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RETURN OF NORTH AMERICAN RIVER OTTERS, *LONTRA CANADENSIS*, TO COASTAL HABITATS OF THE SAN FRANCISCO BAY AREA, CALIFORNIA

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ABSTRACT—We present results from the first-ever study of populations of the North American River Otter, *Lontra canadensis,* in coastal habitats of the San Francisco Bay Area, California. Historically extirpated from the region, wild populations of this sentinel carnivore appear to have made a recovery in recent years. Utilizing a citizen-science network paired with field investigations in 2012 and 2013, we documented 1374 River Otter observations across 8 of 9 San Francisco Bay Area counties. We demonstrate that River Otters are reproducing, and report here on the 1st sightings in decades in Alameda, San Francisco, and Santa Clara counties indicating a possible gradual expansion of the species' range southward. Within our Intensive Study Area in coastal Marin County, conservatively estimated densities ranged from 0.21 to 0.32 River Otters/km, with otters inhabiting a range of habitats from freshwater to marine. A pilot assessment of disease and mortality indicates that otters are being exposed to pathogens such as *Vibrio* and that observable mortality was largely due to car-strikes. We also report on timing of mating, timing of pup-juvenile emergence, and pup-juvenile production. Despite large-scale ecosystem restoration actions underway across the San Francisco Bay Area, River Otters have been overlooked by resource managers. Being apex carnivores that not only directly benefit from restoration actions but also likely play a significant role in the outcome of recovery actions focused on endangered salmonids and waterfowl, we strongly recommend attention to their potential role as a keystone species in the San Francisco Bay Area.

Key words: aquatic carnivore, citizen science, ecosystem restoration, *Lontra canadensis*, North American River Otter, San Francisco Bay Area, sentinel species, species recovery

The North American River Otter (*Lontra canadensis*; hereafter River Otter), is a keystone carnivore and a sentinel for environmental contamination (Ben-David and others 1998; Bowyer and others 2003; Gaydos and others 2007; Salman 2007; Ben-David and Golden 2009; Carpenter and others 2014). Although the species is highly dependent on freshwater, otters traverse through and forage within a variety of habitats that include terrestrial, marine, estuarine, and freshwater ecosystems (Kruuk 2006). They predate an array of species such as native and non-native freshwater, anadromous, and marine fishes, waterbirds, crustaceans, and amphibians (Melquist and others 2003; Penland and Black 2009; Boone 2013; Cosby 2013; Crowley and others 2013; Garwood and others 2013; River Otter Ecology Project, unpubl. data).

Very little is known about the current status, distribution, and ecology of River Otters in California (Brzeski and others 2013; Garwood and others 2013). Historically documented (Grinnell and others 1937) but shortly thereafter extirpated from much of their range in the early 20th century (Satterthwaite-Phillips and others 2013), populations were offered protec-

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tion through fur trapping restrictions in 1961 (Gould 1977). Since then, and only just within the past 5 y, a selection of research has been published on populations in California with these studies limited to Northern California (Black 2009; Penland and Black 2009; Brzeski and others 2013), the San Francisco Delta (Grenfell 1974; Boone 2013), and inland mountainous regions of the state (Garwood and others 2013). Here we present new findings on populations of the coastal San Francisco Bay Area (SFBA). While the California Department of Fish and Wildlife has officially listed this population as ''non-occurring'' (Zeiner and others 1988; CDFW 1995), our study provides new evidence to the contrary and a baseline from which to revise the California range-map for the species.

An understanding of the status and ecological role of a top aquatic carnivore is essential to the science of ecosystem management (Estes and Palmisano 1974; Bowen 1997; Sergio and others 2008) and should be of particular significance in the SFBA where large-scale bay, wetland, and stream restoration efforts are underway. For example, between 1996 and 2014 the San Francisco Bay Joint Venture actively restored, protected, or enhanced a total of 315 km^2 of bay, wetland, creek, and lake habitats targeting waterfowl, salmonids, and overall improved water quality (San Francisco Bay Joint Venture 2014). All of these habitats are accessible and can be used by River Otters, which actively prey on species targeted for recovery and protection.

Additionally, the San Francisco Bay is a major west coast port, and the 2007 Cosco Busan oil spill highlighted a critical data gap for River Otters. Heavy fuel oil contaminated rocky intertidal habitats, beaches, tidal marshes, eelgrass beds, fish, birds, and marine mammals along the Bay and northern outer coast to Drake's Bay, all habitats where breeding groups of River Otter are now officially documented as occurring. Prior to the spill there had not been a single assessment documenting the distribution, abundance, and habitat utilization of the species in the Bay Area, the exception being of a single family group observed at Rodeo Lagoon at Fort Baker in Marin County (D. Fong, National Park Service, pers. comm.). During the spill these otters were observed feeding directly on oiled pelicans (Salman 2007) and oil residues were detected in their scat (Cosco Busan DARP 2012). The Rodeo Lagoon case highlighted the susceptibility of otters to oil exposure and other contaminants, but unfortunately with no pre-spill reference point for populations the actual impact of the oil spill on this sentinel species remains unknown.

