Abundance of Birds in Palau based on Surveys in 2005

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Endemic birds of Palau, from top left: White-breasted Woodswallow, Palau Fantail, Palau Fruit-dove, Rusty-capped Kingfisher. Photos by Eric VanderWerf.

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EXECUTIVE SUMMARY

The avifauna of Palau is the most diverse in Micronesia because of the relatively large size of the islands and its proximity to Australasia (MacArthur and Wilson 2001). A total of 168 bird species have been documented in Palau, of which 45 are resident breeding species, 72 are regular migrants, 47 are considered vagrants, and four were introduced by humans. Palau also comprises a regional biodiversity hotspot, with 10 endemic species and eight endemic subspecies. The only previous quantitative assessment of the status of birds in Palau was conducted in 1991 (Engbring 1992). More up to date information on the status of birds in Palau is needed to help guide conservation efforts and assess management actions and needs.

In 2003, the Palau Conservation Society obtained funding to conduct quantitative bird surveys and for identifying Important Bird Areas in Palau. The goal of the surveys was to assess the status and population trends of bird species in Palau by replicating the quantitative surveys conducted in 1991. The surveys were conducted in April and May of 2005. The survey results were partially analyzed and reported by VanderWerf (2007), but those analyses included only data on relative abundance. This report presents the complete analyses and results of the surveys conducted in 2005, including relative abundance, population density, and population size.

The surveys used the same standard variable circular plot methods used by Engbring (1992) and that are used worldwide. Birds were surveyed at 617 points on 39 transects distributed throughout Palau. The numbers of transects and points were roughly proportional to island sizes, with 26 transects located in all 10 states on Babeldaob, seven transects in the Rock Islands, four transects on Peleliu, and two transects on Angaur. At each station, the observer estimated the horizontal distance to each bird detected by sight or sound during an eight-minute count period, and recorded information about weather conditions, habitat, and vegetation density. The resulting data were used to calculate two measures of relative abundance for each species: the incidence, or proportion of stations at which each species was detected; and the relative abundance, or average number of birds per station. In addition, the distance data associated with each bird detection were used to estimate the population density and population size of each species. The population trend of each species was then assessed by comparing the relative abundance and population size in 1991 and 2005. These surveys were designed for the resident bird species of Palau, most of which occur in forest and savanna habitats. Coastal, marine, and freshwater habitats and the birds that inhabit them were not adequately covered by these surveys.

When the evidence from comparisons of relative abundance and population size are considered together, the cumulative evidence indicates that 11 species increased from 1991 to 2005, four species declined at least locally, 14 species showed no change, and for three species the trend was not clear because they were rare and difficult to detect. Most of the changes in species abundance that occurred from 1991 to 2005 were related to development and changes in habitat. Most species that exhibited declines since 1991, such as the Slaty-legged Crake, occur primarily in forested habitats, suggesting loss of forest habitat was the cause of decline. The species that increased from 1991 to 2005 occurred in disturbed open habitats and roadsides, such as the Chestnut Munia, or that are able to use a variety of habitats including secondary forest, agroforest, and suburban areas, such as the Banded Rail, Micronesian Myzomela, Palau Fantail, and Palau Flycatcher. Species that are sometimes hunted, including the Micronesian Imperial Pigeon, Palau Fruit-dove, and Nicobar Pigeon, were stable or even increasing, indicating their populations were not being seriously affected. The survey results from 2005 are now 15 years old and it would be beneficial to repeat the surveys again to provide more current information.

INTRODUCTION

The Palau Islands (6º54' to 8º12' N, 134º08' to 134º44' E) are the westernmost archipelago in Micronesia and consist of more than 350 volcanic and coralline islands, most of which are enclosed in a large barrier reef. The avifauna of Palau is the most diverse in Micronesia because of the relatively large size of the islands and its proximity to Australasia (MacArthur and Wilson 2001), which is the ancestral source of the resident endemic species and of migratory visitors (Marshall 1949, Baker 1951, Pratt et al. 1987). Palau also comprises a regional biodiversity hotspot, with 10 endemic species and eight endemic subspecies (Engbring 1988, Gupta 2007, Pratt and Etpison 2008). A total of 168 bird species have been documented in Palau, of which 45 are resident breeding species, 72 are regular migrants, 47 are considered vagrants, and four were introduced by humans (Wiles 2005, VanderWerf et al. 2006, Otobed et al. 2018).

The first detailed treatments of the avifauna of Palau were by Marshall (1949) and Baker (1951). Several subsequent works have contributed additional valuable information (Pratt et al. 1980, Engbring 1983, Engbring 1988, Kepler 1993, VanderWerf et al. 2006, Gupta 2007). However, the only quantitative assessment of the status of birds in Palau was conducted in 1991 (Engbring 1992). More up to date information on the status of birds in Palau is needed to help guide conservation efforts and assess management actions and needs.

Several bird species that occur in Palau are considered threatened or endangered by various agencies and organizations. The Republic of Palau has its own Endangered Species Act that was based on former Trust Territory Regulations, and eight bird species are included on the Palau endangered species list: Gray Duck (*Anas superciliosa*), Micronesian Megapode (*Megapodius laperouse*), Nicobar Pigeon (*Caloenas nicobarica*), Palau Ground-dove (*Gallicolumba canifrons*), Palau Owl (*Otus podarginus*), Palau Fantail (*Rhipidura lepida*), Blue-faced Parrot-finch (*Erythrura trichroa*), and White-breasted Wood-swallow (*Artamus leucorynchus pelewensis*).

The Micronesian Megapode is listed as endangered under the U.S. Endangered Species Act, though the subspecies that occurs in Palau (*Megapodius laperouse senex*) is different from the subspecies that is listed under the U.S. Endangered Species Act (*Megapodius l. laperouse*), which occurs only in the Mariana Islands (USFWS 1970). Three other bird species from Palau were previously listed as endangered under the U.S. Endangered Species Act (Palau Ground-dove, Palau Owl, and Palau Fantail; USFWS 1970). They were delisted in 1985 (USFWS 1985), but other than the 1991 survey there has been no systematic or quantitative effort to assess their status since the delisting. Three additional species that occur in Palau were once petitioned for listing under the U.S. Endangered Species Act (Nicobar Pigeon, Blue-faced Parrot-finch, and White-breasted Wood-swallow), but they are no longer considered candidates for listing. The International Union for the Conservation of Nature considers the Micronesian Megapode to be endangered, and the Nicobar Pigeon, Palau Ground-dove, Micronesian Pigeon (*Ducula oceanica*), and Giant White-eye (*Megzaosterops palauensis*) to be near threatened (IUCN 2006).

In 2003, the Palau Conservation Society obtained funding from the European Commission through BirdLife International for bird surveys aimed at identifying Important Bird Areas in Palau (Gupta 2007). Additional funding for quantitative surveys was provided by the Seaworld-Busch Gardens Conservation Program through the United States Peace Corps and by Pacific Islands Office of the U.S. Fish and Wildlife Service. The surveys were conducted in April and May of 2005. The goal of the surveys was to assess the status and population trends of bird species in Palau by replicating the surveys conducted in 1991. The survey results were partially analyzed and reported by VanderWerf (2007), but those analyses included only data on relative abundance, they did not use the distance-based aspect of the data to estimate population density and size. In this report, we present the complete analyses and results of the surveys conducted in 2005, including relative abundance, population density, and population size.

METHODS

Description of Study Area and Transect Locations. The Palau Archipelago consists of approximately 350 volcanic and raised coralline limestone islands, most of which are enclosed in a large barrier reef. The large island of Babeldaob comprises the majority of this area (Figure 1). Babeldaob is mostly volcanic in origin but portions of southern Babeldaob contain steep limestone outcrops that are geologically similar to the "Rock Islands" farther south. These Rock Islands are composed primarily of raised limestone and are steep-sided and have intricate topography, containing a complex mosaic of limestone forest and coastal habitats. For more information on the geology and terrestrial environment of Palau, see Gupta (2007).

In April and May 2005, the bird surveys were conducted at 617 points on 39 transects distributed throughout most of Palau (Table 1). The surveys were designed to represent the diversity of habitats present and included transects on all of the larger islands, except for the urbanized areas of northern Koror, Malakal, and southwestern Babeldaob. The number of transects was roughly proportional to island size, including 26 transects with 409 stations in all 10 states on Babeldaob, seven transects with 98 stations in the Rock Islands, four transects with 75 stations on Peleliu, and two transects with 35 stations on Angaur. Surveys were conducted on the largest Rock Islands (southern Koror, Auluptagel, Ngeruktabel, and Mecherchar), but this geographic area also encompasses numerous small islands that were not surveyed. The surveys did not encompass the "Southwest Islands" of Palau, a string of small atolls that stretch 600 kilometers southwest of the main Archipelago. The biota of the Southwest islands has been described by Engbring (1983) and Kepler (1992). These surveys also did not include Kayangel, a small atoll located north of Babeldaob.

The island areas used for analyses were slightly different between 1991 and 2005 (Table 2), presumably because the areas in 2005 were obtained from GIS shapefiles that were more precise and did not exist in 1991. Engbring (1992) did not report whether island areas included mangroves, but when we added mangroves areas above the shoreline the island sizes were fairly similar to those in 1991, so the 1991 island areas must have included mangroves. For most islands, the difference in area between 1991 and 2005 was small, but for Peleliu the difference was larger and may account for some of the differences in population size estimates between the two time periods.

All 36 transects used in 1991 by Engbring (1992) were used again in 2005 to facilitate comparison of changes in the avifauna over time. Three transects were added in 2005 to fill geographic gaps in survey coverage, including one near the tip of the Ngerchelong Peninsula in northern Babeldaob, one in Ngaraard State in northern Babeldaob, and one in the Rock Islands in the Ngerukuid Islands (Figure 1). Transects followed the same routes as in 1991 to the maximum extent practicable, but a few transects had to be rerouted slightly due to development, construction, and increased traffic, particularly on the newly constructed Compact Road around the perimeter of Babeldaob. One station on transect 26 had to be moved because of a commercial dolphin theme park.

Substantial development occurred in some areas of Palau from 1991 to 2005. Although transects followed the same routes, the proportional habitat sampling in these two periods was somewhat different in certain areas. Some narrow dirt roads used for transects in 1991 had been enlarged and paved by 2005, and construction of the Compact Road in particular had increased the amount of second growth and grassland habitat along roadsides and reduced the amount of primary forest in some areas.

Data Collection. Each transect was surveyed simultaneously by a primary observer and a secondary observer. Each primary observer was familiar with all bird species in Palau, and an effort was made to include a secondary observer from Palau to train and build local resource monitoring capacity. Some secondary observers were just as proficient as the primary observers at detecting and identifying birds, but analyses presented in this report used only data from primary observers because the overall reliability of secondary observers was more variable.

Transects were followed by walking on trails and roads in most cases, but five of six transects in the Rock Islands and transect 14 along the Ngeremeskang River on Babeldaob were surveyed by boat. During these counts, the boat was secured 0-5 meters from shore, the engine was stopped, and waves caused by the boat were allowed to subside before the count started in order to better hear birds. The distance between stations was 150 meters on most transects, 200 meters on a few transects on Babeldaob where it was desirable to cover a larger area, and 400 meters on transects covered by boat in the Rock Islands. Surveys began before sunrise but after the dawn chorus had largely subsided and generally ended by 1100 hours to reduce temporal variation in bird activity.

Data collection followed standard variable circular plot (VCP) methods used by Engbring (1992) in Palau and in Hawaii (Scott et al. 1987, Camp et al. 2009). At each station, the observer estimated the horizontal distance to each individual bird detected by sight or sound during an eight-minute count period. If a species was observed at a station outside the eight -minute count period, its presence was noted but the distance was not estimated. All surveyors went through two days of training prior to the surveys to practice estimating distances of bird species in different habitats. At each station, the observer also recorded the cloud cover, precipitation, and wind and wind gust on the Beaufort scale (World Meteorological Organization 1970). Surveys were conducted only during favorable weather and noise conditions, i.e., no more than light rain and sustained wind no higher than three on the Beaufort scale. If weather conditions or noise from traffic or construction interrupted a count for more than a few seconds, the 8-minute count was restarted after the noise had subsided. Habitat along each transect was described by recording the two or three dominant habitat types at each point (Table 3). Visibility and consequent ability to detect birds at each station was measured using an index of vegetation density that ranged from 1 (most dense) to 5 (most open; Table 4). The visibility index and wind conditions were used as covariates in analyses (see below).

Data Analysis. We used several methods to proof the data set and correct errors. We sorted the data in various ways (by transect and station, by species, by distance, etc.) to expose missing or nonsensical values and typographical errors. Approximately 5% of all entries were double-checked against the original field books.

In previous analyses of this data (VanderWerf 2007), two measures of relative abundance were calculated for each species based on all individuals detected. First, the incidence was defined as the proportion of stations at which each species was detected. The incidence provides an indication of how widespread each species was. Second, the relative abundance was calculated as the average number of birds per station. The relative abundance provides an indication of how common a species was compared to other species but does not allow estimation of population size for each species. The measures of relative abundance from VanderWerf (2007) are included in this report because they complement the estimates of population size estimates derived from distance data in this analysis. To provide the best overall assessment of the status of each species it often is helpful to consider patterns in relative and absolute abundance.

We estimated population density and population size of each species with the package "Distance" (Miller et al. 2019) in Program R version 4.0.2 (R Core Team 2020), using the distances to detected individuals at all stations. We included island as a stratum in all analyses, so that estimates were produced for each island as well as for all of Palau combined. To obtain the most accurate and precise estimates possible, we constructed a series of candidate detection models that included different detection functions, adjustment terms, covariates, and truncation distances. We used Akaike's Information Criterion (AIC) to determine which of the candidate models best fit the data for each species, with the best model having the lowest AIC value. We assessed model fit with a Cramer-von Mises goodness-of-fit test for detection function models. We used density and population size estimates and associated variances from the model that had the lowest AIC value and a goodness-of-fit test p-value > 0.05. However, we also considered other models that had an AIC value < 2.0 from the best model, and if a model had a similar goodness-of-fit value but resulted in smaller standard errors for estimates, then we used estimates from that model instead.

The set of candidate models for each species included one of three detection functions: half-normal (HN), hazard-rate (HR), and uniform (UNIF). Uniform models were fitted with associated series adjustments, cosine terms (cos), or simple polynomial (poly). Covariates were only included in HN and HR models, as UNIF models do not allow covariates. We also compared models with three truncations (0, 5%, and 10%) to assess whether there were fewer detections than expected near the observer. This can occur in species that are shy or hunted because birds avoid or move away from the observer. Some stations were located on trails, roads, or surveyed from a boat, and thus would be expected to have lower densities in the area closer to the observer where there was no vegetation.

We included in the models three covariates that can affect bird detectability: observer, habitat visibility, and wind, and their interactions. Different observers may vary in their ability to detect birds by sight and sound and in their ability to accurately estimate the distance to detected birds, and this variation is known to affect results of auditory and visual survey methods (Emlen & Dejong 1992, Alldredge et al. 2008, Campbell & Francis 2011). Detectability of birds also may differ among habitats, especially habitats with different vegetation densities (Schieck 1997, Pacifici et al. 2008). To account for vegetation density, we included the index of habitat density that was recorded at each station by the observer during the surveys (Table 4) as a covariate. Although surveys were only conducted during suitable weather conditions, we included wind as a covariate because certain species, such as those with soft vocalizations, may be difficult to detect in even moderately windy conditions.

To examine changes in abundance of each bird species over time, we compared the values of relative abundance and population size from the surveys conducted in 1991 and 2005. The total number of detections in the datasets used to measure relative abundance and absolute abundance are slightly different because the measures of relative abundance included 265 detections of birds observed outside the eight-minute count period in 2005, but these detections could not be included in estimates of absolute abundance because they lacked distance data. Comparisons of relative abundance were presented by VanderWerf (2007), but an error was discovered in those analyses and the corrected comparisons are presented in this report to provide a single complete source of information.

