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# CONTRIBUTIONS TO THE KNOWLEDGE OF THE CAPE COD *STERNINÆ*

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That portion of Cape Cod extending from its "elbow" at Chatham in a sandy belt three to five miles wide, northward twenty-five miles to its "wrist" at Truro, is an excellent one in which to study breeding terns. Here four members of the group spend their summers and rear their broods, the Least (*Sterna antillarum*), Common (*Sterna hirundo*), Roseate (*Sterna dougalli*) and Arctic (*Sterna paradisæa*). The latter three species are confined for the most part to four concentrated rookeries, but the Least Tern is scattered more or less at random along the sandiest, least-disturbed beaches. The rookeries are all easy of access during the breeding-season, and, thanks to efficient protection on the largest and most important rookery, Tern Island, Chatham, the birds are common and tame enough to afford more than sufficient material. Lastly, the excellent work carried on during the past six summers by Charles B. Floyd and others in banding immature terns at Tern Island forms an almost unparalleled basis for present and future investigations.

My plan for the season's studies was, first, to make a general survey of conditions on all the rookeries in the district with the exception of Tern Island, which has been most ably attended to by Charles B. Floyd for the past six years; secondly, to trap as many adult terns as possible in an effort to capture banded birds; thirdly, to carry out a few experiments and observations on the territorial relationships of the birds on their breeding-grounds; and lastly, to try to get some figures on the mortality rate at the various nesting-places. I was most fortunate in having as my field assistant Joseph M. Dallavalle, without whose most efficient aid during my six weeks with the terns but comparatively little could have been accomplished. We were joined for part of our time in the

field by my father, Dr. O. L. Austin, who directed most of his efforts to making a cinematographic record of the part of the tern's life-histories passed on the breeding-grounds.

During the six weeks from early June to the middle of July, Dallavalle and I spent thirty-four days on the rookeries, dividing our time almost equally between the four. June and a few days in July were spent among the Hopkins Island, Billingsgate Island, and Pamet River colonies. At Floyd's invitation we were happy to spend six days with him in July at Tern Island.

Hopkins Island is a small one, not two acres in extent, rising about twenty feet above mean high water in the center of Orleans Town Cove. At its edge is an open area of white sand and glacial pebbles backed by a narrow strip of beach grass (*Ammophila arenaria*). Its center boasts a few square rods of short, thick, fine upland grasses on which a number of Common Terns breed, but most of the islet is covered with a dense, scrubby, bushy tangle of bayberry (*Myrica carolinensis*) and beach plum (*Prunus maritima*), among which entwines a thick network of blackberry (*Eubatus* sp.) and rose (*Rosa* sp.) brambles, making a splendid, impenetrable cover for the young birds from all enemies but rats and weasels. Here nested ten pairs of Arctic Terns and about two hundred pairs of Common Terns. On this island we carried out most of our territorial experiments, and banded 62 adult *hirundo* and 13 adult *paradisæa*. As the young shortly after hatching retire to the ample protection of the bramble thickets, it was impossible to band more than a very few of them. I saw no signs on the island of rats, weasels, or skunks, and the summer-boarder pests favored the rookery by not molesting it often. The only other vertebrate inhabitants of the island besides the terns were a pair of Song Sparrows (*Melospiza m. melodia*) and a horde of Voles (*Microtus p. pennsylvanicus*), which, as nearly as I can ascertain, do no harm whatsoever to either the birds or their eggs.

I do not consider either Nausett Point or Rocky Island as worthy of more than passing mention. A mere handful of birds attempted to breed on each. Rocky Island is only about ten yards in diameter and hardly extends above normal high water in the center of Nausett Inlet. Ten pairs of Common Terns laid their eggs there and were incubating June 2d, but the spring tides of July 5th completely inundated the islet, washing away the eggs, and the birds deserted it. Nausett Point, at the very tip of that stretch of dunes made famous by Henry Beston in "The Outermost House," offers slightly better surroundings. June 2d saw forty pairs of Least Terns

and seventy pairs of Common Terns breeding there, but all the nests of the former and all but eight of the latter were washed away by the spring tides. The Least Terns deserted completely, and only three pairs of Common Terns laid again after the floods subsided. The Point is part of the mainland, and those hardy individuals that persisted were wiped out by either skunks or dogs.

