HILL CREEK SPAWNING CHANNEL

KOKANEE FRY PRODUCTION-2006

Prepared
by

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EXECUTIVE SUMMARY

Hill Creek Spawning Channel (HCSC) was built as partial compensation for fish losses as a result of the construction and development of hydro-electric dams on the upper Columbia River. The HCSC compensation provides enhanced spawning habitat with controlled flow and increased survival rates for kokanee (*Oncorhynchus nerka*), a keystone species within Arrow Lakes Reservoir (ALR). The channel also provides important spawning and rearing habitat for adfluvial rainbow trout (*Oncorhynchus mykiss*). HCSC provides an important component of fry production for Arrow Lakes Reservoir and contributes to restoring kokanee abundance to historic pre-impoundment levels.

Based on the 2005 kokanee brood year, total deposition was calculated to be 12,986,880 eggs deposited in the channel. Production was estimated at 4,660,360 fry emigrating from HCSC in 2006. Subsequent kokanee egg-to-fry survival was estimated to be 35.9% in 2006 which was appreciably higher than 2.8% in 2005 and close to the long term average. The peak of the fry out-migration occurred on May 15th and 16th when > 800,000 fry emigrated from the channel nightly.

In summary, 2006 fry production at the HCSC indicated that the channel had recovered from the 2004 and 2005 production problems. Increased monitoring and maintenance probably contributed to the improved conditions for kokanee egg deposition, incubation and subsequent fry emigration at HCSC in 2006.

Keywords

Hill Creek Spawning Channel, Arrow Lakes Reservoir, kokanee, egg-to-fry survival, fry enumeration, migration, production.

ACKNOWLEDGEMENTS

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The Fish and Wildlife Compensation Program (FWCP) is a joint initiative between BC Hydro, the Ministry of Environment and Fisheries & Oceans Canada to conserve and enhance fish and wildlife populations affected by the construction of BC Hydro dams in Canada's portion of the Columbia Basin.

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INTRODUCTION

Hill Creek Spawning Channel (HCSC) was built as partial compensation for the construction and development of hydro-electric dams on the upper Columbia River. Similar to other fish species in British Columbia, kokanee (*Oncorhynchus nerka*) and their habitat have been adversely impacted over the last century by human activities such as logging, urbanization, hydro dams, mining, etc. (Northcote 1973; Ashley et al. 1997, Pieters et al. 2003). HCSC was built as a restorative initiative to compensate for fish losses, primarily kokanee and rainbow trout (*Oncorhynchus mykiss*), incurred from construction of the Revelstoke Dam. The goal of the HCSC operation is to increase kokanee abundance in Arrow Lakes Reservoir (ALR), to historic pre-impoundment levels, through enhanced spawning habitat and increased egg-to-fry survival.

The HCSC is operated and funded by the Fish and Wildlife Compensation Program (FWCP) which is a joint initiative between BC Hydro, the Ministry of Environment (MOE), and the Department of Fisheries & Oceans Canada (DFO). The program's goal is to conserve and enhance fish and wildlife populations affected by BC Hydro dams in the Canadian portion of the Columbia Basin. This report summarizes the 2006 spring fry production estimate and provides recommendations for further assessment and monitoring at HCSC.

The objectives are as follows:

- Estimate fry escapement
- Estimate egg to fry survival
- Compare historical trends to present
- Determine channel performance

BACKGROUND

Construction of the HCSC commenced in the fall of 1979 and was completed in the late fall of 1980 (Lindsay 1982). The objectives of the channel were to restore and enhance kokanee and rainbow trout production lost as a result of dam construction. The channel was designed to produce an adult return of 0.5 million kokanee and ~500 adult rainbow trout. Additional losses of bull trout and large "trophy" rainbow trout would be compensated through hatchery production (Martin 1976, M.S.).

Historically, Hill Creek supported an annual spawning run of approximately 10,000 kokanee (Lindsay 1982). After construction, kokanee initially used the HCSC starting in 1984. To date, the production target of 0.5 million returning spawning kokanee has never been met. However, from a background level of about 10,000 spawners, escapements expanded to a high of 323,000 in 1989. Unexpectedly, escapements in the 1990s dwindled to less than 50,000 due to in-lake survival problems as a result of declining lake productivity. Additionally, for four years (1991 to 1994) the number (75,000) were deliberately held low thus reducing fry production in an experiment to increase adult size through an anticipated density-dependent response in Arrow Lakes Reservoir (B. Lindsay, Nelson Fisheries, pers. comm.).

HCSC escapements declined in the early 1990s as a result of nutrient abatement in Arrow Lakes Reservoir. Proposed lake fertilization in the vicinity of Hill Creek was expected to improve in-lake survival rates similar to what has occurred in the northern portion of Kootenay Lake (Ashley et al. 1997). By the mid 1990s, it was clear the escapement target of 0.5M adults could not be achieved without improvement to in-lake survival that could only be altered through lake fertilization.

In some instances, loss of spawning habitat due to various impacts have left fisheries managers with little choice but to restore wild kokanee populations by constructing semi-natural spawning channels. In all, there are six spawning channels in BC’s southern interior. These include the Meadow, Redfish and Kokanee Creek channels on Kootenay Lake; the Bridge and Hill Creek channels on Arrow Lakes Reservoir; and Mission Creek on Okanagan Lake (Redfish Consulting Ltd. 1999).

The HCSC has performed very well since 1984 with an average egg-to-fry survival rate averaging >35%. However, two extremely low production years were observed in 2004 and 2005 at the HCSC. A variety of variables were investigated as detailed and discussed in Porto (2006abc) and Manson (2005ab), however, it is believed that the most likely causal factor was record-setting rainfalls and increased silt loading shortly after egg deposition in those years (Porto 2006a; Steve Arndt, FWCP Fisheries Biologist, pers. comm.).

SITE DESCRIPTION

The HCSC is located approximately 53 km north of Nakusp and runs adjacent to Hill Creek, a tributary to the north end of Upper Arrow Lake Reservoir (Figure 1). The Hill Creek watershed is ~14.4 km long and has a drainage area of 26 km^2. The spawning channel is 3.2 km long and 6.1 m wide with an overall grade of 0.15 % (Lindsay 1982). Importantly, a backup water supply is utilized from nearby MacKenzie Creek, via a 2.4 km pipeline with a capacity of 0.28 cubic meters per second, to circumvent concerns of low seasonal water flows in Hill Creek. HCSC contains spawning gravel for kokanee (15,200 m^2) and rainbow trout (750 m^2). The initial 30.5 m section of the channel consists of a settling pond to collect fines. The channel is composed of 54 gravel riffles divided by resting pools. The gravel used in the kokanee spawning section ranges from 6 to 38 mm in diameter with a depth of 0.41 m, whereas in the rainbow trout section gravel ranges in size from 6 to 51 mm in diameter with a depth of 0.6 m.

