FIFTEEN YEARS OF RIVER OTTER MONITORING BY CITIZEN-SCIENCE VOLUNTEERS IN NORTHERN CALIFORNIA: LITTER SIZE

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ABSTRACT—We solicited and collated citizen-science volunteer observations of North American River Otters (*Lontra canadensis*) over 15 y in Humboldt, Del Norte, and adjacent counties in northern California. The occurrence of River Otter reproduction is thought to be an indicator of watershed and wetland health. We described when and where observers reported sightings of pups and litters. Citizen volunteers reported 3540 River Otter observations, of which 371 included required information about number and size of smaller pups. From these records, 148 litters were identified in 39 waterbodies. Five to 17 litters per year were reported. Average litter size was 2.0 (SE 0.1; range 1 to 4 pups). Litter size did not vary significantly among years or waterbodies, including coastal and inland sites. The number and size of River Otter litters reported did not increase (or decline) over the study period.

Key words: coastal, litters, *Lontra canadensis*, North American River Otter, northern California, pups, rivers, wetlands

North American River Otters (*Lontra canadensis*) and other otter species are thought to respond to the health and functionality of watersheds and coastlines, making them useful bioindicators of those habitats (*sensu* Lunnon and Reynolds 1991; Lariviére and Walton 1998; Melquist and others 2003). Metrics used to track wildlife populations include numbers and density, but describing the occurrence of successful reproduction provides insight into the potential for population growth or stability (*sensu* Begon and others 1996). We report on number of pups, or litter size, in River Otters submitted by citizen-science volunteers over 15 y in northern California, updating Black (2009), reporting on the first five years. Prior to this citizen-science program, attempts to quantify California's River Otters relied on relatively few sightings, making it difficult to assess trends (Kirk 1975; Gould 1977; Schempf and White 1977).

Successful reproduction is thought to occur in habitats where otters balance energy budgets by obtaining ample food to fuel investment in pups and lactation while keeping safe from predators and disturbance, minimizing foraging and thermoregulatory costs, and coping with pollution and disease (*sensu* Kruuk 1995, 2006). Habitats may vary in these attributes. Kruuk (1995) suggested that Eurasian Otters (*Lutra lutra*) living on coastlines and estuaries may be at an advantage due to replenishing food supply, but that individuals may bear higher thermoregulatory costs than at inland sites. In Europe, otter litter sizes were reportedly smaller along coasts and estuaries (range = 1.6–1.9) and larger in inland streams and rivers (range = 2.3–2.8; reviewed in Kruuk 1995, 2006).

Making use of observations from a long-term citizen-science program, we sought to identify sites where River Otters successfully bred. The current analysis contributes toward documenting whether River Otter litter size and number of litters varied over the 15-y period and among sites.

METHODS

Following methods from Black (2009), we solicited River Otter observations in Humboldt and Del Norte counties (Fig. 1), California, but accepted and catalogued records from neighboring counties (Mendocino, Siskiyou, and Trinity). This region includes coastal bays, estuaries, lagoons, marshes, ponds, lakes, reservoirs, rivers, streams, and associated inland watersheds. Humboldt Bay is roughly the center of the study area (UTM: Zone 10, E 407634, N 4523226, NAD