Billingsgate Island lies three and one half miles westward from Eastham across Cape Cod Bay, and a mile south of Jeremy's Point, Wellfleet. Its northern point just touches on the southern boundary of Wellfleet township, and there is constant bickering between that town and Eastham as to who owns the clamming rights on the flats surrounding the island. It used to be one solid, sizeable island, but during the past twenty years winter storms have eroded it so that to-day it consists of two small islets connected by a sand-bar at low tide. The southern islet is about an acre in extent; the northern one, about two acres. Both are of flat, white sand, held together by a modicum of beach grass interspersed with a few beach peas (*Lathyrus maritimus*), making ideal nesting-conditions for the terns. Indeed, under normal conditions, both islets are crowded to the limit of their capacity by the nesting birds as governed by the peculiar territorial laws of each species. We counted 795 eggs on the northern half of the larger islet alone, and we doubtless missed several hundred in our zeal not to count any nest twice. We estimated nine hundred pairs of terns on the island, and five hundred on the smaller point. The birds were almost all Common Terns, though those areas thickest in beach grass supported about forty pairs of Roseates. There were no Arctics or Leasts, the nesting-conditions not being exactly right for either species. As the island lies so far from the mainland, it is never troubled by cats, dogs, weasels, or skunks. A Screech Owl (*Otus a. asio*) roosted for several days in the little shack on the larger island, but as we found no signs of any depredations it might have committed, we did not bother it. The natives who dig clams on the surrounding flats (there were $20,000 worth dug there in 1928) do not harm the birds at all. They come over in small motor-boats, bring no animals with them, and are usually too busy to go as far ashore as the rookery. Most of them make it a point to visit it once in the season and, cautiously picking their way among the nests so as to break no eggs, to marvel at the abundance of the little "Mackerel Gulls" which they all regard as their friends. However, the island is admirably located for picnicking, and the rough gunning shack on the

larger one serves as a magnet to the curiosity of the summer folk who sail by. We regarded the place as our most promising rookery, and trapped 199 adult *hirundo* and 5 adult *dougalli* there. We had hopes of banding at least two thousand young birds, but the breeding is late, and July 8th found hardly a dozen young hatched. We spent July 9th at Chatham with Floyd, and, returning to Billingsgate early the morning of the following day, found that an atrocity had been committed in our absence. There were just 23 lonely and wary adult birds hanging over the islets where two days previously there had been hundreds, and the ground had been wiped clean of all vestiges of eggs or young! The blackened embers of a drift-wood fire, surrounded by empty clam-shells, bits of wax paper, and fragments of sandwiches and orange-peels in the very center of the larger rookery told the story. Choking down our bitter wrath, we interviewed the clammers who had been on the flats the preceding day. They reported having seen three persons running about the island all day, but had not investigated, thinking at the distance the people might be ourselves. The scoundrels were brought there by a boat early in the morning, marooned there all day, and picked up again late in the afternoon. We spent three days trying to identify the boat and locate the guilty persons, all to no avail, for we could not get a scrap of evidence. The island remained barren of birds the rest of the summer, for the picnickers to enjoy unmolested.

The Pamet River colony, lying at the mouth of the Pamet River in Truro, suffered a somewhat similar fate, though not as deliberate a one. This island is a large one, a quarter-mile long and about 150 yards wide, well covered in spots by beach grass and beach pea, and at the same time affording areas of sparser vegetation and a wide, sandy, flotsam-strewn beach dotted with clumps of Dusty Miller (*Artemisia Stelleriana*) that is much utilized by the birds. The location of the island, however, is against the birds, for besides being too close to the Provincetown Portuguese, it is separated from the mainland only by a narrow stream of water at high tide, and at ebb tide one can walk over to it hardly wetting one's feet. The natives dig clams on the surrounding flats, usually attended by their whole families, including their dogs; a near-by bathing-beach affords a host of summer folk, whose curiosity is constantly whetted by the cloud of circling birds; and as weasels and rats cross over easily from the mainland, the poor birds have hardly a chance. Sixty pairs of Arctics, two of Roseates, and about eight hundred of Common Terns spread themselves over this large area, which is certainly capable of supporting many times

that number. When we first visited it June 21st, everything was in good order, and we spent three days trapping adult birds, banding 75 *hirundo* and 13 *paradisæa*. The young started to hatch June 25th, but the rookery was again beset by its old enemy, a small red ant (see *Bull. Mass. Aud. Soc.*, Oct. 1924, p. 5) which destroyed the young as fast as they emerged. A hurry call to Boston brought down an adequate supply of ant-powder and tobacco-dust. We spent two days spreading it over the island among the nests and ant-hills, and had the keen satisfaction of seeing our efforts rewarded by the disappearance of the ants. Following this, a series of spring tides favored the clammers, and the last of the month brought with it the advance guard of summer visitors. As Dallavalle and I could not spend every moment of our time on that rookery alone, the birds were constantly bothered in our absence, with the logical result. A weasel I managed to shoot later contributed to the damage inflicted by his two-legged relatives and their pets, and, as nearly as I could ascertain, not a single young bird reached maturity on the island.

Our six days with Floyd at Chatham were the most profitable of the whole season. The excellent natural conditions prevailing there under the rigid protection that has allowed the birds to breed so numerously, permitted us to capture a total of 415 adult birds, check our observations on territorial relationships made in the other rookeries, and take a series of motion-pictures under ideal conditions, while Floyd's banding of immature birds afforded us a fair check on the mortality rate.

