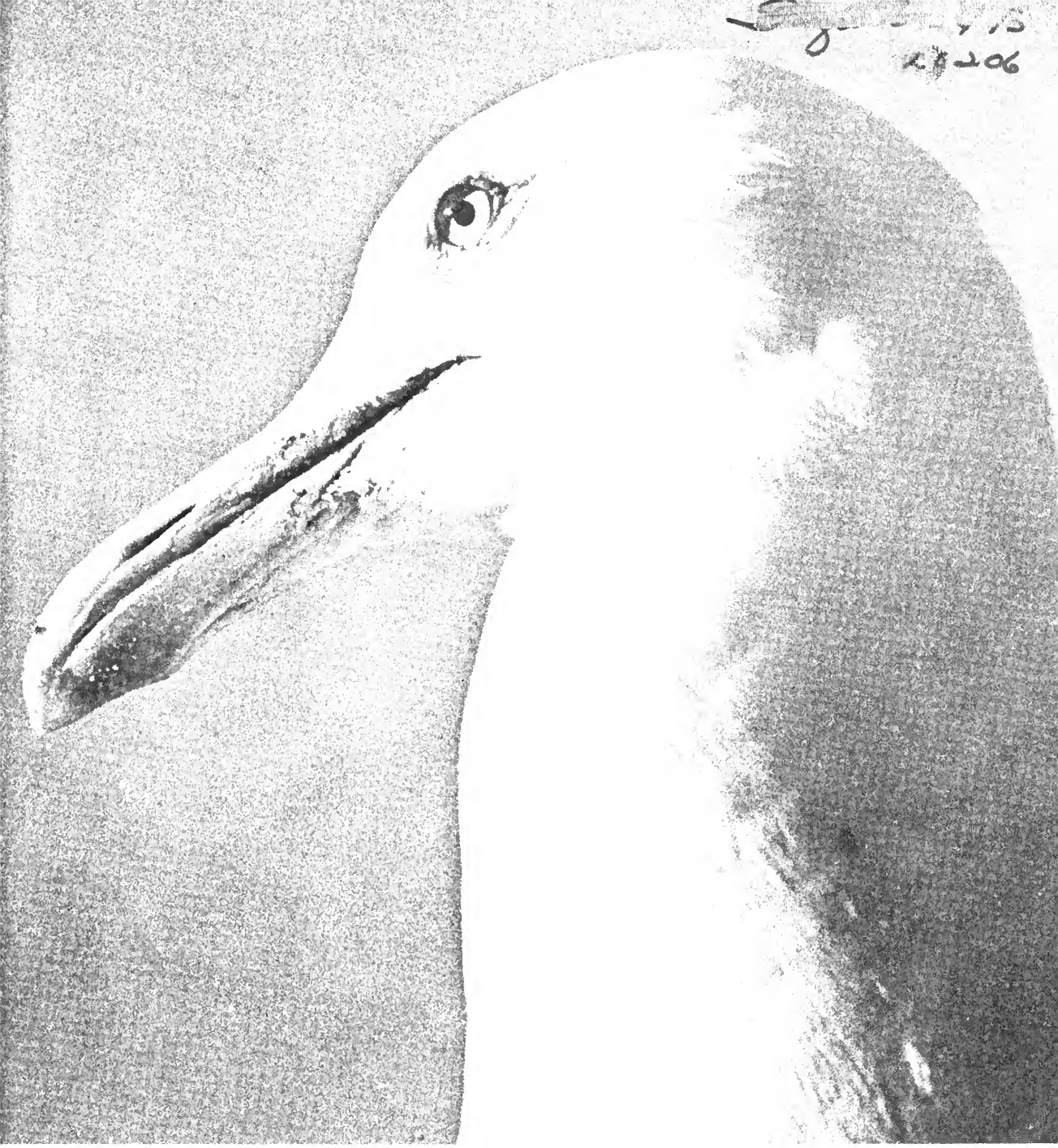

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OCEANUS

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MUNNS

Coming out party on Coco Island in the Indian Ocean. The chick of a Lesser Frigate bird emerging.

This issue was hatched by receiving a pleasant letter from J. Barlee, Senior Lecturer in Oceanography at Brittania Royal Naval College. "There is great competition for Oceanus when it arrives". Mr. Barlee enclosed some of his beautiful photographs of kittiwakes which may be found on some of the following pages.

COVER BY: SHARP

"The Rime of the Ancient Mariner"
Gustave Doré

THERE is a certain majesty in the flight of many seabirds or an appealing charm as in the fluttering flight of petrels as they swoop on the water to pick up a small crumb while lightly "walking" on the water on their little "Jesus feet".

Originally, many seamen had an interest in birds as a possible means to adjust their monotonous diet. Some amusing common names were given by 17th century Dutch sailors in arctic waters where they encountered "Burgomasters" and "Councilmen", both birds of imposing appearance.

At Woods Hole, logs of bird sightings were kept for 25 years by Chief H. Backus. During the collecting of items for this issue we found that there is a renewed interest in the identification and distribution of seabirds.

For those who wish to obtain more information, we recommend, in addition to the books listed by Mr. Willis in this issue, the two preliminary field guides for the Indian Ocean and the tropical Atlantic published by the U.S. National Museum, Smithsonian Institution. See also Oceanus, Vol. X, No. 3 and Vol. XI, No. 3.

"Jesus Feet"

BIRDWATCHING AT SEA

A Woods Hole Tradition

by P. R. WILLIS

BIRDWATCHING at sea is an old tradition at Woods Hole and is very much a part of the ships and the men who sail them. Bird records were started on the early cruises of the R/V 'Atlantis' by H. Backus and among others particularly Dr. A. C. Redfield, A. C. Woodcock, D. F. Bumpus, W. G. Metcalf and later by M. Palmieri. The records are on file. Wherever one of our ships has sailed, be it the Atlantic or the Indian Ocean, a log was generally kept by ships' engineers, mates, helmsmen, and scientists interested in the movements of seabirds. These records are the basis for our ever-expanding knowledge. Even today, little is known of the distribution of pelagic seabirds. G. E. Watson of the Smithsonian Institution and W. R. P. Bourne of Great Britain, both noted ornithologists, have stated that professional seamen and scientists at sea could make important contributions to the knowledge of marine birds, since with few exceptions ornithologists rarely spend time at sea. The bulk of the seabird reporting, therefore, remains in the hands of those whose day-to-day work is on the sea. Such organizations as the Royal Naval Bird Watching Society of England have made notable progress in bringing the officers and men of commercial and naval ships together in a single scientific endeavour. This is only the beginning, since much more data are needed if we are to understand fully the many aspects of seabirds and their life cycle.

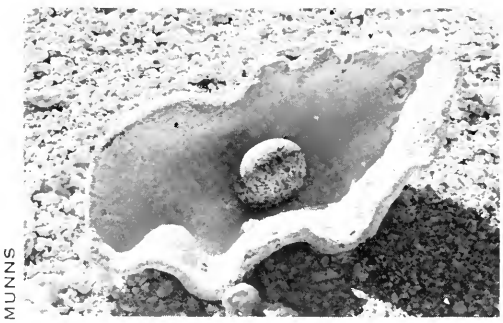
Birdwatchers can assist the professional ornithologist in a number of ways. Before going to sea they can read several excellent books which give not only some idea of what to expect, but also bases for recognition of what actually is seen. Thus, a birdwatcher would be alerted if he saw an unexpected species, or noticed the absence of a species expected in a certain area. W. B. Alexander's, "Birds of the Ocean" (1928, G. P. Putnam's Sons, New York, republished 1954), G. E. Watson's "Seabirds of the Tropical Atlantic Ocean" (1965, Smithsonian Institution, Washington, D. C.), or R. T. Peterson's "A Field Guide to the Birds" (1947, Houghton Mifflin, Boston), are but a few of the many publications available.

Within a few days, after having gathered some preliminary information on what to anticipate, spotting and associating seabirds with their names come with ease. As new birds are seen, a greater awareness is developed for the unique environment in which they live. The author has had the opportunity to share many memorable hours observing birds with both crew and scientists.

There are several points regarding bird observations which should be noted. It is most important that a seabird log, and reference material, should be kept close at hand while watching. Events should be written down immediately, lest they are forgotten. A certain routine should be followed, insuring that at least a minimum amount of data will be recorded.

There are several requirements to keep a good qualitative bird log. In many cases it will be difficult to identify a bird positively due to its distance from the observer, movement of the ship, or specific weather condtions. The size of a bird usually is a problem to determine since there is nothing save the sea to compare it with, and thus the bird often is recorded as smaller than it really is. A good example is the Wandering Albatross, the world's largest seabird. Many birdwatchers are surprised to find that the bird has, as an adult, a wingspan of ten feet or more. The experienced birdwatcher, for this reason, compares two species of in-flight birds to get a relative size, whenever possible. At sea, birds on the wing are much more difficult to identify than on land. When in doubt it is far better to indicate the observation as uncertain. (The author has many such records in his log). Marking the log with "P" for positive and "U" for uncertain is all that is necessary. When regularly watching at certain times of the day a record of "no birds observed" is just as valuable as a record of birds seen at these times.

