

**ATOLL RESEARCH BULLETIN  
NO. 150**

**THE NATURAL HISTORY OF FRENCH FRIGATE SHOALS,  
NORTHWESTERN HAWAIIAN ISLANDS**

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days at French Frigate Shoals on 10 different survey trips. The initial results of BSFW and POBSP investigations, as well as previously published material, are discussed herein; special emphasis is focused on the vertebrate terrestrial fauna and the vascular flora.

#### DESCRIPTION

French Frigate Shoals, lying between the latitudes of 23°37'18" and 23°52'50" North and the longitudes 166°03'14" and 166°20'04" West (USCGS Chart 4172), is given an official location of 23°45'N x 166°10'W by the U.S. Department of the Interior (Office of Geography, 1956: 6). In 1786 La Perouse (1799) named this new atoll Basse des Frigates Françaises, or Shoal of the French Frigates, because it nearly proved to be the termination of his voyage. Several variations of the name have been used over the years--French Frigate Shoal, French Frigates Shoal, and French Frigate Shoals. On 1 October 1924 the U.S. Geographic Board of Names selected French Frigate Shoal as the official name. In July 1954, however, the Board changed its collective mind and adopted French Frigate Shoals.

The atoll consists of a crescent-shaped reef on a 20-fathom-deep oval platform,<sup>1</sup> whose long axis is 19 nautical miles in a northwest to southeast direction (Fig. 2). The crescentic reef is double; the almost continuous outer arc is 31 nautical miles long while the broken inner arc is 18 nautical miles; the resulting 140 square mile lagoon is seven nautical miles wide at its midpoint. The crescent tips point west and are 15 nautical miles apart. La Perouse Pinnacle lies on an imaginary line between these two tips; it is six miles southeast of the northern tip and nine miles northwest of the southern tip.

POBSP personnel found 12 sand islands, covering 111.3 acres, of which 33.3 acres are covered with vegetation<sup>2</sup> within the reef, and two exposed volcanic rocks near the center of the oval platform. Four of the islands--East, Tern, Trig, and Whale-Skate--have well established vegetation.

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<sup>1</sup> Palmer (1927: 28-29) reported this platform to cover about 250 square miles at the 30 fathom mark.

<sup>2</sup> In 1923 Palmer (1927: 30) observed 46 acres of land of which 17 acres were covered with vegetation.

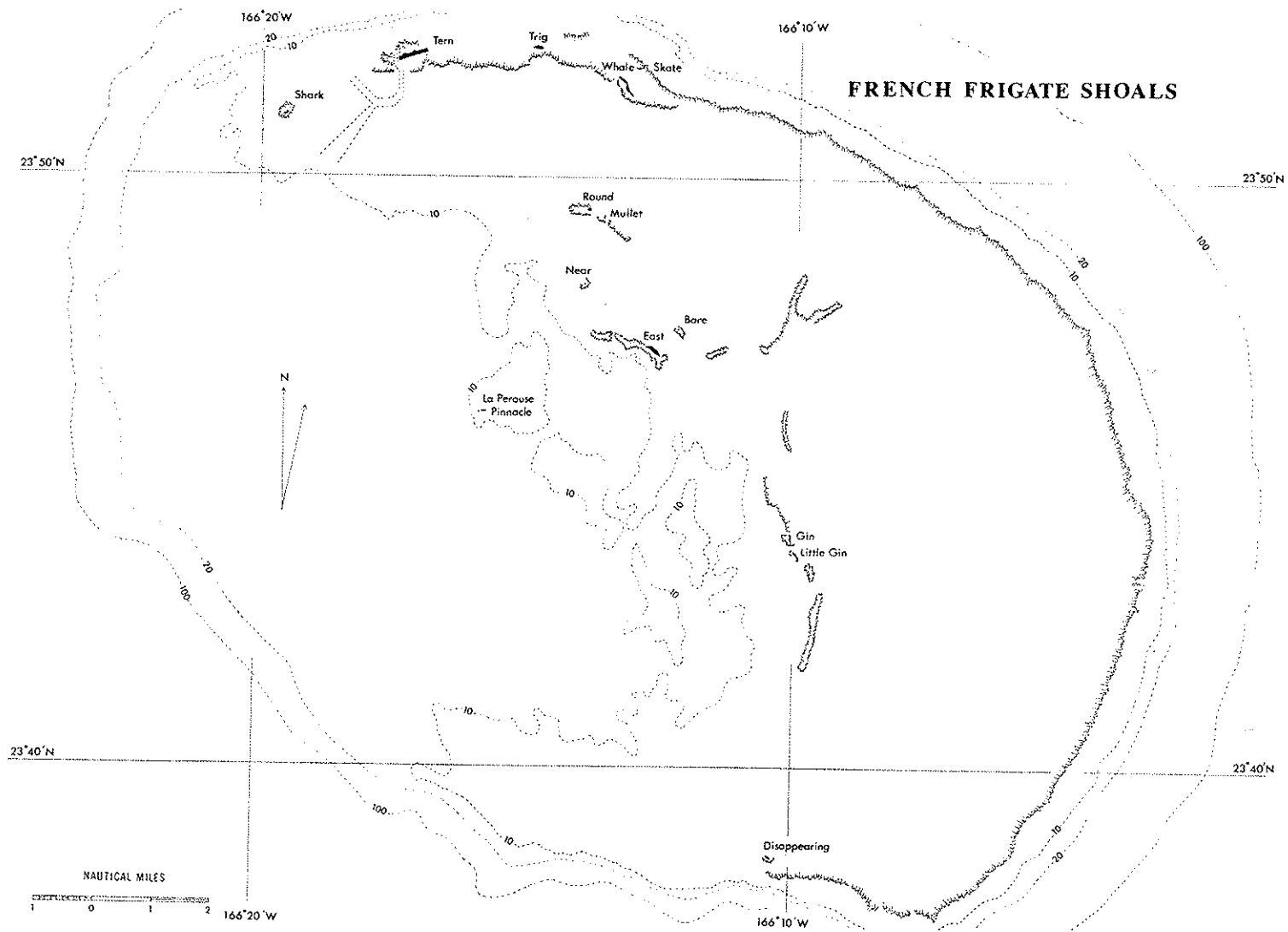


Figure 2. Map of French Frigate Shoals. Redrawn from USCGS Chart No. 4172.

Little Gin Island, although quite large in size, presently has a very limited flora; two other low but sizable islands, Gin and Disappearing, are without vegetation. All three are subject to occasional inundation. La Perouse Pinnacle also supports no vegetation in spite of its size and height. The remaining islands--Bare, Mullet, Near, Round, and Shark--are continually shifting sandbars. Three other nameless sandy islets are awash at high tide.

When La Perouse (1799) discovered the atoll on 6 November 1786, he only examined the southeastern half; he found four sand islands and the two rocks (Fig. 3). Five sand islets and the two rocks are indicated on Hydrographic Office Chart No. 2 (Fig. 4) which appeared in 1867; it was made by Brooke of the USS Fenimore Cooper during January 1859. Another chart (Fig. 5), made by Brooks of the bark Gambia in late April or early May 1859, shows 16 sand islets, as well as the two rocks.

During August and November 1914 personnel of the USS Rainbow conducted the first hydrographic survey of the atoll (Fig. 6); 12 sandspits were noted: East, Bob, Cud, Dim, Rat, Nun, Low, and Tom were more or less permanent though their shorelines continually shifted, and Ark, Mod, Ink, and Pup changed from day to day; the name<sup>1</sup> Hub was given to the rock islet (U.S. Nat. Arch., Mod. Mil. Hist. Div., R.G. 37, letter 1332-100666). In 1923 the Tanager Expedition mapped 16 sand islets (Palmer, 1927: 28-31). Of these 16, they named 12; all names are still used today. In 1928, personnel of the USS Guide surveyed the atoll; the current USCGS Charts 4171 and 4172 resulted from this and the 1913 surveys. The 1928 survey also located 16 sand islets. In 1942, with World War II raging in the Pacific, the U.S. Navy dredged coral from the lagoon to construct an air field on Tern Island; a small vessel channel 200 feet wide and 20 feet deep was cleared to the island.

These data suggest that topographical changes have occurred at French Frigate Shoals over the past 100 years, and that minor changes continue. Photographs from 1923 lent to the POBSP by Alexander Wetmore, and those U.S. Navy photographs taken in the 1930's and 1940's and obtained through the U.S. National Archives, support this hypothesis of change and provide additional material for the discussion of the vegetation in a following section.

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<sup>1</sup> Although the name Lehua Island was used once in 1895 for one of the islets, these names are considered to be the first given to the islands, but were not listed on the ensuing unpublished map.

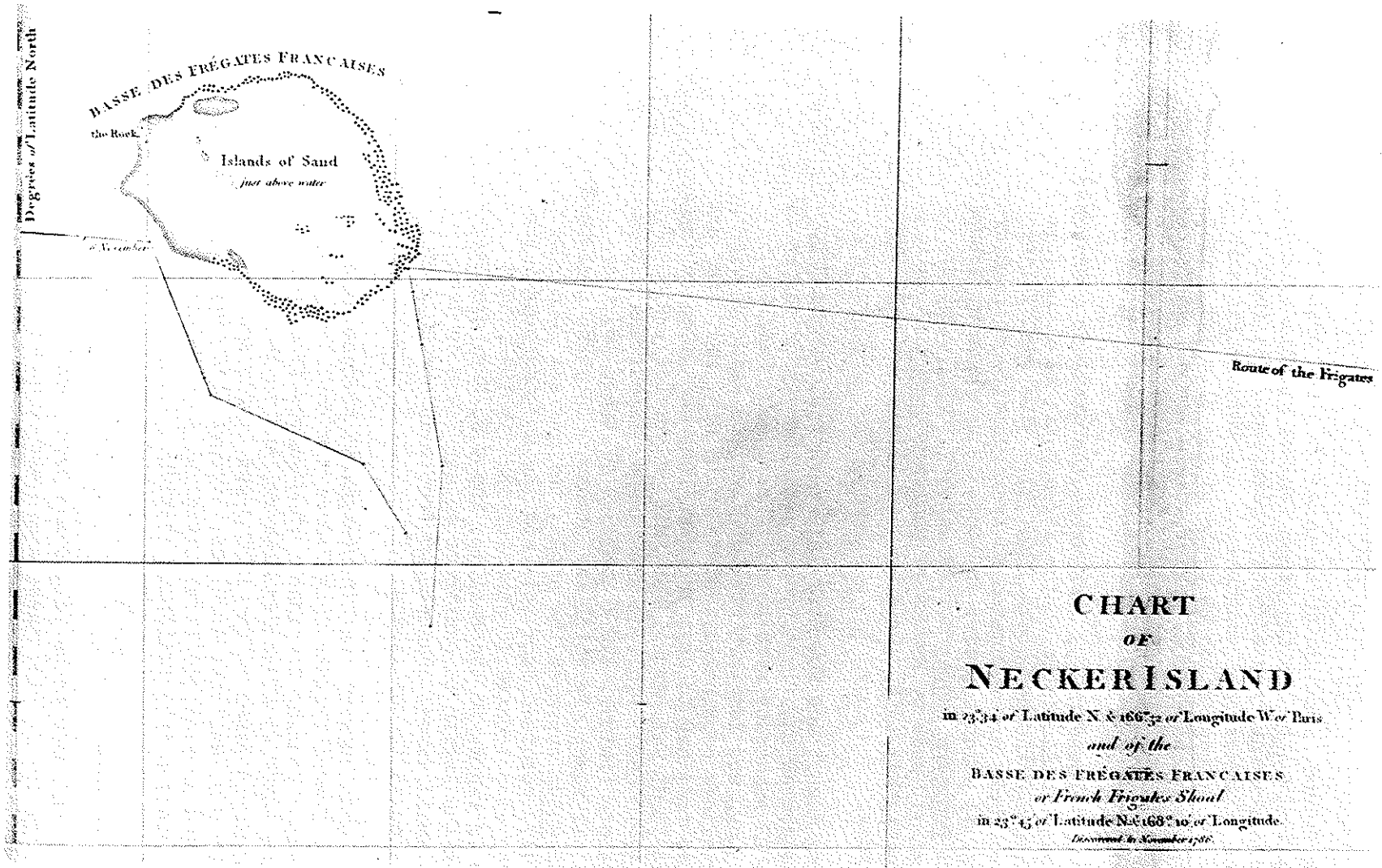


Figure 3. First map of French Frigate Shoals, published 1796 in Paris (French Hydrographic Office Map No. 556).

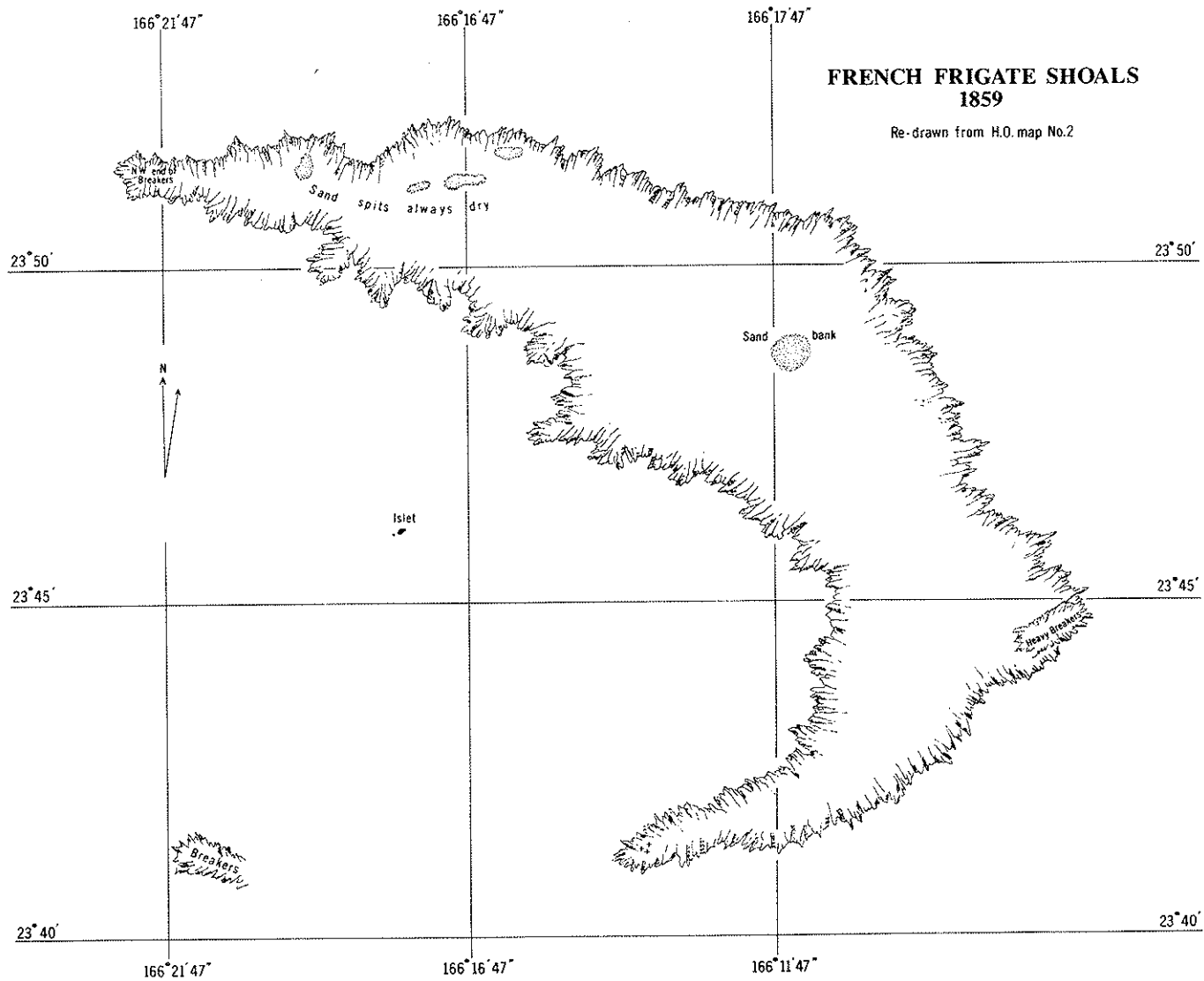


Figure 4. Map of French Frigate Shoals, drawn 1859, printed 1867.

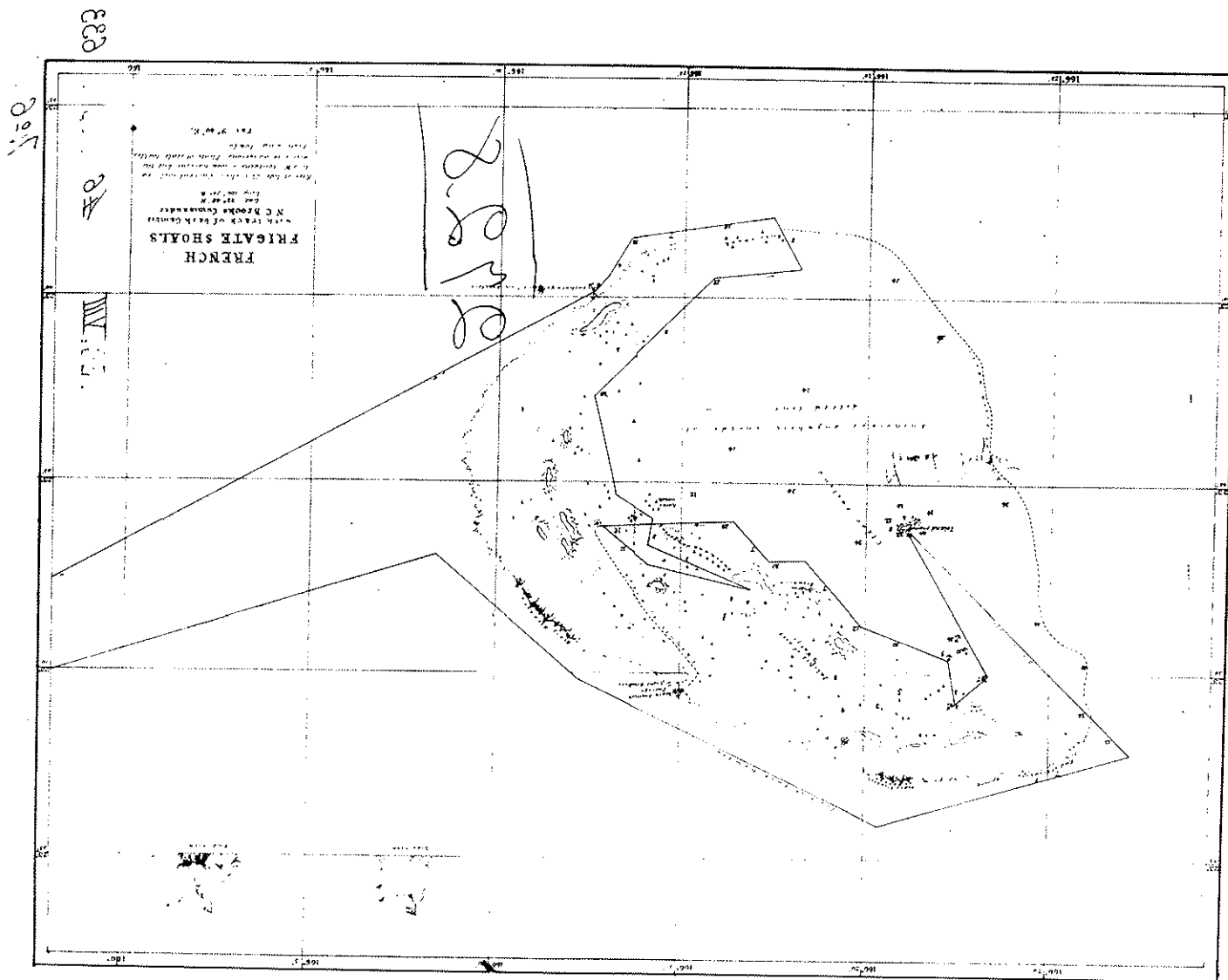


Figure 5. Map of French Frigate Shoals by N. C. Brooks showing track of Gambia and wreck of South Seaman, late April or early May 1859.

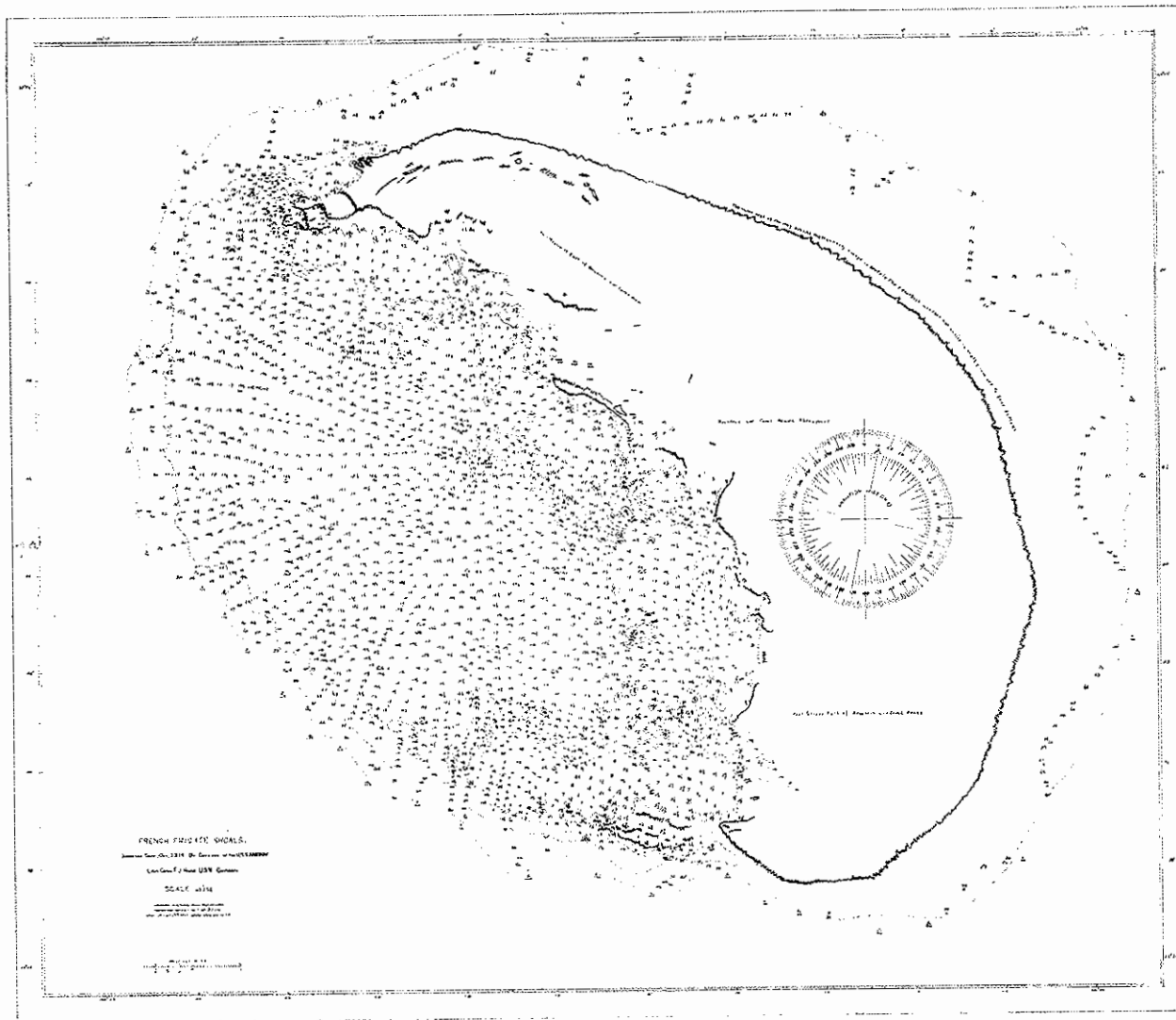


Figure 6. Original 1914 survey map of French Frigate Shoals surveyed by the officers of the U.S.S. Rainbow.



### La Perouse Pinnacle

La Perouse Pinnacle (Fig. 7), at  $23^{\circ}45'N$  x  $166^{\circ}15'W$ , is 6 miles south-southeast of Tern and 3 miles west-southwest of East. The main pinnacle rises 122 feet above sea level at its northwestern end and 120 feet at its southeastern end; it dips in the center to form a saddle. Sources differ, but the main rock is about 730 feet long northwest to southeast, and about 165 feet wide at its widest point. A second rock lies some 390 feet northwest of the main pinnacle; it rises about 9 feet above sea level and is about 200 feet long, northwest to southeast, and 65 feet wide at its widest.

The base of the main pinnacle is black while the upper portion has been whitened by guano deposits. A 5-foot-high, 25-foot-wide ledge is located at the midpoint of the southwest face; in calm seas, when swells are not coming from the southwest, this is an excellent landing. Attempts to climb the southwest face probably have succeeded but it is hazardous because of loose rock and guano. The northwest tip offers a better landing spot; from there one can work his way to the top using various ledges on the northeast face. The final 20 feet have to be traversed over the northwest end.

Loose rock is scattered about the top; guano deposits are primarily in the saddle area. Perhaps the loose rocks and guano were scattered and broken apart by the guano diggers in the late 1800's.

John M. Brooke of the USS Fenimore Cooper first noted guano in January 1859; his men found it on the surface and to a depth of four feet (Brooke, 1955: 619). Many ship captains noted its close resemblance to a full rigged sailing vessel.

Wetmore (ms.) in 1923 described it as "about 150 feet high by 150 yards long. A smaller rock 75 by 25 feet and 15 feet high lies 75 yards west of it. There are rock shelves on both north and south sides of the main islet." As to the guano, he noted that "in places it was encrusted with mineral matter, yellowish or whitish in color washed down from the guano above that at times formed small stalactites."

### Tern Island

Tern Island (Fig. 8), the largest island in the atoll, is located near the northwest tip of the crescent at  $23^{\circ}52'N$  x  $166^{\circ}17'W$ . This man-made island is 3,100 feet long east-northeast to west-southwest. Steel piling, driven to an approximate depth of 15 feet and standing 6-1/2 feet over the mean tide level, surrounds each end of the island and

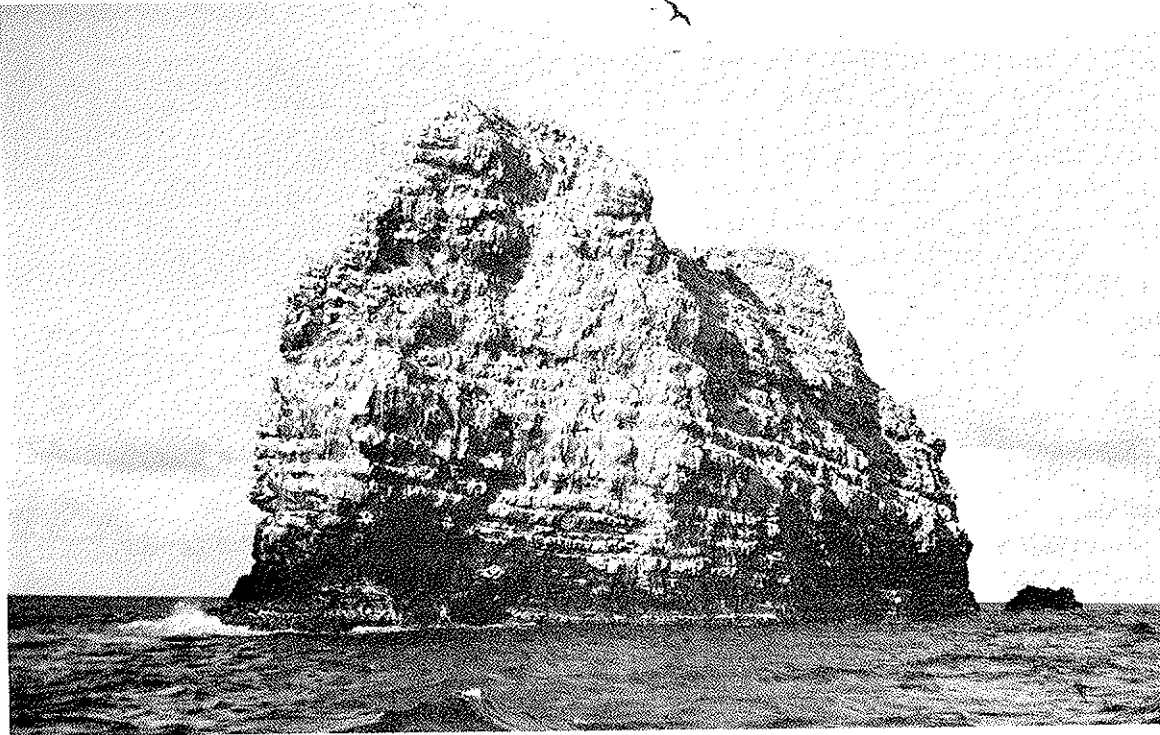


Figure 7. Northeast face of La Perouse Pinnacle, 7 August 1965;  
Little La Perouse at right. POBSP photograph by A. B. Amerson, Jr.

