

NOTES

DIET AND NESTING TRENDS OF TWO SYMPATRIC TERNS BREEDING IN THE SAN FRANCISCO BAY

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Abstract.—The Hayward Regional Shoreline, located along the eastern side of the San Francisco Bay, provides nesting habitat for two sympatric terns. The endangered California Least Tern (*Sternula antillarum browni*) nests near a newly established Forster's Tern (*Sterna forsteri*) colony on a separate island. Their diets overlap slightly. Kleptoparasitism by the larger Forster's Terns on California Least Terns has been observed at this location. Diet trend data, gathered by us by collecting dropped fish at the colonies of species in 2015 and 2016, showed they forage on members of the Gobiidae, Engraulidae, and Atherinopsidae families. There was a significant difference between diets of the terns, with silversides (Atherinopsidae) making up a much larger proportion of the prey of California Least Terns than of Forster's Terns. To understand the effect of possible kleptoparasitism by Forster's Terns on California Least Terns, we collected reproductive success data at both colonies. This site-specific information on the California Least Tern nesting activities and diet choice during the breeding season supports recovery plan tasks that are consistent with preserving and managing habitat for this endangered species. There was no significant difference in nesting or fledgling success between these two colonies. Although kleptoparasitism may affect the individual fitness of a single bird in terms of time and energy spent avoiding parasitism, and the need for additional foraging attempts to make up for these losses, we found no evidence indicating aerial theft by Forster's Terns resulted in reduced food availability for California Least Tern chicks or affected California Least Tern productivity at this site.

Key Words.—California Least Tern; diet; Forster's Tern; reproduction

The California Least Tern (*Sternula antillarum browni*) is a migratory bird, which nests on beaches, bays, and lagoons from San Francisco Bay to Baja California (U.S. Fish and Wildlife 1980). The species was federally listed as endangered in 1970, and as endangered by California in 1971 (Massey 1974). The East Bay Regional Park District manages California Least Tern and Western Snowy Plover (*Charadrius alexandrinus nivosus*) nesting habitat at the Hayward Regional Shoreline (37°37'47"N 122°8'46"W) located along the eastern shore of San Francisco Bay (Riensché 2007; Riensché et al. 2015). A new colony of Forster's Terns (*Sterna forsteri*) established itself 300 m southwest of the California Least Tern colony on a separate island (Island Six) in 2013 (Riensché et al. 2012 a.). California Least Terns (Fig. 1) are the smallest of the tern species, averaging 22.8 cm in length, with a wingspan of 50.8 cm, an average bill length of 29.17 mm, and weighing approximately 42.5 g (Sibley 2003; Robinette 2003). Forster's Terns are medium-sized terns, averaging 33.0 cm in length, with a wingspan of 78.7 cm, an average bill length of 41.1 mm, and weighing approximately 170.0 g (Sibley 2003; Robinette 2003). Body size and bill length contribute to prey size selection (Robinette 2003) because larger species possessing longer bills typically choose larger prey items. Despite size and bill length differences between these two species, there is slight overlap in their diets and this overlap can increase in areas where these two species



FIGURE 1. Nesting California Least Tern (*Sternula antillarum browni*) at the Hayward Regional Shoreline, California. (Photographed by Daniel I. Riensché).

share breeding habitat (Robinette 2003). The size and type of prey captured can have a significant impact on the growth and development of chicks of California Least Terns (Riensché et al. 2012 b.). Competition for adequate prey sizes can result in kleptoparasitism in areas where these two species breed sympatrically. During the nesting season, kleptoparasitism by Forster's Terns on California Least Terns has been documented (Riensché et al. 2012a). This study investigates the diet overlap and its potential effects on reproductive success of these two sympatric terns breeding in the San Francisco Bay.

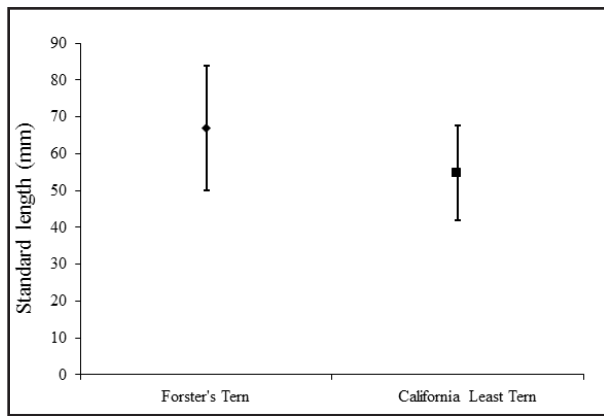


FIGURE 2. The mean (± 1 SD) standard lengths of fish dropped by Forster's Terns (*Sterna forsteri*) and California Least Terns (*Sterna antillarum browni*) at Hayward Regional Shoreline, California, 2015–2016.

