Chapter 3
Birds in Coastal Wetlands of Chile

Cristián F. Estades, M. Angélica Vukasovic, and Juan Aguirre

Abstract Between the extreme north of Chile and the island of Chiloe, there are approximately 300 coastal wetlands. Among them, there are estuaries where the largest waterfowl populations are concentrated, due to their high productivity and diversity of habitats. Around 125 species of birds, approximately 30% of the species that live regularly in Chile, use this type of environment, which makes them high-value sites for conservation of biodiversity. Because the Chilean coast is part of a major migratory route for birds in the Americas, the composition of the avifauna of these ecosystems is also highly dynamic. In addition, the uneven distribution of wetlands on the Chilean coast is reflected in the presence of a small number of sites with concentration of these birds, which are characterized by a good supply of food and the availability of safe resting places (e.g. sand bars). Population data of different bird species in four estuaries of the central zone (Itata, Reloca, Mataquito and Topocalma) indicate that, although the communities of aquatic birds (migratory and resident) are highly dynamic, they also have a very regular and predictable structure. The high degree of overlap in population trends of most species, even among non-migratory ones, suggests that these dynamics are largely due to regional trends rather than individual behavior of each estuary. Among the migratory species it is possible to detect some that settle throughout the summer in the estuaries of central Chile, while others use them only as a place of refueling during trips to and from more southern sites. Additionally, these estuaries have an important role as post-reproductive aggregation sites for many resident species, which apparently move from the country's central valley wetlands. Information on the waterfowl use of estuaries of central Chile clearly indicates that the main role of these environments is to serve as a resting place for most birds. In addition, many marine species gather in these places for bathing, and that way clean the salt of their plumage. A large proportion of the birds that are concentrated in the estuaries, forages at sea, except for some freshwater birds (less abundant) that make it into these wetlands. Reproductive activity of water birds in these estuaries is marginal, due to unfavorable factors for nesting and the high degree of human intervention.

Keywords Waterfowl • Water Birds • Estuary • Nesting

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Introduction

Due to the particular geography of Chile, coastal environments have a high representation in the country (Gonzalez and Victoriano 2005). This means that a very high percentage of Chile's avifauna is composed of species that prefer using these ecosystems (Aparicio 2006). In addition, the Chilean coast is part of a major migration route in the Americas (Morrison and Myers 1987), which gives them a highly dynamic and seasonal communities of shorebirds character.

Among the different coastal environments, the wetlands that are located in this area are one of the most important ecosystems for birds, particularly migratory species (Page et al. 1997). Among the coastal wetlands, estuaries tend to concentrate the largest waterfowl populations due to its high productivity. In addition, the fact that these systems constitute a system interface between freshwater and sea, generating a salinity gradient that is positively influencing the diversity of birds that use them (González and Victoriano 2005).

Relative gridlock that the river water faces in the estuary makes its flow rate decrease significantly, so a new environment, more like a lagoon is generated. These areas of calm waters with high concentrations of nutrients attract many fish to spawn (Haedrich 1983), so there is a great deal of food for fish-eating birds.

However, estuaries are also highly dynamic systems due to the tide action as well as atmospheric factors such as precipitation (Colwell 1993; Chaparro et al. 2008), which significantly affects the supply of food for some water birds (Colwell 1993).

In Chile coastal lagoons are relatively few and not all rivers are clearly recognizable estuaries (Stuardo and Valdovinos 1989). Still, estuaries are valuable for the conservation of many species of waterfowl in the country (Victoriano et al. 2006).

Table 3.1 shows the list of species of water birds (i.e. fully or partially dependent on wet environments) that can be found in coastal wetlands of Chile, not including several species that have only one or two records in the country. The 125 species listed are approximately 30% of the species of birds that live regularly in Chile, which speaks of the importance of such environments as habitat for birds in the country. The background outlined above warrants a consolidated analysis of the available information on the birds of the coastal wetlands of Chile.

In this chapter the role of coastal wetlands in the composition and dynamics of Chilean avifauna is studied. The analysis presented is based on different sources of information about the use of these environments by the migratory and resident birds.

Role of Coastal Wetlands Migratory Birds Geographical Distribution

Long distance migration, on which many water birds embark, requires the existence of numerous rest and refueling sites along the way (Myers et al. 1987). Unlike birds migrating to inland areas, commonly using temporary or questionable quality

Table 3.1 Bird species present in chile's coastal wetlands, together with their protection status, the principal type of habitat associated with each species and a qualitative description of their abundance/ frequency ratio in three latitudinal zones along the country

Family/ Specie		Status	Main	Abundance		
		in Chile	environment	north	center	south
Podicipedidae						
Rollandia rolland	White-tufted grebe	Resident	Humedal	•	o	o
Podilymbus podiceps	Pied-billed grebe	Resident	Humedal		o	o
Podicephorus major	Great grebe	Resident	Humedal	•	o	o
Podiceps occipitalis	Silvery grebe	Resident	Humedal	o	o	o
Sulidae						
Sula variegata	Peruvian booby	Resident	Mar	•	o	•
Pelecanidae						
Pelecanus thagus	Peruvian pelican	Resident	Mar	O	O	O
Phalacrocoracidae						
Phalacrocorax brasilianus	Neotropic cormorant	Resident	Mar	O	O	O
Phalacrocorax bougainvilli	Guanay cormorant	Resident	Mar	O	•	•
Ardeidae						
Ixobrychus involucris	Stripe-backed bittern	Resident			•	•
Ardea cocoi	Cocoi heron	Resident	Humedal		•	•
Ardea alba	Great egret	Resident	Humedal	o	o	o
Egretta thula	Snowy egret	Resident	Humedal	o	O	O
Egretta tricolor	Tricolored heron	Errant	Humedal	•		
Egretta caerulea	Little blue heron	Resident	Humedal	o		
Bubulcus ibis	Cattle egret	Resident	Humedal	•	•	•
Butorides striata	Striated heron	Errant	Humedal/ Praderas		•	
Nycticorax nycticorax	Black-crowned night heron	Resident	Humedal	o	o	o
Threskiornithidae						
Platalea ajaja	Roseate spoonbill	Errant	Humedal	•	•	
Theristicus melanopis	Black-faced ibis	Resident	Humedal/ Praderas	•	•	o
Plegadis chihi	White-faced ibis	Resident	Humedal		•	•
Plegadis rigdwayi	Puna ibis	Resident	Humedal	•		

(continued)

Table 3.1 (continued)

