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THE RELATION OF GULLS AND TERNS TO THE COMMERCIAL FISHERIES OF SAGINAW BAY, MICHIGAN, WITH PARTICULAR REFERENCE TO THE COMMON TERN, *STERNA HIRUNDO* LINNAEUS

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THE RELATION OF GULLS AND TERNS TO THE COMMERCIAL FISHERIES OF SAGINAW BAY, MICHIGAN, WITH PARTICULAR REFERENCE TO THE CASPIAN TERN, *STERNA HIRUNDO LINNAEUS* ⚓

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⚓ Presented in partial fulfillment of the requirement for the degree of Doctor of Science from the University of Michigan.

I. INTRODUCTION

The date of the fisherman's earliest persecution of the larine birds has not been recorded, but it is very probable that in America, this started in the early days of the white man. Barrows (1912) mentioned that in Michigan, the fishermen and the Indians used the eggs of these birds for food since time immemorial. In Saginaw Bay, Michigan, this antagonism has been renewed. The fishermen there have believed that the Common, Black and Caspian Terns and Bonaparte's gull, which they indiscriminately call "minnie gulls", cause great damage to the fish supply of the bay, particularly to the supply of Lake Herring (Leucichthys artedi). Their insistent indignation culminated in 1928, when as a body they determined to secure legislative action against these birds.

The problem is one of great local interest, because Saginaw Bay is one of the most important commercial fishing centers of the Great Lakes.

In order to establish a sound basis of fact, to replace the biased opinions both of the fishermen who have urged the complete destruction of the birds and of the bird lovers who advocate their conservation at any cost, this study was undertaken jointly by the Institute for Fisheries Research and of the Museum of Zoology, both of the University of Michigan. Cooperation was also obtained directly from the officials of the Michigan Department of Conservation.

It is the purpose of this paper to present and discuss the data which were gathered in the effort to estimate to what degree, if any, each or all of the species of birds studied are detrimental to the fishing interests of Saginaw Bay.

Saginaw Bay (Pl. 1)[1] is an indentation lying behind the "Thumb" of the lower peninsula of Michigan and opens directly into Lake Huron. Its shallow shores with different types of bottom are very favorable to the production of forage fishes. Its deeper waters produce a tremendous crop of Mayflies (Hexagenia and Ephemera and possibly others), which is perhaps one important basis for the abundance of commercial fishes in the bay. The marshes furnish ideal homes for the Black Tern, Childonias nigra surinamensis (Gmelin), and the isolated islands have very satisfactory surroundings for the formation of Common Tern colonies.

The birds were observed and collected from the following places: Big Charity Island, Little Charity Island, Gull Island, Maisou Island, Defoe Island including Pitcher's Reef, Lone Tree Island, and along the shores about Pointe aux Barques, Port Austin, Oak Beach, Oak Point near Caseville, Caseville, Sand Point, Mud Creek, Bay Port, Old Pigeon Club and Weale (both near Bay Port), Rose Island, Sebewaing, Fish Point, Bay Park, Quanicassee, Bay City, Linwood, Pinconning, near the mouth of Rifle River, Point au Gres, Point Lookout, Alabaster, Tawas City and East Tawas. The most detailed and prolonged studies were carried out at Sand Point and at Lone Tree Island in 1929, and

[1] Reproduced from Lake Survey Chart No. 5 of Lake Huron, issued 1930.

at Lone Tree Island in 1930 and 1931, because these places had the largest colonies of Common Tern in the years mentioned.

The names of the places recorded do not indicate the exact spot of collecting. They indicate, however, the names of the city, village or island as commonly known. Oftentimes, an island is known under two or three names, but the one adapted here is the name known to the people of the nearest village, or of which the bird literature has already made mention. The name of the nearest town or point is used for the place of shore observation. Thus, East Tawas refers to a place along the shore about three kilometers east of East Tawas, Tawas City refers to a place in the shore about 1.5 kilometers south of Tawas City, etc. Birds and fish collected on the north side of Rifle River were referred to as the Au Gres collection. The materials obtained from the shore about three kilometers east of the village of Au Gres were also included under the same heading. Pinconning, in this paper, indicates the shore about three kilometers east of the village of that name and at the end of the county road that crosses U. S. Highway 23 near the center of the town. Linwood refers to a place about one kilometer east of that village. By Bay City is indicated the shore near the Michigan State Park at Bay City. Sebewaing Bay refers to the clear shore of this part of Saginaw Bay and extends about two and a half kilometers on either side of Sebewaing River. Bay Port refers to the shore line about one kilometer long within the village. Caseville is used to designate the shore about one kilometer on either side of the mouth of Pigeon River, but mainly to the

northeast. Oak Beach refers to the shore at the end of the county road in that village. At Port Austin, the observations were made on the immediate sides of the dock and the collection bears the name of that town. Collection at Pointe aux Barques was made on the sandy shore about one kilometer from the entrance to the resort.

By reason of its greater abundance, the Common Tern presents a more important problem than do the other species. A more detailed account of this species is consequently given in this paper than for any of the other birds studied. The observations on the Common Tern covered breeding, feeding at different periods of the season and at different times of the day, and general movements, for each of these points in the behavior of the species bears upon the problem of its relations to the fisheries.

Except about the Charity Islands and Gull Island seine hauls were made at occasional intervals from the time of the arrival of the birds until midsummer. The detailed study of the fishes was begun in the summer of 1930.

Laboratory examination of the birds' stomachs and the identification of the fishes collected were made in the Division of Fishes of the Museum of Zoology of the University of Michigan. The fish and food materials studied are available in the Division of Fishes, while a few skins of the birds studied are kept in the Division of Birds of the same museum.

Approximately 200 days were spent in the field for this study, in three long periods from late spring to mid-summer of the years

1929, 1930 and 1931, and in shorter trips in the spring when the birds were supposed to have arrived, in late summer and in early fall of 1929 and 1930. Laboratory studies occupied most of the time during the balance of the year.

1. REVIEW OF LITERATURE

The writer is not aware that any extensive study of similar nature has been published to date. There is, however, a scattered literature relating to the life history of each or all of the species of birds investigates, involving a superficial study of their relation to the fisheries of other regions. Some of the pertinent papers are mentioned below.

Dutcher (1901), in a report on his findings as Chairman of the Committee for the Protection of Gulls and Terns, described his throwing a bucket of cod livers into the water where at first no gulls nor terns were in sight. After a while, terns came and later about 100 terns and gulls were feeding on the livers.

In New York, Eaton (1910) made some observations of the food and feeding habits of the Common and Black Terns and also of the Bonaparte's Gull.

Knight (1908) made a similar study in Maine, and in addition observed the food of the Caspian Tern.

After a discussion of the several limiting factors essential to the preservation of a species of wild animal, Taverner (1915), in an investigation of the relation of the Double-crested Cormorant (*Phalacrocorax auritus*) to the salmon fisheries of the Gulf of St. Lawrence, came to the conclusion that the total effect of this species of bird on the Salmon was insignificant and mentioned a complicated problem to be confronted in the alteration of the balance of nature.

Whiterby's ~~Hartert's~~ (1920) observations in England disclosed results, almost like those reported by some American observers, regarding the food of the Common Tern, Caspian Tern and Bonaparte's gull; the two first named species are indicated as pisciverous, the later as insectiverous. He studied the white-winged Black Tern Chlidonias leucopterus, instead of the typical Black Tern.

Bent (1921) seems to have been the first in the United States to have made an almost complete survey of the life histories of birds, including the four species treated in this paper. He reported on the food of the birds, and incorporated findings of many other workers up to that time.

Munro (1923), in a preliminary report on the relation of various ducks and gulls to the propagation of sock-eye salmon at Henderson Lake in British Columbia, believed that certain individual birds only have the habit of eating the salmon eggs.

Forbush (1925) gave a resume of the life of the birds of Massachusetts, including the four species discussed here. His descriptions of the haunts, and habits of the Common Tern are particularly significant, as he collected scattered bits of known and unknown facts, which, added to the results of his unsurpassed experiences as a field naturalist, made possible the picturing for his readers of the peculiarities of the bird.

Similar studies dealing with the relation of other birds to fish life have also been made. Taverner's (1915) study may be mentioned, along with the three other cited below.

Wetmore (1924) made a study of the food and economic relations of North American Grebes. A fairly detailed study of six species of Grebes

was made. He came to the conclusion that the Pied-billed Grebe, Podilymbus podiceps (against which many complaints from fish hatcheries had been received), should be molested only about such establishments, and only with the permission of the Federal and State authorities. It was further recommended that none of the other species investigated are in need of control.

Mattingley (1927) found in Australia that the five species of cormorants studied feed upon crayfish and other enemies of fish in addition to slow moving fishes. He claims that the cormorants have extensively saved the fishes along the shoals, and that the proportion of those saved to those they have killed is several thousands to one.

Lewis (1929) presented a resume of the studies by himself and others in several parts of the United States and Canada, of the food of the Double-crested Cormorant. Although this bird was generally conceded to be piscivorous, the species of fish reported as fed upon varied with the region in which the birds were feeding. The bird was, therefore considered to be significantly deleterious to fish life in only parts of its range.

Clearly, a number of the authors cited have shown a strong bias in favor of the birds.

2. ACKNOWLEDGEMENTS

Since the start of this investigation, I have been indebted to many, without whose hearty cooperation the difficulties encountered would not have been met. I therefore wish to take this opportunity of expressing to them

my deepest obligation.

The guiding interest of President Alexander G. Ruthven, Director of the University Museums, in wild life conservation, made the start and continuance of this investigation possible.

Dr. Carl L. Hubbs, Director of the Institute for Fisheries Research, has directed most of this study. Without his constantly inspiring advice and support this work would not have been accomplished.

Prof. F. M. Gaige, Director of the Museum of Zoology, has manifested a helpful interest in this work since its inception. He is also responsible for many identifications of insects recorded in this paper.

Dr. Josselyn Van Tyne, Curator of Birds in the same museum directed the initial stages of this study and helped in other ways.

Dr. Miles D. Pirnie, until recently Michigan State Ornithologist, and a leading authority in Economic Ornithology, has been a constant source of useful information and suggestions.

Dr. John R. Greeley of the Institute for Fisheries Research has very kindly helped in identifying a number of fishes and insects, and has very often given valuable suggestions.

The Lone Tree Hunting Club has furnished the cabin on Lone Tree Island to serve as living quarters and field laboratories. Mr. Edward F. Jahr of Sebewaing, caretaker of this club and a commercial fisherman, has given help in many ways with utmost generosity.

The Bay Port Fish Company furnished transportation and other facilities by which I was able to extend my observations to the Charity Islands and other points far from the mainland.

Many other individuals, too numerous to mention, -- commercial fishermen, conservation officers, resorters, colleagues in the Institute for Fisheries Research and others, -- have contributed to make the completion of this study possible.

3. MATERIALS AND METHODS

(1) Birds Studied

During the three years of field study, six species of gulls and terns were noted as occurring in Saginaw Bay. They were the Herring, Ring-billed, and Bonaparte's gulls and the Common, Black and Caspian terns. While the Herring Gull and the Common and Black terns may be considered summer residents, as they may be seen throughout the season and breed in certain spots of the region, the others were observed as transients during their northern and southern migrations, and only stragglers or not at all during the intervening summers.

Of these six species, the common Herring Gull, Larus argentatus Pontoppidan, and the Ring-billed Gull, L. delawarensis Ord., were not objectionable to the fishermen. On the contrary, they believed that these birds were beneficial to them as they helped clean the bay of the dead fish and other floating refuse. These two species were collectively called "big gull" or in some places "sea gull". Published studies confirm the view that these large gulls are more beneficial than otherwise. This conclusion has been corroborated by the present investigation: the Herring Gulls were even seen hovering and alighting on fields, apparently in pursuit of insects.

Since there was no good evidence or claim that the Herring and Ring-billed Gulls are destructive to the fisheries of Saginaw Bay, no detailed studies were made on these two species.

The Herring Gull stays throughout the year. Its congener, the Ring-billed Gull seems to occur only during its spring and fall migrations. The Bonaparte's Gull arrives in the first week of May or thereabouts. The Caspian Tern and Common Tern arrive almost simultaneously with the Bonaparte's Gull in the spring. The Black Tern comes last and although no definite data are on hand, it appears that their first arrival is about the middle of May.

In order that each of the species of bird dealt with may be distinguished from the others, it seems desirable to indicate a few of the principal field marks which might help in recognizing each. The Herring Gull is the largest of the larine birds that occur in Saginaw Bay. Its square-cut tail, its pearly or gray-colored back, its pale or flesh-colored legs and bill and its nearness to man's association, besides other characters, may separate this bird from the Caspian Tern. At a distance, one who is not well acquainted with Herring and Ring-billed Gulls would surely confuse the two. The smaller size of the Ring-billed Gull and the presence of a dark-colored ring band near the tip of its bill are prominent diagnostic characters. The Bonaparte's Gull can at once be detected from the other species of gulls by their small size and more rapid movements over the surface of the water. From a distance, they may be mistaken for a flock of shore birds, but after a careful observation, their identity can be confirmed by their habits of flying and alighting and their call note. They can be distinguished from the Common Tern which is of about the same size

by means of their square tail and their horizontal carriage. The bill and the lighter color of the shanks as contrasted to the coral-colored bill and shanks of the Common Tern are quite characteristic. The call note which Blanchan (1898) described as a "plaintive shrill, but rather feeble cry, that was almost a whistle" is very diagnostic.

The Caspian Tern may be distinguished from the others by its size, being the largest of the terns studied. It may, however, be confused with the Herring Gull as has already been mentioned. The Caspian Tern may be distinguished from either the Herring or the Ring-billed Gulls by its loud, hoarse, rasping ca-arr, ca-arr (Forbush, 1925). Their manner of carrying the body in flight is characteristically tern-like (head downward). The slightly forked tail is distinct from the gulls' square-cut tails. It is much warier than either the Herring or the Ring-billed Gulls.

The Common Tern can be distinguished from the Caspian Tern by its size, which is about one-half that of the latter. It may be separated from the Bonaparte's Gull in several ways. The tail is decidedly scissors-like as compared with the square-shaped tail of the Bonaparte's Gull. The call notes of which there are a few distinct ones are also very peculiar. The most commonly heard call in the breeding and feeding grounds was te-ar-r-r, te-ar-r, te-ar-r. This, in my opinion, is the call for the mate. Its graceful flight is also very characteristic. This species was most commonly seen. It could be observed feeding in many spaces along the shore of Saginaw Bay, but particularly at Lone Tree Island and a few other isolated islands where they have their colonies.

The Black Tern could not be confused with any of the birds studied

except occasionally on summer evenings when it joined the Common Tern colony in the air. As the common name indicates, the general appearance is black and it is the smallest of the birds studied. The Black Terns were commonly found along the marshes during the latter part of the spring and in summer. Bent (1921) has a good citation of observers who studied the peculiarities of this species.

Due to the fact that the Bonaparte's Gull occurs in Saginaw Bay in two distinct seasons, it was thought best to divide the data obtained on this species into spring and fall units. The few stragglers that were collected in the summer likewise formed a distinct unit. The materials obtained on the Caspian Tern were grouped in the same way as those of the Bonaparte's Gull. Since the Common and the Black Terns occur continuously through the warm season, there is a good reason to present each year's data on these species as a unit.

(2) Methods of Studying the Birds

The peculiarities of the birds, including the time of their arrival, their movements, association, nature of increase and decrease and their feeding behavior were noted for all the species studied. A detailed observation was made of the food and feeding of the nesting birds and their young, their seasonal abundance and the breeding peculiarities of the Common Tern.

Attempts were made to shoot the birds when they first arrived in the spring. The Bonaparte's Gull, the Caspian and the Black Terns were shot only at certain scheduled periods.

As soon as a bird or a number of birds were killed, the body was immediately opened and the stomach removed to prevent further digestion of the food. The alimentary canal anterior to and including the gizzard was removed and preserved. The intestines were not examined as the material contained in them is fragmentary, difficult to identify or to enumerate and impossible to estimate volumetrically. The oral cavity was slightly pressed downward to save any food that might be lodged there. The size of the tube preserved depended upon the contents of the stomach and ranged from the gizzard alone to the whole of the stomach plus the oesophagus. Accompanied by a label wherein the common name of the bird, place and date of collection were indicated, the materials were separately wrapped within a suitable size of cheese cloth and tied by a piece of string. For the Common Tern, for which a detailed account was desired, the data included the sex of the bird and the time of collection. As soon as convenient, the samples were soaked in a solution of about 5 per cent formaldehyde. They were kept in this condition for about a month or two until the return to the laboratory, where the packages were unwrapped and the material washed in running water for at least 24 hours, to remove the formaldehyde. From the water, they were transferred to 70 per cent alcohol for preservation and examination.

The occupation of the Cabin (Plate II, Fig. 1) at Lone Tree Island in the fall of 1929 was very instrumental in facilitating observations. From its windows, nesting birds were observed in 1930 and 1931. Observations on the Common Tern predators, which otherwise would have been very difficult, were also made from this permanent structure. Feeding experiments were also made here.

In an observation to determine which of the parent birds feed the young in the nest, a two-door bird trap of the Higgin's type was used. A detailed description of this is given by Lincoln and Baldwin (1929).

The annual number of birds occurring in Saginaw Bay was estimated by visiting the places where they were known to have colonies. The fishermen aided me very much in this reconnaisance work both in locating and in taking me to those different places. The actual number of birds in each colony was calculated and the total number of each species in the whole region was roughly estimated. To making this estimate, the size of the different colonies was compared visually with one colony of which the population was more carefully determined. In a few instances, a picture of a sector of a colony was taken (Plate III). This was obtained by: (1) standing in the middle of the colony, causing nearly all the birds to hover and scream around in the air; (2) drawing an imaginary line to divide the group into halves, then into quarters. Then the picture of one of these quarters was taken and the number of birds occurring in the picture was multiplied by 4. A similar process was used in other cases, in which the birds of the divided section were counted in the air as accurately as possible.

It was at first thought that the number of adults on the Bay could be ascertained by counting the nests on the rookeries. But it soon developed that such a method of estimate involved such serious errors as to be of very dubious value. The sources of error are:

(1) There is evidence that the birds do not breed until their third year. This conclusion, by Austin (1929), is confirmed by the fact that

none of the Saginaw Bay birds banded in 1930 were recovered in 1931, despite the fact that almost all the young reared at the one big rookery of the bay were banded in 1930. Some of the yearling birds may of course have been feeding on the bay.

(2) There is evidence, disputed by some to be sure, that two females often lay eggs in one nest, for sets of 4, 5, 6 and even 7 eggs were found in the nests, and very often two distinct types of eggs were found in the nests having large sets.

(3) The eggs are subject to frequent and irregular destruction, and are constantly being laid over a period of about one month.

The number of young Common Terns were estimated in the course of banding operations, in which as many young birds as possible were caught and banded. (This work was carried out in the summers of 1930 and 1931 with Mr. F. Ludwig.) Although this method does not give an entirely accurate number of young Common Terns in their colonies, it is believed that it was the most satisfactory and feasible way possible to obtain a fairly approximate estimate.

Several experiments were performed to determine whether or not feeding birds would pick up freshly killed minnows. First, a bucket of freshly killed minnows were dumped in a given area and were watched from a distance of about 200 meters. The birds were seen to swoop down but it was not precisely proved that they picked the fish. To confirm this apparent result, freshly killed minnows were counted and dumped on the surface of the water where the depth was about 50 centimeters. No result was obtained as the fish were noted to be washed in-shore by the movements

of the water. The freshly killed minnows were then dumped in an area inclosed by a seine at all sides. The float line of the seine was raised about five centimeters above the surface of the water. The fish were counted, but the birds did not pick them up as they apparently were frightened at the presence of the seine. After about 15 minutes, the fish sank without any result. Continuing this experiment in another way, freshly killed minnows of known quantity were dumped into a pool about five centimeters deep. The pool was located within the colony and was created by the withdrawal of the water after it had been high. The fish were left for two hours undisturbed. This gave a good indication that the birds do not take dead fish. In a number of instances, freshly killed minnows were dumped on the sand in the breeding ground and the movements of the birds were noted from the cabin. At first, the birds hovered over the area, but did not actually pick up the fish. After a while, the birds became indifferent to the presence of the fish and even stepped on them, but not one of them was seen to even pick up one of the dead fish.

In order to determine whether the fish fed to the nestling birds and their nestlings were dead or alive, a number of those dropped from the bills of the feeding birds were examined immediately. The first procedure was to examine the gills. It was noted that the gills of the shiners were blood red, indicating freshness, while those of the Trout-Perch were pale, seemingly indicating death for at least some time. The Trout-Perch were thereupon dissected and the heart examined. It was found, almost always, that the heart was still beating.

None of my experiments or observations indicated conclusively that the

Common Terns will pick up dead fishes. However, Prof. T. L. Hankinson tells me that he has actually noted Common Terns feeding on dead minnows in Lake Erie. Despite that observation, I believe that very few dead fishes, if any, enter into the diet of the Common Tern.

Experiments attempting to determine at what depth the birds would dive for the fish, performed by tying live and dead minnows on one end of a piece of thread, the other end of which was weighted down, proved wholly unsatisfactory.

In order to establish the quality and quantity of fish a young Common Tern may take in one day, two series of experiments were run. First, young Common Terns were reared under artificial condition since they were three days old. They were fed with fishes and insects. (Many birds were tried, but only one survived until it reached a stage ready to fly. A few of the birds tried were released after a few days for they refused to eat, while others died in captivity). Second, by the use of blind, the young were observed being fed in their nest. A board box, 145 x 75 x 50 cm was used to watch the birds while they were enclosed in a pentagonal pen or fence as shown in Plate VII Figs. 1, 2, 3 and 4. The end of the box opposite the pen was used as the observer's entrance. At the middle of the end close to the pen was a circular opening about 20 cm in diameter, through which the observer, whether sitting or lying with the head raised inside the box, could see the movements of the birds. The sides of the pen were about 15 cm high and supported at intervals with pegs to prevent its falling to either side when an adult bird stepped on it. The nearest end of the pen is about 20 cm from the end of the box. The longest diameter of the pen is about one meter while its narrowest diameter is about 75 cm.

Daily observations from about 4:30 A.M. to about 8:15 P.M. were made in the middle of July. To prevent the monotony of a very long stay inside the box, three observers took watches of three hours each. A 7-days observation was made of the broods; but a much more detailed study was made of one of them in which the parents happened to be banded, the male with a band on its right leg, the female with one on her left leg.[1]

With a view to establishing which of the parents feed the nestlings and the nesting adult, a few birds carrying fish in their bill were shot.

(3) Methods of Studying the Fish

The nature of this study requires a knowledge of the fish population of Saginaw Bay as well as of the activities of the larine birds in the said region. As mentioned elsewhere, seining was done at occasional intervals to determine the kinds of fish that inhabit the shore of the bay and to determine their abundance. Two sizes of seine were used. Along the shore, a 75-foot (about 23 meter) seine with a central bunt of $\frac{1}{4}$ inch (0.6 cm) mesh was chiefly used. In a few instances, a 125-foot (38.3 meter) seine with a bag of $\frac{1}{2}$ inch mesh was also used. Most of the hauls with the large seine were made away from the shore, the seine being pursed by the operators standing either in the water or in an anchored boat.

The temperature of the water was recorded whenever convenient. Likewise, the presence of any aquatic plant in the areas seined was noted, as was also the nature of bottom, and the depth at which the haul was made. The presence or absence of any feeding birds was also indicated. All of these factors were supposed to have an effect on the kinds and quantity of

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[1] Unfortunately, the number on the bands was not read, for fear that handling might frighten them. It was the writer's belief that this pair was the same one banded the year previous in an attempt to conduct the same experiment, but had deserted their nest after being once caught.

fish present in the area seined.

Representative samples of the fish collected from almost all the regions are kept in the Collection of Fishes of the Museum of Zoology. The vast majority of the fishes seined were thrown back into the same place from which they were obtained after they had been identified and their numbers carefully noted. The fishes preserved were kept in jars with 5 per cent formaldehyde solution. A label indicating the place, date and field number accompanied the fishes in preservation. The field number is a duplicate number of the one kept in the field notebook. This is very essential as the field note bears the details of the collection which could not very well be indicated in the label. Upon the return to the laboratory, the fishes were washed in water for at least 24 hours after which they were preserved in 70 per cent alcohol. They were then sorted according to species and placed in alcohol in separate jars.

Seining was done in the places mentioned before at different times of the day from about 8:00 A.M. until midnight. Late seining was carried on only a few times.

(4) Methods of Studying the Food

All stomach analyses were made in the laboratory. Each stomach was opened carefully and the contents removed. The food was determined in several ways. Often an organism was wholly or partly recovered and was then identified with comparative ease. Sometimes, however, only fragments were recovered. The fragmentary materials, if from fish, were either bones, scales, otoliths or pharyngeal teeth. To facilitate identifications,

otoliths of Perch (Perca flavescens), Lake Shiner (Notropis atherinoides), Spot-tail Shiner (N. h. hudsonius), Trout-perch (Percopsis omisco-maycus) and other common forage fishes collected from Saginaw Bay were mounted on a slide. Those that were recovered were compared with those that were mounted. After a while, it was found that practically all fragmentary materials could be determined at sight. Hubbs' (1926) "Check-List of the Fishes of the Great Lakes" was used extensively in this study. Dr. Hubbs did most of the identification of the fragments recovered in the early part of this study.

Of the insects, the fragments were sometimes in the form of mandibles, elytra, thoraces or legs of beetles; heads or thoraces of carpenter ants; wing parts or chitinous pieces of ephemerids, and dragon flies. The identifications were carefully made chiefly by comparison with the parts of the insects recovered whole or nearly so. For a few insects, identification farther than the family could not be made from the materials recovered. Prof. F. W. Gaige, Mr. H. B. Williamson and Prof. C. H. Hubbel very kindly aided me in the determination of several insect fragments recovered. Comstock's (1925) "An Introduction to Entomology" was frequently consulted for the determination of the insects to their higher group.

Great care was exercised in segregating the various stomach contents that were usually compacted into a mass (Plates IV and VI). In identifying most of the stomach contents, a dissecting microscope was used.

After the determination of the fish or the insects as the case might be, each species was separately placed between paper towels to remove the excess fluid adhering to the tissues. The surface-dried mass was then

dropped into a graduated cylinder.

Depending upon the size of the material to be measured, three cylinders (a 10 cc, a 50 cc and a 100 cc) were used, and the volume of the mass was determined by measured displacement of fluid. The material was then removed from the graduated cylinder and returned into vials or jars for storage.

The records were then arranged in chronological order under each locality. The vials and the jars were also arranged according to the arrangement of the records and were given serial numbers corresponding to those on the record.

(5) Methods of Estimates

The food items after being duly counted and measured volumetrically, were then summed and the appropriate percentages obtained, by different methods.

1. The Individual-frequency of Types.-This was obtained by summing all the individuals of each type of food represented in the stomachs examined. The "types" used were (1) commercial fishes, (2) non-commercial fishes and (3) insects. This frequency was expressed as the per cent of the total number of individuals of all types represented in all the stomachs of the given lot.

2. The Individual-frequency of Items Within Types.-This was obtained by summing all the individuals of each item represented in the stomachs examined. It was then expressed as the per cent of the total number of individuals constituting all the items of the given type, in all the stomach of the lots under consideration.

3. The Percentage Volume of Items.-This was obtained by summing all

the volume determinations of a given item, and was expressed as the per cent of the total volume of food, in all the stomachs under consideration. Only important items were so treated.

4. The Percentage Volume of Types.-This was obtained by summing all the volume determinations of all items constituting a given type, and was expressed as the per cent of the total volume of food in the stomachs involved.

5. The Percentage Volume of Items Within Types.-This was obtained by summing all the volume determinations of a given item, and was expressed as the per cent of the total volume of all the items constituting that type, in the stomachs being considered.

The volume of the materials recovered from the stomachs varies considerably, due to the fact that they had undergone different stages of digestion. The majority of the estimates, however, were made from the number of individuals eaten, and are therefore, not subject to this error.

The constituents of one meal was estimated by dividing the sum of the individuals of each food item by the total number of stomachs examined.

The estimate of the amount of food eaten by all the birds of one species in one year was obtained by the formula: 8 X Y Z:

8 = assumed number of feeding times daily based on experiment (see p.80);

X = the amount of each item taken by one bird at one meal;

Y = estimate daily average number of birds (on the basis of counts made at intervals), and

Z = number of days the birds occurred in the bay.

An average daily abundance of birds was established as a result of the

counts made at intervals.

For estimating the shore area of Saginaw Bay, Coast Chart No. 2 (Lake Huron including Saginaw Bay) was measured. The tracings were made to include the shore lines of the entire Bay (from Pointe aux Barques to Tawas Point), those of the islands, sand spits, river mouths for a short distance, etc.

The calculated number of each species of fish inhabiting Saginaw Bay within 20 meters from the shore was obtained by estimating the number in the area of one seine haul, and by the use of the formula

(1) $\frac{440{,}000 \times 20}{285} \times 2\ N = 61,754\ N$:

440,000 = length of the shore line of Saginaw Bay in meters.

20 = distance from shore line, which represents the area seined at intervals.

285 = area in square meters covered by one haul of the small seine.

N = average number of fish caught per haul of 285 square meters as obtained through repeated seinings. This was multiplied by 2 to allow for escapes, as explained later.

The estimate of fish population in the area from 20 meters from shore up to about 100 meters was obtained by the formula

(2) $\frac{55{,}200{,}000}{1000} \times 1.5\ N = 82{,}800\ N$

55,200,000 = estimated area in square meters of Saginaw Bay from 20 meters out to 100 meters off shore

1000 = area in square meters covered by 125-foot seine when pulled closer to shore.

N = average number of fish per haul as obtained in two seine hauls. The factor 1.5 makes allowance for escapes.

The estimate number of each species inhabiting the area farther than

100 meters from the shore and less than 3.66 meters (2 fathoms) deep (assumed chief habitat of the fishes caught and chief feeding area of the birds) was obtained by the formula

$$(5)\quad \frac{514{,}000{,}000}{740} \times 5\,N = 3{,}478{,}380\,N$$

514,
556,000,000 = estimated area of the bay 100 meters from shore up to 3.66 meters deep, obtained by use of a planimeter.

740 = area covered by one haul of the large seine.

N = number of fish per haul as obtained through repeated offshore seinings using 125-foot seine. The factor of 5 for escapements is justified by a later discussion.

The total number of each species of fish inhabiting the littoral region of the bay was estimated by adding the numbers estimated to occur in each of the three belts.

The total annual catch of legal-sized Perch and Pike-Perch from Saginaw Bay in 1929 and 1930 were converted from poundage into actual number of individuals. This was done by dividing the total poundage of each year by the average weight of a legal-sized fish. The latter was obtained from the measurements of a number of these fishes secured by the Great Lakes Laboratory of the U. S. Bureau of Fisheries, and kindly furnished to the writer.

As far as possible, the metric system is employed in this paper, except for a few measurements for which the English system is found to be essential.

The estimates presented in various parts of this paper are not claimed to possess any high degree of accuracy. I believe, however, that it is of vital importance to make and to present these estimates. In-

accurate as they must be they nevertheless are much better in my opinion than the purely subjective ideas which one would otherwise have to concoct to form an opinion as to the amount of harm inflicted by the birds on the fish life of the bay. The attempt at an objective, quantitative estimate of the relation of the birds to the fish supply, is I believe a step at least in the right direction, and a suggestion of the analytical methods which need to be used in such investigations.

Table 1

RECORD OF STOMACH EXAMINATION OF BONAPARTE'S GULLS FROM SAGINAW, FALL, 1929

All Collected at Middle Ground on November 12

1.---63 Lake Shiners, 22 cc.
2.---59 Lake Shiners, 20 cc.
3.--- 37 Lake Shiners, 11 cc.
4.---80 Lake Shiners, 27 cc.
5.---116 Lake Shiners, 53 cc.
6.---25 Lake Shiners, 16 cc.
7.---69 Lake Shiners, 23 cc.
8.---91 Lake Shiners, 27 cc.
9.---72 Lake Shiners, 20 cc.
10.---52 Lake Shiners, 15 cc.
11.---27 Lake Shiners, 11 cc.
12.---85 Lake Shiners, 21 cc.
13.---93 Lake Shiners, 24 cc.
14.---69 Lake Shiners, 23 cc.
15.---20 Lake Shiners, 7 cc.
16.---59 Lake Shiners, 29 cc.
17.---46 Lake Shiners, 17 cc.
18.---13 Lake Shiners, 8 cc.
19.---1 Perch, 2 cc; 27 Lake Shiners, 15 cc.
20.---39 Lake Shiners, 28 cc.
21.---40 Lake Shiners, 17 cc.
22.---43 Lake Shiners, 23 cc.
23.---46 Lake Shiners, 16 cc.
24.---26 Lake Shiners, 12 cc.
25.---23 Lake Shiners, 11 cc.
26.---26 Lake Shiners, 8 cc.
27.---49 Lake Shiners, 21 cc.
28.---34 Lake Shiners, 12 cc.
29.---43 Lake Shiners, 19 cc.
30.---38 Lake Shiners, 21 cc.
31.---24 Lake Shiners, 11 cc.
32.---1 Perch, 1.5 cc; 26 Lake Shiners, 9 cc.
33.---59 Lake Shiners, 19 cc.
34.---19 Lake Shiners, 10 cc.
35.---[redacted] Lake Shiners, 14 cc.
36.---86 Lake Shiners, 26 cc.
37.---40 Lake Shiners, 13 cc.
38.---43 Lake Shiners, 16 cc.
39.---31 Lake Shiners, 6 cc.
40.---30 Lake Shiners, 12 cc.
41.---22 Lake Shiners, 12 cc.
42.---58 Lake Shiners, 17 cc.
43.---43 Lake Shiners, 15 cc.
44.---42 Lake Shiners, 16 cc.
45.---27 Lake Shiners, 10 cc.
46.---59 Lake Shiners, 20 cc.
47.---42 Lake Shiners, 16 cc.
48.---75 Lake Shiners, 28 cc.
49.---16 Lake Shiners, 5 cc.
50.---14 Lake Shiners, 8 cc.
51.---56 Lake Shiners, 14 cc.
52.---44 Lake Shiners, 16 cc.
53.---37 Lake Shiners, 20 cc.
54.---27 Lake Shiners, 10 cc.
55.---22 Lake Shiners, 9 cc.
56.---28 Lake Shiners, 10 cc; 1 Dragon Fly nymph, 0.5 cc.
57.---49 Lake Shiners, 17 cc.
58.---51 Lake Shiners, 20 cc.
59.---44 Lake Shiners, 11.5 cc.
60.---1 Perch, 1.5 cc; 15 Lake Shiners, 5 cc.
61.---1 Lake Shiner, 1.0 cc; 26 Lake Shiners, 8 cc; 1 Straw-colored Shiner, 0.5 cc.
62.---19 Lake Shiners, 10 cc.
63.---41 Lake Shiners, 15 cc.
64.---41 Lake Shiners, 15 cc.
65.---20 Lake Shiners, 8 cc.
66.---86 Lake Shiners, 15 cc.
67.---52 Lake Shiners, 17 cc.
68.---19 Lake Shiners, 6 cc.
69.---47 Lake Shiners, 22 cc.
70.---30 Lake Shiners, 12 cc.
71.---25 Lake Shiners, 8 cc.
72.---15 Lake Shiners, 5 cc.
73.---13 Lake Shiners, 3 cc.
74.---52 Lake Shiners, 18 cc.
75.---55 Lake Shiners, 21 cc.
76.---18 Lake Shiners, 5 cc.
77.---61 Lake Shiners, 23 cc.
78.---47 Lake Shiners, 20 cc.
79.---32 Lake Shiners, 12 cc.
80.---39 Lake Shiners, 20 cc.
81.---1 Perch, 3.5 cc; 57 Lake Shiners, 26 cc.
82.---45 Lake Shiners, 22 cc.
83.---63 Lake Shiners, 25 cc.
84.---19 Lake Shiners, 5 cc.
85.---28 Lake Shiners, 13 cc.
86.---27 Lake Shiners, 17.5 cc.
87.---74 Lake Shiners, 28 cc.

II. THE RELATION OF THE BONAPARTE'S GULL, LARUS PHILADELPHIA (ORD), TO THE COMMERCIAL FISHERIES OF SAGINAW BAY

1. RESULTS FOR FALL OF 1929

Bonaparte's Gulls were first studied in the fall of 1929, when a short week-end visit was made to Saginaw Bay. During this trip, on November 12, a flock of about 900 birds was seen feeding in a small bayou near the State Game Refuge at Wild Fowl Bay. At first, only a few birds were wading and apparently were calling to each other with a constantly repeated dipping of their bills into the water, which was about five centimeters deep. Soon more birds came, apparently having heard the call note which sounds like a harsh whistle. As they passed, some from high above, they suddenly turned their heads downward and in an instant joined the feeding group. Those flying close to the surface along the shore were equally attracted to the feast. The fact that 87 birds were obtained from three shells of a 12-gauge repeater shot-gun fired from a distance of about 50 meters indicates how thickly the birds were congregated while feeding.

The stomach examination reveals that Lake Shiners were recovered from all the birds as shown in Table 1, (See Plate IV, Fig. 1). In five of them, one Perch from each was obtained. One Straw-Colored Shiner was also collected from a stomach containing also Perch and Lake Shiners. A minimum of 12 and a maximum of 116 Lake Shiners were obtained from one stomach each. A total of 3599 Lake Shiners with a displaced volume of 136 cc.

was recovered from the 87 stomachs. This gives an average per bird of about 41 fish, each displacing 0.38 cc.

The special conditions under which all the Bonaparte's Gulls were taken in 1929 raises some question. First, were all the fish picked from this place which was about 3,000 square meters? Second, how long had they been feeding in this bayou? Third, how many Lake Shiners were in this area? Fourth, what part of the Lake Shiner population was taken by the birds? The first and the second of these questions could not be answered conclusively, while only rough estimates could be made to answer the third and fourth questions. The place was seined but the slender Shiners were so small (about 2.5 cm long) that they passed through the meshes of the seine used and consequently the fish obtained did not comprise a representative sample of the fish then occurring. For this reason, the catch was discarded and the haul was not recorded. Observation indicated, however, that each fish occupied an area in the rough order of magnitude of 20 sq. cm. without regard to the depth of the water, or 500 Lake Shiners to every square meter from the surface of the water. This would yield an aggregate of 1,500,000 Lake Shiners in this area. At an average of 41 fish from each bird, 900 birds must have eaten 36,900 Lake Shiners during this feeding time, granting that all the fish recovered from the stomachs were picked from this area. This number would represent about 2.5 per cent of the Lake Shiner population of this place.

At the rate in which Perch were recovered, the 900 birds would have taken 52 Perch fingerlings.

The estimated meal of each bird according to the results obtained would be Perch, 0.06; Lake Shiner, 41.35; Straw-Colored Shiner, 0.01, and Dragon Fly, 0.01.

