

**EXOTIC SALMONID REMOVAL (ESR) PROJECT
2010 ANNUAL REPORT**

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REPORT SUMMARY

The Exotic Salmonid Removal project continued in 2010 with the goal of evaluating the impacts of non-native salmonid fishes on the native brook trout population in Pictured Rocks National Lakeshore. 2010 was the third full year of the project and saw the removal of nearly 1700 exotic fish, primarily juvenile steelhead trout and coho salmon, from Sevenmile Creek. During this year, in addition to the faculty P.I. for the project at Northern Michigan University, 8 graduate students, over 20 undergraduate students, 1 technician and several National Park Service employees participated in the field aspect of the project; additional undergraduate students are assisting with diet analysis and other aspects of the project in the lab. We continued to evaluate the effects of this activity on the population size, growth and condition, and feeding ecology of the fish. The population estimates of brook trout in the system are highly variable, likely reflecting the annual variability in the system as well as the relatively small population sizes involved. We have characterized the variability in growth and condition in the system and are now evaluating our data for differences between the experimental stream and the reference stream. We have conducted extensive sampling of available forage in the Sevenmile Creek. We have previously documented diet overlap between the juvenile salmonids in the system and are now able to evaluate the importance of particular diet items based on both abundance in the gut and contribution to the biomass of the gut contents. This year we also implemented a sampling strategy to assess the importance of benthic food supplies to the salmonids, although sample analysis is still ongoing. In addition to providing initial data summaries, we have also described the initiation of a geographic information systems approach to habitat use and plans for the final year of the project, 2011.

2010 PROJECT REPORT

This report serves as a summary annual report (2010) with some reference to prior study years (2008-9) for the funding provided to Northern Michigan University for the accomplishment of the project entitled "Examine resident and coaster brook trout response to exotic salmonid removal in Sevenmile Creek and conduct stream creel survey at Pictured Rocks National Lakeshore." This was the third full year of the project.

Sampling Procedures

Exotic salmonid removal continued on Sevenmile Creek in Pictured Rocks National Lakeshore (PIRO) during 2010. Sevenmile Creek (Figure 1) is a tributary of Lake Superior and has a historic coaster brook trout (*Salvelinus fontinalis*) population. Mosquito River, another tributary of Lake Superior, also had a historic coaster brook trout population and continues to be used as an unmanipulated reference stream for this study. Brook trout, coho (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) are the salmonids that reside in these streams.

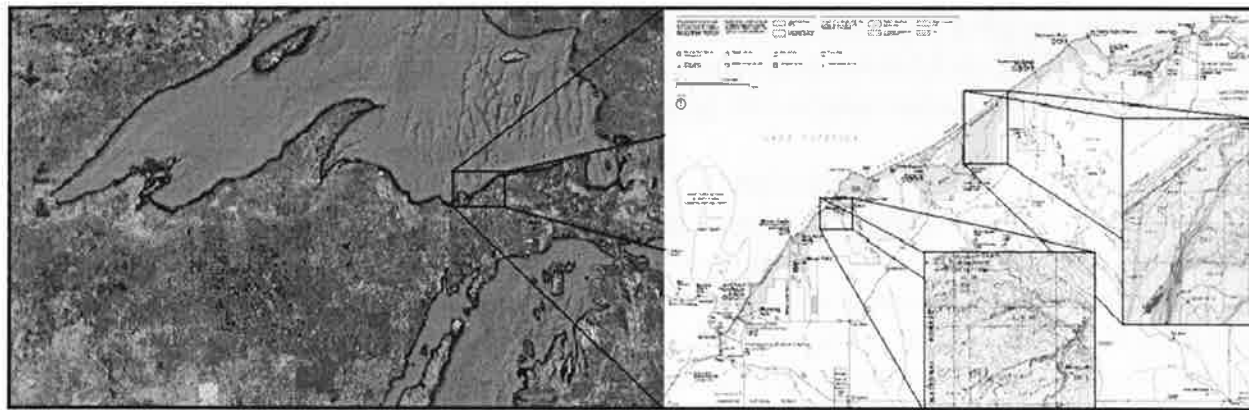


Figure 1: Pictured Rocks National Lakeshore Alger County, Michigan, left enlargement (Mosquito River), right enlargement (Sevenmile Creek)

In 2010 sampling occurred once per month in May through November with some additional sampling (primarily invertebrate drift with some habitat and fish condition work). Every month (May-Nov.) each stream was sampled via DC backpack electroshocker. Each stream is divided into three strata: lower, middle and upper, each consisting of about one third of the stream. Each stratum is divided into four to six reaches each 150m in length. Sevenmile Creek is divided into 14 reaches (each ~150m). Mosquito River is divided into 18 reaches (each ~150m).

Sampling consisted of three different methods each with a different purpose: general, population estimation, and sweeps. General sampling was a stratified random sampling technique that occurred in the months of June, July, and October. This consisted of sampling

the same six sites sampled in 2008 and 2009 using a single electrofishing pass. All salmonids were collected and appropriately processed. The second sampling technique performed was a sweep. Sweeps were done in May, August and November. During a sweep the entire research area of each stream was sampled. This was accomplished by three electrofishing crews each electrofishing one third of the stream. Each electrofishing crew completed a single electrofishing pass and all salmonids were collected and appropriately processed. Because of this sampling design, sweep data can be parsed to separate out the equivalent data to our general sampling protocol allowing us six months of data following that protocol. Population estimates were performed in September by erecting block nets at the beginning and end of three sites and shocking each reach three consecutive times without replacement of captured fishes. In addition to salmonid collection, all other species of fish were collected; weights and lengths were measured before returning fish to the stream. The same reaches were sampled in Sevenmile and Mosquito Creeks during 2007-2009 for population estimation. To obtain a more precise estimation of salmonid populations three additional sites were sampled for salmonids only in Sevenmile and Mosquito creeks during 2010 (repeating our procedure of 2009).

Habitat information such as depth, water velocity, temperature, stream width, canopy cover and substrate type were also collected for the three streams, once a month, from May to November in sampled reaches. Habitat measurements took place within a day of electroshocker sampling. Habitat sampling required one crew of two to four individuals for one day (Table 2). During each habitat assessment, six reaches (per river) were sampled corresponding to the reaches selected for general sampling.

The drift sampling that was started in January 2009 was continued during the 2010 field season. The sampling protocol required 2 drift nets (363 μ m mesh) to be set up 30 minutes before sunset and removed 30 minutes after sunset. Three habitat types (high gradient, low gradient and beaver pools) were sampled simultaneously for two consecutive nights. The surface velocity of the water in front of the drift nets was measured to calculate drift density and total volume of water sampled. All collected material from the drift nets were preserved in the field with 95% ETOH and taken back to the lab for processing. Drift samples were collected each month for the entire calendar year.

