CMER –01-100

DATA COLLECTION FOR DEVELOPMENT OF EASTERN WASHINGTON WATER TYPING MODEL

MARCH 2002
SUBMITTED BY TERRAPIN ENVIRONMENTAL
#PSC 01-178

Data Collection for Development of Eastern Washington Water Typing Model

Terrapin Environmental
988 Twisp River Road, Twisp, Washington 98856

Purpose of Study

Terrapin Environmental was contracted by the Washington State Department of Natural Resources (DNR) to conduct the project titled "Data Collection for Development of the Eastern Washington 'Last Fish Habitat' Water Typing Model". The primary purpose of the study was to collect sufficient data to develop a multi-parameter, field-verified GIS logistic regression model that accurately predicts the locations of the Type F (fish bearing) and Type N (non-fish bearing) boundaries in eastern Washington. The multi-parameter model will use geomorphic parameters such as basin size, gradient, elevation and other indicators. This phase of the project was limited to data collection, screening, and compilation. This report was prepared to provide a brief project summary, description of project highlights, problems encountered, and recommendations for future last fish habitat data collection and model development.

Survey Methods

Sampling was conducted in 10 watersheds spread across forested lands east of the Cascade Crest. Last fish and last habitat locations were gathered throughout the entire drainage area in eight of the ten sampled watersheds (Table 1). Streams were excluded from sampling in these eight watersheds only if access permission was denied or if headwater lakes were supplemented with hatchery fish. In two of the sample watersheds (Taneum and Cabin), last fish and last habitat locations were gathered only in streams that had been previously sampled for last fish locations in past years. Working from a map with last fish points identified by Plum Creek Timber Company efforts, we verified previously established last fish points and additionally located last habitat points at or upstream of last fish points as described below.

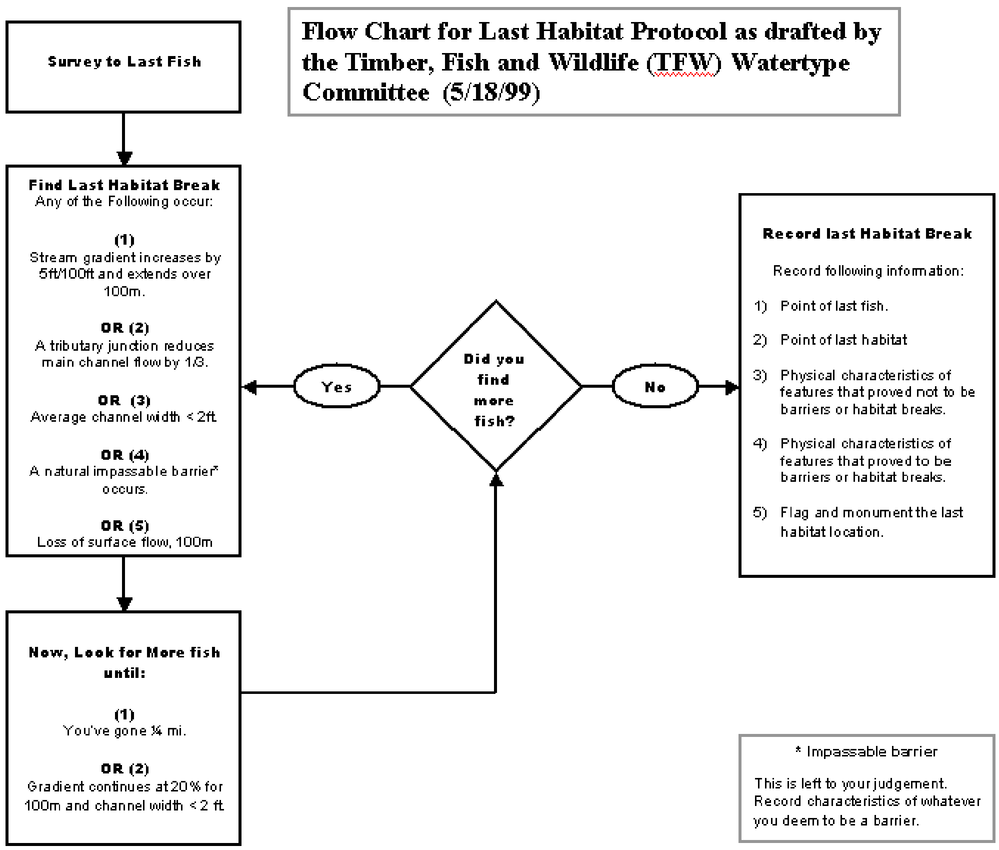
Table 1. Characteristics of survey watersheds

