

# Diet of Imperial Cormorants *Phalacrocorax atriceps* Breeding at Central Patagonia, Argentina

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**Abstract.**—Diets of breeding Imperial Cormorants *Phalacrocorax atriceps* were studied at two breeding colonies, Islas Blancas and Isla Arce, located approximately 30 km apart in an area subject to increasing fishing pressure off Central Patagonia, Argentina. The goal was to assess differences between locations and diet variation among stages of the breeding cycle. Pellet casts (403 and 358 pellets per colony, respectively) were collected from November 2002 to February 2003. Analyses of the pellets revealed that Imperial Cormorants at Islas Blancas and Isla Arce fed on at least 25 and 23 prey types, respectively. Fish showed the highest frequency of occurrence at both colonies (> 70%), followed by crustaceans and molluscs. Of the fish prey, *Merluccius hubbsi* (22-71%), *Engraulis anchoita* (16-51%) and *Raneya brasiliensis* (5-48%) showed the highest frequencies of occurrence, depending on the colony and breeding stage. At Islas Blancas, the consumption of fish and crustaceans was similar among breeding stages (incubation, young chicks and old chicks), while it was significantly different at Isla Arce. Overall contribution by frequency of occurrence showed that *M. hubbsi* was the most frequent prey at Islas Blancas (58%), and *E. anchoita* and *Pleuroluteres muelleri* were more frequent at Isla Arce (48 and 45%, respectively). Also, overall contribution by mass of the main fish prey indicated differences between colonies. Given the commercial value of the main prey species, cormorant feeding requirements and spatial ecological needs should be included as considerations in coastal fisheries management and future development. Received 21 January 2009, accepted 25 April 2009.

**Key words.**—Argentina, diet, Imperial Cormorant, Patagonia, *Phalacrocorax atriceps*.

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Cormorants are pursuit-divers that feed mainly in coastal environments (Johnsgard 1993; Nelson 2005). Like many other seabirds, they are top predators and depend on foraging grounds and resources which may overlap with commercial fisheries (Schreiber and Clapp 1987). Thus, the study of their diet not only contributes to the understanding of predator-prey relationships at the top of the marine food chain, but also provides information that could be used in assessments of fish stock conditions (Casaux and Barrera-Oro 1993; Barrett *et al.* 2007).

Imperial Cormorants, *Phalacrocorax atriceps*, breed in South America from Cape Horn north to 43° on the Atlantic coast and 37° on the Pacific coast, including the Malvinas/Falkland Islands (Yorio *et al.* 1999; Nelson 2005). They are widely distributed along the Argentine coast (Yorio *et al.* 1998; Frere *et al.* 2005), breeding at more than fifty-seven locations and totaling close to fifty-five thousand breeding pairs (Yorio *et al.* 1999; Frere

*et al.* 2005). Imperial Cormorant dietary composition differs between geographical locations along the Patagonian coast (Malacalza *et al.* 1994; Punta *et al.* 2003; Ferrari *et al.* 2004), suggesting Imperial Cormorants use food resources according to local prey composition and availability. Despite this understanding of regional variability in diet, information is lacking from key breeding sites. In addition, Imperial Cormorant diet composition may vary throughout the breeding season (Malacalza *et al.* 1994; Punta *et al.* 2003). Many studies have shown that diet may change throughout the season in response to fluctuations in food availability and in response to energy requirements or restrictions imposed by reproductive factors (i.e. Pierotti and Annett 1991; Suryan *et al.* 2002; Wilson *et al.* 2004).

