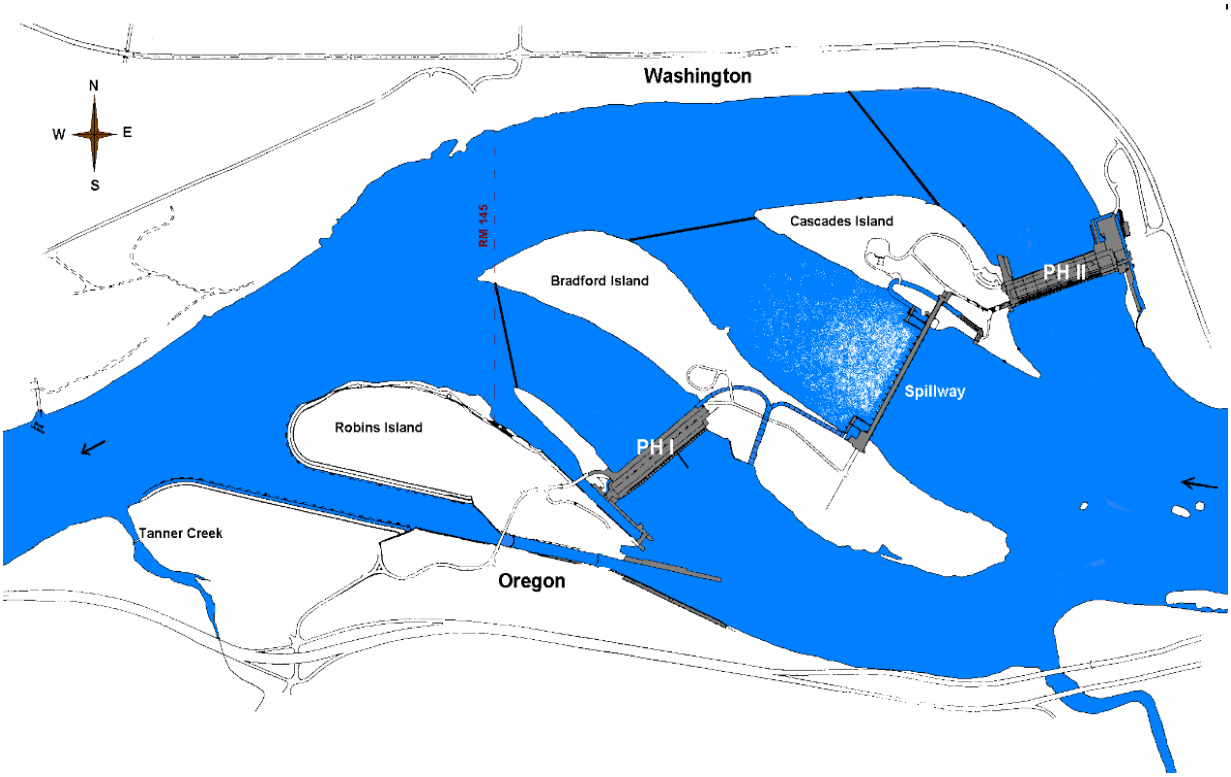
Field Report - Preliminary Observations of Non-lethal Deterrence Measures for California Sea Lion Predation at Bonneville Dam

Brent Norberg, Robert Stansell, Garth Griffin, Robin Brown, Steve Jeffries, and Pat Gearin

INTRODUCTION

In April 2005 and continuing through mid-June the majority of ESA listed adult spring Chinook salmon (*Oncorhynchus tshawytscha*) passed Bonneville Dam at river mile 146 on the Columbia River. (Figure 1) The fish move through the fish passage facilities (fishway) located on the Oregon and Washington sides of the River en route to their spawning grounds. In addition to adult Chinook, salmonids passing through the fishway in April/May include precocious male salmon "jacks" and steelhead (*Oncorhynchus mykiss*).

Figure 1. Overview of Bonneville Dam Project Area



Before 2001, few California sea lions (*Zalophus californianus*) were observed feeding in the area immediately downstream of Bonneville Dam, however the number of sea lions began increasing below the Dam in the spring of 2001. Sea lion numbers have been increasing each year since - with more than 100 sea lions observed, many identified by brands or unique markings, at the Dam in both 2003 and 2004. Since the late 1990s, the Oregon Department of Fish and Wildlife (ODFW) has been capturing and marking California sea lions at Astoria, Oregon, in an effort to describe and evaluate sea lion

movements and foraging patterns in the Columbia River. From 2002 to 2004, as part of the analysis of the impact of the Federal Columbia River Power System on listed salmon species, the US Army Corps of Engineers (COE) began an evaluation of the seasonal abundance of sea lions immediately downstream of Bonneville Dam including surface observations of salmon consumption (COE 2004). The study showed an increase from an estimated mortality of 0.3 percent of the salmon returns in 2002 to 2.0 percent of the returns in 2004. In 2005, at least 85 California sea lions, many individually identifiable by brands or markings, 3 to 4 Steller sea lions and a harbor seal (*Phoca vitulina*) were observed in the tailrace. In March 2005, the COE observed sea lions entering the fish passage facilities at Bonneville Dam and taking fish in the fishway.

In response to concern over increasing predation and potential fish passage impacts, associated with sea lion presence in the fishway and below the fishway entrances, the COE, National Marine Fisheries Service (NOAA Fisheries) and the States of Oregon and Washington (ODFW & WDFW) met to discuss allowable non-lethal deterrence measures to stop sea lion intrusions into the adult fish passage system. Representatives of the Columbia River Inter-Tribal Fisheries Commission (CRITFC) participated in the discussion and expressed their support for actions to stop sea lions from taking salmonids at Bonneville. The timely removal of nuisance sea lions from the fishway was determined to be necessary for the protection of returning salmonids and to ensure the proper function of the fish passage facility.

Under MMPA Section 109(h)(1)(C), the COE, NOAA Fisheries, ODFW and WDFW have similar authorities to take non-listed nuisance pinnipeds. At the initial meeting it was decided that all four agencies would work jointly under the MMPA authorities to conduct preliminary tests of the available non-lethal methods to a) remove and exclude sea lions from the fish passage facility; and b) to remove nuisance sea lions from the tailrace at Bonneville Dam to protect returning adult fish waiting to move through the fishway.

