Eagle Sonar 2007

Progress Report for the Sonar Site at Six Mile Bend

Prepared for:
Yukon River Panel
Restoration and Enhancement Fund
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Table of Contents

Figures:

Abstract

The technical and operational status of the Eagle Sonar Project is examined in the context of a progress report. The general observation is made that the project is maturing and methodologies are becoming more stable. Several current technical issues are discussed and in some cases changes are suggested. In particular, attaching attitude sensors to the sonar transducers is strongly recommended. Staff composition at the site is evolving and season-to-season continuity of DFO staff is recommended so far as that is possible.

Introduction

This year the Eagle Sonar project completed its third season of enumerating Chinook salmon and second season of enumerating chum salmon passage on the Yukon River at Six-Mile Bend. Experience accumulated by staff during the three seasons of operation has resulted in the initially experimental nature of the project becoming a more mature program of effective data collection, management and analysis routines. Despite the general trend toward more standardized operation, new methods, and changes to existing ones are still being explored. The more important of these are documented in this report.

A very important change in 2007 was the participation of DFO staff in the daily operation of the sonar project throughout the field season. These people were well suited to the job and their assistance was appreciated by ADF&G staff. Further involvement by DFO staff and in particular, continuity of individuals from year to year is strongly encouraged.

Several technical issues are discussed. Most important is the need for attitude sensors to be attached to the sonar transducers. This issue came to light this season due, in part, to unusually high turbidity causing reduced sonar sensitivity. This made the job of aiming the transducer more difficult than usual. Attitude sensors would alleviate much of the problem.

Technical Topics

Need for Electronic Attitude Sensors on Sonar Transducers

During the 2007 season it became apparent that aiming the sonar transducers to achieve maximum fish detection could be challenging at times. This is largely due to the remoteness of the operator from the transducer itself. It is easy for an operator to become confused during aiming since a mis-aimed transducer pointing at the surface often results in an echogram which appears reasonable to the eye. Without a sensor to display the actual orientation of the transducer the operator relies on a subjective assessment of the aim by inspecting the echogram visually.

On the left bank at Eagle the operator adjusts the vertical and horizontal angles of the transducer remotely with a switch which controls a rotator supporting the transducer. The rotator controller has readouts which display the relative vertical and horizontal angles of the rotator. Unfortunately, it is difficult to compare the relative position given by the readout to reality since the zero-point changes every time the transducer tripod is moved. Changing river levels often make these moves necessary daily.

On the right bank a technician standing next to the transducer adjusts the aim using a crank mechanism attached to the tripod supporting the transducer. Another technician watching the sonar display communicates with the individual at the transducer by two-way radio. Aiming is achieved by incremental adjustments requested by the technician watching the display and communicated to the other at the transducer. As with the left bank, the adjustments are relative to a zero-point unavailable to the technician making the aiming decisions. The sonar image is the only criterion to judge aim quality.

In the past, ad hoc fixes to this problem have been tried such as attaching a stick to the rotator perpendicular to the face of the transducer and extending above the water surface. However, an additional technician is required to observe the stick angle during aiming and angles are not reproducible since the stick is not calibrated. As well the stick is difficult to see at night.

A good solution for this problem is to install waterproof electronic pan, tilt and roll sensors on the transducers with readouts visible to the technician making the aiming decisions. The technology is readily available and has been used at several sonar sites including the Qualark site on the Fraser River (Enzenhofer and Cronkite 2000). These sensors can give tilt angles relative to a true horizontal zero, roll relative to an upright zero and pan relative to compass angle. With this information at hand the true orientation of the transducer is available to the technician making aiming decisions. For instance, a positive tilt angle should immediately alert the technician that the transducer is aimed toward the surface and needs adjusting downward. Also, roll angle can be used to get a sense of how level the footing of the tripod is after it has been moved. This can be important if the tripod is mostly or fully submerged.

It is likely that the DIDSON sonar can be retro-fitted with an internal sensor since it is an option on the newer units.