In 2012, we launched the River Otter Ecology Project to address this deficit of data on River Otter populations in coastal habitats of the SFBA. This study is the first to document the species' current range across the 9-county SFBA which includes Marin, Sonoma, Napa, Solano, Contra Costa, Alameda, Santa Clara, San Mateo, and San Francisco counties. We report on mating and emergence of pups-juveniles, and our results establish that local breeding populations do occur and that otters are expanding into new habitats. We also present preliminary evidence for River Otter exposure to pathogens such as *Vibrio* spp. and document car-strikes as the primary source of observable mortality.

Methods

''Otter Spotter'' Citizen-Science Initiative

In February of 2012, we launched a citizen-science initiative called ''San Francisco Bay Area Otter Spotter'' to solicit structured data from the public on River Otter sightings from the 9-county region surrounding San Francisco Bay. In tandem with the launch of this web-based portal (see http://www.riverotterecology.org/otter-spotter-citizen-science-project), we initiated outreach and media efforts to train interest groups and the general public in the identification of River Otters and their behavior, and to encourage on-line reporting.

Reports solicited from the public via the Otter Spotter web-based platform included name, contact information, date of sighting, location of sighting, total number of otters observed, number of adults, juveniles, and pups (if they could be distinguished from juveniles), and photographs or video. Observers were also asked to classify their field experience and whether they were sure versus unsure of their sightings. A notes section allowed reporters to record information on habitat type and any behavior of interest.

We validated all observations submitted to the website. Observations that were logged as ''unsure'' were removed from final analysis if

additional information provided in the report did not substantiate a credible sighting. We were conservative in our analyses, and given that otters are fast-swimming, elusive, and sometimes difficult to count accurately, if an observer reported observing a range of number of otters (for example, 6 to 8 otters), we selected the lowest number reported (in this example, 6 otters). We mapped locations of otter sightings in Google Earth™, exported to ArcMap 10.1 (ESRI, 380 New York Street, Redlands, CA 92373).

We assessed total number of otter reports and sightings in 2012 and 2013 with ''reports'' defined as the individual on-line reports submitted by citizen scientists, and ''sightings'' defined as the total number of otters (including pups-juveniles) tallied in reports. Significant events such as mating, reproduction (pups-juveniles) and mortalities were also reviewed and summarized. Given that otter age and size-classes are difficult to assess in the field by untrained observers, reports that noted only single otter sightings and described these as pups-juveniles without any further information for verification purposes were not used for pup-juvenile analysis.

Intensive Study Area and Focal Study Sites

Concurrent with the Otter Spotter initiative, we launched year-round field investigations at key locations in an Intensive Study Area (ISA) (Fig. 1) along a 197-km stretch of coast- and stream-line spanning from San Francisco north to Tomales Bay and inland on Lagunitas Creek and its tributaries and reservoirs. Within this ISA we selected an array of 14 Focal Study Sites (FSS) spanning various aquatic habitats (Fig. 1, Table 1).

At each FSS, we surveyed for active otter latrines which would indicate the regular presence of otters. Once active latrines were detected, field cameras (Bushnell Trophy Cam HD, ver. 2012 or 2013; Bushnell Outdoor Products, 9200 Cody, Overland Park, KS 66214) were set up at or adjacent to accessible latrines to document otter group size and behavior, and reproduction (specifically time of emergence and number of pups-juveniles). Camera sites were selected for: (1) presence of actively-used latrine sites; (2) permission from landowners to access the sites by foot or boat year-round; and (3) locations away from public areas.

A total of 28 cameras were deployed across all sites and habitats over the study period between June 2012 and December 2013 (Table 1), and data were retrieved and stations maintained every 1 to 3 wk by trained field staff. Data collected from each camera unit and for each otter event videoed included date and time, total number of otters, number of adults or pups-juveniles (if distinguishable), and behavior. We utilized this dataset to report on behavior of seasonal interest such as mating, reproduction, and emergence of mothers with litters.

Fresh jelly (otter secretions) and scat were also collected from each latrine site, preserved in 95% ethanol, and frozen at −20°C for future genetic and diet analyses.

