The Early Warning of the Terns

Thousands of terns have replaced the Army on an island fortress originally designed to detect an enemy invasion of New York. The enemy has now arrived, and a major ornithological disaster may be upon us

by Helen Hays and Robert W. Risebrough

Great Gull Island is a small, uninhabited pile of rocks, clay, and shifting sands at the entrance of Long Island Sound between the eastern tip of Long Island and Connecticut. Because of its strategic location, for half a century the island served as part of the defense system of the nation; today, the striking increase of birth-deformed birds there may be a warning of a new and more insidious danger.

The island is an excellent habitat for terns, small members of the gull family that nest on isolated coasts and barrier beaches throughout the world. To survive in these tempestuous areas of winds, tides, and shifting sands, the terns have to be adaptive and sensitive to change: always shifting, colonizing newly formed habitats, or quickly deserting old ones as they are destroyed by the elements or by man.

Nearly a century ago, when the rapacious millinery trade in its pursuit of feathers for fashion threatened the survival of terns on the East Coast, conservationists provided a warden on Great Gull Island to save the birds. The 14,000 terns on the island became the last nesting colony, the last hope for terns in the New York region, as other colonies on Long Island Sound were wiped out by plume hunters and eggers.

Shortly after 1900, terns became a protected species when a pioneering piece of conservation legislation was passed in the United States. But, ironically, the legislation came too late for the terns on Great Gull Island, for in 1897, on the eve of the Spanish-American War, fearing attack by a Spanish armada, the United States government had begun the construction of Fort Michie on the island. With the arrival of the military, the terns disappeared.

In the following decades, the shadow of war rarely lifted from Great Gull Island. During World Wars I and II, the military used the island for its continental warning and defense system. From tall observation towers, soldiers scanned the ocean, always alert to the danger of attack. Over the years, the fort became a complex maze of gun emplacements, ammunition depots, barracks, and towers. By the end of World War II, the island was almost completely covered with concrete and asphalt. And the terns avoided this unnatural transformation of their former habitat.

Then, in the late 1940's, Fort Michie lost its function in the warning and defense system for the continent. It became a symbol of obsolete military equipment and strategy, and in 1949 the Army abandoned the island, leaving behind its concrete and asphalt, junkpiles, man-made hills, and a necklace of traprock boulders placed around the island to stabilize its shores. Although man was gone, the habitat was too disturbed for the terns to return.

Yet by the late 1940's, the terns of Long Island badly needed a new breeding area; the old protective legislation was no longer adequate to save them from new developments. The encroachment of factories and housing developments in coastal areas, along with the conversion of beaches to public parks, drastically reduced the number of undisturbed nesting areas for terns in the New York region.

Aware of the island's history, The American Museum of Natural History and the Linnaean Society of New York worked to acquire Great Gull Island, hoping that it might again become a large colony for nesting terns. In 1949, the Museum received title and assigned to the Linnaean Society the task of returning it to a condition suitable for terns.

In 1949 and 1950, several of the buildings were leveled, vegetation was burned, and sand was deposited in an effort to create artificial beaches. Each year the island was visited by ornithologists from the Linnaean Society and the Museum, but it was not until 1955, after everyone had given up hope that the

birds would ever breed there again, that twenty-five pairs of common terns were found nesting. The birds had not utilized any of the areas prepared for them, but had laid their eggs on the traprock at the eastern edge of the island. The numbers of terns increased each succeeding year and today, once again, the island is the site of one of the largest colonies in Long Island Sound, comprising about 7,000 birds.