Table 2

RECORD OF STOMACH EXAMINATION OF BONAPARTE'S

GULLS FROM SAGINAW BAY, FALL, 1930

All Collected at Wild Fowl Bay on October 25

1.--1 Lake Shiner, tr.
2.--1 Lake Shiner, tr.
3.--1 Lake Shiner, .5 cc.
4.--1 Lake Shiner tr;
1 Lamellicorn beetle, tr.
5.--1 Lake Shiner, tr.
6.--1 Lake Shiner, tr.
7.--1 Lake Shiner, tr.
8.--1 Lake Shiner, tr.
9.--3 Lake Shiners, 2 cc.
10.--2 Lake Shiners, 1 cc.
11.--1 Lake Shiner, tr.
12.--1 Lake Shiner, tr.
13.--3 Lake Shiners, 1 cc.
14.--4 Lake Shiners, 2.5 cc.
15.--1 Lake Shiner, tr.
16.--1 Lake Shiner, 1.5 cc.
17.--1 Lake Shiner, tr.
18.--1 Lake Shiner, tr.
19.--1 Lake Shiner, tr.
20.--1 Lake Shiner, tr.
21.--13 Lake Shiners, 5 cc.
22.--3 Perch, 4 cc; 2 Lake
Shiners, 3 cc.
23.--2 Perch, 6.5 cc.
24.--1 Perch, 1 cc.
25.--22 Lake Shiners, 6 ccc.
26.--6 Perch, 2 cc; 1 Lake Shiner,
.5 cc.
27.--1 Lake Shiner, tr.
28.--1 Lake Shiner, tr.
29.--1 Lake Shiner, .5 cc.
30.--2 Perch, 3.cc.
31.--1 Perch, 5.5 cc.
32.--6 Lake Shiners, 1.5 cc.
33.--1 Leaf Beetle, tr.
34.--1 Perch, 3 cc; 2 Lake
Shiners, 1.5 cc.
35.--14 Lake Shiners, 7 cc.
36.--7 Lake Shiners, 4 cc; 4
Spot-Tail Shiner, 1 cc.
37.--23 Lake Shiners, 10 cc.
38.--1 Lake Shiner, tr.
39.--1 Lake Shiner, tr.
40.--17 Lake Shiners, 6 cc.
41.--7 Lake Shiners, 2.5 cc.
42.--37 Lake Shiners, 15 cc.
43.--23 Lake Shiners, 8 cc.
44.--1 Lake Shiner, 1.7 cc; 18
Mayflies, 1.5 cc. nymphs.
45.--30 Lake Shiners, 12 cc.
46.--empty
47.--3 Blue-bottle flies, tr.
48.--10 Lake Shiners, 5.5 cc.
49.--7 Lake Shiners, 2.5 cc.
50.--38 Lake Shiners, 11 cc.
51.--4 Lake Shiners, 4 cc.
52.--16 Lake Shiners, 7 cc.
53.--17 Lake Shiners, 6 cc.
54.--55 Lake Shiners, 12.5 cc.
55.--1 Mayfly, tr. nymph.
56.--13 Lake Shiners, 5.5 cc.
57.--7 Lake Shiners, 3 cc.
58.--22 Lake Shiners, 5.5 cc.
59.--20 Lake Shiners, 10 cc.
60.--20 Lake Shiners, 5.5 cc.
61.--23 Lake Shiners, 8 cc.
62.--42 Lake Shiners, 13 cc.
63.--17 Lake Shiners, 7 cc; 4 Spot-
tail Shiners, 1.5 cc.
64.--5 Lake Shiners, 1.2 cc; 1
Straw-colored Shiner, .5 cc;
1 Johnny Darter, .5 cc.
65.--1 Lake Shiner, tr.
66.--1 Lake Shiner, tr.
67.--1 Lake Shiner, tr.
68.--1 Lake Shiner, tr.
69.--1 Leaf Beetle, tr.
70.--1 Lake Shiner, tr; 2
leaf beetles, tr.
71.--1 Lake Shiner, tr.
72.--1 Leaf Beetle, tr.
73.--1 Lake Shiner, tr.
74.--empty.
75.--1 Lake Shiner, 2 cc.
76.--1 Perch, 1 cc; 1 Lake
Shiner, .5 cc; 1 Spot-tail
Shiner, .5 cc.
77.--2 Perch, 7 cc.
78.--4 Perch, 7 cc; 1 Lake
Shiner, 1.5 cc.
79.--11 Lake Shiners, 13 cc.
80.--1 Blunt-nose Minnow, 1.5 cc;
53 Lake Shiners, 16 cc.
81.--empty.

No accurate determination of the number of birds occurring in Saginaw Bay was made during this preliminary investigation and for this reason, the call for information regarding the effect of this species to the fisheries of the bay in the fall demanded further investigation, which was supplied the following year.

2. RESULTS FOR FALL OF 1930

In two periods in the fall of 1930, a total of 81 Bonaparte's Gulls were collected from several points in Wild Fowl Bay, particularly in Sand Point and in Bay Port. On November 16, it was exciting to observe the migration of this species. Hundreds in almost continuous movement were watched passing about 200 meters from the shore line of the tip of Sand Point. The movement lasted nearly a whole morning.

The first collecting in the fall of 1930 (see Table 2) was done on October 25, when 41 birds were obtained. As in the fall of the previous year, the contents of their stomachs were largely Lake Shiners (See Plate IV, Fig. 2). This species was recovered from 31 stomachs of this lot. Only a trace of one fish each was secured from 18 stomachs. The others had contents ranging from one fish with a volume of 0.5 cc to 23 fishes measuring 10 cc. Most of the other ten stomachs of this lot contained Lake Shiners also, mixed with other items.

On November 16, forty birds were collected during the migration at Sand Point in Wild Fowl Bay. Of this number, three were empty, while 25 contained Lake Shiners in various numerical and volumetric quantities. Seven of this number had a trace of one fish each. The maximum number of Lake Shiners recovered was 53 with a displaced volume of 16 cc. One

stomach had 42 fish (13 cc), three had 30 or more fish each and five had 20 and 25 fish each. The Lake Shiners were in several instances found to have been eaten with other food items.

The results for the fall of 1930 show that 70 out of 81 stomachs had nothing but fish, chiefly Lake Shiner; five had insects, while three others had mixed foods of fish and insects.

Numerically, commercial fish (Perch) comprise 3.5 per cent of the total food recovered, non-commercial fishes, 92.6 per cent (the Lake Shiner making up 91.4 per cent), and insects, 3.9 per cent.

By volume, Perch comprise 14.5 per cent, non-commercial fishes, 85.0 per cent and insects 0.5 per cent.

The data show that 81 Bonaparte's Gulls had eaten 23 Perch or an average of 0.28 per bird; 607 Lake Shiners, or 7.49 each; five Spot-tail Shiners or an individual average of 0.06 fish each; one Straw-colored Shiner or 0.01 each; one Johnny Darter or 0.01 each; 18 Mayflies (Hexagenia) or 0.22 each; four Leaf Beetles or 0.05 each; three Blue-Bottle Flies or 0.04 each and one lamellicorn beetle or 0.01 each.

3. COMPARISON OF FALL RESULTS: 1929 and 1930

These birds when in Saginaw Bay are almost in continuous movement except when they are feeding, thus making the estimate of their number difficult. However, an estimate of a daily average of 1,500 birds for a period of 37 days from about October 20 to about November 25 is considered safe. This will make a total of 55,500 day-birds. Granting that they have the same rate of digestion as the Common Terns, these birds would

have filled their stomachs eight times daily. Conditions such as continuous feeding when they find food supply and continuous flying when hunting for one are considered compensating. One difference between Common Tern and Bonaparte's Gull as far as feeding in Saginaw Bay is concerned, is that the tern would have an easier time to locate its food because of its being oriented to the environment. On the other hand, when a gull locates the supply of fish, the chance is that the stomach is filled to the capacity in preparation for its flight to another place. Considering these two activities of the bird even, it would be logical to take the average contents of the stomachs collected in 1929 when the birds were feeding and those collected in 1930 when they were shot while flying. The figures from the two years of study give an average as shown in the following table.

Table 3.--Results of the Study of Bonaparte's Gulls in the fall of 1929 and 1930

	1929	1930	Ave.
No. of birds collected	87	81	84
No. of each food item recovered:			
Perch obtained	5	23	14
Lake Shiners obtained	3599	607	2103
Straw-colored Shiners obtained	1	1	1
Spot-tail Shiners obtained	0	5	2.5
Blunt-nose Minnows obtained	0	1	0.5
Johnny Darter obtained	0	1	0.5
Mayflies (Hexagenia) obtained	0	18	9
Leaf Beetles obtained	0	4	2
Blue-bottle Flies obtained	0	3	1.5
Other insects obtained	1	1	1

From this average, 1 Bonaparte's Gull at one feeding according to methods of estimating explained on page 26 would have consumed .166 Perch, 25.026 Lake Shiners, .011 Straw-colored Shiner, .030 Spot-tail

Shiners, .011 other forage fishes, .107 Mayflies, .022 Leaf Beetle, .018 Blue-Bottle Fly and .011 other insects.

The estimate total destruction of each food item by the Bonaparte's Gulls that passed through Saginaw Bay in the fall, according to the methods of calculations explained on page 26 would approximate:

Commercial fish:		
Perch, *Perca flavescens*		74,000
Non-commercial fishes:		
Lake Shiner, *Notropis atherinoides*	11,112,000	
Straw-colored Shiner (*N. deliciosus straminous*)	5,000	
Spot-tail Shiner, *N. hudsonius*	13,000	
Other forage fishes	5,000	
Total non-commercial fishes		11,135,000
Insects:		
Mayflies, *Hexagenia* sp.	46,000	
Leaf Beetle, *Chrysomelidae*	10,000	
Blue-Bottle Fly	8,000	
Other insects	5,000	
Total insects		69,000

The result shows that Bonaparte's Gulls, during their fall migration, feed in Saginaw Bay almost entirely on fishes, and that the Lake Shiner form by huge preponderance the largest item of its food. Perch fingerlings comprise about six-tenths of 1 per cent of its food by numbers. Insects are somewhat less numerous than Perch fingerlings.

4. RESULTS FOR SPRING OF 1930

Usually, a very much lower number of birds was noted in the spring than in the fall of the same year. This is easily accounted for by the circumstance that the young of the year also join the migratory group southward. Furthermore, it is probable that quite a number of adult

birds that do not pass through Saginaw Bay in the spring come back this way in the fall. The most plausible reason that could be advanced in explanation, is the abundance of Lake Shiner fingerlings at that season.

In the spring of 1930, 19 birds were collected from four places at five different periods. The results of the stomach examinations are given in Table 4.

Table 4

RECORD OF STOMACH EXAMINATION OF BONAPARTE'S GULLS FROM SAGINAW BAY, SPRING, 1930

1.--Caseville, April 30: 1 Lake Shiner, 0.8 cc.
2.--Caseville, April 30: 1 Lake Shiner, tr.
3.--Caseville, April 30: 1 Lake Shiner, tr.
4.--Caseville, April 30: 2 Lake Shiners, 4.5 cc.
5.--Caseville, April 30: 10 Lake Shiners, 4.0 cc; 1 diving beetle, tr.
6.--Caseville, May 1: 1 Lake Shiner, 1.5 cc.
7.--Bay Port, May 22: 1 Redsh, tr.
8.--Bay City, June 5: 1 Lake Shiner, tr; 1 leaf beetle, tr.
9.--Bay City, June 5: 1 Lake Shiner, tr; 1 leaf beetle, tr.
10.--Bay City, June 5: 1 Trout Perch, 1.0 cc; 1 dragon fly, 0.5 cc; 3 Lamellicorn Beetles, tr.
11.--Bay City, June 5: 2 Perch, 4.0 cc.
12.--Bay City, June 5: 1 Lake Shiner, 0.2 cc; 2 Long-Horned Leaf Beetles, tr; 2 mayflies, tr.
13.--Bay City, June 5: 1 Perch, 1.5 cc; 3 snails, 0.4 cc; 1 dragon fly, 0.5 cc.
14.--Bay City, June 5: 1 Lake Shiner, tr; 1 Long-horned Leaf Beetle, tr.
15.--Bay City, June 5; 1 mayfly, tr; 1 beetle, tr.
16.--Near mouth of Rifle River, June 7: 22 mayflies, 4.0 cc.
17.--Near mouth of Rifle River, June 7: 18 mayflies, 5.0 cc.
18.--Near mouth of Rifle River, June 7: 20 mayflies, 5.0 cc.
19.--Near mouth of Rifle River, June 7: 9 mayflies, 2.0 cc.

On May 22, scales of one Perch were noted from the only stomach collected.

The spring collection of 1930 indicates that the Bonaparte's Gulls is a mixed feeder in that season of the year. The contents of 19 stomachs examined shows that numerically, 3.87 per cent of the food consists of Perch; 19.27 per cent, non-commerical fishes chiefly Lake Shiners; 77.97

per cent, insects. Volumetrically, Perch comprise 15.94 per cent of the total food, non-commercial fishes 34.78 per cent and insects 49.27 per cent. It is interesting to note that the fall collection of the previous year showed that this bird was almost exclusively pisceivorous, as only one Dragon Fly naiad was recovered from 87 stomachs. This shows how variable the food of the Bonaparte's Gull may be.

These results for the spring of 1930 show that, computing the food item numerically, the Bonaparte's Gulls during this period of study were more insectivorous than otherwise. Volumetrically, however, the amount of insects taken was about equal to the amount of commercial and non-commercial fishes combined.

On the basis of the results obtained, one Bonaparte's Gull at one feeding time had eaten 0.211 Perch, 1.053 Lake Shiners, 0.053 Trout Perch, 0.150 Long-horned Leaf Beetle, 0.105 other leaf beetles, 0.053 Dytiscid beetle, 0.150 lamellicorn beetle, 0.053 other beetles, 0.105 dragon fly and 3.789 Mayfly Nymphs (Hexagenia).

From observations made at various places in Saginaw Bay during their supposed period of spring migration, an estimate of 300 birds daily for a period of 15 days had been made. This will include the few birds that passed through the bay earlier and later than May 5 and May 9 respectively.

Assuming that Bonaparte's Gulls, during this period of migration had on an average, refilled their stomachs eight times in Saginaw Bay (equivalent to one day based on the rate of digestion of Common Tern), the total consumption on the basis of methods explained on page 26 may be expressed thus:

Commercial fishes:
  Perch.....8,000

Non-commercial fishes:
  Lake Shiner.....38,000
  Trout Perch.....2,000
  Total non-commercial fishes.....40,000

Insects:
  Brown Drake (Mayfly).....136,000
  Long-horned Leaf Beetle..... 5,000
  Other leaf beetles..... 4,000
  Dragon Fly..... 4,000
  Dytiscid..... 2,000
  Lamellicorn beetle..... 6,000
  Other beetles..... 2,000
  Total insects.....159,000

The figures show that in the spring of 1930, yearling Perch comprise slightly less than four per cent of the total estimated number of food items consumed by the migrating Bonaparte's Gulls. Non-commercial fishes represent about 19 per cent, while the insects make up the balance of about 77 per cent.

5. RESULTS FOR SUMMER OF 1930

The Bonaparte's Gulls are usually seen in Saginaw Bay only during their northern migration in the spring and on their return journey in the fall. Occasionally, however, abberrant individuals may be seen at certain isolated places in the bay during summer. This occurrence I have attributed (Manuel, 1930) [236] to insufficiency of food in their regular breeding grounds, and to the immaturity of all the birds collected during summer.

In the summer of 1930, six birds were collected from three places in three different periods as shown in Table 5.

Table 5

RECORD OF STOMACH EXAMINATION OF BONAPARTE'S

GULLS FROM SAGINAW BAY, SUMMER, 1930

1.--Pinconning, July 31: 1 Lake Shiner, tr; 1 lamellicorn beetle, tr.
2.--Tawas City, August 18: 2 Trout-Perch, tr.
3.--Lone Tree, August 21: empty.
4.--Lone Tree, August 21: 8 ground beetles, tr.
5.--Lone Tree, August 21: 3 Lake Shiners, 4 cc.
6.--Lone Tree, August 21; 16 Lake Shiners, 12 cc; 1 Straw-colored Shiner, 1 cc.

On July 31, a bird was shot at Pinconning. The stomach contained a trace of one Lake Shiner mixed with a trace of one Lamellicorn Beetle.

Another bird was collected from Tawas City on August 18 sitting with the Common Terns on old posts. Its stomach contained four otoliths of Trout Perch and so was supposed that it had previously taken two of this fish.

Four birds were obtained from Lone Tree Island on August 21. One was empty, the second had a trace of eight ground beetles, the third had 4 cc. of three Lake Shiners and 1 cc. of one Straw-colored Shiner.

The result of the examination shows that the Bonaparte's Gull during the summer is a mixed feeder on fishes and insects with a greater tendency towards forage fishes. No commercial fish was recovered from the six stomachs examined. Non-commercial fishes comprise 72 per cent of the total food recovered from six stomachs.

As these birds were abberrant stragglers, the number of days they would possibly stay in Saginaw Bay could not be determined. The absence of commercial fishes in their stomachs indicates that this species assumes no pernicious feeding habits in the summer.

The destruction of forage fishes caused by the few birds remaining over the summer is considered negligeable.

6. RESULTS FOR SPRING, 1931

In 1931, spring studies of Bonaparte's Gulls were resumed on May 7. In Bay City, eight stomachs were collected on this day. The results of the analyses of these stomachs is given in Table 6.

Table 6

RECORD OF STOMACH EXAMINATION OF BONAPARTE'S GULLS FROM SAGINAW BAY, SPRING, 1931

1.--Bay City, May 7: 23 Lake Shiners, 9 cc.
2.--Bay City, May 7: 45 Lake Shiners, 13 cc.
3.--Bay City, May 7: 30 Lake Shiners, 12 cc.
4.--Bay City, May 7: 29 Lake Shiners, 12 cc.
5.--Bay City, May 7: 4 Perch, 3 cc; 54 Lake Shiners, 17 cc.
6.--Bay City, May 7: 21 Lake Shiners, 8 cc.
7.--Bay City, May 7: 3 Perch, 4 cc; 6 Lake Shiners, 2 cc.
8.--Bay City, May 7: 9 Lake Shiners, 3 cc.
9.--East Tawas, May 7: 10 Lake Shiners, 7 cc.
10.--East Tawas, May 7: 6 Lake Shiners, 4 cc.
11.--Sand Point, May 7:1 Perch, tr.
12.--Sand Point, May 7: 1 Lake Shiner, tr.
13.--Sand Point, May 7: 1 Lake Shiner, tr; 2 ground beetles, tr.
14.--Sand Point, May 7: 1 Lake Shiner, tr; 1 lamellicorn beetle, 0.5 cc.
15.--Sand Point, May 7: 2 Lake Shiners, tr.
16.--Sand Point, May 7: 1 leaf beetle, tr; 1 Cyprindiae, tr.
17.--Sand Point, May 7: 1 Perch, tr.
18.--Sand Point, May 7: 1 leaf beetle, tr; 1 Cyprinidae, tr.
19.--Tawas City, May 24: 19 mayflys, 0.5 cc; 2 whirligig beetles, tr; 1 Tiger-moth, tr.
20.--Tawas City, May 24; 1 Long-horned leaf beetle, tr.
21.--Tawas City, May 24: 1 Long-horned leaf beetles, tr.
22.--Tawas City, May 24: 1 mayfly, tr; 1 whirligig beetle, tr.
23.--Tawas City, May 24: empty.

This examination of 23 stomachs shows that Bonaparte's Gull feeds on a variety of food, both qualitatively and quantitatively. It shows also that the food varies greatly with the different places and at different

periods. The food, however, of the birds collected in one place at one time shows uniformity. The Perch and Lake Shiners obtained were yearlings.

Numerically, Perch yearlings comprised 3.2 per cent of the total food, while the non-commerical fishes, principally Lake Shiner, represented 85.6 per cent and the insects, 11.2 per cent.

According to this result, a Bonaparte's Gull at any one feeding time during this season of study ate 0.391 Perch, 10.52 Lake Shiners, 0.087 other cyprinids, 0.130 ground beetle, 0.043 lamellicorn beetle, 0.087 Long-horned Leaf Beetle, 0.087 leaf beetle, 0.130 whirligig beetle, 0.043 Arctiid moth and 0.869 Mayfly (Ephemera) nymphs.

Assuming that 300 birds daily occurred for 15 days, or an average daily abundance similar to that of the preceding year, the effect of the Bonaparte's Gulls this season may be roughly estimated as follows (see page 26).

Commercial fish:		
Perch		14,000
Non-commercial fishes:		
Lake Shiners	379,000	
Other Cyprinids	3,000	
Total non-commercial fishes		382,000
Insects		
Ground Beetles	5,000	
Mayfly	31,000	
Other insects	14,000	
Total insects		50,000

The figures deviate widely from the results computed for the corresponding season of the preceding year. They indicate that about one and three-fourthes times as many commercial fish (Perch fingerling) were taken as in a preceding spring; that non-commercial fishes increased from about 20 per cent of the food in 1930 to about 85 per cent in 1931, and insects showed a

great decline from about 80 per cent in the spring of 1930 to only about 11 per cent in the corresponding season of 1931.

7. COMPARISON OF RESULTS FOR DIFFERENT SEASONS

If the results of the four seasons study ~~would be~~ are taken as a basis for determining the destruction of the Bonaparte's Gulls in Saginaw Bay, there will be an average annual toll of food as shown in the table below:

Table 7.--Estimate of the food taken by Bonaparte's Gulls based on four seasons of study.

Types of food		Spring	Ave. for springs of 1930 and 1931	Ave. for falls of 1929 & 1930	Total
Commercial fishes	1930	8,000	11,000	74,000	85,000
	1931	14,000			
Non-commercial fishes	1930	40,000	211,000	11,135,000	11,346,000
	1931	383,000			
Insects	1930	161,000	151,000	69,000	220,000
	1931	50,000			

Four seasons' study of the food of 270 Bonaparte's Gulls shows that the food these birds take in the spring is different from that obtained in the fall. The Perch yearlings made up constantly about 4 per cent of the food in the two springs of study, but in the fall, this item comprised less than one-tenth of one per cent of the birds' total food (when the items were considered numerically). Non-commercial fishes, of which Lake Shiners figures preponderantly showed a wide variability in the spring, comprising numerically, 20 per cent of the food

in 1930 and 85 per cent in 1931. In the fall, this item comprised more than 99 per cent of the total food. Insect items also showed a wide variation in number in the two springs studied, but in the fall comprised less than 1 per cent of the total food.

Lake Shiners comprised the bulk of the food in both seasons of both years, except in the spring of 1930 when insects show a numerical preponderance over this fish.

It was noted that during the fall of each year of study, Lake Shiner fingerlings were very thick along the shore of Saginaw Bay. At the recession of the water in the fall, it was a common sight to see thousands of Lake Shiner fingerlings become stranded along the shore. In other instances, they were trapped within small shallow pools formed by the withdrawal of the water. Many of these fishes would have died had not the gulls eaten them, and something of a nuisance might thus have been created.

Near the fish houses at Bay Port and Caseville, in water about one or two meters deep, millions of Lake Shiner fingerlings were observed at certain times, in such abundance as to impart to the water a darker color. These fingerlings were what the fishermen thought to be Lake Herring, and were what caused them to claim that the "minnie gulls" are competing with them for they maintained that, asserting "those minnie gulls eat more fish than we can get in one year".

8. REVIEW OF PERTINENT LITERATURE

A survey of literature concerning the food of Bonaparte's Gull shows considerable variation for different localities. But the accounts tend to

lead to a general opinion that this species is largely insectivorous.

Nuttall (1834, p. 294) found their stomachs to be gorged with ants and larvae of moths.

Knight (1908, p. 53) believed that small fish and surface swimming crustaceans are the chief food along the coasts of Maine.

Norton (1909, pp. 438-439) reporting from the same state (Maine) claims that besides fish and garbage, its diet was found to consist of maggots of a fly that breeds in decaying sea weed.

Eaton (1910, p. 135) reports seeing Bonaparte's Gulls searching for worms and insects over swamps and plowed fields. He says, however, that the bird is usually met with in New York, where his observations were made, hunting for its food on lakes and rivers.

According to ~~Hartet and others~~ Whiteley (1920, p. 729), in addition to insects, the food of this species in Britain consists of small crustaceans, annelids and small fish.

Bent (1921, pp. 177-178) maintains that the food of Bonaparte's Gulls is largely insects.

9. GENERAL CONCLUSIONS

The present study confirms only in part the trend of the results obtained in the studies of other authors. In Saginaw Bay the bird was found to live up to its reputation of being largely insectivorous only in the spring, but in the fall it took to the abundant Lake Shiners, especially those stranded in pools along the shore.

The great abundance of the Lake Shiner (Notropis atherinoides) in

Saginaw Bay, would seem to indicate that even the large numbers of this Shiner eaten by the Bonaparte's Gull probably has little effect on the commercial fisheries, although this Shiner is an important food supply for the market fishes. How great the number of Shiner fingerlings is in the fall was not estimated, owing to the fact that these very slender young fishes passed fully through the small-meshed seine used. There can be little doubt, however, that only a small per cent of the Shiner fingerling population was consumed. Furthermore, these consumed were largely ones which had been stranded in beach pools, and probably would never have survived if the birds had not eaten them.

The only commercial fish found to be eaten in Saginaw Bay was the Perch, and this species was consumed only as fingerlings, and in relatively insignificant quantity.

I conclude that the destruction of the Bonaparte's Gull in Saginaw Bay would have no measurable beneficial effect on the fishery yield. Furthermore, the fact that this species occurs on the Bay almost entirely on its migrations would lend difficulty to any attempts at its control.

III ~~IV~~. THE RELATION OF THE CASPIAN TERN TO THE COMMERCIAL FISHERIES OF SAGINAW BAY

Of the birds studied, this species is the least common in Saginaw Bay. Due to the location of their breeding grounds (Beaver Islands, Charlevoix County and other islands in Lake Michigan (Barrows, 1912)[58], they were studied only as transients during their northern migration in the spring, and on their return trip southward in late summer. They arrived before the other species in small groups sometimes simultaneously. The writer did not have occasion to see a group of more than ten birds. It might be cited that Prof. H. W. Hann of the University of Michigan did not record any Caspian Tern in his two years of bird observation in southern Michigan, which included Saginaw Bay in its northern range. This shows the rarity of the birds in this region.

1. RESULTS FOR SPRING, 1930

In the spring of 1930, only four birds were collected (Table 8). On May 1, 1930, two birds were collected from Sand Point and each stomach was found to contain fragmentary materials of a Lake Herring. One of the birds emitted the posterior part of the fish when it was shot. The fish was observed to have undergone putrifaction. From the other stomach were recovered a few scales and vertebrae of the same species, Leucichthys artedi. Upon examination of the scales, Dr. John Van Oosten of the U. S. Bureau of Fisheries estimated that the fish was about 255 mm. long, probably too large to have been captured alive. All indications tend to show that the fish

were dead when taken by the bird.

Table 8

RECORD OF STOMACH EXAMINATIONS OF CASPIAN TERNS

FROM SAGINAW BAY

1. Results for Spring, 1930

1.—Sand Point, May 1: 1 Lake Herring, tr. (Posterior part of fish, estimated to have been about 180 mm. long omitted).
2.—Sand Point, May 1: 1 Lake Herring, tr. (scales, etc.)
3.—Caseville, May 1: 3 Perch, 5 cc. (fragments).
4.—Caseville, May 28: 1 Perch, 60 cc. (132 mm. long).

2. Results for Summer, 1930

1.—Lone Tree Island, July 21: 2 Perch, 42 cc. (larger 116 mm. long).
2.—Lone Tree Island, July 21: 1 Perch, 45 cc.
3.—Lone Tree Island, July 21: 1 Perch, 18 cc.
4.—Lone Tree Island, July 21: 1 Perch, 10 cc.
5.—Lone Tree Island, July 21: 1 Perch, 10 cc.
6.—Lone Tree Island, July 21: empty.
7.—Lone Tree Island, July 21: 1 Perch, 100 cc. (174 mm. long).
8.—Lone Tree Island, July 21: 1 Perch, 5 cc. (fragments).
9.—Lone Tree Island, July 21: 1 Perch, 2 cc. (fragments).
10.—Sand Point, July 25: 1 Perch, 62 cc. (138 mm. long).

3. Results for spring, 1931

1.—Wild Fowl Bay, May 4: 1 Perch, 45 cc. (128 mm. long).
2.—Wild Fowl Bay, May 4: 1 Perch, 45 cc. (Head digested).
3.—Wild Fowl Bay, May 4: 1 Perch, 27 cc. (101 mm. long).
4.—Wild Fowl Bay, May 4: 1 Perch, 20 cc. (well digested).
5.—Wild Fowl Bay, May 4: 1 Perch, 32 cc. (anterior half gone).
6.—Wild Fowl Bay, June 10: 1 Perch, 45 cc. (anterior half gone).
7.—Wild Fowl Bay, June 10: 1 Perch, 28 cc. (anterior half gone).

Two stomachs collected on May 28 from Caseville were found to contain Perch. From one of the stomachs, three Perch were recovered, but digestion had gone so far that only parts were studied. In another stomach, a Perch measuring 132 mm. and displacing 60 cc. was obtained.

2. RESULTS FOR SUMMER, 1930

In the summer, 1930, a total of ten birds were collected (Section 2 of Table 8). Nine of this number were taken at one time from Lone Tree Island while in association with the Common Terns. One of these stomachs from Lone Tree Island was empty. Seven stomachs had one Perch each, while one contained two Perch. Two of the Perch recovered measured 116 mm. and 174 mm. respectively (See Plate ~~IV~~ V). Most of them, however, had undergone partial decomposition and a few were represented only by fragments. As a consequence of this discrepancy, the volume of the fish recovered measured from 2 cc to 100 cc. The single bird shot at Sand Point contained one Perch 138 mm. long.

3. RESULTS FOR SPRING, 1931

In the spring of 1931, 7 Caspian Terns were collected (Section 3 of Table 8). Examination of their stomachs reveals that all of them had one Perch each. Five of these birds were taken from Wild Fowl Bay at Bay Port on May 4, while two others were collected from the same place on June 6. Of those that were measured, one was 101 mm. long and another was 128 mm. The anterior half of most of the fish recovered was either partly or entirely digested.

4. SUMMARY OF RESULTS FOR TWO YEARS

The data show that a total of 21 birds were collected in two years of study. As noted above, there are indications that the large Lake Herring eaten were dead when picked up by the Caspian Tern. That statement was based on the fact that the Lake Herring emitted by one of the birds would not

have undergone such a stage of decomposition had it been picked alive or distinctly fresh. This conclusion was arrived at by comparison with the other types of food recovered from other stomachs.

At the time that the stomachs were sampled in 1930, the fishermen at Bay Port and in Caseville were catching such tremendous quantities of Lake Herring that they paid no attention to the few fish that slipped away in handling. As a consequence, floating Lake Herring were commonly in sight near the fish houses. Due to this circumstance, hundreds of gulls (Herring and a few Ringbilled) flocked around these places obviously feeding on dead fish. A few Caspian Terns might well have been included in the hovering flock and overlooked because of the abundance of gulls. Sand Point, the place where these terns were collected, is about midway between Bay Port and Caseville, and the birds were going back and forth along the shore line. At about the same time when these birds were collected, floating dead Perch were seen in several places nearby. No direct evidence of the bird feeding on dead fish, however was noted.

The stomach examination reveals that 21 Perch (Perca flavescens) and two Lake Herring, (Leucichthys artedi) were recovered from 21 stomachs studied in two years (1930 and 1931). One stomach was empty. Fourteen of these stomachs containing altogether 14 Perch were collected in 1930. This shows that the Caspian Terns feed on commercial fishes in Saginaw Bay principally on Perch.

Bent (1921) believed that this bird feeds almost wholly on small fish. The sizes of the fish obtained in this study does not seem to confirm his views. In Minnesota, Hatch (1892) observed this bird to feed on fresh

water mussels. In Maine, Knight (1909) observed that the food of the Caspian Tern consisted of small fish and surface swimming water life in general. According to Whitaker (1920), the food of the Caspian Tern in England consists of fish, especially those of the genus Clupea, though Pleuronectes and Scomber were also recorded as being eaten.

Assuming that a daily average of 15 Caspian Terns feed in Saginaw Bay for a period of 40 days in the spring and that a daily average of 30 birds are here for the same length of time in late summer, stragglers included, there would be 1,800 yearly day-birds in the region. Assuming that all the Perch taken by the birds are alive and that each bird gets four individuals of the one, two and three-year old Perch every day, which seems to be a conservative estimate, an annual total of about 7,200 Perch would be consumed by the few Caspian Terns.

Even if it could be definitely proved that the Caspian Tern dives deep into the water to entirely disappear (which they were not observed to do in Saginaw Bay), and to feed on live, healthy Perch, the question still remains to be considered whether or not the few birds as figured above as passing through Saginaw Bay during their northern and southern migrations, cause material damage to the fishery. The writer believes that the control of this bird would ential an expense greater than the value of the Perch estimated to constitute their annual food in the bay. This bird is the wariest of the four species studied and it took extreme patience to shoot one. However, when one of the birds dropped, the others that were in the same group approached as if in rescue, until they became aware of the danger when they flew high and far. Another drawback was that they did not form flocks

of more than a dozen as did the Common Terns or the Bonaparte's Gulls. Mr. Norman A. Wood, however has informed me that on April 27, 1926, he saw a flock of about 40 birds at Fish Point. It is possible that the species is already decreasing in numbers in this region.

All along the region of Saginaw Bay, it is generally conceded that of all the species of gulls and terns occurring in this bay, the Caspian Tern has the most graceful flight and that it adds to the natural beauty of the region. Unquestionably the esthetic value of the species is high and some of the fishermen recognize this. It may also have some value as a scavenger. The destruction of this rare species in Saginaw Bay might accelerate the extinction which Barrows (1912:51) feared might befall it in the state.

IV. THE RELATION OF THE BLACK TERN TO THE COMMERCIAL FISHERIES OF SAGINAW BAY

This species nests along the marshy region of Saginaw Bay. From the base of Point Lookout in Arenac County to Linwood in Bay County, and from the mouth of Saginaw River in Bay City to Wild Fowl Bay in Bay Port, the birds have been observed at intervals. In addition to those places, which form an ideal home for the Black Tern, a few birds were also noted at East Tawas and Tawas City. They could be seen at intervals flying close to the marshes apparently in pursuit of food. In a few of these places, the bird was observed to actually catch insects on the wing. This corroborates Knight's (1908:64-65) findings in Maine.

1. RESULTS FOR 1930

In 1930, 79 Black Terns were collected from ten places at intervals beginning May 22 and ending August 21. The number of birds collected ranges from one individual each from Sand Point, North Point, Rose Island and Maisou Island to 32 birds from Sebewaing Bay. Other places of collection were Fish Point, Lone Tree Island, Middle Ground, Au Gres and Tawas City.

Although collected from the same place and at the same time, the result of the stomach examination shows a wide variation, as indicated in Table 9.

Table 9

RECORD OF STOMACH EXAMINATION OF BLACK TERN FROM SAGINAW BAY, 1930

1.--Sand Point, May 22: 1 Perch, 1.5 cc.
2.--North Point, May 25: 1 Perch, tr.
3.--Sebewaing Bay, May 26: empty.
4.--Rose Island, June 2: 1 ground beetle, tr.

5.--Fish Point, June 2: 2 Long-horned Leaf Beetles, tr.
6.--Au Gres, June 6: 16 Mayflies, 1.6 cc.
7.--Au Gres, June 6: 6 Mayflies, .3 cc.
8.--Au Gres, June 6: 26 mayflies, 1.7 cc.
9.--Fish Point, June 2: 2 dragonflies, .5 cc.
10.--Fish Point, June 2: 2 dragonflies, .7 cc.
11.--Fish Point, June 2: 1 dragonfly, tr.
12.--Sebewaing Bay, July 1: 1 ground beetle, tr.
13.--Sebewaing Bay, July 1: 1 Perch, tr.
14.--Sebewaing Bay, July1: 2 mayflies, tr.
15.--Sebewaing Bay, July 1: 2 mayflies, tr.
16.--Middle Ground, July 7: 14 mayflies, .5 cc.
17.--Maisou Island, July 7: 5 mayflies, .4 cc.
18.--Sebewaing Bay, July 8: 22 mayflies, 1.5 cc.
19.--Sebewaing Bay, July 8: 3 mayflies, tr.
20.--Sebewaing Bay, July 8: 1 Golden Shiner, .5 cc.
21.--Sebewaing Bay, July 8: 2 mayflies, tr.
22.--Sebewaing Bay, July 8: 2 mayflies, tr.
23.--Sebewaing Bay, July 8: empty.
24.--Sebewaing,Bay, July 8: 7 Perch, 2 cc; 2 mayflies, tr.
25.--Sebewaing Bay, July 8: 2 Long-horned Leaf Beetles, tr.
26.--Sebewaing Bay, July 8: 2 mayflies, tr.
27.--Sebewaing Bay, July 15: 12 Long-horned Leaf Beetles, .5 cc.
28.--Sebewaing Bay, July 19: 1 mayflies, tr; 1 ground beetle, tr.
29.--Sebewaing Bay, July 19: 1 mayfly, tr.
30.--Sebewaing Bay, July 19: 9 mayflies, 1 cc; 1 whirligig beetle, tr.
31.--Sebewaing Bay, July 19: 1 mayfly, tr.
32.--Sebewaing Bay, July 19: 2 mayflies, tr; 7 ground beetles, 1 cc; 1 moth, tr.
33.--Sebewaing Bay, July 19: 7 ground beetles, .4 cc.
34.--Sebewaing Bay, July 19: 10 mayflies, 1 cc.
35.--Sebewaing Bay, July 19: 24 mayflies, 1.8 cc.
36.--Sebewaing Bay, July 19: 27 mayflies, 2 cc; 1 Long-horned Leaf Beetle, tr.
37.--Sebewaing Bay, July 19: 16 mayflies, 1 cc.
38.--Sebewaing Bay, July 19: 1 Perch, .5 cc; 12 mayflies, .4 cc; 1 caddis fly, tr.
39.--Sebewaing Bay, July 19: 12 mayflies, .5 cc; 1 ground beetle, tr.
40.--Sebewaing Bay, July 19: 11 mayflies, .3 cc.
41.--Sebewaing Bay, July 19: 16 mayflies, .5 cc; 1 ground beetles, tr.
42.--Sebewaing Bay, July 19: 19 mayflies, .2 cc; 2 caddis flys, tr; 1 moth, tr.
43.--Sebewaing Bay, July 19: 22 mayflies, 1.2 cc; 1 nerve-winged insect, tr.
44.--Sebewaing Bay, July 19: 25 mayflies, 2.5 cc.
45.--Middle Ground, July 21: 2 Perch, .5 cc; 2 Lake Shiners, .6 cc; birds breeding.
46.--Middle Ground, July 21: 1 ground beetle, tr.
47.--Middle Ground, July 21: 3 mayflies, tr.
48.--Middle Ground, July 21: 1 Lake Shiner, tr.
49.--Middle Ground, July 21: 1 Spot-tail Shiner, 2.5 cc; 1 ground beetle, tr.
50.--Middle Ground, July 21: 1 Spot-tail Shiner, tr; 1 ground beetle, tr.
51.--Middle Ground, July 21: 1 ground beetle, tr.
52.--Sebewaing Bay, July 27: 19 caddis flies, .6 cc.
53.--Sebewaing Bay, July 27: empty.
54.--Sebewaing Bay, July 28: 1 Perch, .5 cc; 2 Golden Shiners, 4.7 cc.

55.--Sebewaing Bay, July 28: 1 Lake Shiner, tr.
56.--Tawas City, July 30: 3 mayflies, tr.
57.--Tawas City, July 30: 2 mayflies, tr.
58.--Tawas City, July 30: 1 Lake Shiner, tr; 1 ground beetle, tr.
59.--Tawas City, July 30: 3 Lake Shiners, .5 cc; 3 mayflies, tr.
60.--Tawas City, August 16; empty.
61.--Tawas City; August 16: 2 mayflies, tr.
62.--Tawas City, August 16: 1 Perch, .2 cc; 1 Lake Shiner, .3 cc.
63.--Lone Tree Island, August 20: 177 mayflies, 5.5 cc.
64.--Lone Tree Island, August 20: 224 mayflies, 6.0 cc.
65.--Lone Tree Island, August 20: 222 mayflies, 4.5 cc.
66.--Lone Tree Island, August 21: 1 Lake Shiner, tr.
67.--Lone Tree I sland, August 21: empty.
68.--Lone Tree Island, August 21: 1 Spot-tail Shiner, tr.
69.--Lone Tree Island, August 21: 1 ground beetle, tr.
70.--Lone Tree Island, August 21: empty.
71.--Lone Tree Island, August 21: 1 ground beetle, tr.
72.--Lone Tree Island, August 21: 1 ground beetle, tr.
73.--Lone Tree Island, August 21: empty.
74.--Lone Tree Island, August 21: 1 Lake Shiner, tr.
75.--Lone Tree Island, August 21: empty.
76.--Lone Tree I sland, August 21: empty.
77.--Lone Tree Island, August 21: 1 Perch, 1 cc; 2 Western Grasshoppers, 1.5 cc.
78.--Lone Tree Island, August 21: 1 Perch, 1.5 cc.
79.--Lone Tree Island, August 21: 1 Western Grasshopper, tr.

In Sebewaing Bay, the birds were collected at seven different times, at intervals from May 20 to July 28. The food showed a variety of types.

