2011

Kennebec Barrier Survey 2010

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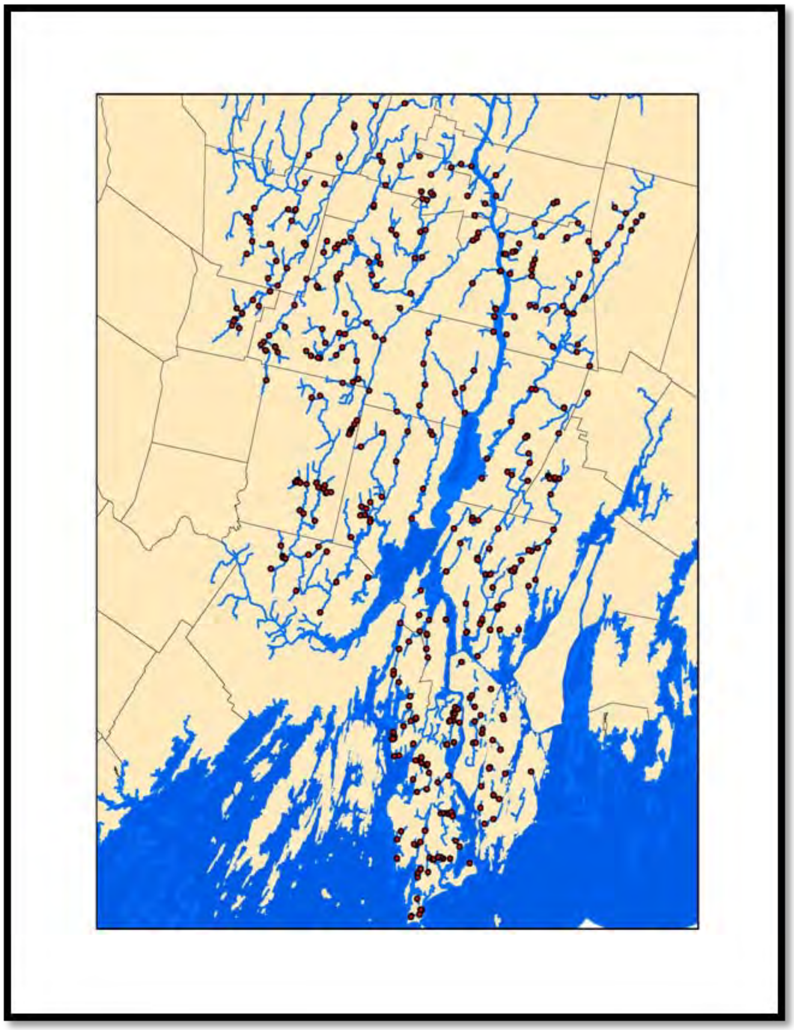
Cover Photo: *The photo shows a "perched" culvert, defined as a culvert whose inlet or outlet is elevated above stream grade. In the lower Kennebec River watershed, perched culverts are the primary reason road-stream crossings block or impair fish passage. Courtesy Charlie Baeder, 2010.*

Introduction

The Kennebec Barrier Survey was organized to initiate fish passage barrier surveys in the lower Kennebec River watershed as part of the statewide effort to inventory fish passage barriers and to prioritize fish and habitat restoration projects.



Road-Stream Crossings and Dams Surveyed in the Lower Kennebec River Watershed, 2010

Key objectives of the survey were to:

a) survey about 400 road-stream crossings and dams in the lower Kennebec River watershed,

b) create GIS layers that will be part of the statewide barrier database, and

c) initiate action to pursue restoration projects.

The project was a collaboration of Sheepscot River Watershed Council (SRWC), Kennebec Estuary Land Trust (KELT), and Kennebec Valley Soil & Water Conservation District (KCSWCD). A Memorandum of Understanding (MOU) was adopted and each organization contributed funding, people, and services to the project.

