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Subsistence Harvest of Birds, Fruit Bats, and Other Game in American Samoa, 1990–1991[1]

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ABSTRACT: Terrestrial birds and large pteropodid fruit bats are hunted year-round for subsistence in American Samoa. To determine harvest levels, 13–18% of the hunters on the main island of Tutuila were interviewed at 3-month intervals in 1990–1991. A high opportunistic harvest occurred after extensive habitat damage caused by a hurricane in February 1990. Adjusting for this factor, we estimated an annual take of 2100–4200 Pacific pigeons (*Ducula pacifica* Gmelin), 500–1000 purple-capped fruit doves (*Ptilinopus porphyraceus* Temminck), 500–1600 fruit bats (*Pteropus tonganus* Quoy & Gaimard and *P. samoensis* Peale, species combined), and small numbers of other species. Even this adjusted harvest rate is extremely high compared with current population sizes of game animals, which are at low levels due to adverse impacts from three hurricanes in the past 5 yr and subsequent opportunistic hunting. For example, after the hurricane in 1990, more bats were harvested than remain alive today. Consequently, a 3-yr ban on all hunting was enacted, but the situation remains critical because hunting restrictions are neither well known nor enforced.

IT IS WIDELY RECOGNIZED that hunting can seriously impact game species on islands in the South Pacific Ocean (Dye and Steadman 1990, Pierson and Rainey 1992, Robertson 1992, Wiles 1992). Beginning with human settlement of Polynesia about 4000 yr ago, archaeological records indicate that hunting by the early colonists caused marked declines in wildlife populations, resulting in the extinction or greatly reduced distributions of many bird species (Dye and Steadman 1990).

In modern times, hunting continues to exert a substantial impact on island wildlife. Increased hunting and habitat loss caused by the rapid growth of human populations is common throughout much of the South Pacific (Pierson and Rainey 1992). In particular, large pteropodid fruit bats, or flying foxes, have been commercially hunted, and overharvested, on many Pacific Islands to supply an exotic food market in Guam (Pierson and Rainey 1992, Wiles 1992). Although this commercial harvest has been reduced in recent years, noncommercial hunting for subsistence, sport, or to eliminate agricultural pests is also thought to be a notable source of wildlife mortality (Merlin and Juvik 1983, Graham 1992), but has not been quantified.

In American Samoa, there has been a growing concern about declining numbers of wildlife, particularly fruit bats, for several reasons (Cox 1983, Pierson and Rainey 1992). First, a period of commercial harvesting in 1980–1986 resulted in the export of over 4000 fruit bats before legislation was enacted to prohibit this activity (Wiles 1992). Second, recent hurricanes in 1987, 1990, and 1991 caused extensive damage to wildlife habitats, contributing to an 80–90% decline in populations of fruit bats (Craig et al. 1994). Third, similar declines in game birds (Trail et al. 1992) indicate that populations of all hunted species are extremely low. Consequently, we initiated this study to determine how many animals were being harvested by