We compared the relative abundance estimates from 1991 and 2005 using 1-sample t-tests with Tukey's correction for multiple comparisons (i.e., the alpha levels were divided by the number of species for which we made comparisons). We calculated the t-statistic using the following formula: $t = (x-\mu)/S_x$, where x is the sample mean (from 2005), μ is the test mean (from 1991), and S_x is the standard error of the sample mean. One sample t-tests had to be used because Engbring (1992) reported abundances as a point estimate without a standard error and the raw data from the 1991 survey are no longer available to calculate the standard error. Engbring (1992) reported relative abundance values with only one significant digit (i.e., rounded to the nearest 0.1 birds per station), but it was possible to calculate more precise measures of relative abundance (to the nearest 0.01 birds per station) from data in Table 3 of Engbring (1992) and these point estimates were used in t-tests. However, in 1991 some transects were surveyed by two observers simultaneously, and the data in Table 3 of Engbring (1992) included all birds detected by both observers combined during 709 counts, not the number of detections at the 592 stations surveyed, and the number of stations surveyed by two observers was not broken down by island. We calculated the precise relative abundance with two significant figures on each island in 1991 by prorating the number of counts on each island based on the number of stations on each island and the overall proportion of stations that were surveyed by two observers. This assumes that a similar proportion of transects were counted twice on each island, which may not be exactly accurate, but the more precise values are better. In VanderWerf (2007), the comparisons of relative abundance in 1991 and 2005 mistakenly used the values from Table 3 of Engbring (1992), without correcting for the number of counts instead of stations.

We compared the population size estimates from 1991 and 2005 using a 2-sample t-test of the means, standard errors, and sample sizes of detected birds. Before conducting the t-tests, it was necessary to calculate the standard error associated with the 1991 estimate using the 90% confidence interval bounds reported in tables 5-33 of Engbring (1992).

The methods used during surveys in 1991 and 2005 were generally similar and involved the same transects, but there were some differences in the methods that were unavoidable and probably had some influence on the results. Analyses in both 1991 and 2005 accounted for differences among observers and in detectability of birds in different habitats by using observer and a detectability index as covariates. In 1991, some stations were surveyed simultaneously by two observers 20 meters apart, and their counts were averaged for analyses. In 2005, only data from one primary observer was used per station. In 2005, we examined the fit of several models with different detection functions and levels of truncation and used model selection to choose the best fitting model. This level of sophistication was not available in 1991 and the simpler models may have underestimated the population size of some species.

Limitations of the Survey. These surveys were designed primarily to sample the endemic and resident avifauna of Palau. Most of these species occurred in forest and savanna habitats and transects were therefore deliberately routed through these habitats (Engbring 1992). Coastal, marine, and freshwater habitats were not adequately sampled by these surveys, and the point count methods used in these surveys were not well suited to many coastal and wetland bird species because these species often are concentrated in a few locations and thus have clumped distributions. Species that are primarily nocturnal, such as the Palau Owl and Jungle or Grey Nightjar (*Caprimulgus indicus*), also were not adequately sampled because these surveys occurred during daylight hours. The status of coastal, wetland, and nocturnal species therefore is not assessed in this report. Observations made during the 2005 survey on the distribution and abundance of wetland birds, non-breeding migrants, and vagrants were reported by VanderWerf et al. (2006).

RESULTS

A total of 14,050 birds of 50 species were detected during surveys at 617 points on 39 transects in Palau in April and May 2005 (Table 5). Sixteen of the birds observed are endemic to Palau at the species or subspecies level, 17 are indigenous species that are resident or visit Palau to breed, 12 are migrants that visit Palau during their non-breeding season, and 5 are alien species that were introduced to Palau by humans. Some species were common and were detected on all islands and at most stations, such as the Palau Fruit-dove, Palau Bush-warbler, and Micronesian Starling (Table 5). Other species were rare and were detected in small numbers at only a few locations, such as the Palau Ground-dove, White-breasted Wood-swallow, and Blue-faced Parrot-finch.

Comparisons of the relative abundance of birds in 1991 and 2005 showed that nine species increased, eight species decreased, and 25 species exhibited no detectable change in relative abundance (Table 5). Eight of the species were not observed in 1991, all of which were migrants except the Palau Owl, so it was not possible to compare their abundance over time.

In the analyses of 2005 distance data, sufficient numbers of individuals were detected to calculate meaningful estimates of population density and size for 33 of the 50 bird species (Table 6). For 17 species it was either not possible to fit a model to the data or the standard errors of the estimates were so large that the estimate was not meaningful. This occurred if either the number of detections was too small or none of the models provided an adequate fit to the data due to the skewed distribution of detection distances. In general, it was possible to estimate population size only for species with at least 10 detections. Species for which it was not possible to estimate population density and size were: Barn Swallow, Black-naped Tern, Common Sandpiper, Great Crested Tern, Gray-streaked Flycatcher, Gray-tailed Tattler, Intermediate Egret, Little Pied Cormorant, Oriental Cuckoo, Palau Owl, Pacific Golden Plover, Pacific Reef Heron, Purple Swamphen, Rufous Night-heron, Wandering Tattler, Whimbrel, and Yellow Bittern

The best models used a HR detection function for 16 species, a HN detection function for 15 species, and a UNIF detection function with a cos adjustment term for two species. For HN and HR detection functions, model selection resulted in a best-fit model that included at least one of three covariates (observer, visibility, and wind) for 28 species, with observer a factor for 21 species, visibility for 26 species, and wind for 10 species. The best model included 10% truncation for 12 species, 5% truncation for 12 species, and no truncation for 9 species.

Comparison of population size estimates from 1991 and 2005 indicated that 14 bird species had increased, one had decreased (Slaty-legged Crake), 14 showed no detectable change, and for four species there was no estimate from 1991 so no comparison was possible (Table 6). The estimates of population density and size are likely to be reliable for 27 species, as indicated by the relatively small standard errors in comparison to the mean (Table 6). The standard errors were relatively large for 6 species, making the population estimates less reliable and hindering the ability to detect changes in abundance over time (Table 6). For example, the estimated population size of Blue-faced Parrotfinch was much higher in 2005 (10,855) than in 1991 (1,023), but the standard error of the estimate in 2005 was so large (14,117) that the estimate was not very meaningful and the test for change in abundance over time was inconclusive. In general, estimates were more reliable for species with at least 20 detections (Table 6).

DISCUSSION

When the evidence from comparisons of relative abundance and population size are considered together, the cumulative evidence indicates that 11 species increased from 1991 to 2005, four species declined at least locally, 14 species showed no detectable change, and the trend was not clear for three species. Most bird species in Palau thus appear to be reasonably secure and their populations remained stable from 1991 to 2005, but a few species continue to be rare or appear to have declined, so there is some cause for concern. Most of the changes in species abundance that occurred from 1991 to 2005 were related to urban development and loss of habitat. Most species that exhibited declines since 1991 occur primarily in forested habitats, suggesting loss of forest habitat has been the cause of decline. The Slaty-legged Crake, a shy species that prefers the forest interior, showed the largest decline of any bird species, particularly on Babeldaob. This decline probably was related to a decrease in forest habitat and increase in noise, disturbance, and non-native predators associated with development. However, several transects followed roads that have been widened since 1991, particularly the Compact Road, which has decreased the amount of forested habitat in the immediate vicinity of many stations. The loss of forest habitat is more apparent along these road transects and may not be representative of the habitat loss throughout all of Palau.

Conversely, several species appear to have benefitted from the increasing development and changes in landscape that occurred from 1991 to 2005. Some of these species favor disturbed open habitats such as roadsides, including the alien Chestnut Munia and migratory Yellow Wagtail. The Chestnut Munia may have benefited from road expansion because it feeds primarily on grass seeds in open grassy areas, and this habitat is abundant along the Compact Road and other roads. Other species that have increased, such as the Banded Rail, Micronesian Myzomela, Palau Fantail, and Palau Flycatcher, are able to use a variety of habitats including secondary forest, agroforest, and suburban areas.

For several bird species, there was conflicting evidence of the population trend from measures of relative abundance and population size. The merits of these two methods of monitoring birds has been the subject of much debate, but some studies have shown that methods without estimations of detectability, such as relative abundance, are likely to be biased and less reliable and can confound trend analyses, and that methods employing distance estimation perform better (Norvell et al. 2003). On the other hand, a common criticism of distance-based methods is that properly implementing distance surveys in the field is more difficult because of the need to estimate distances and, in the case of multi-species surveys, the complexity of recording data on all species and individuals in a limited time. In the case of the Palau surveys, we believe the distance based results are generally more reliable, at least for species with a sufficient number of detections, but that for a few species the conflicting evidence may have been the result of observer bias and/or difficulties with the survey methodology. For example, Brown Noddies, Black Noddies, and White Terns showed large declines in relative abundance but no changes in population size. These species were often observed at a long distance because of their large size and tendency to fly over the forest canopy. At some stations, the number of birds was so large that it was difficult to record all observations within the eight-minute count period. Surveyors were instructed to record forest birds first because they were the focus of the surveys, and to estimate distances to closer individuals first because they have a larger effect on density estimates. Consequently, in some cases there may have been insufficient time to record distant flying birds, such as noddies and White Terns. Observers also were instructed to record flying birds only if they appeared to be using the area around the survey point and not simply transiting through the area, and it is not known if surveyors followed these same protocols in 1991. Another possible source of error was that some surveyors in 2005 had less experience with VCP techniques and may have been less efficient at recording all birds at each station. The combination of a decline in relative abundance and a lack of change in population size suggests that fewer distant birds were recorded per station in 2005, possibly because of time constraints during counts.

The methods available for analysis of distance-based survey data have improved substantially since Engbring (1992), and it possible that some of the apparent increases in bird population sizes from 1991 to 2005 were caused at least in part by differences in analytical methods. The more sophisticated methods available today can produce more refined, and possibly higher, population size estimates, because they account for variation in detectability associated with weather and lower than expected bird detections close to the observer. This may have occurred with species that appeared to avoid the observer, including the Morningbird, Cicadabird, Palau Fantail, Palau Flycatcher, and Micronesian Imperial-pigeon, and Palau Fruit-dove, and with species that have soft calls that can be difficult to hear, such as the smaller white-eyes and Blue-faced Parrotfinch.

The Ngerukuid Islands, or seventy islands, are one of the most iconic landscapes of Palau and have been given the highest level of protection by the government, under which they are off-limits to tourists and commercial activities. This high degree of protection appears to have benefitted the avifauna of the Ngerukuid Islands; they were found to have the highest abundance of several bird species, including the White-tailed Tropicbird, Bridled Tern, Micronesian Megapode, Pacific Reef-heron Brown Noddy, and Nicobar Pigeon. Elsewhere in the Rock Islands, several bird species appear to have declined in abundance, including Micronesian Megapode, Brown Noddy, and Black Noddy. The cause(s) of these declines are not clear because most of the Rock Islands are protected as a nature reserve and human access and activities are regulated. Introduced predators and disturbance from tourism could be issues causing decline for some species (Radley et al. 2020). Transect 25 in Rock Islands was surveyed on a day with intermittent rain showers that caused several delays during counts, and it is possible the weather conditions may have reduced bird activity, but this alone cannot account for some of the large difference observed in some species between 1991 and 2005.

Angaur is a small island has limited forest habitat because of past phosphate mining and military activities during WWII (McGregor and Bishop 2011) and lacks many forest birds found on other islands in Palau. Several bird species declined on Angaur from 1991 to 2005, including the Brown Noddy and Black Noddy. Declines may have been caused by the loss of already diminished forest habitat. It is also possible that these declines have been caused by an increase in predators, particularly the non-native long-tailed macaque (*Macaca fascicularis*; Jones et al. 2018). Loss of agricultural products to these monkeys has become a serious problem on Angaur (McGregor and Bishop 2011), and it is an agile climber capable of preying on bird nests and roosting adults.

Several bird species are hunted at least locally in Palau, including the Micronesian Imperial Pigeon, Palau Fruit Dove, and Nicobar Pigeon, but the populations of these species did not appear to be seriously affected and were generally stable, or even increasing in the case of the Nicobar Pigeon. Although we did not detect a decrease in these species from 1991 to 2005, it is important to continue monitoring their populations, particularly on islands with increasing human population and more hunting pressure.

SPECIES ACCOUNTS

The species accounts below are listed in taxonomic order following Otobed at al. (2018) and provide the English, Palauan, and scientific names, status, and overall population trend. Each account includes a discussion of survey results and interpretation of population trend based on the comparisons of relative abundance and population size in 1991 and 2005.

Micronesian Megapode/Bekai (*Megapodius laperouse senex*). Endemic subspecies. Stable. This endemic subspecies is listed as endangered under the Palau Endangered Species Act and also is considered endangered by the International Union for the Conservation of Nature (IUCN 2006). The subspecies found in the Mariana Islands (*M. l. laperouse*) is listed as endangered under the U.S. Endangered Species Act (USFWS 1998). In Palau, this species builds incubation mounds primarily in sandy soil near beaches and forages in coastal areas and to a lesser degree in upland habitat (Wiles and Conry 2001, Radley et al. 2020). The primary threats to the species are invasive predators, human disturbance, and sea level rise (Radley et al. 2018, 2020).

Micronesian Megapodes were found on all islands surveyed in 1991 and 2005, but they were generally uncommon to rare and only locally distributed. Comparisons of relative abundance and population size both showed there was no change from 1991 to 2005 (Tables 5, 6). Babeldaob supported the lowest density of megapodes of any island, but it contained almost half the population because of its large area. In 2005, only five birds were recorded on Babeldaob, on transects 7, 9, 17, and 18, which were located in some of the more remote areas of the island farther from human disturbance. In the Rock Islands, the relative abundance was lower in 2005 than in 1991 but the population size was higher. This seemingly paradoxical result occurred because the highest abundance of megapodes in the Rock Islands in 2005 was on transect 39 in the Ngerukuid Islands, which were not surveyed in 1991. Elsewhere in the Rock Islands megapodes were rare, with single birds recorded on transect 25 on Ulebsechel, transect 27 on Ngeruktabel, and transect 30 on Mecherchar. Angaur had the highest density of megapodes in 1991 and 2005, and this small island supported 18% and 20% of the total population in 2005 and 1991, respectively. On Peleliu, megapodes were uncommon in the areas surveyed, but several birds and incubation mounds were observed in coastal strand forest on the southeastern side of the island where no transects were located. Similarly, transects in the Rock Islands included very few locations with sandy beaches that are frequently used for mound-building and this species is known to be more numerous on several other of the Rock Islands (Radley et al. 2020). Megapodes were observed to be quite common on a portion of Ulong Island with a sandy beach during a visit on 6 May 2005. The abundance on Peleliu and the Rock Islands thus may be somewhat higher than indicated by these surveys.

Relative abundance and population size estimates (mean±SE) of Micronesian Megapodes in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.01±0.01	0.01	301±171	244±173

Rock Islands	0.09±0.04	0.17	227±133	104±34
Peleliu	0.05±0.03	0.03	48±32	52±41
Angaur	0.26±0.10	0.33	125±71	97±43
Total	0.04±0.01	0.06	700±308	497±291

Red Jungle Fowl/Malkureomel (*Gallus gallus*). Alien. Increasing. Junglefowl, or feral chickens, were common in many areas of Palau but their distribution was uneven. There was no difference in relative abundance between 1991 and 2005, but the estimated population size was higher in 2005 than in 1991. Most of the increase in number of junglefowl occurred on Babeldaob, which supported the vast majority of the population. This is not surprising given that Babeldaob supports the majority of the human population too. The number of junglefowl also increased somewhat on Angaur, but the number of birds there is small. Abundance of junglefowl was already low on the Rock Islands in 1991, and none were detected in 2005, indicating they may be gone from that region of Palau. Junglefowl are easily detected by their loud calls and are unlikely to have been overlooked in portions of the Rock Islands that were surveyed, but it is possible that a few birds may persist somewhere in an un-surveyed part of this complex island group. The disappearance of this non-native species from the relatively undisturbed Rock Islands should be regarded as a positive result for conservation of native flora and fauna. In 2005, junglefowl exhibited a lower than expected detection rate near the observer, suggesting they avoided the observer, and the best model included a truncation of the data to account for this. Truncation of distance data was not available in 1991 and the population size may have been underestimated.

Relative abundance and population size estimates (mean±SE) of Red Junglefowl in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.66±0.07	0.67	5,337±1,608	1,212±131
Rock Islands	0	0.07	0	17±7
Peleliu	0.28±0.08	0.61	165±75	215±60
Angaur	0.40±0.13	0.31	174±75	51±21
Total	0.49±0.05	0.55	5,676±1,635	1,495±219

White-tailed Tropicbird/Dudek (*Phaethon lepturus*). Indigenous resident. Increasing. The White-tailed Tropicbird is a widespread seabird that is found in tropical and subtropical oceans around the world. It nests in holes and ledges on steep cliffs and in tree cavities. In Palau it nests on many islands is often seen flying along coastal areas and high over the forest canopy. The number of tropicbirds present in Palau is not that large, but this species is easily detected because it is large and often flies conspicuously over forested areas and coastlines. The relative abundance of White-tailed Tropicbirds did not differ statistically between 1991 and 2005, but the estimated population size was larger in 2005 than in 1991. The highest abundance was found in the Rock Islands, where the steep terrain, dense forest, and numerous small cavities in coastal limestone cliffs likely provide many nest sites that are inaccessible to predators. Most of the increase in population size was in the Rock Islands and on Peleliu. The increase in the Rock Islands can be attributed to the addition of transect 39 in the Ngerukuid islands, which had the highest abundance of any area and were not surveyed in 1991. Abundance was lowest on Babeldaob and Angaur, possibly due to greater presence of predators on these islands. The reason for the increased abundance on Peleliu is not known.

