AMELIA EARHART ON NIKUMARORO: A SUMMARY OF THE EVIDENCE

Thomas F. King
The International Group for Historic Aircraft Recovery

The fate of American aviation pioneers Amelia Earhart and Fred Noonan, who disappeared over the Pacific in July 1937, is a continuing Pacific historical mystery. Twenty-three years of interdisciplinary research by The International Group for Historic Aircraft Recovery (TIGHAR) has produced results supporting the hypothesis that Earhart and Noonan landed their Lockheed Electra 10E safely on Nikumaroro in the Phoenix Islands, made repeated efforts to radio for help, but eventually expired. This paper summarizes TIGHAR's data relevant to the "Nikumaroro Hypothesis."

Introduction

Aviation pioneers Amelia Earhart and Fred Noonan disappeared over the Pacific on July 2, 1937, while seeking Howland Island, a planned refueling stop on their attempt to circumnavigate the globe near its equator. The International Group for Historic Aircraft Recovery (TIGHAR) hypothesizes that they landed and died on *Nikumaroro,* then called Gardner Island (Fig. 1). Much of the information supporting what we call the "Nikumaroro Hypothesis" is summarized in two books published by TIGHAR members (King et al. 2004; Gillespie 2006); more data and analyses are posted regularly on TIGHAR's web site.[1] The author has also published a novel built around the historically documented discovery of what may have been Earhart's bones on the island by I Kiribati[2] and Tuvaluan colonists in 1940 (King 2009).

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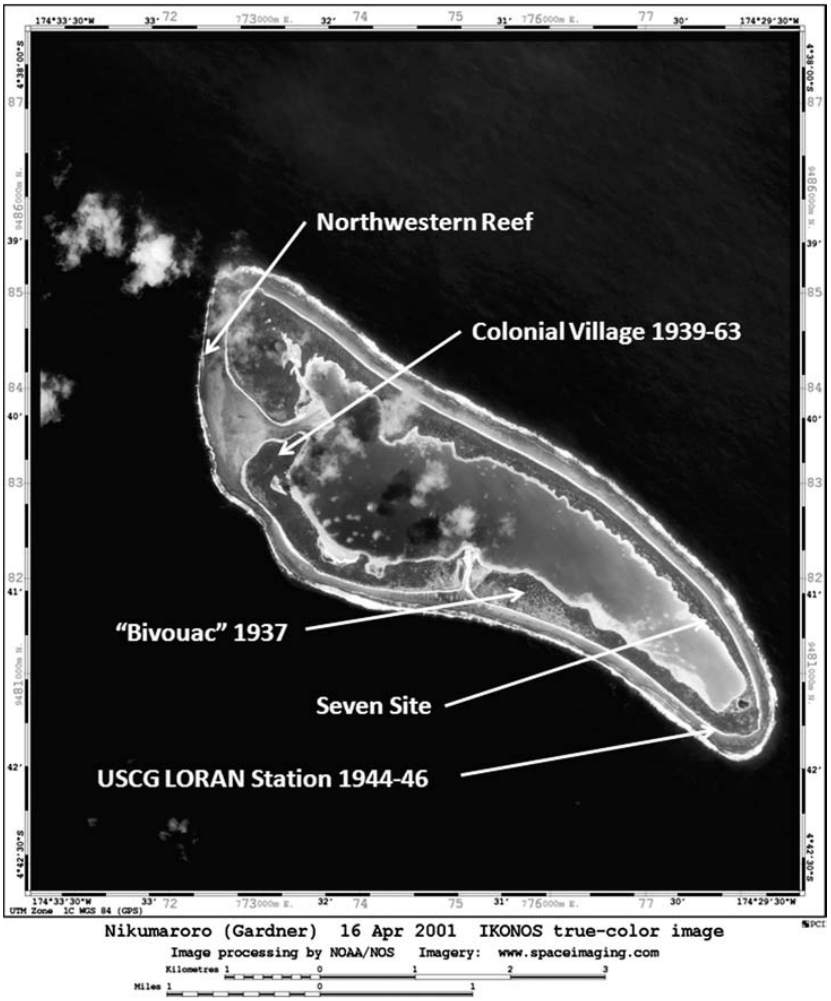

FIGURE 1. **Nikumaroro.**

TIGHAR is a US-based international research organization devoted to aviation historic preservation and the study of aviation history and archaeology. Study of the mystery surrounding the disappearance of Earhart and Noonan has been a TIGHAR priority since 1988, featuring archival and oral historical research in the United Kingdom, Australia, New Zealand, Fiji, Kiribati, Tuvalu, and the Solomon Islands, as well as archaeological research on Nikumaroro, McKean Island, and Kanton Island in the Phoenix

group. On Nikumaroro, archaeological work has included a general survey of the island and of its fringing reef down to approximately 45 m (1989 and subsequent expeditions); a side-scan sonar search of the reef face (1991); search of the lagoon using divers (1989 and subsequent expeditions) and an autonomous underwater vehicle (AUV, 2010); search of the northwestern reef face using a remotely operated vehicle (ROV) down to 300 m (2010); and intensive archaeological surface survey and excavations on selected sites (1991, 1996, 1997, 1999, 2001, 2003, 2007, 2010). Other lines of research include forensic image analysis, tidal hindcasting, radio propagation studies, historical radio message analysis, forensic anthropology, and a variety of studies aimed at identifying and understanding recovered artifacts, faunal material, and possible human remains.