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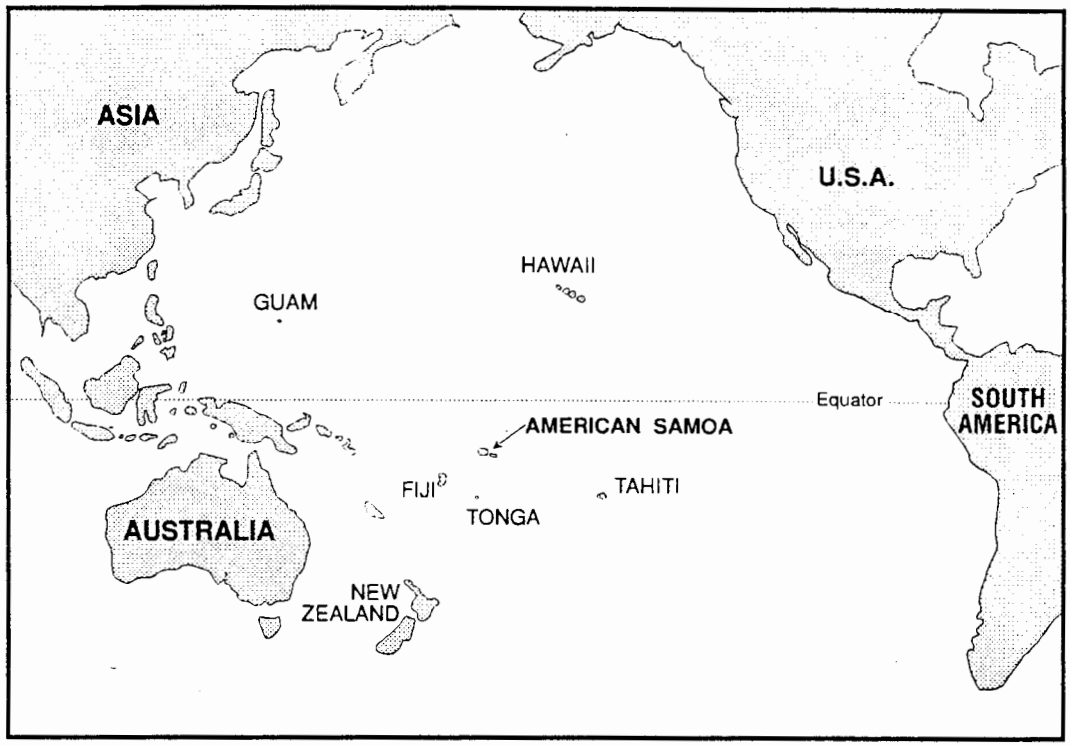

FIGURE 1. Location of American Samoa (14° S, 170° W) in the South Pacific Ocean.

hunters in American Samoa. This harvest is principally a subsistence activity with rifles and shotguns; numbers of wildlife shot strictly for sport, or because the animals are perceived as agricultural pests, are thought to be relatively small.

Study Area

The study was conducted on Tutuila Island (144 km^2), the largest of seven islands in American Samoa (Figure 1), where most of the territory's rapidly growing human population (51,000 in 1992) is located. The island is a steeply sloped volcanic island covered by rain forest, secondary growth, and agricultural plantations. The terrestrial fauna has relatively few species, presumably because of the remoteness and small size of the island; the only indigenous mammals are three bat species. The two fruit bat species described in this paper are large, with a 1-m wingspan and weights of 300–500 g.

MATERIALS AND METHODS

To assess hunter harvests, we interviewed hunters in 20 of the 66 small villages on Tutuila Island (Figure 2). Population sizes of the 20 villages averaged 900 people (range, 49–4093). The 20 villages were selected based on two factors. First, villages were classified as rural or urban, assuming that hunting efforts in these two groups might differ. The six villages surrounding the central and relatively industrialized Pago Pago Harbor area (from Utulei to Leloaloa) were classified as urban; all others were considered rural. We selected ca. 30% of both village types (i.e., two urban and 18 rural villages). Second, we were advised by Samoan staff that hunters might cooperate more freely in our study if a local resident of the villages helped introduce the interviewer to the hunters. Thus we selected villages in which a Samoan staff member of our department (Department of Marine and Wildlife Resources) lived, or vil-