Abundance and Density Estimates

We paired Otter Spotter data with data collected by field teams and camera arrays at FSS's to report on pup-juvenile production at each site and compile a ''minimum population size'' for the ISA. The largest groupings of total otters observed together at any one time from each FSS (either through direct observation or on the camera array) over the course of a year were assigned as the ''minimum population size'' for that area, and then all FSS's were totaled across the ISA. In the absence of detailed genetic analyses and the unreliable ability to visually distinguish individuals within groups, this method provided us with a conservative minimum population estimate for a given FSS.

We used our ''minimum population estimate'' and GIS-derived linear kilometers of coastline to derive a ''population density estimate.'' The total length of coastline spanned from Rodeo Lagoon north to the Giacomini Wetlands at the southern end of Tomales Bay, and included the perimeter of Bolinas Lagoon, Drakes Estero, and the east and west shores of Tomales Bay. We excluded inland reservoir sites and streams from this current analysis because they are relatively new study sites and lack sufficient reliable data at time of publication, including remote camera data.

We present density estimates: (1) utilizing the total minimum number of otters/linear km of coastline across the entire coastal study area of

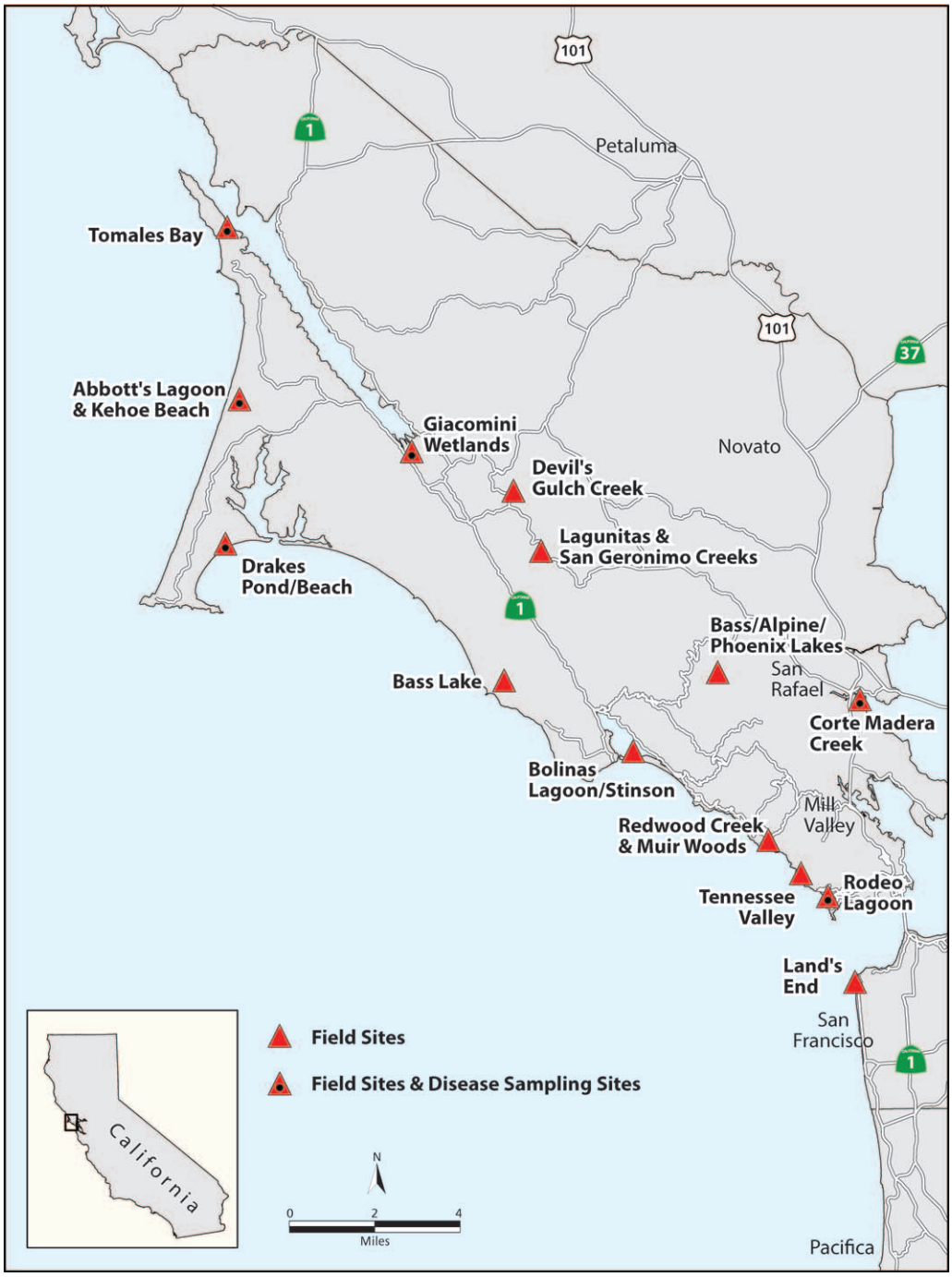

FIGURE 1. River Otter Focal Study Sites (2012 and 2013) and River Otter disease sampling sites (2013) within our Intensive Study Area.