Effect of Silt Load on Sonar Range

On two occasions during the 2007 field season the river level rose with an associated large increase in turbidity and change in water colour. Although no sediment load data are available for this time period, an individual who has lived on the river near Eagle since 1983 noted that this was the highest turbidity he had observed over that time (Pers. Comm. to ADF&G from Gaetan Baudet). During each of the two high turbidity events, both the split-beam sonar on the left bank and the imaging sonar on the right bank of the river had their maximum range of operation reduced by fifty percent or more. In the case of the DIDSON imaging sonar, in high frequency mode, the signal was completely obscured.

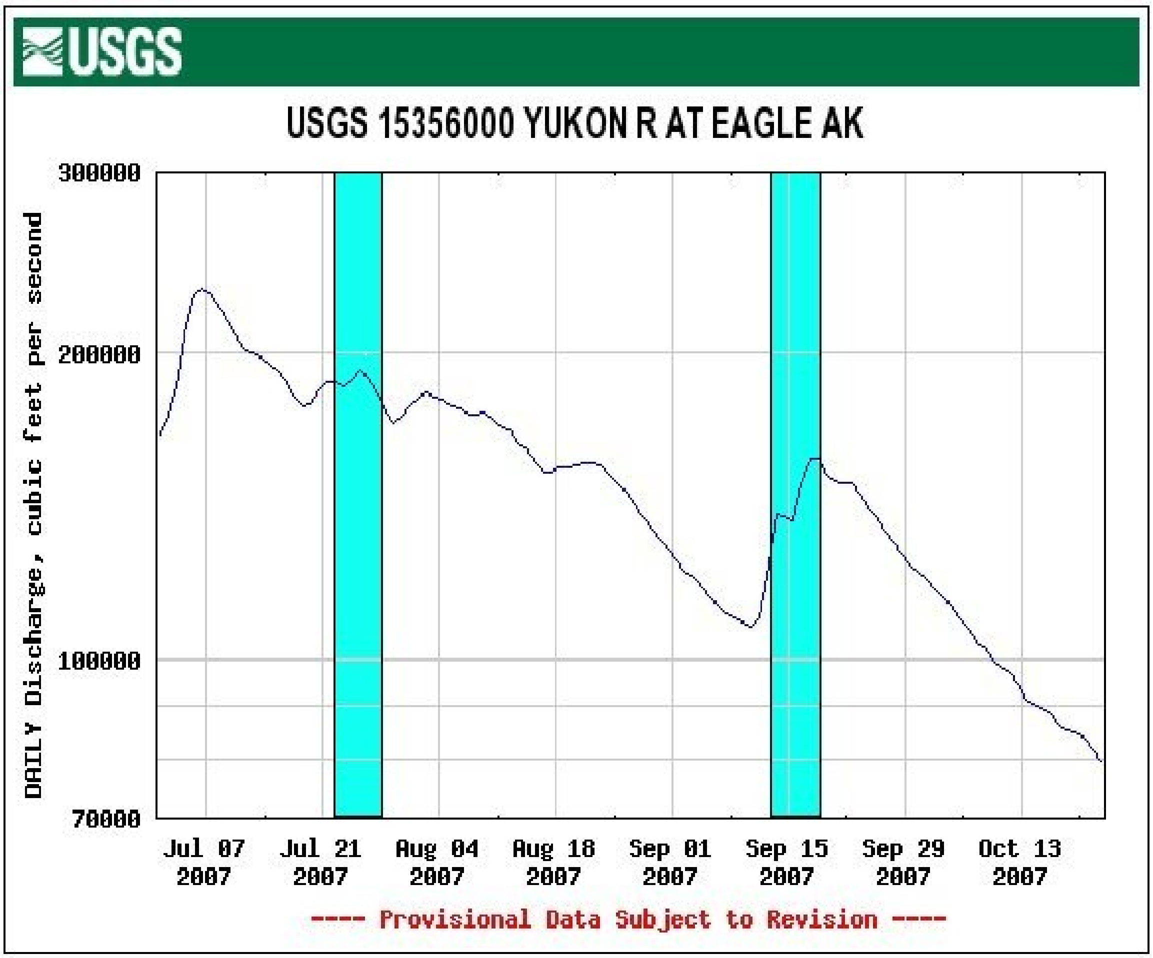

Figure 1. Plot of Yukon River Discharge at Eagle in 2007 from USGS website. (Blue highlights added by author)

Figure 1 shows the Yukon River discharge in CFS at Eagle for the period in 2007 during which the sonar was operating. The plot is available from the U.S. Geological Survey website (http://waterdata.usgs.gov/nwis/). The blue highlighted bars (added by me) show the approximate time periods during which sonar performance was degraded. It is evident that degraded sonar performance is coincident with increasing discharge, however degradation does not occur in every case of increased discharge. This suggests the sonar-critical turbidity may be associated with one or more particular tributaries upstream which were not involved in the other cases of elevated discharge at Eagle. See Appendix II for a table of daily discharge values.

