



CRITFC

TECHNICAL REPORT 11-07

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Sea Lion Monitoring and Non-Lethal Hazing

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Introduction

The intent and focus of this project is to address marine mammal predation on Columbia River salmonids. This is a new and growing impact to salmonids particularly in the last several years (Pinniped Task Force 2007). To date, most of the attention has focused on the area just below Bonneville Dam, where salmon are concentrated before they enter the fish ladders and where visual estimates of predation rates are easier to develop (Stansell et al. 2011). However, there are anecdotal reports of extensive sea lion predation in areas below the dam that are not visible from the dam. This unaccounted for predation may be greater than the observed predation.

This project is collaborative with the States of Oregon and Washington, the Army Corps of Engineers (ACOE), and the U.S. Department of Agriculture (USDA). The scope of the project includes a 3 person, boat-based, sea lion hazing crew operating weekly for approximately 3 months near Bonneville Dam. This crew conducts non-lethal sea lion hazing, assists with trapping (not actual trapping) for attaching acoustic and GPS tags, and other field duties. A second objective is implementing a project to estimate sea lion predation outside of the ACOE observation area. The ACOE observation project is limited to the Bonneville Dam tailrace area that is viewable from the deck of the Dam. We are working to develop a video-based system to enumerate sea lions and predation on salmonids. A video system is deployed to observe river surface activities in quantified areas of the river. Technicians then review these time periods and note sea lion presence and predation activities. The video system was deployed within the Corps observation area below Bonneville Dam where visual observations are being made by the Corps and ground-truthing is possible. Acoustic telemetry data was collected to evaluate movements of California sea lions. Observations regarding affinity to particular feeding stations, fine scale movement of animals in the area near Bonneville Dam, and coarse scale movement of animals downstream in the lower Columbia River were made. The objectives of the project are:

- Objective 1. Conduct boat-based non-lethal sea lion hazing annually generally between March 1 and May 31.
- Objective 2. Develop a video system to enumerate sea lions and estimate predation.
- Objective 3. Track movements of individual sea lions at various spatial scales in the Columbia River using acoustic telemetry.

Each of these objectives is required under the Hydro system Biological Opinion Reasonable and Prudent Actions (RPA) 49 and 69.

Objective 1. Conduct boat-based non-lethal sea lion hazing annually generally between March 1 and May 31.

Non-lethal hazing of nuisance pinnipeds that prey on Pacific salmon is a Hydro BiOp requirement, it is also one of the first steps that is required by the NOAA Environmental Assessment (NOAA 2008) that authorizes the states to remove problem California sea lions (*Zalophus californianus*), and it is the only management tool that can be used to control

predation by Steller sea lions (*Eumetopias jubatus*) as a result of their threatened status. Hazing uses repeated deterrent actions to change animal behavior and in this case we are attempting to change the feeding location and prey source of sea lions near Bonneville Dam. The dam creates a collection point for salmon on their spawning migration and sea lions have used this to their feeding advantage. Discouraging predatory animals from using such a lucrative feeding site can be challenging and overall success of these programs can be difficult to assess. The Action Agencies are responsible for evaluating the effectiveness of this action in reducing immediate predation. At the minimum, this activity helps identify those animals that pose problems and that are candidates for future removal and may have some success at discouraging naïve individuals and curb Steller sea lion predation.

Boat-based hazing activities are conducted during daylight hours between the Bonneville Dam face to approximately 6 miles downstream. The hazing boat is crewed by three people (one boat captain, one data collector and one person hazing), and coordinates activities with the Department of Agriculture hazing crews on Bonneville Dam. Hazing includes the use of acoustic and tactile deterrents (seal bombs, cracker shells, rubber buckshot, and vessel chase) in an attempt to deter pinnipeds.

Data on all sea lion encounters is recorded following protocols established by the states which include the time and location of the initial encounter, species, direction of movement, fish kill information, numbers and types of deterrents used, and time, location and direction at the end of the encounter. All data collected is sent to ODFW/WDFW to be included in the overall hazing evaluation. In-season activities are summarized on a weekly basis by the Corps. Included in those summaries are effects from boat-based hazing.

Project participants receive safety briefings from CRITFC, USACE, ODFW, and WDFW personnel. Briefings cover boat operations and clearance for activities in the Boat Restricted Zone (BRZ) 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 is discussed. Boat teams receive briefings on vessel safety equipment and rescue procedures at the time of launch. While inside the Boat Restricted Zone (BRZ), hazing boats maintain VHF-radio contact with the Bonneville Dam Vessel Control officer for status and vessel traffic updates.

For human and fish safety, boat access within the BRZ was limited to approximately 30 m from all project structures and 50 m from main fishway entrances. No seal bombs were used within 100 m of fishways, floating orifices, Powerhouse 2 (PH2) Corner Collector flume or smolt monitoring facility outfall. In addition, no seal bombs were used once salmon passage exceeded 1000 fish per day. Hazing activities were coordinated daily with USACE Control Room and Fisheries Field Unit (FFU) personnel, as well as with USDA Wildlife Services staff, who were hazing sea lions from project ground facilities.

Table (1) summarizes boat-based hazing activity in 2011.

Table 1. Boat-based hazing activities conducted by CRITFC at Bonneville Dam, 2011

Wk #	Week of	Days	Events	Take*		Munitions used	
				# CSL	# SSL	Cracker shells	Seal bombs
9	2/27/2011	5	23	7	36	625	213
10	3/6/2011	2	9	0	28	400	163
11	3/13/2011	4	24	9	44	976	377
12	3/20/2011	4	43	27	61	1705	433
13	3/27/2011	5	41	31	45	1097	346
14	4/3/2011	1	3	2	5	140	44
15	4/10/2011	4	22	11	35	1324	382
16	4/17/2011	4	30	27	29	529	240
17	4/24/2011	4	20	23	38	308	83
18	5/1/2011	2	24	17	35	376	76
19	5/8/2011	2	17	18	3	355	82
20	5/15/2011	1	1	1	0	4	0
		38	257	173	359	7839	2439

* Take refers to numbers of animal-harassment events (one animal may be harassed); CSL=California sea lion, SSL=Steller sea lion.

The boat-based hazing crew from CRITFC hazed sea lions for a total of 38 days from 2/28/2011-5/16/2011 (Table 1). Hazing resulted in 257 hazing events on 173 and 359 California sea lions and Steller sea lions, respectively. A total of 7839 cracker shells and 2439 seal bombs were used during deterrent activities. The final direction of sea lions at the end of these encounters resulted in 78.6% of sea lions moving down stream of the hazing boat. These numbers are similar to that seen in past years. There was however, no apparent reduction in overall sea lion abundance or predation near the dam in response to hazing, but there does appear to be an immediate effect on the animals while hazing is occurring. Both Brown et al. (2011) and Stansell et al. (2011) have found similar results near Bonneville dam. Other studies have demonstrated that pinnipeds habituate very quickly to acoustic and other deterrents that may be initially effective (reviewed by Bowen 2004, Franker and Mate 1999, Scordino 2010).

Hazing was primarily focused in the Boat Restricted Zone (BRZ) just below Bonneville dam. By design our strategy was to deter sea lions from feeding near fish ways within this zone and it's no surprise that 79.4% of our hazing encounters with sea lions occurred in this location. Granted the density of sea lions tends to be higher within this zone, but our hazing data cannot be used to estimate abundance inside or outside this zone due to biases created by attempting to achieve the ultimate hazing goal of keeping sea lions away from the dam. The data is interesting in that we had 20.6% of our hazing events outside the BRZ which demonstrates that there is a significant sea lion presence outside the Corps visual observation area.

The proportion of sea lion hazing events that included observations of fish predation was 23.3%. Of these observations, 76.7% were determined to be salmonids, 21.7% were sturgeon, and the remaining were unknown fish species. A higher proportion of these fish kills were observed within the BRZ at 65% and the remaining fish kills were observed in the 12 miles between

Phoca Rock and the BRZ. Like the hazing data above, these numbers cannot be used as an estimate of salmon or sturgeon take due to the same biases and fish kills are highly visible due to the swarms of birds that immediately amass. These data are again interesting in that they do demonstrate that not only are sea lions observed in the 12 miles below Bonneville dam but they are also actively feeding in those areas as well. In fact, this area consisted of only 20.6% of our total hazing events but also contained 35% of observed predation events.

It is very difficult to recognize individual sea lions from a boat. Viewing angle, weather conditions, distance, and the duration of time that sea lions are at the surface all are factors that make it problematic to achieve this goal. We were able to identify individual sea lions in 4.7% (12 of 257) hazing events which included 13 observations of instrumented animals (acoustic or GPS tagged) and one branded Steller sea lion. Of the instrumented animals, 4 were California sea lions, 8 were Steller sea lions and 1 was an unknown species. Granted we were not able to categorize these as known "individual" sea lions, but they were from the distinct group of identifiable individuals that were tagged in the spring of 2011. All instrumented animals are identifiable due to bright colored patches fixed to the sea lion fur during the tagging process. Following these 12 hazing engagements, 9 encounters resulted in the sea lions moving downstream of the hazing boat.

