Determining the Trend of Chum Population Dynamics in Area 5 and Measuring the Success of Small Hatcheries for Stock Assistance Year 2

Prepared for: Northern Boundary and Transboundary Rivers Restoration and Enhancement Fund

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EXECUTIVE SUMMARY

This project has now completed its second year which focuses on the contribution of small hatcheries such as the Oona River hatchery to increase chum salmon populations in coastal systems such as the Kumealon River. Habitat measurements were taken within the Kumealon system in 2006 using standard fisheries techniques for determination of spawning area for chum redds and to aid in quantifying the maximum potential population of chum spawners. (Refer to the report ***Determining the Trend of Chum Dynamics in Area 5 and Measuring the Success of Small Hatcheries for Success Year 1*** for maps and measurements).

Reviewing historical chum records from the 1950's to the present indicates that there has been lots of variation in chum populations in Kumealon but an overall decline to the present with a surprising upward spike in 2007. Declines in population can be attributed to various activities such as the past logging activity in the Kumealon watershed, bycatch in the Area 4 sockeye and pink commercial fishery and Area 5 seine pink fishery and the possible effects of climate change. Historical records showed that the decadal average in the Kumealon system for returning chum spawners in the 1950's was 725 and the historical mean from 1950-1989 was 370 with a maximum reported 1500 spawners in the system. The recent records show that the 1990-2001 average was 67 chums with 80 chums reported in the system in 2006 and in 2007 there was just over 500 chums reported in the system but very few pinks. We believe that there was a huge mortality on chum salmon in 2007 because of the lack of pinks in the system and the large bear population as we could see very few morts on our visual surveys.

In 2007 we took approximately 25000 eggs from broodstock takes in the Kumealon system during the month of July and August. Some problems arose from a Trichodina outbreak which under the advice of the Fisheries and Oceans Community Advisor was treated with Parasite S. It was deduced from discussions that taking eggs from partially spawned out chum females may contribute to this outbreak and therefore in the future we will isolate the incubation trays. Approximately 12000 fry had their right ventral fin clipped and returned to the Kumealon system on April 10 2008. There were only 8 mortalities on the transfer from Oona River to Kumealon.

Our measurements based on last year's project showed that the total chum spawning area in the Kumealon system at this present time was 2166 m2. Using the criteria of average chum redd size, consecutive redds per coupling and amount of area needed for coupling we calculated that the system could accommodate up to 850 spawners in its present condition. Determination of hatchery success will be conducted on visual surveys of returning spawners that have been clipped in relation to overall returning spawners. Since 95% of chum spawners in Kumealon system are 3 year old chums (personell communication with Brian Spilsted FAO North Coast biologist) we would expect the first clipped returns to be present in the system in 2009.

Temperature loggers were placed in the Oona River Hatchery, Kumealon main flow and the Kumealon gravel. The daily temperature data for 2007-2008 like 2006-2007 shows a

distinct difference in water temperature as the Kumealon system is a much more warmer than Oona River and therefore results in more accumulated thermal units (ATU's) for faster development of the chum fry.

Determination of residency times for chum spawners in the Kumealon system was done by a systematic marking of the peduncle fin with different coloured elastic bands secured with zap straps.

DNA and scale analysis shows that the majority of the chum salmon that were sampled (91.3%) in 2007 were 3 year old chums.

INTRODUCTION

There appears to be a continuous downward trend in the observed chum salmon stocks in Area 5 from the 1950's to their present population numbers in the first decade of this new millennium according to the Fisheries Salmon Escapement database. The Oona River Resource Association (ORRA) in partnership with the Stock Assessment Branch of the North Coast Fisheries and Oceans decided it would be a beneficial to investigate the spawning potential of a typical chum bearing system in Area 5 alongside using a small hatchery for increasing chum salmon stocks in this system.

The Kumealon system was chosen because it has a small standing chum population, easy access by boat, clarity of water for observing chum populations and in the vicinity of the operating area of the Oona River hatchery for acquiring broodstock. The biologist and fish technicians of ORRA are familiar with the Kumealon system and are experienced in acquiring broodstock and are knowledgeable in hatchery techniques for the successful incubation of eggs to the fry stage.

The project had five objectives:

1. To sample a major chum bearing system in Area 5 for quantifying spawning potential in this system.
2. To enumerate the in migrating adult chum and dead spawners for the duration of their migration into the Kumealon system. Resident time of the chum spawners was to be determined by the observation of different coloured elastic bands placed on the peduncle of spawners to observe their spatial and temporal movement. Coverage would be every 3 -4 days and coordination with the FAO streamwalker would allow even better coverage.
3. To collect DNA samples of chum salmon for FAO Fisheries stock assessment for building up DNA profiles for North Coast streams.
4. To collect broodstock from the Kumealon system and transfer the fertilized eggs into incubation trays in the hatchery at Oona River. These eggs would be monitored for the next six months for disease and water quality to ensure a good egg-fry survival rate.

5. In the early spring, the emergent chums would be held a week to 10 days and then returned back to their natal system. Before they are released they would be fin-cipped in order to differentiate the returning adult chum as wild or enhanced stock.

All objectives were met in this project as shown in the results and discussion of this report. The timing and the monitoring are all reflected in the analysis of the data.