Relative abundance and population size estimates (mean±SE) of White-tailed Tropicbirds in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.05±0.02	0.03	666±372	373±125
Rock Islands	0.62±0.12	0.49	884±206	322±69
Peleliu	0.25±0.06	0.03	237±91	9±6
Angaur	0.03±0.03	0.07	16±17	30±20
Total	0.16±0.02	0.11	1,804±450	734±219

Slaty-legged Crake/Ulerratel, Kok, Och (*Rallina eurizonoides*). Indigenous resident. Declining. The Slaty-legged Crake is a widespread but generally uncommon species that occurs in forested areas from Southeast Asia to the Philippines and Indonesia. Slaty-legged Crakes are widely distributed in Palau, but they are shy and often difficult to detect in the dense forest understory that they prefer. During surveys in 2005, Slaty-legged Crakes were uncommon on Peleliu, rare on Babaledaob, and were not detected in the Rock Islands or Angaur. Comparisons of 1991 and 2005 showed significant declines in both relative abundance and population size. This decline occurred only on Babeldaob; numbers on Peleliu were stable. Slaty-legged Crakes were not observed during surveys in the Rock Islands, but detecting this shy species that favors forest interior would be difficult from a boat, and it is possible it actually does occur on some of the Rock Islands. The decline on Babeldaob should be interpreted with caution because the population estimate in 2005 was based on a small number of observations; only 15 Slaty-legged Crakes were recorded in 2005. There were five detections from widely scattered areas on Babeldaob, with one bird each on transects 3, 11, 15, 17, and 19. Ten Slaty-legged Crakes were recorded on all four transects on Peleliu. Crakes exhibited a lower than expected detection rate near observer and the best model included a truncation of the data to account for this variation. This could have been caused by crakes avoiding either the observer or the more open habitat in the immediate vicinity of the station.

Relative abundance and population size estimates (mean±SE) of Slaty-legged Crakes in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.01±0.01	0.08	228±133	2,002±480
Rock Islands	0	0	0	0
Peleliu	0.13±0.04	0.12	120±47	130±52
Angaur	0	0	0	0
Total	0.024±0.006	0.07	348±141	2,132±532

Banded Rail/Terriid (*Gallirallus philippensis*). Indigenous resident. Increasing. The Banded Rail is widespread in the Indo-Pacific region from Southeast Asia and the Philippines to New Guinea and Australia, particularly on smaller islands. During surveys in Palau, Banded Rails occurred in a variety of primarily open habitats, including savannas, forest edges, agricultural lands, and brushy and grassy areas along roadsides and near villages.

The relative abundance of Banded Rails increased from 1991 to 2005 and the estimated population size was more than 10 times higher in 2005 than in 1991, but the population sizes were not significantly different because of the large standard errors associated with the estimates in both surveys. The vast majority of the population occurred on Babeldaob, and the increased abundance there probably is related to an increase in amount of open habitat along roadsides and suburban and agricultural areas. Abundance remained stable on Peleliu and Angaur. Banded Rails were rarely observed in dense forest, which may explain their absence from the densely vegetated Rock Islands. It is possible that Banded Rails do occur on some of the Rock Islands but were not detected because surveys were conducted by boat in that area. Banded Rails were reported to be common on Kayangel by Engbring (1992, p. 28), but that island was not surveyed in 1991 or 2005. Banded Rails exhibited a lower detection rate near observer and the best model included a truncation of the data. This species often forages in open habitat, so this pattern probably indicated avoidance of the observer and not open habitat around the station. Truncation of data close to the observer may have resulted in a more accurate population size estimate in 2005, and lack of truncation in 1991 could have resulted in an underestimate of the population size, so the comparison to 2005 and should be interpreted with caution.

Relative abundance and population size estimates (mean±SE) of Banded Rails in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.08±0.02	0.01	8,402±4,546	153±89
Rock Islands	0.0±0.0	0.00	0	0
Peleliu	0.33±0.09	0.24	595±360	446±156
Angaur	0.23±0.10	0.10	82±51	125±78
Total	0.11±0.02	0.05	9,079±4,558	724±323

Brown Noddy/Mechadelbedaoch (*Anous stolidus*). Indigenous breeder. Locally declining? Brown Noddies are widespread in tropical and subtropical oceans of the world. Some birds appear to be resident around breeding colonies in tropical areas, but in subtropical areas some birds may leave outside the breeding season (del Hoyo et al. 1996). In Palau, Brown Noddies nest in trees in forested areas on all islands and are often seen flying high over the forest canopy, even in the interior of Babeldaob, and over coastal areas of smaller islands.

Comparison of data from 1991 and 2005 showed a large decline in relative abundance but no change in total population (Tables 5 and 6), with different patterns on different islands. On Babeldaob, which supported the majority of the population because of its large size, there was a decline in relative abundance but an increase in population size. In the Rock Islands both relative abundance and population size were lower in 2005. On Angaur there was a sharp decline in both relative abundance and population size. Only Peleliu showed no significant change in relative abundance or population size. These conflicting patterns are difficult to interpret. Abundance in 2005 was highest in the Ngerukuid Islands, which are the least disturbed area in Palau, suggesting declines in other areas may be related to disturbance or an increase in predators, particularly on Angaur, where the species had almost disappeared. However, it is possible that lower number in 2005 are at least partly due to observer bias and/or difficulties with the survey methodology. At some stations the number of birds was so large that it was difficult to record all observations within the eight-minute count period. Surveyors were instructed to record forest birds and closer individuals first, and in some cases there may have been insufficient time to record distant flying birds, such as noddies and White Terns. The lack of change in population size suggests that fewer distant birds were recorded per station in 2005 due to lack of time during counts and this result should be interpreted with caution. Brown Noddies exhibited a lower than expected detection rate near the observer, suggesting they avoided the observer, and the best models included a truncation of the data to account for this variation. Truncation of distance data was not utilized in 1991, so population sizes could have been underestimated in 1991, which could partly explain the conflicting trends in relative abundance and population size.

Relative abundance and population size estimates (mean±SE) of Brown Noddies in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.12±0.02	0.46	6,218±2,787	3,692±725
Rock Islands	0.48±0.09	5.06	1,874±669	2,881±406
Peleliu	0.24±0.06	0.49	420±181	223±66
Angaur	0.03±0.03	0.52	63±65	1,311±629
Total	0.19±0.02	1.17	8,575±2,968	8,107±1,827

Black Noddy/Bedaoch (*Anous minutus*). Indigenous breeder. Locally declining? The Black Noddy is widespread in tropical and subtropical oceans of the world. It nests in coastal locations more often than the Brown Noddy and forages closer to shore, often over the reef crest and lagoon in association with Black-naped Terns. Nests are placed in trees, often close to water, and tend to be more clustered than Brown Noddy nests.

As with the Brown Noddy, comparison of data from 1991 and 2005 showed a decline in relative abundance but no change in total population (Tables 5 and 6), with different patterns on different islands. There were declines in both relative abundance and population size on Babeldaob and in the Rock Islands, though the species was still fairly common in both of those areas (Tables 5 and 6). On Peleliu, there was no change in relative abundance but an increase in population size. On Angaur, the species was uncommon and declined in relative abundance. Overall the abundance of Black Noddies appears to have declined since 1991, and as with the Brown Noddy, the cause of this apparent decline is unknown and may be due at least partly to observer bias and this result should be interpreted with caution. The difference in number of birds was especially dramatic in the Rock Islands, and it is not clear why this would have occurred since they are less disturbed than other areas of Palau. As with Brown Noddies, Black Noddies exhibited a lower detection rate near the observer and the best models included a truncation of the data to account for this variation. The population sizes may have been underestimated in 1991, which could help explain the conflicting patterns in relative abundance and population size.

Relative abundance and population size estimates (mean±SE) of Black Noddies in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.17±0.03	0.50	6,165±1,168	8,105±1,182
Rock Islands	1.79±0.21	7.10	5,794±868	7,595±992
Peleliu	2.33±0.21	1.83	5,056±638	2,491±482
Angaur	0.03±0.03	0.17	25±26	28±18
Total	0.68±0.06	1.65	17,041±1,735	18,219±2,674

White Tern/Sechosech (*Gygis alba*). Indigenous breeder. Locally declining? The White Tern, sometimes known as the Fairy Tern, is an especially beautiful and graceful seabird that is common and widespread in tropical and subtropical oceans throughout the world. The single egg is laid on bare branches, cliff ledges, and sometime human structures. Adults forage in nearshore and pelagic waters for small fish and squid.

As with the noddies, comparisons of data from 1991 and 2005 yielded conflicting patterns, with a decline in relative abundance but no change in population size, and variation among islands. Both measures showed a decline on Babeldaob, an increase on Peleliu, no change on Angaur, and opposite patterns in the Rock Islands. Although White Terns continue to be common in Palau, the number of White Terns detected per station appears to have declined in some areas since 1991. However, as explained above in the Brown Noddy account, this apparent decline may have been caused partly by limitations on survey methodology. It is possible that fewer distant birds were recorded per station in 2005 due to lack of time during counts. The White Tern nesting season is protracted and variable in some areas, and numbers of White Terns present around breeding islands varies substantially throughout the year, with fewer birds present outside the nesting season (VanderWerf 2003).

Relative abundance and population size estimates (mean±SE) of White Terns in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.44±0.05	1.40	9,845±1,689	14,746±1,490
Rock Islands	2.00±0.26	3.60	3,103±512	2,158±355
Peleliu	2.67±0.29	1.46	4,064±684	2,330±537
Angaur	1.11±0.29	1.10	1,339±414	2,463±830
Total	1.00±0.07	1.72	18,531±2,135	21,697±3,212

Bridled Tern/Bedebedechakl (*Onychoprion anaethetus*). Indigenous breeder. Stable. The Bridled Tern is a widespread seabird that occurs in tropical and subtropical oceans throughout the world. In Palau it nests on cliffs of larger limestone islands and forages primarily in offshore pelagic waters. Bridled Terns were observed only in the Rock Islands in 1991 and 2005, where their preferred nest sites on limestone cliffs are most prevalent. The higher relative abundance in 2005 was caused by the addition of transect 39 in the Ngerukuid Islands, where abundance of this species was highest, and which was not surveyed in 1991. Only 15 terns were detected in 2005, 11 of which (73%) were in the Ngerukuid Islands. In 1991 there was insufficient data to estimate population size. The population estimate in 2005 should be interpreted with caution due to the small number of detected individuals and large standard error.

Relative abundance and population size estimates (mean±SE) of Bridled Terns in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0	0	0	-
Rock Islands	0.15±0.06	0.03	1,960±1,866	-
Peleliu	0	0	0	-
Angaur	0	0	0	-
Total	0.024±0.009	0.004	1,960±1,866	-

Black-naped Tern/Kerkirs (*Sterna sumatrana*). Indigenous resident. The Black-naped Tern occurs in the tropical western Pacific and Indian Oceans. It appears to be resident in Palau, nesting in loose colonies on rocky coastal cliffs and small islets. It forages for small fish over nearshore waters, often over the reef crest, and probably also forages farther offshore. There was no evidence of any change in distribution or abundance since 1991; the number of birds observed per station was remarkably similar in 1991 and 2005. Black-naped Terns were fairly common in the Rock Islands in 1991 and 2005. In 2005, a small number of Black-naped Terns were observed in Airai State in southern Babeldaob. There were insufficient data in 1991 and 2005 to estimate population size, and these surveys were not designed for coastal species like the Black-naped Tern.

Relative abundance and population size estimates (mean±SE) of Black-naped Terns in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.002±0.002	0	-	-
Rock Islands	0.42±0.11	0.37	-	-
Peleliu	0	0	-	-
Angaur	0	0	-	-
Total	0.068±0.018	0.058	-	-

Nicobar Pigeon/Laib (*Caloenas nicobarica pelewensis*). Endemic subspecies. Increasing. The Nicobar Pigeon is found from Southeast Asia, Indonesia, and the Philippines, to New Guinea and the Solomon Islands, primarily on smaller offshore islands. The subspecies *pelewensis* is endemic to Palau. It is listed under the Palau Endangered Species Act and is considered near threatened by the International Union for the Conservation of Nature (IUCN 2006). It was once petitioned for listing under the U.S. Endangered Species Act but is no longer considered a candidate for listing. The main threats to this species are hunting, disturbance to nesting colonies, and loss of coastal forest nesting habitat to development (del Hoyo et al. 1997). Nicobar Pigeons are strong fliers and are frequently observed flying high over open water as they commute between islands.

Comparison of data from 1991 and 2005 showed a large increase in relative abundance and a small but statistically insignificant increase in population size (Tables 5 and 6). On Babeldaob, the relative abundance was 10 times higher in 2005 than in 1991 and the population size was twice as high. Both measures showed positive trends in the Rock Islands too, but the increases were smaller. Only a single Nicobar Pigeons was observed on Peleliu in 1991; more were detected in 2005 but the population was still small. They were not observed on Angaur during either survey. The Nicobar Pigeon was relatively easy to detect because of its large size and habit of flying high over open water among islands. Abundance of this species appears to have increased but the overall population size in Palau is small. Nicobar Pigeons exhibited a lower detection rate near observers, suggesting they avoided the observer, and the best models included a truncation of the data to account for this variation. Truncation of distance data was not possible in 1991 and the population could have been underestimated, so the comparisons should be done with caution.

The Rock Islands are the stronghold of this species in Palau, but numbers increased on Babeldaob and Peleliu, where this species was formerly rare. Abundance was highest in the Ngerukuid Islands, which are the most protected region in Palau. Nicobar Pigeons are hunted for food because of their large size, and it is possible that the primary cause of the population increase has been a ban by the Palauan government on possession of firearms other than air rifles. The restriction on use of shotguns likely has decreased effective hunting pressure on Nicobar Pigeons, which are often difficult to approach closely. Continued protection of this species is still warranted because its population size is small in Palau and elsewhere and because it is sensitive to disturbance around nesting colonies (del Hoyo et al. 1996).

Relative abundance and population size estimates (mean±SE) of Nicobar Pigeons in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.10±0.03	0.01	311±114	134±63
Rock Islands	1.00±0.15	0.51	962±228	588±140
Peleliu	0.13±0.05	0.01	23±21	0
Angaur	0	0	0	0
Total	0.24±0.03	0.09	1,296±274	722±203

Palau Ground Dove/Omekrengukl (*Alopecoenas canifrons*). Endemic. Stable? The Palau Ground-dove is listed as endangered under the Palau Endangered Species Act and is considered near threatened by the International Union for the Conservation of Nature (IUCN 2006). It was formerly listed as endangered under the U.S. Endangered Species Act (USFWS 1970) but was delisted because it was thought to be a naturally rare species with a small but stable population (USFWS 1985).

There were no differences in relative abundance or population size of the Palau Ground in 1991 and 2005, but abundance of this species was difficult to measure because of its rarity and cryptic behavior. During surveys in 2005, only four ground-doves were observed, two on Babeldaob on transects 10 and 19, and two on Peleliu on transects 31 and 32. Three of the four detections were visual, which is unusual because forest birds are typically detected much more often by sound than sight. The deep, cooing call of the Palau Ground-dove is fairly soft and difficult to detect at a distance, and it is also possible observers did not recognize the calls. Abundance was somewhat lower on Peleliu in 2005 than in 1991, but the power to detect changes in abundance of this species was low because it was observed so rarely. The two detections on Babeldaob were in more remote areas farther from human development. Several other detections on transects 8 and 16 on Babeldaob were initially recorded as ground-doves, but the validity of those observations was questionable. They were all of calls described as similar to a yelping call made by the Mariana Ground-dove and were at distances up to 200 meters. The Palau Ground-dove is not known to make such a yelping call, and its soft cooing calls are not audible 200 meters away. It would be worth following up on these observations to ascertain whether ground-doves actually do occur in these areas, but they have not been counted as ground-dove records in this analysis.

