OCCURRENCE, MORPHOMETRICS AND PLUMAGE VARIABILITY AMONG LEACH'S STORM-PETRELS *OCEANODROMA LEUCORHOA* IN THE CALIFORNIA CHANNEL ISLANDS, 1976–2015

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SUMMARY

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We mist-netted and examined Leach's Storm-Petrels *Oceanodroma leucorhoa* (LESP) caught during 1991–2015 at three locations in the California Channel Islands (CCI): Prince Island, Santa Barbara-Sutil islands and Scorpion Rock. Although mist-netting methods and effort varied between two study periods (1991–1995, 2004–2007 and 2015), during 750 h effort we captured 41 LESP during April–August, with two of these recaptured after initial banding. The majority (78%) were classified as likely breeders based on a well-developed incubation patch. We summarize island-specific efforts, capture rates and morphological measurements made at these three CCI locations. Captured LESP displayed a multimodal distribution in the overall degree of white rump plumage, with 28% classified as mostly "dark-rumped." The majority of LESP (72%) captured in the CCI have variable white rumps, similar to what has been reported for northern California and the Farallon Islands. However, the relative proportions of "dark-rumped" individuals captured in the northern CCI is intermediate, within the shift starting at the Farallon Islands and increasing in prevalence toward the San Benito Islands, Baja California. More remains to be learned about LESP in the CCI, for which additional mist-netting efforts are needed, using a standardized approach that targets LESP.

Key words: Leach's Storm-Petrel, *Oceanodroma leucorhoa*, phenotypic variation, mist-netting, plumage variability, California Channel Islands

INTRODUCTION

The California Channel Islands (CCI; 33.0–34.0°N, Fig. 1) lie within the southern half of the California Current System (CCS). Breeding has been confirmed in the CCI for three *Oceanodroma* species: Ashy *O. homochroa* (ASSP), Leach's *O. leucorhoa* (LESP) and Black *O. melania* (BLSP) Storm-Petrels (Hunt *et al*. 1979, 1980; Carter *et al*. 1992, 2016a). LESP breeds from the Aleutian Islands and Gulf of Alaska, where it is very abundant, to central Baja California, Mexico (Huntington *et al*. 1996). Within the CCS, approximately 5 500 LESP pairs were once estimated to nest in northern California (as of 1991, Carter *et al.* 1992) and about 700 pairs at the Farallon Islands in central California (hereafter, "Farallones"; Ainley *et al*. 1974, Sowls *et al.* 1980), United States, but numbers have been reduced off northern California in recent decades (fide M. Parker: D. Ainley pers. comm. 10 Feb 2016). In the CCI, LESP are not very abundant (~160 pairs among the northern CCI in 1991; Carter *et al.* 1992), and relatively little is known about birds occurring there. A small population was recently reported in the southern CCI on Santa Catalina and San Clemente islands (Carter *et al*. 2016; H.R. Carter & R.P. Henderson, unpubl. data). South of the CCI, LESP breed at the Coronado Islands (32.4°N) and San Benito Islands (28.3°N), Mexico (>25 000 pairs total for the two sites; Brooke 2004). Two taxa, currently recognized as subspecies, *O. l. socorroensis* and *O. l. cheimomnestes*, breed on islets offshore of Guadalupe Island, Mexico (~29.0°N; Power & Ainley 1986, Howell 2012, T. Birt & V. Friesen, unpubl. data), thought to number <5 000 pairs (Brooke 2004).