Watershed Name	Tributary To	Drainage Area (acres)	Elevation Range (ft)	Precipitation Range (in)
Big Sheep Creek**	Columbia R.	42,000	1000-7000	10-30
Upper Rattlesnake Cr.*	Naches R.	35,570	3000-8000	40-80
Naneum**	Yakima R.	55,000	2600-4900	15-25
Upper Cle Elum - Cooper R. WAU*	Yakima R.	38,462	2500-8000	45-140
Deer Creek	Colville R.	31,484	1900-5000	15-20
NF Deep Creek**	Columbia R.	30,419	2100-4700	25-40
LeClerc Creek*	Pend Oreille R.	62,321	2300-5600	20-40
N.F. Touchet R.*	Touchet R.	28,644	2300-5500	20-40
Cabin Creek***	Yakima R.	23,546	2500-5500	50-100
Upper Taneum***	Yakima R.	28,417	3000-6500	35-70

*Bull trout present
* *In bull trout overlay - none known to be present
***Last habitat data only and in bull trout overlay

Standardized field protocols were used to determine last fish and last habitat locations. All last fish surveys were conducted using backpack electrofishing equipment. Last fish locations were determined following guidelines provided by (WAC 222-16-030) - Guidelines for Determining Fish Use for the Purposes of Typing Waters. These guidelines call for identifying the upstream extent of fish by electrofishing a minimum of 1/4 mile upstream beyond the last fish detected. In addition, last habitat locations were identified and mapped following protocols illustrated in Figure 1.

Figure1. Field protocol used to survey for last habitat locations.



Survey crews worked their way up the watershed, visiting each mapped stream course, until the last fish and last habitat point was located on each drainage network. Streams that were falsely depicted on water type maps (i.e. no defined channel in the field despite map depiction) were appropriately noted on field maps and assigned a last fish or last habitat point at their mapped "confluence" with an existing, fish bearing stream. Likewise, streams encountered in the field that were not depicted on DNR Water Type Maps were located on the map and surveys conducted accordingly.

The following is a brief description of Terrapin's typical approach to conducting last fish and last habitat surveys. Electrofishing began at or just below the confluence with known fish-bearing waters. Fish are usually sighted or captured near the start point. Holding waters were then sampled periodically (about every 100 feet) to ascertain fish presence. The crew then "bumped" upstream while periodically electrofishing, and also observing habitat conditions and measuring stream gradient to ensure that no last fish habitat breaks are encountered. If no fish were observed at any periodic check, the sampler reversed direction and shocked downstream until a fish was encountered. The point was temporarily marked in the field as a possible last fish point, distance from starting point recorded, and the point is identified on the aerial photograph or map.

From that point on, all waters were sampled moving upstream, tallying criteria pools and measuring stream gradients in route. The survey continued upstream for 0.25 mile, unless the stream gradient exceeds and remains above the 20% gradient threshold **and** channel width decreases to 2 feet or less. If fish were encountered once again, a new temporary last fish point was established and electrofishing efforts described above were continued from that point on.

While electrofishing upstream of temporary last fish points, stream conditions were examined for last habitat features (Figure 1). If the last habitat point was encountered further than 0.25 mile past the last fish, electrofishing continued until the last habitat point is reached. When a last habitat feature was encountered, the distance upstream from the starting point was recorded, stream gradient measured, and other categorical or narrative data recorded. Electrofishing continued upstream of the last habitat for a full 0.25 mile or until the stream gradient exceeds and remains above the 20% gradient threshold **and** channel width decreases to 2 feet or less.

