Estimating Eastern Pacific Coast Populations of Whimbrels and Hudsonian Godwits, with an Emphasis on Chiloé Island, Chile

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Abstract.—A large proportion of the Hudsonian Godwits (*Limosa haemastica*) spending the boreal winter along the eastern Pacific Ocean coast are known to occur in the vicinity of Chiloé Island, Chile, but the importance of the region to Whimbrels (*Numenius phaeopus*) is less known. Ground counts conducted in 2007 and 2008 increased published estimates, at a minimum, of Pacific coast populations by 27% for Whimbrels (33,150 individuals) and 51% for Hudsonian Godwits (21,161 individuals). Bays and shorelines in the Chiloé Island region supported 99% of Hudsonian Godwits and, perhaps, 61% of Whimbrels estimated to occur along the Pacific coast during the boreal winter. Whereas Hudsonian Godwits aggregated in shallow bays on the eastern and northern coast of Chiloé Island, Whimbrels were more dispersed along the island's coastline and reached a density of 7.5 birds/km along sheltered gravel shorelines. Bays in the vicinity of Chiloé's capital, Castro, provided important foraging and roosting habitat for non-breeding birds; these sites supported 52% of the Pacific coast population of Hudsonian Godwits and >4,000 Whimbrels. Low human disturbance in Pullao and Putemún bays makes these sites particularly attractive to non-breeding Hudsonian Godwits, and their permanent protection is urged. *Received February 26 2008, accepted November 26 2008.*

Key words.—Chile, Chiloé Island, Hudsonian Godwit, *Limosa haemastica, Numenius phaeopus,* Pacific Coast, population, survey, shorebird, Whimbrel.

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Whimbrels and Hudsonian Godwits (Godwits) breeding in Alaska and northwestern Canada are thought to spend the boreal winter along the eastern Pacific Ocean coast (Pacific coast), whereas Whimbrels and Godwits breeding in the vicinity of Hudson Bay are suspected of wintering along the western Atlantic Ocean coast (Morrison and Ross 1989; Skeel and Mallory 1996; Haig *et al.* 1997; McCaffery and Harwood 2000; Elphick and Klima 2002; Espinosa *et al.* 2006). Because of their disjunctive breeding distributions, estimates of population size have been generated for eastern and western groups (Morrison *et al.* 2006).

Low densities and scattered, often inaccessible, distributions make surveys of Whimbrels and Godwits during the breeding season logistically and economically challenging. Therefore, estimates of the species' population sizes have been derived mainly from counts on non-breeding grounds during the boreal winter and at North American staging and migration stopover sites (Morrison and Ross 1989; Espinosa *et al.* 2006; Morrison *et al.* 2006).

The Chiloé Island region (≈42°30'S, 73°45'W), in southern Chile, supports the largest non-breeding populations of Whimbrels and Hudsonian Godwits on the Pacific coast (Morrison and Ross 1989; Espinosa *et al.* 2006). An aerial survey of Whimbrels and Godwits conducted in 2006 along the coasts of Chiloé Island and the adjacent mainland

(R. I. G. Morrison and R. K. Ross, unpubl. data) indicated that a combination of factors — behavior, habitat use, and density — influenced the aerial enumeration of Godwits and, particularly, Whimbrels. For example, most Godwits were encountered in large, conspicuous flocks in bays and were easily flushed when the survey aircraft flew overhead. In contrast, Whimbrels were more dispersed along the island's coastline, less prone to flush when the aircraft flew overhead, and were more cryptic while standing and in flight than Godwits. In addition, the convoluted shoreline of Chiloé Island and the many offshore islands made it difficult to obtain complete aerial coverage of the coast. Because of this combination of factors, aerial surveys likely underestimate the number of Whimbrels and Godwits using the Chiloé Island region. To obtain a more complete estimate of the Whimbrel population inhabiting Chiloé region, an intensive ground survey was conducted that included a census of sites that supported known aggregations of birds and a set of randomly selected shoreline segments. To provide some context for counts made in the Chiloé Island region, the literature was reviewed to gather information on the numbers of Whimbrels found along the Pacific coast during the boreal winter; only a few North American Whimbrels are thought to wander to Hawaii and other Pacific Islands each year (Skeel and Mallory 1996). Sites in the Chiloé Island vicinity supporting ≥1% of the Pacific coast populations of Hudsonian Godwits were identified. At present, no coastal sites on the eastern side of the island are afforded any type of enforceable protection, and human activities that may negatively affect shorebirds have expanded rapidly there during the last decade.