METHODS

The North Coast has many river systems but most of these systems are not clear because of the tannic in the water. Kumealon was chosen as the target river because the water clarity for observing in migrating fish and distinguishing the different species is excellent. It also has good historical records for chum presence and it has a small standing crop of spawners. The system has some damage to its spawning habitat from logging in the past and the estimation of the potential of chum spawners is based on spawning area in its present condition. It is approximately 12 nautical miles from Oona River and there is a good trail (1.5km) from the estuary into the main river system. Access on certain stages of the tide (high slack water) through the rapids allows the use of a small skiff for movement into the lower part of the river that flows into a salt lagoon.

The collection of broodstock was accomplished by the use of small mesh barrier nets on the lower and upper target areas where spawners were visually seen and introducing a 152mm mesh gill net in the middle for capturing the chum spawners. In 2007, there was much fewer pink salmon in the Kumealon system which made it much easier to catch the chum spawners. The larger mesh net 61/4 inch ensure less stress on any bycatch of pink salmon as they can be released much faster.

We tried to catch at least 3 males to one female for the purpose of genetic integrity. All males after obtaining some milt or immature females were tagged by using different coloured elastic band on their peduncle for determining resident time. We ensured that all fish were in good condition before release. All chums that were caught had a small clip from the operculum for a DNA sample which was put in a vial containing 30% ethanol. Scales samples were also taken during sampling.

Mature female chums that were captured were stripped of their eggs and the unfertilized eggs were put into separate containers. Milt from the males were taken in small whirlpak or ziplock bags and kept cool in a small cooler and taken back to the Oona River hatchery. We timed it that no more than 3 hours would elapse from the time we took the first eggs or milt to arriving at the hatchery in Oona River. At the hatchery, the eggs were fertilized using at least a 3:1 ratio of males to females and then the fertilized eggs were transported to the incubation trays. The eggs were washed in a solution of Ovadine (10ml in 10 liters of water) for protection against fungus and bacterial infections

The fertilized eggs were monitored during the winter from the egg to fry swim up stage and a technician was paid some hours each week to monitor water quality and pick any dead eggs from the trays and record the temperature in the tank .The fry at swim up stage

were fed using a feed timer that distributed Ewos micro feed using a standard formula calibrated to chum juveniles.

Approximately 12000 chum fry averaging .7 grams had their right ventral fin clipped at the Oona River hatchery from April 6th –April 8th and were released on April 10 2008 in Kumealeon. Transportation of the fry was done by putting the fry in a large insulated tote filled with water and supplied with an air stone running on 12VDC battery power. The tote was placed in a large skiff and towed to Kumealon by a larger vessel. The skiff then was taken through the tidal rapids at high slack water to utilize the bigger tides for allowing further movement up the river for release of the fry.

A thermal temperature logger (StowAway Tidbit TB3237) was placed in the water flow at the Oona River hatchery and two temperature loggers in the spawning area of Kumealon in both the main river flow and one buried in the gravel. The data from the tidbit was downloaded using the BoxCar 3.7 for Windows Program. The interval for readings was 4 times a day and the 4 temperatures were averaged to give an average daily temperature which is shown in Table 7 in the Appendix.

RESULTS

The Table below shows a matrix using information from Groot and Margolis and our data for 2006 for a determination of chum spawning area and Potential spawners

Total Chum Spawning (m2)	**2167**
Chum Redd Size (m2)	**1.7**
Number Consecutive Redds per Coupling	**3**
Total Amount of Spawning Area Needed per male/female coupling	**5.1**
Total Amount of Couples w/o Superimposition	**425**
Total Maximum No Potential Chum Spawners Over System	**850**

Table 1. Determination of Chum Spawning Area and Potential Spawners.

<u>Monitoring of Chum In Migration and Acquiring Broodstock for 2007</u>

The movement of chums into the Kumealon system begins in late July and spawning usually is over by the first part of September. The acquisition of broodstock is much easier in the beginning of their in migration as you do not have to worry about the bycatch of pinks. In 2007 we took our first eggs on July 27th and our last eggs on August 10th and Table 2 below gives an outline of the time frame and acquisition of eggs.

Date	No of females	Approximate amount of eggs
July 27 2007	1	2500
August 1 2008	3	5536
August 6 2008	3	4325
August 7 2008	3	3806
August 8 2008	3	4152
August 10 2008	1	4671

Total	**10**	**24990**

Table 2. Approximation of Chum eggs from broodstock acquisition in 2007.

During this time we tagged males and females at the river mouth to get some estimation of residency by the chums in the system. Table 3 belows shows the colour, dates and number of tags that were placed on the chum salmon. Table 4 shows the result of

Colour of Tag	**Dates of Tagging**	**No of Tags**
White	July 22 2007	10
Yellow	July 31-Aug 2 2007	39
Pink	Aug 6 – Aug 8 2007	40
Green	Aug 10 – Aug 11 2007	30
Yellow (2)	Aug 15 2007	24

Table 3 Dates, Colours and Numbers of Tags placed on Chum spawners.

