FIELD REPORT:
2010 PINNIPED MANAGEMENT ACTIVITIES AT AND BELOW BONNEVILLE DAM

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Robin Brown[1], Steven Jeffries[2], Doug Hatch[3], Bryan Wright[1], and Sandra Jonker[2]

INTRODUCTION

This year (2010) marked the sixth consecutive year of research and management of pinnipeds at Bonneville Dam 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 the US Army Corps of Engineers (USACE) and the National Marine Fisheries Service (NMFS). Other cooperating agencies and organizations include: Bonneville Power Administration (BPA), Northwest Power and Conservation Council, Pacific States Marine Fisheries Commission (PSMFC), US Department of Agriculture Wildlife Services (USDA), US Coast Guard, Point Defiance Zoo & Aquarium, Oregon State University, state and local law enforcement, and others. Background on this work and links to supporting documents can be found at http://www.nwr.noaa.gov/Marine-Mammals/Seals-and-Sea-Lions/States-MMPA-Request.cfm and http://www.nwd-wc.usace.army.mil/tmt/documents/fish/ .

Pinniped management activities led by ODFW and WDFW at Bonneville Dam are authorized under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) Sections 109h and 120. 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 the dam during 2010.

METHODS

Boat-based deterrent activities

Boat-based hazers used a combination of acoustic and tactile deterrents (seal bombs, cracker shells, rubber buckshot, 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 Boat Restricted Zone (BRZ) at the dam in search of sea lions. The following was recorded for each discrete hazing event: species and number of pinniped encountered; starting location, time and direction of travel of pinnipeds; type and number of deterrent devices used; and ending location, time and direction of travel of pinniped. Predation observations and identifying marks of pinnipeds were also noted.

[1] Oregon Department of Fish and Wildlife (ODFW)
[2] Washington Department of Fish and Wildlife (WDFW)
[3] Columbia River Inter-Tribal Fish Commission (CRITFC)

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, the Powerhouse 2 (PH2) 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 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. VHF-radio contact was maintained with Control Room staff while boat hazing crews were active in the BRZ.

Trapping

California sea lions (*Zalophus californianus*) targeted for removal were captured using haul-out traps. Sea lions entered and exited traps via a vertically-sliding door which was pad-locked open whenever a capture event was scheduled to be greater than 48 hours in the future. Traps were monitored daily when locked open. During active capture operations, traps were unlocked and were routinely monitored day and night to be sure the doors remained open until staff chose to close them. Trap doors were closed using a remote-controlled magnetic release mechanism. Monitoring the traps used a combination of physical visits to the trapping site, monitoring from the Washington shoreline and use of cameras. Monitoring was accomplished in coordination with USACE Bonneville FFU, FFU sea lion predation observers, USDA Wildlife Services staff, and Bonneville Project staff including park rangers, security and control room personnel. For interagency coordination, 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 door close unexpectedly.

Four traps were placed below PH2 along the Corner Collector wall during the first week of February. Sea lion abundance in the area was still low at this time and traps were locked open to allow time for animals to habituate to them. Early in the season sea lions (primarily Stellers) used the traps as resting areas sporadically. Trapping operations at Bonneville did not begin until the first week of March. An additional sea lion trap was also operated year-round in Astoria at the East Mooring Basin.

Once sea lions were captured they were herded into holding cages on a barge built specifically to work on sea lions. If an animal was an approved candidate for permanent removal it was transferred to an on-site holding facility for further evaluation. A crane operated by the Bonneville rigging crew was used to lift and transfer candidate sea lions. If a captured animal was not a candidate for removal it was released, possibly after branding and/or instrumentation.

If a NMFS-approved zoo or aquarium facility was available to receive candidate sea lions, then captured animals would be given a health screening by field staff and veterinarians, including members of the States' Animal Care Committee. If an animal passed the health screening it would be transferred to Point Defiance Zoo and Aquarium in Tacoma, WA for temporary housing prior to shipment to a permanent holding facility. 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 typically collected for further analysis.

Acoustic telemetry

Acoustic pingers (ultrasonic transmitters) were attached to five California sea lions and six Steller sea lions captured at Bonneville Dam in order to track movements and infer foraging behavior around Bonneville Dam and in the lower Columbia River. Vemco V16-5H coded pingers (Vemco Ltd., Nova Scotia, Canada) were used, 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 μPa at 1 m. Each pinger emitted a uniquely identifiable pulse train at random intervals every 30-90 s. Pingers were attached to the pelage mid-dorsum of a sea lion using 5-minute epoxy. The pingers attached to California sea lions contained a pressure sensor that allowed the depth of the tag to be determined each time it was detected. Sea lions were passively tracked using fixed arrays of Vemco VR2W acoustic receivers. Receivers were located from Bonneville Dam to Astoria (Figure 1) and were regularly downloaded every 1-2 weeks. Receivers recorded a pinger's identification number, date and time whenever a marked sea lion traveled within a receiver's detection range.

Satellite telemetry

Satellite transmitters were attached to eight Steller sea lions captured at Bonneville Dam in order to track their movements during the summer breeding season when they are typically absent from the river. We used seven location-only Sirtrack (Havelock North, New Zealand) KiwiSat 101 satellite-linked platform transmitter terminals (PTTs), as well as two Sea Mammal Research Institute (St. Andrews, Scotland) satellite relay data loggers (SRDLs). Transmitters were secured to light-weight nylon mesh netting and then glued to the sea lion's pelage mid-dorsum using 5-minute epoxy. Transmitters only function in saltwater and were duty-cycled to conserve battery power, maximize satellite reception, and limit operating cost.

Animal locations were determined by the Argos satellite telemetry system (Collecte Localisation Satellites (CLS) 2008), which calculates locations based on the Doppler shift in PTT radio signals (uplinks) received on polar-orbiting satellites. The accuracy of Argos location fixes is based on the number of uplinks received by a passing satellite. Each fix is assigned a location quality class (LC), which decreases in accuracy in the following order: 3, 2, 1, 0, A, B and Z. Standard deviations of the estimated location errors for location classes 3, 2, 1, and 0 are reported to be <250, 250 to <500, 500 to <1,500, and ≥1,500 m (CLS 2008). Location classes A and B are fixes with no reported accuracy; LC Z are instances in which no valid location was determined.

Food habits

Fecal (scat) samples were collected from haul-out structures as well from the gastro-intestinal tracks of euthanized animals for food habits information. Undigested prey structures were recovered by rinsing scat through a series of nested sieves. Prey were identified to the lowest taxon possible based on species-specific or family-specific diagnostic structures such as otoliths, teeth, gill rakers and vertebrae.

Effect of removals

We estimated the number of salmonids that were not consumed (i.e., "saved") due to removal of California sea lions in 2008-2010 via Monte Carlo simulation. Figure 2 shows a conceptual schematic of the simulation model. The model is comprised of three components. The first part is an energetics model, adapted from the Steller sea lion bioenergetics models of Winship et al. (2002) and Winship and Trites (2003). Inputs to this model include sea lion weights based on removed animals and an assumed diet varying between 90% and 100% salmonids. The bioenergetics component yields an estimate of the daily salmonid requirement expressed in kgs per day for a given number of sea lions.

The second component of the simulation model is an estimate of the number of days an animal forages at the dam (i.e., "residency"). This is based on USACE observations of animals that were branded prior to, and not removed during, a given season. Residency observations based on direct observation are biased low when not all days of the week are observed and when animals are present but fail to be detected. In 2009 and 2010, observations only occurred on 5 of 7 days each week. We therefore multiplied residency counts by 7/5 to adjust for missing days. In 2010, USACE observers recorded acoustic-tagged California sea lions as present on 38 of the 39 days that hydrophone data indicated tagged sea lions were present in the tailraces during daylight hours (i.e., detectability was approximately 0.975). As a result we further adjusted the residency distribution upwards by 1.02 (i.e., 39/38).

The product of the first two components (kgs per day × days per sea lion) yields an estimate of the kgs of salmonids required per sea lion per season. For example, if an animal required 10 kg of salmon per day, and was present for two days, then its estimated seasonal requirement was 20 kgs of salmon. We converted this requirement to numbers of discreet fish by repeatedly dividing it by randomly selected Chinook fish weights until the requirement was met or exceeded. Continuing the example above, a sample of three fish weighing 6 kg, 5 kg, and 12 kg would meet the 20 kg requirement (as would two 10 kg fish, four 5 kg fish, etc.). The population of fish weights from which we sampled was obtained from University of Idaho researchers who sampled Chinook passing Bonneville Dam during April-May 2004, 2006, and 2007.

Further adjustments to the total number of salmon saved per season were made based on whether estimates were being made for the season in which an animal was removed or for subsequent seasons. For within season removals, we multiplied the estimated number of salmonids saved by a random uniform number between zero and one to account for the possibility of having removed the animal at any point within its residency period (a one indicating removal upon an animal's arrival to the dam, and a zero for removal at the end of its residency time). Since we know that not all animals return from year to year, we incorporated uncertainty for this fact by multiplying future annual savings by an empirical return probability calculated from all branded animals after their initial sighting up to 2010 or the year it was removed. For example, if a branded animal was first observed in 2006 and only seen again in 2008 and 2010 then its return probability would be 2/4=0.5.

The entire simulation was programmed into an R function and run 1000 times for each year by removal cohort combination (i.e., 2008 removals for 2008, 2009, and 2010; 2009 removals for 2009 and 2010; and 2010 removals for 2010). Animals removed in the fall of a given year were not included in that year's estimate but were included in subsequent years. Uncertainty was assessed by calculating the 2.5 and 97.5 percentiles from the 1000 iterations. Further details of this approach as well as the R code used to implement the model are available upon request.

RESULTS

Boat-based deterrent activities

Boat-based pinniped hazing crews from ODFW, WDFW, and CRITFC hazed sea lions on 44 days from 1/6/10-5/17/10 (Table 1). Hazing resulted in a total of 202 and 377 "takes" (i.e., pinniped harassment events) of California sea lions and Steller sea lions, respectively. A total of 4,921 cracker shells, 777 seal bombs, and 97 rubber buckshot rounds were used during deterrent activities.

Trapping

A total of 22 individual California sea lions were captured in 2010 (Table 2), fourteen of which met the criteria for removal and were euthanized because no facility was available to receive candidate seas lions. The remainder were branded when necessary and released; five received acoustic transmitters with depth sensors. Animals were captured at the dam from March 3rd to May 26th; two of the euthanized animals were captured in Astoria in early fall 2010. Weights ranged from approximately 250 lbs (113 kgs) to 900 lbs (408 kgs).

A total of 9 individual Steller sea lions were captured in 2010 (Table 2), all except one were branded and received one or more telemetry instruments. Animals were captured at the dam from March 30th to May 26th. Weights ranged from approximately 500 lbs (227 kgs) to 1500 lbs (680 kgs).

Acoustic and satellite telemetry

A short summary of each California sea lion (CSL) and Steller sea lion (SSL) that carried one or more telemetry instruments is as follows:

CSL C-00—California sea lion C-00 was instrumented with a pressure (depth) sensing acoustic transmitter, which provided data for approximately 47 days from 3/9 to 4/25 (Fig. 3). C-00 was euthanized on 5/4. C-00 made at least four trips between the lower estuary and Bonneville Dam, spending approximately a week at the dam before returning to the lower estuary to intermittently haul out at the East Mooring Basin (EMB) for approximately a week, taking 2-3 days to transit between the two areas (often departing or arriving at the dam at night). One noteworthy gap in the movement profile occurred between approximately 4/17 and 4/24 when the animal occurred somewhere between the Phoca Rock and St. Helens hydrophone arrays. The transmitter on C-00 fell off prematurely at the EMB on approximately 4/25 and continued to be detected by the EMB receiver throughout the summer. C-00 occurred in the Bonneville tailraces during repeated boat-based hazing (see symbol "H" in figure) and was always detected by USACE observers when present, and not mistakenly detected when absent (see symbol "B" in figure). Dive data shows that C-00 typically dove to approximately 10 m with single detections to 20 m and 25 m.

CSL C-01—California sea lion C-01 was instrumented with a pressure (depth) sensing acoustic transmitter, which provided data for approximately 36 days from 4/29 to 6/4 (Fig. 4). C-01 made at least four trips between the lower estuary and Bonneville Dam, spending 2-4 days at the dam before returning to the lower estuary to intermittently haul out at the East Mooring Basin (EMB) for approximately 4 days, taking 2-3 days to transit between the two areas. C-01 occurred in the Bonneville tailraces during boat-based hazing and was detected by USACE observers when present on all but one day (which to be fair was a day C-01 departed the dam – see 5/19) and not mistakenly detected when absent. Dive data shows that C-01 typically dove to approximately 10 m while at the dam, with at least several dives occurring at night (e.g., 5/29).

CSL C-02—California sea lion C-02 was instrumented with a pressure (depth) sensing acoustic transmitter, which provided data for approximately 51 days from 5/4 to 6/24 (Fig. 5). C-02 made at least one trip between the lower estuary and Bonneville Dam returning to the lower estuary to intermittently haul out at the East Mooring Basin (EMB) for approximately 2-6 days. Interestingly, C-02 made several trips upriver during late May and June but never as far as the dam. After its capture and release at the dam, C-02 occurred in the tailraces during boat-based hazing and was detected by USACE observers when present, and not mistakenly detected when absent. Dive data shows that C-02 dove to approximately 10-15 m while at the dam.

CSL C-667—California sea lion C-667 was instrumented with a pressure (depth) sensing acoustic transmitter, which provided data for approximately 22 days from 5/4 to 5/26 (Fig. 6). C-667 was euthanized on 5/26. C-667 made at least two trips between the lower estuary and Bonneville Dam, returning to the lower estuary to intermittently haul out at the East Mooring Basin (EMB) for approximately 5 days. C-667 occurred in the Bonneville tailraces during boat-based hazing and was detected by USACE observers when present, and not mistakenly detected when absent. Dive data shows that C-667 dove to approximately 10-15 m while at the dam. While on foraging trips to the dam, C-667 appeared to never leave the BRZ except once on 5/11 when it went downstream near the Phoca Rock array before returning the next day.

CSL C-03—California sea lion C-03 was instrumented with a pressure (depth) sensing acoustic transmitter, which provided data for approximately 105 days from 5/19 to 9/1 (Fig. 7). C-03 was captured late in the season (in the forebay of Bonneville Dam) and departed the dam immediately after capture. After hauling out intermittently at the East Mooring Basin (EMB) for nine days C-03 departed the river around 5/28, presumably on its southward migration to the breeding grounds. C-03 returned to the estuary on 8/9 and was detected through 9/1.