METHODS

Study Area

Located in Chile's 10th Region, and within the Valdivian Temperate Rain Forest ecoregion, Chiloé Island has a maritime climate with cool temperatures and high amounts of precipitation. The island is 190 km long and averages 55-65 km wide (Fig. 1). The western and southern coasts of the island are fairly inaccessible; the predominantly steep, rocky coastline, interspersed with sandy beaches, is directly exposed to the Pacific Ocean. The only federally-protected coastline on the island is found on the rugged west coast. The northern and eastern shores are highly developed and support the majority of the island's human population and industry, primarily agriculture and aquaculture. The northern and eastern coastline, the latter sheltered by numerous islands in the Gulf of Ancud and Gulf of Corcovado, consists mainly of mixed sand and gravel shorelines and is indented by many bays (Morrison and Ross 1989; Subiabre and Rojas 1994). Bays provide mudflat, sand flat, and sand and gravel habitats used by Whimbrels and Godwits for feeding and roosting. Salt marsh adjoins some shallow bays, and Whimbrels and Godwits appear to favor areas where in-flowing streams form small deltas (Morrison and Ross 1989). More linear sand and gravel shorelines on this part of the island are also used by feeding and roosting Whimbrels (Andres *et al.* 2007). Shorelines on the Chilean mainland north and east of Chiloé Island consist of bays, exposed sandy shorelines, and exposed rocky shorelines. The city of Puerto Montt dominates the northern coastline of Seno de Renoclaví. Tidal range in the Gulfs of Ancud and Corcovado can exceed six meters.

Field Surveys

ARCGIS® 9.0, Google Earth® images and descriptions from Morrison and Ross (1989) were used to designate shoreline strata and calculate linear shoreline distances on Chiloé Island and nearby islands, as: exposed sandy, exposed rocky, and sheltered gravel; we ground-truthed our shoreline designations as we completed surveys. Shorelines north of Chiloé Island in Seno de Renoclaví were delineated into eastern and western sections, but we did not evaluate mainland shorelines south of Seno de Renoclaví. Bays on Chiloé Island and the adjacent mainland known to support aggregations of Whimbrels and Godwits were also delineated.

Surveys in the Chiloé region consisted of two components — a complete sample of all road-accessible bays where Whimbrels and Hudsonian Godwits were known to aggregate (Morrison and Ross 1989; L. Espinosa, pers. comm., and J. Valenzuela, unpubl. data) and a randomly selected sample of linear shoreline segments (see Brown *et al.* 2005 for a similar approach). Owing to limited access, the ability to randomly sample exposed shorelines on the western and southern side of Chiloé Island was severely restricted. The most exposed, rocky shorelines were not surveyed, but 17% of western exposed sandy shorelines were sampled (all that were road accessible). The 637 km of exposed rocky shoreline is conservatively assumed to support no Whimbrels; casual observations (Valenzuela, pers. obs.) and an aerial survey conducted in 1985 (Morrison and Ross 1989) corroborate the notion that relatively few Whimbrels are found along exposed outer coast.