The seventy-fifth anniversary of Earhart's and Noonan's disappearance is a timely reason to summarize the evidence pertaining to the Nikumaroro Hypothesis.

Nikumaroro

Nikumaroro, formerly known as Gardner Island, lies at 4°40′30″ S, 174°31′ W, in the Phoenix Island Protected Area[3] of Kiribati (Fig. 1). Access to the island, which is uninhabited, is by permission of the government of Kiribati and is strictly regulated to protect the island's relatively pristine environment. The island is an atoll, about 7 km long and 2 km wide, in the shape of an elongate oval oriented northwest–southeast, with its wider end toward the northwest. There are two openings into its lagoon: Tatiman Passage in the northwest is navigable by small boat, but Bauareke Passage, halfway down the southwest side, usually is not. The island is variously wooded in indigenous forest dominated by the Buka (*Pisonia grandis*), feral coconut and pandanus, and scrub dominated by Ren (*Tournefortia* sp.) and Mao (*Scaevola frutescens*). Animal life includes a variety of tropical marine birds, coconut or robber crabs (*Birgus latro*), strawberry hermit crabs (*Coenobita perlatus*), common sand crabs, Polynesian rat (*Rattus exulans*), and a rich diversity of marine and reef life. The island was uninhabited when Earhart disappeared in 1937 but was colonized in late 1938 as part of the Phoenix Islands Settlement Scheme (PISS) of the Western Pacific High Commission (WPHC). The colony lasted until 1963, when it was abandoned, with its residents mostly relocated to the Solomon Islands.

The Line of Position and Landing on Nikumaroro

In the last radio transmission that all authorities agree came from Earhart, received by the US Coast Guard Cutter *Itasca,* lying off Howland Island,

she said she was flying "on the line 157 337." This is generally understood to be what is known as a "line of position" (LOP), a navigational line oriented, in this case, 337° (NNW) and 157° (SSE). Following standard celestial navigation procedures of the time, Noonan would have established the LOP at sunrise (perpendicular to the azimuth of the sun and almost perpendicular to their course), then advanced it using dead reckoning until he calculated that they should be on the LOP running through Howland Island. If they did not see the island, they would conclude that they were northwest or southeast of it and accordingly fly along the LOP until they found it.

The strength of the "LOP" transmission indicated that Earhart was relatively close to Howland Island at the time she sent it—0843 local time.[4] She was not understood to say which direction she was flying on the line, but US Navy experts, Earhart's husband George Putnam, and her technical advisor Paul Mantz all agreed that the flight probably proceeded southeastward in the hope of reaching either Howland or another island (Gillespie 2006: 127–28). Such a line passing through the vicinity of Howland Island also passes within visual range of Nikumaroro.

Nikumaroro is much easier to see from the air than is Howland Island; it is bigger, tree-covered, and has a brilliant aquamarine lagoon.[5] The atoll is encircled by a broad reef flat on which it would be relatively easy to land an aircraft if the tide were low (Fig. 1). Tidal hindcasting by TIGHAR specialists indicates that at the time Earhart and Noonan would have approached the island along the LOP (probably 1000–1200 local), the tide was just turning; it was not only low but also a neap tide, meaning that both low and high tides were relatively suppressed. The reef flat should have been nearly dry and should not have been deeply covered even at high tide until the tides reached flood stage several days later.[6]

Post-Loss Radio Messages

After the disappearance, at least 121 radio messages were received by stations around the Pacific and elsewhere, most of them by professional radio operators, some of them in a voice identified as Earhart's by operators who had heard her in past transmissions. When the US Navy's extensive search failed to reveal anything, the Navy decided that all the messages were mistakes or hoaxes. If even one of these messages was really from Earhart, she had to be on land with a fairly intact airplane capable of generating power for the radio (Gillespie 2006: 180–94). Detailed analysis of the messages by TIGHAR researchers Richard Gillespie and Robert Brandenburg suggests that at least fifty-seven of them are credible as transmissions from the lost Electra.[7]

Wireless stations at Wake Island, Midway Island, and Hawai'i took radio direction finding (RDF) bearings on six of the transmissions. Four of these bearings crossed in the vicinity of Nikumaroro (Gillespie 2006, 164). The only wireless radio (other than, we suspect, Earhart's) documented as having been in the Phoenix Islands was in the possession of John William Jones, a coconut plantation supervisor on Hull (now Orona) Island, about 150 miles east of Nikumaroro. Jones' wireless is reliably reported to have been out of order between early June and late August of 1937 (Gillespie 2006, 210). TIGHAR analysis of the whole body of radio messages indicates only two plausible explanations for them. Either an extremely well-informed hoaxer with an undocumented radio was on one of the western Phoenix Islands imitating Earhart's voice, or Earhart was there (Gillespie 2006: 116, 135, 157–59).