TABLE 1. Focal Study Sites within the Intensive Study Area. With the exception of San Francisco and the MMWD sites, permanent camera arrays were set up and monitored monthly by trained field crews. NPS = National Park Service; MMWD = Marin Municipal Water District; CASP = California State Parks.

Focal study sites	No. cameras	General habitat type	Jurisdiction	Urban-Rural	County
Abbotts Lagoon	2–3	Coastal freshwater lagoon	NPS	Rural	Marin
Alpine/Bon Tempe/ Phoenix Reservoirs	0	Inland reservoir	MMWD	Rural	Marin
Bass Lake	1	Coastal reservoir	NPS	Rural	Marin
Corte Madera Creek (Greenbrae)	1–2	Intertidal stream	Private	Urban	Marin
Drakes Estero/Bay/Pond	2–3	Estuary and coastal reservoir	NPS	Rural	Marin
Giacomini Wetlands	2–3	Intertidal marsh and stream	NPS	Rural	Marin
Kehoe Beach	1–3	Coastal freshwater lagoon	NPS	Rural	Marin
Lagunitas/Devil's Gulch/ San Geronimo Creek	3	Coastal stream	NPS, CASP	Rural	Marin
Redwood Creek and Muir Woods	2	Coastal stream and freshwater lagoon	NPS	Rural	Marin
Rodeo Lagoon	1	Coastal lagoon	NPS	Rural	Marin
Seadrift/Bolinas Lagoon	1	Intertidal lagoon	Private	Rural	Marin
Sutro Baths	0	Coastal pond (man-made)	NPS	Urban	San Francisco
Tennessee Valley	1–2	Coastal lagoon	NPS	Rural	Marin
Northern Tomales Bay	3–4	Intertidal bay	NPS	Rural	Marin

Marin County (excluding the inland reservoir sites); and (2) a density estimate for just Tomales Bay from the northern-most part of the Bay to the Giacomini Wetlands. We did not include the Tennessee Valley study site in our total estimate given that it is situated centrally and 3 km from both our Rodeo Lagoon and Muir Beach FSS's, and likely only a stop-over point for otters from these adjacent areas. We believe, based on our own observations and on prior studies from Northern California establishing an approximate 8-km range for otter groups (Brezeki and others 2013), that including Tennessee Valley individuals would likely represent double-counting of individuals from both Rodeo Lagoon and Muir Beach.

Preliminary Disease Assessment

During 2013, we partnered with the National Park Service (NPS) (S Allen, NPS, pers. comm.) and The Marine Mammal Center (F Gulland, TMMC, pers. comm.) to perform preliminary sampling for *Vibrio* and *Salmonella* spp. This screening is important given that River Otter habitat use in our ISA overlaps with that of Harbor Seals (*Phoca vitulina*), which are known to be exposed to *Vibrio* spp. including potentially virulent strains that may be of concern to human health (Hughes and others 2013). Samples for disease assessment were collected at 6 sites (Fig. 1) from fresh scat collected with sterile TransPorter swabs. One set of each swab was transferred to selective media following UC Davis Diagnostic Microbiology Laboratory protocols; XLT4 plates and selenite growth broth for the isolation of Salmonella spp., and TCBS plates and peptone water growth broth for the isolation of *Vibrio* spp. At 24 h, plates were read for growth. If growth was present, the colonies were isolated further using biochemicals directed to the specific unknown(s) for identification. The biochemicals included TSI (triple sugar iron), indole, oxidase, urea, and citrate. Any growth from the broths was transferred to an XLT4 plate from the selenite and TCBS from the peptone water. In addition, original plates were held for another 24 h (for a total of 48 h) to make sure no growth was missed.

RESULTS

''Otter Spotter'' Citizen-Science Initiative

Between February 2012 and December 2013, we received a total of 646 reports from citizen scientists across the SFBA spanning sightings between the years 2000 and 2013. Citizen scientists included those defined as naturalist or outdoor enthusiast ($n = 41$); other ($n = 27$); scientist-biologist ($n = 21$); environmental educator ($n = 4$); teacher-professor ($n = 3$); fisherman-fisherwoman ($n = 2$); wildlife-biology student ($n = 1$); and tracker ($n = 1$). We only