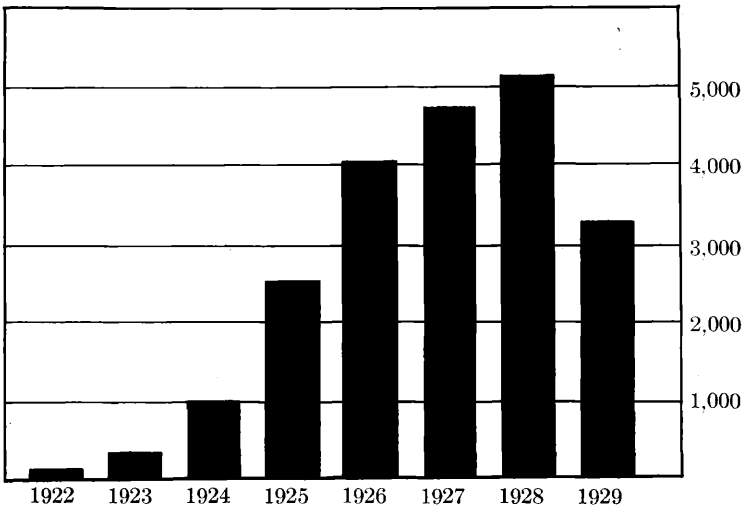
### Concerning Recoveries.

Dallavalle and I trapped in all 701 adult *hirundo*, of which 20 bore bands placed on them at Tern Island. Two of these, trapped and banded as adults on their nests by Floyd in 1928, while valueless as data on the ages of breeding birds, do show that adults may return to the same island to breed two years in succession. At the same time we also found on the breeding islands six dead adults bearing bands. These birds were all freshly dead when found, and may be regarded as individuals breeding on the rookery during the season; I include them in my averages, for their ages are known. Floyd found one dead banded adult, and trapped 76 more, of which 6 bore bands. One of these was banded as an adult in 1928, and so must be disregarded for our purposes. In all, therefore, we have a total of 781 adult birds of which 29, or 3.8 per cent bore bands indicating their ages, from which to draw our inferences. This percentage may be considered a fair sample for such a statistical study as this.

Of the 29 banded birds we are considering, 9 were taken at Billingsgate, 1 at Pamet River, and 19 at Chatham. The Pamet River returns are too slight to be of statistical significance, but the single recapture was a bird banded by F. Seymour Hersey at Chatham as a nestling in 1923, and is the oldest recaptured Common Tern on record to date. Inasmuch as we trapped 199 adults at Billingsgate and 467 at Chatham, it will be seen that at least 4.6 per cent of the Billingsgate adults were reared at Tern Island, while 4.1 per cent of those we caught at Chatham we are sure were raised there. While the difference in percentages is slight, it indicates a tendency for Common Terns to return to localities in the general vicinity of their natal homes to breed rather than to the same island. It is remarkable in this connection that all the recoveries are of birds banded at Chatham, and that none of them are of the large numbers banded at Penikese, Muskeget, and other rookeries on the near-by coast.

I am grateful to Mrs. Alice B. Harrington for furnishing me the data to augment Floyd's published lists of young birds banded at Chatham (*Bull. N.E.B.B.A.*, 1926, p. 71; 1927,

GRAPH NO. 1




GRAPH NO. 1 shows the number of juvenile *Sterna hirundo* banded yearly at Tern Island, Chatham, for the past eight seasons.

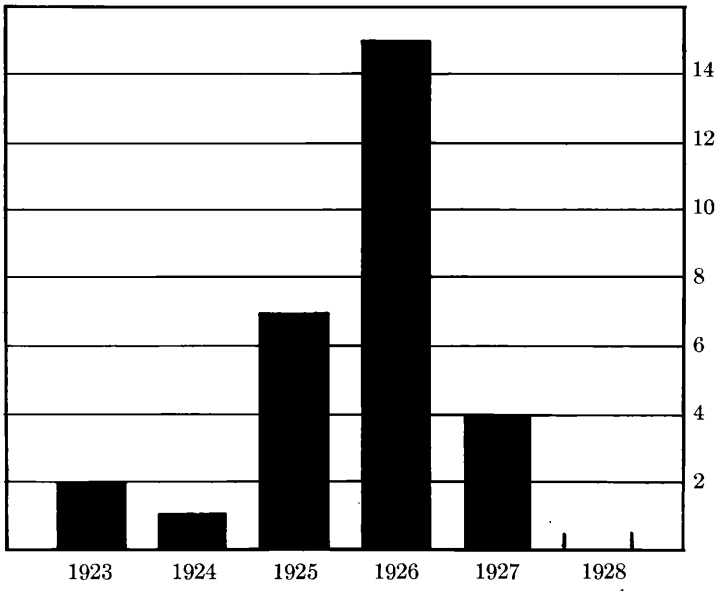
reported in the 1928 *Bull.* p. 64; and 1928, pp. 126-7). Graph No. 1 shows the total numbers of young Common Terns banded yearly at Chatham to be as follows:—

| | |
|---|---|
| 1922 | 94 |
| 1923 | 298 |
| 1924 | 1000 |
| 1925 | 2570 |
| 1926 | 4057 |
| 1927 | 4703[1] |
| 1928 | 5131 |
| 1929 | 3283 |