In Lone Tree Island, 17 birds were collected in two successive days (August 20 and 21). Although much of the summer was spent here, it was only on rare occasion that the Black Tern could be seen on any part of the island, until about the second week in August. Inasmuch as most of the birds were in their juvenal plumage, it is assumed that they were young of the year that had just begun to wander and to feed by themselves. The writer (Manuel, 1930:234) has commented on this unusual occurrence of the Black Tern at this time at Lone Tree Island and ascribed their abundance to the lowering of the temperature and the apparent movement of the minnows in deeper water. But as the minnows recovered from the stomachs of the birds form a very insignificant part of their diet as will be seen in the following results of stomach examination, there must have been some other cause for this movement.

The three stomachs examined that were collected on August 20 had 177, 222 and 224 Mayflies (Ephemera, sp.) respectively, (see Plate V, Fig. 1). This is a smaller species of Mayfly than Hexagenia, sp., often referred to in this paper. This insect must have been the food of the birds which were observed to swoop gregariously (Manual, 1930:234), and must be the cause of their flocking on the island.

It may be noted that of the 79 stomachs of Black Tern collected in 1930, 13 were found to contain fish; four of these had Perch only, three had Perch and non-commercial fishes together while the remaining six had only non-commercial fishes. In three stomachs, Perch were found with insects (mayflies, caddis flies and mayflies and Western Grasshopper). Insects and non-commercial fishes were recovered together in five stomachs. In 49 stomachs nothing but insects were found. Nine stomachs were empty.

The results of the 1930 study may be summarized as follows: numerically, the commercial fish, represented solely by 26 Perch, comprised 2.62 per cent of the total number of food items devoured by 79 Black Terns. The non-commercial fishes, which include Lake Shiner, Golden Shiner and Spot-tail Shiner, comprised 1.69 per cent of the total number of food items. The insect food comprises 95.68 per cent of the total individual food items of the Black Terns examined in 1930. Insects were represented in 57 stomachs, 49 of which had nothing but insects. A total of 1,019 individual insects were recovered, representing 10 or 11 species.

Volumetrically, the commercial fishes comprised 12.66 per cent of the total food. The non-commercial types made up 13.62 per cent, while the insect type represented 73.70 per cent.

Considering the individual frequency of food items within types we first find that the Lake Shiner comprised 50 per cent while the Golden Shiner and

Spot-tail Minnow each made up 25 per cent, of the total non-commercial fishes eaten by the Black Terns. The larger Mayfly (Hexagenia sp.) and the smaller species (Ephemera sp.) which Needham (1920) called "Brown Drakes" and "Mackerel" respectively, made up 93.03 per cent of the total number of insects eaten by the Black Terns examined. Hexagenia (325) represented 31.89 per cent and Ephemera (623) 61.13 per cent of all the insects consumed.

The percentage volume of items within types was: Lake Shiner, 19.72 per cent; Golden Shiner, 45.07 per cent and Spot-tail Shiner, 35.21 per cent of the non-commercial fishes. Of the insects, the mayflies made up 89.06 per cent, and of these the "Brown Drakes" comprised 47.39 per cent while the "Mackerels" made up 41.66 per cent.

Other insects represented in the diet of this species include: 22 caddis flies (Trichoptera); 21 ground beetles (Carabidae); 16 Long-horned leaf beetles (Donacia sp.), five Dragon flies, Gomphus fraternus; three Western Grasshopper, Melanoplus mexicanus; two moths (Lepidotera); one Ant Lion (Neuroptera), and one gyrinid beetle.

Basing my estimate upon the figures obtained above, I assume that one Black Tern collected in 1930, on an average, ate at one feeding time: 0.35 Perch; 0.23 non-commerical fishes, consisting of 0.15 Lake Shiner, 0.04 Spot-tail Shiner and 0.04 Golden Shiner; and 12.90 insects, mainly Mayflies Ephemera, (7.85), and Hexagenia (4.10); and to a very lower degree caddis flies (.28), ground beetles (.26), Long-horned leaf beetle (.20), and other insects (.15).

Or, expressed in terms of volume, the food of each Black Tern studied in 1930 consisted of 0.084 cc. Perch, 0.09 cc. non-commercial fish and 0.48 cc. insects.

At the rate of the figures given above, every Perch taken by the Black Tern is balanced by 0.64 non-commerical fish and 36.39 insects.

In the absence of accurate data regarding the number of Black Terns occurring in Saginaw Bay, it is assumed that an average of 750 birds were present daily for a period of 90 days.

Assuming that the Black Tern has the same digestive efficiency as the Common Tern, there would be on the average eight feeding periods daily.

On the basis of the estimate mentioned in the foregoing paragraph, the total consumption of the Black Terns in Saginaw Bay for 1930, according to the formula on page 26 would be:

Commercial fishes		189,000
Perch fingerlings	189,000	
Non-commercial fishes		
Lake Shiner	81,000	
Spot-tail Shiner	27,000	
Golden Shiner	27,000	
Total non-commercial fishes		135,000
Insects..		
Mayfly (Ephemera)	4,239,000	
Mayfly (Hexagenia)	2,214,000	
Caddis fly	151,000	
Ground Beetle	169,000	
Long-horned Leaf Beetle	108,000	
Total insects		6,933,000

This shows that the Black Tern in 1930 was largely insectivorous. The commercial fish (Perch) comprised less than 3 per cent of the food while the non-commerical fishes represented only about 1.5 per cent.

2. RESULTS FOR 1931

A decided decrease in the Black Tern population in Saginaw Bay noted in 1931 was the chief reason why only 27 birds being collected in that year.

Table 10

RECORD OF STOMACH EXAMINATIONS OF BLACK TERN

FROM SAGINAW BAY, 1931

1.--Pinconning, May 25: 1 Perch, 2 cc.
2.--Pinconning, May 25: 6 Long-horned Leaf Beetles, tr.
3.--Fish Point, June 25: 3 Long-horned Leaf Beetles, tr.
4.--Sebewaing Bay, July 5: 6 mayflies, tr.
5.--Sebewaing Bay, July 5: 3 mayflies, tr.
6.--Tawas City, July 6: 18 mayflies, 5 cc.
7.--Tawas City, July 7: 4 mayflies, tr.
8.--Tawas City, July 7: 6 mayflies, .5 cc.
9.--Tawas City, July 7: 3 mayflies, tr; 1 Western Grasshopper, .5 cc.
10.--Sebewaing Bay, July 12: 21 Long-horned Leaf Beetles, 3 cc.
11.--Sebewaing Bay, July 12: 5 Long-horned Leaf Beetles, tr.
12.--Sebewaing Bay, July 12: 11 Long-horned Leaf Beetles, 1 cc; 1 Nerve-Winged Insect, tr.
13.--Sebewaing Bay, July 12: 11 Long-horned Leaf Beetles, 1 cc.
14.--Long Tree Island, July 15: 7 Western Grasshoppers, 3 cc.
15.--Sebewaing Bay, July 17: 1 Lake Shiner, .5 cc.
16.--Sebewaing Bay, July 17: 2 Killifish, 1.5 cc.
17.--Lone Tree Island, July 22: 2 Lake Shiners, 1 cc.
18.--Lone Tree Island, July 22: 1 Western Grasshopper, .5 cc.
19.--Lone Tree Island, July 22: 18 Western Grasshoppers, 3.5 cc; 2 Meadow Locust, 1 cc; 2 caddis flies, tr.
20.--Lone Tree Island, July 22: 12 Western Grasshoppers, 4 cc.
21.--Pinconning, July 25: 1 Perch, 1 cc; 1 Western Grasshopper, tr.
22.--Pinconning, July 25: 1 Perch, .5 cc; 2 Lake Shiners, 2 cc.
23.--Pinconning, July 25: 1 Carolina Locust, 1 cc.
24.--Pinconning, July 25: 1 Lake Shiner, tr.
25.--Pinconning, July 25: 2 Lake Shiners, 2 cc.
26.--Pinconning, July 25: 1 Carp, .5 cc.
27.--Pinconning, July 25: 1 Common Sucker, 1 cc; 4 Long-horned Leaf Beetles, tr.

The birds were collected from five different places as compared with ten places during the previous year. The first two birds were obtained from Pinconning on May 25. On July 25, seven more Black Terns were collected from this place.

From Lone Tree Island, four birds were collected on July 15 and on July 22. Western grasshoppers were found to have been eaten on both dates.

The last collection for 1931 was made in Pinconning on July 25, when seven birds were collected from among a flock of about 150 birds. Apparently, the Black Terns had nested again in the emergent vegetation close by as some of the birds were young of the year. This place must be one of those retained for breeding by this species. In most other places, where this bird had nested the year previous, not a sign of Black Tern was observed this year.

In 1931 three food items were recovered, which were not represented in the 1930 samples, namely a Common Sucker (Catostomus c. commersonnii.), a Carp (Cyprinus carpio), and a Carolina Locust (Dissosteira carolina) were recovered from the Black Tern stomachs.

Summarizing the results obtained from 27 stomachs of Black Tern collected in 1931, it would be observed that eight of them contained fish only, 17 had nothing but insects and two had a mixture of fish and insects items.

Numerically, the five commercial fish, represented 3.29 per cent of the total food consumed by 27 Black Terns studied in 1931; the non-commercial fishes 6.6 per cent and insects 90.13 per cent.

Volumetrically, the commercial fishes comprised 14.70 per cent of the total food, the non-commercial fishes, 20.20 per cent, while the insects made up 64.70 per cent.

As to the individual-frequency of items, the Perch comprised 1.97 per cent, the Carp and the Common Sucker, each 0.65 per cent. Of the non-commercial fishes, the Lake Shiner comprised 5.21 per cent and the Killifish 1.31 per cent. The Long-horned Leaf Beetle, the largest single item of insect food, comprised 40.13 per cent of all the food eaten. The "Brown Drakes" closely followed with 26.31 per cent. Also of numerical importance is the Western

Grasshopper, which made up 19.73 per cent. Other insects of slight numerical importance to the dietary of the Black Tern, eaten by the birds sampled in 1931, are: two Meadow Locusts (Chortippus curthipennis), two caddis flies, one ant lion and one Carolina Locust.

Considering the percentage volume of items, I found for commercial fishes, Perch, 10.29 per cent; Carp, 1.47 per cent, and the Common Sucker, 2.94 per cent. For the non-commerical fishes, I found that the Lake Shiner represented 16.17 per cent, while the Memona Killifish made up 4.41 per cent of the food.

For the insect food, I found that the Western Grasshopper represented 33.82 per cent; the Long-horned Leaf Beetle 14.70 per cent, and the "Brown Drake" (Hexagenia) 10.29 per cent of the food by volume. Other items of minor volumetric importance are the Meadow Locust and the Carolina Locust.

On the basis of the figures presented above, one Black Tern in 1931, on an avera e would have consumed in one feeding time, .165 commercial fishes consisting of .111 Perch, .047 Carp and .047 Common Sucker; .37 non-commercial fishes (.30 Lake Shiner and .074 Memona Killifish; 5.074 insects, consisting of 2.26 Long-horned Leaf Beetles, 1.481 Brown Drakes, 1.11 Western Grasshoppers, .074 Meadow locust, 0.074 Caddis Fly, 0.04 Ant Lion and 0.04 Carlina Locust.

Volumetrically, the diet of Black Tern on the basis of this study, would be .18 commercial fish, .36 non-commerical fish and .81 insect.

For every commerical fish consumed, there was a corresponding consumption of two non-commercial fishes and 27 insects. Likewise, every cubic centimeter of commercial fish devoured, was compensated by 1.4 cc. of non-

commercial fishes and 4.4 cc. of insects.

Every Perch eaten by a Black Tern in 1931 was consumed on the average with 2.7 Lake Shiners, 19.3 Long-horned Leaf Beetles, 13.3 Mayflies (Hexagenia), 10 Western Grasshoppers and a part of each of other items.

The sudden decrease of the Black Tern population in Saginaw Bay in 1931 may only be assumed to be due to a decided lowering of the water which was accompanied by the diminished growth of emergent vegetation and consequently less breeding area. There may also have been a diminution in the insect food supply for the vegetation serves to harbor the emerging aquatic insects, of the stage fed upon by the birds. In several places where these birds were noted last year, this year's observation showed a decided decrease, and in some places, a total disappearance. After a thorough search of their haunts, it was estimated that 300 Black Terns occurred in Saginaw Bay in the middle of July. Other young that would have been hatched later might have added materially to this number and have compensated for the smaller number present in the earlier season. It was, therefore, considered that an average number of 300 birds per day would be a conservative estimate for a period of 90 days.

Granting again for the purpose of establishing the relation of the Black Tern to the commercial fishing interests of the region that the bird goes out to feed eight times daily, and utilizing the figures obtained thus far, the food of the Black Tern for 1931 would be:

Commercial fishes		
Perch	24,000	
Carp	8,000	
Common Sucker	8,000	
Total commercial fishes		40,000
Non-commercial fishes.		
Lake Shiner	65,000	
Mamona Killifish	15,000	
Total non-commercial fishes		80,000

Insects	
Long-horned Leaf Beetle	486,000
Mayfly	320,000
Western Grasshopper	240,000
Meadow Locust	16,000
Caddis Fly	16,000
Ant Lion	8,000
Carolina Locust	8,000
Total insects	1,096,000

3. COMPARISON OF RESULTS OF THE TWO-YEARS STUDY OF BLACK TERN

As may be gleaned from the figures presented in Tables 11 and 12, the results of a two-year study of 106 stomachs of Black Terns, from Saginaw Bay collected at different places and at different periods and representing different stages of the bird, shew that its food is varied and that the greater part of the food both numerically and volumetrically is insect. The commercial and non-commercial species of fish together represent only about one-fourteenth of the total food of the bird numerically and about one-fifth by volume.

Another observable result of the two year's study is the significant decline of the mayfly item from 93.03 per cent of the total insect food in 1930 to 29.19 per cent in 1931. Volumetrically, the decline was from 89.06 per cent in 1930 to 15.90 per cent in 1931. This reduction in the mayfly consumption was partly compensated for by the increase of the Long-horned Leaf Beetle item from 1.57 per cent in 1930 to 44.52 per cent of the total insect food in 1931, numerically computed, and from 1.30 per cent in 1930 to 22.72 per cent in 1931, volumetrically computed. Another increase will be noted in the Western Grasshopper item, which was 0.29 per cent insect food in 1930 and 21.89 per cent in 1931.

According to the result of the two year's study, only 3.45 per cent by number and 13.68 per cent by volume of the total food of Black Tern was the average toll for commercial fishes. The chief destruction was of Perch fingerlings. The decrease in the number of Perch eaten by the few birds sampled in 1931 was accounted for by the addition of two species of commercial fishes (Carp and Common Sucker), which had not been eaten by the birds previously sampled. As will be seen from figures given in a later chapter, 190,000 Perch fingerlings represent an insignificant proportion of the population in Saginaw Bay.

There was a slight increase in the number of non-commercial fishes from 1.69 per cent in 1930 to 6.58 per cent in 1931. Likewise, there was a corresponding increase in the volume recovered from 13.62 per cent in 1930 to 20.58 per cent in 1931.

It is of possible significance that the decline of the Black Tern population of Saginaw Bay from 1930 to 1931 was accompanied by an apparent reduction in the proportion of insect food taken by the birds sampled.

4. THE COMPETITION OFFERED BY THE BLACK TERN TO THE COMMERCIAL FISHES

From the results presented, it is obvious that two species of Mayflies (Ephemera, sp. and Hexagenia, sp.) comprised the most important food item of the Black Tern in 1930, while Long-horned Leaf Beetles were more important than either of the mayflies in 1931. As far as the Long-horned Leaf Beetle is concerned, there does not seem to be any competition between the Black Tern and the commercial fishes, but there is a competition for the Mayflies. Koelz (1929) reported that 15 Whitefish (Coregonus clupeaformis) collected in Saginaw Bay had fed almost exclusively on the larvae of Mayfly, Hexagenia

sp. Metzelaar's unpublished observation on the food of Pike-Perch from Saginaw Bay reveals that mayfly nymphs enter into the dietary of this fish at all times. Clemens and others (1924:129-130) reported that the insect food of larger Pike-Perch from Lake Nipigon were chiefly ephemerid nymphs. Dymond (1926:79) maintained the same belief. From the stomachs of four Channel Cats, (Ictalurus punctatus) obtained from a fish house in Sebewaing, the writer noted Mayfly nymphs as the chief contents. From Walnut Lake, Hankinson (1908:208) found larvae of Hexagenia from ten stomachs of the common Bullhead (Ameiurus nebulosus). From the stomach of adult Perch collected at Oneida Lake, New York, on February, 1921, Hankinson (1928:930) recovered nothing but Mayfly nymphs, Hexagenia sp.

Since the burrowing Mayflies, (Hexagenia) comprise also a food item of some of the commercial fishes, it is of importance to consider whether this competition can have any effect on the fish supply. The degree of competition I consider to be wholly inconsequential. The abundance of burrowing Mayflies of Saginaw Bay on emergence, when the birds feed on them, rivals the accounts of Needham (1930:1). At the height of Mayfly emergence, the villages close to the bay are forced to extinguish their street lights so as to avoid attracting immense hordes of the so-called "fish flies". At times, the surface of the bay for many miles was observed covered by close-set windrows of the exuviae. A rough estimate of the number of exuviae observed at one time is about 3,000,000,000. As compared with this immense total at a single emergence, the total number of all insects estimated to have been eaten in an entire year by the Black Tern in Saginaw Bay (about 7,000,000 in 1930 and about 1,000,000 in 1931) is too low to cause any just alarm.

It should be observed, incidently, that a considerable percentage of the insects eaten by the Black Tern in 1931, are of species detrimental to agriculture.

B. THE STATUS OF THE BLACK TERN IN OTHER PLACES

In view of the results obtained, it will be important to glance at the findings of other investigators concerning the food of the Black Tern. This will present a comparison between the food of this species of bird in Saginaw Bay and in other places.

According to Hatch (1892:125) the Black Tern in Minnesota is entirely insectivorous.

Brewster (1878:190) did not find anything but macerated remains of small fishes in the few stomaches he examined. Bent (1921:296) on the other hand saw large numbers of this bird catching insects in the air and off the waving grasses. He believes that they have a preference for insect food when available. Both these reports were made from observations of this bird in Massachusetts.

Anderson (1907:125) has been cited by Bent (1921) to notice a large number of this bird following a man plowing, in search for grubs turned up by the plow.

Ridgeway (1909:250) believed that in Illinois, this bird frequents the reedy marshes, "hawking" for dragon flies, grasshoppers and other insects, over meadows or fields some distance from water.

Dawson (1903:569) reported that in Ohio, the food of this bird consists almost exclusively of insects which are obtained a-wing.

According to Bent (1921:296) the bird has been seen capturing the moths of the cotton-boll worm on the wing in the South. His wide experience as an

as an observer caused him to believe that the Black Tern is an insectivorous bird. He cites Thompson (1890:472) whose observations in Manitoba led him to believe that the Black Tern feeds on aquatic insects and insects with other types of habitat.

Knight (1908:65) thought that a large part of the food of this species in Maine consists of insects that were caught on the wing. From the manner of flying, he contends that aquatic swimming insects found near the surface may also be in included in the diet.

According to Eaton (1910:152) in New York the Black Tern searches for insects when flying over the marshes. On the lake, he noted that this bird plunges into the water for minnows.

Pearse and Achtenberg (1920:333) cited A. R. Cahn as seeing Black Terns in Wisconsin feeding on Perch.

Forbush (1925:129) maintained that in Massachusetts, the Black Tern is much more insectivorous than the Common Tern, and in its home lives chiefly on aquatic and land insects which it catches on the wing.

After an examination of 145 Black Tern stomachs, McAtee and Beal (1924:22) arrived at a conclusion that this bird does not prey on food fishes, but what they regarded as enemies of fish. They found that cyprinids and Fundulus compose a little more than 19 per cent of the contents recovered.

6. SUMMARY OF THE RELATION OF BLACK TERN TO COMMERCIAL FISHERIES OF SAGINAW BAY

The beneficial effects of the Black Tern in destroying obnoxious insects as the Western Grasshopper are sufficient to compensate in part for the very slight harm it may do the commercial fish supply. In 1931, when the birds were scarce and grasshoppers numerous, the destruction of insect pest

was of more significance than in 1930.

The results of this study appear to be in accord with those of others in that the species is primarily insectivorous. The harm done to the fishers, if any, is not sufficient to warrant the belief that the destruction of this species would have any beneficial effect on the fisheries.

VI. THE RELATION OF THE COMMON TERN TO THE COMMERCIAL FISHERIES OF SAGINAW BAY

Due to its abundance, this bird constituted the primary basis for the insistent indignation among the commercial fishermen of Saginaw Bay against all the "mimnie gulls". For the same reason, more emphasis was laid on the study of this bird than any of the other birds. Like the Black Tern, the Common Tern is a resident and the records were therefore grouped annually.

1. RESULTS FOR 1929

A. Lone-Tree Island

(See Table 11)

The first collection of the birds for study was made in the spring of 1929 at Lone Tree Island. From May 22 to May 31, 64 birds were collected. Of this number, 30 were females. After a few storms that spring, which caused the water to rise exceedingly high and almost entirely to submerge the tern's breeding ground, the birds deserted the place and moved over to Sand Point. At the latter place, a small island was formed as a result of the natural construction of small channels, and here the birds resumed their breeding. Here they enjoyed what Austin (1929)[14] believed to be the two prerequisites for a successful rookery of any species of tern, namely isolation from predatory enemies and accessibility to a constant supply of food.

On July 24 of the same year, a visit to Lone Tree Island yielded nine more birds, three of which were females.

A summary of the results presented in Table 11 shows 26 stomachs with fishes only, 23 stomachs with insects only (Plate V, Fig. 2), 17 stomachs with fishes and insects mixed and 7 empty.

Table 11

Record of Stomach Examinations of Common Tern

From Lone Tree Island, 1929

1.—♀ May 22; 2:00 P.M.: 1 Lake Shiner, tr; 1 Carpenter Ant, tr.
2.—♀ May 22; 6:00 P.M.: 1 mayfly, tr; 5 Carpenter Ants, .3 cc (pupae).
3.—♂ May 22; 2:00 P.M.: 1 Perch, .5 cc; 1 Spot-tail Shiner, .8 cc.
4.—♂ May 22; 6:00 P.M.: 40 mayflies, 7.0 cc; (P. Omisco-mayeus dropped).
5.—♀ May 23; 5:00 P.M.: 1 ground beetle, tr.
6.—♂ May 23; 5:30 P.M.: 1 ground beetle, tr.
7.—♂ May 23; 6:30 P.M.: 3 ground beetles, .2 cc (18 legs).
8.—♀ May 23; 1 Trout Perch, .2 cc.
9.—♂ May 23; 5:00 P.M.: 1 Trout Perch, 3.5 cc.
10.—♀ May 23; 5:00 P.M.: 1 Trout Perch, .2 cc (otoliths).
11.—♂ May 23; 5:00 P.M.: 1 Trout Perch, .5 cc.
12.—♂ May 24; 5:30 P.M.: 2 Trout Perch, 3.0 cc; 1 may beetle, tr. (fragments).
13.—♀ May 24; 7:30 P.M.: 1 Perch, .5 cc. (fragments); 1 Trout Perch, .1 cc (otoliths).
14.—♀ May 24; 2:00 P.M.: empty.
15.—♀ May 24; 7:30 A.M.: 1 Hoetuidae, tr; 1 Trout Perch, tr. -(fragments).
16.—♂ May 24; 7:30 A.M.: chitinous object, tr; (fragments).
17.—♀ May 25; 6:30 A.M.: 1 Trout Perch, 6.0 cc.
18.—♂ May 26; 10:00 A.M.: 1 Nine-spined Stickleback, .1 cc. (part).
19.—♀ May 26; 10:00 A.M.: empty.
20.—♀ May 26; 4:00 P.M.: 34 may beetles, 5.0 cc. House
21.—♂ May 26; 4:30 P.M.: 1 Lake Shiner, 2.5 cc; 2 mayflies; 1 Fly; 1 Western Grasshopper, tr; 1 ground beetle, tr. (fragments).
22.—♂ May 26; 4:00 P.M.: 2 Trout Perch, 2.0 cc; 16 may beetles, 3.0 cc.
23.—♂ May 26; 10:10 A.M.: 1 Trout Perch, tr. (fragments).
24.—♂ May 26; 7:00 P.M.: 1 Killi fish, .6 cc.
25.—♀ May 26; 10:00 A.M.: empty.
26.—♀ May 26; 10:00 A.M.: 1 Trout Perch, .2 cc.
27.—♀ May 27; 4:30 P.M.: 46 Carpenter Ants, 4.0 cc.
28.—♂ May 27; 5:45 P.M.: 1 Trout Perch, tr; 54 Carpenter Ants, 4.0 cc.
29.—♂ May 27; 6:00 P.M.: 1 Trout Perch, tr; 54 Carpenter Ants, 4.5 cc.
30.—♂ May 27; 4:30 P.M.: 39 Carpenter Ants, 3.5 cc.
31.—♀ May 27; 12:00 M: 1 Trout Perch, .7 cc.
32.—♀ May 27; 4:30 P.M.: 64 Carpenter Ants, 5.0 cc.
33.—♀ May 27; 4:30 P.M.: 29 Carpenter Ants, 2.5 cc.
34.—♂ May 27; 12:00 M: 5 Carpenter Ants, .3 cc (fragments).
35.—♂ May 28; 6:15 P.M.: 2 may beetles, .2 cc; 2 Carpenter Ants, tr.
36.—♀ May 28; 5:15 P.M.: 1 Trout Perch, 3.0 cc.
37.—♀ May 28.-4:00 P.M.: 51 Carpenter Ants, 3.5 cc (heads).
38.—♂ May 28; 9:14 A.M.: 1 Trout Perch, .2 cc; 15 Carpenter Ants, .2 cc (heads
39.—♂ May 28; 4:00 P.M.: 3 Carpenter Ants, .1 cc.
40.—♂ May 28; 6:15 A.M.: 1 Trout Perch, .2 cc; 9 Carpenter Ants, .3 cc.
41.—♀ May 28; 4:00 P.M.: 1 Perch, .3 cc; 1 Lake Shiner, 2.0 cc.
42.—♀ May 29; 6:30 A.M.: 1 ground beetles, tr.
43.—♂ May 29; 6:30 A.M.: 1 may beetle, .3 cc.
44.—♂ May 29; 5:15 P.M.: 1 Lake Shiner, .2 cc.

45.—♂ May 29; 6:30 A.M.: 7 Carpenter Ants, 1.0 cc.
46.—♀ May 29; 5:15 P.M.: 1 Lake Shiner, .8 cc.
47.—♂ May 29; 6:30 P.M.: 1 dragon fly naiad, .5 cc; 7 Carpenter Ants, .4 cc.
48.—♀ May 29; 5:15 P.M.: 1 may beetle, .3 cc; 5 Carpenter Ants, .4 cc.
49.—♀ May 29; 5:15 P.M.: empty.
50.—♂ May 29; 6:30 A.M.: 1 Trout Perch, tr.
51.—♀ May 30; 2:00 P.M.: 1 Trout Perch, 1.5 cc; 29 Carpenter Ants, 2 cc.
52.—♂ May 30; 5:00 P.M.: 1 Lake Shiner, .6 cc; 1 Carpenter Ant, tr.
53.—♂ May 30; 5:00 P.M.: 1 Trout Perch, tr; 26 Lamellicorn beetles, 4 cc.
54.—♂ May 30; 6:30 A.M.: empty.
55.—♂ May 30; 7:00 P.M.: 1 Trout Perch, 1.0 cc; 56 Carpenter Ants, 7 cc.
56.—♂ May 30; 7:00 P.M.: 1 Spot-tail Shiner, .3 cc; 1 Killifish, .4 cc.
1 Nine-spined Stickleback, .2 cc; 6 Carpenter Ants, .9 cc.
57.—♂ May 30; 7:00 P.M.: 2 Spot-tail Shiner, 6 cc; 13 Carpenter Ants, .4 cc.
58.—♂ May 30; 1:45 P.M.: 21 Carpenter Ants, 4 cc.
59.—♀ May 30; 6:30 A.M.: 2 Carpenter Ants, tr.
60.—♀ May 30; 6:30 A.M.: 2 Carpenter Ants, tr.
61.—♀ May 31; 6:30 A.M.: 2 Trout Perch, 9 cc.
62.—♂ May 31; 6:30 A.M.: 1 Trout Perch, .9 cc.
63.—♀ May 31; 6:30 A.M.: 3 Trout Perch, 3 cc; 1 Carpenter Ant, tr.
64.—♀ May 31; 6:30 A.M.: 1 Trout Perch, tr; 8 Carpenter Ants, .2 cc.
65.—♂ July 24; 3:00 P.M.: 1 Lake Shiner, tr.
66.—♂ July 24; 3:00 P.M.: 1 Lake Shiner, .2 cc; 1 Trout Perch, tr.
67.—♂ July 24; 3:00 P.M.: empty.
68.—♂ July 24; 3:00 P.M.: 1 Trout Perch, .2 cc.
69.—♂ July 24; 3:00 P.M.: 1 Lake Shiner, tr.
70.—♂ July 24; 3:00 P.M.: 4 Perch, 5.0 cc.
71.—♀ July 24; 3:00 P.M.: 1 Lake Shiner, .8 cc.
72.—♀ July 24; 3:00 P.M.: empty.
73.—♀ July 24; 3:00 P.M.: 1 Perch, .5 cc.

Numerically, there were included 8 commercial fish, solely Perch; 48 non-commercial fishes (Lake Shiner, Trout Perch, Spot-tail Shiner, Killifish and Nine-spined Stickleback); 673 insects of which the Carpenter Ant and the May Beetle figure conspicuously, while ground beetles, Mayflies (Hexagenia) House fly and Western Grasshopper comprised a small part.

Volumetrically, 6.6 cc. of commercial fish, 50.7 cc. of non-commercial fishes and 62.8 cc. of insects were measured. The commercial fishes were recovered five times and the non-commercial fishes, 43 times, while the insects were obtained from 45 stomachs.

B. Sand Point

The 1929 collection from Sand Point yielded 65 stomachs of the Common Tern, 22 of which were obtained by Dr. Miles D. Pirnie. The data show that

Table 12

Record of Stomach Examinations of Common Tern from Sand Point, 1929 [1]

1.—♂ June 24; 2:00 P.M.: 2 Lake Shiners, 2 cc.
2.—♀ June 24; 7:00 A.M.: 1 Trout-Perch, tr. (otoliths).
3.—♂ June 24; 2:00 P.M.: empty.
4.—♂ June 25; 10:30 A.M.: 1 Trout-Perch, tr. (otoliths); 2 mayflies, tr.
5.—♀ June 26; 8:00 A.M.: 1 Trout Perch, tr.
6.—♀ June 26; 8:00 A.M.: fish fragments.
7.—♂ June 26; 5:00 P.M.: empty.
8.—♀ June 26; 11:00 A.M.: 27 Perch, 7 cc.
9.—♀ June 26; 3:15 P.M.: fish fragments, tr.
10.—♂ June 26; 8:00 A.M.: 1 mayfly, tr. (fragments).
11.—♂ June 26; 5:00 P.M.: 1 Perch, 8.5 cc; 2 mayflies, 1 cc. (and fragments).
12.—♀ June 26; 11:00 A.M.: 2 Trout Perch, 3.5 cc.
13.—♂ June 26; 8:00 A.M.: insect fragments, tr.
14.—♀ June 26; 8:00 A.M.: 14 mayflies, 2 cc.
15.—♀ June 26; 8:00 A.M.: 5 mayflies, .2 cc. (fragments).
16.—♀ June 26; 11:00 A.M.: 39 mayflies, 7 cc.
17.—♀ June 26; 5:00 P.M.: empty.
18.—♂ June 26; 3:15 P.M.: 1 Lake Shiner, .2 cc.
19.—♀ June 26; 3:15 P.M.: 1 Perch, 1.5 cc; 3 Lake Shiners, 6 cc; 2 Trout-Perch, 3.5 cc; 13 mayflies, .5 cc.
20.—♂ June 26; 11:00 A.M.: 6 dragon fly naiads, 4.5 cc.
21.—♂ June 26; 3:15 P.M.: 1 Perch, .5 cc; 3 Lake Shiners, 3 cc.
22.—♂ June 26; 8:00 A.M.: 2 mayflies, tr. (fragments).
23.—♂ June 26; 8:00 A.M.: 2 Trout-Perch, tr.
24.—♂ June 28; 8:00 A.M.: 1 Trout Perch, tr. (otoliths).
25.—♀ June 29; 10:00 A.M.: insect fragments, tr.
26.—♂ June 29; 10:00 A.M.: 1 Trout Perch, 2.5 cc.
27.—♂ June 29; 10:00 A.M.: algae.
28.—♂ June 29; 10:00 A.M.: 1 Trout-Perch, tr.
29.—♂ June 30; 10:00 A.M.: 1 Trout Perch, 3 cc.
30.—♂ June 30; 7:00 P.M.: 1 Lake Shiner, 2 cc.
31.—♂ June 30; 10:00 A.M.: 1 Trout Perch, tr. (fragments).
32.—♀ June 30; 7:00 P.M.: fish fragments, tr.
33.—♀ July 1; 4:00 P.M.: 1 Trout Perch, tr.
34.—♂ July 1; 11:00 A.M.: fish fragments, tr.
35.—♂ July 1; 4:00 P.M.: 11 mayflies, 2.5 cc.
36.—♂ July 1; 9:30 A.M.: 2 Trout Perch, 4 cc.
37.—♂ July 1; 9:30 A.M.: chitinous fragments, tr.
38.—♂ July 1; 9:30 A.M.: 1 Trout Perch, tr; 1 mayfly, tr.
39.—♂ July 1; 4:00 P.M.: 2 Lake Shiners, 3 cc.
40.—♀ July 1; 4:00 P.M.: fish fragments; 1 mayfly, tr.
41.—♂ July 1; 4:00 P.M.: empty.
42.—♀ July 24; 2:00 P.M.: empty.
43.—♂ July 24; 2:00 P.M.: empty.
44.—○ May 29; 1 Lake Shiner, tr; 2 Nine-spined Stickleback, 1.5 cc; 18 Carpenter Ants, 3 cc.

45.--o May 29; 32 Carpenter Ants, 2 cc.
46.--o May 29; 1 Lamellicorn beetle, tr. - (thin chitin); 18 Carpenter Ants, 1 cc.
47.--o May 29; 49 Carpenter Ants, 3.5 cc.
48.--o May 29; 15 Carpenter Ants, tr.
49.--o May 29: 1 Perch, 1.5 cc.
50.--o May 29: 59 Carpenter Ants, 6 cc.
51.--o May 29: 29 Carpenter Ants, 3.5 cc.
52.--o June 13: 1 Lake Shiner, 5 cc; 1 dragon fly nymph, .7 cc.
53.--o June 13: 4 Trout Perch, 2 cc; (8 otoliths).
54.--o June 13: fish fragments, tr; 1 mayfly, tr.
55.--o June 13: 1 Trout Perch, 4 cc.
56.--o June 13: 1 Trout Perch, tr; 5 lamellicorn beetles, 2 cc.
57.--o June 13: fish fragments, tr.
58.--o June 13: fish fragments, tr; 2 dragon fly naiad, 2.7 cc.
59.--o June 14: 14 dragon fly naiad, 7.5 cc.
60.--o June 14: 3 Lake Shiners, 7 cc.
61.--o June 14: insect fragments, tr.
62.--o June 14; fish fragments, tr.
63.--o June 14: insect fragments, tr.
64.--o July 13: fish fragments, tr.
65.--o July 13: 2 Trout Perch, tr. (otoliths).

✓ Stomachs 44 to 65 listed in this Table were collected by Dr. Miles D. Pirnie.

the collection of 43 birds were made at intervals from 7:00 A.M. to 7:00 P.M.: The first date of collection was June 24 while the last was July 24. Dr. Pirnie obtained birds at occasional intervals from May 29 to July 13. Of the 43 birds for which the sexes was recorded 28 were males.

The 1929 Common Tern collection from Sand Point (Table 12) may be briefly summarized as follows: 30 stomachs had fish alone, seven of which were fragmentary, and could not be identified; 18 stomachs had insects only, four of which were unidentified as they were fragments of almost microscopic size; ten stomachs have mixed food, two of which were unidentifiable fragments.

There were included 31 commercial fish, all Perch, and 43 non-commercial fishes, of which the Trout Perch was represented by 26 individuals, and Lake Shiner by 17 specimens, and the Nine-spined Stickleback by 2. The 339 insects recovered were chiefly Carpenter Ants and mayflies; dragonflies and beetles were also recovered, but in smaller numbers.

The commercial fish recovered measured 19 cc.; the non-commercial fishes, 48.2 cc.; and the insects, 48.6 cc.

Commercial fish were noted five times; non-commercial fishes, 28 times, and insects 25 times.

C. Other localities

The analysis of some additional 1929 collections made by Dr. Miles D. Pirnie at Bay Port and Defoe, Waiscu and Little Charity Islands as shown in Table 13 shows that 7 out of 11 stomachs contained fish only, none of commercial species; three had nothing but insects, and one had a mixture of the two types. Numerically, 13 non-commercial fishes were recovered (9 Lake Shiners and 4 Trout Perch). Of the 10 individuals of insects recovered, seven were ground beetles and three were Carpenter Ants.

Table 13

Record of Stomach Examinations of Common Terns

From Different Places in Saginaw Bay, 1929

Collecting done by Dr. Miles D. Pirnie of the Michigan Department of Conservation.

1.--Sharpsteins Pt. Bay Port, May 28, 3 Lake Shiners, 11.5 cc.
2.--Maisou Island, May 28, 1 Carpenter Ant, tr.
3.--Defoe Island, May 28: 4 Lake Shiners, 2 cc. (parts of tail only).
4.--Defoe Island, May 28: 6 lamellicorn beetle, 1.5 cc. (mostly legs).
5.--Defoe Island, May 28: 2 Carpenter Ants, tr.
6.--Defoe Island, May 28: 1 Lake Shiner, tr.
7.--Little Charity Island, June 14: 1 Lake Shiner, 2.0 cc.
8.--Little Charity Island, June 14: 1 Trout Perch; 1 lamellicorn beetle.
9.--Little Charity Island, June 14: 1 Trout Perch.
10.--Little Charity Island, June 14: 1 Trout Perch.
11.--Little Charity Island, June 14: 1 Trout Perch.

Volumetrically, the non-commercial fishes measured 15.5 cc. while the insects made up only 1.5 cc. The non-commercial fishes were recovered from 8 stomachs while the insects were obtained from only 4 stomachs.

It is very interesting to note that the collections from Lone Tree, Maisou and Defoe islands on and about the 28th of May show that the Carpenter Ant comprised an important item in the diet of the bird at that time. These three islands are close to each other.

D. Summary for 1929

Table 14 presents a summarization of the data and computations of the food of the Common Tern in Saginaw Bay in 1929. This table is based on the examination of 149 stomachs. Of these 63 contained fish only, 44 nothing but insects, 28 both fish and insects, 1 a trace of algae; 12 were empty.

The birds were shot with an approach toward uniformity through their feeding hours; those taken at Lone Tree Island and Sand Point were shot at times indicated in the following tabulation:

Time Shot	No. of birds	Time shot	No. of birds	Time shot	No. of birds
6:30 A.M. to 8:30 A.M.	25	10:31 A.M. to 12:30 P.M.	6	4:31 P.M. to 6:30 P.M.	23
8:31 A.M. to 10:30 A.M.	16	12:31 P.M. to 2:30 P.M.	9	6:31 P.M. to 8:30 P.M.	7

Of the birds which were sexed, 68 were males and 48 were females.

The last column in the Table 14 gives the average number of individuals of each food item eaten in an average meal--that is, the average number found in each Tern stomach at any one time. In order to arrive at an approximate computation of the numbers of each food item eaten by all of the Common Terns in Saginaw Bay in the year, it is necessary to make some additional estimates of

1. The length of time required by the bird to digest its food.
2. The length of time the birds feed.
3. The number of times the daily ration exceeds the average meal ration.
4. The number of days the Common Tern inhabited the bay during the year.
5. The average number of birds per day present during the season.