In addition to providing information on the species ecological requirements, diet studies can contribute to the assessment of interactions between Imperial Cormorant

and fisheries. Commercial fisheries throughout the coastal zone of Patagonia have shown a dramatic increase in the last two decades and are based mainly on two target species, Argentine Hake, *Merluccius hubbsi* and Argentine Red Shrimp, *Pleoticus muelleri*. Imperial Cormorant foraging distribution often overlaps with commercial fisheries (F. Quintana and P. Yorío, unpubl. data) and birds regularly gather near trawl vessels to take advantage of fisheries discards (Yorío and Caille 1999; González-Zevallos and Yorío 2006). Here, we analyzed the diet of the Imperial Cormorant breeding at two colonies located approximately 30 km apart off Central Patagonia, Argentina, in an area subject to increasing fishing pressure. In addition, Isla Arce is included in a recently-designated marine protected area. We assess differences in diet composition between breeding sites and stages of the breeding cycle, and compare results with those previously obtained at other Patagonian locations.

#### METHODS

The sector of Bahía Camarones and northern Golfo San Jorge (Fig. 1) is one of the most important coastal areas in terms of marine biodiversity in Argentina (Fundación Patagonia Natural 1996). A total of 18 Imperial Cormorant colonies are located on islands of this coastal sector, representing one third of its total Patagonian population (Yorío *et al.* 1998). The area is subject to a growing commercial fishery and used by 100 trawl vessels targeting Argentine Red Shrimp and Argentine

Hake (Secretaría de Pesca de la Provincia de Chubut, unpublished data).

We studied the diet of the Imperial Cormorant breeding at Islas Blancas (45°05'S, 66°28'W) and Isla Arce (45°13'S, 66°30'W), Chubut, Argentina (Fig. 1). Islas Blancas are located close to shore (2.5 km) within a semi-enclosed bay and Isla Arce is located 7 km offshore. Yorío *et al.* (1998) reported 894 and 960 pairs breeding at Islas Blancas and Isla Arce, respectively. We carried out the study through the analysis of 761 pellet casts, 403 at Islas Blancas and 358 at Isla Arce. This methodology may over-emphasize the presence of types of prey with indigestible hard parts and soft prey may not be well represented (Duffy and Jackson 1986; Barrett *et al.* 2007). However, other studies have demonstrated that the results appropriately reflect diet composition (Harris and Wanless 1993) and are valuable for detecting both seasonal changes and differences in diet composition among locations (Johnstone *et al.* 1990; Barrett *et al.* 1990).

We collected pellets from early November 2002 to February in 2003. We visited colonies every one to two weeks, recording the general breeding status of nests within the study areas. Only fresh pellets were collected during every visit to the colonies, and were sun-dried until they were analyzed in the laboratory. We broke apart each pellet in a tray under a zoom binocular microscope (21×) and identified food to the lowest taxonomic level possible, using fish otoliths, squid beaks, crustacean shell fragments and chelae, mollusc shell fragments, polychaete mandibles and chetae and echinurid remains. We used guides (Torno 1976; Menni *et al.* 1984; Clarke 1986; Boschi *et al.* 1992; Gosztonyi and Kuba 1996) and a reference collection at the Centro Nacional Patagónico. We classified as 'unidentified prey' all items that were too worn to be reliably identified. For each prey type, we calculated the percentage of occurrence in pellets.

We divided the breeding cycle into three stages: incubation, young chicks (chicks up to approximately four weeks old), and old chicks (chicks between approximately four weeks old and fledging). Young and old chicks were distinguished by size and the presence of the first generation of downy plumage (Nelson 2005). For the analysis, we grouped pellet sampling dates within these three stages of the breeding cycle.

Prey remains, particularly otoliths, may suffer differential digestive erosion depending on species and original size (Jobling and Breiby 1986; Johnstone *et al.* 1990). In our study, a large number of otoliths and diagnostic prey parts were too eroded for subsequent analysis, and thus we did not estimate length and mass for most prey types. However, we were able to assess the relative contribution in number and mass of the main fish prey in our study areas using a sub-sample of otoliths with slight erosion. In addition, this sub-sample allowed the estimation of the individual size of the main commercial fish prey (*Engraulis anchoita* and *M. hubbsi*). Otolith length was measured to the nearest 0.01 mm and the size and mass of each item was calculated applying the equations in Koen-Alonso *et al.* (1998), except for *M. hubbsi* mass which was based on Angelescu *et al.* (1958).