The agencies, (COE, NOAA Fisheries, ODFW & WDFW) developed a plan to apply various non-lethal methods to remove and deter sea lions from the tailrace of Bonneville Dam. The first test was conducted on May 5 and 6, 2005 and included the use of noise stimuli (firecrackers, cracker shells and rockets (screamers, bangers)), boat hazing and chasing. A second test conducted from shore on May 17 and 18, and included tactile harassment (rubber sabot rounds and rubber buckshot). The tests were conducted in the tail race area primarily below powerhouse one (PH1) on the Oregon side, and powerhouse two (PH2) on the Washington side, in the Boat Restricted Zone (BRZ) below Bonneville Dam. The tailrace below the spillway portion of the dam was determined to be too hazardous for personnel to work from boats during the initial test period. Shore based hazing was attempted in the spillway area during the second test.

MATERIALS AND METHODS

Safety

Project participants received safety briefings, from COE personnel, prior to each test. Briefings covered boat operations and clearance for activities in the Boat Restricted Zone below the dam, overhead hazards, lockout procedures, hazardous water conditions, personal safety equipment (PFDs, ear and eye protection) communications and project planning details. A safety protocol for pyrotechnic deployment from the boats was also discussed. A dedicated safety vessel was assigned to monitor vessel activities and provide emergency response capability as required by project safety rules. Following the initial safety briefing, participants moved to the deck at PH2 to discuss pyrotechnic deployment from the deck. Boats teams received safety equipment briefings on board individual boats at the time of launch.

Personnel

Project personnel included biologists (salmon, pinniped) from the participating agencies who worked on the project design and implementation, as well as Law Enforcement officers and agents from Oregon State Police, WDFW and NOAA Fisheries who provided logistical and safety support.

Monitoring

Observations of sea lion presence, salmonid kills by sea lions and fish passage were conducted daily at the dam beginning in April and continued through May. Observers scanned the tailrace and recorded the number of sea lions present in the tailrace and/or fishway on an hourly schedule. Similarly, predation (fish killed) counts, and fish passage counts through the fishway were recorded hourly. Monitoring from the Dam continued after the second test to document sea lion reoccurrence in the tailrace, predation events and changes in fish passage. Boat surveys were conducted to detect changes in sea lion distribution in river before and after hazing sessions during the second test.

Test One (May 5 - 6)

Treatment strategies during test one included deployment of pyrotechnics from the dam and from vessels stationed in the tailrace. Harassment began with a survey of the fishway and actions to remove any sea lions present in the fishway entrance galleries followed by multiple seal control firecrackers deployed simultaneously from the deck of the dam into the tailrace below PH2. Hazing teams were instructed to avoid use of underwater firecrackers near fishway entrances and close to shorelines for the protection of adult salmon. Boat teams were equipped with dip nets and instructed to collect any injured or dead fish for examination. The first round of pyrotechnics (firecrackers) was followed 3-5 minutes later with a second round. The intent of this procedure was to move animals from close proximity to the concrete face of the dam and allow movement of boats to position upstream of the animals. After the opening deployments from the deck, three

boats moved to position in the tailrace and then proceeded downstream at steerage speeds deploying firecrackers and aerial pyrotechnics to chase the animals away from the dam and create a refuge area, free of sea lions, from the dam to a line perpendicular from the Washington Shore to the end of the "corner collector" flume at the southern tip of Cascade Island. (see Figure 1)

Once established, the refuge area was maintained by vessels patrolling the area, and hazing individual animals, when they attempted to re-enter the zone, using firecrackers, boat hazing, and aerial pyrotechnics as needed. If a sea lion successfully regained proximity to the dam, additional firecrackers would be deployed from the deck of the dam in coordination with vessel hazing measures to chase the animal from the fish refuge. On day one of the test, all activities were focused on maintaining the fish refuge below PH2.

On day two, the strategy was expanded to include the tailrace below PH1 near the Oregon shore. Initiation of hazing on May 6, followed the same steps as day one at PH2, then boats and deck teams moved to PH1. The teams worked in coordination to conduct treatment and establish a second refuge below PH1 while observing the tailrace at PH2. Once both refugia were established, the boats moved between areas and actively chased any sea lions from the BRZ below the dam. Observers monitored sea lion presence, predation and fish passage at the dam before, during and after the treatment periods.

Test Two (May 17 – 18)

Treatment strategies during test two included deployment of pyrotechnics from the dam, as occurred in test one followed by hazing from shore by personnel stationed around the tailrace and equipped with aerial pyrotechnics, shotgun fired rubber projectiles and firecrackers. Use of firecrackers was limited from shore for the protection of adult salmon as previously described. After the opening deployments from the deck, first at PH2 followed by PH1, hazing teams were positioned and moved around the tailraces at several locations on Cascade and Bradford Islands, the tip of the spit at fishway entrance number one and on the Washington shore. Once the fish refugia were established, hazing teams engaged individual animals as they attempted to re-enter the areas below the dam. Hazing teams used rockets and cracker shells around the tailrace below the spillway as well. Observers monitored sea lion presence, predation and fish passage at the dam before, during and after the treatment periods. Boat surveys were conducted before and after each treatment period to document the presence of sea lions in the river below the BRZ, downstream as far as Skamania Landing (river mile 140.5).

RESULTS

Test One May 4 Pre-Treatment

In May, observations of sea lion presence and predation events at Bonneville Dam were conducted from 0600 through 1800 daily in the tailraces below PH1 and PH2 and the

spillway. Observers recorded the average number of sea lions present during each hour observed and predation events were tallied to prey species when possible.

Fish passage counts were made available from routine monitoring efforts that are ongoing at the facility. Passage was logged hourly from 0400 through 2000 daily. Passage tallies were divided between fishway entrances at Bradford Island (entrances one through three) and the Washington side of the dam (entrances four through eight). In May, hourly fish passage was highly variable with average hourly counts ranging from lows in the 30s and 40s to highs of nearly 200 fish per hour. However, periodic spikes or dips in passage were much more dramatic ranging from a low of two fish per hour to a high of over 1200 fish

Sea Lion Abundance - On May 4, the average sea lion attendance ranged from 12 to 18 animals per hour for all areas combined between 0600 and 1400. From 1400 through 1800 observations continued below PH2 only. After 1400, counts at PH2 ranged from 8 to 9 animals. For all hours observed on the 4th, sea lion presence was highest at PH2, ranging from 4 to 9 animals per hour (average 7). At PH1, hourly presence ranged from 4 to 7 sea lions (average 6). Below the spillway hourly presence ranged from 2 to 7 sea lions (average 4). (Table 1a)

Predation – A total of 71 salmonids were observed taken in the tailrace by sea lions the day before the initiation of hazing. Predation was highest at PH2 where 49 kills were observed (PH1 – 6, spillway – 16). As noted above, observations were conducted at PH2 from 0600 – 1800 while observations at PH1 and the spillway were suspended at 1400 on May 4. (Table 1b)

Fish Passage – A total of 2638 salmonids were observed passing the dam on May 4. The rate of passage ranged from 60 to 342 fish per hour (average 164), for all hours monitored. (Table 1c)

Table 1a. Average number of sea lions observed per hour at Bonneville Dam prior to hazing test one.