1937 Observations on Nikumaroro

Search plane crews from the battleship USS *Colorado*, flying over Nikumaroro seven days after the disappearance, reported "signs of recent habitation." Believing the island to be inhabited (as was Orona), the crews concluded that these signs[8] were not related to Earhart. Therefore, the *Colorado* did not land a search party (Gillespie 2006, 206). At least according to colonial records, the island had in fact not been inhabited since the 1890s, when the entrepreneur John Arundel briefly attempted a coconut plantation there with laborers from Niue. TIGHAR research has unearthed no data suggesting that anyone lived on the island after Arundel abandoned his effort—except as discussed below.

In October 1937, British colonial officers Harry Maude and Eric Bevington visited Nikumaroro with ten delegates from Kiribati (then known as the Gilbert Islands) to see whether the island could be colonized as part of the then-planned Phoenix Islands Settlement Scheme (PISS). They found the island (as expected) to be uninhabited, but Bevington reported signs of someone's "overnight bivouac" (King et al. 2004, 137) near the lagoon on the southwestern side of the island (Fig. 1). The late Harry Maude, recalling the incident in 1996, said he had assumed the site represented something left by Arundel's workers (Harry Maude, pers. comm., 1996; King et al. 2004, 138).

A photograph taken by Bevington from a point offshore to the northwest (probably as he and his party departed the island, and focusing on the impressive wreck of the SS *Norwich City*, which grounded on the reef in 1929) shows an anomaly on the edge of the island's northwestern reef that looks very much like an airplane's landing gear.[9] Detailed forensic image

analysis suggests that the object imaged is consistent with the landing gear of Earhart's Lockheed Electra 10E.[10] Physical inspection of the site by TIGHAR in 2010 revealed no trace of the object.

Aircraft Wreckage

There is no record of an airplane ever being lost on or near Nikumaroro. However, I Kiribati and Tuvaluan residents of the PISS colony established on Nikumaroro in December of 1938, which lasted until 1963, report aircraft wreckage on the northwestern reef flat and in the lagoon. A US Navy pilot who visited the island during World War II reported local residents using aircraft control cable as a fishing line, which they said came from a plane wreck that had been on the island when they arrived (King et al. 2004: 117, 182–86, 267–71). Aerial photos taken in 1953 show objects on the northwestern reef whose spectral signatures are consistent with those of aluminum (King et al. 2004, 187). Mrs. Emily Sikuli of Suva, who lived on Nikumaroro in 1939–40 but left in 1940 for nurse's training in Fiji, has described seeing what she was told was aircraft wreckage at a location very close to that of the possible landing gear shown in Bevington's photo (King et al. 2004: 267–71).[11]

In the course of ten archaeological visits to the island, TIGHAR has recovered dozens of pieces of aircraft structure from the ruins of the colonial village. These appear to have been brought to the village to use in fabricating handicrafts. Some fragments are demonstrably from a World War II era Liberator bomber,[12] probably one that crashed on Kanton (Canton) Island, some 230 miles to the northeast; residents of Nikumaroro worked on Kanton after World War II. Other pieces, including aluminum fragments and fragments of plexiglass, do not appear to match a Liberator but are consistent with a Lockheed Electra like Earhart's (King et al. 2004: 110–39, 157, 188–93, 362–67).

Shoes, Bones, and Sextant Boxes

In 1991, TIGHAR recovered parts of two shoes on Nikumaroro, identified by footwear specialists as a woman's shoe and a man's shoe. The former was identified as a "Blucher-style oxford" dating to the 1930s, with at least its heel manufactured by Cat's Paw, a US company. Earhart wore Blucher-style oxfords on her flight, but the only example that can be measured in photographs appears to have been smaller than the one found by TIGHAR (King et al. 2004: 125–34). Photographic evidence indicates that Earhart had at least three pairs of footgear on the plane, two of them Blucher-style

oxfords, and there is documentary evidence suggesting a pair of hiking boots (King et al. 2004: 125–34, 329–32).[13] The Nikumaroro colonists normally went without shoes, although inexpensive shoes of an indeterminate kind are listed in an inventory of the colony's cooperative store found in the WPHC archives. The shoe parts found by TIGHAR were in the approximate location of the bivouac reported by Bevington.