A discussion of the assumptions and computations involved in obtaining a figure for each of these five estimates is given in the following paragraphs:

1. The length of time required by the bird to digest its food. The experiment to determine the time necessary for a Common Tern to digest its food were performed in 1930 and 1931.

Table 14

Data and Computations on the Food of the Common Tern in Saginaw Bay, 1929

Indicating the Value of the Different Food Items

Food types and items	Number of stomachs containing each item	Per cent of birds feeding at any given time on each item	Numberical determination by food items: Total no. recovered	Numberical determination by food items: Per cent in each type	Numberical determination by food items: Per cent in total food	Volumetric determination by food items: Total volume cc.	Volumetric determination by food items: Per cent in each type	Volumetric determination by food items: Per cent in total food	Number in ave. meal of bird
COMMERCIAL FISHES									
Perch (Perca flavescens).....	10	6.7	39	100.0	5.33	25.6	100.0	10.75	0.262
NON-COMMERCIAL FISHES									
Lake Shiner (Notropis atherinoides).	28	14.7	35	33.0	2.99	48.4	41.6	19.04	0.235
Spot-tail Shiner (Notropis hudsonius)..	3	2.0	4	3.8	0.34	7.1	6.1	2.79	0.027
Trout Perch (Percopsis omisco-maycus)	49	32.8	61	57.5	5.21	57.9	49.7	22.78	0.490
Killifish (Fundulus diaphanus menona).	2	1.3	2	1.9	0.17	1.2	1.0	0.47	0.013
Nine-spined Stickleback (Pungitius pungitius).....	3	200	4	3.8	0.34	1.8	1.6	0.71	0.027
INSECTS									
Carpenter Ant (C.h.novebora-censis).....	36	24.1	762	74.5	65.07	62.5	55.6	24.58	5.114
Mayfly (Hexagenia sp)	15	10.1	135	13.2	11.53	20.2	18.0	7.49	0.906
May Beetle (Phyllophaga sp.).....	7	4.7	81	7.9	6.92	10.8	8.6	4.25	0.544

Food types and items.	Number of stomachs containing each item	Per cent of birds feeding at any given time on each item	Numerical determination by food items: Total no. recovered	Per cent in each type	Per cent in total food	Volumetric determination by food items: Total volume cc.	Per cent in each type	Per cent in total food	Number in ave. meal of bird
INSECTS (Continued)									
Ground Beetle (Carabidae)	6	3.4	7	0.7	0.60	0.2	0.08	0.08	0.047
Lamellicorn Beetle (Scarabeidae)	3	2.0	11	1.1	0.94	3.5	3.1	1.38	0.073
Dragon Fly nymph	6	4.0	24	2.3	2.05	14.9	13.3	5.86	0.16
Western Grasshopper (Melanoplus mexicanus)	1	.6	1	0.1	0.09	tr.	tr.	tr.	0.007
Fly (Diptera)	1	.6	1	0.1	0.09	tr.	tr.	tr.	0.007
Owlet Moth (Noctuidae)	1	.6	1	0.1	0.09	tr.	tr.	tr.	0.007
Summary by Types									
Commercial fishes	10	6.7	39		3.33	25.6		10.74	.262
Non-commercial fishes	79	52.8	106		9.05	116.4		45.79	.711
Insects	75	50.1	1023		87.38	112.1		43.85	6.866
Totals	164		1168			254.1			7.839

Twenty-one crippled birds were fed from 1 to 6 Shiners (Lake Shiners and Mimic Shiners). The time when the fish was offered and when the stomach was opened were recorded. The condition of the fish in the stomach was also noted. This experiment may be questioned on the basis of using a crippled bird instead of a normal individual.[1] There might also be some difference in the rate of digestion due to unusual environmental conditions. The effect of forced feeding might affect the nerve center controlling the digestive apparatus. However, I regard the method used as yielding a sufficiently close approximation.

The experiments in both years showed that on the average, one to three adult Lake Shiners offered at one time, provided they are lodged in the gizzard, are almost completely gone in one hour and fifty minutes. Unfortunately, no data regarding the rate of digestion of Perch and insect food have been obtained. However, it may be assumed that while the heavily chitinized beetles take longer time to digest than a minnow, the soft-bodied mayflies and dragon flies ~~naiads~~ nymphs will undoubtedly take a somewhat shorter time to digest.

In view of these considerations, it is assumed for the purposes of approximate computations that the length of time it takes to digest the insects and fishes devoured is the same, one hour and fifty minutes.

2. The length of time the birds feed. Field observations have disclosed that the birds start feeding at about 5:00 A.M., and retire at about 8:00 P.M. This gives a feeding period of about 15 hours. During

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[1] Normal birds were not used because it was found futile to trap live ones unless young birds were sacrificed. Even at this risk, a live bird was fed, but it insistently refused to devour the fish offered. For some unknown reason, the nest was deserted by the mate and as a consequence, the young all died. Besides, it was thought advantageous to make use of a few crippled birds for purposes other than stomach examination.

this time there may be periods of increased and decreased feeding activity but the sampling was fairly representative of the entire feeding period (Table 15).

Table 15

Number of Stomachs Collected During the Periods Indicated and Per Cent Empty

Year	4:15 to 6:30	6:31 to 8:30	8:31 to 10:30	10:31 to 12:30	12:31 to 2:30	2:31 to 4:30	4:31 to 6:30	6:31 to 9:00
1929	-	25	16	6	9	28	23	7
1930	9	-	32	68	-	38	27	16
1931	48	6	58	63	31	34	24	89
Total	57	31	106	137	40	95	74	112
Per cent of empty stomachs	67	0	16	30	36	20	21	43

3. The number of times the daily ration exceeds the average meal's ration. The number of times the daily ration exceeds the meal ration is assumed to be approximately 8, because the time necessary to digest the food is about one-eighth of the feeding period.

The data show that the birds do not have food all the time, as shown in Tables 15 and 16. On the other hand, some of the birds may take new food before the last lot is digested. These are opposing factors, and from my experience with the birds, I believe they are approximately compensating. It may also be noted that the nesting females spend most of the time on the nest, and are often fed by the males. Generally, however, they go out to feed, usually for short periods but often for a longer time

Table 16

Per cent of birds with and without food at various hours of the day (all collections for which time was recorded, all year)

A. Early morning (to nearest quarter hr.)					B. Mid-day (to nearest half hr.)					C. Evening (to nearest quarter hr.)				
Time	No. of stomachs	% more than with tr.	% with trace	% empty	Time	No. of stomachs	% with more than tr.	% with tr.	% emp.	Time	No. of stomachs	% with food	% with tr.	% emp
4:15	2	-	-	100	8:15-8:30	-	-	-	-	5:15	7	100	-	-
4:30	2	-	-	100	8:45-9:00	16	81	6	12	5:30	27	19	26	37
4:45	1	-	-	100	9:15-9:30	21	62	38	-	5:45	1	100	-	-
5:00	16	27	16	56	9:45-10:00	13	46	38	15	6:00	8	63	25	12
5:15	-	-	-	-	10:15-10:30	46	51	30	20	6:15	1	100	-	-
5:30	13	23	-	77	10:45-11:00	23	35	30	34	6:30	2	100	-	-
5:45	-	-	-	-	11:15-11:30	19	53	26	21	6:45	-	-	-	-
6:00	11	82	-	18	11:45-12:00	46	47	17	37	7:00	11	91	9	-
6:15	1	100	-	-	12:15-12:30	15	63	7	27	7:15	3	67	-	33
6:30	28	50	30	19	12:45-1:00	10	50	-	50	7:30	28	19	10	71
6:45	-	-	-	-	1:15-1:30	26	42	11	46	7:45	13	46	15	38
7:00	1	-	100	-	1:45-2:00	29	45	17	38	8:00	22	45	5	50
7:15	-	-	-	-	2:15-2:30	44	77	4	9	8:15	7	29	28	43
7:30	2	-	100	-	2:45-3:00	32	65	22	12	8:30	7	43	28	28
7:45	-	-	-	-	3:15-3:30	11	46	36	18	8:45	-	-	-	-
8:00	15	54	46	-	3:45-4:00	17	70	12	18	9:00	11	37	27	36
					4:15-4:30	36	47	22	30					
					4:45-5:00	27	66	19	15					

early in the morning, early in the afternoon and in the evening. The nesting females apparently obtain meals by themselves less than 8 times a day, but the males in the nesting period no doubt go out more often than 8 times a day, on some of their trips to obtain food for the females. I think it a fair approximation to assume that the number of times the daily ration exceeds the meal ration is 8.

The first three factors are regarded as constant from year to year.

4. The number of days the Common Tern inhabited the bay during the year. In 1929, the Common Tern occurred on Saginaw Bay from May 5 to August 24, a period of 112 days. The short period of occupation of the bay in 1929 requires some explanation. The water was very high, and the breeding grounds poor and subject to overwash by storms (Plate I, fig. 2 and 3). The early abandonment of the Lone Tree Island colony, following heavy storms, has been mentioned already (page 20). The birds even after adopting the new rookery on Sand Point failed to rear any young to the age of a full day. The nests here were also subject to storm-wash (see Fig. 3). Even the eggs not lost by being wave-washed, were deserted by the birds. We assume this desertion was due to frequent heavy storms. The adult birds did not even return to the nestlings, after the egg-shells were thrown away (it is a habit of this species to pick up the shell after the chick had come out of the shell, as Jones, 1906: 43, has noted). As a result of this desertion, the young died, presumably from cold as they were noted to shiver. In some cases, they died while still in the egg. Under this condition, only a part of the bill could be seen through a small opening. A soft low call of agony could be heard then. The large Blue-bottle fly

Cynomyia cadaverina laid its eggs on the hatching bird and after a short time, the maggots of this fly could be seen in the egg infesting the dying young. The exposure of the eggs in 1929 is indicated by the fact that the periods of incubation observed (22, 24 and 29 days) were longer than the normal period of 21 days reported for this species by Jones (1906).

5. The average number of birds per day present during the season. Due apparently to the same adverse conditions that caused the birds to remain on the bay for a shorter period than normal in 1929, the number of birds on the bay that year was also very small. The average of rough daily occurrence estimates is 471 birds. In computing the average number of birds per day, no distinction was made of the sexes. Some errors may thus be introduced, but I do believe that they are not large enough to be serious, and they would be difficult to correct. The most important error may arise from the fact that the male brings food to the nesting female, as mentioned in the discussion of factor 2. According to the observations made on Lone Tree Island in 1930, the male brings the female most of her food during the incubation of the eggs, and also brings most of the food eaten by the young. As indicated in Table 23 all 22 birds shot carrying food into the rookery were males. Almost all of these birds were shot during the incubation.

Factors Nos. 4 and 5 are variable and require separate estimates each year.

An estimate of the total number of each food item eaten by the Common Tern in one year may be obtained by use of the formula presented on page 26; in other words, by multiplying the numerical value of each

item in a single meal of the bird (given in last column of Table 14), by the estimates for points 3, 4 and 5 just as outlined. The results comprise roughly as follows:

Commercial fish		
Perch fingerling		111,000
Non-commercial fishes		
Lake Shiners	100,000	
Spot-tail Shiners	11,000	
Trout Perch	174,000	
Menoma Killifish	55,000	
Nine-spined Sticklebacks	11,000	
Total non-commercial fish		351,000
Insects		
Carpenter Ants	2,158,000	
Brown Drake (Mayfly)	382,000	
May Beetle	230,000	
Dragon fly naiad	88,000	
Lamellicorn Beetle	31,000	
Ground beetle	20,000	
Noctuid moth Western Grasshopper House fly	9,000	
Total insects		2,898,000

It will be observed that in 1929, the Common Tern in Saginaw Bay ate about ~~14~~ 117 ,000 Perch fingerlings (approximately one-thirtieth of the total food computed numerically; ~~57,800~~ 351,000 non-commercial fishes and ~~562,000~~ 2,898,000 insects. Trout Perch comprised the greater part of the non-commercial fishes, while Carpenter Ants outnumbered the other insects eaten, according to the figures as given. It is probable, however, that the number of ants computed as eaten is too high, because the collecting was heaviest at a period when the ants were flying. If the collection had been better distributed, the estimate for ants would doubtless have been lower, and that for other insects and perhaps fishes would have been higher.

2. RESULTS FOR 1930

The work in 1930 was started with more adequate plans, and thus more results were obtained than in 1929. This was partly due to the fact that more experience in handling the birds had been attained. Besides, the water had gone down and the birds appeared to their regular breeding grounds in greater number than in the previous year. A total of 240 birds were collected from ten places as compared to 149 birds from five places of the previous year. A few experiments concerning the relation of the birds to the fishes were performed.

A. Sand Point

One of the first places of field study where collecting was done in 1930 was at Sand Point. A total of 45 birds, fewer than those obtained in 1929, was collected here from May 22 to July 25 (Table 17). Of this number 30 were males and 15 were females.

Table 17

Record of Stomach Examinations of Common Tern from Sand Point, 1930

1.—♀ May 22; 2:30 P.M.: 1 lamellicorn beetle, tr.
2.—♂ May 22; 2:30 P.M.: 24 Lake Shiners, 17 cc.
3.—♀ May 22; 2:30 P.M.: 14 Lake Shiners, 7 cc.
4.—♀ May 22; 2:30 P.M.: empty.
5.—♂ May 22; 2:30 P.M.: 1 Lake Shiner, 2 cc.
6.—♀ May 22; 2:30 P.M.: fish fragments, tr.
7.—♀ May 22; 2:30 P.M.: empty.
8.—♀ May 22; 2:30 P.M.: 1 Spot-tail Shiner, 2.2 cc.
9.—♂ May 23; 2:00 P.M.: 1 Lake Shiner, .5 cc; 1 Killifish, 1.5 cc.
10.—♂ May 23; 2:30 P.M.: empty.
11.—♀ May 29; 1:30 P.M.: 1 Perch, 1 cc.

12.—♀ May 29; 1:30 P.M.: 1 Perch, .5 cc; 1 Blunt-nose Minnow, 2 cc. and fish fragments.
13.—♂ May 29; 1:30 P.M.: fish fragments; 4 lamellicorn beetles, tr.
14.—♂ May 29; 1:30 P.M.: 1 Johnny Darter, .3 cc; 2 dragon fly nymphs, 1cc.
15.—♂ May 29; 1:30 P.M.: 1 Perch, 2 cc; 2 Lake Shiners, 2 cc.
16.—♂ May 29; 1:30 P.M.: 1 Perch, 3.5 cc.
17.—♂ June 2; 12:15 P.M.: 1 Lake Shiner, 2 cc.
18.—♀ June 5; 5:30 P.M.: insect fragments, tr.
19.—♀ June 5; 5:30 P.M.: fish fragments, tr; insect fragments, tr.
20.—♂ June 5; 5:30 P.M.: 1 Perch, 1 cc.
21.—♂ June 5; 5:30 P.M.: 1 Lake Shiner, .5 cc; 1 dragon fly fragments, tr.
22.—♂ June 11; 10:00 A.M.: fish fragments, tr.
23.—♂ July 12; 2:30 P.M.: 1 Lake Shiner, .6 cc.
24.—♂ July 12; 2:30 P.M.: 4 Lake Shiners, 2.5 cc.
25.—♂ July 12; 2:30 P.M.: 1 Pike Perch, 1.2 cc.
26.—♂ July 12; 2:30 P.M.: fish fragments, tr.
27.—♂ July 12; 2:30 P.M.: 5 Perch, 1.3 cc; 5 Lake Shiners, 2.4 cc; 1 Spot-tail Shiner, .8 cc.
28.—♂ July 12; 2:30 P.M.: 5 Lake Shiners, 2 cc.
29.—♂ July 12; 2:30 P.M.: fish fragments, tr.
30.—♂ July 12; 2:30 P.M.: 1 Perch, .6 cc; 3 Lake Shiner, 1 cc.
31.—♂ July 25; 11:30 A.M.: 2 Lake Shiners, 2.5 cc.
32.—♀ July 25; 11:30 A.M.: 1 Lake Shiner, tr.
33.—♀ July 25; 11:30 A.M.: empty.
34.—♂ July 25; 11:30 A.M.: 1 Lake Shiner, 2 cc.
35.—♂ July 25; 11:30 A.M.: 1 Lake Shiner, 2 cc.
36.—♂ July 25; 11:30 A.M.: 1 Lake Shiner, tr.
37.—♂ July 25; 11:30 A.M.: fish fragments, tr.
38.—♀ July 25; 11:30 A.M.: 1 Lake Shiner, .2 cc.
39.—♀ July 25; 11:30 A.M.: empty.
40.—♂ July 25; 11:30 A.M.: ~~2 Lake Shiners, 1 cc.~~ empty
41.—♂ July 25; 11:30 A.M.: 2 Lake Shiners, 1 cc.
42.—♂ July 25; 11:30 A.M.: 5 Lake Shiners, 2.5 cc.
43.—♂ July 25; 11:30 A.M.: 1 Lake Shiner, tr. (teeth only).
44.—♂ July 25; 11:30 A.M.: fish fragments, tr.
45.—♀ July 25; 11:30 A.M.: 1 Lake Shiner, tr. (teeth only).

Of the 45 stomachs collected, 33 had fishes, six of which were unidentifiable because of the remains were almost microscopic. Only two stomachs had nothing but insect remains. Four had a mixture of insects and fishes while six were empty.

There were included 12 commercial fishes, 11 Perch and one Pike-Perch, 83 non-commercial fishes, 78 of which were Lake Shiners. Other

non-commercial fishes represented were the Spot-tail Shiner, Menona Killifish, Bluht-nose Minnow and Johnny Darter. There were traces of eight lamellicorn beetles.

Volumetrically, the commercial fishes measured 11.1 cc., the non-commercial fishes, 56.4 cc. and the insects 1 cc.

The commercial fishes were recovered from eight stomachs, the non-commercial fishes in 27 stomachs and the insects in four stomachs.

B. Bay Port

From Bay Port, 20 stomachs were obtained in the spring and fall of 1930 (Table 18). The first was obtained on May 22 and the last was on October 26. It should be noted that these late records were of migrating birds which had come to Saginaw Bay on their southward journey. Out of nine birds collected in the spring, one was a female and the others were males. The fall collection consisted wholly of young birds.

Table 18

Record of Stomach Examinations of Common Tern

From Bay Port, 1930

1.---♂ May 22; 1 Killifish, 1.5 cc; 1 lammellicorn beetle, tr.
2.---♂ May 28; 11:00 A.M.: insect and fish fragments, tr.
3.---♂ May 28; 11:00 A.M.: 1 Spot-tail Shiner, 3.5 cc; 4 mayflies, 1 cc.
4.---♂ May 28; 11:00 A.M.: insect anf fish fragments, tr.
5.---♂ May 29; 9:15 A.M.: 1 Lake Shiner, tr. (teeth).
6.---♀ May 29; 9:15 A.M.: fish fragments, tr.
7.---♂ May 31; 5:00 P.M.: 1 Perch, 2 cc.
8.---♂ May 31; 12:30 M.M; 1 Killifish, 3 cc. (one Perch 84 mm. dropped).
9.---♂ May 31; 5:00 P.M.: 1 Killifish, 1.5 cc.
10.---4m October 26: 2:30 P.M.: 4 Perch, 10 cc. (longest 57 mm.)
111--1m October 26; 2:30 P.M.: 2 Straw-colored Shiners, .6 cc; 3 Lake Shiners, 2 cc.

12.--im October 26; 2:30 P.M.: 3 Perch, 12.5 cc.
13.--im October 26; 2:30 P.M.: 3 Perch, 9.5 cc; 5 Black-nosed Shiners, 3.5 cc.
14.--im October 26; 2:30 P.M.: 6 Lake Shiners, 4 cc.
15.--im October 26; 3:30 P.M.: 3 Perch, 9.5 cc.
16.--im October 26; 2:30 P.M.: 3 Perch, 9.5 cc.
17.--im October 26; 2:30 P.M.: 4 Perch, 11 cc.
18.--im October 26; 2:30 P.M.: 5 Perch, 7 cc.
19.--im October 26; 2:30 P.M.: 3 Perch, 7.5 cc.
20.--im October 26; 2:30 P.M.: 5 Lake Shiners, 5 cc.

The figures presented in Table 18 may be briefly summarized as follows: 17 stomachs contained nothing but fish, one of which was unidentifiable, three had mixed food, one of which could not be determined exactly.

Numerically there were 29 commercial fishes, all Perch; 26 non-commercial fishes, largely Lake Shiners and five insects, four of which were Brown Drakes.

Volumetrically, the Perch made up 84.5 cc., the non-commercial fishes 24.6 cc. and the insects 1.0 cc.

Perch were recovered from ten stomachs, non-commercial fishes from ten stomachs and the insects from two stomachs.

C. Gaseville and Vicinity

The 12 birds collected from this vicinity, including two shot near Oak Point, were obtained on three dates; May 22, May 24 and June 4 (Table 19).

Table 19

Record of Stomach Examinations of Common Tern From Gaseville and Vicinity, 1930

1.--♂ May 22; 4:00 P.M.: 1 Lake Shiner, 2.5 cc.
2.--♂ May 22; 5:30 P.M.: 3 Lake Shiners, 5.5 cc.
3.--♂ May 24; 2:00 P.M.: empty.
4.--♂ May 24; 2:00 P.M.: 8 mayflies, .8 cc (and fragments).

5.—♂ May 24; 2:00 P.M.: empty.
6.—♀ May 24; 2:00 P.M.: 1 Spot-tail Shiner, 2.5 cc.
7.—♂ June 4; 3:00 P.M.: 1 Perch, 2.8 cc.
8.—♂ June 4; 3:00 P.M.: 3 Lake Shiners, 4 cc.
9.—♂ June 4; 3:00 P.M.: fish fragments, tr.
10.—♂ June 4; 3:00 P.M.: 2 Lake Shiners, 2 cc.
11.—♀ June 4; 2:00 P.M.: 4 Lake Shiners, 6 cc. (near Port Crescent).
12.—♂ June 4; 2:00 P.M.: 6 Lake Shiners, 9 cc. (near Port Crescent).

The collection consisted of 10 males and 2 females.

The table shows that 9 out of 12 stomachs contained fish, one an insect and two were empty.

Numerically, there were included only one Perch, 20 non-commercial fishes, (all Lake Shiners except one Spot-tail ~~Minnow~~ Shiner) and 6 Brown Drakes.

In bulk, the Perch made up 2.8 cc., the non-commercial fishes 31.5 cc. and the insects 0.8 cc.

Like the Perch, the insects were recovered from only one stomach, while the non-commercial fishes were recovered from seven stomachs.

D. Sebewaing Bay

The birds collected around Lone Tree Island outside of their breeding area were considered as comprising the Sebewaing Bay Collection. In 1930, 14 birds were collected in this area. Of the 10 which were mature, 7 were males. All were feeding when shot. The collection was made at intervals from May 25 to September 13 (Table 20).

Table 20

Record of Stomach Examinations of Common Tern From Sebewaing Bay, 1930

1.—♀ May 25; 10:30 A.M.: fish and beetle fragments, tr. (North Point).
2.—♂ May 25; 10:30 A.M.: empty. (North Point).
3.—♂ May 26; 10:00 A.M.: 1 Lake Shiner, .8 cc (mouth of Sebewaing River).

4.--♀ June 2; 12:15 P.M.: 1 Perch, 1.5 cc; insect fragments, tr. (Fish Point).
5.--♂ June 2; 12:15 P.M.: 1 Lake Shiner, .5 cc; 1 dragonfly nymph, .5 cc (Fish Point).
6.--♂ June 2; 12:15 P.M.: fish fragments, tr. (Fish Point).
7.--♂ July 19; 9:45 A.M.: 1 Lake Shiner, 1.5 cc (mouth of Sebewaing River).
8.--♂ July 19; 8:30 P.M.: 1 Perch, .6 cc (mouth of Sebewaing River).
9.--♂ July 21; 9:45 A.M.: 1 Lake Shiner, .2 cc (mouth of Sebewaing River).
10.--♀ ←im July 27; 3:45 P.M.: 3 Perch, 1 cc. (mouth of Sebewaing River).
11.--♂ July 27; 3:45 P.M.: 1 Golden Shiner, 4.5 cc (mouth of Sebewaing River).
12.--♀ July 27; 3:45 P.M.: empty (mouth of Sebewaing River).
13.--♀ ←im September 12; 10:45 P.M.: empty (mouth of Sebewaing River).
14.--♀ ←im September 13; fish fragments, tr. (mouth of Sebewaing River).

It may be noted that 8 of the stomachs examined fish only were found, three stomachs had mixed food and the remaining three were empty.

These stomachs contained 5 Perch, 5 non-commercial fishes (4 Lake Shiners and 1 Golden Shiner) and 1 dragonfly nymph which was the only insect representative.

The commercial fish were represented volumetrically by 3.1 cc., the non-commercial fishes by 7.5 cc. and the insects by 0.5 cc.

The commercial fish was recovered from 3 stomachs, the non-commercial fishes from 5 stomachs and the insects from 1 stomach.

B. Lone Tree Island

At Lone Tree Island the most extensive collection and observation of 1930 was made. Shooting was done at occasional intervals from June 1 to September 13, and at different periods of the day from 4:30 A.M. to 8:30 P.M. (Table 21). A total of 86 birds were collected. Eleven of the birds collected late in the summer were young. Some of them were probably transients from their more northern colonies to their winter homes that joined the group of young birds from Lone Tree Island.

Table 21

Record of Stomach Examinations of Common Tern

From Lone Tree Island, 1930

1.—♂ June 1; 12:30 P.M.: fish fragments, 1 dragonfly, tr; 1 stink bug, .1 cc (a Trout Perch 84 mm long dropped).
2.—♂ June 1; 12:30 P.M.: 11 Lake Shiner, 4 cc. (a Lake Shiner dropped).
3.—♂ June 17; 4:30 P.M.: 1 Perch, tr. 1 lamellicorn beetle, tr. (A Lake Shiner dropped).
4.—♂ June 17; 4:30 P.M.: 1 Lake Shiner, tr; micro-crustaceans possibly from the fish (A Lake Shiner dropped).
5.—♂ June 17; 4:30 P.M.: chitinous fragments, tr. (A Perch dropped).
6.—♂ June 17; 4:30 P.M.: 2 Lake Shiners, 2 cc. (A Lake Shiner dropped).
7.—♂ June 17; 4:30 P.M.: 23 mayflies, 2.5 cc. (A Trout Perch dropped).
8.—♂ June 17; 4:30 P.M.: 6 Lake Shiners, 11 cc. (Band 371827; A Lake Shiner dropped).
9.—♂ June 18; 1 Trout Perch, tr. (A Lake Shiner,dropped).
10.—♂ June 18; 2 Lake Shiners, 4 cc. (Band 401444; A Lake Shiner dropped).
11.—♂ June 18; 2 Lake Shiners, 2.2 cc. (A Trout Perch dropped).
12.—♂ June 18; 1 Lake Shiner, .2 cc; 16 Mayflies, .5 nymphs (A L ake Shiner dropped).
13.—♂ June 21; 5:00 P.M.: 7 Lake Shiners, 15 cc.
14.—♂ June 21; 5:00 P.M.: 17 Carpenter Ants, .7 cc; (thorax and heads mostly).
15.—♂ June 21; 5:00 P.M.: 1 Lake Shiner, .8 cc; 1 Black-nose Shiner, 1 cc. (A Lake Shiner dropped).
16.—♂ June 21; 5:00 P.M.: 3 Lake Shiner, 4.5 cc; 1 mayfly, tr. (A Lake Shiner dropped).
17.—♂ June 21; 5:00 P.M.: 3 mayflies, tr.
18.—♂ June 21; 5:00 P.M.: 21 Carpenter Ants, 1.5 cc. (heads, etc; A Lake Shiner dropped).
19.—♂ June 22; 6:00 P.M.: chitinous fragments, tr. (A Lake Shiner dropped).
20.—♂ June 22; 6:00 P.M.: 3 mayflies, tr.
21.—♂ June 22; 6:00 P.M.: 24 Perch, 4 cc; 2 Lake Shiners, 2 cc. (the largest 80 mm long; a Lake Shiner dropped).
22.—♂ June 22; 6:00 P.M.: 11 Lake Shiners, 16 cc. (A Lake Shiner dropped).
23.—♂ June 24; 7:00 P.M.: 4 Lake Shiners, 6.2 cc; 1 Spot-tail Shiner, .3 cc.
24.—♂ June 24; 7:00 P.M.: 2 Lake Shiner, 1 cc; 3 Blunt-nose Shiner, 5 cc.
25.—♂ June 24; 7:00 P.M.: 13 Perch, 2 cc; 3 Pike-Perch, 2 cc.
26.—♂ June 24; 7:00 P.M.: fish fragments, tr. (Trout Perch dropped).
27.—♂ June 28; 6:15 P.M.: empty.
28.—♀ June 28; 6:15 P.M.: 4 mayflies, .6 cc; (and fragments).
29.—♀ June 28; 6:15 P.M.: empty.
30.—♀ June 30; 1:45 P.M.: 4 Perch, 1.2 cc; 4 mayflies, tr.
31.—♂ June 30; 1:45 P.M.: 3 Pike Perch, 5.5 cc; 15 Lake Shiners, 7 cc.
32.—♀ June 30; 1:45 P.M.: empty.
33.—♀ June 30; 1:45 P.M.: empty.
34.—♂ June 30; 1:45 P.M.: empty.
35.—♂ July 1; 10:45 A.M.: 2 Lake Shiners, 1 cc. (Lake Shiner dropped).
36.—♀ July 1; 10:45 A.M.: empty.
37.—♂ July 1; 10:45 A.M.: 6 Pike Perch, 4 cc; 4 Lake Shiners, 3 cc. (Band 410543; A Lake Shiner dropped).

38.—♂ July 1; 10:45 A.M.: 3 Lake Shiners, 3 cc; (A Lake Shiner dropped).
39.—♀ July 2; 5:00 A.M.: empty.
40.—♀ July 2; 4:30 A.M.: empty.
41.—♀ July 2; 5:00 A.M.: 1 Trout Perch, 3 cc. (anterior half gone).
42.—♀ July 2; 4:30 A.M.: empty.
43.—♂ July 2; 5:00 A.M.: 1 Perch, 8 cc. (17 mm. long minus head).
44.—♂ July 2; 5:00 A.M.: empty.
45.—♂ July 2; 5:00 A.M.: fish fragments, tr.
46.—♂ July 2; 5:00 A.M.: empty
47.—♂ July 2; 4:30 A.M.: empty.
48.—♂ July 3; 7:45 P.M.: empty.
49.—♂ July 3; 7:45 P.M.: empty.
50.—♀ July 3; 7:45 P.M.: 3 mayflies, tr.
51.—♂ July 4; 6:00 P.M.: empty.
52.—♂ July 24; 8:30 P.M.: 6 Lake Shiners, 3 cc.
53.—♀ July 24; 8:30 P.M.: empty.
54.—♂ July 24; 8:30 P.M.: 2 Perch, 2 cc; 1 Lake Shiner, .5 cc; 1 Trout Perch, 1.5 cc.
55.—♀ July 24; 8:30 P.M.: empty.
56.—♂ July 24; 8:30 P.M.: fish fragments, tr.
57.—♀ July 24; 8:30 P.M.: fish fragments, tr.
58.—♂ July 24; 8:30 P.M.: 5 Lake Shiners, 2 cc. (all tail parts).
59.—♂ July 25; 5:00 P.M.: 4 Lake Shiners, 3 cc.
60.—♂ July 25; 5:00 P.M.: 1 Trout Perch, 2 cc. (bird found following morning).
61.—♂ July 25; 5:00 P.M.: 1 Trout Perch, tr. (two otoliths).
62.—♂ August 6; 8:10 P.M.: empty.
63.—♀ August 6; 8:10 P.M.: 6 Perch, 2 cc.
64.—♀ August 6; 8:10 P.M.: 3 Lake Shiners, 2 cc.
65.—♀ August 6; 8:10 P.M.: fish fragments, tr.
66.—♂ August 20; 4:15 P.M.: 7 Perch, 8.5 cc.
67.—♂ August 20; 4:15 P.M.: fish fragments, tr. (Band A354839).
68.—♂ August 20; 4:15 P.M.: fish fragments, tr.
69.—♂ August 20; 4:15 P.M.: empty.
70.—♂ August 20; 4:15 P.M.: empty.
71.—♂ August 20; 4:15 P.M.: empty.
72.—♂ August 20; 4:15 P.M.: empty.
73.—♂ August 20; 4:15 P.M.: fish fragments, tr.
74.—♂ August 20; 4:15 P.M.: empty.
75.—♀ August 20; 4:15 P.M.: 2 Perch, 3 cc.
76.—♂im August 20; 4:15 P.M.: 6 Lake Shiners, 3 cc. (Band A374287).
77.—♂←im August 20; 4:15 P.M.: 2 Perch, 1.3 cc (Band A374100).
78.—♂←im August 20; 4:15 P.M.: 1 Lake Shiner, tr. (Band A354076).
79.—♂←im August 21; 1:30 P.M.: empty.
80.—♂←im August 21; 1:30 P.M.: empty.
81.—♂←im August 21; 1:30 P.M.: 4 Perch, 6 cc.
82.—♂←im August 21; 2:00 P.M.: empty.
83.—♂←im August 21; 2:00 P.M.: fish fragments, tr.
84.—♂←im August 21; 2:00 P.M.: fish fragments, tr.
85.—♂←im August 21; 4:00 P.M.: empty.
86.—♂←im September 12; 3:30 P.M.: 1 Perch, .5 cc.

A point was made also during this period of shooting birds carrying fish, in their bills, most frequently Lake Shiners. Twenty-two such birds, all males were shot. It was observed (as also in 1931) that one bird never carried more than one fish at a time. This observation does not agree with that of Mr. Franklin E. Campbell, who was cited by Forbush (1925:108) as maintaining that a Tern carried three or four fish at a time in its bill. My observation, however, corraborates one from Altyre, Scotland (1847:1879) where it was noted that the birds fly up to their young with every sand-eel caught.

Out of 86 stomachs studied, 27 were empty. This rather high rate is partly due to the circumstance that quite a number of the birds were shot very early in the morning, when most of them are still empty.

A total of 79 commercial fishes were recovered, 67 of which were Perch and the balance of which were Pike-Perch. The non-commercial fishes were represented by 112 individuals, and of these the Lake Shiner appeared in most of the samples. Brown Drakes (Hexagenia), Carpenter Ants, and Mayflies (Ephemera) in order of their abundance, comprise most of 98 insects recovered.

By volume, Perch measured 38.5 cc., Pike-Perch, 9.5 cc., the non-commercial fishes 109.8 cc. and the insects 5.9 cc.

Perch were recovered from 12 stomachs, Pike-Perch from three; the non-commercial fishes from 34 and the insects from 12.

F. Arenac County

In three periods from June 6 to July 31, seven birds (5 males, 2 females) were collected from Arenac County (Table 22). All the birds obtained were feeding and possibly had their colonies at Big Charity Island.

Table 22

Record of Stomach Examinations of Common Tern

From Arenac County, 1930

1.—♀ June 6; 1 Lake Shiner, 1 cc; 4 mayflies, tr. (near Au Gres).
2.—♂ June 6; 22 mayflies, 2 cc. (near Au Gres).
3.—♂ June 7; fish fragments, tr. (near mouth of Rifle River).
4.—♂ June 7; 2 mayflies, fragments, tr. (near mouth of Rifle River).
5.—♂ July 31; 5 Perch, 3 cc. (near mouth of Rifle River).
6.—♀ July 31; 1 Perch, 2 cc; 2 Lake Shiners, 2.5 cc; 1 Trout Perch, .8 cc. (near mouth of Rifle River).
7.—♂ July 31; 9 Lake Shiner, 7 cc; 1 Trout Perch, tr. 1 lamellicorn beetle, .5 cc; 1 tiger moth, .5 cc.

A summary of the study of this collection indicated that three stomachs contained fish only, two insects and two with mixed fish and insect food.

Six commercial fish, all Perch, 14 non-commercial fish and 30 insects were recovered.

By volume, the commercial fish displaced 5 cc., the non-commercial fishes 11.3 cc. and the insects 3 cc.

Commercial fish were recovered from two stomachs; non-commercial fishes and insects from five each.

G. Pinconning

In 1930, fifteen birds were collected from Pinconning at four different periods from June 7 to September 15 (Table 23).

Table 23

Record of Stomach Examinations of Common Tern

From Pinconning, 1930

1.—♂ June 7; 3:30 P.M.: fish fragments, tr.
2.—♂ June 7; 3:30 P.M.: 3 mayflies, tr.
3.—♂ June 7; 3:30 P.M.: 15 mayflies, 2 cc.
4.—♂ July 31; 5 Lake Shiners, 5 cc.

5.—♂ July 31; 7 Lake Shiners, 10.5 cc.
6.—♀ August 19: fish fragments, tr.
7.—♂ August 19: 5 Perch, 5.5 cc.
8.—♂ August 19: 5 Perch, 5.5 cc.
9.—♂ August 19: 5 Perch, 4 cc.
10.—♂ August 19: 6 Perch, 4.5 cc.
11.—♂ August 19: 1 Perch, 1 cc.
12.— September 15; 3:00 P.M.: 1 Perch, 2 cc.
13.—♂ September 15; 5:15 P.M.: 1 Perch, 2 cc; 1 Western Grasshopper, 1 cc.
14.—♀ September 15; 5:15 P.M.: 3 Perch, 6 cc. (Band A354091; 1 Lake Shiner, 1.5 cc,dropped).
15.—♀ September 15; 5:15 P.M.: 3 Perch, 6.5 cc; 1 Lake Shiner, 3 cc.

The figures in Table 23 show that 12 out of the 15 stomachs studied had fish only, 2 had insects and 1 had mixed fish and insect food.

There were recovered 29 Perch, making up a volume of 35 cc., 14 non-commercial fish, all Lake Shiners with a displaced volume of 20 cc., and 19 insects, mostly Brown Drakes, which measured 3 cc.

The Perch were obtained from 9 stomachs, Lake Shiners from 4 and insects from 3.

H. Defoe Island and vicinity

On three dates from June 8 to June 25, 1930, 12 birds were obtained from Defoe Island (Table 24).

Table 24

Record of Stomach Examinations of Common Tern From Defoe Island and Vicinity, 1930

1.—♀ June 8; 12:00 M: 1 Lake Shiner, 1 cc; 1 Trout Perch, 2 cc; 1 Log Perch, 5.5 cc.
2.—♂ June 8; 12:00 M: 1 Spot-tail Shiner, 3 cc.
3.—♂ June 8; 12:00 M; fish fragments, tr.
4.—♂ June 8; 12:00 M: empty.
5.—♂ June 8; 12:00 M: empty.
6.—♂ June 20; 4:30 P.M.: 11 Lake Shiners, 7.5 cc (tails mostly; 1 Lake Shiner dropped).
7.—♂ June 25; 5:30 P.M.: 4 Perch, 1 cc; 19 Lake Shiner, 7 cc.
8.—♂ June 25; 5:30 P.M.: 1 Spottail Shiner, 3 cc. (Lake Shiner dropped).
9.—♀ June 25; 5:30 P.M.: 8 Trout Perch, tr. (3 otoliths).
10.—♂ June 25; 5:30 P.M.: 1 Perch, tr. (fragments).
11.—♀ June 25; 5:30 P.M.: 1 Perch, tr. (fragments).
12.—♀ June 25; 5:30 P.M.: chitinous fragments, tr.

The collection from Defoe Island in 1930 included 9 stomachs with fish only, one with insect fragments, and two that were empty.

There were five Perch with a volume of 1 cc and 37 non-commercial fishes measuring 29 cc.

Perch were noted twice, the non-commercial 8 times and insect fragments once.

I. Big Charity Island

A day's visit to the Big Charity Island, far out from shore in the mouth of Saginaw Bay, on June 23, 1930, yielded 14 birds (Table 25). All the birds were obtained about 9:30 A.M..