We conducted the study on Island Five and Island Six at the Hayward Regional Shoreline, on the eastern side of San Francisco Bay of California. The habitat area on Island Five was established for the California Least Tern in 2001 and is 0.24 ha (0.6 ac) in size. Volunteers primarily built the island (Rienschke 2007; Rienschke et al. 2015). The area is off limits to the public. We obtained diet data by collecting fish dropped in the colony during the 2015 and 2016 breeding seasons. We stored collected specimens in plastic bags labeled with the gathering date. We soaked and cleaned fish samples with a fine artist's paintbrush and dried them in a laboratory convection oven. We gave all specimens a sample number, which was written with a fine tip marker on the specimen. For each sample, we recorded: species or lowest taxonomic group possible; total length (from the tip of the snout to the end of the caudal fin to 1 mm); standard length (from the tip of the snout to the end of the hypural bone to 1 mm); body depth (the widest part of the fish to 1 mm); and dry weight (to 1 g). Due to caudal fins being frequently broken, we used standard length as the testing measurement for size differences between the tern species. We used taxonomic families to compare prey composition between both species. To test for size differences in dropped prey between the two species (using all years and testing each year separately), we used the non-parametric Mann-Whitney U-test because the standard lengths of the fish dropped by Forster's Terns were not normally distributed (Shapiro-Wilk W test: $W = 5.098$, $P < 0.05$). We conducted a chi-square goodness-of-fit test to compare frequency of occurrence of the different prey groups in each tern species (using all years and each year separately).

During the breeding seasons of 2015 and 2016, we collected nesting and reproductive success data using the Type 1 Colony Survey Method (Marschalek 2005). In this method, permitted biologists entered the colonies twice a week to mark nests using numbered 5-cm diameter washers vertically cemented into a small

plaster of Paris base. This type of intensive, in-colony monitoring yields data on clutch size, hatching and fledgling success, and evidence of any predation. We calculated hatching success as the total number of eggs producing chicks, and fledgling success as the number of fledglings produced per breeding pair. Based on our personal observations, we are assuming that the rate of kleptoparasitism is the same over the years (ranging from seven to 10 events each season and occurring only at the California Least Tern colony on Island Five). To compare the average hatching and fledgling success of the two colonies for both years combined, we used two-sample t -tests. For all tests, $\alpha = 0.05$.

We analyzed 109 fish specimens during the nesting seasons of 2015 and 2016. We collected more dropped prey from the California Least Tern colony ($n = 45$ in 2015; $n = 19$ in 2016) than the Forster's Tern colony ($n = 33$ in 2015, $n = 12$ in 2016). In both years, the mean standard length of prey dropped by Forster's Terns was 67.0 mm (± 17.0 SD), while the mean standard length of prey dropped by California Least Terns was 54.7 mm (± 12.8 ; Fig. 2). The standard length of fish dropped by Forster's Terns was significantly longer than fish dropped by California Least Terns ($U = 3.64$, $P < 0.05$). We identified six families of dropped prey for both years and both tern species. We found significant difference in diet between the species ($\chi^2 = 31.27$, $df = 5$, $P < 0.001$). The difference in dropped prey between the species was attributed to a higher occurrence of silversides (Atherinopsidae) among California Least Terns, and higher occurrences of flatfishes (Paralichthyidae) and anchovy (Engraulidae) among Forster's Terns. Forster's Terns had a more diverse diet (prey from six families), but only prey from four families for California Least Terns (Fig. 3).

During 2015 and 2016, terns at both colonies produced high numbers of nestlings and fledglings (Tables 1 and 2). The number of California Least Tern chicks hatched in 2015 and 2016 were 120 and 152, respectively; the number of Forster's Tern chicks hatched in 2015 and 2016 were 94 and 83, respectively. There was no significant difference between the hatching success ($t = 2.80$, $df = 2$, $P = 0.218$) or the fledgling success ($t = 3.45$, $df = 2$, $P = 0.074$) of the colonies.