The 29 recoveries distribute themselves by years and ages (see graph No. 2) as follows:—

| | | |
|---|---|---|
| 1928 | 1 year old | none |
| 1927 | 2 years old | 4 |
| 1926 | 3 years old | 15 |
| 1925 | 4 years old | 7 |
| 1924 | 5 years old | 1 |
| 1923 | 6 years old | 2 |

GRAPH NO. 2

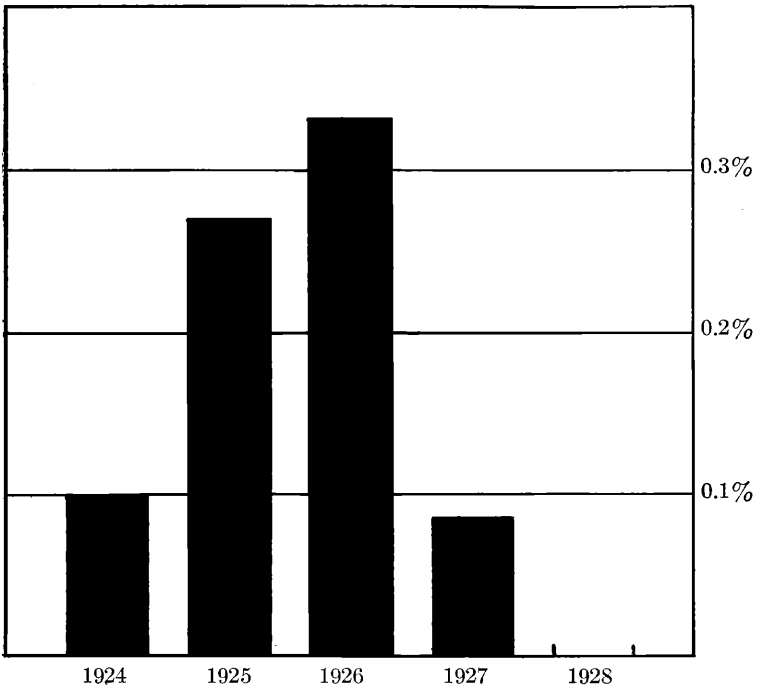



GRAPH NO. 2 shows the number of juvenile *Sterna hirundo* banded each year at Tern Island, Chatham, that returned to breed in the district in 1929.

[1]A deduction of 88 birds of various species, banded in Auburndale, has been made from the reported total.

If we correlate these figures with the numbers banded of each yearly crop of young birds and plot the resulting percentages (see graph No. 3) certain things become evident concerning which we had previously but little idea. I consider the theory that Common Terns do not breed in their first year to be now well proved. It seems evident from the figures that not all of them breed in their second year, but that the third year sees most of them at the height of their sexual life. This continues on through the fourth year, dropping off slightly, probably because of the mortality rate of adults, which factor certainly is responsible for the decided dropping off in percent-

GRAPH NO. 3




GRAPH NO. 3 is based on the numbers of juvenile *Sterna hirundo* banded at Tern Island, Chatham, per year, and refers the number of banded breeding adults recaptured to the year banded. It indicates the percentages of the ages of breeding birds.

age of breeding adults of five and six years of age. This state of affairs was hinted at by the figures of Floyd's 1928 recoveries of breeding adults (*Bull. N.E.B.B.A.*, 1928, pp. 126-7). He caught five birds bearing bands out of 161 adults trapped; four of these were three years old, and the other one was two years of age. Just how long sexual activity keeps on during the life of a tern is a subject concerning which we are still as much in the dark as we are about the mortality rate of adults, but it is more than likely that old birds die before they lose their ability to procreate their kind.

If any one traps large numbers of adults in the vicinity during the summer of 1930, the percentage of recaptures as a whole should be larger, for there should be more banded birds breeding. I should expect the preponderance of banded birds so captured to be individuals banded as young in 1927 and 1926, with a smattering of 1928 and 1925 birds, and possibly a very few of those banded in 1924 and 1923. It seems practically positive that no young banded this summer will be found breeding. It is certainly to be hoped that some one will put in time enough on the rookeries to check these results, for more adequate data will serve to smooth out the graph curves and make our knowledge more accurate.