During the summer and fall of 2010, 431 stream crossing sites were identified and 403 stream crossings were surveyed including 384 road-stream crossings (culverts and bridges), and 19 dams (see Table 1). Surveys were attempted at another 18 sites, but were not completed because the sites did not exist, were inaccessible, or had culverts less that 18" in diameter.

Sites	
bridges	47
bridges (not surveyed)	6
culverts	336
culverts <18" (not surveyed)	3
dams	16
dams w/ fish ladders	3
dams (not surveyed)	4
ford	1
site does not exist	7
site inaccessible	8
	431
surveyed	403
not surveyed	28
	431

Table 1

Surveys began in the lower Kennebec River watershed, in Georgetown, Arrowsic and Phippsburg, and worked up the watershed to Rt 202 in Manchester and Rt 194 in Pittston. The team also surveyed 48 road-stream crossings and 2 dams in the Casco Bay watershed, including the western portions of Phippsburg and West Bath that had not been previously surveyed, on behalf of the Casco Bay Estuary Partnership.

Appendix I contains the Summary Analyses. Appendix II is the Severe Barrier dataset in spreadsheet format. Appendix III contains the Kennebec Barrier Atlas which is a series of maps used to conduct field work. Appendix IV contains several representative lower Kennebec watershed maps with severe barriers identified. Survey forms are attached as Appendix V. Press releases and articles are in Appendix VI. Appendices VII, VIII, IX and X, including a complete set of photos, the TNC PowerPoint presentation, the ArcGIS database, and the complete dataset in Excel format respectively, are on one DVD.

Now that results have been compiled, contacts have been initiated with state and federal fisheries agencies to use this information for barrier removal prioritization. Prioritization is a priority in considering culvert replacement and dam removal projects among state and federal agencies, the State legislature, MDOT, and towns, and the data developed in this survey will be added to the statewide barrier database. This will be elaborated below in the section titled Outreach.

The Kennebec Barrier Survey was organized to be a phased project, carried out over several years, with the goal of surveying the entire Kennebec River watershed. Given that objective, the project team has submitted grant proposals for the 2011 field season. The plan for 2011 is to survey another 400 road-stream crossings, about 100 in the Androscoggin River watershed and about 300 in the Kennebec River watershed. One reason for including the Androscoggin River watershed in 2011 is that the Androscoggin and the Kennebec watersheds make up the Merrymeeting Bay SHRU, an area listed as critical Atlantic salmon habitat. Another is that one of our project partners in 2011, Androscoggin Valley Soil & Water Conservation District, is planning to continue the Androscoggin Barrier Survey as a separate project in coming years. A separate dam survey is underway, funded by NOAA and conducted by Kleinschmidt Associates, so we do not plan to conduct dam surveys in 2011. We plan to limit the 2011 survey to Kennebec subwatersheds that were historically accessible to diadromous fish as these subwatersheds are likely to be priority restoration targets in the future, and as these are the priority species for our prospective grantors.

Methods

Charlie Baeder, SRWC, acted as project manager, managing several aspects of the project including training, field surveys, database and GIS development. Other project partners managed other aspects of the work. Carrie Kinne, KELT, hired staff, provided employee administration, and provided a base of operations for the project. Erin Witham, KELT, did database development and GIS development in addition to doing extensive field work. Alex Abbott, USFWS, provided technical assistance in GIS and database development. Art Grindle, KCSWCD, created the survey atlas and the final maps. Dale Finseth, KCSWCD, provided administrative management.

During June 2010, four interns were hired to conduct surveys. All were college age, two having just graduated. We conducted field training in July and had two two-person crews working full-time through August. Two of our interns returned to college in the fall leaving one two-person crew to finish the surveys. AVSWCD participated in training and conducted surveys on several dates. Several volunteers joined survey crews on several dates. Surveys were completed in October 2010.

Survey teams were trained according to the survey methods described in the *Maine Road-Stream Crossing Survey Manual* (Alex Abbott, Gulf of Maine Coastal Program, U.S. Fish and Wildlife Service, 2008). SRWC conducted a barrier survey in the Sheepscot watershed in 2008, was trained in these methods, and conducted staff training for this project. Survey teams received ongoing coaching in safety, survey methods, photo taking, and data collection. Stream bankfull width and road fill height were measured where possible.

