Size of the California Brown Pelican Metapopulation during a Non-El Niño Year

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Daniel W. Anderson[1], Charles J. Henny[2], Carlos Godinez-Reyes[3], Franklin Gress[4], Eduardo L. Palacios[5], Karina Santos del Prado[6], And James Bredy[7]

Abstract

Overall, we estimated a total metapopulation within the geographical range of the California brown pelican subspecies (*Pelecanus occidentalis californicus*) as about 70,680 ± 2,640 breeding pairs (mean ± SD). Little change in at least three decades is indicated in the total metapopulation south of the Southern California Bight (SCB) subpopulation, but significant improvements in the breeding subpopulation size in the SCB reported elsewhere, support the present high numbers observed in this northernmost subpopulation. The largest breeding aggregation within the entire range (consisting of three immediately adjacent sub-colonies), at the San Lorenzo Archipelago, consisted of about 17,225 breeding pairs, or about 24.4% of the metapopulation in 2006. Other, smaller colonies are no less important, however, although each subpopulation defined by us seemed to have a single or small number of large "core" breeding colonies, plus many smaller colonies (for example, in 2006, one colony consisted of only 2 breeding pairs). Small colonies (< about 70 nests) comprised about 35.6% of the total occupied colonies, but only about 0.87% of the total estimated numbers (values corrected for detectability). The modal colony-size throughout the range was much smaller (about 230 to 1,300 breeding pairs, depending on subpopulation), indicating that small, scattered colonies and sub-colonies, especially on the range peripheries, function in brown pelican population dynamics and are no less important from a conservation viewpoint. These smaller breeding colonies probably represent some colonies of antiquity, but also range expansions and contractions that occur within the typically-defined metapopulation, and local manifestations of source-sink phenomena. Given such dynamics, even unoccupied islands within the range in 2006 have conservation importance from the viewpoint of such dynamics as potential alternate nesting sites. Natural variations in the estimated population levels seem to be related to the natural cycles of El Niño/Southern Oscillation (ENSO) phenomena where very low breeding populations (as low as no nesting in many areas) might be expected to occur in these same areas censused in 2006 at least 40% of the time. From the 2006 aerial survey, extensive commercial and sport-fishing activity, resort/tourist developments and associated human activities along the coastal areas and at offshore islands, and extensive aquacultural (and to a lesser degree, agricultural) developments seen from the Río Colorado Delta region, Sonora, south at least through San Blas, Nayarit (the southern terminus of our 2006 aerial survey) may result in substantial loss of breeding habitat. Juvenile (young of the 2005 breeding season) plus subadult brown pelicans comprised 28.1% ± 0.33% (mean ± 95% CI) of the total numbers in age-ratio samples. Thus, our overall metapopulation estimate for *P. o. californicus* in 2006 was 195,900 ± 7,225 individuals.

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Keywords

California brown pelican, *Pelecanus occidentalis californicus*, breeding pairs, El Niño, metapopulation estimate, subpopulation estimates, survey bias, distribution, range.

Introduction

The California Brown Pelican Metapopulation

Anderson and King (2005) reviewed key metapopulation concepts as they likely applied to the American White Pelican (*Pelecanus erythrorhynchos*). Here, we apply essentially those same definitions to the presumed California brown pelican metapopulation (*P. occidentalis californicus*) (Figure 1), but urge the reader to review Anderson and King (2005) and references therein for more detail. Essentially, our use of the term here has been defined by Newton (1998) as: "…any population composed of a number of discreet and partially independent subpopulations that live in separate areas but are linked by dispersal", and as defined by Morris and Doak (2002:375): "…sets of discrete, largely (but not entirely) independent populations whose dynamics are driven by local extinction and recolonization via movement from other populations…" For example, breeding recruitment from individuals originating in the Gulf of California was documented in the Southern California Bight (SCB) subpopulation of California brown pelicans during a period when SCB breeding colonies were severely declining and classified as "endangered" under the Endangered Species Act (Gress and Anderson 1983). Numbers later recovered (see Anderson et al. 1975, Anderson and Anderson 1976, Anderson and Gress 1983; Gress et al. in preparation, and others), and recruitment of breeding birds into the SCB, from colonies with higher productivity in Mexico likely enhanced that recovery. Anderson and Gress (1983, their Figure 2) also showed that within a region, numbers of breeders at Anacapa Island and Los Coronados (see Appendix 1), shifted in predictable "runs" between these two major breeding colonies in the SCB, probably in response to local variations in predictable food availability (Anderson et al. 1982). Smaller named sub-divisions within the California brown pelican metapopulation, again as suggested by Anderson and King (2005), are given in Table 1.

Effects of El Niño

A well-known and significant cause of year-to-year variation in numbers of breeding seabirds, their productivity, and even survival at times is seen in the El Niño/Southern Oscillation oceanographic phenomenon (ENSO)(e.g., Ainley et al. 1988). It is not our intent here to review ENSO and seabird demography, but only to relate various key specific observations to the numbers of *P. o. californicus* as applied to this specific 2006 survey, to help better interpret our estimates, and evaluate potential variability that might be expected in metapopulation estimates from year-to-year. We do not consider historical frequencies of ENSO to be causes of severe, long-term population declines, but rather a normally-encountered oscillation to which numbers and productivity of brown pelicans, for example, must compensate with a "flexible" demography. Anderson and Gress (1983) demonstrated that in the SCB (and other subpopulations), variable proportions of available adults in the subpopulation attempt to nest from year-to-year. This was partly related to ENSO effects although adult body condition and reproductive rates, as expected, are even more closely tied to the ENSO phenomenon (for example, see Velarde and Ezcurra 2002, Velarde et al. 2004). Near the southern range periphery of the California brown pelican, Sarmiento (1994) described a short year-to-year variation in breeding numbers in his study plots at Isla de Pájaros, Sinaloa: during the 1991-92 cycle (an ENSO), he reported 69 completed nests in contrast to 1992-93 (non-ENSO) when he reported 334 nests. This represented a 79% reduction in nesting attempts. At Isla Piojo, Baja California Norte (and considered representative of the Gulf of California nesting subpopulation), Anderson et al. (2006) demonstrated that breeding attempts varied between 0 and 1,430 from 1969 through 2005 (Mean ± 95% CI = 432 ± 114, CV = 73%, n = 32 years of data in 36 years). In this same region in the Gulf of California, Velarde and Ezcurra (2002) reviewed and reported similarly high annual variations in breeding attempts and reproductive success of other species nesting in proximity to brown pelicans. In the 36-year period reported by Anderson et al. (2006), using standardized, normally distributed Southern Oscillation Indices (SOIs) from the literature (and conversions similar to those of Velarde and Ezcurra 2002), they calculated that ENSO conditions of varying strength occurred about 38% of the time. Based upon several brown pelican colonies studied since 1970 (Isla Piojo, Isla Animas, Isla San Lorenzo Sur, Puerto Refugio, and Isla San Luis-Appendix 2), 2006 represented a year of near-maximum breeding attempts (DWA, unpublished field notes). In the Southern California Bight area, Anderson and Gress (1983) indicated that from 1972-1979, about 20-70% of the available adults in the region bred; the lowest proportion of breeding adults (19%) was in 1977, a "mild" ENSO year, whereas the proportion of adults in the total numbers remained relatively constant through the same period (from 64 to 86%; mean = 72 ± 8%, mean ± 95% CI; CV = 14%). The highest proportion of adults was in 1978, when fewer young were expected. Therefore, we considered the 2006 estimates to be optimal numbers (non-ENSO year) on which to compare lesser numbers expected during those years potentially affected by interactions of ENSO conditions and potential future population changes from other causes.

Our objectives were: (1) during an optimal breeding year, to obtain an estimate of total numbers of breeding pairs of

Figure 1. A diagrammatic representation of hypothesized subpopulation segments of the California brown pelican presumed metapopulation (see Anderson 1983 and further discussion in text). Short dashed lines represent subpopulation boundaries and black patches connected by arrows (movement and dispersal), colonies and sub-colonies. This diagram was generally based on natural history and geographic characteristics that would tend to separate subpopulations into more or less annually independent demographic units: SCB = Southern California Bight Subpopulation, based mainly on confines of the California Current System (Anderson and Gress 1983); SBP = Southern Baja-Pacific Subpopulation, based on isolation along the southwest Baja California coast (Gress and Anderson 1983), terminated by the tropical convergence (Anderson 1983); GOC = Gulf of California, based on the confines of the Gulf of California (Anderson 1983); MME = Mexican Mainland, Estuarine Subpopulation, based on dominant nesting and feeding habitat (mangrove dominated bays with vegetated islands) (GOC and MME populations are essentially also separated by the tropical convergence, see Anderson 1983); and, MMI = Mexican Mainland, Island Subpopulation, is essentially separated from MME by a sudden change in nesting habitat and offshore oceanographic changes. The form of this diagram is adapted from the discussions of Buckley and Downer (1996) with delineations further discussed in the text. This hypothetical diagram should be considered preliminary and subject to future testing with genetic, morphological, movement, ecological, and other studies.

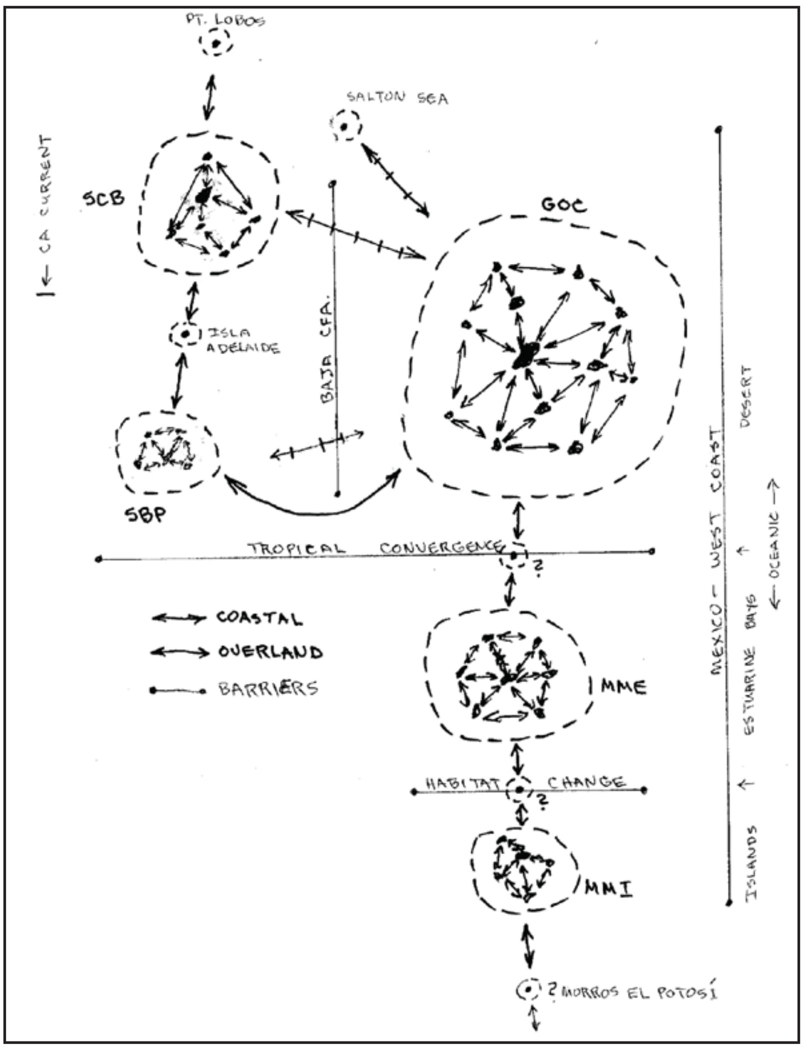


Table 1. Suggested definitions of various geographical subdivisions in the subspecies range of the California brown pelican

Geographic Scale	Suggested Term Used	Criteria
Regional	Metapopulation; *Pelecanus occidentalis californicus*	Separation by a well-defined barrier with dispersal rates very small on an inter-metapopulation (or subspecies) basis compared to intra-metapopulation movements[a]
Local, interactive	**Subpopulation**	Dispersal among subpopulations much greater than between subpopulations; closely sharing demographic characteristics
Single Geographic Location	**Colony or Sub-colony**	One or more nesting groups associated with a single geographic feature or location
Away from Breeding Colony	**Flocks or Aggregations**	Groups of individuals gathered anywhere away from a nesting group; further definition can be made if activity is known (i.e., feeding, loafing, migrating, moving, etc.).

[a]For the California brown pelican, this barrier has been previously identified (but not precisely defined) by numerous previous descriptions of the ranges and distributions of the brown pelican subspecies (see text for references and discussion); and it is supported by movement data based on radio-telemetry and band-recoveries (DWA unpublished data). An important description of this "barrier" has been suggested by de la Torre (1986) who has identified low relative numbers of potential nesting islands per unit of coastline, large distances between these areas, and comparative lack of estuarine habitat on the mainland, exacerbated by extensive human activities and development.

the *californicus* subspecies of the brown pelican, along with several measures of precision; (2) to accurately determine the locations of all breeding colonies for the subspecies; (3) to describe the presumed subpopulations (Figure 1) (subject to a testable hypothesis for future genetic studies) and breeding numbers; and (4) to discuss potential conservation issues.

