

Figure 1. Map of the Jordan River watershed (inset) showing incubation and water quality sampling sites in the lower reach.



Jordan River Total Extractable Copper

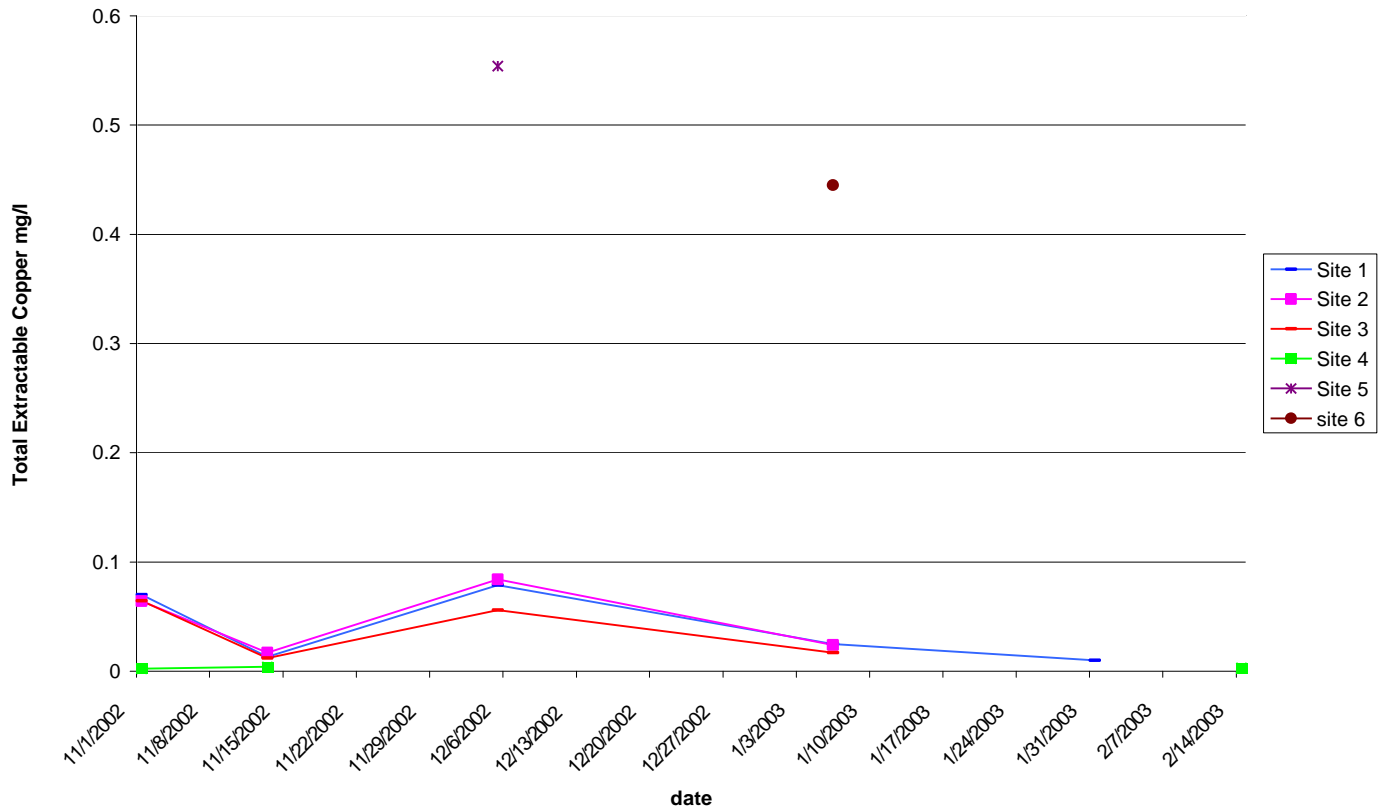


Figure 2. Total extractable copper concentrations in the Jordan River measured during sampling events from November 2002 – February 2003.