	RECOVERED	**TAGS**		
Date	**White Tag**	**Yellow Tag**	**Pink Tag**	**Green Tag**
July 27 2007				
July 31 2007				
Aug 1 2007	1			
Aug 2 2007	1	1		
Aug 7 2007	2	3	1	
Aug 8 2007		5	15	
Aug 10 2007			4	
Aug 13 2007		4	3	10
Aug 15 2007		1	3	5
Aug 18 2007		6		2

Table 4 Recovered Colour Tags for determination of Residence Time

visual sightings of the tags either on live fish or morts. Most of the fish spotted were still alive as the morts in the system get cleaned up pretty quickly by the eagles and bears. The recovery times indicate that the longest duration of a white tag was from July 22 to August 7th which is 16 days, a yellow tag from August 1st to August 15th which is 15 days, a pink tag from August 7th to August 15th which is 8 days and a Green Tag from August 10th to August 18th which is 8 days. The second yellow marking was done on August 15th and we sighted 6 yellow tags but we didn't return back to the system after that duration. So on average the results indicate that the residency time is from at least 8 days to 15 days in the system.

Incubation of Chum Eggs and Development Time for Eyed Stage, Hatch Stage and Swim up stage.

All the chum eggs from broodstock takes were deposited in the incubation trays from late July to early August. There were 7843 dead chum eggs picked from the trays which were probably the result of us taking water hardened eggs from some of the partially spawned out females. This resulted in 17147 eggs remaining in the heath trays. The first alevins

were hatched out around the 15th of September and the first fry observed in the tank was on November 5th 2008 with the peak of the fry emergence during the month of March when 10,909 new fry were counted.

Salmon species	To Eyed Stage(ATU's)	To Hatched Stage (ATU's)	To Swim Up Stage (ATU's)
Coho	217-237	448-475	777-829
Chum	***217-250***	***498-546***	***845-1126***
Chinook	242-258	512-526	825-1029
Pink	224-257	545-662	868-1034
Sockeye	236-257	614-694	943-1088

Table 5. Average Accumulated Thermal Units (ATU's) for Developmental Stages of the Different Salmonids.

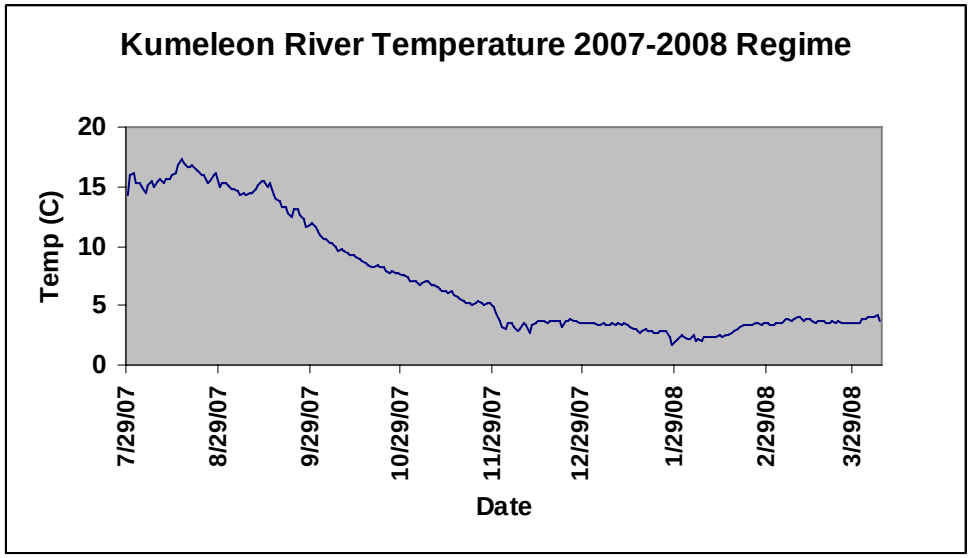

Fig 1. Average Daily Temperature of Kumealon Stream from July 29 2007 to April 7 2008

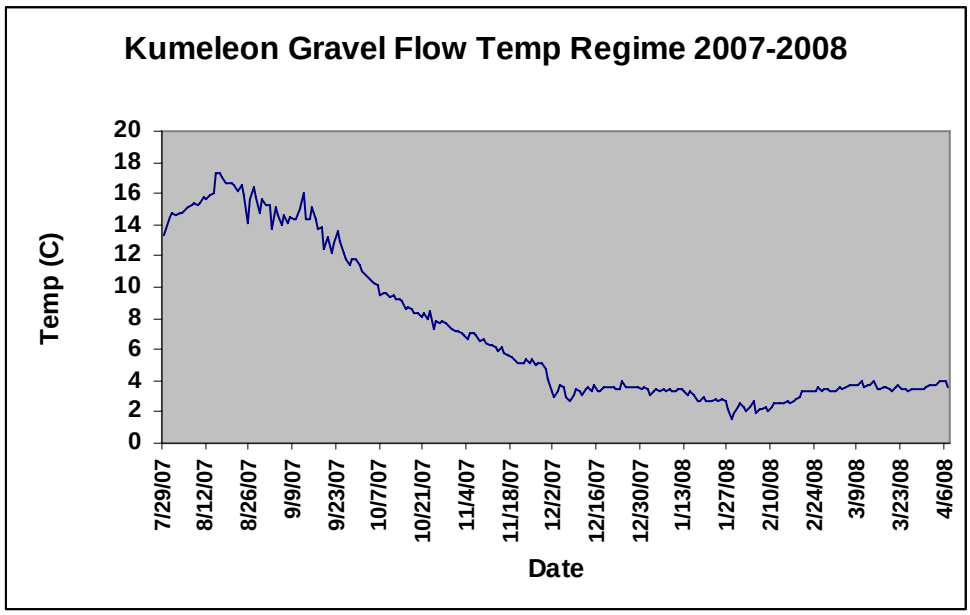

Fig 2. Average Daily Temperature in the Gravel Flow in Kumealon from July 29 2007 to April 7 2008.