In 1997, TIGHAR member Peter McQuarrie found a file of papers in the Kiribati National Archives on Tarawa documenting the 1940 discovery of human bones on Nikumaroro. Subsequent TIGHAR research in the archives of the WPHC has uncovered a good deal more information. In summary:

1. In early to mid-1940, the Nikumaroro colonists found a human cranium on the southeast end of the island and buried it.
2. Upon his arrival on the island in late 1940, PISS Administrator Gerald B. Gallagher learned of the discovery, visited its site, and excavated the cranium. He found twelve other bones of a human skeleton, lying next to the remains of a campfire associated with bird and turtle bones. Nearby, he and the colonists found the remains of a woman's shoe and a man's shoe, together with a sextant box and some small corks on chains. Directed to make a thorough search but keep the matter strictly secret, Gallagher apparently further searched the site and sent all of his discoveries to the WPHC headquarters in Suva, Fiji. The bones were examined by two medical doctors: the late David Hoodless in Suva and the late Lindsay Isaac (later Verrier) on Tarawa. Dr. Isaac opined that the bones came from an elderly Polynesian, while Dr. Hoodless thought they were from an adult male of European or mixed race.
3. TIGHAR was able to find the measurements taken of the bones by Dr. Hoodless and subjected them to analysis by Drs. Karen Burns and Richard Jantz, experienced forensic physical anthropologists, employing the ForDisc program and the related Forensic Data Bank.[14] Their analysis suggests that the bones most likely may have been those of a woman of European ethnic background, about 5′5″ to 5′9″ in height. Earhart would have fit this description. The bones have been lost (King et al. 2004: 206–48; Burns et al. 1998).[15]
4. The sextant box—which has also been lost—is recorded as having had two numbers on it: 1542 and 3500. Recent TIGHAR research has shown that during World War I, the US Navy acquired a large number of nautical sextants, some of which were converted for aviation use.

Known sextants acquired by the Navy from the Brandis Instrument Company carried serial numbers ranging from 3227 to 5760 and were assigned Navy numbers 845 through 4705; these numbers were stamped into the boxes as well as the instruments themselves. Thus, the numbers on the Nikumaroro sextant box suggest that it held a Brandis instrument owned for a time by the US Navy.[16]

5. The second number on the box—3500—is also close to the number 3547, which is written on a sextant box held by the Museum of Naval Aviation in Pensacola, Florida, and documented to have belonged to Fred Noonan (King et al. 2004: 230–34). Noonan, who helped pioneer Pan American clipper routes across the Pacific and served as a navigator trainer, is known to have used a nautical sextant as a backup. A photograph of the navigation room aboard a Pan American clipper shows a box for a Brandis sextant.[17]

The US Coast Guard LORAN Station

In 1944, the US Coast Guard established a Long-Range Navigation (LORAN) station on the southeast tip of the island (Fig. 1), which remained in operation until 1946, manned by a team of about 40 Coast Guardsmen. One of these, the late Floyd Kilts, was told about the 1940 bones discovery by a local resident and in 1960 told the story to a reporter from the San Diego, California, *Tribune*. Allowing for the effects of time and retelling by multiple storytellers, the story Kilts recounted (which TIGHAR discovered and was greatly puzzled by long before the WPHC bones papers were found) is generally consistent with that found in the official records. Other Coast Guardsmen interviewed by TIGHAR purchased wooden boxes built by the residents, inlaid with pieces of aircraft aluminum (King et al. 2004: 54–56, 226).

The Seven Site

TIGHAR has identified a site on the southeast end of the island (Fig. 1) that closely matches the description given by the late Gerald Gallagher in the WPHC British colonial records as that of the 1940 bones discovery. TIGHAR refers to the site as "the Seven Site" because of a natural clearing in the *Scaevola frutescens* scrub that covers it, which resembles the numeral seven. Archaeological work at this site in 2001, 2007, and 2010 has produced a good deal of suggestive data, much of which remains under analysis. In summary:[18]

1. Documentary research in the Kiribati national archives, coupled with 2011 oral historical work with veterans of the colony now residing in the Solomon Islands, indicates that the site was set aside for government use (King et al. 2004: 337–38) and that a "house" or "camp" was established there for Gallagher, who died on the island in 1941. Part of the site was apparently planted in coconuts, which did not survive, and it was used informally in the late 1940s and 1950s by young men and boys hunting turtles and catching birds.[19]
2. The archaeology of the site is further complicated because it was used for informal target practice and bird hunting by Coast Guardsmen from the station less than a kilometer to the southeast; the site is sprinkled with M-1 carbine cartridges and artifacts from the LORAN station. Some material from the LORAN station was probably brought to the site by the colonists after World War II.
3. Archaeological study has revealed evidence of several small and large fires. The smaller fire features probably represent short-term camping or food preparation by turtle/bird hunting parties or coconut planters, but at least two fire features are much larger and more concentrated than seems consistent with one-time use. These features, designated SL and WR, contain bird, fish, and turtle bones together with a variety of artifacts (see below).[20]
4. The site also contains two clusters of giant clam (*Tridacna* sp.) shells, apparently brought there so their meat could be consumed. Many of the clams in one cluster appear to have been opened by someone who tried to pry them apart on the hinge side (as eastern US oysters and some clams are opened); others have been opened by smashing them with rocks (King et al. 2004: 349–51). These ways of opening *Tridacna* are not consistent with indigenous practice. The other cluster apparently represents clams aligned next to a fire, whose heat caused them to open.
5. Fishbones from the large fire features suggest that whoever camped there was unselectively catching mostly rather small reef and lagoon fish, cooking them on the coals, not consuming the heads, and disposing of their bones in the fires; none of this behavior is consistent with fishing and fish preparation by indigenous Pacific Islanders.[21]
6. Finally, we have found a variety of artifacts at the Seven Site. Some of these are clearly of colonial or Coast Guard origin, but others are not (King et al. 2004: 333–51). Among the artifacts recovered that suggest occupation by someone other than I Kiribati and Tuvaluan colonists are:

a. A broken bottle made by the Owens Illinois Glass company in Bridgeton, New Jersey, in 1933; this bottle contains traces of a substance shown by spectrographic analysis to be similar to residue in a bottle of Campana Italian Balm, a popular American hand lotion in the 1930s. The broken bottle's style and the placement of its maker's mark, patent number, mold number, plant code, and date code are identical to those of an Italian Balm bottle acquired by TIGHAR researcher Joseph Cerniglia through Ebay[22].
b. A shattered bottle with the word "Mennen" embossed on its side in Art Deco lettering, apparently a 1930s lotion or cosmetic container of American origin.
c. A broken glass vessel identified as a small cosmetic ointment pot, of American origin and dating to the 1930s or earlier; research to date indicates that Dr. Berry's Freckle Ointment, Dr. Berry's Massage Cream, Dr. Berry's Creme Elite, Woodbury's Facial Cream, Gervaise Graham Hygienic Skin Cream, and E. Burnham Kalos Skin Rejuvenator were all sold in this style vessel between 1908 and 1933 (Joseph Cerniglia, pers. comm. 2011).
d. Two broken, partially melted bottles dating to before World War II, found in the remains of a cooking fire where it appears they may have been used in attempts to boil water; one of the bottles appears to be a 1930s-style liniment container, possibly St. Joseph's Liniment, which had applications in first aid or as a mosquito repellent, while the other appears to be a prewar beer bottle (Joseph Cerniglia, pers. comm. 2011).
e. A US-manufactured jackknife, comparable to one carried on the Earhart Electra,[23] that appears to have been taken apart, perhaps to re-use its parts.[24]
f. The pull and slider from a size 06, "auto-lok" Talon brand zipper manufactured in the United States sometime between 1933 and 1936.[25]
g. Small fragments of red material chemically identified as probable cosmetic rouge.[26]
h. Two small pieces of thin beveled glass that match the mirror of a known 1930s vintage American woman's compact.[27]

Earhart is known to have carried a compact, which, if it was like others of the period, would have contained rouge. US Coast Guardsmen, island colonists, and British colonial officials are unlikely to have had such items. TIGHAR has thus far identified three photographs of Earhart holding a rectangular object whose size is consistent with a compact holding a mirror

the size of the glass fragments found at the Seven Site; one of the images appears to be of the mirror itself (Joe Cerniglia, personal communication, 2011).[28] The apparent cosmetic containers are also more consistent with the presence of a Euro-American woman on the site than with any of the others known to have been there. Zippers were used extensively by Earhart in her own clothing design and by her friend Elsa Schiaparelli in designing some of Earhart's wardrobe. The bottles in the fire suggest an effort to boil or distill drinking water—there is no fresh surface water on Nikumaroro except what can be caught during sporadic rain squalls.

Recent and Current Research

TIGHAR conducted its most extensive excavation of the Seven Site in May and June 2010, and analysis of results is currently underway. This expedition also included a robotic search of the reef face adjacent to the location where we suspect Earhart and Noonan landed, down to a maximum working depth of 300 m. This survey revealed that the reef face has an extremely steep gradient to that depth and below.[29] Exploration to greater depths, where the gradient was thought to be less severe and airplane parts could have been caught by protruding rocks and in crevices was carried out in July 2012. The reef slope was found to be more precipitous than expected, quite rugged, and in many places festooned with coral debris. No probable aircraft parts were observed in real-time scanning, but the expedition's extensive archive of sonar and video imagery is under analysis as this paper is being finalized.

A TIGHAR team conducted archival research in Tarawa, the capital of Kiribati, in early 2011. Another team spent much of May 2011 in Fiji searching the Colonial War Memorial Hospital for the bones found on Nikumaroro in 1940, last reported at the Hospital in early 1942. Still another team visited the Solomon Islands and conducted oral historical research with the descendants of the Nikumaroro colonists. The data produced by these three studies are currently being studied.