Leach's Storm-Petrel in the CCI resides within a phenotypic cline; from Alaska to northern California, only the nominate form of *O. leucorhoa* occurs (i.e. birds are larger and have variable white rumps). At the south end of the range (San Benito Islands), *O. l. chapmani* are smaller and have completely dark rumps (Ainley 1980, Power & Ainley 1986, Huntington *et al*. 1996, Pyle 2008, Howell 2012, T. Birt & V. Friesen, unpubl. data). Ainley (1980) first suggested a major transition in this cline occurs among LESP that reside within the CCI, but to date this possibility has remained unconfirmed owing to little field work and very few specimens. We therefore summarize published (Ainley 1980) and unpublished (Hunt *et al*. 1979, 1980) observations regarding LESP in the CCI since 1976 and report results from our mist-netting efforts, carried out between 1991–1995 (HRC, GJM and DLW) and 2004–2007 and 2015 (JA). Combined results elucidate morphological and phenotypic variation among LESP in the CCI.

STUDY AREA AND METHODS

Prince Island (PI; 34°05′N, 120°20′W; 16 ha, 90 m elevation; Fig. 1), located 2 km north of San Miguel Island, is a steep-sided

island flanked with loose, unconsolidated soils, boulders and many rocky crevices. PI is the westernmost of the study locations. Carter *et al*. (1992) estimated 114 breeding LESPs at PI in 1991. In various years, mist-nets were located on the southeast side of the island, which is accessible without disturbing other breeding seabirds. In 1976–1977, Hunt *et al.* 1979 used an "auklet" net located below the main *Opuntia* patch and a "petrel" net was located above the *Opuntia* patch at the base of the cliff at the top of the slope (see map in Hunt *et al.* 1979: III-31). In 1991–1995, two net locations were used by Carter *et al.*: site #1 (net 9.1 m wide) was near or at the same location as the "auklet" net in 1976–1977, and site #2 (net 5.5 m wide) was on a rock ledge below and east of the auklet net (see map in Carter *et al.* 1992: I-249; Appendix 1, available on the website). In 2004–2007 and 2015, Adams placed a net (Adams's site #1, 12.1 m wide) in the rocks above the supertidal area ~7 m below Carter *et al*.'s site #2 (described above; Appendix 1).

Santa Barbara Island (SBI; 33°28′N, 119°02′W; 260 ha, 193 m elevation; Fig. 1), located 80 km southeast of Santa Cruz Island (SCI), is bounded by steep cliffs, especially along the west- and north-facing perimeter. Sutil Island (SI; 5 ha), located 600 m southwest of SBI, is a small, steep islet, composed of volcanic rock mixed with marine sediments. Carter *et al*. (1992) estimated 204 breeding LESPs combined at SBI (n = 167) and SI (n = 37) in 1991. Carter *et al.* located mist-nets in various locations on both SBI and SI. In 1976, Hunt *et al.* (1979) used a net placed on the cobble beach on the south side of SI (site #16 in Carter *et al.* 1992); in 1977 Hunt *et al.* (1979) placed nets at various undescribed locations around SBI. In 1991, Carter *et al.* used nets placed at 14 locations around SBI and at two locations at SI (see map in Carter *et al.* 1992: I-36; Appendix 1). In 2004–2005, Adams placed nets at SBI at sites #2 (Elephant Seal Point) and #5 (Arch Point; see map in Carter *et al.* 1992: I-36; Appendix 1).

Scorpion Rocks (34°05′N, 119°30′W, <1 ha, 15 m elevation) consist of two small islets (Scorpion Rock [SR] and Little Scorpion Rock) and two small rock pinnacles located <200 m off the northeast end of SCI (Fig. 1). The two islets provide nesting habitat for LESP, but the species has not been observed breeding here. SR is saddle-shaped and slopes upward from the southeast to a high point above cliff-edges along the west to northwest sides. Portions of the southern slope, the top and middle portion of SR have a substantial layer of loamy, ornithogenic soil where invasive plants, dominated by crystalline ice plant *Mesembryanthemum crystallinum*, have been replaced since 2007 with a diverse, native plant assemblage (Adams *et al*. 2014). At SR, Hunt *et al.* (1979) placed a net at an undescribed location in 1976. In 1991–1995, Carter *et al.* placed one or two mist-nets near the highest, western point of the island (Carter *et al.* 1992, unpubl. data; Appendix 1). In 2004–2007, Adams oriented a net east-west near the western end along the south side of the island ~20 m east from the 1991–1995 site.

