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Source: Waterbirds, 35(2):230-238. 2012.

Published By: The Waterbird Society

URL: <http://www.bioone.org/doi/full/10.1675/063.035.0205>

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Environmental Factors Affecting the Distribution of the Red-legged Cormorant in Argentina: A Regional Scale Approach

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Abstract.—Red-legged Cormorants (*Phalacrocorax gaimardi*) breed along a broad stretch of the Pacific coast and a section of the Argentinian coast on the Atlantic Ocean. To understand factors that might determine the breeding range along Argentina, physical and environmental characteristics of cliffed coastlines used by Red-legged Cormorants were compared with those not used. Red-legged Cormorant colonies were found in longer cliffed coastlines (mostly longer than 250 m) with shallow waters (median depth = 12 m) and high sea productivity close to the coast (median chlorophyll *a* concentration = 4.4 mg/m³). Within the Red-legged Cormorants' breeding range the probability of occurrence of their colonies increased with the length of the cliffed coastline and decreased with the median sea depth around the colony. Mixed colonies were found in coastal areas with cliffs where the seawater close to shore was deeper (deeper than = 13 m). North of its distribution, sea productivity close to the coast was lower (median chlorophyll *a* concentration = 1.6 mg/m³) than within its distribution, and cliff faces were more exposed to the strong prevailing winds, which can blow eggs and chicks from their nests. South of its distribution, the climatic characteristics were more adverse to breeding success: higher precipitation, lower ambient temperature, and higher wind speed than within its distribution. At this scale of study (regional), new aspects of habitat structure of the Red-legged Cormorant, such as sea primary production, water depths and climatic features, were indentified. All these aspects could be affecting habitat selections by this species. *Received 1 July 2011, accepted 16 December 2011.*

Key words.—Argentina, breeding range, environmental conditions, *Phalacrocorax gaimardi*, Red-legged Cormorant.

Waterbirds 35(2): 230-238, 2012

For seabirds, the food sources and the availability of suitable nesting habitats are important factors determining their distribution (Bried and Jouventin 2002; Hamer *et al.* 2002). Breeding sites are usually associated with specific characteristics over their geographic range (Buckley and Buckley 1980). A suitable nesting habitat has to provide adequate nesting substrate and offer protection against predators (Buckley and Buckley 1980; Bried and Jouventin 2002). At a local or site scale, these two characteristics are important determinants of breeding habitat use (Bried and Jouventin 2002; Cueto 2006). At a regional scale, long-term effects of weather and oceanic processes can influence breeding habitat use and seabird distribution along the coast (Hunt and Schneider 1987; Schreiber and Burger 2002). The scale at which the habitat of seabirds is measured influences what patterns of habitat use and selection are detected and what underlying processes can be inferred from them (Wiens *et al.* 1986;

Orians and Wittemberg 1996). To determine what aspects of habitat structure birds select, a design that includes a nested hierarchy of scales that encompass the range of habitat parameters to which birds may respond is a useful approach (Maurer 1985; Cueto 2001).

The Red-legged Cormorant (*Phalacrocorax gaimardi*) is listed as near threatened (BirdLife International 2008). Individuals of this species breed along the Pacific coast from Northern Peru to Southern Chile, and along the Atlantic coast, where its range is restricted to Santa Cruz Province, Argentina (Zavalaga *et al.* 2002; Frere *et al.* 2004). In Argentina, Red-legged Cormorants breed in 13 localities, building their nests on steep (80-90°, mainly) and high (more than 5 m) cliffs. Individuals feed primarily on fish in inshore waters of less than 10-15 m depth and within three km of the colony (Gandini *et al.* 2005; Frere *et al.* 2008). In Chile and Peru, the distribution of Red-legged Cormorants is attributed to the availability of nesting habitat along the coast (Zavalaga *et al.* 2002; Frere

et al. 2004). In Chile, the coastal development and the occurrence of El Niño Southern Oscillation (ENSO) events may affect the breeding distribution (Frere *et al.* 2004).