In order to add in benthic sampling of potential fish forage items, in May 2010 modified Hilsenhoff (1969) basket-style artificial substrate samplers were placed in three habitat types in Sevenmile Creek. The substrate used in the samplers reflected the common types of substrate available in each of the habitat types. Functional feeding groups of stream invertebrates were considered when choosing the substrate types used. The high and low gradient habitats had three types of artificial substrate samplers; cobble, wood, and leaf pack. The beaver pool habitat had sand/silt artificial substrate. Two samplers for each type of substrate were placed in each of the three habitat types. Sampling locations are the same as those used in the drift sampling. The samplers were emptied and replaced once a month during our regularly scheduled field work. The contents of each sampler was collected by rinsing the substrate three times and sieving the organisms and debris with 363 μ m mesh and then preserving with 95% ETOH. The samplers were removed in November. In addition to the artificial substrate

samplers, benthic organisms were collected via Surber samplers once every season (total of four months). This method used a 0.25 m² quadrat and one of the drift nets (363 µm mesh) placed haphazardly in the vicinity of the intended drift sampling site. Two samples were collected in each habitat type. The samples needed to be taken several hours prior to the drift sampling to avoid influencing the drift sampling. The stream substrate within the quadrat was disturbed by hand to a depth of 3 cm for 1 min while the current of the stream swept all dislodged organisms and debris into the net. The contents of the net was preserved in the field with 95% ETOH and taken back to the lab for processing. The two methods will be compared to determine if significant differences exist in the abundance, richness, diversity or density of captured invertebrate taxa.

All benthic and drift samples are processed in the lab in a two part method. Raw samples are drained and a sugar solution is added to help separate the organisms from the other organic debris (Anderson 1959). The organisms are then rinsed and preserved in 95% ETOH. The organisms are then identified to either order or family, enumerated, and head capsule and body length is measured to calculate biomass from previously published regression analyses of body size and mass. Processing of 2010 samples is ongoing.

The diet aspects of project initiated in January 2009 and included gut analysis of 5 categories of the three target salmonid species; brook trout age 1 (BKTY1), brook trout young-of-year (BKTYOY), steelhead age 1 (STHY1), steelhead young-of-year (STHYOY) and coho salmon young-of-year (COHYOY) based on stomach content samples gathered through gastric lavage. Only one age class of coho salmon was used because coho usually leave their natal stream after their first year. Young-of-year fish were those under 100mm and age 1 fish were those that are 100-180mm (as defined in P. Kusnierz 2008 NMU M.S. thesis). During each monthly sampling session on Sevenmile Creek, up to 10 individuals from each of the five age classes in each of the three habitat areas were subjected to gastric lavage. Approximately 60-150 individuals were sampled during each session, but the number depended on the time of year and age classes present. This sampling was concluded in November, 2010; 2009 stomach content samples have been identified and initial analysis is underway whilst 2010 samples are still being processed as of this date.

RFID Antenna:

This year in addition to our three Texas Instruments Radio Frequency Identifier (TIRFID) double antennas stationed at each of the mouths of Sevenmile Creek, Mosquito River and Hurricane Creek a new antenna was constructed in site ten on Sevenmile Creek. When a PIT tag crosses an antenna PIT tag number, date and time are recorded on a computer powered by 12 volt batteries charged by solar panels. At each antenna site, there are two antennas approximately 10 meters apart to enable direction of fish movement to be determined.

As of January 2011, the three antennas at the mouths of the rivers are in place and operating through the winter; we have removed the Site 10 Sevenmile antenna due to beaver flooding.

Processing Fish

After collection, each fish was identified, weighed (g) and lengthed (mm). All brook trout over 100mm were scanned with a portable TIRFID reader to check for the presence of a previously implanted Passive Integrated Transponder (PIT) tag. If a tag was present the number was recorded and if no tag was detected one was surgically implanted within the body cavity. To accomplish this, an incision (approximately 5mm) was made with a number 12 recurved scalpel blade through the muscle wall, slightly anterior to the pelvic fin, and a 23mm PIT tag was inserted anteriorly into the body cavity. In October scales were taken from up to 60 fish of each species per stream for aging purposes along with a genetic sample. All brook trout were returned to the stream after recovery from tagging. All exotic salmonids collected in Sevenmile Creek were removed from the system and deposited in the forest near the stream after processing. Exotic salmonids were humanely killed via the NMU IACUC approved method of cranial concussion and decapitation. The exotic salmonids were discarded in the woods so all nutrients were returned to the watershed. In addition gastric lavage was performed on up to ten young-of-year and ten year one fish of each salmonid species collected in each strata of Sevenmile Creek. Young-of-year fish were identified by a total length below 100 mm and year one fish were identified by a total length above 100 mm and below 180 mm (based on P. Kusnierz 2008 NMU M.S. thesis). Gastric lavage was performed to collect the stomach samples (Hakala and Johnson 2004). Each stomach content sample was placed in alcohol and the contents are identified to family and enumerated. Biomass was estimated by previously published regressions for size and mass.

Traps

For the second year, fish traps were placed in Sevenmile Creek to catch and remove adult exotic salmonids during their spawning runs in order to prevent spawning. Two additional technicians were hired to monitor traps from mid-March to May to capture steelhead (~7 weeks). Traps were set in October to capture coho salmon on their spawning run (~3 weeks). During each trap session, there were two traps, one facing upstream and the other facing downstream toward the lake. The remaining portion of the stream was blocked off with netting to guide the fish into the traps and prevent fish from moving upstream. All exotic salmonids were identified, sexed, lengthed, weighed, had scales and a genetic fin clip taken and then lethally removed from the stream. All native fishes were placed on the opposite side of the trap where they were caught. Brook trout were processed according to our standard protocol before returning them to the river in their direction of travel. Redd counts were attempted in the spring and the fall; however, because of the difficulty in positively identifying redds and the likelihood of superimposition, redd counting was deemed unreliable, particularly for brook trout.

Stomach contents analysis

Analysis of diet data was performed using Microsoft EXCEL (2007), SPSS (version 16.0) and PCORD. Processing of samples and data entry and analyses are ongoing. The relative

abundance of each family/order in the drift/stomach samples were calculated using the following equation:

$$RA_o = N_o/T$$

where RA_o is the relative abundance of order o in the drift, N_o is the number of individuals of order o in the drift and T is the total number of invertebrates collected in the drift sample (Hilderbrand and Kershner 2004).

Diet overlap was calculated by month (May, June, and July only), for each habitat type, between brook trout, steelhead and coho (year 1 and YOY) using the following equation:

$$C_{xy} = 1 - 0.5(\sum |p_{xi} - p_{yi}|)$$

where C_{xy} is the index value, p_{xi} is the proportion of food type i used by species x , p_{yi} is the proportion of food type i used by species y , and the vertical bars mean absolute values of the difference. Values range between 0 and 1, with 0 indicating no overlap and 1 indicating complete overlap (Bowen 1996; Schoener 1971).

An ANOVA with Tukey's post hoc analysis was used to compare drift density and number of individuals collected between habitats and months. DCA analysis was performed on the drift density and abundance data to determine composition relationships between the three habitat areas and the different months.

Winter Fish Condition

We are also working to understand overwintering effects on the brook trout population in Sevenmile Creek. Part of this study involves collecting information on fish condition during the winter. To collect length and weight of brook trout, which is needed for Fulton's Condition Factor, electroshocking was conducted during the winter months. Each month, half of the reaches in the stream were electroshocked where openings in the ice allowed. Each reach was shocked for a set amount of time (12 min), determined by the amount of daylight available during the winter months and the amount of time needed to measure fish. Care was taken to not expose fish to freezing air temperatures to minimize adverse effects. Fish were weighed and lengthed in a container of water. The condition factor of the brook trout was divided into two groups, YOY brook trout and 1+ age brook trout.