After confirming the absence of fish past the last habitat point, the surveyor returned to the last habitat point, ensured all required data is collected (Table 2) and located the point on the map. After all information on the last habitat point was collected and marked, the surveyor returned to the temporarily marked last fish point, recorded required data and located the point on the map. If necessary, last fish and last habitat locations were clearly and permanently marked in the field for future reference using a combination of orange flasher tags, numbered aluminum tags, and flagging. Last fish and last habitat points were not marked in the field if they coincided with easily established landmarks, such as stream confluences or prominent waterfalls. In streams where topographic maps indicate low gradient stream reaches (<10%) upstream of long steep (>20%) reaches, the upstream low gradient reaches were surveyed separately, covering a minimum of 0.25 mile upstream of the last habitat point.

Where stream size, channel conditions, flow characteristics, and stream adjacent vegetation allows, a one-person crew conducted last fish surveys in the small headwater tributaries commonly encountered. One person crews ensured accurate channel gradient measures at last fish points and last habitat points by fixing sighting flashers or ribbon to streamside vegetation (or at times a self-standing staff) at eye level for back sighting purposes. Channel gradients were measured for a minimum of 100 meters upstream and downstream of each point; any inflections in slope within the 100-meter distance was recorded separately and provided in the final database.

To ensure sampling effectiveness, we used a two-person crew where stream size, flow conditions, or vegetative cover made it impractical for one person to sight or capture fish. Two-person crews were normally used on third order and larger second order tributaries. Two-person crews were also used when flow conditions created turbulence or velocities that cause fish to go undetected. One-person crews conducted approximately 65% of all last fish surveys. For safety reasons, we used two-person crews where rugged terrain, remote locations, or dense vegetation creates more hazardous work conditions (i.e. portions of the Cooper River WAU, Upper Rattlesnake Creek, and LeClerc Creek).

The attached Microsoft 2000 Excel File (PSC 01-178 Last Fish Habitat Database.xls) contains four worksheets and includes the 1) field form, 2) field form guide, 3) data code book, and 4) database of the all last fish and last habitat points. The data form guide provides instructions as to what should be filled out for each data record, whereas the data codebook provides alpha - numeric codes that are used in the field to complete the forms. The data codebook also instructs the user as to which codes are appropriate to use in the various data fields.

Table 2. Data collected at each last fish and last habitat.

- Reference information
- Stream gradient above and below each point
- Stream bankfull and wetted width
- Water Temperature (°C)
- Conductivity (portable electronic conductivity meter)
- Changes in habitat attributes within 330 feet of last fish location
- Reason(s) for limits to fish or habitat (pre-defined categories)
- Information on impassable barriers (characteristics and distance from last fish location)
- Fish species encountered during the course of the surveys, and specie(s) that defined the upstream limit of fish distribution.
- Number of pools, including those with minimum qualifying dimensions of 2ft^2 surface area and 1-ft depth between last fish and last habitat locations.
- Potential last habitat features observed downstream of last fish locations
- Maps displaying the extent of surveys, last fish and last habitat locations.

Summary of Findings

Surveys were conducted in the 10 watersheds, ranging in size from 23,000 to 62,000 acres between June 8 and September 30, 2001. Field staff investigated 1025 channels depicted on DNR Water Type Maps. Defined channels and evidence of at least seasonal flow were observed at 598 (58%) of the map-depicted channels.

A total of 933 last fish locations and a 1025 last habitat locations were identified on 1:12,000 scale maps, with nearly a third of the points identified in LeClerc Creek and Naneum Creek watersheds (Table 3). The majority of all mapped last fish points (80%) and last habitat points (73%) were situated where low order, non-fish bearing tributaries join with larger, fish-bearing streams.

Table 3. Total number of last fish and last habitat locations surveyed.