The remaining shoreline on Chiloé Island, the mainland directly north of Chiloé, and Seno de Reloncaví was overlaid with a grid of approximate 1.6-km cells. Each cell that intersected the shoreline was assigned a number, and a random selection of cells was drawn. The shoreline segment lying in the cell was surveyed for shorebirds. More cells were selected than could be sampled; if access restricted the ability to survey a selected shoreline segment, surveyors moved on to the next accessible cell. After the survey was completed,

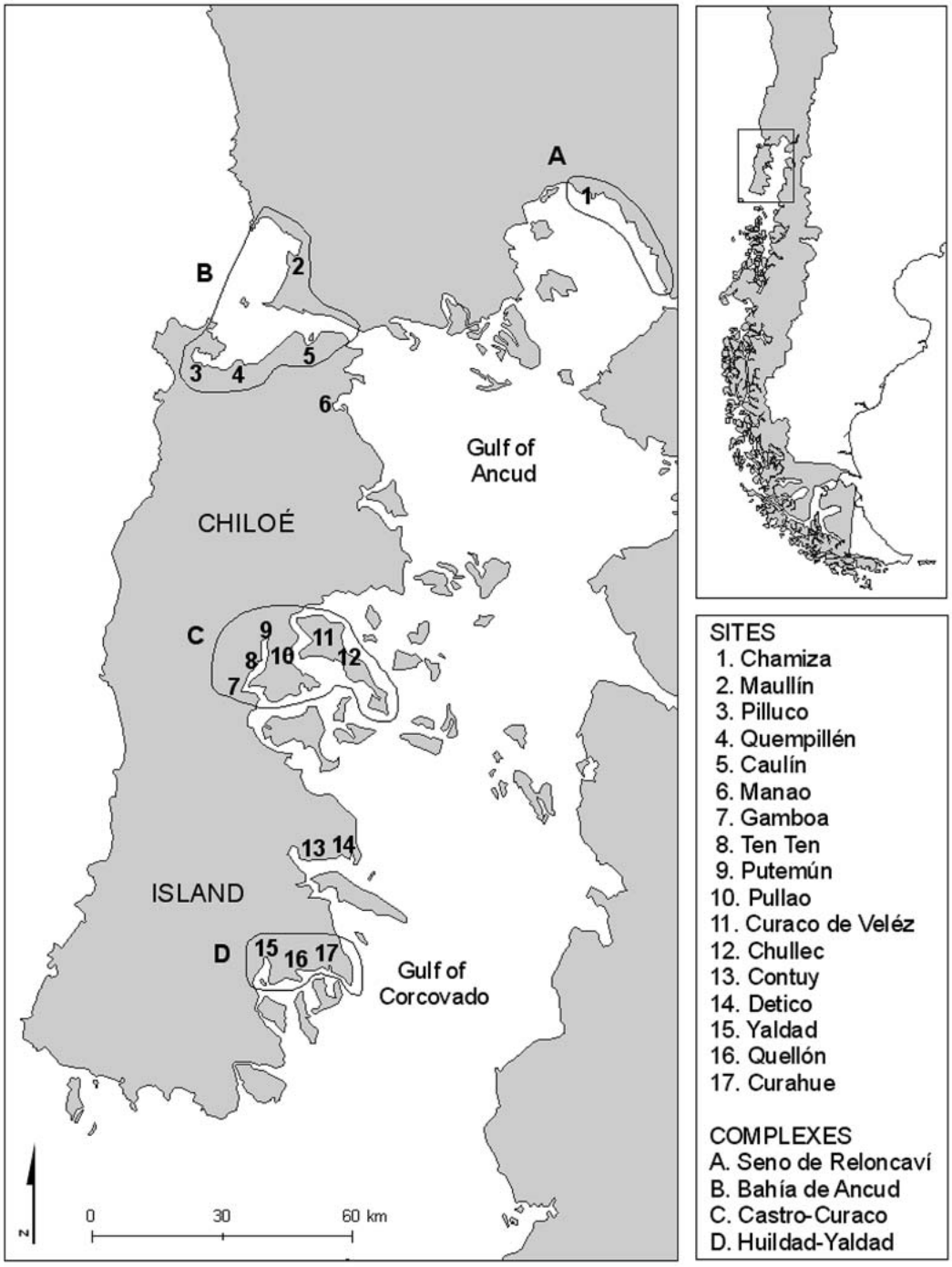

Figure 1. Locations of bays on Chiloé Island and the adjacent mainland of Chile that support ≥1% of the eastern Pacific Ocean coast population of Hudsonian Godwits (212 individuals) or >300 Whimbrels in 2006-2008. Important complexes are indicated by polygons.

segments were post-stratified into sheltered gravel and exposed sandy shorelines.

