

BULLETIN No. 116

**Food and Natural History of Mergansers
on Salmon Waters in the Maritime
Provinces of Canada**

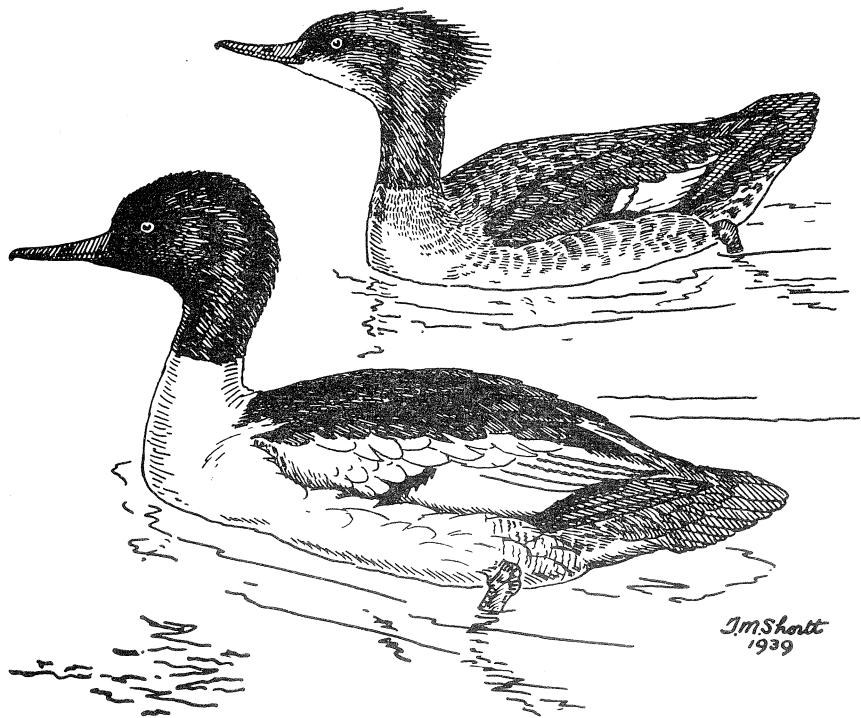
BY

H. C. WHITE

*Fisheries Research Board of Canada
Biological Station, St. Andrews, N.B.*

**PUBLISHED BY THE FISHERIES RESEARCH
BOARD OF CANADA UNDER THE CONTROL OF
THE HONOURABLE THE MINISTER OF FISHERIES
OTTAWA, 1957**

price: 765 cents.



The American merganser, *Mergus merganser americanus*, male (below) and female (above). Drawing by T. M. Shortt.

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92302—1½

W. E. RICKER
N. M. CARTER
Editors

Bulletins of the Fisheries Research Board of Canada are published from time to time to present popular and scientific information concerning fishes and some other aquatic animals; their environment and the biology of their stocks; means of capture; and the handling, processing and utilizing of fish and fishery products.

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All publications of the Fisheries Research Board of Canada still in print are available for purchase from the Queen's Printer. Bulletin No. 110 is an index and list of publications of the Board and is priced at 75 cents per copy postpaid.

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INTRODUCTION

This study of the life history and feeding habits of mergansers is the second of a series on the relation of fish-eating birds to the production of Atlantic salmon and trout. The principal species considered is the American merganser (*Mergus merganser americanus*). A relatively small amount of work has been done on the red-breasted merganser (*Mergus serrator*). Only once have we found the hooded merganser (*Lophodytes cucullatus*) within the area of our salmon studies.

The work on the American merganser is based on observations in the field and on captive and tame birds. Specimens for food analyses have been collected over a period of many years from the Maritime Provinces of Nova Scotia and New Brunswick.

