

FIELD REPORT:
2012 PINNIPED RESEARCH AND MANAGEMENT ACTIVITIES AT AND BELOW
BONNEVILLE DAM

Robin Brown¹, Steven Jeffries², Doug Hatch³, Bryan Wright¹, and Sandra Jonker²

October 29, 2012

¹ Oregon Department of Fish and Wildlife

² Washington Department of Fish and Wildlife

³ Columbia River Inter-Tribal Fish Commission

TABLE OF CONTENTS

LIST OF TABLES	ii
LIST OF FIGURES	iii
INTRODUCTION	1
METHODS	2
Boat-based deterrent activities.....	2
Trapping.....	2
Telemetry	3
Pinniped surveys	3
Effect of removals.....	3
RESULTS	3
Boat-based deterrent activities.....	3
Trapping.....	4
Telemetry	4
Pinniped surveys	4
Effect of removals.....	5
DISCUSSION	5
Boat-based deterrent activities.....	5
Trapping.....	5
Telemetry	5
Pinniped surveys	6
Effect of removals.....	6
Recommendations for 2013	6
ACKNOWLEDGEMENTS.....	7
REFERENCES	8

LIST OF TABLES

Table 1. Summary of boat-based hazing activities at Bonneville Dam, 2012.	9
Table 2. Summary of Steller sea lions that were branded and/or instrumented at Bonneville Dam, 2012.....	10
Table 3. Summary of California sea lions that were branded, instrumented, and/or removed at Bonneville Dam (or Astoria where noted), 2012.....	11
Table 4. Estimated sea lion abundance (combined Steller sea lions and California sea lions) for the Columbia River in the 34 miles below Bonneville Dam (RM 112 to RM 146).	12
Table 5. Predicted numbers of salmonids saved due to California sea lion removals in the lower Columbia River, 2008-2012.....	13

LIST OF FIGURES

Figure 1. Movements of Steller sea lions (O-brands) and California sea lions (C- and U-brands) tagged at Bonneville Dam and Astoria, 2012.	14
Figure 2. Movements of GPS-tagged Steller sea lions (O-brands) and California sea lions (C- and U-brands) by date and river mile (1=mouth of Columbia River, 146=Bonneville Dam), 2012.	17
Figure 3. GPS-tag locations of Steller sea lions (O-brands) and California sea lions (C- and U-brands) at Bonneville Dam, 2012.	18
Figure 4. Point density plots (1 ha cell size and neighborhood) of GPS-tagged Steller sea lions (top) and California sea lions (bottom) below Bonneville Dam, 2012. Cool colors (e.g., blue) indicate low use, warm colors (e.g., red) indicate high use. Upper plot is based on five Steller sea lions and 338 sea lion-days (2/15/2012-5/17/2012); lower plot is based on three California sea lions and 66 sea lion-days (4/9/2012-5/22/2012).	20
Figure 5. Daily activity budgets for Steller sea lions (O-brands) and California sea lions (C- and U-brands) in the lower Columbia River, 2012. Average river mile location per day is denoted atop bar graphs.	21
Figure 6. Example daily activity budget and associated dive and movement profile for Steller sea lion O18. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	23
Figure 7. Example daily activity budget and associated dive and movement profile for Steller sea lion O19. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	24
Figure 8. Example daily activity budget and associated dive and movement profile for Steller sea lion O20. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	25
Figure 9. Example daily activity budget and associated dive and movement profile for Steller sea lion O21. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	26
Figure 10. Example daily activity budget and associated dive and movement profile for Steller sea lion O23. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	27

Figure 11. Example daily activity budget and associated dive and movement profile for Steller sea lion O24. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.....	28
Figure 12. Example daily activity budget and associated dive and movement profile for California sea lion C019. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	29
Figure 13. Example daily activity budget and associated dive and movement profile for California sea lion C018. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	30
Figure 14. Example daily activity budget and associated dive and movement profile for California sea lion U159. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.	31
Figure 15. Time-depth telemetry (left) and approximate location (right) associated with a USACE-documented sturgeon predation by Steller sea lion O21 at 16:29 on February 29, 2012. Sturgeon was estimated at 3-4 feet in length.	32

INTRODUCTION

Bonneville Dam, located approximately 146 miles upriver from the Pacific Ocean, is the lowermost hydroelectric project on the Columbia River. During the 1980s and 1990s, one to two California sea lions (*Zalophus californianus*) were reported annually at the dam during fishway inspections (Stansell 2004). In 2001, however, there were reports of up to six California sea lions observed at one time, and by 2002 the U.S. Army Corps of Engineers (USACE) estimated that 30 California sea lions were foraging at the dam for salmonids (*Onchorynchus* spp.), many of which are listed under the Endangered Species Act (ESA). Since then the minimum number of California sea lions has ranged from approximately 50 to 100 animals, with animals generally arriving earlier and occurring over a longer period each year. Salmonid predation at the dam by California sea lions increased from approximately zero before 2001, to an estimated 5481 fish in 2010 (Stansell et al. 2011).

Steller sea lion (*Eumetopias jubatus*) abundance at the dam has also increased over the last decade, going from zero before 2003 to at least 75 by 2010 (Stansell et al. 2010). While Steller sea lions initially appeared to forage primarily on white sturgeon (*Acipenser transmontanus*), in recent years they have consumed increasing numbers of salmonids. In 2011 the number of sturgeon and salmonids consumed by Steller sea lions was estimated to be at least 3003 and 1294, respectively (Stansell et al. 2011).

In response to increasing pinniped predation at the dam, state, federal, and tribal partners have attempted to deter pinnipeds using a variety of non-lethal deterrents. Starting in 2005, these methods have included aerial and underwater pyrotechnics, acoustic harassment devices, vessel chase, rubber projectiles, and capture-relocation. In 2010 alone, for example, boat-based hazing crews used approximately 5000 rounds of cracker shells, 750 seal bombs, and 100 rounds of rubber buckshot in attempts to deter sea lions from the Bonneville Dam tailraces (Brown et al. 2010). While thought to be potentially effective at deterring predation by new animals arriving at the dam for the first time, they have been ineffective at deterring predation by habituated individuals.

Increasing predation by California sea lions on ESA-listed salmonids and unsuccessful non-lethal deterrence efforts led the States of Washington, Oregon, and Idaho in November 2006 to apply under Section 120 of the Marine Mammal Protection Act (MMPA) for the authority to permanently remove California sea lions that were observed preying on salmonids near Bonneville Dam on the Columbia River (ESA-listed Steller sea lions are not subject to management under Section 120 of the MMPA). In March 2008, the National Marine Fisheries Service (NMFS) partially approved the States' application and issued a Letter of Authority (LOA) for the lethal removal of certain California sea lions under specific conditions (NMFS 2008). Since then this authority has been repeatedly challenged in federal court and has resulted in only intermittent removal activity. Nonetheless, from 2008-2011, a total of 36 California sea lions were intentionally removed from the Columbia River. An additional five animals died due to accidental causes, bringing the total to 41 over the four year period.

This report summarizes research on, and management of, pinnipeds at and below Bonneville Dam in 2012. This work was led by the Oregon Department of Fish and Wildlife (ODFW) and

Washington Department of Fish and Wildlife (WDFW), in association with the Columbia River Inter-Tribal Fish Commission (CRITFC). This work has been conducted in close coordination and cooperation with USACE and NMFS, as well as numerous other agencies.

METHODS

Boat-based deterrent activities

Boat-based hazers from CRITFC used a combination of deterrents (seal bombs, cracker shells, and vessel chase) in an attempt to deter pinnipeds from consuming threatened and endangered Columbia River salmon and steelhead (*Onchorynchus* spp.) as well as white sturgeon (*Acipenser transmontanus*). Hazers primarily patrolled the tailrace Boat Restricted Zone (BRZ) at the dam in pursuit of foraging sea lions. The following was recorded for each discrete hazing event: species and number of pinnipeds encountered; starting location, time and direction of travel of pinniped(s); type and number of deterrent devices used; and ending location, time and direction of travel of pinniped(s). Predation observations and identifying marks of pinnipeds were also noted.

For human and fish safety, boat access within the BRZ was limited to approximately 30 m from all Bonneville project structures and 50 m from main fishway entrances. No seal bombs were used within 100 m of fishways, floating orifices, the Powerhouse-2 corner collector flume or the 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 the USACE Control Room and Fisheries Field Unit (FFU) personnel, as well as with USDA Wildlife Services staff, who were conducting additional sea lion hazing activities from project ground facilities. VHF-radio contact was maintained with Control Room staff while boat hazing crews were active in the BRZ.

Trapping

Sea lions were captured by ODFW and WDFW using haul-out traps placed along the Powerhouse-2 corner collector, below Powerhouse-1 near the old navigation lock, and later in the season near the Powerhouse-1 forebay. An additional sea lion trap was also operated year-round in Astoria at the East Mooring Basin. Sea lions use these traps as haulout sites, entering and exiting traps via a vertically-sliding door which was pad-locked open prior to a scheduled capture attempt. Traps were monitored 24 hours a day by state, federal, and/or private security staff. A telephone contact list was provided to all staff involved with monitoring the traps to insure a quick response by trained staff should any trap be tampered with or close unexpectedly.

Trap doors were closed using a remote-controlled magnetic release mechanism. Once sea lions were captured they were herded into holding cages on a barge built specifically to handle and process sea lions. If an animal was an approved candidate for permanent removal it was transferred to an on-site holding facility for further evaluation. If a NMFS-approved zoo or aquarium facility was available to receive candidate sea lions for permanent holding, then captured animals would be given a health screening by field staff and veterinarians, including members of the States' Institutional Animal Care and Use Committee (IACUC). If an animal

passed the health screening it would be transferred to an approved temporary housing facility prior to shipment to a zoo or aquarium. If an animal failed the health exam, or if there were no approved facilities prepared to accept an animal, then it was chemically euthanized. Euthanized animals were necropsied and tissues were generally collected for a variety of biological analyses.

Telemetry

A variety of telemetry instruments were attached to selected Steller and California sea lions in order to better understand their foraging behavior at the dam and throughout the river. Instruments included GPS-phone tags (Sea Mammal Research Institute, St. Andrews, Scotland), and multi-instrument packages containing satellite-relay time-depth-recorders (Wildlife Computers, Redmond, WA, USA), acoustic transceivers (Vemco, Halifax, Nova Scotia, Canada), and VHF tags. Instruments were glued to the sea lion's pelage using 5-minute epoxy.

Pinniped surveys

Weekly tandem boat surveys were conducted by CRITFC to enumerate sea lions and predation events between Interstate 205 Portland (RM 112) and Tanner creek near Bonneville dam (RM 146). Each boat operated in the navigation channel of the Columbia River travelling at 10 mph and approximately one-half mile apart. The second boat maintained this distance by keeping the lead boat barely in view on the horizon but not close enough to determine observations of the first boat. Each boat was crewed by a captain and sea lion observer equipped with 12x32 binoculars. Sea lion species (if possible), predation events and GPS location data was recorded for all events by both boats.

Statistical abundance estimation models were applied to tandem boat surveys in two distinct ways. The abundance estimate at Phoca Rock was obtained using a joint Poisson estimation technique. The abundance in-river was obtained with a Lincoln-Peterson estimator. The two cases were treated differently because of the way the boats were able to distinguish that the same animals were observed by both boats in the water, but at Phoca Rock, boats were only able to record the number of animals observed. Phoca Rock counts made no distinction that the same animals were seen by both boats. Use of Phoca Rock and other haul-outs were also monitored throughout the season using automated cameras.

Effect of removals

The effect of California sea lion removals from 2008-2012 in terms of number of salmon "saved" was estimating using the bioenergetics model described in Brown et al. (2010, 2011).

RESULTS

Boat-based deterrent activities

Boat-based pinniped hazing crews from CRITFC hazed sea lions on 31 days from 3/5/2012-5/18/2012 (Table 1). Hazing resulted in a total of 112 and 371 "takes" (i.e., pinniped harassment

events) of California sea lions and Steller sea lions, respectively. A total of 1183 cracker shells and 401 seal bombs were used during deterrent activities.

Trapping

Bonneville tailrace traps were opened on 1/26/2012, with successful trapping events occurring between 2/15/2012 and 5/16/2012 (Tables 2 and 3); additional trapping at Astoria occurred year-round. A total of 20 individual Steller sea lions (Table 2) and 20 individual California sea lions (Table 3) were handled during this time period. As allowed under the States' MMPA Section 120 Letter of Authorization, a total of 13 California sea lions were removed: one was sent to the Shedd Aquarium in Chicago and the remaining twelve were chemically euthanized.