To determine the adequacy of sample sizes, cumulative trophic diversity curves were built using EcoSim software (Gotelli and Entsminger 2001). We tested for differences in the frequency of occurrence of prey types between sites and breeding stages using a multivariate

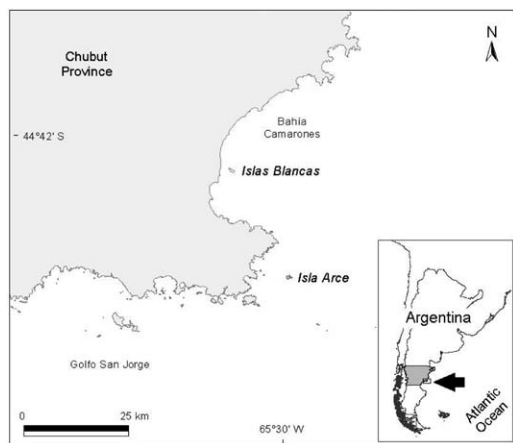


Figure 1. Islas Blancas and Isla Arce, Chubut, Argentina.

analysis with the PRIMER 5 package. First, a similarity matrix of the samples was constructed using the Bray-Curtis similarity coefficient (Clarke and Gorley 2001). To test for statistical differences, a non-parametric permutation-based procedure compared mean ranks of dissimilarities of samples within and between groups. The ANOSIM test statistic R, varies between -1 and 1, reaching its maximum value when all between-group dissimilarities are greater than all within-group dissimilarities. Statistical significance is determined by comparing the sample R with those produced by randomly assigning samples to groups. The P-value of the test is calculated using the proportion of random arrangements with R-values higher than the sample value. Similarity percentages (SIMPER) were employed to

determine the species that contributed most to the dissimilarities between groups (Clarke and Gorley 2001; Clarke and Warwick 2001).

RESULTS

All sample sizes were sufficient for comparison, as the cumulative curves of diversity reached an asymptote. Pellet analyses indicated that Imperial Cormorants at both breeding locations fed on a wide variety of prey types (Table 1). These included at least

**Table 1. Percentage occurrence of prey types consumed by Imperial Cormorants at Islas Blancas and Isla Arce, Argentina, during the 2002 breeding season, obtained by pellet analysis (all breeding stages pooled).**

Taxa	Islas Blancas	Isla Arce
	N = 394	N = 353
Fish	79.2	73.4
<i>Merluccius hubbsi</i>	57.9	30.3
<i>Engraulis anchoita</i>	21.3	48.2
<i>Raneya brasiliensis</i>	16.2	15.9
<i>Notomysine tridentiger</i>	13.7	5.9
<i>Patagonotothen</i> sp.	1.3	1.1
<i>Bovichtys argentinus</i>	0.3	0.6
<i>Agonopsis chiloensis</i>	1.3	0.3
<i>Nemadactylus bergi</i>	3.0	0.3
<i>Odontesthes</i> sp.	1.0	0.0
<i>Pinguipes brasilianus</i>	0.0	0.3
<i>Pseudopercis semifasciata</i>	1.8	0.0
<i>Helcogrammoides cunninghami</i>	0.0	0.3
<i>Acanthistius brasilianus</i>	0.5	0.0
Unidentified fish	4.1	2.0
Crustaceans	30.2	59.2
<i>Pleoticus muelleri</i>	4.6	45.3
<i>Peisos petrunkevitchi</i>	2.3	1.1
<i>Munida</i> sp.	20.3	9.6
<i>Campylonotus</i> sp.	0.8	0.0
<i>Halycarcinus platanus</i>	0.3	0.3
<i>Peltarion spinosulum</i>	3.0	0.6
Isopods	1.0	1.1
Unidentified Decapods	1.5	4.0
Molluscs	24.9	34.0
Squid	15.5	21.2
Octopus	11.9	13.3
Unidentified Cephalopods	5.6	6.2
Gasteropods	1.3	1.7
Bivalves	0.5	1.1
Polychaetes	17.3	14.4
Eunicidae	11.4	8.5
Polynoidae	6.3	5.4
Nereidae	3.3	6.2
Unidentified Polychaetes	1.3	0.6
Unidentified prey	1.3	1.4