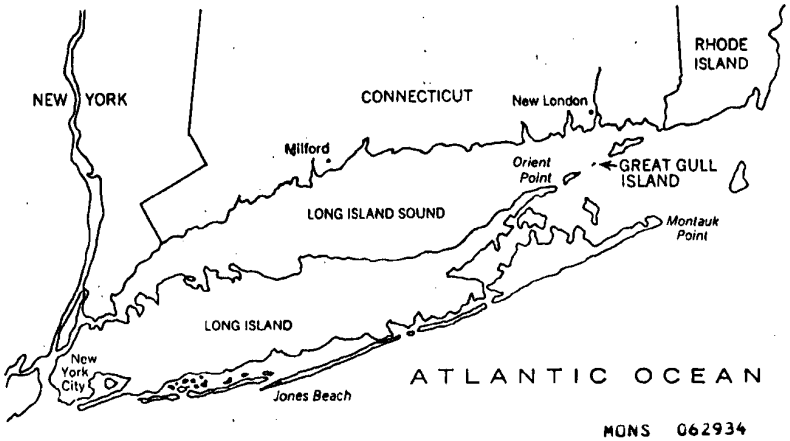
When people now land on the island in late spring or early summer, the terns swirl noisily from the ruins of the fort, challenging the intruders and diving at them should they approach the nest sites. Reminders of the island's occupation by the military still remain everywhere. The ruins of the abandoned fort, overgrown with vegetation, stretch from one end of the island to the other. The battlements are manned, however, by new defenders. On patches of exfoliating concrete in the gun emplacements and in the open areas that were once building foundations, common terns incubate their eggs and feed and brood their young. The roseate terns, less aggressive than the commons, deposit their eggs in the grassy edges of the open areas or under boulders on the outer beaches.

Their utilization of the ruins of the old fort on Great Gull Island demonstrates the tern's remarkable adaptability and use of habitat, a previously unknown characteristic of the species. A number of other species also occupy parts of the ruins. Barn swallows dart in and out of the weathered buildings, patching them with mud for their nests. Bayberry and wild rose, as well as several species of grasses, have invaded the ruins, making them habitable for nesting red-winged blackbirds, song sparrows, and spotted sandpipers. Starlings also nest in the eaves of buildings.

By 1966, the colony appeared sufficiently large and stable to permit ornithologists from the Museum to undertake studies of the breeding biology of both species of terns, as well as of several of the other species nesting on the island.

During the summers of 1967 and 1968, however, there was a great deal of rain and a scarcity of fish.

Chemical pollutants, such as PCB's, are highly suspect as the cause of an alarming increase in gross birth deformities among the terns on Great Gull Island. This four-legged common tern chick died three days after hatching.