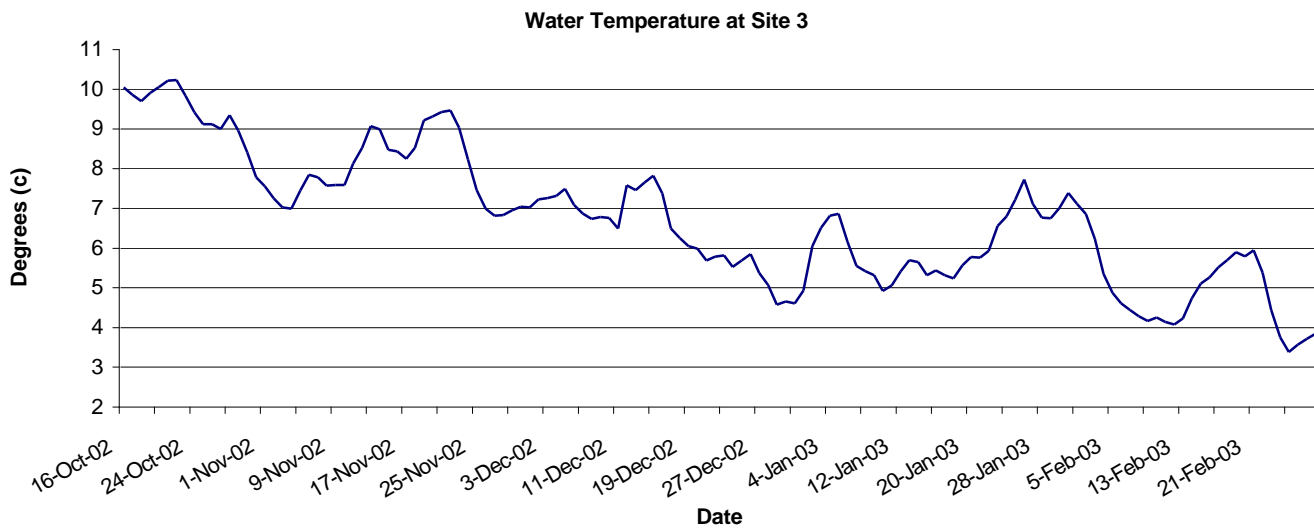
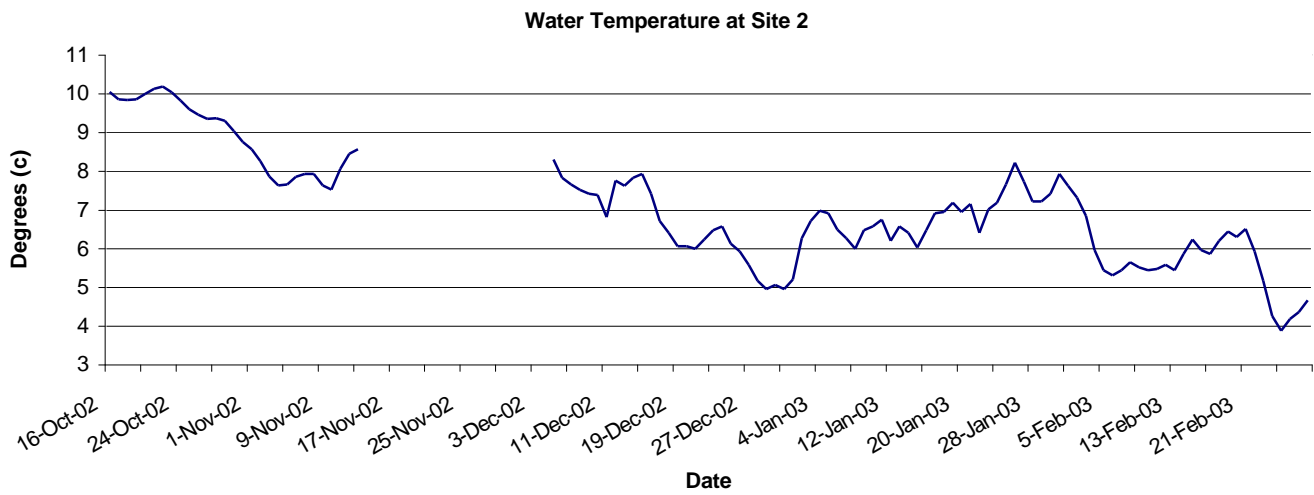
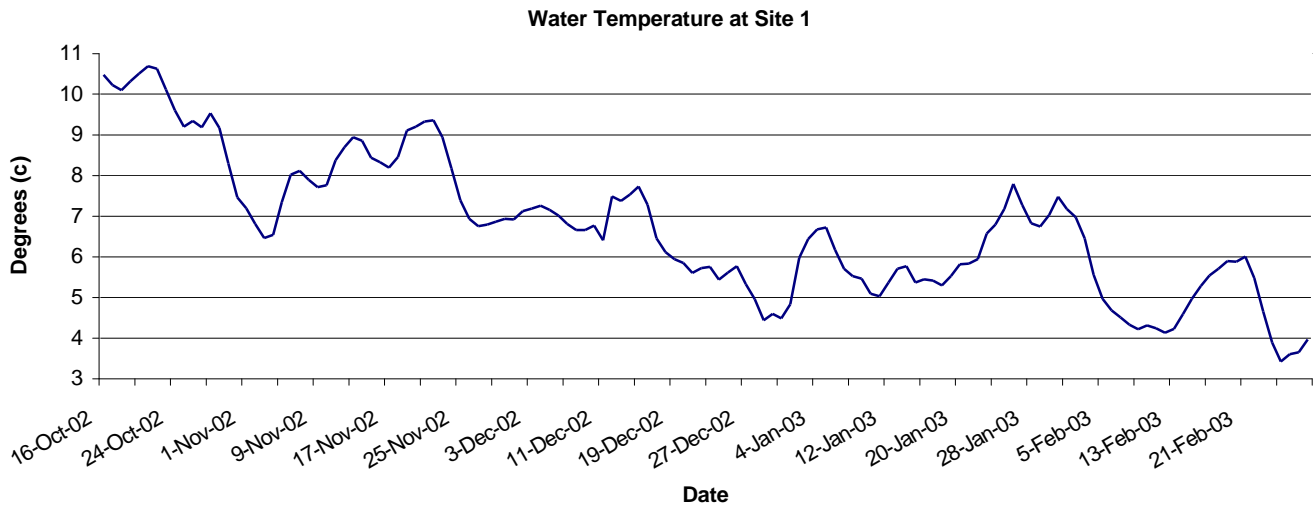


Figure 3. Mean daily water temperature (°C) recorded at three sites on the Jordan River, October 2002 – February 2003.