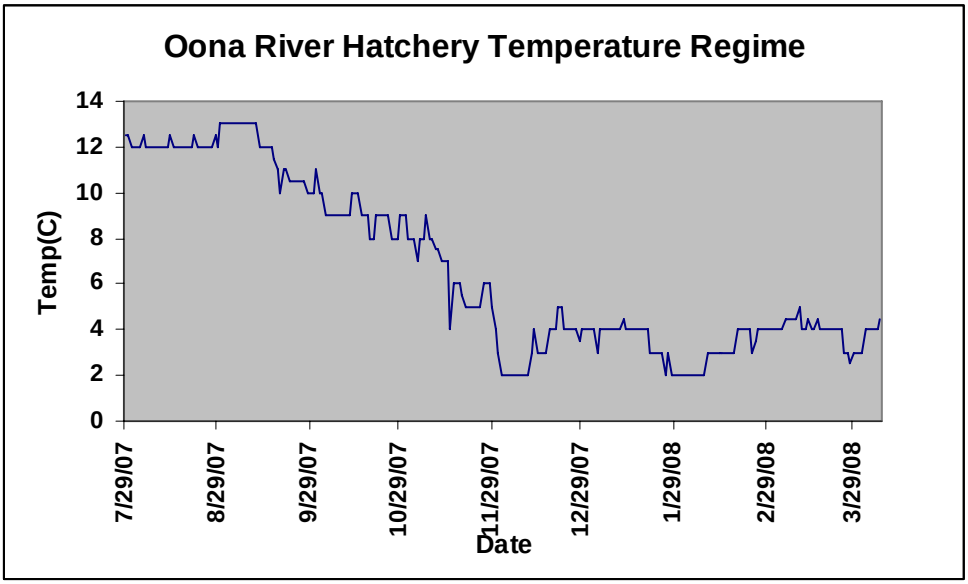

Fig. 3 Average Daily Temperature recorded at Hatchery in Oona River from July 29 2007 to April 7 2008.

DNA and Scale Analysis

Brian Spilsted of Fisheries and Oceans sent us the breakdown of the DNA and scale analysis and the table below is a summary of the results;

Kumealon River 2007 Area 5 North Coast Division Grenville Channel						
Containers 52772,56245,64333,70243,79837 Gear: Unknown						
Sample Dates: 2007-08-01 to 2007-08-31						
Age Distribution						
	Species	**European**	**Gilbert**	**Brood**	**Frequency**	**Percent**
			Rich	**Year**		
	Chum	02	31	2004	3	4.3%
	Chum	03	41	2005	64	91.4%
	Chum	04	51	2006	3	4.3%
				Total	**70**	**100%**

Table 6 Summary of DNA and Scale Analysis for Kumealeon for 2007 from Brian Spilsted Biologist North Coast Division of Fisheries and Oceans.

DISCUSSION

This project is examining the use of small hatcheries in doing stock assistance for chum salmon on the North Coast of British Columbia. The preliminary study of 2006 showed that there are some necessary questions that have to be investigated by using a small scale approach to understand why chum salmon streams in Area 5 are slowing losing their population base when compared with the historical records of the 1950's and onward in the Fisheries and Oceans Salmon Escapement Database.

The recorded number of chum salmon that was estimated by both this project's crew and the FAO Streamwalker was 80 chum in 2006 but Kumealon was exceptional in 2007 with over 500 estimated spawners in the systems.

The approximate 25,000 eggs that were put originally into the incubation trays at the Oona River hatchery resulted in approximately 12000 clipped fish released back into the Kumealon system. These fry were released at .6 grams which is about double what the wild chum smolts would weigh when they out migrate.

The temperature loggers in both Kumealon and Oona River show a striking difference in temperature regimes between the two systems. One temperature logger was put in the main river in Kumealon and the other logger was put in the gravel from (July 29th 2007 to April 7th 2008). The temperature logger in Oona River did not function properly but the water temperature in the hatchery tank was taken daily by a technician. The comparison of the two systems for temperature during the same period is shown in Figure 4. The graph shows that Oona River and the Kumealon temperature regimes do differ as the Kumealon system has a gradual slope with very little spiking which is attributed to the buffering action of the large lake at its headwaters. The Oona system is not a lake fed system and results in more spiking in its temperature profile. The Accumulated Thermal