Our research group started studying the Red-legged Cormorant's pattern of habitat use ten years ago. Since we knew that birds may respond to variations in habitat structure in a hierarchy of scales (Maurer 1985; Kolasa and Pickett 1991), we studied the breeding habitat use by Red-legged Cormorants at different spatial scales. First, we studied breeding site use and found that protection from predators (steep cliffs with small outcrops), availability of usable surface (cliffs with ledges, outcrops or caves), protection from prevailing winds and the effect of sea waves are factors related to differential nesting site use (Millones *et al.* 2008). Secondly, we examined the availability and use of breeding habitats by Red-legged Cormorants at a local spatial scale (Ría Deseado, Argentina). We identified protection from predators and proximity to abundant food as factors involved in habitat selection (Millones *et al.* 2010). Given that a large ecological scale is more useful for finding general patterns than a small scale (a small scale is more useful for further assessing the underlying mechanisms) (Cueto 2006), we included here the study of the habitat use of Red-legged Cormorants at a regional scale. In order to understand regional scale factors that might determine the breeding range of Red-legged Cormorants along the Argentinian coast, we (1) examined differences in physical and environmental characteristics of cliffed coastlines used and unused by the species inside its breeding range; and (2) compared the characteristics of the coastal area within and outside its breeding range.

METHODS

During breeding periods (September-February) from 2001 to 2005, we visited twelve Red-legged Cormorant colonies along Santa Cruz province, Argentina (Fig. 1). We observed that cliffs extended beyond the immediate location of a colony, and that more than one cliff could be used for a single colony; therefore, we use the term "cliffed coastline" to refer to the entire length of the cliff or group of cliffs. We established the lim-

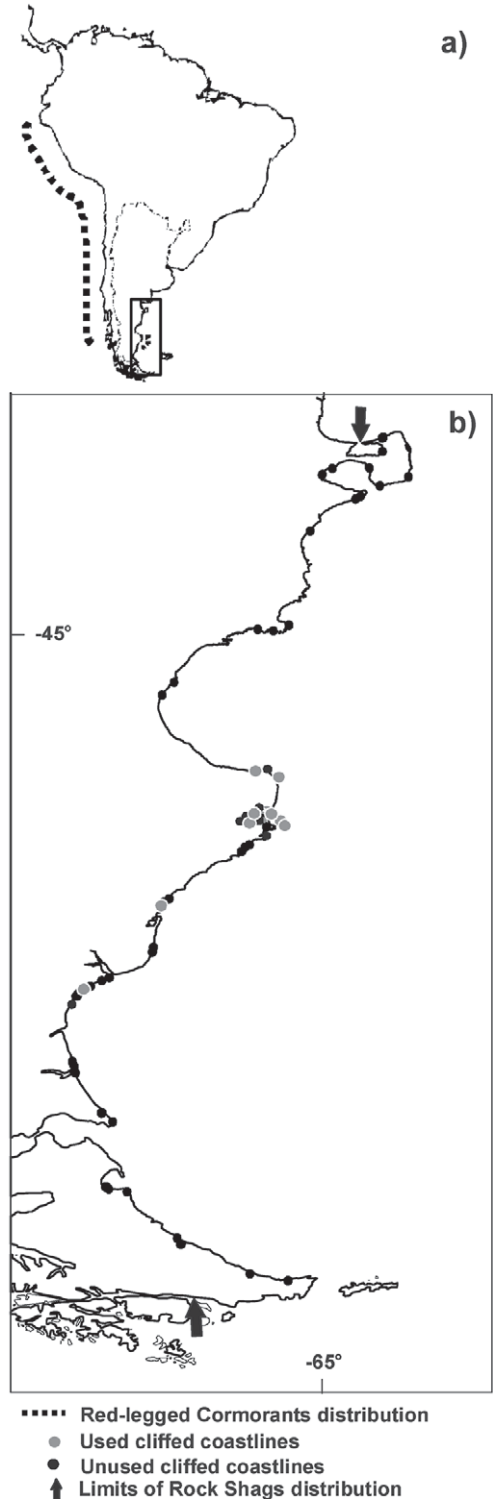


Figure 1. a) Breeding distribution of the Red-legged Cormorant; b) Geographic location of cliffed coastlines used and unused by Red-legged Cormorant colonies along the Santa Cruz Province, Argentina.

its of each cliffed coastline such that no other cliff was closer than 100 m (Fig. 2). For each cliffed coastline, we recorded geographic location, principal orientation (recorded as degrees in the field and then analyzed according to eight principal compass directions), and length (recorded with a GPS in the field).