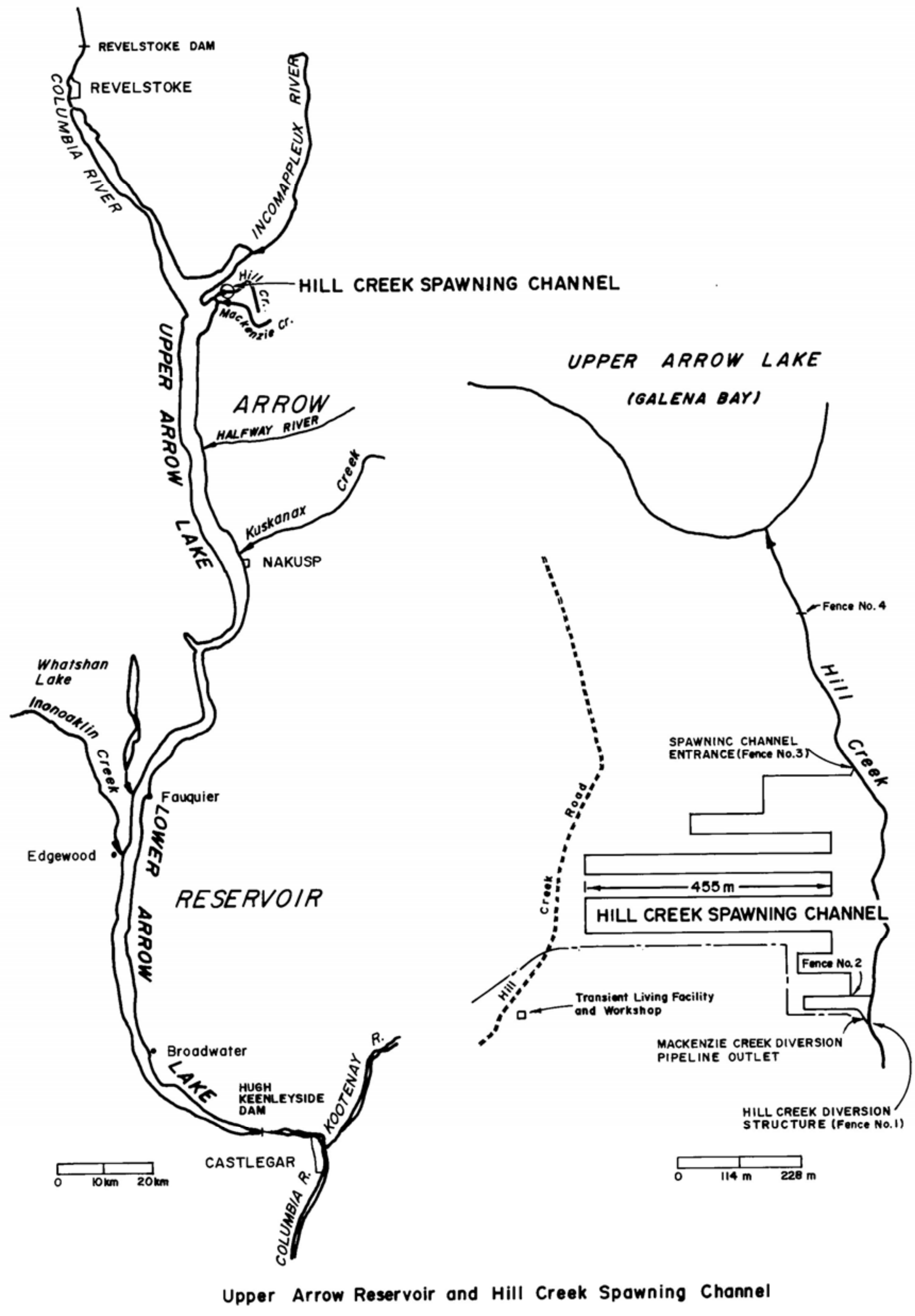


Figure 1. Location of Hill Creek Spawning Channel and stream outlet to upper Arrow Lakes Reservoir.

METHODS

Temperature and Discharge

Temperature (°C) and discharge (m^3/s) were monitored during the spring fry out-migration as part of HCSC operations.

Daily temperatures were recorded using Onset StowAway™ Tidbit™ data loggers installed at the Hatchery Fence and Fence # 2 (for location see Appendix A). Loggers at the Hatchery Fence and Fence # 2 were set to record temperatures every 1.5 hr and 1 hr, respectively, from April 20th to June 15th during the fry migration. Additionally, temperature was recorded from a handheld thermometer during fry sampling at the Hatchery Fence.

Channel flows were monitored by gauge height readings at Fence 2 in HCSC. Water depth data was also recorded from a gauge installed at the Hatchery Fence during fry sampling. Channel discharge at HCSC is calculated from gauge height (cm) at Fence # 2 using the equation:

$$\text{Discharge } (m^3/s) = 0.1545\, e^{9.4169 \text{ (gauge-height (meters))}}$$

Fry Sampling

During the annual fry emergence period, approximately 25 to 35 nights are sampled. Initial sampling in early spring is conducted every six to seven nights and increases proportionally depending on the number of fry captured. The sampling frequency during peak periods increases to every night, or every other night. Sampling is generally conducted every half hour between 1900 hours and 0200 hours as it was previously determined that 91.5% of the fry emigration occurred during this period (Thorp 1987, Manson 2005a).

Three marquisette nets attached to steel frames of known dimensions are lowered into the channel at predetermined locations along the upstream side of the lower enumeration fence (Photo 1). Sample nets are positioned evenly with one at the midway point of the walkway and the remaining two approximately one third of the way along each end of the walkway. Each of the three nets is sampled simultaneously on the hour and half hour during the out-migration period for 10, 5, 2, or 1 minute intervals and the fry captured are enumerated and recorded. The duration of sampling period is adjusted based on the numbers of fry netted and/or the amount of debris present. The more fry captured the shorter the time nets need to be left in the water. Data including date, time, water depth, water temperature and weather conditions are recorded on data collection sheets (Appendix B).

Photo credit: B. Barney 2004

Photo 1. Example of a marquisette net lowered into channel at the Hatchery Fence for fry sampling.

A small sample of kokanee fry were collected periodically from sampling during the 2006 out-migration. General condition of the fry and their length, measured to the nearest millimeter, were recorded before release (Barney 2006).

Fry Calculation and Estimates

The sample nets were 15 cm wide and sampled from the bottom to the top of the water column. The number of fry leaving the channel during each 30 minute period between 1900 and 0200 was totaled. A standard correction factor of 100/91.5 was applied to the nightly estimate to account for fry leaving after sampling terminates. MS Excel was used to calculate total fry emigration for each night sampled and to extrapolate estimates for nights that were not sampled from April 9th to June 14 inclusive.

The catch from the 3 nets per unit time was expanded to estimate the number of fry passing the sampling location in a 30 minute time interval using the following formula:

$$N = n \times W/w \times T/t$$

where N = estimated number of fry leaving channel in 30 minutes:

n = number of fry caught
W = total width of channel (610 cm)
w = width of 3 nets (3 x 15 = 45 cm)
T = time interval (30 minutes)

t = wetted net time (from 1 to10 minutes)

Near the beginning of the emigration period (May 4), it was noticed that some fry were able to pass through the sample nets. This problem was corrected immediately by switching to finer mesh netting, and fry estimates for the few days prior to May 4 were doubled to account for fry passing through the nets. Further details are provided by Arndt (2006) in Appendix C.

RESULTS

Temperature and Discharge

The spring temperature data recorded from loggers indicated a significant (t-Test, $p<0.05$) thermal regime difference between the upper and lower portion of HCSC (Fig 2). The downstream Hatchery Fence recorder consistently demonstrated higher mean daily temperatures compared to Fence # 2 temperatures (Table 1). Daytime heating of water through the length of the channel most likely accounts for the difference in temperature since most of the channel has little instream cover. Large diurnal variation in temperature was also evident from maximum and minimum temperatures at both locations.

