Wedge-tailed Shearwater (*Puffinus pacificus*) Adult Attendance and Morphometrics at Mañagaha Island, Commonwealth of the Northern Marianas, 2003 - 2008

Final Report
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by
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Photo: Adult Wedge-tailed Shearwater on Mañagaha in 2008

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Anecdotal reports of nesting seabirds on Mañagaha Island were confirmed when a small colony of Wedge-tailed Shearwaters (*Puffinus pacificus*) was discovered in February 1999. These birds nest in the sandy soil and under half buried WWII installations of the 4 ha islet, which is situated within the fringing reef of the lagoon on the western side of Saipan, the capital of the Commonwealth of the Northern Mariana Islands (CNMI). The island (15º N latitude and 146º E longitude) is a favored tourist destination with 650,535 visitors reported between December 2003 and December 2005.

Since 1999, timing of the breeding period and threats to the colony have been determined. A group of concerned volunteers, biologists, and representatives from the tourism industry have worked together to reduce colony disturbance (Fig. 1) , monitor nest histories, collect morphological and growth data, and band adults and chicks (Hawley *et. al.* 2006). Additional work has been done to tag birds for long-distance data retrieval to help assess the bird's life history characteristics, foraging range, and migratory routes. In this report, we (1) detail the colony monitoring and bird measurement protocols, (2) document adult attendance dates at the colony from 2003 through 2008, (3) present a summary of the adult morphological data collected to date, and (4) compare adult measurements with those published for other members of the same seabird order, the Procelliiformes. The banding data will eventually allow us to estimate survival and productivity as well as the size of the Mañagaha population. It may also assist in determining dispersal and migration patterns.

Figure 1. Measures to reduce disturbance in the nesting colony on Mañagaha, including signage, fencing, and re-routing the tourist pathways on the island were completed with the assistance of the tourist industry and local school children.

MATERIALS AND METHODS

Monitoring Protocols

From 2003 to 2008, monitoring of the Mañagaha Wedge-tailed Shearwater colony began during the early breeding season and continued through the nesting season until chicks fledged. Monitoring of the breeding adults began in May 2003, but was initiated earlier in each succeeding year to better verify the full range of the breeding season. By 2009, we had documented breeding adults on Mañagaha as early as April 15 (earlier dates continue to be possible), with some breeders not returning until late May. Nesting commenced when the first eggs were laid in early June (see Table 2 for exact dates); egg-laying continued into early July. Hatching began in late July and continued to late August. Chicks that hatched early in the season fledged by mid-November and fledging continued until late December. Adult attendance at the colony diminished as the season progressed, with many failed breeders and non-breeders leaving the island well before chick provisioning ended. Adults generally finished rearing chicks and left the colony for the season by mid-November.

Figure 2. Adult Wedge-tailed Shearwaters outside of a nest burrow dug underneath a Word War II bunker on Mañagaha Island.

During the breeding season, several night field excursions were arranged with the CNMI Division of Fish and Wildlife (CNMI-DFW) Conservation Officers who transported the shearwater team and volunteers to Mañagaha Island in the late afternoon and retrieved them between 10 pm and 11 pm. During this time, adult birds that had landed and were above ground were captured (Fig. 2), and an aluminum U.S. Fish and Wildlife Service band was attached to the tarsus of all unbanded birds. All adults were weighed and the culmen, tarsus, wing, and tail of a sub-sample of birds were measured.

Upon completion of these measurements, a mark (*tika*) was applied to the crown using commercially available whiteout and the birds were released (Fig. 3). Application of the *tika* prevented unnecessary recapture.

Figure 3. Applying a *tika* to the head of an adult shearwater at the Mañagaha colony.

Weekly monitoring of Wedge-tailed Shearwater nests began with the egg-laying season. At that time, nests were checked by hand or with a probing stick for the presence or absence of nesting birds and eggs (Fig. 4). To prevent injury to the bird or egg, probing was a gentle process. Nests were probed by slowly waving the stick back and forth beginning at the entrance and carefully proceeding to the back of the nest. Generally, an adult bird would react defensively by pecking the stick. Birds were then retrieved by gently, but firmly, grasping the culmen and pulling the bird out of the nest. Because many of the nests were built in areas with roots - which lend structure to the nest and prevent intruder entrance - great care was exercised to extract the bird around the roots without damage to the wing. Some burrows were so deep that the bird was beyond reach of the longest stick and no matter what amount of gentle coaxing was applied, the birds would not move forward and so remained unreachable.