For each geographic location of the cliffed coastlines and for each study breeding season, we obtained daily climatic data (six-hourly archive data with one-degree spatial resolution): wind direction, wind speed, ambient temperature and accumulated precipitation. Data were obtained from the Archived Meteorology NOAA's Air Resources Laboratory (Ready Web Server). With these data, we were able to estimate prevailing wind direction, mean wind speed, mean ambient temperature and mean accumulated precipitation at each cliffed coastline over the studied breeding periods. Also, we estimated protection from prevailing winds as a categorical variable. A protection level equal to 1

corresponded to a cliffed coastline faced into prevailing wind direction, whereas a protection level equal to 5 indicated a cliffed coastline completely protected from prevailing winds (Fig. 2). For each of the five breeding study periods, we obtained weekly sea surface temperature data in front of each cliffed coastline location, and a mean surface temperature for the five breeding periods was calculated. Sea surface temperature data were obtained from the Physical Oceanography Distributed Active Archive Center Web (PO. DAAC) with a resolution of 18 km.

As Red-legged Cormorants feed mainly within three km of the colony (Gandini *et al.* 2005), we studied the bathymetry within 3 km of each colony, using digital Nautical Charts from the Servicio de Hidrografía Naval de la República Argentina. For each colony location, and over each digital chart, we created a grid of points (a total of 40 points) over a radius of 3 km (buffer surrounding the colony). For each point we recorded the depth and then estimated the median depth for all the radii. As we knew that Red-legged Cormorants feed in waters of less than 15 m depth, we also obtained the proportion of points with depths shallower than 15 m for all the radii.

As an index of mean ocean primary production around the colony, we obtained chlorophyll *a* concentration (mg/m³) data in the sea. Although there are algorithms for estimating primary productivity from chlorophyll (Behrenfeld *et al.* 2005), the necessary parameters are poorly defined for shallow coastal areas, such as our study area. As we were interested in spatial patterns of relative production rather than absolute values, we used chlorophyll *a* concentration (Boersma *et al.* 2009) directly. For each of the five breeding study periods we obtained weekly average chlorophyll *a* concentration data close to the coast in front of each cliffed coastline location. Values were obtained from chlorophyll *a* concentration images (of 9 km resolution), created by the SeaWiFS project and the Distributed Active Archive Center of Goddard Space Flight Center, NASA. After this, a mean chlorophyll *a* concentration for the five breeding periods was calculated.

At the beginning of each study breeding season, at each colony, we recorded the number of Red-legged Cormorant active nests by direct counts. Some counts were made from a boat at sea, and others were made from clifftops ashore. Also, the presence or absence of other nesting cormorant or shag species in the same area was recorded.

To study the differences in characteristics of cliffed coastlines used and unused by the Red-legged Cormorant, we recorded the geographic location of all unused, but apparently suitable, cliffed coastlines. Based on our previous studies about breeding site characteristics of Red-legged Cormorants (Millones *et al.* 2008, 2010), we considered suitable cliffed coastlines to be all steep and high cliffs (more than 5 m), or sets of cliffs with the sea just below. Digital satellite images (Image 2008 Digital Globe, Google TM), and the "3D" tool from the Google Earth 5.1 Program, were used to identify the suitable cliffed coastlines. We validated our selections by visiting

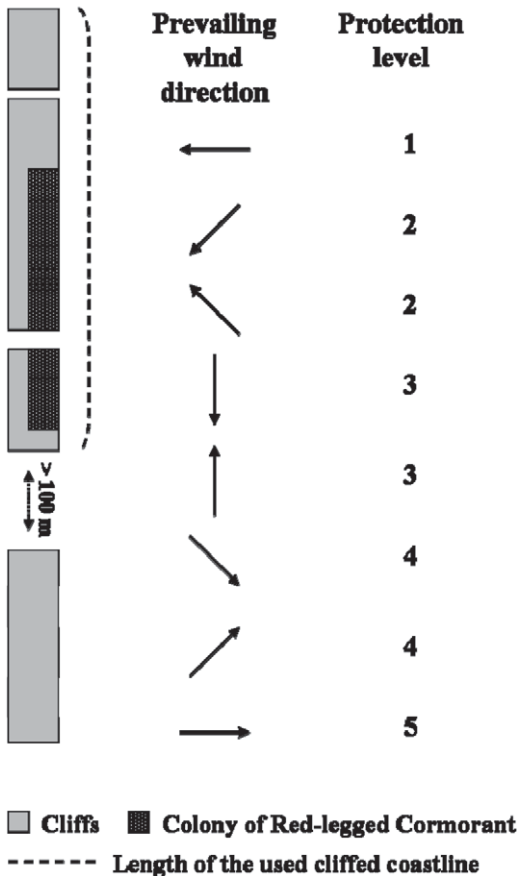


Figure 2. Illustration of how we established the limits of a cliffed coastline and protection levels from prevailing winds. Lengths of used cliffed coastlines by Red-legged Cormorants are determined by including segments spaced less than 100 m apart. The level of protection increases as the cliffs are less exposed to prevailing winds.