Table 1. Temperature profiles (^{o}C) at HCSC April 20 to June 15, 2006.

Location	Mean	StdDev	Max	Min
Fence # 2	6.25	1.10	9.34	3.62
Hatchery Fence	7.40	2.07	14.10	3.30

HCSC channel discharge, measured from gauge height at Fence #2, averaged 0.46 m^3/s (± 0.01 SE) during the fry migration (Fig 2). Maximum discharge of 0.63 m^3/s was recorded on May 16th while minimum flows of 0.36 m^3/s were recorded on June 15th, the last day of fry sampling.

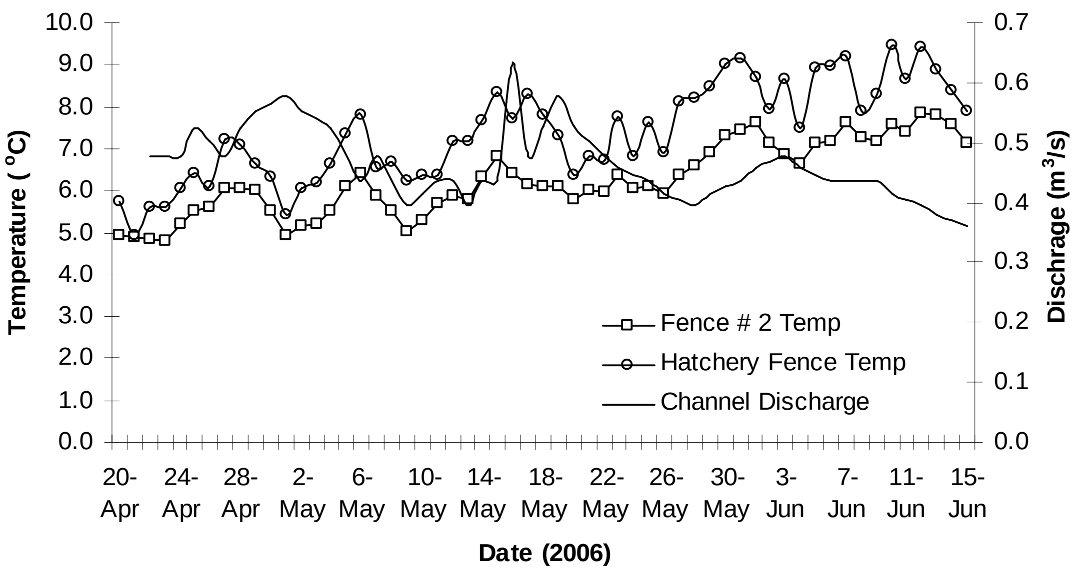


Figure 2 HCSC mean daily temperature and mean daily discharge data from April 20 to June 15, 2006.

Fry Estimates

In 2006, it was estimated that a total of 4,660,360 fry emigrated from the channel. Sampling was conducted for 26 nights from April 22 to June 15, 2006. The peak of the fry out-migration, following a trend of warming water temperatures, occurred on May 15th and 16th where > 800,000 fry emigrated from the channel each night (Fig 3).

Although flows are controlled within HCSC, peak migration of 887,902 fry coincided with peak discharge of 0.63 m^3/s on May 16th. (Fig. 4) Exceedingly high flows resulting from natural spring freshet conditions were experienced on May 16th and 17th during the fry migration. It is presumed that increasing temperature, flows, and turbidity are the cues responsible for the large fry out-migrations.

Based on the 2005 kokanee brood year, total egg deposition in the channel was calculated to be 12,986,880 eggs (Porto 2006b). Importantly, egg-to-fry survival was estimated to be 35.9% in 2006 which was appreciably higher than 2.8% in 2005 and 0.8% in 2004 (Fig 5).

A small sample (n=44) of biological data was collected on kokanee fry six nights from May 6th to May 31st. Mean length was 25.1 mm with a range from 24.0 mm to 27.0 mm

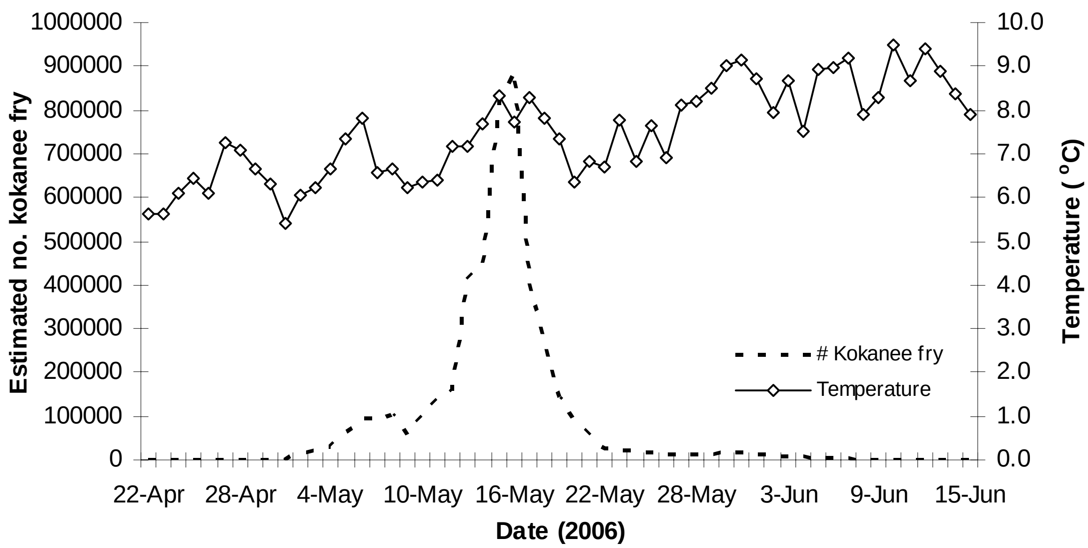


Figure 3. Daily kokanee fry migrants and Hatchery Fence mean daily temperatures.

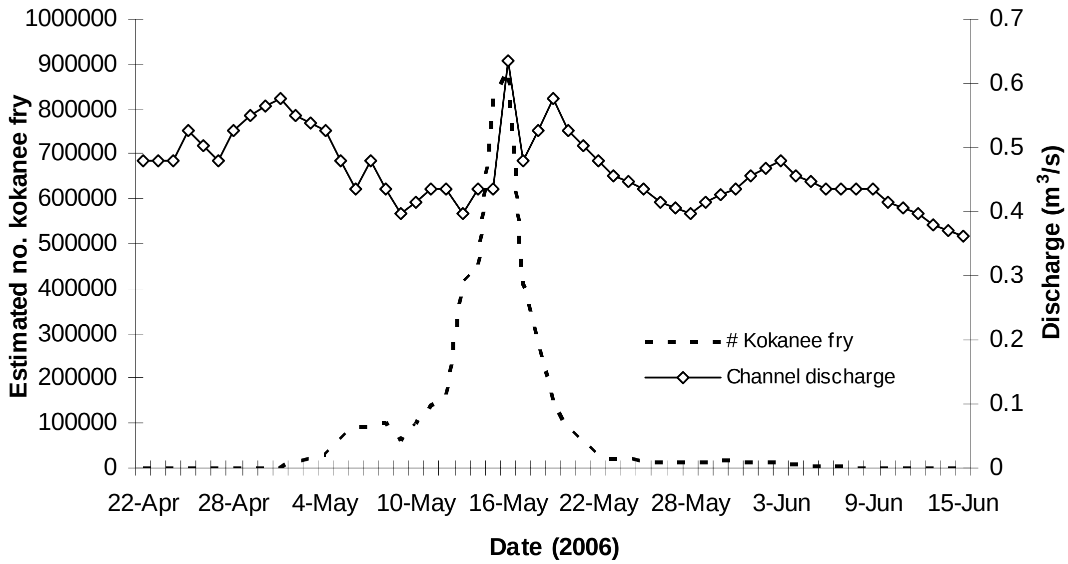


Figure 4. Daily kokanee fry migrants and daily channel discharge (m^3/s) monitored from gauge height at Fence # 2.