	Terminal points		Lateral points		
Watershed	Last fish situated downstream of last habitat on fish bearing stream	Last fish coincidental with last habitat on fish bearing stream	Last habitat coincidental with last fish and on a non fish bearing stream	Last habitat situated upstream of confluence of fish bearing and non fish bearing stream	Total
Big Sheep	2	4	10	47	63
Cabin	6	3	18	25	52
Cooper	3	18	10	91	122
Deer	11	4	24	95	134
LeClerc	23	18	40	122	203
NF Deep	4	4	8	81	97
NF Touchet	9	0	19	81	109
Naneum	23	9	28	141	201
Rattlesnake	12	9	13	22	56
Taneum	12	7	28	46	93
Total	105	76	198	751	1130

Last Habitat Point Features

The most common feature of mapped last habitat points was the absence of channelized flow in areas depicted as streams on the DNR water type maps (Table 4). Otherwise, the majority of last habitat locations are situated where low order, non-fish bearing tributaries join with larger, fish-bearing streams. Both last habitat and last fish points were placed on the non-fish bearing stream at the mouth. It should be noted that more than one last habitat feature was commonly associated with each last habitat point. For instance, the points described above are typically associated with tributary junctions where flow reductions occur, and often also corresponded to rapid increases in channel gradient. In addition, these jumps in channel slope were considered impassable barriers to upstream movement of fish in some situations.

Loss of surface flow for over 330 feet was also a common feature associated with last habitat (Table 4). However, over 90% of these points coincided with tributary junctions or rapid increases in stream gradient. Most "dry" last habitat points were associated with small, ephemeral valley wall tributaries. Only 22 last habitat points were established exclusively because of loss of surface flow, yet fish ended at least 500 feet below all but 7 of these points. Conversely, we observed fish and identified last habitat upstream of extensive (greater than 800 feet long) dewatered reaches. For example, fish were observed in at least 11 different stream reaches in the Rattlesnake, Cooper River, NF Deep, and Big Sheep Creek WAUs situated upstream of the dried channels

The dried reaches are associated with naturally losing reaches located on deep alluvial fill. Upstream reaches with wetted widths exceeding 5 feet were found to be inhabited by cutthroat or brook trout in the steeper, valley slope controlled segments. Bull trout and cutthroat trout were observed in Rattlesnake Creek upstream of a dried reach that extended for over 1/2 mile. A discussion with local resource managers and review of existing data suggests that these ephemeral flow conditions occur during most normal water years.

Only 63 last fish and last habitat locations corresponded to prominent impassable waterfall or cascade barriers. Last fish and last habitat locations at the base of waterfalls were most common in the larger, primary tributary channels. However, it was common that fish ended at a short and abrupt increase in gradient in many of the smaller, low order tributaries inhabited by fish. In fish bearing streams (i.e. excluding steep valley wall streams with no fish and dewatered channels), channel gradients over a 330 feet reach immediately downstream of last fish points averaged 10% (range 2 - 26%), whereas the immediate upstream gradient over the same distance averaged 16% (range 2 - 53%).

On occasion we found fish upstream of what appeared to be apparent barriers to upstream movement of fish (waterfalls or bedrock chutes). Anecdotal evidence provided by the USFS suggests that Hindoo Creek (Rattlesnake Creek) headwaters and many of the drainages in the Waptus/Cooper River Watershed were supplemented with hatchery fish, where in 5 streams we observed fish above numerous, clearly impassable waterfalls.

Table 4. Frequency of channel features associated with mapped last habitat locations. Note that more than one feature was commonly associated with each point, thus the sum of the total of each column exceeds the total number of last habitat locations.

Watershed	Gradient increase of at least 5% for 330 ft	Tributary junction with at least 30% flow reduction	Bankfull width less than 2 ft	Loss of surface flow for 330 ft	Impassable barrier	Poorly Defined Channel	No defined channel	Total
Big Sheep	12	17	0	6	3	1	37	61
Cabin	23	26	2	8	6	2	14	46
Cooper	48	51	0	22	9	4	44	119
Deer	19	40	0	10	0	3	74	123
LeClerc	56	77	1	24	9	14	62	180
NF Deep	21	33	2	6	2	4	48	93
NF Touchet	28	38	1	14	3	3	47	100
Naneum	48	68	2	22	10	5	73	178
Rattlesnake	32	20	0	7	10	2	4	44
Taneum	28	43	2	9	7	11	20	81
Total	315	413	10	236	59	49	423	1025

Observations of Last Fish with Respect to Last Habitat Locations

A total of 827 of the last fish points were coincidental with the last habitat points. Of these, 427 points were located on map-depicted streams despite the lack of a defined channel in the field.

