ST. MARY'S RIVER ASSOCIATION

ATLANTIC SALMON KELT EXPERIMENT - 2009

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INTRODUCTION

The St. Mary's River Association has in past years been granted a scientific fishing licence to angle for Atlantic salmon (*Salmo salar* L.) kelts in order to estimate abundance since 2004, but participation in this experiment had been low and so the data generated from it weak. In Spring 2009, the St. Mary's River Association wished to upgrade its approach to this experiment to increase the value of the derived information, which we believed may be useful in understanding salmon distribution and abundance in the river. Further, the SMRA saw this as a pilot project and felt that if it remained feasible in future years the estimation of kelt abundance would be a very useful addition to other abundance and distribution estimates planned by the SMRA (e.g., angling-season mark-recapture, snorkelling of pools, redd surveys) as well as the DFO fall seining estimates in the St. Mary's.

The purpose of the 2009 kelt experiment was to: (i) estimate abundance of kelts in the St. Mary's River in spring 2009 via Petersen mark-recapture methodology, (ii) collect information on salmon distribution among the branches prior to emigration, (iii) determine timing of kelt movement downstream, and (iv) collect basic biological information on the kelts (length, sex, scale and DNA samples).

METHODS

The basic methodology was a Petersen mark-recapture approach with discrete marking and recapture phases. Under the original schedule, during the period of April 1-15, anglers were to capture salmon and mark them with individual marks for different branches of river (Table 1). Angling effort during marking was to be distributed proportionately to watershed area (~35% West Branch, ~30% East Branch, ~10% North Branch, ~25% Main Branch) and to the extent practical begin in the upper reaches and proceed downstream. Effort during recovery angling was to be predominately on the Main Branch and lower reaches of the East and West branches. Anglers were provided with sampling kits consisting of datasheet, punch, and measuring tape and were asked to record the following information:

- date and specific location of angling,
- time spent at each location,
- gear (fly or lure)
- catch (all species),
- size of salmon or trout,
- collection of scales and DNA from salmon for subsequent analysis,
- whether or not the fish was marked at the time of capture and type of mark (including v-notch marks on the adipose indicating Live Gene Bank released fish),
- whether or not the fish was marked by the angler prior to release and type of mark.

Table 1: Originally proposed schedule of activities for St. Mary's River Association kelt experiment, 2009.

Window of opportunity	Activity	Target	Comments
April 1-15	Intensive fishery to mark salmon	Minimum of 30 salmon marked	West Branch captures marked by punch of dorsal lobe of caudal fin East Branch captures marked by punch of ventral lobe of caudal fin North Branch captures marked by punch of ventral lobe of caudal fin and anal fin Main Branch captures marked by punch of dorsal lobe of caudal fin and anal fin
April 16-25	No fishing		Period to allow mixing of marked and unmarked fish
April 26-May 15	Recapture phase	Minimum of 50 salmon captured	
May 15-June 15	Analysis and reporting		

The coordinator of the project (S. Mitchell) assigned sections of the river for anglers to fish in order to meet this target distribution of effort by branch of the river. Spinning gear (single hook, barbless, unbaited lures) was used in addition to fly fishing. This approach was based on lures generally being more effective and this was intended as a scientific study with a goal of capturing as many fish as possible. Choice of sampling gear rested with the individual fisherman. As part of being listed a registered angler, each participant was asked to agree to commit to a minimum of 10 hours angling for salmon during the period of the experiment.

Captured fish in the marking phase, and unmarked fish in the recapture phase, were sampled for: sex, length (fork length), and scale samples (to determine age, repeat spawning, spawning history). DNA samples were collected from salmon during the marking phase. Scales and DNA samples will be submitted to DFO for analysis.