Family/ Specie		Status	Main	Abundance		
		in Chile	environment	north	center	south
Phoenicopteridae						
Phoenicopterus chilensis	Chilean flamingo	Resident	Humedal	•	o	o
Phoenicoparrus andinus	Andean flamingo	Resident	Humedal	•	•	
Anatidae						
Coscoroba coscoroba	Coscoroba swan	Resident	Humedal		o	o
Cygnus melanocoryphus	Black-necked swan	Resident	Humedal	•	o	O
Chloephaga hybrida	Kelp goose	Resident	Coast			•
Tachyeres pteneres	Fuegian steamer duck	Resident	Coast			•
Tachyeres patachonicus	Flying steamer duck	Resident	Humedal			•
Speculanas specularis	Bronze-winged duck	Resident	Humedal			•
Anas platalea	Red shoveler	Resident	Humedal		o	o
Anas cyanoptera	Cinnamon teal	Resident	Humedal	o	o	o
Anas versicolor	Silver teal	Resident	Humedal		•	•
Anas puna	Puna teal	Resident	Humedal	•		
Anas sibilatrix	Chiloe wigeon	Resident	Humedal	•	O	O
Anas flavirostris	Yellow-billed teal	Resident	Humedal	•	O	O
Anas bahamensis	White-cheeked pintail	Resident	Humedal	o	o	•
Anas georgica	Yellow-billed pintail	Resident	Humedal	o	O	O
Anas platyrhynchos	Mallard	Exotic	Humedal		•	
Netta peposaca	Rosy-billed pochard	Resident	Humedal		•	•
Heteronetta atricapilla	Black-headed duck	Resident	Humedal		•	•
Oxyura vittata	Lake duck	Resident	Humedal		O	o
Oxyura ferruginea	Ruddy duck	Resident	Humedal		•	o
Pandionidae						
Pandion haliaetus	Osprey	Migratory	Humedal	•	•	•
Accipitridae						
Circus cinereus	Cinereous harrier	Resident	Humedal	•	•	•
Circus buffoni	Long-winged harrier	Errant	Humedal		•	

(continued)

Table 3.1 (continued)

Family/ Specie		Status	Main	Abundance		
		in Chile	environment	north	center	south
Rallidae						
Laterallus jamaicensis	Black rail	Resident	Humedal	•	•	•
Pardirallus sanguinolentus	Plumbeous rail	Resident	Humedal	•	o	o
Gallinula chloropus	Common moorhen	Resident	Humedal	o		
Gallinula melanops	Spot-flanked gallinule	Resident	Humedal		o	o
Fulica armillata	Red-gartered coot	Resident	Humedal		O	O
Fulica leucoptera	White-winged coot	Resident	Humedal	o	O	O
Fulica rufifrons	Red-fronted coot	Resident	Humedal		O	o
Haematopodidae						
Haematopus palliatus	Pilpilén	Resident	Coast	O	O	o
Haematopus ater	Pilpilén negro	Resident	Coast	•	•	•
Haematopus leucopodus	Pilpilén austral	Resident	Coast			o
Recurvirostridae						
Himantopus melanurus	Perrito	Resident	Humedal	•	O	o
Recurvirostra andina	Caití	Resident	Humedal	•		
Charadriidae						
Vanellus chilensis	Queltehue	Resident	Humedal/ Praires		O	O
Pluvialis dominica	Chorlo dorado	Migratory	Coast	•	•	•
Pluvialis squatarola	Chorlo ártico	Migratory	Coast	o	o	o
Charadrius semipalmatus	Chorlo semipalmado	Migratory	Coast	•		
Charadrius alexandrinus	Chorlo nevado	Resident	Coast	•	•	•
Charadrius falklandicus	Chorlo de doble collar	Resident	Costa/ Humedal	•	•	o
Charadrius collaris	Chorlo de collar	Resident	Costa/ Humedal		o	o
Charadrius vociferus	Chorlo gritón	Resident	Coast	o		
Charadrius modestus	Chorlo chileno	Resident	Coast	•	o	O
Charadrius wilsonia	Chorlode picogrueso	Migratory	Coast	•		
Oreopholus ruficolis	Chorlo de campo	Resident	Dunes/ praires	•	•	

(continued)

Table 3.1 (continued)

Family/ Specie		Status	Main	Abundance		
		in Chile	environment	north	center	south
Scolopacidae						
Tringa melanoleuca	Pitotoy grande	Migratory	Humedal	o	o	O
Tringa flavipes	Pitotoy chico	Migratory	Humedal	o	O	O
Catoptrophorus semipalmatus	Playero grande	Migratory	Coast	o	•	•
Actitis macularia	Playero manchado	Migratory		•		
Numenius phaeopus	Zarapito	Migratory	Coast	O	O	O
Limosa haemastica	Zarapito de pico recto	Migratory	Coast	•	o	O
Arenaria interpres	Playero vuelve piedras	Migratory	Coast	•	•	•
Aphriza virgata	Playero de las rompientes	Migratory	Coast	•	•	•
Caldera's canutus	Playero ártico	Migratory	Coast	•	•	o
Calidris alba	Playero blanco	Migratory	Coast	o	o	o
Calidris pusilla	Playero semipalmeado	Migratoria	Coast	•		
Calidris minutilla	Playero enano	Migratoria	Coast	•		
Calidris fuscicollis	Playero de lomo blanco	Migratoria	Coast	•		o
Calidris bairdii	Playero de Baird	Migratoria	Coast/ Humedal	o	o	o
Calidris melanotos	Playero pectoral	Migratory	Coast	•	•	•
Calidris himantopus	Playero de patas largas	Migratory	Coast	•		
Gallinago paraguaiae	Becasina	Resident	Humedal		o	o
Phalaropus lobatus	Pollito de mar boreal	Migratory	Mar	•	•	
Phalaropus fulicarius	Pollito de mar rojizo	Migratory	Mar	•	•	•
Phalaropus tricolor	Pollito de mar tricolor	Migratory	Coast/ Humedal ta/	o	•	•
Pluvianellidae						
Pluvianellus sociales	Chorlo de Magallanes	Resident	Coast			o
Thinocoridae						
Thinocorus rumicivorus	Perdicita	Resident	Dunes/ praderas	•	•	•
Laridae						

(continued)

Table 3.1 (continued)

Family/ Specie		Status	Main	Abundance		
		in Chile	environment	north	center	south
Stercorarius chilensis	Salteador chileno	Resident	Mar	•	•	•
Larus serranus	Gaviota andina	Resident	Humedal	•		
Larus maculipennis	Gaviota cáhuil	Resident	Humedal		O	O
Larus pipixcan	Gaviota de Franklin	Migratory	Coast/ Humedal	O	O	O
Larus scoresbii	Gaviota austral	Resident	Coast			o
Larus dominicanus	Gaviota dominicana	Resident	Coast	O	O	O
Larus belcheri	Gaviota peruana	Resident	Coast	o	•	
Larus modestus	Gaviota garuma	Resident	Coast	O	O	
Larus cirrocephalus	Gaviota de capucha gris	Migratory	Coast	•		
Sterna hirundinacea	Gaviotín sudamericano	Resident	Mar/ Humedal	o	o	O
Sterna hirundo	Gaviotín boreal	Migratory	Mar	•	•	
Sterna paradisaea	Gaviotín ártico	Migratory	Mar	•	•	•
Sterna trudeaui	Gaviotín piquerito	Resident	Mar/ Humedal		o	o
Sterna lorata	Gaviotín chico	Resident	Mar	•		
Sterna elegans	Gaviotín elegante	Migratory	Mar/ Humedal	O	O	O
Sterna sandvicensis	Gaviotín de Sandwich	Migratory	Mar	•	•	•
Larosterna inca	Gaviotín monja	Resident	Mar	o	o	•
Rynchops niger	Rayador	Migratory	Wetland	O	O	O
Strigidae						
Asio flammeus	nuco	Resident	Dunes/ praderas	•	•	•
Alcedinidae						
Ceryle torquata	Martín pescador	Migratory	Humedal			•
Chloroceryle americana	Martín pescador chico	Errant	Humedal	•		
Furnariidae						
Cinclodes nigrofumosus	Churrete costero	Resident	Coast	o	o	o
Cinclodes patagonicus	Churrete común	Resident	Humedal		o	o
Cinclodes oustaleti	Churrete chico	Resident	Humedal	•	o	o

(continued)

Table 3.1 (continued)