Then follows the birds' common name (i.e. Booby, Petrel, Tern) as well as a Latin name, if available, and whether the bird is adult/juvenile/immature, male/female, and the plumage, which often changes with the seasons. A sketch can be of value where a bird has unusual color patterns on the wings. Shape and color of the bill, along with foot and eye color, are extremely useful.



MUNNS

Noddy Tern egg in giant clam shell
Coco Island, 1965

MR. WILLIS is a Research Assistant in our Physical Oceanography Department and was on board the 'Atlantic II' during the entire ten months "around the world" cruise in 1965.

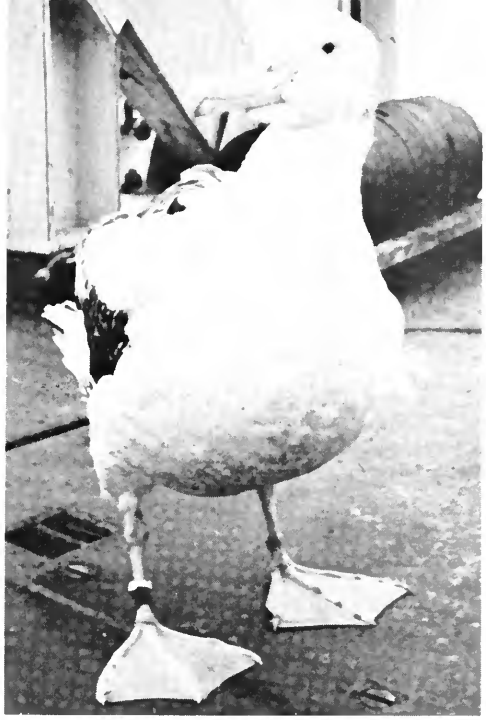
To record numbers where large flocks are seen it is easiest to count them in multiples of ten or more. It is best to be conservative in your estimate. The date and time with the latitude and the longitude must be noted. If close to land, bearings of two positions are acceptable. Weather conditions are to include air temperature, wind force and directions, precipitation if any, and storm conditions in or near the ships' position. The sea surface temperature and if available, the salinity and other chemical values (nutrients, etc.), are important.

It is understood that all the factors may, for some reason or another, be unobtainable. Where seabirds are concerned, many interrelationships exist which are not yet understood so that as much data as possible need to be gathered. Even a completed log kept by an occasional observer is well worth the effort.

Binoculars are a definite asset in observing distant birds. To avoid undue eyestrain, the binoculars should be used only after the bird has been located with the naked eye. Constant looking with field glasses tires the observer rapidly and may cause him to miss birds close at hand. With the aid of binoculars 90% of observed birds can be placed into families.

Although a camera is not necessary, it is good to have one along. On several cruises the author was equipped with a 35mm camera and a series of telephoto lenses. The camera aided in confirming several uncertain observations.

If by chance a bird should come aboard ship, it should be collected, labeled, and



WILLIS

'Atlantis II'—Cruise No. 15. 1965. July 7. Durban to Fremantle. 1700 hrs. 31°56′S. 75°07′N. Brought on board one Wandering Albatross, on right foot band No. 52-859384, U.S. Fish and Wildlife Service, left leg had three plastic bands white-green-red. Photographed and released. This bird appeared to be quite some distance from its nesting site. (extract from Willis log).

if dead, placed in a plastic bag and frozen. Land birds often stray far out to sea due to high winds and storms. These should also be collected wherever possible. Upon return to port a notification sent to the Smithsonian Institution will bring a prompt reply giving directions for the forwarding of the bird.

It is not easy to include all factors relating to bird observations in a short dissertation. What is stressed is a good knowledge of bird families, proper log entries with all possible data, and proper use of field glasses.

There is a new and increased interest in bird observations, making the work worthwhile. We should like to know more about the relationship between certain forms, indications of migrations, new species and/or extended ranges for known species.

Large bird concentrations are usually an indication of the presence of fish, therefore a better knowledge of bird concentrations may be used as an index for fisheries.

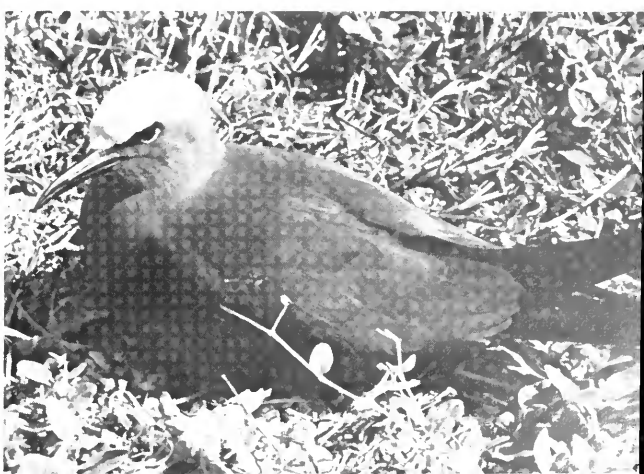
In W. B. Alexander's book, the introduction to the chapter on Tropical Seas, (p. 245), suggests that the distribution of birds specially characteristic of the warm parts of the ocean is considerably influenced by the great ocean currents. While this is partly true, G. E. Watson states (p. vii) that the distribution and local abundances of seabirds are closely associated with particular water masses.

From our own bird logs, preliminary findings seem to agree with Watson. We are now studying the log data gathered in the Indian Ocean on A. R. Miller's cruise of the 'Atlantis II' to try to determine how much of a correlation exists between bird concentrations and certain water masses.

Since our largest ships now carry computers the possibility exists to expand the bird observations by using a numerical code for the data on birds, including the biological and chemical characteristics of the water masses and the meteorological conditions. We attempted to do so on the PDP-5 computer on board the 'Atlantis II', to try to formulate a program to relate the observed environment to the species and/or number of birds seen. To the best of our knowledge this is the first time this has been attempted.

All of this comes from a simple bird log at sea put together by someone who just happens to enjoy the flutter and glide of a petrel winging across the water or the majestic sight of a frigate-bird soaring high overhead.

"I've got mine, Jack!" A Greater Noddy brooding in more ways than one. Coco Island.



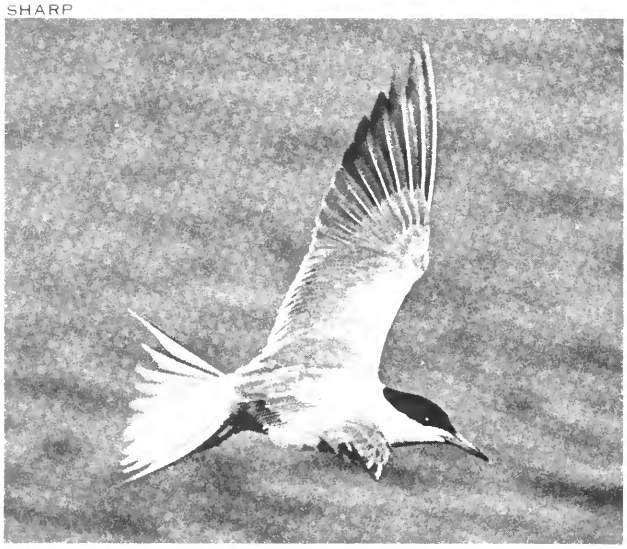
POCKLINGTON

Birdwatching

WILLIS

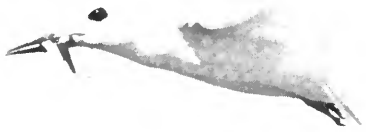
Third Mate M. Palmieri of the R.V. 'Atlantis II' (with beard) and others on a bird watching expedition in the Indian Ocean. Mr. Palmieri is Honorary Research Collaborator of the Smithsonian Institute.

SHARP



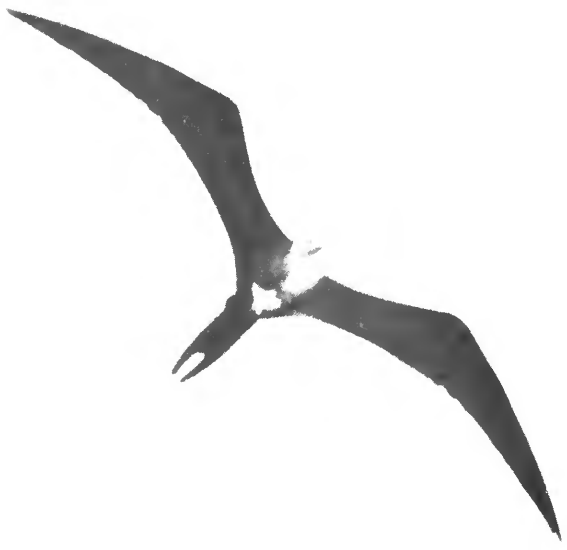
Crested Tern. Woods Hole

POCKLINGTON



Fairy Tern with fish in mouth. Coco Island

Magnificent frigate bird. Off the Coast of Costa Rica.