RESULTS

EFFORT AND PERSONNEL

In 2010, six graduate students were associated with the project. One full time technician worked on the project from January-April. The principal investigator (Leonard) logged ~60 hours in the field and an additional 75 hours of management time. Four individuals were paid 20h/wk through the summer and worked ~1300 hours. The project also logged 520 volunteer hours (20 people; primarily undergrads and NPS employees) to accomplish field work. In addition, undergraduates have provided over 200 hours of volunteer time in the laboratory to assist with diet sample sorting and identification (drift, benthos, gut contents) as well as initial data entry. In total, we have dedicated more than 2600 hours of effort to this project in 2010.

FISH – OVERVIEW AND REMOVAL

In 2010, the project handled over 5600 fish, primarily salmonids, in the two study rivers. The non-salmonids in the count (Table 1) were all captured in September as part of the population estimation protocol. Salmonids were captured throughout the year. During 2010, 17 species were handled as well as one hybrid form.

Fish Captured in 2008-2010 in the PIRO						
Species	Mosquito River			Sevenmile Creek		
	2008	2009	2010	2008	2009	2010
Blacknose Dace	17	17	2	79	16	24
Brook Stickleback	11	0	2	0	5	9
Brook Trout	697	844	764	434	594	725
Burbot	0	0	0	1	1	1
Central Mudminnow	21	11	7	1	1	0
Chinook Salmon	0	1	0	0	0	0
Coho Salmon	373	75	46	515	854	811
Finescale Dace	0	1	0	0	0	0
Johnny Darter	0	0	0	0	1	0
Longnose Dace	7	10	2	121	168	17
Mottled Sculpin	100	19	38	1	0	5
Pink Salmon	0	0	0	1	0	4
Redbelly Dace	1	0	0	5	0	4
Slimy Sculpin	354	383	125	64	72	81
Splake	1	1	3	0	2	4
Steelhead	1008	2844	2048	1217	1043	881
Unknown	4	2	1	1	5	2
Unknown Sculpin	0	112	32	0	64	0

White Sucker	0	0	0	0	2	1
Total	2594	4320	3070	2440	2828	2569

Table 1: All fish captured in Mosquito River and Sevenmile Creek in PIRO during an exotic salmonid removal 2008-2010.

Non-native Salmonid Removal

During 2010, 1696 fish were lethally removed from Sevenmile Creek, a slight decrease over previous years (Table 2). The majority were juvenile steelhead trout. Spring and fall traps were successful in capturing adult spawning coho and steelhead; it appears that 2010 was a strong return year for coho as well as for steelhead. The spring trap appeared to have been in place for most of the steelhead run and few fish were captured outside of trapping season. The fall trap was highly effective, but as is typical, the coho run was extended and trap was likely not in operation for the duration (as evidenced by adult captured outside of the trap period).

We have evaluated the encountered steelhead in the streams and developed size frequency plots that allow us to compare the fish remaining in Sevenmile Creek with Mosquito Creek (Figure 2). Note that all the steelhead in the plot for Sevenmile Creek were removed at capture, while the Mosquito River fish were returned to the stream. Adult spawners are represented in the Sevenmile Creek graph because the trap was in place; no trap was run in Mosquito nor did we sample during the main part of the run, so adults are not represented in that data set. Note the approximately 5 fold higher numbers of steelhead encountered in Mosquito River compared to Sevenmile Creek; this difference reflects both the different in normal productivity of the species in the streams as well as the removal effort in Sevenmile Creek.

Exotic Salmonids Removed from Sevenmile Creek							
Species	2008		2009		2010		Total
	Juvenile (<225mm)	Adult (>225mm)	Juvenile (<225mm)	Adult (>225mm)	Juvenile (<225mm)	Adult (>225mm)	
Coho Salmon	467	49	783	67	654	157	2177
Pink Salmon	0	1	0	0	0	4	5
Steelhead	1210	7	990	50	777	104	3138
Total	1734		1890		1696		5320

Table2 : Juvenile and adult exotic salmonids removed from Sevenmile Creek 2008-2010.

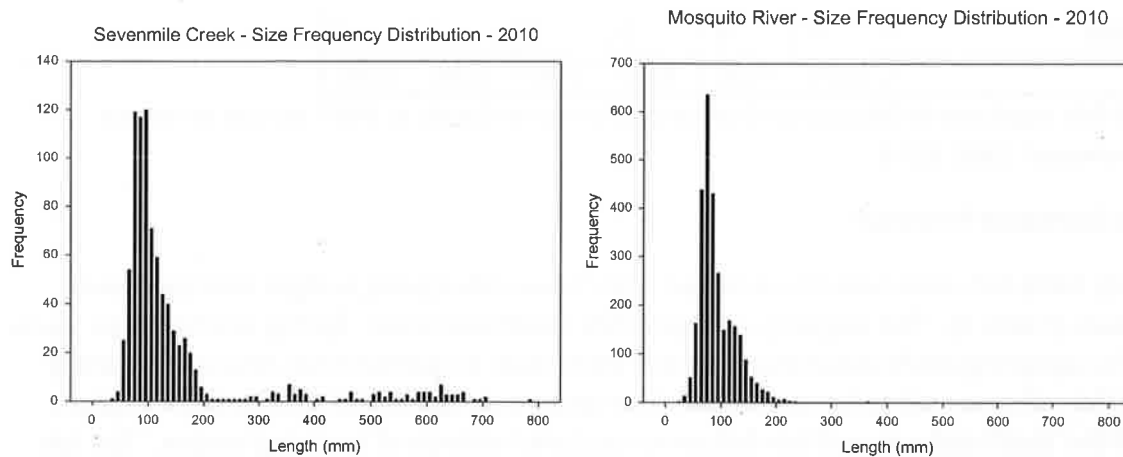


Figure 2: Size frequency plots for steelhead trout captured in Sevenmile Creek (left) and Mosquito River (right) during 2010.

Size frequency plots

The size frequency plots for native brook trout from both streams over the course of the study are shown in the Figures 3 and 4. This data includes all fish collected across the sampling season. Note that young-of-the-year typically do not recruit to our capture gear until mid-summer, and so are underrepresented in these figures. Also note the overall lower numbers of brook trout in Sevenmile Creek compared to Mosquito River; our study section of Mosquito River is a larger river reach. Sevenmile Creek is also heavily colonized by beavers and our sampling efficiency, though relatively stable over time, is substantially lower in these areas. Brook trout are proportionately a larger component of the fish community in Sevenmile Creek than in Mosquito River. We note that the strong year class recruitment in 2009 in Sevenmile Creek persisted into 2010 with the higher numbers of putative year 1 fish in the collection. This pattern was not seen in the reference stream. There was no strong suggestion that the 2010 young-of-the-year showed high recruitment in Sevenmile Creek.