some of them and comparing them with nearby previously visited cliffs of known slope and height. We knew that Red-legged Cormorants did not use those cliffed coastlines because several aerial surveys had been completed along the coast between 2001 and 2005 (Frere *et al.* 2005). Once identified, we recorded principal orientation, length, protection level, median depths within radii of three km, and the proportion of points with depths shallower than 15 m for each of those cliffed coastlines.

To compare coastal area characteristics within and outside the breeding range of Red-legged Cormorants, we compared characteristics of cliffed coastlines used by the species and those unused but suitable cliffed coastlines outside of its breeding range (north and south, separately). To record the location of all unused, but suitable, cliffed coastlines that were outside of their breeding range, once again we used digital satellite images (Image 2008 Digital Globe, Google TM). Only the section of the Argentinian coast over which Rock Shags (*Phalacrocorax magellanicus*) are distributed was considered (Fig. 1). Rock Shags have ecological requirements similar to those of the Red-legged Cormorant (Frere *et al.* 2008) but are more widely distributed along the Argentinian coast (Frere *et al.* 2005; Millones *et al.* 2008). Of all suitable cliffed coastlines identified outside of the breeding range of the Red-legged Cormorant, 30 cliffed coastlines were chosen randomly for comparisons (15 north and 15 south) (Fig. 1). For each of the 30 unused cliffed coastlines, we recorded cliff characteristics (orientation, length and protection level) and environmental characteristics (median depths within radii of three km, proportion of points with depths shallower than 15 m, climatic features, sea surface temperature and chlorophyll *a* concentration).

Data Analyses

To determine which variables best explained the presence or absence of Red-legged Cormorant colonies in cliffed coastlines within its geographic range, we considered only those characteristics with high enough resolution to show variations between neighboring cliffed coastlines: cliff length, cliff orientation, median water depth within three km of the cliff, proportion of points with depths shallower than 15 m and protection from prevailing winds. We did not consider those characteristics with resolution insufficient for discrimination between neighboring cliffed coastlines: climatic characteristics, sea surface temperature and chlorophyll *a* concentration. We performed generalized linear models with binomial error and logit link function (Crawley 2007). We used presence or absence of Red-legged Cormorant colonies within their breeding range as response variables, and cliff length, cliff orientation, median water depth within 3 km of the cliff, proportion of points with depths shallower than 15 m, and protection from prevailing winds as explanatory variables. Akaike's Information Criterion, with the small-sample bias adjustment (AIC_c), was used to choose the models that best fit the data (Burnham and Anderson 2002). We compared candidate models (all subsets or all possible

combinations of our five explanatory variables) using ΔAIC_c , as the difference between the AIC_c for each respective model and the lowest AIC_c observed (Burnham and Anderson 2002). Also, we computed the Akaike weight, which can be considered the weight of evidence supporting the model (Burnham and Anderson 2002). We selected the model with the lowest AIC_c score as the best model.

To compare coastal area characteristics within and outside (north and south) the Red-legged Cormorant breeding range, we used Kruskal-Wallis analyses. Post-hoc tests (Dunn's test) were used in case of significant Kruskal-Wallis analyses.

RESULTS

Red-legged Cormorants used cliffed coastlines whose lengths ranged from 93 to 950 m. The number of active nests in each colony ranged from three to 415, and was not correlated with used cliffed coastline length ($r = -0.1$, $P = 0.92$). Used cliffed coastlines did not show a dominant orientation (Rayleigh test; $Z = 0.5$, n.s.). Climatic features varied between localities. Mean ambient temperature ranged from 13° to 9°C and was positively correlated with latitude ($r = 0.95$, $P < 0.001$). Dominant winds blew from the SW-NW quadrant, but their mean intensity varied between localities, ranging from 10 to 13 knots. Mean sea depth within 3 km of each colony ranged from 6 to 24 m, and mean sea surface temperature in front of each colony from 9 to 12°C. Chlorophyll *a* concentration in front of each colony varied between 3 and 5 mg/m³.