Table 25

Record of Stomach Examinations of Common Tern

From Big Charity Island, 1930

1.—♂ June 23; 9:30 A.M.: 1 lamellicorn beetle, tr. (1 Spot-tailed Shiner dropped).
2.—♂ June 23; 9:30 A.M.: 3 mayflies, tr. (1 Trout-Perch dropped).
3.—♂ June 23; 9:30 A.M.: 4 Lake Shiners, 6.5 cc.
4.—♀ June 23; 9:30 A.M.: 34 mayflies, 2 cc.
5.—♀ June 23; 9:30 A.M.: 5 mayflies, tr.
6.—♂ June 23; 9:30 A.M.: 10 mayflies, 1 cc. (and fragments)
7.—♀ June 23; 9:30 A.M.: 5 mayflies, tr.
8.—♂ June 23; 9:30 A.M.: 5 mayflies, tr.
9.—♂ June 23; 9:30 A.M.: 5 mayflies, tr.
10.—♂ June 23; 9:30 A.M.: 3 mayflies, 1 cc.
11.—♂ June 23; 9:30 A.M.: 34 mayflies, 3 cc.
12.—♂ June 23; 9:30 A.M.: 1 Lake Shiner, 1.3 cc.
13.—♂ June 23; 9:30 A.M.: 16 mayflies, 2.5 cc. (and fragments).
14.—♂ June 23; 9:30 A.M.: 1 Perch, 2 cc.

The data show that 3 stomachs had nothing but fish, while 11 others had insects only, mainly Brown Drakes.

One Perch with a volume of 2 cc. was recovered. The non-commercial fishes (Lake Shiner only) were represented by 5 individuals having a total volume of 7.8 cc, obtained in 2 stomachs, Insects, 111 in all, making a total volume of 9.5 cc. were collected from 11 stomachs.

J. Tawas City

On July 30, 1930, fourteen birds were obtained near the north point of the bay. They were taken while congregating with a few herring gulls about an old dock near Tawas City. The results of the examination are shown in Table 26.

Table 26

Record of Stomach Examinations of Common Tern From Tawas City, 1930

1.--July 30; 2:30 P.M.: 8 Perch, 5 cc; 2 mayflies fragments, tr.
2.--July 30; 2:30 P.M.: 6 Lake Shiners, 4.5 cc.
3.--July 30; 2:30 P.M.: 4 Perch, 3 cc.
4.--July 30; 2:30 P.M.: 1 Perch, 1 cc; 6 Lake Shiner, 3 cc.
5.--July 30; 2:30 P.M.: 1 Perch, .5 cc; 7 mayflies, tr.
6.--July 30; 2:30 P.M.: 3 Perch, 2 cc; 1 stink bug, 1 cc.
7.--July 30; 2:30 P.M.: 3 Perch, 1.5 cc.
8.--July 30; 2:30 P.M.: 1 Lake Shiner, 1 cc.
9.--July 30; 2:30 P.M.: insect fragments, tr.
10.--July 30; 2:30 P.M.: empty.
11.--July 30; 2:30 P.M.: 1 Perch, .5 cc.
12.--July 30; 2:30 P.M.: 1 Perch, 1 cc.
13.--July 30; 2:30 P.M.: 1 Lake Shiner, 1 cc.
14.--July 30; 2:30 P.M.: fish fragments, tr.
15.--[illegible]m August 18; 1:30 P.M.: 1 Log Perch, 1.5 cc.

The figures show that 10 stomachs had fish only, 1 had nothing but an insect fragment, 3 had mixed fish and insect food and 1 was empty.

A total of 22 Perch with a total displacement of 14.5 cc. was recovered from 8 stomachs. 15 non-commercial fish, mostly Lake Shiners and measuring 13 cc. were recovered five times. Ten individual insects with a recorded volume of 1 cc. were noted four times.

K. Summary of stomach examination for 1930

Table 27 presents the data and computations of the food of the Common Tern in Saginaw Bay in 1930. The data are based on the studies of 240 stomachs collected from 10 places. Of these, 149 had fish only, either commercial,

Table 27

Data and Computations on the Food of the Common Tern

in Saginaw Bay, 1950

Food types and items	Number of stomachs containing each item	Per cent of birds feeding at any given time on each item	Numerical determination by food items: Total no. recovered	Numerical determination by food items: Per cent in each types	Numerical determination by food items: Per cent in total food	Volumetric determination by food items: Total volume cc.	Volumetric determination by food items: Per cent in each type	Volumetric determination by food items: Per cent in total food	Number in avg meal of bird
COMMERCIAL FISHES									
Perch (Perca flavescens).....	55	22	176	93.1	21.28	196.3	94.8	36.83	0.733
Pike-Perch (Stizostedion vitreum).....	4	1.6	13	6.9	1.57	10.7	5.2	2.01	0.054
NON-COMMERCIAL FISHES									
Blunt-nose Minnow (Hyborhynchus notatus).....	2	8	4	1.2	0.48	7.0	2.3	1.31	0.017
Golden Shiner (Notemigonus c. crysoleucas)...	2	8	1	0.3	0.12	4.5	1.5	0.84	0.004
Lake Shiner (Notropis atherinoides)..76		30.4	293	88.5	35.42	245.4	81.4	46.04	1.221
Black-nose Shiner (Notropis heterolepis)...	2	.8	6	1.8	0.72	4.5	1.5	0.84	0.025
Spot-tail Shiner (Notropis hudsonius hudsonius)..5		2.0	7	2.1	0.85	15.3	5.1	2.87	0.029
Johnny Darter (Boleosma nigrum nigrum).....1		.4	1	0.3	0.12	0.2	0.1	0.04	0.004
Log Perch (Percina caprodes semifasciata)...2		8	2	0.6	0.24	7.0	2.3	1.31	0.008
Trout Perch (Percopsis omiscomaycus).....	10	4.0	11	3.3	1.33	9.3	3.1	1.74	0.046

Food types and items	Number of stomachs containing each item	Per cent of birds feeding at any given time on each item	Numerical determination by food items: Total no. recovered	Per cent in each type	Per cent in total food	Volumetric determination by food items: Total volume cc.	Per cent in each type	Per cent in total food	Number in ave. meal of bird
Killifish (Fundulus diaphanus menona)	4	1.6	4	1.2	0.48	7.5	2.5	1.41	0.017
INSECTS									
Mayfly (Hexagenia sp)	25	10.0	238	77.8	28.77	18.6	75.3	3.49	0.992
Mayfly (Ephemera sp)	1	.4	16	5.2	1.93	0.3	1.2	0.06	0.067
Carpenter Ant (C. herculeanus noveboracensis)	2	.8	38	12.4	4.59	2.2	8.9	0.41	0.158
Stink Bug (Pentatomidae)	2	.8	2	0.7	0.24	1.1	4.4	0.21	0.008
Lamellicorn beetle (Scarabaeidae)	6	2	9	2.9	1.09	0.5	2.01	0.09	0.037
Dragon fly (Leucorrhina intacta)	1	.4	1	0.3	0.12	tr.	tr.	tr.	0.004
Tiger moth (Arctiidae)	1	.4	1	0.3	0.12	0.5	2.0	0.09	0.004
Dragon fly naiad	1	.4	1	0.3	0.12	0.5	2.0	0.09	0.004
Western Grasshopper (Melanoplus mexicanus)	1	.4	1	0.3	0.12	1.0	4.0	0.19	0.004
Summary by Types									
Commercial fish	59	5.6	189		22.85	207.0		38.84	.787
Non-commercial fishes	105	42.0	351		80.00	301.3		56.52	1.379
Insects	39	15.6	307		37.10	24.7		4.65	1.278
Total	203	81.2	821		99.95	533.0		99.99	3.444

non-commercial or a mixture of both types; 29 had insects; 21 had a mixture of fish and insect food, and 41 were empty. The birds were shot at scattered periods through their feeding hours as shown below:

Time Shot	No. of birds	Time shot	No. of birds	Time shot	No. of birds	Time shot	No. of birds
4:30 A.M. to 6:30 A.M.	9	8:31 A.M. to 10:30 A.M.	32	12:31 P.M. to 2:30 P.M.	-	4:31 P.M. to 6:30 P.M.	27
6:31 A.M. to 8:30 A.M.	7	10:31 A.M. to 12:30 A.M.	68	2:31 P.M. to 4:30 P.M.	33	6:31 P.M. to 8:30 P.M.	16

The records show that 144 males, 51 females and 25 young Common Terns were studied. A few were not sexed.

As for the previous year the last column in the table (27) gives the average number of individuals of each food item assumed to be taken by one Common Tern at one feeding time. An estimate of total destruction caused by all the Common Terns in Saginaw Bay during the period of their occurrence in 1930 was obtained by the method used for the 1929 sample, as indicated on page 77.

By estimating the number of birds occurring in several places at occasional intervals, it was estimated that an daily average of 1880 feeding birds were in the bay in 1930 for a period of 190 days (from May 5 to November 10). This estimate was made to include all the Common Terns that feed in Saginaw Bay. During the first week of May, there were found a few birds which were supposed to be transients in the region, hesitating on their way to pick up fish here and there. Similarly, later in the season, a few of the migrating birds stopped at certain colonies in Saginaw Bay and joined the young that were preparing for their southern journey.

The first record of their occurrence in 1930 was on May 5. It was supposed that only 50 birds were present in the whole Saginaw Bay on this date. This increased little by little until about the 20th of May, when

about 1,000 birds were supposed to occur. The height of their increase was attained at about the end of the first week in June when 3,700 birds were supposed to be in residence. The greatest number of these occurred at Lone Tree Island. At about this date (June 10), 1,167 nests were counted on the island. It was estimated that at about this time, 3,000 birds occurred in Lone Tree Island, 200 on Pitcher's Reef, 300 on Sand Point and 200 on Big Charity Island. This number was maintained until about the 14th of July when a few young birds were able to take care of themselves. The adults then started to leave for some other places, presumably more southern than this bay. The number began to decline gradually but was supposed to fluctuate as sometimes a few birds from the north would come and feed in the bay. By September 1, there were supposed to be present 1,000 feeding birds. All breeding birds must have gone by this time. This number of 1,000 was believed to be maintained as late as September 17, as those leaving were constantly replaced by the birds coming from more northern colonies. A gradual decline was noted thereafter with occasional fluctuation. Most, if not all, the birds present beginning with the early part of September were young of the year.

Having calculated or estimated the average ration for each meal of the Common Tern in 1930 the number of times each bird refills its stomach, every day, the average daily abundance of birds and the period of their residence in the bay, the estimate of the total number of each item of food eaten by all the feeding Common Terns in Saginaw Bay for 1930 may be roughly approximated as follows:

Commercial fishes	
Perch	1,959,000
Pike-Perch	144,000
Total commercial fishes	2,103,000

Non-commercial fishes	
Blunt-nose Minnow	45,000
Lake Shiner	3,264,000
Spot-tail Shiner	78,000
Black-nose Shiner	67,000
Trout Perch	123,000
Menona Killifish	45,000
Other fishes	62,000
Total non-commercial fishes	3,685,000
Insects	
Mayfly (Brown Drake)	2,652,000
Mayfly (Mackerel)	179,000
Carpenter Ant	422,000
Lamellicorn Beetles	99,000
Other insects	62,000
Total insects	3,416,000

L. Food of the young

It will be observed that the estimates given in the preceding paragraphs deal only with the feeding birds. They do not include the items eaten by the young terns when they were dependent upon the parents for food.

From an observation described on page 16 (20), it was definitely proved that the fish offered to the young were freshly killed, but the number of fish given each day was not observed until in 1931. This observation will be described later (pp. 119-122). We need repeat here, for purposes of computation, only the results obtained.

On the average a young Tern was found to be fed each day 18 fish. The fish so utilized consisted of 5 per cent Spot-tail Shiners, 5 percent Perch, 5 per cent Trout Perch and 85 per cent Lake Shiners.

Artificially fed young Common Terns ate a minimum of three and a maximum of 65 minnows, or 126 mayflies, daily for three days. The bird however, when fed a minimum diet showed signs of debility on the fourth day of feeding. (Plate VIII, fig. 2 (3)) shows a bird artificially reared part of the time on a minimum and part of the time on a maximum diet, in

comparison with two others of the same age fed by their parents.) The minimum number of three minnows were offered at three different periods; one in the morning, one at about 2:00 P.M. and another at about 8:00 P.M. while the maximum number was given ad libitum the whole day from 5:30 A.M. to about 8:00 P.M. (The Heinroths (1928:61)) fed a C ommon Tern with small fish and observed that there is a preference in the kind they devour.

It was also observed that the young birds become independent at about the 20th day after hatching. However, they generally start to be fed when they are two days old, very seldom on their third day, as also observed by Jones (1906:42) A period of feeding the young for 18 days is therefore utilized for the computations given below.

An estimate of the number of young being fed is rendered very difficult because of unsettled climatic conditions, starvation, imperfect sitting, parental desertion and invasion of predators (Plate VII, fig. 1). These factors caused heavy and sporadic losses, which were very difficult to analyze. Lack of food and long drought were suggested by Galloway and Thompson (1914:271) as causes of mortality. Floyd (1925:58) believed that sun and rain destroyed young Terns in large numbers. A further difficulty lies in the rather long period over which the young are hatched, causing continuous additions to the stock of young. The first young in 1930 were hatched on the second day of July; hatching then continued until about the latter part of July but had its height about the end of the first week and the first part of the second week in July.

In view of these difficulties it was only possible to make a rough estimate, which is that about 1000 birds were reared to the flying stage in 1930, and that about 2000 had failed to reach the flying stage, but had

been fed for an average of five days.[1]

By using the data obtained above, it is computed that the 1000 birds during their stage of dependency would have eaten 342,000 fish, as follows:

17,100 Perch	17,100 Trout Perch
17,100 Spot-tail ~~Minnows~~ Shiners	290,700 Lake Shiners.

The birds that had not reached the flying stage, assuming that they were fed on an average of five days each, would have consumed 180,000 fish as follows:

9,000 Perch	9,000 Trout Perch
9,000 Spot-tail ~~Minnows~~ Shiners	153,000 Lake Shiners

The result of this estimating is that the dependent young Common Terns in Saginaw Bay in 1930 ate:

26,000 Perch finglerings	26,000 Spot-tail Shiners
443,000 Lake Shiners	26,000 Trout Perch

M. Summary for 1930

Briefly summarizing, the Common Tern in Saginaw Bay in 1930 are estimated to have eaten:

1,986,000 Perch fingerlings
144,000 Pike-Perch fingerlings
4,182,000 non-commercial fishes, largely Lake Shiners
3,417,000 insects

This shows that the birds had eaten about 11 times as many Perch as had been destroyed in 1929, which was a very unfavorable year for the Terns in the bay. The Pike-Perch fingerlings, eaten to the estimated total of 144,000 in 1930 represented an addition to the known dietary of the Common Tern. About twelve times as many non-commercial fishes as were estimated to have been eaten

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[1] About 70 young were reared at Big Charity Island and the rest were from Lone Tree Island. For no known reason, no young was reared at the colony in Sand Point although there were evidences that the eggs were hatched there. It is very likely that the young had been molested by either mammalian or avian predators which could not be resisted by the few Common Terns occurring there. It might be mentioned that on June 11, 1931, a Snowy Owl (Nyctea nyctea) was shot at Lone Tree Island. From its stomach a head and two wings of a Common Tern were recovered (Manuel, 1931:502).

in 1929, were included in the bill of the food for 1930. An increase of about 500,000 insects were also registered in the total food from 1929 to 1930.

The significance to the commercial fisheries of this destruction of fish life will be discussed in a latter section of this report.

3. RESULTS FOR 1931

In 1931, a total of 353 Common Terns was collected from five places. There was a notable increase of birds in and around Lone Tree Island as a result of very low water which caused the exposure of more surface area within the island and the existence of one islet suitable for their breeding at about one kilometer to the northwest. On the other hand, the breeding ground at Sand Point was totally given up by the birds, due perhaps to its direct connection to the mainland as a result of the elimination of the channels that surrounded this place in the two preceding years.

Further observations were conducted in 1931 to check (1) the period of digestion of a number of fish; (2) to find which of the adults bring fish to the nest, and (3) the quantity and kinds of food fed to the nestlings.

A. Lone Tree Island

From Lone Tree Island 307 birds, representing 87 per cent of the year's collection, were obtained from May 24 to July 25 (Table 28).

Table 28

Record of Stomach Examinations of Common Tern

From Lone Tree Island, 1931

1.—♀ May 24; 1:00 P.M.: empty.
2.—♂ May 24; 1:00 P.M.: 20 Lake Shiners, 7 cc. (carrying shiner).
3.—♂ May 24; 1:00 P.M.: 2 Perch, 3 cc; 1 Lake Shiner, .5 cc
4.—♂ May 24; 1:00 P.M.: empty.
5.—♂ May 24; 1:00 P.M.: empty.

6.—♂ May 24; 1:00 P.M.: empty.
7.—♂ May 24; 1:00 P.M.: 3 Perch, 5.5 cc.
8.—♀ June 11; 7:30 P.M.: 2 Lake Shiners, 8 cc.
9.—♀ June 11; 7:30 P.M.: 1 Perch, .5 cc; 3 Carpenter Ants, tr.
10.—♀ June 11; 7:30 P.M.: 2 Carpenter Ants, tr.
11.—♀ June 11; 7:30 P.M.: empty.
12.—♀ June 11; 7:30 P.M.: empty.
13.—♀ June 11; 7:30 P.M.: 2 Carpenter Ants, tr.
14.—♀ June 11; 7:30 P.M.: empty.
15.—♀ June 11; 7:30 P.M.: empty.
16.—♀ June 11; 7:30 P.M.: empty.
17.—♀ June 11; 7:30 P.M.: empty.
18.—♂ June 11; 7:30 P.M.: empty.
19.—♂ June 11; 7:30 P.M.: empty.
20.—♂ June 11; 7:30 P.M.: 3 Carpenter Ants, tr. (thorax).
21.—♂ June 11; 7:30 P.M.: empty.
22.—♂ June 11; 7:30 P.M.: empty.
23.—♂ June 11; 7:30 P.M.: empty.
24.—♂ June 11; 7:30 P.M.: empty.
25.—♂ June 11; 7:30 PM.: empty.
26.—♂ June 11; 7:30 P.M.: empty.
27.—♂ June 11; 7:30 P.M.: empty.
28.—♂ June 11; 7:30 P.M.: empty.
29.—♂ June 11; 7:30 P.M.: empty.
30.—♂ June 11; 7:30 P.M.: empty.
31.—♂ June 11; 7:30 P.M.: empty.
32.—♂ June 11; 7:30 P.M.: empty.
33.—♂ June 11; 7:30 P.M.: 1 Perch, 1 cc. (carrying shiner).
34.—♂ June 11; 7:30 P.M.: 4 Lake Shiners, 8 cc.
35.—♂ June 11; 8:00 P.M.: 8 Lake Shiners, 10 cc; 1 Mayfly, tr. (band 371037).
36.—♂ June 11; 8:00 P.M.: 7 Lake Shiners, 9 cc.
37.—♂ June 11; 8:00 P.M.: 1 Lake Shiner, .5 cc.
38.—♂ June 11; 8:00 P.M.: 1 Lake Shiner, tr.
39.—♂ June 11; 8:00 P.M.: empty.
40.—♂ June 11; 8:00 P.M.: empty.
41.—♂ June 11; 8:00 P.M.: empty.
42.—♂ June 11; 8:00 P.M.: 2 Lake Shiners, 2 cc.
43.—♂ June 11; 8:00 P.M.: empty.
44.—♀ June 11; 8:00 P.M.: empty.
45.—♀ June 11; 8:00 P.M.: empty.
46.—♀ June 11; 8:00 P.M.: 1 Lake Shiner, .4 cc.
47.—♀ June 11; 9:00 P.M.: empty.
48.—♀ June 11; 9:00 P.M.: 2 Lake Shiners, 1.5 cc.
49.—♂ June 11; 9:00 P.M.: empty.
50.—♂ June 11; 9:00 P.M.: 2 Beetles, tr. (mandibles).
51.—♂ June 11; 9:00 P.M.: 1 Perch, 2 cc; 5 Lake Shiners, 4 cc.
52.—♂ June 11; 9:00 P.M.: 1 Lake Shiner, .5 cc.
53.—♂ June 11; 9:00 P.M.: 1 Lake Shiner, tr.
54.—♂ June 11; 9:00 P.M.: 1 Lake Shiner, tr.
55.—♂ June 11; 9:00 P.M.: 1 Lake Shiner, 1 cc.
56.—♂ June 11; 9:00 P.M.: empty.

57.—♂ June 11; 9:00 P.M.: empty.
58.—♀ June 12; 4:15 A.M.: empty.
59.—♀ June 12; 4:15 A.M.: empty.
60.—♂ June 12; 5:00 A.M.: 3 Perch, 1 cc; 2 Lake Shiners, 1.5 cc.
61.—♂ June 12; 5:00 A.M.: 1 Perch, 2 cc.
62.—♂ June 12; 5:00 A.M.: empty.
63.—♂ June 12; 5:00 A.M.: empty.
64.—♂ June 12; 5:00 A.M.: 1 Perch, tr.
65.—♂ June 12; 5:00 A.M.: empty.
66.—♂ June 12; 5:00 A.M.: 6 Carpenter Ants, tr. (thorax).
67.—♂ June 12; 5:00 A.M.: empty.
68.—♂ June 12; 5:00 A.M.: empty.
69.—♂ June 12; 5:00 A.M.: empty.
70.—♂ June 12; 11:00 A.M.: empty.
71.—♂ June 12; 11:00 A.M.: empty.
72.—♂ June 12; 11:00 A.M.: 1 Lake Shiner, tr.
73.—♂ June 12; 11:00 A.M.: 1 Perch, tr.
74.—♂ June 12; 11:00 A.M.: 1 Lake Shiner, tr.
75.—♂ June 12; 11:00 A.M.: empty.
76.—♂ June 12; 11:00 A.M.: empty.
77.—♂ June 12; 11:00 A.M.: empty.
78.—♂ June 12; 11:00 A.M.: 1 lamellicorn beetles, tr.
79.—♂ June 12; 11:00 A.M.: empty.
80.—♀ June 12; 12:00 M: 1 Perch, 1 cc.
81.—♀ June 12; 12:00 M: empty.
82.—♀ June 12; 12:00 M: 1 Perch, tr; 1 lamellicorn beetle, tr.
83.—♀ June 12; 12:00 M: empty.
84.—♀ June 12; 12:00 M: 1 Lake Shiner, .5 cc; 2 dragon fly nymphs, 2 cc.
85.—♀ June 12; 12:00 M: 3 mayflies, tr; 1 dragon fly nymph, .5 cc.
86.—♀ June 12; 12:00 M: 1 Spot-tail Shiner, .5 cc.
87.—♀ June 12; 12:00 M: 1 Lake Shiner, tr.
88.—♀ June 12; 12:00 M: empty.
89.—♀ June 12; 12:00 M: 1 Perch, .2 cc.
90.—♀ June 12; 12:00 M: 1/ lamellicron beetle, tr.
91.—♀ June 12; 12:00 M: 11 dragon fly nymphs, 6 cc.
92.—♀ June 12; 12:00 M: empty.
93.—♂ June 12; 12:00 M: 5 Lake Shiners, 7 cc. (Band 372506).
94.—♂ June 12; 12:00 M: 1 Lake Shiner, 2 cc; 1 Spot-tail Shiner, 2 cc; 1 dragon fly nymph, tr.
95.—♂ June 12; 12:00 M: 2 dragon fly nymphs, 1 cc.
96.—♂ June 12; 12:00 M: 13 dragon fly nymphs, 6.5 cc.
97.—♂ June 12; 12:00 M: 1 Lake Shiner, .4 cc; 4 Spot-tail Shiners, 3 cc; 1 dragon fly nymph, .5 cc.
98.—♂ June 12; 12:00 M: empty.
99.—♂ June 12; 12:00 M: empty.
100.—♂ June 12; 12:00 M: empty.
101.—♂ June 12; 12:00 M: 1 Cyprinidae, tr.
102.—♂ June 12; 12:00 M: empty.
103.—♂ June 12; 12:00 M: 3 mayflies, .5 cc; 1 dragon fly nymph, .5 cc.
104.—♂ June 12; 12:00 M: empty.
105.—♂ June 12; 12:30 P.M.: 2 Perch, 2 cc.
106.—♂ June 12; 12:30 P.M.: 7 dragon fly nymph, 4 cc.
107.—♀ June 12; 12:30 P.M.: 2 Spot-tail Shiner, .5 cc (tail only).

108.--♀ June 12; 12:30 P.M.: empty.
109.--♀ June 12; 12:30 P.M.: 1 Trout Perch, 2 cc.
110.--♂ June 12; 12:30 P.M.: empty.
111.--♂ June 12; 12:30 P.M.: empty.
112.--♂ June 12; 5:30 P.M.: empty.
113.--♂ June 12; 5:30 P.M.: empty.
114.--♂ June 12; 5:30 P.M.: empty.
115.--♂ June 12; 5:30 P.M.: empty.
116.--♂ June 12; 5:30 P.M.: empty.
117.--♂ June 12; 5:30 P.M.: empty.
118.--♂ June 12; 5:30 P.M.: 1 Lake Shiner, tr.
119.--♂ June 12; 5:30 P.M.: 1 Lake Shiner, tr. (Band 432571).
120.--♂ June 12; 5:30 P.M.: 5 mayflies, tr.
121.--♂ June 12; 5:30 P.M.: 6 dragon fly nymph, 3 cc.
122.--♀ June 12; 5:30 P.M.: empty.
123.--♀ June 12; 5:30 P.M.: empty.
124.--♀ June 12; 5:30 P.M.: empty.
125.--♀ June 12; 5:30 P.M.: empty.
126.--♀ June 12; 5:30 P.M.: 1 Perch, 1 cc; 2 Lake Shiners, 1.5 cc; 3 mayflies. tr.
127.--♀ June 12; 5:30 P.M.: 1 Lake Shiner, 2 cc; 1 Trout Perch, 3 cc.
128.--♂ July 6; 8:30 P.M.: 11 Lake Shiner, 7 cc.
129.--♂ July 6; 8:30 P.M.: empty.
130.--♂ July 6; 8:30 P.M.: empty.
131.--♂ July 6; 8:30 P.M.: empty.
132.--♂ July 6; 8:30 P.M.: empty.
133.--♀ July 6; 8:30 P.M.: empty.
134.--♀ July 6; 8:30 P.M.: empty.
135.--♀ July 10; 5:30 A.M.: empty.
136.--♀ July 10; 5:30 A.M.: empty.
137.--♀ July 10; 5:30 A.M.: empty/
138.--♀ July 10; 5:30 A.M.: empty.
139.--♀ July 10; 5:30 A.M.: empty.
140.--♀ July 10; 5:30 A.M.: empty.
141.--♀ July 10; 5:30 A.M.: empty.
142.--♀ July 10; 5:30 A.M.: empty.
143.--♀ July 10; 5:30 A.M.: empty.
144.--♀ July 10; 5:30 A.M.: 12 Perch, 5 cc.
145.--♂ July 10; 5:30 A.M.: 1 Perch, 2 cc; 1 Blunt-nose Minnow, .5 cc. (Band 401559).
146.--♂ July 10; 5:30 A.M.: 5 Perch, 1 cc; 1 Trout Perch, 2 cc. (Band 372837).
147.--♀ July 10; 10:30 A.M.: 1 Lake Shiner, tr.
148.--♀ July 10; 10:30 A.M.: empty.
149.--♀ July 10; 10:30 A.M.: 1 Perch, tr.
150.--♀ July 10; 10:30 A.M.: 1 Lake Shiner, tr; 1 Spot-tail Shiner, tr.
151.--♂ July 10; 10:30 A.M.: 1 Lake Shiner, tr. (carrying fish).
152.--♂ July 10; 10:30 A.M.: 1 Lake Shiner, tr. (carrying fish).
153.--♂ July 10; 10:30 A.M.: empty (carrying fish).
154.--♂ July 10; 10:30 A.M.: 1 Lake Shiner, tr. (carrying fish).
155.--♂ July 10; 10:30 A.M.: 4 Lake Shiners, 2 cc. 1 Trout Perch, 2 cc.
156.--♂ July 10; 10:30 A.M.: 5 Lake Shiners, 7 cc (carrying fish).
157.--♂ July 10; 11:45 A.M.: 1 Lake Shiner, tr.
158.--♂ July 10; 11:45 A.M.: 2 Lake Shiners, 1.5 cc.
159.--♂ July 10; 11:45 A.M.: 1 Spot-tail Shiner, .5 cc.
160.--♂ July 10; 11:45 A.M.: 1 Spot-tail Shiner, 3 cc.

161.—♂ July 10; 11:45 A.M.: 2 Lake Shiners, 2 cc.
162.—♀ July 10; 11:45 A.M.: empty.
163.—♀ July 10; 11:45 A.M.: empty.
164.—♀ July 10; 11:45 A.M.: 1 Lake Shiner, tr.
165.—♀ July 10; 11:45 A.M.: 1 Trout Perch, tr.
166.—♀ July 10; 11:45 A.M.: 1 Trout Perch, 2 cc.
167.—♂ July 10; 3:00 P.M.: 9 Lake Shiners, 6 cc. (carrying shiner).
168.—♂ July 10; 3:00 P.M.: 5 Lake Shiners, 5 cc. (carrying shiner).
169.—♂ July 10; 3:00 P.M.: 8 Lake Shiners, 5 cc. (carrying shiner).
170.—♂ July 10; 3:00 P.M.: 1 Spot-tail Shiner, .5 cc (carrying shiner).
171.—♂ July 10; 3:00 P.M.: 2 Lake Shiners, tr. (carrying shiner).
172.—♂ July 10; 3:00 P.M.: 1 Lake Shiner, tr. (carrying shiner).
173.—♂ July 10; 3:00 P.M.: 3 Lake Shiners, 2 cc. (carrying shiner).
174.—♂ July 10; 3:00 P.M.: 2 Lake Shiners, 1 cc.
175.—♀ July 10; 3:00 P.M.: 2 Lake Shiners, 1 cc.
176.—♀ July 10; 3:00 P.M.: 1 Lake Shiner, tr. (carrying shiner).
177.—♀ July 10; 3:00 P.M.: empty (carrying shiner).
178.—♂ July 14; 6:00 A.M.: 7 Lake Shiners, 3 cc.
179.—♂ July 14; 6:00 A.M.: 4 Lake Shiners, 2 cc.
180.—♂ July 14; 6:00 A.M.: 3 Lake Shiners, 1 cc.
181.—♂ July 14; 6:00 A.M.: 1 Lake Shiner, 1 cc; 3 Perch, 1 cc.
182.—♂ July 14; 6:00 A.M.: 1 Lake Shiner, .5 cc.
183.—♂ July 14; 6:00 A.M.: 1 Lake Shiner, 1 cc.
184.—♀ July 14; 6:00 A.M.: empty.
185.—♀ July 14; 6:00 A.M.: empty.
186.—♀ July 14; 6:00 A.M.: 1 Lake Shiner, tr.
187.—♀ July 14; 6:00 A.M.: 4 Lake Shiners, 2 cc.
188.—♀ July 14; 6:00 A.M.: 2 Perch, 1 cc.
189.—♂ July 14; 12:00 M: empty.
190.—♂ July 14; 12:00 M: empty.
191.—♂ July 14; 12:00 M: empty.
192.—♀ July 14; 12:00 M: 1 Spot-tail Shiner, tr.
193.—♀ July 14; 12:00 M: empty.
194.—♀ July 14; 12:00 M: empty.
195.—♂ July 16; 3:30 P.M.: 1 Trout Perch, tr.
196.—♂ July 16; 3:30 P.M.: empty.
197.—♂ July 16; 3:30 P.M.: 1 Spot-tail Shiner, 1 cc.
198.—♀ July 16; 3:30 P.M.: empty.
199.—♂ July 20; 12:30 M: 3 Lake Shiner, 2 cc.
200.—♀ July 20; 1:30 P.M.: empty (carrying fish).
201.—♀ July 20; 1:30 P.M.: 2 Lake Shiners, 1 cc.
202.—im July 20; 1:30 P.M.: 2 Lake Shiners, 1 cc.
203.—im July 20; 1:30 P.M.: 1 Spot-tail Shiner, 2 cc.
204.—im July 20; 1:30 P.M.: empty.
205.—♀ July 20; 1:30 P.M.: 4 Lake Shiners, 2 cc.
206.—♀ July 20; 1:30 P.M.: empty.
207.—♀ July 20; 1:30 P.M.: empty.
208.—♀ July 20; 1:30 P.M.: empty.
209.—♀ July 20; 1:30 P.M.: empty.
210.—♀ July 20; 1:30 P.M.: 5 Lake Shiners, 5 cc.
211.—♂ July 20; 1:30 P.M.: empty.
212.—♂ July 20; 1:30 P.M.: empty.
213.—♂ July 20; 1:30 P.M.: empty.
214.—♂ July 20; 1:30 P.M.: 1 Lake Shiner, tr. (carrying Log Perch).

215.—♀ July 20; 6:30 P.M.: 1 Lake Shiner, 1 cc; 1 Trout Perch, .5 cc.
216.—♀ July 20; 6:30 P.M.: 5 Lake Shiners, 2 cc.
217.—♀ July 20; 6:30 P.M.: 1 Perch, 1 cc.
218.—♀ July 20; 6:30 P.M.: 1 Lake Shiner, .3 cc.
219.—♀ July 20; 6:30 P.M.: 2 Lake Shiners, .5 cc.
220.—♀ July 20; 6:30 P.M.:1 Lake Shiner, 1 cc.
221.—♀ July 20; 6:30 P.M.: empty.
222.—♀ July 20; 6:30 P.M.: 1 Lake Shiner, tr.
223.—♀ July 20; 6:30 P.M.: empty.
224.—♀ July 21; 6:30 A.M.: empty.
225.—♀ July 21; 6:30 A.M.: empty.
226.—♀ July 21; 6:30 A.M.: empty.
227.—♀ July 21; 6:30 A.M.: empty.
228.—♀ July 21; 6:30 A.M.: 1 Perch, tr.
229.—♀ July 21; 6:30 A.M.: empty.
230.—♀ July 21; 6:30 A.M.: 1 Trout Perch, 2 cc.
231.—♂ July 21; 6:30 A.M.: 7 Lake Shiners, 6 cc.
232.—♂ July 21; 6:30 A.M.: 1 Perch, .5 cc.
233.—♂ July 21; 6:30 A.M.: 1 Lake Shiner, tr.
234.—♂ July 21; 6:30 A.M.: 1 Lake Shiner, .5 cc.
235.—♂ July 21; 6:30 A.M.: 1 Trout Perch, 1 cc.
236.—♂ July 21; 6:30 A.M.: 1 Lake Shiner, tr.
237.—♂ July 21; 6:30 A.M.: 1 Perch, tr.
238.—♂ July 21; 6:30 A.M.: 1 Perch, .5 cc.
239.—♀ July 21; 9:00 A.M.: 6 Lake Shiners, 7 cc.
240.—♀ July 21; 9:00 A.M.: 2 Lake Shiners, .5 cc; 1 Spot-tail Shiner, 3 cc.
241.—♀ July 21; 9:00 A.M.: 1 Spot-tail Shiner, .5 cc.
242.—♀ July 21; 9:00 A.M.: 1 Spot-tail Shiner, 2.5 cc.
243.—♂ July 21; 2:45 P.M.: 3 Perch, 5 cc.
244.—♂ July 21; 2:45 P.M.: 1 Perch, 8 cc; 1 Ttrout Perch, .5 cc.
245.—♂ July 21; 2:45 P.M.: 1 Trout Perch, tr.
246.—♀ July 21; 2:45 P.M.: 1 Lake Shiner, .5 cc.
247.—♀ July 21; 7:15 P.M.: 6 Lake Shiners, 8 cc.
248.—♂ July 21; 7:15 P.M.: empty -(carries fish).
249.—♂ July 21; 7:15 P.M.: 2 Perch, tr. 1 Lake Shiner, .5 cc (carrying fish).
250.—♂ July 22; 7:45 P.M.: 5 Lake Shiners, 3 cc. (Band 372776).
251.—♂ July 22; 7:45 P.M.: 7 Lake Shiners, 6 cc.
252.—♂ July 22; 7:45 P.M.: 9 Lake Shiners, 13 cc.
253.—♂ July 22; 7:45 P.M.: empty.
254.—♀ July 22; 7:45 P.M.: empty.
255.—♀ July 22; 7:45 P.M.: 1 Perch, 1 cc.
256.—♀ July 22; 7:45 P.M.: 1 Lake Shiner, tr.
257.—♀ July 22; 7:45 P.M.: 6 Lake Shiners, 8 cc.
258.—♂ July 22; 7:45 P.M.: empty.
259.—♀ July 22; 7:45 P.M.: 1 Lake Shiner, 1 cc.
260.—♂ July 23; 8:00 A.M.: 6 Lake Shiners, 5 cc.
261.—♂ July 23; 8:00 A.M.: 5 Lake Shiners, 5 cc.
262.—♂ July 23; 8:00 A.M.: 7 Lake Shiners, 5 cc.
263.—♀ July 23; 8:00 A.M.: 2 Perch, 1 cc.
264.—♀ July 23; 8:00 A.M.: 3 Lake Shiners, 2 cc.
265.—♀ July 23; 8:00 A.M.: 3 Lake Shiners, 1 cc.
266.—♂ July 23; 10:30 A.M.: 1 Spot-tail Shiner, tr.
267.—♂ July 23; 10:30 A.M.: 3 Lake Shiners, 2 cc.
268.—♂ July 23; 10:30 A.M.: 1 Lake Shiner, .5 cc.

269.—♂ July 23; 10:30 A.M.: 5 Lake Shiners, 4 cc.
270.—♂ July 23; 10:30 A.M.: 4 Lake Shiners, 3.5 cc. (carrying shiner).
271.—♂ July 23; 10:30 A.M.: 6 Lake Shiners, 6 cc. (carring shiner).
272.—♀ July 23; 10:30 A.M.: 2 Lake Shiners, 1 cc.
273.—♀ July 23; 10:30 A.M.: 2 Lake Shiners, .5 cc; 1 Tiger-moth, .5 cc.
274.—♀ July 23; 10:30 A.M.: 1 Lake Shiner, tr.
275.—♂ July 23; 11:30 A.M.: 1 Spot-tail Shiner, 1 cc.
276.—♂ July 23; 11:30 A.M.: 1 Cyprinidae, tr.
277.—♂ July 23; 11:30 A.M.: 5 Lake Shiners, 4 cc (carrying shiner).
278.—♂ July 23; 11:30 A.M.: empty.
279.—♂ July 23; 1:30 P.M.: empty.
280.—♀ July 23; 1:00 P.M.: 1 Trout Perch, .4 cc.
281.—♀ July 23; 1:00 P.M.: 1 Lake Shiner, .5 cc.
282.—♂ July 23; 2:00 P.M.: 1 Lake Shiner, tr.
283.—♀ July 23; 2:00 P.M.: empty.
284.—♀ July 23; 4:15 P.M.: empty.
285.—♀ July 23; 4:15 P.M.: empty.
286.—♀ July 23; 4:15 P.M.: empty.
287.—♀ July 23; 4:15 P.M.: empty.
288.—♀ July 23; 4:15 P.M.: 1 Perch, 1 cc.
289.—♀ July 23; 4:15 P.M.: 1 Perch, 1 cc.
~~290.—♀ July 23; 4:15 P.M.: 1 Perch, 1 cc.~~
290.—♂ July 23; 4:15 P.M.: 2 Lake Shiners, 2 cc.
291.—♂ July 23; 4:15 P.M.: 6 Lake Shiners, 5 cc.
292.—♂ July 23; 4:15 P.M.: 1 Lake Shiner, tr. (pharyngeal teeth).
293.—♂ July 23; 4:15 P.M.: 1 Perch, tr.
294.—♂ July 23; 4:15 P.M.: empty.
295.—♂ July 23; 4:15 P.M.: empty.
296.—♀ July 25; 8:45 A.M.: 5 Lake Shiners, 3 cc.
297.~~♀~~♀ July 25; 8:45 A.M.: 1 Lake Shiner, 1 cc.
298.—♀ July 25; 8:45 A.M.: empty.
299.—♀ July 25; 8:45 A.M.: 1 Lake Shiner, .5 cc.
300.—♀ July 25; 8:45 A.M.: 4 Lake Shiners, 2 cc.
301.—♀ July 25; 8:45 A.M.: 1 Lake Shiner, tr.
302.—♀ July 25; 8:45 A.M.: empty.
303.—♀ July 25; 8:45 A.M.: 7 Perch, 3 cc.
304.—♀ July 25; 8:45 A.M.: 3 Perch, 1 cc; 1 Shiner, 1 cc.
305.—♂ July 25; 8:45 A.M.: 2 Lake Shiners, 1 cc.
306.—♂ July 25; 8:45 A.M.: 1 Lake Shiner, .5 cc.
307.—♂ July 25; 8:45 A.M.: 5 Lake Shiners, 4 cc.