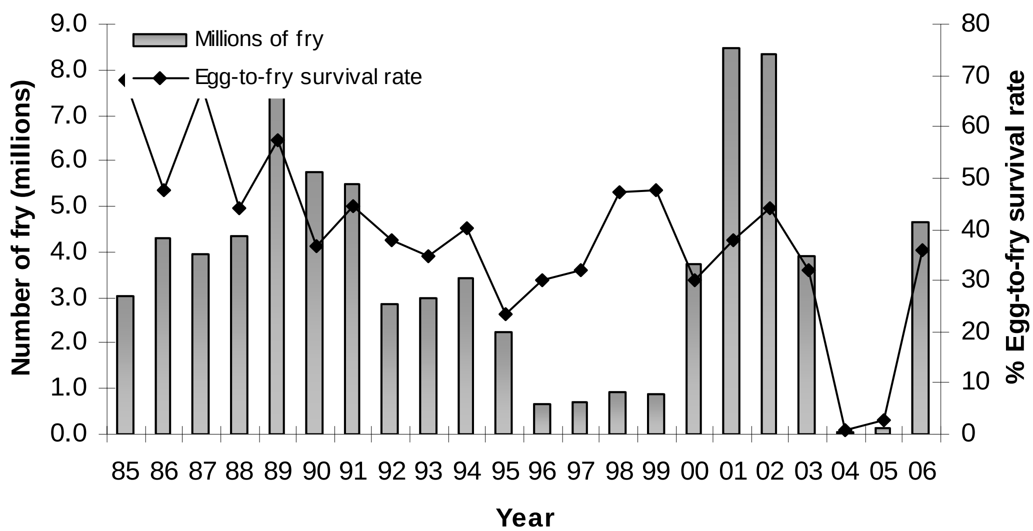


Figure 5. Estimated egg-to fry survival and fry production for HCSC from 1985 to 2006.

DISCUSSION

HCSC operations have proven to have substantially increased kokanee abundance in Arrow Lakes Reservoir. High fry production has been achieved through enhanced spawning habitat, controlled flows, and increased egg-to-fry survival. The channel has performed exceptionally well, providing egg-to-fry survival averaging >30% since 1985 (Redfish Consulting Ltd. 1999, MOE data file). However, cumulative impacts of impoundment of Arrow Lakes Reservoir by upstream and downstream dams, resulting from nutrient abatement (Pieters et al. 2003), have limited much of the production benefits from HCSC. Notwithstanding, HCSC does provide an important component of total kokanee production in Arrow Lakes Reservoir (Andrusak 2005). Restoring pre-impoundment kokanee numbers should be expected from the combined production from HCSC with increased in-lake productivity resulting from lake fertilization.

Fry production exceeded 4.6 million in 2006 based on an egg-to-fry survival of ~36%. Comparatively, excluding production problems in 2004 and 2005 (see Porto 2006a), 2006 observed a ~19% increase in fry production in 2006 compared to the 20 year average of 3.9 million fry (Fig 5). The 2006 egg-to-fry survival exceeded 35% but was still below the 20 year average of ~42% since 1984, excluding production failures in 2004 and 2005. These estimated survival rates for HCSC are comparable to other kokanee channels throughout British Columbia (Redfish Consulting Ltd. 1999). Meadow Creek spawning channel, a major source of kokanee production for Kootenay Lake, has achieved egg-to-fry survivals consistently >30% for the comparable time period.

Since 1995, it is estimated that >30% of the total fry production in ALR comes from HCSC (Fig. 6). Fry production was highest in 2001 (15.8 million) and 2002 (18.3 million) for both HCSC and ALR tributaries combined (MOE data file). Furthermore, benefits from increased in-lake survival due to lake fertilization, notwithstanding density dependent responses, should facilitate maintenance of kokanee abundance in ALR in the future.

Kokanee spawning channels provide enhanced spawning habitat which results in higher egg-to-fry survival compared with the natural streams. However, the primary objective of most of these kokanee channels is to provide maximum production to increase overall kokanee abundance to their nursery lakes (Redfish Consulting Ltd 1999). Seemingly, the fry production capacity at HCSC has not yet been fully utilized, as indicated by no density-dependent response from increasing egg deposition on egg-to-fry survival (Fig 7). For example, fry production in 2001 and 2002 exceeded 8.0 million fry when the largest numbers of spawners were in the channel demonstrating little effects of redd superimposition. Therefore, it might be possible to increase fry production from HCSC beyond the 2001 and 2002 levels by permitting a higher number of spawners into the channel. However, egg-to-fry survival is only one aspect of kokanee production in the ecosystem. Fry-to-adult survival and growth rate in the reservoir are other important aspects that should be considered when setting spawning channel targets. Potential density-dependent impacts of spawning channel fry on spawning populations from other tributaries during the reservoir phase should also be taken into consideration.

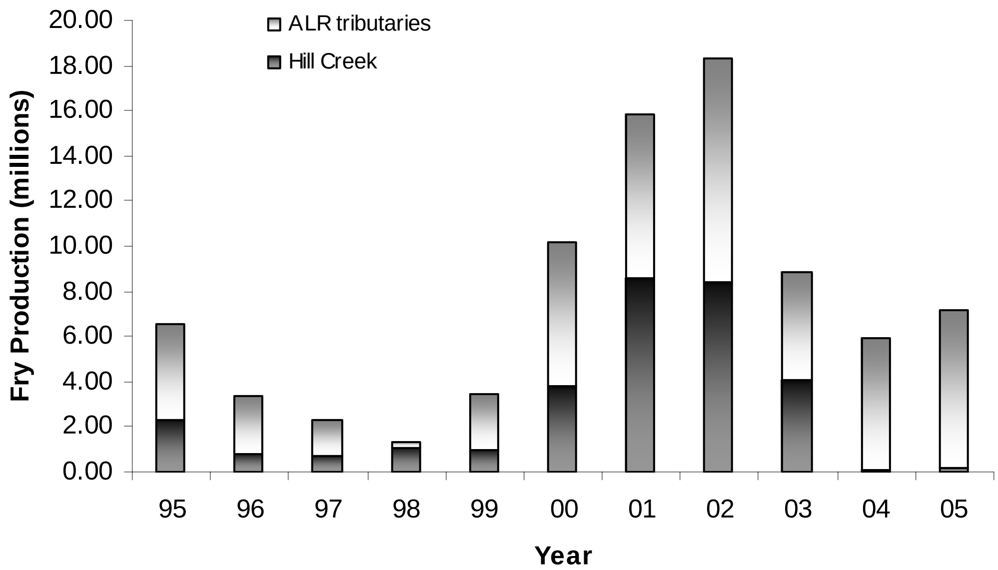


Figure 6. HCSC and ALR tributary fry production from 1993 to 2004.