RESULTS AND DISCUSSION

The experiment began on April 1st and continued until May 4th, 2009 when it was felt by anglers that the kelts had left the river, based on zero catch despite effort. Total angler effort was 261.5 hours of effort. Of 45 anglers listed on the scientific licence as legally entitled to fish in this experiment, only 24 (53%) participated, and among these, 3 anglers accounted for 50% of the effort and 67% of the catch. Ninety percent of the effort, and all of the catch, were by 14 of the 24 anglers (i.e., 31% of the total licensed anglers, and 58% of the participating anglers) (Figure 1). Median effort per angler was 7.3 hours over the period of angling, and ranged from 1.5 to 52

hours. The mean length of an angling day during this experiment was 3.46 hours (SD $\pm$ 2.07 hours). As may be seen from Figure 1, only 6 anglers met or exceeded the expected 10 hour angling commitment. Previous kelt experiments (2004-2008) indicate similar low registered angler participation, as evidenced by the small number of salmon captured (i.e., only 5 fish captured in 2004; data on 2005-2008 with DFO but not yet accessed at time of this writing). I recommend that in the future, rather than an extensive list of registered anglers, this experiment be prosecuted only by those experienced anglers that have shown commitment in the past (*Recommendation #1*).

The experiment was divided into a marking period (April 1-April 23) and recapture period (April 24-May 4). The marking period extended longer than originally planned (i.e., past April 15) due to high water (water level >3.5 m) preventing effective angling through much of early April (Figure 2). Little effort (i.e., only 23% of the total effort) was expended before April 15 (Figure 2) during the originally planned marking period. Thus, the marking was extended into the period originally planned for no fishing. This extension has implications for the ability to derive a Petersen population estimate as one assumption of the method is that all animals have the same chance of being caught in a sample. This is true if there is time for the marked and unmarked fish to completely mix, but less true if time is not provided for mixing to occur. The severity of the violation of this assumption is unknown.

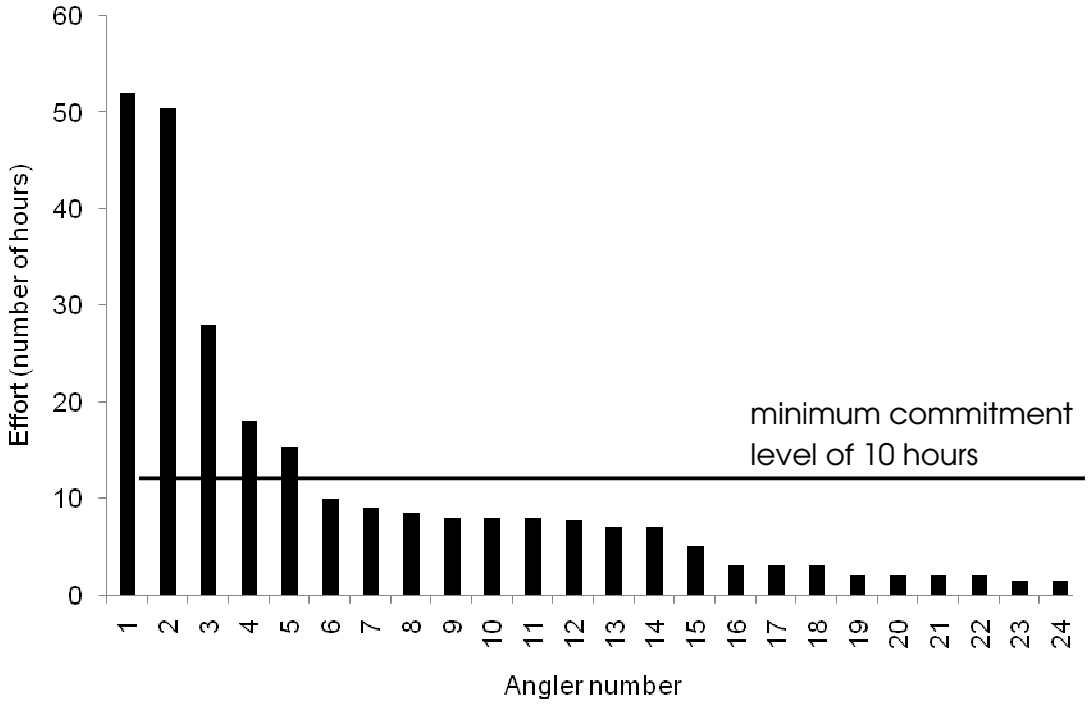

Figure 1: Distribution of effort among 24 anglers during St. Mary's River kelt experiment, 2009.