Methods

Study Area and Survey Methods

Gress and Anderson (1983) provided the original suggested subpopulation delineations used in this report (but with some minor modifications)(Figure 1). Additional historical insights and distributional/numeric data for brown pelicans were derived from Bent (1922), Grinnell (1928), Grinnell and Miller (1944), Wetmore (1945), Hutchinson (1950), A.O.U. (1957), Palmer (1962), Gress (1970), Anderson and Anderson (1976), Anderson and Gress (1983), Johnsgard (1993), and A.O.U. (1998). And, recent general surveys and estimates of nesting brown pelicans throughout their range have been reported by Anderson et al. (1976), Everett and Anderson (1991), and Velarde and Anderson (1994). General distributional information, especially to the south, has also been broadly summarized by Howell and Webb (1995) and Wilbur (1987). The major questions emerging from a review of these references include: (1) what are the sizes (number of breeding pairs) and distribution of individual breeding colonies within the total metapopulation (*P. o. californicus*), (2) what are the sizes of various subpopulations and breeding colonies within the range of the subspecies, and (3) can more detail be provided on the relatively unknown or not recently-described southern peripheral subpopulation of the subspecies?

Through several methods, we surveyed the entire range of the California brown pelican with a total of 97 known active or historical breeding colonies of highly variable size. We conducted aerial surveys from 23 March through 1 April 2006 (n = 68 colonies over-flown by us in 10 days = 70.1% plus n = 9 colonies not flown due to inclement weather or extreme distance with tenuous gasoline levels = 9.3%; total = 79.4%), and supplemented our aerial surveys with additional ground-based surveys through the nesting season of 2006. In the northern subpopulation (Figure 1), our estimates were obtained through ground counts (n = the 8 northernmost colonies without aerial surveys = 8.2%), in the Gulf of California by ground surveys conducted by members of our own team, and in the extreme south only through a literature review and cooperator information (n = 11 potential colonies = 11.3%). Our final estimates of numbers of breeding pairs were based largely on the aerial survey data, but also four additional sources of quasi-double-sampling at some sites (surveys by boat at selected sites, information obtained from co-operators at some sites, surveys of recent and historical records compiled by DWA, and literature sources where no other information existed or to supplement our 2006 observations; all collectively termed here: ground-truth). Final estimates were frequently based upon ground-truth data, either our own or from cooperators, which were selected over the aerial survey results because those values were considered to be more complete and accurate. Ground-truth were compared to aerial survey data, where comparisons could be made (27 of 59, 2006-occupied colonies = 45.8%), to gain insights on sources of variability, to correct aerial estimates where no ground-truth data were available, and to help estimate our overall precision. We summarized, and attempted to correct if deemed necessary, possible biases related to: detectability, phenological variation, observer error, and inaccessibility due to such factors as inclement weather and hazardous flying conditions, so that a future survey solely by air might ultimately be attempted. More details on the aerial survey and its coverage were reported by Henny et al. (2007).

Aerial surveys for the most northern colonies of California brown pelicans of the Southern California Bight subpopulation (see Gress and Anderson 1983) within the state of California, USA (the northern range periphery) were not attempted by us because of expected large phenological differences from nesting colonies to the south (i.e., the survey dates planned for Mexico in 2006 would have been “too early” in the nesting season for this population-segment). Furthermore, we were aware that FG, ELP, and colleagues (cited in Appendix 1) were surveying those colonies from boats in 2006. However, colonies in this SCB subpopulation, south of the U.S./Mexico border, were aerially surveyed and later compared to those more accurate and complete boat and ground surveys in California and northwest Baja California to examine the potential for phenological bias had we not initiated this collaboration and conducted only a one-time, large survey of many degrees latitude. The total previously-known breeding range of *P. o. californicus* roughly extends from about 17° North latitude to about 36° North latitude, or more than 4,800 km of coastline (see Palmer 1962:275). Godínez-Reyes et al. (2006) describe the current Mexican monitoring plan (termed here the Salud Project) for these subpopulations, of which this project was a part.

As stated, we did not survey the extreme southernmost colonies, and therefore only a tentative subpopulation estimate is given (with no estimates of precision), based entirely on literature sources and personal communications (Appendix 5). No detailed studies were conducted in that subpopulation’s range in 2006. Documenting this very small subpopulation will be a future goal of the Salud Project.

Double-crested Cormorants (*Phalacrocorax auritus*) and Brant’s Cormorants (*P. penicillatus*) were also recorded in the Gulf of California (our survey was far too early in the breeding season to detect nesting cormorants in the Southern California Bight (FG and ELP). The mixing of Double-crested with Neotropic Cormorants (*P. brasillianus*) south of about Guaymas, Sonora precluded a summary until further ground-truthing can be conducted to determine species ratios in nesting colonies from Sonora south. Therefore, data on cormorants in this report must be considered preliminary and subject to revision and further analysis. Estimated Double-crested Cormorant numbers are, nonetheless, included in this report as Appendix 6.

Statistical Analysis

Statistical tests and summaries were performed using MINITAB 15.1 (Minitab Inc., www.minitab.com/).

In estimating precision, we considered all ground-truth data equally and began by choosing those values as superior over aerial estimates because of their completeness. We also related aerial values to ground-truth values where available to approximate corrections (correction factor or CF) in instances where no ground-truth data were available. On the colonies where we had no double-sampling and where estimates used 2006 aerial data only, colonies of about <800 nests (CF <1.06) were not corrected, those of greater number as estimated from the air were corrected using the conversion factors derived from regressions of n_a on n_g (n_a = numbers of nests estimated from the air, n_g = ground-truth estimates; correction factor [CF] = n_g/n_a, slope of regression used to approximate CF)(a similar calculation was termed aerial visibility factor by Henny et al. 2007). Overall, and given a large sample of ground-truth data, only 4 estimates of colony-size out of 59 total colonies enumerated by us from the air (= 6.8%) required this conversion and most of our values were therefore derived from our best estimates (those having some type of comparative ground-truth) from multiple-sampling, or where no other information existed, estimates from previous years (those data remained uncorrected, as well). Where only other-year records were available (11 of 59 2006-occupied/or presumed-occupied colonies, or 18.6% of the total number of colonies seen and/or known) (for example Isla San Pedro Martír, Appendix 3; and Isla Cedros, Appendix 2), we had no choice but to use those older (or in one instance, newer) estimates (e.g., Isla San Gerónimo, Appendix 1).

In estimating variance, we used double-sampled data and assumed that the smaller of the numbers in ground-truth versus aerial comparisons were the values seen by both sources (aerial versus ground, or aerial versus aerial-photograph, or aerial versus ground-truth provided by a cooperator). Our best aerial estimate of colony-size was either larger or smaller than the best estimate of ground-truth, but we always accepted ground-truth as the value of our final estimate. Calculations of estimated variance were first assumed to be binomial and then calculated with the formula suggested by Pollock and Samuel (1987) (and essentially the same as that used by Henny et al. 2007), and reduced (because of the large numbers involved) as follows:

$$\hat{V} = \frac{(n_a)(n_g)(n_a - m)(n_g - m)}{(m)^3}$$

where m = smallest number of the double-estimate.

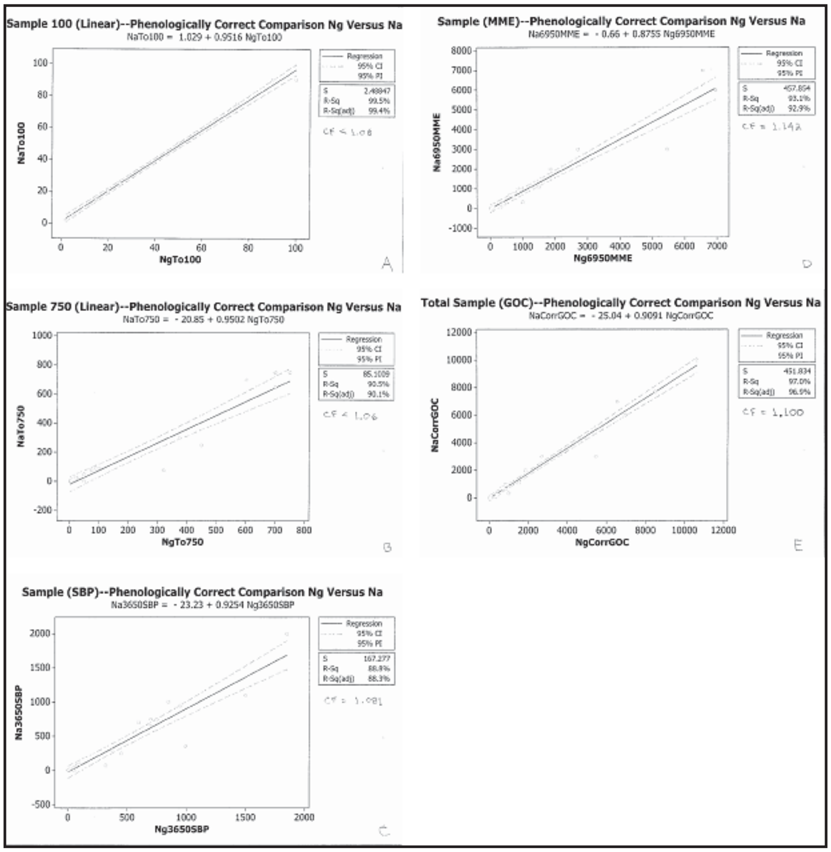
These estimates were applied only to two subpopulations (GOC and MME) because we only had phenologically-correct, double-samplings including ground-truth data from those areas. Since this was the largest sample to estimate variance from the entire metapopulation, the combined GOC and MME variance was also applied to the total metapopulation estimate. Given the large sample of ground-truth data for these estimates (n = 27 of 59 colonies = 45.8%), the implied high levels of precision in the estimates seem warranted.

In our estimates of variance for the two subpopulations, SCB and SBP, we applied the variances derived from regressions of our aerial/ground-truth comparisons, calculated separately for each of these subpopulations and based on a regression that included the total estimate for each of the subpopulations. The regression lines for each of these subpopulations were: SCB = 10,000 (Figure 2E); SBP = 2,000 (Figure 2C) (because no intermediate data at this level were available for 3,000). These estimates were as near those numbers as the available data-set allowed. These error estimates derived from the regressions of na on ng were applied to our values for the SCB and SBP subpopulations, assuming that had we flown those areas at the phenologically-correct time, our precision would have been approximately the same. That this is reasonable was indicated by Henny et al. (2007), in Osprey (Pandion haliaetus) surveys conducted by CJH and DWA on this same aerial survey flight, in showing remarkable consistency among three similar surveys conducted from 1977 to 2006, where the observers were attempting to detect single, large nests.

All estimates of variance were then further converted to standard deviations (SDs) for each subpopulation and then for the total estimate based on the three non-peripheral subpopulations (Appendices 2-4) and applied to the entire sample as a crude measure of precision. Because the northern subpopulation estimates (Appendix 1) were based almost solely on ground counts, and correction factors would have been rather high based on ground-truth/aerial comparisons had we used them (Figure 2), we assumed that the SCB totals were the most precise of all our estimates (Appendix 1), but had no way to provide a value, other than to use our own regression-based precision estimates from the remainder of the metapopulation. We believe, therefore, that for the SCB subpopulation, we have over-estimated variance. It was also obvious that in instances where we had na and ng sampling, our precision estimates were proportionately lower than estimates interpolated from regression data at different sample (colony)-sizes, perhaps by a factor by as much as 1/5 (Table 2). For the southern periphery population (MMI-Appendix 5), given that estimates used were potentially quite out-dated and incomplete, we must emphasize that we cannot provide any estimates of precision for this potentially important subpopulation, and even the total number of estimated nesting-pairs must be considered very crude until more precise surveys can be conducted in that region.

Henny et al. (2007) indicated that Osprey nests in this same survey (large birds with single, large nests) had an average detection probability of 0.57 (converted by us from their aerial visibility rate for 2006). We assumed this value would

Figure 2. Linear regressions of 2006 aerial estimates (n_a) on 2006 ground-truth estimates (n_g) where matched data were available and at different largest-breeding-colony levels, and where phenology differences between the date of aerial survey and ground-truth surveys were small (*i.e.*, the aerial survey was timed correctly for an accurate estimate): A. colony-sizes <101, B. colony-sizes <751, C. colony-sizes <2, 000 (data in this area of the regression were not available for colonies < about 4000), D. colony-sizes <7,000, and E. colony-sizes <11,000 breeding pairs. The conversion factors presented (CFs) were used to correct estimates in instances where only aerial estimates (n_a) were available. The corrected values are marked with an asterisk (*) in the Appendices where done (2-4) and four estimates were corrected using these CFs.



have been similar for single brown pelican nests. In examining detectability (assumed to be largely a function of colony-size [Pollock and Kendall 1987], as our aerial surveys took us over all likely nesting locations throughout the aerial survey areas except where inclement weather prevented us to do so, but where we made our estimates from other data-sources), we applied a simple linear function and predicted the number of nests required to achieve a detection probability of approximately 1. To determine a rate of increase in detection probability with larger colonies sampled, we used an estimated but crude function of 10/11 (our detection rate of colonies of about 60 or less) to estimate the rate of increase to 1, and then used this simple rate to crudely approximate the colony-size where probability of detection would be near one.