Survey teams were provided with an atlas (see Appendix III) which identified road-stream crossings on perennial streams and dams. Intermittent streams are typically excluded from the statewide survey protocol. However, our survey teams were required to survey any moving water stream in summer 2010, a near record dry August in midcoast Maine. We have found that “intermittent” streams on maps are not always correctly depicted.

Atlases are efficient planning tools as they allow teams to plan their day, to cluster sites for surveying, and to track sites already surveyed. Teams averaged 10-12 sites per day depending on distance, weather, and access. Teams were encouraged to make contact with landowners, to explain the purpose of the survey, and to request access. This was important in coastal areas where there are many private roads, and in all areas where there are private driveways. With this approach, few sites proved to be "inaccessible" (8 of 431 sites, or 1.86%).

Data was collected on manual forms and was input to an Access database using templates developed by USFWS. Database input began shortly after the field work started and feedback to the survey teams reduced data collection errors. Following the completion of the field work, database input continued through fall 2010. This data is included in this report in Appendix X. This database will be provided to state and federal fisheries agencies as part of outreach.

GIS development began late fall 2010 and was completed winter 2011. Alex Abbott, USFWS, provided technical assistant to the project. In addition to helping convert the Access database to an ArcGIS layer, USFWS provided assistance in database QA/QC, in the provision of other data layers (e.g., a Kennebec River data layer optimized to work with certain tools), and in the provision and use of the BAT data analysis tool developed by The Nature Conservancy. This GIS layer is included in this report in Appendix IX. This GIS layer will be provided to state and federal fisheries agencies as part of outreach.

Results

As noted in the introduction, 431 stream crossing sites were identified during the survey including 408 road-stream crossings (culverts and bridges), and 23 dams. The results discussion is divided into these three groups.

Road-Stream Crossings: Culverts

Results of the survey show that 44% of the culverts on perennial streams in the lower Kennebec River watershed are "severe" fish passage barriers (see Table 2). This percentage is similar to the percentage of culverts that are severe fish passage barriers in other watersheds in Maine surveyed since 2007 including the Sheepscot and Penobscot watersheds. The table shows the percentage of culverts in the lower Kennebec that are severe fish passage barriers, defined as culverts that are over 50% blocked, usually by woody debris, and/or "perched" (this definition for severe culvert barriers was developed by USFWS).

	Severe Culvert Barriers	(n=336)
>50% blocked	21	6.25%
perched outlet	133	39.58%
perched inlet	11	3.27%
Total Severe Culvert Barriers	149	44.35%

Table 2

About half of the culverts that are blocked or have perched inlets also have perched outlets. These redundancies were eliminated in the table. Of the 336 culverts surveyed in the lower Kennebec, 149 are "severe barriers", or 44.35%.

Perched culverts are defined as culverts whose inlet or outlet is elevated above stream grade, thus preventing or impairing fish passage. Perched culverts are typically referred to as "hanging" culverts by public works officials. The following pictures illustrate perched culverts.

Perch height, the distance from the bottom of the pipe to the water level of the stream, was also measured. For outlet perched culverts where perch height was measured (n=117), the median perch height was 0.18 meters and the mean perch height was 0.35 meters. All outlet perched culverts are considered "severe" barriers, but the severity of the perch and the evaluation of perch height under different flow conditions is worthy of additional consideration on at least a site basis when considering restoration projects.

There are several reasons why culverts are perched. Sometimes it is done to block invasive fish, e.g., Northern pike, from entering an upstream watershed (rare). Sometimes they are installed with an inlet or outlet elevated above stream grade because of ledge (common). More often culverts which are now perched were originally installed at stream grade but were undersized for the volume of water they were required to pass. When culverts are undersized water accelerates and causes a “hose” effect which erodes downstream substrate in the stream channel resulting in an elevated “perch”. This hose effect is illustrated in the photo.