Ground-doves were not detected on the Rock Islands or on Angaur in 1991 or 2005, but they are reported to occur on these islands by Engbring (1992). Two ground-doves were seen in an area of coastal strand forest on the southeast side of Peleliu where no transects were located, and ground-doves were found to be fairly common, or at least easily observed, in a coastal area of Ulong Island on 7 May 2005.

Relative abundance and population size estimates (mean±SE) of Palau Ground-doves in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.005±0.004	0.005	139±214	99±76
Rock Islands	0	0	0	0
Peleliu	0.03±0.02	0.08	74±100	65±32
Angaur	0	0	0	0
Total	0.006±0.003	0.01	213±289	164±108

Palau Fruit Dove/Biib (*Ptilinopus pelewensis*). Endemic. Stable? The Palau Fruit-dove is endemic to Palau and is ubiquitous throughout the archipelago. Fruit-doves are difficult to see in the dense forest canopy, but their reverberating calls are one of the characteristic sounds in the forests of Palau. Fruit-doves were abundant in 1991 and 2005 on all islands except Angaur, where they were uncommon. Comparison of data from 1991 and 2005 yielded conflicting results, with a decrease in relative abundance but an increase in population size. Relative abundance was consistently lower on all islands in 2005. Population size was larger in 2005 only on Babeldaob, which supported the majority of the species because of its large size. These conflicting data suggest there was a difference between 1991 and 2005 in observer proficiency or analytical methods, or both. In 2005, observers were instructed to focus on less common species and closer individuals first. The number of fruit-doves may have been underestimated at stations with many birds if there was insufficient time to record all individuals. This would account for both the lower relative abundance and the higher density. It is also possible that the more sophisticated analytical methods available today resulted in higher population sizes. This species exhibited a lower detection rate near the observer, suggesting it avoided the observer, and the best model included truncation of the data to account for this. Truncation of distance data was not possible in 1991, which may have resulted in an underestimate of the population. The distribution of detections was unusual for this species, with similar numbers of detections close and far from the observer. This pattern made it harder to fit a detection function and may have resulted in less reliable population estimates. Palau Fruit Doves are hunted by humans for food, and it is possible that there have been local declines in fruit dove abundance. On Babeldaob the decline could be associated with loss of forest habitat favored by fruit-doves, but on Peleliu and the Rock Islands the cause of this apparent decline is not clear. Continued monitoring of the status of this species is warranted.

Relative abundance and population size estimates (mean±SE) of Palau Fruit-doves in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	4.99±0.12	6.84	64,802±3,644	40,503±2,940
Rock Islands	2.70±0.23	6.88	3,695±409	3,456±329
Peleliu	2.88±0.19	6.67	1,778±166	2,977±391
Angaur	0.26±0.11	0.43	47±29	44±16
Total	4.10±0.11	6.45	70,322±3,811	46,980±3,677

Micronesian Imperial Pigeon/Belochel (*Ducula oceanica monacha*). Endemic subspecies Stable? The Micronesian Imperial Pigeon is widespread in Micronesia, with different subspecies in Palau and Yap, Chuuk, Pohnpei, Kosrae, and the Marshall Islands. It formerly occurred in

Kiribati on Kuria and Aranuka but has been extirpated. Populations on Chuuk and in the Marshall Islands are very small and highly endangered. The Micronesian Imperial Pigeon is closely related to the Pacific Imperial Pigeon, which occurs from islands off New Guinea east through Melanesia to the Cook Islands in western Polynesia, and to the Polynesian Imperial-pigeon, which is rare in eastern Polynesia on Makatea in the Tuamotu Group and Tahiti in the Society Islands. Hunting is the primary threat to imperial pigeons in all these areas, but loss of forest habitat to development is a problem in some areas, such as Chuuk. The IUCN recently upgraded the status of the Micronesian Imperial-pigeon to near threatened due to population declines of greater than 30% in some areas. Continued monitoring of this species is warranted.

During surveys in 1991 and 2005, Micronesian Pigeons were fairly common on Babeldaob and the Rock Islands, rare on Peleliu, and absent on Angaur. Comparison of data from 1991 and 2005 yielded conflicting patterns, with a decline in relative abundance and an increasing but statistically insignificant trend in population size (Tables 5 and 6). On Babelaob, Micronesian Pigeons were common in more remote areas farther from human populations but were less common on transects near towns and roads, suggesting the decline may be due to hunting pressure. Populations appear to be stable on Babeldaob and Peleliu but have significantly declined in the Rock Islands. The cause of the decline in relative abundance and population size in the Rock Islands, where no hunting is allowed, is not clear. It is worth noting that in 2005, 20% of Micronesian Pigeon detections in the Rock Islands were in the Ngerukuid Islands, which were not surveyed in 1991. Thus, the decline in the Rock Islands from 1991 to 2005 probably has been more severe than indicated by the data. Like other pigeon species, Micronesian Imperial Pigeons exhibited a lower detection rate near observers and the best models included a truncation of the data to account for this variation. Truncation of distance data was not possible in 1991, which may have resulted in underestimates of the population size, so comparisons should be done with caution.

Relative abundance and population size estimates (mean±SE) of Micronesian Imperial Pigeons in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	1.05±0.07	1.21	17,346±1,944	12,057±1,148
Rock Islands	1.06±0.14	2.72	938±147	1,647±210
Peleliu	0.05±0.03	0.03	60±42	14±9
Angaur	0	0	0	0
Total	0.87±0.05	1.22	18,344±1,959	13,718±1,367

Palau Swiftlet/Chebacheb (***Aerodramus pelewensis***). **Endemic. Stable/locally increasing.** The Palau Swiftlet is endemic to Palau. It is closely related to the Guam or Mariana Swiftlet (*A. bartchi*) of the Mariana Islands, the Mossy-nest Swiftlet (*A. salangana*) of Indonesia, the Uniform Swiftlet (*A. vanikorensis*) of New Guinea, the Philippines, and nearby islands, and the Caroline Swiftlet (*A. inquietus*) of Chuuk, Kosrae, and Pohnpei. These species were formerly considered conspecific, and they and other species from various Pacific islands are often merged into the genus *Callocalia*. Swiftlets were common and widespread on all the larger islands in Palau. Comparison of data from 1991 and 2005 showed that both the relative abundance and population size were stable overall. However, the surveys revealed that swiftlets have expanded their range and increased in southern Palau. On Peleliu, the abundance and population size more than doubled from 1991 to 2005. Swiftlets were not observed on Angaur in 1991, but a few were detected in 2005, though the population was small.

Relative abundance and population size estimates (mean±SE) of Palau Swiftlets in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.82±0.11	0.72	56,384±10,499	40,978±6,554
Rock Islands	1.06±0.16	1.07	4,783±852	1,049±224
Peleliu	0.85±0.19	0.40	2,404±675	901±288
Angaur	0.03±0.03	0	99±101	0
Total	0.82±0.08	0.69	63,671±10,728	42,928±7,066

Collared Kingfisher/Tengadidik (*Todiramphus chloris teraokai*). Endemic subspecies. Stable/Increasing. The Collared Kingfisher is a widespread species that occurs from the Red Sea east to the central Pacific. The subspecies *T. c. teraokai* is endemic to Palau, where it is common on all the larger islands. It is found in a variety of habitats, including coastlines, mangroves, forest edge, savanna, and suburban areas, but it is less common in dense forest than the Rusty-capped Kingfisher. Comparison of data from 1991 and 2005 showed that relative abundance remained stable and that population size increased on Babeldaob. The Collared Kingfisher was especially common on Angaur, with this island accounting for 31% of detections in 2005. This species exhibited a lower than expected detection rate near the observer and the best model included a truncation of the data to account for this. The population estimate for 2005 therefore may be more accurate, and the estimate for 1991, which did not involve truncation, may be an underestimate, so comparisons should be interpreted with caution.

Relative abundance and population size estimates (mean±SE) of Collared Kingfishers in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.30±0.03	0.29	5,727±884	2,155±326
Rock Islands	0.31±0.06	0.31	429±150	324±94
Peleliu	0.92±0.12	1.07	1,332±277	995±212
Angaur	2.86±0.27	1.88	1,227±197	965±243
Total	0.52±0.04	0.49	8,716±1,030	4,439±875

Rusty-capped Kingfisher/Cherosech (*Todiramphus pelewensis*). Endemic. Stable. This species is endemic to Palau and was formerly considered a subspecies of the Micronesian Kingfisher, along with the Guam Kingfisher (*T. cinnamominus*) and Pohnpei Kingfisher (*T. reichenbachii*). The Rusty-capped Kingfisher occurs on Babledaob, the larger Rock Islands, and Peleliu, primarily in densely forested areas (Engbring 1992, Pratt and Etpison 2008). The relative abundance and population size remained stable overall from 1991 to 2005, though both measures increased on Peleliu and decreased on the Rock Islands. This species and others that inhabit forest interior may be more difficult to detect from a boat, and abundance in the Rock Islands may be higher than indicated by these surveys. Estimates for Peleliu and the Rock Islands in 2005 should be interpreted with caution because they were based on just six and four detections, respectively.

Relative abundance and population size estimates (mean±SE) of Rusty-capped Kingfishers in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.13±0.02	0.13	3,763±847	3,343±669
Rock Islands	0.04±0.02	0.21	167±91	433±125
Peleliu	0.08±0.03	0.02	186±86	29±22
Angaur	0	0	0	0
Total	0.10±0.01	0.12	4,117±891	3,805±816

Greater Sulphur-crested Cockatoo/Iakkotsiang (*Cacatua galerita triton*). Alien. Stable. The Greater Sulphur-crested Cockatoo is native to New Guinea and eastern and northern Australia. The subspecies introduced to Palau is from New Guinea. This is a popular species in the pet trade worldwide and caged birds are still found in Palau. The large size and extremely loud calls of this species make it easy to detect over long distances, but the actual population in Palau is quite small. The overall abundance and population size showed no change from 1991 to 2005 but there were some local changes in distribution and abundance. In the Rock Islands, cockatoos declined somewhat but were still fairly common, with flocks of up to 11 birds seen in 2005. In 2005 a single bird was heard from two consecutive stations on transect 17 in Aimeliik State in central Babeldaob. Calls of this species were also heard on several stations on transect 23 in Airai State in southern Babeldaob, but a caged bird was observed at a house near the final station on the transect, so none of the detections were counted in analyses. No cockatoos were observed on Babeldaob in 1991.

Relative abundance and population size estimates (mean±SE) of Greater Sulphur-crested Cockatoos in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.005±0.003	0	10±6	0
Rock Islands	0.63±0.19	0.72	68±24	117±26
Peleliu	0	0	0	0
Angaur	0	0	0	0
Total	0.10±0.03	0.11	79±25	117±26

Eclectus Parrot/Iakkotsiang (*Eclectus roratus*). Alien. Stable. The Eclectus Parrot is native to New Guinea and nearby islands and was introduced to Palau by humans. This species exhibits a rare form of reverse sexual dichromatism, where females have bright blue and red plumage and males are green. Eclectus parrots are also unique in that they breed polyandrously or polygynandrously, likely driven by nest hollow selection (Heinsohn 2008). Eclectus Parrots are easy to detect due to their loud calls. There were no changes in its distribution, relative abundance, or population size from 1991 to 2005, indicating this alien species is not spreading and its population is stable. The population is small, but the exact size is difficult to estimate because of the small number of detections. It was detected only in the Rock Islands, only and 17 and 9 parrots were detected in 1991 and 2005, respectively. No more than two birds were detected at any station.

Relative abundance and population size estimates (mean±SE) of Eclectus Parrots in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0	0	0	0
Rock Islands	0.09±0.03	0.16	25±356	99±31
Peleliu	0	0	0	0
Angaur	0	0	0	0
Total	0.02±0.01	0.02	25±356	99±31

Micronesian Myzomela/Chesisebangiau (*Myzomela rubrata kobayashii*). Endemic subspecies. Increasing. This species, also known as the Micronesian Honeyeater, is widespread in Micronesia, with different subspecies in Palau, Yap (*M. r. kurodai*), the Mariana Islands (*M. r. saffordi*), Chuuk (*M. r. major*), Pohnpei (*M. r. dichromata*), and Kosrae (*M. r. rubrata*). In Palau, it is common on all the larger islands and is frequently observed in a variety of habitats, including secondary forest, mangroves, forest edge, agroforet, plantations, and suburban areas, but it is reported to be less common in tall primary forest (Engbring 1992, Pratt and Etpison 2008). Comparison of data from 1991 and 2005 showed an increase in both relative abundance and population size of myzomelas (Tables 5 and 6). The population increased in all four regions, with the largest increase on Babeldaob (138%) and the Rock Islands (448%). The increase in abundance of this species likely is related to its ability to use disturbed habitats. Increasing development and road construction, particularly on Babeldaob, has increased the amount of disturbed habitat such as forest edge, agroforest, and suburban areas. However, myzomelas exhibited a lower than expected detection rate near the observer, indicating they avoided the observer, and the best models included a truncation of the data to account for this. Truncation of distance data was not included in 1991 and the population may have been underestimated, which could account for some of the apparent increase.

Relative abundance and population size estimates (mean±SE) of Micronesian Myzomelas in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	1.07±0.06	0.59	124,372±9,635	52,113±5,895
Rock Islands	0.96±0.16	1.00	9,640±1,634	1,758±282
Peleliu	1.73±0.11	1.41	8,915±797	4,983±864
Angaur	0.66±0.23	0.48	1,827±626	838±285
Total	1.11±0.05	0.75	144,755±10,143	59,692±7,326

White-breasted Woodswallow/Mengaluliu (*Artamus leucorynchus pelewensis*). Endemic subspecies. Status uncertain. The White-breasted Woodswallow occurs from Malaysia and the Philippines to Australia and Indonesia, with resident endemic subspecies in Palau and Fiji. In Palau, it is rare and occurs primarily in savanna habitat and forest edge in northern Babeldaob and the Rock Islands (Pratt and Etpison 2008, Belau National Museum 2019). It was once a candidate for listing under the U.S. Endangered Species Act but is no longer considered a candidate. This species is easily detected because it occurs in open savanna habitat and often perches on bare branches and wires. There are many areas in Palau with seemingly suitable savanna habitat where this species does not occur.

The population trend of this species is difficult to determine because it is so rare. In 1991, only a single wood-swallow was observed during the surveys, on transect 18, too few to allow estimation of the population size. In 2005, the total population was estimated to be only 73±67, making it Palau's rarest resident bird. This estimate was calculated from only three observations and thus should be interpreted with caution. In 2005, single wood-swallows were recorded on four occasions during surveys, at stations 10 and 11 on transect 4 (the same bird was visible from both stations perched on a utility wire), station 18 on transect 5, and station 6 on transect 9. On 26 April 2005, a group of five wood-swallows was observed near station 20 on transect 5 in Ngardmau State two days after the count. Four of the birds flew into the same tree and disappeared in dense foliage, and a single bird landed on the ground and pulled at grass stems, suggesting they may have been constructing a nest. Several other wood-swallows were observed incidentally in 1991, including one in the savanna above Lake Ngardok, a single bird along the edge of Ngeremeduu Bay, and a family group with two recently fledged young in southern Ngardmau. In 2019, a pair raised two young in the Rock Islands and up to five birds were seen in Ngeremlengui (Belau National Museum 2019). The cause of this species rarity and restricted distribution in Palau is not known. Surveys designed specifically for this species should be conducted to obtain more accurate estimates of its distribution and abundance.

Relative abundance and population size estimates (mean±SE) of White-breasted Woodswallows in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.010±0.005	0.001	73±67	-
Rock Islands	0	0	0	-
Peleliu	0	0	0	-
Angaur	0	0	0	-
Total	0.006±0.003	<0.001	73±67	-

Cicadabird/Kiuidukall (*Coracina tenuirostris monachum*). Endemic subspecies. Stable. The Cicadabird is a widespread species in the cuckoo-shrike family (Campephagidae) that occurs in Australia, Melanesia, and Micronesia. Endemic subspecies occur in Palau, Pohnpei (*C. t. insperatum*), and Yap (*C. t. nesiotis*). In Palau, Cicadabirds occur in forest and forest edge habitats on Babeldaob, the Rock Islands, and Peleliu. Comparison of data from 1991 and 2005 showed that the relative abundance remained stable on all islands, but that the population sizes may have increased. Similar numbers of Cicadabirds were detected on all islands in both surveys, but the population estimates were higher in 2005, possibly because of differences in analytical methods. In 2005, Cicadabirds exhibited a lower detection rate near the observer and the best model included a truncation of the data to account for this variation. Wind was also a significant factor impacting the detectability of Cicadabirds and was included in models. Truncation of distance data and wind were not used as covariates in 1991, which could have resulted in an underestimate of the population. An increase in the population could be due to the ability of Cicadabirds to utilize a variety of habitat types, including logged forests, and forest edge habitat.