We are sincerely grateful for help from co-workers and associates. Numerous officers of the Protection Branch of the Department of Fisheries have given assistance in collecting ducks for stomach analyses. Dr. A. W. H. Needler, then Director of the Atlantic Biological Station, gave encouragement and priority to this work. Some ducks were collected by Mr. N. MacEachern of the Fish Culture Branch of the Department of Fisheries and by our co-workers, Dr. P. F. Elson and Mr. R. A. McKenzie. During much of the collecting, Mr. H. W. Coates gave unstinted assistance. Mr. L. R. Day gave invaluable help in organizing the text and criticizing the manuscript. Drs. D. G. Wilder and C. J. Kerswill helped by criticizing the text and proof-reading the manuscript.

AREA OF STUDY

Most of the investigations have been made in the provinces of Nova Scotia, New Brunswick and Prince Edward Island — known as “the Maritimes” (Fig. 1).

The geological formations of the Maritimes are largely those of the Paleozoic Era, but there are some Pre-cambrian areas. Southeastern New Brunswick is mostly Carboniferous (Pennsylvanian and some Mississippian) but the larger, central and northwestern area is mostly older Paleozoic with areas of granitic intrusives and extrusives. In Nova Scotia, the southern part of the eastern mainland is Pre-cambrian, the western half of the province is Pre-cambrian and granitic Devonian; and the northern and eastern part, including parts of Cape Breton Island is largely Carboniferous (Pennsylvanian). Prince Edward Island is Permo-carboniferous. The fertility of the streams varies with the character of the geological formations in which they occur. Streams in the Mississippian and some Devonian areas are most productive of fish, while those of the Pre-cambrian areas are the least productive (Smith, 1949).

Ecologically, the Maritime Provinces lie in the Canadian life zone, with a few small areas which tend to be partly Transitional. The fish species in most of the waters are those which invaded the newly-forming watersheds after the Ice Age, plus a few intentional or accidental introductions made recently. The richest watershed, in number of species, is that of the large Saint John River, which has tributaries reaching deeper into the continent than the other streams. In general, the number of species of fishes and other truly aquatic organisms is greater in the streams of interior Canada than in the Maritimes, where some streams are devoid of all fishes except those which were able to reach them by passing through sea water. We have found only one species of crayfish. This occurs in parts of three large adjacent watersheds, the Saint John, the Restigouche, and the Miramichi, but we have failed to find it in the lower tidal tributaries of these or in any of the smaller coastal streams.

Forty-three species of fishes are reported as living in or entering the fresh waters of the Maritime Provinces (White, 1953).