Blockages are significant fish passage barriers and were present in 9.82% of all culverts (n=33). In addition to 21 “severe” barriers – the “severe” definition is =>50% blocked – another 12 culverts were 25% blocked. Nine of the severely blocked culverts were also outlet perched culverts. Both conditions are caused or made worse by undersized culverts. Representative photos illustrate the problem.

Undersized culverts, in addition to creating perched culvert conditions, also impair fish passage for two other reasons: velocity barriers and reduced substrate inside the culvert. Velocity barriers are caused when streams are confined to narrow culverts, accelerating water flow in excess of fish swim speeds thereby preventing fish passage under certain high flow conditions. It is likely that velocity barriers occur on many culverts during periods of high flow. Measuring these effects was beyond the scope of this project.

Lack of substrate in culverts is identified by fisheries biologists as impairing fish passage and reducing aquatic organism habitat. Over 65% of all culverts surveyed had no substrate inside them. As an indicator of undersizing, and the link between undersizing and perched culvert conditions, over 85% of outlet perched culverts had no substrate inside the pipe.

For the reasons noted above – perching, blockage, velocity barriers, and no substrate – undersized culverts have been targeted by fisheries biologists for replacement with fish friendly culverts. Culvert sizing recommendations made by biologists have supported a 1.2x bankfull width standard for the last decade, meaning that a culvert's diameter should be 1.2x (120%) larger than the bankfull width of the stream it will pass. This sizing standard, when properly implemented, improves fish and aquatic organism passage and habitat.

Of the culverts surveyed in the lower Kennebec watershed, where we were also able to measure bankfull width (n=288), the average span (diameter) was 2.29 meters and the average bankfull width was 4.02 meters. At 1.2x bankfull width, or 4.82 meters, the span:width ratio is 47.48%. On average, the culverts in the lower Kennebec watershed would need to be about twice as wide (210.61%) to meet the 1.2x bankfull width standard. This undersizing of culverts is typical and results in fish passage barrier problems throughout the state.

Table 3 shows these relationships for outlet perched culverts, all culverts, and all bridges where we were able to measure bankfull width. As might be expected, span:bankfull width ratios show that outlet perched culverts are more undersized than average culverts and that bridges are less undersized than culverts as a result of being engineered to pass 50 or 100-year storms.

	span	bankfull width (bfw)	1.2x bankfull width (bfw)	span/ 1.2x bfw	1.2x bfw/ span
outlet perched culverts (n=117)	1.45	2.84	3.40	42.66%	234.40%
all culverts (n=288)	2.29	4.02	4.82	47.48%	210.61%
all bridges (n=20)	9.23	11.46	13.75	67.13%	148.97%

Note: all measurements are in meters

Table 3

An additional concern about undersized culverts – road failure – has been raised by Curtis Bohlen of Casco Bay Estuary Partnership. As noted earlier, we surveyed culverts on the eastern edge of Casco Bay to complete an area missed in earlier surveys. We added a measurement to the survey protocol that Casco Bay routinely includes in its surveys – road fill height. Casco Bay has noted that undersized culverts are more prone to failure because of road overtopping. All things being equal, as road fill height increases road overtopping decreases, as road fill acts as a dam.

One of our survey crews observed this firsthand in the lower Kennebec watershed on Meadowbrook Road in Phippsburg following a storm in July 2010 that washed out the road. These photographs show the road after initial repairs were started and what appears to be the re-installation of an undersized culvert. Road failures were observed on a larger scale in Downeast Maine following a December 2010 storm that blew out several roads in that region. Culverts in that same area that had been replaced in the last few years by Project SHARE with culverts sized at 1.2x bankfull width in order to restore fish passage weathered the storm without incident. In addition to impairing fish passage, undersized culverts are clearly a road infrastructure, public safety, and FEMA cost issue.