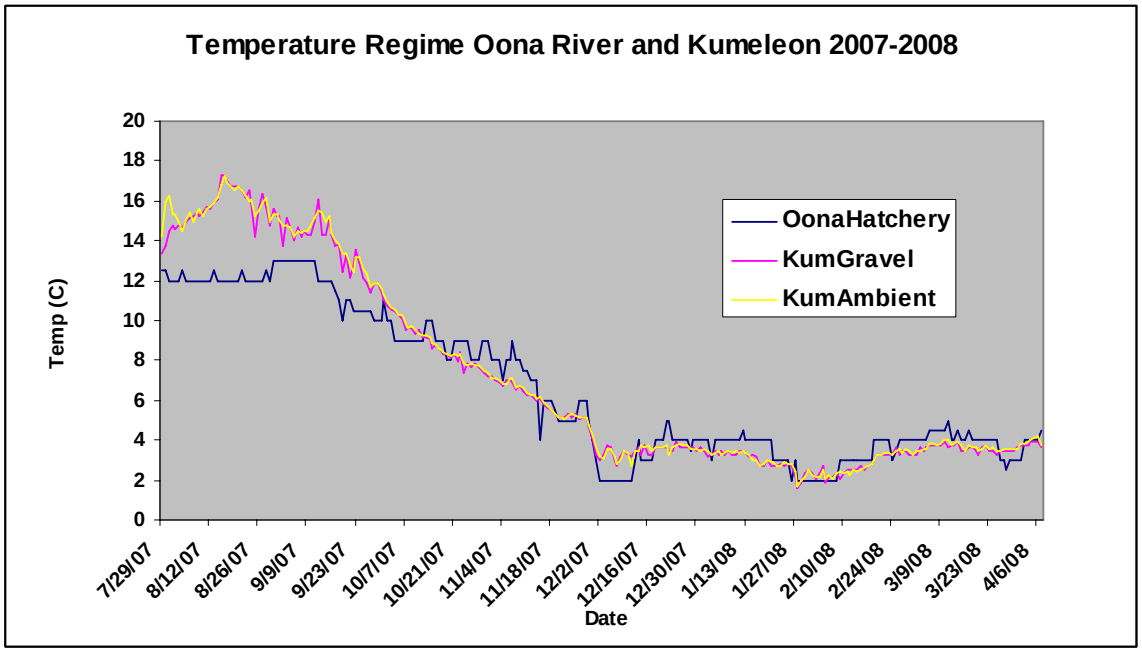

Fig 4 Comparison of Water Temperature in Kumealon and Oona River Watersheds from July 29 2007 to April 7 2008.

Units were quite similar for Oona River and the Main Flow of Kumealon for the period of July 29 to April 7th with Oona River recording 1682 and the Main Flow of Kumealon 1685 but the Accumulated Thermal Units for the gravel in Kumealon was 1827.
The first reported chum at the swimup stage at the Oona River hatchery was in early November but the bulk of the fry emergence was the middle of February to late March.

RECOMMENDATIONS AND CONCLUSIONS

We have some extra funding for 2008-2009 for investigating the out migration of chum smolts for their timing in relation to prediction of the outmigration based on the recorded ATU's. It will be important to investigate the chum fry usage of the estuary and also to sample some of these smolts for doing stomach analysis to see what they are feeding on while they reside in the estuary. Plankton tows and other benthic sampling will be done to associate the availability of food sources for what may be present in their stomachs.

These are some of the areas that will be investigated for understanding the population dynamics of this system and how this may apply to other chum bearing systems in Area 5. There may be a strong relationship with the higher temperature in some of these systems for their speed in early development, their survival rate and the overall reduction in adult chum populations in these areas.

APPENDIX

Date	OonaRiver Temp	ATU's Oona River	KumGravel Temp	ATU's Kum FlowGravel	KumRiver Temp	ATU'sKum Main Flow
7/29/07	12.5	12.5	13.39	13.39	14.2	14.2
7/30/07	12.5	25	13.7	38.7	16.0	30.2
7/31/07	12	37	14.5	51.5	16.2	46.4
8/1/07	12	49	14.8	63.8	15.3	61.7
8/2/07	12	61	14.6	75.6	15.4	77.1
8/3/07	12	73	14.8	87.8	15.0	92.0
8/4/07	12.5	85.5	14.7	100.2	14.5	106.5
8/5/07	12	97.5	15	112.5	15.1	121.6
8/6/07	12	109.5	15.1	124.6	15.4	137.0
8/7/07	12	121.5	15.25	136.75	14.9	151.9
8/8/07	12	133.5	15.42	148.92	15.4	167.3
8/9/07	12	145.5	15.26	160.76	15.6	182.9
8/10/07	12	157.5	15.42	172.92	15.3	198.2
8/11/07	12	169.5	15.74	185.24	15.6	213.8
8/12/07	12	181.5	15.58	197.08	15.7	229.5
8/13/07	12.5	194	15.89	209.89	15.9	245.4