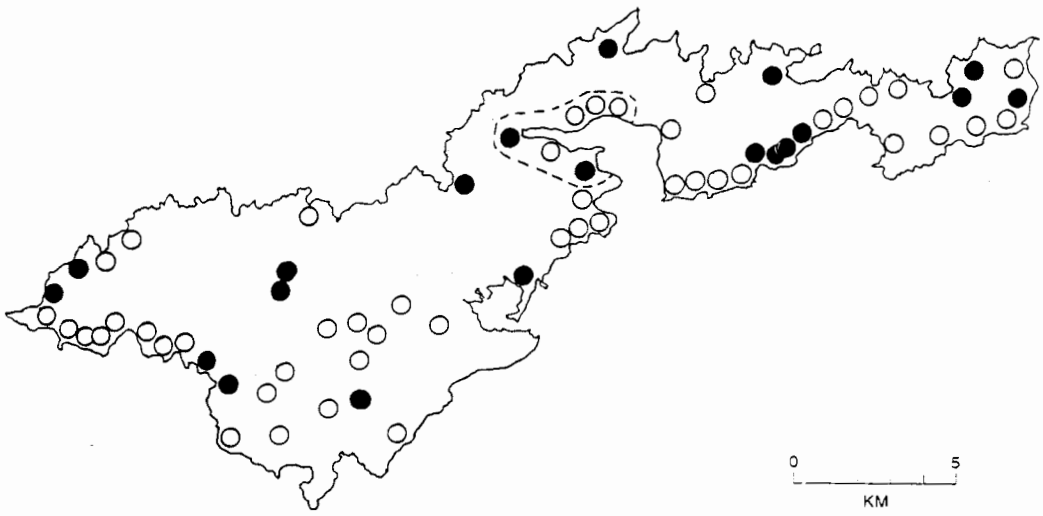

Figure 2. Locations of villages on Tutuila Island, indicating sampled villages (closed circles) and "urban" area (dashed line).

lages in which the interviewers knew some residents. In total, the villages selected were distributed evenly across the island, with nine rural villages selected from both the eastern and western halves of the island and two urban villages selected from the center of the island.

At ca. 3-month intervals from April 1990 to June 1991, an average of four hunters (range, 1–18) was interviewed in all sampled villages with active hunters (19 of 20). This equated to 33–46% of all hunters in the sampled villages. No hunters were active in one rural village during our study, but it was included in analyses nonetheless to determine the proportion of hunters in the general population. The duration of two of the five sampling periods was modified slightly to account for a major holiday in October (White Sunday) when increased hunting has traditionally occurred. Rather than split the hunting effort for this holiday period into two sampling periods, we extended the dates of our second sampling period (July–15 October) to include the holiday, and the following period was correspondingly briefer.

Interviews were conducted by a Samoan in the native language at the hunter's home. In general, the same hunters were interviewed during all five sampling periods.

The total number of hunters in each sampled village was obtained by asking each hunter how many other hunters lived in his village. Because most villages were small, those who hunted were generally well known. Lists of hunters in villages were updated each sampling period to account for hunters who moved into or out of the village.

A hunter was defined as anyone who usually hunted at least one time per year, thus the average kill per hunter incorporated the varied efforts and expertise of both occasional and frequent hunters. During the interviews, each hunter was asked a list of standardized questions about his hunting efforts during the previous 3 months: how many animals of each species were harvested, how many animals of each species were shot but not retrieved, as well as other hunting-related questions. During the interviews, to aid in species identification, hunters were shown pictures of the two fruit bat species (*Pteropus samoensis* Peale, *P. tonganus* Quoy & Gaimard) and two fruit dove species (*Ptilinopus porphyraceus* Temminck, *P. perousii* Peale) that occur in American Samoa. However, most hunters did not distinguish between the two bat species; thus harvest data for both bat species were combined. The total number of animals killed by each hunter

during a 3-month period was calculated as the number of animals retrieved by the hunter plus a proportion, arbitrarily set at 50%, of the animals shot but not retrieved as reported by the hunter.

A nonparametric Wilcoxon two-sample test (Sokal and Rohlf 1981) was used to compare harvest rates of urban and rural hunters. The islandwide harvest for urban hunters was determined by multiplying the average kill per urban hunter times the total number of urban hunters on the island. The latter was estimated by assuming the following proportions:

$$\frac{\text{No. urban hunters in sampled urban villages}}{\text{Total population in sampled urban villages}} = \frac{\text{No. urban hunters in all urban villages}}{\text{Total population in all urban villages}}$$

This procedure was repeated separately for rural hunters, and the two estimates were summed to calculate the islandwide harvest by all hunters. The 1990 population census provided numbers of people in each village (Economic and Development Planning Office 1991).

RESULTS

We interviewed 57–87 hunters at 3-month intervals, which represented 33–46% of all hunters in the sampled villages and 13–18% of all hunters on Tutuila Island. Our estimated total number of hunters on the island, ca. 400–530, averaged six to eight hunters per village and represented ca. 1% of the total population in American Samoa.