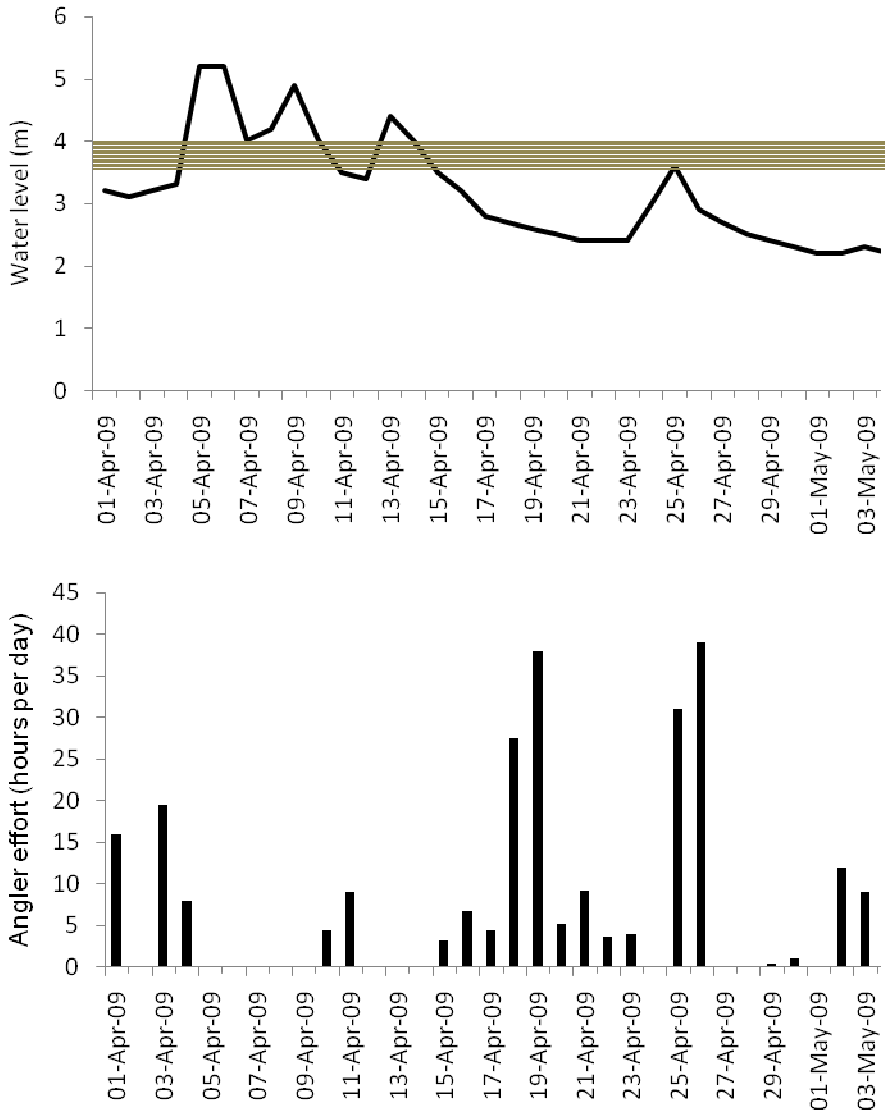

Figure 2: Distribution of water level as estimated from Water Survey of Canada data (upper panel) and angler effort (lower panel) between April 1 and May 3, 2009, during the period of the St. Mary's River 2009 kelt experiment. The gray shaded bar in the upper panel represents the approximate water level at which fishing efficiency becomes questionable, and above which the water level is too high to angle effectively.