Telemetry

Telemetry instruments were placed on 10 Steller sea lions (Table 2; 7 GPS-phone tags, 3 multi-instrument float packs) and 8 California sea lions (Table 3; 3 GPS-phone tags, 5 multi-instrument float packs). Instrument deployment dates ranged from 2/15/2012 to 5/2/2012. Instrument retention and operation dates varied from a couple days to several months. Notable movements included two Steller sea lions that traveled to southeast Alaska and three California sea lions that migrated to the breeding grounds in California (Figure 1). Of the GPS-tagged individuals, Steller sea lions generally stayed upriver throughout the spring whereas California sea lions made repeated trips between the dam and the estuary (Figure 2). While at the dam, individual sea lions showed overlapping but partially distinct usage patterns of the tailraces (Figure 3). Density plots of GPS location fixes below the dam showed usage "hot spots" in the tailrace for both species and at the Phoca Rock haul-out for Steller sea lions (Figure 4). It also showed concentrated use by Steller sea lions in a stretch of river above Skamania Island and below Beacon Rock.

The behavioral budget of sea lions was quantified by a three-state model of time spent diving, at the surface, and hauled-out. While roughly a third of each day was spent in each activity, there was much individual, daily, and site-specific variation in the observed proportions of these behaviors (Figure 5). For example, California sea lions often hauled out continuously for one or more days while in the estuary, and did not haul out at all while transiting between the estuary and upriver foraging areas. Examples of more detailed daily behavioral profiles, and associated dive depth and location information, are depicted in Figures 6-14. At this level of resolution, it can be seen that sea lions often (though not always) followed a diurnal behavior pattern, with daylight hours predominantly spent diving and nighttime hours spent hauled out or rafting.

Pinniped surveys

Tandem boat surveys were conducted nine times below Bonneville Dam from March 16, 2012 to May 14, 2012 (Table 4). Estimated total sea lion abundance ranged from approximately 11 to 54 sea lions across surveys. For the in-river estimates, the probability of both boats not seeing an animal was 6.3%, allowing for 94% of all the animals to be accounted for. Monitoring of Phoca Rock by automated cameras documented use by branded Steller sea lions that have not been seen

at the dam, and by California sea lions, which have rarely been observed hauling out at Phoca Rock.

Effect of removals

The median estimated daily individual salmonid biomass requirement for California sea lions was 14.2 kg (95% confidence interval was 7.8 to 27.1 kg/day), which translated into a median of 3 Chinook/day (95% confidence interval was 2 to 6 Chinook/day). The median estimated seasonal salmonid requirement for each sea lion was 57 salmonids (95% confidence interval was 6 to 216 salmonids/season). The predicted number of salmonids that would have been required from 2008 to 2012 by the 54 California sea lions that have been removed due to any reason ranged from 3742 to 13483 fish (Table 5).

DISCUSSION

Boat-based deterrent activities

As in previous years, the purpose of non-lethal, boat-based deterrent activities was two-fold. First, it attempts to disrupt sea lion foraging behavior and reduce sea lion abundance immediately below Bonneville Dam, thereby increasing salmonid survival. Second, it helps fulfill the LOA requirement that predatory California sea lions be exposed to hazing prior to subjecting them to permanent removal efforts. Observations and telemetry data suggest that these activities only cause a short-term disruption in foraging behavior and fail to deter the majority of sea lions from foraging at the dam. The continued lack of effective non-lethal deterrents that can be used in this situation without having potentially negative impacts on fish passage remains a significant impediment to reducing predation at the dam.

Trapping

Haul-out traps were used without incident to mark and tag Steller and California sea lions, as well as remove California sea lions. As in past years, several California sea lions locked above the dam. While we attempted to trap these individuals by moving a trap into the forebay we have been unsuccessful to date. The construction of a smaller, more easily transportable trap would likely improve the chances of catching such individuals by being able to move the trap to where the animals are foraging (e.g., The Dalles) rather than waiting for them to find their way back downriver.

Telemetry

Continued instrumentation of sea lions allowed us to increase and refine our understanding of sea lion foraging behavior in the Columbia River. While foraging behavior was generally similar to past years, there were some differences including the aforementioned movements of two Steller sea lions to southeast Alaska (Figure 1). In addition, GPS-tagged Steller sea lions tended to stay at or near the dam the entire spring rather than traveling back and forth between estuary haul-outs (Figure 2). Tagged Steller sea lions also appeared to forage more regularly below the BRZ (e.g., Figures 7-8). With respect to the latter behavior, we know from hundreds of anecdotal

observations over the years that sea lions of both species successfully forage for sturgeon and salmonids in these areas. Lastly, using dive depth data to detect predation signatures continued to yield mixed results. While some observed predation events corresponded with a clear dive profile signature (e.g., Figure 15), other profiles were more ambiguous.

Pinniped surveys

Tandem boat survey totals should be interpreted with the standard deviations of the Phoca Rock counts in mind, since the errors on in-river estimates were small in relative terms. The Phoca Rock estimates had larger discrepancies in the numbers (particularly the first week with a 15 animal difference), not because of observation probabilities but due to sea lions hauling out or jumping off the rock between the two boat observations.

Effect of removals

For every California sea lion removed, escapement above Bonneville Dam by salmonids increases by an estimated 57 fish per season. Since habituated sea lions have shown high fidelity to Bonneville Dam, these savings accrue over multiple years. In addition, removal of habituated animals is believed to reduce opportunities for new, naive animals to be recruited into the Bonneville Dam "population", since at least some naive animals are thought to follow habituated animals upriver from the Columbia River mouth haul-outs. Indeed, early indications suggest that continued removal of the most habituated individuals has led to a reduction in annual California sea lion abundance at the dam and their associated predation on salmonids.

Recommendations for 2013

- Continue trapping operations. Trapping was safely and effectively conducted in order to mark and instrument Steller and California sea lions, and permanently remove California sea lions. Continued removals of California sea lions for full the full five-year authorization period is necessary in order to assess the efficacy of using the Section 120 at Bonneville Dam.
- Build new trap for use above Bonneville Dam. Each of the past several years, one or more California sea lions have locked above Bonneville Dam to prey on salmonids from the forebay to The Dalles. Availability of a smaller, more easily transportable trapping platform would allow us to respond more effectively to these individuals.
- Increase observation and survey efforts below the BRZ. When possible, the states and tribes should continue focusing effort at documenting sea lion abundance and predation downriver of the Bonneville Dam tailraces in order to more fully measure the true magnitude and spatial extent of predation throughout the river.

ACKNOWLEDGEMENTS

We wish to acknowledge and thank all those who cooperated in the conduct of this work:

- CRITFC: John Whitaker, Bobby Begay, Agnes Strong and Jeremiah Newell.
- NMFS: Robert DeLong, Pat Gearin, Garth Griffin, Brent Norberg, Tom Gelatt, and Brian Fadley.
- ODFW: Julia Burco, Charlie Corrarino, Colin Gillin, Rick Hargrave, Craig Good, Tom Murtagh John North, Susan Riemer, Jessica Sall, Steve Williams, and Bonneville Hatchery staff.
- PSMFC: Dave Colpo, Dan Heiner, and Matt Tennis.
- USACE: Tony Kirk and the Bonneville Rigging Crew, Ben Haussmann, Andrew Taylor, Glen Smith, Robert Stansell, Karrie Gibbons, and Bjorn van der Leeuw.
- USDA Wildlife Services staff.
- WDFW: Josh Oliver, Mike Brown, Dyanna Lambourn, and Guy Norman.
- PSU: Mandy Cook, Debbie Duffield, and their students.
- Safety and Security: Jeff Samuels, Oregon State Police; Murray Schlenker, Washington Department of Fish and Wildlife; and Ronald McDonald and Greg Webb, USACE.

Funding was provided by ODFW, WDFW, NOAA-Fisheries, and BPA. Law enforcement support was provided by WDFW Enforcement and Oregon State Police. Research and management activities by Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife at Bonneville Dam were authorized under the ESA, MMPA Sections 109h and 120, and MMPA research permits 13430 and 14326. This report is intended to fulfill regulatory and contractual reporting requirements; it is not intended to be a comprehensive report on all pinniped-related activities at Bonneville Dam and the lower Columbia River.

REFERENCES

- Brown, R., S. Jeffries, D. Hatch, B. Wright, and S. Jonker. 2010. Field Report: 2010 Pinniped management activities at and below Bonneville Dam. Oregon Department of Fish and Wildlife, 7118 NE Vandenberg Ave. Corvallis, OR 97330.
- Brown, R., S. Jeffries, D. Hatch, B. Wright, and S. Jonker. 2011. Field Report: 2011 Pinniped research and management activities at and below Bonneville Dam. Oregon Department of Fish and Wildlife, 7118 NE Vandenberg Ave. Corvallis, OR 97330.
- NMFS (National Marine Fisheries Service). 2008. Letter of Authorization to Oregon. <http://www.nwr.noaa.gov/Marine-Mammals/Seals-and-Sea-Lions/upload/Sec-120-LOA-OR.pdf> (accessed 9/27/11).
- Stansell, R. 2004. Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2002-2004. U.S. Army Corps of Engineers, Bonneville Lock and Dam, Cascade Locks, OR 97014.
- Stansell, R. J, K. M. Gibbons, and W. T. Nagy. 2010. Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2008-2010. U.S. Army Corps of Engineers, Bonneville Lock and Dam, Cascade Locks, OR 97014.
- Stansell, R. J, K. M. Gibbons, and W. T. Nagy. 2011. Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2011. U.S. Army Corps of Engineers, Bonneville Lock and Dam, Cascade Locks, OR 97014.

Table 1. Summary of boat-based hazing activities at Bonneville Dam, 2012.

	Week of	Days	Events	Take*		Munitions used	
				CSL	SSL	Cracker shells	Seal bombs
1	3/4/2012	4	21	1	35	118	52
2	3/11/2012	4	38	4	46	126	95
3	3/18/2012	2	15	8	16	76	67
4	3/25/2012	4	48	13	59	154	68
5	4/1/2012	3	29	10	33	104	29
6	4/8/2012	2	18	19	15	79	29
7	4/15/2012	3	40	17	83	227	29
8	4/22/2012	3	29	13	44	157	25
9	4/29/2012	3	35	13	36	101	5
10	5/6/2012	1	7	6	2	17	0
11	5/13/2012	2	8	8	2	24	2
	Total	31	288	112	371	1183	401

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

Table 2. Summary of Steller sea lions that were branded and/or instrumented at Bonneville Dam, 2012.

	Date	Capture/brand	Recapture	aka	GPS tag	Float pack	Comment
1	2/15/2012	O18			st08-09-12		Tag reported lost 4/10/12
2		O19			st08-10-12		Tag recovered near Beacon Rock 10/13/12
3		O20			st08-12-12		
4		O21			st08-08-12		Tag reported lost 4/24/12
5	2/28/2012	O22			st08-11-12		Tag malfunctioned; tag reported lost 4/11/12
6		O23			st08-04-12		Recycled 2011 tag
7	3/20/2012	O24			st08-356-12		
8		O25					
9	3/27/2012	O26					
10	4/3/2012	O27					
11		O28					
12		O29					
13		O30					
14	4/9/2012	O31					
15		O32					
16		O33					
17	4/24/2012		O11			1	
18		O34				6	
19	5/1/2012	O35				5	
20	5/8/2012	O36					

*Astoria capture.

Table 3. Summary of California sea lions that were branded, instrumented, and/or removed at Bonneville Dam (or Astoria where noted), 2012.

	Date	Capture/ new brand	Recapture	aka	GPS tag	Float pack	Comment
1	4/3/2012		C01	B322			Euthanized
2			C015	B303			Euthanized
3	4/9/2012		C016				Euthanized
4		C019		B367	st09-347-12		
5	4/11/2012		C018		st09-13-12		
6			U159		st09-346-12		
7	4/12/2012	C020		B359			
8			C779				Euthanized
9	4/24/2012	C021				2	
10		C022		B368		3	
11		C023		B354		4	
12	4/25/2012		C011	B357			Transferred to Shed Aquarium, Chicago, IL
13			C019*	B367			Euthanized; GPS tag recovered
14			C04	B331			Euthanized
15			C961				Euthanized
16			U65			7	
17	4/30/2012		C013	B356			Euthanized
18			C05	B334			Euthanized
19	5/2/2012**	U207				8	
20	5/16/2012		U159*	B327			Euthanized; GPS tag recovered
21			U61	B315			Euthanized
22		C024		B369			
23	8/30/2012**		C021*				Euthanized

* Same-year recapture

**Astoria capture.

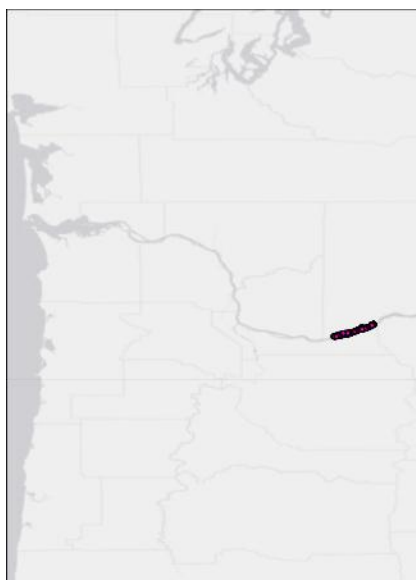
Table 4. Estimated sea lion abundance (combined Steller sea lions and California sea lions) for the Columbia River in the 34 miles below Bonneville Dam (RM 112 to RM 146).