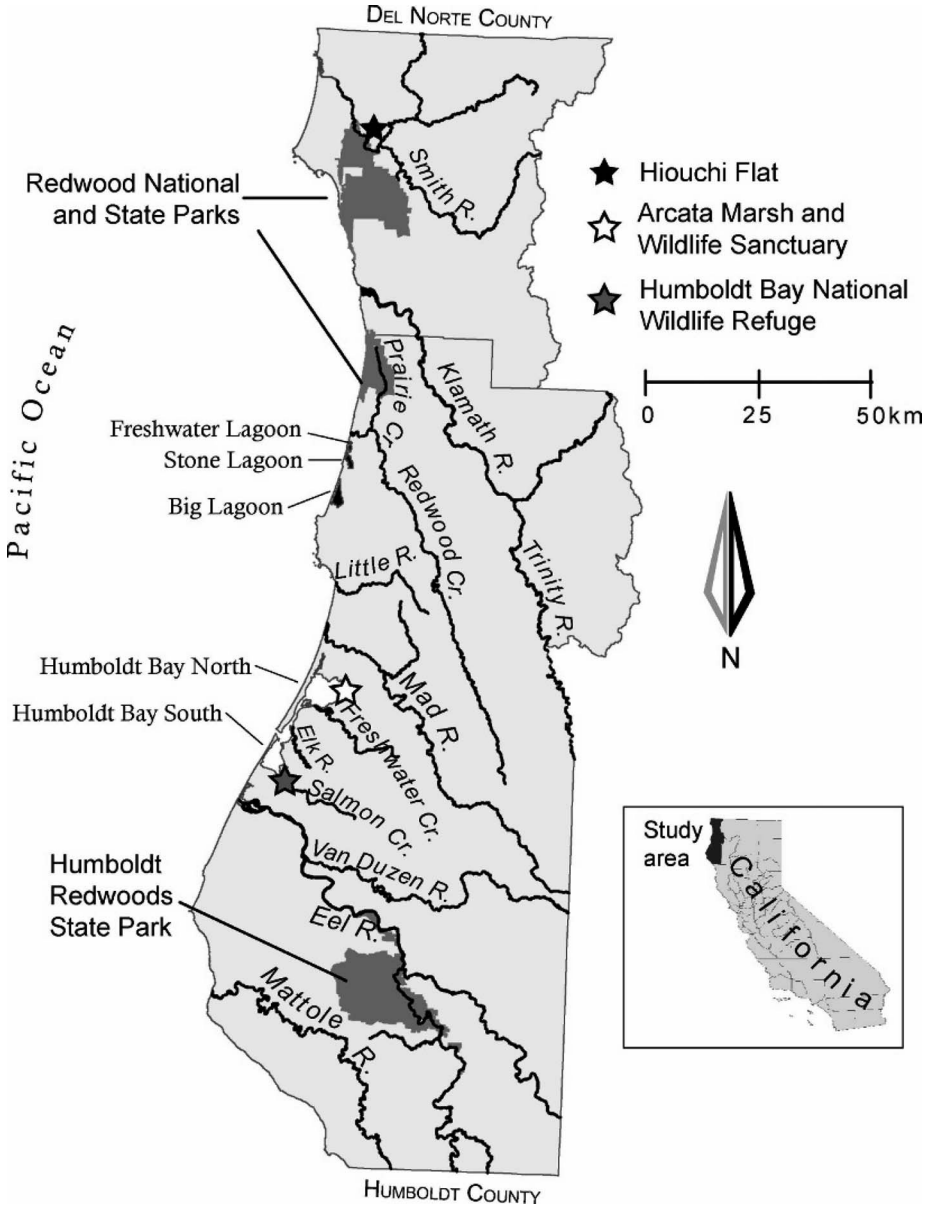

FIGURE 1. Primary study area where citizen science volunteers recorded River Otter observations from waterbodies in Humboldt, Del Norte, and adjacent counties, northern California, 2000–2014. Adapted from Black (2009).

27), which extends from lush coastal habitats, including agricultural and marshland flats, to upland watersheds and rugged mountains dominated by extensive stands of conifers (for example, *Sequoia sempervirens*, *Pseudotsuga menziesii*) and deciduous woodlands (for example, *Alnus rubra*, *Lithocarpus densiflorus*). River Otters in this region have been documented from sea level in the west to 2100 m along North Coast Mountain Ranges in the east (Black 2009; Garwood and others 2013). In northern California coastal areas, winter temperatures rarely drop

below freezing, unlike the typical temperatures in inland areas. Land uses in the study area include logging, mining, recreation, livestock grazing, and some croplands.