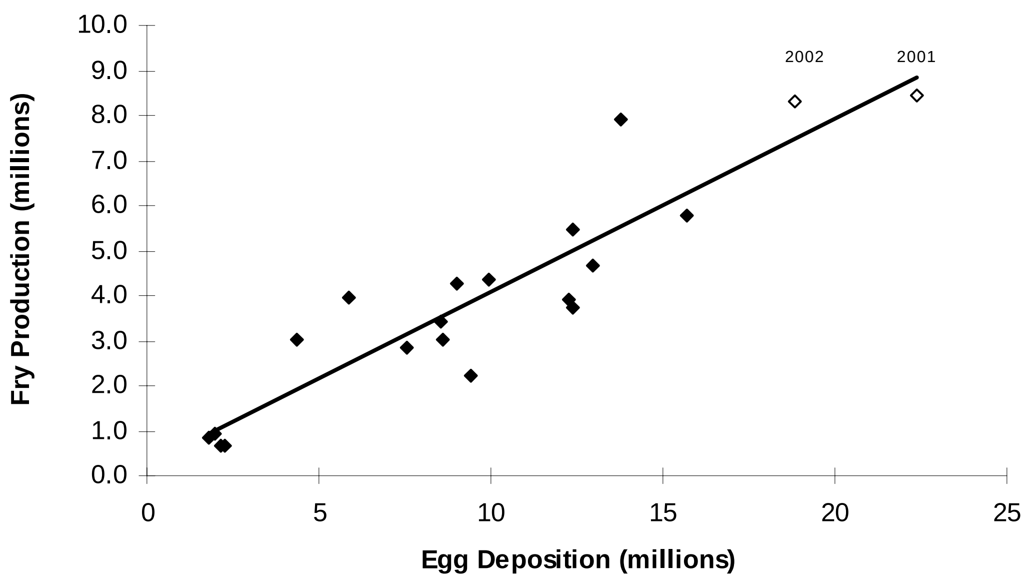


Figure 7. Linear relationship between fall egg deposition and subsequent spring fry recruitment.

In summary, operations at HCSC in 2006 indicate that the channel has recovered from the production problems in 2004 and 2005. Increased monitoring and maintenance, funded by FWCP, provided good conditions for kokanee egg deposition, incubation and subsequent fry emigration at HCSC. Moreover, Meadow Creek spawning channel which has been operating since the 1970s offers valuable insight to related production problems, operations and modifications (Les Fleck pers comm.). From past recommendations, increasing the settling pond size while managing flows to reduce sediment deposition during critical periods should result in continued high fry production at HCSC.

RECOMMENDATIONS

- monitor dissolved oxygen underneath the gravel surface during the egg incubation period using the same methods as 2005/06 to determine whether levels are sufficient for fry development

- monitor egg and alevin survival over the incubation period by hydraulic sampling as in 2005/06, at 4 cells going from the upstream to downstream end with minimum 2 samples per cell

- monitor temperature during the incubation period and determine accumulated temperature units (ATUs) in March to estimate timing of fry emergence

- ensure that channel is checked daily during high rainfall periods so that flows from Hill and McKenzie Creeks can be manipulated to minimize sediment inputs to the spawning channel

REFERENCES

Andrusak, H. 2005. The Strategic Importance of Hill Creek to Fisheries Management on the Arrow Lakes Reservoir. Contract report written for the Department of Fisheries and Oceans (DFO) Nelson BC. November 2005. 16 pp

Arndt, S. 2006. Summary and Analysis of Data Relating to Kokanee Fry Passing Through Sampling Nets at Hill Creek Spawning Channel in 2004 and 2005. Internal briefing note prepared for Columbia Basin Fish & Wildlife Compensation Program. Appendix C, this report.

Ashley, Ken, Lisa C. Thompson, David C. Lasenby, Laurie McEachern, Karen E. Smokorowski and Dale Sebastian. 1997. Restoration of an Interior Lake Ecosystem: the Kootenay Lake Fertilization Experiment. Water Qual. Res. J. Canada, 1997 Volume 32 No. 295-323.

Barney, B. 2006. Hill Creek Spawning Channel – 2005/2006 Annual Summary of Work Report. Prepared for Columbia Basin Fish & Wildlife Compensation Program. Nelson, BC. 17 pp. + 7 App.

Lindsay, R. A. 1982. Physical & biological criteria used in the design of the Hill Creek Spawning Channel. Prepared for the Kootenay Region Fish and Wildlife Branch, Nelson. 25 pp.

Manson, H. 2005a. Hill Creek Spawning Channel Kokanee Fry Enumeration Report – 2004. Columbia Basin Fish & Wildlife Compensation Program. Nelson, BC. November 2004. 13 pp. + 3 App.

Manson, H. 2005b. Hill Creek Spawning Channel Scarification Impact Assessment – 2004. Columbia Basin Fish & Wildlife Compensation Program. Nelson, BC. April 2005. 26 pp. + 4 App.

Martin, A. D., 1976. Interim report of investigations of fish populations that will be affected by the Revelstoke 1880 Dam. MS, Fish and Wildlife Branch, Nelson, BC.48pp.

Northcote, T.G. 1973. Some Impacts of Man on Kootenay Lake and Its Salmonids. Great Lakes Fisheries Commission Tech. Rep. 25.

Pieters, R., Vidmanic, l., Harris, S., Stockner, J., Andrusak, H., Young, M., Ashley, K., Lindsay, B., Lawrence, G., Hall, K., Eskooch, A., Sebastian, D., Scholten, G., Woodruff, P. 2003. Arrow Reservoir Fertilization Experiment Year 3 (2001/2002) Report. M.S., Fisheries Project Report No. RD 103, Province of British Columbia, Ministry of Water, Land and Air Protection.

Porto, L. 2006a. Hill Creek Spawning Channel Scarification & Sediment Related Monitoring Activities – 2005. Columbia Basin Fish & Wildlife Compensation Program. Nelson, BC. March 2006. 19 pp. + 3 App.