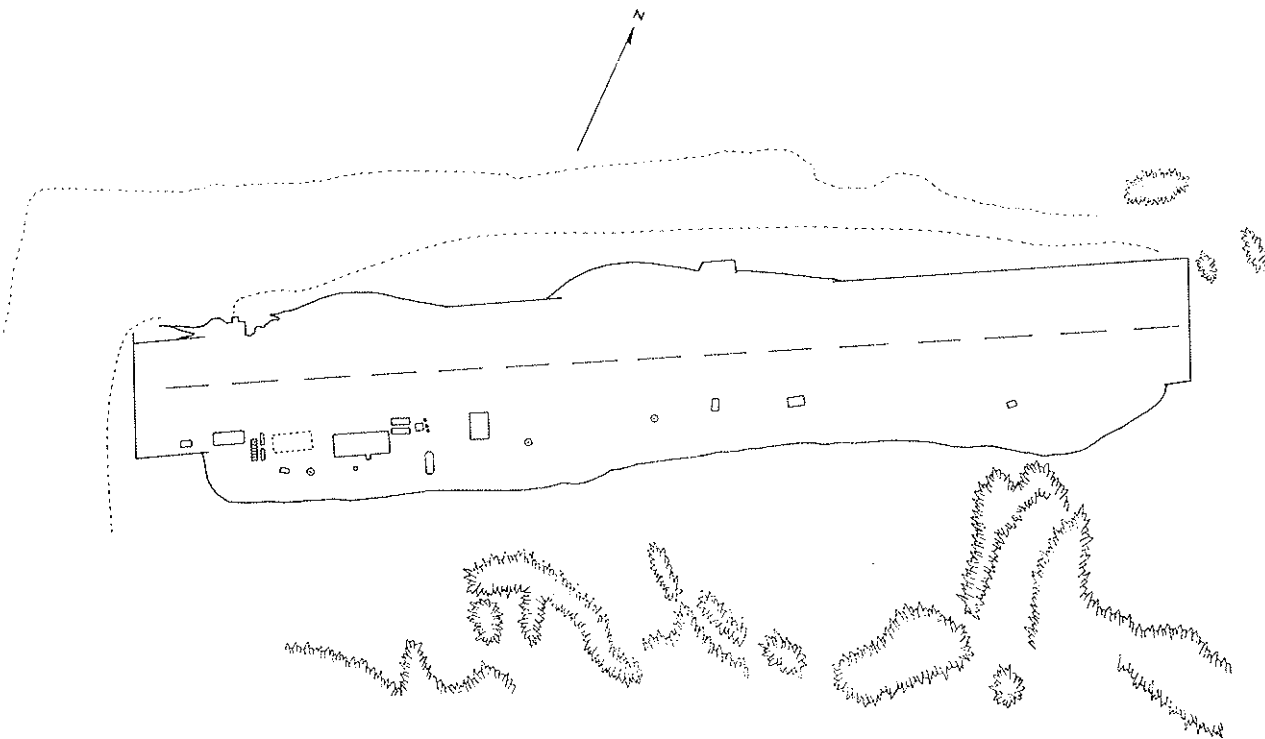


Figure 8. Tern Island, 10 January 1966. Redrawn from official  
U. S. Navy photograph.

extends along the west-northwest side of the island, except for a 975-foot central sand beach section. When newly completed in late 1942, it was 350 feet wide (Fig. 9); the east-northeast end is still this wide, but the west-southwest end is now only 325 feet wide due to a break in the sea-wall in 1958. Along the east-southeast side, a 2,800-foot-long natural sandy section has now added 100 to 175 feet onto the island's width; the widest point is now about 600 feet. It has an area of 56.8 acres, of which vegetation covers 15.5 acres, and buildings cover 1.0 acre.

A runway 250 feet wide extends the length of the island and is composed of packed, fine-crushed coral; an area of fine-to-medium-crushed coral extends for 50 feet on either side. The newly added sand on both long sides ranges from fine- to medium-sized particles. Scattered grass, vines, and low bushes, as well as introduced trees and shrubs are to be found on both sides of the runway.

At least four buildings, several fuel and water tanks, a 129-foot antenna, a small-boat davit, and a tennis-basketball court are clumped on the western third of the east-southeast side; three other buildings are scattered along the western half of this side. Two wooden piers are located near the western end of the west-northwest side. Adjacent to these piers is a 20-foot deep, 400- by 650-foot turning basin which connects southward around the west end of the island to the 12,000-foot small vessel channel leading to the open ocean.

Tern Island is presently the site of a U.S. Coast Guard LORAN Station whose complement is normally one officer and 18 enlisted men. A tour of duty is for one year. The station is supplied by ship several times a year and by weekly air service. Electrical power is available as is fresh water; the latter is rainwater obtained from a roof-catchment system. After a rainstorm, fresh water stands about for days on the hard-packed coral runway.

On 28 June 1923, Wetmore (ms.) described the original Tern Island as "about 600 yards long by 150 yards wide. The eastern half is a long curving sandspit, from 6 to 8 feet above the sea. The western half which is the site of the bird colonies is from 10 to 12 feet above the sea and has a soil of fine coral sand." He found low vegetation covering most of the western half (Fig. 10). Palmer (1927: 30) computed the area to be 11 acres, of which 3 were vegetated. A U.S. Navy photograph taken June 1932 (Fig. 11) showed the island had changed very little (U.S. Nat. Archives, R.G. 80, CF-79783-1).

NAVAL AIR FACILITY  
Proposed Building Locations  
Drawing No. R.N.A.B.-N1-109  
December 15, 1943

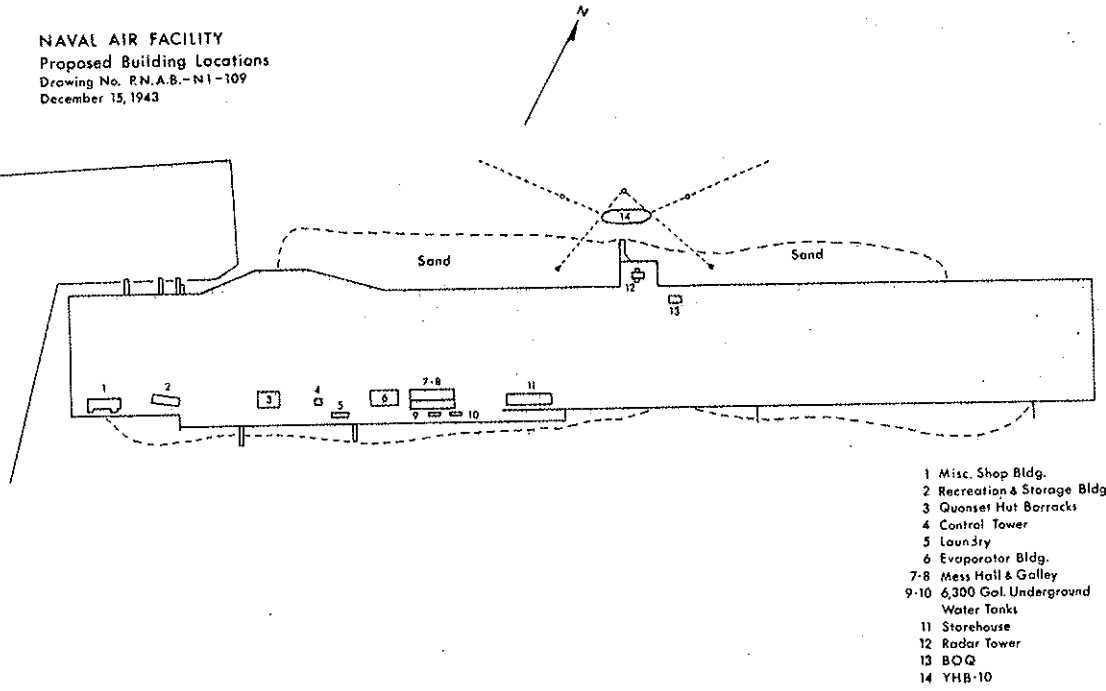


Figure 9. Tern Island Naval Air Facility, 15 December 1943. Redrawn from official U. S. Navy blueprint map.

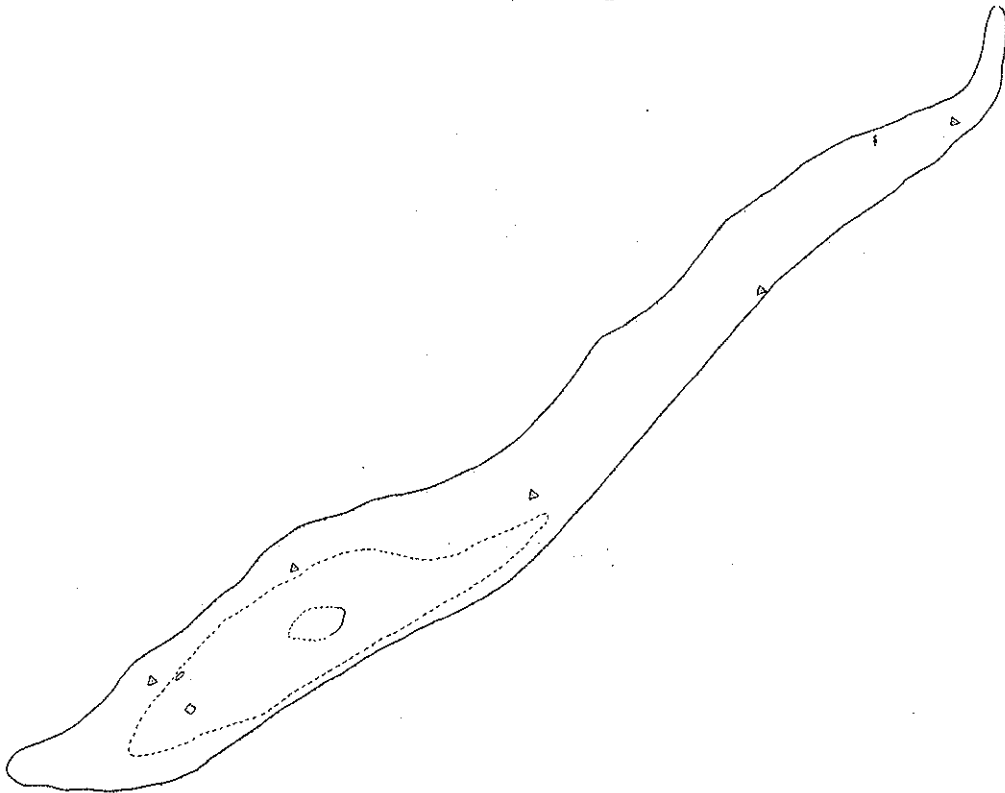


Figure 10. Map of Tern Island, 22-27 June 1923. Redrawn from Tanager Expedition map by A. S. Chaney.

### East Island

East Island (Fig. 12) lies almost midpoint along the inner reef of the crescent at  $23^{\circ}47'N$  x  $166^{\circ}13'W$ , and is six miles southeast of Tern Island. It is irregular trapezium-shaped, with the southwest beach being the longest side. It has an area of 11.3 acres, of which 6.7 are vegetated.

The island is about 2,140 feet long northwest to southeast; the northeast beach is about 875 feet long. The widest part, 330 feet, is about midpoint of the island; the second widest part, 270 feet, is near the southeast end. The island is bluntly-pointed at the southeast tip. It is elongate and sharply-pointed at the northwest tip; the proximal sand portion is about 6 feet above sea level for some 580 feet, and its distal portion is a low shifting sandspit.

The main body of East is 8 to 10 feet above sea level, composed of fine coral sand, and covered with grasses, vines, and a few low bushes and shrubs. Scattered about the middle are the ruins of the U.S. Coast Guard Station which was abandoned in 1952. Rotting wood and rusting metal are strewn about. Five 100-foot wooden poles stand upright on the southeastern half; these provide excellent island markers when approaching by small boat. An overturned whaleboat and several pieces of rusting machinery are to be found near the southeast end. The larger seabirds utilize this debris for roosting, especially at night.

The entire northeast beach is narrow and steep and is composed of fine to medium-sized sand and broken shell. The southwest beach is wide and sloping with fine sand predominating. The best small boat landing area is along the western portion of the northeast beach.

In 1923 East Island's contours were similar to today's. Wetmore (ms.), 22 June 1923, wrote: "It is elongated, slightly curving in shape and according to an accurate map [Fig. 13] made by Judd 1,890 feet long by 400 feet wide at the widest part. The surface...is coarse coral sand with many fragments of large shells. The island rises from 8 to 10 feet above sea level. Vegetation is not continuous over the surface, but grows in mats with little gaps between. The beach is narrow and rather steep." He noted that the island had "been much larger but has been cut away by storm." Palmer (1927: 30), who was with Wetmore, found that East covered 9.6 acres, of which 6.0 acres were sparsely vegetated.

A U.S. Navy photograph taken in November 1935 and reproduced as a line drawing in Figure 14 shows very little

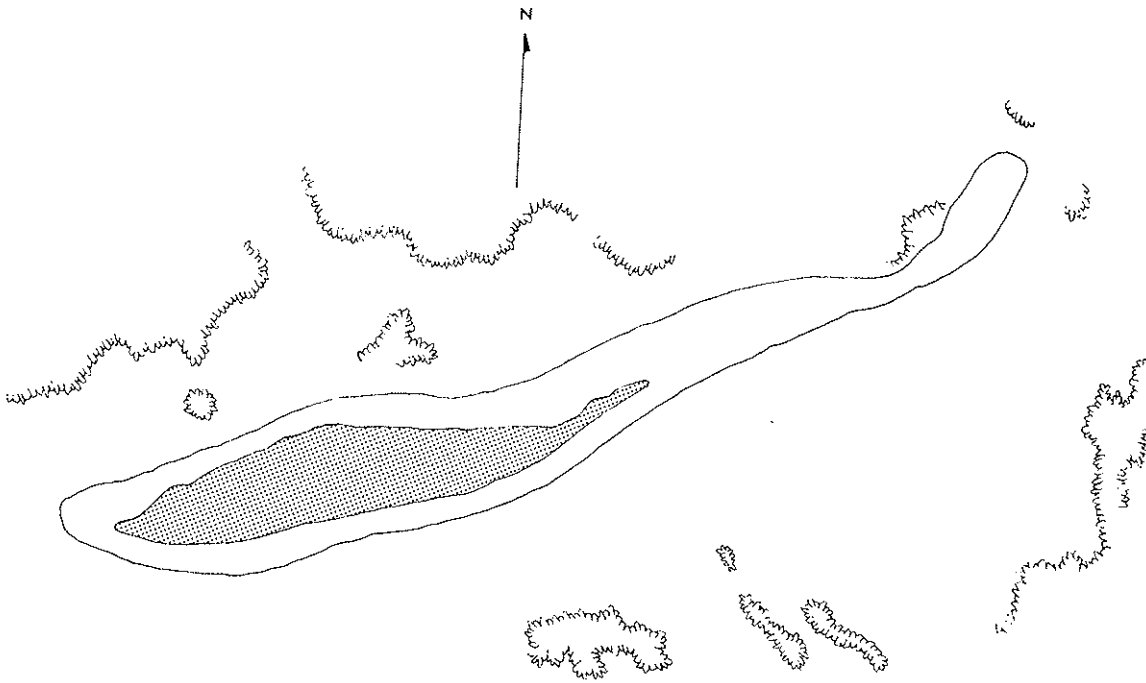


Figure 11. Tern Island, 24 June 1932. Redrawn from official U. S. Navy photograph.

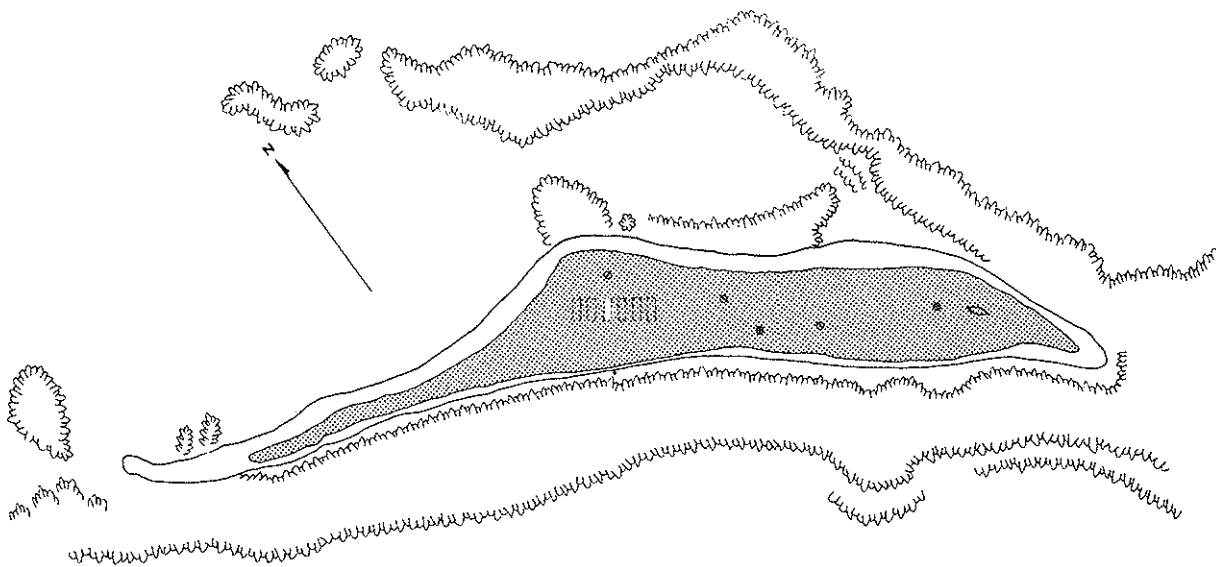


Figure 12. East Island, 10 January 1966. Redrawn from official U. S. Navy photograph.

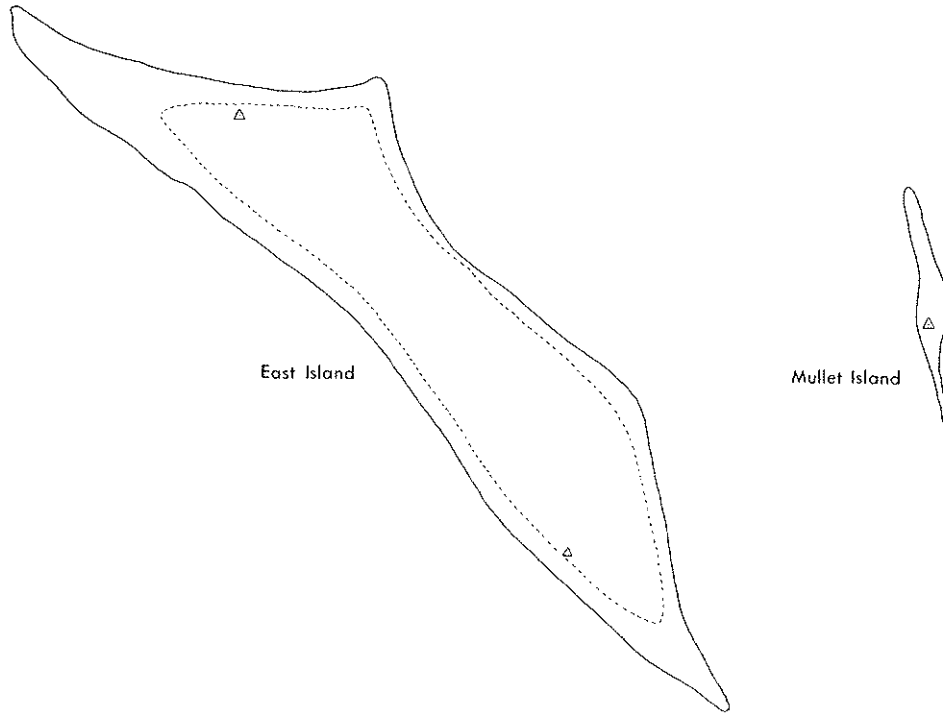


Figure 13. Map of East and Mullet Islands, 22-27 June 1923. Redrawn from Tanager Expedition map by A. S. Chaney.

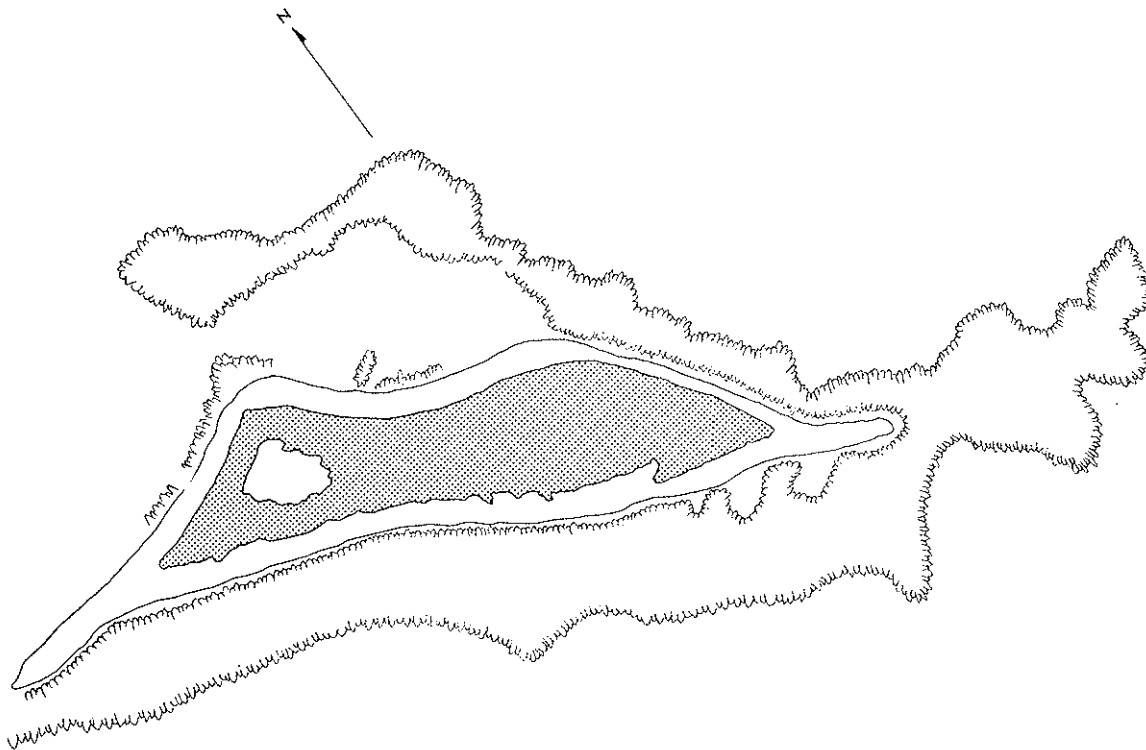


Figure 14. East Island, 11 November 1935. Redrawn from official U. S. Navy photograph.

change from 1923 (U.S. Nat. Archives, R.G. 80, CF-79793-10). When the U.S. Coast Guard built the LORAN station in 1944 the shape of the island was not altered, but various buildings and antennae were added as indicated in Figure 15 (Fed. Rec. Cen., Md., operational report, 1 Nov. 1948).

#### Whale-Skate Island

Whale-Skate Island (Fig. 16) is the easternmost of the northern islands and is situated at 23°51'N x 166°13'W; it is almost 3-1/2 miles east of Tern and 1-1/2 miles east-southeast of Trig. It is composed of two formerly discrete islands, Whale and Skate, which form a long, narrow, slightly curving island covering 16.8 acres. Vegetation covers 6.5 acres.

It is about 2,100 feet long with its axis lying in a northwest to southeast direction. The eastern (Whale) section is about 230 feet wide at its widest point and the western (Skate) section is about 270 feet wide; the connecting portion is approximately 165 feet wide at its narrowest point. The main body of this combined island is 8 to 10 feet above sea level. A short section, also 8 to 10 feet above sea level, at the east tip is separated from the main body by a low sandy strip. The soil ranges from fine to large-sized coral sand and broken shell, to small and medium-sized coral rock. Almost its entire length is vegetated with grass, creepers, low shrubs, and medium-sized bushes. The northeast beach is wide and sloping, while the southwest beach, although wide, is steep near the beach crest. A grounded, rusting barge is located 360 feet southwest of the midpoint of the eastern half of the island.

In June 1923 Wetmore (ms.) found Whale and Skate Islands "separated by a channel 150 yards wide;" he noted, however, that the two islands "are probably joined at times by the shifting sands as the water was not deep." Whale Island, so named by Wetmore because of a skeleton of a small whale on the beach, was "somewhat curved in form 400 yards long by 125 yards high and rose 10 to 12 feet above the sea. It appeared to be the oldest [sand] island in the entire group and had the upper surface covered with fine gray soil." Plant life was abundant. Wetmore observed that Skate Island "was 200 yards long by 100 yards wide and rose 8 to 10 feet above sea level. Its surface was...coral sand with scant vegetation of grass. Humus was slight and plants low and scattered." The islands were also mapped (Fig. 17) by King in June 1923; Palmer (1927: 30) noted the area of Whale to be 5.3 acres, of which 2.5 acres were covered by sparse grass; Skate Island measured 3 acres, half of which were covered by sparse grass.



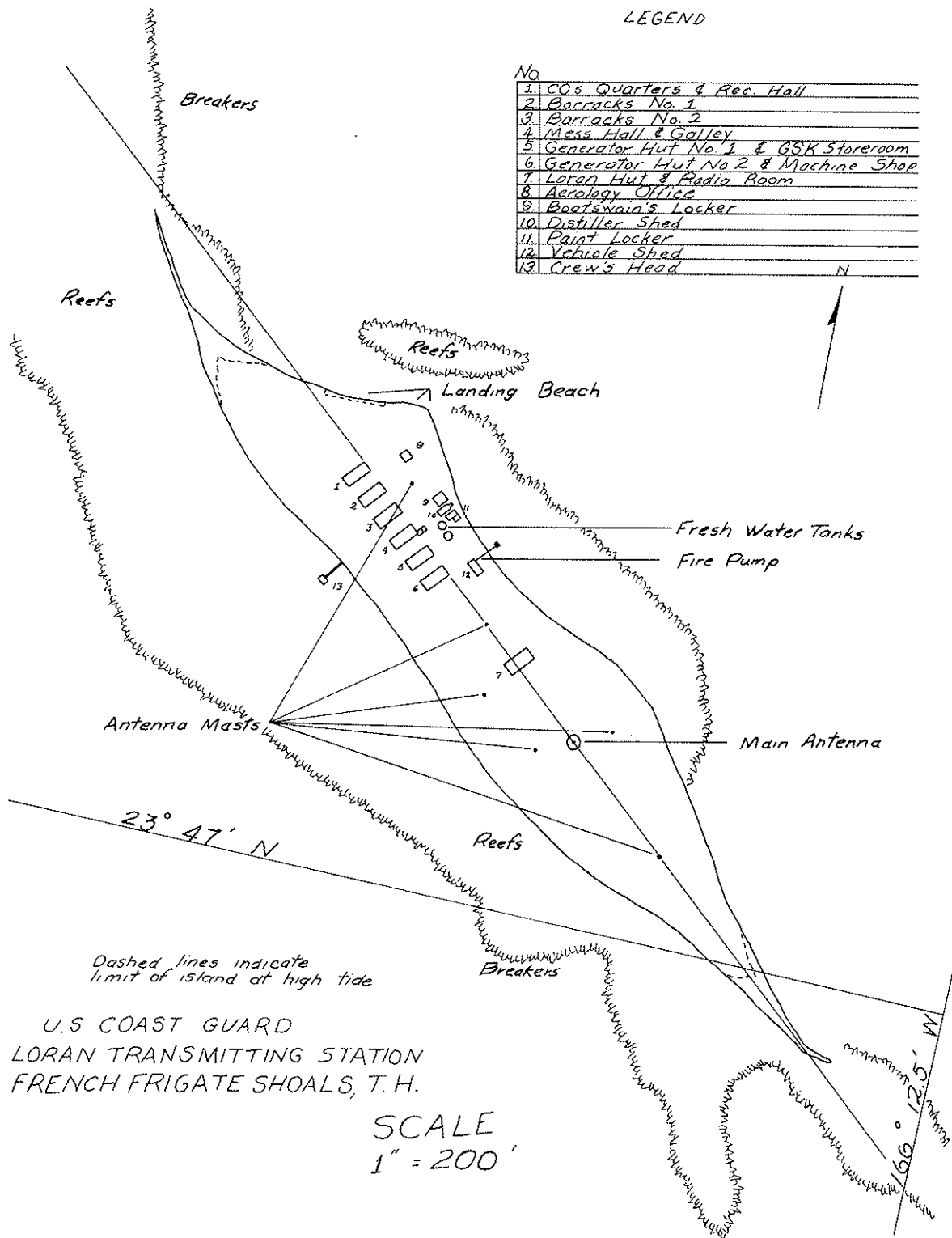


Figure 15. Map of East Island, 1 November 1948. Redrawn from official U. S. Coast Guard Operational Data Report.