Records were sent via email, mail, phone, or online form. Observers were asked to record date, time, location, number of adults and pups, and pup size relative to adults: 0.25, 0.50, 0.75, or same size as adult. Observers also documented otter behavior, habitat features, tracks, slides, scat, dens, prey items, and social interactions. This information was used to assess validity of observer reports. Citizen observers sometimes incorrectly assumed that groups of 3 or more comprised a male and female parent attending pups. Citizen observers typically observed pups with 1 (49%) or more adults (42%), or sometimes alone (10% of 109 records; Black 2009). Sex was not considered in analyses. To further scrutinize records, observers were identified as scientist/naturalist, wildlife/fish/biology student, or layperson. Records from untrained observers of 0.75-sized pups in autumn and winter months were accepted only if smaller pups (0.25–0.50) had been reported previously for that site (approximately 27% of records were excluded; Black 2009). If observers reported a range (such as 2–3 pups), we used the smaller value. Information was linked to coordinates, and data layers were created (ARCMAP). We used distinct point clusters, pup size, and number of pups to distinguish between litters in space and time. Clustering of points at inland river sites amounted to approximately 30-km linear stretches of river. Annual observer effort was indexed by overall number of records submitted (including observations of scat, tracks, and sightings).

We calculated annual mean litter size and number of litters for each waterbody (site). We used Kruskal-Wallis Test (Siegel 1956) to examine variation in litter size and number of litters in relation to year (2000–2014) and waterbody (39 sites). We pooled years and lumped records into categories when testing for difference in litter size and number of litters reported at coastal compared to inland sites, using a student's t-test assuming unequal variance (Microsoft excel 2007). We tested whether annual observer effort (including observations of scat, tracks, and sightings) was correlated with annual mean litter size and number of litters reported, using a Spearman Rank Correlation (Siegel 1956). We also used Spearman Rank Correlation to test whether annual observer effort (including observations of scat, tracks, and sightings) and annual number of litters reported was positively or negatively correlated with year of study (2000–2014).

Results

Over the 15-y study, citizen-science volunteers reported 3540 River Otter observations, of which 371 included information meeting criteria about number of pups (litter size). From these records, 148 litters were identified in 39 watercourses (Fig. 1, Table 1). Litter size ranged from 1 to 4 pups ($\bar{x} = 2.0$, SE = 0.1, $n = 148$), and did not vary significantly among years or waterbodies (Fig. 2, 2000–2014: Kruskal-Wallis Test $X^2 = 6.31$, $df = 14$, $P > 0.05$; 39 sites: Kruskal-Wallis Test $X^2 = 35.5$, $df = 38$, $P > 0.05$, respectively). Mean litter size did not differ between coastal and inland river sites (Table 2; $t = 0.98$, $df = 146$, $P > 0.05$). Mean litter size per year was not correlated with annual observer effort (overall number of records submitted) (Spearman Rank Correlation $r_s = 0.271$, $n = 15$, $P > 0.05$).

Citizen-science volunteers reported 5 to 17 litters annually in the study area ($\bar{x} = 9.9$, SE = 0.2, $n = 15$; Table 1). Mean number of litters per year did not differ between coastal and inland river sites (Table 2; $t = 0.98$, $df = 146$, $P > 0.05$). Number of litters per year was positively correlated with annual observer effort (overall number of records submitted) (Spearman Rank Correlation $r_s = 0.722$, $n = 15$, $P = 0.002$).

Although annual observer effort (overall number of records submitted) increased over the study period (positive correlation between number of records and year of study from 2000–2014, $r_s = 0.611$, $n = 15$, $P = 0.016$), litter size and annual number of litters reported did not increase (or decrease) over the study period ($r_s = 0.271$, $n = 15$, $P > 0.05$; $r_s = 0.144$, $n = 15$, $P > 0.05$, respectively).

Discussion

River Otter populations suffered dramatic declines in some regions due to human impacts (Foster-Turley and others 1990; Lariviére and Walton 1998; Kruuk 2006). Protective legislation and re-introduction programs were implemented in several eastern and mid-western states and provinces in North America (for example, Ralls

TABLE 1. Location and habitat type where River Otter records were reported by citizen-science volunteers in northern California (2000–2014). Values refer to range of litter sizes with mean litter size and number of records in parentheses.