Within the Red-legged Cormorant distribution, we identified 20 not used, but suitable, cliffed coastlines. Physical and environmental characteristics of used and not used cliffed coastlines are summarized in Table 1. The best model describing the presence or absence of Red-legged Cormorant colonies in cliffed coastlines, within the breeding range of the species, included the variables length (L) and median sea depth (MSD) (Table 2). According to this model, the probability of occurrence of Red-legged Cormorant colonies in cliffed coastlines increased with L and decreased with the MSD within radii of 3 km (Table 3). The second- and third-ranked models had substantial support with $\Delta AIC_c < 1$. These mod-

Table 1. Characteristics (means) of cliffed coastlines used and unused by Red-legged Cormorants. Used and unused cliffed coastlines did not show a dominant orientation (both Rayleigh test; n.s.).

Variable	Used cliffed coastlines	Unused cliffed coastlines
Length (m)	457 ± 448	214 ± 222
Sea depth within radii of 3 km (m)	14 ± 5	21 ± 10
Proportion of points with depths shallower than 15 m (%)	57 ± 21	33 ± 27
Protection level from prevailing winds	3 ± 1	3 ± 1

Table 2. Model selection results for the nine highest-ranked candidate models that explain the presence or absence of Red-legged Cormorant colonies in cliffed coastlines along their geographic range.

Model	LogLik	Parameters	AIC _c	ΔAIC _c	AIC _c Weight
L+MSD	-10.41	3	27.79	0.00	0.23
L+MSD+ PDS15+ PLW	-7.74	5	28.09	0.30	0.19
L+MSD+ PLW	-9.34	4	28.35	0.56	0.17
L+OR+MSD+ PLW	-8.08	5	28.77	1.00	0.14
L+OR+ PDS15+ PLW	-8.90	5	30.41	2.62	0.06
L+OR	-11.80	3	30.57	2.78	0.06
CL+ PDS15+ PLW	-10.53	4	30.73	2.94	0.05
CL+OR+ PLW	-11.57	4	32.81	5.02	0.02
CL+ PDS15	-13.07	3	33.11	5.32	0.01

CL: chlorophyll *a* concentration; L: length; MSD: median sea depth within radii of 3 km; PDS15: proportion of depths shallower than 15 m; PLW: Protection level from prevailing winds; OR: orientation.

Table 3. Estimated parameters for the three highest-ranked models, relating the length (L), median sea depth within radii of 3 km of the cliffed coastlines (MSD), proportion of depths shallower than 15 m (PDS15) and protection level from prevailing winds (PLW) to the occurrence of Red-legged Cormorant colonies.

Variable	Model 1			Model 2			Model 3		
	Parameter estimate	SE	<i>P</i>	Parameter estimate	SE	<i>P</i>	Parameter estimate	SE	<i>P</i>
Intercept	0.33	1.25	—	7.97	10.04	—	7.44	5.79	—
L	0.01	0.003	0.03	0.01	0.01	0.16	0.01	0.01	0.06
MSD	-0.17	0.07	0.022	-0.09	0.17	0.58	-0.19	0.11	0.08
PDS15	—	—	—	0.08	0.05	0.10	—	—	—
PLW	—	—	—	-7.90	6.41	0.22	-4.38	3.29	0.18

els also included L and MSD as explanatory variables, plus proportion of depths shallower than 15 m (PDS15) and protection level from prevailing winds (PLW) (Table 2).

In seven localities, Red-legged Cormorants were found nesting with one or two other species of cormorants, Rock Shags and Imperial Cormorants (*Phalacrocorax atriceps*). In these localities, we observed that MSD was significantly higher than in the localities where Red-legged Cormorants were nesting alone (19 m and 12 m respectively; Mann-Whitney *U* test = 5.0, *P* = 0.041). No significant differences were found for the rest of the variables (Mann-Whitney *U* tests; all *P* > 0.05)