### Concerning Territorial Relationships

All four species found in the district are colonial in their breeding—the Least Tern to a somewhat limited degree, seldom under the most favorable circumstances gathering in nesting groups of over a hundred pairs together, but the other three, the Common, Roseate, and Arctic Terns, to an intense degree, limited in numbers under favorable conditions only by the amount of available territory. Each species varies slightly, though consistently, in its choice of nesting-site, so that there is a minimum of competition between the respective species for a maximum occupancy of all parts of the islands offering them the safety they need. There are two prerequisites for a successful rookery of any species of tern: it must be isolated by some natural boundary that will eliminate predatory enemies, and it must be near a constant supply of food. After these two requirements are satisfied, comes the finer, specific differentiation of the type of ground-surface.

The Least Tern, besides being the rarest of the four, is the most distinct in several other ways. It never breeds among the other three, for its choice of nesting-site is so vastly different. Its eggs must be laid in clean, white sand to be properly camouflaged, and the dappled, lightly-tinted chicks are con-

cealingly colored in the same environment. In this district the nests are always unlined, shallow depressions in the open sand, and usually on the bare outer ocean beach. There is one exception, where five pairs of Least Terns hatched two broods of young apiece on an open patch of light, gravelly sand about three acres in extent abutting on the Truro Railway Station, extending from the west side of the railroad tracks a hundred yards westward to an arm of the Pamet River in which the birds catch small minnows for their young. The juvenile mortality is high in such a place from both natural enemies and man, but the adults stuck to their ground all summer. It was only by watching the parents from afar with my field-glasses as they came in to incubate or to feed their chicks that I was ever able to find any of the eggs or young, so excellent is their concealing coloration, and I was never able to find young older than five days. It is noteworthy that the Least Tern is the wariest of the four, and the best able to use its legs for walking. It walks and runs long distances, and whenever I set a trap over a nest, the parent never alighted within twenty-five yards of it, but always approached on foot from afar, running around the suspicious object in wide, ever-narrowing circles until it obtained its objective.

The Arctic, Roseate, and Common Terns are frequently found occupying the same rookeries, and though each species has a particular ecological niche to which it is peculiar, one seldom finds a pure culture of any one species.

The Arctic Tern, if its numbers as recorded for thirty years ago are not underestimated for lack of accurate observation, is the most recent arrival, and is still on the increase, still seeking its level, for certainly the species may be regarded to-day as being a "not uncommon" breeding bird instead of a "rare" one. Being the greatest and most capable migrant of the three, it has the longest wings and the shortest, weakest legs. Its legs are so frail that at times it has difficulty in walking. I have seen individuals blown off their feet by winds into the teeth of which Common Terns walked steadily and unperturbed to their nests. Hence it is often necessary that they drop from the air directly on their eggs, and for them to do so there must be no vegetation surrounding that structure high enough to interfere with their wings. The species breeds in scattered pairs along the peripheries of the mixed rookeries, the nests usually being shallow depressions in the windrows of dead eel grass (*Zostera marina*) that mark the highest water, and I have never found a nest here more than twenty feet from the high-tide line. Another reason for this choice of nesting-site may be that on the fringe of the rookery the bird finds

less competition from the well established more generalized species. It is worth noting, however, that on Billingsgate Island, the only rookery on which I found no Arctic Terns at all, the nesting-area drops abruptly at its edge to a sandy, clean beach which lacks entirely any fringe of vegetable flotsam at high-water mark.

The Roseate Tern has the stoutest legs and the shortest wings of the trio, and is consequently the best walker, and the most capable of handling itself in the long grass. It breeds always in groups in the hearts of the rookeries, and I have yet to see a nest that was not well hidden beneath a tuft of beach grass or dusty miller. In the heavily vegetated areas it is more than a match for the Common Tern, and holds its ground there with ease.

The Common Tern is the most plentiful in point of numbers, and well it deserves to be, for it is the most generalized and least specialized of the three in both habits and morphology. It varies its nest-structure considerably, and builds over widely different types of ground. The nest may be lined or unlined, built on a foundation of sand, gravel, rock, turf, or seaweed, and either placed in the open or concealed under overhanging vegetation. On comparing the measurements of its organs of locomotion, the wings and tarsi, with those of the Arctic and Roseate, we find that they lie approximately between the other two. It is the average bird, best suited to survive over varying conditions, as is indicated by its ability to compete to some extent with each of the other two species for those nesting-sites for which they are more specially adapted.

The Common Tern is the only species on which I was able to make a study of the individual nesting-area relationships. I started my investigations with a definite problem to solve—whether or not communism of any sort exists in the species' nesting-habits. That such cases might possibly occur I was led to believe by that well-known and often observed phenomenon, the occurrance in some nests of widely varying eggs. Theoretically all the eggs from one female should be approximately alike in color, size, and shape, whereas one frequently sees a single egg that stands out markedly from the others in the nest in these physical characteristics. I was too late in starting my work to study the periods of courtship, nest-building, and the laying of the eggs, but I had ample time to study the incubation period. Surely if more than one female lays eggs in the same nest, more than one female should attend the incubation of that nest. The only method of attacking the problem I could see was to mark the birds in a given area sufficiently to individualize them for observation.