Near-Shore Test Fishing

In previous years, the on-shore test fishing referred to as the "beach walk" has been done using nets the same length and depth as those used for the offshore test fishing. Due to their depth (5 fathoms), when deployed in shallow water, these nets are subject to considerable snagging and downstream billowing. Although difficult to measure, it is hard to imagine these nets fish with the same level of efficiency on-shore as they do during the off-shore drifts in deeper water. In 2007 shallower (~1.25 fathom) nets were used for the near-shore test fishing. The fishing crew reported that this resulted in fewer snags and that the hauls were generally more effective.

The intention for next season is to have shallower nets made specifically for the beach walk (pers. comm. Roger Dunbar). These nets will be shallow and may be tapered in depth so that they fit the profile of the river bottom in an optimal manner. This is an important modification to the test fishing strategy since the on-shore fishing is much more sensitive to the presence of chum salmon than are the near-shore and off-shore drifts. The efficiency of the on-shore fishing directly effects the Chinook count cut-off date which is based on the relative numbers of Chinook versus chum salmon caught in the test fishery overall.

See Appendix I for daily test fish catches. These include only the morning catch which was used to estimate species composition. Further test fishing was carried out on and beyond the sonar site for age, sex and length data as well as other samples such as DNA.

Side-by-Side Split-Beam Imaging Sonar Comparison on Left Bank

Side-by-side data collection with the DIDSON imaging sonar on the left bank adjacent to the split-beam sonar was begun in the 2006 season to monitor non-salmon fish passage. The program was continued in 2007 from August 1 to 9. Transducer deployment and operation were similar to those used in 2006 (Withler 2006). The most significant difference in 2007 was that only the range from 0 to 20 m. from the DIDSON transducer was sampled whereas in 2006 both 0 - 20 m. and 20 - 40 m. ranges were sampled. The reduced sampling range reflects findings from a review of the 2006 data that showed no non-salmon species detected in the 20 - 40 m. sampling window. This observation is also supported by test fish catches. Therefore, rather than switching between the two modes on the half hour as in 2006, in 2007 the sonar sampled in the 0 - 20 m. mode for the full hour.

Since the analysis of the 2006 data was incomplete, during the 2007 field season personnel reviewed 2006 data as time permitted. Three hours were chosen randomly from each day's data and targets were visually classified as salmon or non-salmon. Observations of non-salmon on the imaging sonar were then checked against the split-beam data file for the same time period to determine whether the target had been detected by the split-beam and if so, how it had been originally classified based on the split-beam data. The full analysis of the 2006 data remains to be completed and is ongoing.

The 2007 data collection period was shorter (Aug. 1 - 9) than planned due to equipment problems that delayed startup. Sampling coincided with the period of low salmon passage between the Chinook and chum runs. It has been reviewed in a preliminary fashion but will likely not be fully analyzed until after the 2006 data analysis is complete. The review so far indicates that rates of non-salmon passage were very low during this period.

Since the preliminary analysis done at the end of the 2006 season which estimated a mis-classification (non-salmon counted as salmon) rate close to 4%, ongoing analysis of the data indicates this estimate may be slightly high (pers.comm. Anne Crane ADF&G).

The analysis of the side-by-side data has proceeded slowly because it is laborious and for the most part relegated to the off-season when many personnel are laid off and other tasks take priority. Finishing this analysis may require funds to be allocated so that staff can be hired specifically to process this data and tabulate the results. Suitable personnel for the task would be either DFO or ADF&G staff who work at the sonar site during the field season and, due to their temporary employment status, are available during the off-season. Most of these people are already familiar with the sonar and how to operate the necessary software.