Results

Detectability of Small Colonies

Detectability for pelican colonies based on size (numbers of nests) rapidly approached 1 (Figure 3). A linear projection predicted that colonies of >63 nests were almost certain to be detected in our survey which covered all or almost all available nesting habitat. Based on these data (admittedly crude) (Figure 3), we estimate that (based on the mean colony-size of all colonies detected that were >63 nests) about 5 small colonies were undetected during the survey, or about 0.66% of all nests--but about 27.1% of all small colonies. Corrected for reduced detectability, these small colonies (say, < about 70 nests) still comprised about 35.6% of the total occupied colonies, but only about 0.87% of the total estimated numbers (Table 2). Thus, small groups of nesting brown pelicans

Table 2. Estimated subpopulation and metapopulation sizes of *Pelecanus occidentalis californicus* and their general characteristics, based largely on the 2006 aerial and ground-truth surveys.

Designated subpopulation	Estimated size of breeding population (± SD)[a]	Proportion of meta-population	Dominant breeding substrate	Dominant feeding habitat during breeding	No. of known colonies[b]	Occupied colonies in 2006	Mean colony -size (CV)[c]	Median colony-size	Range: colony-size
Southern California Bight	11,695 ± 450**	16.6%	vegetated oceanic island, ground-nests	offshore, pelagic	14 (11)	79%	1,063 (131%)	250	10 to 4,000
Southern Baja-Pacific	3,100 ± 170**	4.4%	oceanic desert island ground nests	offshore, pelagic; estuarine	11 (5)	45%	620 (121%)	350	100 to 1,950
Gulf of California	43,350 ± 230*	61.5%	oceanic desert island, ground-nests	offshore, pelagic	42 (24)	57%	1,806 (164%)	525	5 to 10,625d
Mexican Mainland-Estuarine	10,540 ± 270*	14.9%	estuarine island, tree/bush nests	estuarine; some offshore, pelagic	15 (11)	73%	958 (216%)	90	2 to 6,950
Mexican Mainland-Island	1,845	2.6%	vegetated oceanic island, tree/bush nests	Offshore, pelagic	15 (8)	53%	231 (127%)	98	25 to 850
Total meta-population estimate	70,680[e] ± 2,640** (or ± 485*)	100.0%			97 (64)[e]	66%	1,314 (176%)	320	2 to 10,625[d]

[a]Values given represent the best maximum estimates of numbers of breeding pairs from multiple-samplings and various data sources (cited in the text and appendices), with SD (= standard deviations) given as an estimate of precision. * indicates SD based on binomial distribution and ** indicates SD based on regression estimates.

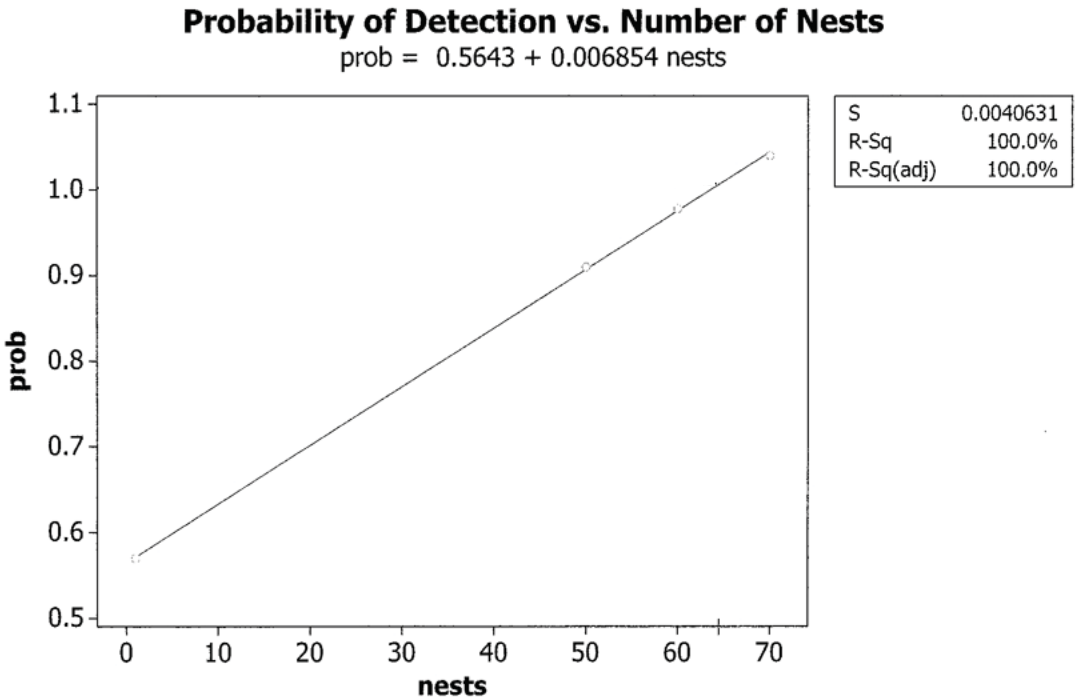
[b]The values given represent the total number of known sites with current or previously-known Brown Pelican nesting ("historical"). The numbers in parentheses represent the number of active colonies or sub-colonies seen in 2006. All known, historical colonies would not be expected to be occupied in a single year (see text) and that percentage for 2006 is given in the next column (6). None of the subpopulation values were significantly different from one-another (P=0.41, Chi2-test).

[c]CV = coefficient of variation.

[d]The largest numbers of breeding pairs on a single island are found at Isla San Lorenzo Norte (Animas) in the Gulf of California (Appendix 3); but three islands in very close proximity, Islas Salsipuedes, San Lorenzo Norte, and San Lorenzo Sur, actually comprise the largest single breeding colony, 17,225 nests in 2006, determined from ground-truth data.

[e]This value was corrected for the estimated reduced detectability of small (<63) colonies, adding about 150 pairs and 5 occupied colonies to the total.

Figure 3. Estimated aerial detectability of small colonies of brown pelicans.



occur commonly throughout the range, commonly enough that these small colonies are likely important for an understanding of metapopulation dynamics, source/sink phenomena, and dynamics of local extinctions/establishments. Yet, due to the high overall aerial detectability of brown pelican concentrations and colonies, augmented by the usually large sizes (>63) of breeding colonies, which include large birds conspicuous in, over, and near occupied nesting substrate (or on the ground in large flocks), usually also "marked" with large, white patches of fresh guano (in contrast to pinkish or yellowish patches, which would be from previous years), we do not believe these small, rare occurrences of nesting brown pelicans are consequential to total metapopulation or subpopulation estimates reported here (we estimate a correction for detectability would add about 150 nests and only 5 more colonies to the overall estimate, which are included only in the totals in Table 2). Given the degree of other known sources of variation that potentially confound overall precision (namely phenological differences, observer error, and even methods and assumptions used to estimate precision), small colonies are of minor importance to the overall estimate. However, small colonies are nonetheless biologically important in metapopulation dynamics, but documenting this phenomenon was not an objective of this report.

Sampling Bias

Sampling biases associated with potential phenological differences over a wide range of latitudes (about 11° of latitude in ten days for the aerial survey portion alone) and observer error are perhaps the most perplexing potential problems. It can be seen that as colony-size becomes larger, aerial estimates tend to steadily and increasingly underestimate ground-truth values (Figure 2), a tendency commonly noted in aerial surveys, but correctable (previous discussion).

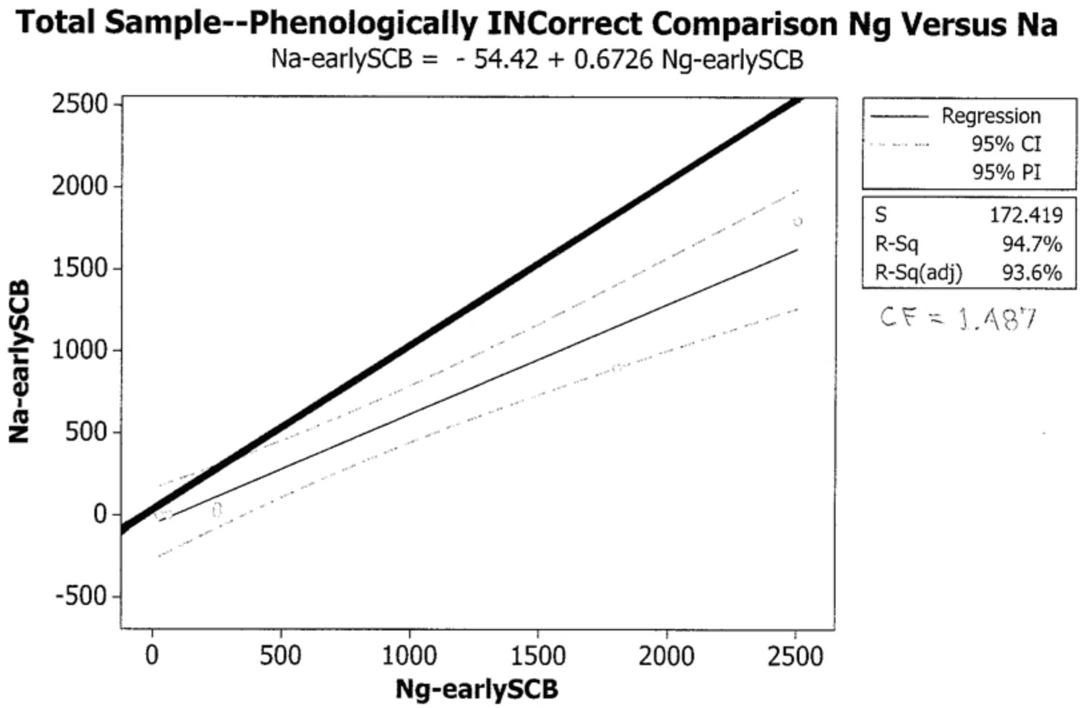
Phenology Bias

For the Southern California Bight (SCB) subpopulation (on northern range periphery) (Appendix 1), it was obvious that our flight occurred too early in 2006 to be useful by itself (Figure 4), but a CF of 1.487 is provided for possible adjustments to future surveys of this nature. Yet, given the high expected year-to-year variations in the nesting cycle, even within a subpopulation (see Anderson and Gress 1983, their Figure 4), a correction based on one year's data may be of limited use.

Overall Distribution and Delineation of Metapopulation and Subpopulations

Personal field work and accumulated records by DWA were summarized here only to record a location as a known site for breeding pelicans sometime in the past. Furthermore, the published literature (see methods and additional citations) was reviewed to supplement the total record (Figure 5A, 5B).

Figure 4. Linear regression of aerial estimates (n_a) on ground-truth determinations (n_g) where matched data were available, but phenology differences between the date of aerial survey and final colony-size estimates were large, resulting in an aerial survey too early in the nesting season for an accurate estimate.



Southern California Bight (SCB) Subpopulation

This subpopulation (Figure 5B, Appendix 1) is defined mainly by the bounds of the California Current System (Anderson and Gress 1983) and includes the mid- and south-coast of California plus the northwest coast of Baja California south to Isla San Gerónimo, Baja California. The most southern, known seabird nesting location, Isla San Gerónimo, was also a potential nesting location for brown pelicans in this zone in 2006. Due to its remoteness and distance from gasoline supplies, Isla San Geronimo was not surveyed by us from the air in 2006. However, ELP and H. Carter (personal communication) observed about 200 nests there in April 2007; that value was used for 2006. Gress (1970) conducted the most comprehensive early review of nesting status of brown pelicans in the SCB. General surveys and estimates of nesting brown pelicans throughout their range were reported by Anderson et al. (1976), Everett and Anderson (1991), and Velarde and Anderson (1994). The general distribution, especially to the south, has also been summarized by Howell and Webb (1995) and Wilbur (1987), with specifics provided in Appendix 1.

Southern Baja-Pacific (SBP) Subpopulation

This subpopulation (Figure 5B, Appendix 2) includes the mid- and southern- Pacific coast of Baja California, south from Isla San Gerónimo, Baja California (29º 47.5’ N), to the south end of Isla Creciente (southern Magdalena Bay, 24° 17’ N). Hutchinson (1950:122-133) documented the nesting of brown pelicans (but with no estimate of numbers) in this area and farther south into Mexico. A potential nesting location in this region for brown pelicans, Isla Adelaide (28º 40.2’ N, 114º 16.7’ W) is not listed in Appendix 2 because brown pelican nesting has never been confirmed, although thousands of Brandt’s Cormorants (*Phalacrocorax penicillatus*) regularly nest on this island with 400-500 brown pelicans usually found loafing in the area. Isla Adelaide was reported once to DWA (K. Nishikawa, personal communication) to have possible, sporadic, but very low numbers of nesting brown pelicans, but it was unconfirmed, although the island is often mentioned by many of the authors cited above as an important nesting location for other seabirds (see “X” in that area, Figure 5A). Our name for this subpopulation was changed slightly from that given by Gress and Anderson (1983) (“Southwest Baja California Coastal Population”) to avoid name confusion with the SCB subpopulation. No nesting records of brown pelicans have been reported for the outermost island groups of western Baja California, the Islas Revillagigedos (Wehtje et al. 1993) and Isla Guadalupe (Jehl and Everett 1985).