Hopkins Island seemed to offer the best situation for our experiments, so, pitching a blind there, we started trapping the old birds. A band alone is insufficient as an identification mark where large numbers are being banded and where most of the observations must be made at a distance. Could the birds be stained in some way to make them conspicuous as individuals, it would greatly facilitate observation, but there is great difficulty in finding a safe stain that will remain for any length of time on the feathers. Acting on suggestions from Dr. A. A. Allen, I first used Higgins' India Inks, in carmine and black. These remained visible for about twenty-four hours, but we found nothing better. The feather-structure is such that no ordinary pigment will penetrate it without boiling, while the oily surface of the plumage makes it impervious to aqueous solutions. Mercurochrome and iodine both failed entirely to penetrate, and lasted but a few minutes. Various patent dyes from the drug-store did no better. I feared using oil paints or thin shellacs that might gum the feathers together and harm the birds. But in spite of our failure to develop a good marking scheme, our marks lasted long enough to tell us what we wanted to know, and we satisfied ourselves thoroughly that there is no communism whatsoever in the incubating habits of the terns. Furthermore, the marking scheme allowed us to make observations on the species' territorial laws, the existence of which makes it seem impossible that there can be communism in any other stage of reproduction. The "sport" eggs must come from the same female that laid the remainder of the clutch.

On the entire island we banded and otherwise marked 62 adults from 45 nests. We selected one convenient area near the edge of the island, roughly 40 feet by 20 feet, which contained 28 nests, four of which held "sport" eggs. We numbered each nest as we trapped its owners and, by painting the wings and tail of each adult in various combinations of red and black, we obtained an easily recognizable individualization for each of the 35 birds we were able to catch. The staining did not seem to bother the terns more than momentarily. Immediately upon its release every one so treated flew directly to the water, where it splashed about a few minutes evidently trying to clean itself, but not a single bird stayed away from its nest more than fifteen minutes after we released it, and five minutes usually sufficed to see it incubating again. In fact, the birds that had been handled were usually the first to settle on their eggs after we retired within the blind. After we had thus marked most of the adults in the chosen area, certain relationships became evident that had been hidden previously in the lack of adult individuality.

There are two birds to every nest, never more and never less, and there seems to be a fine distinction as to ownership of ground. Every pair appears to claim an area of land for some distance immediately around its nest, bounded by an imaginary line within the confines of which it allows no other tern, either adult or young, to trespass. This "home area" is evidently fought for and acquired before the laying of the eggs. By the time the eggs are laid and are being incubated, it has assumed definite proportions, varying in size and shape in each case. The average home area is a rough circle about six feet in diameter with the nest at its center. It is larger in colonies that are sparsely settled, and smaller in thickly populated ones. It tends to be regular in shape on smooth ground where there are few natural obstructions such as grass-clumps, rocks, and small sand hummocks; but on topographically variegated land, such as most of Hopkins Island, it usually assumes eccentric contours, and it is not unusual to find nests within a few feet of one another.

Every home area seems to have certain physical characteristics that are necessary adjuncts to the daily life of the bird. The first and most important requisite is a suitable spot to build the nest, but this, as has been shown, varies exceedingly in the Common Tern. While the "right of way" into the territory lies through the air, a bird flying no more than a foot or so above another's home area is considered an intruder and is immediately attacked and driven off as such. The incoming parent must fly at a height of several feet until its own land is reached if it wishes to be unmolested before coming to earth. The Common Tern does not like to drop directly from the air onto its eggs, though the practice is occasionally indulged in. It prefers alighting several feet from the edge of the nest and walking up to it, selecting as a place to land, an open spot where its wings may have full, undisturbed play. All the terns show a distinct aversion to having their feathers blown back (a friend of mine expresses it has "having their skirts blown over their heads") as must happen if, standing on the ground, they face away from a strong breeze. The Common Tern is no exception and hence, while it always approaches its home area from leeward, and like a good aviator lands facing into the wind, it always drops on the leeward side of its nest and walks up wind to it. There are usually several "landing-fields" in each home area, each for a wind of a different direction. As the bird cannot clamber with ease through tall, heavy grass nor climb over other obstructions, it must have a clear path from each landing-field, directly upwind to the nest. When trapping the birds these habits must be realized and taken into

consideration. The trap over the nest must face away from the wind so the birds will walk up under it. If it be faced the other way, they generally light on the back of it and try to poke through the wire. I have watched some of them poke vainly for over half an hour at a stretch and it is only the exceptional individual that shows brains enough to walk around the wire if the trap crosses its accustomed pathway.