During 2004–2007 and 2015, at the three locations described above, one of us (JA) together with teams of two to three biologists captured storm-petrels throughout all or a large portion of the night between April and September; birds were attracted to mist-nets by broadcasting ASSP vocalizations, which was the species being targeted for study. Teams used a Lohman Predator Master 2560, 15W CD player with a horn loudspeaker (Saint 12V DC, 8Ω, 20W, 10 cm diameter × 10 cm long) to broadcast ASSP vocalizations continuously at ~100 dB from the ground below the middle of the mist-nets (Avinet: 12 m wide, 2.6 m high, 4 shelves, 75/2 denier polyester, 38 mm mesh; see Adams 2016). Capture methods used by three of us (HRC, GJM and DLW) in 1991–1995 were similar to those used by Adams in 2004–2007 and 2015, except that different sizes of nets were used (9.1 m wide × 2.1 m high or 5.5 m wide × 2.1 m high) and storm-petrel vocalizations were broadcast continuously at a lower, unmeasured volume using a portable cassette player. In 1991, most capture methods were the same as in 1994 and 1995, but, in an attempt to ensure detection and capture of all three species, HRC, GJM and DLW broadcast vocalizations of LESP, ASSP, BLSP, or no vocalizations for varying periods of time for different periods during the night (Carter *et al.* 1992). On some nights at SBI in 1991, vocalizations of two storm-petrel species were broadcast simultaneously from two cassette players. Although the time of night in 1991 when LESP vocalizations were broadcast was not standardized, HRC, GJM and DLW typically broadcast LESP vocalizations for relatively short periods of an hour or less after midnight because (1) LESP were considered to arrive later at colonies than ASSP (Harris 1974, Ainley *et al*. 1990) or BLSP; and (2) LESP vocalizations were opportunistically initiated for an hour or less when biologists heard LESP vocalizing near the net, usually in response to ASSP vocalizations.

Most effort was focused on ASSP and BLSP at SBI in 1991, as LESP had not been known to occur there until that year (Hunt *et al.* 1979, Carter *et al.* 1992). At PI, HRC, GJM and DLW focused mainly on ASSP and to a lesser degree on LESP in 1991 because only a few LESP had been captured there in 1976–1977 by Hunt *et al.* (1979). In 1976–1977, mist-net equipment and methods were not