DATE	TIME	PH1	PH2	SPILL	TOTAL	
5/4/2005	6:00	5	4	3	12	**No Haze**
5/4/2005	7:00	4	7	7	18	
5/4/2005	8:00	5	7	5	17	
5/4/2005	9:00	6	6	5	17	
5/4/2005	10:00	6	5	4	15	
5/4/2005	11:00	7	6	2	15	
5/4/2005	12:00	7	8	2	17	
5/4/2005	13:00	6	8	3	17	
5/4/2005	14:00		8		8	
5/4/2005	15:00		8		8	
5/4/2005	16:00		9		9	0600-1300
5/4/2005	17:00		9		9	Avg. = 16

Table 1b. Salmonids observed killed per hour by sea lions at Bonneville Dam prior to hazing.

DATE	TIME	PH1	PH2	SPILL	Total/Hr	
5/4/2005	6:00	0	2	1	3	**No Haze**
5/4/2005	7:00	2	5	5	12	
5/4/2005	8:00	0	4	3	7	
5/4/2005	9:00	0	0	0	0	
5/4/2005	10:00	0	6	0	6	
5/4/2005	11:00	0	1	1	2	
5/4/2005	12:00	2	3	3	8	
5/4/2005	13:00	2	4	3	9	
5/4/2005	14:00		9		9	
5/4/2005	15:00		1		1	
5/4/2005	16:00		5		5	0600-1300
5/4/2005	17:00		9		9	Avg. = 6

Table 1c. Salmonids passing the counting windows at Bonneville Dam prior to hazing.

Date	Time	Bradford Is Salmonids	Washington Salmonids	Total/Hr	
5/4/2005	4:00	24	36	60	**No Haze**
5/4/2005	5:00	37	157	194	
5/4/2005	6:00	25	96	121	
5/4/2005	7:00	28	151	179	
5/4/2005	8:00	22	47	69	
5/4/2005	9:00	26	54	80	
5/4/2005	10:00	42	35	77	
5/4/2005	11:00	52	67	119	
5/4/2005	12:00	20	82	102	
5/4/2005	13:00	83	72	155	
5/4/2005	14:00	73	68	141	
5/4/2005	15:00	116	226	342	
5/4/2005	16:00	134	172	306	
5/4/2005	17:00	73	238	311	
5/4/2005	18:00	61	148	209	
5/4/2005	19:00	64	109	173	Avg. = 164

Test One May 5 Hazing

At the beginning of the treatment period on May 5, boat teams moved into position 200 yards below PH2. Upon arrival teams observed several sea lions foraging in the area including one Steller sea lion. The Steller sea lion left the area when the boats arrived below the dam, prior to the commencement of hazing, and was not observed for the remainder of test one. As described, hazing on May 5 was confined to the tailrace at PH2. Boats were positioned in the tailrace at the start of hazing from the deck of the dam

and were used as mobile hazing platforms to clear the tailrace of sea lions and thereafter to pursue individual animals that attempted to re-enter the tailrace area.

Sea Lion Abundance - On May 5, prior to hazing, hourly sea lion presence was up in the morning, as compared to the previous day, ranging from 19 to 25 animals for all areas combined (PH1 – 6 to 7, PH2 – 9 to 11, spillway – 3 to 7). After the initiation of hazing at 1200, the total sea lion count per hour for all areas combined, ranged from 16 to 19 (average 17) compared with 19 to 25 (average 19) animals in the hours beforehand. Sea lion presence at PH2, dropped to zero during hazing activities, compared to 9 to 11 animals earlier. Sea lion presence was highest at PH1 during hazing at PH2 on May 5, ranging from 11 to 14 animals. Observers were able to identify at least 5 of the animals that were chased out of PH2 and showed up at PH1 subsequently during hazing. Five to 6 sea lions were seen at the spillway during hazing. Sea lion attendance ranged from 17 to 22 animals per hour (average 20) for all areas combined after hazing stopped at PH2. Sea lion attendance at PH2 increased from zero to 5 animals in the two hours following hazing, compared with 6 to 11 animals before hazing. (Table 2a)

Predation – A total of 84 salmonids were observed taken by sea lions on May 5, an increase over the previous day's total. From 0600 to 1200 on May 5, 54 salmonids were observed taken by sea lions, 4 to 14 fish per hour, in the tailrace before hazing began (PH1 – 3, PH2 – 37, spillway – 14). During hazing, a total of 18 fish (3 to 7 fish per hour) were observed taken by sea lions. Predation was down overall, during hazing, compared to earlier in the day. No salmon were observed taken by sea lions below PH2 during hazing, a decrease of from 3 to 8 fish per hour when compared to pre-treatment. Twelve fish were observed taken by sea lions (6.0 fish per hour) after hazing on May 5. The highest observed predation, per hour, following hazing was below PH2 (4). The predation rate following hazing on May 5 was lower than pre-treatment, averaging 6 fish per hour compared to 9. (Table 2b)

Fish Passage – A total of 6315 salmonids were observed passing the dam on May 5, more than double the previous day. Prior to sea lion hazing in the morning, the passage rate was a lower than the previous day, ranging from 23 to 252 fish per hour at the dam (average 93). During the comparable period (0400 to 1200) on May 4, an average of 112 fish per hour passed the dam. During the four hour treatment period, passage ranged from 69 to 1133 fish per hour (average 505) a significant increase from just prior to hazing. The passage rate during hazing was also higher than the previous day when 60 to 342 fish per hour were tallied (average 164) for the whole day and from 102 to 342 (average 185) fish per hour during the comparable time frame (1200 – 1600). Fish passage rates remained higher following hazing and ranged from 220 to 1234 fish per hour (average 888) compared with 173 to 311 (average 249) fish per hour during the comparable period the previous day. (Table 2c)

Effects of Hazing on Fish – One adult salmonid was observed to roll at the surface following the deployment of a seal control firecracker at PH2 on May 5. The fish did not appear to be injured and immediately dove after surfacing. No injured or dead fish were observed on May 5, and no fish were collected at the surface.