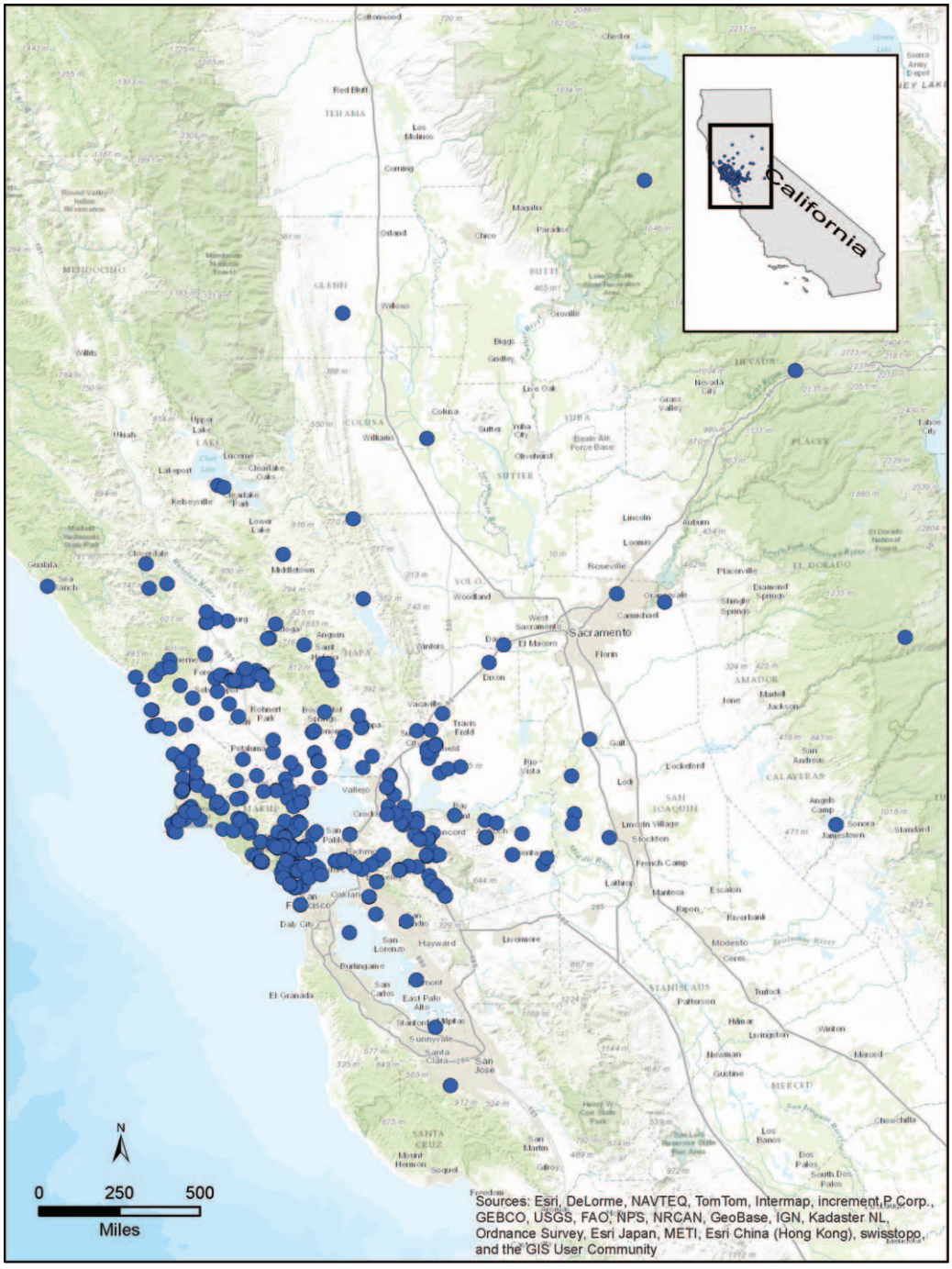

FIGURE 2. Otter Spotter reports from the San Francisco Bay Area, 2012 and 2013.

TABLE 2. Otter Spotter pup-juvenile reports and sightings by county, 2012 and 2013 combined.

County	Reports	Sightings
Marin	36	73
Contra Costa	15	39
Solano	6	16
Sonoma	11	19
Napa	5	12
Santa Clara	1	5
TOTAL	74	164

included 2012 (n = 228) and 2013 (n = 395) reports in our final assessment (Fig. 2). These 623 reports included 12 ''unsure'' reports that were subsequently verified based on sightings having detailed descriptions of characteristics used to distinguish River Otters. From the 623 reports, we tallied 497 individual River Otter sightings in 2012, and 877 in 2013 (total n = 1374) in 8 of 9 SFBA counties. A subset of the 623 reports included 74 pup-juvenile reports (n = 22 in 2012; n = 52 in 2013) and 164 individual pup-juvenile sightings (n = 51 in 2012; n = 113 in 2013) for 6 counties (Table 2).