Last fish points with no apparent change in habitat conditions within 330 feet were mapped on 59 different streams (6% of all mapped points and 10% of all mapped points associated with defined channels). These points were most commonly associated with headwater channels, with only gradual increase in stream gradients in the headwaters. Although the channels commonly steepened above these last fish points, the gradient increase was gradual, with no defined prominent barriers or quick jumps. Flows remained at the surface, but often times habitat complexity (pools and substrate interstice cover) was lacking. In these situations, field staff often questioned the habitat suitability, but did not assign a last habitat point unless one of the predetermined criteria was observed. However, last habitat points were situated within 500 feet of the last fish location in 70% of the disparate LF and LH points. Although habitat features immediately upstream of last fish points were often not distinctly different than downstream, impassable barriers or rapid increases in channel gradient were normally observed within 500 ft of the last fish points.

On two occasions, fish were observed over 1/4 mile upstream of what was temporarily marked as a last fish point. However, in both cases, no last habitat features were encountered between the temporary last fish point and the final last fish point. No fish were detected upstream of any temporarily marked last habitat point. However, fish were commonly observed upstream of features that would meet the predetermined last habitat criteria. For example, we commonly observed fish upstream of dramatic increase in channel gradient (> 5% increase) and upstream of tributary junctions in which the flow was reduced by at least 30%. According to the contract protocol, both of these feature types are criteria for establishment of last habitat locations if no fish are found upstream (Figure 1). Fish were found throughout the steepened section as well as in the lower gradient sections upstream. Fish were found upstream of prominent barriers in 12 streams in 5 different watersheds. Field staff suspected that hatchery supplementation had likely occurred in past years, especially in selected streams of Rattlesnake Creek and Cooper/Waptus Watersheds. Brook trout, obvious remnants of past supplementation, were common in many streams of the survey area.

Last fish points were rarely associated with artificial barriers. Only three last fish points were associated solely with road culverts as indicated in the final database. Five other last fish points were within 330 feet of road culverts, but other impassable barriers or gradient increases were coincidental last habitat features. Conversely, we commonly observed fish upstream of culverts that are clearly out of compliance with State culvert passage criteria. Most culverts encountered exceeded 1% slope, and subsequently are considered barriers according to the WDFW culvert assessment techniques.

Map Accuracy

No defined channels were observed at 427 of the 1025 of the channels depicted as Type 5 or Type 9 streams on the DNR base maps. Otherwise, streams were accurately located on maps for the most part. Notable exceptions to this rule include portions of LeClerc Creek, NF Deep Creek, and Cooper Lake Watershed. We attempted to correct maps only when gross errors were encountered. We rarely encountered fish bearing streams that were unmapped on DNR base maps. Most notable omissions included three unmapped streams that entering Cooper River just upstream of Cooper Lake.

Fish were commonly observed in streams mapped as Type 4 for at least a portion of its length. We found no fish to be present in at least 4 stream reaches mapped as Type 3. In Big Sheep and Deep Creek, no defined channels were found on most of the Type 5 and a few Type 4 channels indicated on the DNR maps. In the Cooper Lake Watershed, at least four substantial tributary streams were sampled that are not included on the DNR water type maps. Each one of them contained fish and LF and LH points were established.

Species encountered

Cutthroat trout were the dominant species encountered in most of the sample watersheds. Brook trout were most common in LeClerc Creek and Deer Creek watersheds. Cutthroat trout were not observed in NF Touchet watershed; rainbow trout were the dominant fish. Sculpin were rarely encountered in most valley wall and headwater channels investigated.

As a general rule, cutthroat trout were LF in streams holding both brook trout and cutthroat trout, especially in moderate to high gradient reaches. Exceptions to this include areas where abandoned beaver ponds were situated at or near the headwaters. Sculpin were the last fish in only one channel in the Cooper/Waptus watershed.