Table 2a. Average number of sea lions observed per hour at Bonneville Dam on May 5, when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/5/2005	6:00	6	9	4	19	**Pre-Haze**
5/5/2005	7:00	6	9	3	18	
5/5/2005	8:00	6	6	3	15	
5/5/2005	9:00	6	10	3	19	
5/5/2005	10:00	7	6	6	19	
5/5/2005	11:00	7	11	7	25	Avg. = 19
5/5/2005	12:00	11	0	6	17	**Haze**
5/5/2005	13:00	14	0	5	19	
5/5/2005	14:00	11	0	5	16	
5/5/2005	15:00	11	0	6	17	Avg. = 17
5/5/2005	16:00	11	0	6	17	**Post-Haze**
5/5/2005	17:00	11	5	6	22	Avg. = 20

Table 2b. Salmonids observed killed, by sea lions, per hour at Bonneville Dam on May 5 when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/5/2005	6:00	0	5	3	8	**Pre-Haze**
5/5/2005	7:00	0	8	3	11	
5/5/2005	8:00	0	8	0	8	
5/5/2005	9:00	0	3	1	4	
5/5/2005	10:00	1	6	2	9	
5/5/2005	11:00	2	7	5	14	Avg. = 9
5/5/2005	12:00	3	0	4	7	**Haze**
5/5/2005	13:00	2	0	1	3	
5/5/2005	14:00	3	0	1	4	
5/5/2005	15:00	2	0	2	4	Avg. = 5
5/5/2005	16:00	3	0	3	6	**Post-Haze**
5/5/2005	17:00	2	4	0	6	Avg. = 6

Table 2c. Salmonids passing at Bonneville Dam on May 5 when hazing occurred.

Date	Time	Bradford Is Salmonids	Washington Salmonids	Total/Hr	
5/5/2005	4:00	4	19	23	**Pre-Haze**
5/5/2005	5:00	67	185	252	
5/5/2005	6:00	73	37	110	
5/5/2005	7:00	40	56	96	
5/5/2005	8:00	30	30	60	
5/5/2005	9:00	24	30	54	
5/5/2005	10:00	40	44	84	
5/5/2005	11:00	30	36	66	Avg. = 93
5/5/2005	12:00	34	35	69	**Haze**
5/5/2005	13:00	26	222	248	
5/5/2005	14:00	38	532	570	
5/5/2005	15:00	71	1062	1133	Avg. = 505
5/5/2005	16:00	94	1021	1115	**Post-Haze**
5/5/2005	17:00	53	1181	1234	
5/5/2005	18:00	56	925	981	
5/5/2005	19:00	44	176	220	Avg. = 888

Test One May 6 Hazing

Active hazing occurred from 1200 to 1600 on May 5 and from 0930 to 1300 on May 6. A method similar to May 5 was used but the tailrace area below PH1 was also cleared of sea lions and maintained as a refuge for fish. Hazing boats moved between the two tailrace areas as needed to intercept and harass sea lions that moved into the refuge zones. Hazing commenced at PH2 on both days but additional time was required the second day to establish refugia in both tailraces. The second refuge (tailrace at PH1) was established at shortly after 1000 on the May 6. Approximately 200 seal control firecrackers, 100 each of screamer and banger rockets and 50 cracker shells were deployed to establish and maintain the refugia below the dam, over the course of the two day test.

Sea Lion Abundance - On May 6, hourly sea lion presence prior to the start of hazing activities was higher than on May 4 or the morning of May 5, ranging from 23 to 27 animals for all areas combined (PH1 – 9 to 11, PH2 – 8 to 10, spillway – 5 to 8). The sea lion presence for all areas combined on May 6, during the 4 hour treatment period, ranged from 4 to 27 animals. The highest count during this period was 14 animals at PH1 during the time hazing was being started at PH2 but before a refuge could be established at PH1 (0930 to 1000). Once hazing was underway at both PH1 and PH2 the overall sea lion presence dropped to a range of 4 to 10 animals (average 7) with the majority found at the spillway where hazing was not attempted. This is a marked decrease in attendance when compared to the 23 to 27 animals seen earlier in the day on May 6. Sea lion presence averaged 7 animals per hour during hazing on May 6 after the refuge was established at PH1 and PH2, compared with 17 animals per hour the previous day when

hazing activities were concentrated at PH2 only. Sea lion attendance ranged from 10 to 20 animals per hour (average 15) after hazing stopped. The average attendance after hazing on May 6 (15) was lower than pre-hazing (25) but higher than during hazing (11). (Table 3a)

Predation – A total of 62 salmonids were observed taken by sea lions on May 6. Fourteen fish were observed taken, 0 to 7 fish per hour, between 0600 and 0900 prior to hazing (PH1 – 0, PH2 – 7, spillway – 7). Hazing began at 0930 below PH2 and moved to PH1 by 1000. From 0 to 11 fish per hour were observed taken by sea lions during hazing (average 5). The average kill rate was mostly influenced by predation at the spillway where hazing was not attempted. Of the 23 fish observed taken by sea lions during hazing, 15 were taken in the spillway. Twenty-five fish were taken in the hours following hazing on the 6th (6 to 7 fish per hour). The majority of predation shifted from the spillway to PH1 after hazing stopped. Seventeen of 25 fish taken after hazing were taken at PH1. (Table 3b)

Fish Passage – A total of 2627 salmonids were observed passing the dam on May 6. Passage was lower overall than the previous day but comparable to May 4. Twenty-four to 71 fish per hour (average 40) passed the dam on May 6, prior to hazing. During hazing 24 to 365 fish per hour passed the dam (average 142). In the 4 hours following the cessation of hazing (1400 – 1800), passage ranged from 46 to 396 fish per hour (average 287 fish per hour). Once again an increase was noted over the hazing period (142) and the pre-hazing period on that date (40). Fish passage was in double digits before hazing and began to increase once refugia were established below PH1 and PH2. Passage remained in triple digits until six hours after hazing ended. (Table 3c)

Effects of Hazing on Fish – No salmonids were observed at the surface during hazing activities on May 6 and injured or dead fish were collected.