SSL 0-001—Steller sea lion 0-001 was instrumented with an acoustic transmitter, which provided data for approximately 30 days from 3/31 to 4/30 (Fig. 8). Upon release after capture 0-001 remained at or above the Phoca Rock array until departing the river around 4/30. During the month it was tracked at the dam, 0-001 typically stayed within the BRZ. Steller 0-001 also received a satellite transmitter (PTT) which provided data for approximately 74 days from 3/30 to 6/12 (Fig. 9). 0-001 stayed near the Columbia River south jetty haul-out until 5/10 at which point it traveled south to the Three Arch Rocks rookery/haul-out where it stayed from 5/12 until the transmitter stopped providing data on 6/11.

SSL 0-002—Steller sea lion 0-002 was instrumented with an acoustic transmitter, which provided data for approximately 74 days from 3/30 to 6/12 (Fig. 10). Upon release after capture 0-002 returned to the mouth of the river at or near the South Jetty haul-out. Approximately three weeks later it returned to the dam where it stayed for approximately two weeks, making several shorter trips back and forth between the tailraces and Phoca Rock. For the remainder of May and into June it was detected at the arrays at the mouth and once further up the estuary. Detections from the acoustic tag ceased around 6/12. Steller 0-002 also received a satellite transmitter (PTT), which provided data for approximately 92 days from 3/30 to 6/30 (Fig. 11). 0-002 stayed near the Columbia River south jetty until detections from the satellite tag ceased at the end of June.

SSL 0-003—Steller sea lion 0-003 was instrumented with an acoustic transmitter, which provided data for approximately 29 days from 3/31 to 4/29 (Fig. 12). Upon release after capture 0-003 remained at or above the Phoca Rock array until departing the river around 4/29. During the month it was tracked at the dam, 0-003 typically stayed within the BRZ, making occasional shorter trips back and forth between the tailraces and Phoca Rock. Steller 0-003 also received a satellite transmitter (PTT), which provided data for approximately 41 days from 3/31 to 5/11 (Fig. 13). Once it entered the ocean on 4/29, 0-003 turned south and traveled to the Rogue Reef rookery where it arrived on 5/4 and remained until detections from the tag ceased on 5/11.

SSL 0-004—Steller sea lion 0-004 was instrumented with an acoustic transmitter, which provided data for approximately 52 days from 3/31 to 5/22 (Fig. 14). Upon release after capture 0-004 remained at or above the Phoca Rock array until departing for the ocean around 5/21. During the seven weeks it was tracked at the dam, 0-004 typically made daily round trips between the BRZ and the Phoca Rock haul-out. Steller 0-004 also received a satellite transmitter (PTT), which provided data for approximately 64 days from 3/31 to 6/3 (Fig. 15). Once it entered the ocean on 5/23, 0-004 turned south and traveled south to at least Cape Blanco where detections from the tag ceased on 6/3. Steller 0-004 was found dead in the Columbia south of Phoca Rock near Cape Horn on 9/19.

SSL 0-005—Steller sea lion 0-005 was instrumented with an acoustic transmitter, which provided data for one day from 4/28 to 4/29 (Fig. 16). Upon release after capture 0-005 returned to the mouth of the river and entered the ocean. Steller 0-005 also received two satellite transmitters (PTT and SRDL), which provided data for approximately 63 days from 4/28 to 6/30 (Fig. 15). Once it entered the ocean on 4/29, 0-005 turned south and traveled to the St. George Reef rookery where it arrived on 5/9 and remained until detections from the tag ceased on 6/30. Unfortunately, dive data recorded by the transmitter was corrupted, possibly due to the age of the tag.

SSL 0-006—Steller sea lion 0-006 was only instrumented with a satellite transmitter (PTT), which provided data for approximately 57 days from 5/4 to 6/30 (Fig. 17). Once it entered the ocean on 5/11, 0-006 traveled north to waters off northwest Washington before returning to the Columbia River mouth on 6/14 where it remained until detections from the tag ceased on 6/30.

SSL 0-007—Steller sea lion 0-007 was instrumented with an acoustic transmitter, which provided data for 47 days from 5/7 to 6/23 (Fig. 18). Upon release after capture 0-007 returned to the mouth of the river. Steller 0-007 also received a satellite transmitter (SRDL), which provided data for approximately 63 days from 5/4 to 6/30 (Fig. 19). Once it entered the ocean on 4/29, 0-007 turned south arriving at Castle Rock, CA on 5/23 where it stayed until 6/2. Steller 0-007 then returned to the mouth of the Columbia River on about 6/10. At this point it traveled back up the Columbia River to around Beacon Rock where it stayed for about a day (6/12-6/13) before heading back to the mouth. After several days at the mouth it again returned to the Beacon Rock area (6/21-6/22) for a day before heading back to the mouth at which point detections from the acoustic tag ceased, followed by detections from the satellite tag on 6/30. Unfortunately, dive data recorded by the transmitter was corrupted, possibly due to the age of the tag.

SSL 0-008—Steller sea lion 0-008 was only instrumented with a satellite transmitter (PTT), which provided data for approximately 56 days from 5/4 to 6/29 (Fig. 20). Once it entered the ocean on 5/7, 0-008 traveled south stopping at Three Arch Rocks (5/13) and Cascade Head (5/15-5/17) before briefly staying at Cape Arago (5/21-5/23) before returning north. It went back to Cascade Head (5/29-5/30) and then south again to Sea Lion Caves (6/1) where it intermittently hauled-out over the next month in-between foraging trips 40 miles offshore over the continental shelf. Detections from the tag ceased on 6/29.

Food habits

Undigested remains recovered from sea lion fecal material and gastro-intestinal tracts have been recovered and are undergoing identification.

Effect of removals

The median daily individual salmonid biomass requirement from 10,000 iterations of the bioenergetics component of the simulation model was 13.6 kg/day (95% confidence interval was 7.7 to 25.5 kg/day), which translated into a median of 3 chinook/day (95% confidence interval was 2 to 5 chinook/day). The median daily individual salmonid requirement (where salmonids were 90-100% of the diet) expressed as a percentage of body weight was 4.0% (95% confidence interval was 2.5% to 6.5% of body weight). The estimated median seasonal salmonid requirement for each sea lion was 54 salmonids per season (95% confidence interval was 6 to 207 salmonids/season).

We modeled the effect of removals based on the 38 of the 40 California sea lions that have been either intentionally or accidentally removed during the past three years and were either on the list for removal or had qualified for the list (i.e., we excluded two accidental mortalities of animals from 2008 that had not yet qualified for removal). The effective sample size, however, was only 36 sea lions because two of the animals were removed in fall 2010 and therefore won't result in fish savings until spring 2011. Based on the simulation model, the predicted number of salmonids that would have been required from 2008 to 2010 by 36 California sea lions at Bonneville Dam was between 1357 and 4921 fish (Table 3). On average, fish saved per sea lion in removal years was estimated to be from 17 to 60 fish and in each subsequent year from 22 to 88 fish.

DISCUSSION

<u>Boat-based deterrent activities</u>

Hazing activities in 2010 were conducted (1) in an attempt to disrupt and reduce sea lion predation near the dam (and possibly minimize recruitment of new, naïve predators to the area), and (2) to fulfill requirements of the Section 120 authorization granted to the States for permanent removal of California sea lions at Bonneville Dam. One component of the Section 120 authorization requires sea lions to have been exposed to non-lethal hazing prior to taking permanent removal actions for individual animals. With boat-based hazing efforts, and efforts by shore-based USDA Wildlife Services staff, any sea lion within the BRZ would have been exposed to nonlethal hazing.

In general, the response to hazing in 2010 was similar to that seen in previous years. There was no apparent reduction in sea lion activity or predation in response to hazing. Sea lion presence in the observation area or in the BRZ did not appear to be significantly influenced by whether or not hazing activities occurred on any day or during any particular period. Furthermore, several sea lions “new” to the area (initially unbranded or unknown by natural markings) continued to forage in the observation area in spite of shore and boat hazing and later qualified for permanent removal within the same season. The latter suggests that hazing as a tool to deter “naïve” sea lions that are new to the area may be ineffective, particularly if there are large numbers of experienced sea lions foraging in the area as well. There was also no observed negative reaction, injury or mortality to salmonids or other fish and wildlife species as a result of the pinniped hazing activities.

As in previous years, shore-based hazing was conducted by USDA Wildlife Services staff under contract with USACE. In 2010 CRITFC staff led the boat-based hazing effort with support and coordination of State program staff. This allowed State staff to concentrate on capture, marking, tracking, and removal efforts. This division of labor still provided for adequate hazing efforts in order to insure that all sea lions in the area were exposed to non-lethal hazing actions as required under the Section 120 LOA.

Based on the recommendations by IMATA in 2009, deterrent techniques were modified by incorporating some of their suggestions for use of deterrent methods. Boat-based hazing was focused in the area above Tanner Creek and in the BRZ. Hazing generally ceased once sea lions began moving downstream out of the BRZ. Hazing efforts were refined and improved in a number of ways, including by working more closely with CRITFC on more effective boat hazing focusing on the BRZ. Other suggestions made by IMATA were evaluated and were determined to be impractical for use in this situation or are not logistically possible to implement.

Trapping and Removal

All candidate California sea lions removed in 2010 were captured on floating traps. During the 2009 season, the States discussed protocols and safety at several meetings with USACE staff and came to an understanding of how firearms could be safely used according to the guidelines presented in the Section 120 LOA. This effort would involve the use of a trained marksman, a biologist experienced with identification of known predatory sea lions, and a Safety Officer provided by USACE. However, opportunities for use of firearms were extremely limited in 2009 and 2010 due to sea lion haul-out patterns. In both years sea lions repeatedly used sections of the apron and rip-rap below the Corner Collector that would not allow use of firearms. Only on one or two occasions were known predatory animals observed in locations and at times where firearms could have been used.

Limiting flat space on the apron below the Corner Collector used as a haulout area by sea lions could increase the likelihood that animals would more frequently rest on the traps. The need for modification of the apron has been discussed with USACE staff at Bonneville. There is general agreement that this could be beneficial to the predator removal program, but there is currently no funding identified for a permanent fix for this problem. In 2010 the States tested a temporary method to block portions of the apron with concrete pier blocks. It is unknown whether this action was highly effective. In contrast to previous years, sea lions rarely used the flat portion of the apron in 2010. However, the tailrace water level was unusually low throughout most of the spring (did not rise up to the flat portion) and sea lions typically hauled out on the rip rap or near the water's edge rather than climbing to the top of the rocks to reach the apron.

Modification of the trapping protocols including locking traps open when not in use, installment of remote door release systems, increased monitoring, and use of remote cameras during the 2009 and 2010 seasons proved successful at preventing unintended capture events. In 2010 all four sea lion traps were equipped with these systems.

In 2010 only one permanent holding facility (Gladys Porter Zoo, Texas) expressed interest in obtaining healthy sea lions for public display. However, before captures began, this facility withdrew its request. As a result, all sea lions captured for permanent removal in 2010 were chemically euthanized. Health screenings for animals that may be captured and potentially be sent to captive display facilities are costly, time consuming, and not always conclusive. The costs for this work was not considered or provided for in initial project budget requests. While it is important to make healthy animals available for facilities that are eligible to receive them, the health screening process put a significant burden on operations that were not directly supported through existing budgets. Some of these costs, including staff time and health screening may require additional funding or be supported by the institutions approved by NMFS to receive healthy animals. This same situation applies to institutions seeking legally transferable biological samples. The States do not have the necessary funding or staff to conduct full post mortem examinations and tissue collection in every case. Again, those requesting materials should provide their staff and be responsible for covering costs of this work.

Acoustic telemetry

As with previous years, the use of acoustic telemetry has allowed us to learn about fine-scale spatio-temporal movement patterns of sea lions in and below the BRZ, and coarser scale movements throughout the river. This year marks the first year we've tagged Steller sea lions. While much of the movements were idiosyncratic, California sea lions generally traveled back and forth between the dam and the lower river (Astoria/EMB), staying in each area from a few days to a week or more at a time. In contrast, Steller sea lions generally stayed upriver longer but traveled back and forth between the dam and Phoca Rock. Both species appeared to be detected more often during the day but it was not uncommon for animals to be detected at night. Depth sensor tags on California sea lions confirmed that nocturnal detections occurred during diving (and hence presumably foraging) rather than just from animals sleeping in the water.

Acoustic telemetry has also allowed us to assess the detectability of animals by comparing USACE observations against hydrophone data. The latter shows that USACE does an excellent job of correctly identifying animals when they are present in the tailrace and not mis-identifying animals when they are absent. (It should be noted however that detectability of branded and instrumented animals is likely to be higher than for animals with only natural marks.) Overlaying boat-based hazing days against movements (e.g., Fig. 6) also shows the apparent lack of response to hazing by acoustic-tagged sea lions.

Satellite telemetry

The main objective of satellite tagging Steller sea lions during 2010 was to determine where they go during the summer breeding season. Of the eight satellite-tagged animals, only one traveled north into Washington waters. Of the remaining seven, two traveled to northern California and five stayed within Oregon waters. Movements, when combined with animal weights, suggest that two of the animals are, or may soon be, breeding bulls: 0-003 weighed 1466 lbs and traveled to the Pyramid Rock rookery at Rogue Reef, Oregon; 0-005 weighed 1500 lbs and traveled to the South Seal Rock rookery at St. George Reef, California.

Removal effect modeling

Our current approach to predicting the number of salmon saved due to sea lion removals is more realistic and accounts for more uncertainty than our past attempts and the model estimates are consistent with both published data on food consumption by captive California sea lions and with data from USACE observers at the dam. For example, Kastelein et al. (2000) reported on food consumption and growth of captive California sea lions in the Netherlands. They found that average annual consumption by mature males stabilized at approximately 4000 kg/year (11 kg/day) based on a diet of mackerel, herring, sprat, and squid. They also report the maximum observed consumption by males was 35.5 kg/day. Although based on a different diet, this consumption compares well with the median predicted requirement of 13.6 kg/day and a maximum model output of 41.5 kg/day. Kastelein et al. (2000) also report that food consumption as a percentage of body weight declined with increasing weight, from about 4-6% of body weight for 2-7 year old males (weighing 75-225 kg) to about 3% of body weight for 19 year old males (weighing 300-400 kgs). This compares well with our model output of salmonid requirements being between 2.5% and 6.5% of body weight.

Bioenergetic model predictions also compare well with USACE observer data from the dam (Stansell et al. 2010). USACE estimates of average annual salmonid consumption by California sea lions at the dam from 2002 to 2010 ranged from 22.4 to 74.3 fish/season/sea lion, and maximum numbers of salmonids consumed by an individual ranged from 35 to 198 fish/season. These estimates compare will with bioenergetic predictions of 54 salmonids/season/sea lion (95% confidence interval of 6 to 207 salmonids/season/sea lion).