Target Detection Experiment

In 2006 Roger Dunbar and I attempted to map the left bank sonar beam by drifting an acoustic target suspended from a wooden float through the beam while recording the result with the split-beam sonar. This effort proved inconclusive due to inexplicable results. In particular, at a given range, the target might be detectable near the surface and near the bottom but not in between. We were unable to explain this type of result except that we were using a non-uniformly shaped (moderately corrugated in fact) plastic bottle filled with pebbles as a target and surmised that it might only be intermittently visible to the sonar as it bobbed and rotated in the current.

For the 2007 field season I obtained three acoustic targets from Hermann Enzenhofer (DFO) to use at Eagle. The targets are hollow plastic balls roughly 10 cm in diameter. The target strength of these balls has been measured to be -31 dB, approximately the same as an adult sockeye salmon (Enzenhofer and Cronkite 2000). This type of target has two advantages for use in beam mapping experiments. One is that they have a known target strength and two, most important in this case, due to their spherical shape they are uniformly visible from any direction. Therefore rolling, pitching and yawing of the target as it is buffeted by the current has little effect on it's visibility to the sonar.

Unfortunately, the beam mapping work was delayed by higher priority activities and once begun, drifting was hampered by strong winds. As a result the amount of effort applied to this work in 2007 was limited. However one afternoon was devoted to these measurements and the target was successfully drifted through the beam seven times. Ranges from the transducer varied from 35 meters out to 68.5 meters. Drifts were done at 1 and 2.5 meters depth. The target was visible to the sonar in all drifts except one at a range of 60 meters and one meter depth. However in a different drift at 61.5 meters and 1 meter depth it was detected.

Despite the relatively few drifts, the rate of detection of the target was high, much better than the attempt in 2006. This suggests that the quality of the target is very important for this type of measurement.

Operational Topics

Participation of DFO Personnel

DFO staff participated in the operation of the Eagle sonar site for the full 2007 field season. Jake Duncan and Ben Snow took turns working as on-site technicians over the entire season and Rick Ferguson participated for a two week period. These people were well suited to the job and their assistance was appreciated by ADF&G staff. Further involvement by DFO staff and in particular, continuity of individuals from year to year is strongly encouraged by ADF&G. During the season they were involved in most of the tasks associated with operating the site. Most importantly, they were involved with sonar operation, test fishing, and data management and analysis on a daily basis. Hands-on experience with these procedures helps to fully understand the strengths and weaknesses of the sonar-based counting procedure and ultimately to judge the degree of confidence one can have in the numbers generated.

As much as possible, the continuity of DFO staff from one season to the next is desirable both to maintain a core group of expert sonar users in DFO and to reduce the burden of training new staff at Eagle. During training, new staff require heavy supervision which increases the workload for everyone else and reduces the number of ancillary tasks which can be undertaken such as data quality monitoring.

Summary and Results

Chinook Count Cutoff Date

The cutoff date is the last day on which sonar passage is enumerated as Chinook salmon. To determine how the sonar counts will be assigned to the respective Chinook and chum salmon tallies, this date is chosen to fall in the period between the two runs such that the number of Chinook salmon mis-classified as chum after the cutoff date will be roughly equal to the number of chum mis-classified as Chinook before the cutoff date.

The 2007 cutoff date was decided by comparing cumulative test fishing catches of Chinook and chum salmon. On a graph, negative cumulative Chinook catch is plotted by day as the total Chinook catch to date subtracted from the Chinook catch for the entire season. This produces a descending line from the date of first Chinook capture in the test fishery to the last date on which one was caught. A second line is plotted showing the cumulative chum salmon catch by day which is an increasing line from the date of first chum capture to the last day of chum capture in the test fishery. The two lines cross on the date when the cumulative number of chum caught equals the number of Chinook caught subsequent to that date. See Figure 2 below.