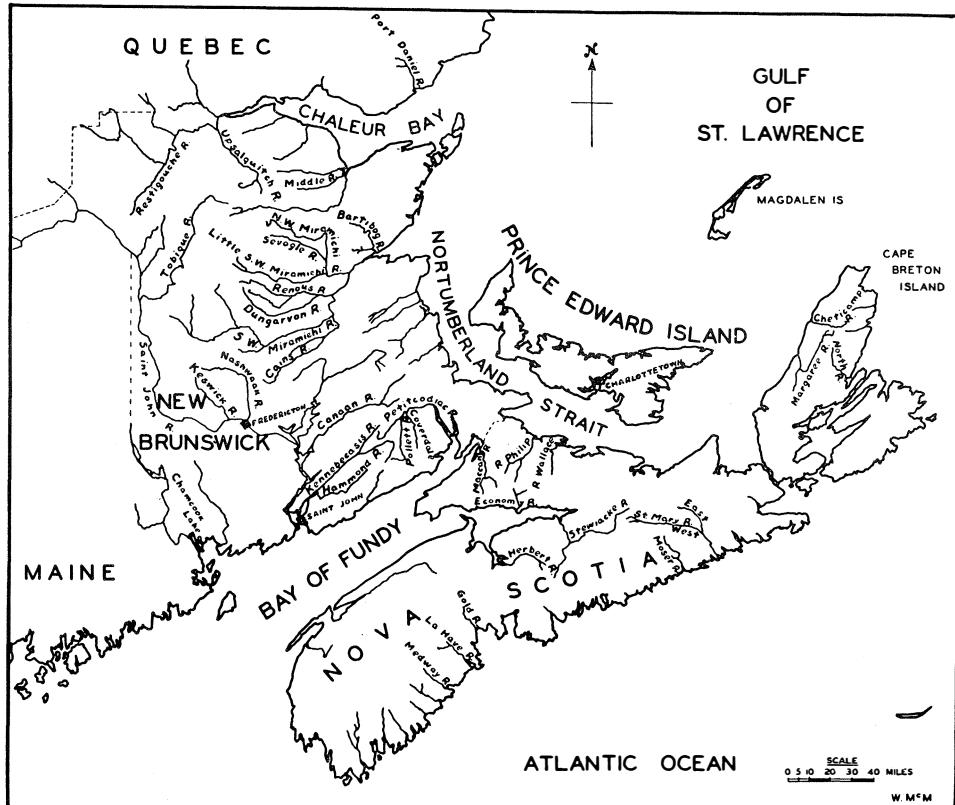


FIGURE 1.—The Maritime Provinces of Canada, showing streams and lakes mentioned in the text.

DESCRIPTION OF MERGANSERS

Our three species of mergansers are fish-eating ducks which have long slender bills with sharp teeth-like serrations on both the upper and lower mandibles (Fig. 2). All but the adult male American merganser have crests.

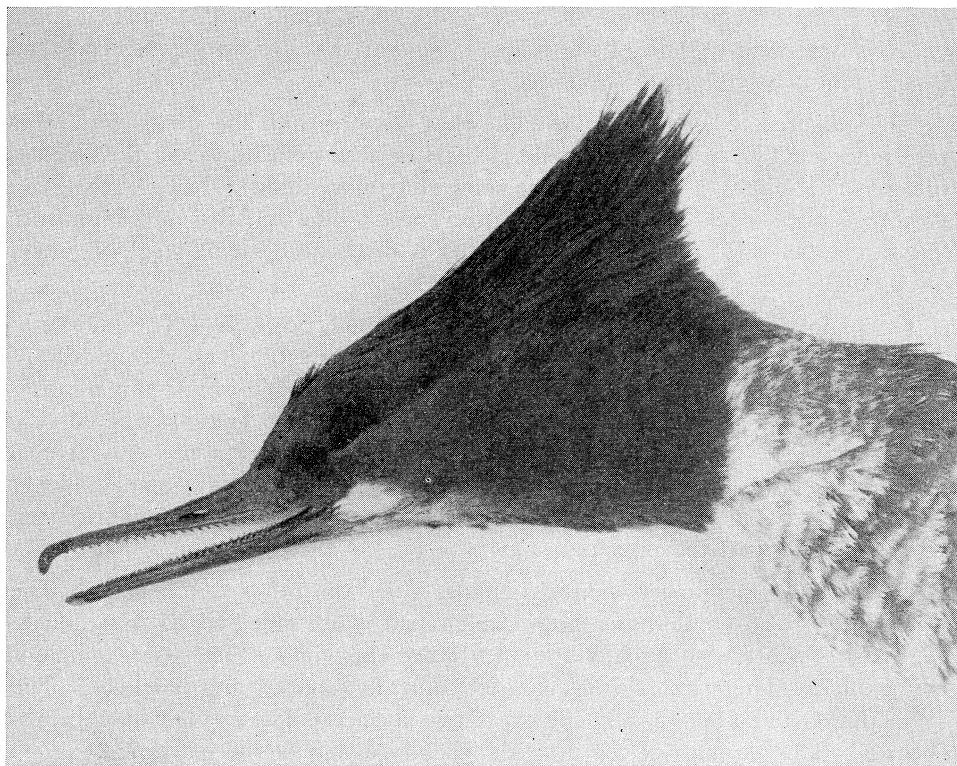


FIGURE 2—Head of the adult female American merganser.

The American merganser is a large duck. The females and the immature males have crested rufous-red heads (Fig. 2). The head of the adult male is green-black but without a crest. The males have a "tip to tip" length of as much as 27 inches with a wing spread of 37 inches. Average weights (less food and grit) of the male and female birds from the juvenile to adult states are shown in the following table.