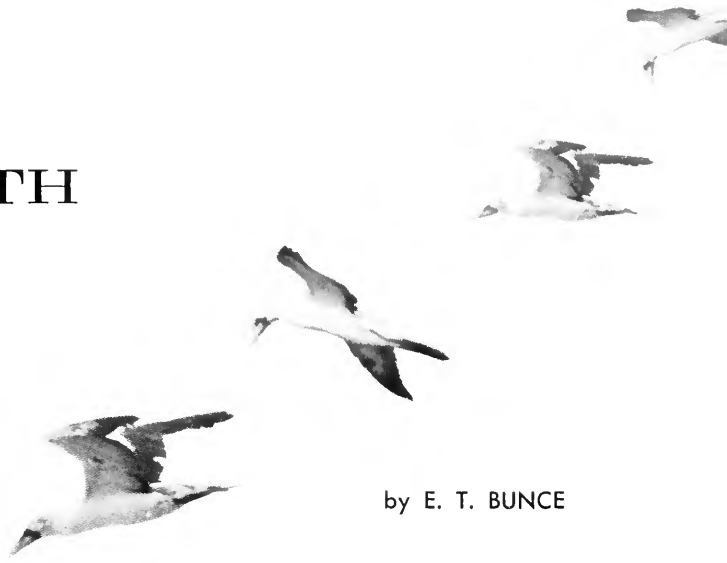


WILLIS

White tailed tropic bird. Indian Ocean

WILLIS

BIRD and MOTH INCIDENT



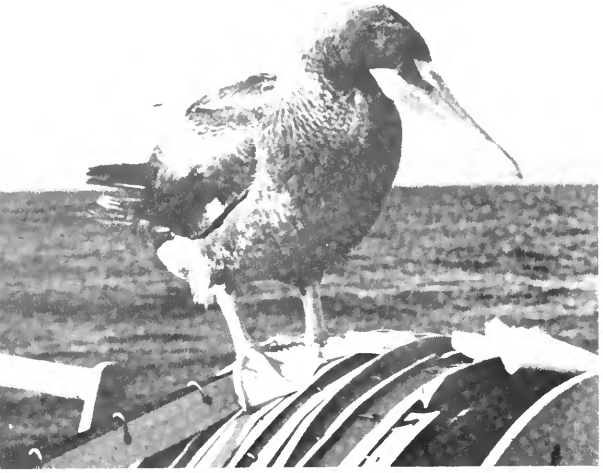
by E. T. BUNCE

An invasion of small birds and moths kept science and crew "hopping"

I have been fascinated by the variety of small, bedraggled, feathered objects that seek landing and resting space on a ship far at sea. We have had flickers on the fantail, boobies on the foremast spreaders, juncos eating crumbs from someone's hand and birds just bumming rides in the English Channel. But perhaps the most peculiar set of coincidences involving birds ocurred on a cruise of the R.V. 'Chain' in the fall of 1692.*

During the early fall of 1962 a number of storms kept the east coast on hurricane alert. Shortly after one of these fairly intense centers had swiped at the Mid-Atlantic states, but passed Cape Cod well offshore, we sailed forth bound first for the area of Bermuda, thence to the Puerto Rico Trench and Outer Ridge region ('Chain' Cruise #34, 21 October 1962). Late that night at about 71°40'W, 39°-40'N the top lab became, literally, a bird's nest. Numerous small, wet, bedraggled, feathered friends settled on the deck spaces, in the lab, on the equipment racks, on the bookshelves in the Chief Scientist's office below and a couple of venturesome souls penetrated to the crew mess on the main deck. This happened during the mid-watch, and our 4 to 8 watch was considerably enlivened by efforts to keep some of the birds from being electrocuted in the assorted equipment. It was squally off and on during the night, there were numerous puddles on deck and the birds landing there looked pretty forlorn in the early morning light. It was also obvious that they were looking for fresh water to drink, as they pecked at the rivulets caused by the ship's roll. Our best identification was a general typing as "confusing fall warblers", as defined by R. T. Peterson. Unfortunately, we did not have a Field Bird Guide aboard, and an attempt at identfication when we arrived home two months later only resulted in the possible conclusion that some of the birds might have been a type of Vireo. We were all pretty busy during the next day, so that while we were aware that the crowd thinned out, none of us could say how. Some may have flown away, some undoubtedly succumbed to exhaustion and fell from their perches into the sea, but enough were still around by late afternoon for us to feed them. We made water dishes from electric tape containers and strewed bread crumbs, assorted cold cereals, and even bits of cold cuts around.

*These bird stories are well documented in top lab logs of the 'Chain' geophysical cruises, which contain all sorts of interesting titbits as well as the geophysical observations.

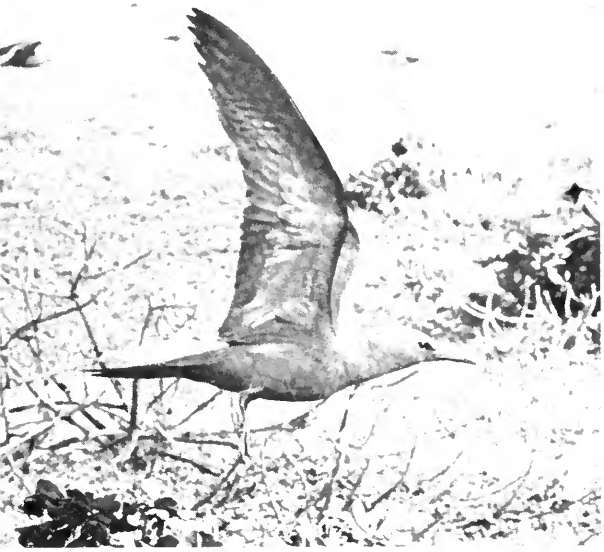


METCALF

Boobies are rather stupid birds. They will fly straight into the rigging of a ship and recoil in horror emitting a raucous noise. This immature brown booby landed on the 'Crawford' near St. Paul's rocks and stayed on board for a day and a half. A neat round bullet hole can be seen in the webbing of the left foot. Healed over it looked like a nicely darned buttonhole.

They turned up their beaks at all of this—except for one which lived happily on a shelf in the crew mess, and eventually departed in San Juan. Fairly obviously, we were not providing the proper dish and the birds would rather starve than eat our offerings. Then the really astounding bit —we were invaded by moths. Large, grayish white, they came in every open door and port hole, they were plastered all over the equipment and the people. The remaining birds had a field day dive bombing the moths. Another guest arrived, apparently to help clean up any leftovers. A large hawk, (identified by a reputable bird watcher as a Marsh Hawk), which had been spotted late in the afternoon, spent the night aboard on the aftermast spreaders. It departed sometime during the morning and as far as we could tell, all our smaller visitors also were gone. The moths took longer to clean up.

We have attributed all these events to the effect of the storm on the normal migration paths. Any other ideas?