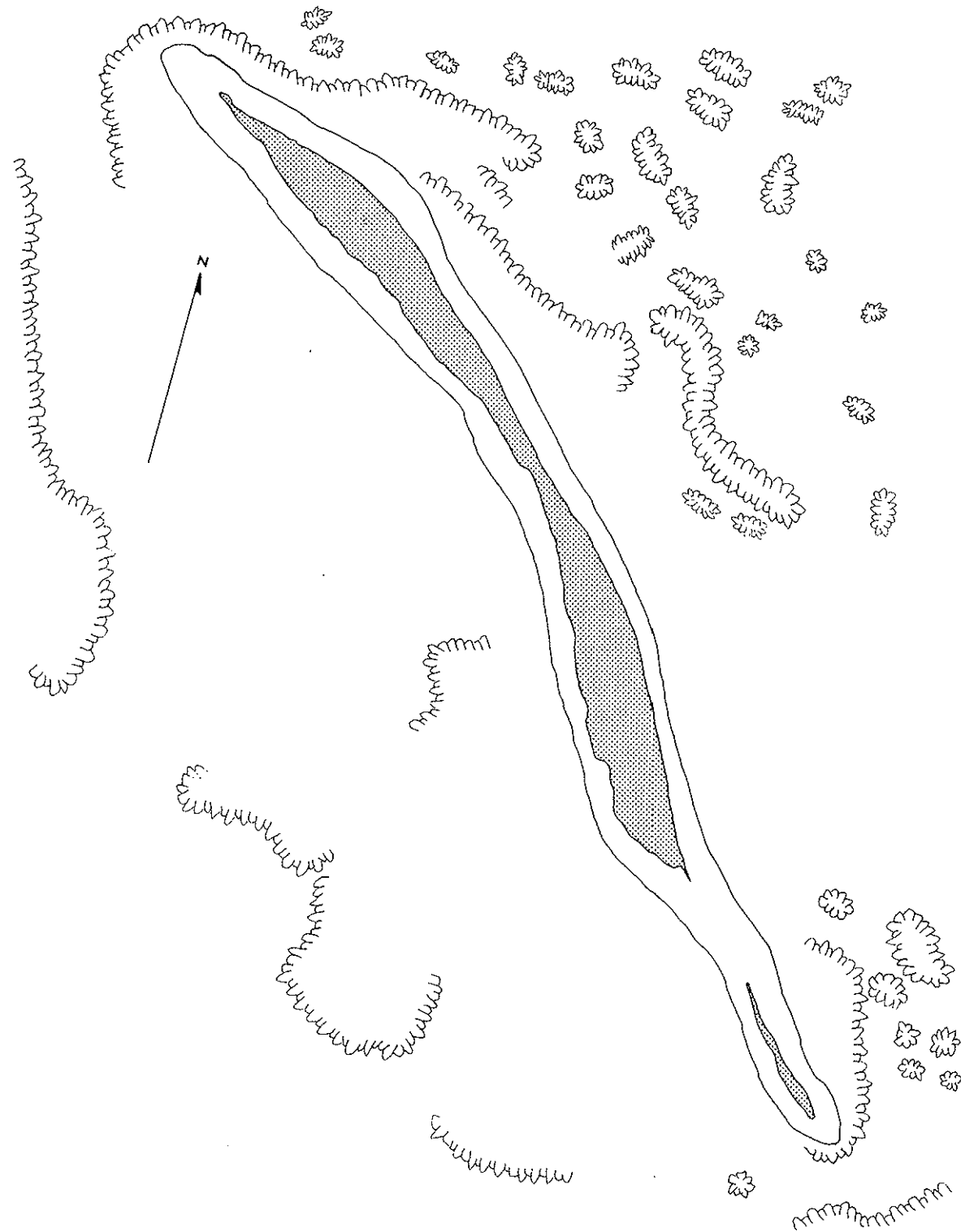


Figure 16. Whale-Skate Island, 10 January 1966. Redrawn from official U. S. Navy photograph.

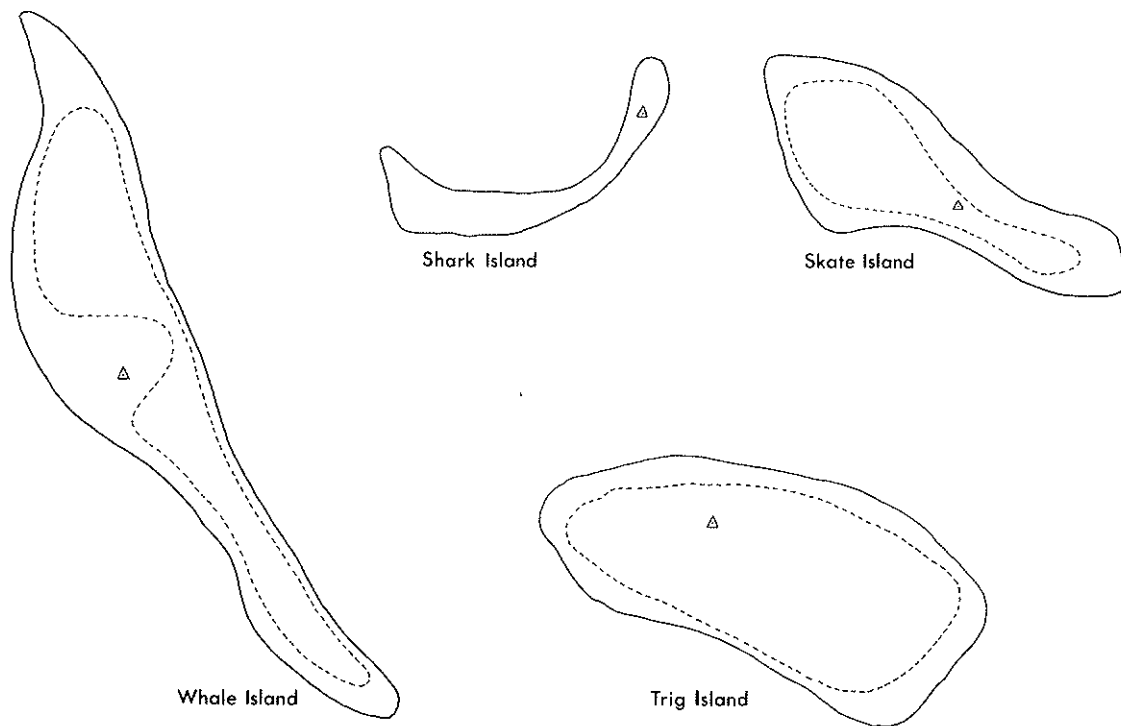


Figure 17. Map of Whale, Shark, Trig, and Skate Islands, 22-27 June 1923. Redrawn from Tanager Expedition map by A. S. Chaney.

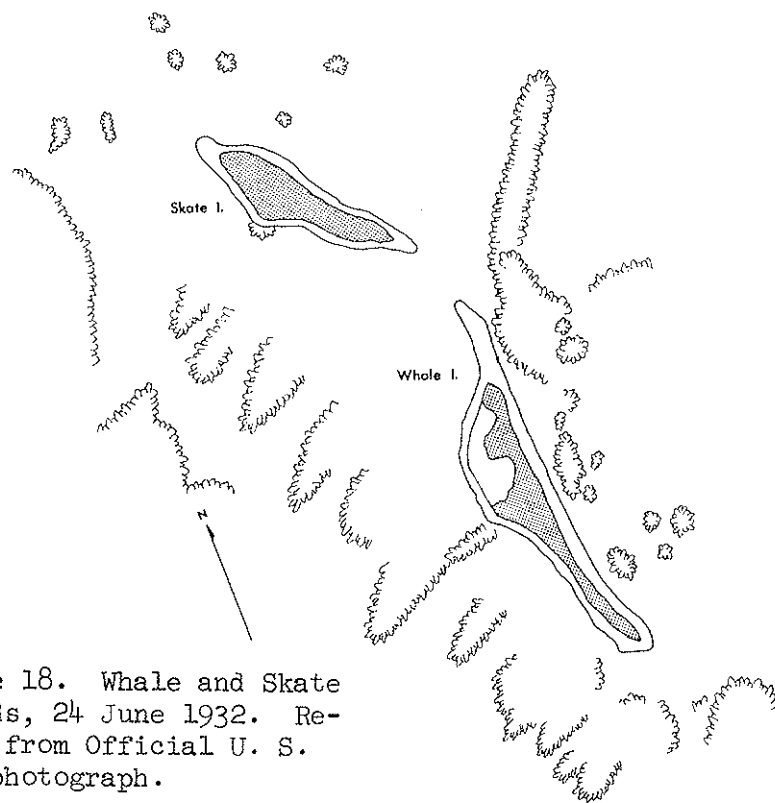


Figure 18. Whale and Skate Islands, 24 June 1932. Redrawn from Official U. S. Navy photograph.

Figure 18 shows the two islands on 24 June 1932 (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph CF-79793-6). An extended sandspit had developed on the northwestern tip of Whale; otherwise there was little change from 1923.

POFI (ms.) personnel observed that Whale and Skate Islands were "joined by a sand bar 40 - 50' wide and 3 - 4' high" on 5 June 1956; they had been separate islands two months earlier when visited on 11 April. An aerial photograph taken 28 December 1957 by Rice and Kenyon also shows the sand connection; in addition, it shows that approximately 450 feet of the eastern section had been separated from the rest of the island by a shallow, narrow stretch of water. It is not known when this section rejoined the main body, but it was joined by June 1962 (HDFG photo).

#### Trig Island

Trig Island (Fig. 19), at 23°52'N x 166°15'W, is located just inside the northreef about 1-3/4 miles east of Tern and about 1-1/2 miles west-northwest of Whale-Skate. This dogleg-shaped island covers an area of 9.9 acres, of which 4.6 are vegetated.

It is approximately 1,170 feet long east to west; the eastern section is 215 feet wide at its widest point; it narrows to 195 feet before widening at its midpoint to 280 feet; the western half is 320 feet wide at its widest point. The north beach is concave and forms a cove about 600 feet long and 115 feet deep. The south beach is pointed at the island's midpoint; the east half is about 640 feet long and the west half is about 600 feet long.

Trig is the highest of the atoll's sand islands; it slopes from a low of 8 feet above sea level on the eastern half to a height of 20 feet above sea level at the edge of the vegetated west half. The west and south beaches are wide, but are steep next to the vegetated area. The entire north beach is sloping. The soil is fine to medium-sized coral sand. Grass and other low plants cover the west half; large bushes predominate on the southern side of the east half.

Wetmore (ms.) in June 1923 found Trig to be "225 yards long by 125 yards wide and...nearly circular in form. It rose from 8 to 19 feet above the water, had the summit covered with a fair growth" of vegetation. King mapped the island (Fig. 17), and Palmer (1927: 30) found the area to be 5.3 acres, of which 3.7 were covered with sparse grass.

Figure 20 illustrates its shape in June 1932 (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph CF-79793-5). The island's shape changed considerably from 1932 to 1963; the north side eroded away and the southeast corner disappeared.

#### Gin Island

Gin Island (Fig. 21), situated at 23°44'N x 166°10'W along the inner southern reef, is 9-1/2 miles southeast of Tern and 4 miles south-southeast of East. This irregular, oval-shaped island has an area of 3.2 acres.

The island is 496 feet long from northwest to southeast and 351 feet wide. It is 6 to 8 feet above sea level with a steep eastern beach and a sloping western beach. It is composed of fine to large-sized coral sand and broken shell. A small tidal pool was found in 1969 near the center. The island is not vegetated.

In June 1923 Wetmore (ms.) described the island as "a curving sand spit, 1/3 of a mile long and from five to 150 feet wide. At the widest point there was a small area 19 feet above sea level and here were a few scattered plants. From this wider point a long curving spit ran out to the north." The island was given its name "by an empty Gordon gin bottle...found cast up by the waves." In June 1923 the island was also long and narrow, but irregular on the southwest side as shown in Figure 22 (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph, CF-79793-3).

#### Little Gin Island

Little Gin Island (Fig. 21) is located less than half a mile southeast of Gin Island at 23°44'N x 166°10'W, and has an area of 5.1 acres. It is 1,170 feet long northwest to southeast; the northeast side is straight, but the southwest side is concave. It is 265 feet wide at the widest point of the northwest half and 6 to 8 feet high; the middle section is 90 feet wide at its narrowest point and 3 to 6 feet high; the southeast half's widest point is 380 feet and 10 to 12 feet wide. Fine to medium-sized sand covers the entire island. The central area of the southeast half is slightly depressed; a few sprigs of vegetation occur here. In June 1967, the northwest half was awash at high tide.

Wetmore (ms.) described the island in 1923 as "approximately 300 yards long by 100 yards wide in its main part and 10 feet high at the highest point. A slight depression at the summit 50 yards across was grown over with plants." Toward the north a long, narrow sand bar extended for 250 yards.

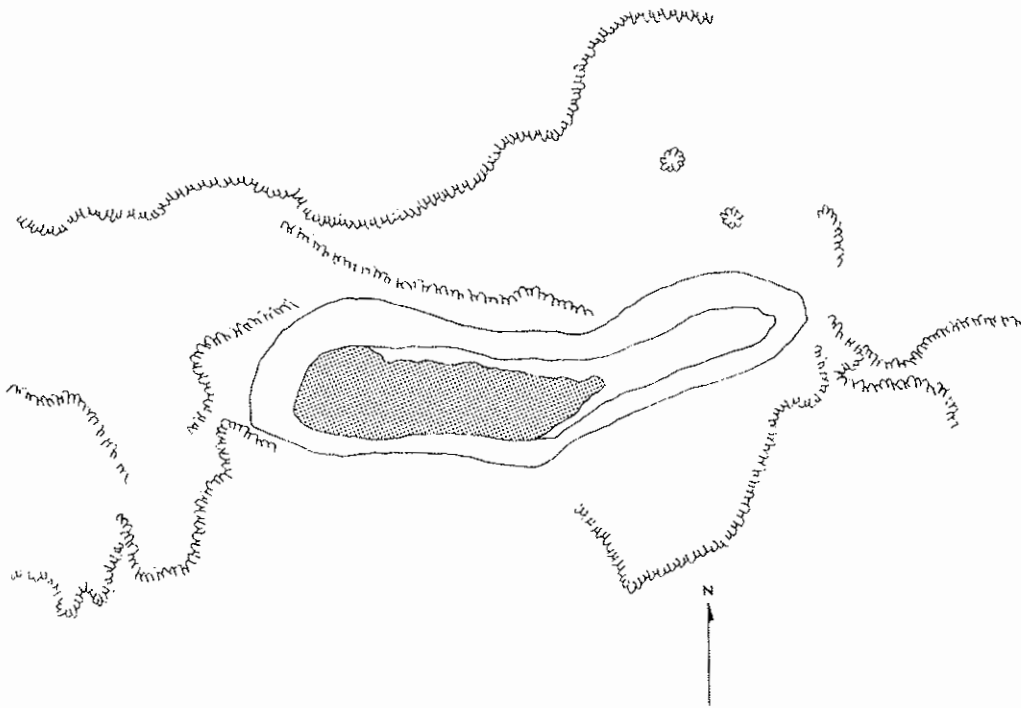


Figure 19. Trig Island, 10 January 1966. Redrawn from official U. S. Navy photograph.

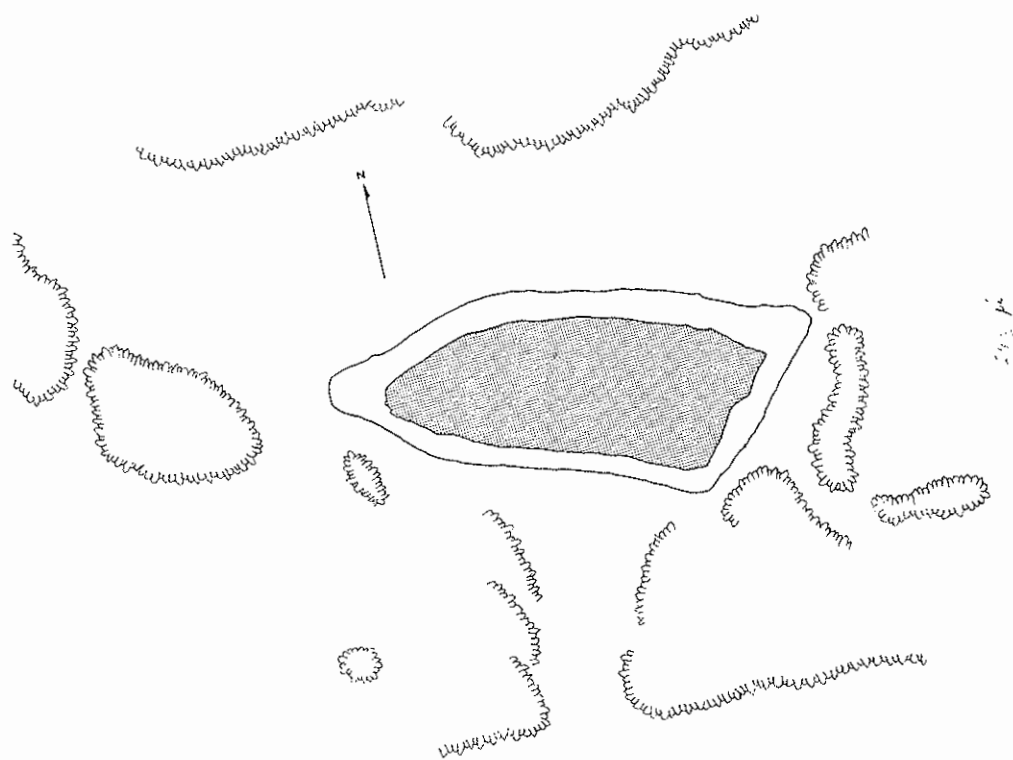


Figure 20. Trig Island, 24 June 1932. Redrawn from official U. S. Navy photograph.

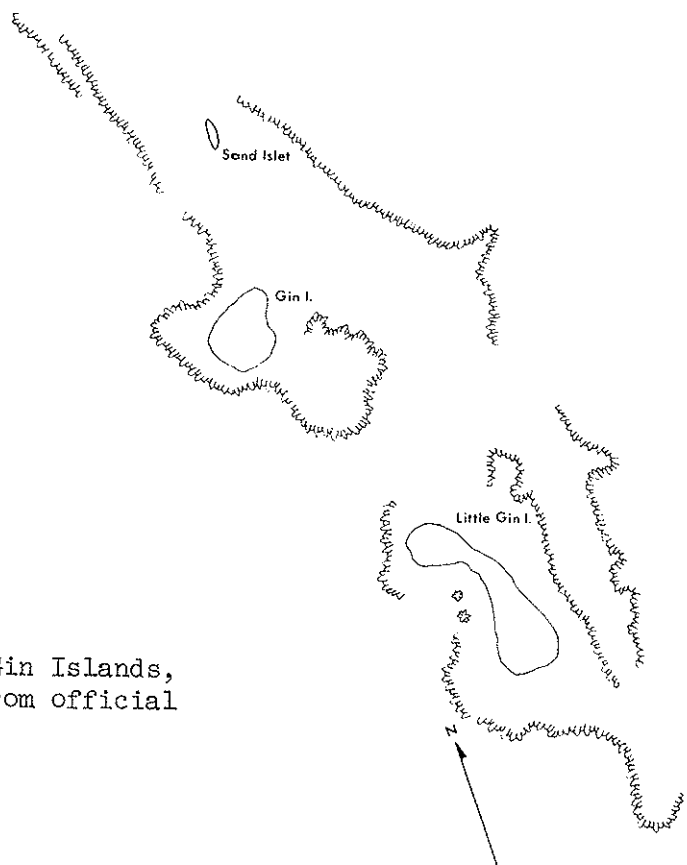


Figure 21. Gin and Little Gin Islands, 10 January 1966. Redrawn from official U. S. Navy photograph.

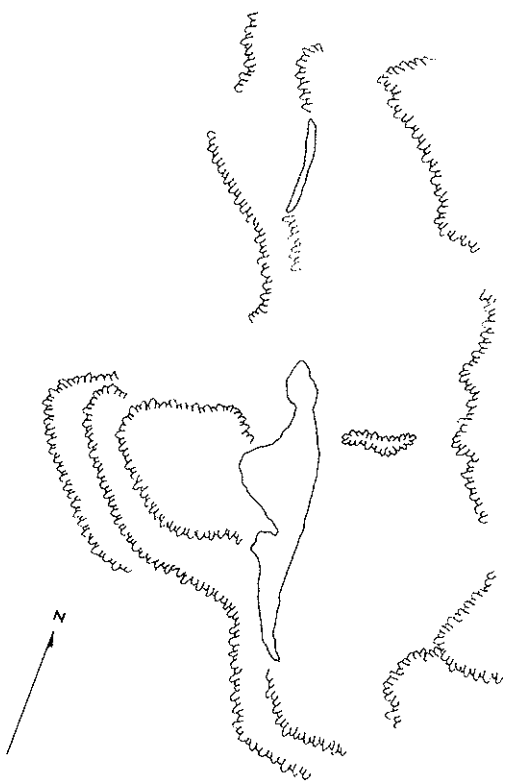


Figure 22. Gin Island and unnamed sandspit, 24 June 1932. Redrawn from official U. S. Navy photograph.

### Round Island

Round Island (Fig. 23) is located near the north center of the lagoon at  $23^{\circ}49'N$  x  $166^{\circ}14'W$ . It is almost 4 miles southeast of Tern, slightly over 2 miles south-southwest of Whale-Skate, and  $2\frac{1}{2}$  miles north-northwest of East. It covers an area of 0.5 acre.

As its name implies, the island is almost round; it is approximately 190 feet long north to south and 175 feet wide. The highest point is only about 4 feet above sea level; all beaches are sloping. The soil is fine to medium-sized coral sand and broken shell; no vegetation exists.

Wetmore (ms.) in June 1923 found "a circular island 100 yards in diameter rising 8 to 10 feet above the sea. The higher portion was covered with plants of four species." Palmer (1927: 30) computed its area at 1.6 acres. By June 1932 Round was an irregular, oval-shaped island (Fig. 24) and still partly covered by vegetation (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph CF-79793-2). An aerial photograph taken by Rice and Kenyon 28 December 1957 shows no vegetation but the shape was still the same as in 1932.

### Mullet Island

Mullet Island (Fig. 23) lies 0.04 miles east-southeast of Round Island at  $23^{\circ}49'N$  x  $166^{\circ}14'W$ . It is 260 feet long north to north and only 55 feet wide throughout its length. Its area is 0.5 acre. It is formed of fine coral sand, and is usually awash at high tide.

Wetmore (ms.) described this sand spit as "bare of vegetation being simply a ridge of coarse shell and coral" some "100 yards long by 30 or 40 feet wide." Chaney mapped it (Fig. 13); and Palmer gave its area as 0.4 acre.

### Shark Island

Shark Island (Fig. 25), at  $23^{\circ}51'N$  x  $166^{\circ}20'W$ , is located at the northwest tip of the atoll's crescent reef. It is just over two miles west-southwest of Tern. In January 1966 it was 215 feet from east to west and 80 feet wide. It is 6 to 8 feet high, composed of fine sand, broken shell, and coarse coral rock, and has no vegetation. It covers 0.8 acre.

Wetmore (ms.) in June 1923 found Shark "of curving form, narrow, 200 yards long by 15 yards wide at the widest point. It supports no vegetation...and is made of much coarse coral and shell thrown up on the beach." King mapped the island (Fig. 17) and Palmer (1927: 30) noted its area as 1.1 acres.



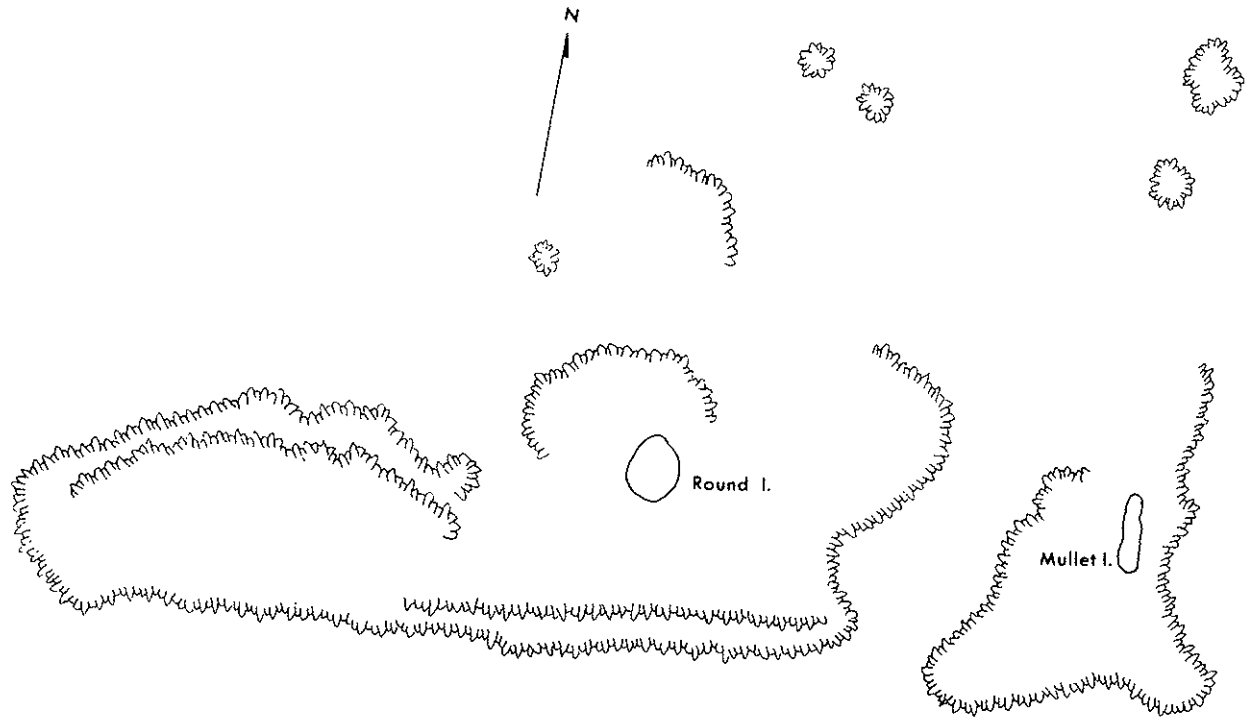


Figure 23. Round and Mullet Islands, 10 January 1966. Redrawn from official U. S. Navy photograph.

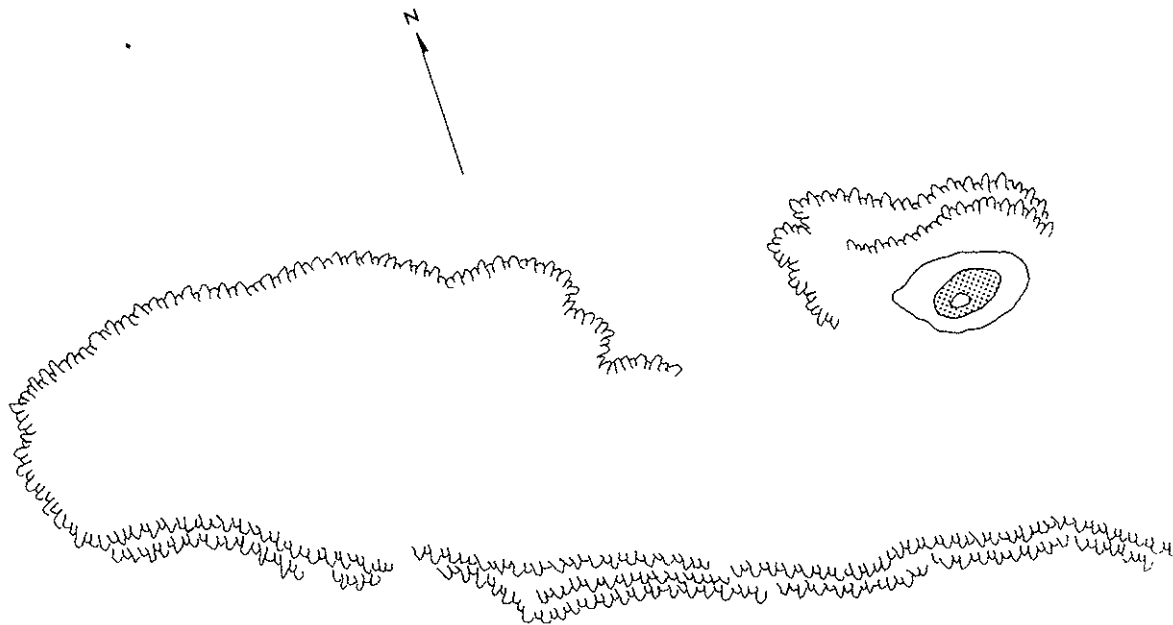


Figure 24. Round Island, 24 June 1932. Redrawn from official U. S. Nav, photograph.