Family/ Specie		Status	Main	Abundance		
		in Chile	environment	north	center	south
Cinclodes fuscus	Churrete acanelado	Resident	Humedal		o	o
Phleocryptes melanops	Trabajador	Resident	Humedal	•	o	o
Tyrannidae						
Tachuris rubrigastra	Siete colores	Resident	Humedal	•	o	o
Pseudocolopteryx flaviventris	Pájaro amarillo	Migratory	Humedal		•	•
Lessonia rufa	Colegial	Resident	Humedal	•	o	o
Hymenops perspicillata	Run run	Migratory	Humedal		•	o
Trogloydytidae						
Cistothorus platensis	Chercán de las vegas	Resident			•	o
Motacillidae						
Anthus correndera	Bailarín chico	Resident	Dunes/ praderas		o	•
Anthus lutescens	Bailarín chico peruano	Errant	Dunes/ praderas	•		
Anthus hellmayri	Bailarín chico argentino	Errant	Dunes/ praderas			•
Icteridae						
Agelaius thilius	Trile	Resident	Humedal		O	O

*Asilvestrado
•Infrecuente/raro
oEscaso/normal
OComún/abundante

wetlands, birds that use the coast as a migration path found in coastal wetlands a highly stable and predictable resource, allowing them to inhabit it by relatively long periods of time (Skagen 1997).

Thus, along a coastal migration route, estuaries are a chain of sites that include not only centers of temporary re-supply, but also places to spend a winter in (Skagen 1997).

Among the factors that determine the selection of wetlands for migratory birds, abundance and quality of the food is probably the most important, but there is also the effect of physical variables of wetlands and the type of human intervention (Cole et al. 2002; Placyk and Harrington 2004). The coincidence of the ideal conditions for each of the above factors, in one place, is usually rare. This evidence makes up the fact that very few sites often concentrate a high proportion (e.g. more than 30-40%) of the world population of some species (Morrison and Harrington 1979).

Along the Chilean coast, between Arica and Chiloe, there are about 300 coastal wetlands, some of which receive substantial amounts of migratory birds, while others

are marginally used by these species. Faced with this phenomenon we ask: What factors influence this pattern? Following, we try to partially answer this question by analyzing the case of two long-distance migratory species, the Elegant Tern (Sterna Elegans) and Black Skimmer (Rynchops Niger). Both species are concentrated in estuaries, although the Elegant Tern forages more on the coast (Schaffner 1986), while the Black Skimmer does it directly on the banks of wide rivers and estuaries (Gochfeld and Burger 1994).

Using different sources of information (censuses AvesChile, public data of the eBird system, and observations of the authors), we have determined that the average and maximum abundance recorded is between the months of October and April for both species in Chile, in different coastal wetlands in the country. We have obtained information (at least through one census) for 85 sites between the mouth of Lluta River and Chiloe, covering virtually the entire range of distribution of these species in Chile (Jaramillo 2003).

Figures 3.1 and 3.2 show the distribution of the Black Skimmer and Elegant Terns, respectively. Along with a description of the average abundance at each site (circle diameter) is also presented a characterization of the quality of information (number of surveys in which the data is based). Both figures show a very similar pattern of distribution observed ($r = 0.85$, $p < 0.0001$), which highlights a point of concentration at the mouth of the Lluta and San Jose (extreme north) rivers, followed by about 1600 km of absence of important records. Further south, the areas of greatest concentration of these species are found in the regions of Maule and Bio-Bio. The southernmost records of these species correspond to the northern part of the island of Chiloe.

To evaluate the existence of physical parameters of wetlands that influence the degree of aggregation of these species, we have estimated from Google Earth's total water surface and the total area of the isolated sand bars (i.e. surrounded by water) for each site. We have also determined that if the river mouth is adjacent to a sandy beach or not (1.0). Finally, based on the concentration of houses and other infrastructures around wetlands, we have defined the quality index of human presence in estuaries (0, 1 and 2). Through a step by step linear model (function stepAIC, R. Ihaka and Gentleman 1996), we have correlated these variables with the maximum abundance logarithm of each species.

Table 3.2 shows that neither the total surface of water nor the degree of human presence, have significantly influenced the abundance of species in different wetlands. By contrast, both the average and maximum abundance of Black Skimmer were explained significantly by the surface of sandbars, while the abundance of Elegant Terns was positively associated with the presence of beaches. However, in all of these cases the percentage of explained variance was very low (3–9%).

A visual inspection of the data identified the Biobio River as a special case, with a high amount of sand bars silting, posing in the final portion of its course, but with very low records of the species studied. This situation, coupled with the fact that the site has reported only two censuses, caused the data to be removed. The lower part of Table 3.2 contains an analysis as above, but without the Biobio River. It is noted that the significance of the sandbars as predictors of the abundance of species

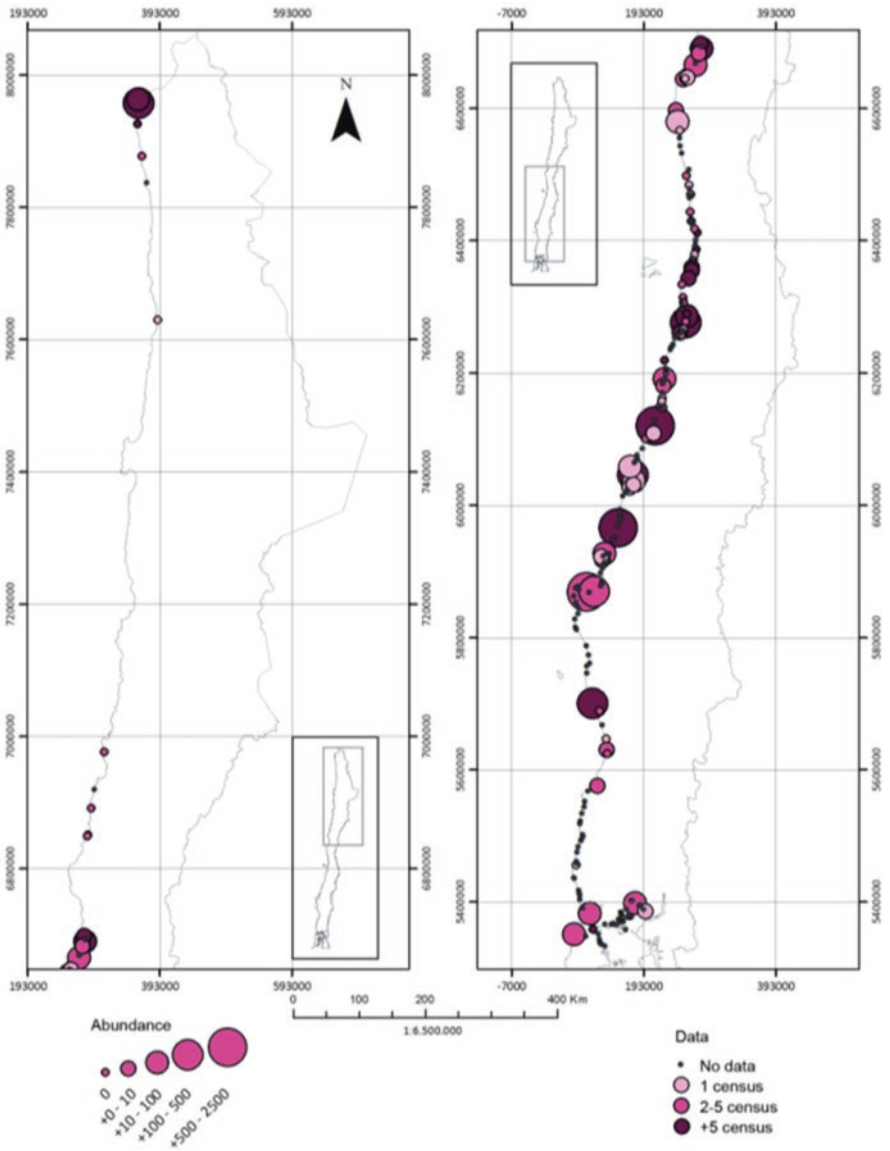

Fig. 3.1 Distribution of Black Skimmer (*Rynchops niger*) in Chile's coastal wetlands. The average size of those populations where a census was carried out in each site is graphically represented by the circle's diameter. The quality of the information (number of census) for each site is represented by the color of the figure

