, there is no predictive model to estimate the amount of spawning habitat blocked by each stream crossing barrier. Further, on the ground spawning surveys have not been conducted in the majority of the DPS watersheds.

One potential remedy for the lack of data was explored, which was to examine whether there is a relationship between the amount of surveyed rearing habitat and the amount of spawning habitat within surveyed areas of the DPS. If so, it would be possible to apply a proportional proxy value to sites where no spawning surveys have been conducted.

All available habitat survey data was analyzed in ArcGIS, which included 21 drainages. Total surveyed rearing habitat units in each drainage were divided by the total surveyed spawning units to derive a simple ratio. The results showed a wide variation from drainage to drainage in the ratio of rearing to spawning habitat, and there does not appear to be a correlation between the two. Rearing to spawning ratios ranged from 2.6:1 in the Saco River to 28.1:1 in the Piscataquis. The Passagassawakeag had a very small survey sample size and was an outlier at a ratio of 161:1.

A further examination of the spatial distribution of the varying ratios revealed no apparent geographic trends. As a result, applying a proxy value for spawning impacts based on a rearing to spawning ratio is not recommended. In the absence of a proxy that can be applied to all DPS sites, it is recommended that spawning survey data be employed wherever it is available.

<u>Incorporating Impacts to Adjacent Habitat</u>

To comprehensively assess the habitat impacts at project sites, impacts to rearing and spawning habitat units immediately at or downstream of project sites were incorporated into fee compensation rate formulas. To quantify adjacent impacts, surveyed habitat within an appropriate search distance may be easily applied using ArcGIS. Alternatively, the quantity of adjacent impacts could be evaluated on a case by case basis using a combination of available mapping tools and professional judgment.

QUALITATIVE HABITAT MEASURES

In 2009, NMFS Northeast Region staff conducted an analysis pursuant to Section 4(b)(2) of the Endangered Species Act (ESA), which supports the proposed designation of critical habitat for the Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon. Section 3(5)(A) of the ESA (16 U.S.C. 1532(5)) defines critical habitat for a threatened or endangered species as: "(i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of [section 4 of the Act], on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection", as well as certain additional areas deemed necessary for the conservation of the species. The Act also provides for the exclusion of certain important areas from designation if the economic impacts of designation outweigh the conservation value.

Forty-five of the 87 HUC10 watersheds within the DPS geographic area have been designated as critical habitat. Given its importance to the species, giving greater weight to impacts (through the ILF fee structure) within critical habitat areas seems appropriate.

As part of its determination of critical habitat, NMFS also conducted an analysis of the Biological Value of each HUC10 watershed within the DPS. For each HUC10 watershed, NMFS "assigned a biological value based on habitat quantity and habitat quality needed to support spawning, rearing and migration of Atlantic salmon" (See excerpt from NMFS 2009 in Appendix). "The Final Biological Value indicates the habitat's current value to Atlantic salmon spawning, rearing and migration activities" (NMFS 2009). The assignment of biological value scores was one of the processes used in determining areas to include or exclude from critical habitat designation, and as such has some similarities as a measure of habitat significance to Atlantic salmon. However, unlike critical habitat this measure does not consider economic or national security impacts but focuses only on the ecological needs of the species.

Some HUC10's have a high Biological Value but were excluded from designation as critical habitat, and so incorporating biological value into the compensation rate calculation formulas seems appropriate if properly applied.

ILF partners and IRT members have expressed an interest in keeping credit and debit calculations both as simple and as ecologically defensible as possible, while still returning a reasonable outcome with respect to ILF fees and credits. Both the measures of critical habitat and biological value are rooted in ecology, based on the needs of the species, and are also directly tied to the Endangered Species Act itself. As such, they are seen as the two key measures of quality to incorporate into the compensation rate formulas.

<u>Task 4.</u> Apply metrics to cost estimates to calculate program credits and debits

CALCULATING BASE RATE FOR CREDITS AND DEBITS FOR EACH SHRU

The amount of accessible habitat units needed for Atlantic salmon recovery varies between the three Salmon Habitat Recovery Units. Likewise, the number of units currently blocked, and the completeness of the stream crossing inventory also varies geographically. A calculation of a base credit (expressed as the value of one blocked unit of rearing habitat) was completed for each SHRU.

Given stream crossing dataset does not currently include private roads, the total number of blocked units for each SHRU likely varies in accuracy. The results are based on the best available data (2014) at this time, and should be updated whenever new and expanded datasets are made available.

Base credit rate was calculated as follows:

$$\textbf{[Base Credit]} = \frac{\textbf{[Total lineal feet of crossing structure] x [Estimated cost per lineal foot]}}{\textbf{[Total blocked rearing habitat units]}}$$

Crossing structure length and blocked rearing unit values are included in the stream crossing inventory data. Estimated cost per lineal foot to upgrade a crossing to 1.2 x bankfull width is from the cost model adapted from The New England Conservation Finance Center.