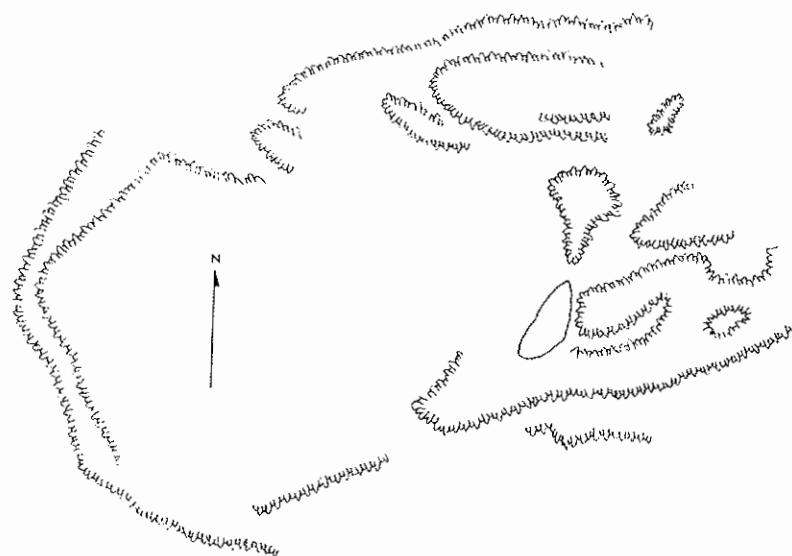
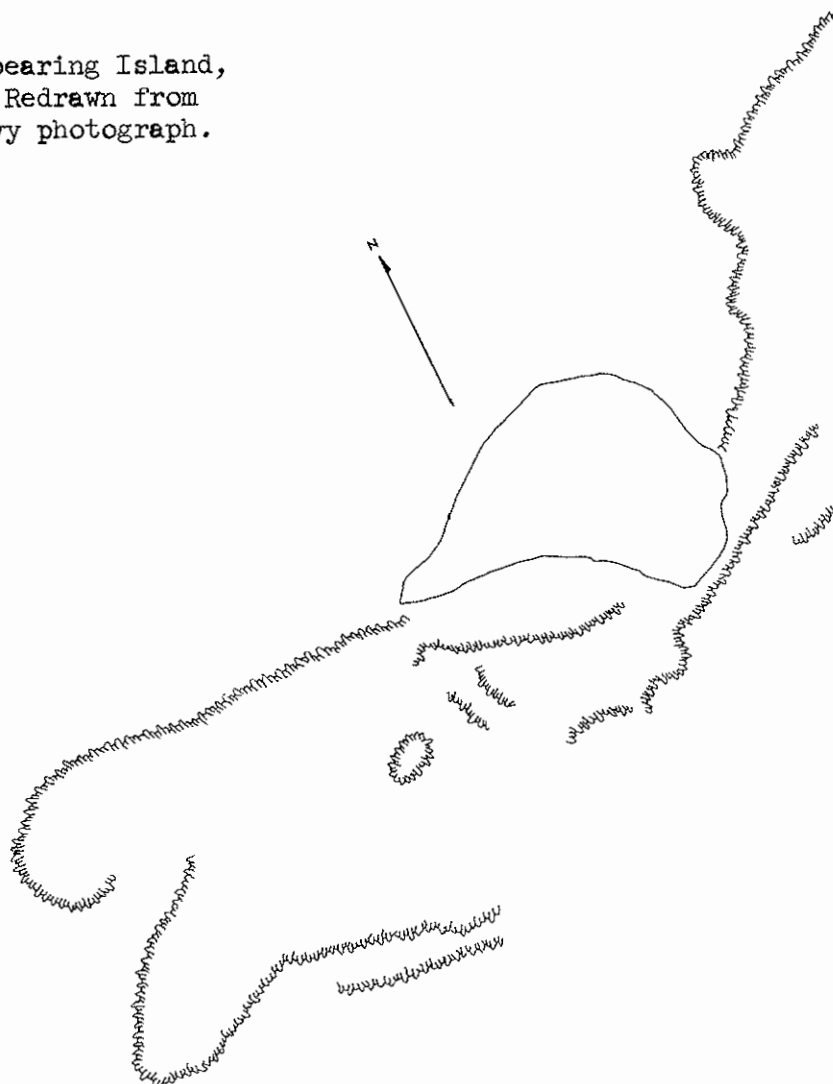


Figure 25. Shark Island, 10 January 1966. Redrawn from official U. S. Navy photograph.

Figure 26. Disappearing Island, 10 January 1966. Redrawn from official U. S. Navy photograph.



### Disappearing Island

Disappearing Island (Fig. 26) is located at the southwestern tip of the atoll's crescent reef at 23°38'N x 166°10'W. The island is 8 to 10 feet high, 700 feet long from northwest to southeast and 505 feet at its widest point. Its composition is of fine to medium-sized coral sand and broken shell; no vegetation occurs. It covers an area of 6.2 acres.

The 1923 Tanager Expedition did not visit Disappearing but passed it in the ship on 28 June. Wetmore (ms.) noted that "it was apparently a bare sand spit 300 yards long with no indication of vegetation."

### Bare Island

Bare Island is located half a mile northeast of East at 23°47'N x 166°12'W. It is awash at high tide and is usually about 100 feet long, 10 feet wide, and 4 feet high. It covers an area of 0.1 acre. Wetmore (ms.) in 1923 described it as "60 yards long by 10 wide, merely a ridge of sand rising 5 feet above the water and evidently swept" by waves. Palmer (1927: 30) found its area to be 0.1 acre.

### Near Island

Near Island, at 23°48'N x 166°14'W, is located 1-1/2 miles northwest of East. It is a very small oval sandbar, covering only 0.1 acre, which is normally awash at high tide. The island was not present in 1923, but was noted in 1928 by USCGS personnel.

### Three unnamed islets

Three unnamed islets, each very small and awash at high tide, presently exist. One is located 1/4 mile northwest of Trig; this islet was present in 1923 (Palmer, 1927: 29-30). A second islet, also present in 1923 (Palmer, 1927: 29-30), is located just north of Gin. The third islet is located about a mile south of Little Gin. Other islets at times have appeared about a mile north of Gin. In 1923 Palmer (1927: 29-30) noted two others just east of Trig.

## GEOLOGY

French Frigate Shoals, like the rest of the Northwestern Hawaiian Islands, was produced by volcanic upheavals which formed a mountain ridge, rising some 2,500 fathoms above the ocean floor. The atoll was once an exposed top of a volcanic mountain, but all that remains are two small exposed volcanic

remnants and a coral reef, supporting sand islands, which has grown around them. The exposed coral reef, which is double and crescent shaped, rises from an 18-mile-long, shallow, oval platform. It sits atop an underwater cone which rises above a 155-mile-long ridge some 500 fathoms deep. This ridge drops off on all sides to a depth of 2,000 fathoms, and deeper.

Palmer (1927: 31), who visited the Shoals in June 1923 as a member of the Tanager Expedition, thought the reef and shallow platform were "the sea level extent of a former conical volcanic island." He suggested that "probably the original volcanic island was somewhat smaller than the area indicated, for the shoal may have been widened two or three miles by a terrace built of debris eroded from the volcano....Erosion by streams and waves leveled off the cone except for the residual La Perouse Rock, which, eventually, will also be removed." Palmer thought the leeward reef was older than the windward reef and stated that "the windward reef, lying in the direction from which the food-bearing currents come, has better nourished reef organisms and therefore has grown more vigorously." He pointed out that the extremities of the windward reef had joined those of the leeward reef, enclosing a lagoon. Finally, he predicted "that the leeward edge of the shoal will develop a reef making a nearly circular atoll or ring of a reef at some time in the future." Earlier Walker (1909) forecast the same thing; in 1891 he had found "that the N.W. horn of the crescent is rapidly extending, and in course of time will no doubt assume a circular form."

The most prominent feature of French Frigate Shoals is the centrally located volcanic remnant, La Perouse Pinnacle. Palmer (1927: 30-31) landed on this precipitous rock, noted that the lava flows dip one to two degrees to the northwest, collected two rock samples, and later described them, as follows:

One is a dark gray, vesicular olivine basalt. The vesicles are rather abundant, roundish, and 0.5 to 3 mm. in diameter. The olivine phenocrysts are somewhat rusty and range from 0.2 to 2 mm. in diameter. Under the microscope the olivine phenocrysts are seen to be fairly idiomorphic, and to contain small inclusions of magnetite. There are no other phenocrysts. The groundmass consists of feldspar laths with intersertal augite and glass [See Table 1, sample 1]. The other specimen is also an olivine basalt, medium gray in color, and with only a few vesicles. Under the microscope the olivine phenocrysts show resorption

rims and bays which indent the otherwise idiomorphic outlines. There are also a few phenocrysts of augite, some of which appear to have been granulated by movement of the lava. Magnetite inclusions are rather common in the olivine phenocrysts but rare in the augite phenocrysts. The groundmass is composed of feldspar laths with intersertal augite, and a little magnetite, but with no glass.

Washington and Keyes(1926: 348-350) analyzed these two rocks (Table 1) and found they were almost identical and noteworthy chiefly for their low  $\text{SiO}_2$  and high  $\text{MgO}$ . This analysis was similar to that of the olivine basalts of Nihoa and Necker Islands, and like some of those in Hawaii.

Table 1. Chemical analysis of laval rock from La Perouse Pinnacle collected by Palmer in June 1923 and analyzed by Washington and Keyes(1926: 350).

Chemical	Sample 1	Sample 2
$\text{SiO}_2$	44.58%	45.67%
$\text{Al}_2\text{O}_3$	11.38	11.30
$\text{Fe}_2\text{O}_3$	3.08	1.77
$\text{FeO}$	6.12	7.99
$\text{MgO}$	17.30	15.95
$\text{CaO}$	9.39	9.34
$\text{Na}_2\text{O}$	2.21	1.98
$\text{K}_2\text{O}$	0.41	0.52
$\text{H}_2\text{O}^+$	0.49	0.76
$\text{H}_2\text{O}^-$	1.52	0.56
$\text{CO}_2$	0.00	0.00
$\text{TiO}_2$	2.90	3.15
$\text{P}_2\text{O}_5$	0.53	0.41
$\text{Cl}$	0.05	0.09
$\text{MnO}$	0.14	0.13
	<u>100.10%</u>	<u>99.62%</u>

Seventy-five percent of the land at French Frigate Shoals, excluding La Perouse, is located in the northern half of the atoll. This is the antithesis of land distribution in the three northwesternmost Hawaiian atolls--Kure, Midway, and Pearl and Hermes--which Standen (1967: 8) found to be 99 percent in the southern half of the atoll. He theorized (pp. 87-89) that land distribution is greatly affected by infrequent winter storms with high winds from the northwest, and not by the normal summer trade winds. He concluded that this land forms in the lee of such northwest winter winds, adjacent to and north of the south and southeast reef, and with its main axis perpendicular to these winds.

Although land distribution at French Frigate Shoals is different from the other three Hawaiian atolls, the location of the islands themselves follows Standen's theories of distribution. The differences can be attributed to different wind conditions and to the shape of the atolls.

At French Frigate Shoals winter storms with winds over 40 knots are infrequent and vary in direction; northern and eastern factors predominate, thus it can be said that winter storms are generally from the northeast. The normal trade-winds are from the east. French Frigate's crescent-shaped outer reef has tips pointing west; another irregular inner reef joins these two tips (Fig. 2). The two reefs thus form a convexo-concave atoll, which is skewed from northeast to southwest; the lagoon is open to the west.

Using Standen's theory, an island formed from infrequent winter high winds from the northeast should have its main axis running from northwest to southeast and should be located in the lee of such northeast winter wind. Five of the larger sand islands--Disappearing, East, Gin, Little Gin, and Whale-Skate--bear out Standen's theory. The other larger sand islands--Trig and the original Tern--have their axes running east to west. The other five sand islands--Bare, Mullet, Near, Round, and Shark--are just small islets, mostly awash at high tide. The four northernmost islands--Shark, Tern, Trig, and Whale-Skate--are situated between the double portions of the outer reef; in each case the island is in the lee of northeast winds and the inner portion of the double reef is adjacent to and just south of each island. Seven of the remaining eight sand islands are scattered along the northeast border of the irregular inner reef; each island is adjacent to and northeast of exposed reef. The twelfth sand island is located at the west tip of the south point; it too is adjacent to and northeast of the reef. Thus Standen's rules apply to the position of all sandy islands at French Frigate.

Palmer (1927: 30) noted that "the portion of the [sandy] islands above sea level consist of loose sand, with small bodies of indurated sand. Much of the sand at or below sea level is hardened into a sandstone." POBSP personnel found that the soils at French Frigate Shoals range from pure coral sand and gravel, including broken sea shells, through coarse coral rock rubble on the beaches, to a mixture of coral sand and some humus in the vegetated areas. Guano deposits are found only on La Perouse Pinnacle. No fresh water exists on any of the islands; perhaps brackish water can be obtained by digging shallow wells on the larger islands.

### CLIMATE

The first climatic data from French Frigate Shoals were gathered in 1943 when the U.S. Naval Air Facility was established. When this unit was phased out after World War II, the data were taken by personnel of the U.S. Coast Guard LORAN Station. The information used in this section is from a summary of the years 1951 through 1962 (Air Weather Service [MATS] Climatic Center, USAF).

In this region of the Pacific, climate is marine and tropical in nature. French Frigate Shoals is influenced most of the year by the Pacific High, with easterly trade-winds prevailing. During winter this High is slightly affected by the Aleutian Low which moves south to the Kure-Midway-Pearl and Hermes area, bringing increased and variable winds and increased precipitation.

The mode of the mean monthly temperatures for the 12-year period from December 1950 to December 1962, and the range of the maximum and minimum modes are presented in Figure 27. The temperature variation shown is typical of a tropical marine environment. The mean annual temperature is 75.5°F; the mean annual range is 10°F. From December through April the means are between 71°F and 74°F, and during the rest of the year between 75°F and 80°F. The warmest months are August and September, and the coolest February and March. A 37-degree difference exists between the extreme high of 91°F and the extreme low of 54°F for this 12-year period.

Mean monthly precipitation in inches and the mean number of days with measurable precipitation are shown in Figures 28 and 29. The mean annual precipitation for June 1954 to January 1960 and for March 1960 to December 1962 was 45.29 inches. Rainfall was heaviest from December through March;

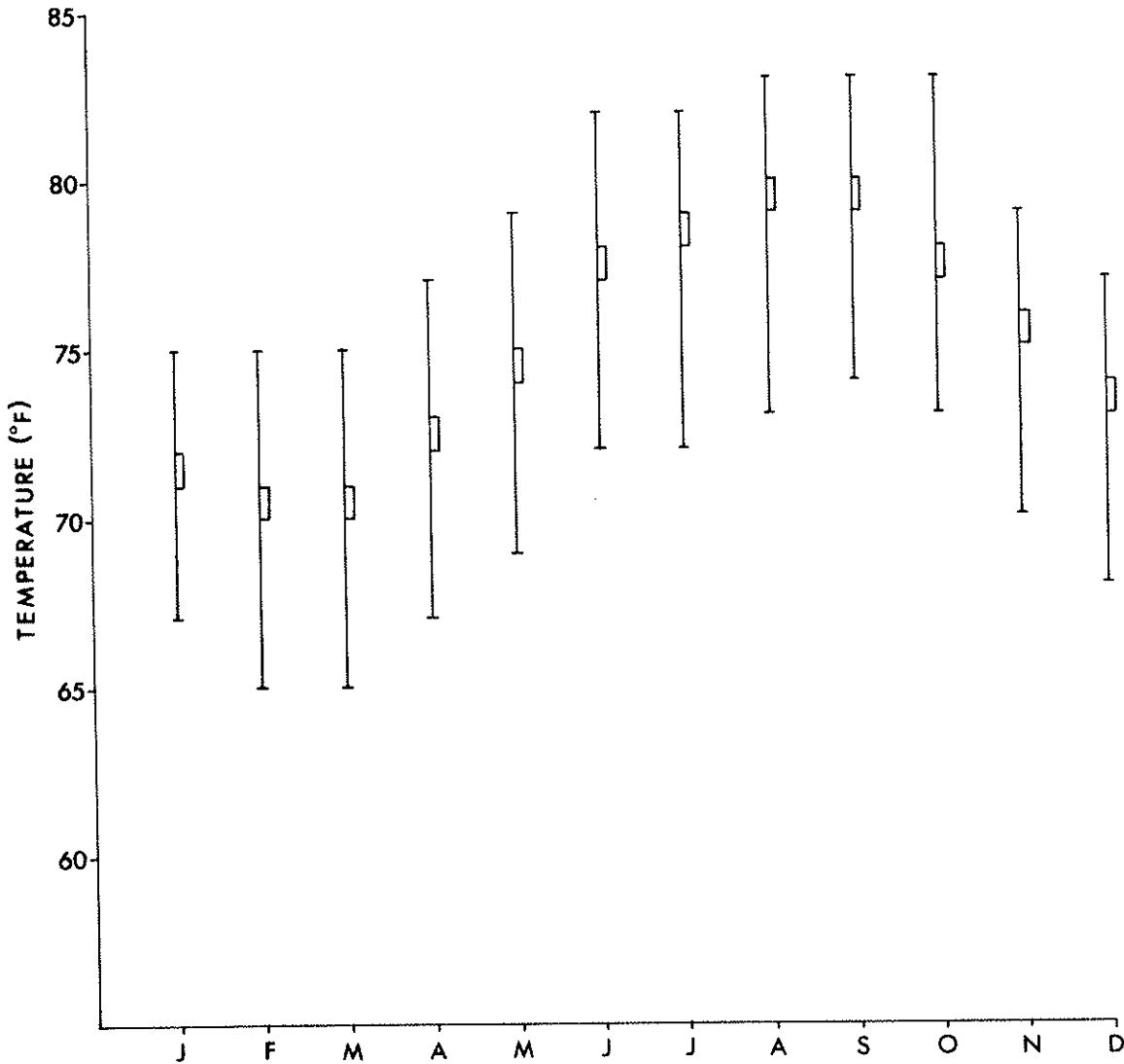


Figure 27. The mode of the monthly means for a 12-year period, December 1950 - December 1962, and the range of the maximum and minimum modes of temperature for French Frigate Shoals.



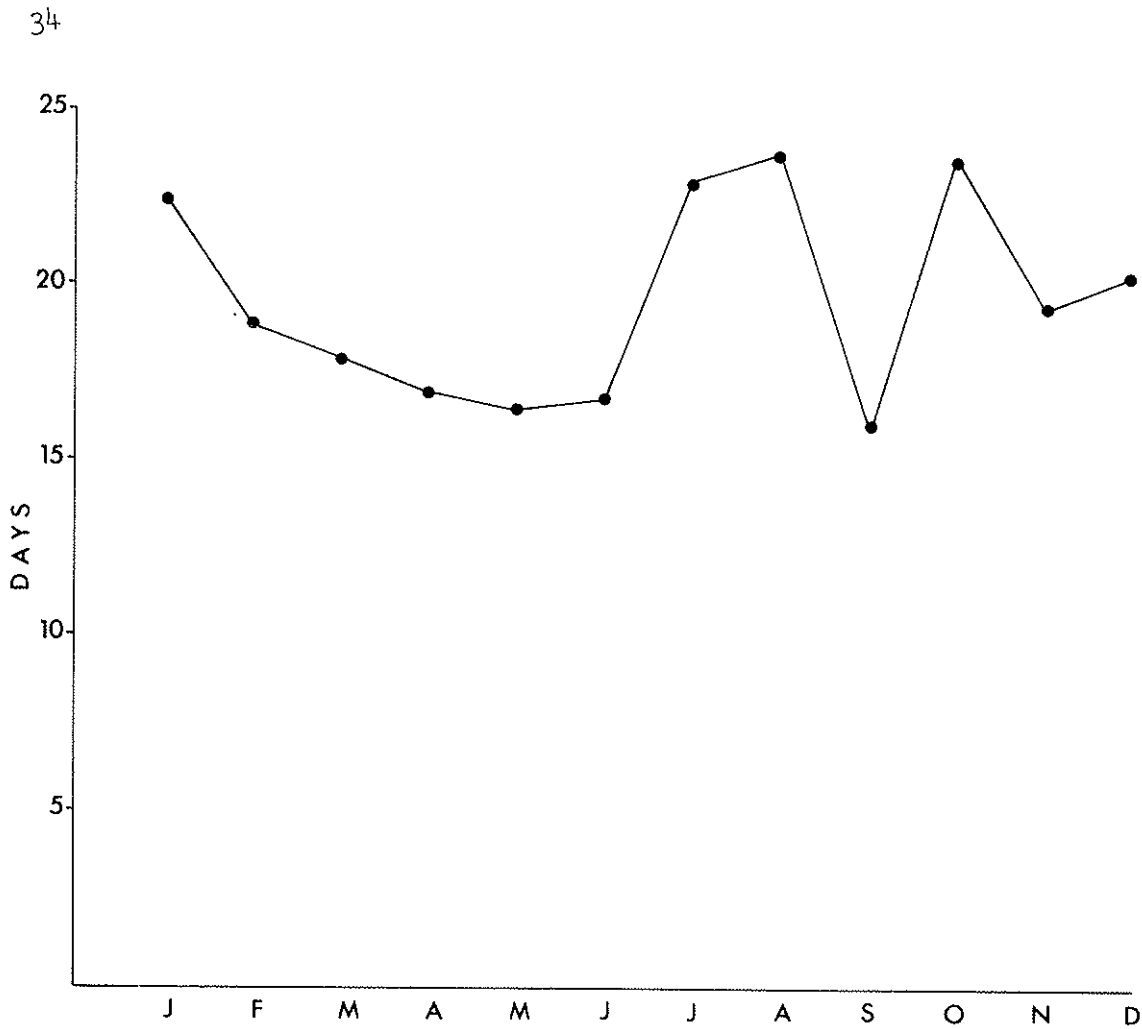


Figure 28. Mean number of days with measurable precipitation for French Frigate Shoals, June 1954 - January 1960, March 1960 - December 1962.

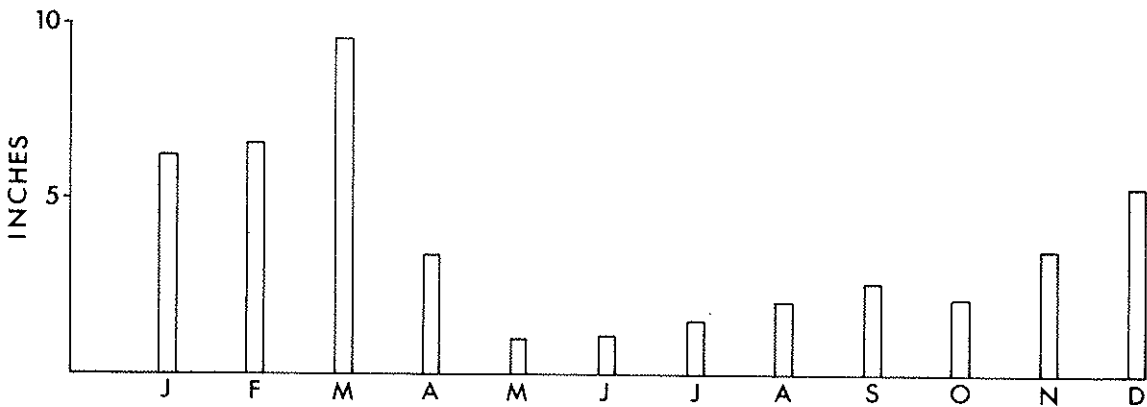


Figure 29. Mean monthly precipitation in inches for French Frigate Shoals, June 1954 - January 1960, March 1960 - December 1962.

a maximum mean of 9.55 inches occurred in March. It was lightest from April through November, with a minimum mean of 1.03 inches in May. Measurable precipitation occurred on at least 16 days each month; it was more frequent (20+ days), however, in July, August, October, and January, and least frequent from February through June, and September. Thunderstorms have been recorded only in April and December.

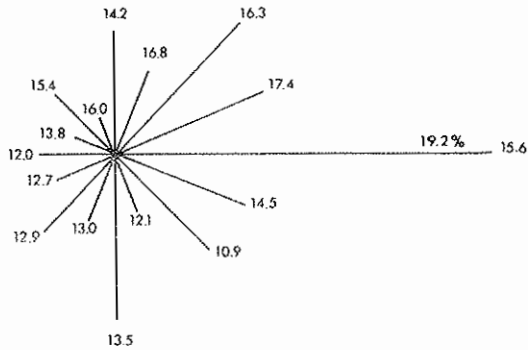
Severe tropical storms or typhoons are rare in the Hawaiian Islands. In August 1950, however, the area came under the influence of such a storm. "Able," "Hiki" in Hawaiian, the first Hawaiian typhoon in 45 years of records, passed just south of French Frigate Shoals. The closeness of this storm forced evacuation of the East Island USCGS LORAN Station from 16 to 24 August; damage to the station was negligible (U.S. Dept. of Commerce, 1950). Another typhoon, "Dot," forced evacuation of the Tern Island LORAN Station from 5 to 9 August 1959; there was no storm damage (Fed. Rec. Cen., Md., Log, 61A275, Box 111). Winter storms were common, causing a noticeable increase in precipitation, winds, and high seas. Such storms included those of October and November 1946, of January 1949, 1953 and 1954, and of September 1957.

The maximum sustained wind record for French Frigate Shoals for the period 1951 through 1962 was 52 knots from east-northeast in December. The annual mean windspeed was 12.6 knots, with a range of 5 knots. Mean monthly windspeeds were higher than the annual mean from November through April, and lower from March through October.

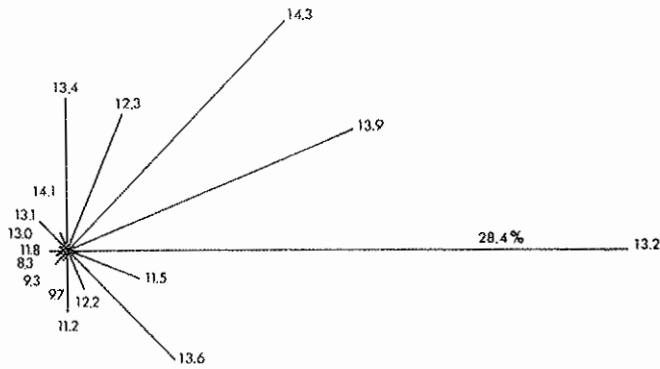
Surface windspeeds and directions for winter (December through February), spring, summer, and autumn are shown in Figure 30. The prevailing wind direction for each of these seasons, as well as for each month during the year, is easterly. During winter the mean windspeed is 14.3 knots; winds are high from all directions; the highest are from northwest to east-southeast, with a mean maximum from the east-northeast. The spring mean windspeed is 13.1 knots; winds are highest from west to south, with a mean maximum from the northeast. During summer the mean windspeed is 11.5 knots; winds are highest from northeast to east-southeast, with the mean maximum from the east. The mean autumn windspeed is 11.6 knots; the highest winds are from the west-northwest and northwest, and north through south-southeast, with the mean maximum being from the northeast.

The mean, in tenths, of total sky cover is almost uniform throughout the year, ranging from a low of 4.6 in February to a high of 5.2 in July and August; the annual mean is 4.9. The occurrence of fog and haze is negligible, but traces, due to heavy rain, are found from December through March.