Species Composition

The harvest consisted primarily of terrestrial birds (70%) and large pteropodid fruit bats (26%) (Figure 3). The principal species taken were the Pacific pigeon (*Ducula pacifica* Gmelin), purple-capped fruit dove (*Ptilinopus porphyraceus*), and two fruit bat species (Tongan fruit bat, *Pteropus tonganus*; Samoan fruit bat, *P. samoensis*). All species were hunted year-round. Fruit bats could be hunted legally only for 3 months (May–July), but this restriction was neither known nor enforced.

Pigeons and doves were generally the most desired game species and were a traditional

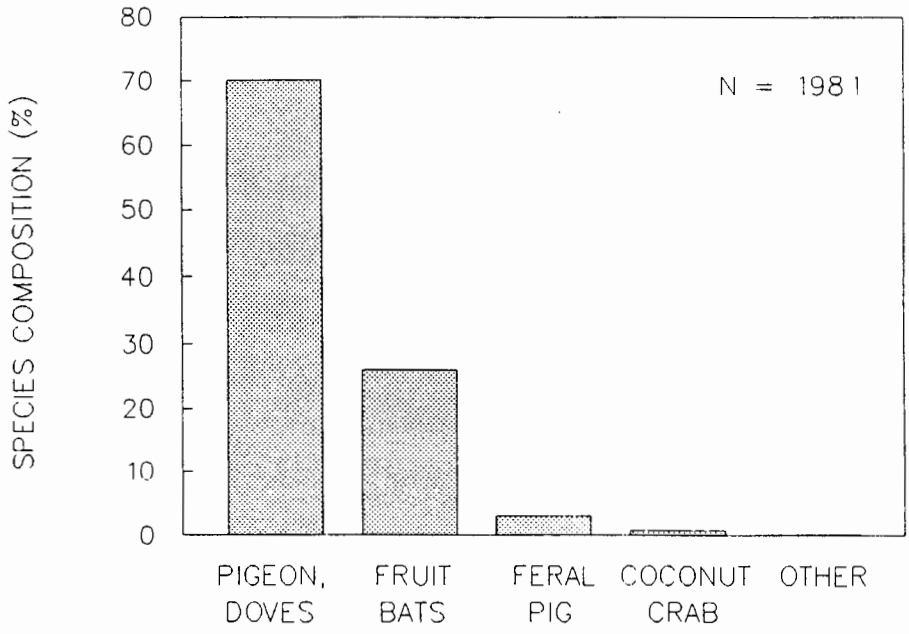

Figure 3. Composition of animals taken by hunters on Tutuila Island, 1990–1991.

food during the holiday period. In 1990, a few pigeons (<40) were also sold at the local market for US $8 each. Some hunters also harvested fruit bats for personal consumption or because the bats were considered to be agricultural pests (bats occasionally eat fruits or flower nectar of bananas, papayas, and coconuts).

Several other species were taken occasionally by hunters. Coconut crabs (*Birgus latro*