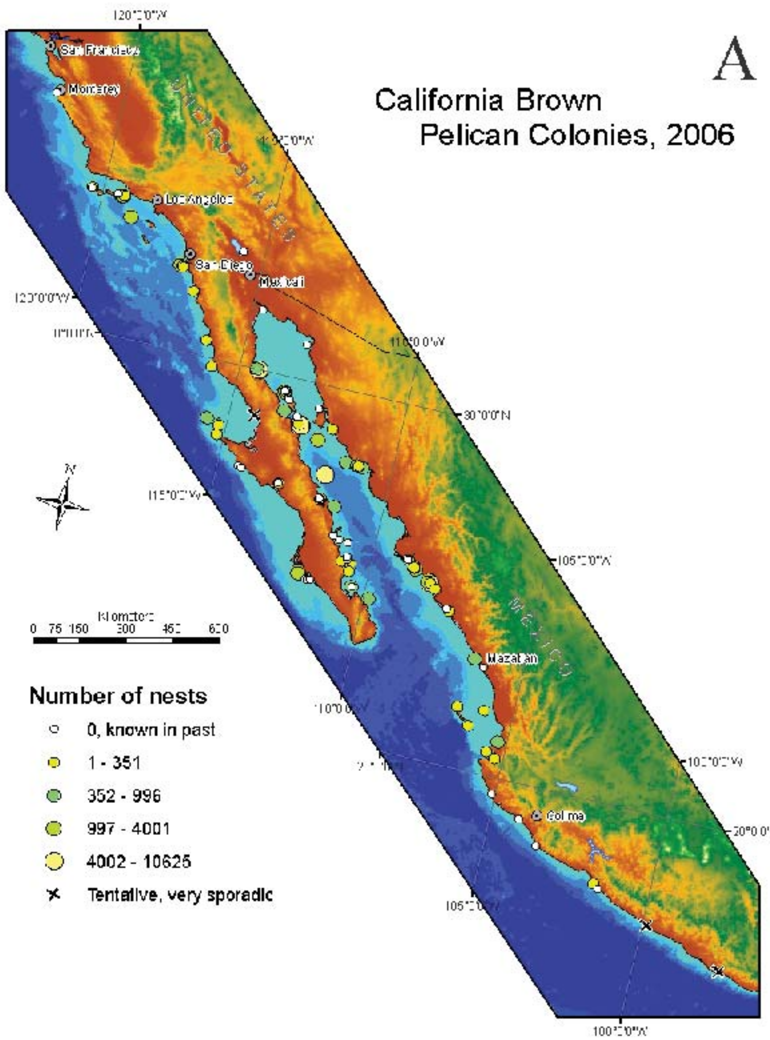
Gulf of California (GOC) Subpopulation

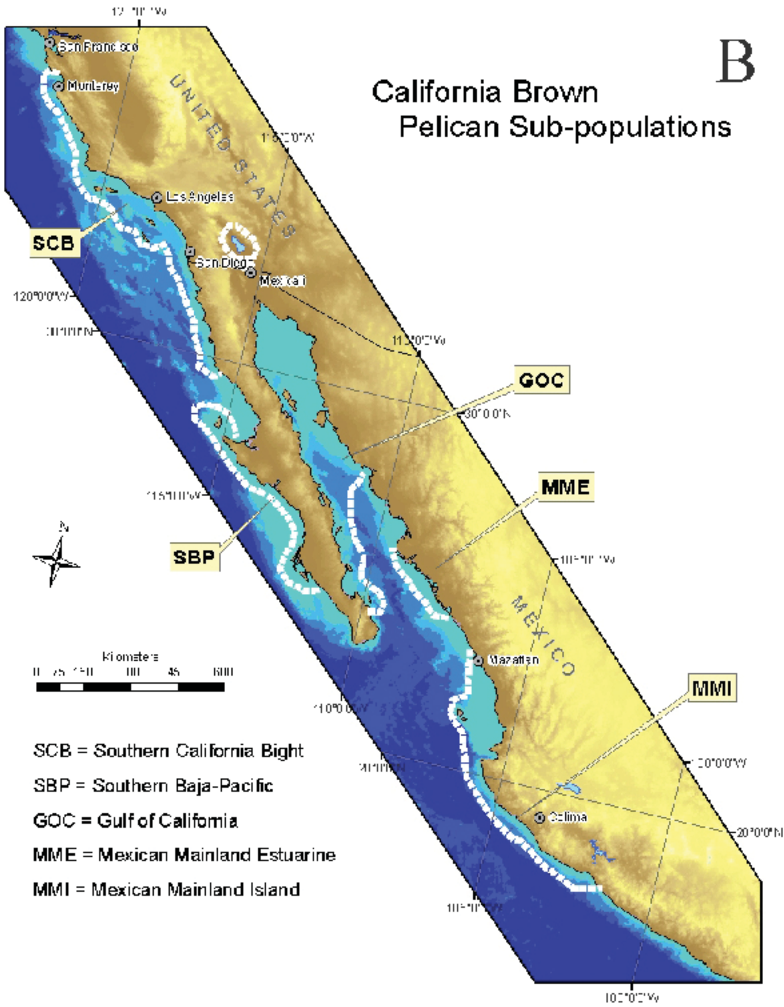
This subpopulation was always known as the largest (Gress and Anderson 1983) and includes the Gulf of California, north from Isla Cerralvo, Baja California Sur (24° 14.6’ N, 109° 51.4’ W) and north from Punta Calavaras (near Guásimos), Sonora (27° 53.4’ N, 110° 40.8’ W) (Figure 5B, Appendix 3). A large gap in brown pelican nesting distribution occurs from about the southern terminus of Bahía de Magdalena (24° 20.0’ N) south and around Cabo San Lucas to the first nesting colony on Isla Cerralvo, in the southwestern Gulf of California (Figure 5A, 5B). South of Punta Calavaras, subpopulation designation is based mostly on dominant nesting habitat association (estuaries) and distance (physical gap) from the more northern and pelagic GOC brown pelican nesting colonies. Much additional information on the GOC subpopulation and the subpopulations farther south is provided by Velarde et al. (2005).

Mexican Mainland, Estuarine (MME) Subpopulation

There is another large gap in the distribution of brown pelican nesting to the south from about Punta Calavaras (near Guásimos), Sonora (27° 53.4’ N, 110° 40.8’ W) south to about

Figure 5. The ranges of the California brown pelican (Basemap data source: NGDC, USGS, ESRI, coordinate system WGS 84, created by K. Keightley and M. Ferrell). A. Nesting colonies on the West Coast of North America plotted by size (yellow circles of various sizes) and occupancy (black and white versus yellow circles). B. Hypothesized subpopulations and their boundaries.





Boca las Piedras at the mouth of the Río Fuerte Nuevo (25° 49.1’ 109° 25.6’) (= about 400 km) where a distinct change in available and utilized nesting substrate (to mangrove and vegetated, estuarine islands) occurs. This subpopulation nests mostly in mangrove habitat south to about Peninsula Quevedo (23° 54.9’ N, 106° 58.2’) (Figure 5B, Appendix 4).

This (MME) subpopulation is also apparently characterized by significant shifting amongst the various bays and islands (details in footnotes, Appendix 4). With nesting colonies frequently shifting location, the numerous presently unoccupied islands of the region (no current colonial waterbird nesting activity seen in 2006) may nonetheless be important for waterbird and biodiversity conservation. The isolated barrier islands, large bays, and extensive mangrove habitats with large numbers of islands along Mexico’s west coast are important for many waterbird species.

Mexican Mainland, Island (MMI) Subpopulation

This subpopulation is found nesting mostly in bushes and trees on offshore islands, south of a gap starting at about Mazatlan (23° 16’ N, 106° 28’ W), and ending at about Isla Grande (17° 40.6’ N)(Figure 5B, Appendix 5). The southern limits of this subpopulation (and the subspecies) are not well defined or well-known. Also evident from a computer “overflight” on “Google Earth”, extensive shoreline development and tourist, agriculture, and mariculture activity characterizes much this area’s coastline; and it is possible, but unknown, if larger numbers of brown pelicans nested along this current geographical gap in earlier times.

MMI subpopulation designation is based mostly on dominant nesting habitat association (offshore islands in pelagic zones), distance (physical gap) from the more estuarine-inhabiting MME nesting colonies of Appendix 4, and several reliable correspondents and references. Knoder et al. (1980) conducted eight aerial censuses of variable coverage from the Guatemala border north into Mexico from 1971-1979 and reported (personal communication, 1980) “no pelican colonies to speak-of” south of Puerto Vallerta, Jalisco. Gonzalo Gaviño de la Torre (personal communication, 1978) reported “little or no brown pelican nesting south of Isla Grande”, Guerrero (see also references under these names).

The brown pelicans that breed in Central America, perhaps as far north in the presumed large gap between *P. o. californicus* and *P. o. carolinensis* (= approximately 1500 km), such as the colony reported in 1971 at Laguna Chacahua (Appendix 5), was likely no more than a sporadic, temporary northern colony of *P. o. carolinensis*, especially given that those brown pelicans were also reported nesting in estuarine mangroves and not on a pelagic, offshore island as seems more characteristic of this subpopulation (Table 2). Importantly, brown pelican nesting is not reported by Binford (1989), the most authoritative author on the birds of Oaxaca, and we must therefore conclude that the Laguna Chacahua record (but based on a reliable source, ref. 28, Appendix 5) must at best be no more than a sporadic, northern record for *P. o. carolinensis* (see also Thurber et al. 1987:128-129). Furthermore, the Laguna Chacahua area has been a National Park (Parque Nacional Lagunas de Chacahua) with constant annual monitoring, but no known brown pelican nesting reported since at least the early-1970s (J. E. Mendoza, personal communication; FG, field notes). We doubt that this record at the range peripheries of both subspecies represents a regular location for nesting brown pelicans. Howell and Webb (1995:126), also recognized authorities for this region, indicate that the first “regular” brown pelican colony to the south of Isla Grande (Appendix 5) is located in the Gulf of Fonseca (about 13° 16’ N, 87° 42’ W), near the border of El Salvador and Nicaragua.

Genetic studies are certainly needed from both north and south of this area, and ecological studies may provide useful information regarding isolating barriers for the two subspecies. Jehl (1974) conducted pelagic seabird surveys from the offshore areas in this region (see Figure 5) and commented on the general rarity of brown pelicans. Thus, the available information indicates that the coast of Guerrero (about 17° 40’ N) likely represents the southern limits of nesting for the California brown pelican subspecies as well as the MMI subpopulation, although as suggested in Figure 5 and Appendix 5, small, perhaps no more than sporadic brown pelican nesting colonies may occasionally be found somewhat farther south, although the two resident breeding subspecies of the larger region (western North America), normally widely separated, may commonly mix as non-breeders (see Thurber et al. 1987), or even rarely breed in this region.

Numbers of Breeding Pairs by Subpopulation and Totals for the Sub-species

Overall results of the survey are presented in Table 2, and summarized by subpopulation in Figure 5B. The entire metapopulation (subspecies) is comprised of about 70,680 ± 2,640 breeding pairs (Table 2). The largest subpopulation within the subspecies’ range is in the Gulf of California (about 43,400 breeding pairs) and the largest single breeding aggregation is presently located in the Midriff Region of the Gulf of California on the San Lorenzo Archipelago (Table 2, Appendix 3). Age-ratio estimates from our 2006 aerial survey for the entire metapopulation indicated 71.9% adults (white-heads) and 28.1% immatures (brown-heads) (mostly comprised of young produced in the two years preceding 2006) (total n = 71,287 individuals categorized). Given these age-ratios, we therefore estimate the total California brown pelican metapopulation in 2006 (an exceptional season preceded by about five years of high production and survival of subadult birds; DWA, field notes), at about 195,900 ± 7,225 individuals.

Discussion

Our total estimate for the subspecies was about 70,680 breeding pairs (Table 2). The Archipelago of San Lorenzo contained the largest colony (comprised of three sub-colonies) with a ground-truth census of about 17,200 breeding pairs (= 24.4%). Yet, no subpopulation breeding colony average (expressed in various ways in Table 2) approaches that level, with considerably smaller colonies more typical. Also, each subpopulation seems to contain at least one or two colonies or colony-areas which dominate subpopulation numbers, and perhaps act as central dispersal areas: SCB, Anacapa Islands Archipelago plus Santa Barbara Island = 9,000 nests (77.0% of the subpopulation); SBP, Isla Santa Margarita = 1,950 nests (62.9%); GOC, San Lorenzo and San Luis Archipelagos plus Isla Tortuga = 31,485 nests (72.6%); MME, Archipelago Isla Pájaros (Bahía Santa Maria) = 9,050 nests (85.9%); and MMI, Isla de Pájaros (Mazatlán) plus Isla la Peña = 1,350 nests (73.2%).