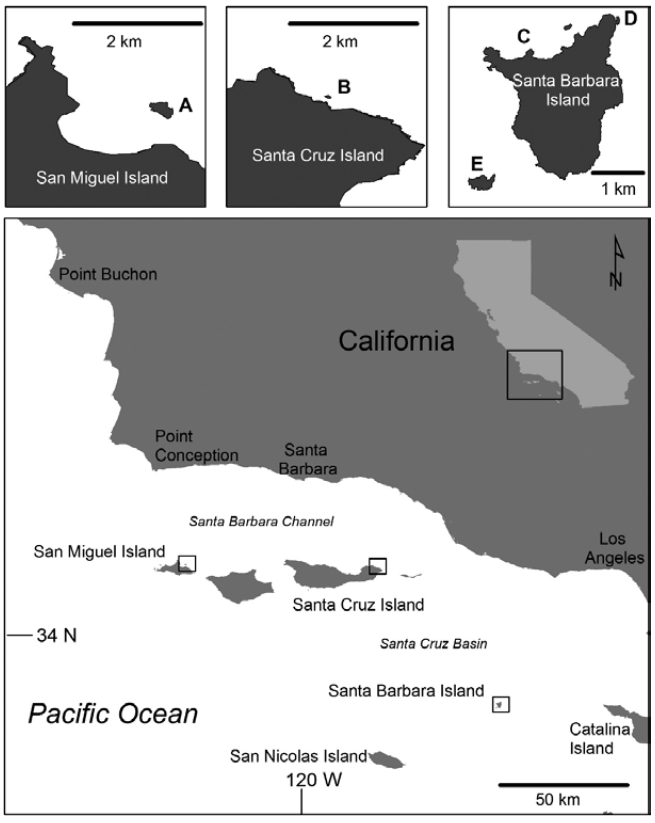

Fig. 1: California Channel Islands study area depicting locations of Prince Island (PI) off San Miguel Island, Scorpion Rocks (SR) off Santa Cruz Island, and Santa Barbara Island (SBI). Leach's Storm-Petrel mist-netting sites are shown for PI (A), SR (B) and SBI (Elephant Seal Point [C], Arch Point [D] and Sutil Island [E]).

described (Hunt *et al.* 1979) but appeared to be similar to those used in 1991–1995, except that netting usually occurred from dusk to about midnight, and only LESP vocalizations were broadcast from a cassette player (S.M. Speich, unpubl. field notes). To determine preliminary capture rates in 1991–1995 and 2004–2007 and 2015, we determined numbers of individuals caught during all hours of netting and did not exclude short periods before or after complete darkness or before any storm-petrels had arrived at the colony; we also did not account for differences in net size or broadcast equipment. Therefore, capture rates reported in this paper must be considered with discretion.

TABLE 1
Mist-netting effort and captures of Leach's Storm-Petrels (n = 48; LESP, includes recaptures) during 1976–2015 at Prince Island (PI), Santa Barbara-Sutil islands (SBI) and Scorpion Rock (SR)

Year	Island	VB[a]	Net nights (total)[b]	No. LESP captured	VB Time (h)	LESP CPUE[c]
1976	PI	LESP	4	3	–	–
	SBI	LESP	2	0	–	–
1977	PI	LESP	8	3	–	–
	SBI	LESP	18	0	–	–
1991	PI	ASSP	11	3	42.45	0.07
	PI	LESP	10	4	10.75	0.37
	SBI	ASSP	35	5	111.30	0.04
	SBI	LESP	16	7	13.12	0.53
	SR	ASSP	2	0	22.18	0.00
	SR	LESP	1	0	0.42	0.00
1994	PI	ASSP	19	5	119.27	0.04
	PI	LESP	5	2	3.87	0.52
	SBI	ASSP	1	0	3.00	0.00
	SR	ASSP	1	0	8.22	0.00
1995	PI	ASSP	2	0	12.42	0.00
2004	SBI	ASSP	9	1	42.40	0.02
	SR	ASSP	9	1	36.12	0.03
2005	PI	ASSP	7	6	30.25	0.20
	SBI	ASSP	6	3	35.12	0.09
	SR	ASSP	6	1	28.57	0.04
2006	SR	ASSP	8	0	35.32	0.00
2007	PI	ASSP	1	2	4.00	0.50
2015	PI	ASSP	12	2	63.65	0.03

[a] Vocal broadcast (VB) tabulated for netting sessions that used ASSP or LESP calls.

[b] Number of nights with ASSP or LESP vocalizations broadcast for all or portions of each night; excludes nights without broadcasting.

[c] Catch-per-unit-effort (CPUE, number captured per hour) is based on non-standardized effort during variable periods throughout the night. No LESP were captured during periods with broadcasted BLSP vocalizations, mixed species vocalizations, or silent periods.

In 2004–2007 and 2015, Adams used Vernier calipers (± 0.05 mm) to measure bill length (exposed culmen; tip to feather insertion), skull length (culmen tip to posterior perietal), and tibiotarsal length (diagonal, cnemial crest to condyle). Mass was determined using a 100 g Pesola spring scale [± 1.0 g]), and maximum flattened outer-wing length was recorded by fully extending the tips of the primaries after flattening them along the stopped wing ruler (± 1.0 mm). Tail length (± 1.0 mm) was measured to the longest outer rectrix by inserting a ruler between the inner rectrices to the uropygium. In 1991–1995, HRC, GJM and DLW took the same measurements with similar equipment, excluding skull length and including outer-wing length (i.e. measured without fully extending the tips of the primaries after flattening them against the ruler). In 1976–1977, wing length, tail length, culmen, bill depth and tarsus were recorded for some individuals without details (S.M. Speich, unpubl. field notes). Before pooling data, we tested for differences in tarsus, culmen and wing between 1991–1995 and 2004–2007 and 2015, but insufficient data were available from 1976–1977.