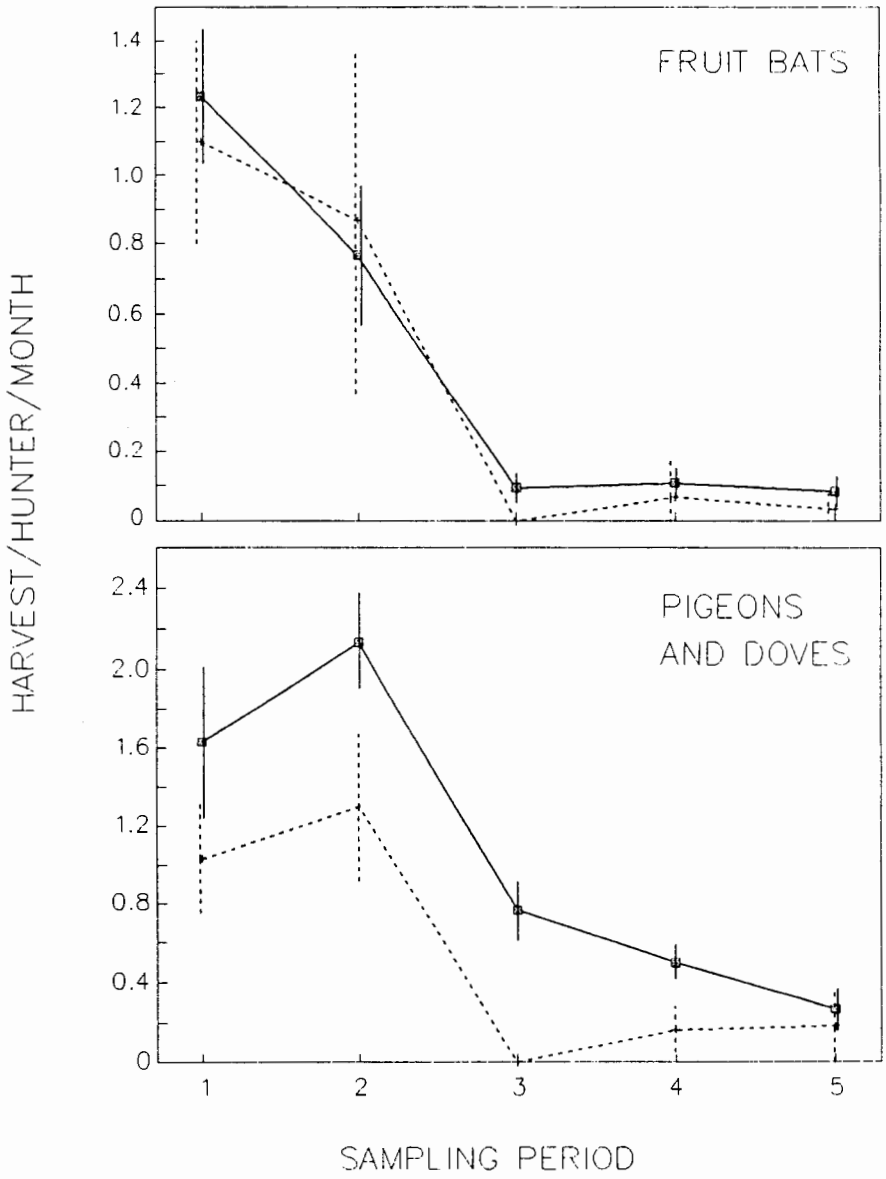

Figure 4. Monthly harvest rates for both rural hunters (solid line) and urban hunters (dashed line) on Tutuila Island, following Hurricane Ofa in February 1990. Estimates (±SE) were derived from hunter interviews conducted at ca. 3-month intervals. Dates of sampling periods given in Table 1.

L.) were highly prized but not abundant. On rare occasions in 1991, a few of these crabs (about 30) were sold at the local market for US $8–20 each, depending on size. Feral pigs were usually hunted when they damaged crops. The purple swamp hen (*Porphyrio porphyrio* L.) was sometimes shot as an agricultural pest. The Samoan starling (*Aplonis atrifusca* Peale) was common on the island but infrequently harvested for food. Gray ducks (*Anas superciliosa* Hartlaub & Finsch) were prized, but few vagrants of this species have entered the territory in recent years. Sea turtles (*Chelonia mydas* L., *Eretmochelys imbricata* L.) were also harvested, but our data underestimate numbers taken because interviews focused on persons who hunted terrestrial game, thus turtle numbers are not reported here (see Tuato'o-Bartley et al. 1993). Seabirds were eaten in former times, but few are taken now.

Harvest Rates

The harvest per hunter was highly variable, with greatest harvest rates for both rural and urban hunters occurring during the 6 months following Hurricane Ofa in February 1990 (Figure 4), when game was especially vulnerable (see *Discussion*). During that period, the combined take of all game species was 3.0 animals per month for rural hunters and 2.8 animals per month for urban hunters, thereafter dropping significantly for both groups of hunters (Wilcoxon two-sample test comparing periods 1 and 3: [*a*] rural hunters (bats), $U = 2505$, $t = 5.38$, df = 115, $P = <0.001$; [*b*] rural hunters (birds), $U = 2806$, $t = 2.24$, df = 115, $P = <0.05$; [*c*] urban hunters (bats), $U = 226$, $t = 2.08$, df = 36, $P = <0.05$; [*d*] urban hunters (birds), $U = 259$, $t = 3.26$, df = 36, $P = <0.01$).