Base credit rates, the cost per blocked rearing unit for each SHRU, are shown below. NOTE: an updated stream crossing inventory dataset for public road crossings was obtained since the report "ILF Progress and Draft Findings" was released. The additional data resulted in changes to the draft base credit amounts included in that report.

SHRU_Name	CostPerBlocked
DowneastCoastalShru	$6,346.80
MerrymeetingBayShru	$4,855.52
PenobscotBasinShru	$3,408.02

Next, base credit rates were modified based on the specific qualitative factors present at each stream crossing project site. For sites within HUC10's designated as critical habitat, the following simple calculation to determine site specific mitigation fees was developed:

If Critical Habitat 'Yes':
[Fee] = [Base Credit] x ([# of Upstream Blocked Rearing Units] + [# of Blocked Surveyed Spawning Units] + [# of Adjacent Impacted Rearing Units] + [# of Adjacent Impacted Spawning Units])

Example calculation #1: A proposed stream crossing structure in the Penobscot Basin SHRU will be required to pay a mitigation fee. It is in a Critical Habitat area. Upstream of the crossing are 5 units of blocked rearing habitat. An additional 4 units of rearing habitat are located at the project site, directly downstream of the crossing structure. A habitat survey has shown that there is 1 unit of spawning habitat upstream of the project and below the next upstream barrier. The mitigation fee would be calculated as follows:

[Fee] = [Base Credit] x ([# of Upstream Blocked Rearing Units] + [# of Blocked Surveyed Spawning Units] + [# of Adjacent Impacted Rearing Units] + [# of Adjacent Impacted Spawning Units])
[Fee] = $3,408 x (5 + 1 + 4 + 0)
[Fee] = $3,408 x 10
[Fee] = $34,080

Data inputs for critical habitat status, adjacent habitats impacted and quantity of surveyed upstream spawning habitat are all easily derived from available GIS data layers, which have been packaged in an ArcGIS Map Document for quick reference. Upstream blocked rearing units are contained within the stream crossing inventory for each crossing.

For areas not designated as critical habitat, the Biological Value of the HUC10 was utilized as follows:

If Critical Habitat 'No':
[Fee] = ([Base credit rate] x ([# of Upstream Blocked Rearing Units] + [# of Blocked Surveyed Spawning Units] + [# of Adjacent Impacted Rearing Units] + [# of Adjacent Impacted Spawning Units])) x [Biological Value Modifier]

Biological Values (BV) for HUC10's in the DPS project area were assigned by NMFS in 2009, and range from 0 (habitat quality and quantity not suitable for rearing, spawning or migration) to 3 (highest suitability for rearing, spawning and/or migration). Biological Values for each watershed were coded into the HUC10 DPS data layer in GIS for easy reference.

The Biological Value Modifier (BVM) in the compensation rate formula was assigned as follows: BV 0 = BVM 0, BV 1 = BVM 0.33, BV 2 = BVM 0.66, BV 3 = BVM 1. This weighting approach is intended to fully value impacts within the most functional and high quality habitat areas, and reduce or waive fees in areas where habitat may be present but moderately or severely impaired.

Example calculation #2: A proposed stream crossing structure has all the same site information as in Example #1, EXCEPT that is not located in a Critical Habitat area. Instead, it is located in a watershed with a Biological Value of '1'. The mitigation fee would be calculated as follows:

[Fee] = ([Base credit rate] x ([# of Upstream Blocked Rearing Units] + [# of Blocked Surveyed Spawning Units] + [# of Adjacent Impacted Rearing Units] + [# of Adjacent Impacted Spawning Units])) x [Biological Value Modifier]
[Fee] = ($3,408 x (5 + 1 + 4 + 0)) x 0.33
[Fee] = ($3,408 x (10)) x 0.33
[Fee] = $34,080 x 0.33
[Fee] = $11,246

SAMPLE RESULTS OF FORMULA CALCULATIONS ON AVAILABLE DATASET

Using ArcGIS and Microsoft Access, the above formulas were applied to the available stream crossing inventory data. The reader should be cautioned that spawning and rearing habitats occurring adjacent to or downstream of project sites are not included in the sample analysis, as they must be quantified iteratively for each proposed project. The results below are intended to show trends and get a better sense of the fee ranges that may be generated through this method.

It also worth noting that there are significant outlier values at the upper portions of the results range that represent unrealistically large fees. This is inherent in the source data, as some single stream crossings may block several hundred habitat units upstream. It is recommended that a fee cap, either absolute or expressed as a maximum percentage of project costs, be considered as a way to address this.

The following table shows the distribution of estimated fees within each of the three SHRU's, for sites where fees are likely to be collected (crossing blocks upstream habitat and is a surveyed barrier or potential barrier). Each percentile category indicates the percentage of all values in the dataset that are below the value shown.