Most surveys on Chiloé Island (97%) were conducted between 25 January and 2 February 2007, a period when numbers of Whimbrels and Godwits were thought to be relatively stable. Two surveys on the remote exposed west coast were conducted on 9 February and one on 17 February. In 2008, additional cells on the main-

land were surveyed on 21 and 22 January. Surveys were generally conducted within three hours of the diurnal high tide and on days with light winds (<20 km/hour) and light to no precipitation. Bays with known aggregations and selected shoreline segments in the same general vicinity were surveyed on the same day to minimize double-counting, which could result from birds moving among sites. Because counts were made around high tide, flocks were readily detectable by making multiple scans of bays. To minimize counting errors and resultant bias in population estimates, counts at bay aggregation sites were made by two observers, who used 10 × 40 power binoculars and 25-60 power zoom telescopes. Counts were conducted 0.5-1.0 km from the birds, and large flocks were counted multiple times by each observer. If counts differed among observers, flocks were re-counted until counts were within 5% of each other, and the mid-point was used as the count datum. Selected shoreline segments were surveyed on foot by one observer. Because shoreline segments had a narrow width (<50 m) during the high tide sampling period, and Whimbrels were conspicuous when approached (either by flushing and calling), we are confident we were able to detect all Whimbrels present on the shoreline segment. At least 1 km of shoreline was surveyed in each selected cell.

Analysis and Synthesis

Due to access and time constraints, ground surveys were not conducted in some portions of the mainland. Therefore, we supplemented intensive ground work with numbers of Whimbrels and Hudsonian Godwits seen on the 2006 aerial counts in mainland bays around Maullín and south of Seno de Reloncaví (R. I. G. Morrison and R. K. Ross, unpubl. data). As with Chiloé Island, mainland exposed rocky shorelines were generally assumed to support no Whimbrels or Godwits.

Normal estimates of the mean and variance were used to derive shoreline densities of Whimbrels, and a two-sample t-test was used to test for differences in mean densities among sheltered gravel and exposed sandy shorelines on Chiloé Island and the shorelines of Seno de Reloncaví. Densities were multiplied by shoreline length of each type and combined with the counts from known aggregation sites to obtain an overall population estimate for the Chiloé region. To provide a range for the population estimate, normal confidence intervals were constructed from the variances of randomly selected shoreline densities (see Brown *et al.* 2005). The population estimate for Hudsonian Godwits only came from counts at aggregation sites, as Godwits were not found away from these areas.

The literature was reviewed and personal communications were made in an attempt to determine the abundance and distribution of Whimbrels and Hudsonian Godwits along the Pacific coast during the boreal winter. Information was restricted to 15 November - 15 February, a period that best represents a sedentary, non-breeding population. The review was undertaken to provide some context for the Chiloé region estimates and to revise, if needed, published estimates for Pacific coast Whimbrel and Godwit populations.

RESULTS

Density of Whimbrels on Chiloé Island was significantly higher along sheltered gravel shorelines (7.54 birds/km) than on exposed sandy shorelines (1.59 birds/km, $P < 0.0001$) or on mainland shorelines of western Seno de Reloncaví (4.01 birds/km, $P < 0.0001$, Table 1). Whimbrel density on the mainland shorelines of western Seno de Reloncaví was also significantly higher than

Table 1. Density and numbers of Whimbrels in the vicinity of Chiloé Island, Chile, 2006-2008.