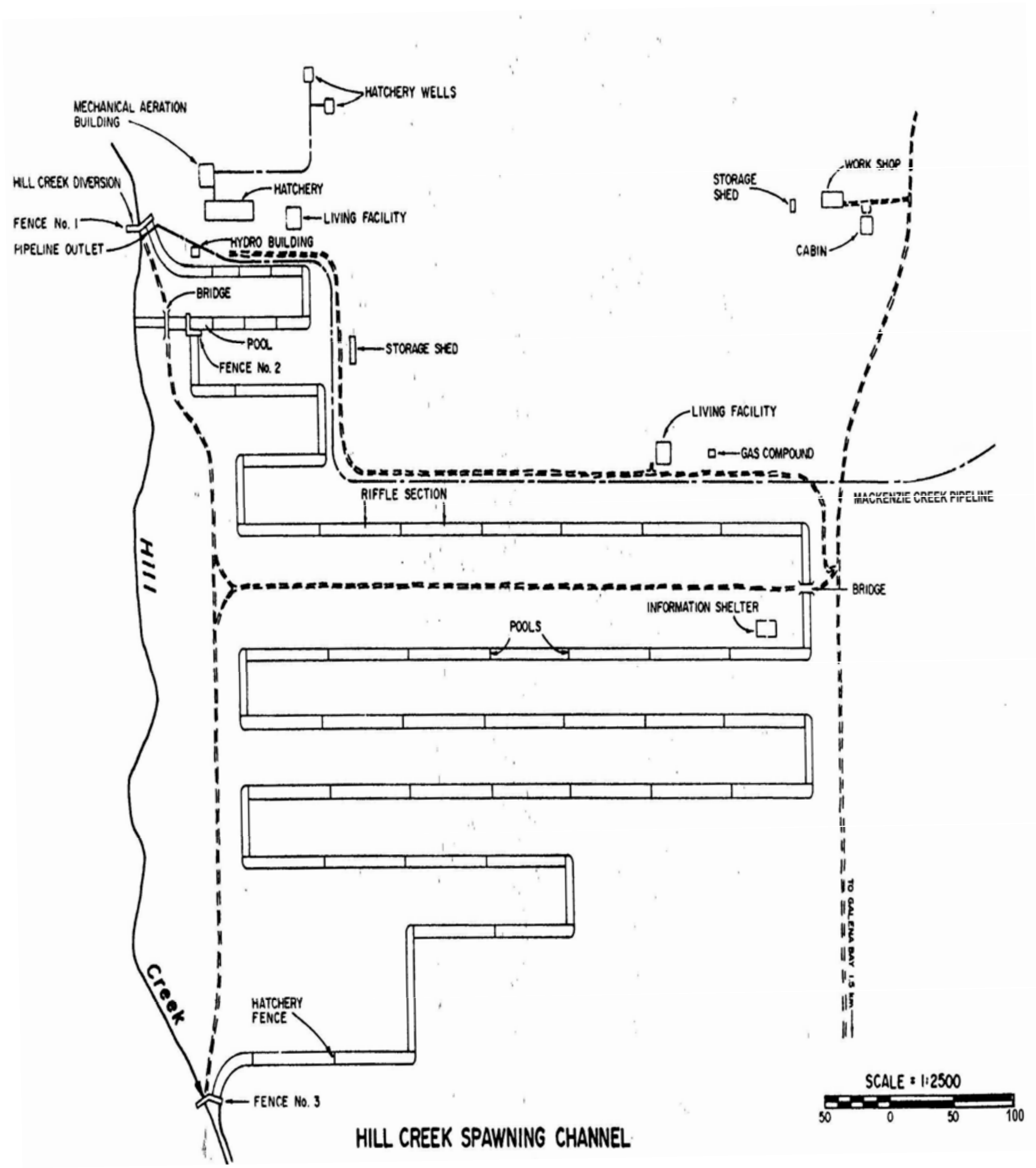
Porto, L. 2006b. Hill Creek Spawning Channel Adult Kokanee Enumeration – 2005. Columbia Basin Fish & Wildlife Compensation Program. Nelson, BC. January 2005. 13 pp. + 3 App.

Porto, L. 2006c. Hill Creek Spawning Channel Kokanee Fry Escapement – 2006. Columbia Basin Fish & Wildlife Compensation Program. Nelson, BC. January 2005. 36 pp.+ 4App.

Redfish Consulting Ltd. 1999. Performance evaluation of six kokanee spawning channels in British Columbia. Unpubl. MS. Ministry of Fisheries, Province of British Columbia Victoria BC.

Thorp, G., 1987. Hill Creek Spawning Channel kokanee fry enumeration, spring 1987. MS Fisheries Branch, Nelson, BC. Report No. KO-22, 18 pp.

APPENDIX A: SCHEMATIC OF HILL CREEK SPAWNING CHANNEL



Schematic of Hill Creek Spawning Channel, completed in 1980 and operational by 1984

APPENDIX B: 2006 KOKANEE FRY ENUMERATION DATA

Date	Sampled	No. Fry Caught[1]	Estimated Daily total No. of fry[2]	Cumulative Total	Water Temperature[3] (°C)	Water Depth[4] (cm)
22-Apr-05	yes	4	354	354	5	10
23-Apr-05	no	-	620	974	-	-
24-Apr-05	no	-	753	1,727	-	-
25-Apr-05	yes	10	886	2,613	6	11
26-Apr-05	no	-	1,682	4,295	-	-
27-Apr-05	no	-	2,080	6,375	-	-
28-Apr-05	yes	28	2,478	8,853	7	10
29-Apr-05	no		2,832	11,685	-	-
30-Apr-05	no	-	3,009	14,694	-	-
1-May-05	yes	136	3,186	17,880	5	12
2-May-05	no	-	16,465	34,345	-	-
3-May-05	no	-	23,105	57,450	-	-
4-May-05	yes	362	29,744	87,194	7	10.5
5-May-05	no	-	61,517	148,711	-	-
6-May-05	yes	542	93,290	242,001	6.5	9.5
7-May-05	yes	455	94,028	336,029	6.5	9.5
8-May-05	yes	406	102,467	438,497	6	8.5
9-May-05	yes	555	57,718	496,215	6	8
10-May-05	no	-	97,820	594,034	-	-
11-May-05	yes	569	137,921	731,956	6.5	9
12-May-05	yes	642	156,866	888,821	6	8
13-May-05	yes	806	411,551	1,300,372	6.5	8
14-May-05	yes	865	445,810	1,746,182	7.5	9
15-May-05	yes	1,060	820,977	2,567,159	8	10
16-May-05	yes	1,141	887,902	3,455,061	8.5	11
17-May-05	yes	817	407,567	3,862,628	8	8.5
18-May-05	no	-	274,714	4,137,342	-	-
19-May-05	yes	577	141,861	4,279,202	7	12
20-May-05	no	-	84,873	4,364,075	-	-
21-May-05	no	-	56,379	4,420,454	-	-
22-May-05	yes	352	27,885	4,448,339	6.5	10
23-May-05	no	-	22,242	4,470,581	-	-
24-May-05	no	-	19,420	4,490,000	-	-
25-May-05	yes	375	16,598	4,506,598	7	9
26-May-05	no	-	14,540	4,521,138	-	-
27-May-05	no	-	13,511	4,534,649	-	-
28-May-05	yes	282	12,482	4,547,131	7.5	8
29-May-05	no	-	14,319	4,561,450	-	-
30-May-05	no	-	15,238	4,576,688	-	-
31-May-05	yes	365	16,156	4,592,844	8.5	9
1-Jun-05	no	-	13,417	4,606,260	-	-
2-Jun-05	no	-	12,047	4,618,307	-	-
3-Jun-05	yes	241	10,677	4,628,984	7	10
4-Jun-05	no	-	7,264	4,636,248	-	-
5-Jun-05	no	-	5,558	4,641,806	-	-
6-Jun-05	yes	87	3,851	4,645,657	8	9
7-Jun-05	no	-	2,590	4,648,246	-	-
8-Jun-05	no	-	1,959	4,650,205	-	-
9-Jun-05	yes	30	1,328	4,651,533	8	8
10-Jun-05	no	-	1,638	4,653,171	-	-
11-Jun-05	no	-	1,793	4,654,964	-	-
12-Jun-05	yes	44	1,948	4,656,912	9	8
13-Jun-05	no	-	1,417	4,658,328	-	-
14-Jun-05	no	-	1,151	4,659,479	-	-
15-Jun-05	yes	20	885	4,660,364	8	9
Totals			***4,660,364***	***4,660,364***		

[1] Actual total number of fry caught per night. These numbers do not extrapolate directly to the daily total, since sampled net time intervals were not always the same. For actual time intervals see Barney (2006).
[2] Catch estimates prior to May 4 were doubled to account for fry passing through the nets. See Appendix C for explanation.
[3] Water temperatures taken using hand-held thermometer.
[4] Water depths taken at Hatchery Fence depth gauge.