Table 3a. Average number of sea lions observed per hour at Bonneville Dam on May 6, when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/6/2005	6:00	9	10	8	27	**Pre-Hazing**
5/6/2005	7:00	10	8	5	23	
5/6/2005	8:00	11	8	5	24	Avg. = 25
5/6/2005	9:00	14	8	5	27	**Hazed PH2 0930**
5/6/2005	10:00	1	0	3	4	**Hazed PH1 1000**
5/6/2005	11:00	1	1	4	6	
5/6/2005	12:00	2	1	4	7	
5/6/2005	13:00	2	3	5	10	Avg. = 11
5/6/2005	14:00	3	3	4	10	**Post-Haze**
5/6/2005	15:00	4	5	4	13	
5/6/2005	16:00	8	5	4	17	
5/6/2005	17:00	11	5	4	20	Avg. = 15

Table 3b. Salmonids observed killed, by sea lions, per hour at Bonneville Dam on May 6 when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/6/2005	6:00	0	3	4	7	**Pre-Haze**
5/6/2005	7:00	0	4	3	7	
5/6/2005	8:00	0	0	0	0	Avg. = 5
5/6/2005	9:00	2	2	4	8	**Haze PH2 0930**
5/6/2005	10:00	0	0	2	2	**Haze PH1 1000**
5/6/2005	11:00	0	0	2	2	
5/6/2005	12:00	0	0	0	0	
5/6/2005	13:00	2	2	7	11	Avg. = 5
5/6/2005	14:00	3	1	2	6	**Post-Haze**
5/6/2005	15:00	4	2	0	6	
5/6/2005	16:00	5	1	1	7	
5/6/2005	17:00	5	1	0	6	Avg. = 6

Table 3c. Salmonids passing at Bonneville Dam on May 6 when hazing occurred.

Date	Time	Bradford Is Salmonids	Washington Salmonids	Total/Hr	
5/6/2005	4:00	13	28	41	**Pre-Haze**
5/6/2005	5:00	23	48	71	
5/6/2005	6:00	17	17	34	
5/6/2005	7:00	10	20	30	
5/6/2005	8:00	10	14	24	Avg. = 40
5/6/2005	9:00	7	17	24	**Haze** PH2 0930
5/6/2005	10:00	14	16	30	**Haze** PH1 1000
5/6/2005	11:00	22	82	104	
5/6/2005	12:00	32	155	187	
5/6/2005	13:00	70	295	365	Avg. = 142
5/6/2005	14:00	101	396	497	**Post- Haze**
5/6/2005	15:00	73	395	468	
5/6/2005	16:00	38	246	284	
5/6/2005	17:00	38	132	170	
5/6/2005	18:00	35	198	233	
5/6/2005	19:00	19	46	65	Avg. = 287

Test One May 7 Post-Treatment

Sea Lion Abundance - On May 7, the total sea lion count per hour for all areas combined ranged from 19 to 30 (average 23) between the hours of 0800 and 1600. For all hours observed on the 7th, sea lion presence was highest in the tailrace below PH2 ranging

from 10 to 15 animals. At PH1 and below the spillway, hourly presence ranged from 6 to 11 and 2 to 4 animals respectively. (Table 4a)

Predation - A total of 53 salmon were observed taken by sea lions in all areas combined on May 7, down from previous days. The predation rate ranged from 2 to 9 fish per hour (average 7) during the eight hours observed from 0800 to 1600. The observed predation was highest below the spillway (26) followed by PH2 (19) and PH1 (8).

Fish Passage – A total of 1064 salmonids were observed passing the dam on May 7, a decline from previous days. Fish passage between 0400 and 2000, ranged from 12 to 188 salmonids per hour (average 66).

Table 4a. Average number of sea lions observed per hour at Bonneville Dam on May 7 after hazing test one.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/7/2005	6:00					**No-Haze**
5/7/2005	7:00					
5/7/2005	8:00	7	10	3	20	
5/7/2005	9:00	7	10	4	21	
5/7/2005	10:00	7	10	2	19	
5/7/2005	11:00	7	10	5	22	
5/7/2005	12:00	6	10	4	20	
5/7/2005	13:00	11	10	4	25	
5/7/2005	14:00	11	15	4	30	
5/7/2005	15:00	11	10	4	25	
5/7/2005	16:00					0800-1600
5/7/2005	17:00					Avg. = 23

Table 4b. Salmonids observed killed, by sea lions, per hour at Bonneville Dam on May 7 after hazing test one.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/7/2005	6:00				0	**No Haze**
5/7/2005	7:00				0	
5/7/2005	8:00	1	5	3	9	
5/7/2005	9:00	1	1	0	2	
5/7/2005	10:00	1	0	3	4	
5/7/2005	11:00	1	4	4	9	
5/7/2005	12:00	3	1	4	8	
5/7/2005	13:00	1	1	3	5	
5/7/2005	14:00	0	3	6	9	
5/7/2005	15:00	0	4	3	7	
5/7/2005	16:00				0	
5/7/2005	17:00				0	Avg = 7

Table 4c. Salmonids passing at Bonneville Dam on May 7 after hazing occurred.

Date	Time	Bradford Is Salmonid	Washington Salmonid	Total/Hr	
5/7/2005	4:00	11	14	25	**No Haze**
5/7/2005	5:00	26	26	53	
5/7/2005	6:00	7	10	17	
5/7/2005	7:00	16	30	46	
5/7/2005	8:00	4	8	12	
5/7/2005	9:00	10	11	20	
5/7/2005	10:00	17	19	36	
5/7/2005	11:00	11	26	37	
5/7/2005	12:00	19	26	46	
5/7/2005	13:00	25	31	56	
5/7/2005	14:00	48	17	65	
5/7/2005	15:00	77	52	128	
5/7/2005	16:00	104	23	127	
5/7/2005	17:00	136	53	188	
5/7/2005	18:00	76	86	162	
5/7/2005	19:00	14	31	46	Avg = 66

Test Two May 16 Pre-Treatment

Sea Lion Abundance – Sea lion abundance ranged from 16 to 20 animals per hour (average 17) for all areas combined on May 16, the day before hazing test two. Sea lion observations were conducted from 0600 to 1400. No Steller sea lions were observed during test two. For all hours observed on May 16, sea lion abundance ranged from 4 to 9 at PH1 (average 7), 5 to 9 at PH2 (average 7), and 2 to 5 at the spillway (average 4). (Table 5a)

Predation – A total of 46 salmonids were observed taken by sea lions in the tailrace on May 16. Predation ranged from 3 to 8 fish per hour (average 6). Sixteen fish were taken at PH1, 22 at PH2 and 8 at the spillway. (Table 5b)

Fish Passage – A total of 1,471 salmonids were observed passing the dam on May 16, and average of 92 fish per hour. Passage was higher on the Washington side (1,156) than at Bradford Island (317). (Table 5c)

Table 5a. Average number of sea lions observed per hour at Bonneville Dam on May 16 before hazing test two.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/16/2005	6:00	5	6	5	16	**No Haze**
5/16/2005	7:00	5	8	5	18	
5/16/2005	8:00	4	7	5	16	
5/16/2005	9:00	6	9	5	20	
5/16/2005	10:00	6	7	3	16	
5/16/2005	11:00	8	7	3	18	
5/16/2005	12:00	9	7	2	18	
5/16/2005	13:00	9	5	2	16	
5/16/2005	14:00					
5/16/2005	15:00					
5/16/2005	16:00					
5/16/2005	17:00					Avg = 17