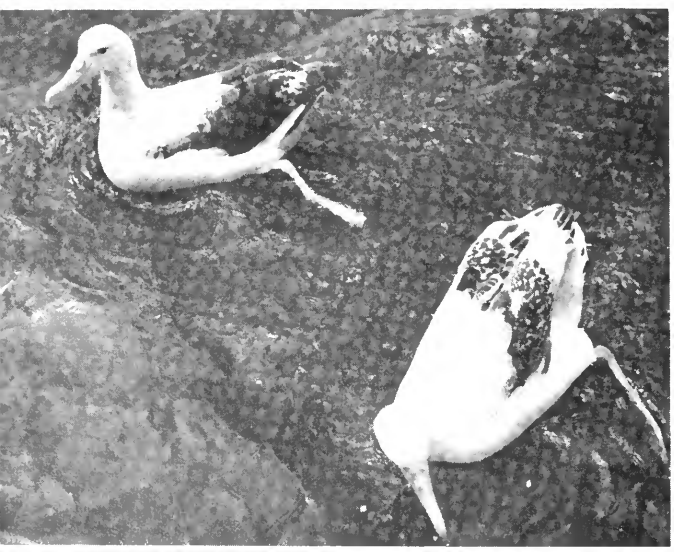


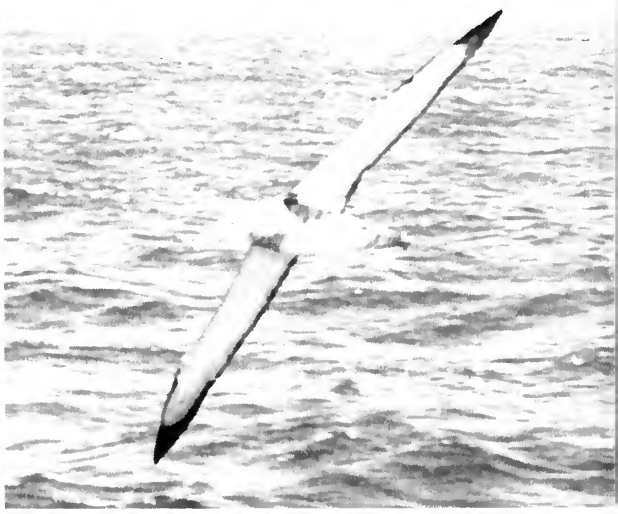
POCKLINGTON

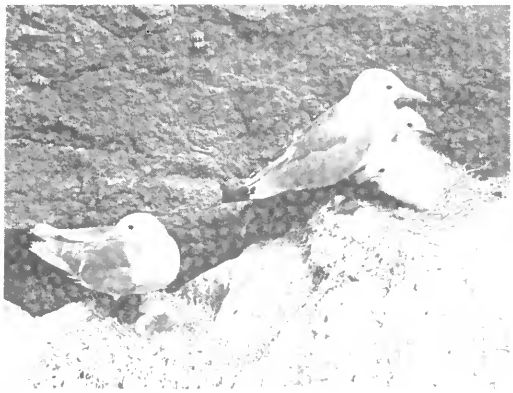
A Noddy taking off from Coco Island. Hundreds of other noddies and Fairy Terns in the background.

Immature Wandering Albatross alongside the 'Atlantis II'. The wings of the Albatross fold up like the wings of some modern aircraft. They look far more imposing when in flight!

MUNN







BARLEE

BARLE

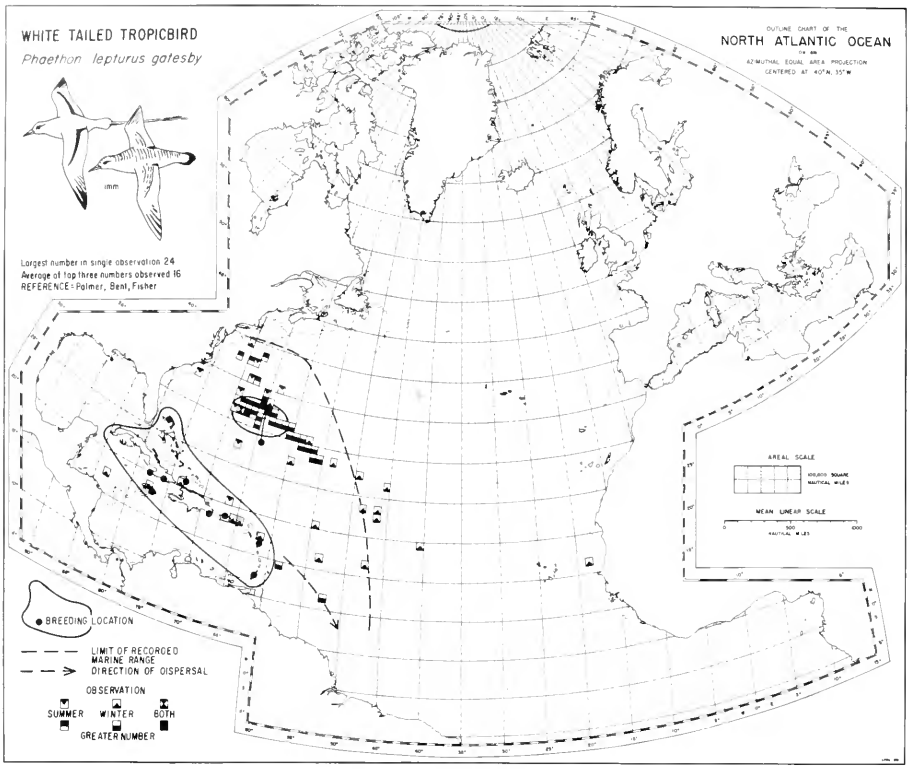
The KITTIWAKE

by J. BARLEE

THE kittiwake is the only truly oceanic gull. Its food is plankton and the small fishes that feed on plankton, and so it is able to sustain itself wherever plankton is abundant. By following ships it is able to get at the plankton brought to the surface by the screws; whales and seals are followed too.

The Kittiwake breeds on the sheer faces of sea-facing cliffs from Newfoundland to about 80°N in Baffin Island and Greenland, and from Britain to Spitsbergen, Novaya Zemlya and Franz Josef land. In the fall they move down to about 40°N, but stay out in the open Atlantic. Some birds, mainly the young ones, wander further south and have been found in such places as the Carnary Islands, the Cape Verde Islands, Morocco, Senegal, the Caribbean and the Gulf of Mexico. At least 30 birds banded in Britain have crossed the Atlantic and have been recovered mainly round Greenland and Newfoundland where thye are considered good to eat and are shot in large numbers. A sub-species, which is almost identical, breeds around the north Pacific, and in winter is found as far south as Japan and Lower California.

The chief distinguishing feature of the kittiwake is its neat black triangular wing-tip. Other gulls have black wing-tips, but with small white marks, called "mirrors" beyond the black at the extreme tip. First year birds have a broad black line, roughly in the shape of an M, along the top of their wings, and black rings round their necks.



BUTCHER ET AL.

NORTH ATLANTIC DISTRIBUTION CHARTS

A labor of love has been prepared by former staff member Dr. Wm. S. Butcher, with R. P. Anthony and J. B. Butcher. They have taken 33 years of recorded bird sightings made by Institution staff members and ships' personnel and translated these records into some 48 charts of the North Atlantic Ocean. One chart for each species of oceanic bird, and one master chart showing the location of all observations.

The authors state that "the data are insufficient to determine possible migrations with any confidence and we present the observations in chart form without interpretation. In spite of the length of time represented by the records there are not enough observations in any given area properly spaced in time to provide a firm basis for analysis. It is our hope that such charts will stimulate and facilitate more observations. Because many readers may not be familiar with oceanographic properties which might affect the distribution of birds at sea we have also included charts of the winds, currents and areas of high organic production in February and August. Since the bird charts may be used profitably at sea we have presented a line drawing of each species on each chart to facilitate identification. . . We hope that many observers will communicate their findings to Woods Hole so that these charts may continue to be improved."

Dr. Butcher and his co-authors hope to find a publisher for this bird atlas which certainly would be in great demand not only on board research vessels but for all bird enthusiasts on merchant and navy vessels, ocean-going yachts, and perhaps even a fisherman or two.

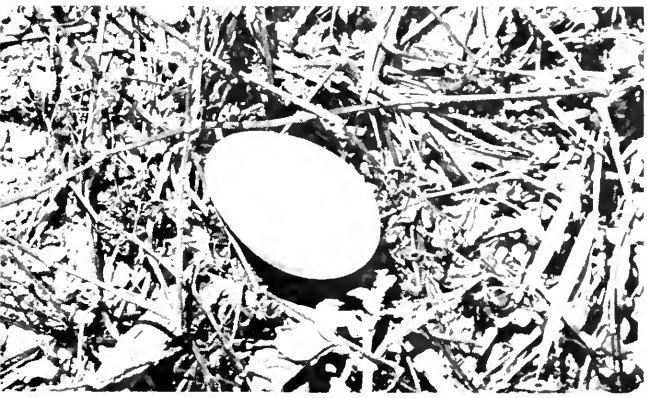
POCKLINGTON

In recent years we have had the opportunity to visit famous hard to reach bird nesting places such as St. Peter and St. Paul Rocks in the South Atlantic and Coco Island in the Indian Ocean. This sequence shows some events in the life of a Lesser Frigate on Coco Island.

Living space is at a premium but in a nice community arrangement the eggs are laid just outside the pecking range of the neighbors.

The silhouette shows a bird with a brilliant red sack under the throat during the mating season.

POCKLINGTON



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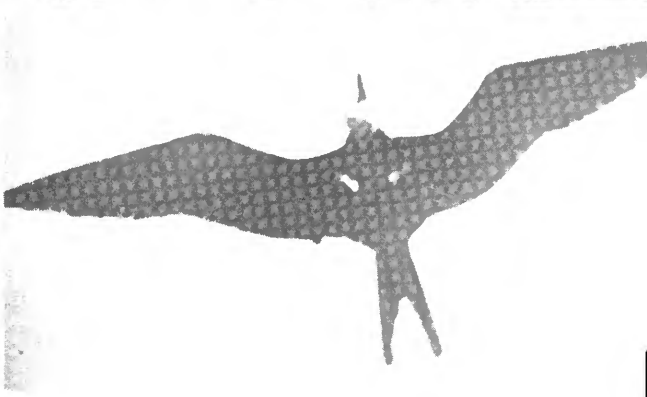


WILLIS

The KITTIWAKE

BARLEE

A MIGHTY BRONZE AGE VOLCANIC EXPLOSION

by J. W. Mavor Jr.

