
Patterns in Winter Distribution at Three Wintering Areas in Baja California—Bahía San Quintín, Laguna Ojo de Liebre, and Laguna San Ignacio—and Probabilities of Migrating to These Areas in Relation to the Proportions of the Population Wintering in Them

Methods

The U.S. Fish and Wildlife Service, in cooperation with the Pacific states, conducts a population survey of wintering brant during January of each year (Conant and Voelzer 2002). A pilot and an observer flew over all of the bays where brant traditionally winter on the Pacific coasts of Baja California and mainland Mexico and counted the brant present, using standard aerial-survey methods. Surveys from Mexico were combined with those from the Pacific states in the United States to estimate the size of the entire winter population. We used count data to estimate the number and proportion of the midwinter population present in each of the lagoons we studied in Baja California, both during the years of the study and over the entire history of the survey (1978–2002).

We used the GLM procedure in SAS to assess spatial-temporal variation in the number of brant in the three lagoons in Baja California. We considered models containing lagoon as a fixed effect and year as a covariate. We included a model that contained a year × lagoon interaction to allow for different temporal trends among lagoons. Finally, we used $t$-tests to compare the probability of migrating from the breeding grounds to a particular wintering area with the proportion of the winter population occupying each wintering area on the basis of U.S. Fish and Wildlife Service surveys (Conant and Voelzer 2002). This analysis evaluated the hypothesis that migration to each wintering area was consistent with that expected under a random fall-migration model.

Results

A model including winter location, a trend across years, and an interaction between winter location and time trend was the only model of the number of brant counted during the January survey to receive support (table D1). This model explained 50% of the variation in the number of brant in the three wintering areas. The number of brant increased at BSQ, declined at LSI, and was relatively stable at LOL (fig. D1). The effect of the 1997–1998 ENSO was clearly evident, with substantial declines at LOL and LSI and a substantial increase at BSQ in January 1998 (fig. D1).

From 1992 through 2002, the number of brant wintering in BSQ represented an average of $0.19 \pm 0.13$ of the entire winter population, while brant wintering at LOL and LSI represented $0.28 \pm 0.06$ and $0.18 \pm 0.05$ of the winter population on average, respectively; 1.7 times as many individuals migrated from breeding (and nonbreeding) to LOL as the proportion of the population that wintered there ($t = 10.86, P < .001, \text{df} = 10$; fig. 3), while only 0.16 as many individuals migrated from breeding to LSI as wintered there ($t = 9.72, P < .001, \text{df} = 10$). BSQ was intermediate: 0.64 times as many individuals migrated to BSQ as wintered there ($t = 1.75, P = .11, \text{df} = 10$).
Appendix D from J. S. Sedinger et al., Carryover Effects in a Migrant Bird

Figure D1: Numbers of brant counted in Bahía San Quintín (BSQ), Laguna Ojo de Liebre (LOL), and Laguna San Ignacio (LSI) during the January U.S. Fish and Wildlife Service survey, 1978–2002. Fitted lines are based on the best model of the number of brant in wintering areas (table D1), which included an effect of winter location, a linear time trend, and an interaction between winter location and the time trend. Circled points are from January 1998.

Table D1. Performance of models of variation in numbers of brant wintering in Bahía San Quintín, Laguna Ojo de Liebre, and Laguna San Ignacio, in Baja California from 1978 to 2002

<table>
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<th>Model</th>
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</table>

Note: Year was modeled as a linear trend and area as a fixed effect. A plus sign indicates an additive effect; a cross indicates an interaction.

*Akaikes weight.