Table 5b. Salmonids observed killed per hour by sea lions at Bonneville Dam on May 16 before hazing test two.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/16/2005	6:00	2	4	1	7	**No Haze**
5/16/2005	7:00	3	1	2	6	
5/16/2005	8:00	1	4	1	6	
5/16/2005	9:00	1	1	1	3	
5/16/2005	10:00	0	5	0	5	
5/16/2005	11:00	3	2	1	6	
5/16/2005	12:00	2	3	0	5	
5/16/2005	13:00	4	2	2	8	
5/16/2005	14:00					
5/16/2005	15:00					
5/16/2005	16:00					
5/16/2005	17:00					Avg = 6

Table 5c. Salmonids passing the counting windows at Bonneville Dam prior to on May 16 before hazing test two.

Date	Time	Bradford Is Salmonids	Washington Salmonids	Total/Hr	
5/16/2005	4:00	48	77	125	**No Haze**
5/16/2005	5:00	48	152	200	
5/16/2005	6:00	12	70	82	
5/16/2005	7:00	22	34	55	
5/16/2005	8:00	16	32	48	
5/16/2005	9:00	4	8	12	
5/16/2005	10:00	16	4	19	
5/16/2005	11:00	10	32	42	
5/16/2005	12:00	8	30	38	
5/16/2005	13:00	18	40	58	
5/16/2005	14:00	18	61	79	
5/16/2005	15:00	25	125	150	
5/16/2005	16:00	23	146	169	
5/16/2005	17:00	19	208	227	
5/16/2005	18:00	22	78	100	
5/16/2005	19:00	8	59	67	Avg = 92

Test Two May 17 Hazing

Active hazing occurred from 1000 to 1400 on May 17 and 18. On both days, hazing began, using firecrackers from deck at PH2 followed by deployment of pyrotechnics and tactile harassment from the shoreline. During downstream hazing below PH2, personnel were repositioned to deploy firecrackers from the deck at PH1 followed by shoreline hazing there. Shoreline teams continued opportunistic hazing around all tailrace areas for the remaining treatment period.

Sea Lion Abundance – The morning of May 17, prior to hazing, hourly sea lion presence was comparable to the previous day, ranging from 17 to 21 animals (average 18) for all areas combined (PH1 – 4 to 6, PH2 – 10 to 12, spillway – 2 to 3). Two sea lions were observed in the river below the tailrace area during the morning boat survey conducted between the Hamilton boat ramp and Skamania Landing. After the initiation of hazing at 1000, the sea lion count per hour, for all areas combined, ranged from 9 to 22 (average 14), down slightly compared with the hours beforehand. Sea lion presence at PH1 and PH2 dropped from 9 and 11 sea lions per hour respectively to 1 and 2 sea lions per hour during hazing activities. At the spillway, sea lion presence increased from 2 to 10 sea lions per hour during hazing. Sea lion attendance ranged from 15 to 20 animals per hour for all areas combined after hazing stopped. During the second boat survey, conducted immediately following the end of hazing, 9 sea lions were observed in the river below the tailrace area. Sea lion attendance at the dam increased from an average of 14 to 18 animals in the four hours following hazing. Sea lion attendance at PH1 returned to pre-hazing levels, 3 to 5 animals per hour, while remaining lower, 2 to 4 animals per hour, at PH2. Post-hazing sea lion attendance at the spillway remained high, 10 animals per hour, for the remainder of the day on May 17. (Table 6a)

Predation – A total of 48 salmonids were observed taken by sea lions on May 17. Before hazing began, 0600 to 1000, 23 salmonids were taken by sea lions, 4 to 8 fish per hour (PH1 – 14, PH2 – 3, spillway – 6). During hazing, 9 fish were taken (average 2). Predation was down by about half overall compared to earlier in the day in the absence of hazing activities. One salmon was observed taken by sea lions below PH1, the most marked decrease when compared to pre-treatment. Sixteen fish were observed taken by sea lions (4 fish per hour) after hazing on May 17. The highest observed predation, per hour, following hazing, was below PH1 (6) equivalent to pre-hazing. The predation rate following hazing on May 17 was lower than pre-treatment, averaging 4 fish per hour compared to 6. Of the fish observed killed by sea lions, 39 were caught before or after the hazing period (23 before, 9 during, 16 after). (Table 6b)

Fish Passage – A total of 2089 salmonids were observed passing the dam on May 17. Passage ranged from 30 to 85 fish per hour (average 43) prior to the initiation of hazing. During hazing, passage ranged from 37 to 359 fish per hour and the average for the period increased to 142 fish per hour. Following hazing fish passage ranged from 66 to 522 fish per hour (average 210). The most marked increases came on the Washington side and the highest passage observed for the day occurred during the final two hours of hazing and the three hours following. (Table 6c)

Effects of Hazing on Fish – Several dozen to several hundred salmonid smolts were observed to roll at the surface following the deployment of a seal control firecracker below PH1 on May 17. No injured or dead fish were seen or collected. Approximately 200 shad were observed to break the surface following the deployment of a firecracker from the observation platform adjacent to the Cascade Island flume. No injured or dead fish were observed.

Table 6a. Average number of sea lions observed per hour at Bonneville Dam on May 17, when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/17/2005	6:00	4	11	2	17	**Pre-Haze**
5/17/2005	7:00	5	10	2	17	
5/17/2005	8:00	5	10	3	18	
5/17/2005	9:00	6	12	3	21	Avg = 18
5/17/2005	10:00	9	11	2	22	**Haze**
5/17/2005	11:00	9	2	2	13	
5/17/2005	12:00	0	2	7	9	
5/17/2005	13:00	1	2	10	13	Avg = 14
5/17/2005	14:00	3	2	10	15	**Post-Haze**
5/17/2005	15:00	6	4	10	20	
5/17/2005	16:00	5	4	10	19	
5/17/2005	17:00	5	4	10	19	Avg = 18

Table 6b. Salmonids observed killed, by sea lions, per hour at Bonneville Dam on May 17 when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/17/2005	6:00	4	1	2	7	**Pre-Haze**
5/17/2005	7:00	6	0	2	8	
5/17/2005	8:00	2	1	1	4	
5/17/2005	9:00	2	1	1	4	Avg = 6
5/17/2005	10:00	0	1	1	2	**Haze**
5/17/2005	11:00	1	0	1	2	
5/17/2005	12:00	0	2	1	3	
5/17/2005	13:00	0	0	2	2	Avg = 2
5/17/2005	14:00	2	2	0	4	**Post-Haze**
5/17/2005	15:00	6	1	0	7	
5/17/2005	16:00	0	0	1	1	
5/17/2005	17:00	2	1	1	4	Avg = 4

Table 6c. Salmonids passing at Bonneville Dam on May 17 when hazing occurred.