8/14/07	12	206	16.06	222.06	16.2	261.6
8/15/07	12	218	17.33	235.33	16.9	278.4
8/16/07	12	230	17.33	247.33	17.3	295.7
8/17/07	12	242	17.01	259.01	16.9	312.6
8/18/07	12	254	16.69	270.69	16.7	329.3
8/19/07	12	266	16.69	282.69	16.6	345.9
8/20/07	12	278	16.69	294.69	16.7	362.7
8/21/07	12.5	290.5	16.53	307.03	16.5	379.2
8/22/07	12	302.5	16.21	318.71	16.2	395.4
8/23/07	12	314.5	16.53	331.03	16.0	411.4
8/24/07	12	326.5	15.89	342.39	16.0	427.4
8/25/07	12	338.5	14.16	352.66	15.3	442.7
8/26/07	12	350.5	15.58	366.08	15.5	458.2
8/27/07	12	362.5	16.37	378.87	15.9	474.1
8/28/07	12.5	375	15.74	390.74	16.1	490.2
8/29/07	12	387	14.79	401.79	14.9	505.2
8/30/07	13	400	15.58	415.58	15.4	520.5
8/31/07	13	413	15.26	428.26	15.3	535.8
9/1/07	13	426	15.26	441.26	15.1	550.9
9/2/07	13	439	13.7	452.7	14.8	565.7
9/3/07	13	452	15.11	467.11	14.8	580.5
9/4/07	13	465	14.63	479.63	14.6	595.1
9/5/07	13	478	14.01	492.01	14.2	609.4
9/6/07	13	491	14.63	505.63	14.4	623.8
9/7/07	13	504	14.16	518.16	14.4	638.2
9/8/07	13	517	14.47	531.47	14.5	652.7
9/9/07	13	530	14.32	544.32	14.5	667.1
9/10/07	13	543	14.32	557.32	14.7	681.9
9/11/07	13	556	14.94	570.94	15.2	697.0
9/12/07	12	568	16.06	584.06	15.5	712.5
9/13/07	12	580	14.32	594.32	15.4	727.9
9/14/07	12	592	14.32	606.32	15.0	742.9
9/15/07	12	604	15.11	619.11	15.3	758.2
9/16/07	12	616	14.32	630.32	14.4	772.5
9/17/07	11.5	627.5	13.7	641.2	14.0	786.5
9/18/07	11	638.5	13.85	652.35	13.8	800.4
9/19/07	10	648.5	12.46	660.96	13.4	813.7
9/20/07	11	659.5	13.24	672.74	13.4	827.1
9/21/07	11	670.5	12.14	682.64	12.8	839.8
9/22/07	10.5	681	12.77	693.77	12.4	852.3
9/23/07	10.5	691.5	13.54	705.04	13.2	865.4
9/24/07	10.5	702	12.93	714.93	13.2	878.6
9/25/07	10.5	712.5	12.14	724.64	12.7	891.2
9/26/07	10.5	723	11.83	734.83	12.3	903.6
9/27/07	10.5	733.5	11.37	744.87	11.7	915.3
9/28/07	10	743.5	11.83	755.33	11.8	927.1
9/29/07	10	753.5	11.83	765.33	11.9	939.0
9/30/07	10	763.5	11.37	774.87	11.6	950.6
10/1/07	11	774.5	11.06	785.56	11.3	961.8
10/2/07	10	784.5	10.76	795.26	10.9	972.8

10/3/07	10	794.5	10.6	805.1	10.6	983.4
10/4/07	9	803.5	10.44	813.94	10.5	993.9
10/5/07	9	812.5	10.29	822.79	10.3	1004.2
10/6/07	9	821.5	10.13	831.63	10.3	1014.5
10/7/07	9	830.5	9.51	840.01	9.9	1024.4
10/8/07	9	839.5	9.66	849.16	9.6	1033.9
10/9/07	9	848.5	9.66	858.16	9.7	1043.7
10/10/07	9	857.5	9.35	866.85	9.5	1053.2
10/11/07	9	866.5	9.51	876.01	9.4	1062.5
10/12/07	9	875.5	9.19	884.69	9.3	1071.8
10/13/07	10	885.5	9.19	894.69	9.2	1081.0
10/14/07	10	895.5	9.04	904.54	9.1	1090.2
10/15/07	10	905.5	8.58	914.08	8.9	1099.0
10/16/07	9	914.5	8.74	923.24	8.8	1107.9
10/17/07	9	923.5	8.58	932.08	8.6	1116.5
10/18/07	9	932.5	8.28	940.78	8.5	1124.9
10/19/07	8	940.5	8.28	948.78	8.3	1133.2
10/20/07	8	948.5	8.12	956.62	8.2	1141.5
10/21/07	9	957.5	8.28	965.78	8.3	1149.8
10/22/07	9	966.5	7.97	974.47	8.2	1158.0
10/23/07	9	975.5	8.43	983.93	8.3	1166.3
10/24/07	9	984.5	7.35	991.85	7.8	1174.1
10/25/07	9	993.5	7.82	1001.32	7.7	1181.9
10/26/07	8	1001.5	7.66	1009.16	7.8	1189.7
10/27/07	8	1009.5	7.82	1017.32	7.8	1197.5
10/28/07	8	1017.5	7.66	1025.16	7.8	1205.3
10/29/07	9	1026.5	7.51	1034.01	7.6	1212.9
10/30/07	9	1035.5	7.35	1042.85	7.5	1220.3
10/31/07	9	1044.5	7.19	1051.69	7.4	1227.7
11/1/07	8	1052.5	7.19	1059.69	7.1	1234.9
11/2/07	8	1060.5	7.04	1067.54	7.1	1242.0
11/3/07	8	1068.5	6.88	1075.38	7.0	1249.0
11/4/07	7	1075.5	6.73	1082.23	6.8	1255.8
11/5/07	8	1083.5	7.04	1090.54	6.9	1262.7
11/6/07	8	1091.5	7.04	1098.54	7.1	1269.8
11/7/07	9	1100.5	6.88	1107.38	7.1	1276.8
11/8/07	8	1108.5	6.57	1115.07	6.7	1283.5
11/9/07	8	1116.5	6.73	1123.23	6.8	1290.3
11/10/07	7.5	1124	6.42	1130.42	6.6	1296.9
11/11/07	7.5	1131.5	6.26	1137.76	6.4	1303.3
11/12/07	7	1138.5	6.26	1144.76	6.2	1309.5
11/13/07	7	1145.5	6.11	1151.61	6.2	1315.8
11/14/07	7	1152.5	5.95	1158.45	6.0	1321.8
11/15/07	4	1156.5	6.11	1162.61	6.2	1328.0
11/16/07	6	1162.5	5.79	1168.29	5.9	1333.9
11/17/07	6	1168.5	5.64	1174.14	5.7	1339.7
11/18/07	6	1174.5	5.48	1179.98	5.5	1345.2
11/19/07	5.5	1180	5.33	1185.33	5.3	1350.5
11/20/07	5	1185	5.17	1190.17	5.2	1355.7
11/21/07	5	1190	5.17	1195.17	5.2	1360.9