Long Lost Atlantis in the Mediterranean?

Evidence from the sea bottom helped to indicate that the Minoan civilization disappeared in a gigantic explosion.

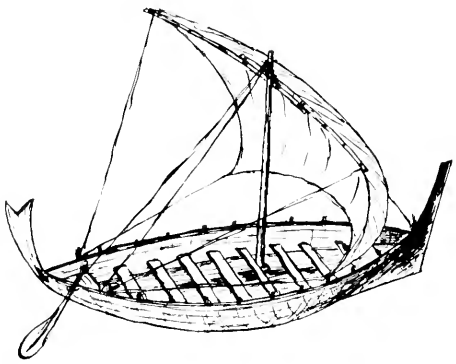
A major archaeological discovery has become possible through submarine geological studies made during the past twenty years. The only volcano in the Aegean Sea known to be active in historical times is on the island of Santorin or Thíra 100 kilometers north of Crete, the southernmost of the Khikládhes. This small island, only 18 kilometers in diameter, invites geological investigation of its characteristics as a caldera,* and historical consideration of the part it played in the destruction of the Minoan civilization.

The chain of islands which includes Santorin and sweeps across the Aegean Sea is in a belt of frequent seismic activity and past vulcanism. The Santorin volcano has long been of interest to geologists. The first records of eruptions are to be found in the writings of the classical Greek historians and date an eruption in 197 B.C. during which the first central cinder cone known as Paleo Kaimeni rose above the surface of the sea. Eruptions have occurred since that time with increasing frequency averaging about one every fifty years, although eruptions in this century have occurred in 1925, 1928, 1939, and 1950. In 1842, Pegues first recognized that, geologically, Santorin is a caldera. The central lagoon of 83 square kilometers area and a maximum depth of 400 meters was once filled in. In 1400 B.C., after a long period of dormancy, the volcanic cone in the center of the island erupted. It is difficult to reconstruct the mechanism, the sequence, or the time scale of the succeeding events, but it appears that a large vent was created, followed by a massive eruption of volcanic ash. Afterward the central portion of the island sank into the sea creating the sheared-off cliffs lining the interior of the caldera. Some of the sheared faces are as much as 850 meters high.

Twenty-five thousand years or more ago, the island had collapsed volcanically. Then cinder cones built up in the center until the island was perhaps a single mass, as much as 800 meters high. The stratified ash shown in the old lithographs confirm repeated buildup of ash over the whole island. It is possible that a heavy ash fall occurred about 1400 B.C. before the

*A collapsed volcanic cone.

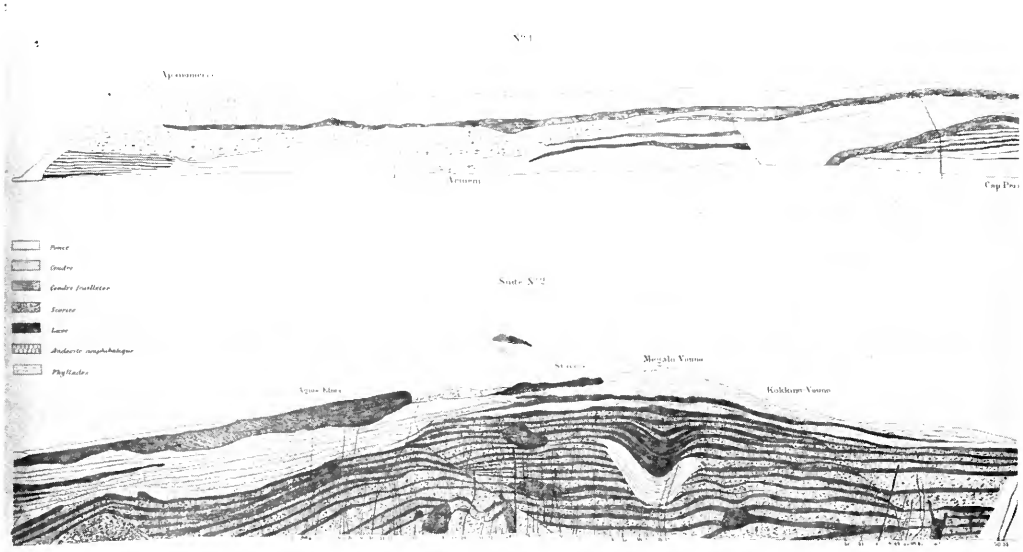
collapse of the island. In fact, there is some evidence that there were tens of years between the events. The collapse could have resulted from a withdrawal of the main volcanic plug or by massive explosion initiated in the gas filled andesitic magma beneath the cone. It is possible that a cavern existed beneath the island having pillars of lava plugs for roof support. A knowledge of the present-day geometry of plugs, dikes, and sills beneath Santorin might clear up this point. Since the collapse, cinder cones have built up again in the center and it can be expected that another collapse will take place at some future time. This author suggests that a seismic profile through the caldera of Santorin could shed some light on the nature of its formation and possibly on its future course.

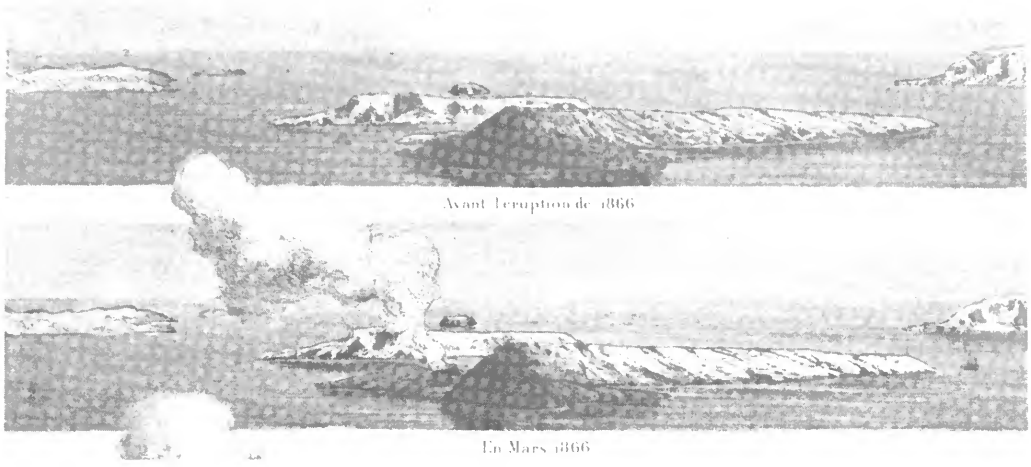


Reconstruction of a Minoan trading vessel ± 40 feet long.

Lt. Leychester of the British Royal Navy visited Santorin where he made notable observations of the geology, flora and fauna, archaeology, and the current inhabitants and their way of life. He also prepared a detailed chart during his visit in 1848 for the Navy. Fouque, a geologist who journeyed from France to study the eruptions of 1866-67 when Neo Kaimeni, one of the three cinder cones, expanded considerably, also wrote extensively on the geology and other aspects of the island. His book contains many fine lithographs, some of which are reproduced here. The island always has been a thickly populated, relatively pros-

View of the interior cliffs of Thera looking due north from the center of the caldera.



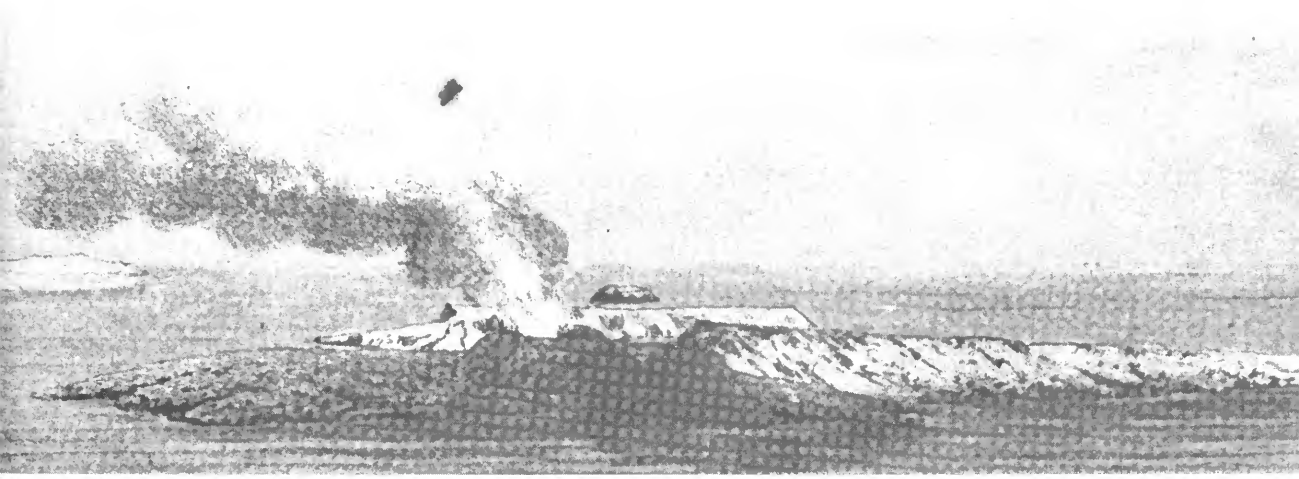


Santorin—before the eruption of 1866 and in March 1866.

perous center of Greek civilizatation. The well known wines and agricultural products found markets in the Black Sea ports.