Date	Time	Bradford Is Salmonids	Washington Salmonids	Total/Hr	
5/17/2005	4:00	12	29	41	**Pre-Haze**
5/17/2005	5:00	14	71	85	
5/17/2005	6:00	14	17	31	
5/17/2005	7:00	24	16	40	
5/17/2005	8:00	22	10	31	
5/17/2005	9:00	7	23	30	Avg = 43
5/17/2005	10:00	7	30	37	**Haze**
5/17/2005	11:00	14	25	40	
5/17/2005	12:00	12	120	132	
5/17/2005	13:00	37	322	359	Avg = 142
5/17/2005	14:00	77	445	522	**Post-Haze**
5/17/2005	15:00	68	328	396	
5/17/2005	16:00	59	77	136	
5/17/2005	17:00	28	46	73	
5/17/2005	18:00	24	42	66	
5/17/2005	19:00	40	30	70	Avg = 210

Test Two May 18 Hazing

Sea Lion Abundance – On May 18, prior to hazing, hourly sea lion presence was down in the morning, as compared to the previous day, ranging from 10 to 15 animals (average 14) for all areas combined (PH1 – 3 to 8, PH2 – 4 to 6, spillway – 3). No sea lions were observed during the morning boat survey of the river below the tailrace are, conducted

prior to hazing activities. After the initiation of hazing at 1000, the total sea lion count per hour for all areas combined, ranged from 4 to 9 (average 6), about half when compared with the hours beforehand. Sea lion presence at PH1 and PH2 dropped during hazing activities. At the spillway, sea lion presence increased slightly from 3 sea lions per hour to 2 to 5 animals per hour (average 4) during hazing. Sea lion attendance ranged from 8 to 12 animals per hour for all areas combined following hazing, a decrease from pre-hazing in the morning. Following hazing, 6 sea lions were counted in the river below the tailrace area during the boat survey conducted between Hamilton and Skamania Landing. Sea lion attendance increased from an average of 6 during hazing to 9 animals in the four hours following hazing. Sea lion attendance shifted from the spillway back to PH1 and PH2 after hazing stopped. (Table 7a)

Predation – A total of 29 salmonids were observed taken by sea lions on May 18. Before the start of hazing, 0600 to 1000, 13 salmonids were observed taken by sea lions, ranging from 1 to 6 fish per hour (average 3). During hazing, predation declined to an average of 1 fish per hour including a two hour period when no predatation was observed. Following hazing, predation returned to pre-hazing levels of from 2 to 5 fish per hour (average 3). Of the fish taken by sea lions, 25 were caught before or after the hazing period (13 before, 4 during, 12 after). (Table 7b)

Fish Passage – A total of 1473 salmonids were observed passing the dam on May 18, down a bit from the previous day. Passage ranged from 23 to 60 fish per hour (average 37) prior to the initiation of hazing. During hazing, passage ranged from 38 to 179 and the average increased to 77 fish per hour. Following hazing, fish passage ranged from 40 to 316 fish per hour (average 157). As on the May 17, the most marked passage increase was on the Washington side and the highest passage observed for the day occurred during the final hour of hazing and the four hours following hazing. (Table 7c)

Table 7a. Average number of sea lions observed per hour at Bonneville Dam on May 18, when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/18/2005	6:00	5	6	3	14	**Pre-Haze**
5/18/2005	7:00	8	4	3	15	
5/18/2005	8:00	8	4	3	15	
5/18/2005	9:00	3	4	3	10	Avg = 14
5/18/2005	10:00	7	0	2	9	**Haze**
5/18/2005	11:00	0	0	4	4	
5/18/2005	12:00	1	0	5	6	
5/18/2005	13:00	2	1	3	6	Avg = 6
5/18/2005	14:00	2	3	3	8	**Post-Haze**
5/18/2005	15:00	2	4	3	9	
5/18/2005	16:00	5	4	3	12	
5/18/2005	17:00	2	3	3	8	Avg = 9

Table 7b. Salmonids observed killed, by sea lions, per hour at Bonneville Dam on May 18 when hazing occurred.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/18/2005	6:00	2	0	0	2	**Pre-Haze**
5/18/2005	7:00	1	3	2	6	
5/18/2005	8:00	1	2	1	4	
5/18/2005	9:00	1	0	0	1	Avg = 3
5/18/2005	10:00	1	0	1	2	**Haze**
5/18/2005	11:00	0	0	0	0	
5/18/2005	12:00	0	0	0	0	
5/18/2005	13:00	2	0	0	2	Avg = 1
5/18/2005	14:00	2	0	0	2	**Post-Haze**
5/18/2005	15:00	1	1	1	3	
5/18/2005	16:00	1	1	0	2	
5/18/2005	17:00	3	2	0	5	Avg = 3

Table 7c. Salmonids passing at Bonneville Dam on May 18 when hazing occurred.

Date	Time	Bradford Is Salmonids	Washington Salmonids	Total/Hr	
5/18/2005	4:00	18	8	26	**Pre-Haze**
5/18/2005	5:00	37	23	60	
5/18/2005	6:00	20	28	48	
5/18/2005	7:00	26	5	31	
5/18/2005	8:00	17	17	34	
5/18/2005	9:00	13	10	23	Avg = 37
5/18/2005	10:00	30	8	38	**Haze**
5/18/2005	11:00	37	1	38	
5/18/2005	12:00	47	7	54	
5/18/2005	13:00	89	90	179	Avg = 77
5/18/2005	14:00	50	265	316	**Post-Haze**
5/18/2005	15:00	77	112	188	
5/18/2005	16:00	89	119	208	
5/18/2005	17:00	53	60	113	
5/18/2005	18:00	20	56	77	
5/18/2005	19:00	18	22	40	Avg = 157

Test Two May 19 Post-Treatment

Sea Lion Abundance - On May 19, the average sea lion attendance ranged from 12 to 17 animals per hour for all areas combined (average 15), about the same as the numbers seen before hazing the previous day. Sea lion presence was highest below PH2 ranging from 6

to 8 animals. At PH1 and the spillway, hourly presence ranged from 4 to 5 and 2 to 4 animals respectively. (Table 8a)

Predation - A total of 40 salmon were observed taken by sea lions on May 19, an increase over the previous day. The predation rate ranged from 1 to 5 fish per hour (average 3). The observed predation was highest at PH1 (23) followed by the spillway (9) and PH2 (8). (Table 8b)

Fish Passage – A total of 622 salmonids were observed passing the dam on May 19, a decline from the previous several days. Fish passage ranged from 14 to 60 salmonids per hour (average 39).