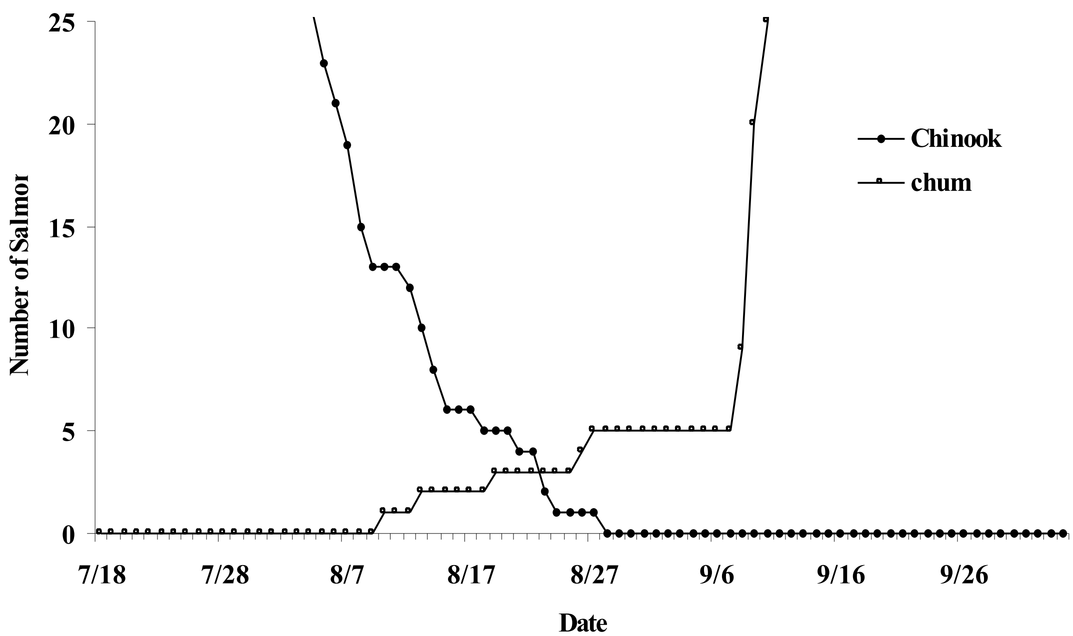

Figure 2. Plot of Negative Cumulative Chinook Capture and Cumulative Chum Capture in the Eagle Sonar Test Fishery. (source ADF&G).

If the efficiency of fishing for the two species of salmon is roughly equal then the above method should identify a date on which sonar counts can start being accumulated as chum salmon rather than Chinook with a minimum error due to species mis-classification. However, as discussed in last years report (Withler 2006), mis-classification rates are relatively insensitive to cutoff date selection.

A table of daily test fishing catches is included in Appendix I and daily sonar counts are tabulated in Appendix III.

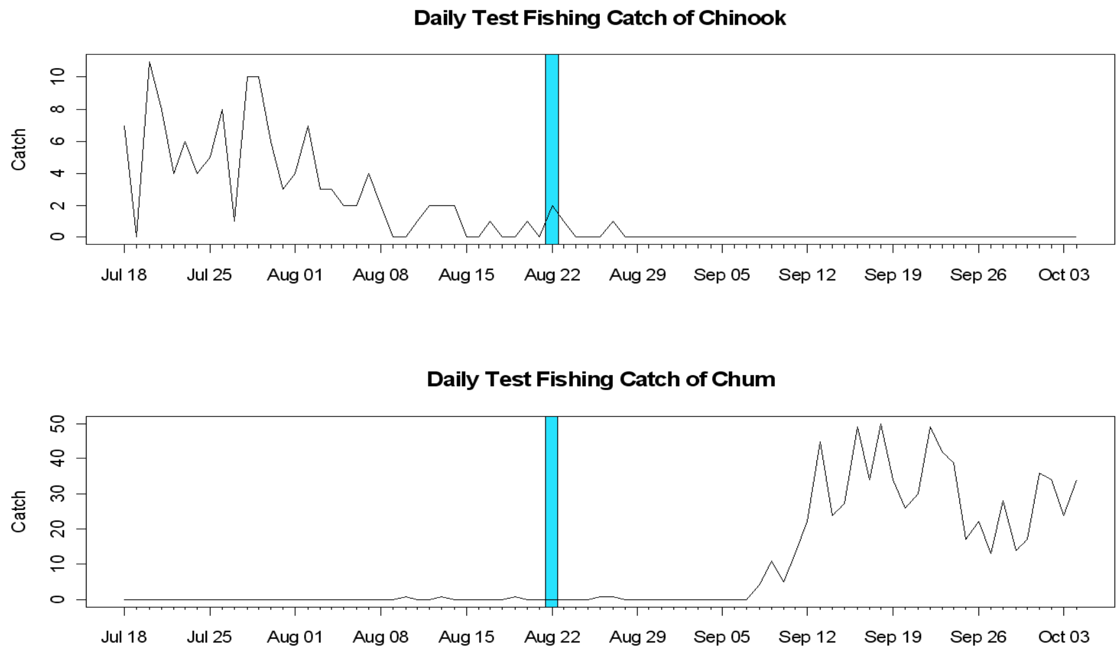

Figure 3. Test Fishing Catch by Species showing Cutoff Date.