Road-Stream Crossings: Bridges

In addition to culverts, 47 bridges were surveyed and four of these (8.51%) would be defined as severe fish passage barriers. One bridge was >50% blocked and three were built at or developed cascades which are generally considered "natural barriers". This data suggests that surveying bridges is important to confirming passability at all road crossing sites, at least when considering restoration projects at other road crossings on the same stream.

As noted above, bridges are typically engineered to pass 50 or 100-year storms. "Engineered" is the operative word as bridges typically qualify for Federal Highway (FHA) funds and must meet FHA standards. As noted in Table 3, bridges in the lower Kennebec watershed are built closer to the 1.2x bankfull width standard than are culverts (67.13% vs 47.48%) resulting in less blockage and much better fish passage. By definition, they have natural stream substrate. Whether the undersizing of bridges versus the 1.2x bankfull width standard creates a velocity barrier at a given location under high flow conditions would need to be measured and was beyond the scope of this project. Bridges are assumed to pass fish and, as a result, are generally not surveyed as part of barrier surveys. We surveyed bridges on small to moderate-sized Kennebec watershed tributaries to test this assumption and to measure bridge sizing versus the 1.2x bankfull width standard.

Dams

Dams were also surveyed as part of this project. Most dams are "severe" fish passage barriers as they lack fish ladders. Nineteen dams were surveyed and only three have fish ladders, one of which leaks and is in need of repair. Representative photos of dams with and without fish ladders are shown below.

Winnegance Creek Dam with fish ladder, Phippsburg

Cobbossee Stream, West Gardiner

Although there are many fewer dams than culverts in the lower Kennebec River watershed, dams remain significant fish passage barriers. After conducting the BAT analysis which provides data on total upstream km blocked by severe barriers, we found that 20 dams block access to

393 stream km. A similar analysis of road-stream crossings (culverts and bridges) showed that 153 crossings block access to 249 stream km. These results are displayed in Table 4 and support the idea that fish passage restoration projects should include both dam removal or fish ladder construction and culvert replacements. Both types of projects are necessary to restore fish passage and access to habitat.

BAT analysis of Severe Barriers	upstream inaccessible stream km		severe barriers	km/ barrier
culverts / bridges	249	38.82%	153	1.63
dams	393	61.18%	20	19.66
	643	100.00%		

Table 4

Outreach

Press releases were sent to papers in the Bath, Maine area, by KELT, and reporters were invited to accompany and photograph survey crews. KELT also published information in its newsletter. Representative media stories are included in Appendix VI.

There have been presentations of this data in various forms and to various groups since fall 2010. Both of the interns who were in college were environmental science majors and were awarded credit for the internship. Each made class presentations and one of the students made a public presentation to the Bath community as part of Kennebec Estuary Land Trust's public lecture series on fish passage issues.

SRWC and KELT made a presentation of the data to The Nature Conservancy (TNC) as part of TNC's lunch lecture series (the PowerPoint presentation is attached as Appendix VIII). Similarly, SRWC and KELT are making a presentation at the Maine Land Trust conference on April 30, 2011 on fish passage, and culvert and road BMPs for land trusts as private land owners. We will ask land trusts to put a notice in their newsletters asking for volunteers from among their members for stream and barrier surveys.

An early set of the Kennebec data was provided to Maine Department of Transportation (MDOT) in fall 2010 during the rulemaking process with respect to the culvert bill at the Maine legislature. MDOT supported a 50-year storm design standard which, very roughly, produces a 1.2x sized culvert below 5', an 80% sized culvert from 5-10', and a 60% sized culvert over 10'. MDOT analysis using our data demonstrated that most culverts, particularly on smaller tribs, need to be upsized to meet MDOT 50-year design standards.

In March 2011, SRWC met with Maine Department of Marine Resources (DMR) staff and Slade Moore, Maine State Planning Office (SPO), to discuss potential restoration projects in the lower Kennebec River watershed. After a discussion of the survey and our interest in putting the data to work on restoration projects, we focused on two potential alewife restoration projects which are of interest to DMR and which include culverts we surveyed (on the unnamed stream to Sewall Pond in Arrowsic, and on Morton Brook to Nehumkeag Pond in Pittston). SRWC and

DMR agreed to discuss ongoing collaboration on these projects. Once the final report is complete and the data is ready for distribution, copies will be provided to DMR and to other state and federal fisheries agencies.