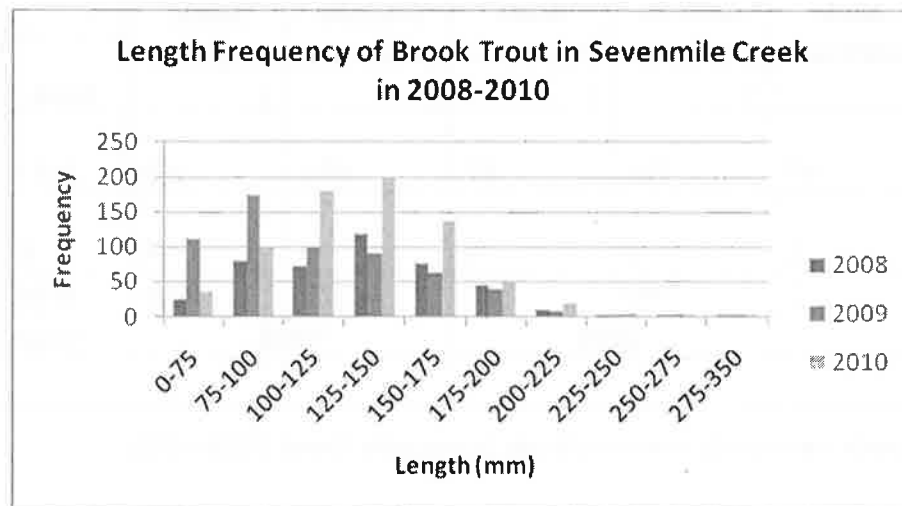


Figure 3: Length frequency of brook trout in Sevenmile Creek 2008-2010.

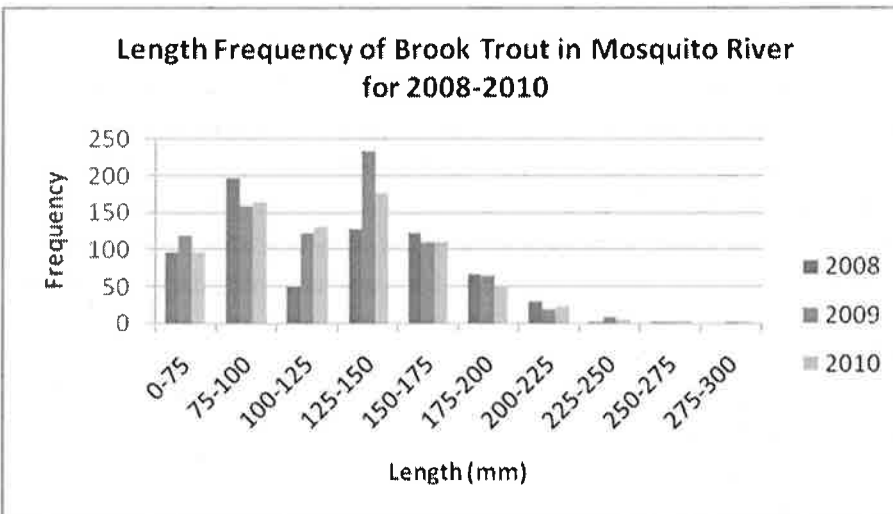


Figure 4: Length frequency of brook trout Mosquito Crook 2008-2010.

PIT Tagging

The following table shows the number of brook trout captured, the number tagged, and the number of brook trout recaptured during subsequent samplings during 2008-2010.

Brook Trout Captured in the PIRO 2008-2010			
Drainage	Tagged (≥100mm)	Untagged (<100mm)	Recaptures
Mosquito River 2008	312	293	92
Mosquito River 2009	390	273	181
Mosquito River 2010	351	250	163
Sevenmile Creek 2008	303	100	31
Sevenmile Creek 2009	281	284	29
Sevenmile Creek 2010	540	130	55

Table 3: Tagging results for brook trout in the ESR rivers and the number of tagged fish recaptured.

Population estimation

The following tables show population estimates using Program MARK for three pass depletion estimation using three stream sections per stream as well as catch-per-unit-effort data (Figure 5). Program MARK does not recommend the calculation of Confidence Intervals with data based on a relatively small data set, such as ours, and the population estimates are highly variable. Data are only shown for brook trout, although we are in the process of developing estimates for the other salmonid species and, where possible, for non-salmonids in the system.

Sevenmile Creek	Abundance Estimates		
	2008	2009	2010
BKT	200.22	128.40	190.30
BKT YOY	86.68	167.15	54.78
COH YOY	720.62	472.93	325.86
STH	88.27	133.69	165.80
STH YOY	1232.47	1031.43	369.84

Table 4: Three-pass depletion estimator population estimates in Program MARK for salmonids in Sevenmile Creek in September of 2008-2010. YOY are fish <100mm.

Mosquito River	Abundance Estimates		
	2008	2009	2010
BKT	234.96	265.25	108.00
BKT YOY	297.93	184.81	72.00
COH YOY	512.55	121.28	39.04
STH	234.00	544.25	333.83
STH YOY	1650.23	2314.00	994.02

Table 5: Three-pass depletion estimator population estimates in Program MARK for salmonids in Mosquito River in September of 2008-2010