The Santorin eruption has been identified by several writers as of the Krakatau type. Krakatau, which erupted in 1883, and Crater Lake in Oregon which was formed about 5000 B.C., are the only other known volcanoes which collapsed since the last ice-age. The volume of solids, rock and ash which blew out and sank at Santorin was about five times that at Kratatau. For the people of the Eastern Mediterranean this tremendous explosion must have produced thunderous noises and aerial vibration, followed by ash which on Santorin included boulders as large as a house, noxious fumes, darkness, lightning, earthquakes, and gigantic tsunamis, the first one of which reached Crete 30 minutes after the collapse and flooded the coastal areas. Probably there were no surviving eye witnesses to the eruption. A 30 to 40 meter thick layer of ash covered Santorin, and in 1939 it was reported that a five-meter thick layer of ash was found on neighboring Anaphi, 25 kilometers to the east at 250 meters above sea level. The residents of the islands of Folegandros,

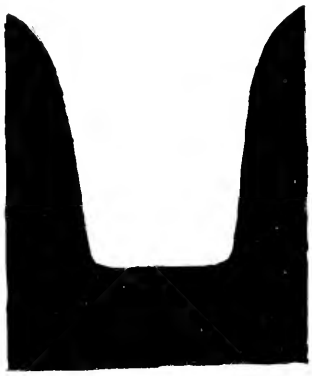
Santorin in February of 1867.



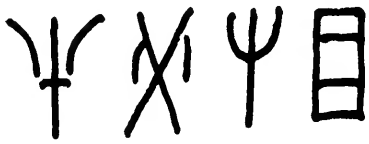
Síkinos, and Íos, 25 to 35 kilometers to the northwest certainly shared in the catastrophic ash fall. Possibly few people who knew the island before the collapse went back to observe the change.

Santorin was a part of the Minoan civilization. Since 1939 evidence has come to light establishing the date of the bronze age eruption of Santorin. Galanopoulos reported in 1960 that Carbon-14 dates have been obtained from a piece of wood found under the top 40-meter thick layer of pumice. The date is 1405 B.C. plus or minus one hundred years. The demise of the Minoan civilization has been dated at 1400 B.C. by examination of Egyptian artifacts found on both Santorin and Crete.

Since the existence of the Minoan civilization of the Eastern Mediterranean was brought to light early in this century by



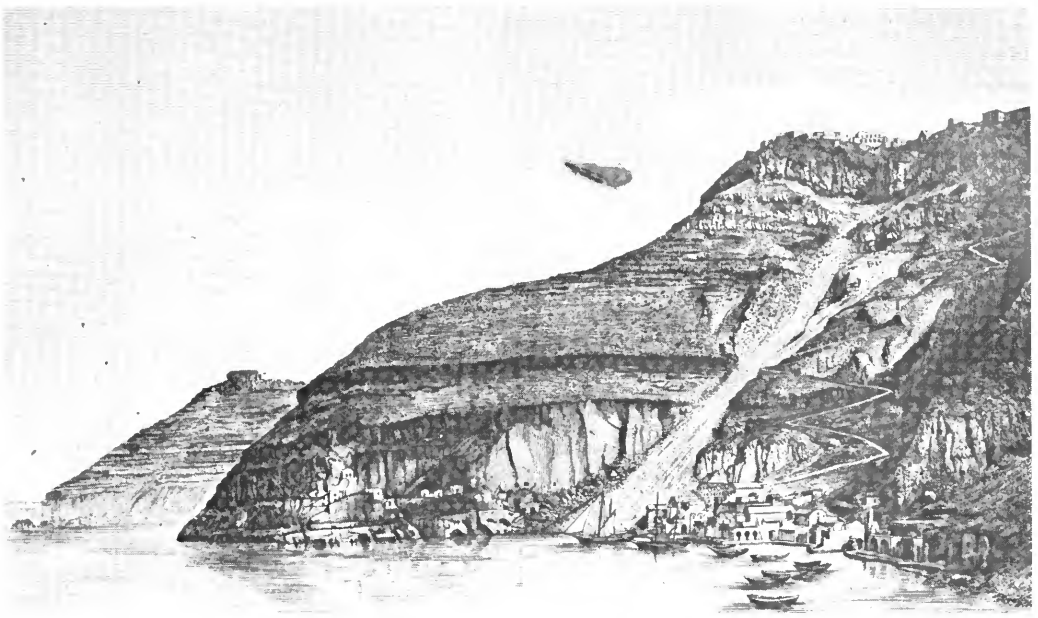
Bull symbol



Linear B Script

Minoan Vase—Octopus motif

Double Axe symbol



Inside cliff of the island of Thera, at the town of Thera.

Evans and others, we have come to know it as a highly developed commercial society which ruled the seas, developed magnificent art forms, created over one hundred palaces and used modern engineering techniques. Their religious practice of bull dancing or human sacrifice has received much attention. The people of the sea lived in peace within their island empire for fifteen hundred years. The name Minoan is derived from the legendary King Minos who, according to the Parian Marble, is reported to have ruled during the period 1462-1423 B.C. The empire included all the Aegean islands and coastal mainland Greece. The commercial sphere of influence of this civilization of 3000 to 1400 B.C. included the early helladic residents of the Asia Minor coast, the Hittities of central and eastern Asia Minor, the ancient Hebrews, the people of the Egyptian ports, and African ports as far as Libya, and coastal Tyhrennia (Italy) and Sicily.

Archaeologists have concluded that the Minoan civilization collapsed quite suddenly in about 1400 B.C. All the major palaces on Crete, believed to be the center of power of the Minoan people, were destroyed simultaneously. The Cretan palaces were destroyed many times by earthquakes since first built about 2200 B.C. However, the catastrophe of 1400 B.C. not only destroyed all at once but the civilization declined quickly and drastically. Refugees settled Western Crete for the first time and mainland Greeks took over the islands establishing the loosely knit, non-seafaring, Mycenean civilization centered at Tiryns and Mycenae (Mikinai) on the Peleponese.

Evans held steadfastly throughout his life to the belief that the catastrophe of about 1400 B.C. was due to natural causes, but most historical thinkers believed that the mainland Greeks invaded Crete and wrought destruction in battle. It is likely that an economic war between the mainland Achaens and the Minoans preceded the volcanic destruction, perhaps symbolized by the legend of Theseus and the Minotaur. The Minoans, rulers of the

seas, controlled maritime commerce to a degree which probably brought the mainland Greeks, who were denied access to the rich Eastern ports, to the point of war. Professor Spyros Marinatos of the University of Athens proposed in 1939 that the destruction of Minoan Crete was caused by a tremendous explosion of the island of Santorin. He observed that many features of the destruction were consistent with the expected effects of such an explosion.

There is substanial evidence on Crete and elsewhere in the Aegean to indicate that such a destruction took place. Eleven Kuhlenberg cores, taken in the Eastern Mediterranean south and southeast of Crete aboard the R/V 'Albatross' of the Swedish 1947-48 expedition contained volcanic ash horizons. By means of carbon dating of globigerina ooze layers and climatic dating from foraminifera, a time stratigraphy was established correlating the cores. Refractive indices of volcanic glass found in these cores were noted in 1954 to be the same as that found on the island of Santorin, and the source of the volcanic ash was tentatively established as Santorin. Unfortunately, mixing of top layers of the cores cast some doubt on the results.

A recent paper by Ninkovitch and Heezen, covers the geology of the Santorin eruptions and summarizes many historical implications and related archaeology and mythology. They report the analysis of 14 additional cores taken in the Aegean and Eastern Mediterranean south of Crete and Rhodes during the 'Vema' Cruises (Lamont Geological Observatory) of 1956-58. The analysis not only confirms widespread ash layers that definitely could be traced to Santorin but establishes two catastrophic eruptions, both of which probably accompanied formation of a caldera. The authors also correlate the high altitude prevailing winds with the distribution of ash horizons over the Eastern Mediterranean. The Minoan eruption carried ash primarily toward the southeast under the influence of prevailing summer northerly winds. The extent of substantial ash fall included all of the Aegean islands south of Ándros, west to Khaniá on Crete, east to Ródhos and south half way from Crete to the mouth of the Nile. The depth of ash fall on all land areas within this region was enough to cause desertion of the land by the people who survived.