25 and 23 species at Islas Blancas and Isla Arce, respectively. Fish were the most frequent prey at both breeding sites (>70%), followed by crustaceans and molluscs (Table 1). Also, polychaetes were recorded at both sites and were the only prey identified in 4.2% of pellets (N = 744).

At Islas Blancas, the frequency of occurrence of fish and crustaceans was similar among all stages of the breeding cycle (ANOSIM, Global  $R = -0.011$ ,  $P = 0.663$ ) (Table 2). At Isla Arce, in contrast, diet composition in terms of fish and crustaceans was significantly different among the three stages analyzed (ANOSIM, Global  $R = 0.078$ ,  $P = 0.001$ ), and also for each of the pair wise comparisons ( $R < 0.208$ ,  $P < 0.02$ ). The prey type that contributed most to the observed differences in diet composition among breeding stages at Isla Arce, as designated by SIMPER, were *E. anchoita*, *P. muelleri*, *M. hubbsi* and *Raneya brasiliensis*. These four species accounted for approximately 75% of the differences in diet composition. During the incubation stage at Isla Arce, *M. hubbsi* was the most frequent fish prey followed by *R. brasiliensis* and *E. anchoita*, while *P. muelleri* was present in less than 10% of samples (Table 2). During both chick stages, *E. anchoita* and *P. muelleri* were most frequent in the diet, while *R. brasiliensis* showed a low frequency of occurrence in the old chick stage (Table 2).

Imperial Cormorants from both sites shared most of the prey types during the incubation stage, and no significant differences in diet composition were observed (ANOSIM, Global  $R = 0.027$ ,  $P = 0.12$ ). During this stage, *M. hubbsi* was the first and second most frequent prey type in Islas Blancas and Isla Arce, respectively, and *P. muelleri* showed a low frequency of occurrence (<10%) (Table 2). Although significant differences were found in dietary composition of Imperial Cormorants between Islas Blancas and Isla Arce during both chick stages (Young chicks: ANOSIM, Global  $R = 0.231$ ,  $P = 0.001$ ; Old chicks: ANOSIM, Global  $R = 0.164$ ,  $P = 0.001$ ) the  $R$  values obtained were low, suggesting an overlap in food resources. The prey type designated by SIMPER as contributing most to

the observed difference in diet composition were *M. hubbsi*, *E. anchoita* and *P. muelleri*. These three species accounted for about 50% of the observed differences. *Merluccius hubbsi* was the most frequent prey at Islas Blancas, particularly during the young chick stage, and the other two prey species were more frequent at Isla Arce. At Islas Blancas, *P. muelleri* was recorded in very low frequencies throughout the chick stages (Table 2).

*Merluccius hubbsi* was the dominant fish prey in terms of biomass, particularly at Islas Blancas (Table 3). Total length for the three main fish prey was significantly larger at Islas Blancas than at Isla Arce (*M. hubbsi*:  $t_{675} = 16.2$ ,  $P < 0.001$ ; *E. anchoita*:  $t_{1079} = 6.0$ ,  $P < 0.001$ ; *R. brasiliensis*:  $t_{254} = 4.1$ ,  $P < 0.001$ ).