Jordan River Mean Daily Water Level

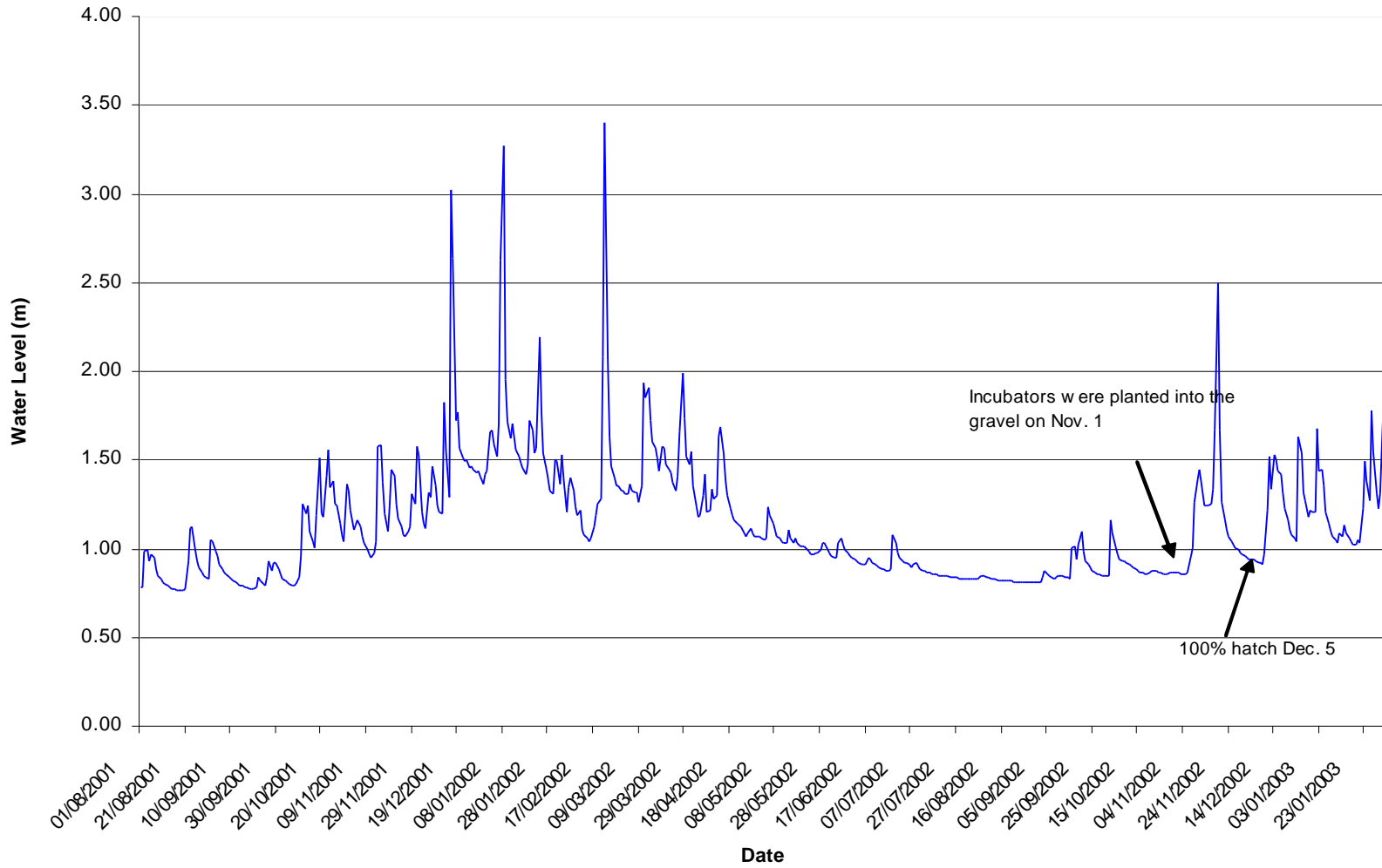


Figure 4. Mean daily water levels recorded at the BC Hydro data logger station, Jordan River, August 2001 – January 2003.

Water levels in Jordan River during the incubation period

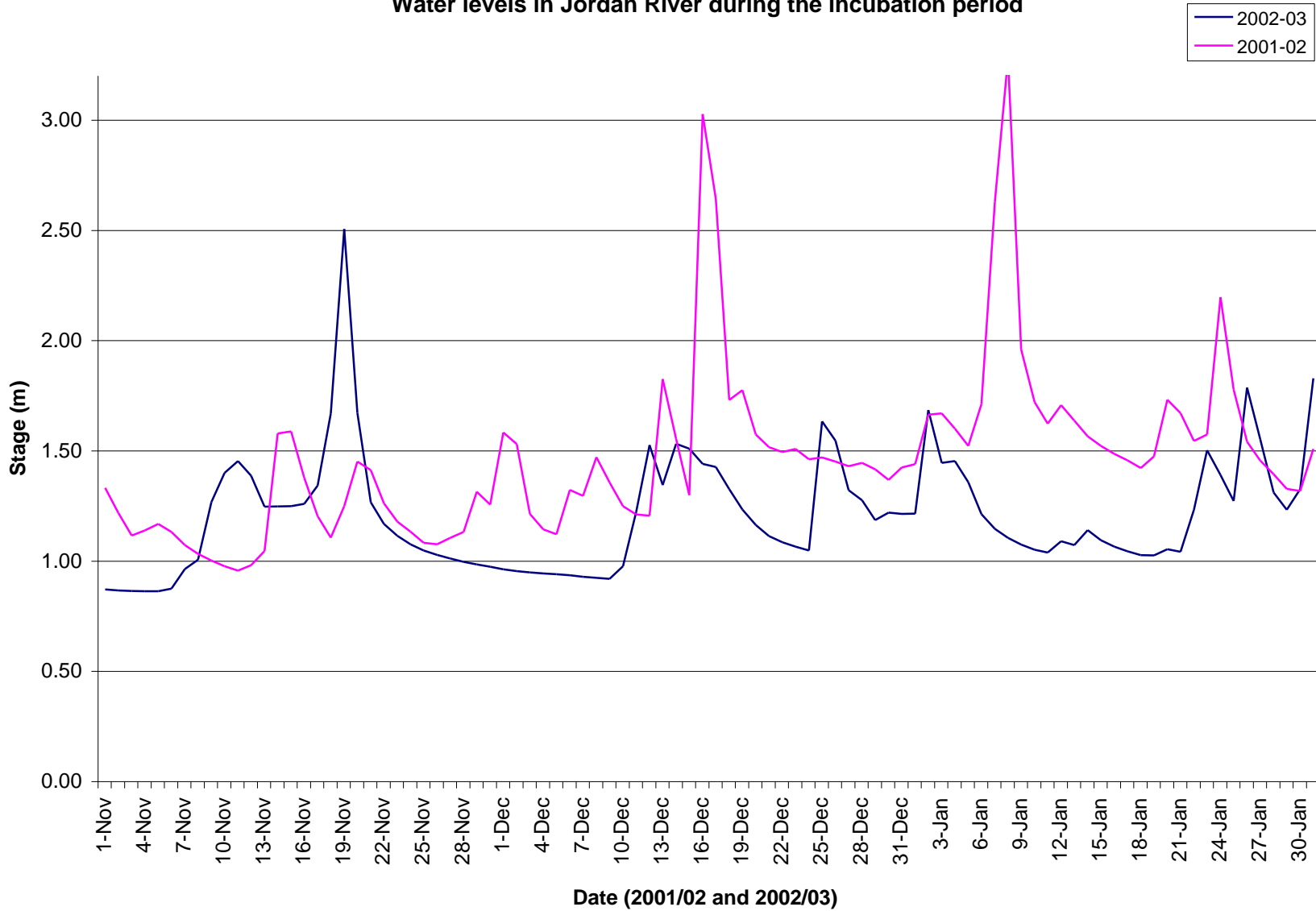


Figure 5. Comparison of water levels in the Jordan River during the pink salmon incubation study (2002/03) to the same period in 2001/02.