	Location	In-river		Phoca Rock		Total
	Date	$\bar{N}$	SD	$\bar{N}$	SD	
1	3/16/2012	18.14	0.41	35	3.80	53.1
2	3/26/2012	7.47	0.17	23	2.40	30.5
3	4/2/2012	7.47	0.17	27	2.80	34.5
4	4/9/2012	11.74	0.26	23	2.50	34.7
5	4/16/2012	18.14	0.41	2.4	0.27	20.5
6	4/23/2012	13.87	0.31	7	0.75	20.9
7	4/30/2012	8.53	0.19	3.4	0.37	11.9
8	5/7/2012	6.4	0.14	4.7	0.50	11.1
9	5/14/2012	10.67	0.24	0.52	0.06	11.2

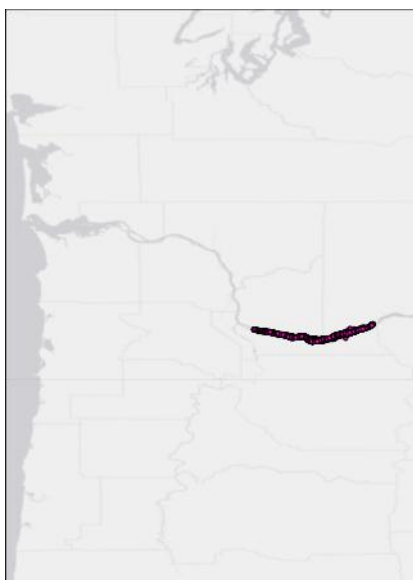
Table 5. Predicted numbers of salmonids saved due to California sea lion removals in the lower Columbia River, 2008-2012.

	Year	Number of CSLs removed*	Predicted number of salmonids saved at Bonneville Dam					
			2008	2009	2010	2011	2012	Total
1	2008	11	184-654	258-968	242-1038	242-1018	254-1010	1180-4688
2	2009	15		251-821	417-1230	380-1240	413-1271	1461-4562
3	2010	14			212-766	318-1181	348-1210	878-3157
4	2011	1				1-142	0-205	1-347
5	2012	13					222-729	222-729
	Total	54	184-654	509-1789	871-3034	941-3581	1237-4425	3742-13483

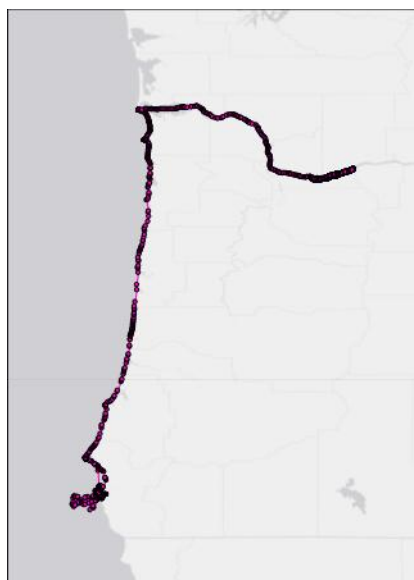
* Note: includes all animals removed during trapping activities, including accidental mortalities in 2008. Fall removals are not included in same-year predation calculations.



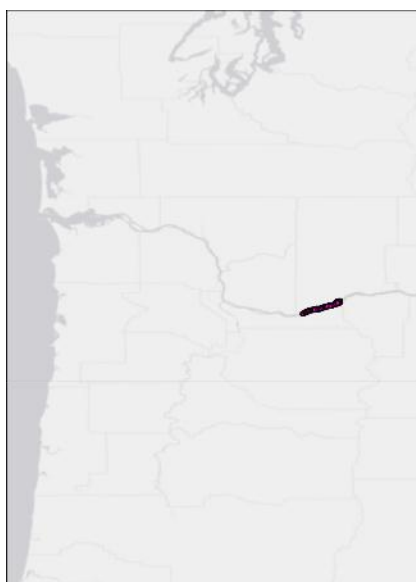
O18 (GPS-phone tag)
Released: 2/15/2012
Last detection: 4/5/2012
Final tag disposition:
Premature detachment



O19 (GPS-phone tag)
Released: 2/15/2012
Last detection: 5/4/2012
Final tag disposition:
Recovered Beacon Rock
10/13/2012

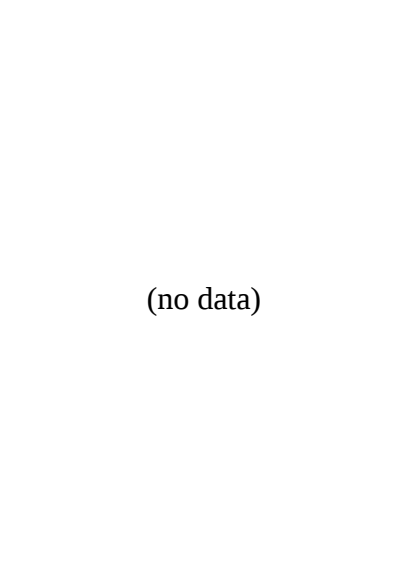


O20 (GPS-phone tag)
Released: 2/15/2012
Last detection: 7/14/2012
Final tag disposition:
Unknown

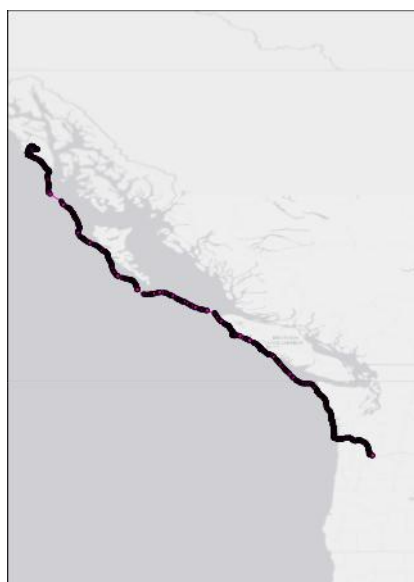


O21 (GPS-phone tag)
Released: 2/15/2012
Last detection: 4/20/2012
Final tag disposition:
Premature detachment

(no data)

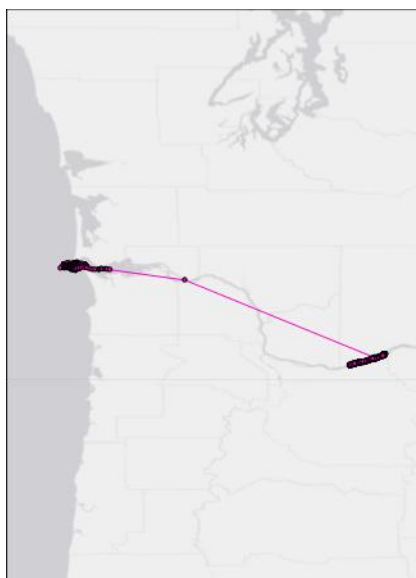


O22 (GPS-phone tag)
Released: 2/28/2012
Last detection:
Final tag disposition:
malfunctioned after release



O23 (GPS-phone tag)
Released: 2/28/2012
Last detection: 3/26/2012
Final tag disposition:
Unknown

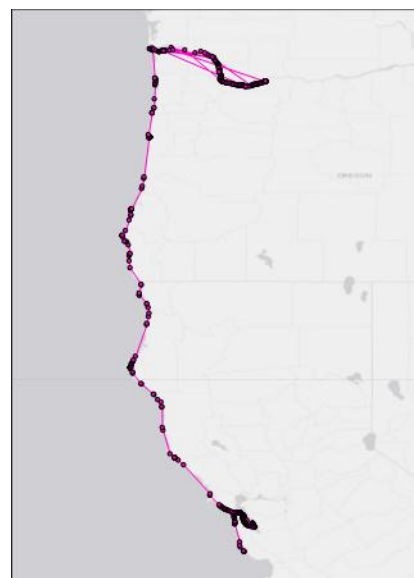
Figure 1. Movements of Steller sea lions (O-brands) and California sea lions (C- and U-brands) tagged at Bonneville Dam and Astoria, 2012.



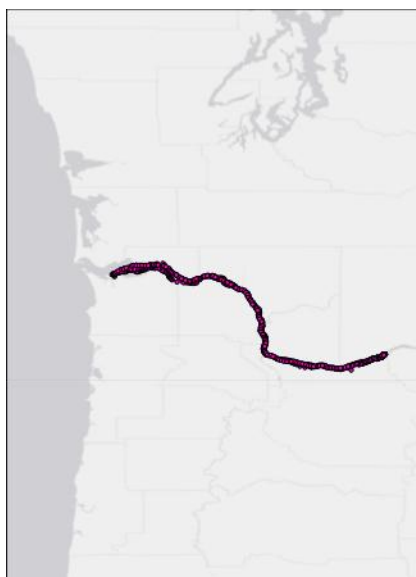
O24 (GPS-phone tag)
Released: 3/20/2012
Last detection: 6/6/2012
Final tag disposition:
unknown (partial malfunction)



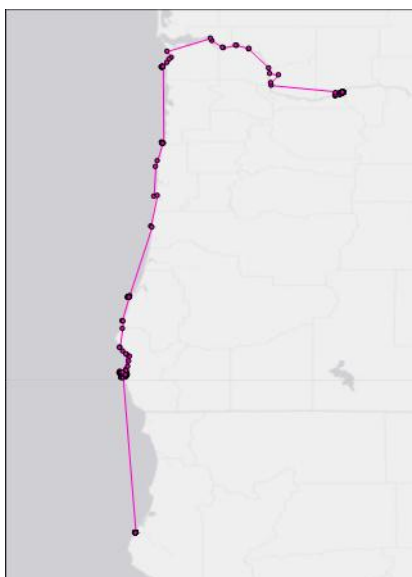
C019 (GPS-phone tag)
Released: 4/9/2012
Last detection: 4/25/2012
Final tag disposition: animal
euthanized, tag recovered



C018 (GPS-phone tag)
Released: 4/11/2012
Last detection: 6/10/2012
Final tag disposition:
unknown (partial malfunction)



U159 (GPS-phone tag)
Released: 4/11/2012
Last detection: 5/16/2012
Final tag disposition: animal
euthanized, tag recovered

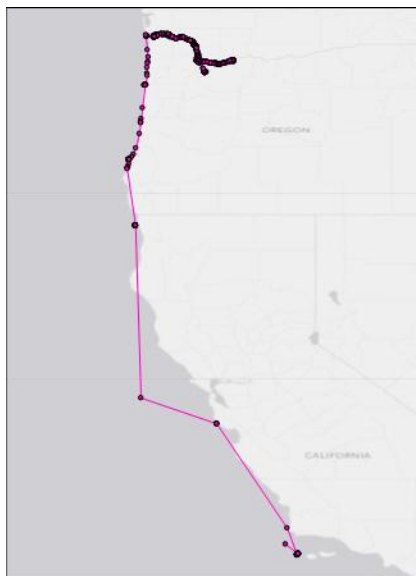


O11 (float pack 1)
Released: 4/24/2012
Last detection: 7/18/2012
Final tag disposition: tag
recovered, Eel River, CA

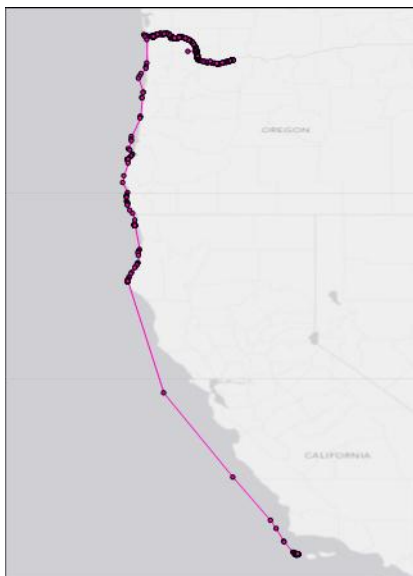


O34 (float pack 6)
Released: 4/24/2012
Last detection: 4/27/2012
Final tag disposition:
Premature detachment
(satellite tag only)

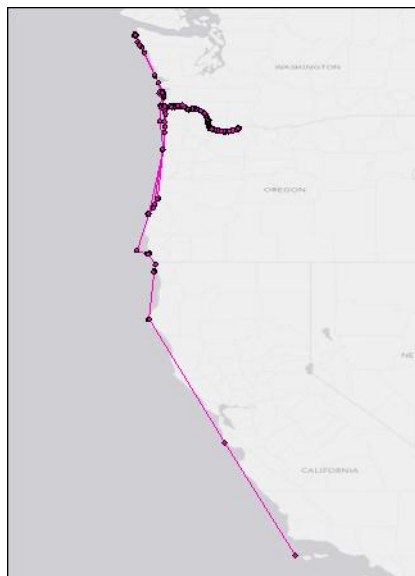
Figure 1 (cont.)