The States and CRITFC have successfully coordinated hazing efforts below Bonneville Dam for the past five years. In order to maximize the beneficial results of hazing, trapping and removing predatory sea lions in future years, the States will focus their staff and resources on trapping and removal efforts, while CRITFC will focus on deterrent and sea lion abundance estimation activities. Both the States and CRITFC will work together on further telemetry studies. The level of hazing activities conducted by CRITFC on the water and by USDA Wildlife Services staff on shore, will be adequate to meet the objectives of disrupting sea lion foraging behavior in the BRZ and exposing predators to significant deterrent efforts.

Objective 2. Develop a video system to enumerate sea lions and estimate predation.

We are working to develop a system for estimating sea lion predation and abundance downstream of the Corps observation area using video surveillance technology. This will be an extension of the video fish counting systems that we pioneered in early 1990's (Hatch et al. 1994, 1998) that are currently being used at numerous locations in New England (Haro and Fryer 2006), Michigan, Oregon, Alaska, and Europe. One video system would be deployed to observe river surface activities in known areas of the river. The camera system will scan the surface recording low and high resolution images that will be recorded on a computer. Technicians will then review these time periods and note sea lion presence and predation activities.

For the 2011 season, we built on what we learned from the 2010 season and upgraded our camera and recording system. Our new system uses 4 5-megapixel digital cameras with 3x zoom and has 17 times the resolution of the 2010 system. This upgrade was necessary to improve image quality in the extensive range covered by individual cameras. Each camera may

have a viewing distance covering 50 to 300 meters. The increased resolution allows us to zoom in on recorded objects and still maintain a certain level of image quality. Figure (1) demonstrates the capacity of the upgraded system on a “near camera” sea lion and Figure (2) demonstrates the capability on a distant sea lion. Poor light conditions and weather conditions still affect image quality. The 2010 recording device only had a 750 GB capacity per hard drive which had to be switched out about every 10 days. The new system uses a windows based server containing six hard drives that have a total capacity of nearly 10 TB. The PC based server also allows for user friendly software for reviewing video and copying files in universally recognized file types. Overall the 2011 system is a vast improvement over last year’s system.



Figure 1. The upper left image is a Steller sea lion image as it is captured on our video system. The upper right, followed by lower left, then lower right are varying stages of zoom on that original image.



Figure 2. The upper image is of an unknown species of sea lion captured at a distance and the lower image is zoomed in.

The video system was deployed on the south monolith of power house 2 at Bonneville dam. Four cameras were used to view the Washington shore from the dam face to the greatest distance possible downstream. The system recorded from April 7th to May 27th during the daylight hours of 7:00 to 19:00. Due to the inability of the cameras to track individual sea lions at all times, number of sea lion observations per hour will be used to standardize abundance with the Corps visual observations. A sea lion observation, or event, is recorded as the initial date and time a sea lion emerges in the video and a final date and time that same identified sea lion disappears. Basically we will produce a density of observations per hour that can be associated to a known number of sea lions.

Video is currently being reviewed and a sample of data set is included in Table (2). For sea lion density we are seeing an average of 107.38 events per day ranging from 31 to 256, along with an average of 4.15 predation events per day ranging from 1 to 12 events. Overall, 3.9% of our total sea lion events have predation. When looking at the distribution of all sea lion observations grouped by hour, a pattern of activity emerges (Figure 3).

Table 2. Count of sea lion observations and predation events per day and hour of day.

Date	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	Total
4/9/2011	11	17	44	15	11	22	5	22	31	27	32	18	10	265
Predation			5				1		2					8
4/10/2011	8	20	23	21	6	6	11	16	27	14	32	30	26	240
Predation		1	5		1			2					3	12
4/11/2011	10		1		1	15		1	3	7	17	2	4	61
Predation						1			1	1				3
4/12/2011	3		3	6	12		1	4	15	8	5		1	58
Predation			1											1
4/13/2011	2	1	8	1	1	7		2	5	2	2	12	1	44
Predation									1		2	3		6
4/14/2011				7	2		4	3	2	6	9	2		35
Predation				4			1			1				6
4/15/2011	9		3			2	1	2	2			8	4	31
Predation						1	1	1					1	4
4/16/2011	11	19	3	5	17	11	1	1	14	8	10	6	9	115
Predation	1	1			1									3
4/17/2011	7	8		1		6	12	28	24	26	27	25	24	188
Predation									1					1
4/18/2011		6	7	1		2	2	2	10	13	8	8	11	70
Predation							1		1					2
4/19/2011	3	8	3	1		3	1	3	10	5	15	21	4	77
Predation	1						1							2
4/20/2011	4	8	1	2	1		1	19	5	14	27	18	24	124
Predation										1	1			2
4/21/2011	16	9	1	4	3	3	7	11	4	6	14	7	3	88
Predation					2	1						1		4
Total	84	96	97	64	54	77	46	114	152	136	198	157	121	1396
Predation	2	2	11	4	4	3	5	3	6	3	3	4	4	54
Proportion	2.4%	2.1%	11.3%	6.3%	7.4%	3.9%	10.9%	2.6%	3.9%	2.2%	1.5%	2.5%	3.3%	3.9%

While there is a morning peak of activity in the 08:00 and 09:00 hours, the bulk of the sea lion activity is occurring in the 14:00 to 19:00 hours. This pattern coincides with boat based hazing operations that typically occur between 08:00+/- and 14:00+/- and likely reduces sea lion presence near the powerhouse. The proportion of observed predation events per hour had the

opposite pattern with the peak predation per event occurring between 09:00 and 13:00. This is likely the result of the observed predation having a relatively constant rate and sea lion occurrence fluctuating throughout the day.

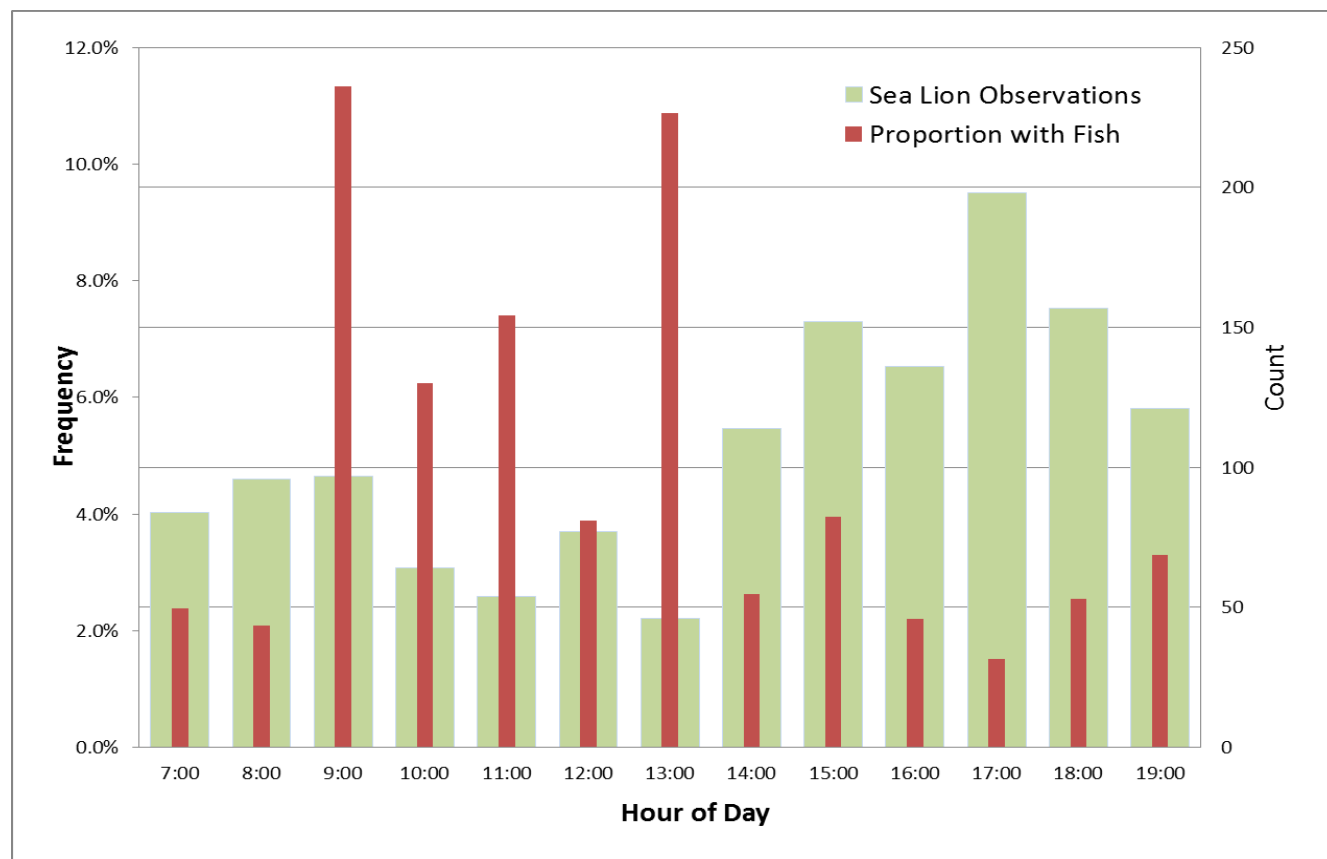


Figure 3. Count of total sea lion observations per hour for the period of April 9 to April 21 and associated proportion of observed predation events.