Focal Study Site Otter Populations

In 2012 and 2013, a total of 2050 videos of otters were captured across our ISA representing 645 camera-trap days. Individuals were not discernible from photo-video data, with a few important exceptions such as: (1) groupings of mothers with their pups-juveniles, and sometimes (2) clans (groupings of young males). By pairing Otter Spotter and camera station data, we were able to identify at least 33 and 50 individuals (adults and pups-juveniles) at our FSS's in 2012 and 2013, respectively (Table 3); we identified 14 pups-juveniles in 2012 and 18 in 2013 (Table 4). In 2012 and 2013 respectively, 45.5 and 48% of the largest otter group sizes were derived from remote field camera data, compared to 54.5 and 52% derived from Otter Spotter data. For the largest number of pups-juveniles observed in 2012 and 2013, respectively, 38.9 and 25% were derived from remote field camera data, compared to 61.1 and 75% derived from Otter Spotter data. These data indicate that remote field cameras and direct observation complement each other well in this type of assessment, with the exception of pup-juvenile observations which were better observed directly.

TABLE 3. Largest otter group size observed at each Focal Study Site and treated as our estimated ''minimum population size'' for each site. * = no data.

Site	2012	2013
Abbotts Lagoon	6	6
Northern Tomales Bay	7	6
Giacomini Wetlands and Lagunitas Creek	4	8
Rodeo Lagoon	4	6
Redwood Creek and Muir Woods	*	3
Lower Corte Madera Creek	3	4
Tennessee Valley Lagoon	1	2
Seadrift/Bolinas Lagoon	3	3
Drakes Bay	5	4
Bass Lake	*	4
Alpine/Lagunitas/Bon Tempe Reservoirs	*	4
TOTAL	33	50

TABLE 4. Largest number of pups-juveniles observed at each Focal Study Site. * = no data, ** = 1 pup-juvenile mortality documented, *** = not assessed for pups-juveniles due to late season start.

Site	2012	2013
Abbotts Lagoon	3	3
Northern Tomales Bay	5	2
Giacomini Wetlands and Lower Lagunitas Creek	*	4
Rodeo Lagoon	1	3**
Redwood Creek and Muir Beach	*	2
Corte Madera Creek (Greenbrae)	1	3
Tennessee Valley	0	0
Seadrift/Bolinas Lagoon	2	2
Drakes Bay	2	2
Bass Lake	*	***
Alpine/Lagunitas/Bon Tempe Reservoirs	*	3
TOTAL	14	18

Population Estimates

The length of Marin County coastline spanning Rodeo Lagoon and north along the coast to the Giacomini Wetlands totals 197 km. By using individual otter sightings (Table 3) and excluding observations from inland reservoirs, we estimated that the minimum otter density in the ISA along the coastline was 0.21 otters/km. In Tomales Bay (44 km in length, east and west shore), densities approached 0.32 otters/km.

Mating, Pup-Juvenile Emergence, and Maternal Groupings

Mating, though rarely observed, was documented within the SFBA study area on camera and by Otter Spotters. A total of 4 unique mating events were documented spanning the months of March, April, and May. Pup-juvenile emergence from dens, or time at which pups-

TABLE 5. Sources of otter mortality. P-J = pup-juvenile.

Size-class	Cause	Source	Date	County	Location
Adult	Road Kill	Otter Spotter	January 2013	Marin-Sonoma	Highway 37
P-J	Unknown	Focal Study Site	July 2013	Marin	Rodeo Lagoon
Adult	Road Kill	Otter Spotter	December 2012	Napa	Napa
Adult	Road Kill	Otter Spotter	May 2013	Solano	Fairfield
Adult	Road Kill	Otter Spotter	November 2012	Contra Costa	Concord
P-J (2)	Stranded, drowned	Otter Spotter	May 2012	Marin	Larkspur
Adult	Unknown	Focal Study Site	July 2012	Marin	Lagunitas Creek
Adult	Road Kill	Otter Spotter	December 2012	Sonoma	Lakeville Road
Adult	Road Kill	Otter Spotter	April 2012	Marin-Sonoma	Highway 37
Adult	Road Kill	Otter Spotter	March 2012	Marin	101N Novato
Adult	Road Kill	Otter Spotter	April 2012	Solano	Benicia
Adult	Road Kill	Otter Spotter	February 2011	Marin	Rowland Blv
Adult	Road Kill	Otter Spotter	February 2011	Marin	Larkspur
Adult	Road Kill	Otter Spotter	October 2011	Marin	Larkspur

juveniles were first seen foraging alongside their mothers, was documented at 4 FSS's through a combination of camera arrays and field observations. With the exception of the May 2012 site where 2 pups-juveniles suffered mortality (Table 5), the earliest month during which live pups-juveniles were observed as part of a family group was June.