Bull trout were observed in only two of the watersheds investigated, NF Touchet and Rattlesnake Creek. Bull trout were found to be LF in only 2 streams in the NF Touchet. Bull trout distribution extends over 1 mile further than USFWS mapped distribution for Spangler Creek, a tributary to NF Touchet. In addition, bull trout were found in two small tributaries not marked on USFWS bull trout distribution map.

In two major bull trout tributaries flowing in middle of NF Touchet watershed, rainbow trout were found to be LF (Spangler Cr., Lewis Cr.). In these tributaries the last bull trout was observed 1/2 mile to over 1 mile, respectively, downstream from LF rainbow trout.

In the Rattlesnake Watershed, bull trout were observed only in the mainstem Rattlesnake, Hindoo, and Wildcat Creek. No bull trout were observed in low order tributaries and were never last fish observed. Conversely, cutthroat trout were abundant in nearly all tributaries, generally right up to the last fish point.

Findings of ISAG Field Revisits

Dave Price, WDFW Habitat Biologist, and Dave Karl, WDFW Southeast Region Biological Technician, along with Darin Cramer, WDNR Project manager, accompanied Terrapin field crews in review of the Naneum, Deer, and N. Fork Touchet watersheds (July 27). A total of 14 points were randomly selected and revisited. Fish were observed upstream of the LF point in 4 of the 14 streams revisited. Three of these relocations were approximately 200 feet upstream of the LF point observed by Terrapin field staff. In each of the three cases, only one fish was found upstream of the originally established last fish location. One additional relocation was 600 feet upstream (in the NF Touchet watershed). In this situation, two bull trout were found upstream of the Terrapin LF point. The Terrapin field staff observed all of the last fish observed in the ISAG revisit without the assistance of the second observer. The fish either moved upstream since the original field survey, or were originally missed. No fish were found at or above two of the last fish points, indicating that fish had moved downstream. The finding of fish upstream of the originally tagged LF point did not result in any change to last habitat points. Stream and habitat characteristics observed at the "new" LF points were similar to the conditions of the "original" LF points. Moreover, no tributaries entered the subject streams between the "new" and "original" LF points.

Findings of Terrapin Field Revisits

Terrapin crews revisited 13 points in Naneum Creek, Deer Creek, Taneum Creek, LeClerc Creek, and Rattlesnake Creek watersheds. Fish were observed upstream of two of the points by less than 60 feet. Last fish locations were downstream of the initial last fish point in three of the streams. Two of these were less than 100 feet downstream, while another was over 260 feet downstream. Last fish locations at the remaining 8 points remained unchanged.

Problems Encountered

Other than difficulty in identifying so-called last habitat criteria, field staff reported that the survey protocol was easy to follow and was more than adequate to establish the upstream extent of fish.

Private Land Issues

Several low order streams within the Deer, LeClerc, NF Touchet, and NF Deep Creek exit forestlands and flow across large expanses of agricultural and grazed pastures. For the most part, these small tributaries have been substantially impacted and often times obliterated by ditching, wetland filling, or agriculture conversion. In some situations, the channels enter the large pasture valley bottoms, where channel definition is lost for over 500 feet, only to resume as man-made ditches constructed for irrigation return flow or to drain wetlands. Because of this highly modified condition, in conjunction with refusal by individual landowners to allow access, we did not sample streams in these given situations.

Validation of LF points in Taneum and Cabin

No last fish point markers remained in Cabin Creek and Taneum Creek from previous efforts, thus complicating our efforts at last fish point "validation" and last habitat surveys. Rather than walking to a known marked location to begin surveys, we had to resurvey the last fish location, as well as complete the last habitat point surveys. We then compared our mapped last fish points with those previously mapped. It appears that last fish points identified by our crews were generally similar to those previously established. Only five last fish location had discrepancies of more than 200 feet, and these may have largely been due to map interpretation. One last fish location identified under this project was 1300 feet downstream of the last fish location previously established. Interestingly enough, we did find a ribbon in the field at the previously established last fish point that read "End of Survey". We surmise that indeed the last fish previously encountered was 1/4 mile downstream of the ribbon, which would have been nearly identical to what we observed.