Example: the value $38,028 in the 60% percentile row for Merrymeeting Bay means that 60% of the estimated fees in the analysis were below $38,028. Dollar figures in the 50% row indicate median values. 0% and 100% rows represent the lowest and highest values, respectively.

	Quantile Estimated Fees by SHRU*		
Percentile	Downeast Coastal	Merrymeeting Bay	Penobscot Basin
0%	$6	$34	$20
10%	$1,917	$1,827	$2,563
20%	$3,852	$5,131	$7,007
30%	$7,400	$9,322	$12,279
40%	$9,572	$14,605	$18,809
50%	$16,946	$24,663	$29,568
60%	$29,532	$38,028	$43,210
70%	$43,789	$53,566	$60,867
80%	$72,817	$84,789	$94,324
90%	$175,419	$151,536	$200,664
100%	$1,596,328	$1,770,055	$5,389,344
SHRU Average	**$65,398**	**$66,780**	**$88,288**
Avg if top 10% removed	**$27,183**	**$32,476**	**$39,209**
Sample Size	235	721	888

*does not include impacts on spawning habitat, which must evaluated separately for each project

Notwithstanding the caveat regarding extremely high values at the top of the fee structure, most estimated fees would be considerably smaller. Median fee values range from $16,946 to $29,568. Fees in the Penobscot Basin SHRU were higher than the other two SHRU's in all quantile categories.

In the Downeast Coastal SHRU, over 70% of the estimated fees fall below $50,000. In all three SHRU's, over 80% of estimated fees are less than $100,000. Zero values were removed from the analysis, as they represent stream crossings in areas that either did not block upstream habitat, or occur in areas of the DPS that are not critical habitat and have Biological Values of zero.

The effect of habitat quality variables in the rate calculation formulas were also evaluated across the geographic scope of all three SHRU's. Of all surveyed stream crossings in the dataset identified as "Barrier" or "Potential Barrier" that are currently blocking upstream habitat, nearly 2/3 are in HUC10's designated as critical habitat. The average estimated fee in these areas is $96,175. In comparison, the other 1/3 of surveyed crossings occurred in areas excluded from critical habitat designation. The average estimated fee in these areas is $43,375, or 45% of the average fee in critical habitat areas.

Estimated fees for surveyed crossings in non-critical habitat watersheds are presented below by their Biological Values:

Surveyed crossings identified as "Barrier" or "Potential Barrier" in HUC10's not designated Critical Habitat		
Biological Value	**Count**	**Average Est. Fee**
0	N/A	$0
1	556	$29,851
2	25	$56,986
3	90	$123,142

Weighting of the critical habitat and biological value variables appear to have had the intended effect, with critical habitat areas demanding larger potential fees, and areas outside critical habitat showing fees increasing commensurate with a rise in habitat biological significance.

FORMULA FOR NON-CROSSING PROJECTS

Though stream crossing structures are the main focus of the proposed ILF program, other projects – those subject to mitigation fees as well as restoration projects that may earn credit – may be evaluated using a slightly modified set of formulas. Non-crossing projects such stream bank alterations (or enhancements) or structural changes to in-stream habitat could use the same formulas as above, but removing upstream blocked habitat units from the computation. Logically, most such projects would impact fewer units of habitat, and therefore generate lower fees or credits.

Example calculation for non-crossing project:

A proposed stream alteration project in the Merrymeeting Bay SHRU will negatively impact 4 units of adjacent rearing habitat and 2 units of adjacent spawning habitat. The site is located in a critical habitat watershed.

[Fee] = [Base Credit] x ([# of Adjacent Impacted Rearing Units] + [# of Adjacent Impacted Spawning Units])
[Fee] = $4,855 x (4 + 2)
[Fee] = $4,855 x 6
[Fee] = $29,130

To calculate the fee for a project with the same attributes outside a critical habitat area, the fee above would be multiplied by the Biological Value Modifier for the watershed.

The base credit rates and calculation formulas may be used for both determining fees and also the potential maximum award for grant applicants wanting to fund fish friendly crossings, streambank stabilization, long term land protection, and other projects. A simple table of potential mitigation ratios for different project types is presented below for discussion and consideration by project partners. It is anticipated that the adoption of mitigation ratios will require significant group deliberation to determine appropriate values.

Resource	**Restoration (re-establishment)**	**Creation (est-ablishment)**	**Enhancement (rehabilitation)**	**Preservation (protection/management)**
Rearing Habitat (units)	1:1	N/A	3:1 to 10:1	15:1
Spawning Habitat (units)	1:1	N/A	3:1 to 10:1	15:1
Riparian land	N/A	N/A	5:1 to 10:1	15:1

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Appendix: Excerpt from Biological valuation of Atlantic salmon habitat within the Gulf of Maine Distinct Population Segment, NOAA's National Marine Fisheries Service, 2009.