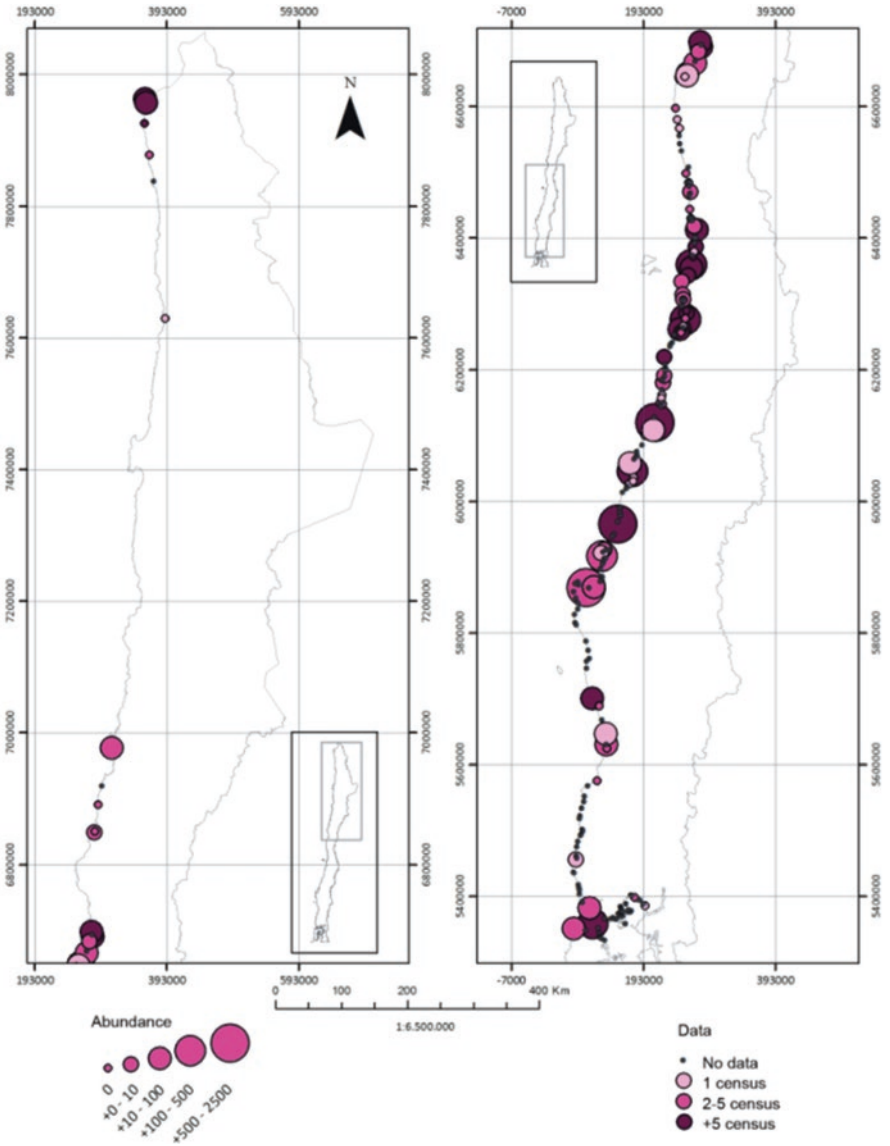

Fig. 3.2 Distribution of Elegant Tern (*Sterna elegans*) in Chile's coastal wetlands. The average size of populations where a census was carried out in each site is graphically represented by the circle's diameter. The quality of the information (i.e. number of census) for each site is represented by the color of the figure

Table 3.2 Effect of different attributes of coastal wetlands on the abundance of Black Skimmer (*Rynchops niger*) and Elegant Tern (*Sterna elegans*). Only the statistically significant relationships are presented

	Black Skimmer		Elegant Tern	
	Average	Max	Average	Max
All data (n=85)				
Water Surface				
Bar Surface	0.004* (0.09**)	0.008 (0.07)		
Beach			0.046 (0.03)	
Human Presence				
Without Biobio River(n=84)				
Water Surface				
Bar Surface	7 e–07 (0.25)	1 e-05 (0.20)	9 e-05 (0.16)	0.001 (0.15)
Beach				
Human Presence				

*value P. All the relations are positive
**R2 adjusted by the grade of liberty

increased significantly, also explaining the concentration of Elegant Terns. In addition, the percentage of the explained variance increased the values between 15 and 25%. In contrast, the variable presence of beaches had no significant effect on the species studied.

Population Dynamics

One of the obvious characteristics of populations of migratory species is the high seasonal variability of their abundances at a given site. Thus, apart from a large geographic concentration, the interaction of these birds with the coastal wetlands has a high degree of temporal concentration. Although a significant percentage of water birds studies, in Chile, has been made in estuaries (Victoriano et al. 2006), the available information on population dynamics is very low (Victoriano et al. 2006; Vilina and Cofre 2006).

Following description is of the population dynamics of the abundance of some of the main species of migratory birds visiting the coastal wetlands of central Chile. To this end, we rely on information collected by us as part of a program of long-term research developed in four estuaries of central Chile: Itata (36o23 ‘S, 72o51’ W), Reloca (35o40 ‘S, 72o35’ W), Mataquito (34o59 ‘S, 72o10’ W) and Topocalma (34o07 ‘S, 71o59’ W). The first three sites have been monitored since 2006, while the fourth was incorporated in 2008.

In all of the estuaries, the four seasonal censuses per year have been organized, focused on the most biologically significant periods for birds. Thus, these campaigns correspond to summer (boreal species wintering), autumn migration (return of boreal species), winter (southern wintering species) and spring migration (arrival of boreal species).

Since the study has focused on Itata, with the other three sites acting as population control trends, the sampling intensity was higher in the first. Thus, while for the control of each campaign there were considered two census visits (eight visits for eight annual surveys) in Itata migration campaigns there were three visits involved, each of which contains censuses for 3 days in a row, with a repeat in the morning and one in the evening (10 visits and 60 censuses per year). However, for purposes of this study, in the case of Itata, the average data per census visit census is presented.

Each census represents the total count of individuals present in each study site (each river estuary) from fixed observation stations. To make the count of individuals, binoculars and telescope are used.

Here on after, in this document, the estuaries of Itata, Reloca, Mataquito, and Topocalma rivers will be referred to as IRMT estuaries. Figure 3.3 shows the population trajectory of Black Skimmer and Elegant Tern for each of the individual sites and for all estuaries. In the case of Black Skimmer there can be seen a high degree of regularity in the patterns of abundance, particularly in the aggregate numbers. The data for this species indicate that there is a population tendency to concentrate on Itata (the southernmost site) at the start of the season and then to slowly move northward through Reloca and Mataquito.