The Hypothesis

As refined based on research to date, the Nikumaroro Hypothesis can be articulated as follows:

1. Earhart and Noonan reached the vicinity of Howland Island on the morning of July 2 but were unable to see or communicate with it or with USCG *Itasca*. Their inability to see the island may have resulted

from being off-course,[30] perhaps exacerbated by difficult morning light conditions and the low inherent visibility of the small coral island. A variety of factors probably contributed to their inability to achieve radio communication with *Itasca* (Gillespie 2006: 81–94; King et al. 2004: 292–305).

2. Earhart and Noonan flew southeast along the LOP and in the late morning sighted Nikumaroro. They landed safely on the broad, smooth northwest reef flat, north of the *Norwich City* wreck.
3. Over the next several days and nights, they transmitted repeated radio distress calls. After a few days, however, flood tides lifted the Electra and carried it over the reef edge, leaving behind the landing gear inadvertently photographed by Eric Bevington three months later. The airplane broke up in the surf on the reef edge or at least was sufficiently obscured by breaking waves as to make it invisible to the USS *Colorado* flyers who flew over on July 9 (during high tide). The *Colorado* flyers also did not see Earhart and Noonan; TIGHAR's experience is that in the highly contrastive visual environment of the Nikumaroro shore it is very difficult to see people on the ground from the altitude flown by the *Colorado* planes.[31]
4. The content of some of the post-loss radio messages suggests that Noonan may have been injured in the landing (Gillespie 2006: 170–86);[32] it is possible, but by no means necessary to the hypothesis, that he did not survive long.
5. Earhart (and Noonan, if still alive) eventually set out to explore the island, probably with special interest in finding fresh water, carrying with her/them a few supplies, including cosmetics for protection from the equatorial sun and Earhart's compact with its handy mirror. She or they may have camped for a time at Bevington's bivouac site, perhaps discarding shoes that no longer fit due to injuries and swelling.
6. Earhart wound up at the Seven Site, where she survived for some days or weeks, but finally succumbed, probably to thirst. Her body was largely consumed by the site's numerous hermit and coconut crabs, leaving only thirteen bones, a few artifacts, and the remains of her cooking fires.
7. Meanwhile, the wreckage of the Electra was distributed down the face of the reef, with pieces being occasionally thrown up onto the reef flat by storms, where they were collected by the PISS colonists for use in handicraft production. Larger and heavier pieces may still lie obscured on the reef slope.

Obviously, even if the above hypothetical reconstruction approximates what really happened, there are many uncertainties. Does wreckage from the Electra lie deep on the reef? Were the bones found in 1940 really Earhart's? If so, what particulars can we reconstruct about Earhart's time at the Seven Site? What happened to Noonan? TIGHAR's continuing research is aimed at addressing these questions.

Beyond the Mystery

TIGHAR's efforts to work through the mystery of Earhart's and Noonan's disappearance has highlighted some potentially fruitful avenues for historical and archaeological research having little or nothing to do with the disappearance itself, including the following.

The history of the Phoenix Islands Settlement Scheme

The PISS was arguably one of the last, if not the last, expansion of the British Empire before the drastic realignments following World War II. Extensive historical documentation is available on the rise and fall of the PISS, in the archives of the Western Pacific High Commission now housed at the University of Auckland Library,[33] among the papers of Harry and Honor Maude at the University of Adelaide Library,[34] and in the National Archives of Kiribati (on Tarawa) and Tuvalu (on Funafuti). There remain opportunities for oral historical/ethnohistorical research among veterans of the PISS now resident in Kiribati, Tuvalu, and especially the Solomon Islands.[35] The archaeological remains of the PISS settlements are evident on Nikumaroro[36] and on Orona and Manra as well.[37] A comprehensive study of PISS history would not be an easy or inexpensive task, but it could be a rewarding one; the PISS can be seen as the British Empire in very small microcosm. Its creation reflected a thoughtful exercise of imperial responsibility (seeking both to relieve population/resource pressures and to build economic self-sufficiency), whereas its decline and fall reflected both the independence movements of the post–World War II era and Great Britain's unavoidable economic retrenchment and political reorganization. The personal story of PISS administrator Gerald B. Gallagher is in itself a fascinating and tragic one (King 2000).

Household archaeology

The archaeological remains of PISS villages like the one on Nikumaroro have potential for the study of household archaeology (c.f. Allison 1999). A

village site like the one on Nikumaroro has several potential advantages as a place to study relationships between social and archeological households. It was occupied for a rather short period of time, by a known population and is the subject of very extensive documentary records. Residential sites on the ground can be linked with specific families of residents, who represented two different groups of people—those of Kiribati and those of Tuvalu—and came from a number of different islands. The village was abandoned at a known, recorded time, and its archaeological leavings are largely undisturbed (erosive overwash is eating at the seaward side of the village site as sea level rises). Research at the village site, or those on Orona or Manra, might explore the differences and similarities between Kiribati (Micronesian) and Tuvaluan (Polynesian) residential groups as expressed in the archeology of their households. Other lines of research might include exploring how household organization in this British-overseen colonial village differed from traditional models documented in the ethnographic literature; seeing what people left behind during the rapid but not catastrophic evacuation of their homes; looking into differences and similarities among households in this regard; investigating status differences and variation based on occupation; and examining differences and similarities between Catholic and Protestant households (King 2003).