Place name - North to South	County	Habitat type [1]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1 Smith River Estuary	Del Norte	4		3 (3,2)		1 (1,2)											
2 Smith River (East Fork of Mill Creek)	Del Norte	9														1 (1,1)	
3 Smith River (Jedediah Smith State Park / Hiouchi Flat)	Del Norte	9		3-4 (3.5,2)	2-4 (3.0,2)	1-4 (2.0,5)				1 (1,1)	2 (2,1)		1-4 (1.46,15)	1-3 (1.8,5)	1-2 (1.67,3)	2 (2,1)	
4 Lake Tolowa / Lake Earl (nr Crescent City)	Del Norte	6											2 (2,1)			2 (2,1)	
5 Elk Creek Park (Crescent City beaches)	Del Norte	3			1 (1,1)												3 (3,1)
6 Klamath River inland (Happy Camp south to Ti Bar access)	Siskiyou	9			3 (3,1)					2 (2,1)						2 (2,1); 3 (3,1)	4 (4,1)
7 Del Norte Redwoods State Park (Damnation Creek Trail Beach)	Del Norte	1			2 (2,1)												
8 Klamath River estuary to Highway 101	Del Norte	4												2 (2,2)	2 (2,1)		
9 Klamath River Inland (T12N R2E sec 22)	Humboldt	9			3 (3,1)					2-4 (3,2)		1-3 (2,2)					
10 Freshwater Lagoon (Humboldt Lagoons State Park)	Humboldt	8											2 (2,1)				

TABLE 1. Continued.

Place name - North to South	County	Habitat type [1]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
11 Stone Lagoon (Humboldt Lagoons State Park)	Humboldt	6									1 (1,1)						
12 Big Lagoon (Humboldt Lagoons State Park)	Humboldt	6											1-2 (1.5,4)		4 (4,1)		
13 Redwood Creek Estuary	Humboldt	4	1-2 (1.7,6)			2 (2,2)		1-2 (1.5,3)	1 (1,1)				1-2 (1.5,4)			3 (3,1)	1-3 (1.75,4)
14 Redwood Creek moderate inland (Praire Creek,Bridge Creek,Tall Trees; Redwood National Park)	Humboldt	7	2 (2,1)	1 (1,1)					4 (4,1)				2-3 (2.5,6)	3 (3,2)			
15 Redwood Creek inland (Panther Creek confluence, Coyote Creek)	Humboldt	9			2 (2,2)							1 (1,1)					
16 Redwood Creek inland (Bair Rd nr Blue Lake)	Humboldt	9									1 (1,1)						
17 Trinidad Harbor,rocks and beaches [2]	Humboldt	1	1 (1,1)		1 (1,1); 2-4 (3,3)		1 (1,1)			1 (1,7)	2 (2,1)	1 (1,3); 2-4 (3.14,7)	1-3 (1.5,14)	4 (3.5,2); 1 (1,2)	1 (1,3)		2 (2,2); 2 (2,3)
18 Little River Estuary (Moonstone Beach,Little Rv State Park)	Humboldt	5		1 (1,1)	1-3 (2.0,3)				2 (2,1)								
19 Trinity River nr Willow Creek (Kimtu beach,Hoopa)	Humboldt	9			1 (1,2)										3 (3,1)	1 (1,1)	

TABLE 1. Continued.