Relative abundance and population size estimates (mean±SE) of Cicadabirds in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.22±0.03	0.21	19,823±3,469	11,384±1,853
Rock Islands	0.19±0.05	0.23	1,578±521	784±221
Peleliu	0.28±0.06	0.20	1,295±378	474±179

Angaur	0	0	0	0
Total	0.21±0.02	0.20	22,696±3,686	12,642±2,256

Morningbird/Tutau (*Colluricincla tenebrosa*). Endemic. Stable. The Morningbird is endemic to Palau and occurs in forested areas on most of the larger islands. It is most closely related to birds from New Guinea in the genus *Pitohui*, and it is sometimes placed in that genus (Pratt et al. 1987). The elaborate dawn song of the Morningbird explains how this drab species got its common name. During the day, Morningbirds may be difficult to detect because they forage quietly in the forest understory and are typically solitary (Pratt et al. 1980). Comparison of data from 1991 and 2005 showed that the relative abundance remained stable on all islands, but that the population size may have increased. However, the larger population estimate in 2005 may have been a result in differences in analytical methods available. In 2005, Cicadabirds exhibited a clear pattern of lower detection rates near the observer, indicating this shy species actively avoided the observer, and the best model included a truncation of the data to account for this. Truncation of distance data was not available in 1991 and thus estimates for 1991 may be less accurate than those from 2005.

Relative abundance and population size estimates (mean±SE) of Morningbirds in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.59±0.04	0.68	21,958±3,692	10,405±1,141
Rock Islands	0.28±0.06	0.26	661±163	825±219
Peleliu	0.37±0.07	0.43	1,097±294	670±170
Angaur	0	0	0	0
Total	0.48±0.03	0.54	23,717±3,828	11,900±1,530

Palau Fantail/ Melimdelebteb, Chesisirech (*Rhipidura lepida*). Endemic. Increasing. The Palau Fantail is endemic to Palau and occurs in a variety of habitats, including dense primary forest, secondary forest, forest edge, and suburban areas. It was formerly listed as endangered under the U.S. Endangered Species Act (USFWS 1970) but was delisted in 1985 (USFWS 1985). It is still included on the Palau list of endangered species. The relative abundance and population size of the Palau Fantail both increased from 1991 to 2005, indicating the status of this endemic species has improved. The largest increase occurred on Babeldaob. As with the Micronesian Myzomela, the increase in abundance of this species probably is related to its ability to use disturbed habitats and the increase in development that occurred in Palau during this time period, particularly on Babeldaob. Fantails were reported to be scarce on Peleliu in 1951 (Baker 1951) but in 2005 they were most abundant on that island. Fantails were absent from Angaur in 1991 and 2005. Fantails had lower detection rates near the station and the best model included truncation of data close to the observer, but they are not shy, suggesting they sometimes may have avoided the area near the station because it did not have suitable habitat. Wind was also a significant factor impacting the detection of fantails, likely because its soft calls were more difficult to detect during windy conditions. Neither wind nor truncation of data close to the observer were available in 1991, so population estimates from 1991 may be less accurate and comparisons to 2005 and should be interpreted with caution.

Relative abundance and population size estimates (mean±SE) of Palau Fantails in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.41±0.04	0.17	58,929±6,657	20,963±4,425
Rock Islands	0.39±0.07	0.90	6,801±1,409	3,091±722
Peleliu	1.24±0.13	0.87	9,763±1,395	3,100±649
Angaur	0	0	0	0
Total	0.48±0.03	0.36	75,493±7,407	27,154±5,796

Palau Flycatcher/ Charmelachull. (*Myiagra erythrops*). Endemic. Increasing. The Palau Flycatcher is endemic to Palau and occurs on most of the larger islands in a variety of habitats, including dense forest, mangroves, secondary forest, forest edge, and suburban areas. It is sometimes called Mangrove Flycatcher and is reported to be particularly numerous in mangroves (Pratt et al. 1987, Engbring 1992). The relative abundance and population size of the Palau Flycatcher both increased from 1991 to 2005, indicating the status of this endemic species has improved. This species exhibited increasing trends similar to those of the Palau Fantail but generally was more numerous, and its increase in abundance also probably is related to its ability to use a wide range of habitat types and tolerance of human activity. Similar to fantails, flycatchers had lower detection rates near the station and the best model included truncation of data close to the observer to obtain more accurate estimates of population size. Flycatchers are not shy, suggesting they sometimes may have avoided the area near the station because it did not have suitable habitat. The estimates from 1991, when truncation of data was not available, may be less accurate and comparisons to 2005 and should be interpreted with caution.

Relative abundance and population size estimates (mean±SE) of Palau Flycatchers in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	1.07±0.05	0.65	90,852±6,722	39,179±4,476
Rock Islands	0.96±0.10	2.14	7,543±957	4,728±629
Peleliu	0.96±0.10	0.59	5,043±682	2,347±763
Angaur	0	0	0	0
Total	0.98±0.04	0.83	103,438±7,070	46,254±5,867

Palau Bush Warbler/Wuul, Chesisebarsech (*Horornis annae*). Endemic. Increasing. The Palau Bush-warbler is endemic to Palau and is common on most of the larger islands that have forest habitat. Its distinctive call is commonly heard in many forested areas, but it is secretive and not easily seen, usually remaining hidden in thick undergrowth and dense forest understory. Vocalizations appear to exhibit some seasonality, with lower call rates in the winter. Bush warblers were observed on Babeldaob, in the Rock Islands, and in Peleliu, but were absent from Angaur. Both measures of abundance were higher in 2005 than in 1991. The relative abundance increased on Babeldaob but decreased in the Rock Islands and Peleliu. The estimated population size was larger on all islands in 2005.

Relative abundance and population size estimates (mean±SE) of Palau Bush-warblers in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	2.16±0.08	1.27	59,605±2,935	14,984±1,342
Rock Islands	1.09±0.13	2.77	4,096±611	2,673±345

Peleliu	3.37±0.16	3.66	4,358±339	3,864±461
Angaur	0	0	0	0
Total	2.02±0.07	1.73	68,059±3,158	21,521±2,148

Giant White-eye/Charmbedel (*Megaosterops palauensis*). Endemic. Stable. The Giant White-eye, also sometimes known as the Palau Greater White-eye or Large Palau White-eye (Pratt et al. 1987, Engbring 1992), is endemic to Palau. It is found only on Peleliu and on Ngeruktabel in the Rock Islands. It is strangely absent from the other Rock Islands, even those between Peleliu and Ngeruktabel. It is a noisy and conspicuous bird that often forms small flocks, sometimes mixed with Citrine White-eyes and Dusky White-eyes. This species uses a variety of habitats including dense forest and scrub. As in the past, Giant White-eyes were found only on Peleliu and Ngeruktabel. Comparison of data from 1991 and 2005 showed an increase in both measures on Peleliu but a decrease in the relative abundance in the Rock Islands. Overall, the species appears to be stable or possibly increasing. Part of the decrease in numbers in the Rock Islands may have caused by addition of transect 39 in the Ngerukuid Islands, where this species does not occur. Giant White-eyes appeared to avoid observers, with lower detection rates near the observer. Wind was also a significant factor impacting the detection of the species. Observations of the Giant White-eye were more clumped than those of other species, particularly on Peleliu. Population size estimates from clumped data should be interpreted with caution.

Relative abundance and population size estimates (mean±SE) of Giant White-eyes in Palau in 1991 and 2005, by island.

Island	**Relative abundance (birds/station)**		**Population size**	
	2005	**1991**	**2005**	**1991**
Babeldaob	0	0	0	0
Rock Islands	0.49±0.10	1.23	3,838±1,022	4,049±705
Peleliu	4.01±0.29	3.40	25,925±2,883	9,827±1,056
Angaur	0	0	0	0
Total	0.57±0.06	0.62	29,764±3,099	13,876±2,212

Citrine White-eye/Charmbedel (*Zosterops s. semperi*). Endemic subspecies. Stable. This species was formerly known as the Caroline Islands White-eye and is endemic to central Micronesia, with different forms currently regarded as subspecies in Palau, Chuuk (*Z. s. owstoni*), and Pohnpei (*Z. s. takatsukasai*). In Palau it occurs on all the larger islands except Angaur (Pratt et al. 1987, Engbring 1992). This small, active forest bird forages in a variety of forested and second-growth habitats. It often forms flocks, sometimes mixed with Dusky White-eyes and Giant White-eyes.

Comparison of data from 1991 and 2005 yielded conflicting results, but overall the species appears to be stable. Relative abundance was lower overall in 2005, but with variation among regions. Abundance was stable on Babeldaob, lower in the Rock Islands, and higher on Peleliu. Population size was somewhat higher in 2005 than in 1991 but the difference was not statistically significant. Citrine White-eyes were generally more common in southern and central Babledaob and were not observed on three of nine transects in northern Babeladob. Abundance on Peleliu was much higher in 2005 than in 1991 and the species clearly has increased on that island. In the Rock Islands abundance was particularly high on transect 39 in the Ngerukuid Islands, which accounted for 25% of all detections in the Rock Islands, but in other areas of the Rock Islands there was a decline from 1991 to 2005. Abundance of several bird species was much lower in the Rock Islands in 2005, and the cause for these apparent declines is unknown.

The calls of this species are similar to those of the Dusky White-eye and both species sometimes occurred in mixed flocks. It was sometimes difficult to distinguish their calls and determine how many birds of each species were present, especially in larger flocks. It is possible that the abundance of Citrine White-eyes, which were generally less numerous than Dusky White-eyes, was underestimated. Like Giant White-eyes, Citrine White-eyes appeared to avoid observers, with lower detection rates near the observer. Wind was also a significant factor impacting the detection of the species, likely because its calls are soft. Observations of the Citrine White-eye were more clumped than those of other species, which was not surprising because of its flocking behavior.

Relative abundance and population size estimates (mean±SE) of Citrine White-eyes in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.36±0.05	0.34	83,974±11,272	27,820±4,829
Rock Islands	1.30±0.18	3.25	7,537±1,580	6,975±1,229
Peleliu	0.69±0.13	0.04	3,688±894	567±373
Angaur	0	0	0	0
Total	0.53±0.05	0.73	55,199±11,592	35,362±6,431

Dusky White-eye/Chetitalial (*Zosterops finschii*). Endemic. Stable. The Dusky White-eye is endemic to Palau and occurs on all the larger islands except Angaur. It is found in a variety of forested habitats, including primary forest, secondary forest, and forest edges. It is gregarious and often forms mixed species flocks with Caroline Island White-eyes and Giant White-eyes. These flocks are noisy and conspicuous, but they can move quickly and the size of the flock can be difficult to determine in dense forest canopy.

Comparison of data from 1991 and 2005 yielded conflicting results, with a decrease in relative abundance on all islands but an increase in population size on all islands. All evidence combined indicates the species probably is stable. The Dusky White-eye was common in 2005 even where there was some evidence of a decline in relative abundance, and it is one of the most numerous bird species in Palau. The largest flock observed contained 17 birds and was found on Babeldaob. Like other white-eye species, observations of Dusky White-eyes were more clumped than those of other species, and population size estimates from clumped data should be interpreted with caution. Like Citrine and Giant White-eyes, Dusky White-eyes appeared to avoid observers, with lower detection rates near the observer, and wind was a significant factor impacting the detection of the species.

Relative abundance and population size estimates (mean±SE) of Dusky White-eyes in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	3.37±0.15	3.48	313,316±18,810	137,382±11,238
Rock Islands	1.41±0.18	3.23	9,736±1,480	6,011±902
Peleliu	2.63±0.26	2.96	12,320±1,278	6,922±1,396
Angaur	0	0	0	0
Total	2.78±0.11	3.17	335,372±19,121	150,315±13,536

Micronesian Starling/Kiuid (*Aplonis opaca*). Indigenous resident. Stable. The Micronesian Starling occurs in much of western and central Micronesia, from Palau and the Mariana Islands east to Kosrae. It is one of the most common bird species in Palau and occurs on all the larger islands. It is an adaptable species and is common in almost all habitats, including urban and suburban areas. It is noisy and conspicuous and often gathers in large flocks. Micronesian Starlings were common or abundant and widely distributed on all islands and were particularly abundant on Angaur. Comparison of data from 1991 and 2005 showed that the species is stable overall, but with some geographic variation. Relative abundance declined on Angaur and the Rock Islands but increased on Babeldaob and Peleliu. Like several other species, Micronesian Starlings exhibited a lower detection rate near the observer and the best model included truncation of the data to account for this variation. Starlings are not shy, and this likely occurred because starlings sometimes avoided the area near the station because it did not contain suitable habitat, such as a road. Because data truncation was not available for analyses in 1991 the resulting population estimates may be lower and less accurate, which could partially account for the lower population estimates in 1991. Like white-eyes, observations of starlings were more clumped, with flocks of up to 16 birds detected. Population size estimates from clumped data should be interpreted with caution.

Relative abundance and population size estimates (mean±SE) of Micronesian Starlings in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	2.85±0.15	2.27	201,729±14,827	152,568±12,983
Rock Islands	1.65±0.15	3.52	8,172±928	6,327±753
Peleliu	2.11±0.17	1.55	6,903±726	3,652±711
Angaur	5.77±0.38	8.90	10,595±1,033	13,662±3,095
Total	2.73±0.11	2.76	227,400±15,492	176,209±17,542

Blue-faced Parrotfinch/no known Palauan name (*Erythrura trichroa*). Indigenous resident. Status uncertain. The Blue-faced Parrot-finch is a widespread species that occurs from northern Australia and Indonesia east through Melanesia to Micronesia, where it occurs in Palau, Chuuk, Pohnpei and Kosrae (Pratt et al. 1987). In Palau it is found only in areas with limestone, from southern Babeldaob, where it is rare, south to the Rock Islands (Pratt et al. 1987, Engbring 1992). Parrotfinches occur in dense forest on steep limestone islands but are often seen in coastal *Casuarina* forest because that habitat is more easily accessible and more frequently visited. They are difficult to detect because of their small size, soft, high-pitched calls, and frequent use of the forest canopy. This species often occurs in small flocks or family groups. It is included on the Palau list of endangered species and was once petitioned for listing under the U.S. Endangered Species Act but is no longer considered a candidate.

The population trend of this species was difficult to determine because of the small number of detections (Tables 5 and 6), but all evidence combined indicates that the species probably is stable. Parrot-finches were not recorded on Babeldaob in 1991 or 2005, but only a single transect was located in the limestone area of Babeldaob, which occurs only in the very southeastern part of the island. Relative abundance decreased in the Rock Islands, where 23 individuals were detected in 1991 but only four in 2005. Three birds were observed at station 7 on transect 25 on Ulebsechel Island and one bird was observed at station 4 on transect 26 on Ngeruktabel, outside of the survey period. Population size estimates should be interpreted with caution, particularly for 2005, because estimates were based on only three birds that were all close in distance to the observer. In 2005, eight Blue-faced Parrotfinches were detected on Peleliu while none were detected on that island in 1991. Individuals were documented on transects 31 along the northern shore of Peleliu at stations 3, 5, 7, and 16. This apparent range expansion to Peleliu is significant considering the rarity and restricted distribution of the species in Palau. The high population estimate in 2005 (10,567±14,118) is not realistic. The inflated size and very large standard error resulted because three of the four individuals detected during surveys were very close to the observer.

We observed parrot-finches on several occasions outside the standardized surveys and these anecdotal observations indicate the species is more widespread than suggested by the surveys. These observations include: one and two birds in *Casuarina* trees at the north tip of Ngermalk Island between Koror and Malakal on 28 April and 10 May, three feeding in a large fruiting *Ficus* tree on the outskirts of Kloulklubed village, Peleliu, on 3 May, three feeding in *Casuarina* trees in southwestern Peleliu on 5 May, four feeding in *Casuarina* trees on Ngermeaus Island on 5 May, five including one begging juvenile feeding in a large fruiting *Ficus* tree on Ulong Island on 6 May, and two in a large *Casuarina* tree on the grounds of the former Nikko Hotel in eastern Koror on 7 May. More focused surveys for Blue-faced Parrotfinches are needed to obtain accurate estimates of abundance. Surveys should focus on limestone habitat and *Casuarina* forests and be performed by experienced observers.