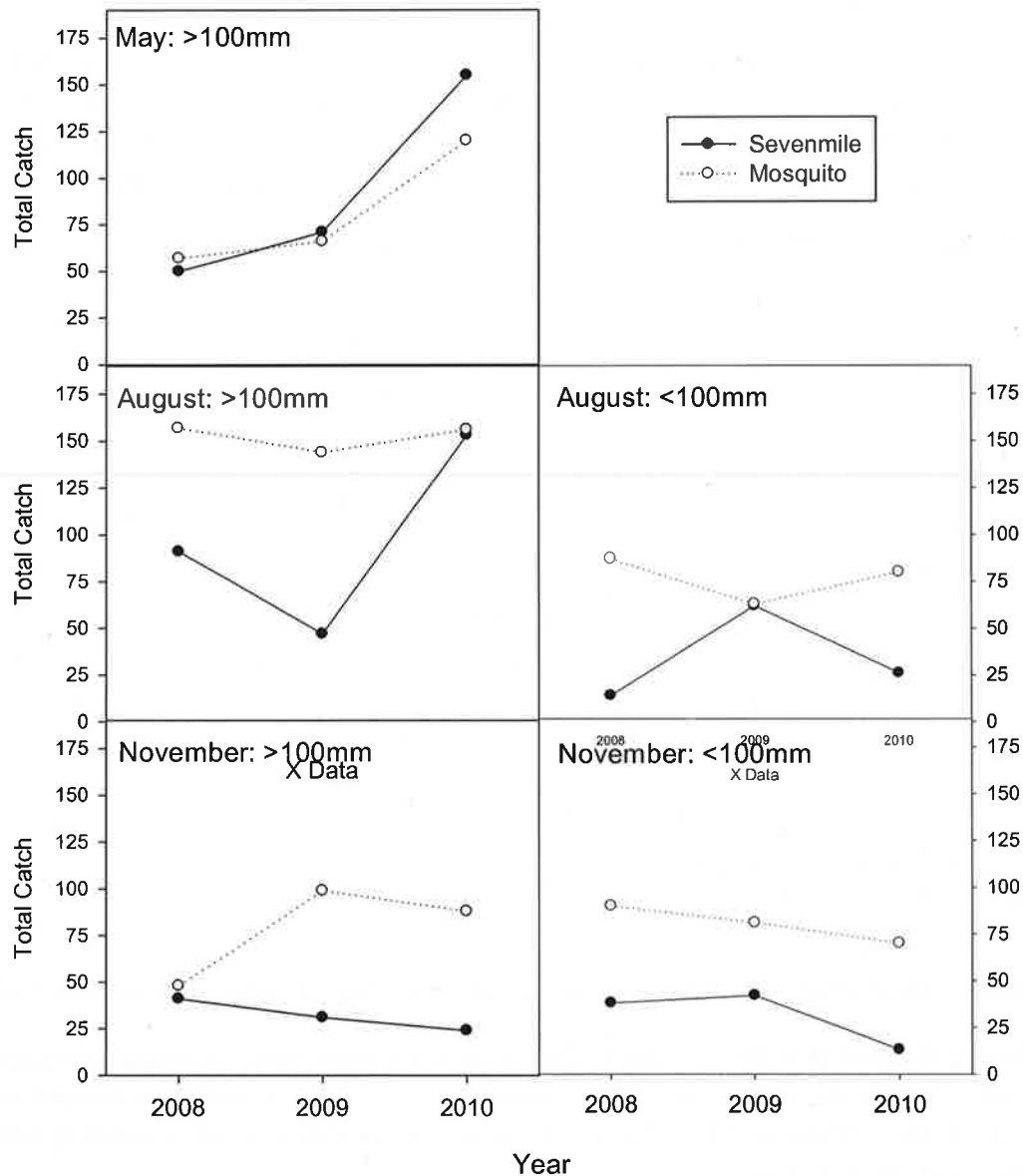


Figure 5: Total brook trout catch from each Sweep sampling (single pass of the entire stream study section) for May, August and November in each year of the study.

Fish Condition

Fish condition was calculated from May 2008 through April 2010 (Figure 6), with several winter months absent as electroshocking was not possible due to the stream being completely frozen over. Fish condition, for both sub-100 mm brook trout and 100 + mm brook trout was lowest at the end of the winter season, just before spring break up. Spring break-up varied between the two winter seasons, as winter 2008-2009 ended in April and winter 2009-2010 ended in March. Both size fish classes followed a similar trend in fish condition, as condition

rose sharply following spring break-up, remained somewhat stable throughout summer, and then gradually declined throughout the winter season. For sub-100 mm brook trout, this decline in fish condition throughout the winter months resulted in a 10.6% (winter 2008-2009) and 7.6% (winter 2009-2010) decrease, as 100+ mm brook trout resulted in a similar trend of decrease, a 17.6% and 12.7% decrease in condition. Interestingly, both size classes resulted in a greater loss during the first winter, in which spring break-up was one month later.

Fish Condition - Sub-100 mm and 100+ mm BKT, May '08 - Apr '10

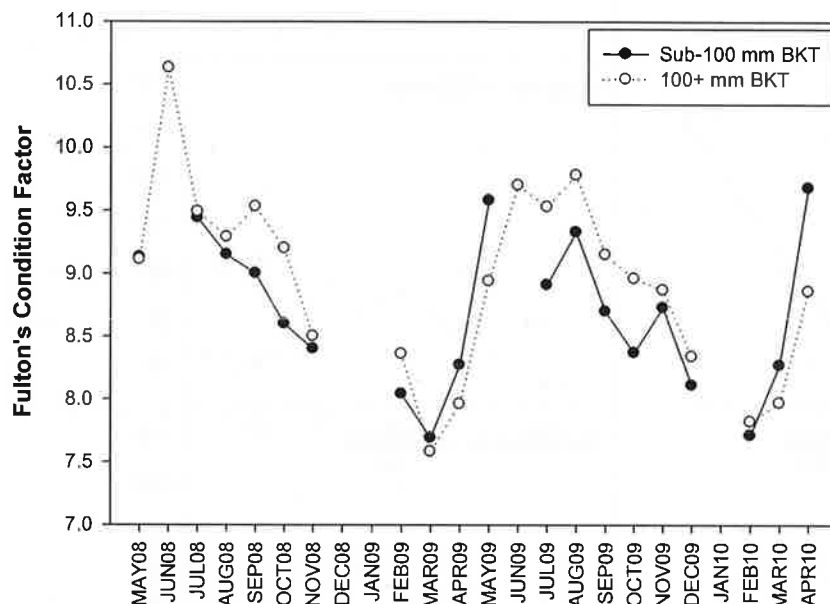


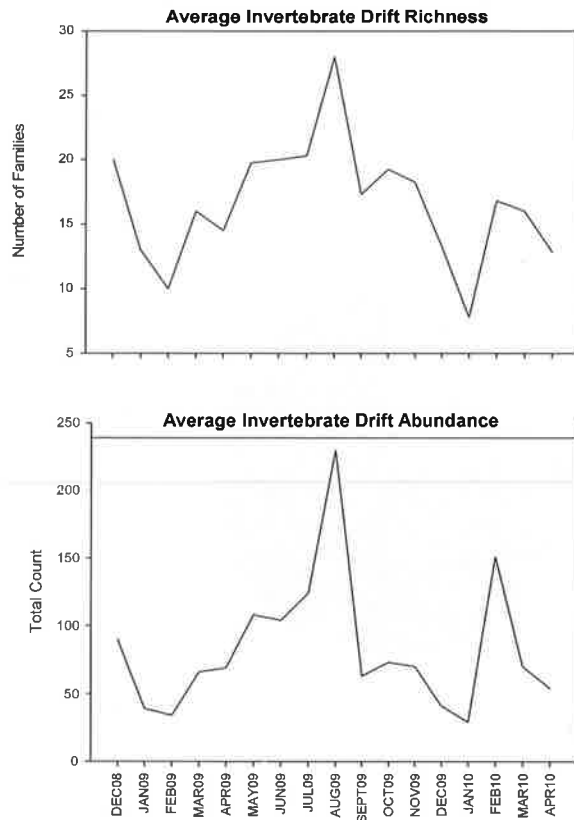
Figure 6: Brook trout Fulton's condition factor for YOY and larger fish from Sevenmile Creek

ANOVA analysis showed that fish condition did not vary between years or stream sections. Between years, the results were: sub-100 mm brook trout ($P=0.117$), 100+ mm brook trout ($P=0.069$). Between stream sections, the results were: sub-100 mm brook trout ($P=0.923$), 100+ mm brook trout ($P=0.811$).

Further condition and relative weight analysis is ongoing.

Fish diet

Samples from 2009 have now been sorted and identified, mostly to family, for the stream drift and fish stomach contents. We have begun calculating diet overlap between different categories of juvenile salmonid fish (BKT YOY, BKT Age 1, STH YOY, STH Age 1, COH YOY) as well