Harvest rates of fruit bats by rural and urban hunters were similar (Figure 4). Rural hunters shot more pigeons and doves, but the differences were only significant for period 3 (Wilcoxon two-sample test, $U = 546$, $t = 2.98$, df = 66, $P = <0.01$).

An expansion of harvest rates to the total hunter population on Tutuila Island pro-

TABLE 1

HUNTER HARVEST ESTIMATES OF FRUIT BATS, BIRDS, AND OTHER ANIMALS ON TUTUILA ISLAND AT 3-MONTH INTERVALS, APRIL 1990–JUNE 1991

SAMPLING PERIOD[a]	MONTHS AFTER HURRICANE	HARVEST ESTIMATES							
		FRUIT BATS	PACIFIC PIGEON	PURPLE-CAPPED FRUIT DOVE	FERAL PIG	COCONUT CRAB	SWAMP HEN	MANY-COLORED FRUIT DOVE	SAMOAN STARLING
1	3	1,900	2,000	430	270	0	15	5	110
2	6	1,200	2,600	630	70	0	90	50	0
3	9	130	870	180	60	90	0	0	0
4	12	150	510	130	30	0	10	0	0
5	15	90	230	80	0	0	0	0	0
Estimated annual harvest[b]		500–1,600	2,100–4,200	500–1,000	120–160	90–120	10–100	0–50	?

[a] Sampling periods: 1 (April–June 1990), 2 (July–15 October 1990), 3 (15 October–December 1990), 4 (January–March 1991), 5 (April–June 1991).
[b] Based on harvest rates during the last three sampling periods; data rounded; see text for further details.

duced a harvest estimate of 3470 fruit bats, 6210 Pacific pigeons, 1450 purple-capped fruit doves, and miscellaneous other species during the 15-month period of study (Table 1).

DISCUSSION

Annual Harvest Estimate

An estimate of annual harvest was complicated by a hurricane (Ofa) that occurred just before the study period and resulted in a dramatic increase in the harvest of fruit bats and birds (Dashbach 1990, Craig and Syron 1992). Because Hurricane Ofa destroyed most of the fruit crops eaten by these animals, normally wary bats and birds were forced to search for food wherever it remained, and those that flew into villages were exceptionally vulnerable to human harvest. Consequently, the estimated harvest of 1900 bats and 2000 pigeons during the first 3 months after the hurricane (Table 1) was not indicative of typical hunting pressures. The high numbers of animals taken during the next sampling period (July–15 October) may also have been influenced by the hurricane's effects or may realistically reflect an increased hunting pressure before the White Sunday holiday, when hunting activity typically increases. Conversely, the progressively lower harvests during each sampling period may have been lower than usual because of declining game abundance or the high price and limited supply of ammunition on the island at that time.

We attempted to estimate the average annual harvest in two ways, both of which exclude the high harvest immediately following the hurricane. Our upper harvest estimate assumes that the last four sampling periods monitored represent typical hunting pressures during the course of a year; our lower estimate assumes that only the last three sampling periods reflect typical hunting rates. In this manner, we estimate that 2100–4200 Pacific pigeons, 500–1600 fruit bats, 500–1000 purple-capped fruit doves, 120–160 feral pigs, and assorted other animals are killed annually by hunters on Tutuila Island (Table 1).

Impact of Harvest Rate

The hunter survey revealed two notable aspects about subsistence hunting in American Samoa. First, there was a high opportunistic kill of animals immediately following a hurricane. Hurricanes are a regular feature of the South Pacific environment (Craig and Syron 1992, Pierson and Rainey 1992). Weather records indicate that a hurricane or severe tropical storm strikes somewhere in the Samoan Archipelago every 3 yr, on average. It is therefore likely that long-lived species such as fruit bats, which live up to 31 yr in captivity (Pierson and Rainey 1992), possess adaptations that enable their populations to persist in such an environment. It is unlikely, however, that the populations are also able to contend with the additional and substantial mortality caused by opportunistic subsistence hunting during the months following a hurricane. The following calculations bear this out.

