Marine Mammal Science

MARINE MAMMAL SCIENCE, 27(2): E14–E25 (April 2011)

DOI: 10.1111/j.1748-7692.2010.00414.x

Latitudinal variation in diet and patterns of human interaction in the marine otter

J. C. MANGEL
Pro Delphinus,
Octavio Bernal, 572-5, Lima 11, Peru
and
Centre for Ecology and Conservation,
School of Biosciences,
University of Exeter, Cornwall Campus,
Penryn, Cornwall TR10 9EZ, United Kingdom
E-mail: jeffrey_mangel@yahoo.com

T. WHITTY
Scripps Institution of Oceanography,
University of California, San Diego,
9500 Gilman Drive, La Jolla, California 92093, U.S.A.

G. MEDINA-VOGEL
Facultad de Ecología y Recursos Naturales,
Universidad Andres Bello,
República 252, Santiago, Chile

J. ALFARO-SHIGUETO
Pro Delphinus,
Octavio Bernal, 572-5, Lima 11, Peru
and
Centre for Ecology and Conservation,
School of Biosciences,
University of Exeter, Cornwall Campus,
Penryn, Cornwall TR10 9EZ, United Kingdom

C. CÁCERES
Pro Delphinus,
Octavio Bernal, 572-5, Lima 11, Peru

B. J. GODLEY
Centre for Ecology and Conservation,
School of Biosciences,
University of Exeter, Cornwall Campus,
Penryn, Cornwall TR10 9EZ, United Kingdom

ABSTRACT

The marine otter (*Lontra felina*) inhabits patches of rocky coastline from central Peru to southern Chile and is classified as Endangered by the IUCN. Given the limited information available about the species, we set out to assess marine otter diet with a view to detecting latitudinal differences, and to assess marine otter activity budgets and interspecific interactions (including anthropogenic) at Peruvian fishing villages and to compare results with similar Chilean studies. Nine study sites from central Chile to southern Peru were sampled for otter spraints to assess relative frequency of prey types and two fishing ports in southern Peru were monitored through focal and scan observations to assess activity patterns, interspecific interactions, habitat use patterns, and dive durations. Results indicate that toward the northern part of its range, crustaceans become less important and fish more important in the diet. Interactions were observed between marine otters and other species, including stray dogs and cats. The strong dependence of marine otters on the availability of safe rocky shelters, and the species' apparent tolerance to living alongside humans raise conservation concerns about vulnerability to anthropogenic threats. These factors, if not correctly managed, could turn some of these rocky seashore patches into population sinks.

Key words: *Lontra felina*, marine otter, human interaction, latitudinal variation, Peru, Chile.

The marine otter (*Lontra felina*) has a limited and patchy distribution that ranges from central Peru (6°S) to the southern tip of Chile (56°S) (Alvarez and Medina-Vogel 2008, Medina-Vogel *et al*. 2008), with isolated populations in Argentina (Larivière 1998). The species was historically hunted for pelts in Peru and Chile, resulting in considerably reduced abundance and geographic distribution (Brownell 1978, Cabello 1978, Iriarte and Jaksić 1986, Iriarte *et al*. 1997). The species population is thought to be declining and is classified as Endangered by the International Union for the Conservation of Nature (IUCN 2008).

Published studies on marine otter distribution, activity budgets, prey composition, and anthropogenic effects are limited to populations in Chile (Ostfeld *et al.* 1989; Medina 1995*a*,*b*; Medina-Vogel *et al*. 2004, 2006, 2007, 2008). Similar studies of marine otters in Peru are confined to unpublished works. Previous research in Chile suggests that foraging is the dominant category of activity while marine otters are in sight, and that otters feed opportunistically, with a diet primarily comprised of crabs, followed by fish (Ostfeld *et al.* 1989; Medina-Vogel *et al*. 2004, 2006). Since studies of prey composition suggest that there is between-site and possibly latitudinal variation in marine otter diet (Cabello 1978, 1983; Castilla and Bahamondes 1979; Castilla 1982; Ostfeld *et al*. 1989), it is likely that differences in the diet, and possibly activity budgets, of otters may exist between Peru and Chile.

This otter species is forced to coexist with humans given its habitation of the marine littoral zone and exploitation of the same resources from the intertidal, subtidal, and terrestrial seashore that humans exploit for food, commerce, and housing (Moreno *et al*. 1984; Ostfeld *et al*. 1989; Moreno 2001; Medina-Vogel *et al*. 2004, 2007). Thus anthropogenic impacts on marine otters are of particular concern given the continuing human population expansion and development of the Peruvian and Chilean coast which may lead to habitat loss, degradation, or fragmentation (Larivière 1998, Medina-Vogel *et al*. 2008).

