

# Diet Trends and Nesting Success of Two Sympatric Terns Breeding in the San Francisco Bay

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## References

California Least Tern Recovery Plan.  
1980. U.S. Fish and Wildlife Service,  
Region I. Portland, Oregon.

Massey, B. W. 1974. Breeding  
biology of the California Least Tern.  
Proceedings of the Linnean Society of  
New York 72:1-24.

Robinette, D. 2003. Partitioning of  
food resources by four sympatric  
terns (Aves: Laridae) breeding in  
southern California. Unpublished  
master's thesis. California State  
University, Long Beach. 86 pp.

Riensche, D. L., S. Dulava, E.  
Brownlee, D.A. Bell, S. High, M.  
Schynert, D. Wiley, S. Wiley and L.  
Vallee. 2012. a. Kleptoparasitism by  
Forster's Tern on California Least  
Tern. Pacific Seabirds. 39:2: 55-56.

Riensche, D. L., M. L. Elliott, and  
S.H. Euing. 2012. b. Breeding Status,  
Nesting Densities and Diet Trends  
of Two Endangered California  
Least Tern Colonies. Journal of  
Environmental Science and  
Engineering. 1135- 1145.

Riensche, D. L., 2007. California  
least tern habitat enhancement and  
nesting in the East Bay Regional Park  
district, California, Transactions of  
the Western Section of the Wildlife  
Society. 43: 62-71.

Sibley, D. A., The Sibley Field Guide to  
Birds of Western North America.  
2003. Chanticleer Press, Inc., New  
York. 200-205.a

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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 nests in close proximity with a newly established Forster's Tern colony. 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 collecting dropped fish at both species' colonies in 2015 and 2016 showed they forage on members of the Gobiidae (gobies), Engraulidae (anchovies), Cyprinidae (goldfish) and Atherinopsidae (silversides) families. Statistical analysis using two-sample t-tests and chi-squared goodness-of-fit tests showed a significant difference between their diets, with silversides making up a much larger portion of the California Least Terns prey. To understand the effect of kleptoparasitism by Forster's Terns on California Least Terns, reproductive success data was collected at both colonies. Statistical analysis using unpaired t-tests revealed no significant difference in nesting or fledgling success between these two colonies. While kleptoparasitism may affect the individual fitness of a single bird in terms of time and energy spent avoiding parasitism, there is no statistical evidence indicating aerial "piracy" by Forster's Terns has resulted in negative effects on California Least Terns due to reduced food availability to their chicks, or their reproductive productivity at this site.

## Introduction

The California Least Tern (*Sternula antillarum browni*) is a migratory bird, which nests in beaches, bays and lagoons from the San Francisco Bay south to Baja California (US Fish and Wildlife 1980). The species was listed as federally endangered in 1970, and as a state endangered species in 1971 (Massey 1974). The East Bay Regional Park District manages California Least Tern nesting habitat at the Hayward Regional Shoreline (37° 37' 47" N 122° 8' 46" W) which is located along the eastern shore of the San Francisco Bay. A new Forster's Tern (*Sterna forsteri*) colony established itself 300 m southwest of the California Least Tern colony (Riensche et al 2012 a.). California Least Terns are the smallest of the tern species (*Image 1*), averaging nine inches in length with a wingspan of 20 inches and weighing approximately 1.5 ounces (Sibley 2003). California Least Terns have an average bill length of 29.17 mm (Robinette 2003). Forster's Terns are medium sized terns (*Image 2*), averaging 13 inches in length with a wingspan of 31 inches and weighing approximately six ounces (Sibley 2003). The mean Forster's Tern bill length is 41.10 mm (Robinette 2003). Body size and bill length contribute to prey size selection. There is a slight overlap in their diets. This overlap can increase in areas where these two species share breeding habitat (Robinette 2003). The size and type of prey captured can have a significant impact on the growth and development of California Least Tern chicks (Riensche et al 2012 a.). Competition for adequate prey sizes can result in kleptoparasitism in areas where these two sympatric species breed. During the nesting season, kleptoparasitism by Forster's Terns on California Least Terns was documented (Riensche et al 2012 b.). We are assuming that the rate of kleptoparasitism is the same over the years. This study investigates the possible diet overlap and its potential effects on reproductive success of these two sympatric terns breeding in the San Francisco Bay.

## Study Area

The area in which this study was conducted is located at the Hayward Regional Shoreline (Island Five), on the eastern side of the San Francisco Bay. The habitat area was established in 2001, and is 0.24 ha (0.6 ac). It was built mostly by the help of volunteers (Riensche 2007). The colony is off limits to the public.

## Methods

**Diet Trends:** Data on diet was obtained by collecting fish dropped in the colony during breeding season. Once collected, the specimens were stored in plastic bags labeled with the collection date. Next, they were soaked in water and cleaned with a fine artist's paintbrush and then dried in a laboratory convection oven. The specimens were given a sample number, which was written on

the specimen with a fine tip marker.

The following was recorded for each sample: species or lowest taxonomic group possible; total length (from the tip of the snout to the end of the caudal fin (mm)); standard length (from the tip of the snout to the end of the hypural bone (mm)); body depth (the widest part of the fish (mm)); and dry weight (g). Due to caudal fins being frequently broken, we used standard length as the measurement to test for size differences between the two tern species. We used taxonomic families to compare prey composition between the tern species. Two-sample t-tests with unequal variances were used to test for size differences in dropped prey between the two species (using all years and testing each year separately). 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).

**Nesting Success:** Nesting and reproductive success data was collected using the Type I Colony Survey Method. In this method, permitted biologists entered the colony to mark nests, record the number of eggs and chicks which results in data on clutch size, hatching and fledgling success.