Behavioral observations of special note were the observed merging of groups composed of 2 separate mothers and their associated litters. In 2012, a single mother and her 1 pup-juvenile and a 2nd mother and her 2 pups-juveniles were observed together and frequenting the same latrine sites on northern Tomales Bay. We observed a 2nd case of this at the Giacomini Wetlands in southern Tomales Bay in 2013, where 2 mothers (one with 1 pup-juvenile, and the second with 2 pups-juveniles) were observed together at a latrine site over the course of a few days.

Mortality and Disease

A total of 15 mortalities (12 adults and 3 pups-juveniles) were detected, the majority through Otter Spotter reports (Table 5). Of the 12 adult mortalities, 11 were confirmed road kills. Of the 3 pup-juvenile mortalities, the cause-of-death for one was indeterminate on necropsy, and the remaining 2 pups-juveniles occurred together and appeared to have been abandoned by their mother. A 3rd sibling was rescued by a kayaker and transferred to a wildlife rehabilitation facility. Preliminary disease sampling resulted in 4 species of *Vibrio* detected, and no *Salmonella;* 5 of the 12 samples tested positive for *Vibrio* spp. (Table 6).

DISCUSSION

River Otters are important predators on fishes, aquatic birds, and invertebrates, and can therefore have significant influence on the structure of local ecosystems. Once widespread across the west coast of North America but extirpated from the SFBA for several decades, our study documents the recovery of the species throughout most of the counties of the San Francisco Bay Area and their likely expansion into the southern reaches of the SFBA. Given the lack of any detailed prior studies, evidence for a recent recovery (from very low densities to being more widespread and more likely to be encountered) relies solely on observations made by expert naturalists and wildlife resource managers who have extensive experience in the region over the past 3 decades. A renowned local biologist reported the 1st otter sighted in decades in northern Marin County in 1989 up on Walker Creek, a tributary of Tomales Bay (Rich Stallcup, Point Reyes Bird Observatory, pers. comm). A NPS scientist (D Fong, NPS Aquatic Ecologist, pers. comm.) reported that otter sightings were rare for Rodeo Lagoon in southern Marin County from 1986 to 2000 and comprised only a single individual, but that post 2000 the number of observations has increased; the 1st sighting of multiple otters here occurred in 2001 and peaked in 2007 with 8 otters. The only other confirmed sightings documented thereafter were groups in Olema Marsh and Olema Creek, a tributary of Tomales Bay in the mid-1990s (D Fong and S Allen, NPS, pers. comm.). The consensus among these expert sources is that otter populations and

TABLE 6. Results of pilot disease sampling for *Vibrio* and *Salmonella* at Focal Study Sites, 2013. Swabs of scat were collected from individual scats at latrine sites within our study area. Only 1 sample originated from outside of our study area, a fresh carcass that was reported to us through Otter Spotter.

Site	Collection date	Results
Northern Tomales Bay #1	1 April	*V. algynoliticus* isolated. No *Salmonella*
Northern Tomales Bay #2	1 April	No *Salmonella* or *Vibrio* isolated
Northern Tomales Bay #3	1 April	No *Salmonella* or *Vibrio* isolated
Northern Tomales Bay #4	1 April	No *Salmonella* or *Vibrio* isolated
Abbotts Lagoon	1 April	No *Salmonella* or *Vibrio* isolated
Drakes Pond	13 November	No *Salmonella* or *Vibrio* isolated
Drakes Beach	13 November	No *Salmonella* or *Vibrio* isolated
Corte Madera Creek #1	1 April	*V. algynoliticus* isolated. No *Salmonella*
Corte Madera Creek #2	24 April	*V. algynoliticus* and *V. parahemolyticus*. No *Salmonella*
Giacomini Wetlands	16 April	No *Salmonella* or *Vibrio* isolated
Rodeo Beach	15 November	*Vibrio metschnikovii* isolated. No *Salmonella*
Fairfield	21 May	*V. cholera* isolated. No *Salmonella*

sightings have been increasing locally. One hypothesis to examine to help explain the resurgence, particularly in northern Marin County which is dominated by a ranching landscape, is that the 1998 County Board of Supervisors ban of the use of steel-jaw traps and poison targeting Coyotes (*Canis latrans*) by ranchers likely also benefited otters by reducing such mortality. This is certainly possible given that a nation-wide assessment indicated that 84% of River Otters trapped and killed in steel-jaw traps since 2006 were non-targeted, incidental catch (Knudson 2012).

River Otters appear to utilize a range of aquatic habitats present in the SFBA spanning rural protected parks along coastal Marin County, to suburban and urban habitats along the shores of San Francisco Bay. These habitats also include newly restored areas. For example, the 1st sighting of an otter in Lake Merritt, Alameda County, occurred in October 2013 just after tidal action was increased to the lake-bay system for the first time since it was dammed in 1869.