The dam data and photos were provided to Kleinschmidt Associates in November 2010 as part of NOAA's non-FERC dam and dam owner survey. That survey will rank dam removal projects and lead to on-the-ground restoration work.

KELT made a presentation of the data to the Bath public works director in March 2011 and plans similar meetings with other town officials in its service area. It is hoped that these outreach efforts with town officials will result in restoration projects at the municipal level. KELT has received feedback from its members that these projects are of interest and that the survey results should be put into action. KELT received a follow on grant from Merrymeeting Bay Trust to do this outreach work.

A KELT board member has discussed a site in Georgetown that involves an estuary restoration project where an undersized culvert is restricting tides and may have an effect on adjacent clam flat closures. An on-site meeting is planned this spring to assess the project.

Finally, SRWC and KELT plan to present the data at a meeting of the Maine Interagency Stream Connectivity Work Group. This group is led by the Maine Coastal Program, Maine State Planning Office and the Bureau of Sea Run Fisheries and Habitat, Maine Department of Marine Resources, and includes state and federal fisheries agencies and NGOs. In its first report, in 2010, the Work Group recommended that the state:

- Develop and maintain a statewide barrier database and mapping system providing geographic and physical attributes of individual dams, road-stream crossings representing barriers, and other structural barriers to connectivity.
- Inventory barriers to connectivity throughout the highest priority sections of Maine's watersheds.

Collaborations have been key to funding and managing this project, and will be an ongoing part of our outreach strategy. These outreach efforts demonstrate the interest in developing these databases, acting on the data to initiate restoration projects, and the need for field data to inform policy discussions and legislation.

Recommendations

The following recommendations are made with respect to data, training and equipment:

- Bridges – Only one bridge out of 47 surveyed was documented as a severe barrier because of blockage or perching. However, three of 47 were documented as severe barriers because of ledge / cascade conditions. Because bridges are often undersized with respect to the 1.2x bankfull width standard, it may be useful to conduct flow velocity testing with respect to fish passage to determine whether bridges act as velocity barriers. With limited funds, it makes sense not to routinely survey bridges. However, before conducting restoration projects at other crossings on a stream, it will

be important to assess the bridges on the stream and not to assume that they are passable.

- Culverts <18" – Culverts under 18" in diameter are routinely excluded from barrier surveys. We decided after the first week of this project to survey <18" culverts because: a) they are usually on perennial streams, and b) they are undersized and are typically on streams one meter wide or larger (which appears to be about the minimum width for a perennial stream in this region of the state). Also, nearly all the <18" culverts surveyed were perched. Our recommendation is to survey all culverts on all perennial streams.
- Perennial streams – Intermittent streams are typically excluded from barrier surveys. However, map depictions of perennial and intermittent streams should be field verified so that perennial streams are not excluded from surveys just because they are marked as intermittent streams on maps. This does not mean checking every intermittent stream (because of cost). However, when already in the field, if a perennial stream is observed, even when marked as intermittent on a map, its culverts should be surveyed. There were several instances during August 2010, a near record dry August, that field crews observed perennial streams that were marked as intermittent. Our field crews were instructed to trust their observations and to conduct surveys.
- Natural Barriers – It is strongly recommended that stream surveys be conducted before restoration projects begin. In the Sheepscot River watershed, we conducted stream surveys on 15 streams in 2009 and 2010 that documented impassable ledges, beaver dams, remnant structures and other fish passage obstacles on nearly every stream surveyed. These streams were selected for the stream survey by Melissa Laser, DMR, and by SRWC, after conducting the 2008 Sheepscot Barrier Survey, to identify natural barriers and to assess habitat before initiating culvert replacement projects.
- Training – Training in safety, survey protocols, photo taking, and form completion is critical upfront and on an ongoing basis. From one of our survey team leaders, Erin Witham: "The barrier survey began in early July with a training day for the summer field interns…. Members from all partner groups were there to present on the work as well as lead the two field site visits to give the interns a chance to practice collecting field data at an actual culvert site. To ensure that the field work was being done with accuracy, the project manager participated in the initial days of field work with the interns to be there to guide the survey and data collection processes. He was also present to review photos at the end of the day with field teams. The review of photos was essential to the training, first to answer specific feature questions about what the interns encountered in the field, as they became familiar with the different kinds of road stream crossings. The review was also important to critique photo technique. The field teams spent ten weeks (six for the college interns) spending four to five days a week in the field. This intensive method of field work allowed the interns to very quickly familiarize themselves with the survey work and become very adept at using the tools and navigating to each site using the field maps."
- Data Management – Erin Witham: "To ensure quality, accuracy and efficiency of gathering and inputting field data, the data from the field forms was reviewed at least three times. First by the field crew at the end of the day to insure they did not leave any part of the form blank, again as the field data on the form was entered into the Access database and finally as the Access database data was loaded into ArcGIS and used to