1.6 Procedure used to determine biological value of habitat within specific areas

NMFS is required under Section 4(b)(2) of the ESA to consider the economic, national security, and other impacts of designating a particular area as critical habitat. NMFS may exclude an area from critical habitat if we determine that the benefits of exclusion outweigh the benefits of specifying the area as part of the critical habitat, unless we determine that the failure to designate the area as critical habitat will result in the extinction of the species. In order to consider exclusions in the 4(b)(2) analysis, we assigned a biological value based on habitat quantity and habitat quality needed to support spawning, rearing and migration of Atlantic salmon. The Final Biological Value indicates the habitat's current value to Atlantic salmon spawning, rearing and migration activities and is applied in the 4(b)(2) exclusion analysis, where it is weighed against the economic, national security, and other relevant impacts to consider whether specific areas may be excluded from designation.

The variables used to develop the Final Biological Value include a combination of Habitat Units, Habitat Quantity, Habitat Quality, and the value of the HUC 10 to migration of smolts and adults and are presented in the tables at the end of Chapters 2, 3, and 4.

1.6.1 Methods and procedures used to determine the biological value of HUC 10 Watersheds

Habitat units

A habitat unit represents 100 m^2 of spawning and rearing habitat. To determine habitat units for each HUC 10 we relied on a GIS based habitat prediction model (*see Appendix C*). The model was developed using data from existing habitat surveys conducted in the Machias, Sheepscot, Dennys, Sandy, Piscataquis, Mattawamkeag, and Souadabscook Rivers. 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 DPS. Existing habitat surveys were used to validate the output of the model.

Habitat quantity

Habitat quantity reflects the units of habitat generated by the model and were calculated for each HUC 10. The units of habitat were then binned into four categories for each of the three SHRUs. A HUC 10 with no habitat was assigned a score of "0" and was considered unoccupied. HUC 10's with the lowest 25 percent of total units of habitat across the entire SHRU received a "1" score, the middle 50 percent received a "2" score, and the upper 25 percent received a "3" score. A "3" score represents the highest relative habitat quantity score. This method resulted in the majority of the habitat receiving a

score of “2” and therefore representing an average habitat quantity. Habitat scores outside the middle 50 percent were considered to have above average habitat quantity or below average habitat quantity.

Habitat quality

Habitat quality scores were assigned to HUC 10s based on information and input from fisheries biologists working with the State of Maine Department of Inland Fisheries and Wildlife, the MDMR, NMFS, and Kleinschmidt Energy and Water Resource Consultants, who retain specific knowledge and expertise about the geographic region. For each of the three SHRUs, a minimum of three biologists with knowledge and expertise of the geographic area were asked to independently assign habitat scores, using a set of scoring criteria developed by fisheries biologists from NMFS (Figure 1.6.1) to HUC 10s 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. During the scoring process, biologists were given the option to consider all the HUC12 sub-watersheds present within each HUC 10 watershed to aid in reaching a final HUC 10 watershed score. Emphasis was placed on identifying whether or not the physical and biological features needed for Atlantic salmon spawning and rearing are present and at what level.

Habitat Quality Scoring Criteria

Temperature:

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 not known to exceed ***29C at any time

Marginally Suitable (1) = Stream temperatures may not 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)*

Biological Communities:

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*

Water Quality:

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)*

Substrate and Cover:

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 1.6.1: Criteria used to score biological quality within HUC 10 watersheds

Final habitat value

Final Habitat Values were generated for each HUC 10 by combining habitat quantity and habitat quality scores within each HUC 10. Scores were combined by multiplying the two variables together giving scores of 0, 1, 2, 3, 4, 6, 9. HUC 10s with zero scores received a zero score for Final Habitat Value. Scores of 1 or 2 were valued as low or “1” final habitat value. Scores of 3 or 4 were valued as medium or “2” final habitat value, and scores of 6 or 9 were valued as high or “3” final habitat value.

Final Migration Value

A final migration value was generated based on the final habitat values and the migratory requirements of adults to reach spawning areas and smolts to reach the marine environment. We determined the final migration value of a HUC 10 to be equal to the highest final habitat value upstream from the HUC 10 as we concluded that access to spawning and rearing habitat was equally as important as the spawning and rearing habitat itself.

Final Biological Value

The final biological value for each HUC 10, which is the value used in weighing economic cost against the biological value of habitat to salmon, was determined by selecting the higher of the final habitat value and the final migration value of each HUC

10. This approach assures the preservation of spawning and rearing habitat as well as migration habitat. The method was used in order to accommodate for migration and the species need to access spawning and rearing habitat as well as the marine environment by treating access to spawning and rearing habitat as being equally important as the spawning and rearing habitat itself.