Location	Shoreline type	Total shoreline length (km)	Shoreline sampled (km)	Number of sites sampled	Birds/km (mean ± SE)	Total number
Chiloé Island						
	Eastern sheltered gravel	1,182	52	40	7.54 ± 0.60	8,913
	Exposed sandy	426	45	17	1.59 ± 0.31	675
	Known bays	174	174	48		5,444
	Total island[1]	2,419	251	105		15,032
Mainland						
	Seno de Reloncaví - west	369	12	7	4.01 ± 0.40	1,479
	Seno de Reloncaví - east	15	2	2	7.25 ± 0.07	109
	Known bays - Seno de Reloncaví, Maullín	160	160	8		3,023
	South of Lenca	850[2]	337	3		448
	Total mainland	1,394	511	20		5,059
All locations		3,813	762	125		20,091

[1]Includes 637 km of exposed rocky shoreline, where we assume Whimbrel density is 0 birds/km.

[2]Aerial surveys, which includes 513 km of exposed rocky shoreline and where we assume Whimbrel density is 0 birds/km.

density on Chiloé Island's exposed sandy shorelines (P = 0.0004). Whimbrel density in eastern Seno de Reloncaví (7.25 birds/km) was similar to the sheltered gravel shorelines of Chiloé, but only a few surveys were conducted in the former area. Whimbrels aggregated in high densities (40.3 birds/km) in bays favored by Godwits.

During the boreal winter, we estimate that 15,032 Whimbrels ($CI_{95\%}$ = 13,324 - 16,741) occurred on Chiloé Island and 5,059 Whimbrels ($CI_{95\%}$ = 4,683 - 5,436) on mainland shorelines, resulting in a total of 20,091 Whimbrels ($CI_{95\%}$ = 18,007 - 22,177) for the region (Table 1). Counts of Hudsonian Godwits on Chiloé Island (18,140 birds) and the adjacent mainland (2,821 birds) totaled 20,961 individuals.

Combining information from the literature and personal communications, we conservatively estimate that 33,150 Whimbrels inhabit the Pacific coast during the boreal winter, and that the Chiloé region could support up to 61% (54%-67%) of that population (Table 2). Estimates of Hudsonian Godwits in the Chiloé region represent 99% of the Pacific coast population. Outside of this region, Morrison and Ross (1989) only observed an additional 200 Godwits in Paracas Bay, Peru, during their aerial survey.

Sixteen individual bays that supported ≥1% of the Pacific coast population of Hudsonian Godwits were identified; many of these sites also supported >300 Whimbrels (Table 3). Godwits aggregated in bays in four main areas (Fig. 1, Table 3). Estuaries in the east-central part of Chiloé Island (Castro - Isla Quinchao - Península de Rilán) supported 52% of the Godwits found along the Pacific coast and >4,100 Whimbrels.

DISCUSSION

Despite human development on the eastern side of Chiloé Island, shorelines there supported a high density of Whimbrels and large aggregations of Hudsonian Godwits. Whimbrels seem to adjust to human presence and will even use aquaculture floats as roost sites (Andres *et al.* 2007). Although Godwits use sites close to human habitation, the largest, and most consistent, aggregations were found in Pullao and Putemún, both large shallow bays with little human development along the shoreline and little human disturbance. Few Whimbrels were found along exposed sandy shorelines near large human population centers, as these shorelines were used extensively for recreation.