APPENDIX C. FRY NET EFFECIENCY.

Summary and Analysis of Data Relating to Kokanee Fry Passing Through Sampling Nets at Hill Creek Spawning Channel in 2004 and 2005

By Steve Arndt, FWCP Fisheries Biologist
December 11, 2006

Introduction and Background:

Fry production is estimated at Hill Creek Spawning Channel by placing 15 cm (wide) by 30 cm nets into the flow at the lower end of the channel to capture downstream moving fry during the spring emigration period. The number of fry emigrating in a given night is extrapolated from the number of fry captured in the sample nets, taking into account the duration that the net was in the channel (see main body of report for further explanation). The sampling duration that the net is left in the channel is shortened as the number of emigrating fry increases to reduce the number of fry handled and time spent counting.

In 2004, the netting found on the fry nets in the sampling shack appeared worn, and was replaced with new netting found in the storage shed at the spawning channel. This new netting was already sized and stitched to fit onto the frames of the fry nets. The mesh size of the new netting was identical to the old netting (2 mm maximum un-stretched, or 3 mm maximum stretched), but the newer mesh was made of a slightly more flexible material than the old.

This new 2 mm netting was used for the fry sampling in 2004 and 2005. Catch rates were extremely low in those years mainly due to very poor egg-to-fry survival; consequently, few fry were captured in the nets, and there was little opportunity to notice a problem. In 2006, fry output was dramatically higher and the channel operator, Brian Barney, noticed almost immediately (May 4) that some fry were able to wriggle through the mesh of the sample nets. Another net with smaller mesh (~1.2 mm) was available and the counts were continued using the smaller mesh size from that point on.

This summary examines all available data comparing the two net types to determine: (1) whether the fry estimates for 2004 and 2005 should be increased, and (2) if the amount of underestimate relates to the duration that nets were in the water. If the percentage of fish going through the nets increased with a longer period of sampling then the underestimate of fry production would have to be calibrated accordingly, since the duration of sampling was typically longer in 2004 and 2005 because of the low number of fry emigrating in those years.

Methods:

Comparisons of the two net types were done on May 4, 10, 11, 12, and 13. Initial comparisons (May 4) were made by putting two nets (2 mm and 1 mm mesh) side by side in the channel and removing them at the same time. Later comparisons were made by sequentially placing the two different net types at the exact same place in the channel for the same length of time. It was felt that the sequential comparisons were more reliable because observations showed that the number of fry captured could differ substantially in different locations across the channel, likely being influenced by slight differences in the amount of light and current. We did not attempt to place a small mesh net directly behind the larger mesh net because we felt that fry might drift in between the two nets if they were placed far enough apart to ensure that the second net was not causing a backwatering effect on the first.

Results and Discussion:

The number of fry drifting downstream varies in both time and space (across the channel). No perfect method of comparing the two net types was possible; therefore we had to use either side by side comparisons (spatial difference) or sequential comparisons (temporal difference). Side by side comparisons on May 4 showed extremely low numbers of retained fry in the 2 mm nets compared to the 1 mm for both 5 and 10 minute durations (Fig. A1; Table A1). These results contradict a side by side comparison made with the same nets on May 10 (Fig. A1), as well as later sequential comparisons. It is possible that these early migrating fry were smaller than later fry. Unfortunately, no fry were measured on that night. These atypical results for May 4 are considered to be less reliable and side by side comparisons were eliminated from further consideration.

Sequential comparisons of the number of fry retained showed that on average about 50% of the fry were passing through the 2 mm mesh (Table A2). This percentage did not appear to increase with an increase in the number of fry caught (Fig. A2) or the duration of fishing time (Fig. A3).

Conclusion and Recommendation:

There is evidence that a substantial proportion of the kokanee could have passed through the 2 mm sampling nets in 2004 and 2005 due to the change to a more flexible 2 mm netting material. The percentage was likely about 50% if fry were the same size range in 2004 and 2005 as they were in 2006, but could have been higher if the fry in those years were significantly smaller. Low oxygen conditions are suspected for the 2004 and 2005 cohorts and spawner size was also marginally smaller in 2004 than 2005. Both factors might contribute to reduced fry size at emergence. Unfortunately, there are no length data to test this possibility. Extremely small fry would be less likely to survive upon reservoir entry so underestimating their numbers may be less important to understanding the contribution of the spawning channel in those years.

It is recommended that fry estimates for 2004 and 2005 be doubled to account for the known underestimate in 2006 comparisons. Fry estimates for the few days sampled prior to May 4, 2006 should also be doubled. There is no evidence that the duration of time affected the percentage of fry that passed through, so the 50% factor can be applied simply to the previous total fry emigration estimate.

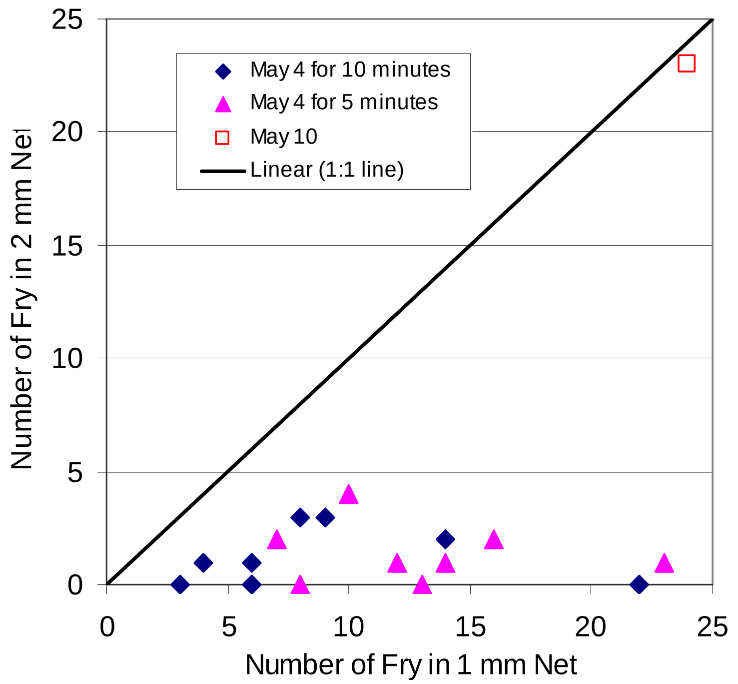


Fig.A1. Comparison of the number of kokanee fry captured in nets of 1 mm and 2 mm mesh size when placed side by side in Hill Creek Spawning Channel on May 4 and May 10, 2006. The line shows a 1:1 ratio.