De la Torre (1986) has aptly pointed-out that from about Nayarit and south (the MMI subpopulation), offshore nesting islands are very scarce, and rarely does one encounter breeding brown pelicans. Thus, he concludes (and we agree, see Anderson et al. 1976 and 2006) that such smaller and more widespread breeding colonies are no less important in conservation, but perhaps more vulnerable, than those larger colonies to the north (Appendices 3 and 4, for example). This importance would seem especially true for such nesting colonies at Isla Peña and Isla Grande. From literature reviews for this region (Appendix 5), we are confident that subpopulation numbers are very low, but perhaps even lower than estimated here.

We have not specifically evaluated trends in this report or conducted a specific Population Viability Analysis (see Beissinger and McCullough 2002), but in most instances where long-term data are available, this metapopulation should be considered similar to when it was more crudely estimated by Gress and Anderson (1983:9,176), at “55,000-60,000 pairs”, except that the SCB population has increased (recovered) greatly in numbers since the early-1980s (Gress et al., in preparation). Gress and Anderson (1983:11) stated: The number of pairs breeding in the SCB from 1969 through 1981 ranged from 339 to 3,510 (average = 1,228). Our 2006 estimate of about 11,700 (Appendix 1, Table 2) indicates an increase over the earlier average by almost one order of magnitude (a factor of approximately 9.5). If one subtracts the SCB early/late difference (10,470) from our 2006 metapopulation total, the remainder is about 60,200, a value remarkably close to an earlier estimate by Gress and Anderson (1983). Reclassification of the California brown pelican under the Endangered Species Act as first proposed in 1985 (Letter from L. L. Leschner, Chair Pacific Seabird Group, to U.S. Fish and Wildlife Service, 18 March 1986) was partly postponed until some assurances that the large, viable segment of the overall metapopulation to the south of the California Current had assurances for conservation. Indeed, conservation has made significant strides in Mexico since that time (Carabias-Lillo et al. 2000), so that now, a formal petition to re-classify or delist has been put forward (U.S. Fish and Wildlife Service 2006) We consider our estimate as a maximum estimate; numbers in other years, likely to be less than this number, are likely to be most influenced by ENSO conditions and the effects of human development pressures and disturbances (e.g., Anderson and Keith 1980, Tershy et al. 1999, and Primavera 2005) along the Mexican coastlines of the subspecies' range, especially from the Colorado Delta region south to the southern limits of its range along the coasts of Western Mexico. Maricultural, agricultural, and tourist activities in this region are extensive and may result in substantial loss of breeding habitat leading to decreased brown pelican and waterbird populations. The Mexican Mainland Estuarine subpopulation and its habitat are especially dependent on the persistence of estuarine/mangrove habitats and estuarine/mangrove nesting islands. Much of this habitat also represents significant habitat for wintering waterfowl (shorebirds, ducks, geese, coots). Further descriptions, threats, and conservation (along with waterfowl census data) have been provided by Saunders and Saunders (1981), Kramer and Migoya (1989), Wilson and Ryan (1997), and Pérez-Arteaga et al. (2002).

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APPENDIX 1. Summary of active (2006) and otherwise-known breeding colonies of the California Brown Pelican for the ***Southern California Bight (SCB) Sub-population***[a].

Site Name	Approx LAT	Approx LONGI	Nests (Air)	STG[b]	Da/Mo	r/s[c]	#Nests	Da/Mo/Yr	#Nests (fin. est.)	Source Final Est[d]	Dis[e]	# not @ Nests[f]	Est Non-YY #[f]	% BH[f]	REM[g]
Bird Island, Point Lobos, CA	36 30.4	121 56.6	?	UK	2006	1	0	multiple	0	8	NC	*	*	*	
Scorpion Rock, CA	34 02.9	119 32.8	?	UK	2006	2	0	multiple	0	6	NC	*	*	*	
San Miguel Island, CA	34 02.4	120 20.1	?	UK	2006	2	0	multiple	0	6	NC	*	*	*	
Prince Island, CA	34 03.4	120 20.2	?	UK	2006	3	100	multiple	100	6	NC	*	*	*	
East Anacapa Island, CA	34 00.9	119 21.9	?	UK	2006	2	10	multiple	10	6	NC	*	*	*	
West Anacapa Island, CA	34 00.6	119 25.4	?	UK	2006	2	2,500	multiple	2,500	6	NC	*	*	*	1
Middle Anacapa Island, CA	34 00.2	119 23.6	?	UK	2006	2	2,500	multiple	2,500	6	NC	*	*	*	
Santa Barbara Island, CA	33 28.5	119 02.3	?	UK	2006	2	4,000	multiple	4,000	6	NC	*	*	*	
Isla Coronado Norte, BCN	32 26.4	117 17.9	900	MM	23/03	4	1,800	multiple	1,800	6	PE	400	*	<5	2
Mid-Coronados Complex, BCN	32 25.0	117 15.6	0	NO	23/03	4	60	multiple	60	6	PE	75	75	<1	2
Isla Coronado Sur, BCN	32 24.3	117 14.7	0	NO	23/03	4	25	multiple	25	6	PE	25	25	0	2
Isla Todos Santos Sur, BCN	31 48.0	116 47.4	15	VE	23/03	4	250	multiple	250	6	PE	60	<100	<5	2
Isla San Martín, BCN	30 29.3	116 06.8	50	VE	23/03	4	250	multiple	250	6	PE	1550	1,100	40	2
Isla San Gerónimo, BCN	29 47.5	115 47.5	?	UK	2007	4	200	04/2007	200	6	NC	*	*	*	3
SUB-TOTAL--SCB									11,695						

NOTES & REMARKS (footnoted from above):

[a]Estimates of numbers in various columns above are rounded to the nearest 5 (if actual counts or estimates varied from 1-300), the nearest 10 for intermediate values (>300-1000), or to the nearest 50 or 100 for higher values (>1000). The source for LAT/LONGI values was "Google Earth" (earth.google.com) with positions given at a point approximately centered on each island or the part of island with known nesting, but not the specific locations of the nesting colonies (due to frequent, annual shifts in their specific locations). An asterisk (*) in any column indicates that additional 2006 or related confirming data were not available, or not needed (ex. because of lack of nesting in 2006, further information was not necessary). A question mark (?) in any column indicates that there are no definite historical records of nesting, but that nesting at this location is highly possible in some years (i.e., the island appears to be suitable for BRPE nesting); or, "?" indicates that data are unknown.

[b]STG = phenological stage on the date of our 2006 aerial survey: UK = unknown, NO = known colony area empty, not occupied, VE = very early nesting, EE = early nesting, MM = est. mid-season nesting, LL = late nesting, VL = very-late nesting.

[c]r/s = References and Sources (as numbered):

1—Baldridge (1974) and A. Baldridge, *personal communication (2007)*.

2—F. Gress and L. Harvey, CIES, *personal communications (2006-2007).*

3—P. Capitolo and CDFG, *personal communication (2006);* Capitolo et al*.* (2007) reported that this small colony had been successful (produced young) in 2006.

4—F. Gress, E. Palacios, L. Harvey, CIES and CICESE, *personal communications* (2006-2007); H. R. Carter, *personal communications* (2007).

[d]Source(s) of final estimate(s) of number of active nests: 1 = aerial visual, 2 = aerial photo estimate, 3 = aerial photo count, 4 = ground-truth count, 5 = ground-truth, sample-count projected, 6 = ground-truth cooperator(s) in 2006 (or 2007), 7 = ground-truth cooperator(s), in previous year(s), 8 = number of nests taken from literature of previous years, 9 = previous survey(s) by cooperators (date given in column 9, “DA/MO/YR”).

[e]Source of Discrepancy in estimates given as: PE = phenological, our aerial survey was too-early for determination of maximum numbers; PL = phenological, aerial survey was too-late; CD = due to census-technique differences; NC = not surveyed aerially for various reasons; ND = no (or minor) discrepancy encountered.

[f] Column 13--Approximate numbers given are BRPE not on nests but roosting near occupied nests (in the colony, on the nearest beach or cliff, etc.); Column 14--Approximate numbers given are BRPE in the “vicinity” (on nearby islands and beaches), but not on the island of nesting; % BH is the proportion of these non-nesting individuals that are juveniles ('brown-heads" fledged in 2005, but not 2006). At the time of our survey, there were no flying young-of-the-year.

[g]ADDITIONAL REMARKS FROM THIS COLUMN, “REM”:

1--Since the recovery of SCB BRPE after the mid-1970s from DDE-related pollution problems (Anderson et al. 1975), most nesting of BRPE has occurred at West Anacapa and Santa Barbara Islands; after about 2005, and especially noticeable in 2006, historical colonies began to become significantly re-occupied on a larger scale (ref. 2, above).

2--Details on nesting BRPE from the SCB in 2005 are summarized by Carter et al. (2006) and Gress et al. (2005). Data for 2006 will be available in the same format by December 2007, but are summarized above through the *personal communications* cited. Late-nesting segments of the SCB colonies were not established at the time of our single over-flight, thereby necessitating strong dependence on boat and ground-based survey data.

3--Due to distance from gasoline supplies, we did not conduct an aerial survey at Isla San Gerónimo in 2006. This island was reported as a BRPE nesting site in 2005 by Nelson (1922:86) and a visit in 2007 by E. Palacios and H. R. Carter (ref. 4 above) indicated 200 active nests that we likely missed in 2006.

APPENDIX 2. Summary of currently active (2006) and otherwise-known breeding colonies of the California Brown Pelican for the ***Southern Baja-Pacific (SBP) Sub-population***[a]**.**

Site Name	Approx LAT	Approx LONGI	Nests (Air)	STG[b]	Da/Mo	r/s[c]	#Nests	Da/Mo/Yr	#Nests (fin.est.)	Source Final Est[d]	Dis[e]	# not @ Nests[f]	Est Non-YY #[f]	% BH[f]	REM[g]
Islas San Benito, BCN	28 18.4	115 34.8	?	UK	*	5	400	2002	400	9	NC	*	*	*	4
Isla Cedros, BCN	28 10.7	115 12.7	?	UK	*	5	300	2002	300	9	NC	*	*		4
Isla Natividad, BCS	27 53.4	115 12.7	?	UK	*	5	±100	2002	100	9	NC	*	*		4
Isla San Roque, BCS	27 08.8	114 22.6	0	NO	26/03	*	*	*	0	1	*	0	0	*	5
Isla la Asunción, BCS	27 06.2	114 17.5	0	NO	26/03	*	*	*	0	1	*	0	0	*	
Isla Garzas, BCS	26 55.7	113 09.8	0	NO	26/03	*	*	*	0	1	*	0	0	*	6
Isla Pelícanos, BCS	26 54.3	113 09.3	375	EE	26/03	6	*	*	350	1,2	PE	800	1,500	5	6
Isla Santa Margarita Norte (uplands), BCS	24 30.9	111 59.5	1,800+	EE	25/03	7	2,000	21/07/02	1,950*	1,7	PE	2,500	7,500	20	7
Isla Santa Margarita Sur (uplands), BCS	24 23.1	111 45.6	0	NO	25/03	*	*	*	0	1	*	0	0	*	8
Isla Santa Margarita Sur (mangroves-Las Tijeras), BCS	24 21.7	111 42.1	0	NO	25/03	*	*	*	0	1,2	CD	10	*	*	9
Isla Creciente Norte, BCS	24 22.6	111 36.9	0	NO	26/03	*	*	*	0	1,7	*	0	10	*	10
SUB-TOTAL--SBP									3,100						

NOTES & REMARKS (footnoted from above):

[a, b, d, e, f, g]These footnotes are identical to those from Table 1.

r/s = References and Sources (as numbered):

5—B. Keitt, S. Wolfe, and B. Tershey, ISCB, personal communication.

c 6—Gustavo Danemann, PRONATURA; Martín Garcia Aguilar, Guerro Negro Salt Company; Benito Bermudez, CONANP, personal communications.

7—Eduardo Palacios, CICESE and Edgar Amador, CIBNOR, personal communication; Zárate-Ovando et al. (2006).

ADDITIONAL REMARKS FROM THIS COLUMN, "REM":

g 4—Not censused by us in 2006 due to fog; we used the values reported by Keitt et al. (ref. 5 above) for our recent estimate. In 1977, this colony contained 150 nests (DWA and CJH, field notes). Nelson (1922:88) reported Isla Natividad as an important BRPE colony site as early as 1905.

5—In 1977, this island had 250 BRPE nests (DWA and CJH, field notes) and in 2007, there were about 200 active nests (E. Palacios and H. Carter, personal communications); but we saw no activity in 2006.