Kleptoparasitism is defined as the harassment of one bird species by another to force the victim to give up its food. Seabird species engaging in this behavior often obtain a significant portion of their diet through this aerial theft (Brockman and Barnard 1979; Furness 1987; Schnell et al. 1983) and tern species are frequently kleptoparasitized (Quintana and Yorio 1999). During the breeding season, interspecific kleptoparasitism may result in negative effects on host species due to the reduction of food availability to chicks, time and energy spent avoiding parasitism, and loss of prey (Quintana and Yorio 1999).

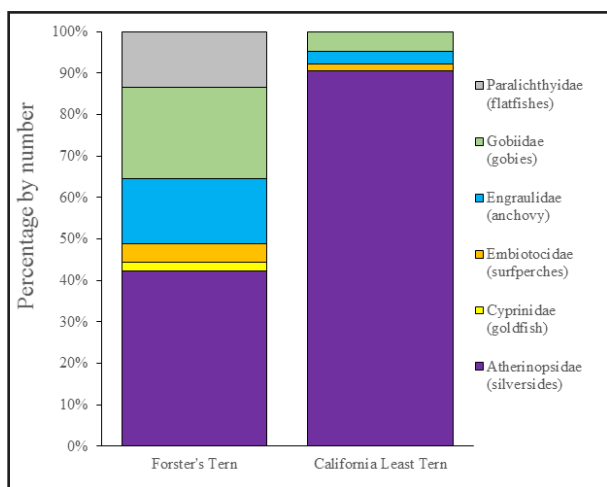


FIGURE 3. Dropped prey composition of Forster’s Terns (*Sterna forsteri*) and California Least Terns (*Sternula antillarum browni*) in both years at Hayward Regional Shoreline, California, 2015–2016.

Although we found evidence of kleptoparasitism by Forster’s Terns, it does not seem to be a significant factor affecting the breeding success of the California Least Terns at this location. We base this on several lines of evidence: both tern species had comparable number of nesting pairs, and (assuming kleptoparasitism rates were similar between years) California Least Terns hatched more chicks and produced more fledglings prior to and following the Forster’s Terns arrival. According to Frost (2017), the ratio of fledging per pair of California Least Terns ranges from 0.35 to 0.50 statewide. The colony of California Least Terns at Hayward exceeded this state ratio of fledging per pair. Other factors (e.g., predation, protection from other species nesting nearby, types of prey available and consumed) may explain the lower breeding success of the Forster’s Tern colony.

Further information will improve our knowledge on both kleptoparasitism, diet trends, and overall competition at breeding sites where terns co-occur. Study designs that compare diet and reproductive success at California Least Tern colonies in the presence of other tern species will likely contribute to their future conservation by helping to determine the site-specific factors affecting their choice of nesting, roosting, loafing, and feeding area during the breeding season. Such information will assist in developing management programs that identify special site protection plans and hopeful recovery of this endangered species.

TABLE 1. Breeding metrics of Forster’s Terns (*Sterna forsteri*) at Hayward Regional Shoreline, California, 2015–2016. The abbreviation FPBP = fledglings per breeding pair.

Year	Nesting		Hatching			
	Pairs	Eggs	Chicks	Success	Fledglings	FPBP
2015	80	176	94	53%	51	0.63
2016	75	163	83	50%	25	0.33

TABLE 2. Breeding metrics of California Least Terns (*Sternula antillarum browni*) at Hayward Regional Shoreline, California, 2013–2016. The 2013 and 2014 data shown for comparison, which were the years prior to and following the arrival Forster’s Terns (*Sterna forsteri*). The abbreviation FPBP = fledglings per breeding pair.

Year	Nesting		Hatching			
	Pairs	Eggs	Chicks	Success	Fledglings	FPBP
2013	83	170	155	91%	120	1.44
2014	85	167	150	90%	125	1.47
2015	71	136	120	88%	98	1.38
2016	84	174	152	87%	134	1.59

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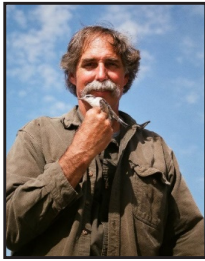
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