Place name - North to South	County	Habitat type [1]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
20 Trinity River (Ceder Flats,Hayden Flats)	Trinity	9			2 (2,1)												
21 Trinity River (Lewiston Village)	Trinity	9		3 (3,1)													
22 Mad River Estuary	Humboldt	4	2-3 (2.5,2)	2 (2,1)		1 (1,1)			1 (1,1)		2 (2,2)	2-3 (2.5,4)	2 (2,1)				
23 Mad River inland (Maple Creek)	Humboldt	9										3 (3,1)					
24 Mad River inland (Pilot Creek)	Humboldt	9									2 (2,2)						1 (1,1)
25 Arcata Marsh (ponds,bay and sloughs)	Humboldt	6	1-2 (1.2,6); 1 (1,1)	1 (1,3)	1-2 (1.3,4)	2-4 (3.0,2)	1-3 (2.3,4)	1-3 (1.8,5)	1-3 (1.86,7)	1-2 (1.5,2)	1-3 (2.1,11)	1-2 (1.27,11)	1 (1,2)			1-3 (2,7)	1-3 (2,5)
26 Humboldt Bay (Eureka,Somoa)	Humboldt	2	1-2 (1.5,2)				2-3 (2.0,7)			1 (1,1)					1-2 (1.2,5)		
27 Freshwater Creek (Eureka)	Humboldt	5								4 (4,1)							
28 Elk River Estuary (Eureka,Swain Slough)	Humboldt	5	2-3 (2.5,2)				1 (1,1)				1-2 (1.75,4)	4 (4,4)			1-2 (1.5,2)		
29 Humboldt Bay (Kings Salmon)	Humboldt	2												1-3 (2,2)			1 (1,1)
30 Humboldt Bay National Wildlife Refuge (incl. Hookton Slough)	Humboldt	3	2 (2,1)		3 (3,1)	2 (2,2)		3-4 (3.5,2)		1 (1,1)		1-2 (1.67,6)	1-4 (2.6,5)	1 (1,3)	2 (2,3)	2 (2,1)	1 (1,1)
31 Eel River Estuary	Humboldt	4		1-4 (3.5,6)	1-2 (1.5,2)	2 (2,1)	3 (3,1)		1-2 (1.5,2)								5 (4,1)
32 Van Duzen River (Bridgeville)	Humboldt	9					1 (1,1)										
33 Bear River (Petrolia)	Humboldt	9			2 (2,1)												

TABLE 1. Continued.

Place name - North to South	County	Habitat type [1]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
34 South Fork of Trinity River (Hell's gate campground nr Forest Glen)	Trinity	9					1 (1,1)				2 (2,1)						
35 Mattole River (A.W.Way County Park)	Humboldt	9		1 (1,1)	3 (3,1)			1 (1,2)									
36 Headwaters for Sproul Creek (west of South Fork Eel River)	Humboldt	9				2 (2,1)											
37 Shelter Cove	Humboldt	1										2 (2,1)					2 (2,1)
38 South Fork Eel (Meyer's Flat)	Humboldt	9						1-3 (2,2)			1-2 (1.5,2)	1 (1,3); 3 (3,2)		3 (3,1)	1 (1,4)		2 (2,1)
39 South Fork Eel River (Redway to Piercy)	Humboldt / Mendocino	9	3 (3,2)	2-3 (2.5,2)	2-3 (2.4,5)	2 (2,1)					3 (3,1)	2 (2,3); 3 (3,2)	1 (1,1)			1-3 (2.17,6)	2-5 (2.83,3)

[1] Habitat type: (1) coastal ocean and harbors and beaches; (2) deep tidal bays – permanent parts of Humboldt Bay; (3) large bay, sloughs and tidal areas; (4) large estuary near mouth; (5) smaller sloughs and brackish marshes; (6) coastal lagoons (brackish); (7) freshwater river within coastal zone; (8) large freshwater lake (coastal zone); (9) inland and upland freshwater rivers and streams.

[2] Trinidad Harbor was the site of Scott Shanon's long-term observational study (Shannon 1989). We acknowledge use of records from his website and blog (Shannon 2008); 2000 (1 record), 2002 (5), 2005 (1), 2006 (14), 2007 (10), 2008 (4), 2009 (1), 2010 (1), 2011 (11), 2013 (1).