Angler effort among the marking and recapture periods is indicated in Table 2. Overall, effort was higher than the target values on the West Branch, and lower than target values on the North and East Branches. Actual effort matched target effort for the Main Branch. Effort shifted from the East Branch to the Main Branch between the marking and recovery phases. There were difficulties fishing the upper reaches of the branches in early April due to presence of ice. This limited the ability to mark fish throughout the branches in order to understand distribution. This

may be a significant limitation in trying to understand distribution of salmon in the early spring in this system (*Recommendation #2*). Further, local anglers were more prone to fish where they believed would be best on the premise that they "*simply pick up their rod and head out for a couple of hours*". Being assigned areas was problematic for local anglers but not those travelling a distance to participate in the fishery. In future years the assignment of fishing locations to local anglers must increase in rigor (*Recommendation #3*).

Table 2: Effort and distribution of effort among branches, and among marking and recapture phases of the 2009 St. Mary's River kelt salmon experiment. (Target total effort for each branch in brackets).

	Marking period (April 1-23)	Recapture Period (April 24-May 4)	Total period (April 1-May 4)
Effort	158.25 hours	103.25 hours	261. 5 hours
	% of effort	% of effort	% of effort
West Branch	45.6	50.1	47.4 (35)
East Branch	36.2	8.2	25.1 (30)
North Branch	3	0	1.8 (10)
Main Branch	15.2	41.6	25.6 (25)

From this angler effort, 77 salmon kelts were captured (43 males, 29 females and 5 unsexed). Mean (± SD) fork length was 57.3 (±5.5) cm for males and 55.9 (±9.3) cm for females. Of these 77 captured fish, 5 were identified as Live Gene Bank released fish (201 live gene bank salmon released in Autumn, 2008), 68 identified as not being Live Gene Bank fish, and 4 either uncertain or this part of the form was not completed. Fifty nine fish had scale samples taken for ageing, and 60 salmon had samples taken for DNA. Sixty one percent of the total captures came from three pools (Harrisons, Silvers, and Mitchell's) (Figure 3). Sixty three of the 77 fish captured (81%) were angled in either the Main Branch or the lower 3.5 km of the West Branch (Archibald's Pool downstream), which prevents any inferences on distribution of salmon throughout the river, as they were caught in a relatively small area of the lower part of the river.

In addition to salmon, 28 brook trout were captured ranging in size from 22.9 to 39.0 cm fork length (mean 29.8 cm; SD 4.1).

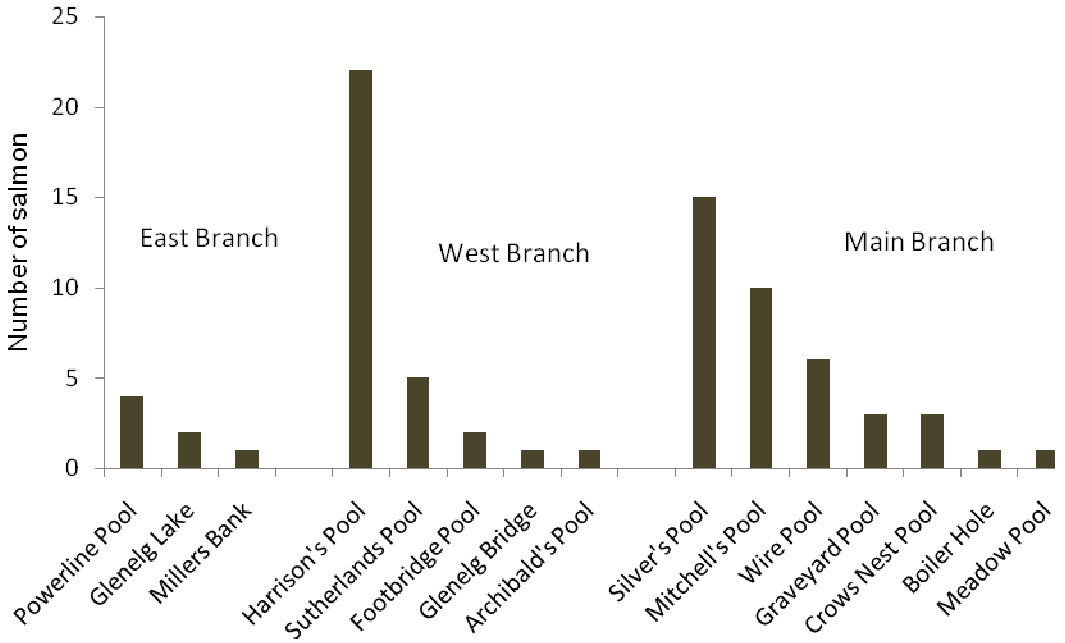

Figure 3: Distribution of salmon catch among branches during the period of the St. Mary's River 2009 kelt experiment.