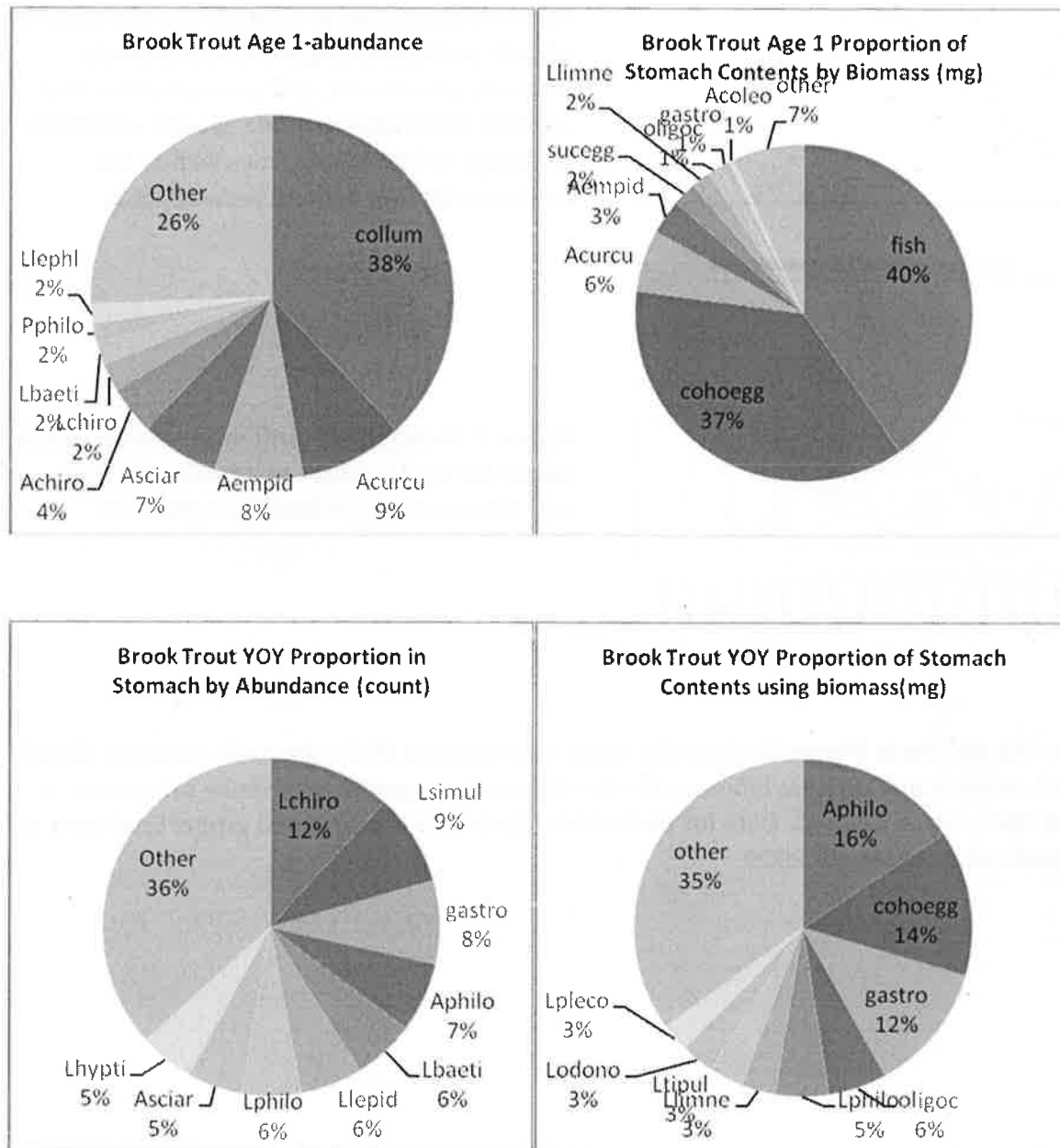


as selectivity of fish for particular items available in the drift (see 2009 Annual Report). Samples from 2010 have been collected and are in the process of sorting/identification. We have been able to characterize the pattern of drift availability (Figure 7) in the study streams, year round, and we expect our final analysis to be able to relate season variability of forage to fish condition as well as the potential for diet overlap between fish.

Figure 7: Invertebrate drift in Sevenmile Creek based on total number of items in the drift and total number of families in the drift.

The following pie charts (Figure 8) show the major components of the stomach contents, based on item abundance and on item biomass, for the different categories of juvenile salmonids. A key to the item names follows. Data for each chart represents the summed proportions over all months and habitat types for 2009.

Figure 8: Pie charts show the proportion of stomach content for each salmonid fish category in terms of both abundance of items and biomass.



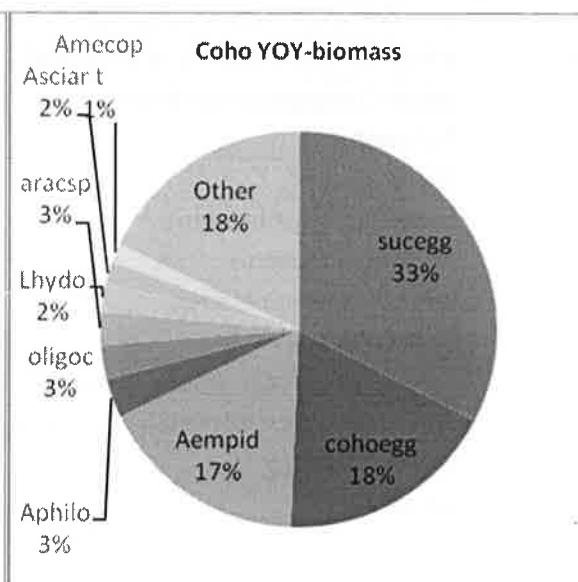
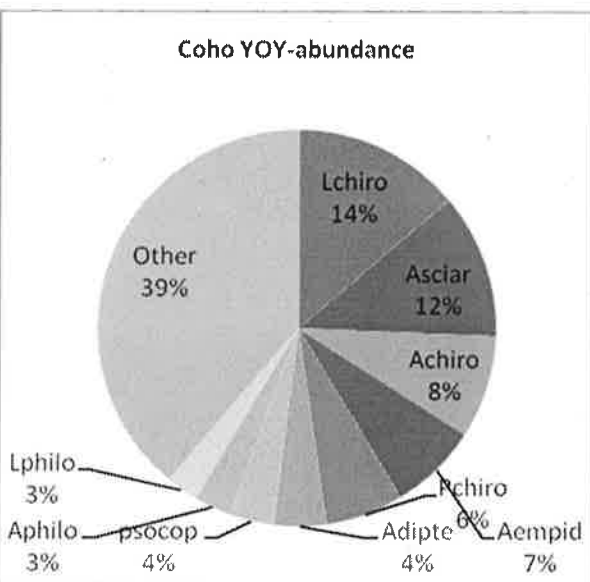
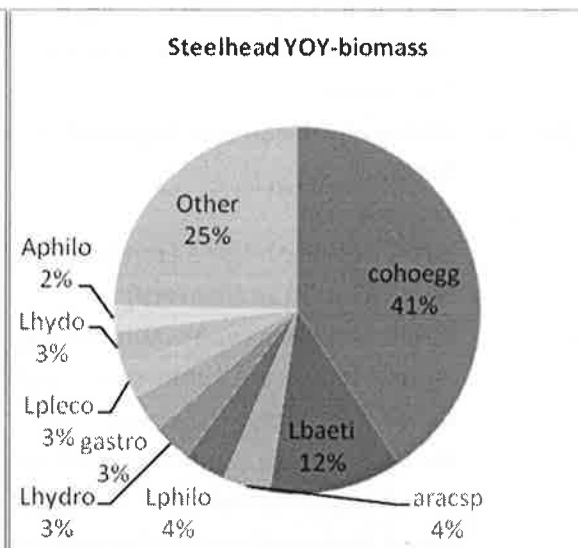
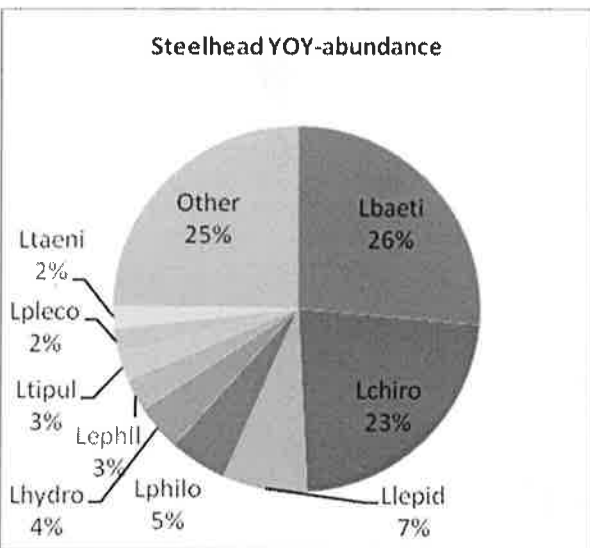
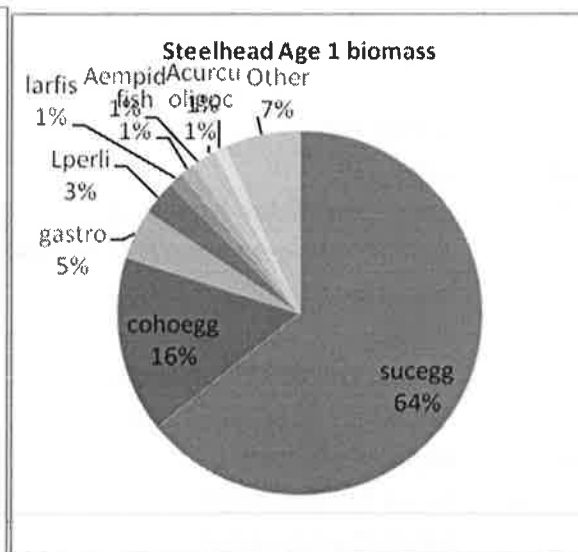
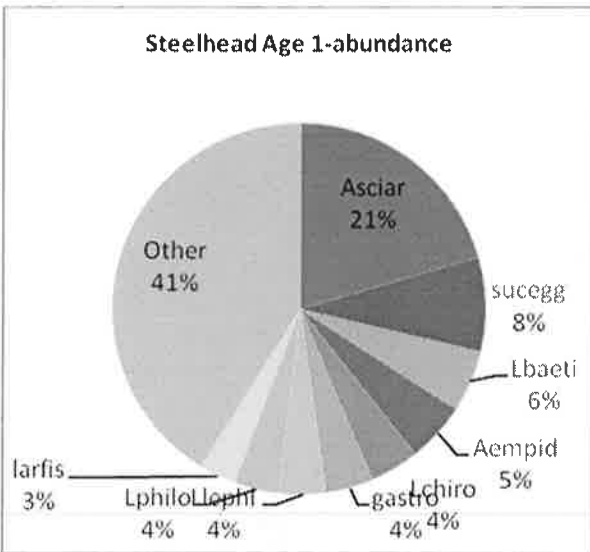