Jordan River Pink Salmon Bioassay

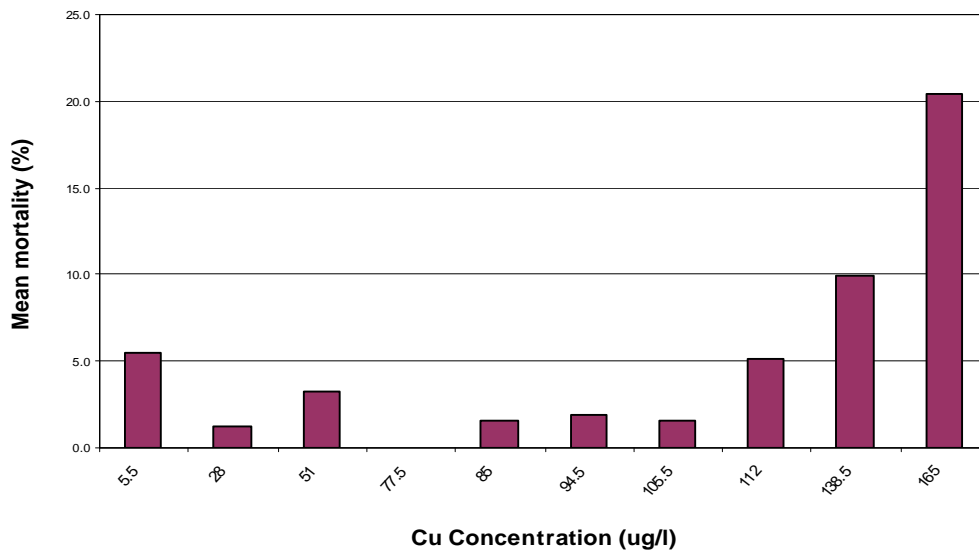


Figure 6. Mean mortality (%) observed for varying copper concentrations used in the Jordan River pink salmon bioassay.

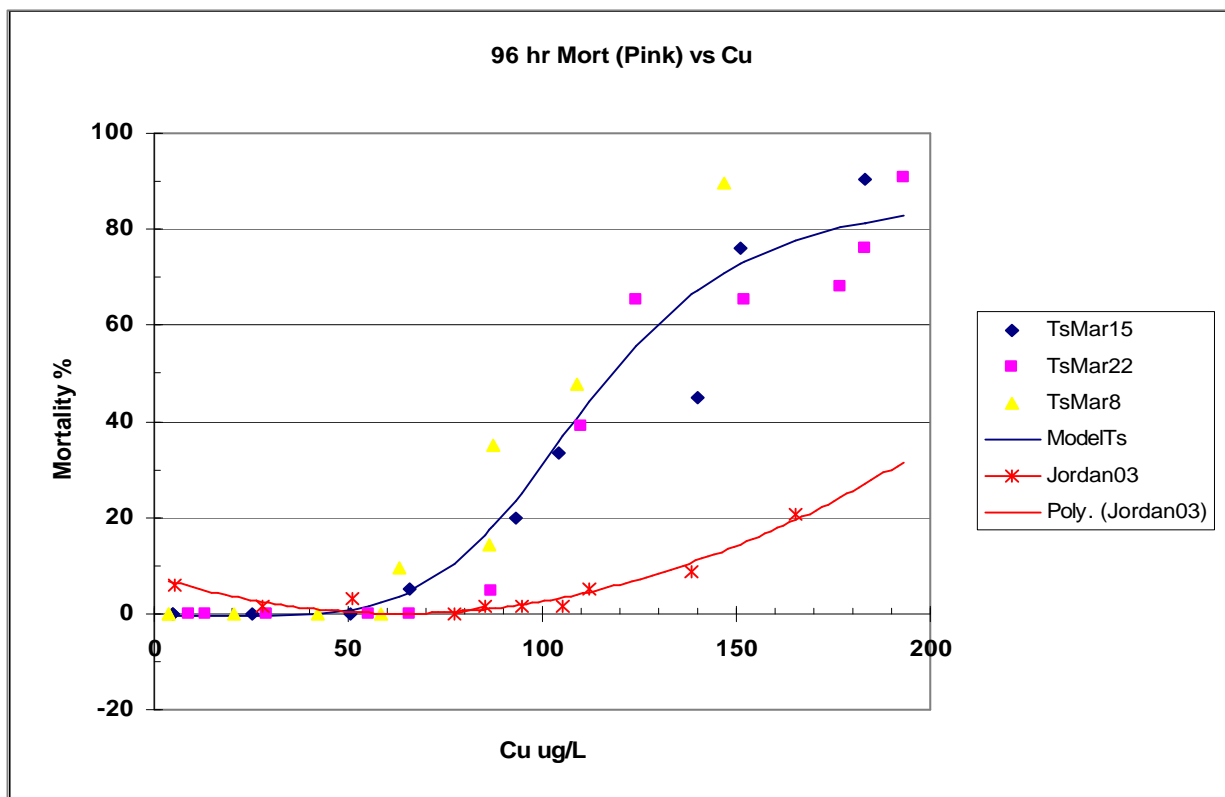


Figure 7. Mortality of pink fry as a function of copper concentration for Tsolum (1999) and Jordan Rivers (2003). The Tsolum least square model is for combined data (Mar. 8, 15, and 22) (Sweeten and McLean, 1999).

Table 1. A summary of egg to fry survival for the Jordan River incubation sites 1, 2 and, 3, 2002 - 2003.