The data obtained show that 129 stomachs were empty, 155 contained fishes only, commercial or otherwise, 15 had insects and eight had a mixed fish and insect food. A total of 73 Perch, 372 non-commercial fishes and 80 insects were collected. These figures represent 14 per cent, 70 per cent and 16 per cent respectively of the total food of this collection. Lake Shiner, Spot-tail Shiner, Trout Perch and Blunt-nose Minnow, in the order of their occurrence represented the non-commercial fish. Likewise, dragon fly nymphs, Carpenter

Ants, Brown Drakes (Hexagenia), lamellicorn beetles, a Moth and an unidentified beetle constitute the insect food.

Volumetrically, 46.2 cc. of Perch comprised 13 per cent of the total volume recovered. The non-commercial fishes, with a volume of 275.0 cc. represented 75 per cent, while 25.0 cc. of insects made up 7 per cent of the food.

Perch were recovered from 34 stomachs, non-commercial fishes 144 times, and insects from 34 stomachs.

B. Bay Port

On May 23, seven birds were collected at Bay Port (Table 29). Three birds were obtained in the morning and four were taken in the afternoon.

Table 29

Record of Stomach Examinations of Common Tern

From Bay Port, 1931

1.—♂ May 23; 10:30 A.M.: 1 Perch, 2 cc.
2.—♀ May 23; 10:30 A.M.: 1 Perch, tr.
3.—♀ May 23; 2:00 P.M.: 1 Cyprinidae, tr.
4.—♀ May 23; 2:00 P.M.: 1 dragon fly nymph, .6 cc.
5.—♀ May 23; 2:00 P.M.: 1 Killifish, 2 cc.
6.—♀ May 23; 2:00 P.M.: empty.
7.—♀ May 23; 2:00 P.M.: 1 Killifish, tr.

This collection contains a total of five stomachs with fish, one with insects and one which was empty. The result shows that numerically, the commercial fish comprise 33 per cent of the total food, non-commercial fish make up 50 per cent and insect represents 17 per cent. By volume, the commercial fish and the non-commercial fishes each comprise 44 per cent and the insects 11 per cent of the food.

C. Pinconning

The 1931 Common Tern collection from Pinconning consists of nine birds, eight of which were obtained on May 25, when the birds were probably still

on their way to their breeding colonies (Table 30).

Table 30

Record of Stomach Examinations of Common Tern

From Pinconning, 1931

1.—♂ May 25; 5:00 P.M.: 2 Perch, 1.5 cc; 1 Lake Shiner, tr.
2.—♂ May 25; 5:00 P.M.: 2 Perch, 3 cc.
3.—♂ May 25; 5:00 P.M.: 1 Perch, .5 cc.
4.—♂ May 25; 5:00 P.M.: empty.
5.—♂ May 25; 5:00 P.M.: empty.
6.—♀ May 25; 5:00 P.M.: 1 Cyprinidae, tr.
7.—♀ May 25; 5:00 P.M.: 1 Perch, 2 cc. (Sand 372065).
8.—♀ May 25; 5:00 P.M.: 1 Perch, 1 cc.
9.—♂ July 25; 3:00 P.M.: 1 Carp, 2 cc.

The only Carp fingerling (Cyprinus carpio) recovered in this study was found in the stomach of the one bird collected on July 25.

A total of eight commercial fishes, seven Perch and the one Carp were recovered from six stomachs. These fish had a combined volume of 10.0 cc. Only a trace of two non-commercial fishes was obtained from two stomachs.

In this small sample the commercial fishes comprised 80 per cent of the food numerically, and the non-commercial fishes 20 per cent.

Volumetrically, the commercial fishes made up practically 100 per cent of the food.

D. Big Charity Island

At Big Charity Island, 20 birds were shot at about 10:30 A.M. on July 13 (Table 31).

Table 31

Record of Stomach Examinations of Common Tern

From Big Charity Island, 1931

1.—♀ July 13; 10:30 A.M.: empty.
2.—♀ July 13; 10:30 A.M.: empty.
3.—♀ July 13; 10:30 A.M.: empty.
4.—♀ July 13; 10:30 A.M.: 1 Lake Shiner, tr.

5.—♀ July 13; 10:30 A.M.: empty.
6.—♀ July 13; 10:30 A.M.: empty.
7.—♀ July 13; 10:30 A.M.: 2 Lake Shiners, 1.5 cc.
8.—♀ July 13; 10:30 A.M.: 6 Lake Shiners, 6 cc.
9.—♀ July 13; 10:30 A.M.: 7 Perch, 3 cc; 1 Lake Shiner, .5 cc.
10.—♀ July 13; 10:30 A.M.: 2 Perch, 1 cc; 1 Trout Perch, 1.5 cc.
11.—♀ July 13; 10:30 A.M.: 3 Lake Shiners, 2 cc; 2 Trout Perch, 3 cc.
12.—♂ July 13; 10:30 A.M.: 1 Perch, tr.
13.—♂ July 13; 10:30 A.M.: 1 Trout Perch, tr.
14.—♂ July 13; 10:30 A.M.: 1 Lake Shiner, tr.
15.—♂ July 13; 10:30 A.M.: empty.
16.—♂ July 13; 10:30 A.M.: 3 Perch, .5 cc; 1 Lake Shiner, .5 cc.
17.—♂ July 13; 10:30 A.M.: 1 Lake Shiner, .5 cc.
18.—♂ July 13; 10:30 A.M.: 1 Lake Shiner, .5 cc; 1 Spot-tail Shiner, .5 cc.
19.—♂ July 13; 10:30 A.M.: 4 Lake Shiners, 5 cc.
20.—♂ July 13; 10:30 A.M.: 1 Perch, .5 cc; 2 Lake Shiners, 1 cc.

Like the 1931 collections from Pinconning and Pitcher's Reef, this sample is peculiar in the total absence of insect food. Fourteen Perch comprised 35 per cent of the total number of all food items recovered. By volume, the 5 cc. of Perch was 19 per cent of the food. The remaining 87 per cent of the food, figured numerically, was composed of 28 non-commercial fishes measuring 22.5 cc., and constituting 81 per cent of the food by bulk.

Perch were recovered five times, while non-commercial fishes were found 15 times.

E. Pitcher's Reef.

On July 14, ten birds were taken from Pitcher's Reef, five of which had no stomach contents. (Table 32). During the visit, four dead adult birds were noted tangled in the meshes of worn out pieces of gill-nets that were lying about in several places on the beach.

Table 32

Record of Stomach Examinations of Common Tern

From Pitcher's Reef, 1931

1.—♂ July 14; 8:00 P.M.: empty.
2.—♂ July 14; 8:00 P.M.: empty.

3.—♂ July 14; 8:00 P.M.: 3 Trout Perch, tr.
4.—♂ July 14; 8:00 P.M.: empty.
5.—♂ July 14; 8:00 P.M.: empty.
6.—♂ July 14; 8:00 P.M.: 1 Trout Perch, 1 cc.
7.—♂ July 14; 8:00 P.M.: 1 Perch, tr.
8.—♀ July 14; 8:00 P.M.: 4 Lake Shiners, 5 cc.
9.—♀ July 14; 8:00 P.M.: 2 Lake Shiners, 1.5 cc; 1 Trout Perch, .5 cc.
10.—♀ July 14; 8:00 P.M.: empty.

Table 32 shows that 5 Trout Perch and 6 Lake Shiners made up 92 per cent by number of the food of the Common Tern in Pitcher's Reef in 1931. The remaining 8 per cent by number was represented by one Perch fingerling. Non-commercial fishes comprised practically 100 per cent by volume of the food.

F. Summary of the stomachs examined for 1931

The summary of data and computations of the food of the Common Tern in Saginaw Bay for 1931 are shown in Table 33. The data were obtained from 353 stomachs which were collected from five different places as follows: Lone Tree Island, 307; Bay Port, 7; Pinconning, 9; Big Charity Island, 20; Pitcher's Reef, 10. Of this total, 186 stomachs contained fish only either commercial, non-commercial or both, 16 had insects, 8 had mixed fish and insect types while 143 were empty. The birds were collected at different periods from 4:15 A.M. to 9:00 P.M. as shown in the table below.

Time Shot	No. of birds	Time shot	No. of birds	Time shot	No. of birds	Time shot	No. of birds
4:30 A.M. to 6:30 A.M.	48	8:31 A.M. to 10:30 A.M.	58	12:31 P.M. to 2:30 P.M.	31	4:31 P.M. to 6:30 P.M.	24
6:31 A.M. to 8:30 A.M.	6	10:31 A.M. to 12:30 P.M.	63	2:31 P.M. to 4:30 P.M.	34	6:31 P.M. to 9:00 P.M.	89

The data show that 202 males and 147 females were sexed.

The average number of individuals of each food item estimated to have been eaten by one Common Tern at one feeding time in 1931 are shown on the last column of Table 33.

Table 33

Data and Computations on the Food of the Common Tern in Saginaw Bay in 1931

Food types and items	Number of stomachs containing each item	Per cent of birds feeding at any given time on each item	Numerical determination by food items: Total no. recovered	Numerical determination by food items: Per cent in each type	Numerical determination by food items: Per cent in total food	Volumetric determination by food items: Total volume cc.	Volumetric determination by food items: Per cent in each type	Volumetric determination by food items: Per cent in total food	Number in ave. meal of bird
COMMERCIAL FISHES									
Perch (Perca flavescens).....	48	13.44	96	99.0	16.16	61.2	96.8	15.52	0.272
Carp (Cyprinus Carpio)..	1	.3	1	1.0	0.17	2.0	3.2	0.51	0.003
NON-COMMERCIAL FISHES									
Blunt-nose Minnow (Hyborhynchus notatus).....	1	.3	1	0.2	0.17	0.5	0.2	0.13	0.005
Lake Shiner (Notropis atherinoides).....	126	35.28	366	87.95	61.60	261.1	85.5	66.20	1.037
Spot-tail Shiner (Notropis hudsonius hudsonius).....	17	4.86	21	5.1	3.53	20.5	6.7	5.20	0.059
Cyprinidae.....	3	.8	4	1.0	0.67	-	-	-	0.01
Trout Perch (Percopsis omiscomaycus).....	19	4.32	22	5.3	3.70	21.4	7.0	5.42	0.062
Killifish (Fundulus diaphanus menona).....	2	.6	2	0.5	0.34	2.0	0.6	0.51	0.006
INSECTS									
Mayfly (Hexagenia, sp.)....5		1.4	13	18.0	2.19	0.5	0.2	0.13	0.037
Dragon fly naiad (nymph)....12		3.36	46	56.8	7.74	24.5	8.0	6.21	0.130
Carpenter Ant (C. herculeanus novaeboracensis).....	5	1.4	16	19.7	2.69	-	-	-	0.045

Food types and items	Number of stomachs containing each item	Per cent of birds feeding at any given time on each item	Numerical determination by food items: Total no. represented	Numerical determination by food items: Per cent in each type	Numerical determination by food items: Per cent in total food	Volumetric determination by food items: Total volume cc.	Volumetric determination by food items: Per cent in each type	Volumetric determination by food items: Per cent in total food	Number in ave. meal of bird
lamellicorn beetle	3	.8	3	3.7	0.5	-	-	-	0.006
Tiger moth (Arctiid)	1	.3	1	1.2	0.7	0.5	0.8	0.13	0.003
Unidentified beetle	1	.3	2	2.5	0.54	-	-	-	0.006
Summary by types									
Commercial fishes	49	13.74	97		16.33	63.2		16.03	.27
Non-commercial fishes	168	47.06	416		70.01	305.5		77.49	1.188
Insects	27	7.56	81		13.64	25.5		6.47	.229
Total	244	68.36	594		99.98	39.42		99.99	1.704

According to these figures, every Perch eaten by the Common Tern in 1931 was accompanied by 3.8 Lake Shiners, 4.78 dragon fly nymphs, and fractions of other less important fishes and insects.

As in previous years, the number of times the daily ration exceeds the average meal ration is considered to be 8.

Observations regarding the number of adult Common Terns in 1931 show that almost the same number of adults occurred as in the previous year, with a little alteration of places. It seems that the birds which nested at Sand Point in 1930 had moved to Lone Tree Island in 1931. About 50 per cent of the birds at the Big Charity Island in 1930 or 100 birds moved to the Little Charity in 1931. For this reason, it is assumed that there was an aggregate of 1,880 feeding birds in Saginaw Bay in 1931. These birds had occupied the bay for a period of 190 days. It is, however, estimated that there were 500 more young that reached the flying stage in 1931 than in 1930. Allowing 30 days for these birds to feed themselves in Saginaw Bay before they finally leave would mean approximately 15,000 bird-days. If this number be added to the estimated population as given above, there would be a total of about 349,000 bird-days in 1931.

The amount of each food eaten by the Common Terns in 1931, obtained by the formula as shown on page 28 is roughly estimated as follows:

Commercial fishes	
Perch	759,000
Carp	8,000
Total commercial fishes	767,000
Non-commercial fishes	
Lake Shiner	2,897,000
Spot-tail Minnow	165,000
Trout Perch	173,000
Other fishes	55,000
Total non-commercial fishes	3,290,000

Insects.

Carpenter Ant	126,000
Mayfly (Brown Drake)	103,000
Dragon fly nymph	363,000
Other insects	37,000
Total insects	639,000

C. Food of the young

Before giving the estimate of the kinds and amount of food taken by the young, it may be in place to narrate the result of a typical one-day observation (Table 34) which will illustrate the manner in which the young are fed (Plate VI). The date was July 12, 1931, and the observations were made with the aid of two assistants. The movements of the adults could be followed closely, as they, fortunately, had been banded on some previous occasion. The adult which went fishing the more frequently had been banded on the left leg, and was assumed to be the male. The other, presumably the female, bore the band on the right leg. There were two young in the nest. One was four days old and for convenience was called "A". The other was three days old and was named "B".

Table 34

Record of One Day's Feeding of Two Young Common Terns by their parents

4:40 A.M.: "A" fed Lake Shiner by male. Female on nest.
5:15 A.M.: "B" fed Lake Shiner by male. Female on nest.
5:20 A.M.: "B" fed Lake Shiner by male. Female on nest.
5:50 A.M.: "A" fed Lake Shiner by male. Female on nest.
5:55 A.M.: "A" fed Lake Shiner by male. Male induces B to take the fish; sits awhile close to nest; moved around to nest; flew away with the fish, came back after two minutes; poked young but to no avail; flew away again and dipped the morsel in water. All this behavior was repeatedly carried out for about 30 minutes. He finally gave the fish to the female who ate it. The male then sat by the nest, while the female kept the young under her breast. 7:15 A.M. both adults flew away. 7:25 A.M. the male came with a shiner and tried to give it to the young, but neither one would take it. The female came, and took the fish from the male. At first she

offered it to the young, but when neither took it, she ate it herself.

7:40 A.M.: "B" fed Lake Shiner by male. Female on nest.

8:50 A.M.: "A" fed Lake Shiner by male. Female on the nest but flew away later. 9:10 A.M. the female came with a Shiner anf after unsuccessfully offering it to "B" she ate it herself.

9:30 A.M.: "A" fed Lake Shiner by male. Female on nest but left later.

10:18 A.M.: "B" fed Lake Shiner by female. Male was out.

10:45 A.M.: "A" fed Lake Shiner by male. Female on nest.

11:05 A.M.: "A" fed Lake Shiner by male. Female on nest.

11:30 A.M.: "B" fed Lake Shiner by smal. Female on nest.

12:30 P.M.: "B" fed Lake Shiner by male. Female on nest.

1:30 P.M.: "A" fed Lake Shiner by male. Female on nest.

1:50 P.M.: "B" fed L ke Shiner by male. Female on nest.

1:55 P.M.: "A" fed Lake Shiner by male. Female on nest but flew.

2:00 P.M.: "B" fed Lake Shiner by female. Male was out.

2:37 P.M.: the male watched the nest while the female flew away. She came back at 2:38 P.M. with a living tettigonid locust. "B" bit it and then dropped it. The female flew away again.

2:43 P.M.: "B" fed Perch by female. Both male and female stepped off the pen, and played a little. Then female stayed on the nest, while the male flew away. The female also left apparently. Female flew later because "A" had been screaming in hunger and the male had not come back yet. She stepped out of the nest at first, looked around and then flew off.

3:12 P.M.: "A" fed Lake Shiner by female. Male still out.

3:17 P.M.: "B" fed Perch by male. Male flew, female stayed.

5:30 P.M.: "A" fed Lake Shiner by male. Female on nest.

5:40 P.M.: "B" fed Lake Shiner by male. Female on nest.

5:42 P.M.: "A" fed Lake Shiner by male. Female on nest.

5:44 P.M.: "B" fed Lake Shiner by male. Female on nest.

5:45 P.M.: "A" fed Lake Shiner by male. Female on nest.

5:48 P.M.: "B" fed Lake Shiner by male. Female on nest.

6:15 P.M.: "B" fed Lake Shiner by male. Female on nest.

6:43 P.M.: "A" fed Lake Shiner by male. Female on nest.

7:15 P.M.: "B" fed Lake Shiner by male. Female on nest.

7:30 P.M.: "A" fed Lake Shiner by male. Female on nest.

7:35 P.M.: "A" fed Lake Shiner by male. Female on nest.

7:40 P.M.: "B" fed Lake Shiner by male. Female on nest.

7:44 P.M.: "A" fed Lake Shiner by male. Female on nest.

7:48 P.M.: "B" fed Lake Shiner by male. Female on nest. Both the male and the female went out presumably to feed for themselves. The female came at 8:15 P.M. and stayed on the nest until dusk, when she felw off again because she was frightened by the observer's retirement from the box.

(The observations just recorded are interesting biologically in that they illustrate the division of labor between the sexes in the breeding season. The female spends most of her time brooding the eggs and young, while the male specializes in obtaining food. He also takes the brunt of

frightening off intruders from the nest region.)

When the morsel was too big for the young to swallow conveniently it took a long time before the fish could finally be devoured. Sometimes the adult offering it had to go out and dip the fish into the water two or three times, apparently to moisten the food so as to make its swallowing easier. Even at this the fish could be swallowed only halfway.

On another day, it was noted that when the young in the nest under observation were screaming for food after the male had gone out for about an hour, the female rushed out twice in succession and came back within a minute each time. Each time she brought in a moth which was devoured by one of the young. It is very probable that the female did this to save the hungry young when no fish could be obtained immediately. That the females occasionally also bring in fish for the young is indicated, not only by the July 12 observations tabulated above, but also by the fact that three of the birds shot bringing in fish in their bills during the period of feeding the young (birds no. 176, 177 and 200 in Table 28), were females.

The average number of fish fed to each nestling bird was determined from 7 day's observation, covering 3 different nests each with 2 young. Fourteen daily rations were thus obtained, for 6 different nestlings. The number of fish eaten by each nestling varied from 8 to 23. The average proved to be about 18 fish.

The proportionate number of individuals of different species of animals eaten by the nestlings was determined by the same 7 days of observation. The percentages were:

Perch (Perca flavescens).....8 %

Lake Shiner (Notropis atherinoides).....85%

Spot-tail Shiners (Notropis hudsonius)[1].....5%

Trout Perch (Percopsis omiscomaycus)[1].....5

Moths (species unknown)*

Long-headed Grasshopper (killed though not eaten)*

Although insects were offered three times they were not considered in the computation. The condition when they were offered was very unusual. As a result, the young refused to take one of the three. The absence of Perch or other commercial fishes in the observed dietary of the young Terns is notable. The feeding of the young on the softer and less spinous non-commercial fishes is probably the result of selection of material by the parent birds. One reason for so thinking is the fact that during the period of observation Perch fingerlings were plentiful about Lone Tree Island.

According, the result of the observation on the food of the young, 1,500 birds that were fed to flying stage would have eaten:

25,000 Perch fingerlings	25,000 Spot-tail Shiners
428,000 Lake Shiners	25,000 Trout Perch

It was estimated that in 1931 about 1,500 young Common Terns did not reach the flying stage, but had been fed on an average of five days. The destruction of these birds would aggregate:

6,750 Perch fingerlings	6,750 Spot-tail Shiner
114,750 Lake Shiners	6,750 Trout Perch

H. Summary for 1931

The estimates and computations presented above give a rough total consumption of the Common Terns in Saginaw Bay for 1930 as follows:

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[1] The Spot-tail Shiner and Trout Perch were not accurately distinguished by the assistants. Their total for the two species was apportioned among the two on the assumption that the proportion observed by me held for thier observation too.
*Offered only once, probably accidentally, thus no computation was made.

791,000	Perch fingerlings	55,000	Other forage fishes
8,000	Carp	103,000	Mayfly (Hexagenia)
3,439,000	Lake Shiners	363,000	Dragon fly naiad nymphs
197,000	Spot-tail Shiners	126,000	Carpenter Ants
295,000	Trout Perch	37,000	Other insects

These figures show that a total of 799,000 commercial fishes, 3,896,000 non-commercial fishes and 629,000 insects have been estimated to be consumed by all the Common Terns in Saginaw Bay in 1931. The commercial fishes comprised about 15 per cent, the non-commercial fishes about 73 per cent and the insects about 12 per cent of the total food.

4. SUMMARY OF RESULTS FOR THE THREE YEARS STUDY OF THE FOOD OF THE COMMON TERNS IN SAGINAW BAY

In the three years study of the Common Tern a total of 742 stomachs were examined. The Commercial fishes recovered were Perch, Pike-Perch and Carp. Perch was the dominant element in the commercial fish food. The heaviest annual consumption of Perch was in 1930. In this year, each bird was supposed to have taken an average of 0.735 of a Perch at each feeding time as compared with only 0.262 in 1929 and 0.272 in 1931. The lesser abundance of birds in 1929 than in either 1930 or 1931 contributed to the circumstance that the smaller number of Perch was consumed in 1929. In addition to the large number of Perch eaten in 1930, a total of 144,000 Pike Perch fingerlings were also estimated to have been eaten this year, but not in any of the other two years. In 1931, but not in previous years, a Carp fingerling was taken from the stomach of a bird.

The non-commercial fishes eaten show an increase of about 4,144,500 from 1929 to 1930 and about 96,000 from 1930 to 1931. The most important single item of this type of food was the Lake Shiner. The annual curve of this item was aparallel with that of the total non-commercial food type. It should be observed that about 7,548,000 out of 8,506,000 non-commercial fishes estimated to have been consumed in that three years were Lake Shiners. In 1929, Trout Perch was the preponderant species in the bill of fare while Lake Shiner took the lead in two years that followed. The toll of Spot-tail Shiners also showed an increase from year to year. Blunt-nose Minnows were recovered in only two years, and the estimated consumption of this fish showed a decrease from 1930 to 1931. The Nine-spined Stickleback was included in the food sample of 1929 only, while Black-nose Shiner, Straw-colored Shiner, Golden Shiner, Johnny Darter and Log Perch were taken only in 1930.

The results show that ten species of non-commercial fishes were the largest number of items found in any one year, while five species represents the minimum. In three years of study, 11 species were certainly identified.

The data exhibited by the insects show that in 1929, when only 83,000 day-birds were supposed to occur in Saginaw Bay, 4,568,000 individuals insects comprising nine species were estimated to have been consumed.[1] The results show a gradual decrease of the annual consumption with an increase of annual day-birds. In 1930, when 334,175 day-birds were supposed to be present in the bay, only 3,740,000 insects were estimated to be consumed. In 1931, only 640,000 insects were calculated to have been taken by 349,175 day-birds. The largest single insect item in 1929 were the Carpenter Ants, in 1930, with Mayflies (Brown Drakes), while in 1931 were Dragon Fly nymphs.

[1] The high estimate for insect food in 1929 may have been due to the fact that most of the stomachs were collected in a short period when the Carpenter Ants were flying in large numbers.

May beetle, ground beetle, Noctuid Moth and House Fly were found only in 1929, while Mackerel or the smaller Mayfly, adult Dragon fly and Stink Bug were recovered only in 1930. A minimum of six and a possible maximum of 14 species of insects were obtained in 1931 and 1929 respectively.

Considered numerically by individual items, the food of the Common Tern in 1929 consisted of about 3 per cent commercial fishes, 9 per cent non-commercial fishes and 87 per cent insects. In the year 1930, the commercial fishes comprised 23 per cent; the non-commercial fishes, 40 per cent and the insects, 37 per cent. In 1931, 16 per cent was commercial fishes, 70 per cent was non-commercial fishes and the insects made up 14 per cent.

A survey of the work of other investigators shows varying results.

Wood (1911:86) observed that the food of the Common Tern in Charity Island was ants.

Hastings (1924:41) saw these birds feeding on non-commercial fishes and also on insects at Lone Tree Island.

Barrows (1912:61) mentioned that the food of Common Terns in Michigan consists chiefly of small fish.

McAtee and Beal (1924:191) examined 116 stomachs of these birds and found that 1 per cent of the food consisted of mollusks, crustaceans and worms which feed upon oysters, 2 per cent consisted of moths, 1.5 per cent of other insects and 95.5 per cent of fishes, the largest item of which was fresh-water minnows. Of the fish item, they found that 5 per cent was composed of food fishes and almost 85 per cent consisted of fishes of neutral importance.

According to Bent (1921:245) the food consists almost wholly of small fishes.

Besides small fish, Knight (1908:60) saw a tern in Maine pursue, catch and swallow a Yellow Swallow-tail Butterfly, Papilio turnus.

Floyd (1925) described an observation in Massachusetts about the adult bird feeding its young with fish. The same writer (1927:98) noted an adult bird swallowing a newly hatched young.

Eaton (1910) maintained that in New York, the principal food of this bird are small fish and aquatic insects.

Pearse and Achtenberg (1920:338) cited A. R. Cahn as having seen Common Tern in Wisconsin feeding on Perch.

Munro (1931:36) reported that the Common Terns in British Columbia were feeding on Herring eggs which floated amongst the dirt and rubbish.

Wetmore (1916:47-48) recovered minnows from the stomachs of Common Terns obtained in Porto Rico.

In Great Britain, Whiterby (1920:211) claimed that the food of this bird consists mainly of small fish, such as young Herrings, Whiting, Coal fish, Codling, Sand Eels, Plaice, Lump Suckers, 15-Spined Stickelbacks; also insects including coleoptera, odonata, diptera etc.

According to Collinge (1926), the whole of the food of the Common Tern is of an animal nature and 53.7 per cent consists of fish; 18 per cent food fishes and 35.7 per cent non-food fishes.

This survey of literature shows that there is a unanimity of opinion regarding the feeding of this bird on the fishes and insects. Different investigators from different places, however, differ in their results or opinions as to the relative qualities and value of each of these groups, the reason for the divergence of opinion seemingly lies in the prevailing food supply of different regions and in the incompleteness of the observations.

VII. RELATION OF FISH DESTRUCTION BY THE COMMON TERN TO THE FISH SUPPLY OF THE BAY.

The analysis of the food of the Common Tern as given in the preceding pages cannot be intelligently interpreted in its economic aspects without a comparison of the destructiveness of the bird with the total fish population of the bay.

The estimating of the total fish population of any large body of water is a problem replete with difficulties and sources of error. Nevertheless it has been thought necessary to make the best possible estimates, for the reasons advanced in the discussion of this point in the Introduction (see p. 28).

In order to determine the extent of destruction by the birds under study to the fish supply of the region, an effort was made to estimate the total population of fish in the feeding area of the birds. For this purpose, quantitative seine hauls were made at intervals of approximately two weeks at numerous points along the whole shore of the bay. At first, it was thought that a qualitative determination of the fishes that occurred along the shores where the birds were seen feeding might be sufficient, but it soon developed that quantitative determinations were needed. These were begun about the middle of July, 1930, and continued through the summer of 1930 and spring and summer of 1931. Seining was done both where birds were seen feeding and where none of them were seen.

The bases for comparison used below are (1) the estimated total population of commercial fish fingerlings and of forage fishes, as determined by seining, and (2) the commercial fish catch of the bay, as determined from

statistics furnished by the Michigan Department of Conservation.

For convenience, the results of the seine hauls made in two years were arranged in three belts: (1) within 20 meters of shore (Table 37); (2) 80 to 100 meters off shore (Table 38), and (3) 100 meters off shore to a depth of 2 fathoms. It will be noted in the tables that the number of seine hauls varies at different stations. This is primarily due to the fact that sometimes one place could not be seined on account of the high seas, or, sometimes, because people bathing were so thick that there was no room for pulling the seine.

The basis for estimating the "in-shore" population was the results of seining with a 75-foot seine having a mesh of 3/8 inch in the wings and ¼ inch in the bunt. The estimate of the "off-shore" population resulted from the operation of a 125 foot Baird seine having a mesh of 3/8 inch in the wings and ¼ inch in the bag.

The Fish Population Within 20 Meters of Shore (In-shore Hauls)

In asmuch as the birds' feeding is done mostly close to the shore, and as this area is most easily seined, the most detailed studies were made in the belt from shore to 20 meters (65.6 ft.). As explained on p. 27 , this belt is 440,000 meters long, giving an area of about 8,800,000 square meters. After the average number of each species per seine haul of known area is estimated, it is a simple matter to estimate the total population of the species of fish in the shore belt of the bay.

Certain factors made it necessary to estimate the population per given area as greater than indicated in the actual counts of the seinings. The seining was done mostly on clear shores, where the density of fish population was observably less than on the marshy shore, where the dense growth of rushes prevented effective shore seining. In several places submerged

boulders, old logs, etc., interfered with the catching of the fish, many of which escaped when the lead line was lifted. The small fingerlings could pass through the meshes of the seine (¼" square mesh in center, 3/8" in wings). No doubt a large number of fish escaped above, below or around the seine while pulling it. Considering all the escapements, and the clustering of fish in unseinable places, it is estimated that the indicated catch is not more than half as high as it would be under ideal conditions of sampling. For this reason, the actual catch of the smaller seine was multiplied by 2.

Early in the fall, the Lake Shiner fingerlings could often be seen in big schools along the shore. However, they were so small that they easily slipped through the meshes of the seine. A good example to illustrate is the following observation. On October 26, 1930, when the water was 5°C, a large school of this fish was noted in a place at Sand Point. Bonaparte's Gulls had been feeding in this area, where the deepest water was about 15 cm. When this place was seined with the 75 foot seine, only 58 Lake Shiners were collected although there had been thousands in the area seined over. On account of this difficulty, the result of fall seining was not included in the record presented in Table 37. The same experience had been encountered with the Spot-tail Shiners during the summer seining.

Another situation for which allowance should be made was that in most of the hauls made in 1930, the catch was preserved. This might have diminished the number of fish caught at the same seining station on the next seining trip.

A total of 56 seine hauls were made within 30 meters off shore in 1930. Several places were seined two or three times, each time the catch contained fishes different from the sample just preceding. Perch, Pike Perch, Mullet, Common Sucker, Long-nosed Sucker, Hog Sucker, Bullheads, Carp, Rock Bass,

Table 37

Record of Quantitative Seine Hauls by Seining

Stations Using 70-Ft. Seine

1. Pointe aux Barques; sand and gravel over rock; to 1 meter grading.

July 28, 1930; 22°C: 1 Perch, 1 Common Shiner, 1 Spot-tailed Shiner, 1 Mimic Shiner (hundreds of small Spot-tailed Shiners escaped through the mesh).
September 13, 1930; 22°C: 3 Perch, 266 Lake Shiners, 2 Common Shiners, 9 Spot-tailed Shiners.
May 5, 1931; 12°C: 4800 Lake Shiners.
May 21, 1931; 10°C: 40 Lake Shiners.
July 4, 1931; 20°C: 7 Perch, 20 Lake Shiners, 15 Straw-colored Shiners, 25 Spot-tail Shiners (many smaller fishescaped).
July 24, 1931; 20°C: 17 Common Shiners, 7 Spot-tail Shiners, 4 Steel-colored Shiners, 6 Log Perch.

2. Port Austin; sand and gravel; deepest part seined was about 75 cm.

July 28, 1930; 22°C: 1 Small-mouth Bass, 73 Lake Shiners, 38 Spot-tail Shiners.
September 13, 1930; 22oC: 1 Perch, 472 Lake Shiners, 1 Common Shiner, 13 Spot-tailed Shiners.
May 5, 1931; 12°C: 4000 Lake Shiners, 80 Straw-colored Shiners, 30 Spot-tail Shiners.
May 21, 1931; 10°C: 48 Lake Shiners, 5 Common Shiners, 5 Straw-colored Shiners.
July 4, 1931; 20oC: 3 Perch, 25 Lake Shiners, 17 Spot-tailed Shiners.
July 24, 1931; 20°C: 5 Large-mouth Bass, 5 Lake Shiners, 4 Straw-colored Shiners, 8 Steel-colored Shiners, 5 Mimic Shiners.

3. Oak Beach; sand with scattered boulders.

July 28, 1930: 22 Perch, 2 Small-mouth Bass; 2005 Lake Shiners, 1 Straw-colored Shiner, 4 Spot-tail Shiner, 1 Log Perch.
September 13, 1930: 16 Perch, 1 Sunfish, 124 Lake Shiners, 9 Common Shiners, 1 Straw-colored Shiner, 193 Spot-tailed Shiners, 133 Mimic Shiners.
May 5, 1931: 17°C; 200 Lake Shiners.
May 21, 1931: 8 Lake Shiner.
July 4, 1931; 25°C: 15 Perch, 74 Lake Shiners, 8 Straw-colored Shiners, 25 Spot-tail Shiners.
July 24, 1931: 5 Perch, 200 Spot-tail Shiners.

4. Caseville; sand bottom with Musk Grass, Bushy Pond Weed, Algae, Bulrushes; Deepest area seined was 70 cm.

July 12, 1930; 15 Perch, 14 Common Suckers, 1 Tadpole Cat, 1 Rock Bass, 1 Large-mouth Bass, 10 Small-mouth Bass, 1 Stone Roller, 30 Blunt-nose Shiners, 1 Lake Shiner, 45 Black-nose Shiners, 296 Common Shiners, 2 Spot-tail Shiners, 3 Johnny Darters, 138 Log Perch, 1 Killifish.

July 28, 1930; 29°C; 78 Perch, 2 Pike Perch, 1 Common Sucker, 1 Small-mouth Bass, 1 Blunt-nose Shiner, 1505 Lake Shiners, 1 Common Shiner, 3 Straw-colored Shiners, 13 Spot-tail Shiners, 3 Log Perch.

September 15, 1930; 24°C; 500 Perch, 20 Spot-tail Shiners, (In another place close by). 50 Lake Shiners, 25 Spot-tail Shiners.

May 5, 1931; 17°C; 6 Perch, 13 Lake Shiners, 5 Spot-tail Shiners.

May 21, 1931; no catch.

July 4, 1931; 5 Perch, 10 Lake Shiners, 17 Common Shiners, 4 Spot-tail Shiners, 9 Blunt-nose Minnows.

July 24, 1931; 3 Large-mouth Bass, 7 Lake Shiners, 23 Common Shiners, 60 Spot-tailed Shiners, 6 Steel-colored Shiners.

5. Sand Point; (Collecting was done 5 times in the summer of 1930).

July 12, 1930; sand bottom.
(1) 2 Perch, 3 Blunt-nose Shiners, 572 Lake Shiners, 55 Common Shiners, 20 Spot-tailed Shiners, 2 Mimic Shiners, 2 Johnny Darters, 5 Log Perch, 3 Killifish.
(2) (Seine pursed in Water) 2 Perch, 24 Common Shiners, 1 Mimic Shiner, 2 Log Perch, 24 Common Shiners, 1 Mimic Shiner, 2 Log Perch (Thousands of dead Lake Shiner fingerlings were noted along shore).

July 28, 1930. (3) In bay and at tip of Point; mud and sand bottom; Algae and Leafy Pond Weed were noted. 17 Perch, 1 Large-mouth Bass, 1 Sunfish, 1 Tadpole Cat, 8 Iowa Darters, 8 Killifish.

September 13, 1930. (4) 8 Sunfish, 39 Blunt-nose Shiners, 1 Lake Shiner, 3 Straw-colored Shiners, 9 Mimic Shiners, 5 Johnny Darters, 1 Killifish.

September 15, 1930. (5) 1 Sunfish, 30 Lake Shiners, 1 Common Shiner, 15 Johnny Darters.

May 5, 1931; 30 Lake Shiners, 9 Blunt-nose Shiners, 14 Killifish.

May 21, 1931; 40 Lake Shiners.

July 24, 1931; 24°C; 78 Perch, 3 Carp, 2 Small-mouth Bass, 5 Blunt-nose Shiners, 12 Lake Shiners, 34 Common Shiners, 28 Straw-colored Shiners, 6 Steel-colored Shiners.

6. Bay Port; sand with pieces of rock; vegetable debris along shore line; one date.

July 11, 1930. (1) 50 cm. at its deepest. 22 Perch, 7 Sunfish, 2 Small-mouth Bass, 1 Long-nose Gar, 1 Blunt-nose Minnow, 6 Lake Shiners, 1 Steel-colored Shiner, 1 Log Perch, 3 Killifish.
July 11, 1930 (2) 1 meter at its deepest. 10 Perch, 1 Blunt-nose Shiner, 3 Lake Shiners.
July 21, 1930; 21°C: (1) 22 Perch, 1 Pike Perch, 4 Carp, 5 Blunt-nose Minnows, 6 Lake Shiners, 3 Black-nose Shiners, 3 Spot-tail Shiners, 5 Mimic Shiners, 1 Johnny Darter, 3 Log Perch, 1 Killifish.
July 21, 1930. (2) 43 Perch, 1 Sunfish, 1 Lake Shiner, 1 Log Perch.
September 14, 1930: 16 Perch, 4 Rock Bass, 1 Large-mouth Bass, 14 Blunt-nose Minnows, 1 Lake Shiner, 21 Common Shiners, 15 Johnny Darters, 2 Log Perch, 11 Killifish.
May 5, 1931: 14°C; 200 Perch, 50 Blunt-nose Minnows, 27 Golden Shiners, 50 Common Shiners, 50 Killifish.
May 23, 1931; 14°C: 4230 Lake Shiners.
July 9, 1931: 24 Perch, 8 Blunt-nose Minnows, 83 Lake Shiners, 11 Common Shiners, 8 Straw-colored Shiners, 6 Johnny Darters.

7. Rose Island; sand and gravel bottom.

July 12; 10:30 P.M.: 8 Perch, 1 Pike Perch, 2 Sunfish, 1 Blunt-nose Minnow, 2 Lake Shiners, 6 Common Shiners, 2 Log Perch, 4 Killifish.
July 12; 12:05 A.M.: 46 Perch, 1 Large-mouth Bass, 3 Black-nose Shiners, 3 Johnny Darter, 1 Iowa Darter, 10 Killifish.
May 5, 1931: 47 Blunt-nose Minnows, 35 Lake Shiners, 105 Straw-colored Shiners, 100 Spot-tail Shiner, 125 Killifish.
July 9, 1931: 17 Perch, 1 Long-nose Gar, 18 Killifish,

8. Sebewaing Bay Shores; Thin Bulrushes, Musk Grass, Leafy Pond Weed, Bushy Pond Weed growing on clay, sand and gravel bottom.

July 19, 1930. (1) 38 Perch, 5 Lake Shiners, 1 Mimic Shiner, 5 Johnny Darter, 7 Log Perch, 2 Killifish.
July 19, 1930 (2) 1 Stone Roller, 1 Blunt-nose Minnow, 6 Lake Shiners, 1 Black-nose Shiner, 3 Common Shiners, 2 Johnny Darters, 9 Log Perch, 510 Killifish.
July 19, 1930 (3) 450 Perch, 1 Johnny Darter, 1 Killifish.
July 19, 1930 (4) 18 Perch, 8 Log Perch.
July 19, 1930 (5) 5 Perch, 2 Log Perch.
July 21, 1930: 4 Perch, 1 Blunt-nose Minnow, 89 Lake Shiners, 21 Common Shiners, 2 Straw-colored Shiners, 2 Mimic Shiners, 1 Johnny Darter, 5 Log Perch.