When we compared differences in coastal area characteristics within (*N* = 12) and outside (*N*_{north} = 15, *N*_{south} = 15) the Red-legged Cormorant breeding range (Fig. 1), we observed significant differences. South of its breeding range, ambient temperature was significantly lower than within its breeding range, whereas accumulated precipitation and wind speed were significantly higher than within of its breeding range (Dunn's Multiple Comparisons, *P* < 0.05) (Table 4). Within and south of its range, the most frequent wind directions were SW-NW ($\chi^2_7 = 62$, *P* < 0.001, $\chi^2_7 = 147$, *P* < 0.001, respectively), whereas north of its breeding range the most

frequent wind directions were SW and NE ($\chi^2_7 = 56$, $P < 0.001$). North of its breeding range, the protection level from prevailing winds was lower than that within its breeding range (Dunn's Multiple Comparisons, $P < 0.05$) (Table 4). North of its breeding range, sea surface temperature was significantly higher than within its breeding range (Dunn's Multiple Comparisons, $P < 0.05$) (Table 4). Moreover, chlorophyll *a* concentration to the north of the Red-legged Cormorant breeding range was significantly lower than within its breeding range (Dunn's Multiple Comparisons, $P < 0.05$) (Table 4). For the rest of the studied variables, there were no significant differences between within and outside its breeding range (Table 4).

DISCUSSION

In this study, we identified several factors that appear to influence, at a regional spatial scale, the pattern of breeding habitat use by the Red-legged Cormorant. Some of these factors, such as the length of the cliffed coastlines and water depths near the coast, appear to influence the use of potential breeding sites inside its breeding range. Some other factors, such as primary productivity along the coast and climatic characteristics, appear to influence not only the pattern of use of breeding habitat by this species, but also determine the limits of the Red-legged Cormorant breeding distribution on the Argentinian coast.

All Red-legged Cormorant colonies were found on long cliffed coastlines, mostly

longer than 250 m. We did not find a positive correlation between the number of active nests at each colony and the length of the used cliffed coastline. We observed that the most abundant colonies did not necessarily use longer cliffed coastlines. For example, the colony of Isla Elena, with 96 ± 10 active nests, used cliffed coastlines of 400 m in length, while the colony of Cabo Blanco, with 22 ± 2 active nests, used cliffed coastlines of 990 m in length. At a smaller study scale, we found that the number of active Red-legged Cormorant nests was positively correlated with cliff length (Millones *et al.* 2008). In that study, we also showed that cliff length and available area of potential breeding sites (defined by the presence of ledges, outcrops, or caves) were positively correlated. Therefore, we may assume that longer cliffed coastlines provide a high availability of potential breeding sites and that the use of a given cliffed coastline could be determined by this variable.

Red-legged Cormorants feed mainly in shallow waters close to the shore (Gandini *et al.* 2005; Frere *et al.* 2008). Along the Chilean coast, Red-legged Cormorant colonies are located on the external coast, where the continental shelf is present and depths are, in general, shallower than 20m (Frere *et al.* 2004). In our study, when we examined differences in characteristics of cliffed coastlines used and not used by the Red-legged Cormorant within its breeding range, we observed that water depths close to the coastline seem to be a factor affecting the presence of colonies. All of the colonies

Table 4. Characteristics (medians) of cliffed coastlines used by Red-legged Cormorants, and characteristics of unused cliffed coastlines outside (north and south of) its breeding range.

Variable	Used	Unused North	Unused South	Test score	<i>P</i>
Ambient temperature (°C)	12.2	14.3	7.5	H = 30.4	<0.001
Accumulated precipitation (mm)	101	133	234	H = 32.3	<0.001
Wind speed (Kts)	10.7	9.7	11.9	H = 30.3	<0.001
Sea surface temperature (°C)	9.0	12.5	8.3	H = 37.4	<0.001
Chlorophyll <i>a</i> concentration (mg/m ³)	4.4	1.6	4.0	H = 12.3	0.002
Length (m)	313	248	136	H = 4.2	0.11
Median sea depth within the radii of 3 km (m)	12	15	11	H = 3.1	0.21
Proportion of points which depths shallower than 15 m (%)	62.4	50.0	84.6	H = 5.2	0.076
Protection level from prevailing winds	3.1	2.5	3.5	H = 5.02	0.04
Orientation				$\chi^2_7 = 10.3$	$P > 0.05$
Wind direction				$\chi^2_7 = 88.8$	$P < 0.001$

were found on cliffed coastlines with shallow waters close to the shore. For other cormorants that breed on the Argentinian coast, such as Rock Shags and Imperial Cormorants, deeper foraging dives were recorded (Frere *et al.* 2005; Frere *et al.* 2008). The diving performance of Rock Shags and Imperial Cormorants could explain why these two species were found breeding in sympatry with Red-legged Cormorants on the cliffed coastlines with deeper water close to shore.