Objective 3. Track movements of individual sea lions at various spatial scales in the Columbia River using acoustic telemetry.

Acoustic pingers (ultrasonic transmitters) were attached to 13 sea lions captured at Bonneville Dam in order to track movements and infer foraging behavior around Bonneville Dam and in the lower Columbia River. Five California sea lions and 8 Steller sea lions were tagged. We used Vemco V16-5H coded pingers (Vemco Ltd., Nova Scotia, Canada) which were 16-mm in diameter, 955-mm in length, weighed 16-g in water and operated at a frequency of 69-kHz with a power of 165 dB re 1 μ Pa at 1 m. Each pinger emitted a uniquely identifiable pulse train at random intervals every 30-90 s. Pingers were attached to the dorsum of a sea lion using 5-minute epoxy.

Sea lions were passively tracked using fixed arrays of Vemco VR2W acoustic receivers. Receivers were located from Bonneville Dam to Astoria (Figure 4). In narrow locations, a single receiver was used to provide acoustic coverage over the width of the river, whereas in wider areas two or more receivers were used to create "passage gates". Receivers recorded a pinger's identification number, date and time whenever a marked sea lion traveled within a receiver's detection range. For the California sea lions, depth was also recorded simultaneously with each detection. Range testing was conducted three times early in the season by towing a pinger with a boat. The velocity of the boat was ~13 km/hr and the pinger used continuously pulsed signals at 5 s intervals. The boat / pinger unit traveled throughout the study area during each test. An onboard GPS unit recorded the location of the boat / pinger and these data were combined with detections from the array of fixed receivers to study detection range. Detection range varied among receiver groups and echoes, turbulence, bubbles and other disturbances impacted efficiency of receivers in the Boat Restricted Zone (BRZ). However, by studying the detection pattern on receivers it was possible to ascertain legitimate detections from echo detections. Receivers located outside of the BRZ arranged as detection gates always detected range tags during testing.

California sea lions (CSL) were tagged on 4 different occasions in 2011: March 30, April 14, April 19, and April 20. Two CSL's (C-006 and C-013) shed their tags shortly after they were fitted and therefore have limited data (Figure 5). C-011 was tagged on April 14 and was detected for 10 days before the signal was lost. This individual demonstrated similar behavior to other CSL's we've tagged in the past by spending the vast majority of its time (75% of the detections) in the Bonneville dam tailrace within the BRZ (Figure 6, Table 3). It did take three trips outside the BRZ down to marker 85 (RM 140) and Phoca rock (RM 132).

A completely different behavior than we've ever seen before was exhibited by CSL C-012. This individual was tagged on April 19 and immediately left the Bonneville Dam area and was detected at the East Mooring Basin in Astoria the next day. This sea lion never returned to the dam but did take 3 trips up river (Figure 7, Table 4). The first was to the upper estuary and other trips were to Willamette Falls. This individual did exhibit behavior similar to other CSL's we've seen in the past by returning to the estuary several times during the season. In total C-012 had 94.9% of its detections away from Bonneville Dam, of which 43% of them were at Willamette Falls.

Eighty-six percent of the detections for C-971 were in the BRZ area near Bonneville Dam which is typical for CSL's. After a 14 day residence near the dam this individual migrated to the estuary and never returned to the dam (Figure 8, Table 5).

For comparison sake we've included the acoustic tracks from 6 of 8 Steller sea lions (SSL) tagged. Steller sea lions were tagged on March 30, April 6, and April 7. Two tags were lost shortly after they were deployed (O-09, O-11). Four of the instrumented animals (O-10, "No ID", O-14, O-15) exhibited similar residence behavior near Bonneville Dam as other SSL's that we've tagged in the past with their detections occurring inside and outside of the BRZ (Figures 9-12, Tables 6-9). Close examination of these tracks shows that while these animals have an affinity for feeding and residing near Bonneville Dam there are many examples where these

animals are residing extended periods between RM 132 and RM 142 where they likely feed as well. Two of the SSL's (O-16, O-17) migrated to the estuary after they were tagged. O-16 returned to the dam after 6 days and exhibited normal residence behaviors (Figure 13, Table 10). An unusual residence and migratory pattern was seen in O-17 (Figure 14, Table 11). Shortly after being tagged O-17 migrated to the estuary and was detected for 7 days near Astoria, then spent another 7 days near the mouth of the Lewis River before returning to the Bonneville Dam area. Presumably this individual was feeding during the time it spent away from dam between April 7 and May 2nd.

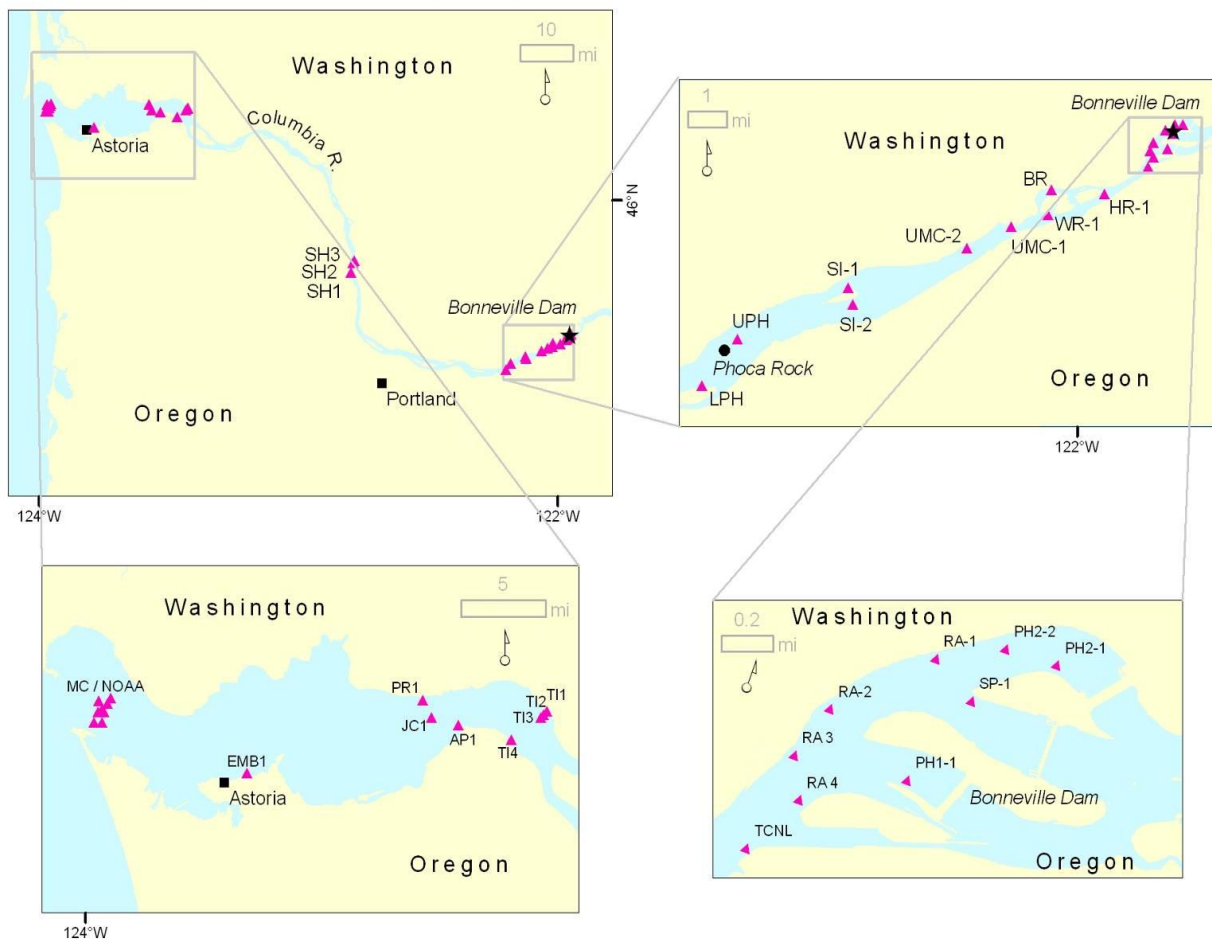


Figure 4. Hydrophone locations used to track sea lions tagged at Bonneville Dam, 2011.