Date Incubators were Planted	Location	Cassette Number	Number of eggs per cassette	Date of removal	Number of dead eggs	Mortality at hatch	Number of dead alevins	Number of dead fry	Total Dead	% Survival	Comments
01-Nov-02	Jordan River Site 1	1	200	11-Feb-03	0	193	0	0	193	3.5	All of the mortality occurred at hatch or a short time after hatch. There was low silt content in the incubation cells. Fungus was noted in 4 of the cells.
		2	200	28-Feb-03	0	73	102	1	176	12	
		3	200	28-Feb-03	0	160	36	0	196	2	Very little silt in the incubation cells.
		4	200	06-Jan-03	0	177	0		177	11.5	This cassette had some silt in the upper left hand cells.
		5	200	11-Feb-03	4	85	64	0	153	23.5	20 fry completely buttoned up. 7 were approximately 1 week from button up and 20 had a slit remaining.
		6	200	31-Jan-03	3	86	40	0	129	35.5	Low silt content in cells in lower half of the cassette. Moderate to low silt content in the upper half of the cassette
01-Nov-02	Jordan River Site 2	1	200	28-Feb-03	180	20	0	0	200	0	No silt
		2	200	28-Feb-03	80	80	40	0	200	0	
		3	198	06-Jan-03	0	157	0		157	20.5	The stage of development was more advanced than Site 1. The mortality would have occurred at or post hatch. This cassette was the one closest to the right bank tributary. There has been high deposition of fines and sand at this location since the incubators were planted.
		4	200	28-Feb-03	80	90	30	0	200	0	Low silt content in the cells. Heavy deposition of silt and sand at this site.
		5	200	14-Feb-03	0	167	3	0	170	15	minor amounts of silt in the incubation cells.
		6	200	14-Feb-03	8	165	4	2	179	10.5	Very little silt in the incubation cells.

Table 1 (cont'd). A summary of egg to fry survival for the Jordan River incubation sites 1, 2 and, 3, 2002 - 2003.

Date Incubators were Planted	Location	Cassette Number	Number of eggs per cassette	Date of removal	Number of dead eggs	Mortality at hatch	Number of dead alevins	Number of dead fry	Total Dead	% Survival	Comments
01-Nov-02	Jordan River Site 3	1	200	14-Feb-03	0	0	11	0	11	94.5	Approximately 50% of the fry were retained and transported to the Pacific Biological Station for a sea water challenge test. The remainder were released into the Jordan River at Site 3. Very little silt in the cassette.
		2	200	06-Jan-03	0	114	0	0	114	43	Very little silt in the incubation cells.
		3	200	14-Feb-03	0	0	2	0	2	99	Approximately 50% of the fry were retained and transported to the Pacific Biological Station for a sea water challenge test. The remainder were released into the Jordan River at Site 3. Very little silt in the cassette.
		4	200	28-Feb-03	0	0	2	0	2	99	On Dec. 5, 2002 this cassette was completely exposed and was found attached to the rebar. The cassette was opened to check the condition of the eggs. All of the eggs had hatched with 99% survival. The cassette was returned to the gravel in a more secure area along the right bank margin. On Feb. 28 the cassette was removed. The fry were >95% buttoned up. Half of the fry were released into the river at Site 3, the remainder were released into the estuary downstream of the highway bridge.
		5	200	28-Feb-03	4	0	0		4	98	On Dec. 5, 2002 this cassette was completely exposed as above. Again, all of the eggs had hatched with 98% survival. The cassette was returned to the gravel in a more secure area along the right bank margin. On Feb. 28 the cassette was removed as above.
		6	200								Cassette was lost during storm pre-Dec. 5, 2002

Table 2. Mean surface and intragravel dissolved oxygen measurements at Sites 1, 2, and 3.

Site number	Mean surface DO (mg/l)	Range	Mean Intragravel DO (mg/l)	Range
1	11.91	11.5 – 12.4	10.85	8.66 – 11.1
2	11.57	11.0 – 12.3	8.25	6.68 – 10.0
3	11.82	11.0 – 12.93	10.99	10.4 – 11.72

Table 3. Mean velocities observed over incubation cassettes at Sites 1, 2 and 3.

Date	Mean Water Level (m)	Site 1 – Mean Velocity m/sec	Site 2 – Mean Velocity m/sec	Site 3 – Mean Velocity m/sec
November 13, 2002	1.24	0.13 range: 0.08 – 0.16	0.063 range: 0.01 – 0.09	0.398 range: 0.26 – 0.52
December 5, 2002	0.94	0.001 range: 0.001 – 0.001	0.001 range: 0.0 – 0.001	0.166 range: 0.001 – 0.26
January 6, 2003	1.21	0.107 range: 0.06 – 0.13	0.037 range: 0.01 – 0.08	0.38 range: 0.04 – 0.68
January 31, 2003	1.82	0.348 range: 0.25 – 0.45	No reading	No reading

Appendix 1. Water quality data collected at Sites 1, 2 and 3, Jordan River, October 2002 - January 2003

Jordan River Site 1										Comments		
Date	unit	Dissolved Oxygen				Hardness (mg/l)	Conductivity 1	Conductivity 2	Temp 1		Temp 2	
		Surface 1	Surface 2	Subsurface 1	Subsurface 2		µS/cm	µS/cm	°C		°C	
16-Oct-02	mg/l						55.8			10.4	Conductivity 1 = Jordan River Site1 Temperature 1 = surface water temp. Temperature 2 = sub-surface water temp.	
	% Sat.											
1-Nov-02	mg/l	11.59		9.5	8.05				7.6	7.8		
	% Sat.	96.5		79.5	67.6							
13-Nov-02	mg/l	11.5		11.1		12	28.3		8.8	9		
	% Sat.	102		97								
5-Dec-02	mg/l	12.01	11.92	8.35	8.97	60			6.75	7.1		Hardness reading should be ignored. Probably a sampling error
	% Sat.	98.5	98	69	74.3							
6-Jan-03	mg/l	12.39	11.83	11.73	9.97	8	25.1		6.2	6.6		
	% Sat.	100	97.6	95.6	81.5							
31-Jan-03	mg/l	12.4		10.9		8	18.9		7.5	8.7		
	% Sat.	103		92								
Jordan Rive Site 2										Conductivity 1 = Jordan River Site 2 Conductivity 2 = Left Bank Trib Site 2 Temperature 1 = surface water temp. Temperature 2 = sub-surface water temp. Water Temp. LB trib = 7.9 C		
Date	unit	Dissolved Oxygen				Hardness (mg/l)	Conductivity 1	Conductivity 2	Temp 1		Temp 2	
		Surface 1	Surface 2	Subsurface 1	Subsurface 2		µS/cm	µS/cm	°C		°C	
16-Oct-02	mg/l						77.3	77.3			10.6	
	% Sat.											
1-Nov-02	mg/l	11.6		9.86	9.36				7.6		8.05	
	% Sat.	97.4		83.4	79.1							
13-Nov-02	mg/l	11		10			28.8	84.8	8.8		9.1	
	% Sat.	96		88								
5-Dec-02	mg/l	11.65		7.87	5.48		46.6	70.4	7.3		8.1	
	% Sat.	96.9		67.2	46.3							
6-Jan-03	mg/l	12.3	11.77	6.73		8	25.7	54.3	6.2		6.8	
	% Sat.	99.2	96	55.7								
Jordan Rive Site 3										Conductivity 1 = Jordan River Site 3 Temperature 1 = surface water temp. Temperature 2 = sub-surface water temp.		
Date	unit	Dissolved Oxygen				Hardness (mg/l)	Conductivity 1	Conductivity 2	Temp 1		Temp 2	
		Surface 1	Surface 2	Subsurface 1	Subsurface 2		µS/cm	µS/cm	°C		°C	
16-Oct-02	mg/l						54.3				10.3	
	% Sat.											
1-Nov-02	mg/l											
	% Sat.											
13-Nov-02	mg/l	11		10.4			29.1		8.7		9	
	% Sat.	95		90								
5-Dec-02	mg/l	11.86	11.87	10.86	10.28		40.5		7.1		7.7	
	% Sat.	97.7	98.2	90.5	86.6							
6-Jan-03	mg/l	12.93	12.26	11.72			25.5		6.2	6.4		
	% Sat.	104.4	100.2	95.2								