6—G. Danemann (reference 6, column 7) reported a complete abandonment of this BRPE colony (along with Double-crested Cormorants, *Phalacrocorax auritus*) about 3 weeks after our aerial survey; this abandonment was believed most importantly due to coyote predation but also some human-related disturbances. On our over-flight, we observed an unidentified person in one of the previously-known, nearby pelican and cormorant nesting areas on nearby Isla Garzas. Our photographs indicated about 350 BRPE nests (birds on nests and incubating, thus difficult to see) along with about 50 DCCO nests, but photos were not clear. Our final estimate is a compromise between our visual estimate and our photograph estimate. Danemann and Guzman-Poo (1992) believed the BRPE is a recently-established nester at this location and they reported wide fluctuations in the numbers of nesting BRPE at this colony (on Isla Garzas when they studied on the island), from 50 nests in 1988 to 1100 nests in 1989. Knoder et al. (1980) first reported 65 nests in San Ignacio Lagoon in 1971. The colony (with two known locations), although located within the el Vizcaino Reserva de la Biosfera, is still subject to disturbance.

7—Given the number of birds in the immediate nesting area and below on the water, the total nesting population in 2006 was likely higher, perhaps by at least 500 to 1,000 nests. Zárate-Ovando et al. (2006) reported this site as a 3,000-nest BRPE colony, and they also report about 9,700 BRPE of all age-classes in the local area in summer (prior to fledging from the colony). Percent BH (brown-head) BRPE, column 15, was estimated from but one photo of IN/OUT feeding flocks moving toward the large loafing-group just below the nesting canyons (see column 13). Our final estimate of numbers was based on a correction factor of 1.081 (Fig. 2c).

8—Old guano deposits in this unoccupied BRPE nesting area (first seen with BRPE by DWA and CJH in 1992) was photographed, but was not seen to be occupied in 2006. Gomez-C. et al. (1982) first identified this general location as a known (but perhaps intermittent) BRPE nesting location on Isla Santa Margarita in 1980. And in fact, Nelson (1922:90) reported this area contained “considerable numbers” nesting on the south end of Isla Santa Margarita in 1905.

9—This mangrove colony of mostly Magnificent Frigatebirds (*Fregata magnificens*) and Double-crested Cormorants, was not directly over-flown due to extreme hazard of bird-strikes (numerous, dense MAFR soaring over the colony area). Thus, we only flew by the edges of the colony on one pass and photographed the nesting colony from a distance. No more than a few immature pelicans near a fishing village nearby were the only identifiable BRPE in this nesting area of Isla Santa Margarita in 2006.

10—On 27 March 1977, this small colony contained 25 active pelican nests in mangroves (DWA and CJH, field notes), and it represents the extreme known southern limits of the SBP sub-population.

APPENDIX 3. Summary of active (2006) and otherwise-known breeding colonies of the California Brown Pelican for the ***Gulf of California (GOC) Sub-population***[a].

Site Name	Approx LAT	Approx LONGI	Nests (Air)	STG[b]	Da/Mo	r/s[c]	#Nests	Da/Mo/Yr	#Nests (fin. est.)	Source Final Est[d]	Dis[e]	# not @ Nests[f]	Est Non-YY #[f]	% BH[f]	REM[g]
Isla Cerralvo, BCS	24 14.6	109 51.4	300	EE	25/03	*	*	*	375	1,2	CD	40	120	<20	11
Isla Gallo, BCS	24 27.0	110 23.1	0	NO	25/03	*	*	*	0	1	ND	12	12	?	12
Isla Ballena, BCS	24 28.9	110 24.3	950	EE	25/03	*	*	*	1,030*	1,2	ND	200+	350	?	13
Isla Caya, BCS	24 52.5	110 36.2	20	EE	25/03	*	*	*	20	1	ND	0	235	?	14
Islote las Animas, BCS	25 06.2	110 35.1	25	EE	25/03	*	*	*	25	1	ND	0	0	<5	15
Isla Habana, BCS	25 07.7	110 51.7	5	EE	25/03	*	*	*	5	1	ND	0	0	0	16
Isla San Diego, BCS (?)	25 12.0	110 41.9	0	NO	25/03	*	*	*	0	1	ND	0	0	*	
Isla Santa Cruz, BCS (?)	25 17.2	110 42.8	0	NO	25/03	*	*	*	0	1	ND	0	20	?	
Isla Santa Catalina, BCS	25 41.4	110 46.8	0	NO	25/03	*	*	*	0	1	ND	0	40	?	17
Isla Monserrat, BCS	25 42.2	111 02.9	0	NO	25/03	*	*	*	0	1	ND	0	30	?	
Isla Danzante, BCS	25 47.2	111 15.1	0	NO	25/03	*	*	*	0	1	ND	0	0	*	18
Isla San Ildefonso, BCS	26 38.1	111 25.5	750	EE	24/03	*	*	*	700	1,2	CD	few	580+	<5	
Isla Guapa (Blanca), BCS (?)	26 43.3	111 52.0	0	NO	24/03	*	*	*	0	1	ND	0	20	?	19
Isla el Coyote, BCS	26 43.4	111 53.3	0	NO	24/03	*	*	*	0	1	ND	0	10	?	
Isla la Cueva, BCS	26 44.6	111 52.5	75	EE	24/03	*	*	*	75	1	ND	150	200+	<1	
Isla la Pitahaya, BCS	26 45.1	111 52.3	20	VE	24/03	*	*	*	20	1	ND	0	0	0	
Isla (San) Ramón, BCS	26 45.4	111 53.2	0	NO	24/03	*	*	*	0	1	ND	<5	<5	?	20
Isla Tortuga, BCS	27 27.0	111 52.8	7,700	EE	27/03	*	*	*	8,800*	1,2	ND	few	many	?	21
Isla Pájaros (Guaymas), SON	27 54.6	110 52.3	650	EE	31/03	8	*	*	700	1,2	CD	few	450+	>80	
Isla Pastel, SON	27 56.1	110 59.5	0	EE	31/03	8	±50	26/04	50	1,3,6	CD	25	25	0	22
Isla Chaperona, SON	27 57.0	111 01.8	250	EE	31/03	8	±450	26/04	450	1,3,6	CD	3,000+	4,000+	>80	
Isla San Pedro Nolasco, SON	27 57.6	111 22.4	350	EE	31/03	8	995	08/05	995	1,2,6	ND	few	many	>80	22

Isla San Pedro Mártir, SON	28 22.9	112 18.4	?	UK	*	8,9	2,500	2005	2,500	6	CD	?	?	?	23
Isla San Lorenzo, BCN	28 40.0	112 52.2	7,000	EE	27/03	10	6,550	25/05	6,550	1,5	CD	1,000s	>20,000	<10	24
Isla las Animas, BCN	28 41.7	112 55.0	10,000	EE	27/03	10	10,625	25/05	10,625	1,5	CD	--	--	--	24
Isla Salsipuedes, BCN	28 43.6	112 57.4	50	EE	27/03	10	*	*	50	1	ND	--	--	--	24
Isla Alcatraz, SON	28 48.6	111 58.2	75	EE	31/03	11	320	29/03	320	1,6	CD	?	200+	?	25
Isla Partida, BCN	28 53.8	113 02.1	0	NO	27/03	*	*	*	0	1	NO	0	?	?	26
Isla Piojo, BCN	29 01.1	113 27.9	700	MM	01/04	10	650	20/05	600	1,4	CD	?	?	?	27
Isla Patos, SON	29 16.2	112 27.6	0	NO	27/03	*	*	*	0	1	ND	0	1225	<30	28
Isla Angel de la Guarda (MID) (Playa Bahía Pulpíto), BCN	29 19.4	113 22.3	0	NO	27/03	10	0	23/05	0	1	ND	0	few	?	
Isla Angel de la Guarda(NE), BCN	29 32.3	113 31.6	0	NO	27/03	10	0	23/05	0	1,4	ND	0	>250	>10	29
Isla Angel de la Guarda(NW), BCN	29 32.3	113 33.9	3,000	EE	27/03	10	2,700	23/05	2,700	1,4	CD	1500+	>550	>10	29
Isla Pelícano(Navio), BCN	29 33.1	113 33.5	750	EE	27/03	10	200	23/05	750	1,4	CD	--	--	--	29
Isla Mejia, BCN	29 33.3	113 33.7	0	NO	27/03	*	*	*	0	1	CD	--	--	--	
Isla Granito, BCN	29 33.9	113 32.4	<100	MM	27/03	*	*	*	100	1	ND	--	--	--	29
Isla San Luis, BCN	29 58.8	114 24.4	3,000	EE,LL	01/04	10	5460	28/05	5,460	1,4	PL	few	800	>5	30
Isla Encantada(Cholluda), BCN	30 01.1	114 28.8	250	EE	01/04	*	*	*	450	1,4	PL	few	50	>5	31
Isla San Jorge, SON (?)	31 00.6	113 14.6	0	NO	*	12	0	2005	0	7	ND	?	?	?	32
Isla Montague, SON (?)	31 42.0	114 41.5	0	NO	*	13	*	*	0	6	ND	?	?	?	32
Obsidian Island, Salton Sea, CA	33 10.4	115 38.6	0	NO	*	14	*	*	0	6	ND	?	?	?	33
Mullet Island, Salton Sea, CA	33 13.5	115 36.6	0	NO	*	14	*	*	0	6	ND	?	?	?	33
SUB-TOTAL--GOC									43,350						

NOTES & REMARKS (footnoted from above):

[a, b, d, e, f, g]These footnotes are identical to those from Table 1.

[c]r/s = References and Sources (as numbered):

8—Ana Luisa Figueroa, CONANP; Juan Pablo Gallo Reynosa, CIAD, Unidad Guaymas; E. Mellink, CICESE, *personal communications*.

9—Because of logistical problems, we conducted no ground survey at Isla San Pedro Mártir in 2006; but in a recent report issued by the Reserva de la Biosfera Isla San Pedro Mártir (2007), 2,000 to 3,000 nesting pairs are considered as "normal" BRPE nest numbers for that island; we compromised at 2,500 nests. Biosphere staff figures are based largely on Tershy & Breese (1997), who based their estimates on Velarde & Anderson (1994). Previous counts by DWA (field notes) have been as high as 5,000 pairs, so we do not feel our "estimate" is unreasonable for 2006, and if anything, could be higher by about 1,000 more pairs.

10—CGR and CSDP; Thomas Bowen, Fresno State University; DWA.

11—Juan Pablo Galván (2006).

12—Erik Mellink, CICESE, *personal communication.*

13—Mellink and Palacios (1993) reported substantial seabird nesting on Isla San Jorge but no known BRPE nesting ever for the island, although without disturbance, we believe this island has potential for it. Palacios and Mellink (1992, 1993) and Peresbarbosa and Mellink (2001) also report significant seabird nesting on Isla Montague, but no BRPE have ever been recorded at this isolated site either. We considered both of these islands as potential sites for BRPE, however, because of their history and nesting activity regarding other waterbird species.

14—Sonny Bono Salton Sea National Wildlife Refuge staff, *personal communications*.

[g]ADDITIONAL REMARKS FROM THIS COLUMN ("REM"):

11—Despite having spent around 45 days exploring this island, Banks (1963a) did not report nesting Brown Pelicans on Isla Cerralvo.

12--Data are reported for two near islands, Isla Gallo and Isla Gallina, "satellites" of Isla Ballena, both of which have had small numbers of nesting pelicans in the past (Carmona et al. 1994). Much boating and kayak activity was seen in the area and there were 145 additional BRPE scattered in the general area (Isla Espirítu Santo/Isla Partida). About 20 old, unoccupied BRPE nests were see on Isla Gallo, thus its being reported here as a BRPE nesting site.

13—Multiple-passes over this island to survey, with estimates by DWA and pilot, JB, made this aerial estimate more reliable, nor could it be revised from the aerial photos. A correction factor of 1.081 was used to derive the final estimate (Fig. 2c). This entire area was one of high boating, kayak activity, and touristic activities, however.

14—About 70% of the BRPE numbers were associated with feeding activity on the SE end of Isla San José.

15—R. W. Risebrough, UC Berkeley (*personal communication*) reported to DWA that on 28 May 1969, there were 10 active nests on this islet; although small, this is apparently a "regular" nesting island for BRPE, as Banks (1963b) reported more than 100 nests there in 1962.

16—There were people kayaking, boating, etc. literally everywhere and few BRPE or other bird species seen in this general area, other than about 5 adult BRPE incubating on nests on this island.

17—There was scattered solitary feeding by 25 BRPE from this total along the east side of the island; but there were few other pelicans in the general area. Based on past visits to this island by DWA (*field notes*), relatively-isolated Isla Santa Catalina has been considered a "regular" BRPE nesting island in the past. Although we circled close to the island's northern uplands (where the previous nesting activities had been known to occur, DWA *field notes*), we saw no signs of activity (white-wash, large numbers of birds, etc.).

18—Banks (1963b) reported 200 BRPE nests on this island, but on our survey, there were no Brown Pelicans associated with the island.