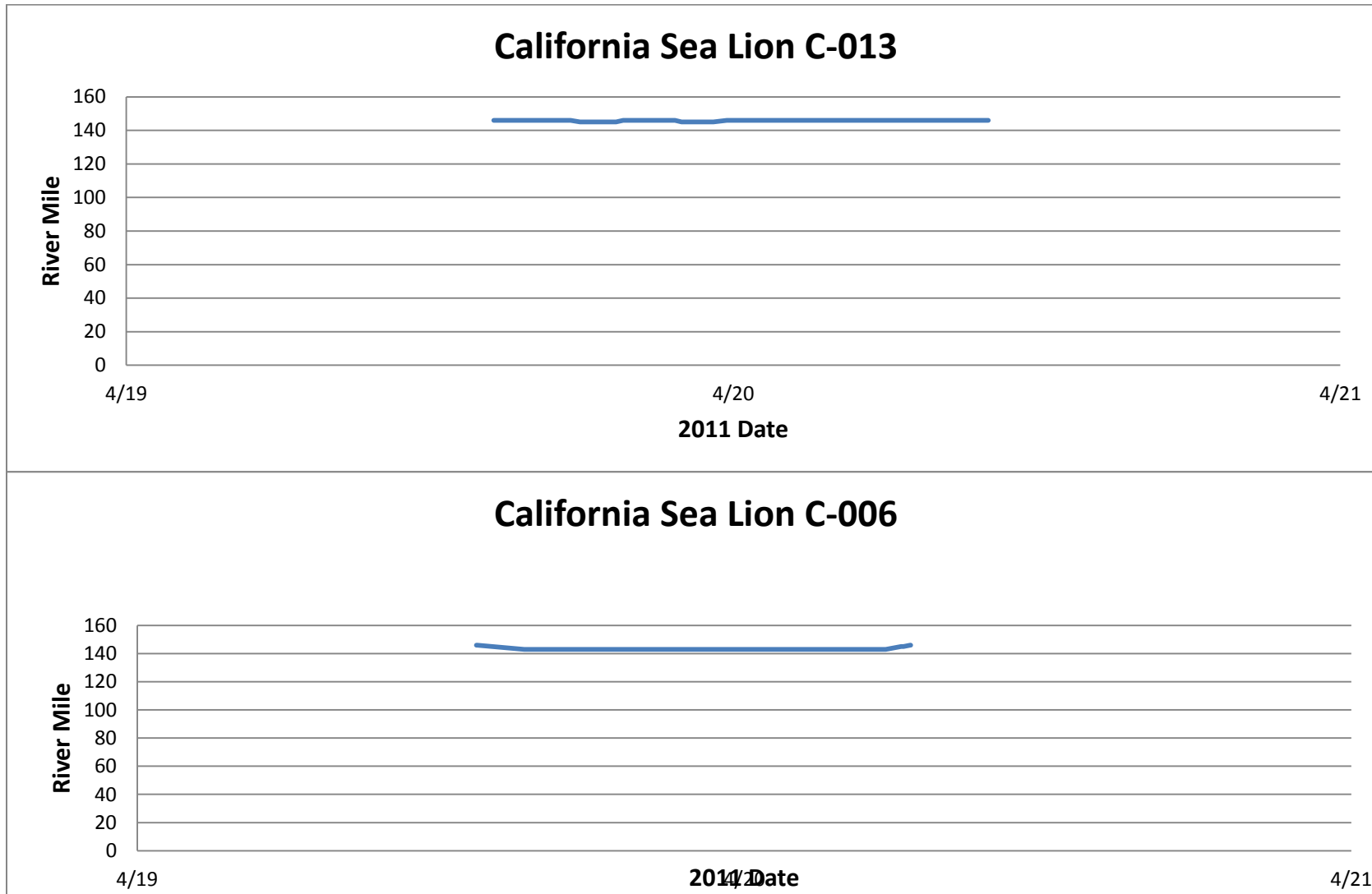


Figure 5. Acoustic telemetry data from sea lions C-013 and C-006. Both tags fell off prematurely near Bonneville Dam river mile 144-146.

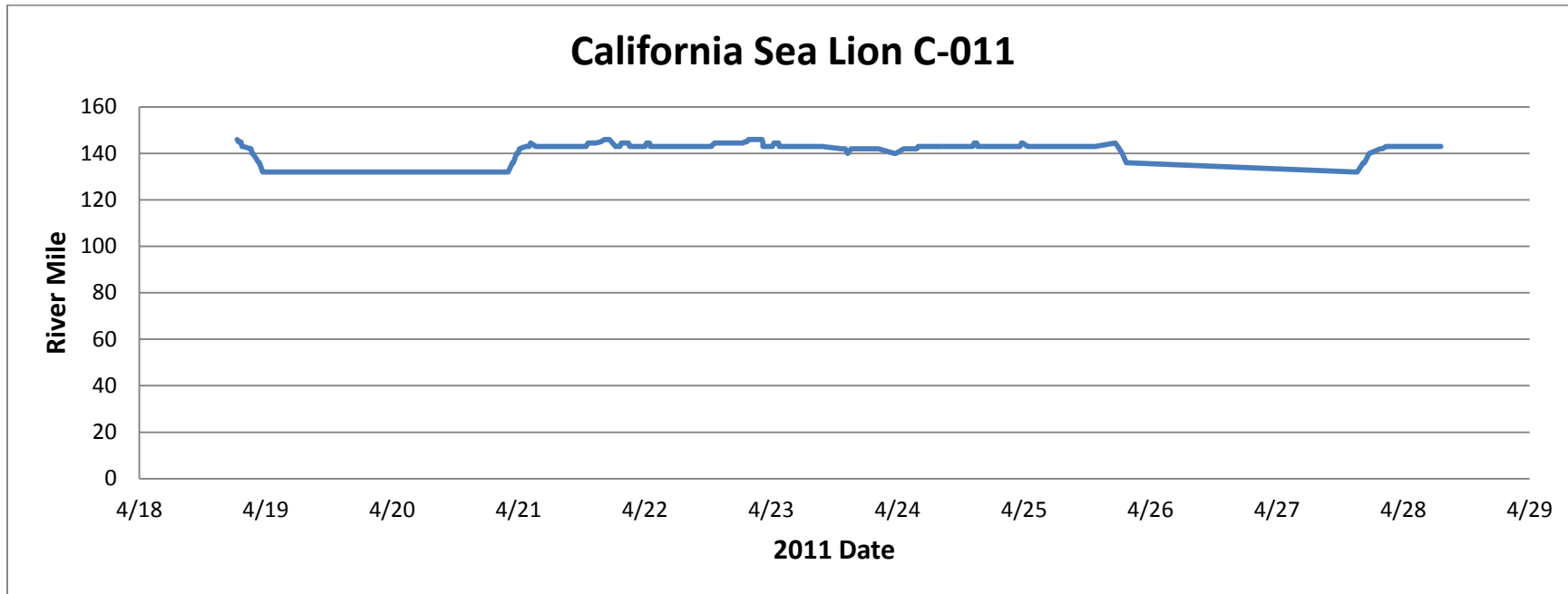


Figure 6. Acoustic telemetry data from sea lion C-011. River mile 146 is Bonneville Dam.

Table 3. Number of detections by location and date for California sea lion C-011.

C-011	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/18/2011	1	5		2	1	2	3	2							16
4/20/2011						6	4	4							14
4/21/2011	13	1	25	34	1										74
4/22/2011	27	7	14	25											73
4/23/2011			7	6	21	4									38
4/24/2011			4	27	6										37
4/25/2011			1	13		1	1								16
4/27/2011				10	6	2	8	4							30
4/28/2011				9											9
Total	41	13	51	126	35	15	16	10							307