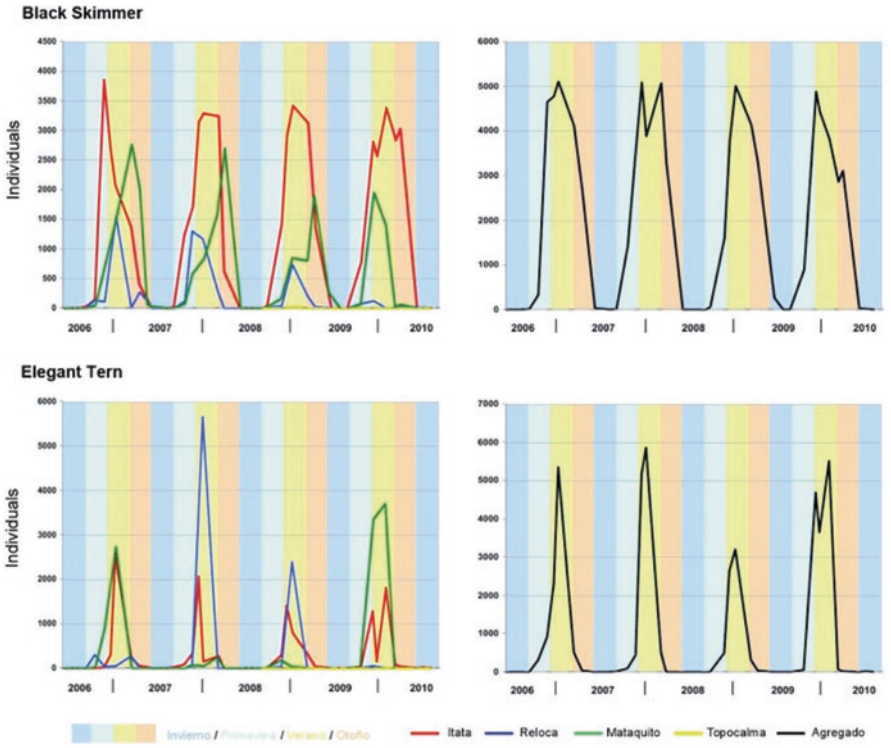

Fig. 3.3 Population trajectories for `Black Skimmer (*Rynchops niger*) and Elegant Tern (*Sterna elegans*) in four estuaries in central-south Chile (*color lines*) and for all these sites as a whole (*black lines*). Data shown correspond to the period of winter 2006 – winter 2010

The shape of the curve of the abundances accumulated suggest that Black Skimmer populations visiting the IRMT estuaries are a relatively closed group, where birds remain throughout the summer. This implies that these sites have an important role as a station stop for birds traveling further south (see the case of the Baird's Sandpiper), although there are indeed places further southern concentration (Fig. 3.1), but not of the same importance as the IRMT estuaries.

The case of Elegant Terns (Fig. 3.3) is relatively different. While it is true that the accumulated abundance has a high degree of regularity, the situation at the site has varied significantly during the study period, and a clear negative relationship between the abundance of the species in Mataquito (high in 2006–2007 and 2009–2010) and Reloca (high in 2007–2008 and 2008–2009) was observed. Both results suggests a redistribution of birds between sites in different seasons. Figure 3.4 shows the population trajectory of the Baird's Sandpiper (Calidris bairdii), another boreal migratory species that, unlike previous ones, uses the IRMT estuaries as a transit station, rather than wintering site. This follows from the clear and regular trend where two annual peaks are observed: one in spring, associated with the migration of individuals to the south, and one in summer, due to the migration of individuals to the north.

Lastly, in Fig. 3.5 two examples of short-distance migratory species that visit the estuaries of central Chile during the winter are shown. The first is the Rufus-chested Plover (Charadrius modestus), a species that nests in the southern part of the country and migrates to the central area during the autumn-winter (Kusch and Marin 2004). The trajectory the site and aggregate level shows a fairly regular pattern where the arrival of the birds seen in autumn is peaking in winter. A worrying aspect when it comes to these species is the clear declining trend shown during the five seasons of monitoring.

Even though, the Chilean Flamingo (Phoenicopterus chilensis) population trajectories in different sites are dissimilar (Fig. 3.5), the added trend shows a high

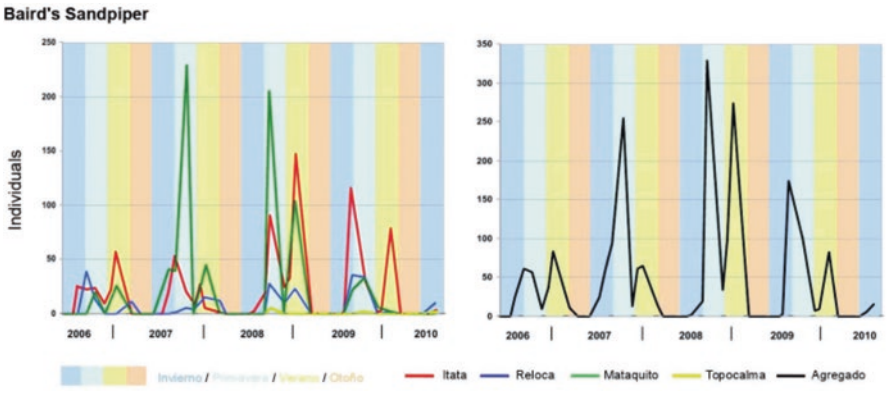

Fig. 3.4 Population trajectories of Baird's Sandpiper (*Calidris bairdii*) in four estuaries in central-south Chile (*color lines*) and for all these sites as a whole (*black lines*). Data shown correspond to the period of winter 2006 through winter 2010

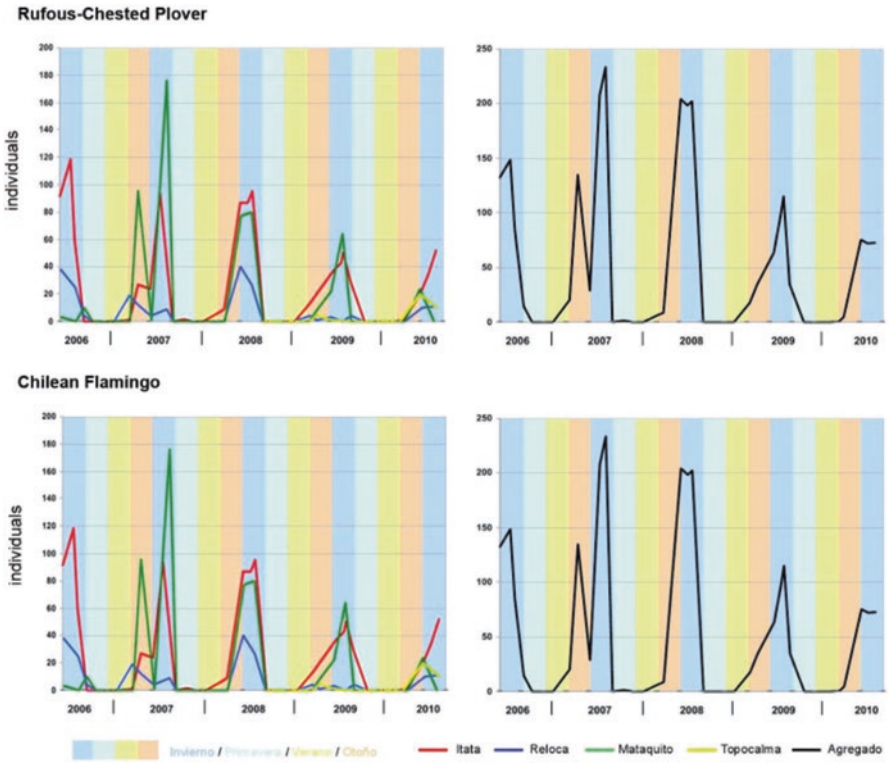

Fig. 3.5 Population trajectories for Rufus-chested Plover (*Charadrius modestus*) and *Chilean Flamingo* (*Phoenicopterus chilensis*) in four estuaries in central-south Chile (*color lines*), and these sites as a whole (*black lines*). Data shown correspond to the period of winter 2006 through winter 2010