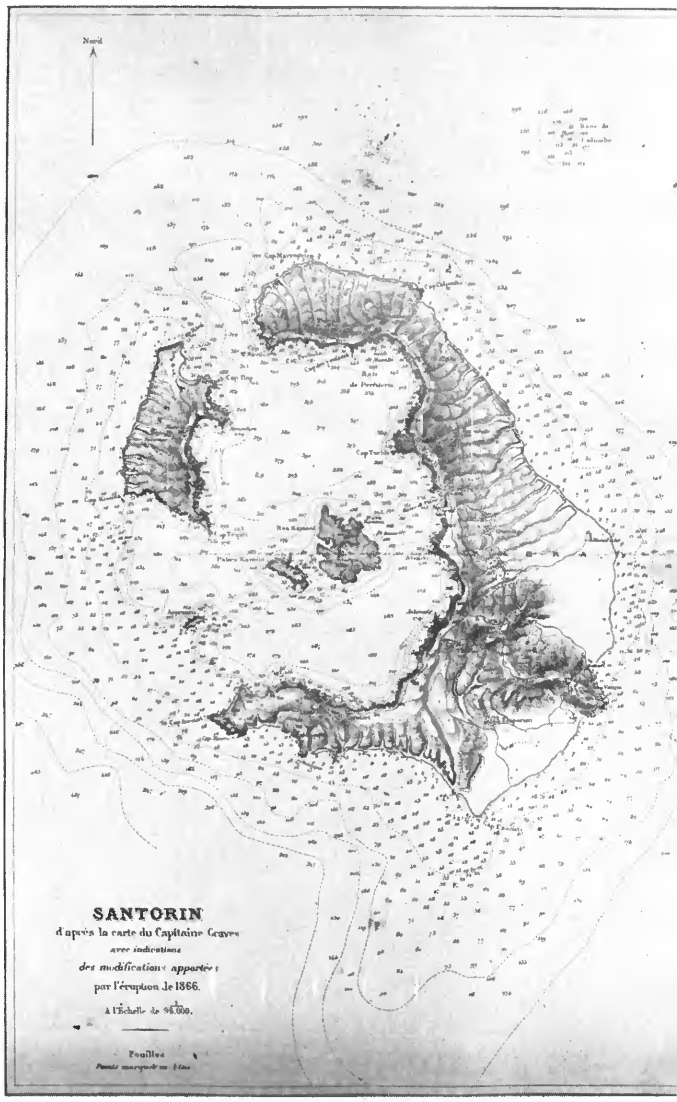
Galanopoulos has studied seismic activity in the Aegean Sea from historical records and observed that the tsunamis caused by eruptions of Santorin have been the most destructive of many in the Aegean. Since there is practically no lunar tide, coastal cities and towns have been built habitually within a few feet of sea level. Minor tsunamis associated with earthquakes typically have not overrun the banks, but an unusual and giant wave will destroy most coastal habitations. Galanopoulos observed also that tsunamis originating in the Aegean have reached the coast of Asia Minor, Syria, the ancient Hebrew lands and Egypt and Libya. This is rather hard to believe because of the blocking action of the islands of Kríti, Kásos, Kárpathos and Ródhos. It is, nevertheless, true.

While there may be records of the Santorin eruption in the legends of mainland Greece which are yet to be uncovered, the known records lie in the lands of the ancient Hebrews and Egyptians. Many refugees left Crete after the catastrophe and settled in Egypt, where they were known as Keftians, and in Palestine, where they were known as Philistines. There are evidences of the effects of the Santorin eruption all along the coast of the Eastern Mediterranean. Shaeffer excavated Ugarit, a coastal city of Northern Syria which was apparently the Hong Kong of the mid-second millenium B.C. A truly international port, scripts in six languages were discovered here. The port reached a peak

of activity in the fifteenth and fourteenth centuries B.C. and was a major center of Minoan commercial influence. In about the fourteenth century B.C., Ugarit suffered an eclipse. The beginning of the new Hittite empire when Syria and Mesopotamia were overrun, coincided with the eruption. Galanopoulos has attributed the legendary Greek flood of Deukalion, when much of coastal mainland Greece was flooded, to the Santorin eruption.

The Linear A and B script developed on Crete during 1600-1400 B.C. has so far yielded only inventories of commercial and military activities. These were probably the purposes for which the script was developed and we may not find a narrative of the disaster. Acceptance of the fact of the eruption in 1400 B.C. leads to an interesting conclusion relative to the settlement of mainland Greece. Since the decipherment of Linear B by Ventris in 1953, historians have considered that the Minoan people during the period 1600-1400 B.C. were strongly influenced or perhaps dominated by the mainland Acheans since the Linear B script has the form of the Greek language of later times. The present evidence indicating that the civilization was destroyed by vulcanism rather than by invasion reinforces the thesis that the Minoan people are truly of Semitic-African descent and were the dominant people on the mainland coast as well as the islands up to their demise when the Mycenean culture replaced them briefly until the Dorian invasion from the North in 1150 B.C. In 1957, C. Gordon of Brandeis University claimed that certain words of the Linear A script were Akkadian, a Semitic language of the second Millenium.

It is possible that the Minoan and Phoenician peoples were one and the same. In the light of increasing archaeological evidence tying the two cultures together and the eruption of Santorin, the Phoenician-Minoan center may have moved from Crete to one of the well-known Phoenician ports of the Semitic coast.



THE CALDERA OF SANTORIN

This chart of Santorin clearly shows the outline of the volcano and the collapsed crater in the center of the island. Modifications are outlined after the eruption of 1866.

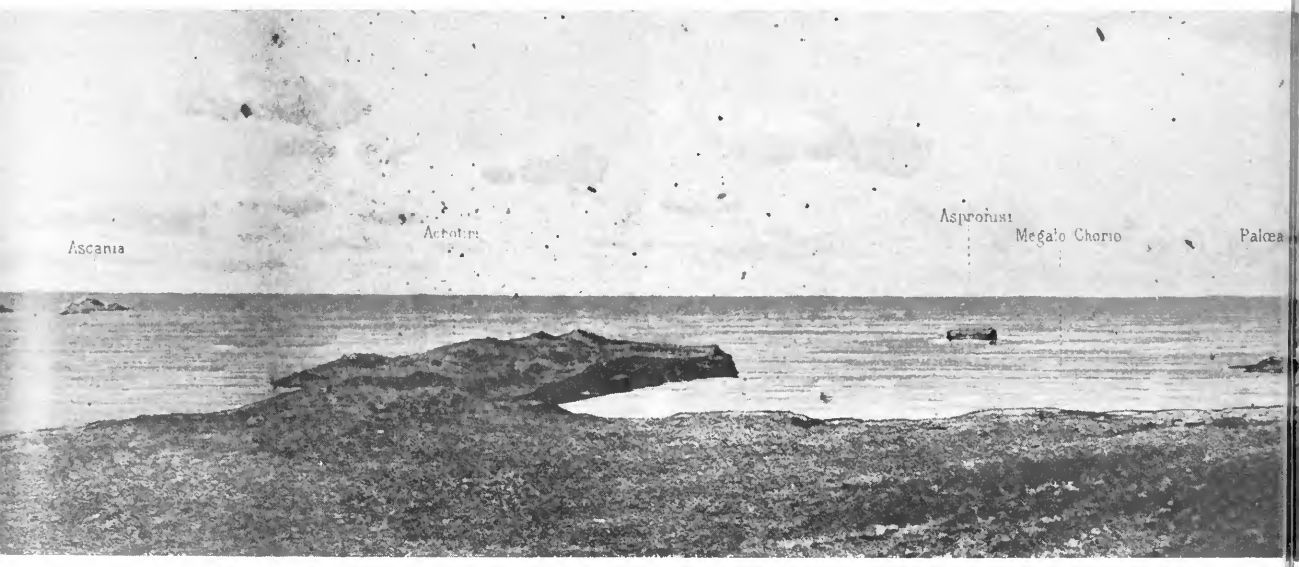
At least two written records which describe the Minoan civilization and its destruction exist. One of these is in the Old Testament discussion of the Philistines, and the other lies in Plato's dialogues

Timaeus and Critias. Future excavation, and translation and re-translation of tablets and papyri, may turn up more. Ninkovitch and Heezen recognized the Biblical passages written in a prophetic form which describe the evacuation of the islands, the tsunamis, the ash, the destruction. Amos 9, Jeremiah 47 & 48 and Zephaniah 1. are the references. "Have I not brought up Israel out of the land of Egypt? and the Philistines from Caphtor, and the Syrians from Kir?" Amos 9.7. This passage written in the eighth century B.C. dates the exodus of the Israelites from Egypt with the exodus of the Minoans from Crete (Caphtor). Galanopoulos presented a most convincing case for the exodus and the plagues of Egypt being closely related to the Santorin eruption.