Prehurricane populations of fruit bats were estimated at ca. 13,500 bats, species combined (Table 2). During the 6 months following Hurricane Ofa, hunters killed ca. 3100 fruit bats, which amounted to 23% of prehurricane standing stocks (although some of these bats may well have died of starvation had they not been shot). In a similar comparison, 11% of the purple-capped fruit dove population and 70% of the many-colored fruit dove population were harvested during the first 6 months after the hurricane. The unrealistic proportion of pigeons harvested during this 6-month period (216%) is likely an artifact of an unsuitable sampling method used to estimate population sizes for this species (P. Trail, pers. comm.).

Second, even the adjusted annual harvest rates (i.e., excluding the posthurricane kill—see previous section) for some species are high compared with estimates of their prehurricane population sizes (i.e., many-colored fruit dove, Pacific pigeon). For fruit bats, the impacts of the adjusted subsistence harvest are equivocal but of potential importance to

TABLE 2

POPULATION ESTIMATES OF HUNTED SPECIES ON TUTUILA ISLAND BEFORE (1986–1987) AND AFTER (1992) HURRICANE OFA IN FEBRUARY 1990

SPECIES	POPULATION ESTIMATES		AVERAGE CHANGE
	1986 or 1987	1992	
Tongan fruit bat	12,000[a]–12,750[b]	1,500–2,500[b]	−84%
Samoan fruit bat	1,500[b]	200–400[b]	−80%
Pacific pigeon	2,132[c]	1,684[d]	−21%
Purple-capped fruit dove	9,407[c]	928[d]	−90%
Many-colored fruit dove	78[c]	47[d]	−40%
Samoan starling	40,777[c]	13,889[d]	−66%

[a] Wilson and Engbring (1992), based on roost counts.
[b] Craig et al. (1993), based on roost counts for *P. tonganus*, and an extrapolation from indices of abundance for daytime-active *P. samoensis*.
[c] Engbring and Ramsey (1989), based on density estimates derived from variable circular plots corrected for detection distance.
[d] Trail et al. (1992), extrapolated from density estimates derived from variable circular plots, and using the correction for detection distance used by Engbring and Ramsey (1989).

their recovery. To illustrate this, the adjusted annual harvest of 500–1600 bats per year equates to a 4–12% exploitation rate of the prehurricane population estimate for combined species. The impact of this mortality rate depends, in large part, on maturity and survival parameters, which are not well known for these species. Using best estimates of the fruit bats' reproductive biology and survival rates (one young per female per year, 2 yr to sexual maturity, 60% survivorship of young per year, 80% survivorship of adults per year), Pierson and Rainey (1992) calculated that such hunting rates could cause substantial population declines because of the bats' long life span and low reproductive rate. However, the maturity estimate used in that model may be somewhat restrictive. If, for example, the age at sexual maturity is decreased to 1.5 yr, which may occur in some pteropodid bats (Falanruw 1988), the same model shows that the bat populations could withstand a 4% harvest rate and slowly recover within 25 yr. It becomes clear, then, that until the life history parameters of fruit bats are better understood, we are unable to predict the impact of various subsistence harvesting rates.

Because of the extremely low population sizes of game animals on Tutuila Island, however, it seems prudent to assume that any subsistence hunting pressure is excessive at the current time. The opportunistic post-hurricane harvest, for example, exceeded the total number of fruit bats now remaining on the island. The hurricanes and subsequent hunting have reduced fruit bat and bird populations by 80–90% in just the past 5 yr (Trail et al. 1992, Craig et al. 1994). Consequently, a 3-yr ban on all hunting in the territory was enacted in early 1992. Nonetheless, because of the general disregard for imposed hunting restrictions and the lack of an effective enforcement program, we suspect that populations of fruit bats and game birds will remain in jeopardy. The decline or loss of these populations may have serious long-term impacts on island ecosystems. Fruit bats and presumably the fruit-eating doves and pigeons are important as pollinators and seed dispersers, and their loss may affect plants that have coevolved with them (Cox et al. 1991, Fujita and Tuttle 1991).

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