## DISCUSSION

Imperial Cormorants consumed a wide variety of prey, including fish, crustaceans, molluscs and polychaetes, although only a few species, such as *M. hubbsi*, *E. anchoita* and *P. muelleri*, showed high frequencies of occurrence relative to the rest of the identified prey. Fish was the main prey group consumed by cormorants at both study sites, as previously recorded in other breeding locations along the Chubut coast (Malacalza *et al.* 1994; Gosztonyi and Kuba 1998; Punta *et al.* 2003; Bulgarella *et al.* 2008). Of the fish prey, *M. hubbsi*, *E. anchoita* and *R. brasiliensis* showed the highest frequency of occurrence, depending on the colony and breeding stage. Because of the observed occurrence and body size, these prey represent a major component of the cormorants' diet in the study area. *Merluccius hubbsi* was the dominant prey, reaching almost ninety percent of contribution in biomass at Islas Blancas. However, the length and biomass of *E. anchoita* may have been underestimated as its otoliths are softer and smaller in size than those from the other main fish prey. This, in addition to the higher energy content of *E. anchoita* in comparison to other fish prey (González-Miri and Malacalza 1999; Ciancio *et al.* 2007), suggests that its importance to Imperial Cormorant diet, particularly at Isla Arce, should not be underestimated.

**Table 2.** Differences in Imperial Cormorant prey consumption (percentage occurrence) between Islas Blancas and Isla Arce, Argentina, during the 2002 breeding season, obtained by pellet analysis.

Taxa		Islas Blancas	Isla Arce
		N = 31	N = 36
(a) Incubation	<i>Mertuccius hubbsi</i>	54.8	41.7
	<i>Engraulis anchoita</i>	16.1	30.6
	<i>Raneya brasiliensis</i>	48.4	36.1
	<i>Notomyxine tridentiger</i>	29.0	11.1
	<i>Pseudopercis semifasciata</i>	9.7	0.0
	<i>Acanthistius brasilianus</i>	3.2	0.0
	Unidentified fish	3.2	8.3
	<i>Pleoticus muelleri</i>	6.5	8.3
	<i>Munida</i> sp.	32.3	8.3
	<i>Peltarion spinosulum</i>	9.7	0.0
	Unidentified Decapods	6.5	5.6
	Squid	29.0	50.0
	Octopus	25.8	27.8
	Unidentified Cephalopods	6.5	2.8
	Bivalves	0.0	5.6
	Eunicidae	12.9	2.8
	Polynoidae	12.9	2.8
	Nereidae	9.7	2.8
	Unidentified Polychaetes	3.2	5.6
		N = 91	N = 121
(b) Young chicks	<i>Mertuccius hubbsi</i>	71.0	21.5
	<i>Engraulis anchoita</i>	20.4	48.8
	<i>Raneya brasiliensis</i>	15.1	28.1
	<i>Notomyxine tridentiger</i>	10.8	8.3
	<i>Agonopsis chiloensis</i>	2.2	0.0
	<i>Pseudopercis semifasciata</i>	1.1	0.0
	Unidentified fish	4.3	0.8
	<i>Pleoticus muelleri</i>	8.6	47.1
	<i>Peisos petrunkevitchi</i>	2.2	0.0
	<i>Munida</i> sp.	19.4	10.7
	<i>Peltarion spinosulum</i>	4.3	0.8
	Isopods	1.1	0.8
	Unidentified Decapods	1.1	6.6
	Squid	14.0	24.8
	Octopus	10.8	19.8
	Unidentified Cephalopods	2.2	11.6
	Gasteropods	0.0	2.5
	Eunicidae	5.4	17.4
	Polynoidae	1.1	5.0
	Nereidae	1.1	8.3
		N = 268	N = 195
(c) Old chicks	<i>Mertuccius hubbsi</i>	53.7	33.7
	<i>Engraulis anchoita</i>	22.2	51.0
	<i>Raneya brasiliensis</i>	13.0	4.6
	<i>Notomyxine tridentiger</i>	13.0	3.6
	<i>Patagonotothen</i> sp.	1.9	2.0
	<i>Bovithys argentinus</i>	0.4	1.0
	<i>Agonopsis chiloensis</i>	1.1	0.5
	<i>Nemadactylus bergi</i>	4.4	0.5
	<i>Odontesthes</i> sp.	1.5	0.0
	<i>Pinguipes brasilianus</i>	0.0	0.5
	<i>Pseudopercis semifasciata</i>	1.1	0.0
	<i>Helcogrammoides cunninghami</i>	0.0	0.5