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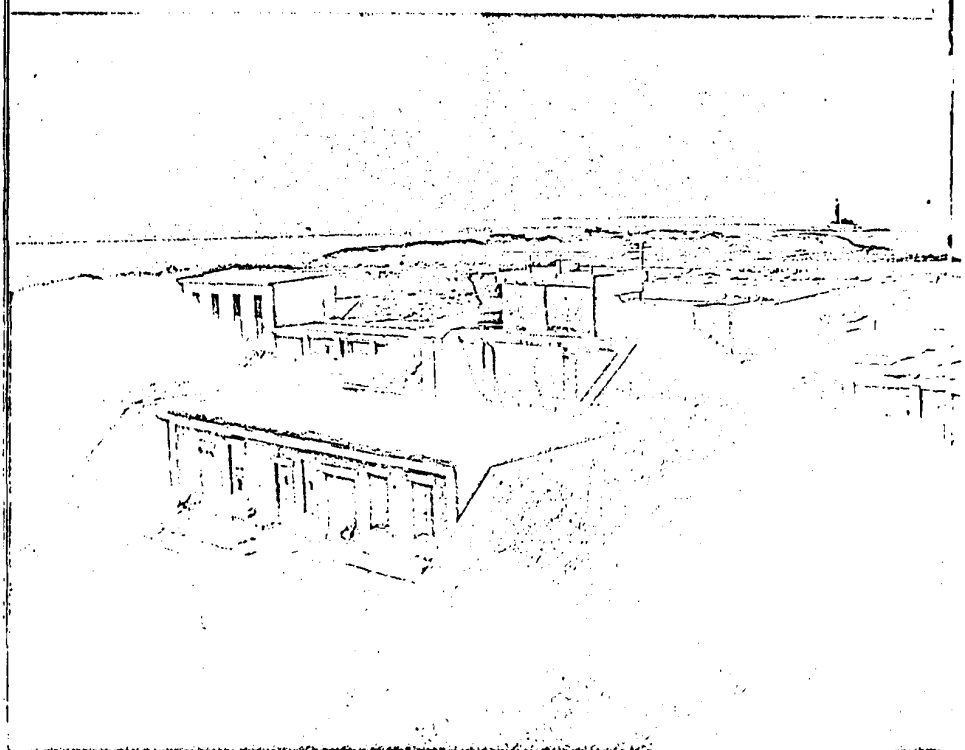
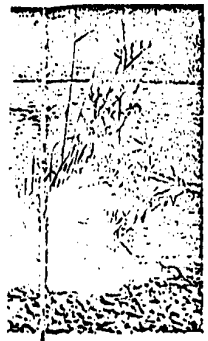
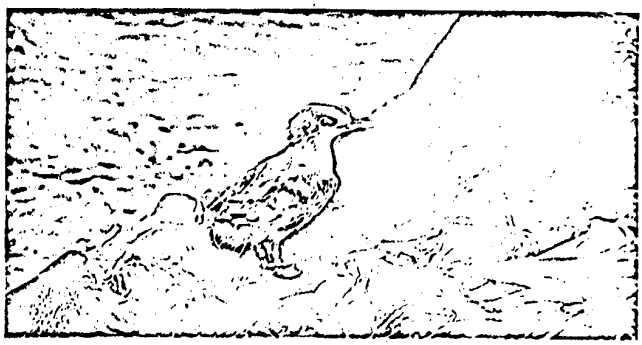
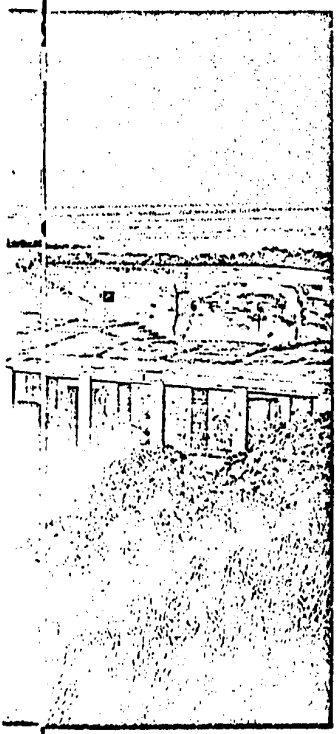
Still straining to fly after fourteen weeks, the abnormal common tern, right, can only manage to rise a few feet. It had the double misfortune of being born without secondary flight feathers in a nest built within the insurmountable rim of a huge gun emplacement. It is doomed in this concrete enclosure. The fate of the five-week-old chick, far right, is similarly sealed: it was born without tail feathers, primary, and secondary flight feathers. Fort Michie's ruins, below, still dominate the landscape.









Many young terns died from exposure, starvation, or both. A major problem in the field of population biology is determining the productivity of a species under a variety of environmental conditions, favorable and unfavorable. The colony on Great Gull Island appeared to be an appropriate site to study this problem in relation to terns because the island's size, seventeen acres, was small enough to permit a daily checking of all nesting areas.

Daily coverage of the nesting grounds permitted large numbers of young terns to be marked at hatching, then followed with relative ease up to the time of fledging and departure from the colony. Studies of survival and mortality of both species of terns were begun in 1969. The number of field workers increased each weekend with the arrival of volunteers from the Museum. To avoid exposing the eggs and the young terns to the midday sun, all work in the colony was carried out whenever temperatures were favorable, usually in the early morning or late afternoon. The terns invariably put up a vigorous defense. Working in a tern colony is strictly a "hard hat" job, since the terns do not hesitate to strike unsuspecting heads with formidable force and very sharp beaks. Usually several workers would traverse an area together, looking for new nests and young birds.

At hatching in 1969, more than 2,000 young terns were examined and marked with temporary plastic bands. Of these, one young common tern was found with an abnormal bill and an upper mandible crossed over its lower. Then, two young roseate terns were found, which appeared normal, but which were missing flight feathers in both wings. We noted these deformities, but the flight feathers of the roseates appeared to be growing again. In a sample as large as 2,000 individuals, a few abnormalities are to be expected, and we did not attach special significance to these.

In 1970, however, when the study was repeated, we noted a sharp increase in the number of abnormalities. Four young roseate terns and thirty-three young common terns were found with visible defects. Some of these appeared normal at the time of hatching, but later, when they were between two and four weeks old, lost their primary and secondary flight feathers.