Once extracted, the number on the band of previously marked birds was recorded, or if unmarked, a band was attached. While keeping hold of the adult, the nest was gently probed for the presence of an egg. The adult was returned and the nest number

assigned in previous years was recorded. Early in the season, new nests were assigned a temporary number that was either reconciled with previous nest numbers or assigned a new permanent number (Fig. 5).

Figure 4. Nest occupancy was determined by gently probing the nest manually, or for longer nests, very carefully with the aide of a stick.

Figure 5. Wedge-tailed Shearwater nesting burrow on Mañagaha Island identified with a small flag.

Determining the band number of nesting adults was an important way of identifying individuals so that nest philopatry and partner fidelity could be determined. Accordingly, band numbers, listed by nest number, were recorded each week. Weekly lists were compared to determine if both partners had been identified. Once paired partners and the presence of an egg were verified, it was no longer necessary to extract the adults and the nests were checked only for occupancy. Occasionally, more than two adults were noted in a particular nest, but generally, only one adult was found incubating the egg during diurnal checks. We recorded the occupants of each nest weekly, and if the nest was unsuccessful, we noted the cause of failure if it could be determined.

At the close of the incubation period, newly hatched chicks were often accompanied by adults for several days. After a short brooding period, adults were commonly not in attendance at the nest during the day, but returned periodically at night to feed the chick. During the chick provisioning period, we took standard measurements weekly of a sub-sample of chicks that could be extracted from the nest safely. Chicks remained in the nest for nearly four months, maturing slowly and growing from downy 60 g fluff balls to nearly 500 g downy young around their third month of life (Fig. 6). By mid-October, when chicks were about 12 - 14 weeks old, the chick's tarsus had reached its maximum length. At this time adult plumage feathers had emerged, and down was greatly decreased except for remnant patches. Also, chicks that were previously unreachable tended to move closer to the nest entrance and could be extracted, so chicks were often banded during this period. Banding continued over the next few weeks, depending on the state of chick development.

Figure 6. Left (A.): recently hatched Wedge-tailed Shearwater chick. Right (B.): maturing chick close to the age when it was banded.

Morphological Measurement Protocols

Five measurements, including mass, and length of exposed culmen, length of tibio-tarsus, wing chord and tail length, were taken of a sample of adults and all reachable chicks (Figure 7). Mass (weight) was obtained for young chicks using a Pesola® 300 gm (± 1 gm) scale. Older chicks and adults were weighed using Pesola® 500 gm (± 10 gm)

or 1,000 gm (± 10 gm) scales. The Pesola scales were tared for the weight of the mesh, Avinet®, bird bag. A digital Fowler Sylvac® sliding caliper was used to obtain measurements of the culmen and tarsus. Wing and tail measurements were acquired using a stopped wing gauge, graduated in millimeters (mm). Measurements followed standard protocols established for birds (Pyle 1997).

Figure 7. Adult shearwater being weighed at the Mañagaha colony in 2008.

Length of the exposed culmen was measured by placing one end of the caliper at the distal end of the culmen (tip of the beak) and the other end of the caliper at the base of the feathers. Great care was used with the calipers as the ends were very sharp. To limit damage to the bird's eyes and head, the bird was grasped lightly but firmly around the neck so the culmen rested in the cradle between the recorder's thumb and forefinger. To determine the length of the tarsus, the foot was bent at 90 degrees to the tarsus shaft and the length of the tibio-tarsus from the inter-tarsal joint to the distal end of the last leg scale was recorded.

Wing measurements were taken by sliding a stopped wing gauge under the wing to the first carpal. The carpal was held firmly against the stop and very gentle pressure was applied to the covert feathers to flatten the wing. The distance between the first

carpal and the tip of the longest primary feather was recorded for the wing length. Tail length was measured from the origin of the longest retrix to its distal end.