The estimates reported here greatly exceed those generated from aerial surveys and previous ground counts in the Chiloé region (65% for Hudsonian Godwits and 259% for Whimbrels). Aerial counts made of both species in 2006 were within 10% of aerial counts made in 1985 and averaged 12,826 Godwits and 5,595 Whimbrels (Morrison and Ross 1989; Morrison *et al.* 2006; R. I. G. Morrison and R. K. Ross, unpubl. data). In 13 years of February surveys, Espinosa *et al.* (2006) recorded an annual average of about 12,000 Godwits, and in only one year did their counts of Godwits exceed 20,000 individuals. Most of the additional Godwits found on Chiloé Island in 2007 were recorded at sites not previously surveyed during ground counts (L. A. Espinosa, unpubl. data); Godwits often occurred in small flocks in small bays where they would have been undetected on aerial surveys. Our higher estimate for Whimbrels resulted from a more complete survey of aggregation sites, and, more importantly, from the inclusion of birds dispersed along the region's sheltered, gravel shorelines. Higher estimates reported here could also have resulted from the occurrence of flocks in late January and early February that contain individuals from local populations and those moving north from more southern regions. Although Godwits that were color-flagged at more southern sites (Bahía Lomas, Chile and San Sebastian, Argentina) have been observed on Chiloé Island, Godwits leave the Chiloé Island region in April, and counts made in late January and early February should represent a sedentary population. Stability of local populations during our survey period was substantiated by obtaining similar counts from surveys at the same sites multiple times during re-sighting efforts. Perhaps some western

Table 2. Distribution of non-breeding Whimbrels, during the boreal winter (15 November-15 February), along the Pacific coast of the Americas. Previous estimates of the size of the eastern Pacific Ocean coast population of Whimbrels (*N. p. rufiventris*) is thought to be 26,000 individuals (Morrison *et al.* 2006).

State/Province/shoreline section	Number	Year	Source
United States			
Washington, Oregon, California	710	1988-95	Page *et al.* 1999
Mexico			
Baja California, Gulf of California	910	1992-93	Page *et al.* 1997
Sinaloa	640	1993-94	Englis *et al.* 1998, Morrison *et al.* 1994
Nayarit to Chiapas	1,270	1994	Morrison *et al.* 1994
Guatemala	220[1]	—	Eisermann 2006
El Salvador	340	—	Herrera *et al.* 2006
Honduras	80[1]	—	
Nicaragua	400[1]	—	
Costa Rica	830[2]	—	Alvarado Quesada 2006
Panama			
Costa Rica to Peninsula de Azuero	440	1993	Morrison *et al.* 1998
Panama Bay	1,050	1993	Morrison *et al.* 1998
Colombia			
Panama to Bahia Guapi	190	1986	Morrison and Ross 1989
Sanquianga National Park	3,000	2006	R. Johnston, unpubl. data
Mosquero to Tumaco	130	1986	Morrison and Ross 1989
Ecuador			
Colombia to Punta Santa Elena	90	1986	Morrison and Ross 1989
Gulf of Guayaquil	470	1986	Morrison and Ross 1989
Peru			
Ecuador to Casma	170	1986	Morrison and Ross 1989
Casma to Tanaca	680	1986	Morrison and Ross 1989
Tanaca to Chile	80	1986	Morrison and Ross 1989
Chile			
Arica to Punta Obispo	80	1985	Morrison and Ross 1989
Punta Obispo to Matanzas	300	1985	Morrison and Ross 1989
Matanzas to Arauco	570	1985	Morrison and Ross 1989
Arauco to Rio Bueno	410	1985	Morrison and Ross 1989
Chiloe Island	15,030	2007	this study
Mainland Golfo de Ancud to Gulfo Corcovado	5,060	2007	Morrison and Ross, unpublished data; this study
Total	33,150		

Numbers, which are maximum counts, are rounded to the tens ([1]based on density reported for El Salvador and Costa Rica.
[2]Based on lower limit reported and adjusted for shoreline length on the Pacific coast).

North American-breeding Godwits continue on to Tierra del Fuego in some years.