8. Sebewaing Bay Shores (Continued).

July 16, 1931. (1) 52 Perch, 3 Carp, 6 Blunt-nose Minnows, 17 Straw-colored Shiners, 63 Spot-tail Shiners, 8 Johnny Darters.
July 16, 1931. (2) 19 Perch, 32 Straw-colored Shiners, 5 Johnny Darters, 5 Log Perch, 80 Killifish.

9. Fish Point; Bulrush, Naias and Algae growing on clay and sand bottom.

September 14, 1930; 23°C: 10 Perch, 2 Large-mouth Bass, 3 Sunfish.
May 6, 1931; 20°C: 5 Blunt-nose Minnows, 50 Straw-colored Shiners, 250 Killifish.
May 26, 1931; 16°C: 53 Blunt-nose Minnows, 2000 Lake Shiners, 100 Straw-colored Shiners, 254 Killifish.
July 6, 1931; 37 Perch, 12 Common Shiners, 14 Johnny Darters, 85 Killifish.

10. Bay City; sand bottom.

July 31, 1930: 20 Perch, 1 Common Sucker, 16 Large-mouth Bass, 5 Blunt-nose Minnow, 253 Lake Shiners, 37 Straw-colored Shiners, 1 Johnny Darter, 1 Log Perch, 1 Killifish.
August 19, 1930; 22°C: 163 Perch, 2 Pike Perch, 1 Carp, 10 Sunfish, 117 Lake Shiners, 91 Straw-colored Shiners, 77 Spot-tail Shiners, 1Rosy-faced Shiner, 6 Log Perch.
September 15, 1930; 21°C: 4 Perch, 1 Sunfish, 16 Lake Shiners, 3 Straw-colored Shiners, 5 Rosy-faced Shiners, 1 Mimic Shiner.
May 7, 1931; 13°C: 25 Perch, 88 Lake Shiners.
May 26, 1931; 17°C: 67 Blunt-nose Minnows 282 Lake Shiners, 53 Killifish.
July 7, 1931; 28°C: 500 Perch, 72 Lake Shiners, 27 Straw-colored Shiners, 25 Black-nose Shiners.

11. Linwood; Bulrush, Leafy Pond Weed, Naias growing on sand and gravel bottom.

July 31, 1930; 25°C: 94 Perch, 39 Common Suckers, 2 Sunfish, 17 Blunt-nose Minnows, 1 Spot-tail Shiner, 5 Rosy-faced Shiners, 1 Mimic Shiner.
September 15, 1930; 20°C: 1 Perch, 1 Large-mouth Bass, 13 Sunfish, 12 Blunt-nose Minnows, 1 Straw-colored Shiner, 1 Mimic Shiner, 6 Johnny Darters, 2 Log Perch, 106 Killifish.
May 7, 1931; 14°C: 255 Perch, 20 Golden Shiners, 1200 Lake Shiners, 75 Spot-tail Shiners.
July 7, 1931; 26°C: 27 Perch, 4 Carp, 8 Large-mouth Bass, 6 Small-mouth Bass, 19 Straw-colored Shiners, 34 Spot-

11. Linwood (Continued).

tail Shiners, 15 Black-nose Shiners, 6 Iowa Darters, 16 Killifish.
July 25, 1931; 27°C: 54 Perch, 23 Straw-colored Shiners, 47 Spot-tail Shiners, 7 Johnny Darters.

12. Pinconning; sand bottom coated with saw dust. Thin growth of Bulrush and Naias in late spring and summer.

July 30, 1931: 50 Perch, 2 Blunt-nose Minnows, 56 Lake Shiners, 1 Spot-tail Shiner, 5 Johnny Darters, 3 Log Perch, 2 Killifish.
August 19, 1931; 22°C: 9 Perch, 1 Large-mouth Bass, 1 Blunt-nose Minnow, 4 Common Shiners.
September 15, 1930; 21°C: 1 Perch, 34 Blunt-nose Minnows, 2 Straw-colored Shiners, 1 Mimic Shiner, 21 Steel-colored Shiners, 3 Johnny Darters, 1 Log Perch, 2 Killifish.
May 7, 1931; 19°C: 49 Perch, 5 Blunt-nose Minnows, 15 Straw-colored Shiners, 35 Spot-tail Shiners, 5 Johnny Darters.
May 25, 1931: no catch.
July 7, 1931; 28°C: 60 Perch, 6 Large-mouth Bass, 20 Common Shiners, 74 Straw-colored Shiners, 12 Johnny Darters.

13. Au Gres; sand bottom; Leafy Pond Weed, Sago Pond Weed.

July 30, 1930: 279 Perch, 7 Pike Perch, 4 Brown Bullheads, 1 Black Bullhead, 1 Large-mouth Bass, 5 Blunt-nose Minnows, 118 Lake Shiners, 5 Spot-tail Shiners, 1 Johnny Darters, 9 Log Perch.
July 31, 1930: 26 Perch, 20 Common Suckers, 20 Mullets, 6 Black Sucker, 6 Blunt-nose Minnows, 3 Straw-colored Shiners, 2 Mimic Shiners, 28 Steel-colored Shiners, 33 Killi-fish.
September 15, 1930: 22°C: 1 Large-mouth Bass, 1 Golden Shiner, 7 Blunt-nose Minnows, 1 Black-nose Shiner, 20 Killifish.

14. Point Lookout; sand bottom; water was about 1 meter at its deepest.

July 30, 1930; 9 Perch, 6 Lake Shiners, 19 Straw-colored Shiners, 20 Spot-tail Shiners, 8 Mimic Shiners, 9 Long-nose Dace, 15 Copeland Darters, 3 Log Perch.
August 19, 1930: 2 Perch, 3 Straw-colored Shiners, 6 Spot-tail Shiners, 23 Johnny Darters, 21 Log Perch.

July 25, 1931; 450 Perch, 7 Common Suckers, 67 Lake Shiners, 16 Strawcolored Shiners, 38 Spot-tail Shiners.

15. Alabaster; sand, gravel and scattered boulders.

July 30, 1930: 2500 Perch, 100 Lake Shiners.
September 15, 1930: 1 Spot-tail Shiner, 3 Long-nose Dace.

16. Tawas City; sand bottom with scattered pieces of lumber boards.

July 30, 1930: 40 Perch, 1 Long-nose Sucker, 1 Blunt-nose Minnow, 305 Lake Shiners, 1 Straw-colored Shiner, 23 Spot-tail Shiners, 1 Mimic Shiner, 5 Log Perch.
May 7, 1931: 125 Perch, 300 Lake Shiners, 39 Common Shiners, 87 Spot-tail Shiners.
May 25, 1931: no catch.
July 7, 1931: 22 Perch, 40 Common Suckers, 11 Blunt-nose Minnows, 15 Common Shiners, 100 Straw-colored Shiners, 12 Johnny Darters, 8 Log Perch.
July 25, 1931: 17 Perch, 3 Common Shiners, 67 Spot-tail Shiners, 6 Johnny Darters, 8 Killifish.

17. East Tawas; sand bottom with scattered pieces of lumber boards.

July 30, 1930: 51 Perch, 1 Blunt-nose Minnow, 635 Lake Shiners, 316 Spot-tail Shiners, 3 Log Perch.
August 18, 1930: 4 Perch, 1 Straw-colored Shiner, 4 Spot-tail Shiners, 5 Johnny Darters, 1 Copeland Darter, 1 Log Perch.
September 14, 1930. (1) 15 Blunt-nose Minnows, 50 Lake Shiners, 10 Johnny Darters.
September 14, 1930 (2) 6 Perch, 15 Lake Shiners, 3 Long-nose Dace, 3 Johnny Darters, 3 Log Perch.
May 7, 1931; 21°C: 10 Lake Shiners.
May 25, 1931: 17°C: 25 Spot-tail Shiners, 3 Killifish,
July 7, 1931: 10 Perch, 15 Common Suckers, 150 Straw-colored Shiners, 10 Johnny Darters.
July 25, 1931: 10 Perch, 4 Common Suckers, 2 Golden Shiners, 8 Straw-colored Shiners, 125 Spot-tail Shiners, 4 Johnny Darters.

18. Lone Tree Island; Bulrush, Leafy Pond Weeds and Algae around on sand and gravel bottom.

July 21, 1930: 7 Perch, 4 Lake Shiners, 9 Straw-colored Shiners, 2 Spot-tail Shiners, 104 Mimic Shiners, 3 Copeland Darters.
August 6, 1930: 54 Perch, 2 Stone Rollers, 1 Blunt-nose Minnow, 3 Lake Shiners, 12 Straw-colored Shiners, 35 Spot-tail Shiners, 35 Mimic Shiners, 8 Copeland Darters.
July 8, 1931: (1) 57 Perch, 8 Lake Shiners, 86 Straw-

18. Lone Tree Island (Continued)

colored Shiners, 15 Spot-tail Shiners, 7 Johnny Darters, 9 Iowa Darters.
July 8, 1931 (2) 16 Perch, 3 Lake Shiners, 38 Straw-colored Shiners, 10 Spot-tail Shiners, 6 Johnny Darters, 9 Iowa Darters.

19. Maimou Island and vicinity; Bulrushes and Leafy Pond Weeds.

July 21, 1930: (1) 18 Perch, 1 White Carp, 1 Blunt-nose Minnow, 124 Lake Shiners, 2 Common Shiners, 1 Johnny Darter, 4 Log Perch.
July 21, 1930: (2) 7 Perch, 25 Lake Shiners, 2 Straw-colored Shiners.
July 21, 1930: (3) 21 Perch, 4 Common Suckers, 1 Sunfish, 7 Blunt-nose Minnow, 3 Lake Shiners, 1 Common Shiner, 9 Straw-colored Shiners, 1 Spot-tail Shiner, 52 Mimic Shiners, 2 Johnny Darters, 3 Log Perch, 1 Killifish.
July 21, 1930: (4) 1 Large-mouth Bass, 1 Sunfish, 3 Blunt-nose Minnows, 1022 Killifish.

Table 38

Record of Quantitative Seine Hauls by Seining Station Using 125-Ft. Seine in Belt 20 to 100 Meters Off-shore. [1]

1. Lone Tree Island; sand bottom and partly surrounded by bulrushes.

July 9, 1930; (1): 123 Perch, 14 Common Suckers, 4 Rock Bass, 6 Large-mouth Bass, 5 Brown Bullheads, 1 Silver Lamprey, 26 Long-nose Gar, 23 Blunt-nose Minnows, 13 Golden Shiners, 10 Lake Shiners, 420 Mimic Shiners, 57 Johnny Darters, 1 Iowa Darter, 8 Log Perch, 15 Killifish.
July 9, 1930; (2): 199 Perch, 7 Lake Shiners, 7 Straw-colored Shiners, 43 Mimic Shiners.

[1] Seining operation was done between 20 meters and 100 meters of shore.

Table 39

Record of Quantitative Seine Hauls by Seining Stations

Using 125-Ft. Seine in Water more than 100 Meters

Off-shore

1. Long Tree Island; sand bottom.

July 8, 1930; 82°F: 16 Perch, 1 Common Sucker, 1 Stone Roller, 11 Blunt-nose Minnows, 70 Straw-colored Shiners, 41 Mimic Shiners, 8 Johnny Darter, 1 Copeland Darter, 4 Iowa Darter.

July 9, 1930: (1) 123 Perch, 14 Common Suckers, 4 Rock Bass, 6 Large-mouth Bass, 3 Brown Bullheads, 1 Lamprey, 26 Long-nose Gar, 23 Blunt-nose Minnows, 15 Golden Shiners, 10 Lake Shiners, 420 Mimic Shiners, 37 Johnny Darters, 1 Iowa Darter, 8 Log Perch, 15 Killifish.

July 9, 1930: (2) 199 Perch, 7 Lake Shiner, 7 Straw-colored Shiners, 43 Mimic Shiners.

July 10, 1930: (1) 10 Perch, 26 Lake Shiners, 4 Mimic Shiners.

July 10, 1930: (2) 280 Perch, 2 Pike Perch, 8 Lake Shiners, 5 Straw-colored Shiners, 11 Mimic Shiners, 8 Johnny Darters, 4 Copeland Darters, 5 Log Perch,

July 20, 1930: 5 Perch, 27 Lake Shiners, 6 Straw-colored Shiners, 7 Spot-tail Shiners, 3 Mimic Shiners, 3 Johnny Darters, 2 Log Perch, 1 Trout Perch.

July 21, 1930: (1) 32 Perch, 1 Lake Shiner, 34 Straw-colored Shiners, 2 Mimic Shiners, 6 Johnny Darters, 8 Copeland Darters, 2 Log Perch.

July 21, 1930: (2) 20 Perch, 1 Sunfish, 7 Blunt-nose Minnows, 2 Lake Shiners, 1 Golden Shiner, 11 Mimic Shiners, 2 Johnny Darters.

September 12, 1930: (1) 25°C: 55 Perch, 2 Blunt-nose Minnows, 2 Lake Shiners, 17 Straw-colored Shiners, 18 Spot-tail Shiners, 6 Rosy-face Shiners, 35 Mimic Shiners, 13 Johnny Darters, 7 Copeland Darter,s 16 Log Perch.

September 12, 1930: (2) 32 Perch, 1 Lake Shiner, 220 Straw-colored Shiners, 60 Spot-tail Shiners, 5 Mimic Shiners, 18 Johnny Darters, 9 Log Perch.

September 12, 1930: (3) 17 Perch, 3 Pike Perch, 1 Rock Bass, 1 Mimic Shiner, 12 Johnny Darters, 14 Log Perch.

September 13, 1930: (4) 10 Perch, 1 Lake Shiner, 4 Straw-colored Shiners, 10 Spot-tail Shiners, 39 Johnny Darters, 18 Log Perch, 28 Killifish.

September 12, 1930. (5) 95 Perch, 56 Blunt-nose Minnows, 21 Lake Shiners, 186 Straw-colored Shiners, 27 Spot-tail Shiners, 71 Mimic Shiners, 74 Johnny Darters, 3 Copeland Darters, 18 Log Perch.

2. Fish Point (In Sebewaing Bay, close to Fish Point).

July 10¼, 1930: (1) 10 Perch, 1 Pike Perch, 1 Blunt-nose Minnow, 1 Straw-colored Shiner, 4 Johnny Darter, 3 Copeland Darters, 2 Log Perch.
July 10, 1930: (2) 48 Perch, 2 Pike Perch, 5 Lake Shiners, 20 Spot-tail Shiners, 2 Mimic Shiners, 22 Johnny Darters, 2 Log Perch.
July 10, 1930: (3) 18 Perch, 2 Blunt-nose Minnows, 41 Lake Shiners, 1 Straw-colored Shiner, 5 Spot-tail Shiner, 16 Johnny Darters, 7 Copeland Darters, 1 River Darter, 7 Log Perch.
July 10, 1930: (4) 157 Perch, 4 Mimic Shiners, 1 Copeland Darter, 2 Log Perch, 1 Trout Perch.

3. Bay Park; surrounded by Bulrush and Algae.

July 11, 1930: (1) 7 Perch, 26 Blunt-nose Minnows, 35 Lake Shiners, 28 Spot-tail Shiners, 37 Mimic Shiner, 2 Steel-colored Shiners, 18 Johnny Darters, 5 Log Perch.
July 11, 1930: (2) 7 Perch, 3 Blunt-nose Minnows, 36 Lake Shiners, 1 Straw-colored Shiners, 10 Spot-tail Shiners, 6 Mimic Shiners, 2 Steel-colored Shiners, 2 Johnny Darters, 4 Log Perch.

4. Tawas City

August 18, 1930: (1) 5 Perch, 1 Pike Perch, 4 Common Suckers, 1 Creek Chub, 5 Common Shiners, 22 Spot-tail Shiners, 1 Johnny Darter, 1 Rice Sculpin, 2 Log Perch.
August 18, 1930: (2) 2 Perch, 1 Pike Perch, 166 Lake Shiners, 18 Straw-colored Shiners, 9 Spot-tail Shiners, 3 Johnny Darter, 2 Log Perch.
August 19, 1930: 3 Pike Perch, 145 Lake Shiners, 68 Straw-colored Shiners, 71 Spot-tail Shiners, 1 Trout Perch.

Large-mouth Bass, Small-mouth Bass and White Carp were mostly caught in their fingerling stage, while only yearling and adult minnows and shiners were secured. As a whole, this seining shows a preponderance of Perch over other commercial fishes and game fishes, while among the non-commercial fishes, there were more Lake Shiners than any of the others.

The result of 1930 seining operations shows that Lake Shiners, Perch, Menona Killifish and Spot-tail Shiners, in the order named, are the four most abundant fishes along the shore. The figures are, however, characterized by the total absence of Trout Perch which is one of the most important food of the Common Terns.

The data obtained in the spring and summer seasons of 1931, as presented in Table 37, show that as a whole there were more Perch fingerlings along the shore of Saginaw Bay in the summer than in the corresponding spring. It should be noted that the Perch collected in the spring were yearling and those obtained later in the summer were fingerlings. In very rare instances adult Perch were caught, although their presence was often noted. The fry were too small to be caught by the mine used.

Among the non-commercial fishes, the result shows that in the spring, Blunt-nose Minnow, Golden Shiner, Lake Shiner and Menona Killifish were more abundant than in the summer of the same year.

A significant seasonal difference in the number of fish caught is shown by Lake Shiners, of which 17,043 were caught in 24 hauls during the spring as compared to 369 individuals in 27 hauls during the summer. The scarcity of this species in the summer I attribute to the fact that this species frequents the deeper water at this period, as Adams and Hankinson (1928) indicate it does in Oneida Lake. Besides there appears to be a tendency for this Shiner to leave the place after being caught and returned to the water

once, as is evidenced by the variability in the numbers caught at one place at different times. The discrepancy between the numbers caught in spring and summer close to shore should have been compensated by a summer increase in population in the deeper water (20 meters off shore to a depth of 2 fathoms). Unfortunately, no seining was done at this region during the spring. For this reason, it was considered best to eliminate from the total estimate the fish obtained in the spring.

Table 37 shows that in two years, along the shores of Saginaw Bay, 4 hauls were pulled at Pointe Aux Barques, 4 At Port Austin, 4 at Oak Beach, 6 at Caseville, 6 at Sand Point, 7 at Bay Port, 4 at Rose Island, 8 at Sebewaing Bay, 4 at Bay City, 4 at Linwood, 4 at Pinconning, 3 at Au Gres, 2 at Alabaster, 3 at Point Lookout, 3 at Tawas City, 6 at East Tawas, 4 at Lone Tree Island and 4 at Maisou Island and vicinity.

The 83 seine hauls from the two summers' in-shore collection indicate that the area of one seine haul (285 square meters), assuming as done above that only half of the fish in the area were seined, contained on the average the number of fishes of each species indicated in the first column of Table 40.

Table 40

Estimated Population of Fish in Saginaw Bay in Summer, Within 20 Meters of Shore

	In area of one haul (285 sq. m.)	Total no. in area 1/
Perch	183.8	4,500,000
Pike Perch	0.3	9,000
Mullet	0.5	15,000
Common Sucker	3.5	110,000
Carp	0.5	15,000

1/Obtained by multiplying the figures for each haul by 30,877 (estimate number of times 285 sq. meters is contained in the area along the shore of Saginaw Bay to 20 meters from shore).

	In area of one haul (285 sq. m.)	Total no. in area
Rock Bass	0.1	3,000
Large-mouth Bass	1.2	37,000
Sunfish	1.1	34,000
Small-mouth Bass	0.7	22,000
Blunt-nose Minnow	6.1	190,000
Golden Shiner	0.3	9,000
Lake Shiner	178.0	5,500,000
Common Shiner	16.4	500,000
Straw-colored Shiner	20.6	630,000
Black-nose Shiner	2.2	68,000
Spot-tail Shiner	39.2	1,210,000
Mimic Shiner	9.1	281,000
Steel-colored Shiner	1.5	46,000
Killifish	46.9	1,450,000
Johnny Darter	4.9	150,000
Log Perch	6.8	200,000
Other Fishes[1]	2.9	90,000

The Fish Population From 20 Meters to 100 Meters Off-shore.

The summer fish population in this belt was estimated from two seine hauls from Lone Tree Island. The areas seined represent an approximate average of the conditions 20 meters to 100 meters off-shore of Saginaw Bay. There was here a thin growth of bulrushes, considerably algae and few boulders thinly scattered, less cover than along the marshy shore, but more than along the sand beaches. The hauls covered a greater area than usual,- an area of about 1000 square meters. The 125 foot Baird seine was set about 65 meters offshore and pulled to shore, after being pursed at about 20 meters off shore. Judging from the conditions upon which the seine was pulled, it was estimated that only two fish were caught for every three present. These fish caught are listed in Table 36. From the data in that table, making allowance for escapements as indicated above, the number of fish per area in one seine

[1] The item "Other fishes" includes Brown and Black Bullheads, Red Horse, White Carp, Tadpole Cat, Long-nose Gar, Stone Roller, Rosy-face Shiner, Copeland's Darter and Iowa Darter.

haul of about 1000 square meters and in the entire belt was roughly estimated as shown below:

Table 41

Estimated Population of Fish in Saginaw Bay in Summer in Belt Between 20 and 100 Meters Off-shore

Fish	No. in one haul (1000 sq. m.)	Total no. in belt
Perch	241.5	8,500,000
Common Sucker	10.5	370,000
Rock Bass	3.0	107,000
Large-mouth Bass	4.5	158,000
Brown Bullheads	2.25	79,000
Long-nose Gar	19.5	690,000
Blunt-nose Minnow	17.25	610,000
Golden Shiner	9.75	341,000
Lake Shiner	12.75	449,000
Mimic Shiner	347.25	12,235,000
Killifish	11.25	400,000
Straw-colored Shiner	5.25	170,000
Johnny Darter	27.75	250,000
Log Perch	6.0	200,000
Other fishes [1]	1.5	50,000

The Fish Population From 100 Meters Off-shore to a Depth of 2 Fathoms

The shore fishes no doubt wander in the deeper water also and the birds feed there to some degree. For these reasons, seine hauls were pulled as far as the net was able to catch fish. In all deeper operations, the larger seine was used. Most of the hauls with the larger minnow seine (a 125 foot Baird seine with $\frac{1}{8}$" mesh in bag), made to determine the fish population of this area, were made far from shore, so that the net had either to be pulled into an anchored boat, or to be pursed directly into the water where the operators

[1] Other fishes include Silver Lamprey and Iowa Darter.

could wade. One can imagine the crudeness of this process, which I estimate led to the catching of not more than one fifth of the fish present in the area seined. Another handicap was that most of the seining operations with the larger seine was done around Lone Tree Island where the fish population per given area might be less than in other places on account of the presence of the large colony of Common Terns when the seining was done. To make reasonable allowance for these factors, the number of fish caught in the large seine was multiplied by 5 to indicate the papulation per given area seined over. The escapement of the very small, slender and swift Perch fingerlings presumably was even greater. The results of seining with the larger seine are given in Table 39. From data in that table, making allowance for escapements indicated above, the number of fish per area in the seine haul and in the entire area are calculated (Table 42).

Table 42

Estimated Population of Fish in Saginaw Bay in Summer in Belt Between 100 Meters Off-shore to a Depth of 2 Fathoms

Fish	No. in one haul (740 sq. m.)	Total no. in belt
Perch	205.5	143,000,000
Pike Perch	3.25	2,261,000
Common Sucker	1.25	870,000
Blunt-nose Minnow	20.75	1,400,000
Lake Shiner	134.00	93,221,000
Common Shiner	1.25	870,000
Spot-tail Shiner	71.75	49,920,000
Straw-colored Shiner	148.00	103,200,000
Mimic Shiner	58.25	40,524,000
Trout Perch	1.50	1,000,000
Menoma Killifish	7.00	4,870,000
Johnny Darter	61.75	42,950,000
Copeland's Darter	8.50	5,900,000
Log Perch	27.75	19,300,000

	No. in one haul (740 sq. m.)	Total no. in belt [1]
Other fishes.[2]	6.75	4,860,000

Total Fish Population in Litteral Zones

According to the figures presented for the results of seining from the three belts which I was able to sample by seining, the total fish population in the shallower waters of Saginaw Bay within the 2 ~~meter~~ fathom contour is roughly as indicated in Table 43.

Perch	156,000,000	Lake Shiner	99,170,000
Pike Perch	2,270,000	Common Shiner	1,370,000
Mullet	15,000	Straw-colored Shiner	104,000,000
Common Sucker	1,350,000	Black-nose Shiner	68,000
Carp	15,000	Spot-tail Shiner	51,130,000
Rock Bass	110,000	Mimic Shiner	557,000,000
Large-mouth Bass	280,000	Steel-colored Shiner	46,000
Sunfish	34,000	Killifish	6,700,000
Small-mouth Bass	22,000	Trout Perch	1,000,000
Brown Bullheads	79,000	Johnny Darter	44,000,000
Long-nose Gar	690,000	Copeland Darter	5,900,000
Blunt-nose Minnow	22,300,000	Log Perch	19,700,000
Golden Shiner	350,000	Other fishes	5,000,000

It will be observed that, for the entire area, Perch fingerlings outnumber any other species collected. Along the shore line this item rated next to Lake Shiner in abundance, in the 20-100 meter belt, it followed Mimic Shiner, while in the deepest area seined it was preponderant. In the early part of the seining season, the Perch yearlings were in shore and these were the ones caught. The Perch fry were not included in early hauls, probably because they slipped through the seine. Adams and Hankinson (1928:426) believe that the larger Perch inhabit the deeper water while the smaller ones are in shallow part and the very small ones are in the marginal shallows. This seems to uphold the

[1] Obtained by multiplying the figures for each haul by 695,676 (estimate number of times 740 sq. m. is contained in the area between 100 meters off-shore to a depth of 2 fathoms.)

[2] The term "other fishes" includes Rock Bass, Sunfish, Stone Rollers, Lake Chub, Golden Shiner, Rosy-faced Shiners, Steel-colored Shiners, Trout Perch, River Darter, and Rice Sculpin.

result obtained in this study. In the summer, the fingerlings were then large enough, so that they were caught. This undoubtedly represented the larger per cent of those that are shown in the figures above. If the very young fish of the early summer had been caught in any numbers, the average number per haul and the estimated average Perch population of the bay would be increased.

Very few Pike Perch were collected. It is surprising, however, that in one haul made at night a Pike Perch fingerling was caught. It may not be improbable that this fish inhabits the deeper water of Saginaw Bay and comes to shore chiefly at night to feed. This does not appear to be in accord with the results of Adams and Hankinson (1928) and of Dymond (1926) who studied this condition in Oneida Lake and Lake Nipigon respectively. In any event, the estimated number of Pike Perch fingerlings as shown in the figures in the preceding page does not seem to be consistent with the number of adults caught by the fishermen.

Obviously, the Lake Shiners that were along the shore when seining was done were fry and yearlings. The size of these yearlings caught was the same as those recovered from the Common Tern and Black Tern. Apparently, this species spend only a short time in the shore during early summer, as later collecting did not yield as many as were obtained during the early hauls. They were generally caught in clear waters of sandy or sand and gravel bottoms, and more frequently with sparse growth of Bulrush (Scirpus). Adams and Hankinson (1928)[351] attributed their collection of only a few Lake Shiners to the fact that their collection was done in the summer when according to them this species was in deeper water. The extreme difficulty of catching the very small and slender Lake Shiner fingerlings in the summer has already been referred to, and probably has caused

the estimated number to be far below the total population. Furthermore, many of the Lake Shiners probably occupy parts of the bay where the depth is greater than 2 fathoms. General observations on the excessive abundance of the species lead to the belief that the estimate of about 100,000,000 Lake Shiners for Saginaw Bay is far too low.

Both mature yearling Spot-tail Shiners were caught while fry generally escaped away from the seine, only those being dragged along by the bottom line and by the weight of the seine being caught. For this reason I believe the estimated number of this species to be also too low.

Straw-colored and Mimic Shiners are fairly abundant along the shores. Both species spawn in summer, as those collected were mostly ripe.[1] The first years young of these species must also have almost entirely escaped the seine.

The estimate of fish population shows that there are very few Trout Perch in littoral regions of Saginaw Bay. In fact none were noted in the seine hauls made along the shores. Unquestionably, this species inhabits the deeper water during the day through the period of sampling the shore regions. When I observed the birds carrying Trout Perch in their bills, coming from far off shore, I was puzzled about the method employed by the birds in capturing this fish. M. B. Trautman, however, had informed me that in Lake Erie, he saw the Common Terns in June actually feeding on Trout Perch. The fish were spawning and came in great abundance to the surface, where many were dying and were being washed ashore. This observation is very interesting as far as this investigation is concerned, for most of thos that were dropped by the birds in Saginaw Bay were ready to spawn. Adams and Hankinson (1928:418) say that in Oneida

[1] Hubbs (1924: 214) noted that in Douglas Lake, Straw-colored Shiners, Notropis deliciosus, (then called N. blennius) spawn from July to August.

Lake Trout Perch were abundantly represented in a number of shallow places during early summer. Bensley (1915: 37) believes that this species inhabits the deep, cold water of Georgian Bay. Colbert (1916: 30) maintains that Trout Perch are very abundant in Douglas Lake in water about 10 to 20 feet deep. Dr. Carl L. Hubbs told me that In that lake and also in the Great Lakes, the Trout Perch come into shallow water at night, but the birds do not feed in the dark.

Menona Killifish were very abundant along the shores of Saginaw Bay. They were commonly seen in big schools in early summer. However, they frequent waters of clay and mud where there is a thin or thick growth of emergent vegetation, thus sampling them became very difficult. This is the reason why the estimate shows relatively few of them.

Comparison of Fish Eaten by Common Terns With the Total Fish Population

Assuming that the estimates of fish population obtained through seining applied to all three years of study, the effects of the Common Terns on the fish population of the shallow waters of Saginaw Bay may be tabulated:

Table 45.—Relation of the Annual Fish Food of the Common Terns to the Estimated Fish Population.

Fishes	Estimate of population	Estimate destruction by Common Terns					
		Number 1929	%	Number 1930	%	Number 1931	%
Perch.....	156,000,000	111,000	0.07	1,986,000	1.3	792,000	0.5
Pike Perch.....	2,870,000	-	-	144,000	6.3	-	-
Lake Shiner....	99,170,000	100,000	0.1	3,707,000	3.7	3,829,000	3.8
Spot-tail Shiner.....	51,130,000	11,000	0.02	104,000	0.2	197,000	0.4
Trout Perch....	1,000,000	174,000	1.7	149,000	1.0	205,000	2.0

Table 43. (Cont.)

Fishes	Estimate of population	Estimate destruction by Common Terns Number 1929	%	Number 1930	%	Number 1931	%
Other fishes	264,849,000	66,000	0.02	219,000	0.08	55,000	0.02
Commercial fishes	159,729,000	111,000	0.07	2,130,000	1.3	792,000	0.5
Forage fishes	413,634,000	351,000	0.08	4,179,000	0.1	4,286,000	0.1

The Effects of the Common Tern in the Destruction of Fingerlings of the Commercial Fishes

The estimates presented in Table 43 indicate that 0.07 per cent of the Perch fingerling population in Saginaw Bay was eaten by the Common Terns in 1929, 1.3 per cent in 1930 and only 0.5 per cent in 1931, in spite of the fact that more young Terns were reared in that year than in 1930.

If the figures presented in Table 43 are to be accepted at their face value, it would appear that the number of Perch and Pike Perch fingerlings estimated to have been eaten by the Common Terns in 1930 should need careful consideration. The estimate of 1.3 per cent of the Perch fingerling population computed to have been taken by the birds in 1930, however, was probably too high due to the fact that the estimate of Perch fingerling population was too low. The average number of fingerlings per haul would certainly be expected to be too low, when it is considered that seine hauls made early in the summer did not yield the small Perch that slipped easily through the meshes of the seine. As will be shown on p. 169 there is another reason to believe that the estimate of 156,000,000 Perch fingerlings inhabiting the shallow water of Saginaw Bay is rather a low estimate.

Due apparently to the fact that the habitat of the Pike Perch fingerling was not sampled (p. 45) the estimate of its population was consequently very low. This is the reason why the few Pike Perch fingerlings indicated to have been eaten by the Common Terns in 1930 comprised 6.3 per cent of the estimated total population. In the years 1929 and 1931, the Common Terns which were sampled did not take any Pike Perch at all.

The destruction by the Common Terns of the two species of commercial fishes as estimated, is 0.07 per cent in 1929, 1.3 per cent in 1930 and 0.5 per cent in 1931. It is very probable that these estimates are too high.

The Effects of the Common Tern as a Food Competitor of Commercial Fishes

The variety of food of the Common Terns obviously affects the interrelation of life in the bay. How deleterious these effects will be to other forms, particularly to the commercial fishes, it is the aim of this paper to indicate. In addition to being predators on the fingerlings of Perch and Pike Perch, as noted in the previous section, these birds are competitors of some of the mature commercial fishes, because the food of some of them is common with that of the Common Terns. Among the food items eaten by both the birds and the commercial fishes are the forage fishes and commercial fish fingerlings and also Mayfly nymphs, Carpenter Ants and dragon fly nymphs. The effects of the Common Tern on the commercial fishes as a feeder on forage fishes and insects will be dealt with in the present section.

Competition for Forage Fishes

Commercial fishes undoubtedly subsist to a certain degree on the forage fishes. Even the Whitefish at times eats fishes. Clemens and others (1924: 115-118) determined 20%, 45% and 15% of the food of 5, 1 and 12 individuals respectively of Whitefish to be fish remains. The Whitefish studied from Saginaw Bay, however, had fed almost entirely on Mayflies (Koch, 1920). :528-529

As indicated in Table 43, the Common Tern in Saginaw Bay also feeds heartily on forage fishes. Whether this bird feeds on as high a percentage of the forage fishe population as indicated in that table is open to doubt.

According to the indicated estimate, 0.1 per cent of Lake Shiners in Saginaw Bay was eaten by the Common Terns in 1929, 3.7 per cent in 1930 and 8.8 per cent in 1931. Personal observation has made it appear that the estimate of total population of Lake Shiners is very low. If apparently millions of this fish could be seen at one time in the fall in one place alone, as mentioned on p. 45, one must think it probable that more than 500,000,000 Lake Shiners must exist in the entire Saginaw Bay in the summer.

As has been pointed out in Table 37, many slender Spot-tail Shiner fingerlings slipped through the meshes of the seine. This caused the total estimate to be very low.

The habitat of the Trout Perch obviously was not sampled, presumably because the placed of diurnal retreat was too deep for the seine, so the figures given in Table 43 must represent only a very insignificant part of its actual population. From the estimated total population based on the few individuals caught outside of its habitat, about 1.7 per cent was calculated to have been eaten by the Common Terns in 1929, 1 per cent in 1930 and 2 per cent in 1931.

Perch, unquestionably feed on fishes other than its own kind. This was reported by Reighard (1915: 237) from Douglas Lake, Michigan, by Pearse (1921: 48) from three lakes in Wisconsin and by DeRyke (1922: 38) from Winona Lake, Indiana. The Common Terns doubtless also feed on some of these fishes. Other investigators have also reported that fishes comprise a considerable part of the food of the Perch, but whether these species are the same as those which the Common Terns take cannot be ascertained. However, in view of the varied

food of the Perch, it is assumed that at least a certain percentage of its food consists of fishes which are also taken by the Terns. Unfortunately, no definite mathematical comparison could be made due to lack of figures. In all probability, however, the number taken by the birds is not sufficient to cause alarm as the Perch seem to take any species of forage fish which are plentiful in the bay and also feed largely on insects.

The Common Terns and the Pike Perch are also competitors as they have fish food in common. Metzelaar (M S) reported that the Pike Perch in Saginaw Bay feed on Trout Perch and concluded that the Pike Perch and the Lake Trout are competitors. As Trout Perch is an important food of the Common Tern, then the birds compete to some degree with both the Lake Trout and Pike Perch. Pearse (1921: 48) found that 78% of the food of 8 Pike Perch he examined from Lake Geneva was fish. Fish remains were also found by him from other lakes in the same state. Greeley (1927: 64) recovered minnows from the stomachs of 7 Pike Perch from Genesee System in New York. Clemens and others (1924: 129-130) reported Nine-spined Sticklebacks and other fish remains from Pike Perch collected at Lake Nipigon. Bensley (1915: 45) reported fishes as food of Pike Perch at Georgian Bay. In addition to the findings of the workers named above, many others have indicated that Pike Perch are carnivorous, feeding like the Common Terns on fishes and insects. The competition cannot be expressed in quantitative terms, but I do not believe the birds have thus any serious effect on the Pike Perch.

The Channel Cat feeds on minnows, according to Henshall (1919:245). There is a good reason to believe therefore, that Common Terns compete to some extent with the Channel Cat for fish as food. Black Bullheads, Ameiurus melas,

were found by Forbes (1888: 460-461) to have one-fifth of their food consisted of fish.

The Lake Trout feeds mostly on Lake Herring, and also on Sculpins (Cottidae) Trout Perch and other fishes. Since the Terns were found not to feed on either Lake Herring or Sculpins, and to only a relatively small degree on Trout Perch, the competition the birds offer the Lake Trout cannot be serious.

All results from several places tend to show that the Common Tern competes to some degree with most if not all of the commercial fishes. It is, however, very unfortunate that the degree of competition cannot be estimated as oftentimes mathematical data are lacking. In view of all considerations, it appears, however, that the Common Terns cannot be a very serious competitor to the commercial fishes in Saginaw Bay as they pick up only species that feed close to the surface.

Certain species of forage fish, abounding in Saginaw Bay are known to be acceptable to the fish-eating fishes, yet are almost never eaten by the birds, probably because these species of fish do not swim close to the surface. This circumstance greatly mitigates the competition between birds and fish. Outstanding examples of forage fish neglected by the birds are the Straw-colored and Mimic Shiners, which abound right around the big colony of Common Terns in Lone Tree Island (see Table 38), yet are very seldom recovered from the stomachs of the birds.

Only a small per cent of the population of the Spot-tail Shiner is eaten by the Common and Black Terns, and it seemed to escape entirely the Bonaparte's Gulls as shown elsewhere in this paper. Therefore the great bulk of the population of this small fish must serve as food of fishes during their struggle for survival into maturity. In Oneida Lake, Adams and Hankinson (1928:346) believe that this fish migrates into deeper water early in the fall and this is perhaps the reason why they escape the Bonaparte's gulls in Saginaw Bay.

In spite of their abundance, it is surprising that only a very insignificant number of Menona Killifish was found to be taken by the birds.

From the fact that the Common Terns were estimated to take only 0.1 per cent of the total number of forage fishes and from the fact that most of the forage species are doubtless preyed upon by the food fishes, it may be safely assumed that the birds are not doing any serious harm to the commercial fishes by competing with them for food.

Competition for Insects.

The Carpenter Ant was the chief insect food of the Common Terns sampled in 1929 when about 2,900,000 were estimated to have been eaten. This estimate, however, is apparently far too high, for the reason that the birds were collected in 1929 only within a limited period, when the winged ants were flying in swarms. There is thus indicated some competition between the Common Tern and the Lake Herring, which feeds also on this insect when abundant (Koelz, 1920: 498). Their competition offered by the birds, however, can not be serious as the ants were found to be eaten by the birds only in one brief period, when they were too numerous for the fish to clean up.

Dragon fly nymphs entered into the composition of the Common Terns meal to the amount of 68,000 in 1929 and 363,000 in 1931. The finding of some of the workers on the food habits of fish show that this item is also a food of some of the commercial fishes. Among these workers are Baker (1918: 192) who found this insect from the stomach of Perch at Oneida Lake, New York. Hankinson (1908: 208) found this item among the food of the Common Bullhead, Ameiurus nebulosus in Walnut Lake, Michigan. Wilson (1920: 226) described Channel Cat, Ictalurus punctatus, eating these nymphs near Fairport, Iowa. These observations make it evident that the Common Tern and these fishes are

competitors for dragon fly nymphs. The relatively few nymphs taken by the birds, however, will not in my opinion, produce a serious condition of competition for this food item.