Interdisciplinary collaboration

One of the most positive aspects of TIGHAR's Earhart Project, at least from the author's standpoint, has been and continues to be its interdisciplinary, collaborative, collegial character. The project features an Internet-linked "Earhart Project Advisory Council" (EPAC) comprising experts in fields ranging from astronomy to zoology as well as non-specialist citizen researchers, who vigorously debate issues and participate in planning; it is further enlivened by an open internet forum and a Facebook page. The project at various times has taken us into the ethnography of Kiribati and Tuvalu, the logistics and economics of trans-Pacific shipping during World War II, the history of forensic osteology, the physics of long-range radio reception, the foraging behavior of coconut crabs, the packaging and marketing of cosmetics, the dynamics of atoll geology, and a host of other topics. The Earhart Project may or may not be a model for other studies of its type, but it is one worth considering.

What constitutes "proof" in historical inquiry?

It is a pervasive demand of the media, of many members of the public interested in the Earhart/Noonan mystery, and sometimes of scholars with

whom TIGHAR interacts that we produce the "smoking gun"—the piece or pieces of evidence that by themselves will prove unequivocally that Earhart and Noonan ended their world flight on Nikumaroro. The most plausible candidates for such evidence are their airplane itself, a piece with a part number that could be tied directly to the airplane, or a bone with identifiable Earhart or Noonan DNA. TIGHAR is, of course, always on the lookout for such evidence. We have manuals containing the part numbers and descriptions relevant to the Lockheed Electra 10E. We have been generously given a reference sample of DNA from Earhart's maternal line, which is securely stored for future comparative use. We have not yet been able to obtain a sample of Noonan DNA but are seeking it.

This author likes to stress, however, that historical and archaeological research rather rarely provides smoking gun proofs. Much more often it is a preponderance of evidence—no single piece of it determinative—that causes historians and archaeologists (among others in the humanities, sciences, and social sciences) to conclude that a hypothesis is correct. In the case of Earhart on Nikumaroro, for TIGHAR's hypothesis *not* to be correct in at least broad outline, each of the following would *have* to be true:

1. Someone other than Earhart or Noonan transmitted at least four wireless signals from the Phoenix Islands in the days following the disappearance (the four whose RDF bearings crossed there), or all four receiving stations misread their receptions or made erroneous plots.
2. Someone (or ones) other than Earhart or Noonan transmitted at least fifty other wireless messages in the days following the disappearance whose characteristics make analysts credit them as possible messages from Earhart and Noonan.
3. Someone other than Earhart or Noonan died on Nikumaroro some time before 1940, while in possession of a man's shoe, a woman's shoe, and a sextant box that had most likely been in the post–World War I inventory of the US Navy.
4. That someone's stature, gender, and ethnicity were by coincidence consistent with Earhart's, or the analysis of Dr. Hoodless's metric data carried out by Drs. Burns and Jantz is wrong.
5. Someone other than Earhart or Noonan camped at the Seven Site, catching, cooking, and eating fish and opening clams in ways inconsistent with those typical of indigenous Pacific Islanders, doing something that involved setting bottles upright in a campfire, and leaving American-made cosmetic bottles and other items, apparently including a woman's compact and rouge.

6. The I Kiribati and Tuvaluan colonists on the island obtained all the airplane parts they left in their village from other islands and misremember or misreport seeing wreckage on the reef.
7. The thing in Bevington's 1937 photograph of Nikumaroro's northwest reef that looks to forensic imaging specialists like the landing gear of a Lockheed Electra 10E was really something else.

Each of the above statements may be true, but to this author and to TIGHAR, it seems more efficient to account for them by concluding that Earhart, Noonan, and their Electra ended their world flight on Nikumaroro.

The Earhart Project is ongoing; readers are invited to participate and particularly to contribute ideas and information about relevant bodies of data or avenues of research that we have not considered.[38]

Notes

1. http://www.tighar.org.

2. I Kiribati is the name by which the people of Kiribati refer to themselves.

3. See http://www.phoenixislands.org/index.php.

4. Recent TIGHAR computer modeling suggests that a range of about 150 nautical miles is most likely.

5. The reader can judge the accuracy of this statement by having Google Earth fly to 0°48′21″ N, 176°37′ W to view Howland Island, then to 4°40′30″ S, 174°31′ W to view Nikumaroro.