**Table 2. (Continued) Differences in Imperial Cormorant prey consumption (percentage occurrence) between Islas Blancas and Isla Arce, Argentina, during the 2002 breeding season, obtained by pellet analysis.**

Taxa	Islas Blancas	Isla Arce
<i>Acanthistius brasilianus</i>	0.4	0.0
Unidentified fish	4.1	1.5
<i>Pleoticus muelleri</i>	3.0	51.0
<i>Peisos petrunkevitchi</i>	2.6	2.0
<i>Munida</i> sp.	19.3	9.2
<i>Campylonotus</i> sp.	1.1	0.0
<i>Halycarcinus platanus</i>	0.4	0.5
<i>Peltarion spinosulum</i>	1.9	0.5
Isopods	1.1	1.5
Unidentified Decapods	1.1	2.0
Squid	14.4	13.8
Octopus	10.7	6.6
Unidentified Cephalopods	6.7	3.6
Gasteropods	1.9	1.5
Bivalves	0.7	1.0
Eunicidae	13.3	4.1
Polynoidae	7.4	6.1
Nereidae	3.3	5.6
Unidentified Polychaetes	1.5	0.0

**Table 3. Percent biomass and size (mean  $\pm$  standard deviation; range in parentheses) of the main fish prey consumed by Imperial Cormorants at Islas Blancas and Isla Arce, Argentina, during the 2002 breeding season, obtained by pellet analysis. N = number of individual fish.**

Fish prey	Islas Blancas		Isla Arce	
	% Mass	Size (mm)	% Mass	Size (mm)
<i>Merluccius hubbsi</i>	87.7 N = 468	231 $\pm$ 53 (95-404) N = 468	50.9 N = 209	156 $\pm$ 61 (69-361) N = 209
<i>Engraulis anchoita</i>	7.5 N = 368	120 $\pm$ 20 (72-250) N = 368	34.0 N = 713	113 $\pm$ 19 (60-170) N = 713
<i>Raneya brasiliensis</i>	4.8 N = 105	171 $\pm$ 35 (76-251) N = 105	15.1 N = 151	152 $\pm$ 37(55-247) N = 151

At both study sites, crustaceans, molluscs and polychaetes complemented the diet of Imperial Cormorants, as observed in other locations (Punta *et al.* 2003; Ferrari *et al.* 2004; Bulgarella *et al.* 2008). At least during the incubation stage at Isla Arce, squid made an important contribution to diet. Polychaete consumption may be overestimated, as they can be present as the result of secondary consumption (Casaux *et al.* 1995; Johnson *et al.* 1997). However, the observation of pellets composed exclusively of polychaetes suggests they could have been selected as primary prey by Imperial Cormorants. Further, Green *et al.* (1990) reported that

cormorants at the main roosting site at Heard Island preyed almost exclusively on polychaetes.

Although the islands are close to each other and the recorded fish prey can be found throughout the coast of the Chubut Province (A. Gosztonyi, unpublished data), dietary composition differed between breeding sites during the chick stages. Lack of differences between sites during the incubation stage may have been due to the small sample size. During the chick stages, *M. hubbsi* was the most frequent prey at Islas Blancas while *E. anchoita* was the dominant fish prey at Isla Arce, although at this latter site the crusta-



cean *P. muelleri* had an important contribution to the dietary composition. Information on the overall contribution by mass of the main fish prey also indicated differences between colonies, but small sample sizes precluded the analyses of differences between sites for each breeding stage. The differences in dietary composition observed between the close Islas Blancas and Isla Arce suggest that Imperial Cormorants take advantage of prey according to geographical differences in the composition of fish assemblages and the availability of potential prey, even at small spatial scales.