The nymphs of the Mayfly form the chief insect item in the food of the Common Terns, about 380,000 being estimated as eaten in 1929; 2,800,000 in 1930, and 105,000 in 1931. Due to the number of this insect estimated annually to have been eaten by the Common Terns, and to the fact that almost all fishes (commercial, game, forage) feed on the same insect, the competition between the birds and the fishes for this food is obvious. Some of the investigators who found and reported the fishes to feed on Mayfly nymphs are: Hubbs cited by Koelz (1920:498) found that the food of Lake Herrings he examined from Saginaw Bay consisted chiefly of Mayflies (Hexagenia). In the same paper, Hubbs was reported to have examined White fish, Coregonus clupeaformis, from Bay City (Saginaw Bay), and to have found this fish to subsist almost exclusively on the larvae of the Mayfly (Hexagenia) Adamstone (1924:76) reported that Mayfly nymphs were always included in the stomachs contents of Whitefish he examined from Lake Nipigon. Hankinson (1928:420) reported that the Perch he examined from Oneida Lake in 1921 had eaten only Mayfly (Hexagenia) nymphs. Metzelaar in a report to the Michigan Department of Conservation believed that the Pike Perch in Saginaw Bay eats Mayfly nymphs in addition to other types of food. Clemens and others (1924: 107-109) found ephemerid larvae as food of the Common Suckers in Lake Nipigon. Dymond (1926: 30) whose work was done in the same region, corroborated the findings of Clemens and others. Adamstone (1924: 79) and Clemens and others (1924: 110) reported that Mayfly nymphs were found in the stomachs of Red Horse, Moxostoma aureolum, from Lake Nipigon. The same group reported these insects as important food of Northern Sucker, C. catostomus. McAtee and Weed (1915: 9) found that 90% of the contents of one stomach of Channel Cat was Mayflies (Hexagenia). Hankinson (1908: 208)

found Mayflies among the food of Common and Yellow Bullhead, A. nebulosus and A. natalis, respectively in Walnut Lake, Michigan. Bensley (1915: 14) believed that throughout the summer, the food of the Common Bullhead in Georgian Bay consists almost wholly of Mayfly larvae, for which the fish burrows in the mud bottom. The writer noted Mayfly nymphs from the stomachs of Channel Cat collected from Saginaw Bay. In addition to these observations, this insect has also been recorded from the stomach of other fishes from other regions. Even some of the forage fishes have been reported to take mayfly nymphs.

In spite of the large numbers of Mayflies estimated to be taken by the birds in Saginaw Bay, and of the importance of this item in the dietary of the commercial fishes, the degree of competition cannot be at all serious. The reason is the almost incredable abundance of Mayflies in Saginaw Bay. As mentioned on p. "", it is estimated that as many as 3,000,000,000 of these large insects may emerge at one time from the bay. Since less than 3,000,000 are estimated to be eaten in a year by the terns, plenty must be left for the fishes.

A Comparison of the Destructiveness of the Common Tern and Other Fish Predators.

In preparing to arrive at a general estimate of how serious may be the harm done by the Common Tern to the commercial fish supply; it has been thought desirable to present in comparison some idea of the relative destructiveness of other fish predators in the bay. The chief comparison will be made with an arch-predator, the Lawyer, Lota maculosa.

Comparison with the Lawyer

From an examination of 1,368 stomachs of Lawyers (Lota maculosa) by Dr.

Metzelaar and the writer of which only 6.6 contained food. The items which had been eaten were Lake Herring, Whitefish, Pike Perch, Perch, Sauger, Straw-colored Shiner, Spot-tail Shiner, Trout Perch, Stickelback, Log Perch, and May-fly nymphs, in varying amounts. The significance of these data becomes more manifest when the total effect of the Lawyers estimated to occur in the bay was calculated. The basis for estimating the total number of Lawyers in Saginaw Bay was Metzelaar's report to the Department of Conservation that Mr. Loumsberry had made a record lift of 9 tons of Lawyer in 1928. The total number of Lawyers in the bay, if only 20 times the number in this one lift, would be about 190,000 (this estimate was made on the assumption that the average Lawyer caught in the fishermen's nets in Saginaw Bay weighs 1.9 pounds (962 grams) -- a figure obtained from records furnished by the U. S. Bureau of Fisheries). On this basis, I calculate that at one feeding time, the Lawyers in Saginaw Bay would consume roughly the following:

Lake Herring	45,500	Straw-colored Shiner	13,000
Whitefish	4,000	Spot-tail Shiner	5,000
Perch	178,000	Trout Perch	408,500
Pike Perch	98,000	Log Perch	34,000
Sauger	4,000	Nine-spined Stickleback	9,500
		Mayfly nymphs	190,000

If each Lawyer feeds once every day, the annual bill of fare, considering other the fish to feed in Saginaw Bay for only three months in the spring and three months in the fall would be roughly as follows:

Lake Herring	5,000,000	Straw-colored Shiner	270,000
Whitefish	360,000	Spot-tail Shiner	450,000
Perch	16,000,000	Trout Perch	36,000,000
Pike Perch	8,800,000	Log Perch	3,000,000
Sauger	360,000	Nine-spined Stickleback	850,000
		Mayfly nymphs	17,000,000

This is based on the assumption that the Lawyer competes only with the Common Tern in the spring and in the fall. During the summer they may be in the deeper water of the lake, and during the winter, the Common Terns are not in the bay.

According to these results, the comparison of destructiveness between the Common Tern and the Lawyer lies in the following:

Table 44. - Comparison of Destructiveness of the Common Terns and the Lawyers

Food Item	Annual destruction by:	
	Common Terns	Lawyers
Lake Herring	-	5,000,000
Whitefish	-	360,000
Perch	943,000	16,000,000
Pike Perch	48,000	8,800,000
Sauger	-	360,000
Lake Shiner	2,415,000	-
Straw-colored Shiner	-	270,000
Spot-tail Shiner	85,000	450,000
Trout Perch	135,000	36,800,000
Log Perch	-	3,000,000
Nine-spined Stickleback	4,000	850,000
Other fishes	110,000	-
Mayflies	382,000	17,000,000
Other insects	1,208,000	-
Total:		
Commercial fishes	991,000	30,520,000
Forage fishes	3,129,000	41,370,000
Insects	1,590,000	17,000,000

The data obviously show that the Lawyer is more destructive than the Common Terns. The figures can be of better significance when other factors involved are presented.

Destructiveness Compared

The data on Table 44 show that, on assumptions which I think yield low estimates, that the Lawyers destroy annually about 5,000,000 Lake Herring, and 360,000 Whitefish, each with an average standard length of more than 200 mm, while the Common Terns do not take any of this species.

About 360,000 Saugers, Stizostedion canadense are estimated on the same basis to be eaten by this predator annually, but not found to be eaten by the Common Terns.

An aggregate of 16,000,000 Perch, mostly yearlings and subadults, is the figure arrived at for the destruction of the Lawyer, or about 17 times as many as were estimated to be eaten by the Common Terns. But it should be noted that the Perch taken by the Lawyer were much larger than those taken by the Terns. The size as indicated by the volume of Perch received averaged more than 100 mm., probably more; the 34 largest Perch found in 84 lots were 115 to 187 mm. long, averaging 143 mm. If, for the sake of comparison, it is admitted that it takes about 15 Perch fingerlings (of the size taken by the Terns) to attain 1 of the size taken by the Lawyer, the comparison of destruction would, therefore, be 255 by the Lawyer to 1 by the Common Tern.

An average of 48,000 Pike Perch fingerlings estimated to have been eaten by the Common Terns in 1 year represent only about 1/180 of the Pike Perch (8,800,000) calculated to be taken by the Lawyers. Those taken by the Lawyer had an average standard length of more than 178 mm., and a few large individuals recovered measured 188 to 230 mm. (nearly one foot long over all). If it is taken for granted that 15 Pike Perch fingerlings (of the average size taken by the Common Tern, 40 mm.) are required to produce 1 of 178 mm. length, then the ratio of destructiveness to the Pike Perch is 2,700 by the Lawyer to 1 by the Common Tern.

The comparison of the extent of destructiveness for forage fishes is about 1 of the Common Tern to 13 of the Lawyer.

For the insect the ratio of destructiveness is about 1 to 10, the Lawyer doing the greater damage.

Considering the total number of commercial fishes eaten, the conclusion is reached that the Lawyer, if its numbers in the bay be only 20 times that estimated to have been taken in a single net lift, and if it feeds on the average only once in two days for six months, eats 30 times as many commercial fishes as the Terns. Since the fish eaten by the Lawyers are mostly half-grown and subadult, it may be assumed that at least 15 fingerlings of the size eaten by the Terns are required to produce one commercial fish of the size eaten by the Lawyer. On the basis of these assumptions, the destructiveness by the Lawyer in the Bay is about 450 times as great as that by the Common Tern.

Comparison with Other Predators

The Lawyer, although roughly estimated as being at least several hundred times as destructive to the commercial fish supply as the Common Tern, is by no means the only other fish predator in the bay. Another recognized arch-predator among the fishes, also occurring in the bay is the Long-nosed Gar.

Out of 25 stomachs studied, 14 were empty as all of them were obtained at one time when apparently the food in their stomachs were very far digested. A total of 12 Perch, most of them in fragmentary forms, were recovered from 7 out of 11 stomachs with food. Other food items recovered were 1 Straw-colored Shiner from 1 stomach, 1 Spot-tail Shiner from 1 stomach and 39 May-fly nymphs from 8 stomachs. Although no data regarding the extent of destruction to the fishes done by the Long-nosed Gar could be given, it still shows that this predator may compare favorably with the Common Tern for the result shows both predators subsist on the same kind of food.

Perch has a predatory habit in being cannibals. This condition was reported by Reighard (1915: 257) from Douglas Lake, Michigan, by DePyke (1922:36) from Winona Lake, Indiana, by Pearse (1921: 48) from some Wisconsin Lakes and by some other investigators from other places.

(1921:48)

Perch fingerlings were preyed upon by Pike Perch as Pearse had found in Wisconsin Lakes. Greeley (1927: 54) reported young Perch and Suckers from Pike Perch he studied from the Genesee System in New York. Clemens and others (1924: 129) reported 1 Pike Perch in addition to other fish items from the stomach of Pike Perch they examined from Lake Nipigon. In Georgian Bay, Bensley (1915: 45) reported Perch among other fishes to be the food of the Pike Perch.

Pickerel (Esox lucius) is also a predator, according to Pearse and Achtenberg (1920: 332) who believe it feeds on Perch. Hankinson (1908: 209) also reported this fish to subsist on some other commercial fishes.

Forbes (1888) 460-461) found Perch to be included in his estimate that fish comprised about one-fifth of the food of the Common Bullhead, Ameiurus nebulosus from Illinois.

All these results tend to prove that Perch falls victim to many predators. The degree of destruction, however, cannot be determined, thus comparison with the Common Tern is impossible.

If any of these predators, including the Common Tern and the Lawyer are doing any harm to the commercial fishes, the destruction of the Lawyer should above all receive attention.

Table 45. - Catch of six important commercial fishes of Saginaw Bay in five years*

Fish	1926	1927	1928	1929	1930
	lbs.	lbs.	lbs.	lbs.	lbs.
Lake Trout	101,058	52,539	15,380	117,469	96,033
Whitefish	497,411	525,354	885,395	574,757	1,079,850

*From the Michigan Department of Conservation. Started Sept. 1927

Table 45 (Cont.)

Fish	1926 lbs.	1927 lbs.	1928 lbs.	1929 lbs.	1930 lbs.
Perch	541,848	118,711	192,008	443,283	605,187
Pike Perch	528,875	620,875	629,614	396,417	953,301
Suckers and Mullet	855,154	1,588,293	858,626	1,087,283	1,710,469
Herring	3,326,008	4,005,228	737,818	1,750,009	3,589,162

Table 46. - The Common Tern Population and the Catch of the Lake Herrings 4 years later

	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Tern population	Constant and approximately same as in 1930 and 1931.							daily average of 471	daily average of 1,880	
Herring catch 4 years later..	3,326,000	4,005,000	738,000	1,750,000	3,589,000	-	-	-	-	

The Relation Between Abundance of Common Tern and the Commercial Fish Yield of the Bay

Perhaps one of the most satisfactory procedures to demonstrate the effect of the "minnie gulls" to the commercial fisheries of the bay is to present the statistics of catch by commercial fishermen for a period including the time of the study. With this aim in view, the catch of six important commercial fishes of Saginaw Bay is shown in Table 45.

It will be seen that there is an irregular fluctuation of each item during the five years from 1926 to 1930. The most significant was the decrease of the poundage of Lake Herring and of Lake Trout in 1928. The reduction of the former

had been attributed to the destruction by the "minnie gulls", and, as had been mentioned on p. 4 was the cause of the indignation among commercial fishermen in Saginaw Bay. This assertion, however, seems to be unfounded, because Mr. Walter E. Hastings of the Michigan Department of Conservation, who had observed the Common Terns at Lone Tree Island informed me that the number of birds during his three years (1924-1926) of observation had been constant. Mr. H. Müllerweise of Sebewaing, Michigan, supplementing Mr. Hastings information said that the number of birds in 1930 and 1931 appeared to be the normal number in the former years including the time when Hastings visited the colonies a few years before. This reliable information should acquit the Terns from the cause of the decrease in catch since commercially caught Lake Herrings are on the average 3, 4 or 5 years old with a preponderance of the 4 yr. olds (Van Oosten, 1928) If the birds had any effect at all, the fish caught should be directly proportional to the number of birds three, four or five years previous. The constancy of number of Common Tern in 1924 to 1926 could not be the cause of the decrease in the catch in 1928 (Table 46) neither could it be the cause of increase the next two years that followed. Dr. Van Oosten told me that several storms during the fishing seasons in 1928 partly caused the diminished catch of that year. This fluctuation in poundage of commercial fish catch must be a natural fluctuation not caused by the birds, although the Department of Conservation admits that it was partly due to incomplete return of statistics that year.

Besides the relative values of catch of commercial fishes, the figures presented in Table 45 has another significance. To obtain a rough estimate of mature Perch population of Saginaw Bay, the figures for the years 1929 and 1930 were converted into actual number of fish. Legal-sized Perch caught in Saginaw Bay is at

least nine inches (22.86 cm.) long. The U. S. Bureau of Fisheries had done some measurements of commercial fishes in 1928 and 1929 in Saginaw Bay and their records which were kindly furnished to the writer proved that an average legal-sized Perch caught weighs 200 grams (1 lb. = 454 gms.). According to this, 443,383 pounds of Perch caught in 1929 would be the weight of about 1,003,000 legal-sized Perch. In 1930, about 1,275,000 legal-sized Perch would have been caught. It should be observed that this was the year of maximum destructiveness of Perch fingerlings. The number of Perch fingerlings estimated to have been eaten by the Common Terns is about two times the estimated number of adult Perch caught by the commercial fishermen, but probably much less than one-third the total adult Perch population in the bay was caught that year. If the adult Perch population was 5,000,000 (five times the actual catch in 1930) then my estimate of 153,000,000 Perch fingerlings for that year seems to be a rather low estimate, in view of all the chances for destruction which a Perch fingerling must face. The mature Perch below the legal-sized are not considered in this estimate, which would certainly increase the ratio.

Conclusion

The Common Terns, in addition to being competitors of commercial and non-commercial fishes also prey upon both types. The number of Perch and Pike Perch fingerlings taken by the birds may seem alarming, but careful consideration of the factors involved in the solution of the situation will lead one to think that destruction done to fisheries is more apparent than real. The persecution of the birds, will not , in my opinion, materially increase the production of commercial fishes.

VII GENERAL SUMMARY

1. This investigation was conducted as a result of the indignation of the commercial fishermen in Saginaw Bay against the "minnie gulls", which they believed caused a great damage to the fish supply of the bay, particularly to the supply of Lake Herring, Leucichthys artedi.

2. The present study was undertaken jointly by the Institute for Fisheries Research and the Museum of Zoology of the University of Michigan. Cooperation was also obtained directly from the officials of the Department of Conservation.

3. Field and laboratory studies were made in Saginaw Bay and in the Museum of Zoology of the University of Michigan respectively.

4. Approximately 200 days in three years were spent in the field. Laboratory studies occupied most of the time during the balance of each year.

5. A number of pertinent publications reviewed have shown in general a strong bias in favor of the birds.

6. Six species of gulls and terns were noted as occurring in Saginaw Bay. Of these, the Bonaparte's Gull, the Black, the Caspian and the Common Terns were objectionable to the fishermen and thus form the text of this paper.

7. The peculiarities of the birds, including the time of their arrival, their movements, association, nature of increase and decrease and their feeding behavior were noted for all the birds studied. In addition, the breeding activities and behavior of the young of the Common Terns were also observed.

8. The results of several experiments show that the Common Terns probably do not pick up dead fish.

9. Representative samples of the fishes seined were preserved.

10. The food recovered from the stomachs of the birds was determined systematically, numerically and volumetrically.

11. Several estimates not claimed to possess any high degree of accuracy were made. It is important, however, to attempt an objective quantitative estimate of the relation of the birds to the fish supply of the bay.

Bonaparte's Gulls

12. In the fall of 1929, 87 Bonaparte's Gulls were collected from among a feeding flock of about 900 birds.

13. All the stomachs of Bonaparte's Gulls studied in 1929 contained 3,599 Lake Shiners with a volume of 156 cc. In addition, Perch were found in five stomachs. The contents of each stomach ranged from 13 to 116 Lake Shiners with an average of 41.

14. In the fall of 1930, 91 Bonaparte's Gulls were obtained from migrating groups at Wild Fowl Bay.

15. As in the previous year, the Lake Shiner was the principal food recovered from the stomachs.

16. It was roughly estimated that a daily average of 1,800 Bonaparte's Gulls for a period of 37 days occurred in Saginaw Bay each fall in 1929 and 1930.

17. Because the Bonaparte's Gulls studied in 1929 were collected while feeding and those in 1930 were obtained while flying, it was thought best to state the results for the two years on an average.

18. After calculating the meal constituents of one Bonaparte's Gull at one feeding time, the total destruction of this species each fall in Saginaw Bay was roughly estimated as follows: Perch, 74,000; non-commercial fishes, principally Lake Shiners, 11, 155,000 and insects, chiefly Mayfly (Hexagenia) 69,000.

19. More Bonaparte's Gulls were observed passing through Saginaw Bay in the fall than in the spring of the same year. This was accounted for in part by the fact that Lake Shiner fingerlings were much more plentiful in the fall than in the spring.

20. Nineteen Bonaparte's Gulls studied in the spring of 1930 showed that, numerically, the food consisted largely of insects.

21. The total destruction of 300 Bonaparte's Gulls estimated to occur daily for 15 days in the spring was roughly computed as follows: Perch, 8,000 yearlings; forage fishes, chiefly Lake Shiner, 40,000 and insects, mainly the Mayfly Hexagenia, 159,000.

22. In the summer of 1930, six abberrant stragglers were collected in Saginaw Bay. No estimate of destruction was made as the number of days they were present could not be determined. The stomach examinations indicated, however, that they did not have any pernicious feeding habits.

23. Examination of 23 stomachs of Bonaparte's Gulls collected in the spring of 1931 showed that numerically, the chief food was Lake Shiner.

24. A rough estimate of total destruction of Bonaparte's Gulls in the spring of 1931 gave: Perch yearlings, 14,000; forage fishes, chiefly L ake Shiners, 385,000 and insects mainly mayflies 30,000.

25. Four seasons study of the Bonaparte's Gulls showed that the food in the fall was different from that in the spring. In the falls of 1929 and 1930, and in the spring of 1931, Lake Shiners comprised the larger bulk of their food, while in the spring of 1930, insects showed a numerical preponderance.

26. Young Perch comprised about 4 per cent of the food of the Bonaparte's Gulls in the spring, but less than one-tenth of one per cent in the fall. Lake Shiners comprised about 99 per cent of the food in the fall.

27. Lake Shiner fingerlings were very abundant in certain places along the shore of Saginaw Bay in the fall as to impart the water a darker color. It was during this period that thousands of this fish were seen dead along the shore.

28. Published accounts tend to lead to a general opinion that Bonaparte's Gull is largely insectivorous. The results of this study do not agree with this general belief.

29. Destruction of Bonaparte's Gulls in Saginaw Bay would have no beneficial effect on the commercial fisheries.

Caspian Tern

30. The Caspian Terns like the Bonaparte's Gulls were transients. This species is considered the rarest of the birds studied. In 1930, four birds were collected in the spring, while in the summer, 10 were obtained. In 1931, seven birds were collected.

31. All the Caspian Terns studied showed that the birds feed entirely on commercial fishes; mature and sub-mature Perch and Lake Herring.

32. There were evidences that they picked up dead fish.

33. A review of important pertinent literature reveals that this species has a varied diet, but leans largely on fishes.

34. Even if the Caspian Tern could be proved to feed on live fishes, important nor practicable is it to attempt destruction of this bird, the rarest and most graceful of the gulls and terns that occur in Saginaw Bay.

Black Tern

35. In 1930, 79 Black Terns were collected from 10 places.

36. Both numerically and volumetrically, the food of the Black Terns was chiefly insects.

37. It was assumed that 750 Black Terns stayed daily for 90 days in Saginaw Bay in 1930.

38. The estimate of destruction by the Black Terns for 1930 was roughly indicated as follows: Perch fingerlings, 189,000; non-commercial fishes, largely Lake Shiners, 135,000 and insects, chiefly Mayflies (Hexagenia), 6,935,000.

39. There was a decided decrease of Black Tern population in Saginaw Bay in 1931, when only 27 birds were collected. The decrease was assumed to be due

directly and indirectly to diminished food supply.

40. The food of the Black Terns in 1931 comprised largely of insects, both numerically and volumetrically.

41. It was estimated that there were 300 Black Terns daily in the bay over a period of 90 days.

42. The estimate of destruction by Black Terns in 1931 was roughly as follows: commercial fishes, mainly Perch fingerlings, 40,000; non-commercial fishes, chiefly Lake Shiners, 80,000 and insects principally Long-horned Leaf Beetles, and mayflies, 1,096,000.

43. Two years study of Black Terns show that this species has a varied food with a greater preponderance of insect over other types. Mayflies (Ephemera and Hexagenia) form the principal insect items in 1930. In 1931, the Long-horned Leaf Beetle was more important than either of the mayflies.

44. A summary of literature shows that mayflies are eaten also by nearly all commercial fishes, thus a competition between the Black Tern and the commercial fishes exists.

45. Because of the immense number of mayflies (3,000,000,000 estimated to emerge at one time) the degree of competition offered by the Black Tern is considered to be wholly inconsequential.

46. A review of literature on the food of the Black Terns shows that this species is either insectivorous or piscivorous with a greater tendency towards the former habit.

47. The Black Terns are mixed feeders on fishes and insects, but primarily insectivorous. Obnocious insects were also recorded. The destruction of these birds could not have any beneficial effect on the fisheries.

Common Tern

48. The Common Tern constituted the primary basis for the indignation among commercial fishermen against the "minnie gulls".

49. In 1929, 149 stomachs of Common Terns were studied from five places.

50. The results of several experiments show that it takes a bird one hour and 50 minutes to digest the food lodged in the stomach.

51. The birds feeding period is about 15 hours a day.

52. The number of times the daily ration exceeds the average meal ration was estimated to be 8.

53. In 1929, the Common Terns were in the bay for a period of about 112 days.

54. An average daily abundance of 471 Common Terns was estimated to occur in Saginaw Bay in 1929.

55. The data and computations on the food of the Common Terns in 1929 are given on Table 14.

56. The total destruction by Common Terns in 1929 was roughly estimated to include 111,000 Perch fingerlings, 351,000 non-commercial fishes mainly Trout Perch and Lake Shiners and 2,898,000 insects largely Carpenter Ants.

57. In 1930, 240 Common Terns were collected from 10 places.

58. The data and computation of the food of the Common Tern in 1930 are shown in Table 27.

59. It was estimated that a daily average of 1,880 feeding Common Terns occurred in Saginaw Bay in 1930 for a period of 190 days.

60. The destruction of adult Common Terns in 1930 was estimated to include about 1,959,000 Perch fingerlings and 144,000 Pike Perch fingerlings; 3,885,000 forage fishes chiefly Lake Shiners and 3,416,000 insects, mainly mayflies.

61. On the average, a naturally fed young Common Tern ate 18 fish a day. This consisted of about 5 per cent Perch fingerlings, 85 per cent Lake Shiner, 5 per cent Spot-tail Shiner and 5 per cent Trout Perch.

62. Artificially fed young Common Terns ate a minimum of 3 and a maximum of 65 minnows, or 126 mayflies, daily for 3 days.

63. Young Common Terns became independent at about 30 days after hatching.

64. It was difficult to estimate the number of young terns being fed to maturity because of unsettled climatic conditions, starvation, imperfect sitting, parental desertion and invasion of predators.

65. Hatching commenced within the first week in July and ended around the last days in July.

66. In 1930, it was roughly estimated that about 1,000 young Common Terns reached the flying stage and twice as much had failed to fly.

67. The total destruction of the Common Terns in 1930 was roughly indicated as follows: Perch fingerlings, 1,986,000, Pike Perch fingerlings, 144,000; forage fishes chiefly Lake Shiner, 4,188,000 and insects, 3,417,000.

68. A total of 353 Common Terns was collected from five places in 1931.

69. The data and computations of the food of the Common Terns in 1931 are shown in Table 33.

70. Every Perch eaten by the Common Tern in 1931 was accompanied by 3.8 Lake Shiners, 4.78 dragon fly nymphs and fractions of other fishes and insects.

71. As in 1930, it was estimated that a daily average of 1,880 adult Common Terns were in the bay in 1931 for a period of 190 days.

72. The estimate destruction by adult Common Terns in 1931 was shown to include 787,000 commercial fishes chiefly Perch fingerlings, 3,290,000 non-commercial fishes largely Lake Shiners and 639,000 insects.

73. Determinations of the food of the young Common Terns under natural conditions were made in 1931 from a 7-day observation covering three different nests each with two young.

74. It was assumed that 1,500 young Common Terns were fed to flying stage and an equal number died before being able to fly.

75. The total food of all the Common Terns in Saginaw Bay in 1931 was estimated as follows: 799,000 commercial fishes, principally Perch fingerlings,

3,696,000 forage fishes and 629,000 insects.

76. The commercial fishes comprised about 13 per cent, the forage fishes about 73 per cent and the insects about 14 per cent of the total food of the Common Terns in 1931.

77. A total of 748 stomachs of Common Terns were studied in three years.

78. Perch fingerlings was the most important commercial food fish of the Common Terns in Saginaw Bay. Lake Shiner was the most favored forage fish except in 1929 when Trout Perch showed a numerical preponderance over Lake Shiners. The most important insect item was mayfly nymphs except in 1929 when more Carpenter Ants than mayflies were indicated as being devoured.

79. There was a gradual decrease in the number of insects consumed from 1929 to 1931.

80. A review of the results on the food of the Common Tern shows a unanimity of opinion regarding their feeding on fishes and insects diverging, however, on the relative qualities and value of each of these groups. The reasons for this discrepancy seemingly lie in the variations in prevailing food supply of the different regions and in the incompleteness of most observations.

81. The Common Terns, like the Bonaparte's Gulls and the Black Terns were found to feed on a mixed diet of fish and insect food.

Fish Population Compared With Destruction by Birds

82. A total of 107 quantitative seine hauls were made in 1930 and 1931. These were made in the summer except 24 which were pulled in the spring of 1931.

83. The area from the shore line to a depth of about 3 fathoms (5.6 m) was conviently arranged into three seining belts. (1) Shore-line to 20 meters out, (2) 20 meters to 100 meters from shore and (3) 100 meters out to 5.6 meters deep.

84. To obtain a closer estimate of the total fish population, the actual number of fishes seined was multiplied by certain factors.

85. There are good reasons to believe that the estimate of the total population of some species was far too low.

86. The percentages of the fish population taken by the Common Terns are shown in Table 43.

87. A survey of the literature of the food of some important commercial fishes makes it appear that the Common Tern, like the other birds studied competes partly with the different commercial fishes in the consumption of forage fishes and insects. Unfortunately, the degree of competition cannot be estimated quantitatively.

Comparison of Fish and Bird Predators

88. An extensive study of the food of the Lawyer (L. maculosa) results in the rough estimate that to the commercial fishes, it is about 450 times as destructive as the Common Tern; that the harm inflicted by this fish to the forage fishes is about 13 times as much as that by the Common Tern; and that it destroys about 10 times as many insects as the bird.

89. No quantitative conclusion has been drawn as to relative destructiveness of the Long-nosed Gar and the Tern, due to lack of sufficient materials, but the Gar is indicated as a very destructive.

90. Several investigations on the food of the commercial fishes have shown that they were predators on other valuable fishes. However, the lack of data of their destructiveness does not, permit the quantitative comparison of their harm with that of the Common Tern.

91. The significant decrease in catch of Lake Herring in 1928 and the fluctuations of other commercial fishes in other years were not due to any variations in the number of Common Terns in the bay, but to some other natural causes.

92. Estimates of population of the fingerlings of Perch and Pike Perch based on seining operations are very low when compared with the legal-sized Perch

and Pike Perch caught!

93. The Common Terns are competitors and predators to commercial fishes. The harm inflicted, however, is slight and the destruction of the birds would not greatly increase the fish supply.

VIII. GENERAL CONCLUSION

This study indicates that the Bonaparte's Gull, the Caspian, Black and Common Terns are not doing any very serious harm to the commercial fisheries of Saginaw Bay. The Bonaparte's Gull subsists largely on Lake Shiners in the fall when this fish is very abundant, but turns to insect feeding habits in the spring. The rarity of the Caspian Tern would prevent the perpetration of serious harm to the fisheries of the bay even if all the fishes it takes were picked alive. The Black Tern is largely insectivorous, although it takes fishes occasionally. The Common Tern like the Black Tern feeds on a variety of food but shows a greater tendency for fish-eating. Although the constituents of the food of commercial fishes are in part the same as those of the birds, the evidence does not indicate that the birds destroy a seriously high percentage of the food of the commercial fishes. The direct destruction of the young of the commercial fishes by the birds is not great enough to warrant the belief that the destruction of the birds would produce results of any great benefit to the commercial fish industry.

The other fish predators, the Lawyer in particular, are vastly more destructive than the birds.

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Plate I. Saginaw Bay showing the littoral area within the depth of 2 fathoms (3.66 meters).

Plate I

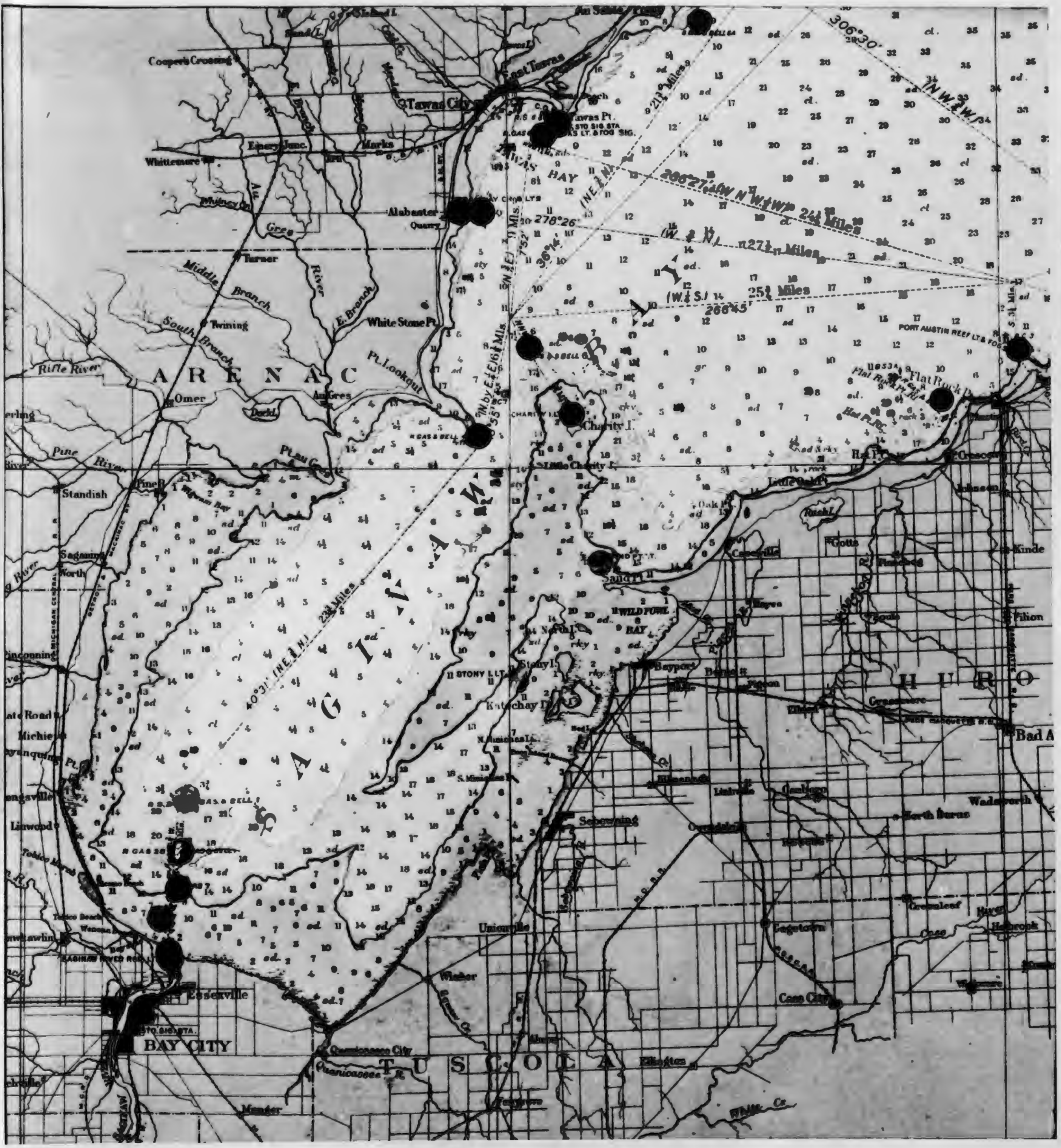
Cooper's Crossing
East Tawas
Tawas City
Tawas Pt.
Whittemore
Emery Junc.
Alabaster
Quarry
Turner
Middle Branch
South Branch
Twining
Rifle River
A R E N A C
Omer
White Stone Pt.
Pt. Lookout
Au Gres
Pine River
Pt. au Gres
Standish
Charity I.
Little Charity I.
B A Y
S A G I N A W
23½ Miles
25¾ Miles
27¼ Miles
24½ Miles
306°30'
278°26'
266°45'
PORT AUSTIN REEF LT & FOG
Flat Rock
Crescent
Caseville
Kinde
Pinnebog
Filion
WILD FOWL BAY
Bayport
Stony I.
Katechay I.
Sebewaing
H U R O
Bad A
Wadsworth
North Burns
Greenleaf
Owendale
Gagetown
Cass City
Unionville
Essexville
BAY CITY
Linwood
Quanicassee City
T U S C O L A
Elkton
Munger
Fairgrove
Akron

Plate II.

Fig. 1. West end of Lone Tree Island, showing cabin surrounded by willow association.

Fig. 2. Bar connecting the two ends of Lone Tree Island, after a high tide. Wave-washed eggs are shown scattered about.

Fig. 3. A Common Tern colony at Sand Point in 1929 after a storm. Scattered eggs are shown in abundance.

Plate II

Fig. 1

Fig. 2

Fig. 3

Plate III. Approximately one quarter of a colony: 420 Common Terns are shown in the picture.

Plate III

Plate IV.

Fig. 1. Stomach contents (Lake Shiners) of Bonaparte's Gull.

Fig. 2. (1) A full stomach before and after opening.

(2) A stomach with fragmentary food materials before and after opening.

Plate IV

Fig. 1

Fig. 2

Plate V. Stomachs of Caspian Tern

(1) Mature Perch

(2) Empty

Plate V

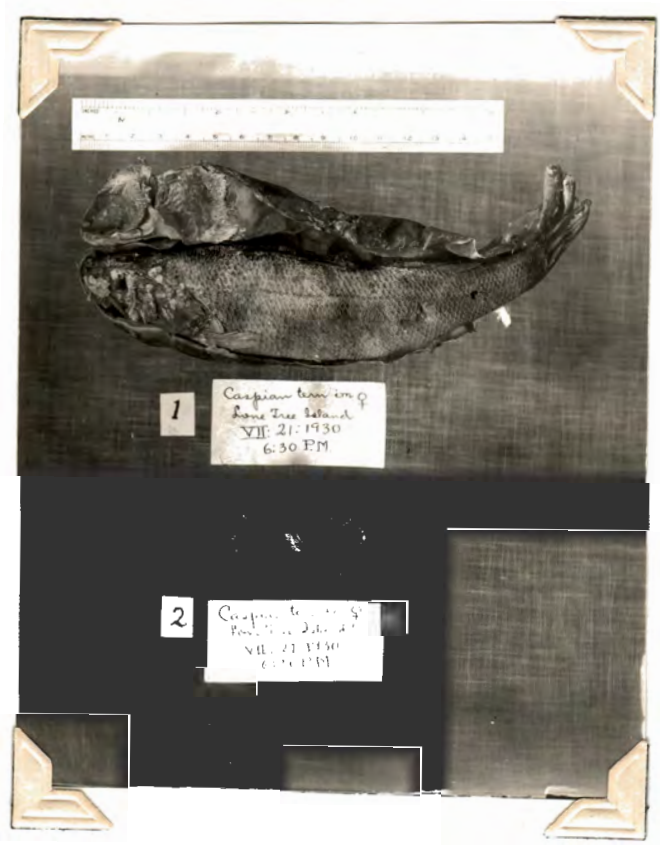

Plate VI.

Fig. 1. Stomachs of Black Terns.

(1) Filled with mayfly nymphs.

(2) Empty.

Fig. 2. Stomach contents of Common Terns.

(1) Carpenter Ants.

(2) Lake Shiners.

Plate VI

Fig. 1

Fig. 2

Plate VII.

Fig. 1. Observation outfit.

Fig. 2. Female Common Tern on the nest, male on guard.

Fig. 3. Male Common Tern in act of offering the morsel to the young.

Fig. 4. Young Common Terns.

Plate VII

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Plate VIII.

Fig. 1. Young Common Terns dead as a result of starvation.

Fig. 2. Comparison between natural and artificial feeding: (1) and (2) were fed by the adult birds, (3) was fed artificially.

Plate VIII

Fig. 1

Fig. 2

Our Country report

March 7, 1932

Dr. A. J. Pearse,
Zoology Dept.,
Duke University,
Durham, S. C.

Dear Colonel:

One of my graduate students, Canuto G. Manuel, who has just finished his doctorate work, has written what we think to be a very good piece of ecological research. It deals with the relation of the gulls and terns to the commercial fish populations of Saginaw Bay. It involves the study of hundreds of bird stomach samples, quantitative estimates of the number of birds, amount eaten per day, number of fingerlings fish present, total consumption of fish by birds, comparison of fish consumption by birds and other predators (the lawyer especially). While the research is most specifically in the field of fishery research, it involves many contributions to ichthyology, ornithology, and to the general competitional and habitat inter-relationships of organisms.

The problem of publishing these results is before us. The paper is wholly too large for Copeia, and does not fit well into any of our Museum series. It has occurred to me that it might fit into "Zoological Monographs". But before I send on the manuscript, I would like to know if for any reason the subject matter might exclude the paper from publication in your series; also how much it may be necessary for us to cut the manuscript. It now stands as about 150 typewritten pages. We have expected to eliminate or summarize some of the detailed data as presented, but do not want to carry the process farther than needed.

The handling of the matter is in my hands, as Mr. Manuel is on his way home (to the Philippines).

With best regards,

INSTITUTE FOR FISHERIES RESEARCH

Carl L. Hubbs,
Director.

Report No. 210

Institute for Fisheries Research

"The relation of gulls and terns to the commercial fisheries of Saginaw Bay, Michigan, with particular reference to the common tern, Sterna hirundo Linnaeus." By. Canuto G. Manuel

December 31, 1931 (180 pages + 8 pages of figures)

NOTE: The only copy of this report is in the Library of the Institute for Fisheries Research in Ann Arbor, Michigan.

Note Do not copy this page.

Barb