19—C. T. Mitchell (*personal communication*) reported 550 BRPE nests on "Isla San Ramón" in 1999; Banks (1963b) reported BRPE nesting on Isla Blanca in 1962, but did not give estimates of numbers of nests. Nesting BRPE likely shift-around frequently on the many islands of Bahía Concepción, perhaps in response to the high level of human activity and tourism characteristic of that area.

20—Our pilot, JB, believed that there were more than 7,700 BRPE nests on Isla Tortuga; photos also indicated more than the estimate by DWA, but due to the remoteness of the island from mainland, our pilot was cautious about altitude and time spent there; thus, our estimate is a compromise between DWA and JB, using a correction factor of 1.142 to obtain our final estimate (Fig. 2d).

21—This island was traversed aerially only once and Brown Pelicans were observed to be present along with other species of seabirds, but no nesting was detected although small numbers may have been over-looked.

22—Apparently this island has contained much higher BRPE breeding numbers in the past (early- to mid-1900s). For example, Mailliard (1923) reported nesting BRPE as "quite numerous" and van Rossem (1932) stated that this colony was "probably the largest one in the Gulf." L. W. Walker (*personal communication* to J. O. Keith, USFWS) reported in the early-1960s, that Isla San Pedro Nolasco was the largest colony of nesting BRPE known to him at that time.

23—See footnotes 8 and 9, r/s above; this island has been a designated RAMSAR site since 2004.

24—Our estimates of numbers of associated pelicans at the time of census are at best, crude, but thousands of BRPE (+other species) we seen in long flight-lines, along the nearby coast, and in extensive "pileup" feeding throughout this area, thus the total represents the entire San Lorenzo Archipeligo (San Lorenzo Sur, Animas or San Lorenzo Norte, and Salsipuedes).

25—Galván (2006) reported his maximum counts only a few days later than our aerial censuses; the difference between his maximum counts and our aerial counts were attributed to difficulty in seeing nesting BRPE on the rough, rocky terrain of Isla Alcatraz, and there being two sub-colonies on the island, whereas we only discovered one of the two by air.

26—Old BRPE nests from previous years were seen from the air, but none were occupied in 2006; this island has a variable, sporadic history of BRPE nesting, for several years in the past, as high as 4,000 nests (DWA *personal observations*).

27—On the day of our ground-truthing and banding, some young had already fledged and were gone; yet, about 10 nests also still contained eggs. Our final estimate of nests therefore represents a compromise between our aerial survey and our ground survey.

28—Jorge E. Mendoza, PROFEPA (*personal communication*) reported 50 active BRPE nests on Isla Patos in 1973 (an El Niño year).

29—A discrepancy between aerial counts and ground-truthing (see data for other nesting areas at Puerto Refugio) may have been due to disturbances that eliminated many nests on the central and southern parts of Isla Pelícano (maps of nesting distributions, comparing the two censuses, indicated that this part of the island had been abandoned between censuses (two major boat anchorages for this island are also located in this part of the island); yet disturbance was not confirmed, although a group of approximately 550 active nests had disappeared and been abandoned on Isla Pelícano. Numbers of pelicans associated with the Puerto Refugio area were crude and represent numbers associated, not with individual islands, but the entire Puerto Refugio area.

30--Isla San Luis has often had a protracted breeding season in years past (DWA, *field* notes) and that was apparently the case in 2006, with basically two nesting cohorts throughout the total season. Many birds apparently came in to nest after our first survey (aerial) which likely represented the earlier cohort for 2006 because we can determine from surface distribution maps between the two surveys, that apparently, more than 1,000 birds came into the colony to nest after our aerial survey (or we somehow missed them on the first survey). We have no other explanation for this large discrepancy.

31—Isla Encantada (Cholluda) is considered a "satellite" colony of Isla San Luis, and numbers in the past are correlated between the two islands (DWA, *field notes)*; because this island was not visited by our ground-truthing crew, we made the assumption that numbers between aerial survey and ground-truthing at both islands would have been proportionate, as they have been in the past.

32—It is not certain if BRPE have ever nested on Isla San Jorge, although both Brown Boobies (*Sula leucogaster*), Double-crested Cormorants (*P. auritus*) and other species of seabirds abundantly nest there, the boobies numbering into the thousands (Mellink and Palacios 1993). In addition, lower, flat areas of Isla San Jorge, where BRPE would be expected to nest, are subject to disturbances (Mellink and Palacios 1993), as the island is a common site for boat anchorages, but also a common site for large numbers of roosting BRPE (at times commonly exceeding >5000 individuals, DWA *personal observations*).

33--BRPE nesting at the Salton Sea is a recent phenomenon, and it was documented sporadically in the 1990s (DWA, *in preparation*); since a migration has been established by pelicans from the Gulf of California to the Salton Sea, and visa-versa (DWA, *in preparation)*, we consider this BRPE nesting to be a recent range expansion that bears study in the future.

APPENDIX 4. Summary of active (2006) and otherwise-known breeding colonies of the California Brown Pelican for the ***Mexican Mainland, Estuarine (MME) Sub-population***[a].

Site Name	Approx LAT	Approx LONGI	Nests (Air)	STG[b]	Da/Mo	r/s[c]	#Nests	Da/Mo/Yr	#Nests (fin. est.)	Source Final Est[d]	Dis[e]	# not @ Nests[f]	Est Non-YY #[f]	% BH[f]	REM[g]
Bahía Ohuira (nr. Topolobompo), SIN	25 37.2	109 00.8	0	NO	30/03	*	*	*	0	1,2	ND	0	±500	?	34
Bahía Ohuira (nr. Lazaro Cardenas), SIN	25 36.1	108 59.0	50	MM	30/03	*	*	*	50	1,2	ND	0	few	?	35
Bahía Ohuira (nr. Lazaro Cardenas), SIN	25 35.6	108 59.3	0	NO	30/03	*	*	*	0	1	ND	0	few	?	35
Bahía Navachiste (nr. Huitussi), SIN	25 29.5	108 47.5	<100	MM	30/03	*	*	*	90	1,2	ND	0	3,000+	?	36,37
Estero Colorado (outer peninsula island), SIN	25 25.3	108 47.4	2	MM	30/03	*	*	*	2	1	ND	0	*	?	36,37
Estero Island (mouth of Bahía Navachiste), SIN	25 23.3	108 46.7	10	MM	30/03	*	*	*	10	1	ND	?	*	*	36,37, 38
Isla Pájaros ("Leonard's Island", inside Isla Macapule), SIN	25 22.9	108 43.5	1,000+	MM	30/03	15,16	1,500	25/4	1,080*	1,2,6	CD	?	400	<5	39,40
Isla el Mero (N Bahía Santa Maria), SIN	25 05.6	108 15.0	2,000	MM	30/03	17	*	*	1,850	1,2	CD	many	many	<5	41,42
Isla el Saltero (N Bahía Santa Maria), SIN	25 05.1	108 13.9	Present	?	30/03	17	*	*	250	1,2	CD	many	many	<5	41,42
Isla Pájaros (N Bahía Santa Maria), SIN	25 04.8	108 13.9	6,000	MM	30/03	17	*	*	6,950	1,2	CD	many	many	<5	41,42
Isla las Tunitas (N Bahía Santa Maria), SIN	25 04.5	108 13.2	?	?	30/03	17	*	*	90	1,2	CD	many	many	<5	41,42
Isla Talchichilte (mid-east edge), SIN	24 56.2	108 02.6	15	MM	30/03	*	*	*	15	1	ND	?	?	?	
Islas las Tijeras (4 close islands + islets, Ensenada Pabellones), SIN	24 27.4	107 34.0	0	NO	30/03	*	*	*	0	1,2	ND	?	few	?	41,43
Islas la Brasilera (outermost of series in Ensenada Pabellones), SIN	24 24.6	107 31.5	Present	MM	30/03	*	*	*	150	1,2	ND	?	few	<10	44
"Bird Island" (Bahía Tempe-huaya), SIN	24 06.1	107 10.8	0	NO	30/03	*	*	*	0	1	ND	0	210	80	45
SUB-TOTAL--MME									10,540						

NOTES & REMARKS (footnoted from above):

[a, b, d, e, f, g]These footnotes are identical to those from Table 1.

[c]r/s = References and Sources (as numbered):

15—Leonard Montenegro, Jr., Arizona State University, *personal communications*.

16—González-Bernal et al. (2002).

17—Carmona & Danemann (1994).

[g]ADDITIONAL REMARKS FROM THIS COLUMN ("REM"):

34—Although some species of waterbirds (mostly ardeids) commonly nest in two important estuaries to the north (Esteros Tóbari and San José, southern Sonora), there are no known colonies of Brown Pelicans (Palacios & Mellink 1995). On our 2006 survey, this area contained about 5500 loafing Brown Pelicans, approximately 90% immatures.

35—All of the three major islands in Bahía Ohuira, near Topolobompo, Sinaloa had numerous nesting seabirds and ardeids, but few pelicans nesting; there were many hundreds of Brown Pelicans and Magnificent Frigatebirds throughout this bay associated mostly with human activities.

36—At least 10 other islands in Bahía Navachiste could be potential Brown Pelican and other species' nesting sites.

37—Several thousand (estimated at 3000+) BRPE were seen scattered about in this and nearby bays (San Ignacio and Navachiste Bays).

38—Later, DWA recalled Osprey plus Double-crested Cormorant nesting in close proximity with BRPE in mangroves at this location (a very unusual situation), but in the excitement, did not record the pelican nesting (I will trust my memory on this).

39—There are 3 additional, potential Brown Pelican nesting islands in this bay (precise name unknown, just inside Isla Macapule). Isla Pájaros was visited later, on pure co-incidence, by his nephew after DWA learned that he was in the area on vacation and then asked him to visit the island with a local ecotourism guide to obtain some detailed photographs. Mean age of pelican chicks at this location on 25 April (about 3 weeks after our survey) was 6.0 weeks (N = 55 broods tallied from photos). A correction factor of 1.081 was used to obtain final estimate (Fig. 2c).

40—An offshore island in the Topolobampo area, Isla Farallón de San Ignacio (25 26.5, 109 21.9), is not listed here as a potential Brown Pelican nesting site because BRPE has never been reported as nesting there (see review by González-Bernal et al. 2002). This flat-topped island is an important nesting area for other seabird species, however.

41—Carmona and Danemann (1994) report about 1500-2000 Brown Pelican nests as "regular" for this colony in the late-1980s (on 4-5 separate, close islands) and Knoder (1980) also reported 1500 nests at this location in Bahía de Santa María in 1972. DWA (*field notes*) also previously confirmed about the same numbers in several past aerial surveys; yet, our 2006 estimates in Bahía Santa Maria were much higher. To the south about 100 km, and in the 1970s and 1980s, about 5000-6000 Brown Pelican nests were "regular" at Islas los Tijeras in Ensenada Pabellones (DWA, *field notes*); and, Knoder (1980) reported 5000 Brown Pelican nests at this same location in 1971. Yet, there were no Brown Pelicans nesting there in 2006 (but many nesting individuals of other species). The numbers in Bahía Santa Maria were enough to "account-for" the much lower numbers of pelicans seen on our 2006 survey in Ensenada Pabellones.

42--In passing overhead several times to photograph and census at Isla el Mero and Isla Pájaros, only an overall estimate of totals for the main two nesting islands was recorded, as indicated above. Further examination of photographs led us to the conclusion that there had been some undetected pelican nesting on two additional, small islands in this archipeligo. There are about 4 additional islands in the north end of Santa Maria Bay, for example, and another 16 or so in the south, that could support nesting waterbirds.

43—In Ensenada Pabellones, there were many potential islands for Brown Pelican nesting, but few nesting pelicans were found; in addition, very low numbers of Brown Pelicans were seen in this bay, in general. In contrast, large numbers of ardeids, Magnificent Frigatebirds, and two species of cormorants (plus other species such as Wood Stork, *Mycteria Americana,* Roseate Spoonbill, *Ajaia* ajaja, and White Ibis, *Eudocimus albus)* were found nesting on about 5-6 of the many islands. There are at least 17 islands in the south bay and another 25 or more in the mid- and north-bay that could be suitable pelican and waterbird nesting habitat, plus many more small islets. Due to the high numbers of other species nesting in this area, it is possible that we did not detect small numbers of nesting Brown Pelican in some of the areas; but, low numbers of pelicans elsewhere in the bay (and being mostly immatures) indicated that not many breeding pelicans were in this general area in 2006.

44—On the coast south of this last colony in the MME sub-population, amongst several thousand non-breeding pelicans, age-ratios again shifted to dominantly “brown-heads” (immatures)(80-90%).

45—In the 1970s and 1980s, DWA (*field notes*) reported 25-175 Brown Pelican nests near this location in trees. The position given is estimated, as a new channel has been cut to the outer ocean since the earlier surveys, and even the nesting island is now gone, apparently due to erosion or dredging.

APPENDIX 5. Summary of active (2006) and otherwise-known breeding colonies of the California Brown Pelican for the ***Mexican Mainland, Island (MMI) Sub-population***[a].