## Results

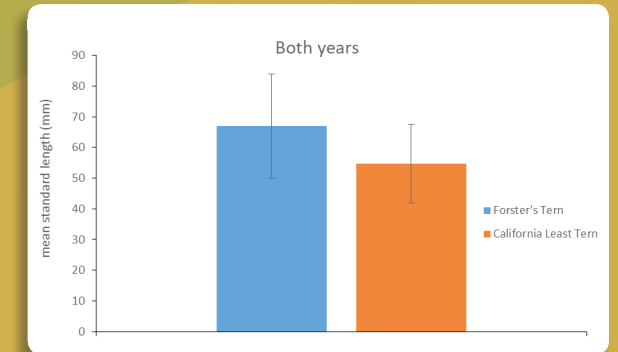
**Diet Trends:** A total of 109 specimens were analyzed for both years and both tern species. We collected more dropped prey from the California Least Tern colony (n=45 in 2015; n=19 in 2016) than the Forster's Tern colony (n=33 in 2015, n=12 in 2016).

A total of six different families of dropped prey were identified for both years and both tern species. The variation in dropped prey between the two species is attributed to a higher occurrence of silversides (family Atherinopsidae) with California Least Terns, higher occurrences of flatfishes (family Paralichthyidae) with Forster's Terns, and a higher occurrence of anchovy (family Engraulidae) with Forster's Terns. Forster's Terns have a more diverse diet, with six different families of prey, and Least Terns have four different families of prey.

**Nesting Success:** During 2015 and 2016, both colonies had successful nesting seasons (*Figures 3 and 4*). In the respective years, the number of California Least Tern chicks hatched were 120 and 152; the number of Forster's Tern chicks hatched were 94 and 83. Unpaired t-tests were used to compare the average hatching and fledgling success of the two colonies for both years combined. The results showed no statistically significant difference between the hatching success (p=0.218) or the fledgling success (p=0.074) of the colonies. Based on this evidence, and assuming kleptoparasitism rates were similar between years, and the fact that the California Least Terns hatched more chicks and produced more fledglings than the Forster's Terns, it appears that aerial piracy by Forster's Terns is not a significant factor affecting the breeding success of the California Least Terns at this location. 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.



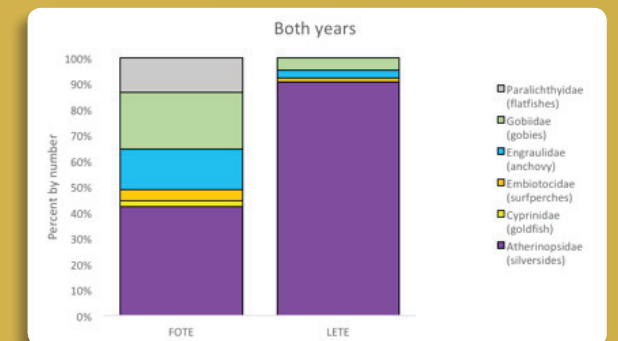
*Image 1.* Nesting California Least Tern.  
Photo: Daniel I. Riensche



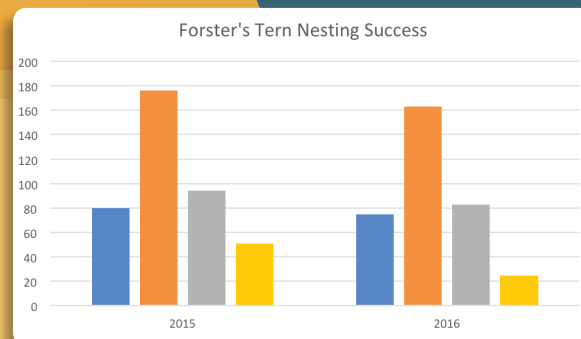
*Figure 1.* The standard length of fish dropped by Forster's Terns (mean=67.0 mm ± 17.0 s.d.) was significantly larger than fish dropped by California Least Terns (mean=54.7 mm ± 12.8 s.d.; t-test: t=4.0073, Satterthwaite's degrees of freedom=77.4766, p=0.0001).



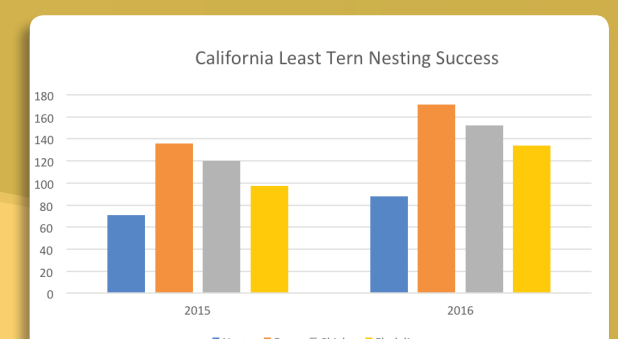
*Image 2.* Nesting Forster's Tern.  
Photo: Daniel I. Riensche



*Figure 2.* Diet differences between the two sympatric tern species. A Chi-square goodness-of-fit showed significant differences in diet between the two tern species ( $\chi^2 = 31.27$ , df=5, p<0.0001). Silversides make up 40% of the Forster's Tern (FOTE) colonies diet, while they make up 90% of the Least Tern (LETE) colonies diet.



*Figure 4.* Forster's Terns established 80 nests (2015) and 75 nests (2016). Fledgling success decreased from 51(2015) to 25(2016).



*Figure 3.* California Least Terns established 71 nests (2015) and 88 nests (2016). Fledgling success increased from 98(2015) to 134(2016).