6. For data on studies in progress, see http://tighar.org/testhtml/Projects/Earhart/Archives/Research/ResearchPapers/Brandenburg/TidalStudy/TidalStudy.htm.

7. Numbers given here reflect adjustments based on research since publication of *Finding Amelia* (Richard Gillespie, pers. comm., January 1, 2012).

8. The nature of the "signs" was not recorded, and the crew members that noted them are all deceased.

9. See http://tighar.org/Projects/Earhart/Research/Bulletins/57_Bevingtonphoto/57_HidinginSight.htm.

10. Analyses in progress by Jeff Glickman, Photek (http://www.photekimaging.com).

11. For details, see "The Carpenter's Daughter" at http://tighar.org/Publications/TTracks/1999Vol_15/carpenters.pdf.

12. A B-24, or in the US Navy's classification, a PB4Y.

13. For details, see "Shoe Fetish" at http://tighar.org/Projects/Earhart/Research/Bulletins/31_ShoeFetish2/31_ShoeFetish2.html.

14. See http://web.utk.edu/~fac/fordisc.html.

15. For a history-based conjectural account, see King 2009. A thorough search of the Colonial War Memorial Hospital in Suva, Fiji, where the bones were last reported, was conducted in 2011 with negative results; human bones were found, but their number, types, and measurements did not match those described by Gallagher and Hoodless.

16. See TIGHAR research notes at http://tighar.org/wiki/Sextant_box_found_on_Nikumaroro.

17. See http://tighar.org/wiki/Air_Navigation:_State_of_the_Art_in_1937.

18. Note: much of the information summarized here is from field and analytic notes by the author and others that are under study and have not yet been formally reported.

19. Solomons data: Gary Quigg, pers. comm., 2011, re. results of 2011 Solomon Islands Oral History Project.

20. Two other features are similarly concentrated but do not contain such suggestive artifacts.

21. See http://tighar.org/Projects/Earhart/Archives/Expeditions/NikuV/Analysis_and_Reports/Faunals/NikuVanalysisfaunals.html.

22. Joseph Cerniglia and Bill Lockhart, pers. comm. 2011, re. ongoing TIGHAR research, and see http://tighar.org/Projects/Earhart/Archives/Expeditions/NikuV/Analysis_and_Reports/Bottle/BackgroundofOrganicLabAnalysisReport.pdf.

23. But also probably comparable with knives carried by the Coast Guardsmen.

24. See http://tighar.org/Publications/TTracks/2008Vol_24/2_8_S_5.pdf.

25. See http://tighar.org/Projects/Earhart/Archives/Expeditions/NikuV/Analysis_and_Reports/Zipper/Zipper.html.

26. See http://tighar.org/Projects/Earhart/Archives/Expeditions/NikuV/Analysis_and_Reports/Compact/NikuVanalysiscompact.html.

27. See http://tighar.org/wiki/compact. The compact used for comparison was found on EBay by TIGHAR member Karen Hoy.

28. See http://www.summitpost.org/carl-dunrud-giving-amelia-earhart-a-haircut-1934/654501 and http://earchives.lib.purdue.edu/cdm4/item_viewer.php?CISOROOT=%2Fearhart&CISOPTR=398&DMSCALE=19.82816&DMWIDTH=600&DMHEIGHT=600&DMMODE=viewer&DMFULL=0&DMOLDSCALE=3.16389&DMX=0&DMY=0&DMTEXT=%2520Box&DMTHUMB=1&REC=11&DMROTATE=0&x=55&y=105.

29. See http://tighar.org/Projects/Earhart/Archives/Expeditions/NikuVI/Niku6results.html.

30. Current TIGHAR research suggests that Earhart and Noonan turned onto the LOP about 150 miles southeast of Howland and 110 miles southeast of its neighbor, Baker Island (Richard Gillespie, pers. comm., 2012).

31. See TIGHAR Research Video #1 at http://www.youtube.com/watch?v=DL9FGsvB3E8.

32. For details, see http://tighar.org/wiki/Betty's_Notebook.

33. University of Auckland Library Special Collections: http://www.library.auckland.ac.nz/about/speccoll/home.htm.

34. University of Adelaide Library: http://www.adelaide.edu.au/library/special/mss/maude/.

35. Most Nikumaroro residents were relocated in 1963 to Rawaki and Nikumaroro Villages in the Solomons. TIGHAR has sponsored two brief interview projects with them and their descendants, one in 1996 (http://tighar.org/Projects/Earhart/Archives/Expeditions/SolomonIslands/solomonsreport.pdf) and the other in 2011 (Gary Quigg, pers. comm., 2011; interview recordings currently being transcribed), but further work would undoubtedly be rewarding.

36. See http://tighar.org/wiki/Archaeology_of_Nikumaroro.

37. The village sites on Orona and Manra have not been described archaeologically but are apparent in Google Earth imagery.

38. TIGHAR can be contacted at http://tighar.org/contact.html, and the author at tfking106@aol.com.

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