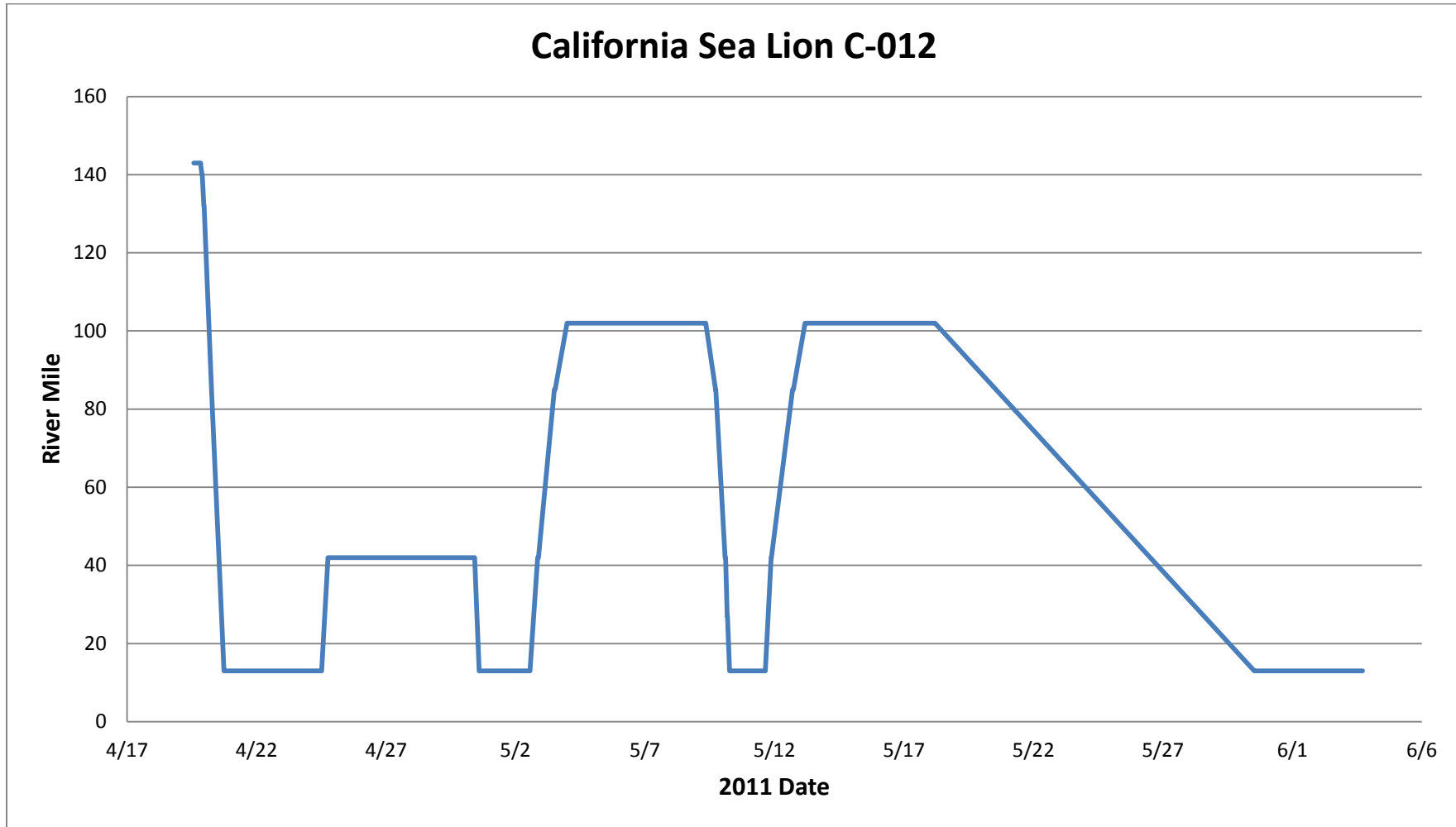


Figure 7. Acoustic telemetry data from sea lion C-012. River mile 146 is Bonneville Dam.

Table 4. Number of detections by location and date for California sea lion C-012.

C-012	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/19/2011				5	1	9	4	4							23
4/20/2011										1			1		2
4/22/2011													5		5
4/23/2011													4		4
4/24/2011											11		1		12
4/26/2011											7				7
4/27/2011											44				44
4/30/2011											10		2		12
5/1/2011													1		1
5/2/2011											15		2		17
5/3/2011									1	8					9
5/4/2011									22						22
5/5/2011									11						11
5/6/2011									11						11
5/7/2011									28						28
5/8/2011									1						1
5/9/2011									57	3					60
5/10/2011											16	2	56		74
5/11/2011											4		3		7
5/12/2011										5					5
5/13/2011									14						14
5/14/2011									34						34
5/15/2011									3						3
5/16/2011									3						3
5/17/2011									2						2
5/18/2011									6						6
5/30/2011													3		3
5/31/2011													18		18
6/1/2011													5		5
6/2/2011													2		2
6/3/2011													4		4
Total				5	1	9	4	4	193	17	107	2	107		449

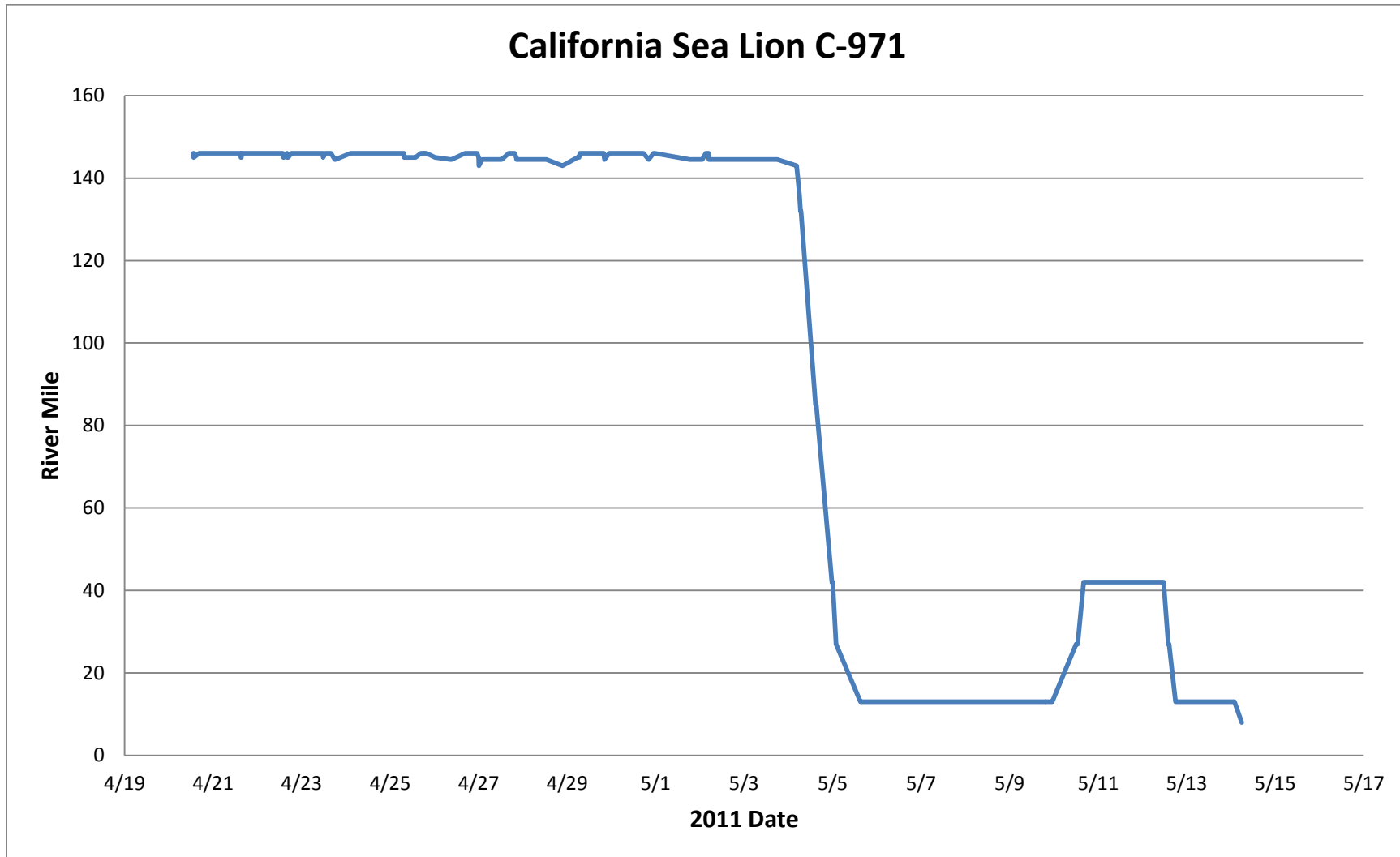


Figure 8. Acoustic telemetry data from California sea lion C-971. River mile 146 is Bonneville Dam.

Table 5. Number of detections by location and date for California sea lion C-971.

C-971	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/20/2011	6	4													10
4/21/2011	61	7													68
4/22/2011	10	10													20
4/23/2011	69	1	5												75
4/24/2011	77														77
4/25/2011	120	14													134
4/26/2011	12	4	2												18
4/27/2011	5	2	8	1											16
4/28/2011			2	1											3
4/29/2011	18	13	1												32
4/30/2011	157		1												158
5/1/2011			1												1
5/2/2011	26		4												30
5/3/2011			8												8
5/4/2011				1		2	2	2		4	4				15
5/5/2011												2	5		7
5/6/2011													9		9
5/7/2011													8		8
5/8/2011													10		10
5/9/2011													28		28
5/10/2011											11	5			16
5/12/2011											4	4	2		10
5/14/2011													1	1	2
Total	561	55	32	3		2	2	2		4	19	11	63	1	755