To evaluate rump color among LESP, the degree of white feathering in 1991–1995, 2004–2007 and 2015, were scored according to Ainley (1980, see also Howell *et al*. [2012]) from 1 (all white) to 11 (all dark); if the rump score in 1991–1995 ended in 0.5, it was rounded up for analysis. Determining breeding status from incubation patch (IP) development among storm-petrels is problematic because they can have a partly developed IP well before the egg is laid, or even without an egg (Ainley *et al*. 1974, 1990, Warham 1996, Rayner *et al*. 2013). In 1991–1995, 2004–2007 and 2015, IP was scored from 0 (all downy) to 5 (fully refeathered) (Carter *et al*. 1992, Adams 2016). After 1 May, we considered birds with scores of 2 or greater (i.e. completely bare or refeathering) to be "likely breeders" and scores of 0–1 (i.e. no patch evident or only partly defeathered) to be "unknown," i.e. either subadults or breeders before they developed a fully developed IP (Carter *et al*. 1992). In the Hunt *et al.* 1976–1977 study, IP was scored from 1 to 6, with 6 representing a lack of an IP (S.M. Speich, unpubl. field notes), but details of other scores are not available; we assumed scores represented similar stages of IP development as in 1991–1995, 2004–2007 and 2015.

RESULTS

Among the first LESP documented at Prince Island (PI) off San Miguel Island in 1976–1977 were six birds captured in mist-nets; at least two captured on 23 June 1976 did not have incubation patches, but breeding was suspected (Hunt *et al.* 1979, 1980; S.M. Speich, unpubl. field notes [archived at the Bureau of Ocean Energy Management, Camarillo, CA], Appendix 1). In addition, one was captured at Santa Barbara Island in 1978 (Hunt *et al.* 1980). Owing to a lack of effort, no other LESP were captured at colonies in the CCI before 1991.

Mist-netting effort in 1991–2015 totaled 749.6 h (303.6 h at PI, 314.1 h at SBI and 131.9 h at SR) during which time we captured 41 individual LESP (Appendices 1 & 2). At PI, we captured 24: 18 during ASSP vocalizations (272.0 h), six during LESP vocalizations (14.6 h) and none during BLSP vocalizations (9.2 h) or during silent periods (7.8 h). At SBI, we captured 15: eight during ASSP vocalizations (191.8 h), seven during LESP vocalizations (13.1 h) and none during BLSP vocalizations (85.7 h), combination vocalizations (12.0 h) or silent periods (11.5 h; Table 1). At SR, we captured two during ASSP vocalizations (130.4 h) and none during briefly broadcast LESP vocalizations (0.4 h) or silent periods (1.1 h; Table 1).

Insufficient information was available in 1976–1977 to describe netting effort, but six individual LESP were captured at PI during 12 net nights for those two years (Table 1). LESP capture rates at PI in 1991 were an order of magnitude greater when targeting LESP with their vocalizations (0.37/h versus 0.07/h with ASSP vocalizations); a similar difference also was noted at SBI (0.53/h with LESP vocalizations versus 0.04/h with ASSP vocalizations; Table 1). Fewer LESP individuals captured at PI (and none at SBI) in 1976–1977 compared with 1991 likely resulted from netting efforts carried out mainly before midnight in 1976–1977. During more complete nighttime efforts during 1991–2015, LESP were captured most often after 23h00 (93% of captures; n = 41). All 12 LESP captured at SBI in 1991 were captured after midnight. In 1991, 25% of LESP (n = 12) captured at SBI-SI were captured at SI; netting occurred at SI on only two nights in 1976 and not at all in 1977, likely contributing to few captures at SI in 1976–1977. During 2004–2007 and 2015, when ASSP vocalizations were used and effort was standardized to time of local sunset (see Adams 2016), captures of LESP initiated 2.7 h after sunset, but usually occurred closer to midnight (average = 4.4 ± 1.2 SD h after sunset, n = 16). Time of year of netting efforts at SBI in 1977 and 1991 were similar. In 1991, mist-net effort with LESP vocalizations at SBI occurred on 10 net nights and LESP were captured during May (n = 5 at two net sites) and July (n = 4 at four net sites). In 1977, 18 net nights were conducted between 28 May and 8 July at several locations around the island.