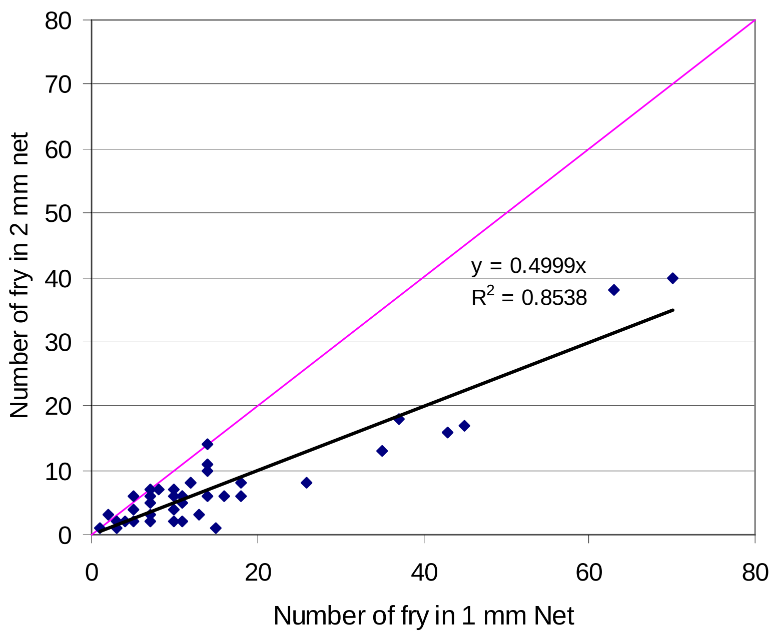


Fig. A2. Comparison of the number of kokanee fry captured in nets of 1 mm and 2 mm mesh size when placed sequentially in the exact same channel location in Hill Creek Spawning Channel from May 10 - 13, 2006. A 1:1 ratio line and a linear regression line are shown.

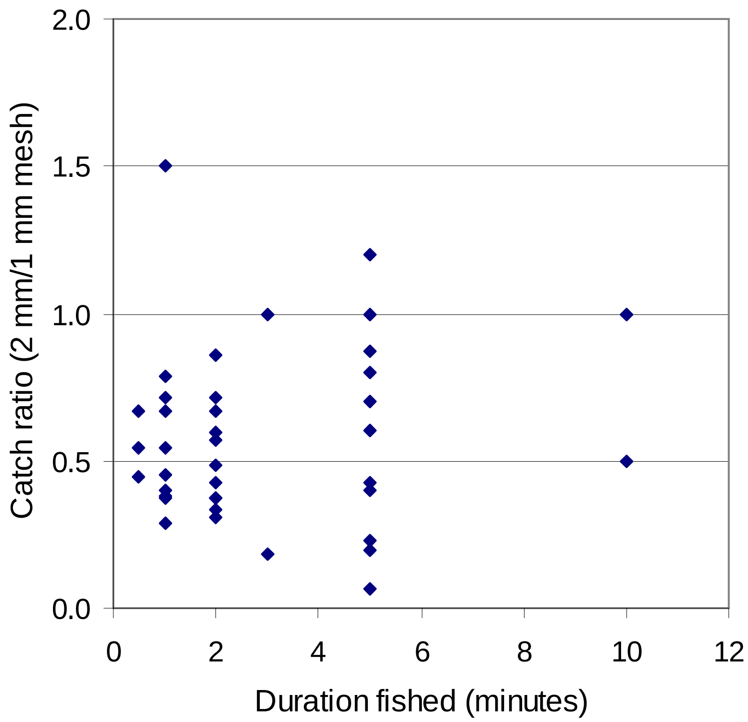


Fig. A3. Percentage of kokanee fry retained in 2mm nets compared to 1 mm nets in relation to the time duration that nets were fished in Hill Creek Spawning Channel. Sets were made sequentially in the same channel location.

Table A1. Comparison of the number of emigrating kokanee fry retained in two net types at Hill Creek Spawning Channel. For the side by side comparisons, the larger mesh net was always on the right upstream side of the smaller mesh net. Sequential comparisons were at the exact same location in the channel.

Date	Duration (min)	Mesh Size 1mm	Mesh Size 2mm	1mm/2mm Ratio	Method
04-May-06	10	6	0	na	Side by Side nets
04-May-06	10	3	0	na	Side by Side nets
04-May-06	10	4	1	4.00	Side by Side nets
04-May-06	10	9	3	3.00	Side by Side nets
04-May-06	10	22	0	na	Side by Side nets
04-May-06	10	6	1	6.00	Side by Side nets
04-May-06	10	8	3	2.67	Side by Side nets
04-May-06	10	14	2	7.00	Side by Side nets
04-May-06	5	16	2	8.00	Side by Side nets
04-May-06	5	8	0	na	Side by Side nets
04-May-06	5	14	1	14.00	Side by Side nets
04-May-06	5	12	1	12.00	Side by Side nets
04-May-06	5	23	1	23.00	Side by Side nets
04-May-06	5	10	4	2.50	Side by Side nets
04-May-06	5	7	2	3.50	Side by Side nets
04-May-06	5	13	0	na	Side by Side nets
10-May-06	na	24	23		Side by Side nets
10-May-06	3	1	1	1.00	Sequential
10-May-06	3	11	2	5.50	Sequential
10-May-06	5	8	7	1.14	Sequential
10-May-06	5	10	4	2.50	Sequential
10-May-06	5	5	4	1.25	Sequential
10-May-06	5	13	3	4.33	Sequential
10-May-06	5	7	7	1.00	Sequential
10-May-06	5	5	6	0.83	Sequential
10-May-06	5	10	2	5.00	Sequential
10-May-06	5	10	7	1.43	Sequential
11-May-06	10	4	2	2.00	Sequential
11-May-06	5	14	6	2.33	Sequential
11-May-06	2	7	6	1.17	Sequential
11-May-06	1	7	2	3.50	Sequential
11-May-06	1	5	2	2.50	Sequential
11-May-06	1	2	3	0.67	Sequential
11-May-06	2	3	1	3.00	Sequential
11-May-06	2	3	2	1.50	Sequential
11-May-06	2	10	6	1.67	Sequential
11-May-06	2	7	3	2.33	Sequential
12-May-06	10	14	14	1.00	Sequential
12-May-06	5	63	38	1.66	Sequential
12-May-06	2	70	40	1.75	Sequential
12-May-06	1	45	17	2.65	Sequential
12-May-06	1	43	16	2.69	Sequential

12-May-06	1	14	10	1.40	Sequential
12-May-06	1	12	8	1.50	Sequential
12-May-06	2	35	13	2.69	Sequential
12-May-06	2	26	8	3.25	Sequential
12-May-06	2	16	6	2.67	Sequential
13-May-06	5	15	1	15.00	Sequential
13-May-06	2	37	18	2.06	Sequential
13-May-06	1	11	5	2.20	Sequential
13-May-06	0.5	12	8	1.50	Sequential
13-May-06	0.5	18	8	2.25	Sequential
13-May-06	0.5	11	6	1.83	Sequential
13-May-06	1	14	11	1.27	Sequential
13-May-06	1	11	6	1.83	Sequential
13-May-06	2	7	5	1.40	Sequential
13-May-06	na	18	6	3.00	Sequential

Table A2. Summary of the number and percent of kokanee fry retained in 2 mm mesh nets compared to 1 mm mesh for sequential comparisons made in Hill Creek Spawning Channel.

	1 mm Mesh	2 mm Mesh	Percent
N	40	40	40
Minimum	1	1	0.067
Maximum	70	40	1.500
Mean	15.85	8.00	0.505
Standard Deviation	15.72	8.42	-