create a personal geodatabase. During the data input process, any confusing or incomplete forms were flagged and the field team was asked about the issues. Occasionally, a field would be left blank due to confusion in the field, at which point the field team could email the project manger a photo of the site and the questionable feature. These issues cropped up more frequently at the beginning of the field work and were used as good learning moments for the whole group to clarify and define the data fields before they went out into the field each day.

An important aspect of the field work was to ensure that the field teams had all the correct forms with them each day. The Road-Stream Crossing Survey, Dam Survey, and an Unsurveyed Site Log all are important field sheets to ensure that all the work done each day can be converted into information in the database. One issue we ran into was ensuring that sites that were either inaccessible, needed landowner permission or did not exist were entered into the database to indicate that additional survey work was or was not needed. The "unsurveyed site log" was essential to ensure this communication happened. As these surveys continue, more groups are moving towards using electronic data entry while in the field, which eliminates many of these quality control issues. However, in this survey, the team created very intentional quality control systems that would still be useful to carry out even when using an electronic data entry device like a Trimble."

- Equipment – Good field equipment is essential and Alex Abbott's field guide, *Maine Road-Stream Crossing Survey Manual*, does a great job preparing survey teams. We are looking at two pieces of equipment to improve data collection and to reduce processing costs (converting manual forms to an Access database). One is a GPS-enabled camera that will tag each photo with GPS information. The second is a Trimble unit that will have the barrier survey forms installed eliminating redundant data entry.

Conclusion

Inventories and assessments of road-stream crossings and dams will play a critical role in the prioritization of fish passage restoration efforts in the state for the next decade. There is a lack of information about these structures at both the state and municipal levels which is being addressed in the barrier surveys that have been conducted since 2007. USFWS estimates over 10,000 culverts on perennial streams in diadromous fish habitat in the state but this number remains an educated guess. In the last four years about 4,000 road-stream crossings have been surveyed but this number includes crossings not in diadromous fish habitat areas. In addition to working to complete these inventories, the database requires ongoing maintenance and updating as new surveys are completed and as culverts are replaced and dams removed. These inventories are but one critical component of the statewide connectivity restoration prioritization effort being conducted by the Maine Interagency Stream Connectivity Work Group which will also include cost, habitat quality, natural barriers, invasives species, and other factors.

Given the need for data and the use of this data to initiate restoration projects, it is recommended that these surveys continue especially in important "focus areas" such as historical diadromous fish habitat and Eastern brook trout habitat as these are priority species for state and federal fisheries agencies. The background context in which these surveys are being conducted is depleted fisheries. These surveys and the restoration efforts underway are

building awareness and support throughout the state for the need to restore fish passage and to address the impacts that transportation infrastructure and dams have on fisheries – the concern now is cost and who will pay for restoration.

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