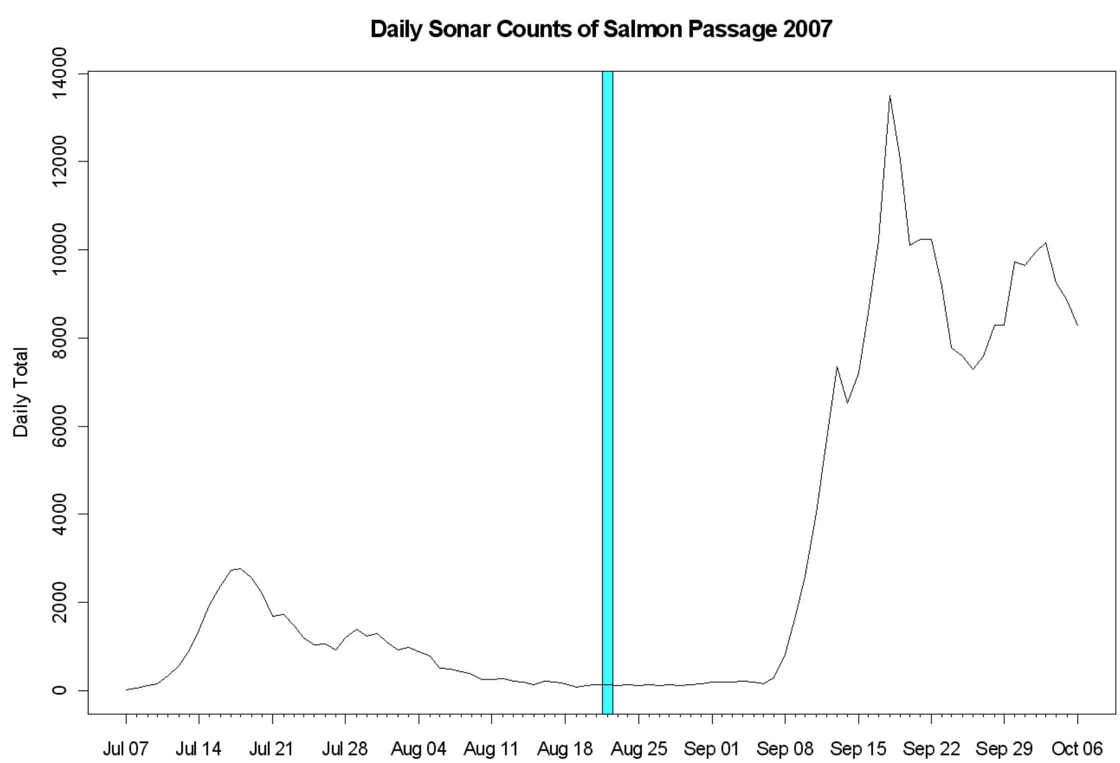

Figure 4. Salmon Passage Estimate from Sonar Count with Cutoff Date.

Acknowledgments

Alaska Department of Fish and Game staff were very supportive of my participation at the Eagle sonar site during both visits in 2007. Ann Crane, Roger Dunbar and Carl Pfisterer made sure I had access to all relevant aspects of the operation and vehicles and boats when needed. It is a pleasure to work with ADF&G staff. My work would not be possible without their assistance. Canadian technicians Jake Duncan and Ben Snow were both pleasant to work with and expressed useful suggestions and points of view.