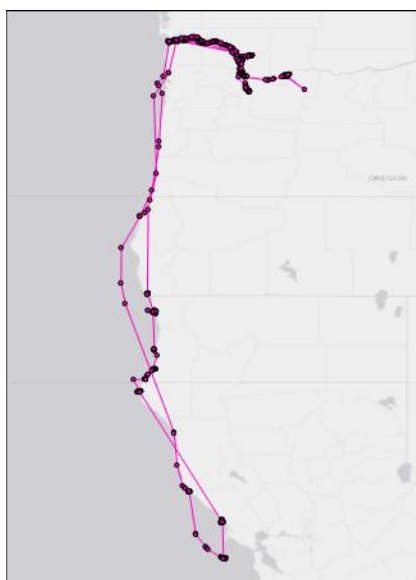
C021 (float pack 2)
Released: 4/24/2012
Last detection: 7/17/2012
Final tag disposition:
unknown; last location
offshore of Crescent City, CA



C022 (float pack 3)
Released: 4/24/2012
Last detection: 6/19/2012
Final tag disposition: last
location on San Miguel Island



C023 (float pack 4)
Released: 4/24/2012
Last detection: 6/23/2012
Final tag disposition: last
location on San Miguel Island



U65 (float pack 7)
Released: 4/25/2012
Last detection: 6/23/2012
Final tag disposition:
recovered, Columbia River,
8/1/2012



O35 (float pack 5)
Released: 5/1/2012
Last detection: 8/21/2012
Final tag disposition:
recovered Dall Island, AK,
9/15/2012



U207 (float pack 8)
Released: 5/2/2012 (Astoria)
Last detection: 5/30/2012
Final tag disposition:
recovered on dead animal,
Columbia River mouth.

Figure 1 (cont.)

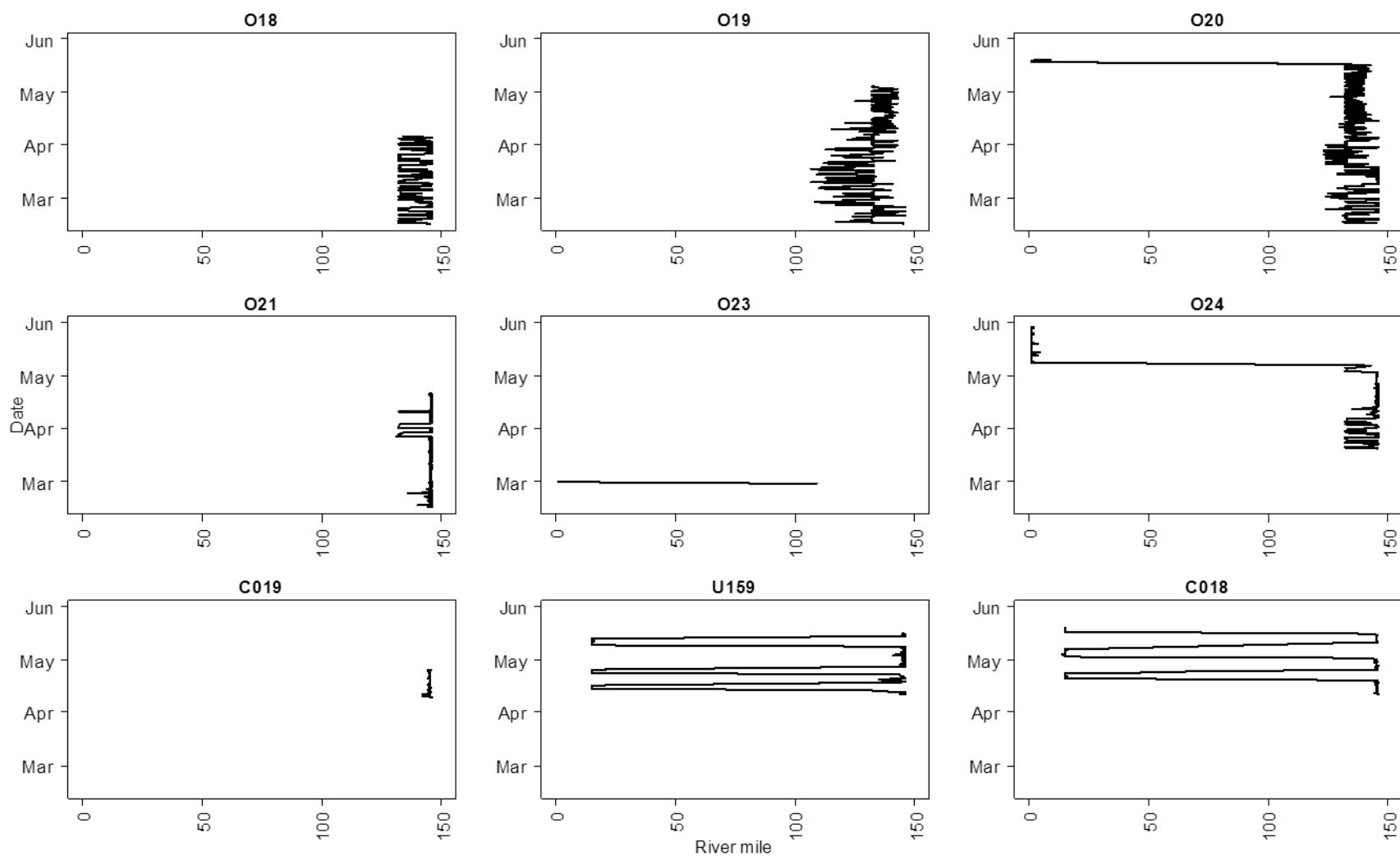


Figure 2. Movements of GPS-tagged Steller sea lions (O-brands) and California sea lions (C- and U-brands) by date and river mile (1=mouth of Columbia River, 146=Bonneville Dam), 2012.

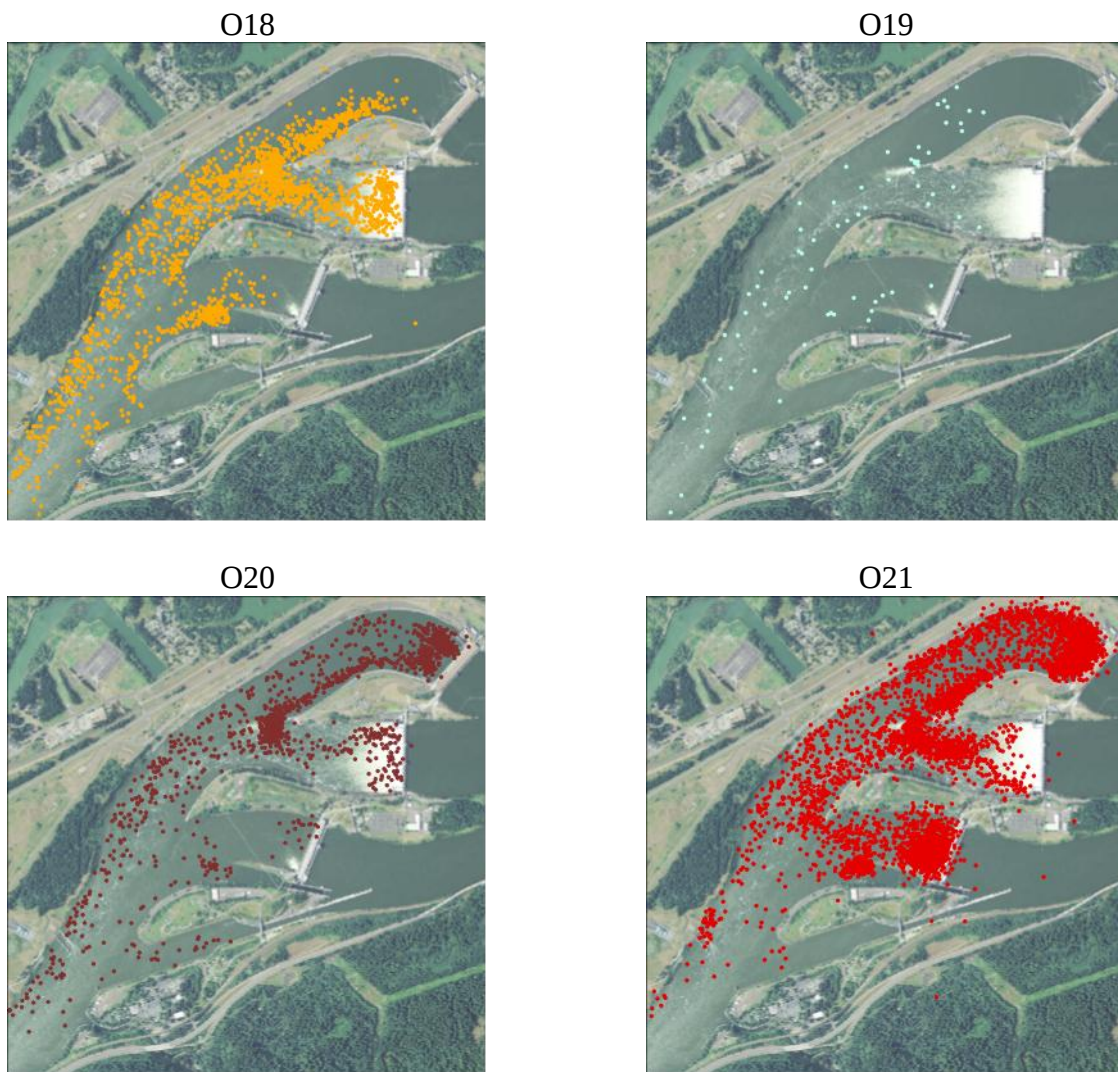
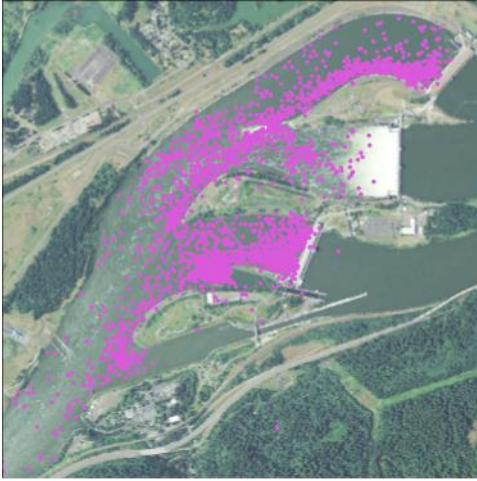
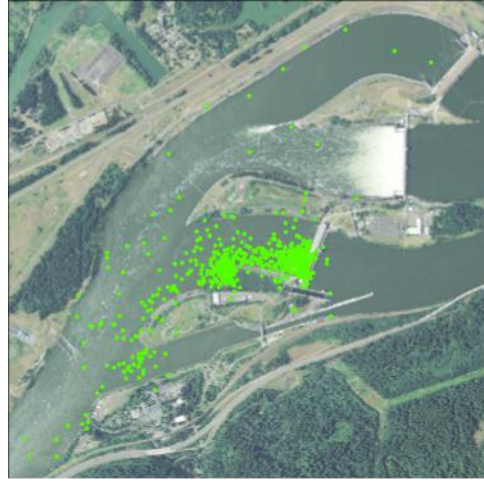


Figure 3. GPS-tag locations of Steller sea lions (O-brands) and California sea lions (C- and U-brands) at Bonneville Dam, 2012.

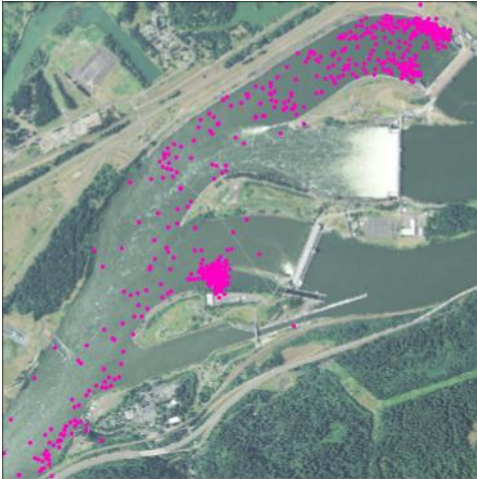
O24



C019



U159



C018

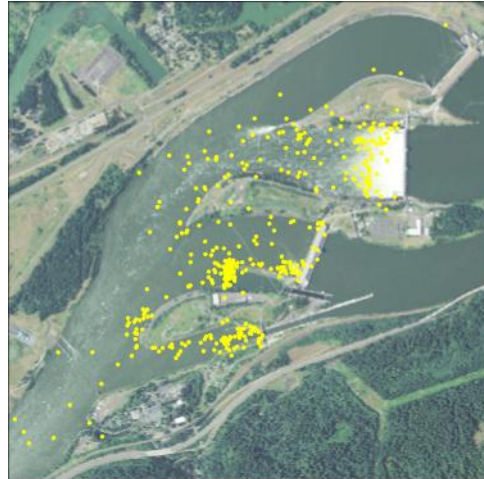


Figure 3 (cont.)