Fishing villages are one interface between human activity and marine otter habitat (Medina-Vogel *et al*. 2007). By creating artificial den sites (*e.g.*, wharfs and shipwrecks) and providing food in the form of fish refuse, fishing villages may attract marine otters (Medina-Vogel *et al.* 2007). For example, groups of marine otters have been observed feeding together at fish refuse piles (Medina-Vogel *et al.* 2007) which has the potential of increasing exposure to direct and indirect anthropogenic threats (Castilla 1999; Medina-Vogel *et al*. 2004, 2008; Gaydos *et al.* 2007; Miller *et al.* 2008).

Given the paucity of information on the behavior, ecology, and conservation of marine otters throughout a large part of its continental distribution, our objectives were to (1) assess marine otter diet with a view to detect any latitudinal differences, and (2) assess marine otter activity budgets and interspecific interactions (including anthropogenic) at Peruvian fishing villages and to compare results with similar studies from Chile.

Methods

Study Area

Four distinct study sites, 54.7–111 km long and more than 100 km apart, along the Chilean Pacific seashore between 28.05°S and 39.67°S, and five distinct study sites in Peru, 0.2–21.0 km long and separated by 7–40 km of coastline between 17.64° and 18.05°S were sampled for otter spraints (Fig. 1).

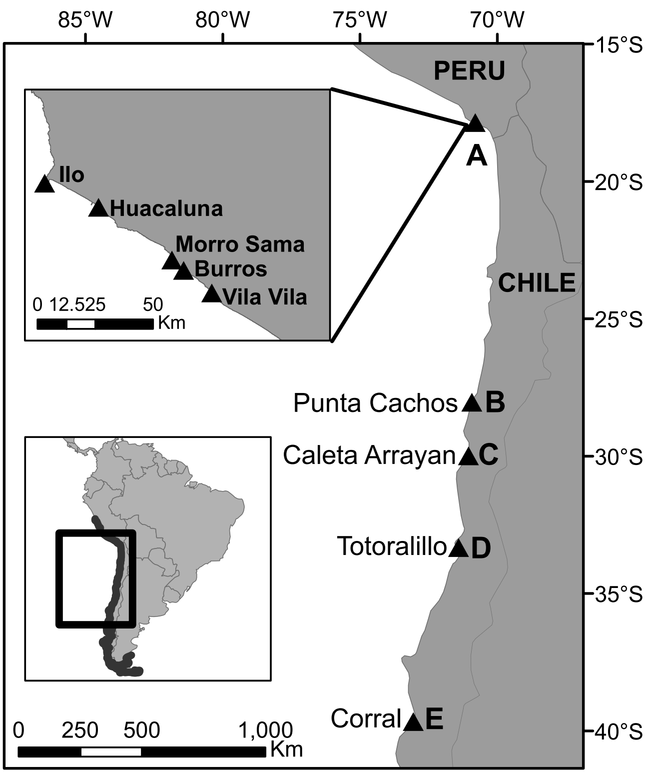

Figure 1. Locations of field sites for this study distributed along approximately 2,400 km of coastline in Peru and Chile. The upper inset map shows the five Peru study sites while the lower inset map shows the project area extent (black square) and the entire range of marine otters (in gray).

To obtain information on activity budgets and interactions with humans in Peru and for subsequent comparison with populations in Chile, otter observations were conducted from Morro Sama (17.98°S, 70.86°W) and Vila Vila (18.12°S, 70.71°W), two fishing villages in southern Peru separated by 23 km of rocky coastline (Fig. 1). Morro Sama and Vila Vila are active fishing ports with permanent human populations of approximately 200 and 350, respectively. Rats (*Rattus rattus*) as well as stray dogs and cats are common (Mangel, personal observation.). Both villages have developed around the placement of artificial breakwaters and fish processing facilities that have daily activity related to the arrival and departure of artisanal dive, net, and longline fishing vessels that use the ports as mooring and landing sites. Human activity is regular at both sites as are shore-based and nearshore fishing for fishes and invertebrates. These sites both possess resident groups of marine otters that use the breakwaters as den sites and forage in the vicinity of the ports.

Latitudinal Variation in Diet

Chilean sample sites were surveyed once between June 2005 and March 2006. For southern Peru, samples were collected at regular intervals from June 2003 to March 2009. Spraints were washed and dried at 75°C for 24–48 h and stored in paper bags (Bagenal 1978, Medina-Vogel *et al.* 2004). Spraints were analyzed for prey composition based on presence of fish or crustacean remains. Direct observations of otters feeding at the two Peruvian study sites were also made during focal follow observations (see *Human–Marine Otter Interactions* below). Prey were classified to genus or species when possible and grouped into broad categories (Table 1). Prey items that could not be identified because they were too small or were out of view, were classed as unidentified. Prey identification was guided by Chirinchigno and Cornejo (2001).

In order to compare with previous studies, data were expressed as frequency of occurrence (number of spraints in which a species occurred divided by the total number of spraints collected), and percentage of relative frequency (number of spraints in which a species occurred divided by the total occurrence of all species tested) (Medina 1997, 1998; Medina-Vogel *et al*. 2004).