While the bioenergetics model, USACE observations, and captive animal data (Kastelein et al. 2000) are all relatively consistent, they all probably underestimate actual consumption by sea lions at Bonneville Dam to some extent. This is due to the fact that USACE observations are minimums due to imperfect detectability, captive study animals have lower metabolic requirements than wild animals, and sea lions kill more fish then they actually consume (e.g., due to cleptoparasitsm, delayed mortality due to wounding, and partial ingestion of killed fish). Future refinements to the modeling will try to account for some of these and other issues.

Recommendations for 2010

- NMFS and the Pinniped Task Force should review the requirements for adding sea lions to the authorized removal list (e.g., reducing the number of days an animal must be seen at Bonneville Dam could increase opportunities for removal of predatory California sea lions).

- NMFS and the Pinniped Task Force should reconsider the requirement for non-lethal hazing in light of the costs and apparent ineffectiveness of the activity. If no change to hazing requirement is made, we will proceed with activities similar to those conducted in 2010.

- The first two years of results from the acoustic tracking work were very encouraging and could potentially lead to a better understanding of predator foraging patterns in this area. We plan to continue deploying tracking tags in 2011 on California sea lions that are not listed for removal and on Steller sea lions.

- In cooperation with USACE, we will continue refining our methods for predicting the number of salmonids saved due to sea lion removals.

- The Corner Collector apron needs a permanent modification to limit its use as a haulout in areas near the traps and where use of firearms could be safely carried out. Ultimately USACE should plan, budget, and carry out this action. In the meantime, the States will continue to test the effectiveness of the concrete pier blocks to reduce sea lion use of this area.

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Table 1. Weekly summary of 2010 boat-based hazing activities at and below Bonneville Dam.

Wk #	Week of	ODFW	WDFW	CRITFC	Events	# CSL	# SSL	Cracker shells	Seal bombs	Rubber buckshot
1	1/3/10	1			6	0	8	39	3	1
2	1/10/10	2			10	0	22	155	32	3
3	1/17/10	2			8	4	21	112	19	3
4	1/24/10	2			9	5	18	119	16	7
5	1/31/10		1		5	3	10	79	0	0
6	2/7/10	2	2		22	19	43	430	10	30
7	2/14/10		2		11	6	19	329	0	40
8	2/21/10		2		13	7	29	227	0	0
9	2/28/10									
10	3/7/10			5	27	7	35	151	42	0
11	3/14/10			5	28	17	26	305	81	13
12	3/21/10			2	15	11	11	207	56	0
13	3/28/10			3	18	16	30	544	154	0
14	4/4/10			2	17	8	30	537	108	0
15	4/11/10			1	9	13	37	184	11	0
16	4/18/10			2	20	14	21	480	69	0
17	4/25/10			1	12	17	1	184	29	0
18	5/2/10			3	20	22	9	447	77	0
19	5/9/10			3	27	31	6	326	68	0
20	5/16/10			1	3	2	1	66	2	0
Total		9	7	28	280	202	377	4921	777	97

* Take refers to numbers of animal-harassment events; CSL=California sea lion, SSL=Steller sea lion.

Table 2. Summary of 2010 sea lion capture activities in the Columbia River.

Species	Date	Brand	Alt ID	Euthanized	Released	Satellite tag	Acoustic tag	Weight (lbs)
California sea lion	1/25/2010	C 697			X			
	3/3/2010	C 653		X				509
	3/9/2010		B258	X				559
	3/9/2010		B194	X				591
	3/9/2010		B267	X				534
	3/9/2010	C 00	B305		X		X	
	3/9/2010	C 417		X				698
	3/9/2010	C 697*			X			
	3/9/2010	C 926		X				484
	3/30/2010	C 805		X				847
	3/30/2010	C 934		X				591
	4/6/2010	C 697*		X				708
	4/29/2010	C 01			X		X	
	5/4/2010	C 00*	B305	X				
	5/4/2010	C 02			X		X	250
	5/4/2010	C 667			X		X	
	5/18/2010	C 03	B324		X		X	
	5/25/2010	C 04	B331		X			
	5/26/2010	C 05	B334		X			
	5/26/2010	C 06			X			
	5/26/2010	C 07			X			
	5/26/2010	C 08	B340		X			
	5/26/2010	C667*		X				705
	5/26/2010	C 841		X				920
	9/8/2010	U 18**		X				
	9/9/2010	C 797**		X				
Sub-total				14	12		5	
Steller sea lion	3/30/2010	0 001			X	X	X	900
	3/30/2010	0 002			X	X	X	1100

	3/31/2010	0 003	S122		X	X	X	1466
	3/31/2010	0 004	S123		X	X	X	
	4/28/2010	0 005			X	X***	X	1500
	5/4/2010	0 006			X	X		500
	5/4/2010	0 007			X	X	X	800
	5/4/2010	0 008			X	X		600
	5/26/2010				X			~500
Sub-total					9	8	6	
Total				14	21	8	11	

* Recapture

**Astoria capture.

*** Received two tags.

Table 3. Predicted numbers of salmonids saved at Bonneville Dam due to California sea lion removals in the Columbia River, 2008-2010. Estimates from year of removal are adjusted for removal date; estimates in subsequent years are adjusted for return rate.

		Predicted number of salmon saved at Bonneville Dam			
Removal year	Number of listed animals removed	2008	2009	2010	Total
2008	9*	135-549	173-838	185-826	493-2213
2009	15	-	266-822**	400-1180	666-2002
2010	14	-	-	198-706***	198-706
	38	135-549	439-1660	783-2712	1357-4921

* Includes one animal that died accidentally that was not on the list for removal but had qualified.
** Excludes one animal that was removed during fall 2009.
*** Excludes two animals that were removed during fall 2010.

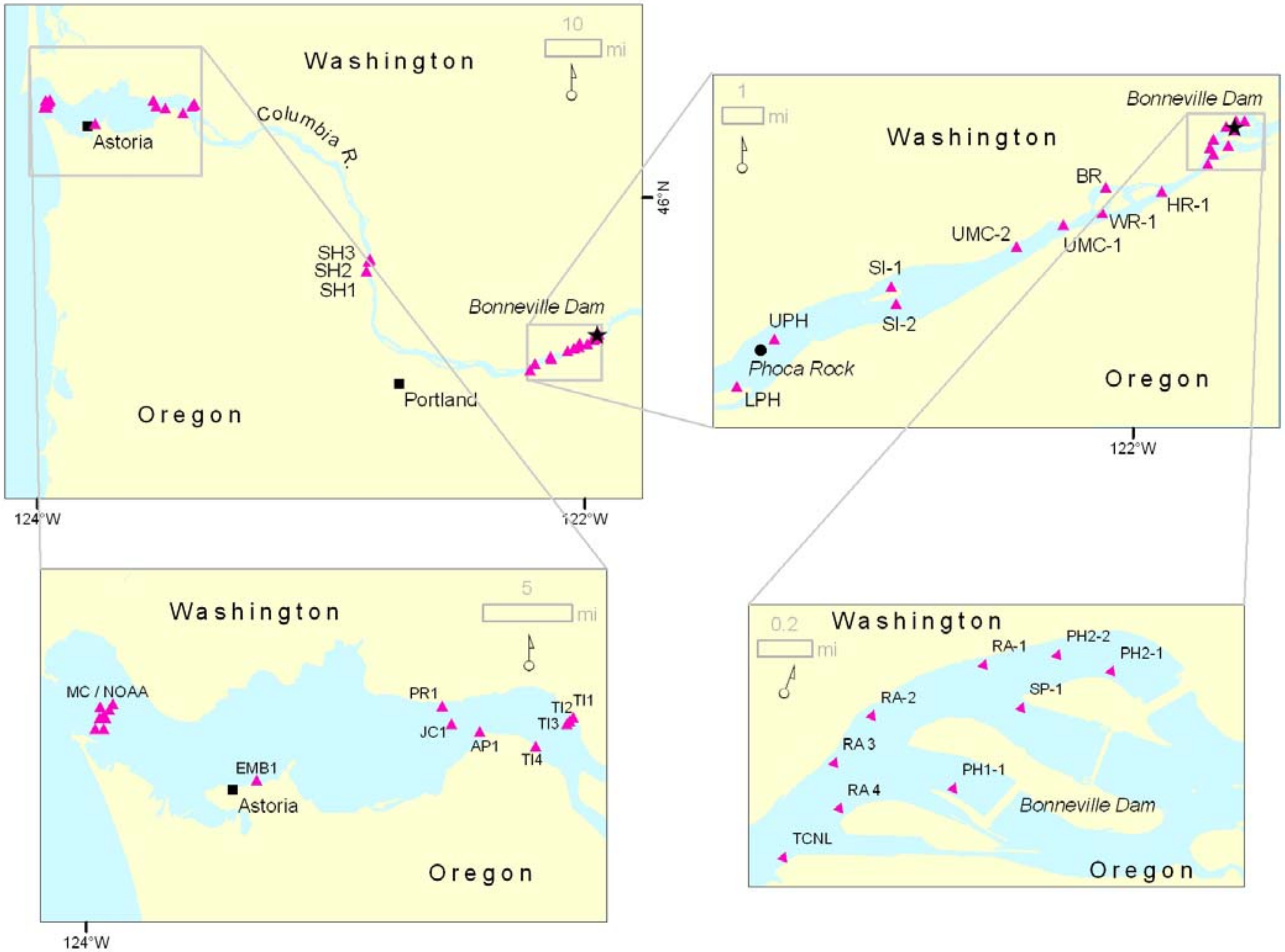

Fig. 1. Hydrophone locations used to track sea lions tagged at Bonneville Dam, 2010.

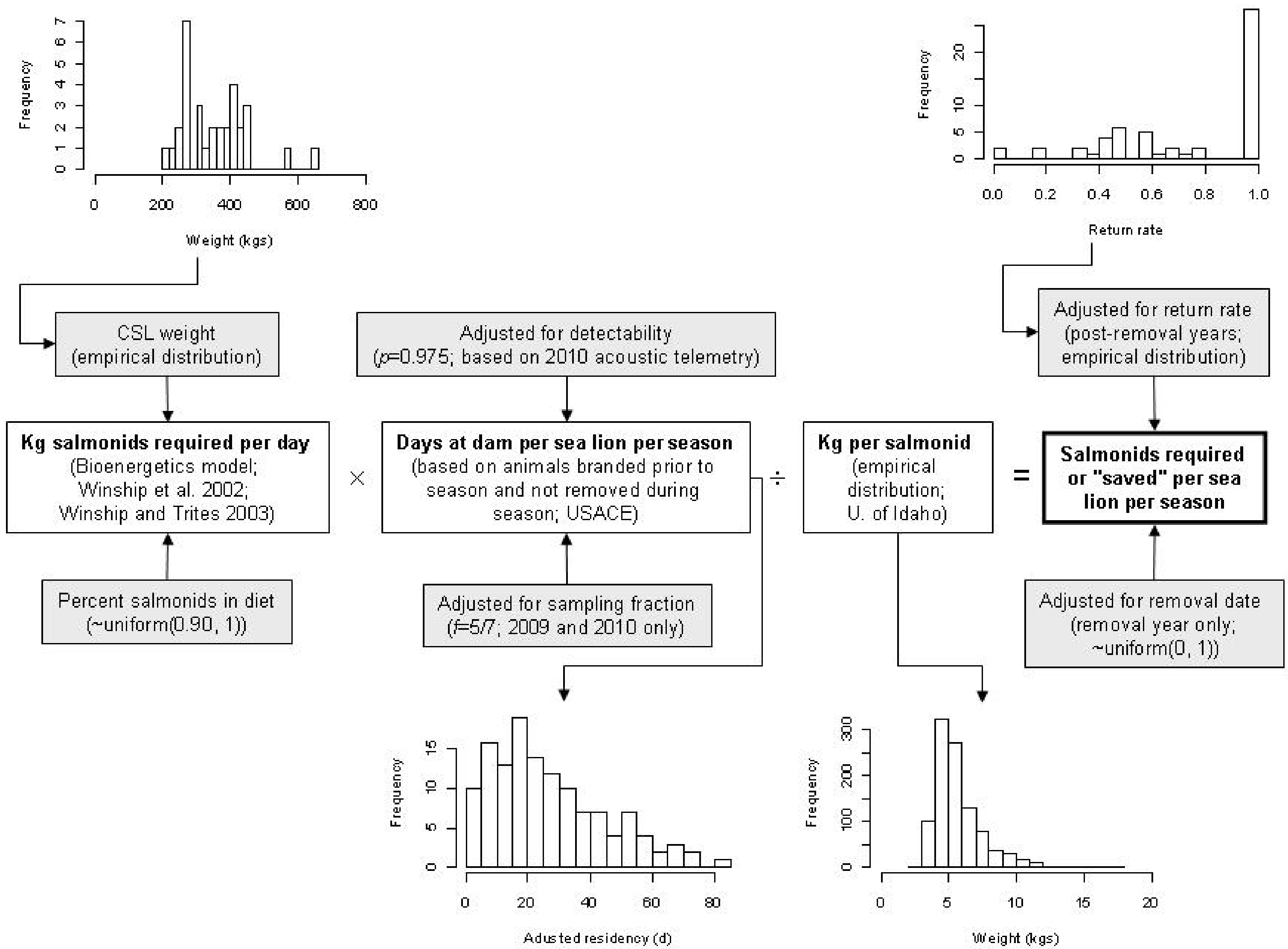

Figure 2. Schematic of Monte Carlo simulation process used to estimate the number of salmonids "saved" due to California sea lion removals in the Columbia River from 2008-2010.