Table 6: Drift item codes used in Figure 8

code	
sucegg	sucker egg
cohoegg	coho egg
Aempid	adult Empididae (Diptera)
Aphilo	adult Philopotamidae (Trichoptera)
oligo	oligochaete
aracsp	spider
Lhydo	larval Hydrophilidae (coleop)
Asciar	adult Sciaridae (Diptera)
Amecopt	adult Mecoptera
Lchiro	larval Chironimidae
Achiro	adult Chironimidae
Pchiro	pupal Chironimidae
Adipte	adult Diptera (unknown family)
psocop	Psocoptera
Aphilo/Lphilo	Philopotamidae (trichop adult and larval)
gastro	Gastropoda
Llimne	larval Limnephilidae (Trichoptera)
Ltipul	larval Tipulidae (Diptera)
Lodono	larval Odonata (unknown family)
Lpleco	larval Plecoptera (unknown family)
Lsimul	larval Simuliidae (Diptera)
Lbaeti	larval Baetidae (Ephemeroptera)
Llepid	larval Lepidostomatidae (Trichoptera)
Lhypti	larval Hydroptilidae (Trichoptera)
fish	any fish other than larval fish
Acurcu	adult Curculionidae (Coleoptera)
Acoleo	adult Coleoptera (unknown Coleoptera)
collum	Collumbola
Llephl	larval Leptophlebiidae (Ephemeroptera)
Lephll	larval Ephemerellidae (Ephemeroptera)
Ltaeni	larval Taeniopterygidae (Plecoptera)
Lhydro	larval Hydropsychidae (Trichoptera)
Lperli	larval Perlidae
larfish	larval fish

NEW ELEMENTS – GIS

We have added several new layers to the project and work began on the incorporation of GIS techniques to assess habitat use in the system in 2010. A graduate student was brought on to focus on this area and both the student and Leonard attended an aquatic GIS workshop. We have also formed a collaboration with Dr. Jason Krought at St. Louis University, an expert in aquatic GIS, for this element of the project. The goals are to refine our understanding of habitat use by brook trout, particularly in light of the removal, and to be able to assess critical areas within the streams for brook trout.

Map Layers:

In order to develop the map framework upon which the salmonid capture and habitat data is to be spatially displayed and modeled, two georeferenced Digital Ortho Quarter Quads containing the necessary riparian areas within Alger County, MI will be obtained from the Michigan Geographic Data Library (MiGDL). This map layer contains large scale representations of both Sevenmile and Mosquito creeks and will be imported into ArcGIS 9.3 to act as a base-layer (Figure).

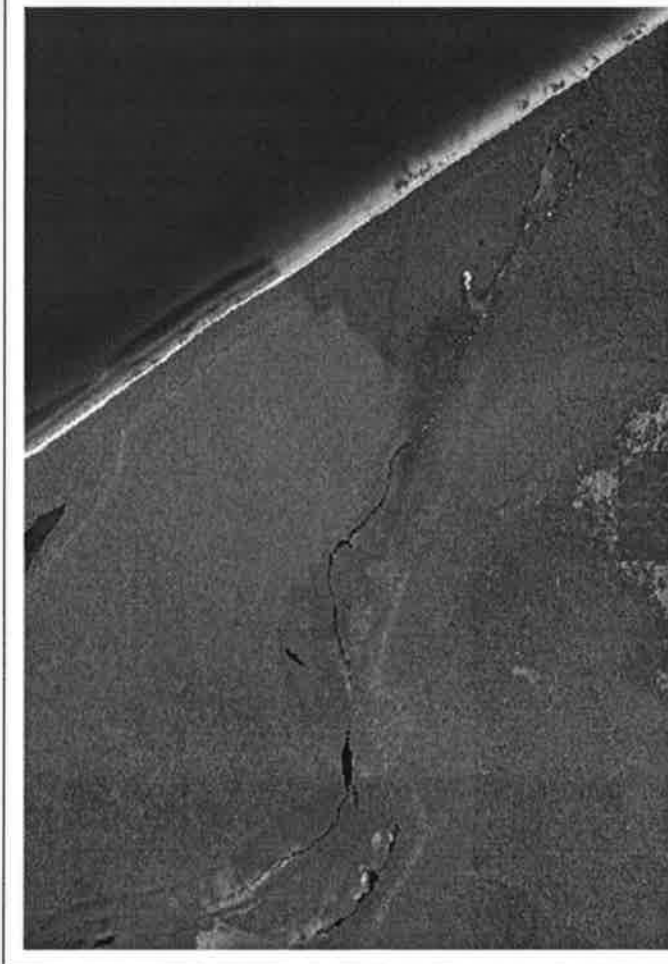


Figure 1: 2005 Digital Ortho Quarter Quad: Trappers Lake NE (Sevenmile Creek)

Georeferencing:

Due to the limited resolution of the Ortho Quarter Quads obtained from the MiGDL and the proposed aim to represent this data at a fine scale, UTM coordinates will be collected to display the sampling sites as “point features” in Trimble GPS Pathfinder Office (Version 5.00). Using the programs ability to create “features”, we will ultimately convert the collected points into “area features” that represent each individual transect. Point and area features will be exported from Pathfinder Office and layered on top of the Ortho Quarter Quads within ArcGIS.