Foraging dive durations were also recorded for the Peru study sites and compared with equivalent data from Curiñanco, Chile (39°30′S, 73°W) collected from December 1990 to December 1992 (Medina 1995*a*). Dive times were grouped and separated by site (Peru, Chile).

Table 1. Marine otter prey composition at Morro Sama (MS) and Vila Vila (VV), Peru based upon focal follow observations (MS $n = 513$; VV $n = 211$).

	Composition of otter prey (%)	
	MS	VV
Fish	40.6	48.2
Crab	29.3	20.3
Unidentified prey	13.6	29.2
Shrimp	15.2	1.4
Squid (bait)	1.0	0
Unidentified crustacean	0.2	0
Echinoderm	0	0.5
Mollusk	0.2	0

Human–Marine Otter Interactions

Focal samples were collected as a method of constructing activity budgets, estimating activity bout duration and assessing human–otter interactions. Observations were conducted from the breakwaters, docks, and coastline of Morro Sama and Vila Vila. Given the distance between sites and the known home range of marine otters (Medina-Vogel *et al*. 2007), they were considered independent. Monitoring was conducted by a total of 11 observers, with one to five observers per shift. Observers were professional biologists or trained undergraduate student volunteers. Observers used direct observation and 8 × 25 binoculars to aid in monitoring. Morro Sama was divided into 14 and Vila Vila into nine continuous, nonoverlapping zones approximately 50 m in length and delineated by natural or manmade markers. As the observation points selected were at locations with regular human activity related to port operation, the presence of observers did not result in otter fear or avoidance behavior. Monitoring was conducted during daylight hours (0600–1800) from October 2003 through November 2007 (excluding June and August 2004, January and February 2007, July through September 2007), for a total of 701 h at Morro Sama and 586 h at Vila Vila.

Otter behavior was categorized as foraging, traveling, socializing (intraspecific), interacting (interspecific), resting, or grooming (based upon Shimek and Monk 1977). Human–otter interactions in Morro Sama and Vila Vila study sites were assessed by (1) otter use intensity of the study sites zones, and (2) the level of human activity per zone. Human activity per zone was classified based upon the frequency of human use (constant daily activity, sporadic daily, infrequent) and the presence of permanent structures (docks, buildings, *etc*.) in the zone. Human activity was classified as low (no structures and infrequent activity), medium (permanent structures and sporadic daily activity), or high (permanent structures and constant daily activity).

Scan samples were collected in order to assess habitat use within the study areas and used the same activity categories and monitoring zones as focal follows. Two-minute scans were conducted every 10 min during daylight hours (0600–1800), in March and October through December in 2003, and January through April in 2004. A total of 553 scans were conducted over 9 d at Morro Sama and 8 d at Vila Vila. Only scans that had full coverage by observers of all study site zones were used in this analysis.

To standardize zone sizes, aerial photographs of each site were obtained from Google Earth and zone boundaries were demarcated. Relative area utilization frequency (controlled for different zone sizes) was then determined by multiplying the total number of observations per zone by the log transformed proportional zone size. Finally, the percent of time used by otters in each zone was determined by dividing the relative area utilization frequency of each zone by the total frequency.

Statistical tests were performed using SYSTAT v.12 (Systat Software, Inc., Chicago, Illinois).

RESULTS

Latitudinal Variation in Diet

There was a significant latitudinal variation in the relative importance of crustaceans (GLM for unbalanced design, $F_{1,3} = 23.4$, $P = 0.02$) and fish (GLM for

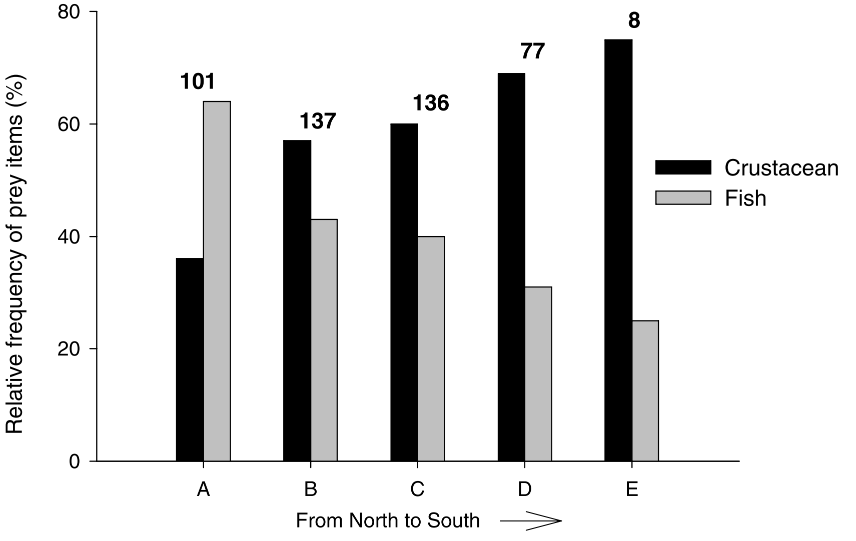

Figure 2. Diet composition given in relative frequency (RF%) by crustaceans and fish prey, found in fecal samples of marine otters collected in southern Peru (A) and four study sites in Chile (B–E). Sample size is shown for each sampled site.