In the city of San Francisco (San Francisco County), the 1st River Otter observed there in recent history occurred in Sutro Baths (a man-made pool) at Lands End beginning in October 2013. Our field team continues to strategically survey areas south of this site extending to Santa Cruz (Santa Cruz County), but have to date found no evidence of River Otters. The single San Francisco male represents the southern-most coastal River Otter documented along the coast in this study. For coastal inland San Francisco Bay, the furthest southern River Otter was documented in January 2013 in Los Gatos (Santa Clara County).

We anticipate a southward expansion of the species along the coast, unless barriers preventing dispersal exist. If the SFBA River Otter population continues to grow, further investigation into the southward expansion is warranted particularly given the eventual overlap between River Otter and Sea Otter (*Enhydra lutris*) ranges and habitat use.

River Otters move and forage within freshwater habitats including ponds, lagoons, lakes, reservoirs, and streams; however, we made regular observations and gathered photo documentation of River Otters foraging in the marine environment and returning from the ocean via beaches adjacent to freshwater habitats. Monitoring the overland movements of non-tagged otters is challenging and depends mostly on having good substrate to follow tracks overland. In one specific case, we were able to utilize fresh spoor to track a group of 3 otters over a dune-system for 1.9 km.

Our approach in determining minimum population estimations was conservative and reasonable given that maternal family groups have home-ranges that span 7 to 8 km (Brezeki and others 2013) and all of our study sites, with the exception of the Redwood Creek-Tennessee Valley-Rodeo Lagoon span, encompass a distance greater than 8 km. Despite Redwood Creek and Rodeo Lagoon being only 5.3 km from each other, our direct observation of groups led us to conclude that these otters are distinct individuals in that the Rodeo Lagoon site is highly active on a daily basis, as evidenced by latrine site activity and remote camera data, and the otters appear to be resident in the lagoon with only some offshore

movements noted. Tennessee Valley on the other hand appears to represent a stopover location rather than a residential site for otters.

Our otter density estimates are similar to those found for inland California (Mowry and others 2011) and Alaskan populations (Testa and others 1994; 0.26 to 0.46 River Otters/km in Alaska, Bowyer and others 2003), but 4.5 times lower than that reported for Humboldt Bay in Northern California where DNA sampling methodologies were utilized to estimate the population (Brzeski and others 2013). Given that the coastal sites of the SFBA are also resource-rich habitats, the population density estimates that we derived using observation-based methodology are either: (1) accurate and reflect a still-recovering population; or (2) an underestimate of the actual population.

Road kills were the most frequently observed source of mortality (79% of mortalities documented). Unfortunately, deceased otters are very difficult to detect given their low densities and occurrence in oftentimes inaccessible aquatic habitats. Our data may reflect the fact that carcasses along roadways are more visible and detectable versus being an accurate reflection on the range of sources of mortality present in the population. Nevertheless, roadways have an impact on otters, particularly those roads and highways bisecting aquatic habitats or separating aquatic habitats from upland areas utilized by otters. Roads are a major cause of mortality for many meso-carnivore species in California (Caro and others 2008), but unlike terrestrial mammals, otters usually transit overland between adjacent water bodies compared to terrestrial mammals that can transit through large culverts. For example, in 1 case, road construction crews installed plastic barriers to prevent debris from entering an adjacent wetland which also may have functioned as a barrier to movement for otters.

Preliminary disease sampling indicates that River Otters are exposed to and are carrying pathogens, and could serve as sentinels across the SFBA particularly given their occurrence within and adjacent to the San Francisco Bay, a highly urbanized estuary. Whether our sampling reflects asymptomatic individuals is not discernible at this time. Only 1 carcass, outside of our ISA and found along a roadway (road kill), was sampled and tested positive for *V. cholerae,* the 1st-ever report of this pathogen in a River Otter. In other areas along the US Pacific coast, researchers have documented the presence of pathogens in River Otters (Gaydos and others 2007; Gaydos 2014), but never *V. cholera*. We did not sample for pollutants in the SFBA otters, but researchers studying Harbor Seals in the SFBA have shown a correlation between anthropogenic pollutants and disease (Neale and others 2005). More detailed population and ecological data on River Otters in the SFBA will be needed to refine distributions, understand habitat needs, and determine if River Otters are expanding their range. As a potential keystone species in the SFBA aquatic habitat we would strongly prioritize: (1) a wide-spread baseline population assessment utilizing non-invasive genetic techniques; and (2) an assessment of the role River Otters play in local aquatic food-webs, particularly given the extent of restoration activities taking place across the SFBA targeting recovery of protected species such as salmonids and migratory birds.

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