Relative abundance and population size estimates (mean±SE) of Blue-faced Parrot-finches in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0	0	0	0
Rock Islands	0.04±0.03	0.21	10,567±14,118	1,023±308
Peleliu	0.11±0.06	0	288±357	0
Angaur	0	0	0	0
Total	0.02±0.01	0.03	10,855±14,117	1,023±308

Chestnut Munia/ Kanaria (*Lonchura atricapilla*). Alien. Increasing. The Chestnut Munia is native to Southeast Asia from India to the Philippines and Indonesia and was introduced to Palau by humans, probably as an escaped cage bird. It was first recorded in Palau in 1951 (Engbring 1992). It is found primarily in disturbed open areas with tall grass, often along roadsides and in urban and suburban areas. Chestnut Munias increased substantially from 1991 to 2005. Munias were not detected in the Rock Islands or on Angaur but they were fairly common on Peleliu and Babeldaob. Both the relative abundance and population size were higher in 2005 than in 1991. On Babeldaob, munias were particularly numerous on transects 4, 20, and 23 in areas of tall grass that had been created during construction of the Compact Road. The largest flock observed during standardized counts contained 25 birds, but larger flocks estimated to contain over 50 birds were observed at other times outside the count periods. The increase of this alien bird in Palau since 1991 is related to increased prevalence of its preferred habitat, open grassy areas along roadsides. Like white-eye species, observations of Chestnut Munias were clumped because of their flocking behavior.

Relative abundance and population size estimates (mean±SE) of Chestnut Munias in Palau in 1991 and 2005, by island.

Island	Relative abundance (birds/station)		Population size	
	2005	1991	2005	1991
Babeldaob	0.69±0.12	0.29	65,578±12,109	33,266±6,981
Rock Islands	0	0	0	0
Peleliu	0.44±0.17	0.28	1,929±976	650±236
Angaur	0	0	0	0
Total	0.51±0.08	0.23	67,506±12,266	33,916±7,218

RECOMMENDATIONS FOR FUTURE SURVEYS AND MONITORING

The survey results from 2005 are now 15 years old and it would be beneficial to repeat the surveys again to provide more current information. Below are some recommendations for improving the existing survey methods and for additional methods that could be useful for monitoring the status of birds in Palau.

Timing of Surveys. The dates on which surveys were conducted were very similar in 1991 (17 April to 22 May) and 2005 (25 April to 12 May), so any differences in abundance of birds between the surveys probably is not the result of differences in timing of surveys. Timing of future surveys should remain generally similar in order to avoid confounding effects of seasonal variation in bird abundance and detectability. However, surveys probably could be conducted one or two weeks earlier to help avoid rainy weather that becomes more common in May. In May 2005, one day of surveys in the Rock Islands was completely lost to persistent rain, and on another day surveys were done intermittently between rain showers, which may have caused lower bird activity and resulted in low counts at some stations. Nests of several species were observed during counts, including Palau Fantail, Palau Flycatcher, and Morningbird, indicating the nesting season was underway and bird activity likely had started to increase before the surveys began. Abundance of migratory birds also would be higher in April than in May, and although migratory species are not the focus of these surveys, information about migratory species could be gathered simultaneously.

Frequency and Scale of Surveys. Conducting a complete survey of the 39 transects throughout Palau is labor intensive and expensive. It probably will not be feasible, or necessary, to conduct such a large-scale survey every year. Conducting a survey once every five probably would be sufficient, unless the results indicate declines are occurring in certain species or areas that warrant more frequent or intensive survey effort to determine the cause(s). These large-scale surveys could be complemented by more frequent surveys of particularly important or sensitive areas, such as the Rock Islands and Peleliu, or for species of particular concern, such as Palau Ground-dove, Micronesian Megapode, and Micronesian Pigeon. Frequency and scale of surveys likely will depend on the people and resources available to conduct surveys, and efforts should be made to secure resources in advance of when they will be needed.

Survey Locations. The distribution of transects used in 2005 provided good coverage in most areas of Palau, and the addition of three transects since 1991 improved the coverage. Addition of transect 39 in the Ngerukuid Islands was a particularly important improvement because that area proved to contain high abundance of many species. A few more changes would further improve the surveys, and other changes in number and location of transects may become warranted as development continues in Palau and conditions change.

Since 2005, 14 permanent bird survey stations have been established in the Rock Islands, including seven stations that are monitored monthly (Euidelchol, Ulong, Jellyfish Lake Merechar, Ngchus, Ngeanges, Ngemelis, and Ngeremdiu) and seven stations that are monitored semi-annually (Babelomekang, Kmekumer, Mecherachar, Ngerchong, Ngeruktabel, Ngerukiuid and Ulebsechel; Belau National Museum 2019). These additional transects have provided more detailed information about the abundance of several important bird species (Belau National Museum 2019). Consideration should be given to adding some or all these stations to future nation-wide surveys like those conducted in 1991 and 2005.

Peleliu also contained important populations of several species, including Micronesian Megapode, Palau Ground-dove, Blue-faced Parrot-finch, Giant White-eye, and Slaty-legged Crake, and bird abundance was generally high throughout the island. Some transects on Peleliu are probably less suitable now than in 1991 because the roadways they follow have been widened and paved in some cases. The roads now occupy more space on these transects, resulting in less forest habitat and presumably lower bird abundance in the immediate vicinity of stations. The coastal strand forest along the southeastern coast of Peleliu supported relatively high densities of Micronesian Megapodes and Palau Ground-doves were observed twice in this area, but none of the existing transects encompass this area. In 2005 there was a little-used dirt road running through this forest approximately 100 meters from the shore, and a transect could be added along this route to improve coverage on Peleliu.

Species of Special Interest. Several bird species in Palau are of special interest because they are endemic to Palau, are rare or have a restricted distribution within Palau, or there is evidence they are threatened or declining. The status of some of these species, such as the Giant White-eye and Micronesian Imperial-pigeon, can be adequately assessed with current survey methods. For other species that are rarer, such as Palau Ground-dove and White-breasted Woodswallow, other survey methods are needed to complement the point counts. For still other species the point-count survey methods used in 1991 and 2005 may not be appropriate due to the behavior of the species, and other survey methods may be needed to be developed.

The **Palau Ground-dove** is of special concern because it is endemic to Palau, is rare, and is included on the Palau endangered species list. Ground-doves are difficult to detect because they are found primarily in dense forest, are shy, and their soft call is not easily heard over long distances. Few ground-doves were recorded during point count surveys, resulting in insufficient data to adequately assess the species' status. Efforts to monitor the status of ground-doves should focus on areas known to support ground-dove populations, such as Ulong and Peleliu. Increasing the number or frequency of transects in these areas would improve monitoring efforts. Anecdotal reports of ground-doves should be followed up to determine whether they are valid and how many birds may be present in the area.

The **Nicobar Pigeon** is of special concern because it is listed as endangered under the Palau Endangered Species Act and is considered near threatened by the International Union for the Conservation of Nature (IUCN 2006). Nicobar Pigeons are hunted in some parts of the world and are sensitive to disturbance, and there is evidence populations are declining in some parts of its range (del Hoyo et al. 1997). Abundance of this species in Palau appears to have increased since 1991, making Palau a globally important area for this species. The existing surveys methods are adequate for monitoring this species, but they could be supplemented with other methods. For example, if the locations of roost sites are known, morning or evening counts at selected vantage points might be an effective means of identifying flight paths and important nesting and feeding areas.

The **Micronesian Imperial Pigeon** is also a species of special concern because population declines have been documented in many parts of its range. Its status was recently upgraded to near threatened by the International Union for the Conservation of Nature (Birdlife International 2016). Micronesian Pigeons are hunted for food in Palau, and nestlings are sometimes taken to raise in captivity. The current survey methods are adequate for monitoring this species, but additional analyses that examine trends at a finer scale would help to assess whether it is declining in proximity to human habitation.

The **White-breasted Woodswallow** is rare in Palau and occurs in only a few areas of savanna habitat on Babeldaob. This species is easily detected because it occurs in open habitat and often perches conspicuously, but very few birds were recorded during point counts because it is so rare, and insufficient information was collected during surveys to adequately assess its status. All observations of wood-swallows are important and should be followed up to determine how many birds may be present in the area and what they are doing. Special surveys designed for wood-swallows could be conducted by thoroughly searching savanna habitat. Initially such surveys would not necessarily have to follow prescribed survey routes and would not require stations to be established. Once locations with wood-swallow birds are found, those locations could be systematically searched each year to determine whether the number of birds has changed.

Population assessment for the **Micronesian Megapode** could be enhanced by counts of active incubation mounds, which have been used by researchers previously (Wiles and Conry 2001, Radley et al. 2020). These mounds are an obvious clue to the presence of megapodes and counting the number of active mounds might provide at least an index of megapode abundance and would allow collection of information on frequency of nest predation.

The **Palau Owl** is included on the Palau endangered species list and was once listed under the U.S. Endangered Species Act. A few Palau owls were heard during the earliest point counts in 2005, but the status of this species was not adequately assessed by surveys in 1991 or 2005 due to its nocturnal behavior. Assessing the status of the Palau Owl will require special surveys that are conducted at night when the owls are active. Some or all of the same transects and stations could be used, but counts must be made at night. Many owl species are most vocal just after dusk and just before dawn, and these might be the best times to conduct point counts. The same surveys likely could be used to assess the status of the Jungle Nightjar.

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Figure 1. Map of Palau showing the locations and numbers of bird survey transects and islands mentioned in the text.

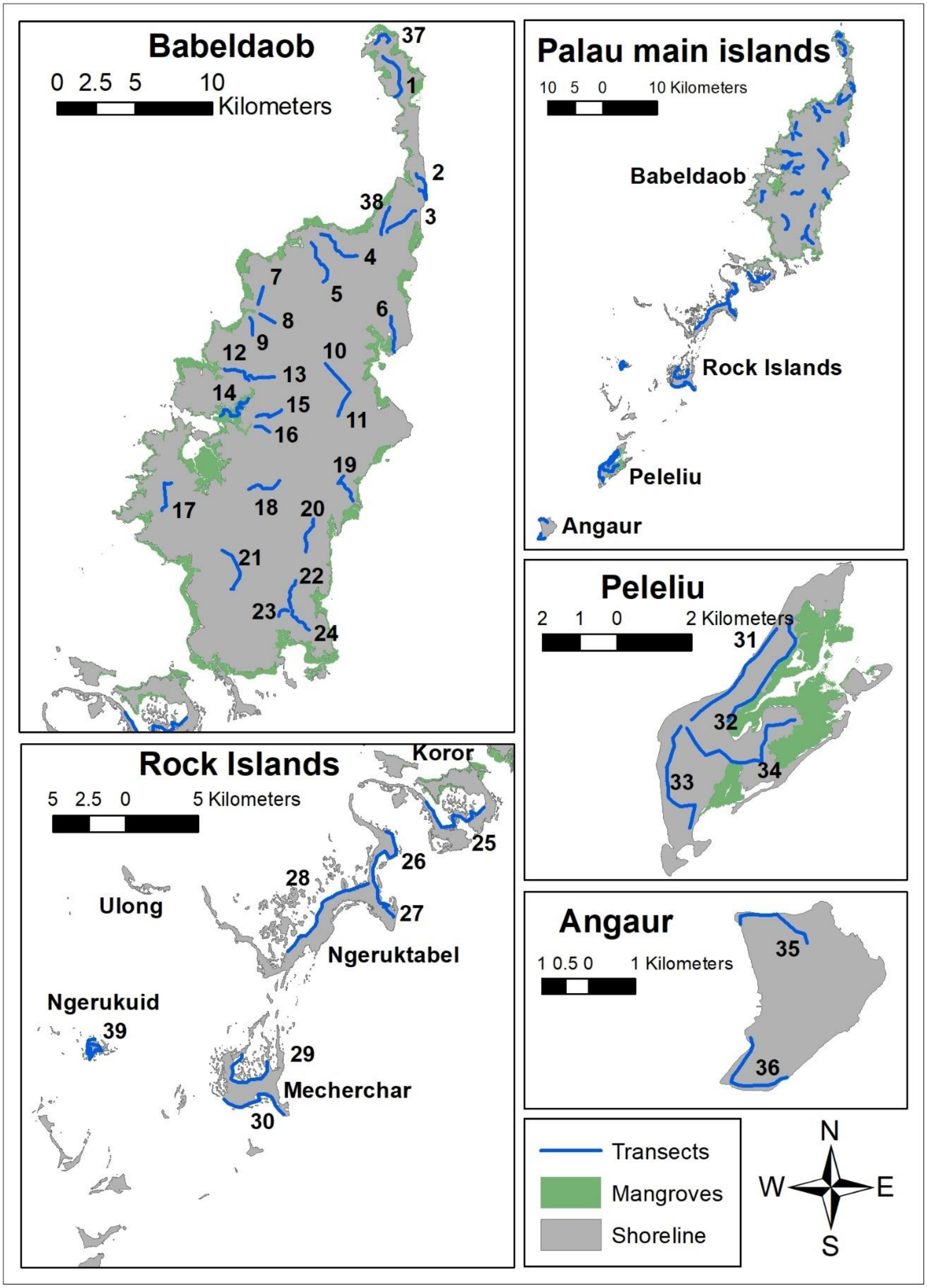

Table 1. Summary of transects used during Palau bird surveys in 2005. Transect numbers are the same as those used by Engbring (1992). Asterisks (*) indicate new transects added in 2005.

Transect #	Island	Date surveyed	# Stations	Primary counter	Secondary counter
1	Babeldaob	Apr 25	20	Gary	Anu
2	Babeldaob	Apr 25	18	Melia	Julian
3	Babeldaob	Apr 26	15	Gary	Anu
4	Babeldaob	Apr 26	17	Eric	Jerry
5	Babeldaob	Apr 26	20	Annie	Butler
6	Babeldaob	May 1	19	Gary	Anu
7	Babeldaob	Apr 29	12	Gary	Julian
8	Babeldaob	Apr 29	13	Annie	Melia
9	Babeldaob	Apr 29	15	Eric	Jerry
10	Babeldaob	May 2	15	Eric	Jerry
11	Babeldaob	May 2	15	Gary	Anu
12	Babeldaob	May 1	15	Melia	Butler
13	Babeldaob	May 2	13	Annie	Julian
14	Babeldaob	Apr 27	20	Gary	Julian
15	Babeldaob	Apr 27	17	Eric	Jerry
16	Babeldaob	Apr 26	14	Annie	Butler
17	Babeldaob	Apr 30	19	Eric	Jerry
18	Babeldaob	Apr 24	18	Annie/Melia	Butler
19	Babeldaob	May 2	19	Melia	Butler
20	Babeldaob	Apr 24	18	Melia	Anu
21	Babeldaob	Apr 30	18	Annie	Anu
22	Babeldaob	May 5	15	Melia	Julian
23	Babeldaob	Apr 24	11	Eric	Julian
24	Babeldaob	Apr 24	12	Gary	-
25	Rock Islands- Koror+ Ulebsechel	May 8	17	Eric	Gary
26	Rock Islands- Ngeruktabel	May 9	18	Gary	Anu
27	Rock Islands- Ngeruktabel	May 9	10	Eric	(Gary)
28	Rock Islands- Ngeruktabel	May 11	17	Eric	Gary
29	Rock Islands- Mecherchar	May 4	12	Gary	Butler
30	Rock Islands- Mecherchar	May 5	14	Eric	Jerry
31	Peleliu	May 5	17	Annie	Anu
32	Peleliu	May 5	18	Gary	Butler
33	Peleliu	May 4	18	Annie	Anu
34	Peleliu	May 4	22	Eric	Jerry
35	Angaur	May 6	19	Melia	Julian
36	Angaur	May 7	16	Melia	Julian
37*	Babeldaob	Apr 25	10	Eric	-
38*	Babeldaob	Apr 26	11	Melia	Julian
39*	Rock Islands- Ngerukuid	May 12	10	Melia	Julian

Table 2. Palau Island areas (square kilometers) used to calculate population sizes by extrapolation of density estimates for each bird species in 1991 and 2005. Areas in 2005 were produced from GIS layers and include land area above the mean shoreline and mangrove areas.

Island	**1991**	**2005**		
		Above shoreline	**Mangroves**	**Total**
Babeldaob	366.4	326.7	36.0	362.7
Rock Islands	44.2	46.6	0.1	46.7
Peleliu	14.8	13.3	4.3	17.6
Angaur	8.3	8.1	0.0	8.1
Total	433.7	396.5	40.4	436.8

Table 3. Habitat types and codes used in surveys.