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Appendix I. Daily Test Fishing Catch – Morning Only

Date	Chinook	Chum
18-Jul	7	0
19-Jul	0	0
20-Jul	11	0
21-Jul	8	0
22-Jul	4	0
23-Jul	6	0
24-Jul	4	0
25-Jul	5	0
26-Jul	8	0
27-Jul	1	0
28-Jul	10	0
29-Jul	10	0
30-Jul	6	0
31-Jul	3	0
1-Aug	4	0
2-Aug	7	0
3-Aug	3	0
4-Aug	3	0
5-Aug	2	0
6-Aug	2	0
7-Aug	4	0
8-Aug	2	0
9-Aug	0	0
10-Aug	0	1
11-Aug	1	0
12-Aug	2	0
13-Aug	2	1
14-Aug	2	0
15-Aug	0	0
16-Aug	0	0
17-Aug	1	0
18-Aug	0	0
19-Aug	0	1
20-Aug	1	0
21-Aug	0	0
22-Aug	2	0
23-Aug	1	0
24-Aug	0	0
25-Aug	0	0
26-Aug	0	1
27-Aug	1	1

Date	Chinook	Chum
28-Aug	0	0
29-Aug	0	0
30-Aug	0	0
31-Aug	0	0
1-Sep	0	0
2-Sep	0	0
3-Sep	0	0
4-Sep	0	0
5-Sep	0	0
6-Sep	0	0
7-Sep	0	0
8-Sep	0	4
9-Sep	0	11
10-Sep	0	5
11-Sep	0	13
12-Sep	0	22
13-Sep	0	45
14-Sep	0	24
15-Sep	0	27
16-Sep	0	49
17-Sep	0	34
18-Sep	0	50
19-Sep	0	34
20-Sep	0	26
21-Sep	0	30
22-Sep	0	49
23-Sep	0	42
24-Sep	0	39
25-Sep	0	17
26-Sep	0	22
27-Sep	0	13
28-Sep	0	28
29-Sep	0	14
30-Sep	0	17
1-Oct	0	36
2-Oct	0	34
3-Oct	0	24
4-Oct	0	34

Appendix II. Yukon River Discharge at Eagle 2007

JULY			AUGUST			SEPTEMBER		
Date 2007	CFS (Mean)	Height (Mean)	Date 2007	CFS (Mean)	Height (Mean)	Date 2007	CFS (Mean)	Height (Mean)
07/01	166,000	16.97	08/01	181,000	17.95	09/01	125,000	14.02
07/02	174,000	17.52	08/02	183,000	18.06	09/02	122,000	13.81
07/03	189,000	18.42	08/03	181,000	17.93	09/03	120,000	13.62
07/04	213,000	19.85	08/04	180,000	17.86	09/04	118,000	13.44
07/05	227,000	20.65	08/05	177,000	17.69	09/05	115,000	13.23
07/06	231,000	20.90	08/06	176,000	17.61	09/06	113,000	13.03
07/07	229,000	20.78	08/07	174,000	17.52	09/07	111,000	12.87
07/08	221,000	20.30	08/08	174,000	17.50	09/08	110,000	12.78
07/09	215,000	20.00	08/09	175,000	17.59	09/09	109,000	12.72
07/10	208,000	19.59	08/10	171,000	17.31	09/10	108,000	12.66
07/11	202,000	19.26	08/11	169,000	17.18	09/11	110,000	12.84
07/12	200,000	19.09	08/12	168,000	17.10	09/12	121,000	13.67
07/13	198,000	18.98	08/13	163,000	16.78	09/13	139,000	15.11
07/14	195,000	18.82	08/14	161,000	16.67	09/14	138,000	15.04
07/15	192,000	18.62	08/15	156,000	16.29	09/15	137,000	14.96
07/16	188,000	18.41	08/16	153,000	16.11	09/16	148,000	15.75
07/17	182,000	18.02	08/17	153,000	16.11	09/17	157,000	16.38
07/18	177,000	17.71	08/18	154,000	16.18	09/18	157,000	16.39
07/19	178,000	17.77	08/19	154,000	16.17	09/19	152,000	16.03
07/20	184,000	18.14	08/20	155,000	16.22	09/20	150,000	15.88
07/21	187,000	18.34	08/21	156,000	16.33	09/21	149,000	15.82
07/22	187,000	18.33	08/22	156,000	16.33	09/22	149,000	15.80
07/23	185,000	18.18	08/23	155,000	16.25	09/23	145,000	15.56
07/24	188,000	18.36	08/24	152,000	16.01	09/24	141,000	15.25
07/25	192,000	18.60	08/25	148,000	15.76	09/25	138,000	15.00
07/26	189,000	18.46	08/26	146,000	15.57	09/26	134,000	14.75
07/27	182,000	18.04	08/27	142,000	15.29	09/27	130,000	14.45
07/28	175,000	17.58	08/28	138,000	15.04	09/28	127,000	14.15
07/29	170,000	17.26	08/29	134,000	14.75	09/29	124,000	13.93
07/30	173,000	17.44	08/30	131,000	14.52	09/30	122,000	13.79
07/31	177,000	17.70	08/31	128,000	14.29			