unbalanced design, $F_{1,3} = 30.4$, $P = 0.01$) across the latitudinal range of the study such that the proportion of fish in the diet increased from south to north while the proportion of crustaceans declined from south to north (Fig. 2). Focal observations of the marine otter diet at the Peru study sites also indicated that prey consisted mainly of fishes followed by crabs (Table 1). Of 14 identified prey species, 10 were observed more than once. The most commonly identified prey item was deep red crab (*Petrolisthes desmarestii*), followed by rock crab (*Cancer setosus*), and rock shrimp (*Rhynchocinetes typus*), but also included queen rock crab *(Cancer coronatus*), sally lightfoot crab (*Grapsus grapsus*), and several fish species, including Peruvian jack mackerel, (*Trachurus murphyi*), Peruvian silverside (*Odontestes regia*), Peruvian morwong (*Cheilodectylus variagatus*), lorna drum (*Sciaena deliciosa, Doydixodon laevifrons*), damselfish (*Chromis* spp.), flounder (*Paralichthys* spp. and *Genypterus* spp.), rays from the family Rajidae, as well as discarded Humboldt squid (*Dosidicus gigas*) previously used as bait.

Human–Marine Otter Interactions

Focal follow data had equal variances (Bartlett test for equal variances $P = 0.52$), so a general linear model (GLM) for unbalanced designs and repeated measurements was used to assess for differences in behaviors, dive time, seasons, and study sites in Peru. As there were no differences between both Peruvian study sites ($F_{7,71} = 0.83$, $P = 0.43$), data were grouped and separated by season.

Assessment of activity budgets based upon focal follows in Morro Sama and Vila Vila indicated that foraging was the most frequently observed activity at both study sites followed by traveling and that these were significantly more frequent than all other behavior categories (GLM for unbalanced design, $F_{5,138} = 198.1$, $P < 0.01$). Otters at Morro Sama spent significantly less time traveling than otters at Vila Vila

Table 2. Frequency (%) of marine otter interactions with humans, fisheries, and other species ($n = 190$) as observed during 1,392 h of focal follows.

		Interaction type				
	Interaction with	Avoid/watch	Search/steal	Feeding	Fight/follow	Total
Human	Fishing gear	1.6	21.6	–	0.5	23.7
	Person	22.1	7.4	6.3	–	35.8
	Subtotal	23.7	28.9	6.3	0.5	59.5
Mammals	Stray cats	1.6	0.5	–	1.1	3.2
	Otaria byronia	0.5	–	–	–	0.5
	Subtotal	2.1	0.5	–	1.1	3.7
Seabirds	*Pelecanus thagus*	1.6	–	–	32.1	33.7
	Larus sp.	–	0.5	–	1.1	1.6
	Phalacrocorax bougainvilli	–	–	–	0.5	0.5
	Arenia sp.	–	–	–	1.1	1.1
	Subtotal	1.6	0.5	–	34.7	36.8

(Mann–Whitney $U_1 = 110$, $P = 0.03$), but more time foraging (Mann–Whitney $U_1 = 22$, $P = 0.04$).

Dive durations were compared between Peruvian and Chilean study sites. Results indicate that dive times were similar between study sites (GLM for unbalanced design, $F_{3,8} = 3.6$, $P > 0.16$), with average dive times of 27.9 ± 14.4 s ($n = 395$) in Peru and 33.3 ± 12.2 s ($n = 190$) in Chile.

Marine otter habitat usage by observation zones was assessed for each study site in Peru and compared with human activity classifications. In Morro Sama, otter presence was significantly higher in areas categorized by medium human presence (Kruskal–Wallis $H_2 = 6.2$, $P < 0.05$) but in Vila Vila, otter sightings did not vary in relation to intensity of human activity ($H_2 = 1.781$, $P = 0.41$; Fig. 3).

Focal follow observations of anthropogenic interactions included 113 recorded events, of which 45 (40%) were interactions with boats, and 68 (60%) were interactions with people (Table 2). This includes one instance when a marine otter was trapped in a fishing net. Of the interactions between marine otters and boats, 41 (91%) involved marine otters "searching" for food, which includes marine otters approaching boats and jumping into boats to forage for fish.

Interactions with pelicans (*Pelecanus thagus*) were frequent, with 64 events observed, including 60 instances of marine otters engaging in aggressive behavior toward pelicans. Events involving sea gulls (*Larus* spp.), guanay cormorants (*Phalacrocorax bougainvillii*), and black-crowned night herons (*Nycticorax nycticorax*) were rare, with only one-to-two interactions observed per genus. Similarly, there was only one observed interaction between a marine otter and a South American sea lion (*Otaria byronia*), which did not result in any harm to the otter.