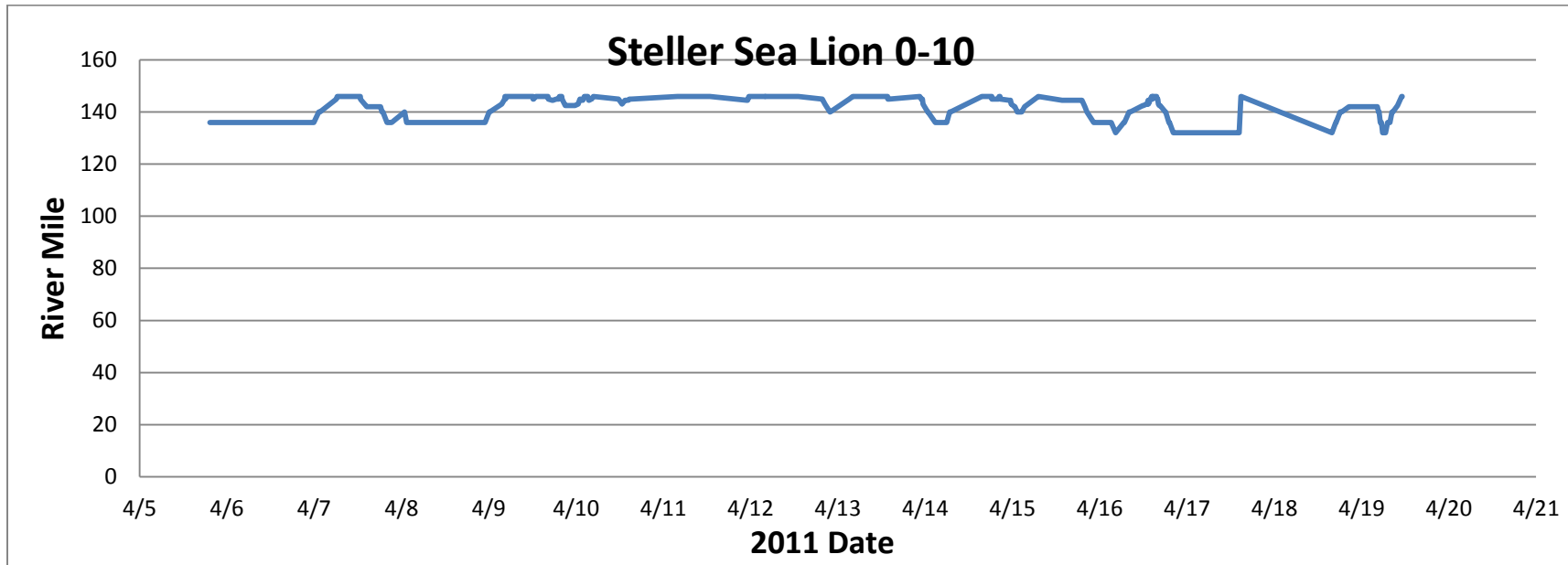


Figure 9. Acoustic telemetry data from Steller sea lion O-10. River mile 146 is Bonneville Dam.

Table 6. Number of detections by location and date for Steller sea lion O-10.

O-10	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/5/2011							1								1
4/6/2011							1								1
4/7/2011	2	4			8	20	4								38
4/8/2011						1	118								119
4/9/2011	126	25	14	2	9	9									185
4/10/2011	36	45	44	8											133
4/11/2011	11		14												25
4/12/2011	34	3		1		5									43
4/13/2011	26	25		1											52
4/14/2011	24	16	16	2		17	25								100
4/15/2011	1		22		13	24	16								76
4/16/2011	16	11	3	6	13	18	26	6							99
4/17/2011	4							3							7
4/18/2011					1	8	7	2							18
4/19/2011	5				4	17	51	15							92
Total	285	129	113	20	48	119	249	26							989

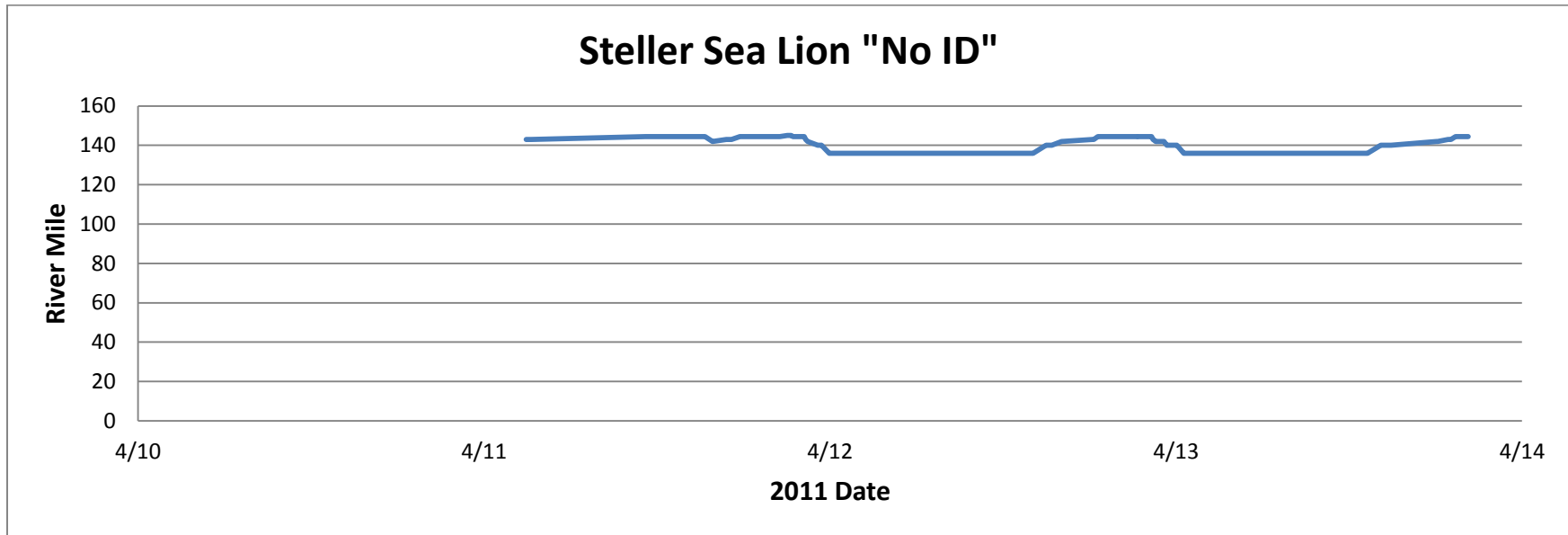


Figure 10. Acoustic telemetry data from Steller sea lion “No ID”. River mile 146 is Bonneville Dam.

Table 7. Number of detections by location and date for Steller sea lion “No ID”.

No ID	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/6/2011					1	45	29								75
4/7/2011						26	62								88
4/8/2011						5	136								141
4/9/2011			34	22	5	27									88
4/10/2011	3	13	25	1	1	22	59								124
4/11/2011	1	15	69	28	2	7	2								124
4/12/2011			29	7	6	41	70								153
4/13/2011			2	4	2	15	111								134
Total	4	28	159	62	17	188	469								927

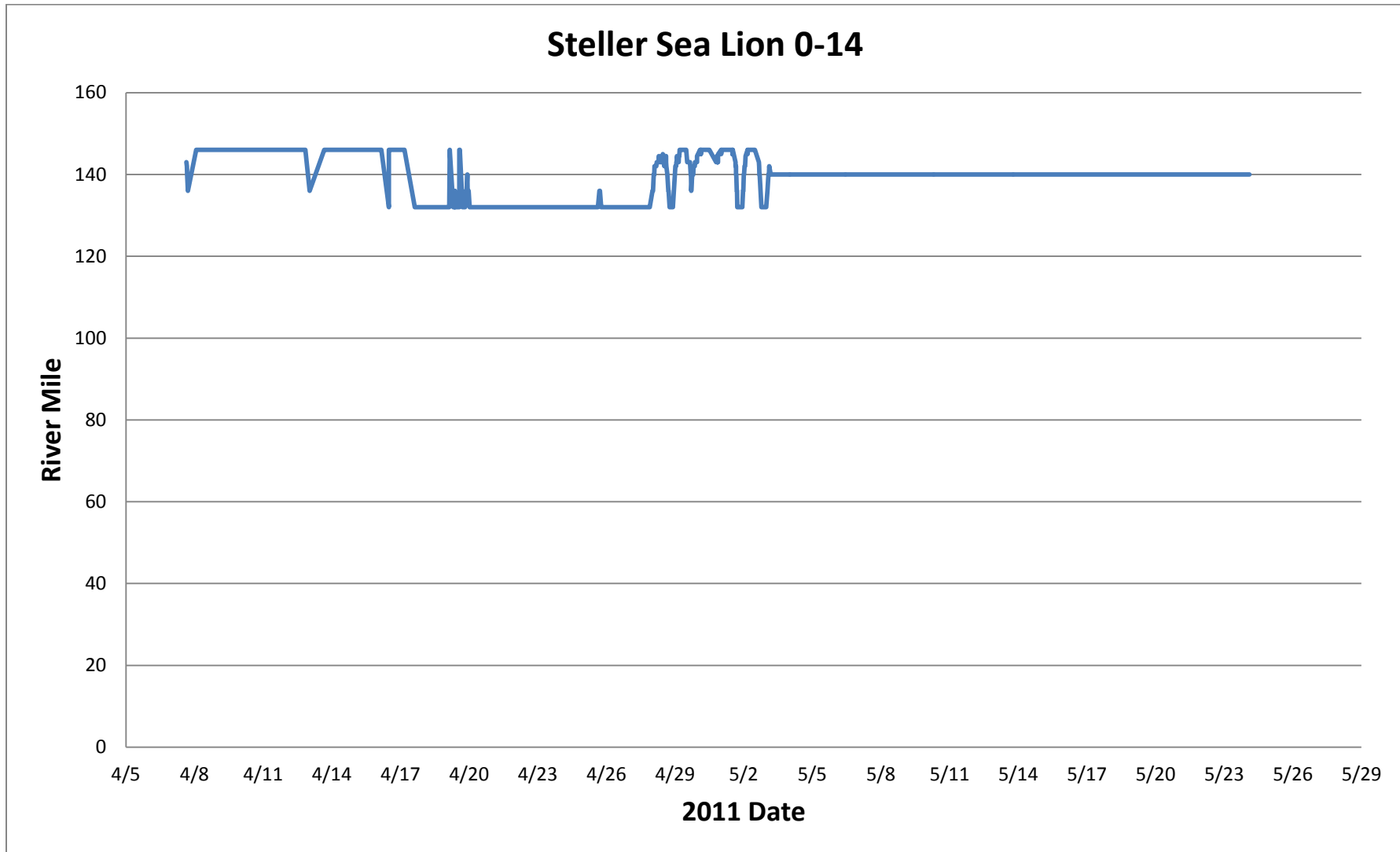


Figure 11. Acoustic telemetry data from Steller sea lion 0-14. River mile 146 is Bonneville Dam.