Appendix 2. Water velocities recorded at individual incubation cassettes by date and site, 2002 -2003.

Date	Water Level (m)	Site	Flows at individual incubation cassettes (m/s)												Comments	
			C-1 Depth	C-1 Velocity	C-2 Depth	C-2 Velocity	C-3 Depth	C-3 Velocity	C-4 Depth	C-4 Velocity	C-5 Depth	C-5 Velocity	C-6 Depth	C-6 Velocity		
16-Oct-02	0.31															
13-Nov-02	0.66	1	0.75	0.12	0.83	0.08	0.82	0.16	0.63	0.15	0.64	0.1	0.64	0.17		
		2	0.87	0.08	0.7	0.09	0.65	0.03	0.85	0.01	0.79	0.08	0.67	0.09		
		3	0.58	0.45	0.55	0.43	0.54	0.52	0.63	0.26	0.81	0.37	0.78	0.36		
05-Dec-02	0.375	1	0.52	0.001	0.62	0.001	0.55	0.001	0.34	0.001	0.38	0.001	0.44	0.001		
		2	0.57	0	0.52	0	0.4	0	0.47	0	0.31	0	0.31	0		
		3	0.23	0.2	0.18	0	0.25	0.26	0.52	0.2	0.4	0.17	cassette missing			
06-Jan-03	0.65	1	0.72	0.1	0.7	0.09	0.75	0.13	0.63	0.13	0.63	0.06	0.67	0.13	C1-4 removed	
		2	0.75	0.04	0.73	0.04	0.68	0.02	0.72	0.01	0.73	0.03	0.57	0.08	C2-3 removed, C2-4 located behind a boulder	
		3	0.59	0.46	0.5	0.16	0.53	0.68	0.67	0.04	0.53	0.56	cassette missing			
31-Jan-03	1.04	1	1.16	0.35	1.27	0.29	1.2	0.36	0.95	0.45	1.03	0.25	1.04	0.39	C1-6 removed	
		2													Water levels too deep to sample site 2	
		3													Water levels too deep to sample site 3	

Appendix 3. A summary of water samples taken for copper analysis (total extractable and from Sites 1, 2, 3, 4 and 5 in the Jordan River, November 2002 - February 2003.

Date	Site	Total Extractable Cu		Dissolved Cu	
		Surface	Intragravel	Surface	Intragravel
01-Nov-02	1	0.07	0.0615	0.069	0.054
13-Nov-02	1	0.013	0.017	0.012	0.015
05-Dec-02	1	0.079	0.067	-	-
06-Jan-03	1	0.025	0.014	-	-
31-Jan-03	1	0.01	0.013	-	-
01-Nov-02	2	0.064	-	0.0635	-
13-Nov-02	2	0.017	0.035	0.015	0.027
05-Dec-02	2	0.084	0.03	-	-
06-Jan-03	2	0.024	0.015	-	-
31-Jan-03	2	-	-	-	-
01-Nov-02	3	0.0645	-	0.0625	-
13-Nov-02	3	0.012	-	0.011	-
05-Dec-02	3	0.056	-	-	-
06-Jan-03	3	0.017	0.018	-	-
31-Jan-03	3	-	-	-	-
01-Nov-02	4	0.0025	-	0.0025	-
13-Nov-02	4	0.004	-	0.004	-
14-Feb-03	4	0.003	-	-	-
05-Dec-02	5	0.554	-	-	-
06-Jan-03	6	0.445	-	-	-

Appendix 4. Water quality analysis of Jordan River stock water from Site 4 and analysis of water samples spiked with varying concentrations of copper.