Code	**Habitat Type**
UP	Upland Native Primary Forest
SW	Swamp Forest
G	Grassland/Savanna
M	Mangrove
SV	Secondary Vegetation/Forest
MF	Marsh
LF	Limestone Forest
AG	Agroforest
U	Urban
BE	Beach and Strand Forest

Table 4. Definitions of visibility codes used in surveys.

Code	**Definition**
1	Dense forest with complete canopy and thick understory. Visibility 15 m or less in all directions.
2	Forest with relatively complete canopy and open understory. Visibility 15-50 m in all directions.
3	Like #2, but more open, visibility over 50 m in 5-20% of area surrounding observer.
4	Open or scattered forest or shrubland, or mixed forest and open field. Visibility over 50 m in 20-50% of area surrounding observer.
5	Open field or nearly open field. Visibility 50 m or more in over 50% of area surrounding observer.

Table 5. Comparisons of relative abundance of bird species in Palau in 1991 and 2005. Trend determined by 1-sample t-test; ↑ = increase, ↓ = decrease, NC = no change, * = trend significant at p = 0.05, ** = trend significant at p = 0.01, - = insufficient data for comparison.

Species	2005 #birds detected	2005 Incidence (# / % of stations)	2005 Rel. abundance (mean±SE birds/station)	1991 Rel. abundance (mean birds/station)	Trend
Banded Rail	65	41 / 6.7%	0.11±0.02	0.045	↑*
Barn Swallow	3	2 / 0.3%	0.005±0.003	0	-
Black Noddy	422	185 / 30%	0.68±0.06	1.65	↓**
Black-naped Tern	42	18 / 3%	0.068±0.018	0.058	NC
Blue-faced Parrotfinch	12	6 / 1%	0.019±0.009	0.032	NC
Bridled Tern	15	9 / 1.5%	0.024±0.009	0.004	↑*
Brown Noddy	115	79 / 13%	0.19±0.022	1.17	↓**
Cattle Egret	14	10 / 1.6%	0.022±0.008	0.014	NC
Chestnut Mannikin	314	78 / 13%	0.51±0.08	0.23	↑**
Cicadabird	129	104 / 17%	0.21±0.02	0.20	NC
Citrine White-eye	325	133 / 22%	0.53±0.05	0.72	↓**
Collared Kingfisher	320	180 / 29%	0.52±0.04	0.49	NC
Common Sandpiper	8	7 / 1.1%	0.012±0.005	0.001	NC
Dusky White-eye	1,714	426 / 69%	2.78±0.11	3.17	↓**
Eclectus Parrot	9	8 / 1.3%	0.015±0.005	0.024	NC
Giant White-eye	349	94 / 15%	0.57±0.06	0.62	NC
Great Crested Tern	4	4 / 0.7%	0.006±0.003	0	-
Greater Sulphur-crested Cockatoo	64	26 / 4.2%	0.10±0.03	0.11	NC
Grey-streaked Flycatcher	2	2 / 0.3%	0.003±0.002	0	-
Grey-tailed Tattler	2	2 / 0.3%	0.003±0.002	0	-
Intermediate Egret	6	6 / 1%	0.010±0.004	0	-
Little Pied Cormorant	2	2 / 0.3%	0.003±0.002	0.007	NC
Micronesian Imperial Pigeon	537	255 / 41%	0.87±0.05	1.22	↓**
Micronesian Megapode	27	22 / 3.6%	0.044±0.010	0.055	NC
Micronesian Myzomela	683	358 / 58%	1.11±0.05	0.75	↑**
Micronesian Starling	1,687	496 / 80%	2.73±0.11	2.76	NC
Morningbird	297	203 / 33%	0.48±0.03	0.54	NC
Nicobar Pigeon	148	73 / 12%	0.24±0.03	0.087	↑**
Oriental Cuckoo	1	1 / 0.2%	0.001±0.001	0	-
Pacific Golden-plover	3	3 / 0.5%	0.005±0.003	0.003	NC
Pacific Reef-heron	12	8 / 1.3%	0.019±0.007	0.034	NC
Palau Bush-warbler	1,244	470 / 76%	2.02±0.07	1.73	↑**
Palau Fantail	297	201 / 33%	0.48±0.03	0.36	↑**
Palau Flycatcher	604	364 / 59%	0.98±0.04	0.83	↑**
Palau Fruit-dove	2,530	551 / 89%	4.10±0.11	6.45	↓**
Palau Ground-dove	4	4 / 0.6%	0.006±0.003	0.013	NC
Palau Owl	6	4 / 0.6%	0.010±0.006	0	-
Palau Swiftlet	504	195 / 32%	0.82±0.08	0.69	NC
Purple Swamphen	3	2 / 0.3%	0.005±0.004	0.003	NC

Red Junglefowl	305	169 / 27%	0.49±0.05	0.55	NC
Rufous Night-heron	13	10 / 1.6%	0.021±0.007	0.006	NC
Rusty-capped Kingfisher	64	55 / 9%	0.10±0.01	0.12	NC
Slaty-legged Crake	15	14 / 2.2%	0.024±0.006	0.068	↓**
Wandering Tattler	2	1 / 0.2%	0.003±0.003	0	-
Whimbrel	4	1 / 0.2%	0.006±0.006	0.003	NC
White Tern	615	229 / 37%	1.00±0.07	1.73	↓**
White-breasted Woodswallow	4	4 / 0.6%	0.006±0.003	0.001	NC
White-tailed Tropicbird	100	62 / 10%	0.16±0.02	0.11	NC
Yellow Bittern	6	5 / 0.8%	0.010±0.005	0.004	NC
Yellow Wagtail	36	18 / 2.9%	0.06±0.02	0.003	↑**
Unknown bird species	60	46 / 7.5%	0.10±0.02	-	-
Total all bird species	14,050	-	22.7±0.33	31.9	-

Table 6. Comparisons of density and population size estimates of birds in Palau in 1991 and 2005. Trend determined by 2-sample t-test; ↑ = increase, ↓ = decrease, NC = no change, * = trend significant at p = 0.05, ** = trend significant at p = 0.01, - = insufficient data for comparison. Blank = population not estimated. Values are mean ± SE. Density units are birds/km^2.

Species	2005 #birds detected	Density (birds/km^2)		Population size		t-value	Trend
		2005 (mean±SE)	1991 (mean)	2005 (mean±SE)	1991 (mean±SE)		
Banded Rail	57	20.86±10.47	1.70	9,070±4,558	724±323	1.37	NC
Black Noddy	421	39.16±3.99	42.00	17,041±1,735	18,219±2,674	0.36	NC
Blue-faced Parrotfinch	11	24.94±32.44	2.40	10,855±14,117	1,023±308	1.02	NC
Bridled Tern	14	4.50±4.29	-	1,960±1,866	-	-	-
Brown Noddy	118	19.70±6.82	18.70	8,575±2,968	8,107±1,827	0.11	NC
Cattle Egret	10	1.68±2.54	-	730±1,104	-	-	-
Chestnut Mannikin	315	155.12±28.19	78.20	67,506±12,266	33,916±7,218	2.17	↑*
Cicadabird	120	52.15±8.47	29.10	22,696±3,686	12,642±2,256	2.43	↑*
Citrine White-eye	317	126.84±26.64	81.50	55,199±11,592	35,362±6,431	1.62	NC
Collared Kingfisher	315	20.03±2.37	10.20	8,716±1,030	4,439±875	3.18	↑*
Dusky White-eye	1,682	770.62±43.94	346.60	335,372±19,121	150,315±13,536	8.13	↑**
Eclectus Parrot	4	0.06±0.82	0.22	25±356	99±31	0.21	NC
Giant White-eye	346	68.39±7.12	32.00	29,764±3,099	13,876±2,212	4.18	↑**
Greater Sulphur-crested Cockatoo	40	0.18±0.06	0.30	79±25	117±26	0.93	NC
Micronesian Imperial Pigeon	516	42.15±4.50	31.60	18,344±1,959	13,718±1,367	1.98	NC
Micronesian Megapode	23	1.61±0.71	1.10	700±308	497±291	0.45	NC
Micronesian Myzomela	669	332.62±23.31	137.60	144,755±10,143	56,692±7,326	6.48	↑**
Micronesian Starling	1,666	522.52±35.60	406.30	227,400±15,492	176,209±17,542	2.15	↑*
Morningbird	291	54.50±8.80	27.40	23,717±3,828	11,900±1,530	3.14	↑*
Nicobar Pigeon	117	2.98±0.63	1.70	1,296±274	722±203	1.42	NC
Palau Bush-warbler	1,227	156.39±7.26	49.60	68,059±3,158	21,521±2,148	12.18	↑**
Palau Fantail	287	173.47±17.02	62.60	75,493±7,407	27,154±5,796	5.04	↑**
Palau Flycatcher	602	237.68±16.25	106.60	103,438±7,070	46,254±5,867	6.21	↑**
Palau Fruit-dove	2,472	161.59±8.76	108.30	70,322±3,811	46,980±3,677	4.07	↑**
Palau Ground-dove	3	0.49±0.66	0.40	213±289	164±108	0.20	NC
Palau Swiftlet	497	146.30±24.65	99.00	63,671±10,728	42,928±7,066	1.61	NC
Red Junglefowl	293	13.04±3.76	3.40	5,676±1,635	1,495±219	2.91	↑*
Rusty-capped Kingfisher	55	9.46±2.05	8.80	4,117±891	3,805±816	0.25	NC
Slaty-legged Crake	10	0.80±0.32	4.90	348±141	2,132±532	2.52	↓*
White Tern	615	42.17±4.91	50.00	18,351±2,135	21,697±3,212	0.70	NC
White-breasted Woodswallow	3	0.17±0.15	-	73±67	-	-	-
White-tailed Tropicbird	95	4.14±1.03	1.70	1,804±450	734±219	1.97	↑*
Yellow Wagtail	20	19.5±1.38	-	850±600	-	-	-

Appendix 1. Relative abundance of bird species in Palau in 1991 by island. Calculated from Engbring (1992).

Species	Species code	Anguar		Babeldaob		Peleliu		Rock Islands		Total	
		# detected	relative abundance	# detected	relative abundance	# detected	relative abundance	# detected	relative abundance	# detected	relative abundance
Banded Rail	BARA	4	0.10	6	0.01	22	0.24	0	0.00	32	0.05
Barn Swallow	BASW	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Blue-faced Parrotfinch	BFPA	0	0.00	0	0.00	0	0.00	23	0.21	23	0.03
Black Noddy	BLNO	7	0.17	235	0.50	164	1.83	765	7.10	1171	1.65
Black-naped Tern	BNTE	0	0.00	1	0.00	0	0.00	40	0.37	41	0.06
Brown Noddy	BRNO	22	0.52	216	0.46	44	0.49	545	5.06	827	1.17
Bridled Tern	BRTE	0	0.00	0	0.00	0	0.00	3	0.03	3	0.00
Cattle Egret	CAEG	0	0.00	10	0.02	0	0.00	0	0.00	10	0.01
Chestnut Mannikin	CHMA	0	0.00	138	0.29	25	0.28	0	0.00	163	0.23
Cicadabird	CICA	0	0.00	99	0.21	18	0.20	25	0.23	142	0.20
Caroline Islands White-eye	CIWE	0	0.00	161	0.34	4	0.04	350	3.25	515	0.73
Collared Kingfisher	COKI	79	1.88	138	0.29	96	1.07	33	0.31	346	0.49
Common Sandpiper	COSA	0	0.00	1	0.00	0	0.00	0	0.00	1	0.00
Dusky White-eye	DWEY	0	0.00	1633	3.48	266	2.96	348	3.23	2247	3.17
Eclectus Parrot	ECPA	0	0.00	0	0.00	0	0.00	17	0.16	17	0.02
Greater Sulphur-crested Cockatoo	GSCC	0	0.00	1	0.00	0	0.00	78	0.72	79	0.11
Giant White-eye	GWEY	0	0.00	0	0.00	305	3.40	133	1.23	438	0.62
Little Pied Cormorant	LPCO	0	0.00	1	0.00	0	0.00	0	0.00	1	0.00
Micronesian Honeyeater	MIHO	20	0.48	275	0.59	127	1.41	108	1.00	530	0.75
Micronesian Kingfisher	MIKI	0	0.00	60	0.13	2	0.02	23	0.21	85	0.12
Micronesian Megapode	MIME	14	0.33	4	0.01	3	0.03	18	0.17	39	0.06
Micronesian Imperial Pigeon	MIPI	0	0.00	566	1.21	3	0.03	293	2.72	862	1.22
Micronesian Starling	MIST	373	8.90	1067	2.27	139	1.55	379	3.52	1958	2.76
Morningbird	MORN	0	0.00	317	0.68	39	0.43	28	0.26	384	0.54
Nicobar Pigeon	NIPI	0	0.00	6	0.01	1	0.01	55	0.51	62	0.09
Palau Bush-warbler	PABW	0	0.00	596	1.27	329	3.66	299	2.77	1224	1.73
Palau Fantail	PAFA	0	0.00	78	0.17	78	0.87	97	0.90	253	0.36
Palau Fruit-dove	PAFD	18	0.43	3212	6.84	599	6.67	742	6.88	4571	6.45
Palau Flycatcher	PAFL	0	0.00	303	0.65	53	0.59	231	2.14	587	0.83
Palau Ground-dove	PGDO	0	0.00	2	0.00	7	0.08	0	0.00	9	0.01

Species	Species code	Anguar		Babeldaob		Peleliu		Rock Islands		Total	
		# detected	relative abundance	# detected	relative abundance	# detected	relative abundance	# detected	relative abundance	# detected	relative abundance
Pacific Golden Plover	PGPL	0	0.00	2	0.00	0	0.00	0	0.00	2	0.00
Pacific Reef Heron	PRHE	0	0.00	4	0.01	0	0.00	20	0.19	24	0.03
Purple Swamphen	PUSW	0	0.00	2	0.00	0	0.00	0	0.00	2	0.00
Red Junglefowl	REJU	13	0.31	315	0.67	55	0.61	8	0.07	391	0.55
Rufous Night-heron	RNHE	0	0.00	0	0.00	0	0.00	4	0.04	4	0.01
Slaty-legged Crake	SLCR	0	0.00	37	0.08	11	0.12	0	0.00	48	0.07
Palau Swiftlet	SWIF	0	0.00	337	0.72	36	0.40	115	1.07	488	0.69
White-breasted Woodswallow	WBWO	0	0.00	1	0.00	0	0.00	0	0.00	1	0.00
Whimbrel	WHIM	0	0.00	2	0.00	0	0.00	0	0.00	2	0.00
White Tern	WHTE	46	1.10	658	1.40	131	1.46	388	3.60	1223	1.72
White-tailed Tropicbird	WTTR	3	0.07	16	0.03	3	0.03	53	0.49	75	0.11
Yellow Bittern	YEBI	0	0.00	2	0.00	1	0.01	0	0.00	3	0.00
Yellow Wagtail	YEWA	0	0.00	1	0.00	1	0.01	0	0.00	2	0.00

Appendix 2. Relative abundance of bird species in Palau in 2005 by island. Incidence is the proportion of stations at which a species was recorded. Relative abundance is the mean±SE number of birds recorded at each station.