Last Habitat Criteria

Last habitat points can vary widely in physical and biological conditions and can be difficult to apply consistently both among and between survey crews unless a prominent waterfall or extended dry reach is encountered. In portions of several watersheds, we commonly surveyed headwater tributaries until we encountered source areas (e.g. seeps or springs) or until flows went subsurface. This included sampling on streams that exceeded 20% for extended distances, but no prominent barriers were encountered. On some streams we electrofished well over 1/2 mile of stream above the last fish and we encountered no pool habitat greater than 4 inches in depth. Yet we still did not encounter any of the last habitat criteria until we ran out of water. Field staff believed that we ran out of suitable fish habitat well below the end of survey, due largely to diminutive flows and absence of sufficient fish holding water. Still in other streams we encountered a sustained 5% gradient increase that met last habitat criteria at which point we established last habitat locations, yet the stream upstream still appeared suitable for salmonids.

The problem of assigning last habitat locations is further confounded by the observations that seemingly poor habitats situated lower in the drainage network were at times inhabited by fish, yet these same conditions in upstream headwater areas rarely contained fish. The absence of prominent impassable barriers between fish bearing waters and these upstream reaches further confounded the problem.

Perhaps the most subjective call is associated with impassable barriers. We frequently observed last fish locations at or just below steep and short increases in gradient. Yet, field staff were often apprehensive about calling steep reaches impassable barriers unless prominent steep bedrock scour areas were evident

Recommendations

We question the use of last habitat points in developing watertype models. As described previously, considerable subjectivity goes into applying the last habitat criteria in the field. Moreover, even with careful application of the criteria, suitable fish habitat sometimes occurs upstream of the last habitat location.

One such example of concern is associated with valley wall and headwater tributaries. Following the protocol procedures, last habitat locations are situated at the mouth of these small streams if no fish are observed (i.e. tributary flow reduction criteria) in the tributary itself. Yet it is plausible that fish may seasonally or periodically enter these channels, if even just for a short distance. Another last habitat criteria may not be encountered for a considerable distance upstream. Yet the upstream extent of fish in most instances is more likely to occur proximal to the mouth of the channel.

As for the points with large discrepancies between last habitat and last fish locations in the current database, we recommend a systematic review of each point to reveal associations between stream size, gradient, and elevation. We believe that in most instances, last habitat calls were made well above where we would reasonably expect to find fish under current conditions. Exceptions to this general rule include reaches were last habitats are well above last fish points in the main trunk of primary tributaries. Most notable examples of this include selected channels in the NF Touchet, Cabin Creek, and Naneum Creek Watershed.

If last habitat protocols are continued, we question the value gained of electrofishing upstream of last habitat locations if these points are situated more than 1/4 mile upstream of last fish locations, especially on small and steep headwater tributaries. We never located fish more than 1/4 mile upstream of temporarily last fish points in channels with BFW of less than 8 feet and over 7% gradient.

From the start of the project, controversy arose over the use of one-person electrofishing crews. In general, a one-person crew conducted Terrapin's last fish surveys. We ensured accurate channel gradient measures at last fish points and last habitat points by fixing sighting flashers or ribbon to streamside vegetation (or at times a self-standing staff) at eye level for back sighting purposes. For safety reasons, we used two-person crews where rugged terrain or dense vegetation creates more hazardous work conditions. We also used a two-person crew where stream size, flow conditions, or vegetative cover made it impractical for one person to sight or capture fish. Two person crews are generally used on third order or larger second order tributaries to ensure sampling effectiveness. We believe that the use of two person crews in many situations can be cost prohibitive in collecting adequate number of samples. That is, the value gained in increased number of data points outweighs the cost of using two person crews on each stream. It is recommended that we conduct systematic comparisons between one and two person crews to evaluate sampling effectiveness of the two methods for the future. Any such study would need to ensure that the time frame between sample visits is minimal, that the crews be alternated as to who visits the site first, and that no marks are left along the stream to bias the follow-up visits.

Last fish locations will also vary annually and perhaps even seasonally. It follows that a subset of these sites should be revisited to assess temporal variability of last fish locations. Sites that were evaluated late in the season should be evaluated earlier in the sampling period during follow-up surveys.