The estimates produced here are likely conservative because some sheltered bays and estuaries on the southern coast of Chiloé Island and some of the larger islands east of Chiloé were not surveyed and may support aggregations of both species. Presence of small numbers of Whimbrels on exposed rocky shorelines, where we assumed

Table 3. Sites on Chiloé Island and the adjacent mainland of Chile that support ≥1% of the eastern Pacific Ocean coast population of Hudsonian Godwits (212 individuals) or ≥300 Whimbrels. Counts are the maxima made during January or February, 2006-2008. Numbers at complexes include counts at known aggregation sites and those along shorelines during a single time period.

	Whimbrel	Hudsonian Godwit		Coordinates	
Locations	number	number	%	latitude (°S)	longitude (°W)
Individual sites					
Curahue	500	3,000	14.2	43.050	73.617
Chamiza	1,900	4,300	20.3	41.500	72.850
Caulín	273	1,000	4.7	41.825	73.625
Chullec	220	3,000	14.2	42.469	73.540
Contuy	225	1,089	5.1	42.825	73.611
Curaco de Vélez	220	4,500	21.3	42.440	73.439
Detico	42	300	1.4	42.878	73.508
Gamboa	249	232	1.1	42.486	73.774
Manao	91	521	2.5	41.878	73.531
Maullín	341	181		41.600	73.650
Pilluco	310	1,400	6.6	41.858	73.983
Pullao	423	7,000	33.1	42.475	73.686
Putemún	666	7,000	33.1	42.433	73.742
Quellón	34	250	1.2	43.124	73.640
Quempillén	20	1,400	6.6	41.872	73.750
Ten Ten	28	570	2.7	42.475	73.760
Yaldad	136	990	4.7	43.108	73.711
Complexes					
Estero Huildad—Yaldad—Quellón	997	2,826	13.3	43.130	73.625
Castro—Isla Quinchao—Península de Rilán	4,123	10,956	51.8	42.480	73.675
Bahía de Ancud	1,965	2,468	11.7	41.860	73.900
Seno de Reloncaví—east	2,529	2,640	12.5	41.580	72.775

no birds for 1,150 km, would also increase the estimate for the region, as would more thorough surveys of the mainland south of Seno de Reloncaví. Double-counting did not inflate estimates because ground counts in the same area were conducted at the same time, and no flocks were observed moving into a site while surveys were being conducted. We are also confident that we were able to detect all individuals along shoreline segments and all roosting flocks at aggregation sites; we adopted field methods to minimize flock counting errors.

The estimate presented here for the Pacific coast population of Hudsonian Godwits exceeds that previously published by 51% (Morrison *et al.* 2006), although accuracy of the published estimate is rated as moderate (i.e. estimate is within 50%, based mainly on expert opinion). Based on the literature search, we are confident that virtually all Hudsonian Godwits (99%) spending the boreal winter along the eastern Pacific coast do so in the vicinity of Chiloé Island.

Although our estimate for Whimbrels increased the published estimate by 27% (Morrison *et al.* 2006), the published estimate's reliability was rated as low (i.e. the estimate is probably in the right magnitude, based mainly on expert opinion). The estimate provided by Morrison *et al.* (2006) was based on the sum of migration counts in the western United States, the mid-point of a high migration count in Alaska, and the sum of counts from the boreal winter period. At a minimum, we can suggest that ≥13,000 Whimbrels occur along the Pacific coast outside of the Chiloé region. We realize that the reliability of our country/regional numbers varies among the types of information used in their generation, and we suggest that this estimate is likely a minimum. We previously discussed why we suspected that aerial surveys might underestimate numbers of Whim-

brels on Chiloé Island and suggest that shoreline type and configuration likely influence aerial detectability of Whimbrels. It is easy to imagine differences in detectability of Whimbrels on the desert coasts of northern Chile and Peru and the mangrove-lined bays of Colombia and Panama. Whimbrel densities from aerial surveys in Chile north of Chiloé Island ranged 0.04-1.15 birds/km (Morrison and Ross 1989) and were lower than mean Whimbrel density recorded on any shoreline type from ground surveys in the Chiloé region; our casual observations in northern Chile and Peru suggest that densities there are likely lower. Determining what factors influence detectability and incorporating these influences into estimates of population size might increase their accuracy, as would more intensive information from sites known to support large numbers of Whimbrels (e.g., Sanquianga National Park in Colombia; R. Johnston, pers. comm.). Even if the numbers in the north were tripled, the Chiloé region would still support one-third of the Pacific coast population of Whimbrels and is clearly an important boreal-wintering area for the species. Our country/regional summaries can serve as testable null hypotheses of Whimbrel abundance and distribution during the boreal winter.