Species	Species code	Anguar		Babeldaob		Peleliu		Rock Islands		Total		
		incidence	relative abundance	incidence	relative abundance	incidence	relative abundance	incidence	relative abundance	# detected	Incidence	relative abundance
Banded Rail	BARA	0.14	0.23±0.10	0.05	0.08±0.02	0.21	0.33±0.09	0	0	65	0.07	0.11±0.02
Barn Swallow	BASW	0	0	0.005	0.007	0	0	0	0	3	0.003	0.005±0.003
Blue-faced Parrotfinch	BFPA	0	0	0	0	0.05	0.11±0.06	0.02	0.04±0.03	12	0.01	0.019±0.0009
Black Noddy	BLNO	0.03	0.03±0.03	0.13	0.17±0.03	0.87	2.33±0.21	0.66	1.79±0.21	422	0.30	0.68±0.06
Black-naped Tern	BNTE	0	0	0.002	0.002±0.002	0	0	0.17	0.42±0.11	42	0.03	0.068±0.018
Brown Noddy	BRNO	0.03	0.03±0.03	0.08	0.12±0.02	0.20	0.24±0.06	0.30	0.48±0.09	115	0.13	0.19±0.022
Bridled Tern	BRTE	0	0	0	0	0	0	0.09	0.15±0.06	15	0.02	0.024±0.009
Cattle Egret	CAEG	0	0	0.02	0.03±0.01	0.01	0.01±0.01	0	0	14	0.02	0.022±0.008
Chestnut Mannikin	CHMA	0	0	0.16	0.69±0.12	0.15	0.44±0.17	0	0	314	0.13	0.51±0.08
Cicadabird	CICA	0	0	0.17	0.22±0.03	0.24	0.28±0.06	0.16	0.19±0.05	129	0.17	0.21±0.02
Citrine White-eye	CIWE	0	0	0.15	0.36±0.05	0.32	0.69±0.13	0.48	1.30±0.18	325	0.22	0.53±0.05
Collared Kingfisher	COKI	0.94	2.86±0.27	0.20	0.30±0.03	0.53	0.92±0.12	0.24	0.31±0.06	320	0.29	0.52±0.04
Common Sandpiper	COSA	0	0	0.05	0.01±0.01	0.07	0.07±0.03	0	0	8	0.01	0.012±0.005
Dusky White-eye	DWEY	0	0	0.78	3.37±0.15	0.73	2.63±0.26	0.51	1.41±0.18	1,714	0.69	2.78±0.11
Eclectus Parrot	ECPA	0	0	0	0	0	0	0.08	0.09±0.03	9	0.01	0.02±0.01
Greater Sulphur-crested Cockatoo	GSCC	0	0	0.005	0.005±0.003	0	0	0.25	0.63±0.19	64	0.04	0.10±0.03
Giant White-eye	GWEY	0	0	0	0	0.96	4.01±0.29	0.22	0.49±0.10	349	0.15	0.57±0.06
Little Pied Cormorant	LPCO	0	0	0	0	0.03	0.03±0.02	0	0	2	0.003	0.003±0.002
Micronesian Imperial Pigeon	MIPI	0	0	0.49	1.05±0.07	0.04	0.05±0.03	0.53	1.06±0.14	537	0.41	0.87±0.05
Micronesian Megapode	MIME	0.17	0.26±0.10	0.01	0.01±0.01	0.05	0.05±0.03	0.07	0.09±0.04	27	0.04	0.044±0.010
Micronesian Myzomela	MIHO	0.31	0.66±0.23	0.56	1.07±0.06	0.91	1.73±0.11	0.50	0.96±0.16	683	0.58	1.11±0.05
Micronesian Starling	MIST	1.00	5.77±0.38	0.80	2.85±0.15	0.84	2.11±0.17	0.73	1.65±0.15	1,687	0.80	2.73±0.11
Morningbird	MORN	0	0	0.38	0.59±0.04	0.33	0.37±0.07	0.21	0.28±0.06	297	0.33	0.48±0.03
Nicobar Pigeon	NIPI	0	0	0.05	0.10±0.03	0.11	0.13±0.05	0.47	1.00±0.15	148	0.12	0.24±0.03
Palau Bush-warbler	PABW	0	0	0.84	2.16±0.08	0.93	3.37±0.16	0.56	1.09±0.13	1,244	0.76	2.02±0.07
Palau Fantail	PAFA	0	0	0.29	0.41±0.04	0.71	1.24±0.13	0.31	0.39±0.07	297	0.33	0.48±0.03
Palau Fruit-dove	PAFD	0.17	0.26±0.11	0.97	4.99±0.12	0.91	2.88±0.19	0.81	2.70±0.23	2,530	0.89	4.10±0.11
Palau Flycatcher	PAFL	0	0	0.62	1.07±0.05	0.67	0.96±0.10	0.62	0.96±0.10	604	0.59	0.98±0.04
Palau Ground-dove	PGDO	0	0	0.005	0.005±0.004	0.03	0.03±0.02	0	0	4	0.006	0.006±0.003

Species	Species code	Anguar		Babeldaob		Peleliu		Rock Islands		Total		
		incidence	relative abundance	incidence	relative abundance	incidence	relative abundance	incidence	relative abundance	# detected	Incidence	relative abundance
Palau Swiftlet	SWIF	0.03	0.03±0.03	0.29	0.82±0.11	0.35	0.85±0.19	0.49	1.06±0.16	504	0.32	0.82±0.08
Pacific Golden Plover	PGPL	0	0	0.002	0.002±0.002	0.03	0.03±0.02	0	0	3	0.005	0.005±0.003
Pacific Reef Heron	PRHE	0	0	0	0	0	0	0.08	0.12±0.04	12	0.01	0.019±0.007
Purple Swamphen	PUSW	0	0	0.002	0.002±0.002	0.01	0.03±0.02	0	0	3	0.003	0.005±0.004
Red Junglefowl	REJU	0.29	0.40±0.13	0.36	0.66±0.07	0.19	0.28±0.08	0	0	305	0.27	0.49±0.05
Rufous Night-heron	RNHE	0.06	0.06±0.04	0.01	0.01±0.004	0.01	0.01±0.01	0.03	0.06±0.04	13	0.02	0.021±0.007
Rusty-capped Kingfisher	MIKI	0	0	0.11	0.13±0.02	0.08	0.08±0.03	0.04	0.04±0.02	64	0.09	0.10±0.01
Slaty-legged Crake	SLCR	0	0	0.01	0.01±0.01	0.12	0.13±0.04	0	0	15	0.02	0.024±0.006
White-breasted Woodswallow	WBWO	0	0	0.010	0.010±0.005	0	0	0	0	4	0.006	0.006±0.003
Whimbrel	WHIM	0	0	0.002	0.01±0.01	0	0	0	0	4	0.002	0.006±0.006
White Tern	WHTE	0.37	1.11±0.29	0.24	0.44±0.05	0.76	2.67±0.29	0.64	2.00±0.26	615	0.37	1.00±0.07
White-tailed Tropicbird	WTTR	0.03	0.03±0.03	0.03	0.05±0.02	0.2	0.25±0.06	0.33	0.62±0.12	100	0.10	0.16±0.02
Yellow Bittern	YEBI	0	0	0.01	0.01±0.01	0	0	0.01	0.01±0.01	6	0.008	0.010±0.005
Yellow Wagtail	YEWA	0	0	0.04	0.07±0.03	0.04	0.05±0.03	0	0	36	0.03	0.06±0.02

Appendix 3. Population density and size estimates of bird species in Palau in 1991 by island. From Engbring (1992). SE = standard error.

Species		Anguar			Babeldaob			Peleliu			Rock Islands			Total		
	Species code	Dens.	Pop. size	Pop SE	Dens.	Pop. size	Pop SE	Dens.	Pop. size	Pop SE	Dens.	Pop. size	Pop SE	Dens.	Pop. size	Pop SE
Banded Rail	**BARA**	15	125	78	0	153	89	30	446	156	0	0	0	1.70	724	323
Blue-faced Parrotfinch	**BFPA**	0	0	0	0	0	0	0	0	0	23	1023	308	2.40	1,023	308
Black Noddy	**BLNO**	3	28	18	22	8,105	1,182	168	2,491	482	172	7,595	992	42.00	18,219	2,674
Brown Noddy	**BRNO**	158	1,311	629	10	3,692	725	15	223	66	65	2,881	406	18.70	8,107	1,827
Bridled Tern	**BRTE**															
Chestnut Munia	**CHMA**	0	0	0	91	33,266	6,981	44	650	236	0	0	0	78.20	33,916	7,218
Cicadabird	**CICA**	0	0	0	31	11,384	1,853	32	474	179	18	784	0	29.10	12,642	2,256
Citrine White-eye	**CIWE**	0	0	0	76	27,820	4,829	38	567	373	158	6,975	1,229	81.50	35,362	6,431
Collared Kingfisher	**COKI**	116	965	243	6	2,155	326	67	995	212	7	324	94	10.20	4,439	875
Dusky White-eye	**DWEY**	0	0	0	375	137,382	11,238	468	6,922	1,396	136	6,011	902	346.60	150,315	13,536
Eclectus Parrot	**ECPA**	0	0	0	0	0	0	0	0	0	2	99	31	0.20	99	31
Greater Sulphur-crested Cockatoo	**GSCC**	0	0	0	0	0	0	0	0	0	3	117	0	0.30	117	0
Giant White-eye	**GWEY**	0	0	0	0	0	0	664	9,827	1,506	92	4,049	705	32.00	13,876	2,212
Micronesian Imperial Pigeon	**MIPI**	0	0	0	33	12,057	1,148	1	14	9	37	1,647	210	31.60	13,718	1,367
Micronesian Megapode	**MIME**	12	97	43	1	244	173	3	52	41	2	104	34	1.10	497	291
Micronesian Myzomela	**MIHO**	101	838	285	142	52,113	5,895	337	4,983	864	40	1,758	282	137.60	59,692	7,326
Micronesian Starling	**MIST**	1,646	13,662	3,095	416	152,568	12,983	247	3,652	711	143	6,327	753	406.30	176,209	17,542
Morningbird	**MORN**	0	0	0	28	10,405	1,141	45	670	170	19	825	219	27.40	11,900	1,530
Nicobar Pigeon	**NIPI**	0	0	0	1	134	63	0	0	0	13	588	140	1.70	722	203
Palau Bush-warbler	**PABW**	0	0	0	41	14,984	1,342	261	3,864	461	60	2,673	345	49.60	21,521	2,148
Palau Fantail	**PAFA**	0	0	0	57	20,963	4,425	209	3,100	649	70	3,091	722	62.60	27,154	5,796
Palau Flycatcher	**PAFL**	0	0	0	107	39,179	4,476	159	2,347	763	107	4,728	629	106.60	46,254	5,867
Palau Fruit-dove	**PAFD**	5	44	16	111	40,503	2,940	201	2,977	391	78	3,456	329	108.30	46,980	3,677
Palau Ground-dove	**PGDO**	0	0	0	1	99	76	4	65	32	0	0	0	0.40	164	108
Palau Swiftlet	**SWIF**	0	0	0	112	40,978	6,554	61	901	288	24	1,049	224	99.00	42,928	7,066
Red Junglefowl	**REJU**	6	51	21	3	1,212	131	14	215	60	0	17	7	3.40	1,495	219
Rusty-capped Kingfisher	**MIKI**	0	0	0	9	3,343	669	2	29	22	10	433	125	8.80	3,805	816
Slaty-legged Crake	**SLCR**	0	0	0	5	2,002	480	9	130	52	0	0	0	4.90	2,132	532
White-breasted Woodswallow	**WBWO**															
White Tern	**WHTE**	297	2,463	830	40	14,746	1,490	157	2,330	537	49	2,158	355	50.00	21,697	3,212
White-tailed Tropicbird	**WTTR**	4	30	20	1	373	125	1	9	6	7	322	69	1.70	734	219
Yellow Wagtail	**YEWA**															

Appendix 4. Population density and size estimates of bird species in Palau in 2005 by island. Species are in the same order as in Table 7. For full species names see Table 7. N = number of individuals detected. SE = standard error.

Species	N	Angaur				Babeldaob				Peleliu				Rock Islands				Total			
		Density	SE	Pop size	SE	Density	SE	Pop size	SE	Density	SE	Pop size	SE	Density	SE	Pop size	SE	Density	SE	Pop size	SE
BARA	**57**	10.13	6.34	82	51	23.17	13	8,402	4,546	33.83	20.44	595	360	0.00		0		20.86	10.47	9,079	4,558
BFPA	**11**	0.00		0		0.00		0		16.35	20.29	288	357	225.79	301.67	10,567	14,118	24.94	32.44	10,855	14,117
BLNO	**421**	3.15	3.24	25	26	17.00	3.22	6,165	1,168	287.29	36.26	5,056	638	123.80	18.55	5,794	868	39.16	3.99	17,041	1,735
BRNO	**118**	7.74	7.99	63	65	17.14	7.68	6,218	2,787	23.89	10.28	420	181	40.05	14.30	1,874	669	19.70	6.82	8,575	2,968
BRTE	**14**	0.00		0		0.00		0		0.00		0		41.88	39.87	1,960	1,866	4.50	4.29	1,960	1,866
CHMA	**315**	0.00		0		180.80	33.38	65,578	12,109	109.59	55.43	1,929	976	0.00		0		155.12	28.19	67,506	12,266
CICA	**120**	0.00		0		54.65	9.57	19,823	3,469	73.57	21.46	1,295	378	33.73	11.13	1,578	521	52.15	8.47	22,696	3,686
CIWE	**317**	0.00		0		121.24	31.08	43,974	11,272	209.54	50.77	3,688	894	161.06	33.77	7,537	1,580	126.84	26.64	55,199	11,592
COKI	**315**	151.53	24.27	1,227	197	15.79	2.44	5,727	884	75.68	15.77	1,332	277	9.17	3.21	429	150	20.03	2.37	8,716	1,030
DWEY	**1682**	0.00		0		863.84	51.86	313,316	18,810	700.00	72.63	12,320	1,278	208.04	31.62	9,736	1,480	770.62	43.94	335,372	19,121
ECPA	**4**	0.00		0		0.00		0		0.00		0		0.54	7.60	25	356	0.06	0.82	25	356
GSCC	**40**	0.00		0		0.03	0.02	10	6	0.00		0		1.46	0.51	68	24	0.18	0.06	79	25
GWEY	**346**	0.00		0		0.00		0		1,473.03	163.81	25,925	2,883	82.02	21.85	3,838	1,022	68.39	7.12	29,764	3,099
MIPI	**516**	0.00		0		47.82	5.36	17,346	1,944	3.42	2.37	60	42	20.04	3.14	938	147	42.15	4.50	18,344	1,959
MIME	**23**	15.49	8.79	125	71	0.83	0.47	301	171	2.71	1.82	48	32	4.84	2.83	227	133	1.61	0.71	700	308
MIMY	**669**	225.57	77.30	1,827	626	342.91	26.57	124,372	9,635	506.56	45.28	8,915	797	205.99	34.91	9,640	1,634	332.62	23.31	144,755	10,143
MIST	**1666**	1,308.07	127.48	10,595	1,033	556.19	40.88	201,729	14,827	392.22	41.25	6,903	726	174.62	19.83	8,172	928	522.52	35.60	227,400	15,492
MORN	**291**	0.00		0		60.54	10.18	21,958	3,692	62.35	16.70	1,097	294	14.13	3.48	661	163	54.50	8.80	23,717	3,828
NIPI	**117**	0.00		0		0.86	0.31	311	114	1.33	1.18	23	21	20.55	4.87	962	228	2.98	0.63	1,296	274
PABW	**1227**	0.00		0		164.34	8.09	59,605	2,935	247.63	19.26	4,358	339	87.52	13.05	4,096	611	156.39	7.26	68,059	3,158
PAFA	**287**	0.00		0		162.47	18.35	58,929	6,657	554.71	79.26	9,763	1,395	145.32	30.11	6,801	1,409	173.47	17.02	75,493	7,407
PAFL	**602**	0.00		0		250.49	18.53	90,852	6,722	286.55	38.77	5,043	682	161.19	20.45	7,543	957	237.68	16.25	103,438	7,070
PAFD	**2472**	5.85	3.57	47	29	178.66	10.05	64,802	3,644	101.04	9.43	1,778	166	78.95	8.73	3,695	409	161.59	8.76	70,322	3,811
PGDO	**3**	0.00		0		0.38	0.59	139	214	4.19	5.70	74	100	0.00		0		0.49	0.66	213	289
PASW	**497**	12.28	12.42	99	101	155.46	28.95	56,384	10,499	136.61	38.33	2,404	675	102.19	18.20	4,783	852	146.30	24.65	63,671	10,728
REJU	**293**	21.48	9.23	174	75	14.72	4.43	5,337	1,608	9.36	4.27	165	75	0.00		0		13.04	3.76	5,676	1,635
RCKI	**55**	0.00		0		10.38	2.33	3,763	847	10.57	4.87	186	86	3.58	1.94	167	91	9.46	2.05	4,117	891
SLCR	**10**	0.00		0		0.63	0.37	228	133	6.84	2.70	120	47	0.00		0		0.80	0.32	348	141
WBWO	**3**	0.00		0		0.20	0.19	73	67	0.00		0		0.00		0		0.17	0.15	73	67
WHTE	**615**	165.25	51.13	1,339	414	27.14	4.66	9,845	1,689	230.90	38.89	4,064	684	66.31	10.94	3,103	512	42.17	4.91	18,351	2,135
WTTR	**95**	2.03	2.11	16	17	1.84	1.02	666	372	13.44	5.19	237	91	18.90	4.40	884	206	4.14	1.03	1,804	450
YEWA	**20**	0.00		0		2.31	1.65	838	600	0.66	0.67	12	12	0.00		0		1.95	1.38	850	600