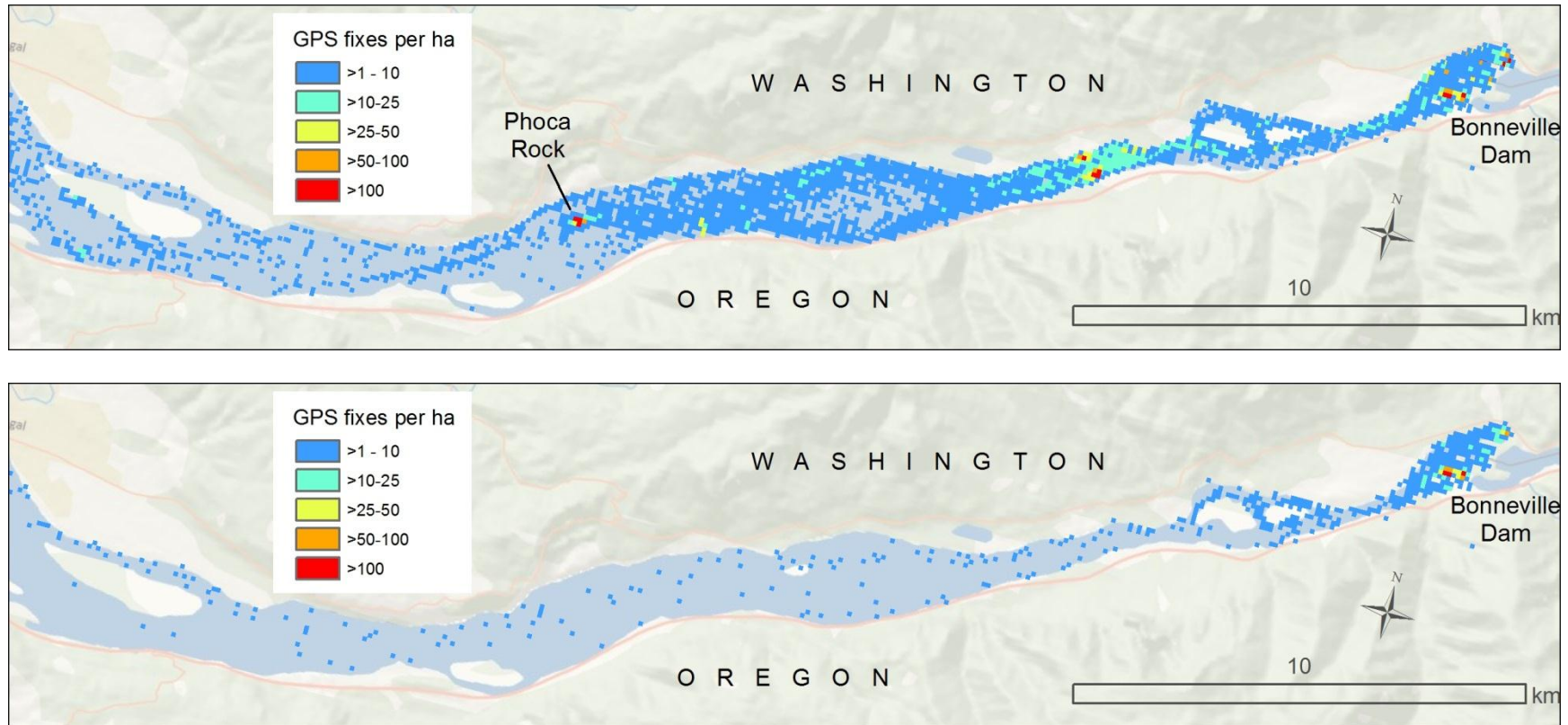


Figure 4. Point density plots (1 ha cell size and neighborhood) of GPS-tagged Steller sea lions (top) and California sea lions (bottom) below Bonneville Dam, 2012. Cool colors (e.g., blue) indicate low use, warm colors (e.g., red) indicate high use. Upper plot is based on five Steller sea lions and 338 sea lion-days (2/15/2012-5/17/2012); lower plot is based on three California sea lions and 66 sea lion-days (4/9/2012-5/22/2012).

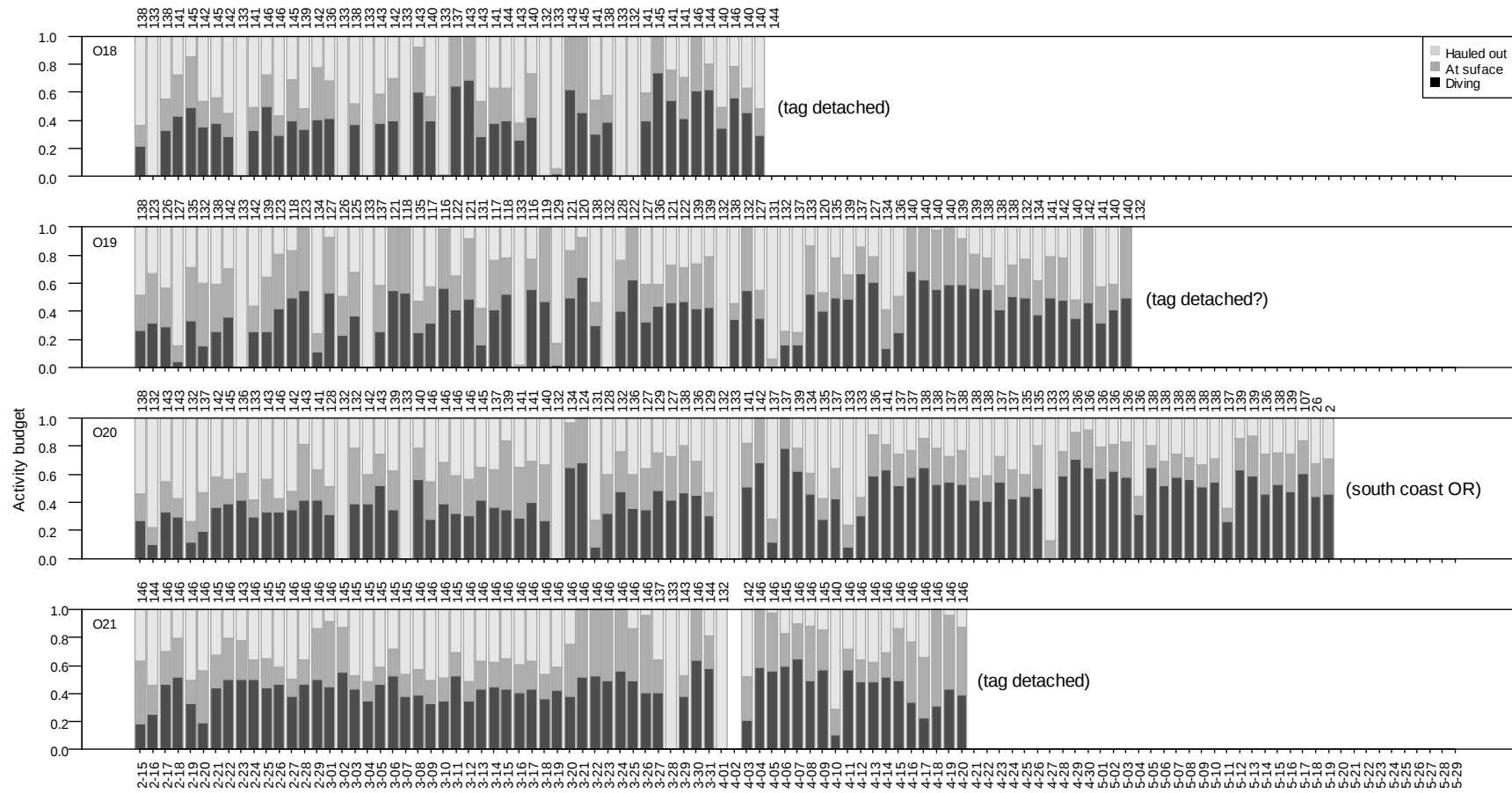


Figure 5. Daily activity budgets for Steller sea lions (O-brands) and California sea lions (C- and U-brands) in the lower Columbia River, 2012. Average river mile location per day is denoted atop bar graphs.

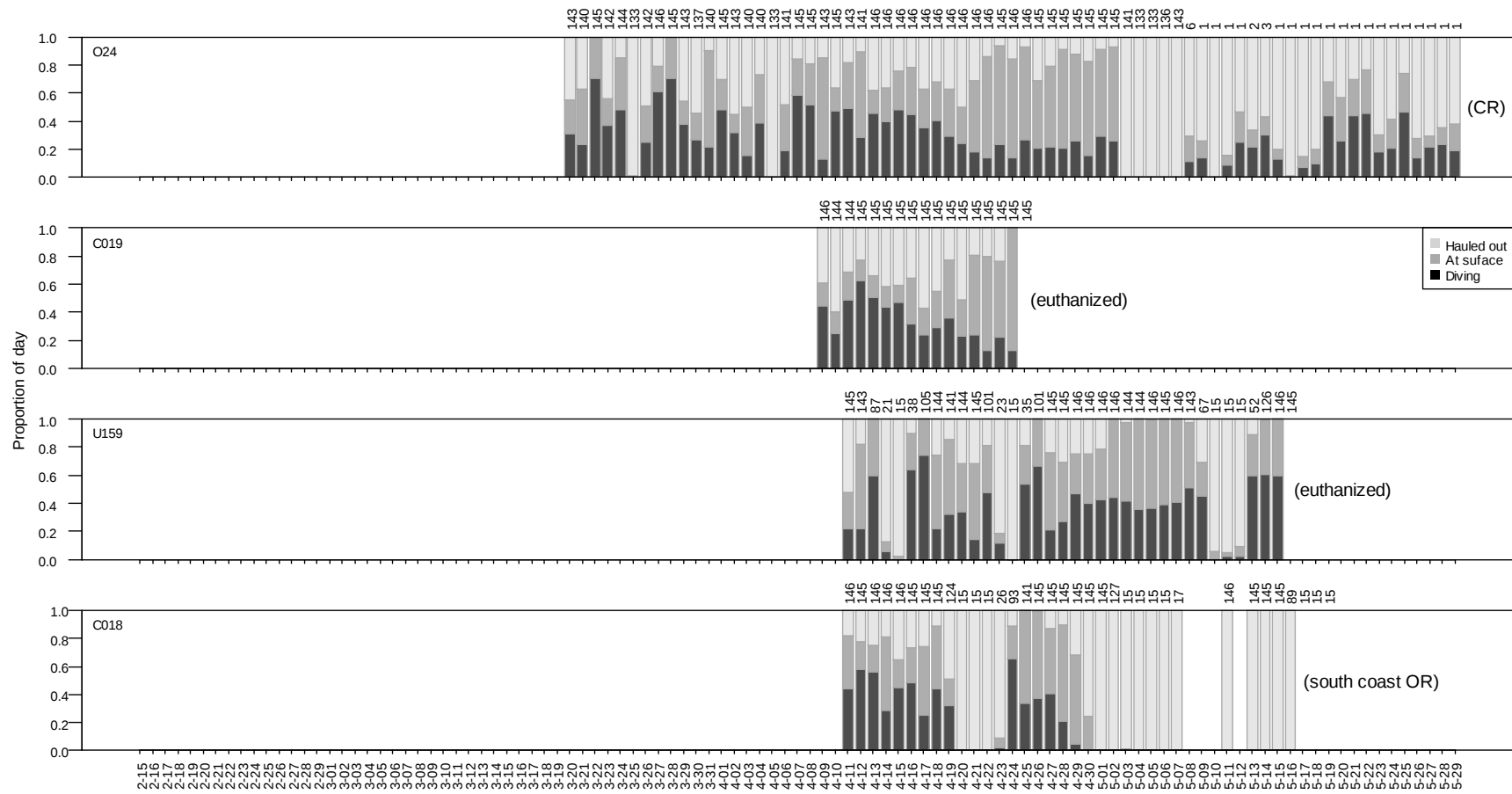


Figure 5 (cont.)