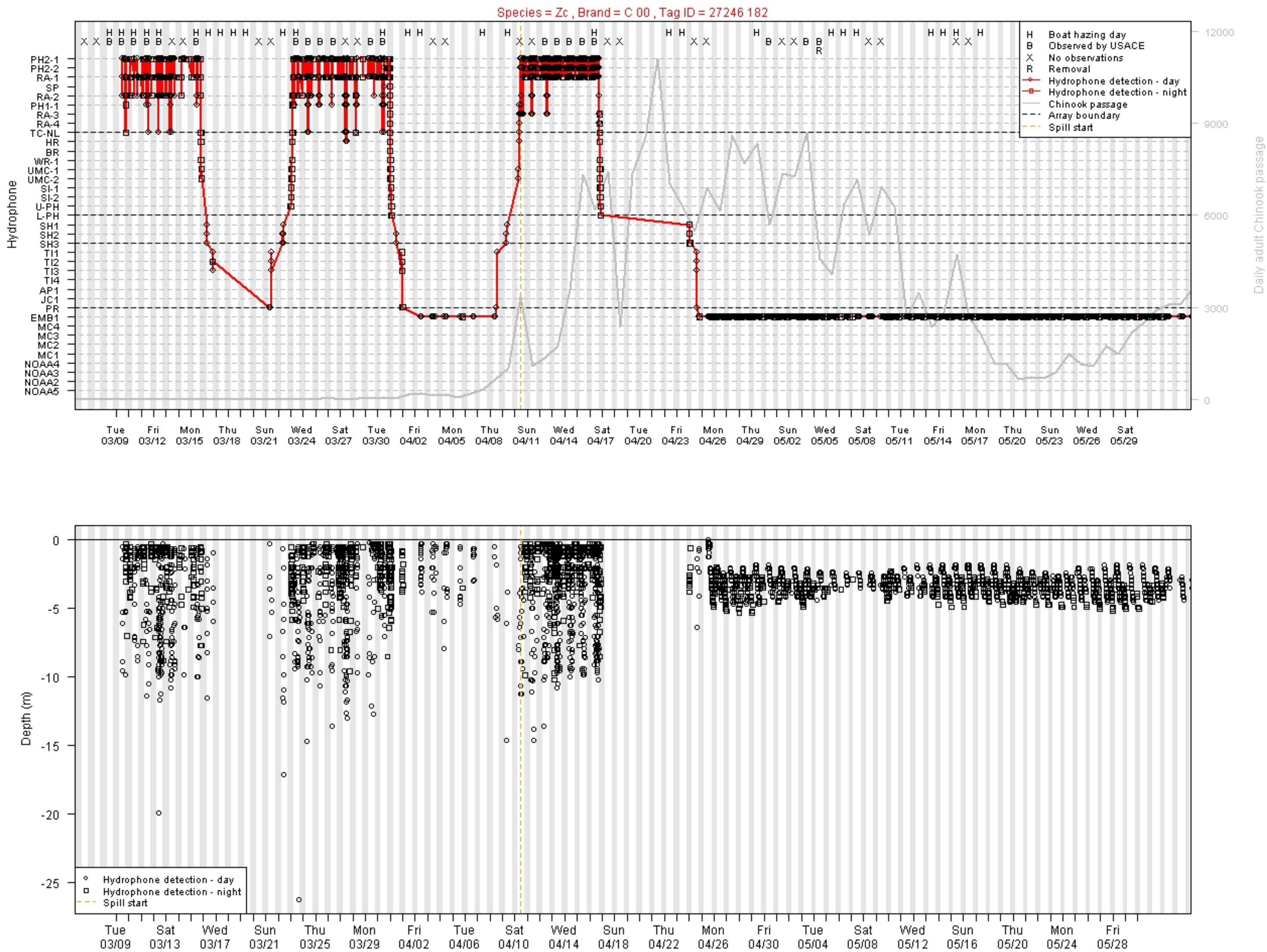

Fig. 3. Acoustic telemetry data from California sea lion C00. See Fig. 1 for location of hydrophones listed on the y-axis. Note that the tag fell off prematurely at the East Mooring Basin (EMB) in Astoria on approximately 4/26/10.

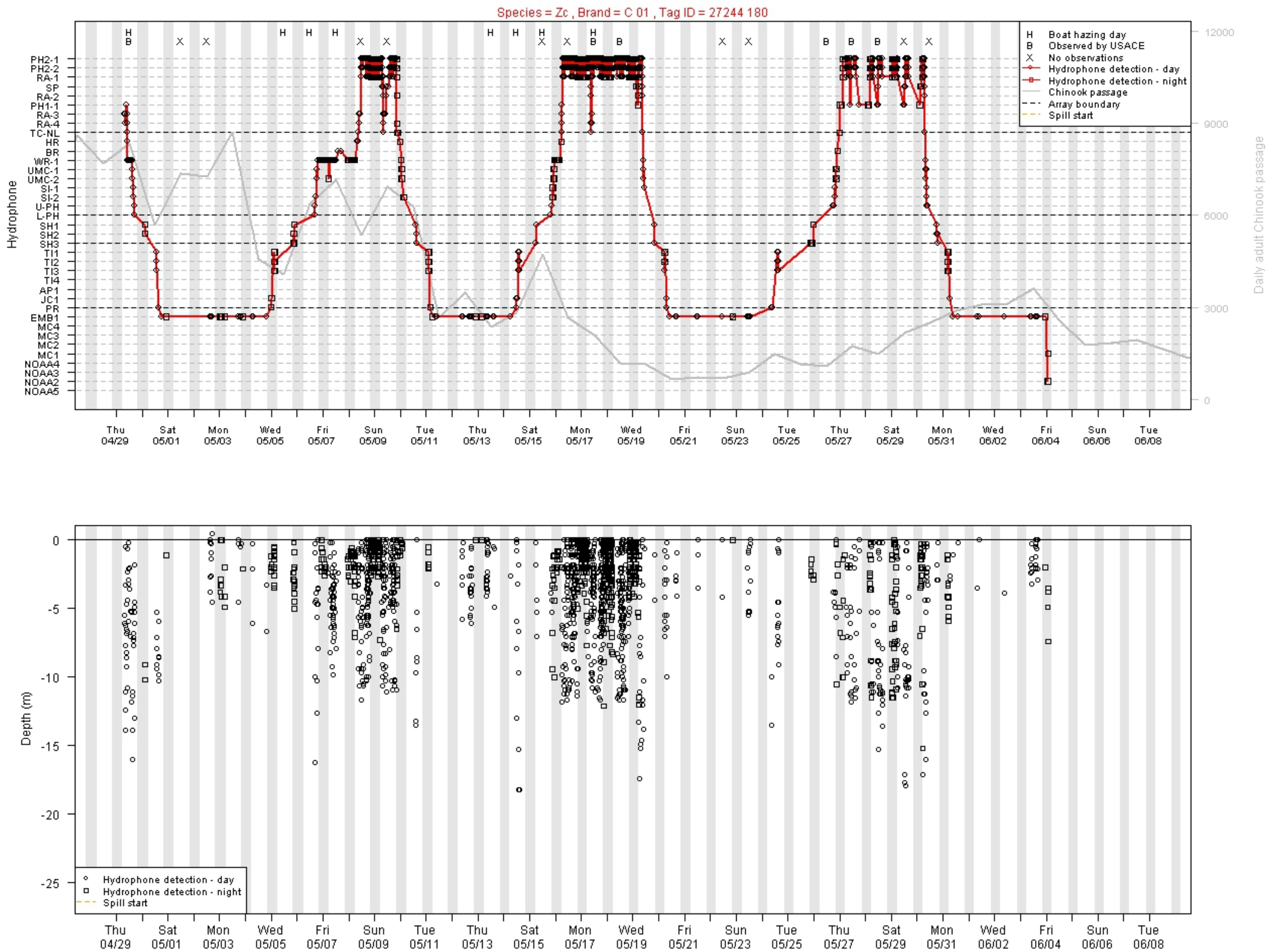

Fig. 4. Acoustic telemetry data from California sea lion C01. See Fig. 1 for location of hydrophones listed on the y-axis.

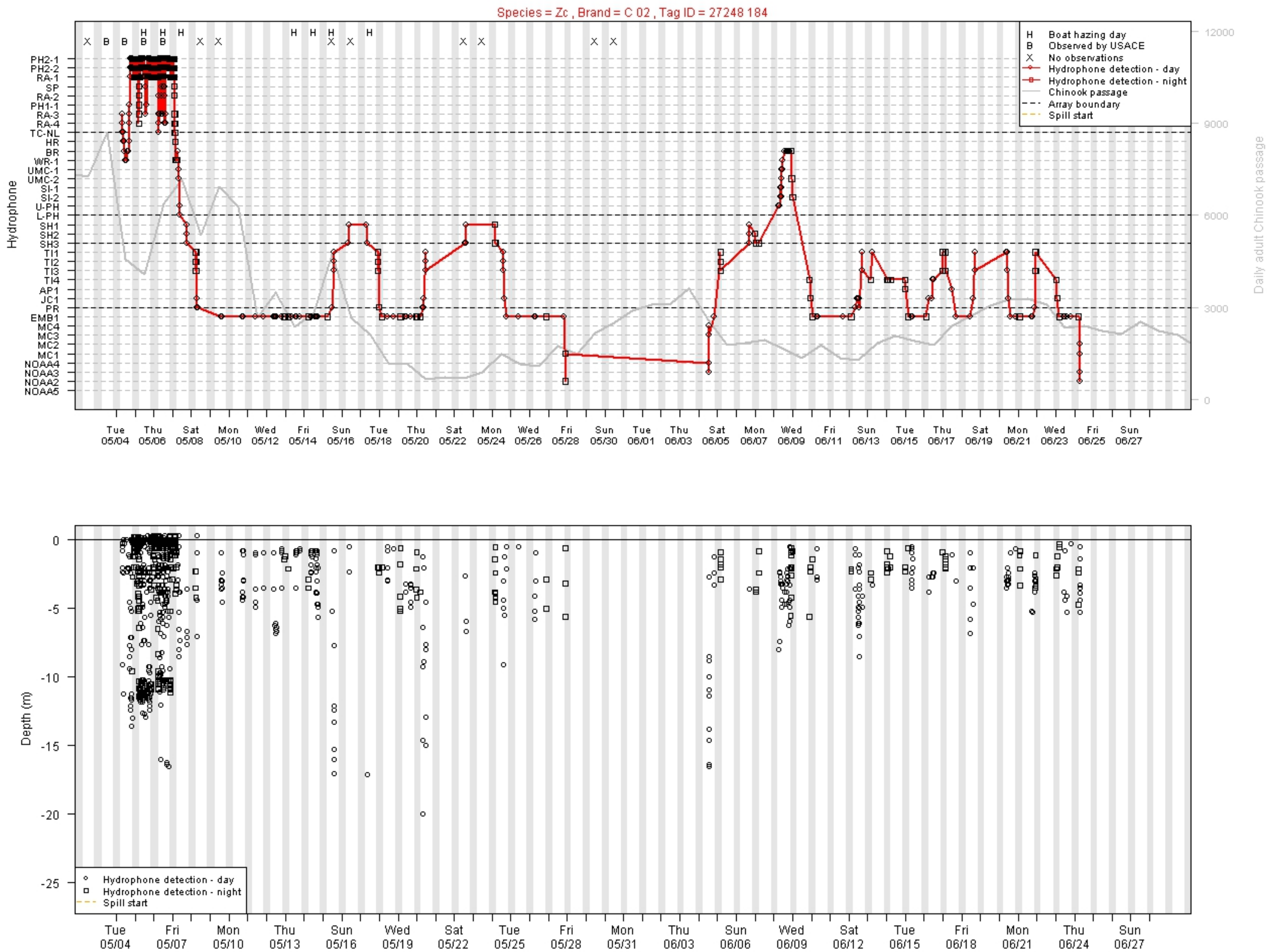

Fig. 5. Acoustic telemetry data from California sea lion C02. See Fig. 1 for location of hydrophones listed on the y-axis.

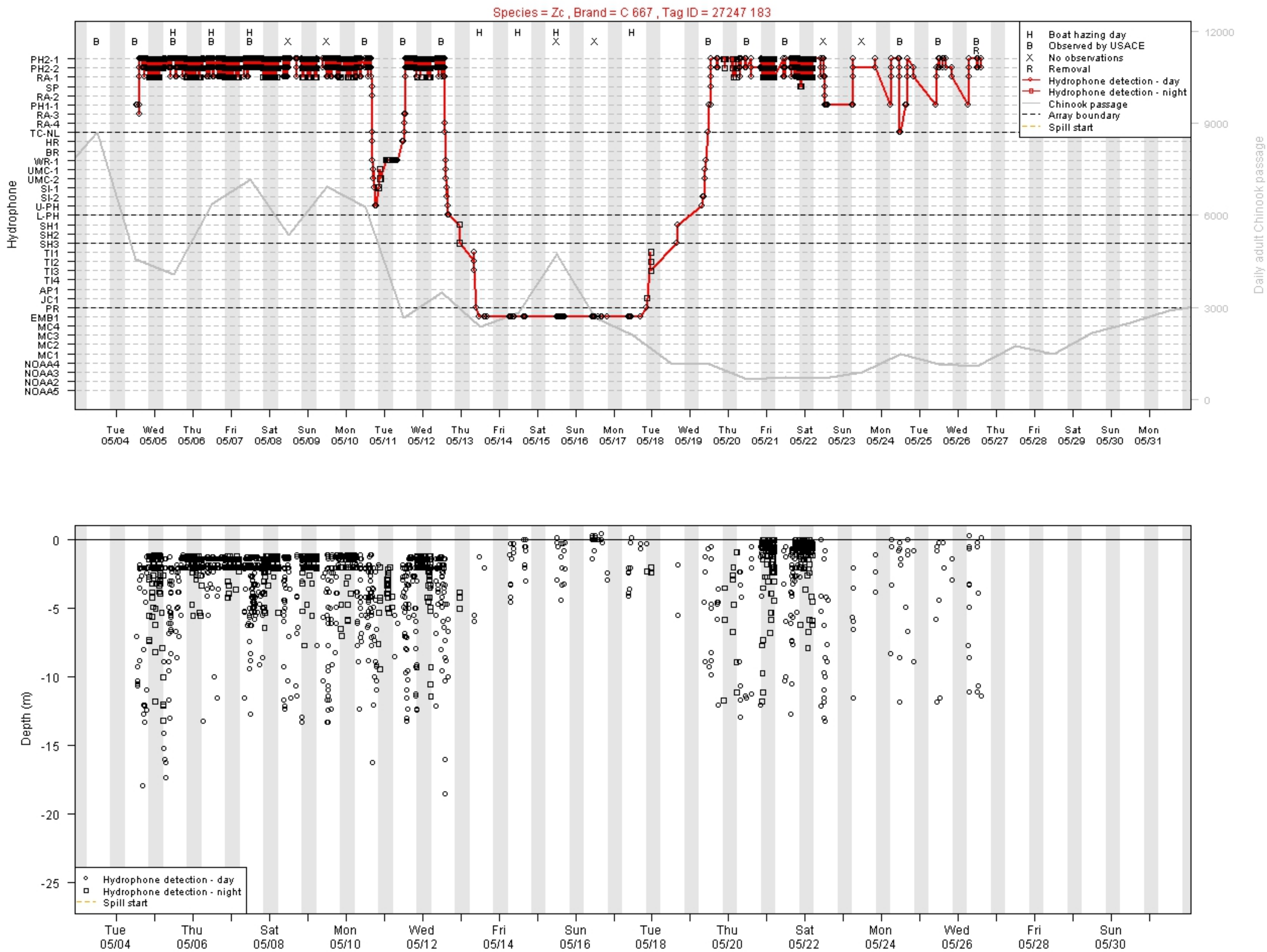

Fig. 6. Acoustic telemetry data from California sea lion C667. See Fig. 1 for location of hydrophones listed on the y-axis.