Fig. 2: Dark-rumped Leach's Storm-Petrels (LESP) and Ashy Storm-Petrels (ASSP) captured in mist-nets in the California Channel Islands: (A & B) LESP captured 16 August 2004 at Santa Barbara-Sutil islands (SBI) (rump score = 9), showing brownish underwing coloration; (C & D) LESP captured 18 August 2004 at SBI (rump score = 9), showing brownish underwing coloration; (E) LESP above and ASSP below captured 16 August 2004 at SBI, showing differences in bill shape and more posterior, longer and more pronounced gape in LESP; (F) LESP on left and ASSP on right, showing differences in bill morphology and more posterior extent of gape in LESP.

There were no differences in measurements among individuals for those captured during 1991–1995 versus 2004–2007 and 2015, and values were combined for summary statistics (mean ± SD; Appendix 1): mass ($F_{1,39}$ = 0.128, P = 0.722; 35.7 ± 5.3 g, n = 41), culmen ($F_{1,30}$ = 0.349, P = 0.515; 15.1 ± 0.7 mm, n = 32), or tarsus ($F_{1,30}$ = 0.285, P = 0.598; 22.4 ± 1.6 mm, n = 32). Tail length was most frequently measured in 1991–1995 (77.0 ± 6.0, n = 29). Wing length was measured differently in 1991–1995 (see Methods; flattened outer wing; 146.2 ± 5.9 mm, n = 26) than in 2004–2007 and 2015 (maximum flattened outer wing; 150.3 ± 5.7 mm, n = 15). Although only whitish-rumped LESP were reported for six LESP captured at PI in 1976–1977 (Hunt *et al.* 1979), almost the entire range of rump variation was noted in the larger sample in 1991–2015 (i.e. from completely "light-rumped" (rump score = 1) to completely "dark-rumped" (rump score = 11), although no individuals with scores of 7 or 8 were captured (Fig. 4A).

During late-night mist-netting sessions, using artificial light from head lamps, we found it difficult to distinguish ASSP from dark-rumped LESP, but took care to carefully evaluate each individual. Dark-rumped LESP often had darker, brownish head plumage, with all brownish underwings, compared with ASSP (Fig. 2B,C). However, dark-rumped LESP from the San Benito Islands often have darker gray or blackish head plumage compared with lighter gray head plumage for LESP at the Coronado Islands and at Santa Catalina Island (Carter *et al.* 2016), with the latter more closely resembling ASSP (Pyle 2008). We found that the best plumage color characteristic for separating dark-rumped LESP from ASSP is the silvery wing lining in ASSP versus the brownish one in LESP (Fig. 2B,C). Bill size and shape also appear slightly different between ASSP and LESP (no measurements available). LESP have a "heavier" bill with (a) slightly greater bill depth; (b) straighter, perhaps narrower, culmen; and (c) gape that extends further posterior than in ASSP (Fig. 2E,F).