In each home area is often a structure, somewhat comparable to the "singing tree" in some passerines, where the non-brooding parent sits when not otherwise engaged in fishing or bringing in food. Both parents incubate, but there seems to be no set watch for either. One, presumably the female, does most of the work and is at all times more anxious to reach the eggs and less fearful of the traps; the other, presumably the male, relieves her occasionally, but is not as eager to brood and is usually slightly more shy. The exact relationships between the parents in taking charge of the nesting-duties is a subject that requires much more study, but at any rate the non-incubating bird, when off other duties, has a favorite perch it occupies in the vicinity. This is most often a bare spot alongside the nest, and may be one of the landing-fields, but it is frequently some pet rock or stake well out of the home area, and is at times some indistinguishable point on the near-by beach.

The method by which the birds find their own nests is another point needing much future study. I covered several nests with bits of seaweed, grass, and paper so as completely to hide the nest-structure and the eggs, and awaited developments. In every case the parent came to the spot without hesitation and started at once to clear away the rubbish, using its head and beak as a pusher, and squatting down through the material, twisting and turning its body as though it were hollowing out its nest, until it had the eggs snuggled up between its belly feathers. This reaction indicates that the parent knows the location of its own nest and eggs other than by the sight of them. Further experimentation by moving and substituting nests and eggs to determine whether or not a marked individual can recognize its own nest and eggs was prevented by lack of time.

### Concerning Mortality

The yearly crop of terns suffers a terrific mortality, and of the approximately 17,500 eggs laid in this district only about 42 per cent developed as far as fully plumaged juvenile birds and flew away. This mortality is about equally divided, thanks

to man's interference, between the period of incubation of the eggs, and the period of development of young after hatching. Under normal conditions, when the birds are not disturbed by man, the death-rate should be much higher after hatching than before, but most of the damage done by man is to the eggs and not to the young, though his influence is felt at both stages.

Basing my figures for Nausett Point, Hopkins Island, and Billingsgate Island on partial counts, and those for Pamet River and Tern Island on the numbers observed and the young banded, I estimated the numbers of eggs laid in the district as follows:—

| | |
|---|---|
| Tern Island | 12,000 |
| Billingsgate Island | 2,800 |
| Pamet River | 2,000 |
| Nausett Point and Rocky Island | 250 |
| Hopkins Island | 450 |
| Total | 17,500 |

A very small percentage of the eggs proved sterile—not over one in five hundred; about 1 per cent were eaten or destroyed by natural enemies such as rats, skunks, and weasels; about 2 per cent were floated away during inundations of the nesting-aress by high courses of tides; but at least 30 per cent were prevented from hatching this summer by the interference of man. Most of this 30 per cent damage was done consciously, either by vandals who robbed with downright intention, as occurred at Billingsgate, or by careless visitors who stepped on the eggs, and allowed their pets full run of the rookery, as happened at Pamet River. Some of the harm, however, was done unwittingly by people remaining near the nests, thus preventing incubation, on extremely hot days. I was forcibly struck by the tendency of the terns to incubate much more avidly on hot, still, sunny days than on cooler ones, for this was directly opposite to my suppositions. I expected our best trapping would be on the raw, overcast, windy damp days when there would be danger of damage to the eggs by chilling, but in such weather we found the birds always exceedingly wild and wary. This was also the case in the early hours of the morning before the sun grew hot, and late in the evening after the heat of day had passed. At such times the blind had to be placed as far as possible from the nests, and the traps worked with long strings to get any results at all. But in extremely hot weather, the moment we retired out of sight within our blind, the birds came down almost at once, and time and again resumed incubation within a foot of the blind, so close that one could reach out and touch them with ease. The first

time I went barefooted in the sand on such a day told me why, and I took many temperatures of 120 degrees Fahrenheit on the sands and in the nests in such weather, and twice my thermometer registered 125 degrees on the hottest days. There are no data on the exact temperatures to which a tern's egg may be subjected without harm, but as the embryo in a hen's egg dies if subjected to a steady heat over 105 degrees, it seems almost out of the question that a tern embryo should be able to live after long exposures to such temperatures as are found under a sweltering sun. The sand gets so hot at times that it dries out the legs of the adults as they perch upon it, and during one of the hot days we had at Pamet River the old birds made constant short sallies from their nests to dip their feet momentarily in the still waters of the bay. I do not believe there was any effort made to wet the eggs—such a practice might be disastrous in affecting the breathing of the embryo—but that it was simply a move for personal comfort on the part of the adults.

It can be seen readily that if the depredations by vandals can be stopped, and curious summer folk prevented from wandering on the rookeries, the mortality during the egg stage can be reduced from its present 33 per cent to almost nil—5 per cent at most.