Table 8a. Average number of sea lions observed per hour at Bonneville Dam on May 19 after hazing test one.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/19/2005	6:00	4	8	2	14	**No Haze**
5/19/2005	7:00	5	8	4	17	
5/19/2005	8:00	4	8	4	16	
5/19/2005	9:00	5	8	4	17	
5/19/2005	10:00	5	8	2	15	
5/19/2005	11:00	5	8	3	16	
5/19/2005	12:00	4	6	4	14	
5/19/2005	13:00	4	6	4	14	
5/19/2005	14:00	4	5	3	12	
5/19/2005	15:00	5	6	3	14	
5/19/2005	16:00	4	6	2	12	
5/19/2005	17:00	4	7	2	13	Avg = 15

Table 8b. Salmonids observed killed, by sea lions, per hour at Bonneville Dam on May 19 after hazing test one.

Date	Time	PH1	PH2	Spill	Total/Hr	
5/19/2005	6:00	0	0	1	1	**No Haze**
5/19/2005	7:00	3	0	1	4	
5/19/2005	8:00	2	0	1	3	
5/19/2005	9:00	3	0	1	4	
5/19/2005	10:00	0	2	1	3	
5/19/2005	11:00	0	1	0	1	
5/19/2005	12:00	1	3	1	5	
5/19/2005	13:00	3	0	1	4	
5/19/2005	14:00	3	0	0	3	
5/19/2005	15:00	4	0	0	4	
5/19/2005	16:00	2	0	1	3	
5/19/2005	17:00	2	2	1	5	Avg = 3

Table 8c. Salmonids passing at Bonneville Dam on May 19 after hazing occurred.

Date	Time	Bradford Is Salmonids	Washington Salmonids	Total/Hr	
5/19/2005	4	14	26	41	**No Haze**
5/19/2005	5	5	36	41	
5/19/2005	6	13	10	23	
5/19/2005	7	16	26	42	
5/19/2005	8	10	12	22	
5/19/2005	9	11	4	14	
5/19/2005	10	6	20	26	
5/19/2005	11	10	17	26	
5/19/2005	12	23	28	50	
5/19/2005	13	24	36	60	
5/19/2005	14	19	30	49	
5/19/2005	15	13	43	56	
5/19/2005	16	14	36	50	
5/19/2005	17	17	22	38	
5/19/2005	18	26	26	53	
5/19/2005	19	16	16	31	Avg = 39

DISCUSSION

Sea Lion Abundance

Sea lion presence was well established at Bonneville Dam prior the beginning of any attempts to protect returning fish. As described, approximately 85 animals had been seen at the facility prior to the start of May and at no time during the hazing activities were sea lions completely absent from the tailrace. In general, sea lion attendance ranged from a low of 8 to a high of 27 animals per hour in the tailrace during periods when hazing activities were not being conducted (May 4 – 7 and May 16 – 19).

When active hazing was conducted, sea lion attendance dropped in areas where activity was concentrated. During test one, sea lion presence at PH2 dropped from an average of 9 animals per hour to zero on the first day of hazing from boats. On the second day of hazing, sea lion presence at PH1 and PH2 dropped from an average of 11 and 9 animals per hour respectively, before active hazing, to an average of 2 and 1 animals per hour respectively once refugia were established. During test two, sea lion attendance at PH1 and PH2 dropped from 9 and 11 animals per hour at the start of hazing from shore to 1 to 2 animals per hour during hazing on the first day. The next day the sea lions responded more quickly to shore based hazing and attendance dropped to 1 to 2 animals at PH1 and PH2 from 3 to 4 animals per hour prior to active hazing.

Sea lions returned to the treatment areas within a few hours after hazing stopped. On the first day of test one, overall sea lion abundance hardly changed during the day (19 before, 17 during and 20 after hazing) but attendance shifted away from PH2 where hazing was

concentrated. On the second day of test one, overall sea lion abundance dropped in half during hazing and increased once hazing ended. During test two a similar pattern was seen (i.e., variations in abundance and shifts in attendance during hazing activities). Boat surveys in the area below the tailrace, conducted before and after hazing each day during test two, indicated that some sea lions moved farther downstream during hazing and then likely returned to the dam once hazing stopped.

Predation

Predation increased in areas where sea lions moved in response to hazing. Predation dropped in areas abandoned by sea lions during hazing. On the first day of test one, sea lions vacated PH2 and numbers increased at PH1 and the spillway along with an increase in observed predation. Similarly on the second day, the majority of predation observed during hazing occurred at the spillway where hazing was not done. A similar pattern was seen during test two. It was not possible to determine any individual or residual effect on predation efficiency, by sea lions subjected to harassment.

Fish Passage

Fish passage rate appears positively correlated with hazing activity. In general, fish passage tends to build during daylight hours with higher rates encountered in the afternoon. Nevertheless, passage appeared to pick up during hours of hazing and remain elevated for up to several hours afterward. Fish passage was the highest of the season on day one of test one with a smaller but detectable spike the second day. Similarly, during test two passage appeared higher during and following hazing. Although we suspect a reduction in sea lion presence immediately below the fishway entrances may have resulted in increased fish passage, this hypothesis remains in question. Small sample size makes interpretation of passage trends difficult in light of season long variability in daily passage rates.

The relationship between fish passage rate and predation is unclear. The relationship between sea lion abundance and attendance patterns in the tailrace and fish passage is also unclear.

Recommendations for Future Action

- Hazing should be initiated immediately upon the arrival of sea lions at the dam. Sea lions should be actively discouraged from resting on or near the dam to avoid building a large resident cadre of animals at the facility. Hazing activities should be directed toward animals hauled out or rafting, as well as foraging animals.
- Sea lions should be excluded from fish passage galleries and ladder weirs.
- Continue to test non-lethal deterrence methods at the facility for broader applicability and to determine level of habituation.
- Continue to evaluate the relative importance of sea lion predation in the river in comparison with other sources of mortality.

- Monitor lockages to determine if sea lions are present in the lock chamber before closing the downstream gates. If sea lions are present, active hazing should be conducted to chase the animals out and downstream. Sea lions should not be locked through upstream.