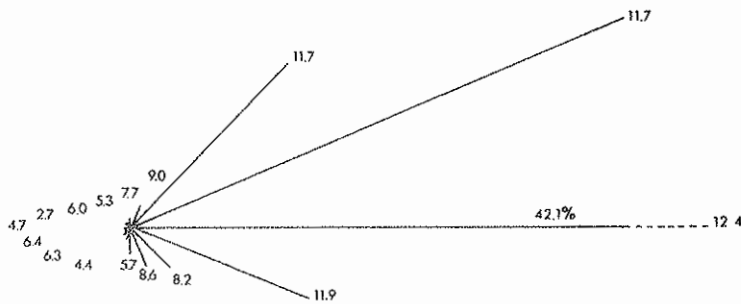
Winter



Spring



Summer



Autumn

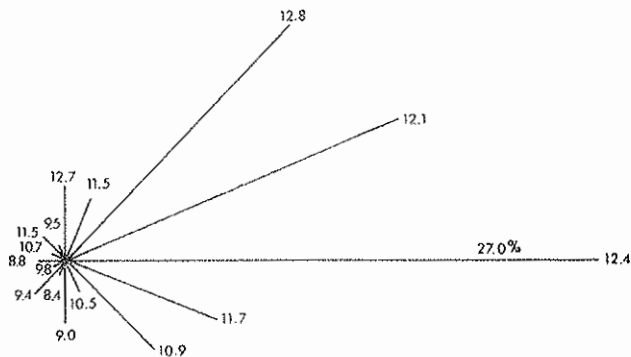


Figure 30. Wind direction and speed at French Frigate Shoals from December 1950 to December 1962. Length of directional line indicates percent of observations from that direction; figure at end of directional line is mean wind speed in knots.

Hydrographical surveys were conducted in 1859, 1914, and 1928 by the U.S. Navy and U.S. Coast and Geodetic Survey. K.T. Adams (USCGS Archives, Special Report, 1928), who headed the July to October 1928 survey, found the area inside the shoals to be very foul with coral heads; he felt that no anchorage should be recommended inside the reef for vessels not willing to pick their own way through the shoals. His chart (USCGS 4172) shows a lagoon depth of from 1/4 to 10 fathoms. The average depth appears to be about 3 fathoms and the bottom is covered with white coral sand.

To the west of the crescent-shaped reef and associated lagoon is an area of from 5 to 20 fathoms. There are numerous coral heads 1 to 5 fathoms below the surface at the intersection of the two areas. The bottom throughout this western area is coral and hard sand; this area provides good anchorage and offers excellent protection from the north, northeast, east, and southeast.

USCGS Chart 4172 reports a tidal range of 2.4 feet. Adams (USCGS Archives, Special Report, 1928) made no specific current observations in 1928, but noted some generalities.

A few miles inside of and north of the southwestern horn of the reef the current sets north-west and west, with quite a velocity. At the anchorage near East Island a slight current sets west. Just north and east of the northwestern horn of the reef the current sets west quite strongly. Outside the barrier reef and to the eastward the current sets north, and to the north-east of the reef the current sets northwestward. The current is strongest at about the hundred fathom curve and the steeper the slope of the bottom the stronger the current. In fact, outside the barrier reef the current seemed to flow counter clockwise and about parallel to the reef....On our deep sea sounding lines in the open ocean we have noticed a constant westerly set. This set varies from one or two tenths to four or five tenths of a knot and the direction is from west to west-north-west. This set differs over the shoals and appears to have no regular formula. For instance, over a small shoal area in the open sea which has recently been developed we encountered a set from NW to NNW with about an ENE wind.

Tidal waves from distant earthquakes and ground swells from distant storms infrequently affect French Frigate Shoals. A tidal wave on 1 April 1946 completely inundated the islands in the atoll; damage to the military stations was light; its effect on nesting wildlife was unknown. Another occurred on

4 November 1952; a wave 15 feet high was observed one-fourth mile offshore but broke up on the reefs. Still another caused a 3-foot rise in the water level on 27 March 1954. Ground swells, caused by a distant storm, severely damaged the Tern Island airstrip and Coast Guard facilities on 1 December 1969; nothing is known of its effect on the wild-life (Amerson, in prep.).

## HISTORY

Although there are no records in historic Hawaiian lore, the earliest visitors to French Frigate Shoals probably came from the nearby Hawaiian Islands to the east which are known to have been settled by Polynesians between 1100 and 1300 A.D. (Emory, 1928). The Spanish and Portuguese began exploring the Pacific following Magellan's successful crossing in the 1520's. Early sailing vessels followed the Equatorial Current westward and the North Pacific Current eastward and the Hawaiian Islands were seldom, if ever, visited. Many writers believe that it was not until January 1778 that Captain James Cook, an Englishman, discovered the Sandwich (Hawaiian) Islands. Other Europeans soon visited the area.

### A French Discovery

The discovery of French Frigate Shoals on 6 November 1786 was almost marred by disaster. The French explorer Jean François de Galaup, Comte de la Perouse, aboard his frigate, the Broussole, accompanied by the Astrolabe, was sailing westward on a tranquil sea from Monterey to Macao. At 0130 hours men on both ships sighted breakers directly ahead at a distance of only 2/10 mile. Both vessels were immediately brought about and headed south-southeast, passing as close as 1/10 mile to the breakers (La Perouse, 1799).

At daybreak, both ships reversed course, and at 0800 breakers were sighted north-northwest. Soon "a small island, or cleft rock, fifty toises [100 yards] at most in diameter, and about twenty or twenty-five [40 or 50 yards] in height" was sighted (La Perouse, 1799). Many years later this rock was named La Perouse Pinnacle after its discoverer.

La Perouse examined only the southeastern half of the atoll, as shown in his original 1786 map (Fig. 3) published in Paris in 1796 (French Hydrographic Office, Map. No. 556). He thought the rock was at the extreme northwest end of the reef and found only three sand-banks no more than four feet high. Before leaving he named his new discovery Basse des Frigates Françaises, or Shoal of the French Frigates.

Several variations of la Perouse's original name have been used over the years: French Frigate Shoal, French Frigates Shoal, and French Frigate Shoals. The most recent ruling was in July 1954 when the U.S. Board of Geographic Names adopted French Frigate Shoals.

#### United States Possession

During the late 1700's and early 1800's European and American traders called at the larger Hawaiian islands and by 1825 Honolulu had become the most important port in the entire Pacific. The United States became more and more interested in the Pacific and in August 1838 the United States Exploring Expedition put to sea under command of Lt. Charles Wilkes. This expedition spent some six months in the Hawaiian area; on 3 December 1841 they sighted French Frigate Shoals but were unable to land due to bad weather.

In early October 1858 the U.S. Schooner Fenimore Cooper, commanded by Lt. John M. Brooke, U.S. Navy, left San Francisco to sound out a route via Hawaii to Japan for a possible underwater telegraph cable. The Fenimore Cooper visited French Frigate Shoals from 3 to 7 January 1859; Brooke took depth soundings and charted the various islets for the first time. More importantly, however, Lt. Brooke took formal possession of French Frigate Shoals for the United States on 4 January in accordance with the U.S. Guano Act of August 1856 (U.S. Nat. Archives, R.G. 48).

The first complete published map of French Frigate Shoals resulted from the Fenimore Cooper's visit. Made under the direction of Lt. Brooke, it appeared in 1867 as H.O. Map No. 2.

#### Guano and Shipwrecks

Brooke also reported the discovery of guano at French Frigate Shoals, a fact which produced much excitement in Honolulu among guano investors. The bark Gambia sailed to the Shoals on 5 March 1859 and on the 23rd the American clipper ship Modern Times also set sail (Polynesian, 5 March 1859, 2: 3; Pacific Commercial Advertiser, 24 March 1859, 2: 1). Both ships returned with disappointing news concerning the size of the deposits and the cost of their removal.

The first wreck recorded on the Shoals was of the American whaling ship South Seaman, which wrecked on 13 March 1859. Fortunately the Hawaiian schooner Kamehameha IV was in the area and brought back to Honolulu 12 of the South Seaman's crew. The remaining 30 or so crewmen were left on one of the islands until the Kamehameha IV (chartered by the American consul) returned to pick them up. (Pacific Commercial Advertiser, 31 March 1859, 2: 1, 3).

The Gambia, under the command of Captain N.C. Brooks, again visited French Frigate Shoals in late April or early May 1859. While at the Shoals, Brooks noted an abundance of seals, turtle, fish, and birds and later described the atoll (Brooks, 1860).

A second ship, the brig Wanderer, bound from Honolulu for Japan, was totally lost on the night of 1 September the same year. The Wanderer's crew was also rescued by the schooner Kamehameha IV.

On 14 April 1867 French Frigate Shoals was the site of the shipwreck of the bark Daniel Wood. All of the crew managed to reach one of the islands. On the 16th Captain Richmond, the second mate, and 6 men embarked for Honolulu in one of the ship's whaleboats, leaving 27 shipmates behind. They landed at Honolulu on the 24th. The U.S.S. Lackawanna was dispatched by the American Consul to rescue the rest of the crew (The Friend, May 1867, 37: 1-3). On 20 May the schooner Malolo sailed for the Shoals in search of the wreck of the Daniel Wood. The Malolo returned to Honolulu on 22 June without finding a trace of the wrecked ship (Pacific Commercial Advertiser, 25 May 1867, 2: 1; 29 June 1867, 2: 1, 2: 2, 3: 5).

When U.S. Naval Hydrographic Office Maps 2, 3 and 4 showing the entire Northwestern Hawaiian Islands in detail were published in 1867, other countries became interested. The Japanese soon began to fish in the area.

The Japanese-owned American-chartered schooner Ada, working out of Yokohama, visited French Frigate Shoals from 3 February to 1 May 1882 (Hornell, 1934). It left the Shoals with a cargo of sharks' flesh, fins and oil, turtle shells and oil, dried bêche-de-mer and birds' down.

In early 1888 the schooner Wandering Minstrel, with Captain Walker, his wife and three sons aboard, spent a week at French Frigate. This was the first record of a woman visiting the Shoals (Farrell, 1928).

The first biological survey of French Frigate was made by Henry Palmer and George C. Munro aboard the Hawaiian bark Kaalokai 30 May to 5 June 1891 (Walker, 1909). During late spring 1894 the yacht Eben, commanded by John Cameron, anchored at the Shoals. With him were his wife, daughter, a friend's child, servant, and crew (Farrell, 1928).

The North Pacific Phosphate and Fertilizer Company was interested in mining guano on the central Pacific islands. A letter from J.P. Hackfeld, secretary of the company, dated

6 January 1894, to James A. King, Minister of the Interior of the new Republic of Hawaii, requested that King order the lease by public auction of French Frigate Shoals, Kure, Midway, and Pearl and Hermes Reef for a term of 25 years and that the purchaser should have the exclusive right to mine guano, phosphate, fertilizers, and other materials.

The islands were leased on 15 February 1894 for a period of 25 years to the North Pacific Phosphate and Fertilizer Company.<sup>1</sup> This company was also granted exclusive rights to the guano deposits provided they would be worked within five years; otherwise, the rights would revert to the Hawaiian government. Since the Pacific Guano and Fertilizer Company never worked French Frigate Shoals, their guano rights presumably reverted in 1899; their lease, however, was probably valid.

#### Hawaiian Control

In order to obtain clear titles to the northwestern islands for the Republic of Hawaii, President Sanford B. Dole on 9 July 1895 appointed James A. King, Minister of the Interior, Republic of Hawaii, as Special Commissioner to take possession of French Frigate Shoals. On that same date, King sailed from Honolulu on the Revenue Cutter Lehua, commanded by Captain Berry, in pursuance of President Dole's commission. King (Hawaiian State Archives), in a subsequent letter to Dole on 22 July, noted that the Lehua sighted the rock islet of French Frigate Shoals on 13 July, that he landed and took possession; on a nearby sand island they planted the Hawaiian Flag.

On 22 February 1896 the sealing schooner Mattie E. Dyer wrecked. Captain Mockler and his 23 crewmen were able to get to the largest island in four whaleboats. Finding no water, they set out for Niihau; all arrived safely by March 2nd (Pacific Commercial Advertiser, 2 March 1896, 1: 5-6, 2: 1-2; and Hawaiian Gazette, 3 March 1896, 3: 1-3).

#### United States Territory

The U.S. Navy, as well as other U.S. Government agencies, became interested in the Northwestern Hawaiian Islands in the late 1890's and early 1900's. Hawaii became a United States

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<sup>1</sup> This company changed its name to the Pacific Guano and Fertilizer Company on 3 April 1894.



Territory on 30 April 1900.<sup>1</sup> On 28 and 29 May 1902 the U.S. Fish Commission Steamer Albatross stopped at the Shoals; among their activities was wildlife survey.

A French ship, the Connetable de Richmond, wrecked at the Shoals on 10 October 1903. All hands escaped in three boats and arrived safely in the Main Hawaiian Islands by the 27th (Paradise of the Pacific, 8 November 1903, 8: 2; 9: 1).

Preservation of wildlife was of prime importance in the early 1900's and President Theodore Roosevelt signed an Executive Order on 3 February 1909 setting aside all the Northwestern Hawaiian Islands, except Midway, as a preserve and breeding ground for native birds. This preserve, to be known as the Hawaiian Island Reservation, was to be administered by the Department of Agriculture.<sup>2</sup>

Subsequently, U.S. Revenue Cutter Service vessels were used to patrol the area for bird poachers. The USRC Thetis made several trips to the islands. Her stops at French Frigate Shoals include 19 December 1912, 9 September 1914, 20-21 March 1915, and 28 January 1916<sup>3</sup> (U.S. Nat. Archives, Thetis log, R.G. 26). The USS Hermes visited on 4-5 September 1918 on a similar inspection survey (U.S. Nat. Archives, Hermes log, R.G. 45).

From 25 August to 30 September and from 10 October to 4 November 1914 the USS Rainbow conducted a hydrographic survey outside of the reef. The subsequent map, first printed in June 1915, is considered to be the first modern map of French Frigate Shoals (U.S. Nat. Archives, Cartographic Div., R.G. 37).

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<sup>1</sup> The City and County of Honolulu hold jurisdiction over French Frigate Shoals by virtue of Section 1717 of Chapter 118 in the Revised Laws of Hawaii dated 1925 (see also Morris, 1934). The atoll also became part of the State of Hawaii when the Territory of Hawaii was admitted as the 50th State in the Union on 21 August 1959 (Percy, 1959; U.S. Dept. of State, 1965).

<sup>2</sup> In 1940 the preserve was transferred to the Department of the Interior.

<sup>3</sup> Other inspection trips included those by the USS Pelican on 8 May 1924, the USRC Itasca of 9-10 February 1931 and 20 June 1934, and the USCGC Reliance of 4 to 6 March 1936.

Despite the availability of such maps, another ship, the Churchill, ran aground and caught fire just before midnight on 25 October 1917. Fortunately the sampan Makiawa was fishing nearby and all crewmen were saved (Honolulu Star Bulletin, 30 October 1917, 1: 6-7, 2: 1-2). Eight persons returned aboard the J.A. Cummins to salvage whatever possible from the wreck; they stayed from 2 to 9 November but left with only 12 bags of wet and sand-covered copra. The ship was completely broken up as a result of a severe storm (Tucker, 1917).

As part of a biological survey of central Pacific islands, the Tanager Expedition, with 11 scientists, visited the atoll from 22 to 28 June 1923. Alexander Wetmore was the field director for this survey; his unpublished field notes (Wetmore, ms.) reveal details on the avifauna present as well as a description of each island. Many scientific collections were made. This survey was the first overall scientific survey of French Frigate Shoals.

The U.S. Coast and Geodetic Survey Steamer Guide conducted a complete hydrographic and topographic survey of French Frigate from 11 to 19 May, 5-23 July, 3-21 August, and 8-29 September 1928 (U.S. Nat. Archives, Guide log, R.G. 27). The current charts, numbers 2922, 4171, and 4172, were drawn from the combined 1914 and 1928 survey data.

While the Guide was conducting its survey of French Frigate Shoals, correspondence took place concerning publication of the final chart. On 8 June 1928--prior to the Guide's first return to Honolulu--J.H. Peters, Officer in Charge, U.S. Coast and Geodetic Survey, Honolulu Field Station, wrote a letter to the Commandant, U.S. Naval Station, Pearl Harbor, in which he pointed out "that French Frigate Shoals might be a very important point in case of a war between this nation and some power to the westward which would require troop movements in that direction. Preliminary descriptions indicate a long area suitable for anchorage of large vessels . . . which would be protected from prevailing winds as well as many smaller vessels such as submarines or destroyers . . . which would be protected from all winds. There appears to be sufficient land area for the construction of a landing field and any amount of shallow quiet water for the use of seaplanes." Peters noted that the results of this survey were to be published but suggested that, since the atoll was of so little commercial value and of such great military potential, it would be wise for the Navy Department to request the Commerce Department to keep the results of the survey confidential.

From a subsequent letter from R.S. Patton, Acting Director, U.S. Coast and Geodetic Survey, to the Hydrographer, U.S. Hydrographic Office, dated 14 July 1928 (U.S. Nat. Archives, Mod. Mil. Hist. Div., R.G. 37, QH 78/41-18, 95026), it is learned that the Secretary of the Navy requested the Secretary of Commerce to treat the chart for French Frigate Shoals as confidential. Patton pointed out that no chart had yet been constructed and that a large-scale chart would not be published without first consulting the Navy Hydrographic Office. The French Frigate Shoals survey was, however, "being performed for the purpose of safeguarding trans-Pacific commerce...[and] navigation."

On 22 June 1932 the U.S.S. Quail (AM 15) anchored at French Frigate Shoals; the ship's seaplane was hoisted into the calm waters near East Island on the 23rd; it took off and photographed the islands within the sprawling atoll. The next day it was up again, and on the 25th the ship departed for Pearl Harbor. The resulting photographs were the second set of aerial photographs to be taken of the shoals (U.S. Nat. Archives, Log of U.S.S. Quail for 1932, R.G. 24).

The June photographic mission paved the way for a coordinated plane-ship exercise by the U.S. Navy in August 1932 involving five ships and six seaplanes. Two ships anchored at the Shoals on the 17th; using the other three ships as guides, the planes arrived on the 18th. All departed for Pearl Harbor on the 20th. This exercise produced one of the first long-distance flights by U.S. Navy planes in the Central Pacific (U.S. Nat. Archives, Logs of U.S.S. Quail, Oglala, Breese, Gamble, and Montgomery for 1932, R.G. 24).

From 17 to 29 April 1933 a larger naval air maneuver took place. Thirty seaplanes, guided by seven ships, flew from Pearl Harbor to French Frigate Shoals, and on to Johnston Atoll; they returned by the same route (U.S. Nat. Archives, Mod. Mil. Hist. Div., R.G. 24, QU 78/41-18, 305598).

These 1932 and 1933 Naval air maneuvers were the forerunners of many such operations. From 7 to 28 May 1935 Phase Three of Fleet Problem Sixteen<sup>1</sup> utilized the Shoals as a training area; eight ships and 45 seaplanes took part in the exercise. The atoll provided the needed lagoon landing area for a mass flight to and from Midway; this was the first such long-distance flight by that many planes, which was even more significant since bombs were attached to their wings. Although two serious air

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<sup>1</sup> The Annual Fleet Problem's purpose was to advance the training of the entire U.S. Fleet; conditions of war were to be simulated as nearly as practicable under peace-time training.

accidents occurred killing seven persons, the experience gained in this operation was of great benefit to naval aviation (U.S. Nat. Archives, R.G. 80, A 16-3--5-XVI; Grimes, ms.).

Other Naval training exercises utilized French Frigate Shoals in September and November 1935 and October and November 1936. A wooden cook shed and a "tent city" were constructed on East Island (Fig. 31). The Honolulu Advertiser reported portions of the November 1935 maneuver on the 11th (1: 6), 14th (5: 3), and 18th (1: 4); these were the first newspaper accounts of the usually secretive advanced base activities of the Navy's Pearl Harbor VP seaplane squadrons.

French Frigate Shoals was again used by the U.S. Fleet from 1 to 10 May 1937 for Fleet Problem Eighteen. East Island was used as a base camp and some nine ships and two seaplane squadrons participated. This fleet problem provided valuable data on aircraft anti-submarine activities, as well as important experiences in carrier tactics (Grimes, ms.).

Another U.S. Navy exercise, in which three ships and 33 seaplanes took part, was held in late October and early November 1937 (Fig. 32). The atoll's first recorded death, however, marred the exercise (U.S. Nat. Archives, Log of USS Langley for 1937, R.G. 24).

Part Five of Fleet Problem Nineteen, which took place from 25 to 30 March 1938 was also held at French Frigate Shoals. Some 25 ships, including five submarines, and numerous seaplanes, took part. Part Five demonstrated the possibilities of successful carrier-based air attacks on shore objectives (Grimes, ms.).

The Shoals was also involved in Part Six of Fleet Problem Twenty-One. From 13 to 21 April 1940 six ships and one VP squadron utilized the lagoon and surrounding ocean. This exercise also provided useful information and experience for naval aviators (Grimes, ms.).

### World War II

When Japan attacked China in 1937 and increased its military activity in the Marshall and Gilbert Islands, tension mounted in the Pacific. Thus in February 1941 President Franklin D. Roosevelt issued Executive Order No. 8682 setting aside such islands as Midway, Wake, Johnston, and Palmyra as naval defensive areas (Bailey, 1956).

French Frigate Shoals was, however, not entirely forgotten. By 1940 it was considered so important to the United States

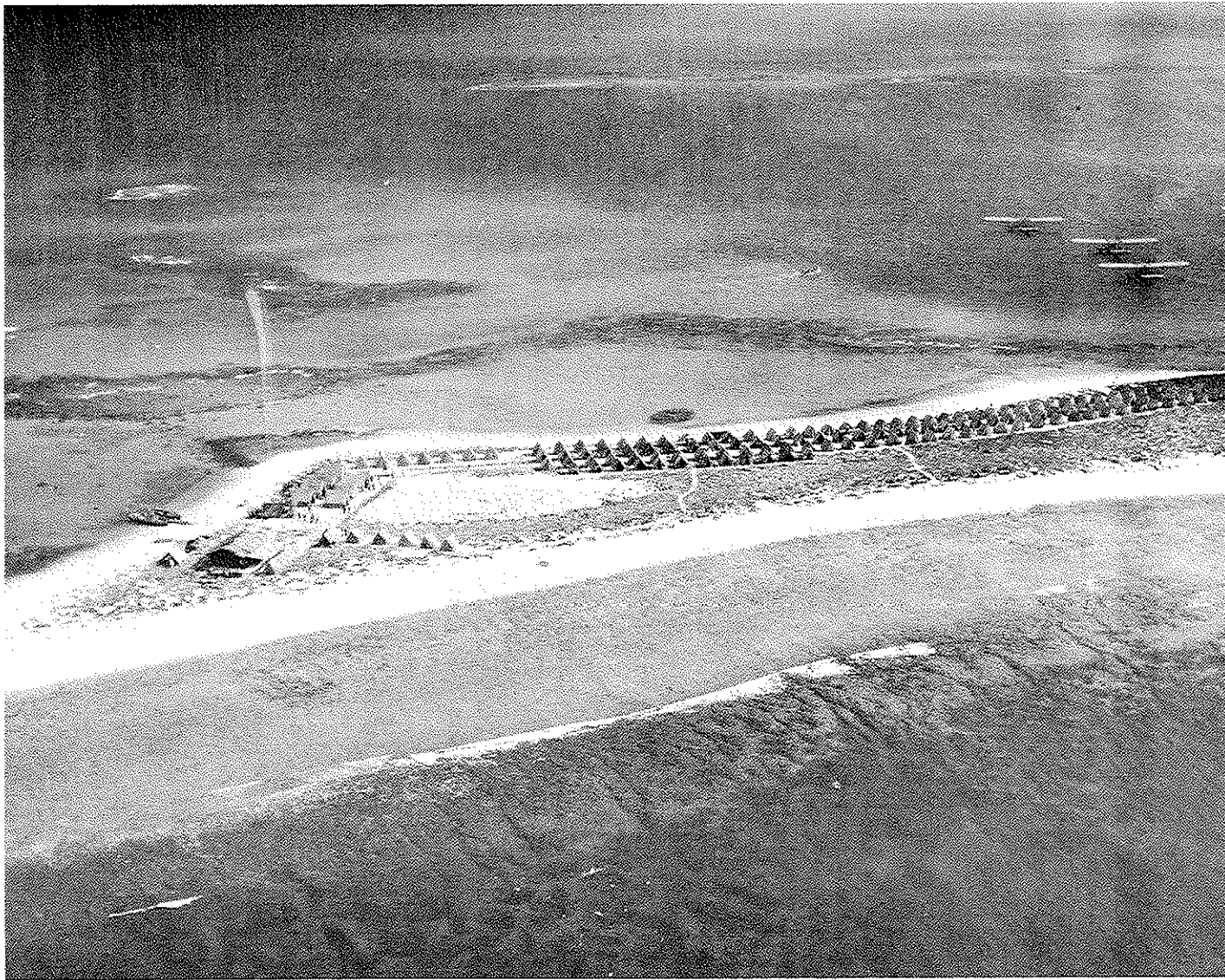


Figure 31. East Island "tent city" 11 November 1935. Official U. S. Navy photograph.

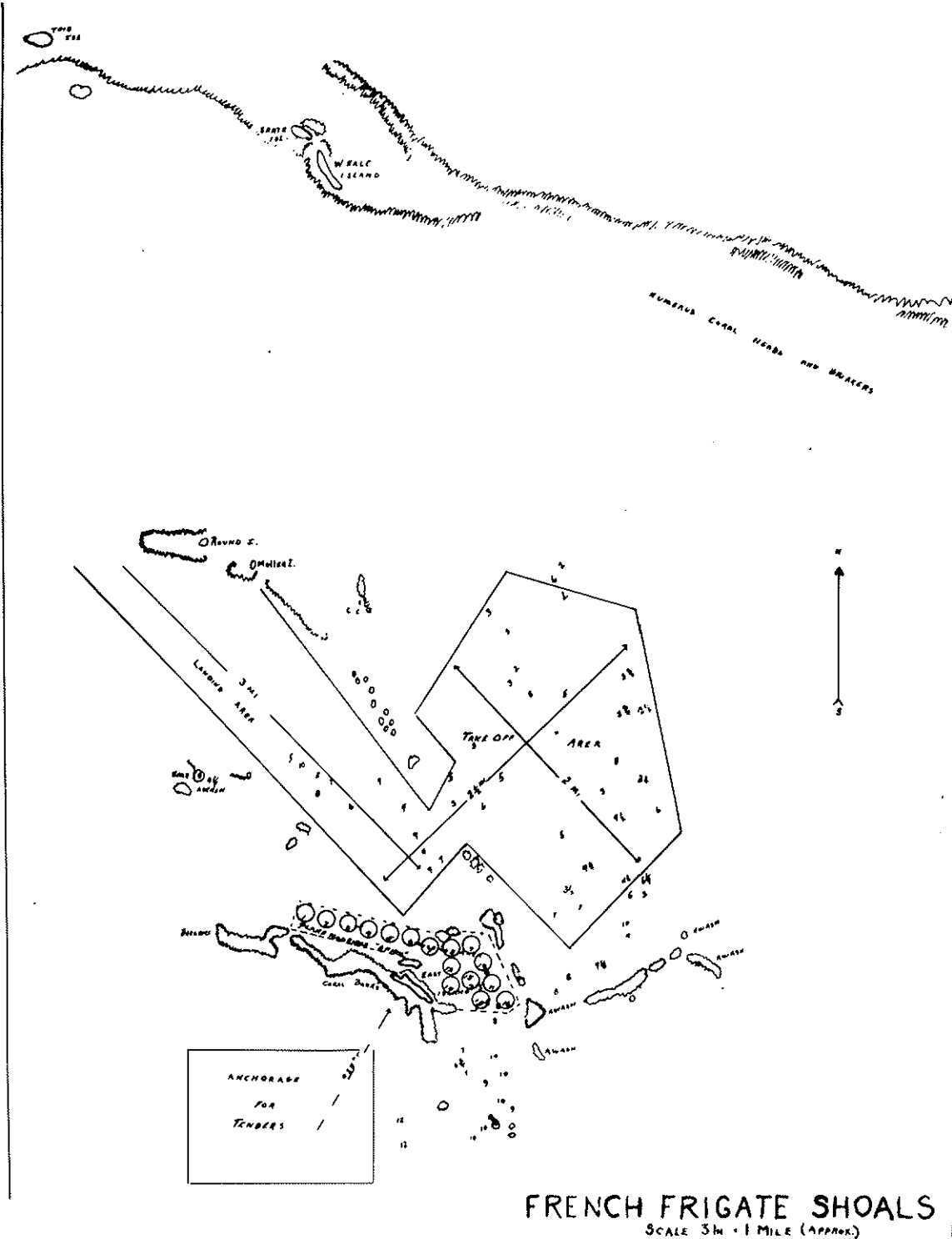


Figure 32. Map of East Island seaplane anchorage, 1 October, 1937. Official U. S. Navy photograph.

that only Hydrographic Chart No. 2, made from the 1859 survey, was issued to the public; the charts from the 1914 and 1928 surveys were classified (U.S. Nat. Archives, Mod. Mil. Hist. Div., R.G. 37, QH 78/41-18, 95026).