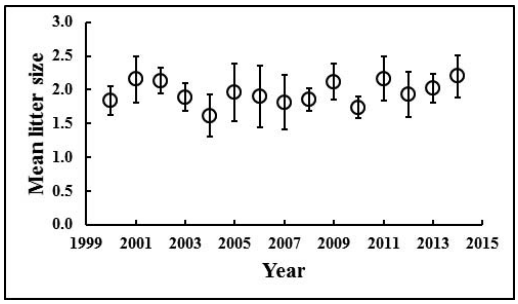

FIGURE 2. Mean (SE) litter size of River Otters reported by citizen-science volunteers in northern California, 2000–2014. Sample sizes for means (SE) ranged from 13–54 records.

1990; Serfass and others 1998). The comprehensive review by Melquist and others (2003) encouraged additional monitoring to better assess trends in River Otter population.

In California, River Otters received protected status in 1961. Trapping information prior to this documented the presence of otters in 31 of the state's 58 counties, and reported annual take of River Otters ranged from 14 to 163 animals (Gould 1977). In attempts to quantify the status of River Otters in northern California after trapping was banned, Kirk (1975) and Gould (1984) collated 136 and 387 records, respectively, in historical databases from the National Forest Service/National Park Service and California Department of Fish and Game. Black (2009) suggested that the paucity of records for such a large geographic region could mean either that a population was at risk or that monitoring efforts were minimal.

Since 2000, citizen volunteers in northern California contributed an increasing number of River Otter records over this 15-y study, demonstrating a growing interest in participation to track the population's demography. An average of 234 records was received per year, amounting to 3540 observations. Bouley and others (2015) began soliciting citizen-science observations of River Otters in the San Francisco Bay area in 2012, and successfully collated 228 and 395 records in the first 2 y of that study. Citizen-science programs have provided useful information in a variety of systems, and fostered a growing sense of ownership leading to conservation action on behalf of study species and associated habitats (*sensu* Bonney and others 2009; Dickinson and others 2012).

River Otter litter size in our study area did not vary significantly over the 15-y period (range = 1.6–2.2). Mean litter size was not correlated with citizen science effort (the number of all records received, which increased during the study period), showing consistency of this population demographic (litter size, Fig. 2). Documenting no change in pups per female over time is important when describing demographic trends for a population (*sensu* Begon and others 1996). Kruuk and others (1991) also reported no significant change in litter size over a 5-y study in Shetland, Scotland (range = 1.3–1.8 pups).

Although litter size was similar for coastal and inland sites (2.0 pups compared to 1.9 pups, respectively), almost twice as many litters were reported from coastal compared to inland sites (94 litters compared to 54 litters). This may have been due to the distribution of contributing observers on the landscape; 70% of submitted records were from coastal areas and 30% from inland sites. Annual number of litters reported was correlated with citizen-science effort (the annual number of all records received). However, annual number of litters did not increase or decrease over the study period even though observer effort (annual number of records received) did increase.

While we can confirm similar litter sizes over the study period, it may prove difficult to use citizen-science contributions to identify whether coastal or inland River Otters reproduce more often. However, a closer look at the number of

TABLE 2. Litter statistics for sites from coastal and inland river areas during 15-y study using citizen-science volunteers in Humboldt, Del Norte, and adjacent counties, northern California, 2000–2014.

Location (*n*)	Number of litters	Mean (SE) litter size	Mean number of litters reported per site over 15-y study period	Maximum litters produced at a site in a year	Records of litters
Coastal habitats (21)	94	1.9 (0.1)	4.5 (0.8)	14	261
Inland rivers (18)	54	2.1 (0.1)	3.0 (0.6)	10	110
Total (39)	148				371

TABLE 3. River Otter litters reported by citizen-science volunteers within 5-y intervals, 2000–2014, at sites in Humboldt, Del Norte, and adjacent counties, northern California.