There were six observed interactions with stray cats, including two observed fights and one observed instance of an otter stealing food from a cat. One otter kill as a result of a stray dog attack was recorded in Morro Sama in September 2008. There were no observed interactions with rats, but given their nocturnal behavior this was not unexpected. Nevertheless, rats have been seen exiting the manmade breakwater at Vila Vila during storm events.

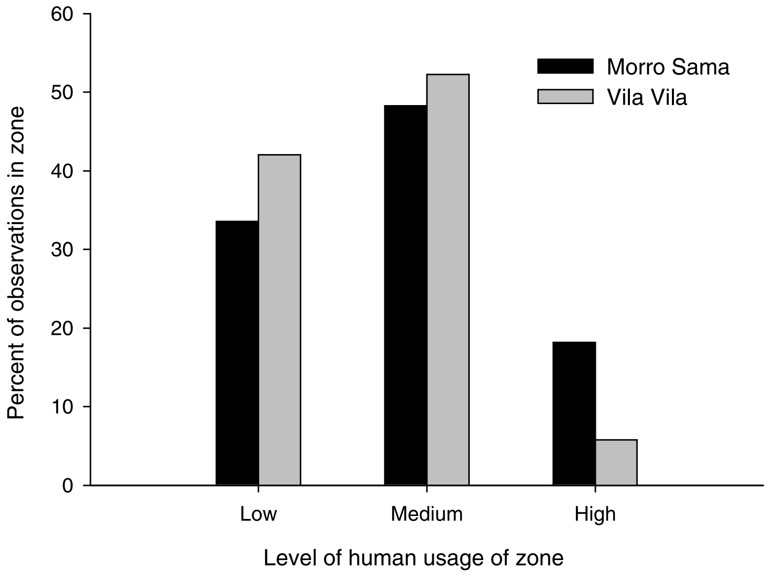

Figure 3. Habitat use by observation zones for Morro Sama and Vila Vila based upon scan sampling observations. Bars indicate the percent of total observation time otters were seen in zones grouped by level of human presence (low, medium, high).

Discussion

Latitudinal Variation in Diet

This study has shown that fish become more prevalent and crustaceans less prevalent in the diet of the marine otter as one moves north along its distribution (Medina-Vogel *et al.* 2008). Crustaceans are lower quality (in terms of energy) food for otters than fish (Kruuk 1995, Medina-Vogel *et al.* 2004, Medina-Vogel and González-Lagos 2008). Furthermore, at the Peruvian study sites we recorded less time spent foraging than in previous studies (Ostfeld *et al.* 1989, Medina 1995*a*) and a higher percentage of fish in the diet. The higher energy content of fish compared to crustaceans (Medina-Vogel *et al.* 2004) may contribute to this difference in activity patterns between this and previous studies, *i.e.*, otters at our study sites may more easily fulfill their energetic needs and therefore can spend less time foraging. Thus, we postulate that capture and handling time and effort of fish prey was not sufficiently costly at our study sites to render them less "valuable" than crustaceans, as previous studies suggested (Estes 1989, Medina-Vogel *et al.* 2004). Hence, toward the northern part of its range, marine otter habitat seems to be of better quality in terms of prey quality, which might be concentrating otters and leading to higher population densities (Medina-Vogel *et al.* 2007). Similar prey gradients have also been identified in other mammal species such as Eurasian otter (*Lutra lutra*; Clavero *et al.* 2003, Remonti *et al.* 2009), puma (*Felis concolor*, Iriarte *et al.* 1990), and genet (*Genetta genetta*, Virgós *et al.* 1999).

Study results also indicated that otters at Vila Vila spent more time traveling and less time foraging than otters at Morro Sama. The greater reliance of otters at

Morro Sama on lower quality shrimp prey could help account for the difference. The disparity may also be due in part to the fact that the main den locations in Vila Vila were situated further from foraging sites than in Morro Sama. Distance from dens to foraging sites has been suggested as an important habitat limitation for marine otters (Medina-Vogel *et al.* 2007, 2008) consequently, influencing the distribution of the species as individuals balance risks and net energy gain (Buskirk 1984, Weber 1989).