Geolocation Project Measurement Protocols

In addition to the measurements listed above, an expanded protocol was required to conform with other studies when Lotek® archival tags were attached to adults to determine adult provisioning and post-breeding migration behavior. The description of these measurements follows the explanation and sketches provided by Scott Shaffer, Ph.D. (May 9, 2007 pers. comm). We recorded additional measures of bill (culmen) depth at its narrowest and widest portions, maximum body girth, head plus bill length, wing span, and wing trace.

Figure 8. Additional morphological measures were taken in 2007, including the adult's maximum body girth, as above.

Bill depths were measured at a right angle to the culmen at the narrowest part (at approximately half of the bill length), and at the widest part (near the termination of the lower culmen and the bend of the upper culmen). Maximum body girth was measured with a cloth tape under the wing and around the widest part of the lower breast/upper belly (Fig. 8). Head plus bill length was measured with a caliper from the back of the

head to the tip of the culmen. The wing span was measured from the vertebrae (spine) to the wing tip by stretching the wing out on a flat surface at a right angle to the body. A wing trace was made of the fully stretched wing as it was held gently yet firmly on a flat board (Fig. 9).

Figure 9. Taking a wing trace of a wedge-tailed's outstretched wing.

Data Entry

Upon completion of data collection, all observations were entered into a Microsoft Excel spreadsheet. We coded observations by nest number, consecutive day, and date (week) of observation. Observations were stored in separate data files for nest histories (nest status), adult morphometrics, and chick growth. For nest status, all banded adults were noted according to nest, and each week data were entered on the line corresponding to the adult band number. Notes on behavior, nest fate, bird condition, and other observations were added as "comments" (an option under the "View" menu selection in Excel) each week. Digital and hard copies of the data, as well as field notes and data sheets, were stored at CNMI-DFW with an additional copy maintained by the Conservation Team. Table 1 contains explanations of codes used to classify data in the Excel files.

Table 1. Explanations of codes used in data files detailing the nest and chick growth histories of Wedge-tailed Shearwaters at the Mañagaha colony from 2003 to 2008.

Code	Explanation
AOE	Adult on egg
AON	Adult on nest
UAOE	Unknown adult on egg
UAON	Unknown adult on nest
Yellow highlight	Nest monitored but no egg detected
Red highlight	Nest with failed egg
Gray highlight	Nest with dead chick
Green highlight	Nest with successfully fledged chick
Tftr	Too far to reach

RESULTS

On Mañagaha, the courtship season began in April and continued through May (Table 2). A pre-laying hiatus occurred between late May and mid-June which, as described for *P. pacificus* nesting colonies on Rottnest Island in Western Australia (Bancroft *et. al.* 2006), allowed the adults to build up energy reserves. Weekly monitoring indicated that egg-laying commenced as early as mid-June and peaked between late June and early July with both parents taking incubation turns, as is common in other Procillariformes. Chicks began hatching in late July and hatching peaked in August. Fledging occurred after 15 to 16 weeks with most young-of-the-year departing from November through mid December. Our banding program indicated that fledged shearwaters spend at least 4 years at sea before returning to this colony.

Table 2. Adult attendance patterns at the Mañagaha Island Wedge-tailed Shearwater colony 2003 – 2008.

Year	Date returned adults first banded[1]	Length of incubation period	Recorded first and last chick hatching dates	Recorded first and last chick fledging dates	Length of chick rearing period
2003	22 May	50.3 ± 8.5 days (n = 13)	6 August - 3 September	14 November – 24 December	110.4 ± 5.8 days (n =11)
2004	4 May	na	29 July – 26 August	5 November – 12 December	105.8 ± 9.2 (n = 19)
2005	19 May	na	29 July – 25 August	3 November – 1 December	109.1 ± 4.9 (n = 18)
2006	11 May	na	27 July – 30 August	9 November – 7 December	107.6 ± 4.6 (n = 30)
2007	22 May	55.8 ± 4 days (n = 13)	1 August – 23 August	8 November – 9 December	112.0 ± 6.4 (n = 24)
2008	29 April	52.8 ± 3 days (n = 4)	31 July – 20 August	12 November – 3 December	108.6 ± 5.7 (n = 15)

[1] Observers began working with adults after large numbers had already returned in each year; the date of first return to the island is not reflected in the data.