degree of regularity, suggesting that the birds arriving to the study area are relatively defined group, but that individuals are redistributed differently between sites in different seasons. Estades et al. (2008) indicate that this "transfer" between sites is probably due to the existence of a negative relationship between the presence of the species in large estuaries and the level of rainfall of the year, probably due to the rainfall effect on habitat availability for these birds.

Role of Coastal Wetlands for Birds Residents – Selection and Habitat use

While higher concentrations of birds in coastal wetlands are migratory species, the greatest diversity of species is given by resident species (Table 3.1). Therefore, a large number of species of sea, coastal and freshwater birds that are breeding in the

country, converge on these coastal wetlands, particularly onto estuaries. However, patterns of resident birds' habitat selection and use of these ecosystems are poorly understood, with very few published works (e.g. Quezada et al. 1986; Victoriano and González 2005) on the subject.

One of the basic aspects that describe the functional relationship between species and their habitat is the time that individuals engage in various alternative activities. During bird surveys conducted in the estuary of the Itata River, we have recorded the activities of different birds, when being observed. Figure 3.6 shows the main activities of three species of resident birds in the area, through the four seasons of the year (spring 2006 – winter 2007). There were considered data from all censuses (morning and afternoon), so the charts show the average proportions of the population recorded for each season. The abundance of birds in each season is represented graphically by the diameter of the figures and the average number. Furthermore, the number of surveys, out of which the average number was calculated, is shown next to each season.

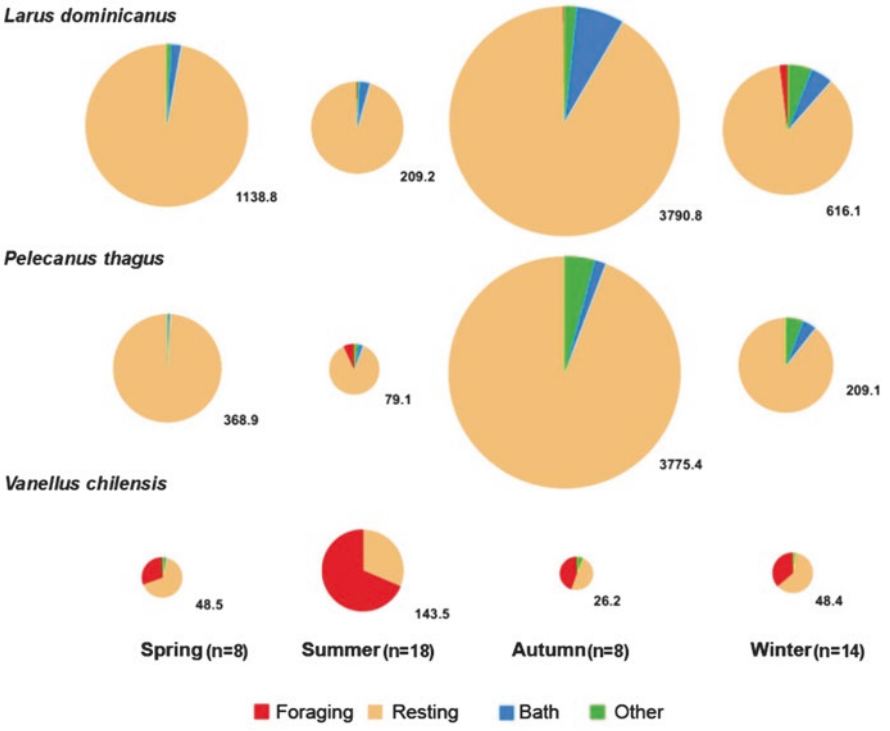

Fig. 3.6 Frequency of activities performed by three bird species in the Itata river estuary between spring 2006 and winter 2007. The dimensions of the *circles* represent the total number of individuals based on which the proportions were calculated. The category "other" includes aggression and flight

It is noted that in the case of the two marine species, the Kelp Gull (Larus dominicanus) and the Peruvian Pelican (Pelecanus Thagus), the largest proportion (87–99%) of individuals was recorded at rest. Second in importance was the bath (0.5–7%), frequent activity among these birds, which apparently use fresh water to remove salt from their plumage. The percentage of birds foraging was low (0–7%) as well as other activities (flight, aggression, etc.). No breeding activities of these species were recorded in the area.

The Southern Lapwing (Vanellus chilensis), a common species in all types of wetlands and agricultural areas, had a higher ratio of foraging dedication than the previous species (30–69%), although the number of individuals resting was also high (31–66%). Dedication to activities such as bathing and other was minimal. Unlike the two marine species, Southern Lapwing itself had some degree of reproductive activity in the area, although it was not registered during the census.

Population Dynamics

Although pretty significant number of ornithologists, both professional and amateur, conducts periodic surveys of water birds in numerous wetlands of central Chile (Espinoza 2009), the analysis of these data are almost nonexistent, so it does not yet have a reasonable characterization of the waterfowl residents' dynamics in this region.

Data derived from surveys conducted by us (CFE and MAV) in the IRMT estuaries indicate that even for most waterfowl species considered residents in central-southern Chile, there is evidence of displacement of the large numbers of the population.

Figure 3.7 shows the added population trajectories in IRMT estuaries, for six common species living in the wetlands of central Chile. It highlights the existence of a general pattern common to all species, with a minimum population observed in the spring, followed by a very sharp increase in population during the summer-autumn season. The low presence during the subsequent breeding season and high growth rate and small number of offspring observed, suggests that the dynamics of these populations is not governed by births and deaths, but mainly by the migration of individuals.

To determine the possible origin of birds, evidence of inverse population trends were sought throughout other sites in central Chile, which could account for seasonal re-distribution of individuals. For this census, data obtained by JA in environmental lagoon Farfana (33o28 'S, 70o47' W, Maipu, Metropolitan Region) were used. This lagoon, specially designed to house waterfowl, is probably the only interior wetland of the central region of Chile that has a concentration of adequate data for comparison purposes.