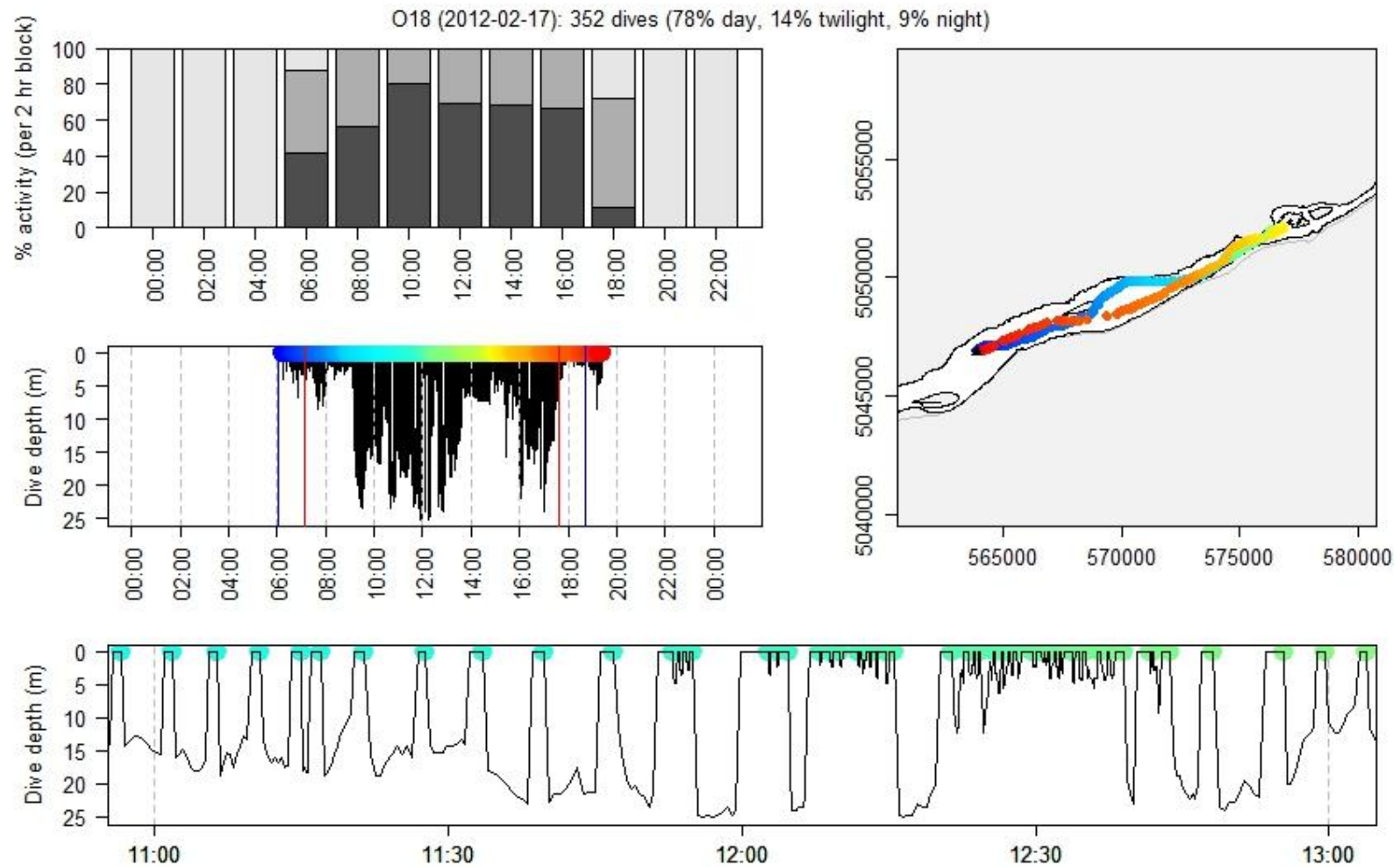


Figure 6. Example daily activity budget and associated dive and movement profile for Steller sea lion O18. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

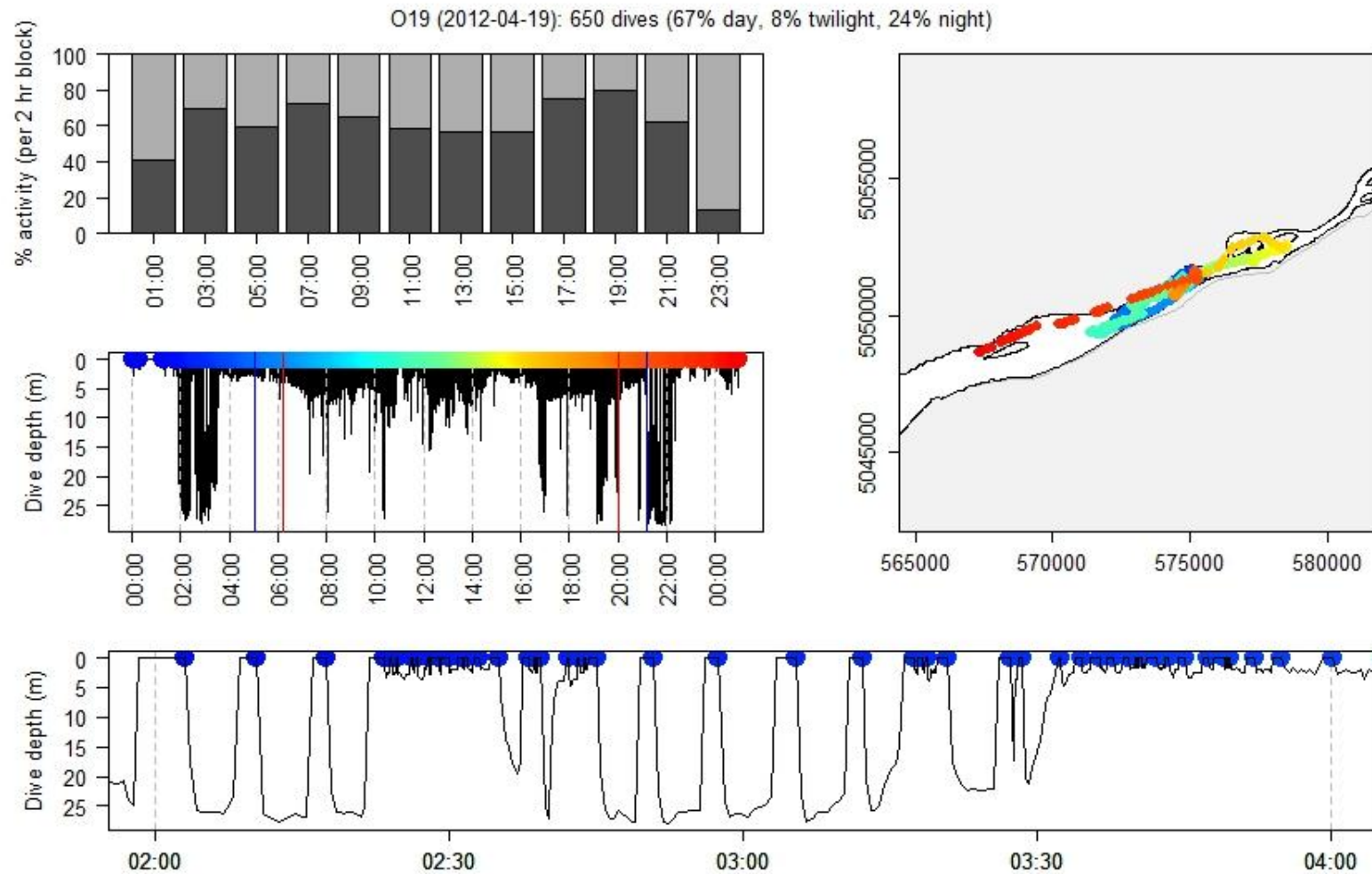


Figure 7. Example daily activity budget and associated dive and movement profile for Steller sea lion O19. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

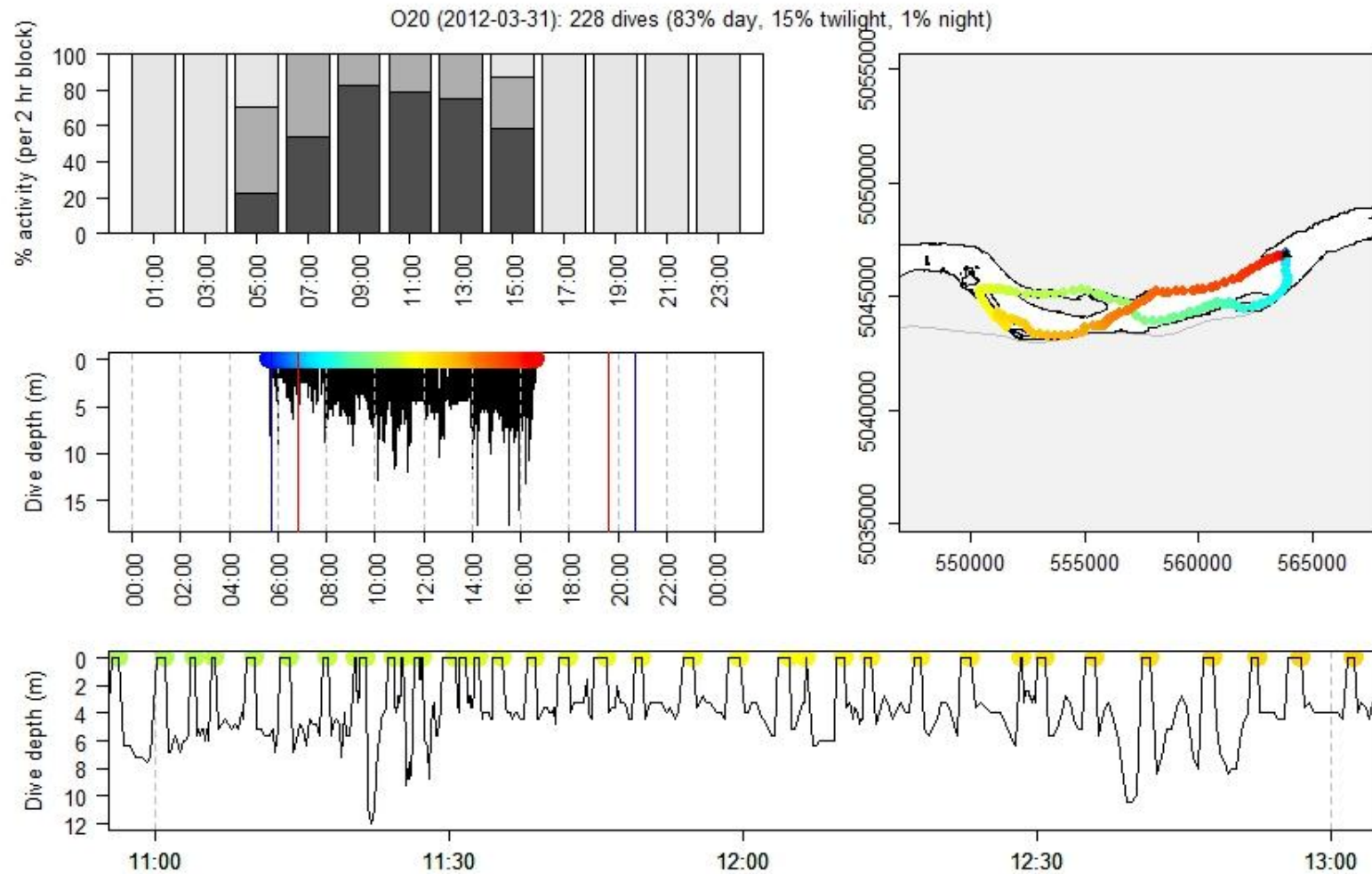


Figure 8. Example daily activity budget and associated dive and movement profile for Steller sea lion O20 Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

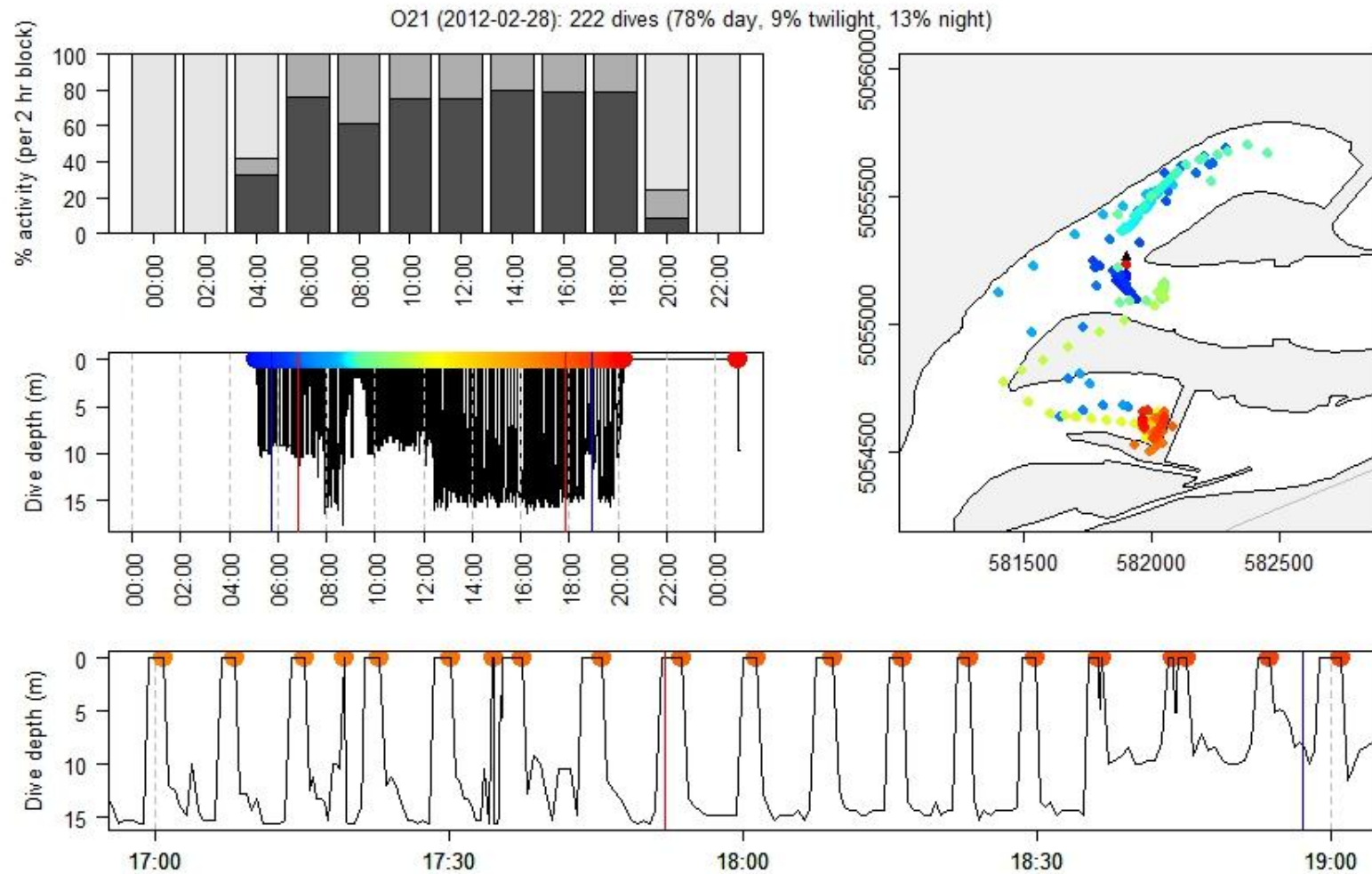


Figure 9. Example daily activity budget and associated dive and movement profile for Steller sea lion O21. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