Human–Marine Otter Activity

This study found a large number of interactions between marine otters and other species, including humans. Interactions between seabirds and otters were the most frequent, perhaps due in part to competition for prey items. Otters, including marine otters, have also been shown to feed upon seabirds (Sheldon and Toll 1964, VanWagenen *et al.* 1981, Mattern *et al.* 2002, de la Hey 2008). Observed interactions between otters and anthropogenic activities support concerns over potential human impact on marine otters (Medina-Vogel *et al.* 2007, 2008). Based upon our observations, otters appear to have adjusted to living near fishing villages in Peru, as in other fishing villages in Chile (Medina-Vogel *et al.* 2007). However, with otters stealing fish from nets and boats (including one occasion of an otter entangled in a fishing net) and interaction with populations of stray cats and dogs—whether through agonistic encounters, indirect competition, or disease transmission (Davis *et al.* 1972, Kimber and Kollias 2000, Funk *et al.* 2001, Butler *et al.* 2004) there could be detrimental effects that threaten marine otters population survival (Medina-Vogel *et al.* 2007, Medina-Vogel 2010). Infectious diseases, possibly associated with nearby terrestrial human development have been posited as impeding the population recovery of the southern sea otters, *Enhydra lutris nereis* (Conrad *et al.* 2005, Miller *et al.* 2008, Johnson *et al.* 2009). Moreover, recent declines in European populations of the Eurasian otter have been attributed, in varying degrees, to anthropogenic impacts such as pollution, habitat loss, persecution, and accidental mortality (Macdonald 1983, Macdonald and Mason 1994, Cortés *et al.* 1998, Barbosa *et al.* 2001, Prenda *et al.* 2001).

Because marine otters demonstrate apparent tolerance to living alongside fishing communities (and may actually be attracted to habitat altered by fishing communities), these anthropogenic threats could turn some of these small rocky seashore patches into population sinks. However, the overlap between marine otters and fishing villages also demonstrates the flexibility of marine otter behavior toward people. Thus, if the artificial otter habitats made by wharfs, breakwaters, and shipwrecks are correctly managed in terms of otters habitat needs, they could be used as stepping stones between rocky seashore patches already separated by human dominated environments (Meegan and Maehr 2002, Wikramanayake *et al.* 2004, Medina-Vogel *et al.* 2008). The construction of a set of small artificial otter habitats along more isolated regions of rocky seashore could also be a strategy for marine otter conservation. Additional studies of marine otter ranging behavior (Medina-Vogel *et al.* 2007) and population densities (Medina-Vogel *et al.* 2006) in the northern portion of the species' range would help further characterize environmental limits for this species. The existence of a latitudinal gradient in marine otter diet also highlights the need for additional research into marine otter prey selection and the potential for overlap with commercially exploited species (Medina-Vogel *et al.* 2004).

Acknowledgments

We warmly thank all the volunteers that participated in this project: M. Pajuelo, J. Valqui, G. Biffi, P. Melly, and D. Apaza. We also thank Dr. Rick Ostfeld for his helpful advice regarding project design in Peru. Helpful comments and suggestions on the manuscript were provided by the editor and two anonymous reviewers as well as by Dr. Lisa Ballance and Luke Gibson. Support and funding for this work was provided by Columbus Zoo and Aquarium, Darwin Initiative, Fulbright Commission, Societe D'Encouragement pour la Conservation des Animaux Sauvages, and People's Trust for Endangered Species. The marine otter project in Peru is a World Association of Zoos and Aquariums (WAZA) branded project. JCM and JAS are Overseas Research and Students Awards Scheme and University of Exeter scholarship awardees, respectively. Studies in Chile were funded by Rufford Small Grants for Nature Conservation and Project DI-01-09/R Universidad Andrés Bello. Permits for this study were provided by INRENA (No. 084-2004-IFFS-DCB).

Literature Cited

Alvarez, R., and G. Medina-Vogel. 2008. *Lontra felina*. IUCN Red List of Threatened Species. Version 2009.1. Available at http://www.iucnredlist.org (accessed 7 July 2009).

Bagenal, T. 1978. Methods for assessment of fish production in freshwater. Handbook No. 3. International Biological Program. 3rd edition. Blackwell Scientific Publications Ltd., Oxford, UK.

Barbosa, A. M., R. Real, A. L. Márquez and M. A. Ángel Rendon. 2001. Spatial, environmental and human influences on the distrbution of otter (*Lutra lutra*) in the Spanish provinces. Diversity and Distributions 7:137–144.

Brownell, R. L., Jr. 1978. Ecology and conservation of the marine otter *Lutra felina*. Pages 104–106 *in* N. Duplaix, ed. Otters: Proceedings of the First Working Meeting of the Otter Specialist Group. International Union for Conservation of Nature and Natural Resource, Moreges, Switzerland.

Buskirk, S. W. 1984. Seasonal use of resting sites by marten in south-central Alaska. Journal of Wildlife Management 48:950–953.

Butler, J. R. A., J. T. Toit and J. Bingham. 2004. Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: Threats of competition and disease to large wild carnivores. Biological Conservation 115:369–378.

Cabello, C. C. 1978. La nutria del mar (*Lutra felina*) en la Isla de Chiloe, Chile. Pages 108–111 *in* N. Duplaix, ed. Otters: Proceedings of the First Working Meeting of the Otter Specialist Group. International Union for Conservation of Nature and Natural Resource, Moreges, Switzerland.

Cabello, C. C. 1983. La nutria del mar en la Isla de Chiloé. Corporación Nacional Forestal, Boletín Técnico 6:1–37.

Castilla, J. C. 1982. Nuevas observaciones sobre conducta, ecología y densidad de *Lutra felina* (Molina 1782) (Carnívora: Mustelidae) en Chile. Museo Nacional de Historia Natural (Santiago, Chile), Publicación Ocasional 38:187–206.