After the surprise carrier plane attack on Pearl Harbor 7 December 1941 by the Imperial Japanese Navy, the United States declared war on Japan on 8 December 1941.

The Japanese had not used French Frigate Shoals and it is doubtful that their warships had visited the atoll. When Japan captured Wake Island on 23 December 1941, however, they came into possession of a classified publication--"U.S. Naval Air Pilot, Pacific Islands, 1936"--from which they learned of the Shoals' excellent seaplane lagoon-landing capabilities.

On the night of 3 March 1942, the Japanese successfully used French Frigate's excellent lagoon as a rendezvous point for two submarines to refuel, as well as to load with bombs, two "Emilies" for a trial raid on Pearl Harbor. Suspecting the atoll's role in this raid, U.S. Navy experts mined the anchorage area on 3 and 8 April, placed a U.S. Marine detachment on East Island on 13 April, and ordered naval vessels to patrol the area beginning 13 May. Finding these deterrents on 26 to 31 May, three Japanese submarines called off a second Pearl Harbor reconnaissance. Thus the Japanese combined Fleet was forced to start its attack on Midway without knowledge of the whereabouts of the U.S. Fleet, which had secretly departed Pearl Harbor and headed north of the Hawaiian Chain for Midway. The stunning United States' victory at the Battle of Midway is now history. Had the Japanese captured Midway, however, they intended to seize French Frigate Shoals and use it as a staging area for raids on the main Hawaiian Islands (Layton, 1953; Lord, 1967; Shibuya, ms.; Amerson, in prep.).

#### Tern Island Naval Air Facility

Midway was still smouldering from the unsuccessful Japanese attack when one of the most secret projects in the Pacific Theatre was instituted. The Navy was determined that Midway be better protected (Woodbury, 1946) and decided on an air base at French Frigate Shoals as the means.

The idea of building a landing strip at French Frigate Shoals was considered prior to the Battle of Midway, but the decision to build was a direct result of the battle. The purpose of the airstrip was threefold. First, it would provide fueling and landing facilities for ferrying aircraft between Pearl Harbor and Midway. Fighter planes in 1942 did not have fuel capacity for the 1,300-mile trip to Midway and the Navy needed to get large numbers of planes to Midway in case the

Japanese struck again. Moreover, fighters could operate out of French Frigate Shoals to engage any enemy in the area. Second, it would serve as an emergency landing facility for either land or seaplanes. Third, it would be an outpost for the defense of Pearl Harbor; radio, radar, lookouts, and planes could detect and report any enemy activity in the area (R.M. Ricketts, ms.; Quaile, 1947; Anon., 1949).

Thus, Project "ME-36" (most often called "ME-6"), the Navy's code for the Naval Air Station Project at French Frigate Shoals, was born.

On 12 June 1942 a Navy vessel made a secret trip to the atoll to see if construction of a land base was feasible. The survey team, headed by Edward Brier, found very little land and thousands of seabirds, but decided a land base could be built by dredging and constructing a new island on the site of little Tern Island. The newly formed Seabees, along with the Hawaiian Dredging Company, were called upon to do the job. Men of Company B, Fifth Naval Construction Battalion, went to French Frigate in mid-July 1942 (Woodbury, 1946).

Dredging started on 13 August, and a 12,000 foot ship channel, 200 feet wide and 20 feet deep, was soon opened to Tern Island. Next, a seaplane landing area, 8,000 feet long and 1,000 feet wide, was cleared of coral heads adjacent to the island. Coral removed from these areas was dumped on Tern, covering the 1,800- by 450-foot original island. By November 1942, all dredging--660,000 cubic yards of coral fill--was complete; the island had been turned into a landing field 3,100 feet long and 350 feet wide, partially rimmed with 5,000 feet of steel sheet piling driven to a depth of 15 feet; it stood only 6-1/2 feet over the mean tide level (Fig. 33). By March 1943 ground facilities consisted of eight buildings, both above and below ground, 21 fuel tanks, and a 90 foot radar tower. The construction crew left on 21 March 1943; the new island had cost nearly \$2,000,000 (Beech, 1946b, Woodbury, 1946; Quaile, 1947; Anon., 1949).

To American naval pilots flying reconnaissance missions out of Honolulu in mid-1943, Tern Island suddenly took on a strange but familiar shape--that of an aircraft carrier. Although much larger than a regular carrier, the new island featured a "flight deck," with "storage decks" along its sides. Seen from a distance, the white water breaking over the extensive reef to the east gave a pilot the impression that the "coral carrier" was steaming to the west with its wake arching behind.

The new Naval Air Facility was commissioned on 17 March 1943 when the first draft of men arrived with Lt. W.S. Tenhagen in charge. The organization allowed for 118 men, who rotated



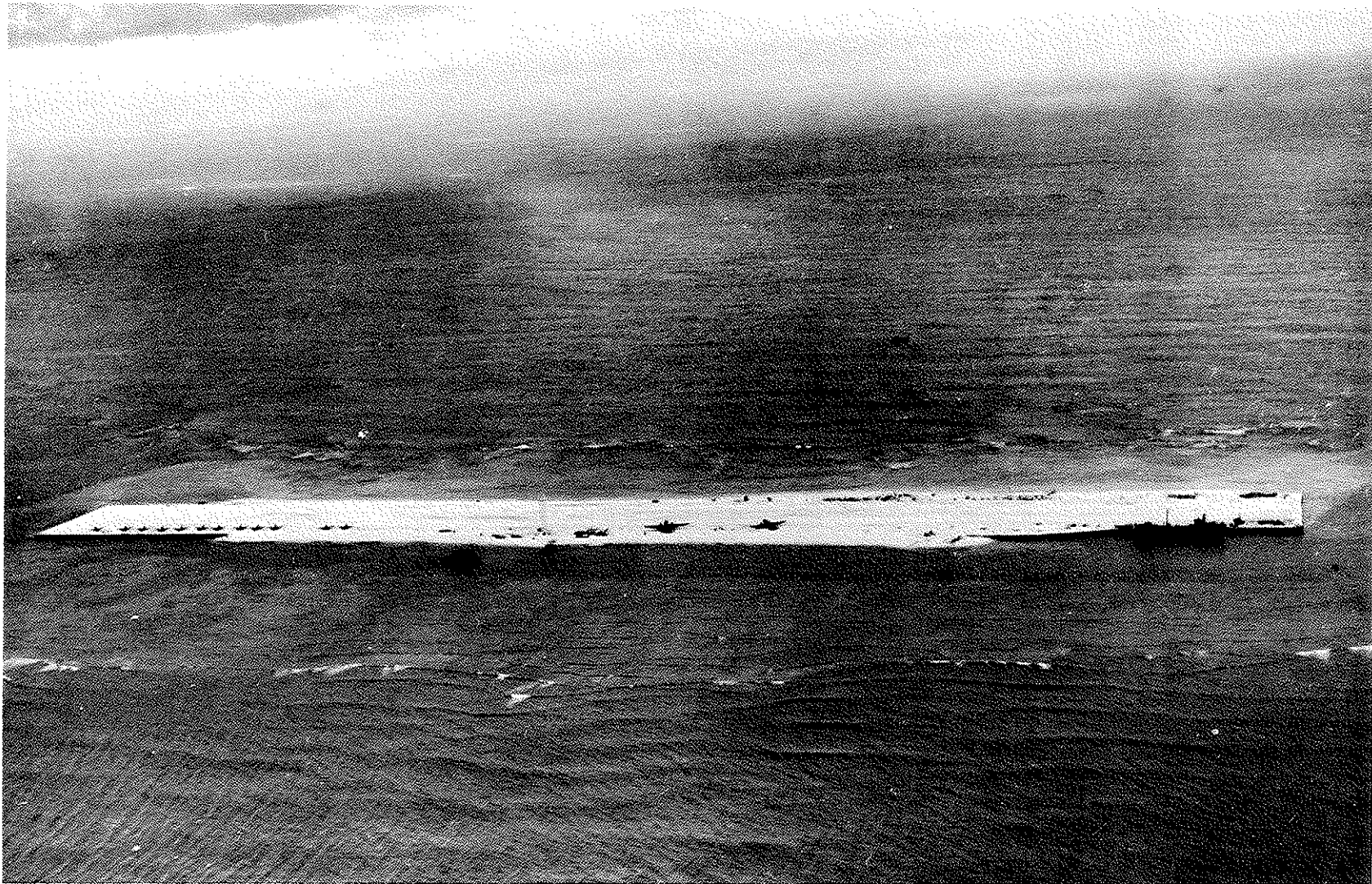


Figure 33. Newly constructed Tern Island Naval Air Facility, 9 September 1943.  
Official U. S. Navy photograph.

every three months. Lt. A.B. Clarke was designated as officer-in-charge, but he did not arrive until 23 March. The facility at first was a department of the Naval Air Station, Pearl Harbor. In May 1943 it was transferred to the control of the Naval Air Center, Pearl Harbor<sup>1</sup> (Ricketts, ms.; Dater et al., ms.).

In November 1943 plans were initiated to add new barracks and galley facilities. Construction by a Seabee detachment didn't start, however, until 30 January 1944. By 24 September the original temporary base had been converted to a semi-permanent installation. In November 1944 there were four officers and 123 enlisted men. Land plane capacity was 18 VF's or small VB's, with 22 plane parking spaces available. The coral runway was in use as an emergency refueling strip, and certain aircraft repairs could be made (U.S. Naval Const. Bn. Cent., 99th NCB summary report, 1942-1944; U.S. Navy, Class. Oper. Archives, 14th Naval Dist., corresp., Op 441H).

During the war, daily reconnaissance flights were flown for a radius of 100 miles. Radar scanned a 40-mile radius. Weather data were constantly supplied to Fleet Weather Control, Pearl Harbor (U.S. Naval Const. Bn., 99th NCB summary report, 1942-1944).

Enemy action at or near the Shoals after the Battle of Midway was very light and the station was never attacked. The War Diary of the Commander Hawaiian Sea Frontier (U.S. Navy, Class. Oper. Archives, War Diary, 14th Naval Dist.) from October 1942 through 1945 reveals only seven instances of possible enemy ships in the area.

The war ended 2 September 1945 and the Navy no longer needed the Air Facility. On 7 October 1945 it was placed in a caretaker status; final disestablishment came on 9 June 1946 (U.S. Navy, Class. Oper. Archives, 14th Naval Dist., War Diary, 1945; U.S. Nat. Archives, R.G. 80, Op. 24-1 jn. A 4-2/NA; Buchwach, 1946a).

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<sup>1</sup> In January 1944, the Naval Air Facility at French Frigate Shoals was designated Task Group 97.2 and operated under the Commander Hawaiian Sea Frontier (Task Force 97). On 28 September 1944 this unit was designated a detached or separate command with authority to convene summary court martials, deck courts, and to administer punishments set forth in Article 24, Articles for the Government of the Navy (U.S. Navy, Class. Oper. Archives, War Diary, Jan. 1944, 14th Naval Dist. corresp., 1944).

### Fishing Interests

The U.S. Navy, forgetting about French Frigate's status as a federal wildlife reservation and thinking they owned Tern Island, tried to hand over the disestablished base to the Territory of Hawaii. The Territory refused, but discussion on the issue continued. In early November 1948 the Territory's Hawaiian Aeronautics Commission notified the Commandant of the 14th Naval District, Pearl Harbor, that it was "in a position to take over the airstrip and other facilities...and...make them available...to the fishing industry" (Hawaiian State Archives, FFS file #1871).

As early as June 1946 Hawaiian commercial fishermen began to use the facilities. Early fishing boats enjoyed good fishing which prompted the Hawaiian Tuna Packers, Ltd. to send a vessel to the Shoals in mid-September 1946. Both Honolulu newspapers (Beech, 1946a, 1946b, 1946c, 1946d, 1946e; Buchwach, 1946a, 1946b) carried stories on the venture. Two shipments of fish were subsequently sent from Tern to Honolulu by chartered plane.

In a joint venture two companies, the Hawaiian-American Fisheries, headed by Louis K. Agard, Jr., and the Seaside Fishing Co., run by Frank Opperman and Warren Haines, established a fishing base on Tern Island early in November 1946. They chartered a DC-3 from Trans-Air Hawaii for transporting the fish. The companies obtained permission to use the air strip from the proper Territory offices; the Hawaiian Fish and Game Department gave them permission to use large fixed traps (Agard, in litt.).

During the first three years of operation, Hawaiian-American Fisheries grossed over \$73,000 at the Shoals; profits totaled almost \$20,000. Had the company owned its plane, profits would have been greater. Thus, a new corporation, Aero Fisheries, was formed and a plane purchased by Agard and his partners. In late July 1949 one flight was completed. Mechanical difficulties grounded the plane in mid-August and the corporation did not have the reserve finances to continue the plane operation (Agard, in litt.).

Various commercial fishing vessels visited the atoll in the 1950's with varying success. In 1959 Agard started another joint venture, and even purchased a refrigerated vessel and a plane. This too was short-lived (Agard, in litt.).

In August 1948 the Pacific Oceanic Fishery Investigation (POFI), with headquarters in Honolulu, was organized by the Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service. Since 1948, POFI vessels visited French Frigate Shoals on numerous occasions (POFI, ms.).

East Island LORAN Station

As early as January 1940, the Chief of the U.S. Navy Bureau of Aeronautics recommended to the Chief of Naval Operations that French Frigate Shoals be the site of a radio station. This was subsequently approved by the Civil Aeronautics Administration (CAA), and on 22 July 1940 the Secretary of Navy gave permission to the CAA and Department of Commerce to occupy East Island. Two days later the Judge Advocate General of the Navy informed the Chief of Naval Operations that, although East Island had been used by the Navy, it had not been placed under Navy control by Executive Order; furthermore, the island was under the jurisdiction of the Department of Interior. The Interior Department was contacted and they, in turn, consulted Governor J.B. Poindexter of Hawaii. On 9 September Poindexter signed Executive Order #893 which set aside East Island for government use by the United States. They were reminded, however, that French Frigate Shoals was a bird reservation (U.S. Nat. Archives, R.G. 80, NR EG 62--390603, and H 4-6/QG-400613; R.G. 48, 9-4-56).

The men, materials, and equipment for building the Radio Communications Station were in Honolulu by early June 1941, but due to the Pacific crisis the U.S. Navy was unable to provide the necessary transportation. Thus the proposed construction of the station was postponed and finally cancelled (U.S. Nat. Archives, R.G. 80, H 4-6/QG--400613-1).

On 16 December 1943 the Chief of Naval Operations directed the U.S. Coast Guard to establish and operate three Long Range Navigation (LORAN) transmitting stations in the Hawaiian Islands; ~~one of these~~--CG unit 204 or code GEORGE or GNAW--was to be located at East Island. Coast Guard Detachment C construction personnel and LORAN operating personnel, as well as material and equipment, were taken to the Shoals in early June 1944 (U.S. Coast Guard, 1946).

By the end of July the station was complete and contained 7 Quonset huts in which personnel lived and worked, 6 smaller buildings or sheds used for a weather station, distillation plant, and storage, a 96-foot dock, and a 7-pole antenna network (Fig. 34). On 15 July Lt. (jg) John J. Roshti, USCGR, was assigned as commanding officer with a crew of 26 enlisted men. The 3-station system went on the air on 23 July and was informally commissioned in August. The Commander, Coast Guard Construction Detachment, Pacific Area, officially turned over jurisdiction of the Hawaiian Chain of LORAN stations to the Commander, Coast Guard District, 14th Naval District, on 8 November 1944 (U.S. Coast Guard, 1946; Bragg and Cronk, ms.; Fed. Rec. Cen., Md., 14th CG corresp., 1944).

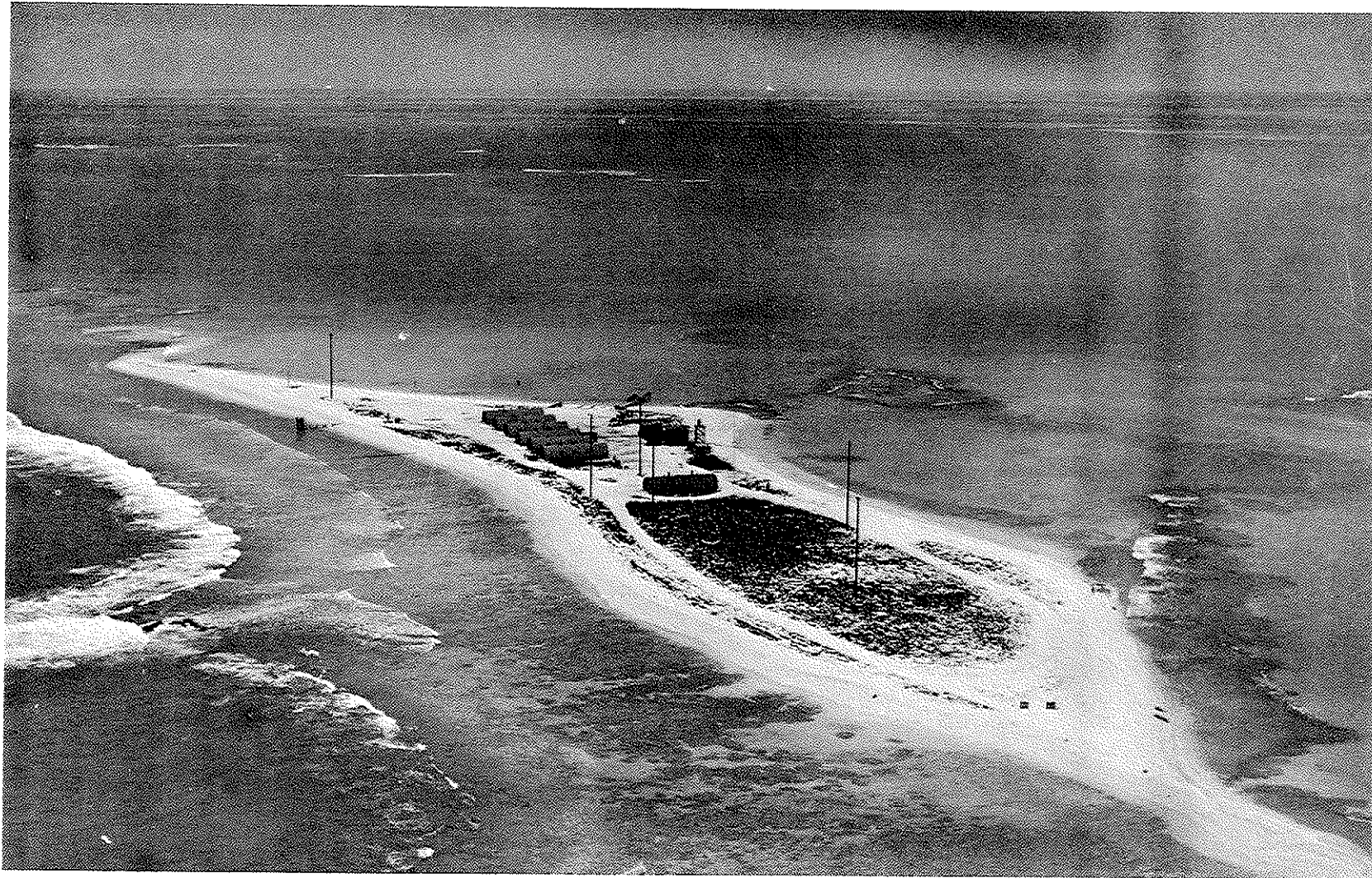


Figure 34. Newly constructed East Island Coast Guard LORAN Station, 24 April 1945.  
Official U. S. Navy photograph.



Morale at first was high due to the newness of the station; by late October, however, the important question on the men's minds was: How long before rotation? By 1 January 1945 most men had been there six months and were getting tired of the isolated duty. The situation was aggravated by the fact that the entire crew at the nearby Tern Island Navy station was rotated every three months. In addition, requisitions for fresh food and routine station supplies went unfilled, and the station began to show the effects of heavy wind and salt air. Supplies began arriving with regularity in April and soon the station's appearance improved. During June a rotation plan took effect and by early July all personnel except the Commanding Officer had been rotated with the unit at Hawaii (Fed. Rec. Cen., Md., Summary Report, 1944-1945).

After the Japanese surrender in August 1945, the men at East Island immediately began thinking of returning home. In October 1945 flights to Tern Island were reduced to one per week. This further isolated the East Island station and morale dropped. To make matters worse, a tidal wave inundated the station on 1 April 1946. None of the personnel suffered injury and damage to the station was comparatively light (Fed. Rec. Cen., Md., Summary Report, 1945-1946).

When the Navy Air Facility at Tern closed on 9 June, the East LORAN station lost its weekly delivery of supplies and mail. Instead, a Coast Guard buoy tender serviced the island twice a month. This took care of station needs, but many times over the next six years the ship arrived without mail or movies, a fact which always greatly disappointed the isolated crew (Fed. Rec. Cen., Md., Summary Reports and Logs, 1946-1950).

By 1951 normal operation continued despite a reduction in logistics support to one supply vessel per month. Morale was good considering the isolated duty, reduced fresh food and mail service, and lack of variety in recreational activities. Storms and salt spray caused the buildings to be in need of almost constant repair (Fed. Rec. Cen., Md., Log for 1951).

In October 1951 the Coast Guard Commandant decided to renovate the East Island Station; Headquarters set aside \$200,000 for the job. A field survey in December suggested, however, that it would be better, and no more expensive, to renovate the old Navy buildings at Tern Island and on 17 January 1952 CG Headquarters tentatively approved the move. On 28 January the Hawaii Aeronautics Commission, which thought it had control over the island, granted a license to the Coast

Guard permitting them to use and occupy Tern Island.<sup>1</sup> On 6 March final approval for the Tern Island project was made and on 24 April 1952<sup>2</sup> a contract was awarded to C.W. Winstead, Ltd., of Honolulu. Construction began shortly thereafter (Fed. Rec. Cen., Md., corresp., 67A2057, Box 2).

On 24 October 1952 the East Island LORAN station secured transmission and on 3 November the station was formally de-commissioned. All personnel who had not been transferred to the new Tern Island facility were removed to the USCGC Kukui which was anchored offshore (Fed. Rec. Cen., Md., Log, 61A726, Box 1312).

#### Tern Island LORAN Station

On 14 October 1952 U.S. Coast Guard LORAN Transmitting Station Tern Island was placed in commission and command was assumed by Lt. (jg) Thomas E. Hawkins, USCG. The station consisted of a power and signal building, a barracks containing living areas, galley and mess deck, and a recreation building. There was also an antenna system, 5 water tanks, and 9 fuel tanks (Fed. Rec. Cen., Md., corresp., 67A2057, Box 2; Log, 61A726, Box 1312).

The isolated duty at Tern was similar to that on East. Tern, however, was larger and the biweekly plane service and bimonthly ship service brought fresh vegetables, supplies, and mail regularly. The monotony was occasionally interrupted by visitors, especially fishermen and scientists, and by winter storms and tidal wave alerts. The tour of duty was for one year (Fed. Rec. Cen., Md., Log 1952-1958).

In February 1959, material and equipment were transported to Tern Island for repairs on the seawall. That spring Naval air and surface operations were held in the area and several ships visited the Shoals. In late 1960 it was decided to place a Pacific Missile Range (PMR) team on French Frigate to track satellites and missiles and on 3 December the USS Skagit (AKA 105) anchored and commenced landing equipment, supplies, and personnel for the PMR Facility (Fed. Rec. Cen., Md., Log, 61A275 and 62A352).

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<sup>1</sup> The Department of Interior in 1965 questioned the legality of the Coast Guard's occupation of Tern Island. A formal agreement was signed on 22 September 1966 between the U.S. Coast Guard and the Department of the Interior giving the Coast Guard permission to occupy Tern Island.

<sup>2</sup> The final cost totaled \$286,793.81 (Fed. Rec. Cen., Md., report, 67A2057, Box 2).

After the opening of the new facility, plane service in 1961 almost tripled: 109 planes and 13 helicopters landed in 1961 compared with 44 planes and 11 helicopters in 1960. During 1962, landings increased to 125 planes and 25 helicopters. The numbers of ship visits also increased as well as personnel (Fed. Rec. Cen., Md., Log 62A352, 64A319, Box 12 and 80; 65A593, Box 173).

By late August 1963 ships and planes had removed the PMR equipment and personnel. During early 1964 plans were drawn up for rehabilitation of the station facilities. On 8 April the first cement was poured for the foundation of a new cement block LORAN building (Fig. 35). Repairs were also made to the recreational building and barracks (Fig. 36); new pilings were placed seaward of the old seawall along the east and west ends of the runway. Two air-conditioned trailers left by the PMR were moved near the barracks for use by personnel. Construction and repairs were completed by 6 August (Fed. Rec. Cen., Md., Log 65A593, Box 173; and 66A761, Box 13).

The island's routine for the next several years was interrupted only by a few visiting ships and periodic visits by BSWF and POBSP personnel.

During the predawn darkness of 1 December 1969 the station was hit by tremendous waves which washed completely over the 8-foot-high island. The power equipment was flooded, forcing a shut-down of all electronic equipment. The men sought refuge on the roof of the LORAN building. A Coast Guard rescue plane arrived just after noon, but since it couldn't land dropped survival equipment (Kofron, in litt.).

No one was hurt, but the island's seawall was crushed in various places, soil was badly eroded along the north shore and around the base of the 129-foot LORAN tower, and the vegetation, especially on the northwest side, was washed away. The carpenter's shop and Quonset hut storage building were demolished. The double doors of the engine room were smashed; the equipment inside was wet and useless. The wooden barracks was in shambles; doors, windows, and some walls were destroyed. Furniture was broken and wet and many of the men's personal belongings were water damaged or washed away (Kofron, in litt.).<sup>1</sup>

At dawn on the 2nd, the men and their three dogs were rescued by a helicopter from the New Zealand frigate HMS

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<sup>1</sup> The damage was later placed at approximately \$142,000.



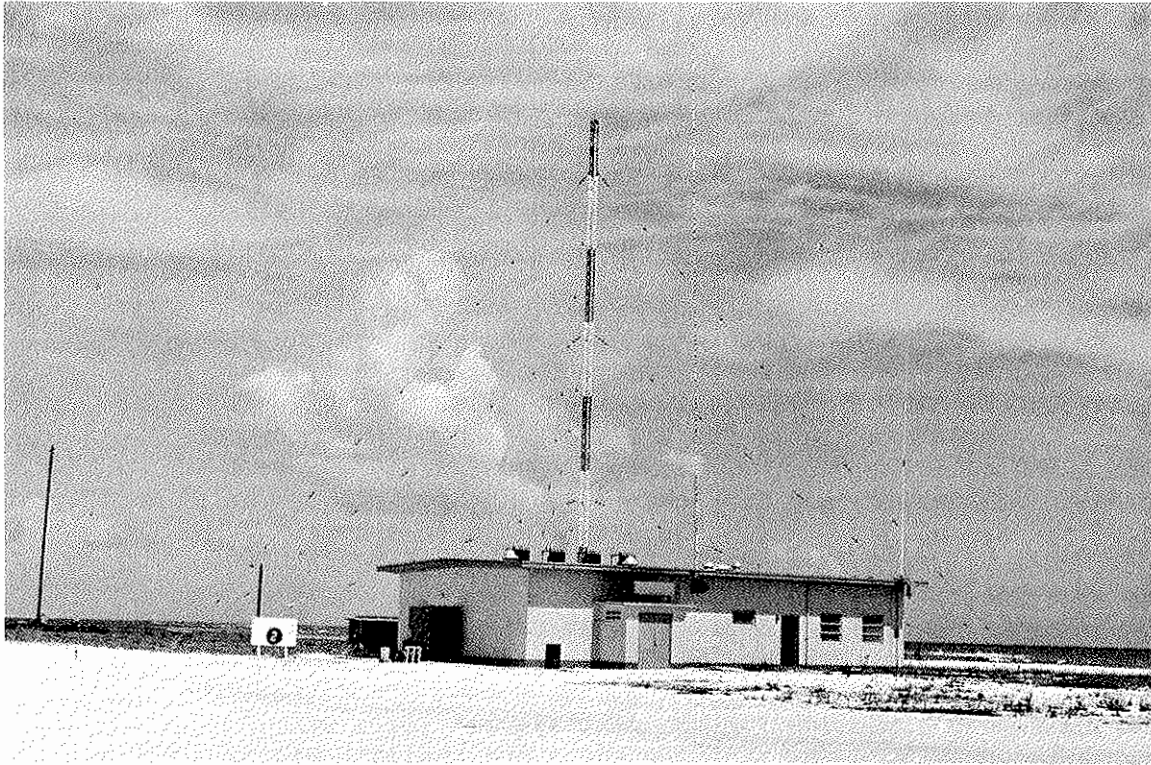


Figure 35. Tern Island Coast Guard LORAN and power building, 21 August 1965. POBSP photograph by A. B. Amerson, Jr.