Feather loss is a new phenomenon that has not been previously described, although in the past many thousands of terns have been banded in Massachusetts, the Carib-

Crossed mandibles were discovered in the colony in 1969, the first full year of the research project. This roseate tern chick, from the 1970 breeding season, was collected when three weeks old for chemical analysis of its tissues.

bean, and on islands in the Pacific. Although these birds appeared to be healthy and vigorous, they could not fly. Two lived as long as six weeks. Many disappeared, however, so complete observations of their mortality rate were not possible. The feather loss did not seem to be necessarily permanent, as one of the young common terns found with no primary and secondary flight feathers was seen flying a month later at Milford, Connecticut, about 80 miles away.

Other abnormalities were comparable to those observed in human "thalidomide babies." One chick had underdeveloped legs and feet with almost no down, and another had four legs. Several showed abnormalities in the development of the bill. One chick had extremely small eyes.

It was at this time that the authors combined forces and experience in an attempt to determine the causes of the abnormalities. Our suspicions centered on environmental pollutants in Long Island Sound, the flush for much of the effluvia of New York and Connecticut. An investigation of this type, however, encompasses many different disciplines, and only detailed studies, over a period of time, will tell us what is actually happening to the population structure and reproductive capacity of the species affected by pollutants. In order to identify the pollutants that might be responsible for the abnormalities observed in the field, complex research in the chemistry laboratory is also necessary. The studies during the present year, therefore, were carried out with the realization that we were dealing with a new kind of enemy force, far different from the ravages of the plume hunters or the destruction of breeding sites. This enemy foreshadowed grave consequences for the future of the terns and quite possibly for man himself. There was no doubt that we were looking at the tip of a potentially disastrous iceberg.

This year's incidence of gross defects among newly hatched chicks was approximately comparable to that in 1970. The first to be found had an abnormal foot and leg. The second had a rudimentary upper mandible, which had grown out from above its eyes. The third appeared as if injected with air or water; its skin was swollen about the head, neck, and abdomen. The fourth had no left eye and a slightly crossed bill. Three others had bald spots on their bodies where feathers had not developed. The loss of flight feathers was again observed in many of the chicks. These are the kinds of effects that might be expected from a chemical capable of affecting gene reproduction during embryonic cell division.

Added to this, in 1971 a new abnormality was observed in the colony for the first time: thin-shelled eggs not sufficiently strong to support the weight of the incubating parent. This phenomenon is now familiar to pollution biologists, having been first reported in British peregrine falcons in the 1950s. The brown pelicans in California have not bred successfully for a number of years because of this problem, and some of the birds of prey in this country are suffering serious population declines for the same reason.

Researchers in this area believe that shell-thinning is caused primarily by the DDT compound, DDE. This pollutant, a derivative of the insecticide, is only slightly poisonous to most individual organisms, but it may produce such effects as shell-thinning, which lowers the reproductive capacity of the species. DDE has been shown to produce shell-thinning under experimental conditions in mallard ducks, American kestrels, quails and doves. Wild species that are suffering from the thin eggshell syndrome have also been found to be contaminated with DDE.

The DDT levels we measured in the abnormal young terns on Great Gull Island and in the fish brought to the colony by the adults in 1970, however, were no higher than in many other bird populations. In fact, they were lower than some. While we have no basis for believing that any of the DDT compounds are responsible for the observed deformities in the young terns, we cannot rule it out as a possible cause of shell-thinning. This was not observed until 1971, and we have not yet measured DDT levels in the 1971 specimens.

Levels of other heavy metals, such as lead and cadmium, are currently being measured, but until much more data from other populations are accumulated, we shall not know what the expected natural levels of these elements in tern eggs should be, or how to interpret the concentrations found.