Castilla, J. C. 1999. Coastal marine communities: Trends and perspectives from human exclusion experiments. Tree 14:280–283.

Castilla, J. C., and I. Bahamondes. 1979. Observaciones conductuales y ecológicas sobre *Lutra felina* (Molina 1782) (Carnívora: Mustelidae) en las zonas Central y Centro Norte de Chile. Archivos de Biologia y Medicina Experimentales (Santiago, Chile) 12:119–132.

Chirinchigno, N., and R. M. Cornejo. 2001. Catálogo comentado de los peces marinos del Perú. Instituto del Mar del Perú. Publicación Especial.

Clavero, M., J. Prenda and M. Delibes. 2003. Trophic diversity of otter (*Lutra lutra* L.) in temperate and Mediterranean freshwater habitats. Journal of Biogeography 30:761–769.

Conrad, P. A., M. A. Miller, C. Kreuder, E. R. James, J. Mazet, H. Dabritz, D. A. Jessup, F. Gulland and M. E. Grigg. 2005. Transmission of *Toxoplasma*: Clues from the study of sea otters as sentinels of *Toxoplasma gondii* flow into the marine environment. International Journal of Parasitology 35:1155–1168.

Cortés, Y., R. Fernández-Salvador, F. J. García, E. Virgós and M. Lorente. 1998. Changes in otter *Lutra lutra* distribution in central Spain in the 1964–1995 period. Biological Conservation 86:179–183.

Davis, J. W., L. H. Karstad and D. O. Trainer. 1972. Enfermedades infecciosas de los mamíferos salvajes. Editorial Acribia, Zaragoza, Spain.

de la Hey, D. C. 2008. The importance of birds in the diet of otter *Lutra lutra* on Shapwick Heath. Bioscience Horizons 1:143–147.

Estes, J. A. 1989. Adaptations for aquatic living by carnivores. Pages 242–282 *in* L. L. Gittleman, ed. Carnivore behavior, ecology, and evolution. Cornell University Press, New York, NY.

Funk, S. M., C. V. Fiorello, S. Cleaveland and M. E. Gompper. 2001. The role of disease in carnivore ecology and conservation. Pages 443–466 *in* J. L. Gittleman, S. M. Funk, D. Macdonald and R. K. Wayne, eds. Carnivore conservation. Cambridge University Press, Cambridge, UK.

Gaydos, J. K., P. A. Conrad, V. K. Gilardi, G. M. Blundell and M. Ben-David. 2007. Does human proximity affect antibody prevalence in marine foraging river otters (*Lontra canadensis*)? Journal of Wildlife Diseases 43:116–123.

Iriarte, J. A., and F. M. Jaksić. 1986. The fur trade in Chile: An overview of seventy-five years of export data (1910–1984). Biological Conservation 38:243–253.

Iriarte, J. A., W. L. Franklin, W. E. Johnson and K. H. Redford. 1990. Biogeographic variation of food habits and body size of the American puma. Oecologia 85:185–190.

Iriarte, J. A., P. Feinsinger and F. M. Jaksić. 1997. Trends in wildlife use and trade in Chile. Biological Conservation 81:9–20.

IUCN. 2008. 2008 IUCN Red List of Threatened Species. Available at http://www.iucnredlist.org (accessed 30 October 2008).

Johnson, C. K., M. T. Tinker, J. A. Estes, P. A. Conrad, M. Staedler, M. A. Miller, D. A. Jessup and J. A. Mazet. 2009. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system. Proceedings of the National Academy of Science of the United States of America 106:2242–2247.

Kimber, K. R., and G. V. Kollias. 2000. Infectious and parasitic diseases and contaminant-related problems of North American river otters (*Lontra Canadensis*): A review. Journal of Zoo and Wildlife Medicine 31:452–472.

Kruuk, H. 1995. Wild otters: Predation and populations. Oxford University Press, Oxford, UK.

Larivière, S. 1998. *Lontra felina*. Mammalian Species 575:1–5.

Macdonald, S. M. 1983. The status of the otter (*Lutra lutra*) in the British Isles. Mammal Review 13:11–23.

Macdonald, S. M., and C. F. Mason. 1994. Status and conservation needs of the otter (*Lutra lutra*) in the western Palaearctic. Nature and Environment 67, Council of Europe, Strasbourg, France.

Mattern, T., U. Ellenberg and G. Luna-Jorquera. 2002. A South American otter *Lontra felina* preys upon chicks of the Perúvian diving petrel *Pelecanoides garnotii*. Marine Ornithology 30:95–96.

Medina, G. 1995*a*. Feeding habits of marine otter (*Lutra felina*) in southern Chile. Pages 65–68 *in* C. Reuther and C. D. Rowe-Rowe, eds. Proceedings of the VI International Otter Colloquium, 6–10 September 1993, Pietermaritzburg, South Africa. Habitat No. 11, Hankensbüttel, Germany.