Figure 36. Tern Island Coast Guard barracks, 21 August 1965. POBSP photograph by A. B. Amerson, Jr.

Waikato. They were taken to Midway and subsequently returned to Honolulu. The crew returned to Tern Island on the 12th aboard the USCGC Buttonwood and began the long, hard, messy job of cleaning up. The USCGC Mellon, USCGC Planetree, and USS Union had arrived earlier and had succeeded in getting the LORAN system into operation on the 6th. Repairs were begun in late December on the damaged barracks. The runway was operational by 15 January 1970 and the station was back to normal shortly thereafter (Kofron, in litt.; U.S. Coast Guard, Hdqtrs. files).

Although in the past the question of whether to continue the LORAN station has been much debated, the matter seems settled for the next 10 years. Funds have been allocated for improvement to the seawall, the runway, and the barracks. The station will probably be in operation until such time as a satellite-aids-to-navigation system is perfected.

#### Refuge Status

French Frigate Shoals' value as a wildlife sanctuary is generally acknowledged and it will continue as part of the Hawaiian Islands National Wildlife Refuge. The atoll offers a unique opportunity to terrestrial and marine biologists: there are few places where one can find isolated undisturbed islands and waters teeming with wildlife so close to an airport and lodging facilities.

Unquestionably the importance of French Frigate Shoals will continue, and probably will increase, over succeeding years.

#### SCIENTIFIC VISITS

The logs and reports from early ship captains sailing among the Northwestern Hawaiian Islands provide the first lists of scientific information about French Frigate Shoals. Among them were Lt. Brooke of the Fenimore Cooper (Brooke, 1955), and Capt. Brooks (1860) of the Gambia, both of whom visited the atoll in 1859, and Mate Mansbridge (Hornell, 1934) of the Ada who stopped in 1882.

The schooner Kaalakai, commanded by F.D. Walker, visited in late May and early June 1891 on the first biological survey of the atoll<sup>1</sup> (Walker, 1909). Aboard were two naturalists,

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<sup>1</sup> On 3 December 1841 two ships of the United States Exploring Expedition sighted French Frigate Shoals, but were unable to stop due to bad weather.

Henry Palmer and George C. Munro, who had been sent by Walter Rothschild to collect birds. Later Rothschild (1893-1900) published on the birds and Munro (1941a, 1941b, 1944) published his notes on the atoll's wildlife. On 28 and 29 May 1902 the Albatross Expedition visited the Shoals; aboard were naturalists Charles H. Gilbert, Walter K. Fisher and John O. Snyder. Fisher (1903, 1906) published the ornithological results of this trip.

After the depredations by bird poachers in the late 1800's, the importance of the preservation of wildlife was recognized. President Theodore Roosevelt signed an Executive Order on 3 February 1909 setting aside French Frigate Shoals and most other Northwestern Hawaiian Islands as a preserve and breeding ground for birds, and thereafter the U.S. Revenue Cutter Thetis started periodical patrols of all the northwestern islands. These continued until the mid-1920's. Various scientists accompanied the Thetis on many of the trips. D.T. Fullaway, an entomologist, George Willett, an ornithologist, and Alfred M. Bailey, a naturalist, went there in December 1912; Bailey (1952, 1956) later published details about the wildlife. W.H. Munter (1915), the Thetis' First Lieutenant, filed a comprehensive biological report after a spring 1915 visit to the Shoals.

The Tanager Expedition, organized by the Biological Survey of the U.S. Department of Agriculture and the B.P. Bishop Museum of Honolulu, visited French Frigate Shoals from 22 through 28 June 1923. All islands except one were visited and the names given to them then are still in use. The scientific collections--birds, mammals, fish, insects, molluscs, plants and marine invertebrates--made by the Tanager Expedition were extensive and added a wealth of information on the ecology of the Northwestern Hawaiian Islands. Twenty bird species were recorded by Wetmore (ms.), the Expedition's leader; Wetmore (1925) later wrote a popular account of the field work. Fowler and Ball (1925) published an account of the fishes collected. In 1926, E.H. Bryan, Jr., and collaborators published a paper on the insects collected. Christophersen and Caum (1931) published on the vascular plants.

On 4 and 5 March 1928 Dr. Victor Pietschmann, Curator of Fishes, Museum of Natural History, Vienna, Austria, paid a scientific visit to French Frigate Shoals. He was on a five-weeks' cruise up the northwestern Hawaiian chain aboard the fishing schooner Lanikai, commanded by Captain William G. Anderson. Pietschmann collected 11 fish species (Pietschmann, 1938), 14 mollusc species (Schilder, 1933), and 5 polychaete species (Holly, 1935) from the lagoon off Tern and East Islands.

The U.S. Revenue Cutter Itasca, on an inspection trip, sighted the atoll on 18 and 27 June 1934, but seeing no poachers or other ships soon left. The U.S. Coast Guard Patrol Boat Reliance investigated the wildlife during March 1936; eight bird species were noted (U.S. Nat. Archives, Logs of Itasca and Reliance, R.G. 26).

Since 1948 various Pacific Ocean Fisheries Investigation (POFI) ships of the Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service, have visited French Frigate Shoals. Published reports from these visits include those of Smith and Schaefer (1949), Eckles (1949), June and Reintjes (1953) and Ikehara (1953).

On 25 July 1952, C.R. Joyce, an Hawaiian entomologist, visited Tern Island and subsequently (Anon., 1953) it was revealed that he found a tick species that was biting military personnel. Joyce became the first non-marine biologist to visit the atoll since the end of World War II.

Frank Richardson (1954a, 1954b) visited the Shoals from 26 October to 2 November and 18-19 December 1953, and 20 March 1954; he recorded 15 bird species and a few seals on the first visit, 15 bird species on his second visit, and 11 species on his last. On the basis of his three visits to French Frigate and other Hawaiian Islands, Richardson (1957) later published an extensive paper on the breeding cycles of Hawaiian seabirds.

From 11 to 21 February 1956 Arthur Svihla (1957, 1959) of the B.P. Bishop Museum visited Tern Island to study the life habits and abundance of the Hawaiian monk seal. He recorded six plant, six insect, seven bird, three mammal (other than man), and one reptile species. On 3 August 1956 two zoologists, not identified in the station log, arrived at Tern Island by Coast Guard plane (Fed. Rec. Center, Md., Log, 58A602, Box 101); perhaps one of these was Archie F. Carr (1964), turtle specialist from the University of Florida. On 28 December 1957 Dale Rice and Karl Kenyon (1962) made a low-level photographic run over French Frigate Shoals to check the albatross population.

Richard E. Warner of the University of California and three other scientists accompanied the USCGC Matagorda on its brief 26 May 1958 supply stop at Tern Island. Before heading for Laysan, Warner (1958) observed seven bird species on Tern Island.

Dr. Hubert Casper from Hamburg University, Hamburg, Germany, visited Tern by a Coast Guard plane on 19 August 1959 (Fed. Rec. Center, Md., Log, 61A275, Box 111); his purpose for visiting the atoll is not known.

Chandler S. Robbins of the U.S. Fish and Wildlife Service (BSFW) visited the atoll via Coast Guard plane on 13 April 1960 to inspect the Refuge. He recorded 3 species of birds. Hawaiian Division of Fish and Game (HDFG) personnel made additional survey visits on 19 October 1960, March and September 1961, and June 1962. They recorded the bird species present, and (in 1961) collected algae (Tsuda, 1966).

On 2 September 1961, 10 scientists of the Coolidge Expedition spent an hour on Tern Island between disembarking from a Coast Guard plane and departing for the USCGC Ironwood, anchored offshore, which was to take them to Laysan. In subsequent publications, Udvardy (1961a) and Udvardy and Warner (1964) noted that they had observed six bird species, on, or flying over, the island but saw no signs of nesting birds. Lamoureux (1961) published notes on the plants he collected during his brief stopover.

POBSP personnel have spent 203 days at French Frigate Shoals on 11 separate trips since June 1963. BSFW personnel have been present on four of these trips. BSFW personnel spent an additional 73 days on 10 other trips. Dates and islands visited for each trip are listed in Table 2. Personnel for all surveys are listed in Appendix Table 1.

Papers resulting from POBSP activities at French Frigate Shoals were published by Amerson (1968), Amerson and Emerson (1971), Clapp and Woodward (1968), Gould and King (1967), Hendrickson (1969), Kohls (1966), Kohls and Clifford (1967), Maa (1968), Sibley and McFarlane (1968), and Tsuda (1966).

One hundred scientific publications have resulted from the various surveys to French Frigate Shoals. Some are specific; others cover several topics. The various topics and number of publications for each are: Coelenterata (2); Mollusca (3); Echinodermata (5); Annelida (3); Arthropoda: Crustacea (1), Arachnida (8); Insecta (15); Chordata: Pisces (11), Reptilia (10), Mammalia (18), Aves (26); Flora: Vascular Plants (4), Algae (2); Geophysical (2). These publications are listed in Appendix Table 2.

#### VEGETATION

Neither Brooke (1955: 618-620) nor Brooks (1860: 500) recorded vegetation when they visited French Frigate Shoals in 1859. The first mention of vegetation came from the shipwrecked crew of the Daniel Wood, who in April 1867 reported one "small sand bank, barren, with the exception of here and there a tuft of grass" (The Friend, May 1867, 37: 1-3). In July 1872

Table 2. Dates of POBSP and BSFW surveys of islands at French Frigate Shoals

Date of Visit	Survey Party	Tern	East	Whale-Skate	Trig	La Perouse	Little Gin	Gin	Round	Disappearing	Shark	Mullet	Bare	Near
1963 7-15 June	POBSP	11	7-11	12-15	14-15	10	9	9	8	9	11	8	8	
1964 27 July	BSFW		27											
27-28 Sept.	BSFW POBSP	27	27	27	27	27								
1965 16 Mar.	BSFW POBSP	Did	Not	Go	Ashore									
4 Aug.- 2 Sept.	POBSP	4-5 10-12 17-23 28-29 31-2	5-10 23-28	11-17 1	16,29 31	7	25	25	10,23			10,23		
1966 21-24 Mar.	BSFW	21	23	22	22	23	23	23						
8 June- 9 July	POBSP	8-10 14-16 21-23 29-1 4-7	10-14 16-21	10,23- 29	10,23 1,3-4									
11 Aug.- 16 Sept.	POBSP	11-15 17-18 24-26 30-16	18-24 26-30	13,15- 17,4	13-14 4,12	4			26					
12-15 Sept.	BSFW	12-13	12-13	13			13**	13						
1967 11-14 Mar.	BSFW POBSP	11-14	11-12	14	13-14									

Table 2. (continued)

Date of Visit	Survey Party	Tern	East	Whale-Skate	Trig	La Perouse	Little Gin	Gin	Round	Disappearing	Shark	Mullet	Bare	Near
1967 25 May- 22 June	POBSP	25-26 31-2 7-9,13 15,18 20-22	26-31 9-13	2-7 15-19	2,8-9 19-20	12	9	9	13			13**	**	**
16-19 Sept.	BSFW	17-19	17	17	17									
7-11 Dec.	BSFW	7-11	9*	9*	9*	9*	9*	9*						
1968 11-15 Mar.	BSFW POBSP	11-15												
29 May- 27 June	POBSP	29-30 11-14 16-17 19-20 22,23- 27	6-11 14-16 25	6,16 17-25	6,11 22,24- 25		7	7	11,25			25		
6-27 June	BSFW	No Data												
1969 22-24 Feb.	BSFW	22-24		23	22	24*								
23 Mar.	BSFW	23												
30-31 May	BSFW					30								
2-26 June	POBSP	2-4 12 25-26	5-10 21	3,16- 20,22	3,14 23-24	16,23	7,21	7,21	5					
21 Aug.- 7 Sept.	BSFW	21-7	22,30	24	23,27	1	23,30		25	4**		2	25	

\* Aerial survey

\*\* Observed from nearby

Wood of the Kamehameha V also found very little vegetation (The Friend, October 1872, 81: 2-3). But by February 1882 the crew of the Ada found an island with "bushes growing on it" (Hornell, 1934). Walker (1909), who spent a week at French Frigate in mid-1891, pointed out that some of the sand islets were profusely covered with scrub.

The Tanager Expedition visited the atoll in June 1923 and found six species of plants--Lepturus repens, Chenopodium oahuensis, Boerhavia diffusa [=repens], Portulaca lutea, Tribulus cistoides, and Ipomoea pes-caprae (Christophersen and Caum, 1931: 8)--on nine of the islands. Wetmore (ms.) noted that another nine species were planted by expedition personnel. It is not known how long these introduced plants lived, but none apparently survived long. Some, however, have been reintroduced since.

During World War II, military activities completely altered one island and partially altered another. With this activity came plant introductions.

A plant collection of 10 species from various islands in the atoll was made by H. Ivan Rainwater in October 1953; these unnumbered specimens are deposited in the B.P. Bishop Museum in Honolulu. Svihla (1957: 1-2) published observations of vegetation after visiting Tern from 11 to 21 February 1956. He reported Ipomoea pes-caprae, Scaevola, Cocos nucifera, and Casuarina sp., and collected seven additional species. On 2 September 1961 Lamoureux (1961: 7-10) visited Tern Island and collected 21 of 22 species of vascular plants observed; 14 of these 22 were new records for the atoll.

POBSP and BSWF personnel have collected vascular plant specimens, or have taken notes and photographs, on most visits to the Shoals. In June 1963 POBSP personnel collected 15 specimens of 8 species and observed 2 other species on four islands. Twenty-one plant species were collected and four others were observed on four islands in September 1964 by C. Robert Long, a POBSP botanist from the University of Hawaii. The islands and their major vegetation associations were mapped in June 1967. Plant specimens collected by the POBSP, its cooperators, and past botanical collectors may be found in the herbaria of the National Museum of Natural History (USNM), the B.P. Bishop Museum (BFBM), and the University of Hawaii (UH).

#### Vascular Plants

Forty species of vascular plants, representing 24 families, have been observed or collected from eight islands at French Frigate Shoals (Table 3 and Appendix Table 3).



Table 3. Distribution of vascular plants at French Frigate Shoals

Species	Tern	East	Trig	Whale- Skate	Round	Little Gin	Gin	Shark
<u>Cenchrus echinatus</u>	x	x	x					
<u>Cynodon dactylon</u>	x							
<u>Eleusine indica</u>	x							
<u>Eragrostis whitneyi</u>	x							
<u>Lepturus repens</u>	x	x	x	x	x	x		
<u>Setaria verticillata</u>	x	x	x	x				
<u>Fimbristylis cymosa</u>	x							
<u>Cocos nucifera</u>	x	x						
<u>Livistona australis</u>		x						
<u>Pritchardia gaudichaudii</u>		x						
<u>Pritchardia pacifica</u>	x	x						
<u>Ficus sp.</u>	x							
<u>Casuarina equisetifolia</u>	x	x						
<u>Atriplex muelleri</u>	x							
<u>Chenopodium oahuensis</u>	x	x	x	x				
<u>Salicornia virginica</u>	x							
<u>Coccoloba uvifera</u>	x							
<u>Boerhavia repens</u>	x	x	x	x	x	x		x
<u>Portulaca lutea</u>	x	x	x	x	x	x	x	
<u>Portulaca oleracea</u>	x							
<u>Coronopus didymus</u>	x							
<u>Spergularia marina</u>	x							
<u>Haematoxylon compechianum</u>		x						
<u>Tribulus cistoides</u>	x	x	x	x	x			
<u>Euphorbia thymifolia</u>	x							
<u>Euphorbia prostrata</u>	x							
<u>Hibiscus tiliaceus</u>	x	x						
<u>Thespesia populnea</u>	x	x						
<u>Calophyllum inophyllum</u>	x	x						
<u>Frankenia grandifolia</u>	x							
<u>Barringtonia asiatica</u>	x							
<u>Plumeria obtusa</u>	x							
<u>Ipomoea pes-caprae</u>	x	x						
<u>Tournefortia argentea</u>	x	x	x	x				
<u>Solanum lycopersicum</u>	x							
<u>Scaevola taccada</u>	x	x	x	x				
<u>Conyza bonariensis</u>	x							
<u>Lactuca sp.</u>	x							
<u>Pluchea odorata</u>	x	x						
<u>Sonchus oleraceus</u>	x	x						

The following vegetation discussion, by island, is based on POBSP data, as well as all previous botanical accounts. Islands are listed in order of magnitude of occurrence of plant species. Whenever plant associations are discussed, the species are listed in order of decreasing abundance.

#### Tern Island

Thirty-seven vascular plants have been recorded from Tern Island (Table 3). Of these 37 species, 30 are exotic plants. The vegetation is presently dominated by 18 species.

Vegetation is limited to both sides of the airstrip (Fig. 37). The area southeast of the airstrip is covered with an herbaceous growth of Ipomoea pes-caprae, Boerhavia repens, Cenchrus echinatus, Setaria verticillata, Sonchus oleraceus, and Conyza bonariensis. Widely scattered shrubs of Tournefortia argentea and Pluchea odorata, as well as a few Scaevola taccada, are found throughout this side. Of less frequent occurrence here are Eleusine indica, Lepturus repens, Portulaca lutea, and P. oleracea. Spergularia marina and Fimbristylis cymosa are common along the margins of the packed-coral airstrip.

The narrow area along the northwest side of the airstrip is rather densely covered with shrubs of Pluchea, Tournefortia, and Casuarina equisetifolia. Tribulus cistoides and Cynodon dactylon were found, as well as the same herbaceous species found on the southeast side.

Introduced exotic plants around the U.S. Coast Guard buildings include several 50-foot-high Casuarina, and a few Coccoloba uvifera, Cocos nucifera, and Plumeria obtusa. From 1964 through 1969, Solanum lycopersicum was cultivated by USCGS personnel.

In June 1923 the Tanager Expedition recorded Lepturus repens, Chenopodium oahuensis, Boerhavia diffusa [=repens], Portulaca lutea, and Tribulus cistoides from Tern (Christophersen and Caum, 1931: 8). Wetmore (ms.) noted that on 26 June Judd (Fig. 38) planted sprouted Cocos nucifera, slips of Hibiscus tiliaceus, and seeds of Calophyllum inophyllum, Thespesia populnea, Casuarina equisetifolia, and Pritchardia pacifica on Tern. If any of these survived, they were destroyed in 1942.

From July to November 1942, U.S. Navy personnel and civilian workers dredged coral from the lagoon, covered the original Tern Island, and constructed a new island in its place.

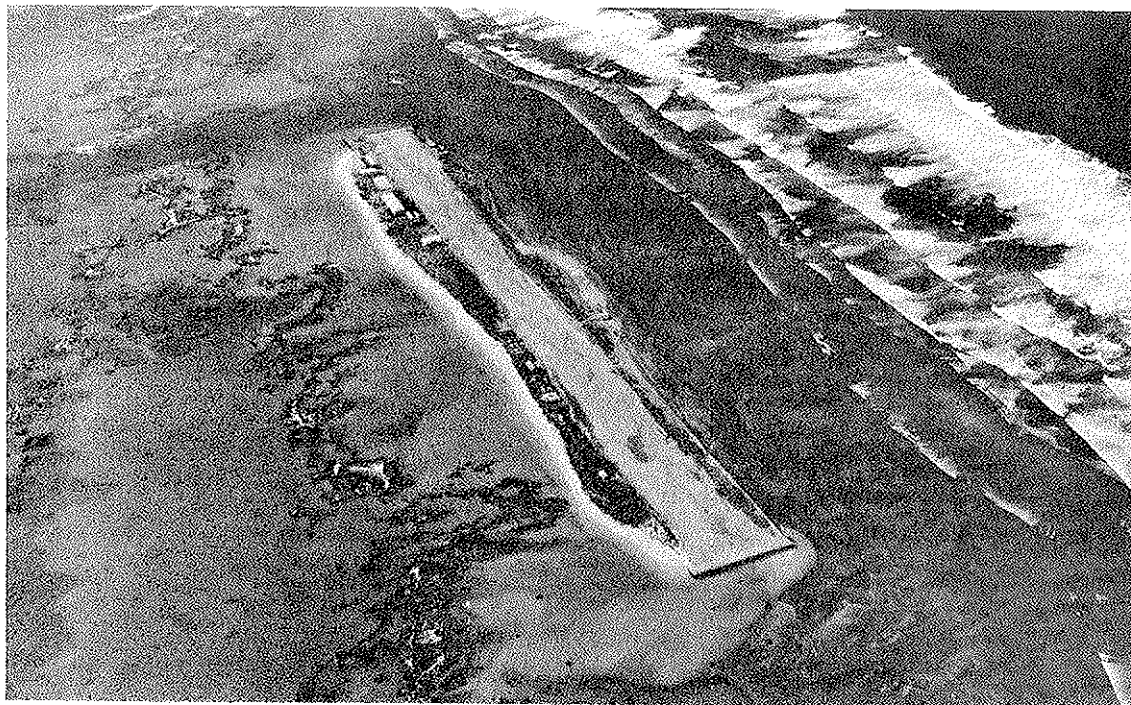


Figure 37. Aerial view of Tern Island, 11 December 1966, showing vegetation growing along both sides of the airstrip. Official U. S. Coast Guard photograph.



Figure 38. C. S. Judd planting Hau trees west end of Tern Island, 26 June 1923. B. P. Bishop Museum photograph by E. H. Bryan, Jr.

This new Tern Island was devoid of vegetation (Fig. 33); furthermore, several of the first Commanding Officers would not allow even a blade of grass to grow. The first recorded vegetation, Tribulus cistoides, reappeared in late December 1943 or early January 1944. Dabagh, the new C.O., carefully watered it and shortly the plant produced a small, yellow blossom. He carefully picked the bloom and enclosed it in his next letter home; his wife Jean still has the pressed Tribulus in her possession (Dabagh, in litt.).

U.S. Navy photographs taken in April 1945, a year prior to disestablishment of the Navy station, show Tern as a white-coral expanse. Sparse vegetation probably did occur, however. U.S. Coast Guard photographs taken in 1949 show Ipomoea and Lepturus scattered around the abandoned Navy buildings, but overall (Fig. 39) the island was still bare.

Between June 1946 and March 1952 Tern Island was abandoned by the military. During this period, the Coast Guard personnel on East kept the airstrip usable, and an occasional plane landed. Commercial fishermen also used the island. Lamoureux (1964: 8) reported that "in 1948 Dr. Vernon E. Smith visited the island and did not find any higher plants growing there."

In April 1952 workers began renovating the old Navy buildings so that the Coast Guard could use Tern instead of East. The small amount of vegetation growing around the buildings was probably destroyed during this period; USCGS photographs show very sparse vegetation in June, July, and August 1952. The new LORAN station went into operation in October.

Photographs taken in January 1953 by Price (in litt.) show a narrow growth of low grass along the central portion of the northwest edge of the airstrip; scattered grass clumps grew around the old Quonset huts on the west half of the southeast side; the eastern portion of the southeast side was completely bare. Lamoureux (1964: 8) noted that "by October 1953 re-vegetation had progressed to the point where H.I. Rainwater was able to collect 9 [10] species."

A U.S. Coast Guard photograph (Fig. 40) taken in January 1956 shows little vegetation along the northwest side of the airstrip, but shows two large vegetated areas on the eastern half of the southeast side. Svihla (1957: 1-2), who visited Tern Island from 11 to 21 February 1956, collected seven plant species and reported four others. He noted that the island "consists largely of the barren landing strip but there is a small area of approximately three acres in extent which still retains some of the original flora." As for exotics, he

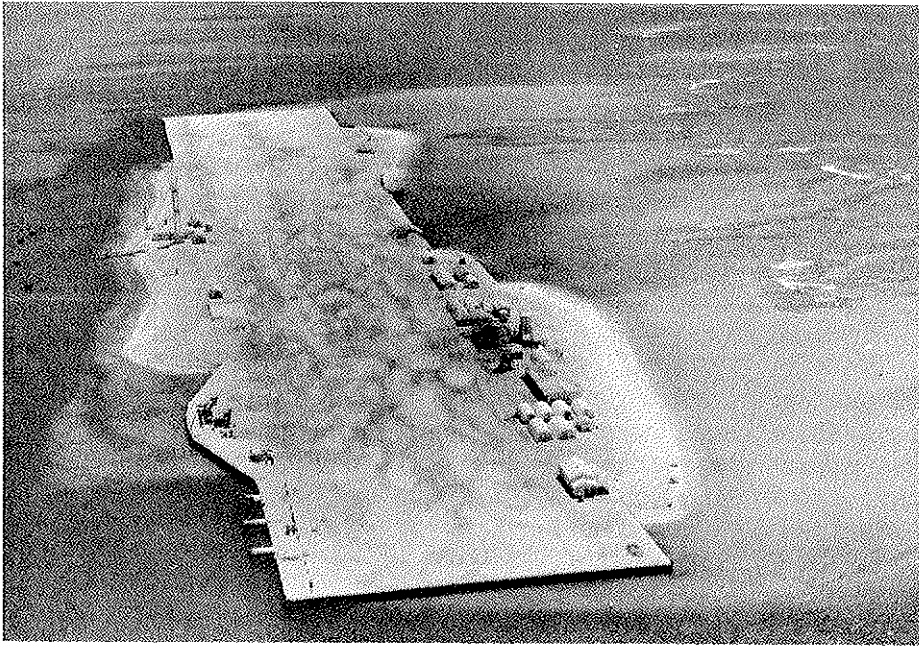


Figure 39. Abandoned Tern Island Naval Air Facility, 16 August 1949, showing its barren, white-coral expanse. Official U. S. Navy photograph.

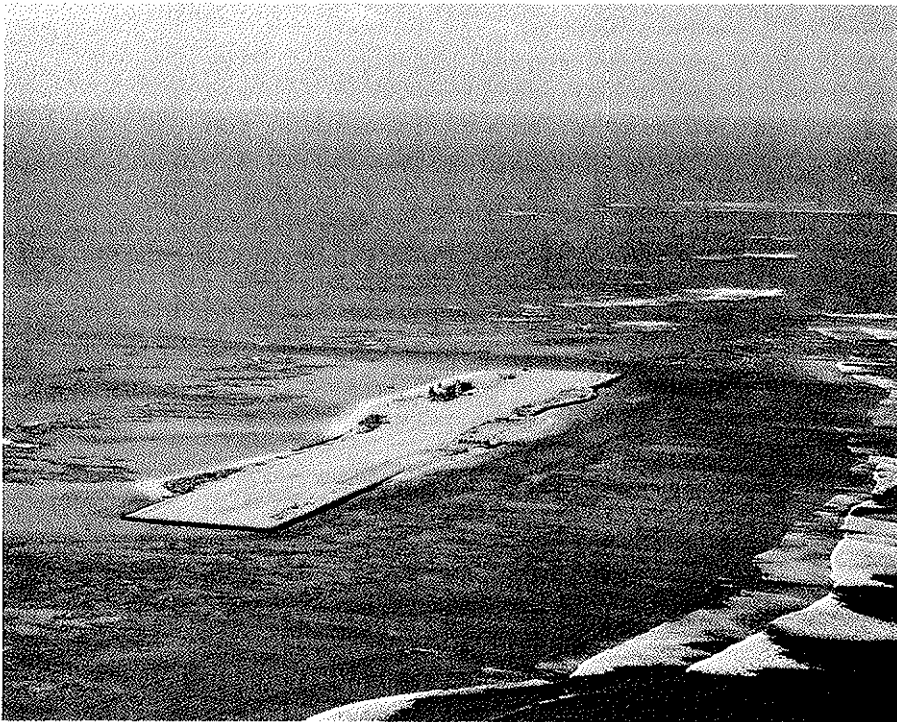


Figure 40. Aerial view of Tern Island, 3 January 1956, showing little vegetation along the northwest side of the air-strip, but two large vegetated areas on the eastern half of the southeast side. Official U. S. Coast Guard photograph.

observed that around the buildings "the three coconut trees are about one foot high and seem to be established. The *Casuarina* [sic], planted in front of the mess hall are about 15 feet high."