11/22/07	5	1195	5.17	1200.17	5.1	1366.0
11/23/07	5	1200	5.33	1205.33	5.3	1371.2
11/24/07	5	1205	5.17	1210.17	5.3	1376.6
11/25/07	5	1210	5.33	1215.33	5.3	1381.8
11/26/07	6	1216	5.02	1221.02	5.1	1386.9
11/27/07	6	1222	5.17	1227.17	5.1	1392.1
11/28/07	6	1228	5.17	1233.17	5.2	1397.3
11/29/07	5	1233	4.71	1237.71	4.8	1402.0
11/30/07	4	1237	4.08	1241.08	4.3	1406.4
12/1/07	3	1240	3.29	1243.29	3.6	1410.0
12/2/07	2	1242	2.98	1244.98	3.2	1413.1
12/3/07	2	1244	3.29	1247.29	3.1	1416.2
12/4/07	2	1246	3.77	1249.77	3.6	1419.8
12/5/07	2	1248	3.61	1251.61	3.6	1423.4
12/6/07	2	1250	2.98	1252.98	3.2	1426.5
12/7/07	2	1252	2.67	1254.67	2.8	1429.3
12/8/07	2	1254	3.14	1257.14	3.0	1432.3
12/9/07	2	1256	3.45	1259.45	3.5	1435.8
12/10/07	2	1258	3.29	1261.29	3.4	1439.2
12/11/07	2	1260	3.14	1263.14	2.8	1441.9
12/12/07	3	1263	3.45	1266.45	3.4	1445.4
12/13/07	4	1267	3.61	1270.61	3.5	1448.9
12/14/07	3	1270	3.29	1273.29	3.7	1452.6
12/15/07	3	1273	3.77	1276.77	3.6	1456.2
12/16/07	3	1276	3.29	1279.29	3.7	1460.0
12/17/07	3	1279	3.29	1282.29	3.5	1463.5
12/18/07	4	1283	3.61	1286.61	3.7	1467.1
12/19/07	4	1287	3.61	1290.61	3.6	1470.7
12/20/07	4	1291	3.61	1294.61	3.6	1474.4
12/21/07	5	1296	3.61	1299.61	3.7	1478.1
12/22/07	5	1301	3.45	1304.45	3.3	1481.3
12/23/07	4	1305	3.45	1308.45	3.6	1484.9
12/24/07	4	1309	3.92	1312.92	3.7	1488.6
12/25/07	4	1313	3.61	1316.61	3.8	1492.5
12/26/07	4	1317	3.61	1320.61	3.7	1496.2
12/27/07	4	1321	3.61	1324.61	3.7	1499.9
12/28/07	3.5	1324.5	3.61	1328.11	3.6	1503.5
12/29/07	4	1328.5	3.61	1332.11	3.5	1507.0
12/30/07	4	1332.5	3.45	1335.95	3.5	1510.6
12/31/07	4	1336.5	3.61	1340.11	3.5	1514.0
1/1/08	4	1340.5	3.45	1343.95	3.5	1517.6
1/2/08	4	1344.5	3.14	1347.64	3.5	1521.0
1/3/08	3	1347.5	3.29	1350.79	3.3	1524.3
1/4/08	4	1351.5	3.45	1354.95	3.3	1527.7
1/5/08	4	1355.5	3.29	1358.79	3.5	1531.2
1/6/08	4	1359.5	3.45	1362.95	3.3	1534.5
1/7/08	4	1363.5	3.29	1366.79	3.4	1537.9
1/8/08	4	1367.5	3.45	1370.95	3.5	1541.3
1/9/08	4	1371.5	3.29	1374.79	3.3	1544.7
1/10/08	4	1375.5	3.29	1378.79	3.5	1548.1