Table 8. Number of detections by location and date for Steller sea lion O-14.

O-14	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/7/2011				1	1	5	6								13
4/8/2011	7														7
4/9/2011	8														8
4/10/2011	8														8
4/11/2011	15														15
4/12/2011	14														14
4/13/2011	9						2								11
4/14/2011	5														5
4/15/2011	1														1
4/16/2011	3							1							4
4/17/2011	3							5							8
4/18/2011								13							13
4/19/2011	20					1	66	80							167
4/20/2011								23							23
4/21/2011								16							16
4/23/2011								5							5
4/24/2011								8							8
4/25/2011							14	7							21
4/26/2011								3							3
4/27/2011								3							3
4/28/2011		1	12	125	6	32	23	7							206
4/29/2011	20	1	4	84	16	37	2								164
4/30/2011	141	19	27	31											218
5/1/2011	121	2		3	3	6	22	7							164
5/2/2011	275	1	1	1	6	26		4							314
5/3/2011					4	751	5								760
5/4/2011						462									462
5/5/2011						764									764
5/6/2011						812									812
5/7/2011						684									684
5/8/2011						225									225
5/9/2011						22									22
5/10/2011						111									111
5/11/2011						149									149
5/12/2011						245									245
5/13/2011						270									270
5/14/2011						280									280
5/15/2011						36									36
5/18/2011						2									2
5/20/2011						3									3
5/21/2011						24									24
5/22/2011						10									10
5/23/2011						31									31
5/24/2011						8									8
Total	650	24	44	245	36	4996	140	182							6317

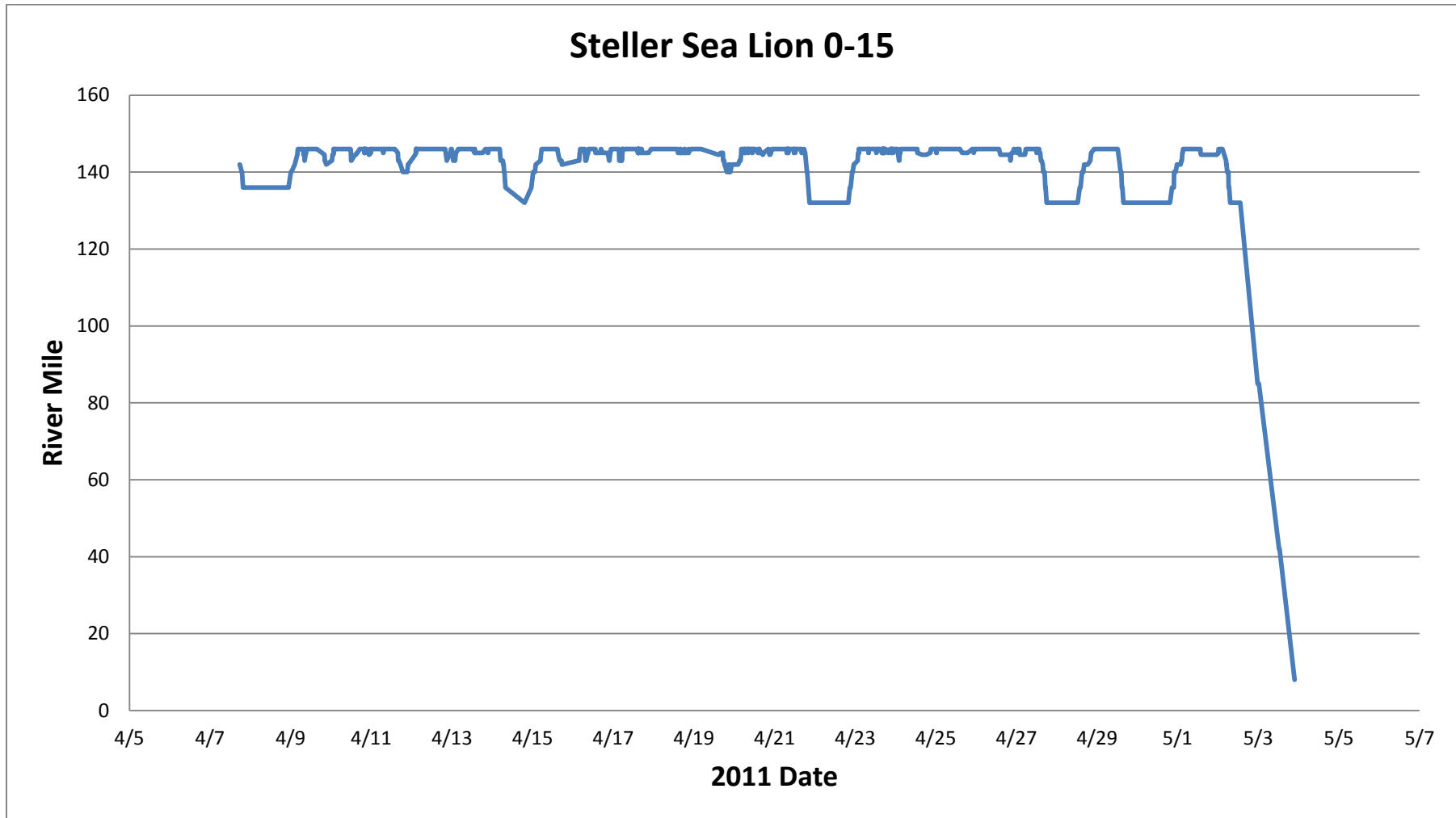


Figure 12. Acoustic telemetry data from Steller sea lion 0-15. River mile 146 is Bonneville Dam.

Table 9. Number of detections by location and date for Steller sea lion O-15.

O-15	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/7/2011					2	8	9								19
4/8/2011							12								12
4/9/2011	59	2	14	6	2	14									97
4/10/2011	56	33	26	11											126
4/11/2011	182	6		12	5	28									233
4/12/2011	32	22	1	4											59
4/13/2011	28	38		5											71
4/14/2011	13	2		37	3	4	4	1							64
4/15/2011	61	2		9	4	27									103
4/16/2011	35	167	2	24											228
4/17/2011	121	71	6	22											220
4/18/2011	172	40													212
4/19/2011	46	9	15	2	7	12									91
4/20/2011	174	54	10	7	3										248
4/21/2011	231	34				7		6							278
4/22/2011					4	13	21	27							65
4/23/2011	266	47		1											314
4/24/2011	226	21	2	4											253
4/25/2011	257	16													273
4/26/2011	332	19	37	1											389
4/27/2011	210	10	24	10	1	27	12	1							295
4/28/2011	14	10		1	5	14	7	5							56
4/29/2011	150				1	10	8	3							172
4/30/2011					8	27	31	50							116
5/1/2011	168	14	4	8	3										197
5/2/2011	15	9		3	2	26	21	7		7					90
5/3/2011										14	15			3	32
Total	2848	626	141	167	50	217	125	100		21	15			3	4313