Ainley (1980) and Power & Ainley (1986) reported two LESP specimens from the San Miguel Island area: SDNMH 39942 (Fig. 3) from PI in 1976 (rump score = 4) and USNM 544522 (Castle Rock; 14 May 1968; rump score = 10). USNM 544522 was later re-identified as an ASSP (see Carter *et al.* 2016a), and

Fig. 3: Leach's Storm-Petrel (SDNHM #39942) captured by R.L. Pitman and S.M. Speich on 23 June 1976 at Prince Island, California. Photo by P. Unitt and A. Tremor.

we excluded it from our evaluation of rump scores. Based on 1991–2015 CCI captures and SDNMH 39942, the proportion of rump color scores was multimodal, with modes at 2, 4, and 9; the dominant mode reflected mostly light-rumped individuals (average rump score = 5.1 ± 3.3 SD, n = 40; Fig. 4A). Most (78%) LESP captured had IP scores of 2–4, indicative of "likely breeders" (Fig. 4B). Of 41 LESP captured, only one individual LESP (#1401-61300) captured at PI on 12 July 1994 (IP = 4) was noted to have regurgitated.

DISCUSSION

With greater capture effort, and by combining individuals examined by us and other researchers during 1976–2015, we obtained a larger sample size to characterize LESP occurrence, morphology and plumage variability in the northern CCI than was previously available (i.e. Ainley 1980). This information provides valuable baseline data for evaluating past and future long-term patterns of LESP occurrence in the CCI and useful information to consider before improving methods and effort for measuring and interpreting any population trends. Given the substantial amount of mist-netting effort expended throughout nights during the sampling periods 1991–2015, LESP were infrequently captured in the CCI (Table 1). In previous studies, none were captured at SR or at other mist-net locations on Santa Cruz Island in 1991–1996 (Carter *et al.* 1992; H.R. Carter, unpubl. data) or at Anacapa Island in 1994 (H.R. Carter & D.L. Whitworth unpubl. data) and 2011–2012 (Harvey *et al*. 2016). At San Clemente Island, none were captured in 1994, but three were captured in 2014–2015 (H.R. Carter & R.P. Henderson unpubl. data); on the basis of nest-searches rather than mist-netting, LESP are now also known to occur at Santa Catalina Island (Carter *et al*. 2016). Hunt *et al.* (1979) mentioned that one individual ASSP captured in 1976–1977 may have been a LESP, based on its larger size and whitish bases of retrices, but this rough description could also fit an ASSP in fresh plumage (see Pyle 2008). Hunt *et al.* (1980) later reported that at least one LESP was captured at SBI in 1978, documenting presence at SBI in the 1970s. LESP likely occurred at SBI in 1976–1977 but simply were not documented (see Carter *et al.* 1992). The consistent presence of LESP at PI and SBI-SI during each year of mist-netting in 1991–2015 indicates that LESP likely breed at these islands. The capture of only two individuals at SR (2004, 2005) versus none in 1991, 1994 and 1995 may indicate that prospecting or transiting individuals along the Santa Cruz Island coastline were attracted to mist-nets with broadcasted ASSP vocalizations or head lamps (see McIver *et al.* 2016). Moreover, only two banded individuals have been recaptured: one banded at PI in 1976 was recaptured at the same net site a month later (Hunt *et al.* 1979; S.M. Speich, unpubl. field notes) and one banded on 1 June 2005 at PI was recaptured 9 July 2005 on SBI (Appendix 2, available on the website). It is not known if the rarity of LESP recaptures in the CCI is related to insufficient netting hours with broadcast of LESP vocalizations, recapture avoidance, differing patterns of nest attendance (i.e. compared with ASSP), or colony attendance without breeding (i.e. prospecting by non-breeders).