Copper Bioassay Analytical Report - Feb. 28, 2003

			Results			
Inorganic Nonmetallic Parameters		Units	Jordan Stock Water	Distilled Water	# 9	Detection Limit
Phosphate	as P	mg/l	<0.05	<0.05	<0.05	0.05
Metals Extractable						
Silicon		mg/l	2.74	0.09	2.72	0.05
Sulphur		mg/l	0.51	<0.05	0.43	0.05
Mercury		mg/l	<0.0001	<0.0001	<0.0001	0.0001
Aluminum		mg/l	0.073	<0.005	0.078	0.005
Antimony		mg/l	<0.0002	<0.0002	<0.0002	0.0002
Arsenic		mg/l	<0.0002	<0.0002	<0.0002	0.0002
Barium		mg/l	0.003	<0.001	0.005	0.001
Beryllium		mg/l	<0.0001	<0.0001	<0.0001	0.0001
Bismuth		mg/l	<0.0005	<0.0005	<0.0005	0.0005
Boron		mg/l	0.002	<0.002	0.002	0.002
Cadmium		mg/l	0.00012	<0.00001	0.00019	0.00001
Chromium		mg/l	<0.0005	<0.0005	<0.0005	0.0005
Cobalt		mg/l	<0.0001	<0.0001	<0.0001	0.0001
Copper		mg/l	0.004	<0.001	0.178	0.001
Lead		mg/l	0.0109	0.0002	0.029	0.0001
Lithium		mg/l	<0.001	<0.001	<0.001	0.001
Molybdenum		mg/l	<0.001	<0.001	<0.001	0.001
Nickel		mg/l	<0.0005	<0.0005	0.0005	0.0005
Selenium		mg/l	<0.0002	<0.0002	<0.0002	0.0002
Silver		mg/l	0.0001	0.0001	0.0001	0.0001
Strontium		mg/l	0.005	<0.001	0.005	0.001
Thallium		mg/l	<0.00005	<0.00005	<0.00005	0.00005
Tin		mg/l	<0.001	<0.001	<0.001	0.001
Titanium		mg/l	0.0008	<0.0005	0.0011	0.0005
Uranium		mg/l	<0.0005	<0.0005	<0.0005	0.0005
Vanadium		mg/l	0.0002	<0.0001	0.0002	0.0001
Zinc		mg/l	0.007	0.001	0.011	0.001
Zirconium		mg/l	<0.001	<0.001	<0.001	0.001
Physical and Aggregate Properties						
Temperature of observed pH		°C	18	17.5	17.5	
Solids	Total Suspended	mg/l	<1	6	<1	1
Routine Water						
pH			1.81	1.71	1.65	
Chloride	Dissolved	mg/l	4.3	0.8	5.2	0.5
Fluoride		mg/l	<0.04	<0.04	<0.04	0.04
Nitrate - N		mg/l	240	309	346	0.004
Nitrite - N		mg/l	<0.02	<0.02	<0.04	0.002
T - Alkalinity	as CaCO ₃	mg/l	<5	<5	<5	5
Hardness	as CaCO ₃	mg/l	6.9	<1	6.3	
Calcium	Extractable	mg/l	1.7	<0.2	1.7	0.2
Magnesium	Extractable	mg/l	0.6	<0.2	0.5	0.2
Potassium	Extractable	mg/l	<0.4	<0.4	<0.4	0.4
Sodium	Extractable	mg/l	2.9	<0.4	2.6	0.4
Iron	Extractable	mg/l	0.02	<0.01	0.01	0.01

Water Sample ID #	Extractable Copper Start (mg/l)	Water Sample ID #	Extractable Copper End (mg/l)
Stock	0.004	10	0.007
1	0.029	11	0.027
2	0.053	12	0.049
3	0.087	13	0.068
4	0.097	14	0.073
5	0.103	15	0.086
6	0.117	16	0.094
7	0.120	17	0.104
8	0.150	18	0.127
9	0.178	19	0.152

Appendix 5. Results of the 109 hour sea water challenge at 27.5 ppt

Date	Time	Number of Fry per Bucket	Fresh Water Control Temp (°C)	Number of Mortalities in Control Group	Salt Water Temp (°C)	Number of Mortalities in Salt Water	Comments
Feb. 14	1830	50	8.5	0	8.0	0	Fry in the saltwater group concentrated at the surface. Fry in the freshwater group were concentrated at the bottom of the bucket
	2114			0		0	
	2215			0		0	
	2315			0		0	
Feb. 15	0815	50	8.5	0	8.5	0	
	1015			0		0	Both groups of fish were concentrated at the bottom of the buckets
	1430			0		0	
	1530			0		0	
	2015			0		0	
	2230			0		0	
Feb. 16	0745		8.5	0	8.5	0	
	1045			0		0	
	1630			0		0	
Feb. 17	0830		8.5	0	8.5	0	
	1830			0		0	
Feb. 18	0830		8.5	0	8.5	0	
Feb. 19	0730		8.5	0	8.5	0	

Appendix 6. Results of the copper bioassay study for Jordan River pink salmon fry, February 2003.

Bucket #	Cu Added (ml)	Cu Conc (ppb)	Total fry at start	% Mortality	Water Sample ID		Copper Levels (ppb)		
					Start	End	Start	End	Mean
1	0	0	20	0.00	Stock	10	4	7	5.5
2	0	0	25	8.00	Stock	10	4	7	5.5
3	0	0	24	8.33	Stock	10	4	7	5.5
4	3	0	21	0.00	1	11	29	27	28.0
5	3	26	26	3.85	1	11	29	27	28.0
6	3	26	20	0.00	1	11	29	27	28.0
7	6	50	20	0.00	2	12	53	49	51.0
8	6	50	19	5.26	2	12	53	49	51.0
9	6	50	22	4.55	2	12	53	49	51.0
10	9	73	21	0.00	3	13	87	68	77.5
11	9	73	19	0.00	3	13	87	68	77.5
12	9	73	19	0.00	3	13	87	68	77.5
13	10.5	85	21	0.00	4	14	97	73	85.0
14	10.5	85	20	0.00	4	14	97	73	85.0
15	10.5	85	21	4.76	4	14	97	73	85.0
16	12	96	18	5.56	5	15	103	86	94.5
17	12	96	21	0.00	5	15	103	86	94.5
18	12	96	20	0.00	5	15	103	86	94.5
19	13.5	108	21	0.00	6	16	117	94	105.5
20	13.5	108	21	4.76	6	16	117	94	105.5
21	13.5	108	17	0.00	6	16	117	94	105.5
22	15	120	21	0.00	7	17	120	104	112.0
23	15	120	19	10.53	7	17	120	104	112.0
24	15	120	20	5.00	7	17	120	104	112.0
25	18	143	20	0.00	8	18	150	127	138.5
26	18	143	16	25.00	8	18	150	127	138.5
27	18	143	21	4.76	8	18	150	127	138.5
28	21	166	22	13.64	9	19	178	152	165.0
29	21	166	26	26.92	9	19	178	152	165.0
30	21	166	24	20.83	9	19	178	152	165.0

Results Summary	
Cu Conc (ppb)	Mean Mortality (%)
5.5	5.44
28	1.28
51	3.27
77.5	0.00
85	1.59
94.5	1.85
105.5	1.59
112	5.18
138.5	9.92
165	20.46

Appendix 7. Photos from the Jordan River Pink Salmon Incubation Study, 2002 - 2003.



Plate 1. Photograph looking downstream from the left bank at Site 3 on the Jordan River. Note mine tailings on the left bank.