On 2 September 1961, Lamoureux (1961: 7-10) visited Tern and found 22 species of plants. He noted that 6 of these were cultivated species, 5 were species which were part of the original vegetation, 1 was probably intentionally introduced but could be a native species, and 10 were probably unintentionally introduced weeds. Figure 41 shows an aerial view of Tern's vegetation in December 1961, three months after Lamoureux's visit.

Lamoureux (1961: 8) speculated on the modes of introduction of the weedy species. He noted that "it seems likely that the seeds of some of these came to the island in the soil which was reportedly brought there from Honolulu (Svihla, 1957)." Svihla, however, was in error, for no soil was barged or otherwise brought from Honolulu (Amerson, in prep.). Lamoureux (*op. cit.*) further noted that "other weedy species may have reached Tern ... accidentally via construction equipment, aircraft, or personnel." He also did not "discount the possibility of 'natural' dispersal by wind, birds, or ocean currents." He stressed that "most of the weedy species were present in the main Hawaiian Islands for many years before 1923, but the species were not found on French Frigate Shoal then. Thus, the weeds appeared there only after man began to make frequent visits."

#### East Island

Twenty-one species of vascular plants have been recorded from East Island. POBSP personnel recorded eight species in June 1963, and two additional species in September 1964.

East Island is covered throughout with *Tribulus cistoides*; an almost pure stand grows in the center of the length of the island. Towards the edges *Tribulus* is mixed with *Boerhavia repens* and *Portulaca lutea*. *Lepturus repens* is scattered along the lagoon side of the northwest half, as well as on the middle portion of the southwest side. *Chenopodium oahuensis* is scattered around the ruins of the LORAN station, as well as on the southeast portion of the southeast side. One low *Scaevola taccada* occurs near the lagoon beach about midpoint of the southeast half. A large, 4-foot-high *Tournefortia argentea* is situated at the southeast tip of the vegetated portion; a dead one occurs near the ocean beach at the midpoint of the northwest half. Sparse *Sonchus oleraceus*, *Setaria verticillata*, and *Cenchrus echinatus* grow among the building ruins.

In June 1923, Christophersen and Caum (1931: 8) reported *Lepturus repens*, *Chenopodium oahuensis*, *Boerhavia diffusa*

[=repens], Portulaca lutea, Tribulus cistoides, and Ipomoea pes-caprae from East. Wetmore (ms.) also noted that Judd planted nine species in June 1923. They were: 50 cuttings of Hibiscus tiliaceus, 8 sprouted Cocos nucifera, and seeds of Haematoxylon campechianum, Thespesia populnea, Casuarina equisetifolia, Pritchardia pacifica, P. gaudichaudii, Livistona australis, and Calophyllum inophyllum. Only Cocos nucifera has been recorded since, and that not from the original introduction.

Vegetation on the lagoon side of the island was partially destroyed in the mid-1930's due to military camp sites connected with various U.S. Naval fleet exercises. In 1944 the U.S. Coast Guard constructed a LORAN station on East. The eight main buildings and a few roads disrupted vegetation on the north-western half of the island (Fig. 42). In 1952 the station was abandoned. By 1962 the buildings were still present, but all evidence of the road had disappeared (Fig. 43). POBSP personnel burned the remains of the buildings in 1965.

#### Trig Island

Nine species of vascular plants have been recorded from Trig Island, all since 1963 (Table 3).

The western half is covered predominately with Tribulus cistoides and Lepturus repens. Scattered throughout this section are Portulaca lutea and Boerhavia repens. Chenopodium oahuensis occurs on the south and west portions of this half. Several low Scaevola taccada grow along the north border of this half. A large 15-foot-high, 30-foot-wide Tournefortia argentea grows in the center of the island. Smaller Tournefortia occur on the south and east side of the eastern half; two occur near the west end of the island. Sparse Setaria verticillata and Cenchrus echinatus<sup>1</sup> have been found on the island.

Christophersen and Caum (1931: 8) collected Lepturus repens, Boerhavia repens, Portulaca lutea, and Tribulus cistoides from Trig in June 1923. No seeds were planted on this island by Tanager personnel (Wetmore, ms.)

POBSP personnel have noted considerable vegetation changes at Trig since 1963. From 1963 through 1965 the eastern half was almost barren sand (Fig. 44). In subsequent years, Tournefortia grew so rapidly on the south crest (Fig. 45) that by 1969 the bushes were about five feet high; these now provide

<sup>1</sup> BSWF personnel eliminated this species in late 1969.



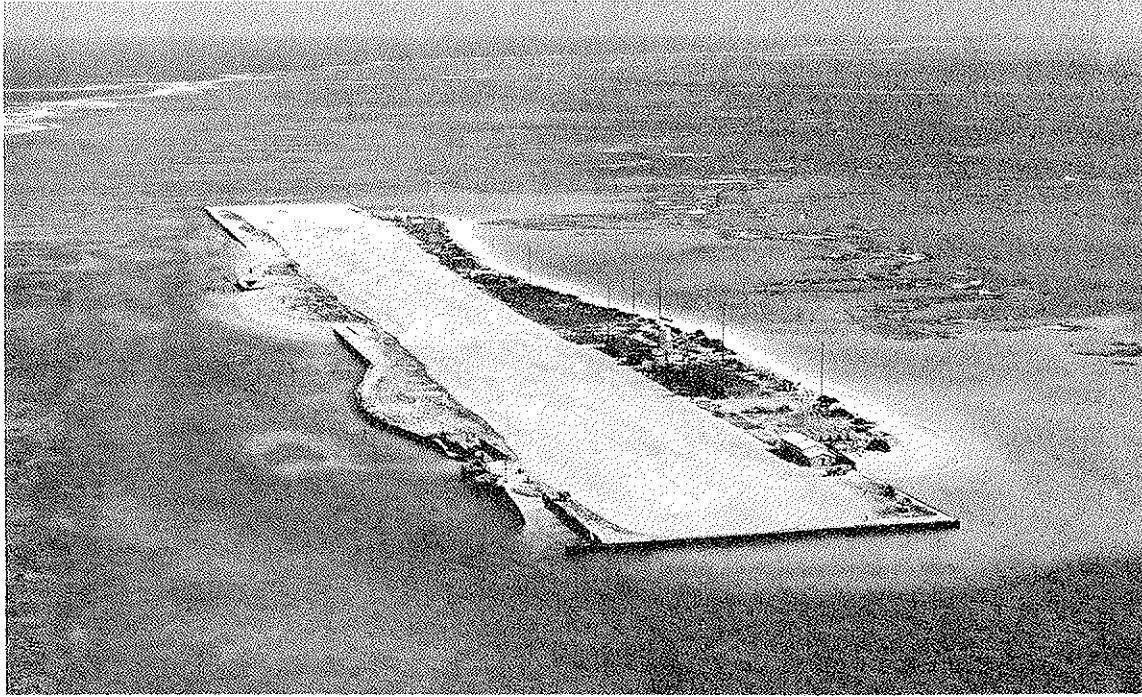


Figure 41. Aerial view of Tern Island's vegetation, 13 December 1961; Lamoureux (1961:7-10) found 22 plant species here on his September visit. Official U. S. Coast Guard photograph.

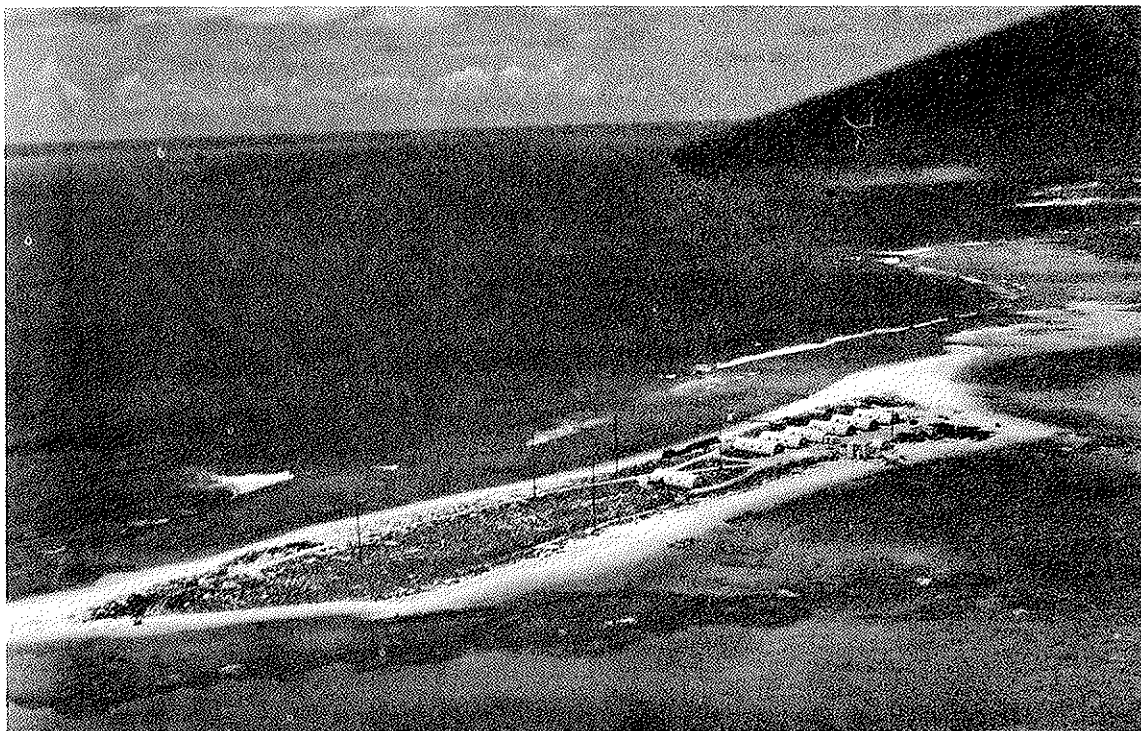


Figure 42. Aerial view of East Island Coast Guard LORAN Station, circa 1949, showing extent of vegetation. Official U. S. Coast Guard photograph.





Figure 43. East Island's vegetation, June 1962. Hawaiian Division of Fish and Game photograph by David B. Marshall.



Figure 44. West view from east end of Trig Island, 16 August 1965; dug-up area in foreground caused by turtles laying eggs; small Tournefortia plants on the left. POBSP photograph by A. B. Amerson, Jr.

added nesting and roosting space for Red-footed Boobies, as well as roosting space for Great Frigatebirds. The grassy western half underwent a drastic reduction in vegetation between June 1968 and February 1969; this reduction, which was still apparent in June 1969, was perhaps caused by excessive turtle nesting activity or by a drought. Storm damage was ruled out for this island was otherwise unaltered. This area undoubtedly will revegetate and should return to its prior status in a short time.

#### Whale-Skate Island

Eight vascular plant species have been recorded from Whale-Skate Island (Table 3); all still occur.

Except for the beaches and a short sandy stretch near the southeast end (Fig. 46), Whale-Skate is mainly covered by vegetation. Tribulus cistoides and Lepturus repens form the predominant ground cover over all vegetated portions. Scattered throughout are Portulaca lutea and Boerhavia repens. Two large areas of Chenopodium oahuensis occur in the central portion of the two halves. Scattered 4- to 5-foot-high Tournefortia argentea grow along the beach crests on both lagoon and ocean sides. Several small Scaevola taccada occur near the southeast tip. A few clumps of Setaria verticillata grow on the lagoon side in the middle portion of the southeast half.

In June 1923 during the Tanager Expedition, Whale and Skate were separate islands. Five plant species collected from both islands were identified by Christophersen and Caum (1931: 8) as Lepturus repens, Chenopodium oahuensis, Boerhavia repens, Portulaca lutea, and Tribulus cistoides. Wetmore (ms.) reported no introductions to either island in 1923.

With the exception of the addition of large Tournefortia and the two minor species, Whale-Skate Island's vegetation has changed little since 1923. The island has had very little human disturbance.

#### Round Island

Four plant species are known to have occurred on Round Island (Table 3); none presently grows there.

In 1923, Christophersen and Caum (1931: 8) reported Lepturus repens, Boerhavia diffusa [=repens], Portulaca lutea, and Tribulus cistoides. The island was considerably larger then. A U.S. Navy aerial photograph taken in June 1932 also shows considerable vegetation present. None exists, however, in Kenyon and Rice's aerial photographs taken in December 1957.

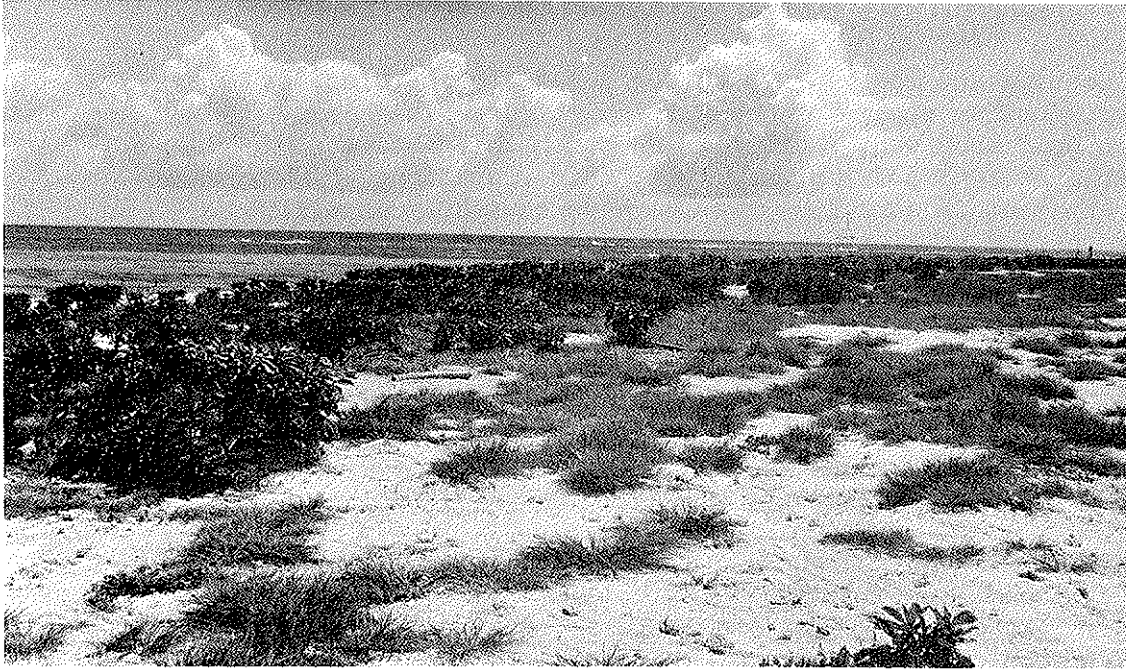


Figure 45. Southwest view from east end of Trig Island, 3 July 1966; Tournefortia along south crest has grown two feet in less than a year (see Figure 44). POBSP photograph by A. B. Amerson, Jr.

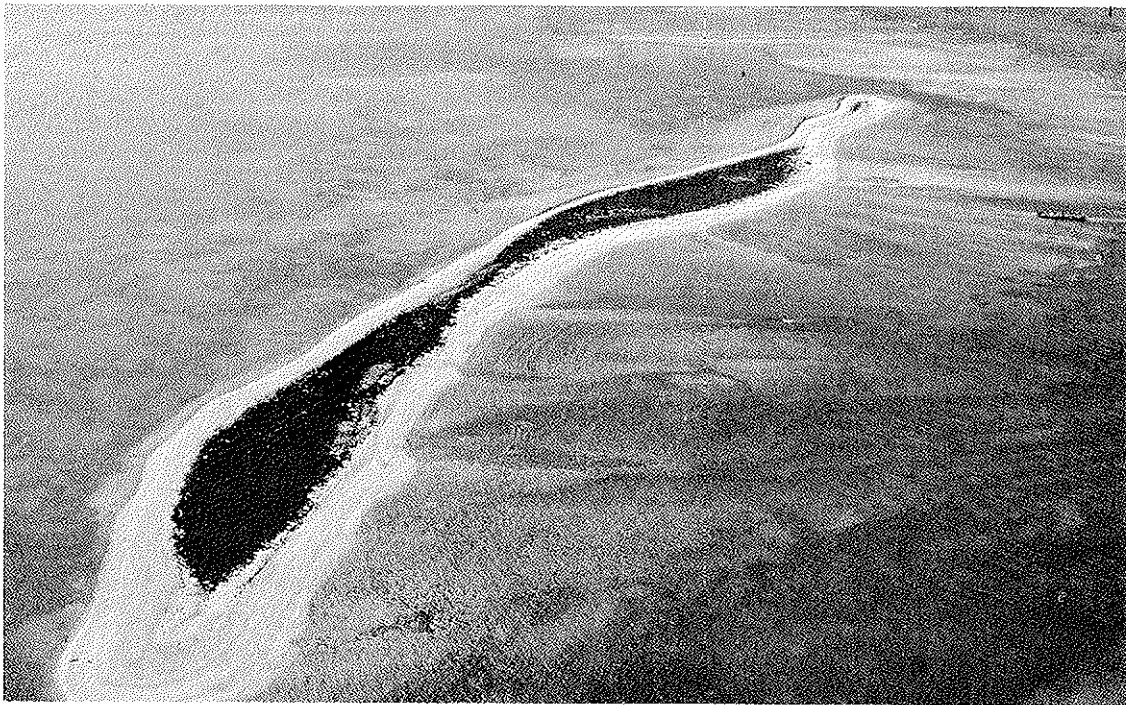


Figure 46. Vegetation covers all of Whale-Skate Island except the beaches and a short sandy stretch near the far southeast end, June 1962. Hawaiian Division of Fish and Game photograph by David B. Marshall.

The island's extremely low height and small size made it susceptible to wave and wind action, and its vegetation, and consequently four nesting bird species, was eliminated. POBSP personnel recorded no vegetation from 1963 through 1969.

#### Little Gin Island

Three plant species have been recorded from Little Gin Island (Table 3); only two have been recorded in recent years.

POBSP personnel observed and photographed (Fig. 47) Boerhavia repens and Portulaca lutea growing in small numbers in the central depression during August 1965. No plants were recorded during the June 1963 visit, and none has been found subsequent to 1965.

Christophersen and Caum (1931: 8) reported small clumps of Lepturus repens, Boerhavia diffusa [=repens], and Portulaca lutea from Little Gin in June 1923. None was subsequently observed until the 1965 POBSP records.

Little Gin's usual lack of vegetation despite its large size demonstrates the effect of wave action during winter storms. In years having violent storms, the plants are covered up or destroyed. In those years with few winter storms, the dormant vegetation has a chance to grow.

#### Gin Island

One plant species has been recorded from Gin Island (Table 3); no vegetation presently grows.

Christophersen and Caum (1931: 8) found sparse Portulaca lutea in June 1923. No vegetation has since been observed and the island is presently bare sand. This island, like Little Gin, is probably affected by winter storm wave action.

#### Shark Island

Table 3 shows that one plant species has been recorded at Shark Island. No plants presently grow there.

A small amount of Lepturus repens was recorded at Shark by Christophersen and Caum (1931: 8) in June 1923. None has been found since. This island's present lack of vegetation is undoubtedly due to wave action during winter storms.

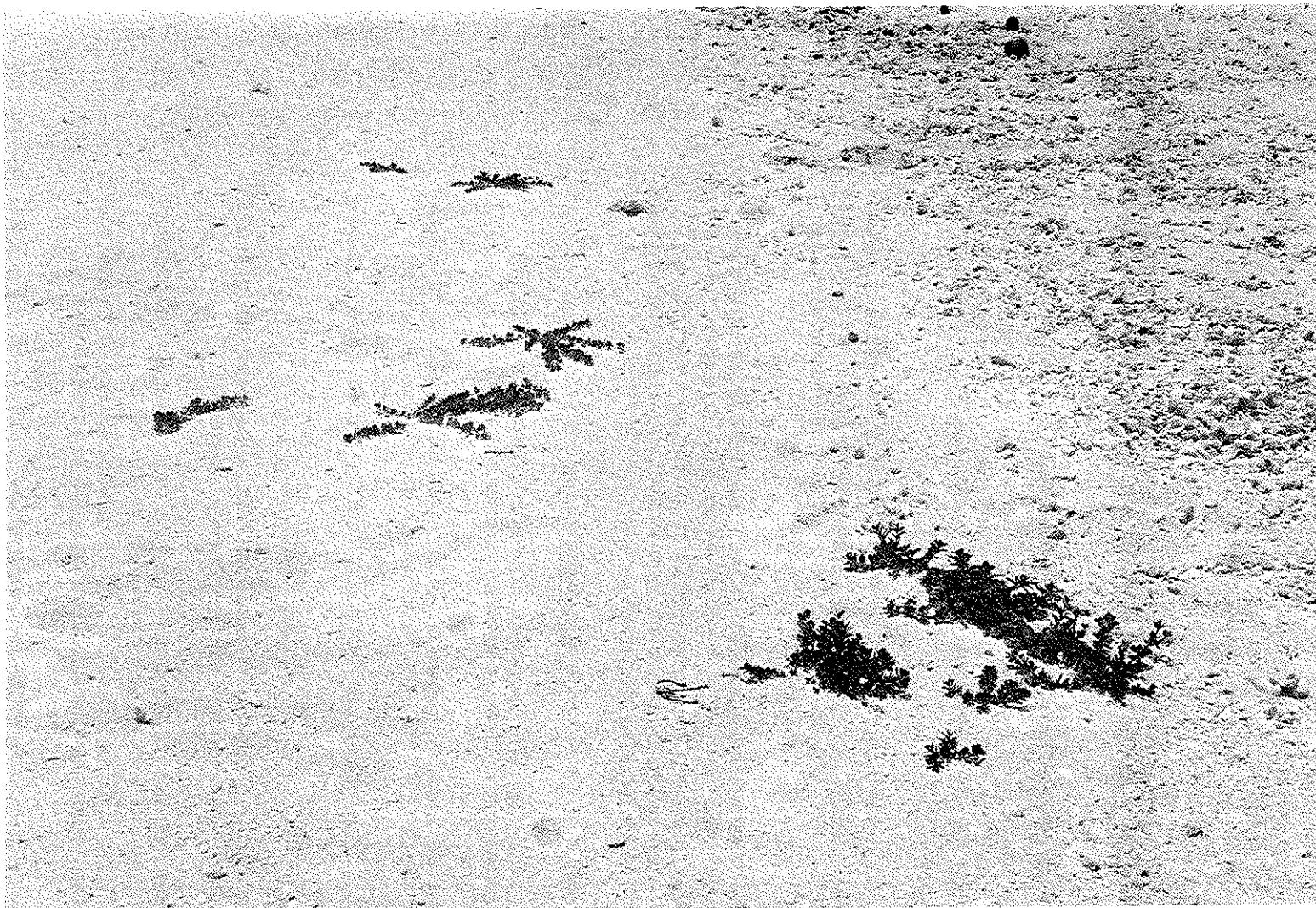


Figure 47. Total vegetation (Boerhavia repens and Portulaca lutea) on Little Gin Island, 25 August 1965. POBSP photograph by A. B. Amerson, Jr.



### Other Islands

The other sand islands--Bare, Disappearing, Mullet, and Near--have no records of vegetation because of their small size and low height. Salt water washes over them regularly, precluding growth of vegetation.

No vegetation has been recorded from La Perouse Pinnacle. Wetmore (ms.) found none when he climbed the rock in 1923. Richardson (1954a: 63) found no vegetation on the cliff faces around the west end on 31 October 1953. POBSP personnel found no vegetation on the northeast face or on the entire top of the main rock in June 1969. The nearby little rock is also barren.

### REPTILES

Two reptiles--the Green Sea Turtle and the Mourning Gecko--are known from French Frigate Shoals. Both species breed on the atoll. The gecko is an introduced species, whereas the turtle species is a resident. Possibly the Pacific Hawksbill Turtle, Eretmochelys imbricata, an uncommon species in the Hawaiian Islands, has visited the atoll, but no records exist of its occurrence.

#### GREEN SEA TURTLE

#### Chelonia mydas

#### Status

Common resident breeder; occurs on all islands, except those awash at high tide; nests on the six major sand islands. Maximum recent population estimate 1,300 in August 1965.

#### Observations

Sea turtles were first recorded from the sand islands of French Frigate Shoals 3 to 7 January 1859 by Lt. John M. Brooke of the USS Fenimore Cooper (U.S. Nat. Archives, Old Mil. Hist., Log of USS Fenimore Cooper for 1859). In May (?) of the same year Captain N.C. Brooks of the Gambia also found the Shoals abounding with turtles.

From 3 February to 1 May 1882, the crew of the Japanese-owned American-chartered schooner Ada, with two sampans, visited French Frigate Shoals "to get anything they could sell in the way of fish, shark, [and] turtle" (Hornell, 1934). When the Ada departed on 1 May its cargo included 47 gallons of turtle oil and 1,543 pounds of turtle shell. The Ada's log gives some indication as to how much turtle was actually taken. Prior to

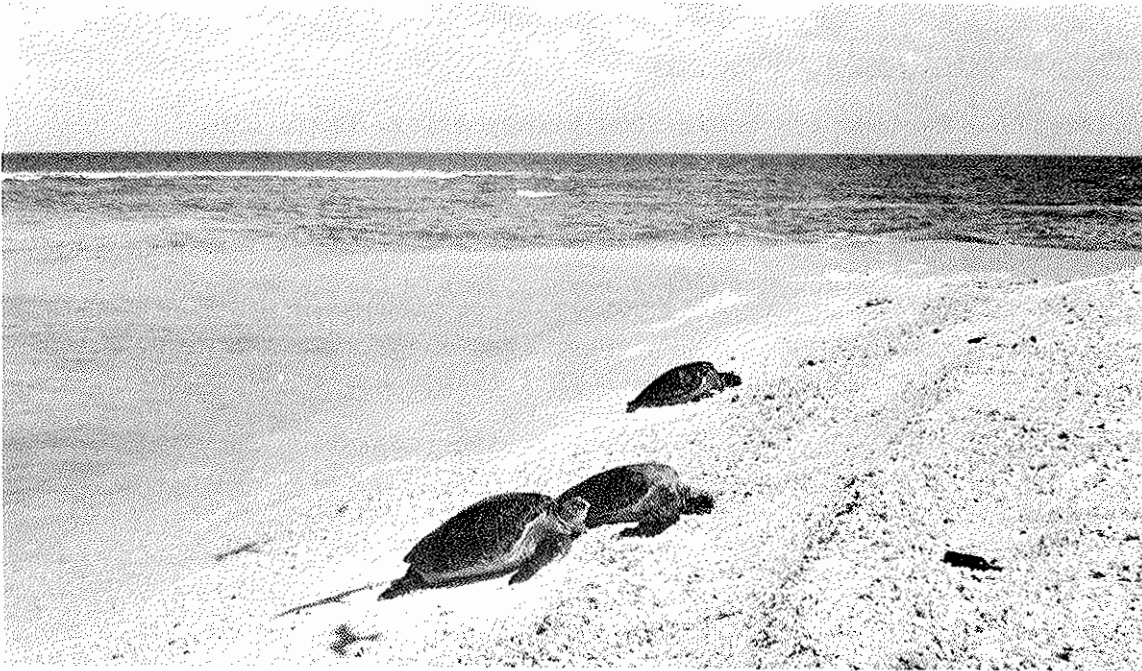


Figure 48. Green Sea Turtles sun-basking on the southeast lagoon beach of East Island, 19 June 1966. POBSP photograph by A. B. Amerson, Jr.



Figure 49. South seaward 50-foot edge of East Island utilized by Green Sea Turtles for nest pits, 19 June 1966. POBSP photograph by A. B. Amerson, Jr.



Figure 54. Nesting birds on east portion of Whale-Skate Island, 24 June 1966. POBSP photograph by A. B. Amerson, Jr.



Figure 55. Great Frigatebirds and Red-footed Boobies nesting on Tournefortia bush, Whale-Skate Island, 24 June 1966. POBSP photograph by A. B. Amerson, Jr.



French Frigate Shoals offers a unique opportunity to terrestrial and marine biologists: there are few places where isolated undisturbed islands and waters teeming with wildlife occur so close to an island with port, airport, and lodging facilities.

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