Figure 3.8a contrasts the population trajectory of White-tuft Grebe (Rollandia Rolland) in IRMT estuaries and Farfana. Here we see a clear reverse trend, where birds were concentrating in Farfana during reproductive periods (with the exception

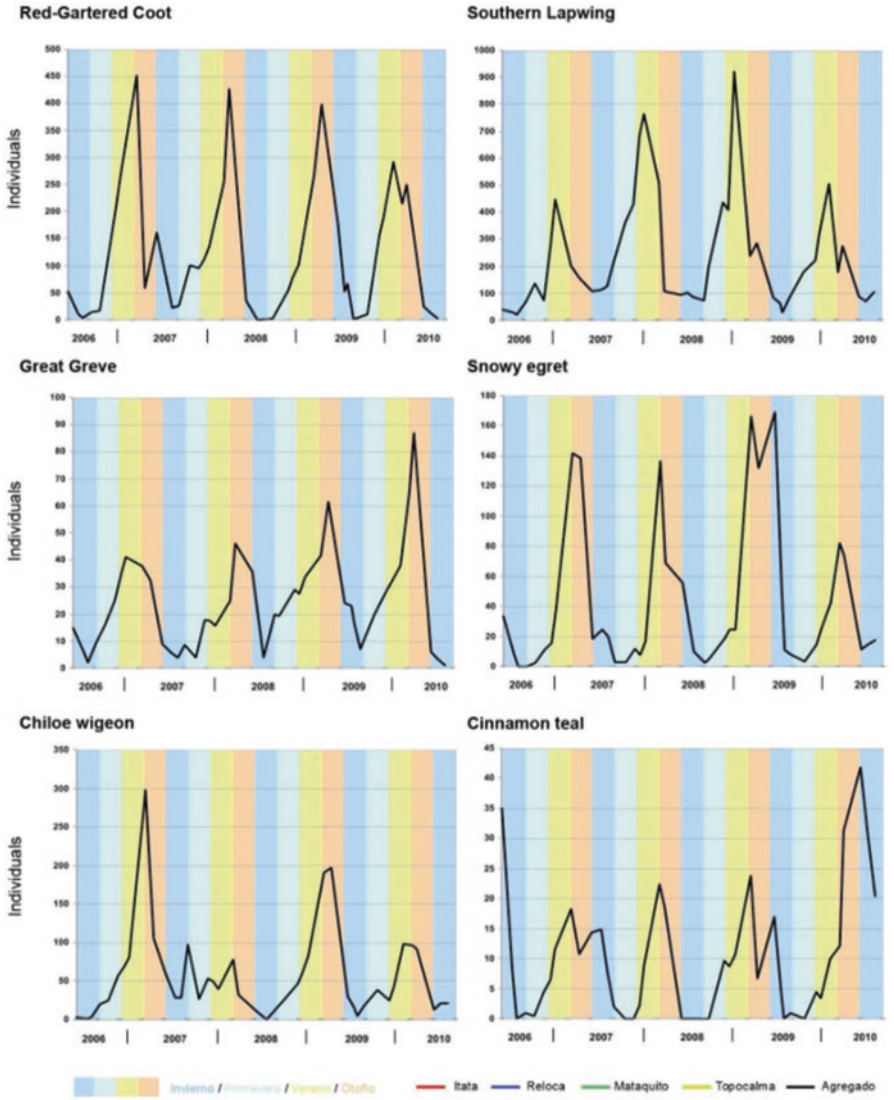

Fig. 3.7 Aggregated population trajectories for estuaries of six bird species that reside in central Chile: Red-gartered Coot (*Fulica armillata*), Southern Lapwing (*Vanellus chilensis*), Great Grebe (*Podiceps major*), Snowy Egret (*Egretta thula*), Chiloe Wigeon (*Anas sybilatrix*) and Cinnamon Teal (*Anas cyanoptera*). Data shown correspond to the period of winter 2006 through winter 2010

of spring 2007), then they would leave the area in the summer, the same period in which the species began arriving to the IRMT estuaries.

Although it is not possible to argue that there is a movement of birds from the Farfana to the IRMT estuaries (located 150–350 kilometers SW), the trend seems to suggest that at least some of the species that are concentrated in the estuaries of the

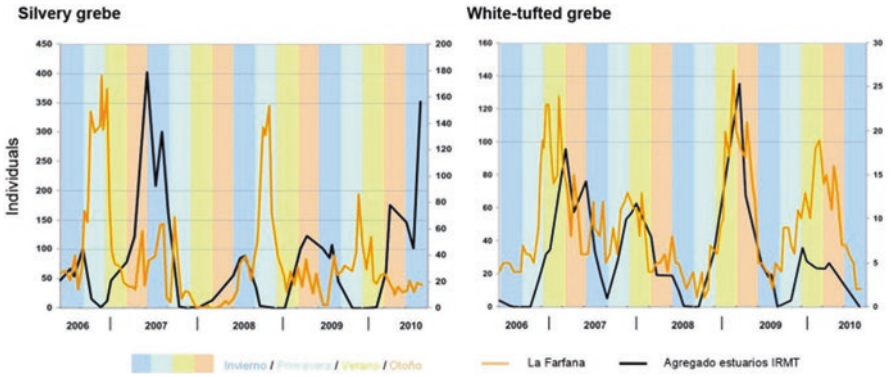

Fig. 3.8 Population trajectories of Silvery Grebe (*Podiceps occipitalis*) and White-tuft Grebe (*Rollandia rolland*) observed in the IRMT estuaries and the Farfana (Metropolitan Region). Data shown correspond to the period of winter 2006 through winter 2010

central-southern area during the post-reproductive period, are from the country-s central valley wetlands.

Far from showing a reverse trend, Fig. 3.8b reveals that the population trajectory of White-tufted Grebe (Rollandia Rolland), a relative of the previous species, virtually replicates the pattern observed in the IRMT estuaries. This suggests that in both systems, the reproduction of this species is low and that the significant population increase observed during the summer is due to individuals from other wetlands with appropriate characteristics for reproduction of these birds or, as suggested by the results of a study of the Chacabuco basin (Lopez et al., in preparation), corresponds to birds that come from the surrounding landscape.

Lopez et al. (In preparation) have observed that many water birds are dispersed in the landscape during the breeding season, so they are not registered in the regular censuses of large wetlands. Most likely, these birds breed in low extension wet environments, such as canals and small irrigation dams, wet meadows, marshes, etc., and then return to large wetlands during the post-reproductive period, during which a large portion of small scattered wetlands has dried out.

Therefore, while it is true that coastal wetlands in the central-southern Chile area have little importance as breeding sites, they play an important role in the population dynamics of many resident waterfowl, acting as post reproductive aggregation sites.

Discussion and Conclusions

The factors that determine the presence and abundance of different species of birds in coastal wetlands, at some point, include aspects of the biology of the species (e.g. resident and migratory), and the physical and biological characteristics of these environments.

The evidence presented in this chapter show that simple physical variables (e.g. surface sandbars) may account for not insignificant percentage of the variance in abundance of some species of birds in coastal wetlands of Chile. The great importance of sandbars as predictors of the abundance of Black Skimmer and Elegant Terns are most likely based on the role that these structures have as resting stations for many birds (Alfaro and Clara 2007). Studies of other similar environments, in other parts of the world, emphasize that the presence of this type of rests significantly influences the use that birds can make of an estuary (Rogers et al. 2006).

In our analysis, we have only included sandbars isolated from the banks (the others were included in the variable beach), as they have secure sites with limited access to predators like dogs. While it is normal to see significant numbers of birds resting on beaches connected with mainland, the frequent movement of people, vehicles and animals (domestic and livestock) tend to repeatedly scare the birds, so presumably, in isolated areas there should not have a higher rate of turnover. Contrary, the existence of isolated bars could ensure the permanence of flocks longer. This suggests that our model should better predict the average abundance than the maximum (more variable). In fact, although there was a dramatic difference, in all of the cases there was a better adjustment with the average abundance than with the maximum (Table 3.2).