Mean Catch per Unit Effort (CPUE) was 0.19 salmon per hour (SD = 0.39), ranging from 0 for 16 anglers to 1.25 and 1.43 for the two most successful anglers. The number of salmon caught increased after April 15 and plateaued after April 25 (Figure 4). This same period accounts for 74% of the total effort and so the catch is likely a reflection of increased effort during this period. The kelt are probably on their migration downstream at this point but the clear determination of downstream timing is confounded by the relatively great effort applied over these 10 days compared to the rest of the period. That is, it is not possible to determine if the increased catch was due to (i) kelt moving downstream and so being intercepted by anglers, or (ii) increased effort on a stationary population. Mean water temperature exceeded 8^{o}C about April 23rd (Figure 5). This temperatures is significant as at this temperature juvenile Atlantic salmon are known to shift behaviour from being active (at temperatures >8 ^{o}C) to less active (at <8 ^{o}C) (Rimmer et al, 1983) and an analogous fish species, the steelhead (*Oncorhynchus mykiss*), begins its spring spawning activity following overwintering at this temperature (Scott and Crossman, 1973). Similar information of spring temperature triggers for Atlantic salmon is not available, but if the spring behaviour of salmon is similar to steelhead, movement may be expected to be initiated in this range of temperatures. Due to the lack of marked fish from upstream sites, and incomplete documentation of recaptures (see below) it is not possible to estimate accurately timing of downstream migrants. Circumstantial evidence (water temperature, angling success) suggests it occurred between approximately April 15 and 25.

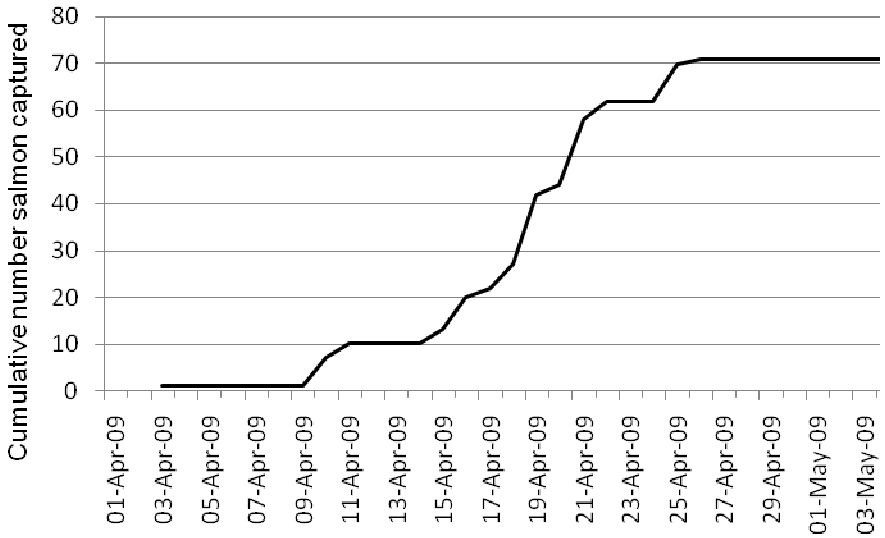

Figure 4: Cumulative number of salmon caught during the period of the St. Mary's River 2009 kelt experiment. Note the total number of salmon indicated here is 71; 6 other salmon were undated with respect to date of capture and so not included here.