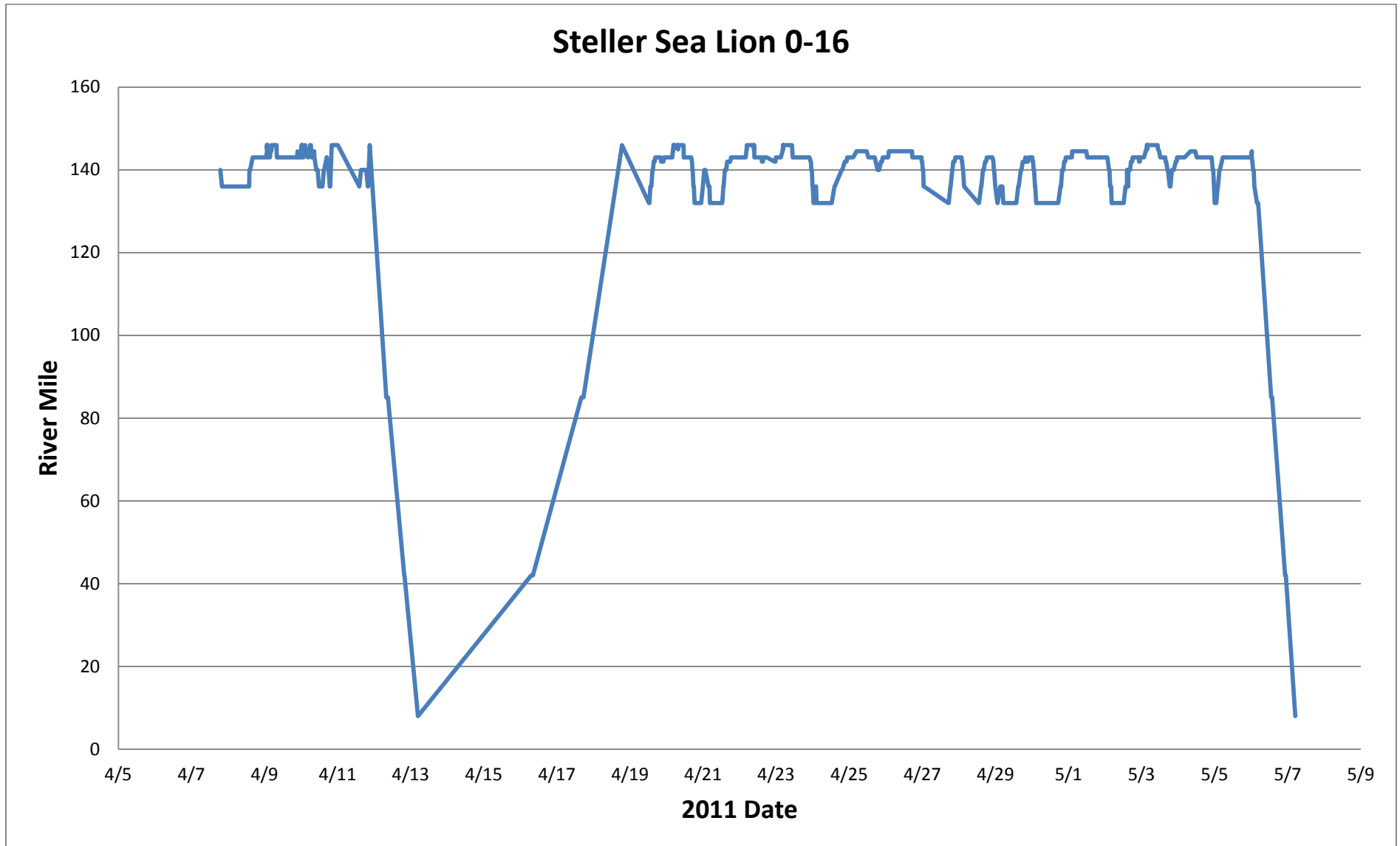


Figure 13. Acoustic telemetry data from Steller sea lion 0-16. River mile 146 is Bonneville Dam.

Table 10. Number of detections by location and date for Steller sea lion O-16.

O-16	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock	Willamette falls	Mouth of Lewis	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/7/2011						6	21								27
4/8/2011				34	1	9	26								70
4/9/2011	89	13	13	122											237
4/10/2011	16	44	21	24		31	28								164
4/11/2011	9					18	9								36
4/12/2011										10	8				18
4/13/2011														3	3
4/16/2011											41				41
4/17/2011										27					27
4/18/2011	3														3
4/19/2011				34	24	11	32	12							113
4/20/2011	161	11	2	71	1	9	21	16							292
4/21/2011				28	29	50	29	9							145
4/22/2011	108	5	3	58	14										188
4/23/2011	151	10	1	148	3	7	4								324
4/24/2011				17	4	15	11	23							70
4/25/2011			2	99	3	3									107
4/26/2011			45	137	3										185
4/27/2011				7	4	19	12	11							53
4/28/2011				65	5	26	11	8							115
4/29/2011				43	53	20	14	19							149
4/30/2011				29	10	28	34	26							127
5/1/2011			21	170											191
5/2/2011				88	14	31	68	42							243
5/3/2011	111	23	3	70	23	41	12								283
5/4/2011			4	160		11	4								179
5/5/2011				200	1	12	10	8							231
5/6/2011			1	1	2	17	7	3		16	18				65
5/7/2011														2	2
Total	648	106	116	1605	194	364	353	177		53	67			5	3688

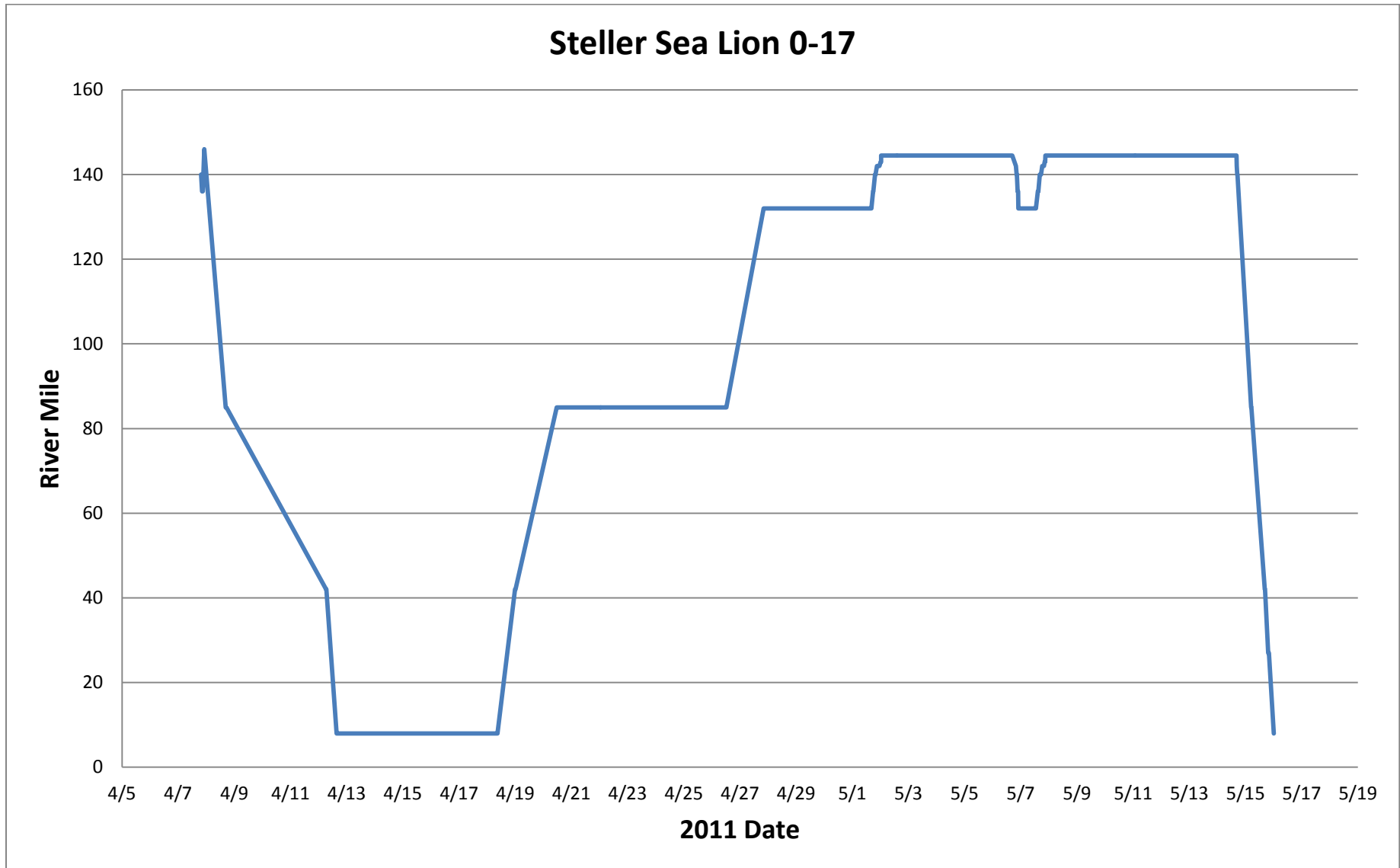


Figure 14. Acoustic telemetry data from Steller sea lion 0-17. River mile 146 is Bonneville Dam.

Table 11. Number of detections by location and date for Steller sea lion O-17.

O-17	Bonneville BRZ (Rm 146)				Rm 142	Marker 85 (Rm 140)	Rm 136	Phoca Rock (Rm 132)	Willamette falls	Mouth of Lewis (Rm 85)	Upper Estuary (Rm 42)	Middle Estuary (Rm 27 and Rm 13)		Ocean entry (Rm 8)	Total
Date	PH2	RA	PH1	TCNL								Pillar Rock	Astoria		
4/7/2011	4					6	24								34
4/8/2011										7					7
4/12/2011											6			10	16
4/15/2011														3	3
4/17/2011														7	7
4/18/2011											5			21	26
4/19/2011											11				11
4/20/2011										474					474
4/21/2011										1026					1026
4/22/2011										904					904
4/24/2011										640					640
4/26/2011										65					65
4/27/2011								3							3
4/30/2011								7							7
5/1/2011					9	20	19	25							73
5/2/2011			68	2											70
5/3/2011			73												73
5/4/2011			25												25
5/5/2011			27												27
5/6/2011			134		1	4	5	3							147
5/7/2011			6	13	21	16	8	7							71
5/8/2011			64												64
5/9/2011			81												81
5/10/2011			36												36
5/11/2011			94												94
5/12/2011			280												280
5/13/2011			57												57
5/14/2011			13		1	2		2							18
5/15/2011										5	7	13			25
5/16/2011														5	5
Total	4		958	15	32	48	56	47		3121	29	13		46	4369

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