Generally, seabirds breed in localities that are close to their foraging areas (Buckley and Buckley 1980; Bried and Jouventin 2002). Oceanographic characteristics such as ocean currents, sea temperature, turbidity, etc., affect food availability and accessibility (Shealer 2002). The Southern Patagonian coast is characterized by cold waters, where the Malvinas Current and the Brazil Current mix. Water mixing is an important determinant of primary productivity along the coast, resulting in a greater number of taxa from different trophic levels (Glorioso and Flather 1995; Trivas *et al.* 2006). Productive waters provide spawning and nursery habitats for different species of fish (the most frequent prey for seabirds), so seabirds are more common where primary productivity is higher (Brooke 2002; Shealer 2002; Boersma *et al.* 2009). In this study, we found zones of high sea productivity close to the coastal areas used by Red-legged Cormorant colonies. This species feeds mainly upon fishes (Millones *et al.* 2005), making several short trips each day (Gandini *et al.* 2005); therefore, breeding in coastal areas close to zones of high productivity should be beneficial for Red-legged Cormorants.

In this study, we observed that, outside the breeding range of the Red-legged Cormorant, some climatic and marine characteristics became more adverse or less optimal for Red-legged Cormorants. For example, north of its distribution sea productivity close to the coast was lower. We may assume that during the breeding seasons Red-legged Cormorants' feeding trips from the colony to an abundant source of food would be longer, which is not consistent with its normal feeding behavior (several short trips each day).

North of the Red-legged Cormorant breeding range, we observed that cliffed coastlines were less protected from prevailing winds than those within its breeding range. The Patagonian coast is characterized by strong winds, especially during spring and summer. Therefore, high wind exposure could be another adverse characteristic for Red-legged Cormorants north of their distribution. Strong winds can blow eggs and chicks away from the nests (Frere and Gandini 2001). Furthermore, higher egg and chick mortality from increased opportunistic predation by avian predators during windy weather has been reported for a number of seabird species, including the Red-legged Cormorant (Frere and Gandini 2001; Schreiber and Burger 2002).

South of the Red-legged Cormorant distribution, we observed that some climatic characteristics were more adverse, at least during the breeding season: high precipitation (more than 230 mm accumulated precipitation), low ambient temperature (generally a median lower than 7°C), and high wind speed (with a maximum of 35 kts). The breeding success of Red-legged Cormorants located at the center of their range is nearly twice that of colonies located further south (0.56 vs. 0.30, Frere and Millones, unpublished data). Along the southern Chilean coast, Red-legged Cormorant colonies are also located in high rainfall zones (Frere *et al.* 2004). However, in those zones strong winds are much less common or frequent than on the southern Argentinian coast (Garreaud and Falvey 2008), so the effect on breeding success would be lower.

The importance of factors acting at different spatial scales is recognized as being of great importance for understanding ecological patterns (Wiens 1986). Variations in habitat structure to which birds may respond exist in a hierarchy of spatial scales (Maurer 1985; Kolasa and Pickett 1991). In the present study, we observed that factors acting at larger ecological scales (hundreds of kilometers) seem to determine the Red-legged Cormorant breeding range, while factors acting at local scales (tens of kilometers) seem to determine the use of potential

breeding sites within its breeding range. In previous studies, factors related to differential site and local habitat use of the Red-legged Cormorant (such as protection from predators, availability of usable surface, protection from prevailing winds and proximity to abundant food) were identified (Millones *et al.* 2008; Millones *et al.* 2010). In the present study, we expanded the ecological spatial scale of analysis, and thus identified new aspects of habitat structure, such as sea primary production, water depths and climatic features, that could be affecting habitat selections by Red-legged Cormorants. Knowledge of the factors affecting spatial distribution of Red-legged Cormorants could help us predict how this threatened species could respond to global threats, such as coastal development and climatic changes.

ACKNOWLEDGMENTS

The Universidad Nacional de la Patagonia Austral and Wildlife Conservation Society funded this work. We thank V. Falabella and A. Piola for assistance in the analysis of oceanographic data and S. Kling for English language assistance. Sea surface temperature data were obtained from the SeaWiFS Project (Code 970-2) and the Distributed Active Archive Center (Code 902), Goddard Space Flight Center, NASA, provided chlorophyll *a* concentration data. These data were processed by M. Carranza, S. Romero and A. Piola (SHN – UBA – CONICET) and funded by the project CRN2076 from the Instituto Inter-Americano para el Estudio del Cambio Global - U.S. National Science Foundation (GEO-0452325).

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