1/11/08	4	1379.5	3.45	1382.95	3.4	1551.5
1/12/08	4.5	1384	3.45	1387.45	3.5	1555.0
1/13/08	4	1388	3.37	1391.37	3.3	1558.4
1/14/08	4	1392	3.14	1395.14	3.3	1561.6
1/15/08	4	1396	3.29	1399.29	3.0	1564.7
1/16/08	4	1400	3.14	1403.14	3.0	1567.6
1/17/08	4	1404	2.67	1406.67	2.7	1570.3
1/18/08	4	1408	2.67	1410.67	2.8	1573.1
1/19/08	4	1412	2.98	1414.98	3.0	1576.1
1/20/08	4	1416	2.67	1418.67	2.9	1579.0
1/21/08	3	1419	2.67	1421.67	2.9	1581.9
1/22/08	3	1422	2.67	1424.67	2.7	1584.6
1/23/08	3	1425	2.82	1427.82	2.7	1587.3
1/24/08	3	1428	2.67	1430.67	2.9	1590.2
1/25/08	3	1431	2.82	1433.82	2.8	1593.0
1/26/08	2	1433	2.67	1435.67	2.8	1595.8
1/27/08	3	1436	2.19	1438.19	2.4	1598.3
1/28/08	2	1438	1.56	1439.56	1.7	1599.9
1/29/08	2	1440	1.88	1441.88	2.0	1601.9
1/30/08	2	1442	2.35	1444.35	2.1	1604.0
1/31/08	2	1444	2.51	1446.51	2.6	1606.6
2/1/08	2	1446	2.35	1448.35	2.3	1608.8
2/2/08	2	1448	2.03	1450.03	2.2	1611.0
2/3/08	2	1450	2.35	1452.35	2.2	1613.2
2/4/08	2	1452	2.67	1454.67	2.5	1615.7
2/5/08	2	1454	1.88	1455.88	2.1	1617.8
2/6/08	2	1456	2.19	1458.19	2.2	1620.0
2/7/08	2	1458	2.19	1460.19	2.1	1622.0
2/8/08	2	1460	2.35	1462.35	2.4	1624.4
2/9/08	3	1463	2.03	1465.03	2.4	1626.8
2/10/08	3	1466	2.35	1468.35	2.3	1629.1
2/11/08	3	1469	2.51	1471.51	2.4	1631.5
2/12/08	3	1472	2.51	1474.51	2.3	1633.8
2/13/08	3	1475	2.51	1477.51	2.6	1636.3
2/14/08	3	1478	2.51	1480.51	2.4	1638.7
2/15/08	3	1481	2.67	1483.67	2.6	1641.3
2/16/08	3	1484	2.51	1486.51	2.6	1643.9
2/17/08	3	1487	2.67	1489.67	2.8	1646.6
2/18/08	3	1490	2.82	1492.82	2.8	1649.4
2/19/08	4	1494	2.98	1496.98	3.0	1652.5
2/20/08	4	1498	3.29	1501.29	3.3	1655.7
2/21/08	4	1502	3.29	1505.29	3.3	1659.0
2/22/08	4	1506	3.29	1509.29	3.3	1662.4
2/23/08	4	1510	3.29	1513.29	3.3	1665.7
2/24/08	3	1513	3.29	1516.29	3.3	1669.0
2/25/08	3.5	1516.5	3.61	1520.11	3.5	1672.6
2/26/08	4	1520.5	3.29	1523.79	3.5	1676.1
2/27/08	4	1524.5	3.45	1527.95	3.3	1679.4
2/28/08	4	1528.5	3.45	1531.95	3.5	1683.0
2/29/08	4	1532.5	3.29	1535.79	3.5	1686.4

3/1/08	4	1536.5	3.29	1539.79	3.3	1689.7
3/2/08	4	1540.5	3.29	1543.79	3.4	1693.2
3/3/08	4	1544.5	3.61	1548.11	3.5	1696.7
3/4/08	4	1548.5	3.45	1551.95	3.6	1700.2
3/5/08	4	1552.5	3.61	1556.11	3.6	1703.8
3/6/08	4.5	1557	3.77	1560.77	3.9	1707.7
3/7/08	4.5	1561.5	3.77	1565.27	3.9	1711.5
3/8/08	4.5	1566	3.77	1569.77	3.8	1715.3
3/9/08	4.5	1570.5	3.77	1574.27	3.9	1719.2
3/10/08	4.5	1575	3.92	1578.92	4.0	1723.1
3/11/08	5	1580	3.61	1583.61	4.0	1727.1
3/12/08	4	1584	3.77	1587.77	3.7	1730.9
3/13/08	4	1588	3.77	1591.77	3.9	1734.7
3/14/08	4.5	1592.5	3.92	1596.42	3.9	1738.7
3/15/08	4	1596.5	3.45	1599.95	3.7	1742.4
3/16/08	4	1600.5	3.45	1603.95	3.5	1745.9
3/17/08	4.5	1605	3.61	1608.61	3.7	1749.6
3/18/08	4	1609	3.61	1612.61	3.7	1753.3
3/19/08	4	1613	3.45	1616.45	3.6	1756.9
3/20/08	4	1617	3.29	1620.29	3.5	1760.4
3/21/08	4	1621	3.61	1624.61	3.6	1764.0
3/22/08	4	1625	3.77	1628.77	3.8	1767.7
3/23/08	4	1629	3.45	1632.45	3.6	1771.3
3/24/08	4	1633	3.45	1636.45	3.6	1774.9
3/25/08	4	1637	3.29	1640.29	3.5	1778.4
3/26/08	3	1640	3.45	1643.45	3.5	1781.9
3/27/08	3	1643	3.45	1646.45	3.5	1785.4
3/28/08	2.5	1645.5	3.45	1648.95	3.5	1789.0
3/29/08	3	1648.5	3.45	1651.95	3.6	1792.5
3/30/08	3	1651.5	3.45	1654.95	3.5	1796.1
3/31/08	3	1654.5	3.61	1658.11	3.5	1799.6
4/1/08	3	1657.5	3.77	1661.27	3.8	1803.4
4/2/08	4	1661.5	3.77	1665.27	3.8	1807.3
4/3/08	4	1665.5	3.77	1669.27	4.0	1811.2
4/4/08	4	1669.5	3.92	1673.42	4.1	1815.3
4/5/08	4	1673.5	3.92	1677.42	4.1	1819.4
4/6/08	4	1677.5	3.92	1681.42	4.2	1823.6
4/7/08	4.5	1682	3.61	1685.61	3.8	1827.4

Table 7 Readouts from Temperature Tidbits in Kumealon and Oona River and the Accumulated Thermal Units (ATU's)