Although non-breeding Whimbrels and Hudsonian Godwits found along the Pacific coast are thought to originate in Alaska and western Canada, recent evidence suggests that Whimbrels breeding in northern Alaska may use migration stopovers on the Atlantic coast (B. Watts, B. Truitt, unpubl. data). To clarify population composition, blood samples collected from Godwits and Whimbrels in 2007 and 2008 will be compared to samples from birds on breeding areas and non-breeding sites in Tierra del Fuego and other locations along the Patagonia coast (see Johnson *et al.* 2007). We also plan to attach satellite transmitters to Chiloé Whimbrels in December 2008. Some connection to Alaska has been established; Whimbrels banded on Chiloé Island were re-sighted in southern California and southwestern Alaska, and Hudsonian Godwits flagged on Chiloé have been re-sighted in south-central, southwestern, and western Alaska (Johnson *et al.* 2007, J. Johnson, unpubl. data).

Bays and shorelines in the Chiloé region are critical for supporting large numbers of Pacific coast Hudsonian Godwits and Whimbrels in the non-breeding season. In fact, non-breeding godwit aggregations in the Chiloé Island region represent >30% of their global population. Sixteen individual bays would qualify for Ramsar designation as a Wetland of International Importance and as a Western Hemisphere Shorebird Reserve Network (WHSRN) site of regional importance (1% of a biogeographic population). The complex of bays in the east central section of Chiloé Island supports >52% of the Pacific coast population of Godwits. Birds regularly move among bays within these complexes, probably as a result of disturbance and weather; individually color-flagged birds marked in one bay in the Castro area were observed in other bays within the complex. Although Curaco de Vélez and Castro areas are developed, Putemún and Pullao bays remain relatively intact and support some of the highest numbers of Godwits and Whimbrels observed on Chiloé. Individually, Pullao and Putemún Bays would qualify as WHSRN sites of hemispheric importance to shorebirds (≥30% of a biogeographic population). Although sites in this region are critically important to sustain populations of these species, no bays are designated as protected areas (Espinosa *et al.* 2006).

Threats to Whimbrels and Godwits and their habitats, are numerous on Chiloé Island and the surrounding mainland and include increasing aquaculture, shoreline housing development, intertidal algae farming and loose dogs (pers. obs., Espinosa *et al.* 2006). To give an example, counts in Caulín Bay dropped from >1,000 Godwits in January 2004 to <300 individuals in January 2006, when 225 people were observed harvesting farmed algae within approximately 65 hectares of intertidal sand flat. Harvesting was reduced in 2007 and higher numbers of Godwits (1,000 individuals) were recorded in the bay. Although birds could shift their use of bays in response to human disturbance, development could eventually eliminate alter-

native foraging and, in particular, roosting sites. Our field observations suggest that Godwits are likely most vulnerable to human-induced disturbance when at their high-tide roosts.

Because of current low levels of human disturbance, local governments, federal agencies and non-governmental organizations have the opportunity to provide protection for Hudsonian Godwits and Whimbrels at Putemún and Pullao, and, secondarily, at Chullec. Godwit and Whimbrel use has apparently increased in recent years at Chullec, where aquaculture development is tempered by local community leaders. Bays at Quempillén and Carahue also provide fairly disturbance-free environments and would be good targets for protection. Protecting these wetland areas for Whimbrels and Hudsonian Godwits would also benefit numerous other migrant and resident waterbirds.

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