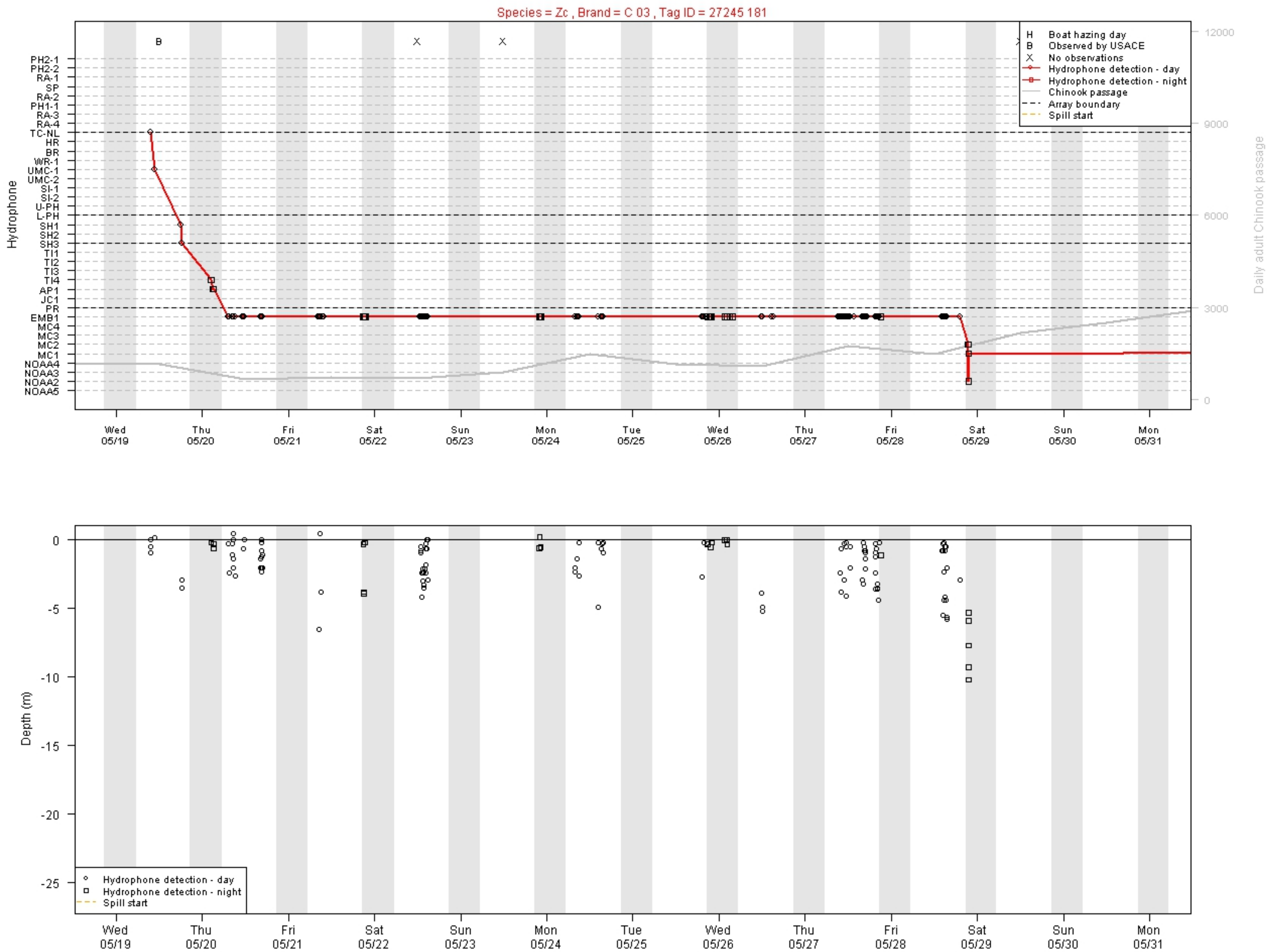

Fig. 7. Acoustic telemetry data from California sea lion C03. See Fig. 1 for location of hydrophones listed on the y-axis.

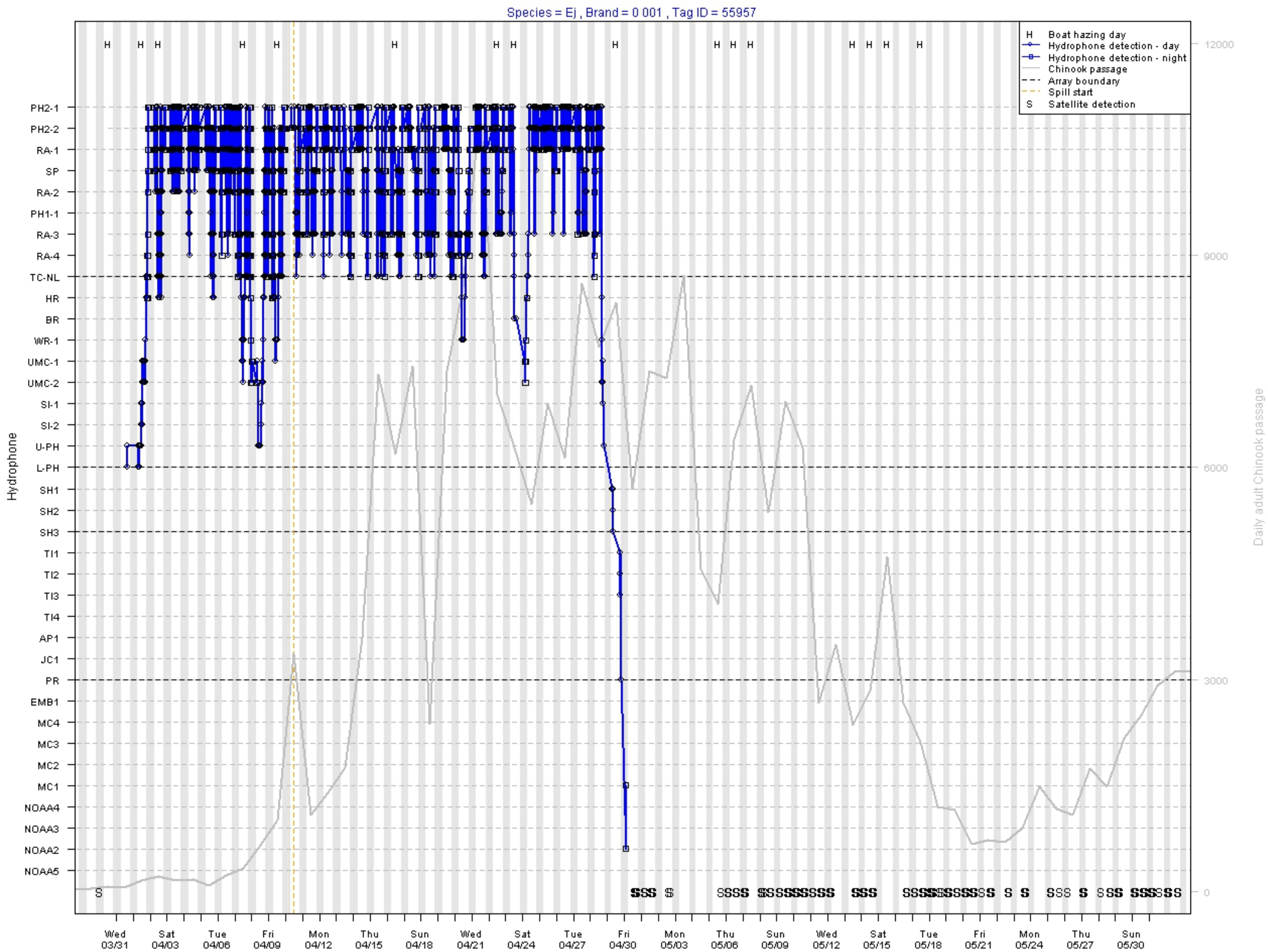

Fig. 8. Acoustic telemetry data from Steller sea lion 0-001. See Fig. 1 for location of hydrophones listed on the y-axis.

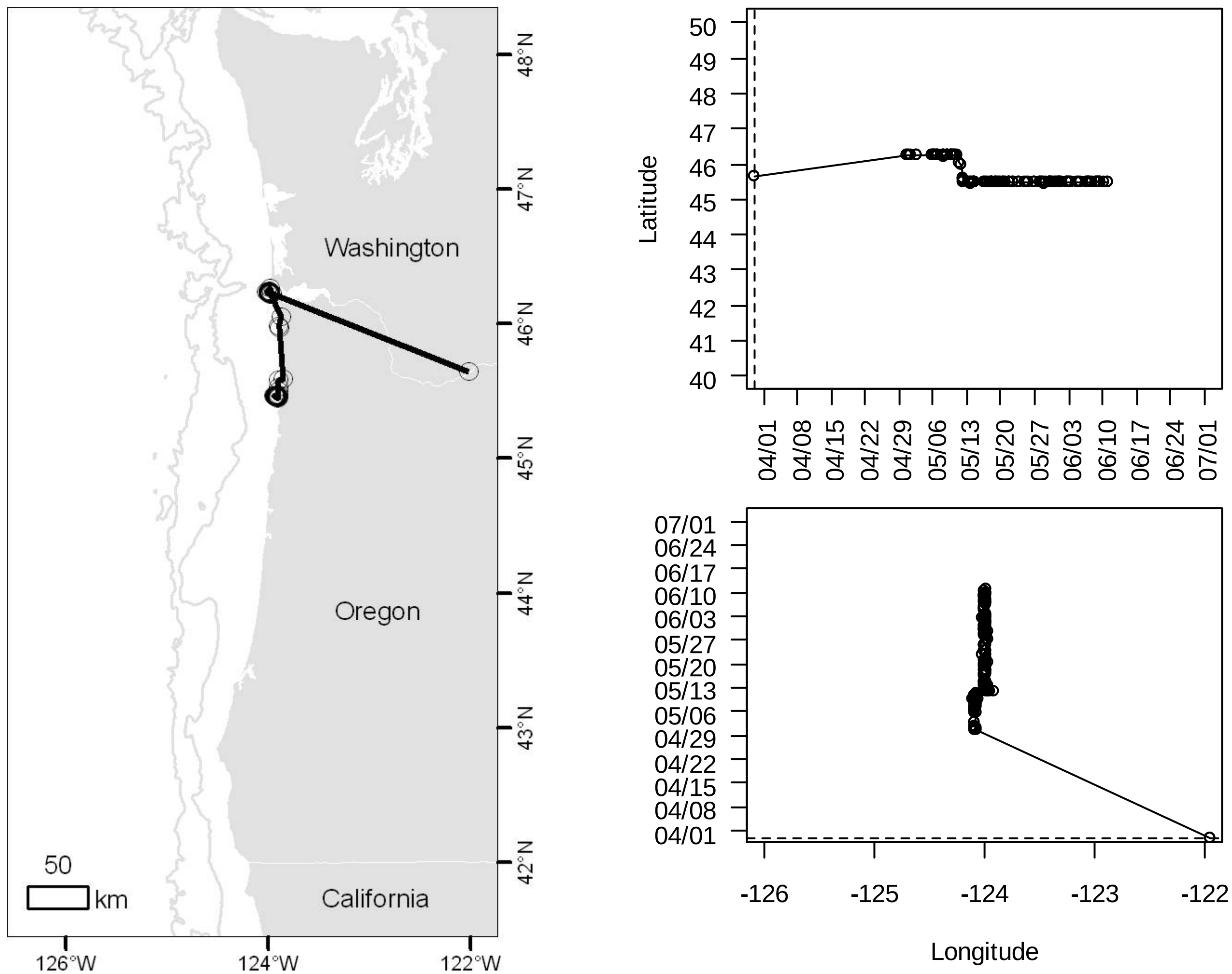

Fig. 9. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-001.

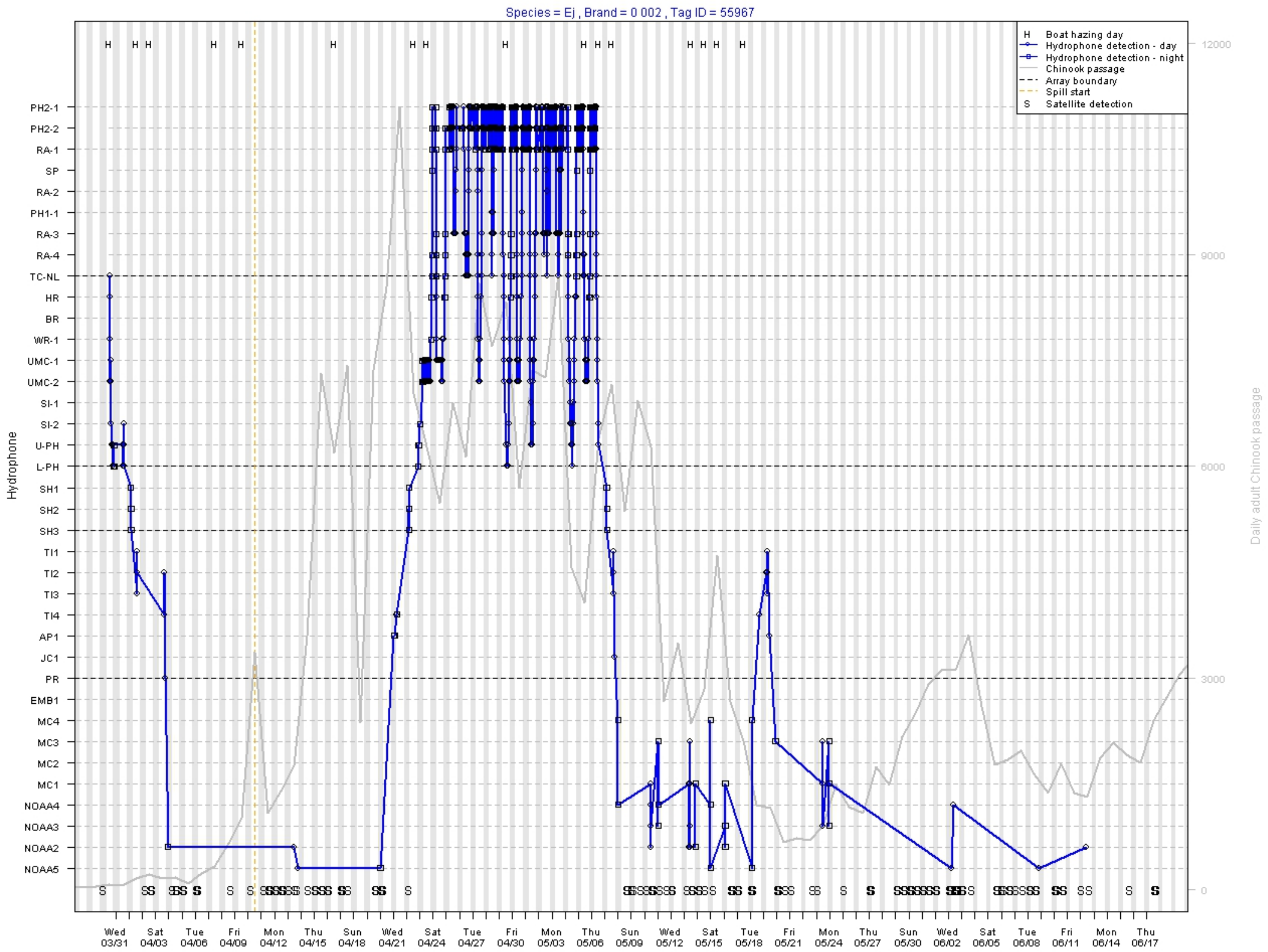

Fig. 10. Acoustic telemetry data from Steller sea lion 0-002. See Fig. 1 for location of hydrophones listed on the y-axis.