There are many sources of error in estimating the area of sand bars in estuaries from Google Earth. Thus, the existence of images from different years, times, tide levels, etc., coupled with possible errors in photo interpretation, and the variability in the quality of data abundance of birds, suggest that in our analysis there is a high noise level. It is possible that with better information, the effect of sand bars on the abundance of birds, such as those studied, is even greater than that found by us. Nevertheless, it is possible to analyze the mechanisms by which other factors may affect the presence of birds in coastal wetlands of our country.

The uneven distribution of wetlands on the Chilean coast poses restrictions on migratory birds when it comes to the possibility of stopover sites during their movements. This is reflected in the presence of a small number of sites of concentration of these birds (Figs. 3.1 and 3.2).

For the Elegant Terns, that forages mainly in salt water (Schaffner 1986), it is possible to make intermediate stops in places without wetlands (e.g. beaches, rocks, etc.), accessing food in the sea. However, the Black Skimmer has difficulty feeding in waters with some degree of wave surf, so, with the exception of some very calm bays, this species is not foraging at sea. This implies that, notwithstanding that these birds can rest on many points between wetlands described in Fig. 3.1, they can only feeding lagoons and estuaries. Hence, the distance of over 1100 kilometers between the Lluta River and next estuary of relatively significant dimensions (Huasco, 5 ha of water) should imply greater restriction on the Black Skimmer, since it is likely that there are no important refueling places in between these points. Being so, the records of the species in Huasco are practically nil, and the wetland of Punta Teatinos (2 ha of water, La Serena, 1300 kilometers south Of Lluta) is the first place of some importance, as feeding site for the species on their journey south.

Along the Chilean migratory coastal route, the estuaries form a chain of sites that include not only centers of temporary resupply, but also wintering sites. This pattern, previously described by Skagen (1997), is exemplified by the cases of Black Skimmer and Baird's Sandpiper. So while the first species have established themselves in the IRMT estuaries throughout the season (Fig. 3.3), the second one uses these sites to stock and rest during their journey to and from more southern sites (Fig. 3.4). Aparicio (2006) observed that Sandpiper's Baird was present only in their area of study (Valdivia) during migration south, indicating that this species uses different places of detention and resupply during their migrations from and to south and north.

Water bird communities (migratory and resident) present in the estuaries on the coast of Chile are highly dynamic, albeit with a very regular and predictable structure. Although this situation does not necessarily replicate in wetlands farther south or farther north, in the IRMT estuaries the existence of a high degree of coincidence in population trends of most species between sites, even among non-migratory ones, suggests that these dynamics are largely due to regional trends rather than individual behavior of each estuary.

Thus, in many cases, the aggregate data of the population trajectories, in different sites analyzed, showed more consistency than that of each individual site, indicating the existence of a non-independent behavior of bird populations studied. The opposing trends in populations at some sites strongly suggest the existence of a redistribution of birds among sites in different seasons (e.g. Elegant Terns, Fig. 3.3, Chilean Flamingo, Fig. 3.5).

Existing information on the use that waterfowl makes of the IRMT estuaries (exemplified in this work with the case of the Itata River), clearly indicates that the main role of these environments is to serve as a resting place for many birds. Data on the activities of Kelp Gull and Peruvian Pelicans (Fig. 3.6) are representative of most species, both resident and migratory (data not shown). In particular, many sea birds foraging at sea, sleep on sandbars and beaches surrounding estuaries, so their concentration in these sites tends to increase early or late during the day.

In turn, many seabirds take advantage of the low salinity of estuarine waters for bathing, an activity that often is second in importance in terms of the number of individuals involved. Although the bathing of seabirds in freshwater sites is a common and normal behavior throughout the world, it is noteworthy that, to our knowledge, there is no assessment of the real importance this activity has on biological adaptation of individuals.

The percentage of time spent foraging is greater for freshwater species than marine ones (e.g. Southern Lapwing vs. Pelican, Fig. 3.6). Still, it is possible that the real importance of the IRMT estuaries as feeding sites for some species are underestimated due to factors such as differences in efficiency when foraging (e.g. in terms of calories per unit of time) or the effectiveness of our protocol sampling. For example, although our surveys in Itata covers a significant period of time of the day (8: 00-12: 00 and 14: 00-17: 00 h.), some species such as Black Skimmer tend to feed at night (Erwin 1977) so the observations of foraging individuals should be clearly under-represented in our samples.

Reproductive activity of water birds in the estuary of the Itata is marginal. This is a common situation in this type of environment in Chile (Victoriano et al. 2006), as well as other parts of the world, because the dynamics of the tides and their interaction with changes in river flows become very unstable in supply of nesting sites. This phenomenon is also associated with the scarcity of aquatic vegetation, which also restricts the abundance of herbivorous species.

In addition to the limitations noted, many estuaries have a high degree of human intervention. For example, in Itata, the presence of pets in the area, as well as cows and horses certainly affects the development of vegetation in which many birds build their nests. For this reason the most abundant nesting areas for species that build nests away from water, are neighboring fields and meadows.

While it is true that estuaries of central Chile play a minor role in the waterfowl nesting, these coastal wetlands do have an important role as post-reproductive aggregation site for many of these species. Indirect evidence suggests that there should be significant and regular bird movements between interior and coastal wetlands. However, the lack of detailed information on population dynamics of birds in the central valley of the country hinders proper understanding of this phenomenon.

Although there is a high predictability in the structure and dynamics of bird communities in coastal wetlands of central Chile, it is also true that there are significant yearly variations in the abundances of some species. One of the factors influencing these changes is the ENSO phenomenon, during which it has been observed that some species like the Black-necked Swan (Cygnus melanocoryphus) and some grebes increase in number in the wetlands of central Chile during wet years (Schlatter et al. 2002; Villina and Cofré 2000; Villina et al. 2002).

On the other hand, major changes in the abundances of some long-distance migratory species respond, most likely, to factors affecting mobilization and survival of these species in the Northern Hemisphere. For example, it has been described that the anchovy fisheries on the West Coast of the United States influence the numbers Elegant Terns (Schaffner 1986), which could certainly lead to changes in the amounts of these birds that visit the coasts of Chile every year.

Finally, coastal wetlands of Chile, as well as the world, are undergoing a major anthropic pressure. Deterioration factors associated with increasing human population, as well as increased levels of eutrophication, pollution and wildlife and water extraction, among others, clearly threaten the integrity of these ecosystems (Kennish 2002).

Regarding waterfowl, a disturbing aspect of this trend is the significant increase in human recreation in estuaries and other coastal wetlands, resulting in numerous impacts, particularly the shortage of peaceful rest sites for many species (Placyk and Harrington 2004). In Chile, a very important factor is the growing presence of stray dogs, which can severely affect the quality of a site as a waterfowl habitat. In addition, “off road” transit of vehicles causes great damage to ecosystems dunes commonly associated with estuaries, affecting some birds’ nesting.

The data obtained by us in the IRMT estuaries delivers a relatively clear picture of how bird communities use them. However, this is a correlational information that does not allow meaningful inferences about causal relationships. Therefore, the

conclusions in this paper are only valid for the conditions under which the data were taken. This poses a certain limitation to the use of this information to understand the response of birds to the future changes in these ecosystems.

For example, the knowledge of specific functional role of wetlands in the path of migratory species is essential to predict the implications that the disturbance of each of these sites could have on the conservation of these species. The lack of such information in Chile, coupled with the fact that clearly different species of migratory birds have different restrictions on their habitat requirements, makes such predictive capacity is still minimum in the country.

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