Our measurements of adults on Mañagaha (Tables 3 & 4) confirm that this shearwater weighs just under 400 g and is large for tropical members of the family, but is smaller than higher latitude relatives (Table 5).

Table 3. Measurements of adult Wedge-tailed Shearwaters from 2003 – 2006, Mañagaha Island, CNMI. Data are means followed by one standard deviation from the mean (SD).

Year	Sample size	Mean mass (g)	Mean wing chord (mm)	Mean culmen length (mm)	Mean tarsal length (mm)	Mean tail length (mm)
2003	57	384.7 (45.27)	297.8 (6.24)	39.0 (1.82)	50.2 (1.85)	145.9 (13.01)
2004	85	383.3 (29.87)	296.3 (6.69)	39.5 (1.70)	48.9 (1.58)	182.4 (9.60)
2005	55	382.9 (33.30)	293.8 (15.28)	39.4 (1.58)	48.5 (1.79)	145.3 (4.24)
2006	44	387.1 (32.77)	292.9 (7.42)	39.2 (1.24)	48.6 (1.37)	146.7 (6.28)
ALL	242	385.2 (35.27)	295.2 (9.62)	39.3 (1.64)	49.1 (1.78)	159.0 (20.00)

Table 4. Additional morphological measurements of adult shearwaters on Mañagaha Island in 2007. Means are followed by one standard deviation from the mean (SD).

Year	Sample size	Mean girth (cm)	Mean wing span (cm)	Mean head + bill length (mm)	Mean culmen depth narrow (mm)	Mean culmen depth wide (mm)
2007	29	23.4 (0.7)	50.9 (1.9)	85.7 (1.6)	8.3 (0.5)	9.1 (0.5)

Table 5. Comparison of Mañagaha Wedge-tailed Shearwater measurements and reported size and weight of other tropical shearwaters.

Species	Sample size	Mean mass (g)	Mean wing chord (mm)	Mean culmen length (mm)	Mean tarsal length (mm)	Mean tail length (mm)
Audubon's Shearwater (*Puffinus l'herminieri*), Mann Head, Bahamas[1]	10	244 ± 6	200 ± 0	29 ± 0	40 ± 0	92 ±2
Christmas Shearwaters (*P. nativitatis*), Christmas Island	87	340 ± 19[2]	249.18 ± 7.84[4]	31.43 ± 1.14[4]	44.93 ± 1.30	na
Short-tailed Shearwaters (*P. tenuirostris*), Phillip Island, Australia[3]	384	583 ± 32[3]	269.43 ± 12.38[4]	32.19 ± 1.50	51.04 ± 1.49	na

Species	Sample size	Mean mass (g)	Mean wing chord (mm)	Mean culmen length (mm)	Mean tarsal length (mm)	Mean tail length (mm)
Newell's Shearwater (*P. newelli*)[4] Hawaii	37	na	232.5 ± 9.04	32.79 ± 1.13	46.73 ± 1.37	na
Manx Shearwater (*P. puffinus*)[4]	43	na	237.02 ± 4.72	35.07 ± 1.49	45.38 ± 1.18	na
Sooty Shearwater (*P. griseus*)[4]	126	na	292.5 ± 10.86	42.02 ± 1.67	56.13 ± 2.02	na
Sooty Shearwater (*P. griseus*) California[5]	59	865 ± 135	na	41.5 ± 3.0	58.0 ± 1.6	na
Townsend's Shearwater (*P. auricularis*)[4]	10	na	229.33 ± 4.36	31.3 ± 1.33	45.25 ± 1.10	na
Wedge-tailed Shearwaters (*P pacificus*)[4]	253	na	293.6 ± 9.4	38.5 ± 1.81	48.81 ± 1.86	na
Wedge-tailed Shearwaters (*P. pacificus*) Mañagaha Island, CNMI	242	385.2 ± 35.27	295.2 ± 9.62	39.3 ± 1.64	49.1 ± 1.78	159.0 ± 20.00

[1] Data from Trimm, N.A. 2001.
[2] Data from Ricklefs, R.E. 1984.
[3] Data from Lill, A. and J. Baldwin. 1983.
[4] Data from Bull *et al*. 2004.
[5] Data from Josh Adams (*in litt*.). 2009

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Photo: The Shearwater Conservation Team taking morphological measurements.