Frequent fish prey at Islas Blancas and Isla Arce differed from those recorded at other coastal breeding locations. At Bahía Bustamante, 80 km south of the study area within the Golfo San Jorge, *E. anchoita*, *Patagonotothen* spp., *Ribeiroclinus eigenmanni* and *Agonopsis chiloensis* were the most frequent among twelve fish prey recorded (Punta *et al.* 2003). The most frequent of the 14 fish prey recorded at Caleta Malaspina, adjacent to Bahía Bustamante, were “nototenia” (*Patagonotothen* spp.) and *Helcogrammoides cunninghami*, followed by *E. anchoita* and *M. hubbsi* (Bulgarella *et al.* 2008). At Punta Lobería, 30 km north of our study area, Gosztonyi and Kuba (1998) recorded a total of twelve fish species, mostly *Tripterygion cunninghami*, *E. anchoita* and *Patagonotothen* sp. Finally, at Punta León, 210 km north of our study area, Imperial Cormorant diet included seven fish species, mainly *Triathalassothia argentina* and *Raneya fluminensis* (Malacalza *et al.* 1994). Of the fish prey at other locations, *R. eigenmanni*, *T. cunninghami* and *T. argentina* were not recorded in our two study areas, and *A. chiloensis* and *Patagonotothen* sp. had only a low occurrence.

Dietary composition of Imperial Cormorants did not vary throughout the breeding cycle at Islas Blancas, although significant differences were found among stages at Isla Arce. At the latter island, the frequency of schooling prey such as *P. muelleri* and *E. anchoita* increased during the chick stage. *E. anchoita* schools approach the coast during November and December (R. Fondacaro, pers. comm.), and the availability of *P. muelleri* is

higher in the northern sector of Golfo San Jorge as the Imperial Cormorant season progresses (M. E. Góngora, pers. comm.). The reason why differences were not detected at the Islas Blancas colony is unclear. However, its location within a semi-enclosed bay and close proximity to shore could be factors responsible for the low availability of *P. muelleri* and *E. anchoita* near the colony and, consequently, their low occurrence in Imperial Cormorant diet during the chick stage. Also, seasonal changes in the consumption of these two prey species could be the result of a change in prey and/or foraging location influenced by energetic constraints or avoidance of competition with other top predators, as has been suggested for other seabirds (Abraham and Sydeman 2006). In a study conducted at Bahía Bustamante, Punta *et al.* (1993) reported an increase in the consumption of fish, particularly *E. anchoita* and nototheniids, as the season progressed, although no seasonal changes were observed in the consumption of fish in that same area during subsequent years (Punta *et al.* 2003).

Three of the most frequent Imperial Cormorant prey at both breeding locations, *M. hubbsi*, *P. muelleri* and *E. anchoita*, are of commercial value, and the first two are the main target of trawlers in Chubut waters. Fishing grounds are within the foraging range of breeding Imperial Cormorants (Sapoznikow and Quintana 2003; Quintana *et al.* 2007) and studies at nearby locations have shown that cormorants regularly overlap with fisheries during their foraging trips (P. Yorío and F. Quintana, unpubl. data). The length of *M. hubbsi* in samples was on average smaller than the minimum size allowed to be harvested (>35 cm in length). However, *M. hubbsi* is the main discard, in terms of biomass, in both the *M. hubbsi* and *P. muelleri* fisheries (Petovello 1999; Gandini *et al.* 1999; González-Zevallos 2003) and Imperial Cormorants regularly take advantage of this supplementary food source (Yorío and Caille 1999; González-Zevallos and Yorío 2006). Currently, *E. anchoita* is not an important commercial target, although an experimental fishery is underway in coastal

Chubut (Skewgar *et al.* 2007). Given the relevance of these fish prey species to breeding Imperial Cormorants, cormorant feeding requirements and spatial ecological needs should be considered in coastal fisheries management and future development.

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