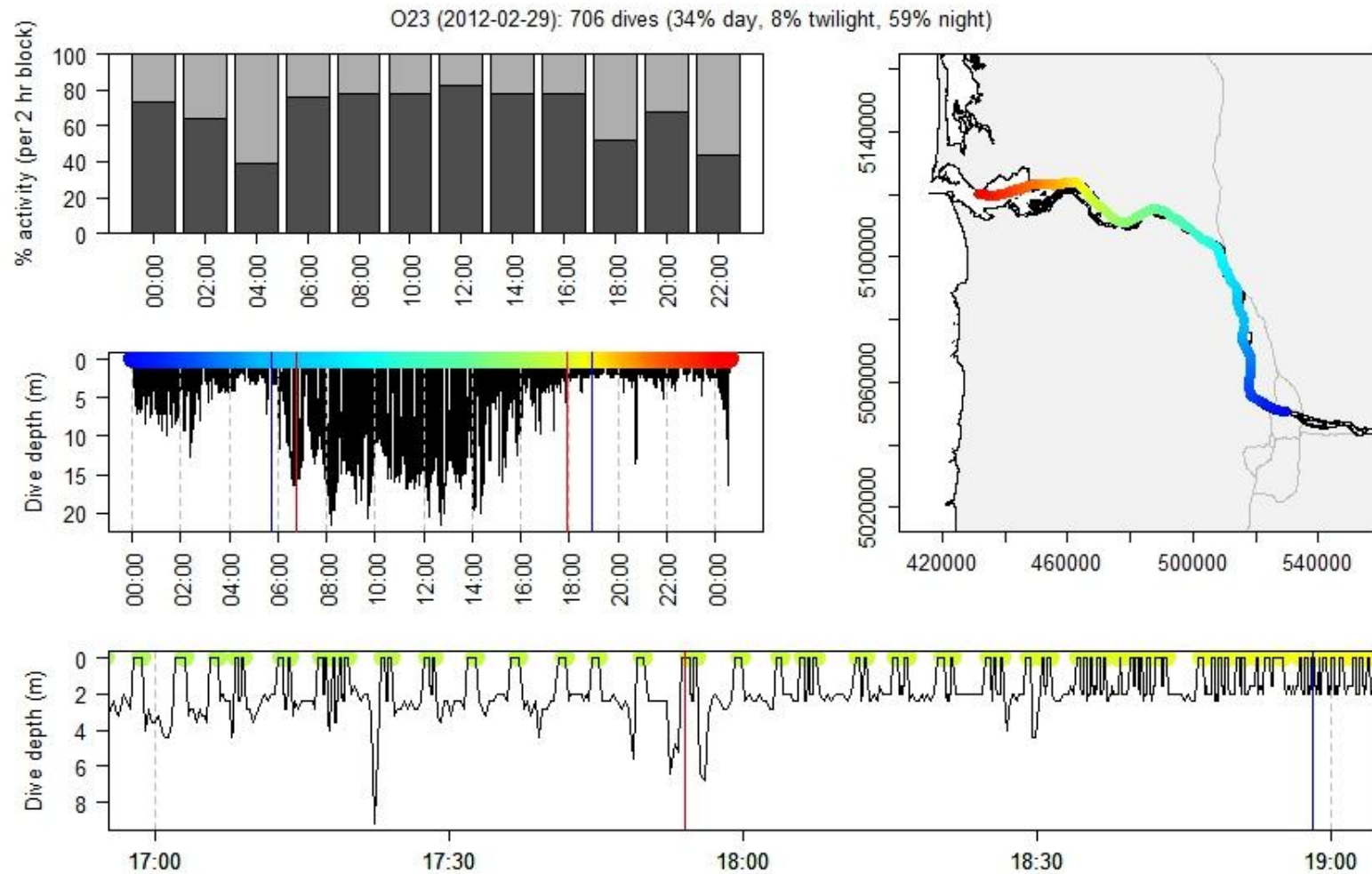


Figure 10. Example daily activity budget and associated dive and movement profile for Steller sea lion O23. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

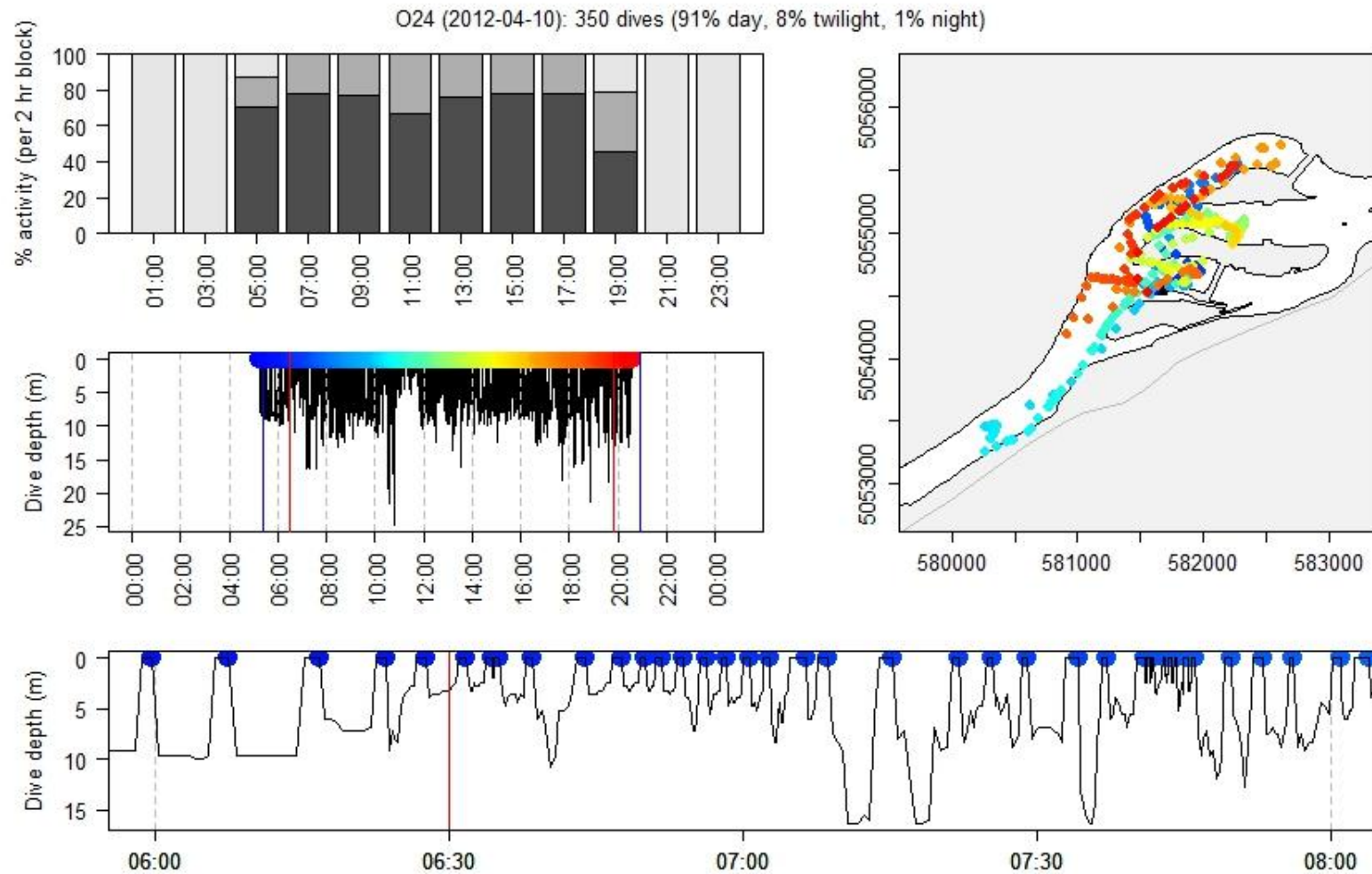


Figure 11. Example daily activity budget and associated dive and movement profile for Steller sea lion O24. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

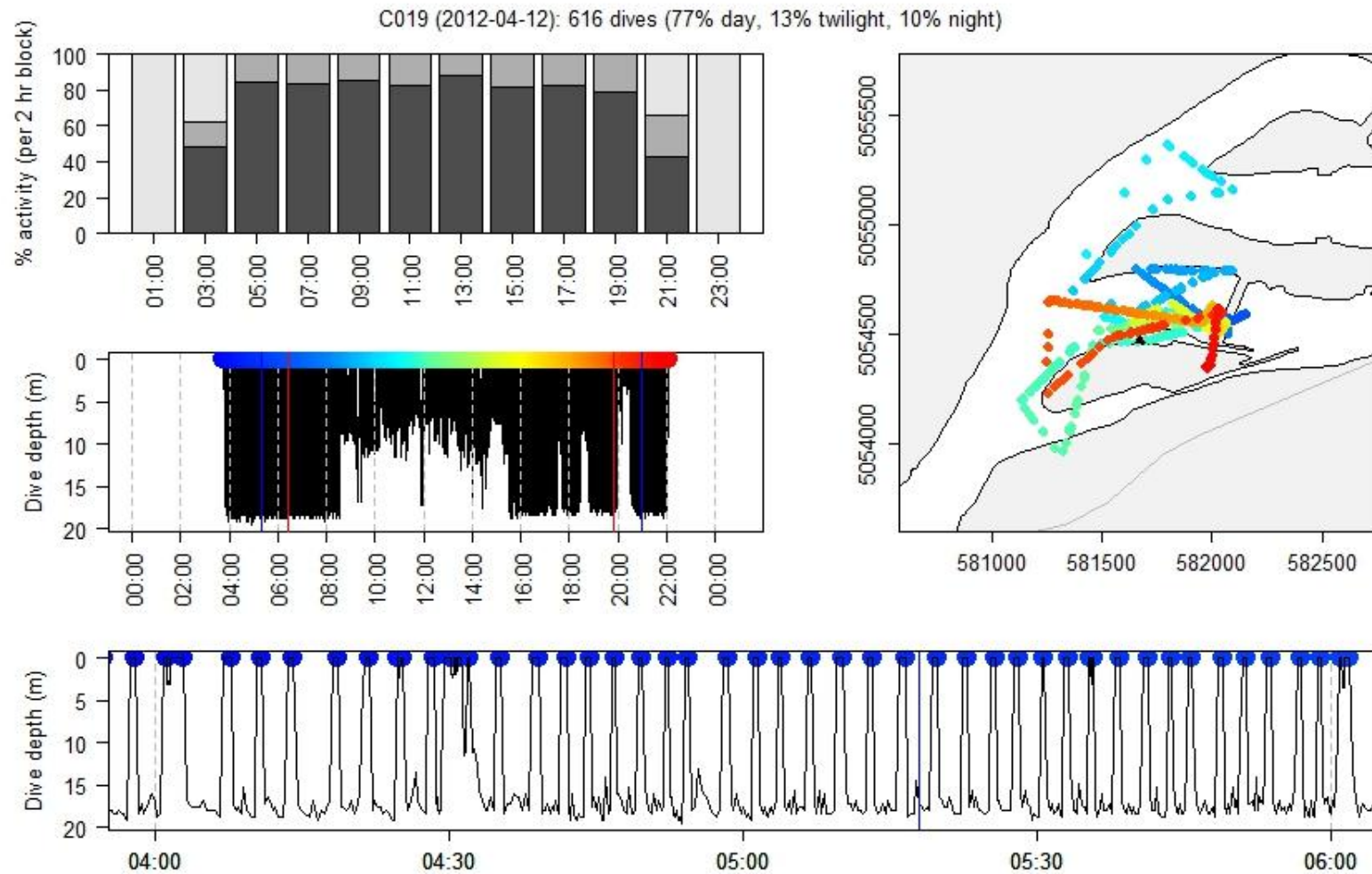


Figure 12. Example daily activity budget and associated dive and movement profile for California sea lion C019. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