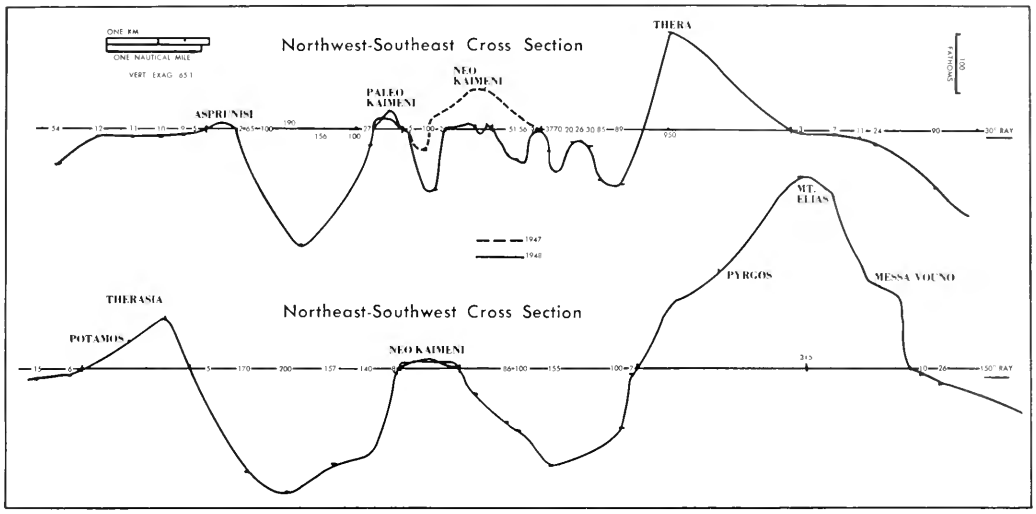
Long Lost Atlantis.

In Plato's dialogues Timaeus and Critias lies the story of the islands of Atlantis. James Baikie in 1910 first observed the similarity between the Minoan civilization and the Atlantis of Plato. Since then Balch, Knapp, Frost, Marinatos, and Galanopoulos have written on this thesis. Galanopoulos has assembled knowledge to date and introduced further archaeological evidence as well as new interpretations of several portions of Plato's 10,000 word story. The present author has followed through Galanopoulos' arguments and made a careful study of the comparison between Plato's story and what is now known of the Minoan civilization and its destruction. There can be little doubt that Plato's Atlantis is indeed an historical account of the Minoan people. Among archaeologists, a theory is accepted if it not inconsistent with a major or significant fact and if it agrees with fact in more particulars than any other theory. The story of Atlantis qualifies and also occupies a rather unique position in this context. It has been an extensive and detailed story or theory available for a long time, but the facts to support it have only been discovered in

MR. MAVOR is a research specialist in the Department of Applied Oceanography and has been on the staff for eight years. He was one of the key people in the development of our submergence vehicle, 'Alvin'!



View of Santorin from the top of Mount Elias o

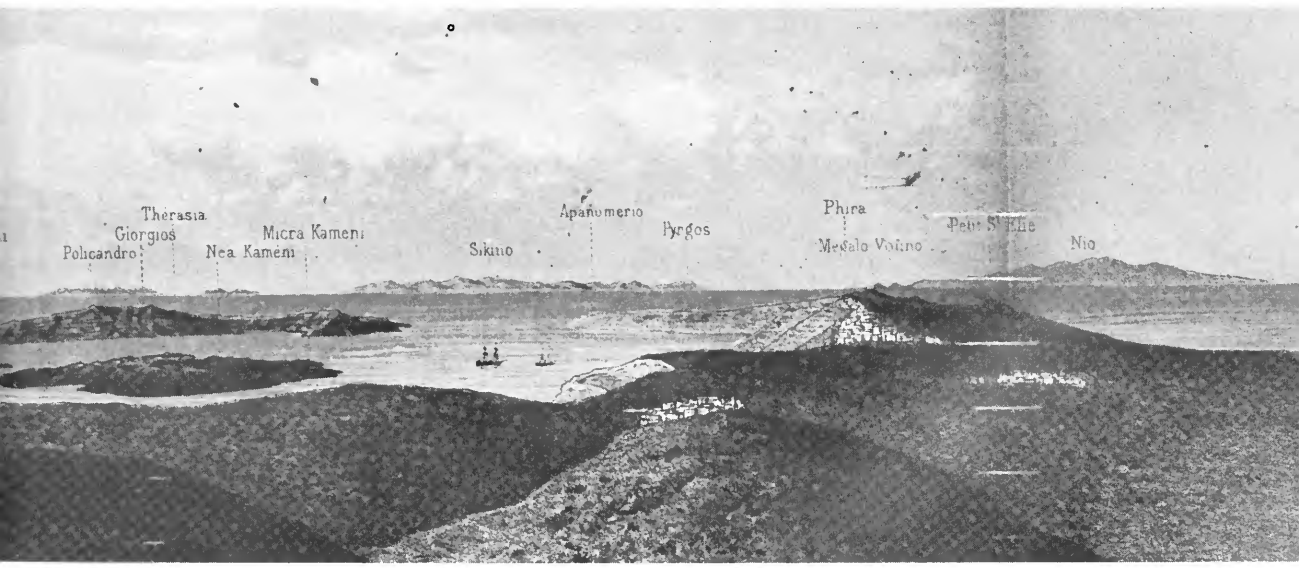


Topographic Section through the Caldera of Santorin

the past 75 years. This turnabout of procedures has confused investigators, it appears. The same applies to many other stories previously classed as legends which have been established as historical fact.

There is evidence that a long period of dormancy preceded the eruption of Santorin and that the island was heavily populated. It can be inferred that a city existed on the volcanic cone which sank into the sea. There are many cases of cities sinking into the sea in both history and legend. In historical times a city off the northeast coast of Santorin sank into the sea during the eruption of 1650 A.D. The city of Eliki on the Gulf of Corinth sank into the sea in 373 B.C. as the result of an earthquake. The region of "Shotts" at the head of the Gulf of Gabes in Tsunisia was the location of a civilization that was sunk under the sea by tectonic disturbance. The Tarim basin in Asia had a similary fate.

On the island of Santorin itself, at least three underwater ruins of cities and towns await excavation.



Thera looking to the west—made in September 1875.

Recent books

McLellan, Hugh J., **"Elements of Physical Oceanography"**, Pergamon Press, $9.50

Lacombe, H., **"Cours d'Oceanographie Physique"**, Gauthier-Villars, Paris, 90 Francs

Sakai, T., **"The Crabs of Sagami Bay"**, Collected by His Majesty the Emperor of Japan, East-West Center Press, Honolulu, $25

Worzel, J. L., **"Pendulum Gravity Measurements at Sea 1936-1959"**, John Wiley & Sons

Stenuit, Robert, **"The Deepest Days"**, Coward-McCann, Inc., $5.95

Cotter, C. H. **"The Physical Geography of the Oceans"**, American Elsevier Publishing Company, $7.00

Sears, M. (editor), **"Progress in Oceanography"**, Vol. 3, (Dedicated to Professor Hans Pettersson), Pergamon Press, $15.50

Whittard, W.F. and Bradshaw, (editors), **"Submarine Geology and Geophysics"**, Colston Papers, No. 17, Butterworths, $21.00

Published Reports

Some contributions to the knowledge of birds, their ecology and the geographical distributions can be found in the Collected Reprints of the Woods Hole Oceanographic Institution. Among these are:

No. 281—1941. **"Petrels in the Gulf of Maine,"** by Dr. A. C. Redfield.

No. 260—1940. **"Convection and Soaring Over the Open Ocean,"** by Mr. A. C. Woodcock.

No. 560—1951. **"The Seasonal Distribution of Oceanic Birds in the Western North Atlantic,"** by Dr. H. B. Moore.

No. 742—1955. **"Summer Ecology of Oceanic Birds Off Southern New England,"** by Mr. M. S. Gordon.

No. 773—1955. **"Landbirds Over the Western North Atlantic,"** by Susan Irving (Mrs. Per Scholander).

The Editor went to sea before the page proof check of this issue could be made. He begs forgiveness for any minor errors which may appear.

Wonderful Names

Oceanic birds certainly have wonderful common names: Blue-faced and Red-footed Boobies, Long tailed Jaeger, Yellow-billed Tropic Bird, Cory's Shearwater, Wilson's Petrel, Great-winged Gadfly Petrel, Lesser Noddy, Frigate Bird, Fairy Tern.

MUNNS

Fairy Tern—Coco Island, Indian Ocean

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