What we did find were relatively high levels of polychlorinated biphenyls, PCB's, in the tern tissues and in the fish upon which the birds feed. These compounds have a number of chemical properties similar to DDT. Like DDT and its derivatives, they become concentrated in the fatty tissues of animals when present in a food chain, but they are even more stable. Used extensively as heat-exchange and insulating fluids in high-voltage electrical equipment, PCB's are also added to paints, plastics, and rubber to make these materials more resistant to breakdown. This property of resistance to most kinds of biological and chemical degradation, which has made them so use-

ful to industry, are what make PCB's such persistent pollutants when released in the environment. Interestingly, in some of the studies in which PCB's were fed to birds in order to determine toxic effects, the birds lost feathers. The PCB's may well, therefore, be responsible for the feather loss observed in the young terns on Great Gull Island.

Recent research conducted in the Netherlands has demonstrated that PCB preparations often contain small concentrations of compounds that are chemically similiar to the extremely toxic dioxins. These are the chlorinated dibenzofurans, and the relationship is significant because these dioxins have produced a high incidence of birth defects in recent experiments. Small amounts of the chemicals were injected into fertile chicken eggs, producing grossly deformed chicks of the same type we have observed in the young terns. Obviously, much further research is necessary before we can definitely pinpoint just what pollutants are responsible for what deformities, and what the cause-and-effect relationships are.

It is important to point out that although all the evidence is not yet in and weighed, what is happening to the terns on Great Gull Island is of critical significance—not only to the local survival of the species, but quite possibly to humans as well.

We might hypothesize that the effects of environmental pollutants, such as those mentioned, would be detected first in the tern colony. Long Island Sound is one of the more polluted areas of the world's oceans, a distinction it shares with the Baltic, the Mediterranean, and the southern California coastal waters. And the effects of chemical pollutants could be expected to appear first in a species that is relatively high on the food chain, especially one that preys upon fish.

Not all the pregnant women who ingested thalidomide gave birth to defective children. Rather, the incidence of defects was significantly increased. We could assume that environmental chemicals producing comparable effects would behave similarly and that their presence would not mean that all individuals would be equally affected. A normal-looking individual might have a higher concentration of certain pollutants than one with four legs. Consequently, many thousands of young must be examined to detect the first effects of pollutants building up in a population of any species. It is probable that as the levels of harmful pollutants increase in a population, more individuals will show adverse effects. But only continued work will verify this.

In addition, high priority should be given to a detailed study of the pollutants now present in the waters of Long Island Sound. All of these, we must emphasize, are waste products. Normally, the waste products within an ecosystem are recycled, used again and again. Thus the tissues of a dead bird gradually are converted into elementary material. Carbon dioxide re-enters the atmosphere to participate once again in photosynthesis. Phosphates re-enter the water to be incorporated once again into phytoplankton, from which they pass into zooplankton, then up the food chain through fish to terns, and so on.

Technological man has made two fundamental changes in this natural process. By mining vast amounts of certain heavy metals and salts, such as phosphates, the mobilization has been greatly increased. When these become waste products in excessive amounts, the threshold of harm to certain species is passed. Also some of the new synthetic chemicals are relatively resistant to breakdown, and so more readily build up to concentrations harmful to a great many more species.

If our priorities are rearranged to meet the mounting environmental and biological crises caused by the exploitation of natural systems, sufficient warning will be needed to provide time to change our technological direction and commitment of natural resources. We have had such warnings about air pollution, sewage in our waterways and lead poisoning, for example, and some measures are being taken to correct these threats to human health and well-being. Now the terns on Great Gull Island are issuing a warning through their pitiful deformities and threatened survival. That seventeen-acre island that is home to the colony occupies a strategic position analogous to when it served as a military outpost. The terns occupying the approaches to New York City are now inadvertently detecting a newer, more insidious enemy to man: contaminants. Presently disturbing the reproduction of the terns, these contaminants may, someday soon, result in an increase in the numbers of human birth defects as they work up through the food chain to the ultimate consumer. Fort Michie, now in ruins, may yet provide us with an early warning against encroaching danger.

Boulders dumped by the Army to prevent erosion cover the island's shoreline. It was thought that this ruination of habitat would prevent the terns from reclaiming their lost colony, but they have adapted and now nest in the network of rocks.

As we go to press, verified reports of significant feather loss among chicks in tern colonies in Massachusetts; Jones Beach, New York; and the Dry Tortugas, off Florida, have been received. The scope of the disaster is broadening.