Collection of UTM coordinates corresponding to known sampling locations within both Sevenmile and Mosquito creeks is the first step. Along

the banks of both rivers, a series of transects and reaches have been identified by flagging and rebar respectively. In order to collect UTM coordinates for each point, a Trimble GeoXH handheld GPS unit outfitted with a Tempest external antenna that is capable of obtaining sub-foot accuracy will be used. Beginning at the mouth of each creek and systematically working upstream, points will be collected for both banks at each reach and transect. Sevenmile and Mosquito creeks are divided into fourteen and eighteen reaches respectively. Each reach is divided into ten transects which measure fifteen meters in length. Total distance for each reach is one-hundred and fifty meters. A total of 640 GPS data points (280-Sevenmile, 360-Mosquito) will be collected.

Once all of the coordinated have been collected they will be displayed in Trimble GPS Pathfinder Office as point features. To ensure accuracy, the point features will be corrected using the "differential correction" utility in Pathfinder Office. Post-correction, the point features will be manually drawn into area features using the "feature creation" utility. These point and area features will be exported as an ESRI Shapefile for use in ArcGIS 9.3. Creation of this layer provides the fine scale component of the GIS which will allow the spatial display of all past and future data (Figure).



Figure 2: 2005 Digital Ortho Quarter Quad: Trappers Lake NE with UTM Point features (Sevenmile)

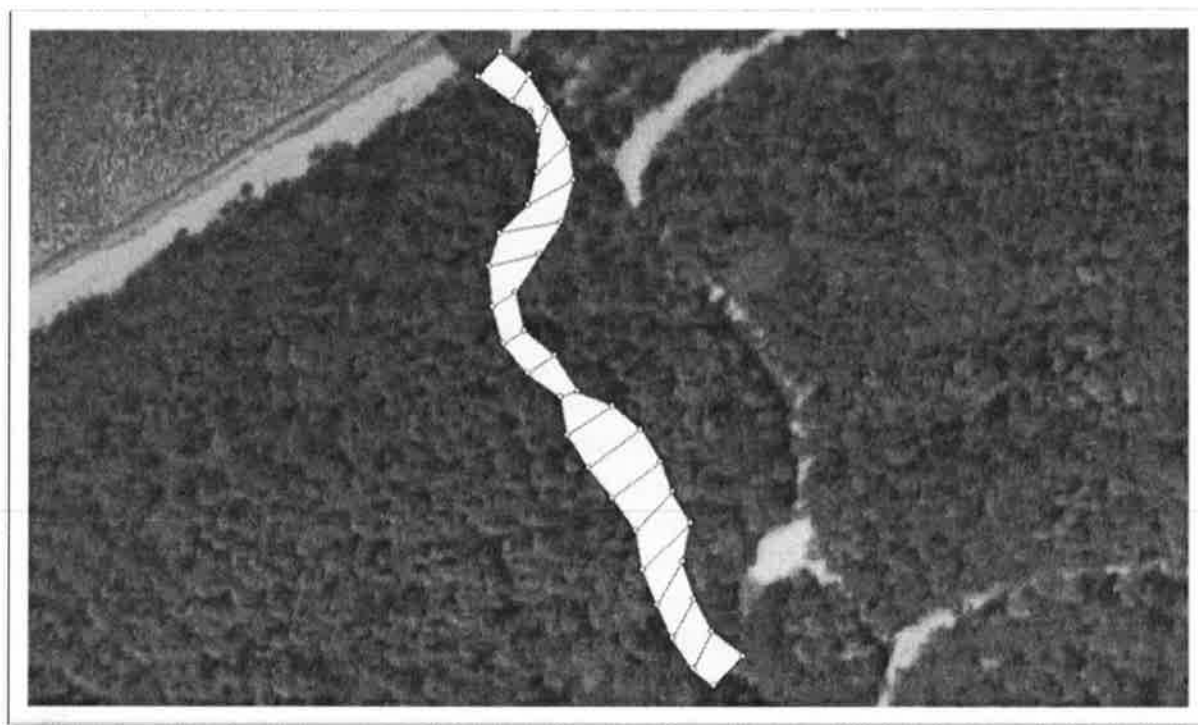


Figure 3: 2005 Digital Ortho Quarter Quad: Au Sable Point SE with Point and Area features (Hurricane River, PIRO)

Database Development:

Salmonid Data (In addition to ESR sampling protocol):

Due to the design of the sampling protocol, when creating the fish sampling database the capture data will have to be compressed into seasons (summer, spring and fall) as not every reach will be sampled every month. Capture data has been compiled in an Access database and will be manipulated into various Excel *dBASE* files. These *dBASE* files will be linked with their corresponding area features within ArcGIS. Each transect that is represented by an area feature will be assigned individual values that correspond to population demographics and abundance. This database will ultimately become a raster graphic that gives spatial representation to all aspects of the capture data.

Habitat Data (In addition to ESR sampling protocol):

Habitat variables will be spatially referenced in a very similar manner to salmonids data. Preliminary data manipulation will entail conversion from field notes to an Excel *dBASE*. Later manipulations will include the linking the *dBASE* files to the already displayed area features. Ultimately the data will be spatially represented as a raster graphic in ArcGIS. These variables will be used in later statistical modeling processes as the basis for a predictive model.

FUTURE PROJECT PLANS

2010 was the last scheduled year of physical removal of exotic salmonids in Sevenmile Creek. Work will continue in 2011 to monitor continued effects of the removal. The fieldwork involved will be our standard fish and habitat sampling scheme which combines general sampling, sweeps, and a fall population estimation carried out by a part-time field crew augmented by volunteers. Diet, drift and benthic sampling are finished, however substantial work remains to finish identification and sorting of the samples and the analysis of the data. The GIS work is ongoing and will likely more georeferencing and possibly additional habitat measures as well as work with the already collected habitat data. We plan to start a new graduate student in May 2011 to provide comprehensive assessment of fish movements, within stream and between streams and the lake, using PIT and RFID data already collected. This piece of the project will allow us to evaluate the effects of the removal on individually tagged brook trout and also to assess the overall effect of the project on coaster movements. While this has always been a project priority, it was placed late in the project from an analytical perspective because the data collection (PIT detections at antennas) is slow. All field work is expected to cease on this project in November 2011 with the exception that the RFID will be maintained in place to detect tagged fish through summer 2012.

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