Data from USGS website: http://waterdata.usgs.gov/nwis/

Appendix III.   Daily Sonar Counts at Eagle Sonar 2007

Date	Left	Right	Total	Cumulative
7/07	2	32	34	34
7/08	9	48	57	91
7/09	34	75	109	200
7/10	48	128	176	376
7/11	117	218	335	711
7/12	280	302	582	1293
7/13	530	422	952	2245
7/14	886	501	1387	3632
7/15	1197	752	1949	5581
7/16	1392	1000	2392	7973
7/17	1837	915	2752	10725
7/18	1768	1008	2776	13501
7/19	2006	562	2568	16069
7/20	1640	564	2204	18273
7/21	1327	375	1702	19975
7/22	1186	540	1726	21701
7/23	900	578	1478	23179
7/24	818	387	1205	24384
7/25	748	310	1058	25442
7/26	853	234	1087	26529
7/27	734	200	934	27463
7/28	927	276	1203	28666
7/29	1159	258	1417	30083
7/30	1015	236	1251	31334
7/31	1102	194	1296	32630
8/01	904	194	1098	33728
8/02	746	206	952	34680
8/03	783	200	983	35663
8/04	645	235	880	36543
8/05	572	226	798	37341
8/06	410	130	540	37881
8/07	373	117	490	38371
8/08	379	72	451	38822
8/09	310	80	390	39212
8/10	213	38	251	39463
8/11	224	40	264	39727
8/12	245	42	287	40014
8/13	200	20	220	40234
8/14	194	16	210	40444
8/15	123	16	139	40583
8/16	208	29	237	40820
8/17	187	20	207	41027

Date	Left	Right	Total	Cumulative
8/18	138	20	158	41185
8/19	88	12	100	41285
8/20	106	15	121	41406
8/21	139	12	151	41557
8/22	124	16	140	41697
8/23	104	6	110	41807
8/24	117	21	138	41945
8/25	110	20	130	42075
8/26	128	14	142	42217
8/27	112	14	126	42343
8/28	132	22	154	42497
8/29	118	6	124	42621
8/30	132	16	148	42769
8/31	150	13	163	42932
9/1	176	18	194	43126
9/2	182	22	204	43330
9/3	182	16	198	43528
9/4	223	8	231	43759
9/5	187	18	205	43964
9/6	141	38	179	44143
9/7	255	46	301	44444
9/8	722	112	834	45278
9/9	1446	272	1718	46996
9/10	1949	670	2619	49615
9/11	3290	740	4030	53645
9/12	4940	780	5720	59365
9/13	6582	774	7356	66721
9/14	6237	282	6519	73240
9/15	6926	290	7216	80456
9/16	7953	633	8586	89042
9/17	9677	566	10243	99285
9/18	12939	580	13519	112804
9/19	11510	560	12070	124874
9/20	9334	786	10120	134994
9/21	8771	1484	10255	145249
9/22	6930	3322	10252	155501
9/23	5970	3230	9200	164701
9/24	4904	2880	7784	172485
9/25	3935	3657	7592	180077
9/26	3377	3932	7309	187386
9/27	3607	3988	7595	194981
9/28	3981	4336	8317	203298
9/29	3528	4778	8306	211604
9/30	4084	5656	9740	221344
10/1	4198	5444	9642	230986

Date	Left	Right	Total	Cumulative
10/2	4115	5872	9987	240973
10/3	4280	5894	10174	251147
10/4	4918	4352	9270	260417
10/5	4545	4314	8859	269276
10/6	3764	4528	8292	277568

Note: The highlighted date (Aug. 22/07) is the cutoff used in 2007 to demarcate between Chinook and chum counts. All counts up to and including the 22nd were tallied as Chinook and all subsequent counts were tallied as chum.