5-y interval	Number of litters observed	Number of waterbodies observed with litters	Mean (SE) of mean litter size observed	Approx. number of pups	Records of litter observations	Total River Otter records (including tracks, scat, sign)
2000–2004[a]	53	26	2.0 (0.1)	106	110	715
2005–2009	44	23	2.0 (0.1)	88	117	1104
2009–2014	51	23	2.0 (0.1)	102	141	1721

[a] Updated from Black (2009)

litters reported for the 3 most productive sites in coastal (Table 1: Arcata Marsh = 14 litters; Trinidad Harbor = 14 litters; Humboldt Bay National Wildlife Refuge = 11 litters) and inland rivers (South Fork Trinity River at Redway to Piercy = 10 litters; Smith River at Hiouchi Flats/Jedediah Smith State Park = 9 litters; South Fork Trinity River at Meyer's Flat = 7 litters) may add to the comparison. Each of these sites was visited annually by thousands of outdoor recreationists (potential citizen-science reporters). If we assume a similar likelihood of reporting across these 6 sites, then it would appear that coastal sites produced approximately 33% more litters than inland river sites (39 compared to 26 litters).

It was noteworthy that 2 of the coastal sites (Arcata Marsh in 2000; Trinidad Harbor in 2002, 2009, 2011, 2014) and 2 of the inland sites (2 segments of the South Fork of the Eel River in 2009) had 2 females produce pups in the same year at the same site (Table 1). Shannon's (2008) web page describes the 'superfamily' that formed at Trinidad Harbor in 2002. Two cases of multiple females with young pups at single sites were also documented by Bouley and others (2015) in the San Francisco Bay area.

A more detailed field study may reveal whether coastal or inland river sites are higher quality in terms of River Otter food supply, energetic return from foraging, thermoregulatory properties, pollution, and parasites (*sensu* Kruuk 1995, 2006). We suspect that River Otters living at coastal and inland sites in northern California face challenging energetic constraints. For example, River Otters in coastal estuaries may be challenged to find food when rivers swell with turbid water from runoff after heavy rainfall in winter and spring resulting from regional upriver forestry practices, whereas River Otters in inland rivers may face challenging conditions during unanticipated pulses of fast-flowing, frigid water released from dams in spring and summer. Coastal habitats would seem to be advantageous for River Otters with regard to augmenting a primarily fish-based diet with higher concentrations of migratory fishes, shorebirds, and waterfowl (Blundell and others 2000; Penland and Black 2009; Crosby 2013). However, the landscape along coastal watercourses may be more open, allowing prey to travel more freely, thus reducing capture success, compared to inland streams and rivers with log jams and woody debris (*sensu* Kruuk 1995).

Black (2009) suggested that comparison of citizen-science records over 5-y intervals may compensate for annual variation in citizen-science effort. Table 3, listing values for the 1st, 2nd, and 3rd 5-y periods, shows that citizen-science volunteers have successfully identified 44 to 53 River Otter litters (296 litters overall) at 23 to 26 waterbody sites. The middle 5-y period (2005–2009) may show a slight decline in number of River Otter litters, in spite of increasing number of overall records. Mean litter size remained at 2.0 pups throughout the 3 periods.

Although citizen-science records may provide insight into River Otter reproduction, the approach does not yield a complete survey for the 5-county study area, as citizen-science effort and coverage was haphazard. Brzeski and others (2013) identified 41 River Otters in the Humboldt Bay area in 2008 from unique DNA extracted from extensive collection of River Otter scat, while citizen volunteers reported only 27 individuals in that year.

Our measure of mean litter size, rather than maximum litter size, provided a conservative assessment of reproduction; means were based on single or multiple observations at sites (Table 1). Pup survival in otters is known to vary over time (reviewed by Kruuk 2006). Shannon (2007), reporting the fate of 52 River Otter pups closely monitored at Trinidad Harbor (1983–2007),

documented 71% mortality between den emergences through the 1st year. Black (2009) described a significant decline in mean River Otter litter size from of 3.2 in spring to 1.6 in fall.

Although northwestern California has had a relatively short period of habitat-altering activities in its 200-y post-European history, it has experienced its share of mining, forest clearing, and road construction, which negatively affects waterbodies (Mount 1995). As use and alteration of natural areas continues, there is need to monitor effects on regional wildlife. The consistent collation of natural history records from interested citizens may continue to provide a useful source of information with which to track the fate of River Otter and other key populations.

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