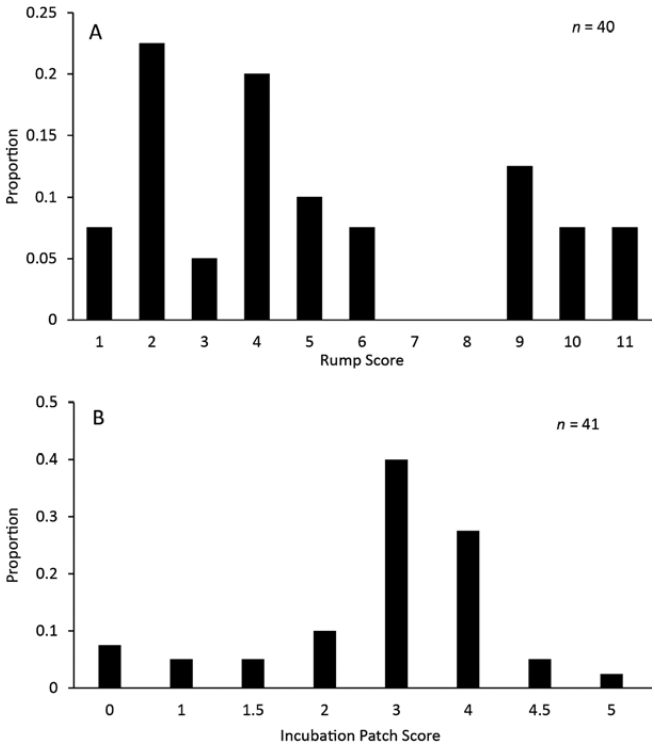

Fig. 4: (A) Rump scores of Leach's Storm-Petrels captured at Prince Island, Santa Barbara-Sutil islands and Scorpion Rock during 1976–2015 (after Ainley 1980). (B) Incubation patch scores of Leach's Storm-Petrels. See Appendix 1 (available on the website) and text for details.

The range of rump scores observed for the northern CCI (Fig. 4A) is similar to that at the Farallones (e.g. modes at rump score = 4), but a greater proportion (28%) in the northern CCI had mostly dark rumps (i.e. rump score ≥ 9; see Fig. 2 in Ainley 1980) compared with the proportion of LESP in the Farallones (6%; see Fig. 2 in Ainley 1980). Our results provide missing information and added support for Ainley's (1980) and Power & Ainley's (1986) observations of an equatorward shift in rump color proportions, from only a few dark-rumped individuals at the Farallones to almost all dark-rumped individuals at the San Benito Islands. Most of the shift appears to occur within the CCI. Mostly light-rumped LESP occur within the northern CCI (72%) as far south as SBI-SI, and mostly dark-rumped LESP occur as far north as the Coronado Islands, Mexico. More data off California for the southern CCI are being collected at Santa Catalina and San Clemente islands to better evaluate LESP at these islands; these data should help us better understand population variability within this biogeographical boundary zone (Carter & Henderson, unpubl. data; 2015, Carter & T.M. Dvorak, unpubl. data).

We have yet to find a LESP nest in the CCI to the north of Santa Catalina Island. Although it is impossible to prove breeding at any island of capture solely using IP scores, most (78%) LESP captured had IP scores of 2–4, indicative of "likely breeders" (Fig. 3B, Carter *et al*. 1992, Rayner *et al*. 2013, Adams 2016). However, unlike many ASSP captured in the CCI, only one individual LESP (#1401-61300) captured at PI on 12 July 1994 (IP = 4) was noted to have regurgitated upon capture, perhaps indicating chick provisioning at PI.

More standardized mist-netting effort targeting LESP at PI and SBI (see Adams 2016 for standardization of ASSP capture) would better determine capture rates per night. Our failure to find LESP nests at PI and SBI likely results from their use of largely, if not entirely, inaccessible habitats, coupled with the difficulty of visually distinguishing LESP from ASSP in many accessible nests, and the need to avoid disturbance to other seabirds and wildlife.

Autonomous digital acoustic recorders for detecting presence and measuring trends for storm-petrel attendance have recently been implemented, but acoustic techniques do not provide information on numbers of individuals, plumage, measurements or rump and IP scores that can be obtained by evaluating individuals captured in mist-nets. A combination of research efforts will be required to further elucidate the status of LESP in the CCI, but with our results we now have insights to better direct that effort.

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