Site Name	Approx LAT	Approx LONGI	Nests (Air)	STG[b]	Da/Mo	r/s[c]	#Nests	Da/Mo/Yr	#Nests (fin. est.)	Source Final Est[d]	Dis[e]	# not @ Nests[f]	Est Non-YY #[f]	% BH[f]	REM[g]
Isla de Pájaros (Mazatlán), SIN	23 15.3	106 28.6	1000	LL	30/03	18	*	*	850	1,2	PL, CD	150	500	<05	46
Islote en Laguna Caimanero, SIN	23 01.3	106 09.1	0	*	29/03	19	*	*	0	1	ND	*	*	*	47
Isla María Isabelita, NAY	21 50.9	105 53.0	present	LL	29/03	20	150	03/2006	125	6	CD	100	5	<05	48
Isla Juanito (Tres Marías), NAY	21 46.3	106 40.4	*	*	*	21	?	1950s	50?	8	NC	*	*	*	49
Isla María Cleofas (Tres Marías), NAY	21 19.6	106 14.0	*	*	*	21	?	1950s	50?	8	NC	*	*	*	49
Isla la Peña, NAY	21 02.9	105 16.4	*	*	*	22	?	1984, 1985	500	8,9	NC	*	*	*	50
Islas Maríetas (islets), NAY	20 42.5	105 32.7	*	*	*	23		*	25?	8	NC	*	*	*	51
Islas Los Arcos, JAL	20 32.7	105 17.5	*	*	*	24	*	05/2001	70	8,9	NC	*	*	*	52
Islas en Bahía Chamela (3 plus islets), JAL	19 31.8	105 05.4	*	*	*	25	*	*	0?	*	NC	*	*	*	53
Laguna Cuyutlán, COL	18 59.7	104 11.4	*	*	*		*	*	0?	*	NC	*	*	*	53
Punta Tejupan (2 islets), MIC	18 21.0	103 31.0	*	*	*		*	*	0?	*	NC	*	*	*	53
Isla Grande (nr. Punta Ixtapa), GUE	17 40.6	101 39.4	*	*	*	26	*	*	175	8,9	NC	*	*	*	54
Morros el Potosí area, GUE	17 32.0	101 29.3	*	*	*	27	*	*	0	8	NC	*	*	*	53,55
Isla Roqueta (Acapulco), GUE	16 49.3	99 54.6	*	*	*		*	*	0	*	NC	*	*	*	53
Laguna Chacahua (nr. Puerto Angel), OAX	15 59.3	97 34.5	*	*	*	28	*	*	0	9	NC	*	*	*	56
SUB-TOTAL--MMI									1,845						

NOTES & REMARKS (foot-noted from above):

[a, b, d, e, f, g]These footnotes are identical to those from Table 1.

[c]r/s = References and Sources (as numbered):

18—Sarmiento (1994).

19—A local fisherman in the area reported to DWA (*personal communication*, 1975) that about 50 pairs of Brown Pelicans once nested at this location in mangroves.

20—Howell (1975), de la Torre (1988), Velarde et al. (2005), and H. Drummond (*personal communication*).

21—Stager (1957), Grant and Cowen (1964).

22—Knoder et al. (1980) and de la Torre (1986).

23—Lamb (1910), Grant (1964), de la Torre and Peña (1981).

24—de la Torre (1986), Grant (1964), and M. A. Kirkman (*personal communication*).

25—G. G. de la Torre (*personal communication*) to DWA, 5 September 1978.

26—M. A. Melo-García (*personal communication)* to DWA, 1979 and Gaviño et al. (1979).

27—Mellink and Riojas-López (2005).

28—J. E. Mendoza, PROFEPA, and A. Vargas, SEDUE (*personal communications*).

[g]ADDITIONAL REMARKS FROM THIS COLUMN ("REM"):

46--Sarmiento (1994) and Garcia-Guerro (1982) provide additional demographic and behavioral data on this breeding colony; and Sarmiento (1994) compares an El Niño to a non-El Niño year at this nesting colony. Already fledged young-of-the-year were seen in the Mazatlan area in small numbers at the time of our aerial survey, and adult-sized young on nests at Isla Pájaros indicated that fledging had already begun on 30 March; thus our estimate of original nest numbers is tentative.

47— Our aerial survey included this area, but no nesting Brown Pelicans were seen and only 86 loafing Brown Pelicans were found in the immediate area (29% immature), although 690 more were seen in the entire bay (92% immature). This bay is currently characterized by surrounding sand flats and large palm tree plantations; thus, any current nesting is highly unlikely due to heavy land-use changes since our report in 1975 (ref. 19 above), although most of the adult Brown Pelicans were seen loafing at this location.

48—Dr. Hugh Drummond (*personal communication)* reported to DWA that Brown Pelicans nested on Isla Isabelita in 2006 (100-150 nests), but we could not identify numbers of nests from the air (only suspected nests) in the dense tree/shrub vegetation of the island; and, <100 Brown Pelican adults were seen on the entire island. De la Torre (1988) reported that no more than 105 Brown Pelican nests were registered between 1976 and 1984, during detailed seabird studies at this location.

49—There are no published data on the numbers of Brown Pelican nests on the two known locations in the Islas Tres Marías Archipelago, although the presence of breeding Brown Pelicans has been listed there by Wetmore (1945), and for the two islands specifically listed here by Stager (1957). Yet, Grant and Cowan (1964) could not find evidence of Brown Pelican nesting on this archipelago from 1957-1963. Given that Jehl (1974) mentions (based on pelagic observations) that Brown Pelicans in this general region (western Mexico and Central America) are "rare and local", until precise breeding surveys can be conducted, and also given that all known breeding colonies in this region are small compared to those of other sub-populations (compare MMI to GOC, for example), we would not expect large numbers of nests at these locations. We have thus arbitrarily assigned 50 nests to each of the two known locations and state that this is the most obvious "unknown" for the total survey. Accessibility has been problematic at the Islas Tres Marías in the past due to its use as a penal instution, but the islands are now proposed as a Mexican natural reserve (http://en.wikipedia.org) and in coming years, nesting seabird populations will hopefully become better-known.

50—Knoder et al. (1980) reported this site, calling it "Wheeler Ranch Islet", with about 100-600 active tree nests in the 1970s. De la Torre (1986) reported around 600 active nests on Isla Peña in 1984 and 1985.

51—This was a known Brown Pelican breeding site in the early-1900s (Lamb 1910) and Grant (1964) also reported nesting on this archipelago in 1961, but only on the rock stacks surrounding the two larger islands. Thus, there was probably never a large pelican colony at this location and therefore our estimate is minimal and even questionable because de la Torre and Peña (1981) did not report them and only recorded small numbers of non-breeding pelicans.

52—De la Torre (1986) had not seen more than about 70 active nests at this site in the 1980s. M. A. Kirkman (*personal communication,* 23 May 2001, in DWA Field Notes p. 3614*)* while on vacation, provided photos of this nesting colony; from the photos, DWA estimated the number of pairs at 100-150.

53—In a Google Earth computer “flyover”, these sites appeared to be suitable as Brown Pelican nesting islands, but no data confirming nesting is available in the literature. Schaldach (1963) reported the Brown Pelican as a “common breeding resident of the Laguna de Cuyutlán and of the other coastal lagoons of Colima”, but offered no estimates of numbers and only reported small numbers of non-breeders. These and other possible nesting locations south of Mazatlán need to be reconnoitered from a boat.

54—M. A. Melo-Garcia (*personal communication*) conducted a census in April 1979 and reported nests in trees containing eggs and large young; Gaviño et al. (1979) reported 150-190 Brown Pelican nests at this location.

55—Due to its isolation from human disturbance, nearby important Brown Pelican nesting (de la Torre 1986), and abundant other species of nesting seabirds, we consider this to be a potential, albeit sporadic pelican nesting site, although Mellink and Riojas-López (2005) did not report BRPE as a nesting species at this location in 2004, nor could they find any records of it.

56—Two reliable biologists reported to DWA that there were about 50 active Brown Pelican nests in mangroves at this location in the early-1970s (ref. 27, above)(see also text evaluating this colony as a part of *P. o. californicus* versus *P.o. carolinensis)*.

Appendix 6. Estimated 2006 colony-sizes of the double-crested cormorant (DCCO) from the southern limits of the California Current System (south of Punta Eugenia, Baja California Norte, through and including the Gulf of California, but stopping in the south, where DCCO and neotropic cormorants breed together in mangrove estuaries, and cannot be distinguished from an airplane.

Colony Name	North Latitude	West Longitude	# Total N In Colony (aerial)	# Birds at Colony[a]	Ratio[b]	Final Est. of # N	CF[c]	# Indivs. in Vicinity[d]	Remarks/ References
SOUTHERN BAJA-PACIFIC REGION:									
Isla Garzas, BCS	26 55.7	113 09.8	0 (200)[e]	0	n/a	200	0**	215[f]	G. Danemann 2006;[f]Punta Abreojos
Isla Pelícanos, BCS	26 53.7	113 09.1	90	90	±1	90	0**	95	
Near Las Tinajas, BCS (area of Magdalena Bay)	25 35.6	112 04.3	3,640	many	>1	3,640	0**	2,200+	nesting in 3 sub-colonies (290, 1450, and 1900)
Bahía Santo Domingo, BCS (area of Magdalena Bay)	25 31.7	112 04.8	3,900	many	>1	3,900	0**	800+	
Canal Punta Banderitas, BCS (area of Magdalena Bay)	24 56.6	112 07.4	500	many	>1	500	0**	4,400[g]	[g]mixed Brant's CO and DCCO (mostly DCCO)
Isla Pajaros, BCS (area of Magdalena Bay)	24 43.1	112 06.3	0	0	n/a	major roost	n/a	12,500[g,h]	[h]only DCCO were identified
Isla Tijeretas, BCS (area of Magdalena Bay)	24 22.7	111 42.4	800	many	>1	800	0**	150	
GULF OF CALIFORNIA REGION:									
Proximity of Cabo San Lucas and La Paz, BCS	--	--	0	0	n/a	n/a	n/a	125[i]	[i]most in Bahía de La Paz
Isla San Damion, BCS (Gulf of California starts here)	25 35.2	111 07.8	5 (100)[e]	5	±1	105	0**	60	
Isla Pardo, BCS	25 43.8	111 13.5	10	10	±1	10	0**	10	
Isla las Islitas, BCS	25 45.4	111 16.5	2 (20)[e]	2	±1	22	0**	50	

Isla Carmen, BCS	25 58.7	111 07.4	(50)[e]	0	n/a	50	0**	0	followed by a large gap to N
Isla Gemelitos Grande, BCN	28 57.4	113 28.5	60	100	1.7	60		<30	
Isla San Luis, BCN	29 58.0	114 25.3	40	80	2.0	40		few	
Area of mouth of Río Colorado, BCN, SON	31 31.7	114 14.3	0	0	n/a	n/a	0**	2,000+	
Isla San Jorge, SON	31 00.6	113 14.6	?	1,100	3.7	300	0**	see above	E. Mellink 2006
Santo Tomas/Desemboque area, SON	30 38.9	113 03.9	0	0	n/a	0	0**	200	
Punta Tepoca/Tepopa, SON	30 06.3	112 45.3	0	0	n/a	0	0**	555	
Isla Alcatraz, SON	28 48.6	111 58.2	?	<50	?	500	0**	570	J. P. Galvan 2006
So. thru San Augustín, SON	28 16.5	111 24.3	0	0	n/a	0	0**	50	followed by a large gap to S[j]
Estero Tóbari area[j]	27 04.8	110 02.8	0	0	n/a	0	0**	14,600	

TOTAL (South Baja-Pacific) = **9,100** N (none unoccupied in 2006); about 13,650 birds associated with nests[k] + 20,250 away = **33,900** individuals.

TOTAL (Gulf of California) = 1,100 N (170 unoccupied in 2006 = **920** active N); about 1,375 birds associated with nests[k] + 3,525 away = **4,900** individuals.

[a]Number of individuals near and on nests, or very near the breeding colony (includes loafers on nearby beaches); total individuals associated with colony and/or specific location.
[b]Expressed as: no. individuals active in or near breeding colony (previous column) x no. nests^{-1}.
[c]The conversion factor (CF) represents # active nests in colony (NA) seen from the air x ground-truth estimate (marked with *) or simply, the best estimate (aerial or cooperator if nothing else was available) (marked with **).
[d]Approximate number of individual DCCO away from breeding colony approximately to halfway point toward nearest colony, or where numbers distinctly dropped-off going away from or distinctly increased approaching, the nesting colony.
[e]Numbers in parentheses are numbers of empty nests seen.
[j]From this area south, large bays with extensive mangrove estuaries are prevalent along the coast and DCCO numbers again increase substantially, as do numbers of Neotropic Cormorants, where the two species nest in mixed colonies and roost together in large groups. These will be reported separately.
[k]A factor of 1.5 was used to convert number of nests to breeding adults, then counts of birds seen away from the breeding colonies were added to obtain a final population estimate.