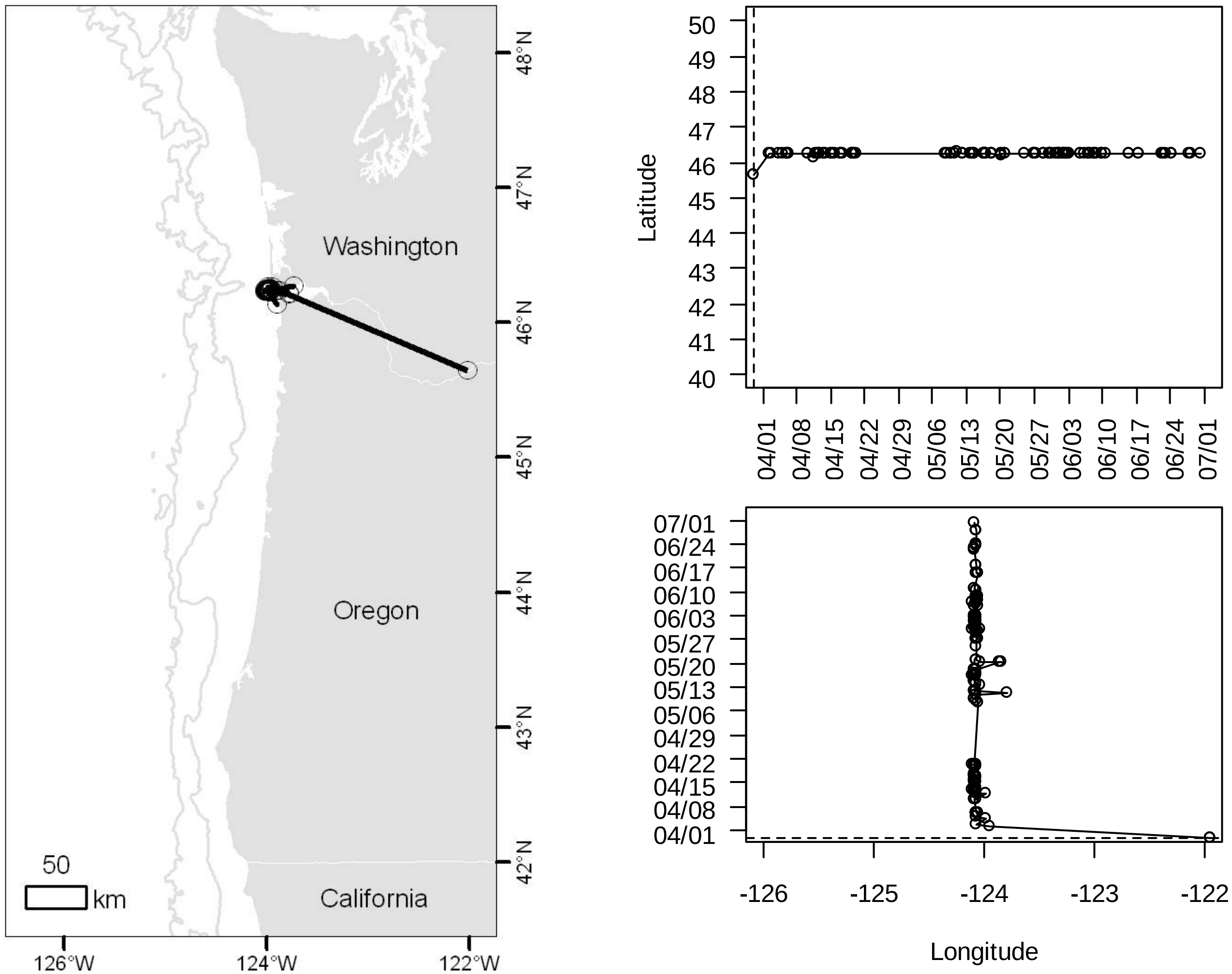

Fig. 11. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-002.

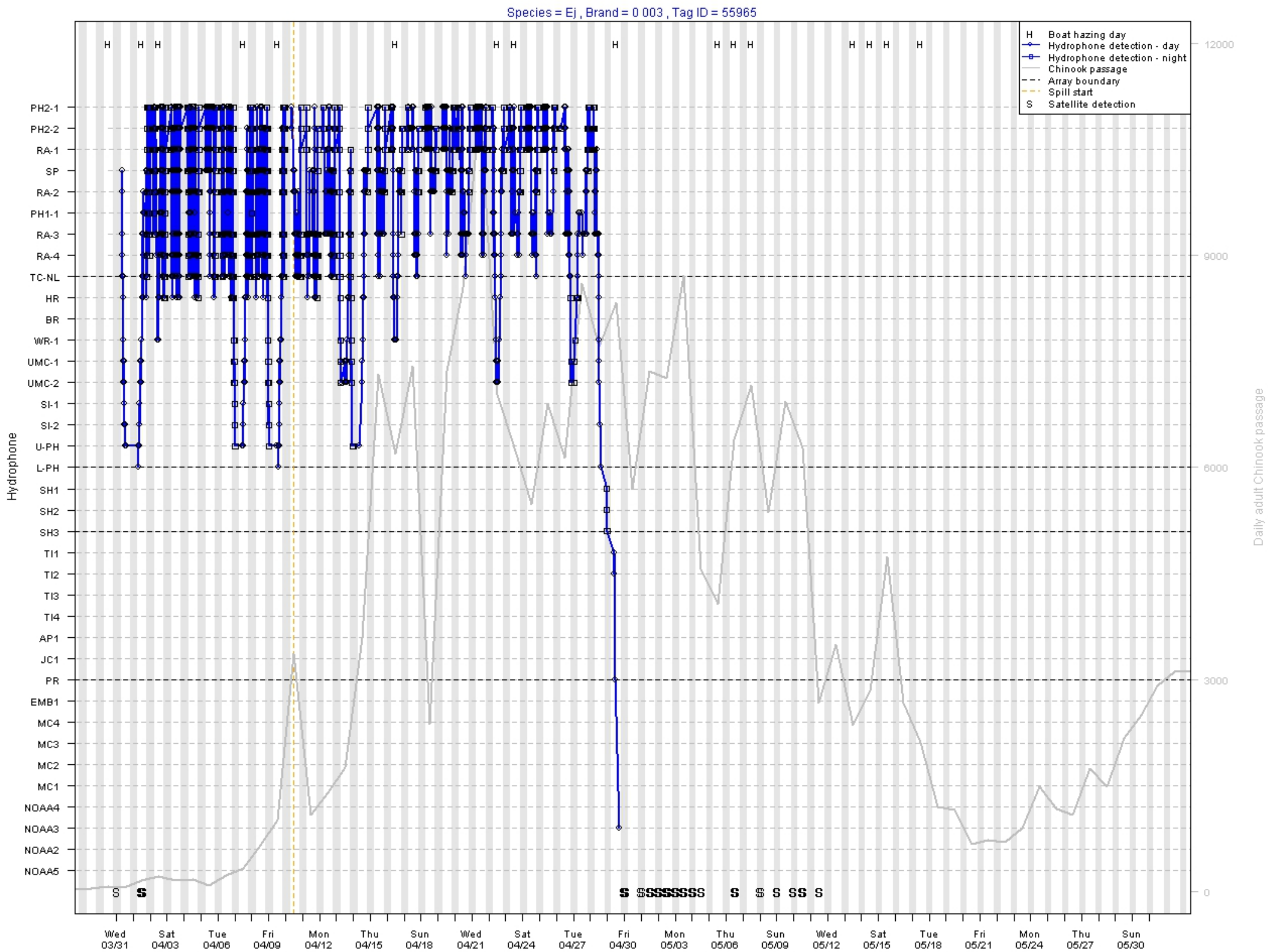

Fig. 12. Acoustic telemetry data from Steller sea lion 0-003. See Fig. 1 for location of hydrophones listed on the y-axis.

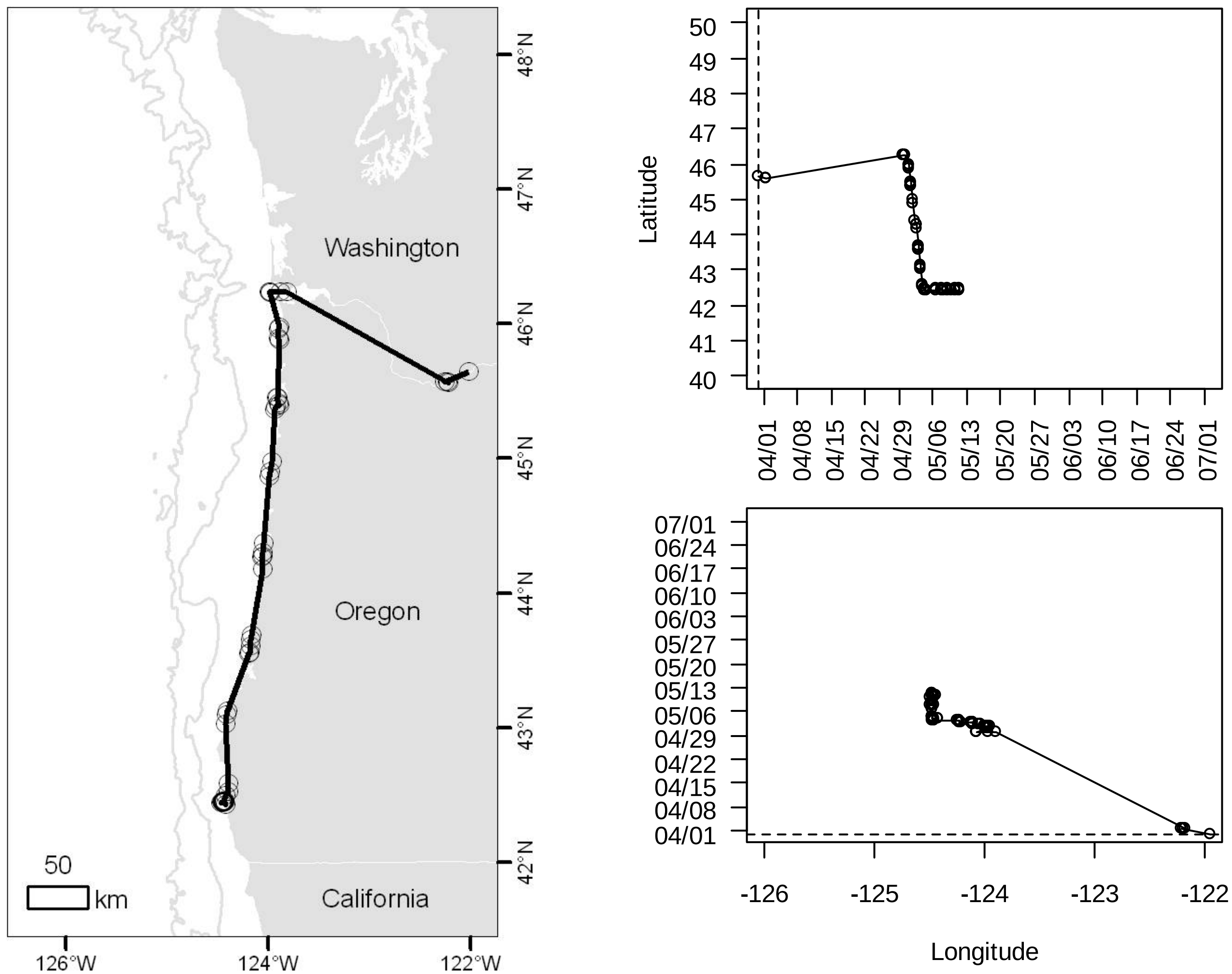

Fig. 13. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-003.