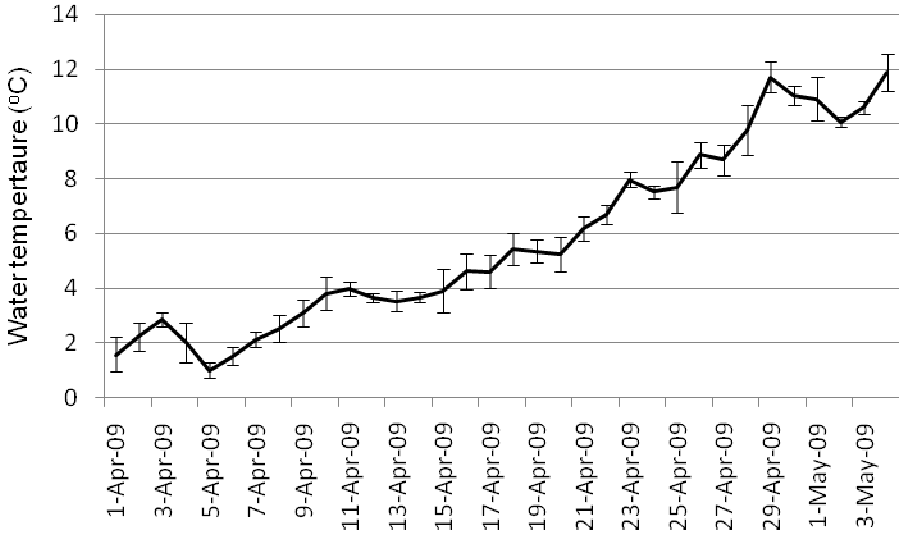

Figure 5: Mean daily water temperature of the St. Mary's River, as measured in the Main Branch approximately 500 m upstream of the Sherbrooke Bridge during the period of the 2009 kelt experiment. Error bars are SD.

Nine of the 77 captured salmon were released without being marked (3 of these were recaptures and released without being marked as such). Eight of the 77 salmon were reported as recaptures

and a further 8 were ambiguously recorded so it was not possible to determine if they were recaptures or not. Of the 8 salmon reported as recaptures, 1 was undated to date of capture and the other 7 were all captured before April 21 and so during the marking phase, not the recapture phase.

These ambiguities in first capture versus recapture for a significant number of fish (10%), and that all of the recaptures occurred during the marking phase (i.e., little opportunity provided for mixing), means that assumptions of the Petersen method were likely badly violated and so a resulting Petersen population estimate may not be reliable To derive a reliable Petersen estimate requires a clear, unambiguous estimate of (i) the number of fish marked (M), (ii) the total number captured in the recapture phase (C), and the number of marked fish recaptured during the recapture phase (R)[1]. Between April 1 and 23, the number of marked fish was 53. The recapture phase of April 24-May 4 resulted in 9 captures of unmarked fish, and 0 recaptures. A Petersen estimate would thus be 539 salmon in the population. Due to zero recaptures confidence intervals could not be calculated, as the number of recaptures must be non-zero to generate meaningful confidence intervals. I wish to emphasize that little confidence should be placed in this estimate due to suspected significant violations of at least two of the underlying assumptions (see below).

Limitations of the Petersen population estimate for this type of experiment included that marked fish were difficult to recognize as the mark (caudal punch) was the same as the mark used in the autumn seined fish as part of DFO's seining mark-recapture work on the West Branch. An unambiguous mark is required to improve effectiveness of this experiment (*Recommendation #4*). As well, several anglers expressed concern that the punches to the fins (caudal as well as dorsal and anal) resulted in torn fins. Several anglers reported catching fish with fins torn that appeared to have been initiated by a punch and then a large amount of tissue being torn out (possible as a result of spawning activity). I recommend that we move away from punches of fins to identify fish and instead use individually numbered identification tags (*Recommendation #4*).

Significantly, two fundamental assumptions of the Petersen method (that the population is closed and that each fish has an equal probability of capture) are violated in the current methodological approach as the fish emigrate over time (not a closed population) and not all areas are equally available for sampling due to ice cover or high water. Recommendation for improving this aspect of the experiment are provided in *Recommendations #5, #6 & #7*.