Man's share in the mortality of the young after hatching this summer was comparatively slight, not over 5 per cent, though it would have doubtless been higher had the eggs been allowed to hatch at Pamet River and the other rookeries not under constant guard. The 5 per cent damage was done for the most part by pet dogs that accompanied their masters to the rookeries and were allowed to run at random among the young birds. About 3 per cent of the young were killed by natural enemies, including the ants, and about 2 per cent died from starvation or exposure to the hot sun when deserted over-long by their parents during the first few days of life outside the shell. I tethered one five-day-old chick under a trap in the open beneath a broiling sun in a well-meant effort to catch its parents. The old birds were probably both off fishing, and under normal conditions the chick would have retired to the shade of a clump of grass, but here, tied in the open, it lasted just twenty minutes, at the end of which time it suddenly stiffened out and died. I did not repeat the experiment. Less than 1 per cent of the young died of disease. I saw three birds with malformed feet, and picked up five with ulcerated eyes. A surprisingly large percentage of the young in a large and crowded rookery as Tern Island, however, are pecked to death by the adults! This infanticide does not

happen until the young are old enough and strong enough to wander at random all over the island. When they happen to cross another parent's home area, they are immediately set upon by the rightful owner of the land and driven away by ferocious stabs on the head and neck. To be immune they must either stay at home (which they never do), keep to neutral land, or hide under cover where the infuriated adults cannot reach them. While taking moving-pictures from the blind at Chatham, we took into the blind with us about twenty young birds that were not quite old enough to fly, and released them one by one after the old birds had settled back on their nests around us. The poor youngsters had to run a fearful gauntlet of sharp, strong beaks before reaching the shelter of the long grass. The moving pictures show the adults rising from nest after nest as the young cross their respective home areas, each in turn striking viciously at the trespassers until they stumble into the next bird's land. The adults also have a more inexplicable habit of striking at any misguided youngster that strays off the nesting-ground proper onto the open beach or into the water. They hover over the venturesome chick in a cloud, each bird zooming at it in turn until it either dies or else makes its way back to the shelter of the long grass. The birds swoop down in exactly the same manner over a wounded comrade in the water, and I agree with those who claim that at such times the birds, though they might be partially actuated by curiosity, are trying to eliminate a useless and dependent member of society. This charming little custom, wrongly observed and interpreted, has given rise in the past to much writing to the effect that terns help another in distress away from the zone of danger, which to my belief is untrue. It is a common sight to see young birds so pecked that the down feathers are worn completely off the head and neck region. The skin there is usually so lacerated and cyanosed it is a wonder they live at all, and I have watched several such die. While banding 500 young terns on Tern Island during the height of the banding activity, Dallavalle and I picked up and removed bands from 152 dead banded young, every one of which showed a lacerated head. At the time, about half the young had been banded, and the ratios of banded to unbanded birds, dead and alive, were practically equal. Therefore in a total of 1300 young handled, approximately 300 were killed by pecking, and we can estimate a mortality of 23 per cent from this cause alone, which will remain a vital factor as long as the terns are able to breed in large numbers. The mortality of young after hatching in the district for the summer is hence

34 per cent, which under adequate protection should drop to about 28 per cent.

These figures show that of the 17,500 eggs laid in this district, with the total mortality of 58 per cent to eggs and young this summer, only about 7,350 developed to the stage where the young birds were able to fly from the rookeries. I offer without further comment the observation that if all the damage done by the hand of man alone had been prevented, approximately 11,800 young birds would have been able to wing their ways from our hospitable shores this autumn.

### Concerning Further Developments

It is sincerely to be hoped that work on the Cape Cod tern colonies will continue year after year, for the amount of work to be done there is endless, and there are new problems constantly coming up to be investigated. One thing leads to another, and at present we have hardly scratched the surface.

Were I to work in the district again next summer, I should select one of the smaller colonies, preferably Billingsgate Island, and concentrate on it, trying to make a more thorough and comprehensive study of individual territorial relationships. I should like to map certain thickly populated areas, trying to sketch in the boundaries of the home areas as shown by the actions of the birds. That would be the basis for a set of experiments to try to find out the method of selection of the home area. Nests could be carefully shifted within the home areas, and exchanged between several such areas, and the reactions of the birds would soon show whether the territory itself or the nest within it is the more important structure. It is to be hoped that by then some dye will be developed whereby the adults can be marked without harm for permanent quick identification until they moult the feathers so stained. Besides facilitating the handling of the other investigations outlined, this will be of great aid in finding out how parents identify their own young, which is still a moot question.

More banding of both immature and adult birds will serve to increase our knowledge of the nesting-ages and the mortality-rate as well as the distribution of the adults at nesting-time in relation to the place where they were reared. I should like to make complete counts of all the eggs laid, and their fates, so as to get even more accurate checks on the mortality-rate, with an aim to improving conditions if possible. Man has done so much damage to this most interesting group of birds that no matter what he does to help their numbers increase, he will always be their debtor.

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