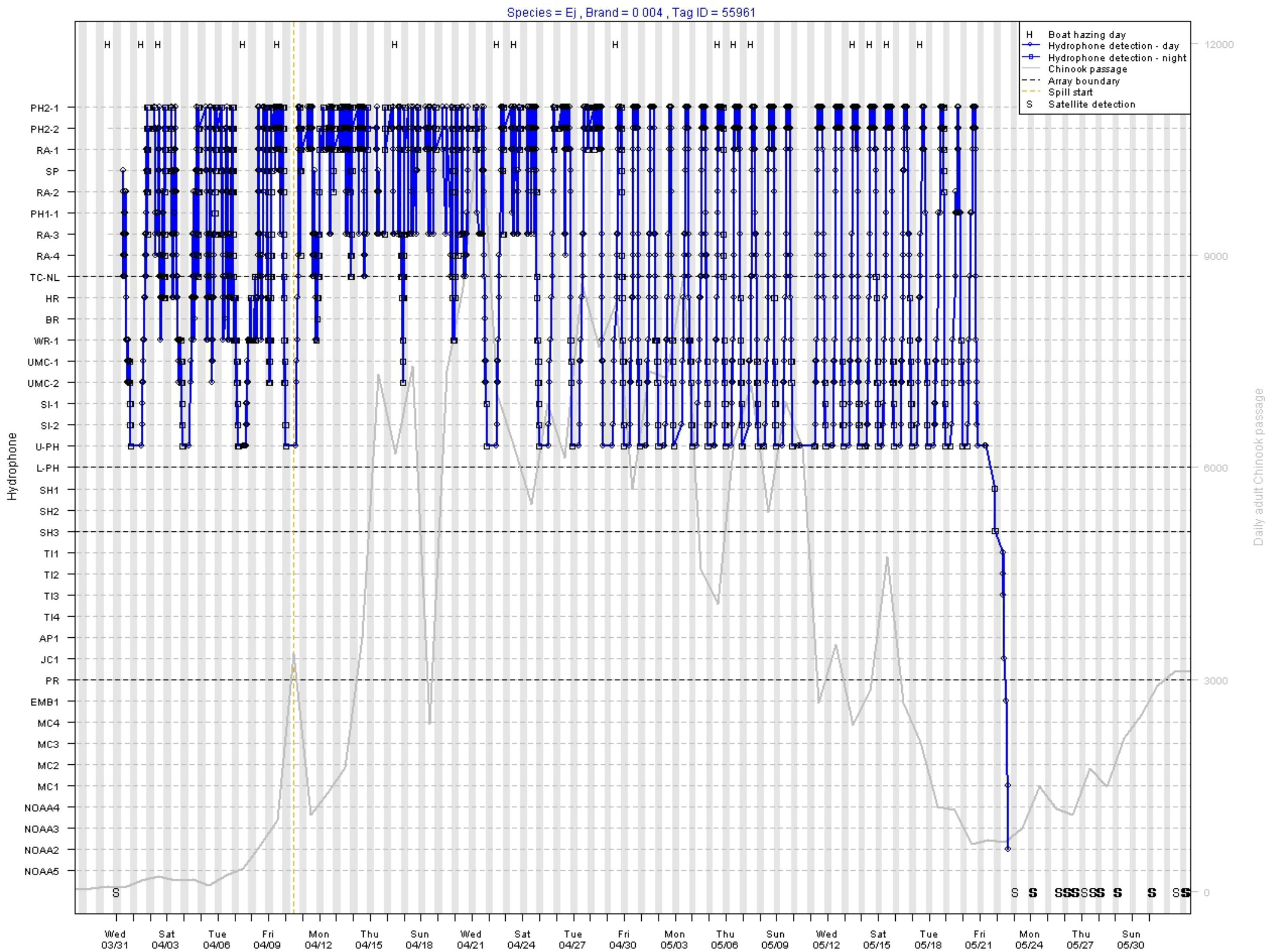

Fig. 14. Acoustic telemetry data from Steller sea lion 0-004. See Fig. 1 for location of hydrophones listed on the y-axis.

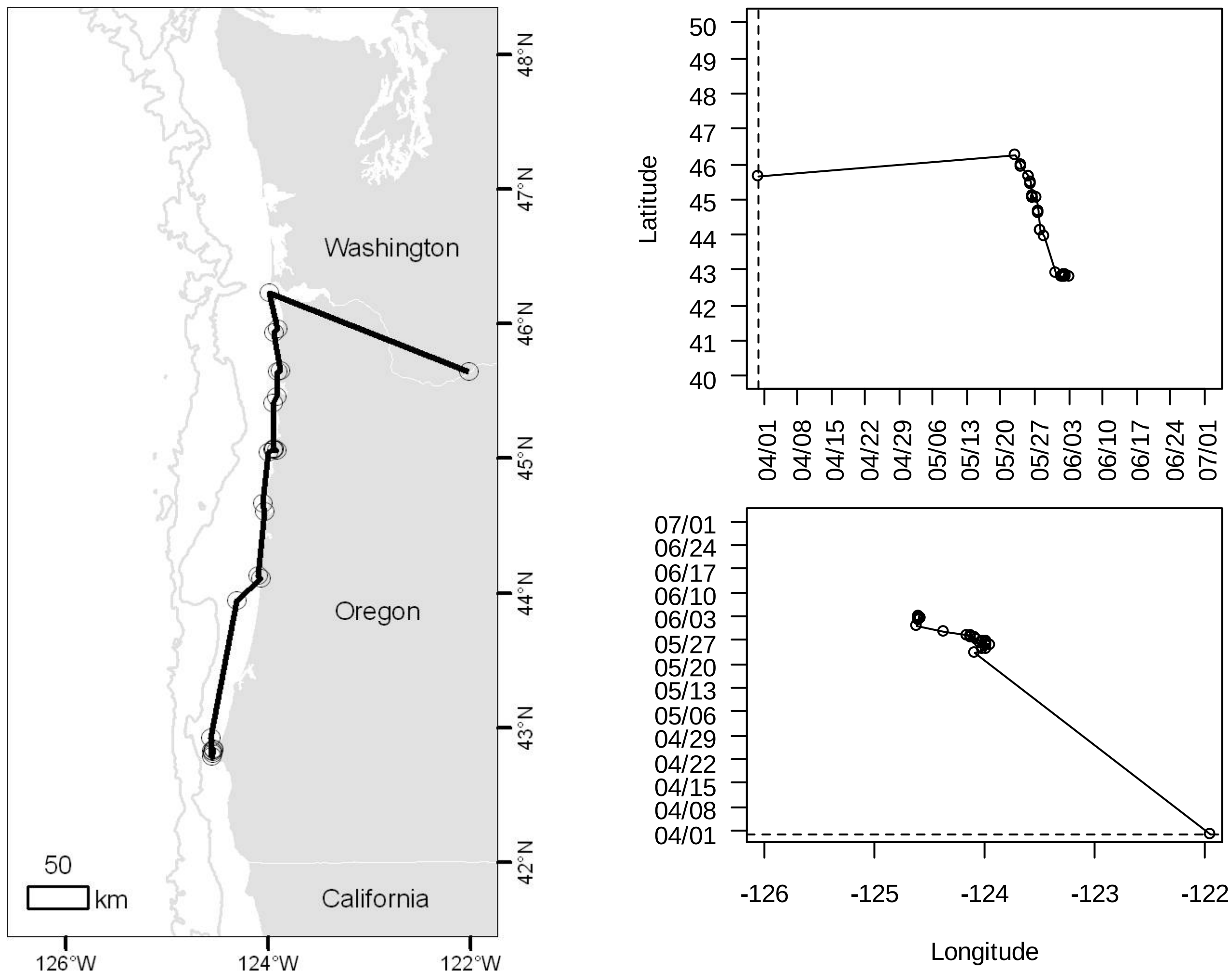

Fig. 15. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-004.

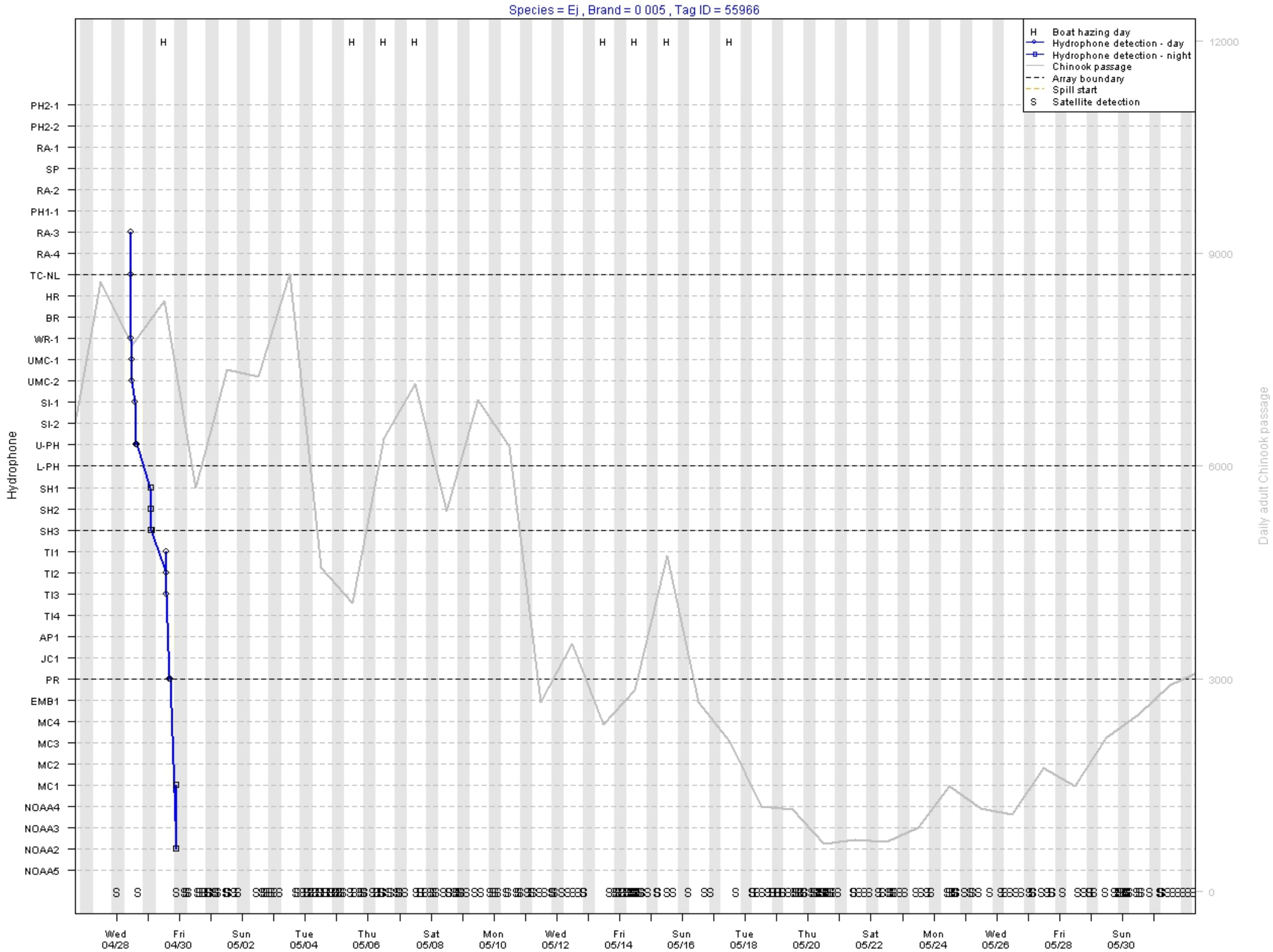

Fig. 16. Acoustic telemetry data from Steller sea lion 0-005. See Fig. 1 for location of hydrophones listed on the y-axis.

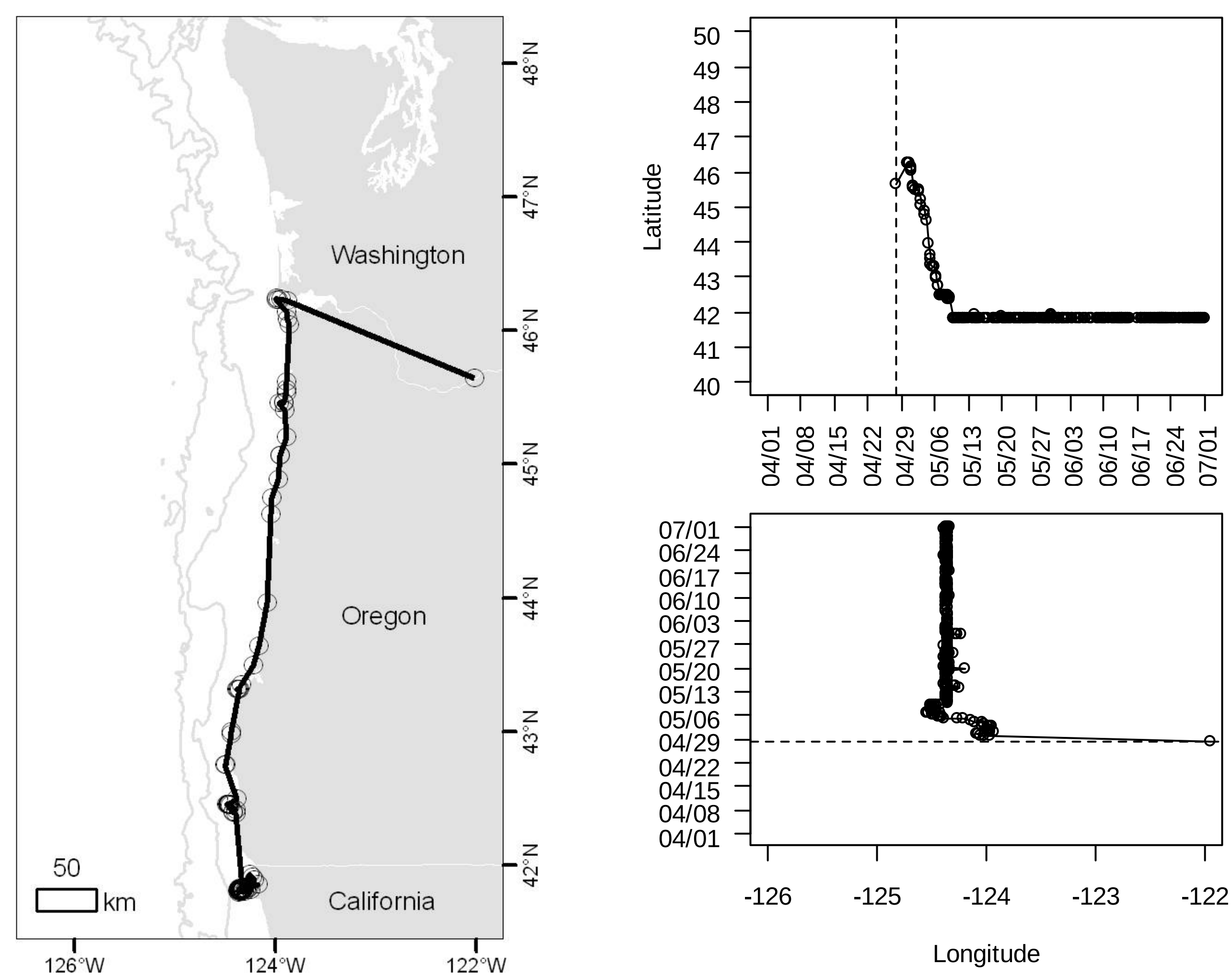

Fig. 17. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-005.