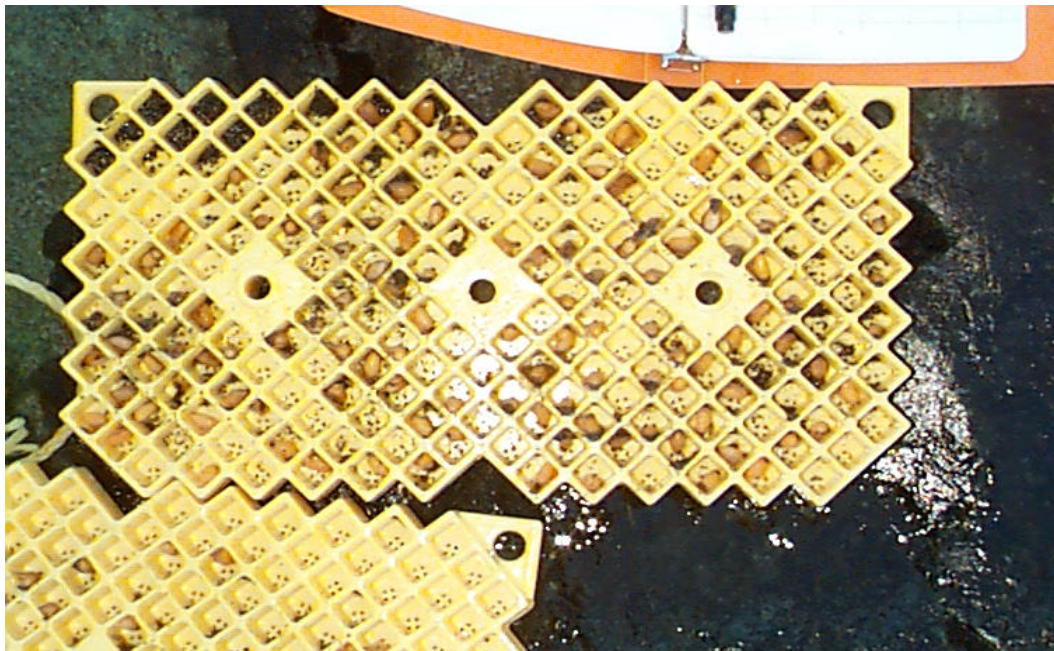


Plate 2. An example of a Jordan - Scotty Incubation cassette removed from the substrate at Site 2, January 6,2003.

Appendix 7. Photos from the Jordan River Pink Salmon Incubation Study, 2002 - 2003.

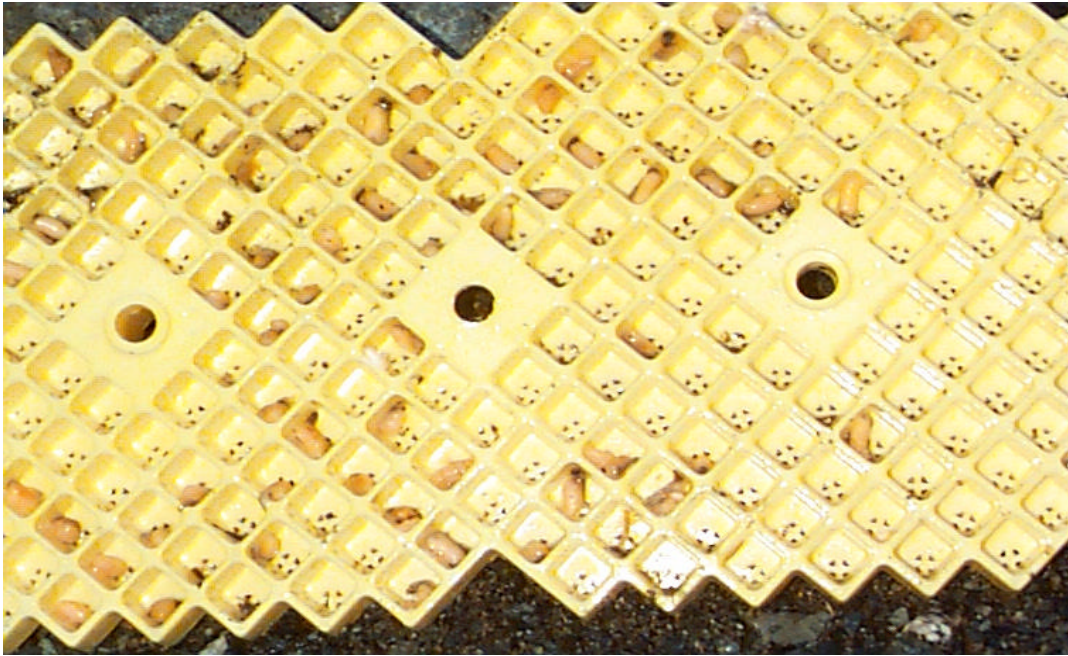


Plate 3. An example of a Jordan - Scotty Incubation cassette removed from the substrate at Site 2, January 6, 2003. Note the dead alevins in the individual cells.



Plate 4. Dead alevins removed from an incubation cassette at Site 2 on January 6, 2003.

Appendix 7. Photos from the Jordan River Pink Salmon Incubation Study, 2002 - 2003.



Plate 5. Looking upstream from Site 3 at the Jordan River. Spawning substrate was limited to isolated patches interspersed throughout the boulder substrate.

Appendix 8.



Financial Statement

Income & Expenses

	Income	Expensed	
Income			
BCRP	\$ 5000		
(DFO In-kind)	\$ 10,994.53		
Total Income	\$ 15,994.53		
Expenses		BCRP	(DFO In-kind)
Project Personnel			
Wage	3700		3700
Consultant fees	8585.94	3555.64	5030.30
(Technician)			
Equipment & Expenses			
Equipment rental	200		200
Equipment purchase			
Materials purchased	563.94	294.36	269.58
Travel expenses	1478	350	1128
Permits			
Water sample analysis	1291.65	800	491.65
Overhead			
Office supplies			
Photo copies & printing	25		25
Postage, courier	100		100
Lab space	250		250
Subtotal	16,194.53	5000	11,194.53
Total Expensed	16,194.53	5000	11,194.53
Balance	0	*0	0

*Unspent BCRP financial contribution to be returned to: BC Hydro, BCRP
 6911 Southpoint Drive (E16)
 Burnaby, BC. V3N 4X8
 ATTENTION: JANICE DOANE