This experiment met two of the original four objectives, those of collecting biological information and estimating population size. Abundance estimates should be considered weak due to the lack of clearly discriminated marking versus recapture periods and ambiguous reporting of marking. The other two objectives, distribution of salmon and timing of kelt movement, could not be achieved. The distribution of salmon among branches could not be determined as high water in the early a part of the experiment prevented concerted angling effort

[1] Petersen population estimate formula is N = {((M+1) * (C+1))/ (R+1)} – 1 (Krebs, 1989), which in this case is {(54 * 10) /1} -1 = 539

throughout the watershed; the great majority of catches were in the lower reaches of the watershed. Due to the lack of unambiguous recaptures, timing of movement downstream was also not possible. Given that this was a pilot project to determine the feasibility, I believe that repeating the experiment in Spring 2010, ensuring close adherence to the seven following recommendations, will yield higher quality data and be useful to understand abundance of kelts in the St. Mary's River.

RECOMMENDATIONS

Recommendation #1: Having too many participants in the experiment is unwieldy and it is shown that only 6 of 45 registered anglers (14%) exerted a minimum of 10 hours of effort as requested for this to be successful. Therefore, I recommend that in future experiments a small number of committed anglers (<8) be used to ease coordination of the experiment, and reduce the expectation of large effort. A handful of committed anglers would be much more efficient and effective than a large number of interested people that do not fulfill the required 10 hour effort. Increased training of selected personnel is also required, emphasizing (i) the need to exert effort in a stratified manner rather than where they believe they will be successful, (ii) accurate and comprehensive note-taking, and (iii) identifying marks and tags on fish. A small number of anglers would facilitate such a more intensive training opportunity.

Recommendation #2: Early season angling is not a feasible method to determine salmon distribution throughout the watershed as ice cover or high water interferes with effective sampling. Use of telemetry is likely the most effective approach to understanding the spring distribution of these fish. Future kelt work should not use an angling approach to investigate distribution throughout the river.

Recommendation #3: More explicit training and instruction of anglers is required to ensure they understand the critical importance of representative distribution of effort rather than simply fishing to catch salmon. This may be assisted by following *Recommendation #6*, below.

Recommendation #4: To unambiguously mark the fish and be able to identify individuals, I suggest we stop using hole punching of fins and instead start using individually numbered tags (e.g., Carlin, Spaghetti, or opercular tags). I am concerned that the punching method not only prevents unambiguous identification but also may result in significantly damaged fins to the fish, which may subsequently affect survival (particularly when the caudal fin is significantly damaged).. I recommend that in 2010 we use external tags rather than punches

Recommendation #5: To more closely approximate the required Petersen assumption of a closed population, I recommend future kelt experiments be confined to a very short (2-4 day) intensive tagging period, followed by a period for mixing, and a second very short (2-4 day) recapture period. If this is done prior to the kelts emigrating, the assumption of a closed population should be met.

Recommendation # 6: To more closely approximate the required Petersen assumption of each fish having an equal chance of being captured, I recommend future kelt experiments be confined to a only the lower portions of the river. That is, confined to the Main Branch, the East Branch up to McKeens Brook, and the West Branch to Archibald's Pool (Hattie Road area). If this is coupled to *Recommendations #1 & #5* this should ensure tagging and recapture of a stationary population in which the assumption of equal capture probability is more closely met.

Recommendation # 7: To estimate the approximate number of fish required to be tagged, and the number to be examined for tags, in future studies, for a given level of accuracy, I present below results from Krebs (1989). These should be used to estimate the required effort to carry out the experiment. Choice of whether or not the experiment should proceed can be based on the likelihood of catching the required number of fish.

Recommended sample sizes to meet three levels of accuracy assuming three different population sizes of kelts (Derived from Krebs, 1989).

	Accuracy ± 10%		Accuracy ± 25%		Accuracy ± 50%	
Estimated population size	Required number marked (M)	Required number examined (C)	Required number marked (M)	Required number examined (C)	Required number marked (M)	Required number examined (C)
500 salmon kelts	300	200	200	100	100	80
1000 salmon kelts	500	300	200	200	200	100
2000 salmon kelts	700	600	300	200	300	150

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