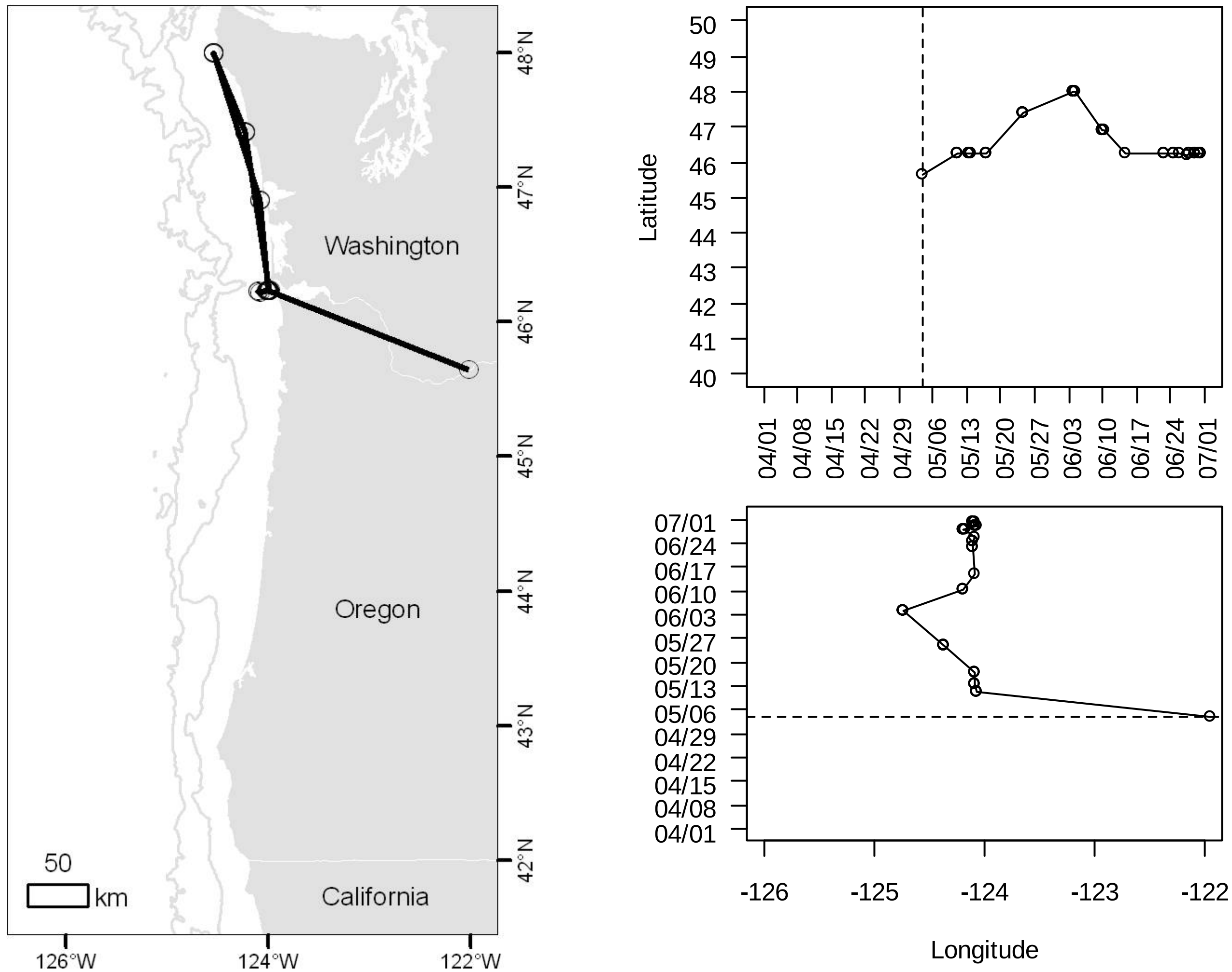

Fig. 18. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-006.

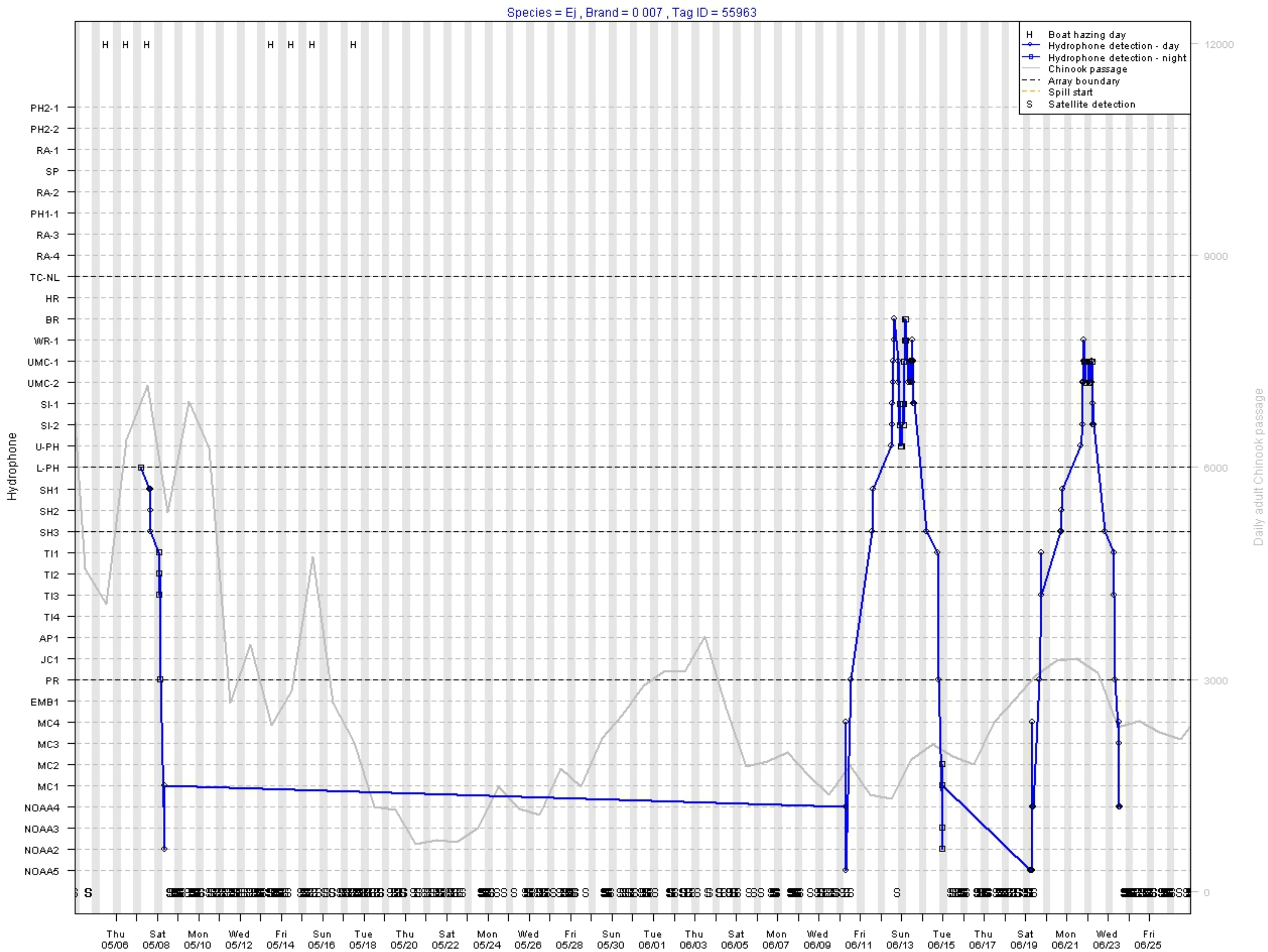

Fig. 19. Acoustic telemetry data from Steller sea lion 0-007. See Fig. 1 for location of hydrophones listed on the y-axis.

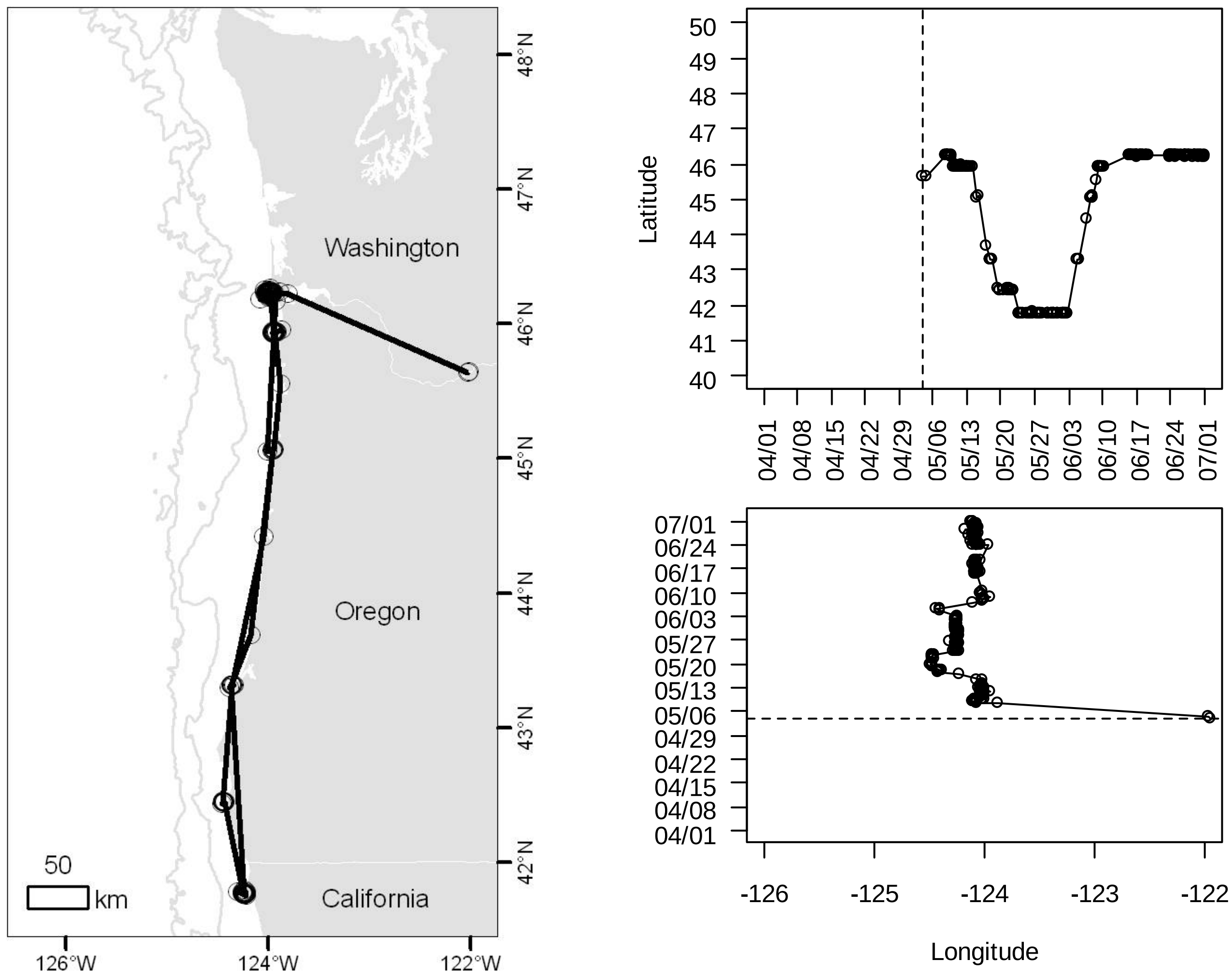

Fig. 20. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-007.

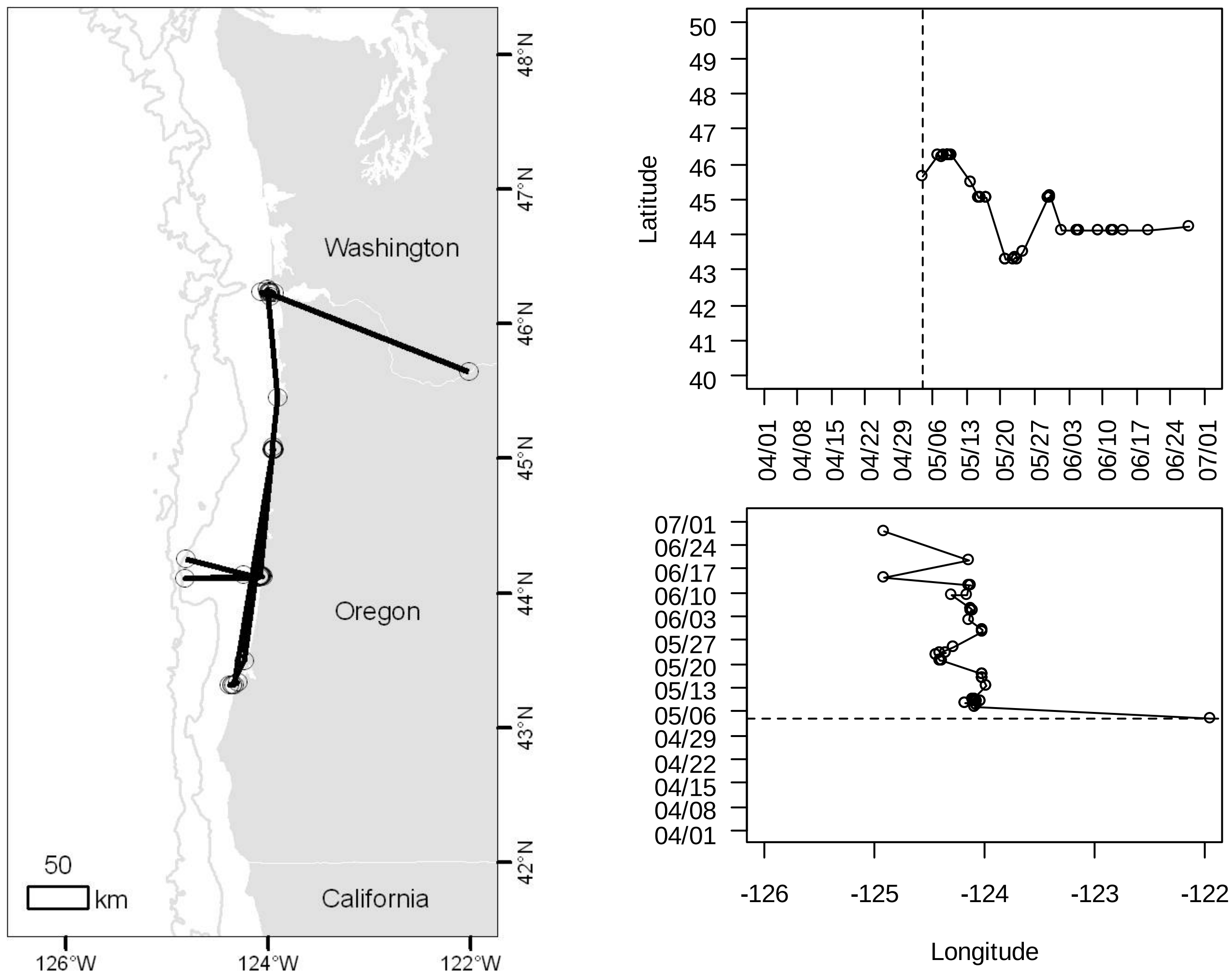

Fig. 21. Satellite telemetry data (Argos location class>0) from Steller sea lion 0-008.