Medina, G. 1995*b*. Activity budget and social behaviour of marine otter (*Lutra felina*) in southern Chile. Pages 62–64 *in* C. Reuther and C. D. Rowe-Rowe, eds. Proceedings of the VI International Otter Colloquium, 6–10 September 1993, Pietermaritzburg, South Africa. Habitat No. 11, Hankensbüttel, Germany.

Medina, G. 1997. A comparison of the diet and distribution of southern river otter (*Lutra provocax*) and mink (*Mustela vision*) in Southern Chile. Journal of Zoology (London) 242:291–297.

Medina, G. 1998. Seasonal variations and changes in the diet of southern river otter in different freshwater habitats in Chile. Acta Theriologica 43:285–292.

Medina-Vogel, G. 2010. Ecología de enfermedades infecciosas emergentes y conservación de especies silvestres. Archivos de Medicina Veterinaria 42:11–24.

Medina-Vogel, G., and C. González-Lagos. 2008. Habitat use and diet of endangered southern river otter in a predominantly palustrine wetland in Chile. Wildlife Biology 14:211–220.

Medina-Vogel, G., C. Delgado, R. Alvares and J. L. Bartheld. 2004. Feeding ecology of the marine otter (*Lutra felina*) in a rocky seashore of the south of Chile. Marine Mammal Science 20:134–144.

Medina-Vogel, G., J. L. Bartheld, R. Alavarez Pacheco and C. Delgado Rodríguez. 2006. Population assessment and habitat use by marine otter *Lontra felina* in southern Chile. Wildlife Biology 12:191–199.

Medina-Vogel, G., F. Boher, G. Flores, A. Santibañez and C. Soto-Azat. 2007. Spacing behavior of marine otters (*Lontra felina*) in relation to land refuges and fishery waste in central Chile. Journal of Mammalogy 88:487–494.

Medina-Vogel, G., L. O. Merino, R. Monsalve Alarcón and J. Vianna. 2008. Coastal-marine discontinuities, critical patch size and isolation: Implications for marine otter conservation. Animal Conservation 11:57–64.

Meegan, R. P., and D. S. Maehr. 2002. Landscape conservation and regional planning for the Florida panther. Southeastern Naturalist 1:217–232.

Miller, M. A., W. A. Miller, P. A. Conrad, E. R. James, A. C. Melli, C. M. Leutenegger, A. E. Dabritz, A. E. Packham, D. Paradies, M. Harris, J. Ames, D. A. Jessup, K. Worcester and M. E. Grigg. 2008. Type X *Toxoplasma gondii* in a wild mussel and terrestrial carnivores from coastal California: New linkages between terrestrial mammals, runoff and toxoplasmosis of sea otters. International Journal of Parasitology 38:1319–1328.

Moreno, C. 2001. Community patterns generated by human harvesting of Chilean shores: A review. Aquatic Conservation 11:19–30.

Moreno, C., J. Sutherland and F. Jara. 1984. Man as a predator in the intertidal zone of southern Chile. Oikos 42:155–160.

Ostfeld, R. S., L. Ebensperger, L. L. Klosterman and J. C. Castilla. 1989. Foraging, activity budget, and social behavior of the South American marine otter *Lutra felina* (Molina 1782). National Geographic Research 5:422–438.

Prenda, J., P. López-Nieves and R. Bravo. 2001. Conservation of otter (*Lutra lutra*) in a Mediterranean area: The importance of habitat quality and temporal variation in water availability. Aquatic Conservation: Marine and Freshwater Ecosystems 11:343–355.

Remonti, L., A. Balestrieri and C. Prigioni. 2009. Altitudinal gradient of Eurasian otter (*Lutra lutra*) food niche in Mediterranean hábitats. Canadian Journal of Zoology 87:285–291.

Sheldon, W. G., and W. G. Toll. 1964. Feeding habits of the river otter in a reservoir in central Massachusetts. Journal of Mammalogy 45:449–455.

Shimek, S. J., and A. Monk. 1977. Daily activity of sea otters off Monterey Peninsula, California. Journal of Wildlife Management 41:277–283.

VanWagenen, R. F., M. S. Foster and F. Burns. 1981. Sea otter predation on birds near Monterey, California. Journal of Mammalogy 62:433–434.

Virgós, E., M. Llorente and Y. Cortés. 1999. Geographical variation in genet (*Genetta genetta L.*) diet: A literature review. Mammal Review 29:119–128.

Weber, D. 1989. The ecological significance of resting sites and the seasonal habitat change in polecats (*Mustela putorious*). Journal of Zoology (London) 217:629–638.

Wikramanayake, E., M. McKnight, E. Dinerstein, A. Joshi, B. Gurung and D. Smith. 2004. Designing a conservation landscape for tigers in human-dominated environments. Conservation Biology 18:839–844.

Received: 9 March 2010
Accepted: 21 May 2010