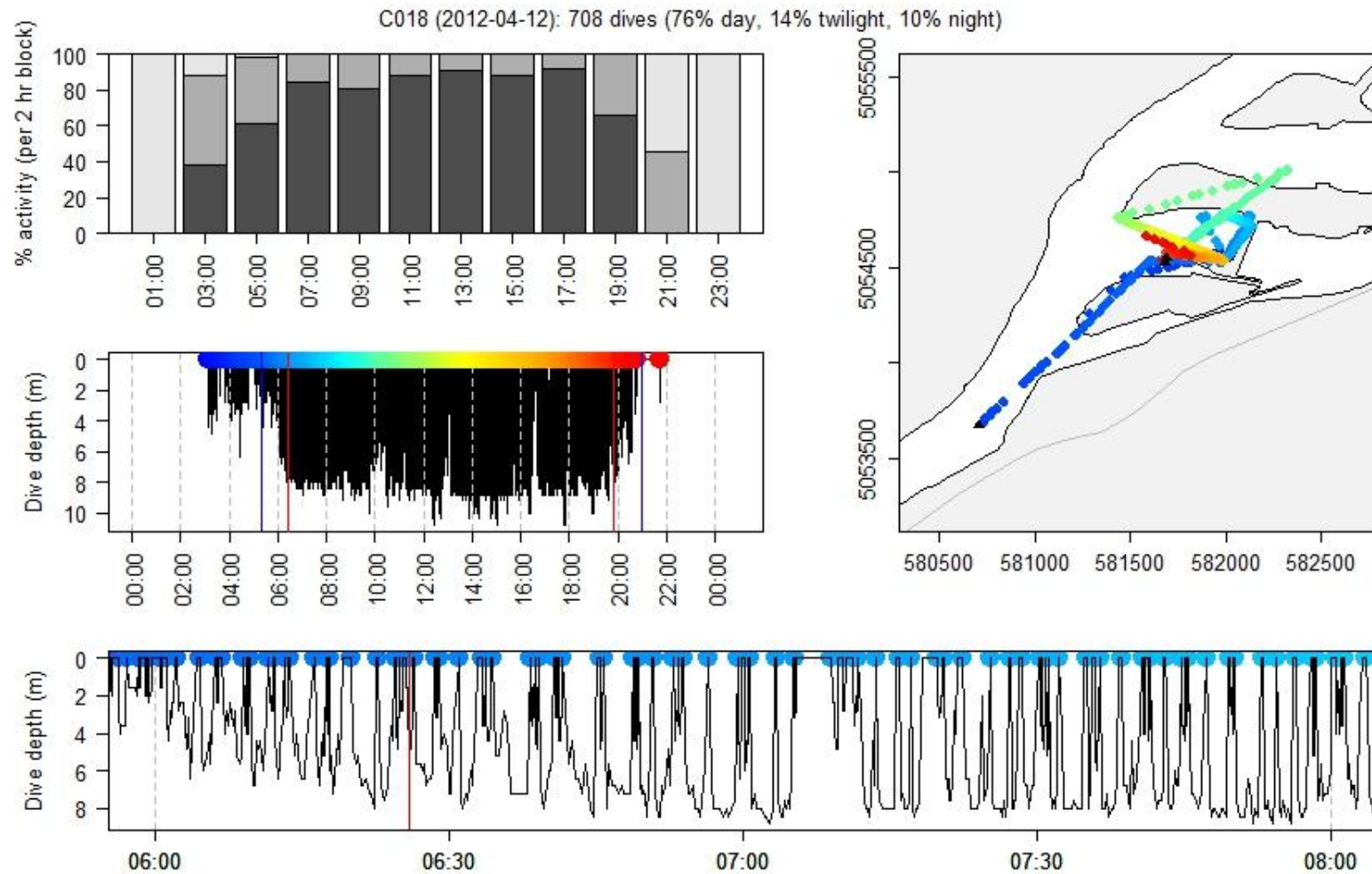


Figure 13. Example daily activity budget and associated dive and movement profile for California sea lion C018. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

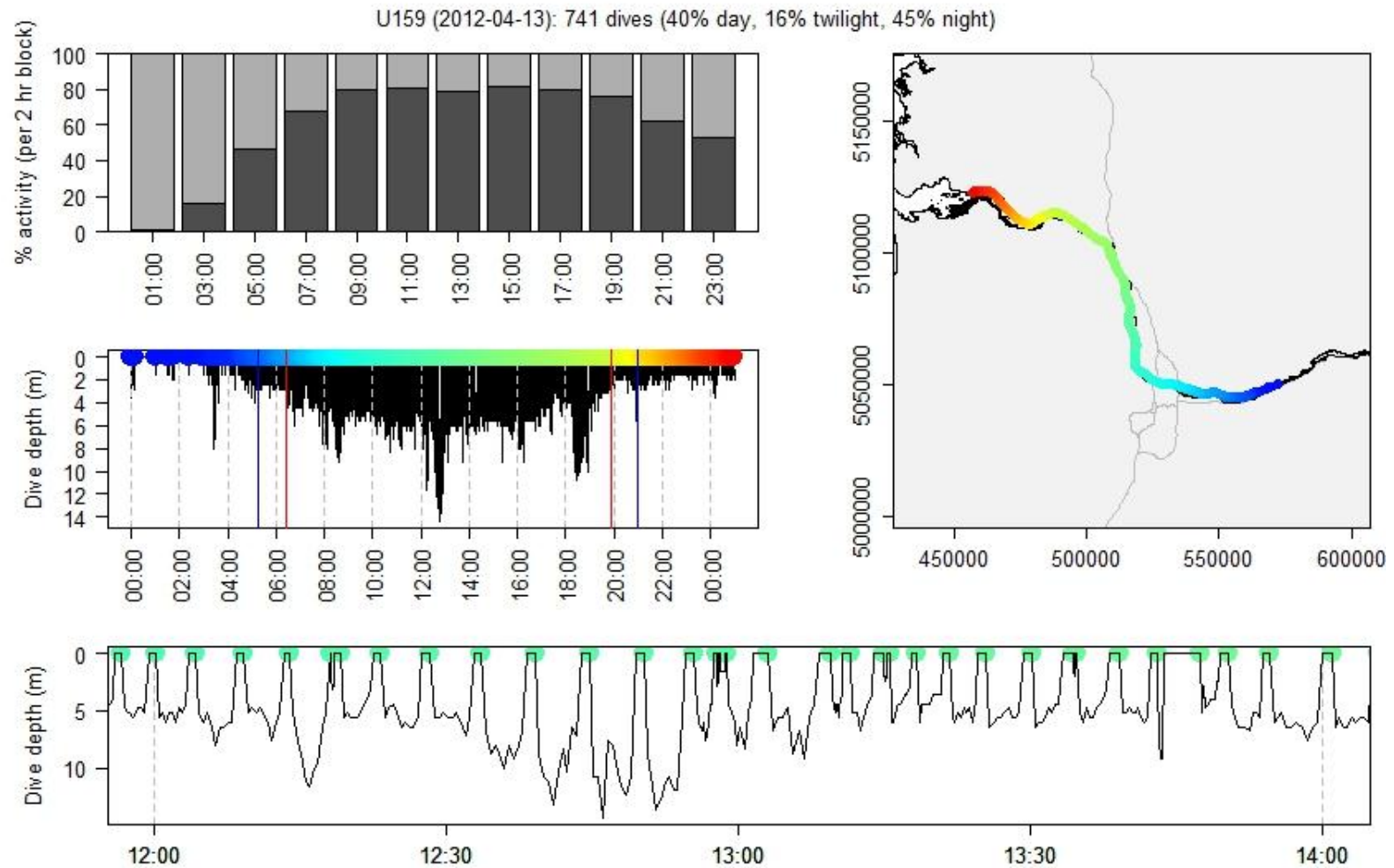


Figure 14. Example daily activity budget and associated dive and movement profile for California sea lion U159. Color ramp in dive profiles corresponds to location in map. Blue and red vertical lines in dive profile indicate start/end of nautical twilight and sunrise/sunset, respectively. See Figure 5 for activity budget legend.

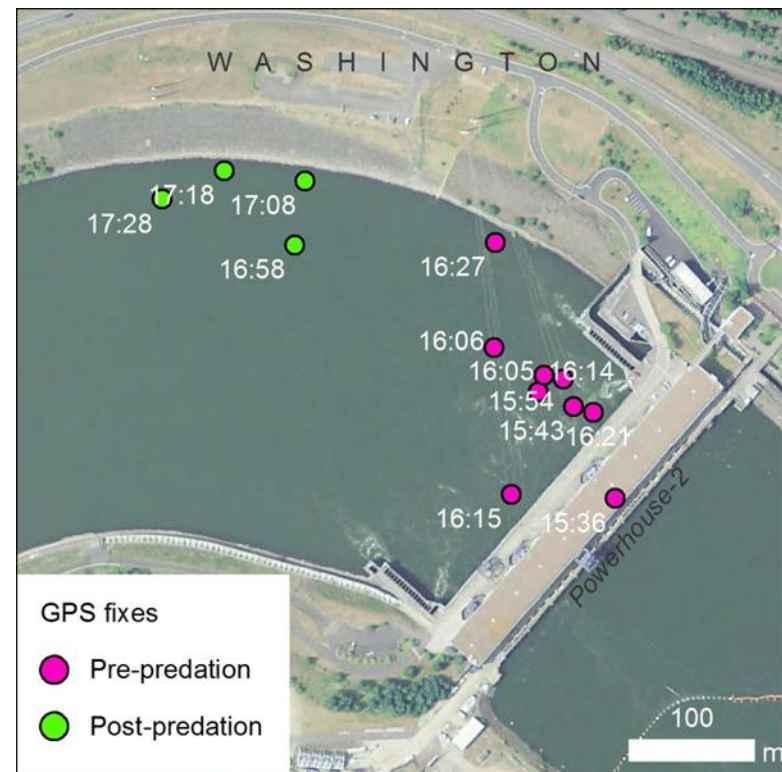
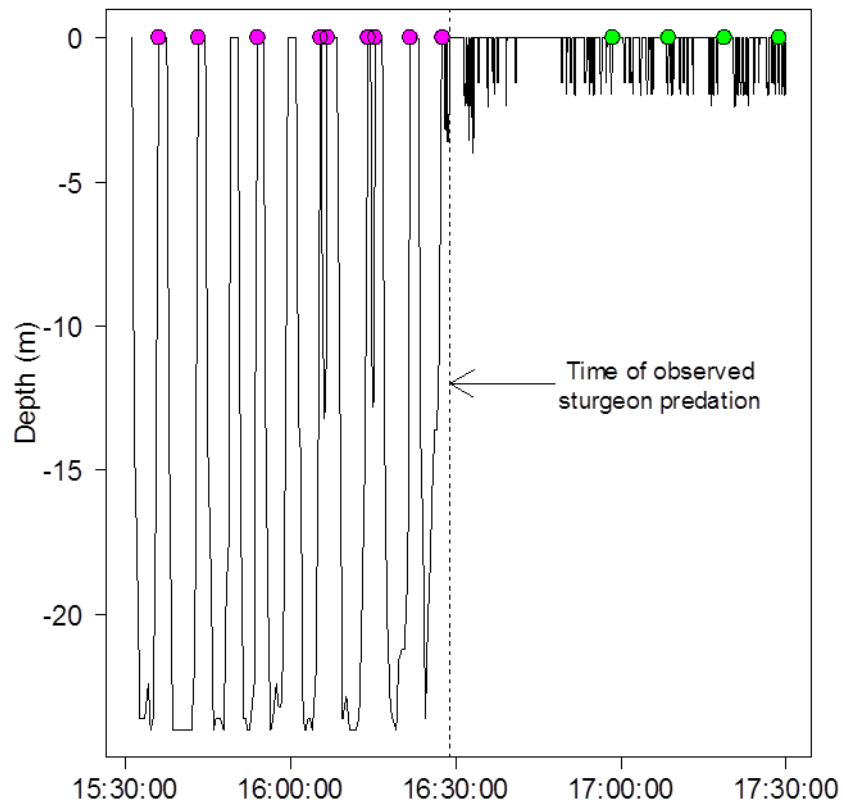


Figure 15. Time-depth telemetry (left) and approximate location (right) associated with a USACE-documented sturgeon predation by Steller sea lion O21 at 16:29 on February 29, 2012. Sturgeon was estimated at 3-4 feet in length.