Season	♂ Juvenile	♀ Juvenile	♂ Immature	♂ Adult	♀ Adult
Fall.....	3 lb. 8 oz.	2 lb. 7 oz.	—	—	—
Spring.....	—	—	3 lb. 11 oz.	3 lb. 10½ oz.	2 lb. 14 oz.

Birds-of-the-year (juveniles) approach full growth by late fall. Males are much larger than the females. The heaviest male which we have examined weighed 4 pounds 5 ounces, including stomach contents which weighed 5 ounces.

On salmon streams it is possible to identify the older flightless broods of American mergansers even at a considerable distance. They generally scurry from anything strange with much commotion and continue to flee until they are out of sight around a bend of the river. None of the other ducks which breed on our streams behave in this manner.

The red-breasted merganser is somewhat smaller than the American and is more slender. The head of the male is black with a definite green gloss and is crested. The name "red-breasted" is somewhat misleading. The mature male has a brownish speckled band across the chest. The females and immature ducks are much like the American and at a distance difficult to distinguish, even by experts.

Ducks in the hand may be readily distinguished, however. The middle of the nostril of the American merganser is just halfway between the middle of the eye and the tip of the bill (Fig. 2). The nostril of the red-breasted merganser is much closer to the eye than to the tip of the bill. The finely-feathered skin at the base of the upper mandible of the American merganser is the same length as that on the lower mandible. On the red-breasted the feathering is much longer on the upper mandible than on the lower. The eye is brown in the American but cherry red in the red-breasted.

The hooded merganser is much smaller than the other two species. The bill is slender. The male has a large fan-shaped white crest edged with black. The breast is white with 2 black bars in front of the wings. The adult female is a small duck. The crest is buff-coloured, thin, fan-shaped and hairlike. The body is darker in colour than in the other two species. The eye is yellow-brown to brown. The plumage of the juvenile resembles that of the female.

The American merganser is known in the Maritimes by a wide variety of names. In the various localities where we inquired about mergansers, most of the residents did not know a merganser from any other duck. When we did find a person who recognized mergansers he generally used a somewhat descriptive name. On the Morell River of Prince Edward Island it was "pencil bills". On the Macann River of New Brunswick we heard "skitter ducks", a name descriptive of the flightless broods. "Wood duck" and "hell-diver" were widely used throughout eastern Nova Scotia and southern New Brunswick. These names evidently refer to the merganser's nesting and diving habits. Along the larger salmon angling streams they were generally known as "shelducks", "sheldrakes", "fish ducks", or "saw bills". It is also known as Bec-Scie and Harle commun. We believe that the name "sheldrake" comes from the presence of the large shell-like syrinx present on the trachea or windpipe of the drakes. Along the southwestern shore of Nova Scotia, where both the American and red-breasted mergansers have long been used as food, we met several residents

who knew that there were two kinds of "shelducks". Along the main Saint John River, where much duck shooting is done, the name merganser seems to be in common use for both species.

REARING MERGANSERS

Both *captive* and *tame* (but free) American mergansers were used in the work.

Taming wild creatures without keeping them in captivity has been a life-long hobby which has paid dividends in the pleasure of learning about their ways of life. The one merganser which we tamed and later observed when at liberty was a nearly half-grown male caught July 4, 1936, in a net at the Margaree River. He was later taken to Apple River, N.S., to the Atlantic Biological Station, St. Andrews, N.B., and finally to Prince Edward Island where he was liberated. This duck was very tame and when given his freedom on a stream could be easily caught. He did not resent handling and was always co-operative.

For quantitative food studies it was necessary to keep some birds in captivity. For this purpose 4 ducklings were captured on July 4, 1950, in a salmon-smolt counting trap on the Miramichi River. The same day they were taken to the Petitcodiac River at Petitcodiac where a pen had been built. During transportation and the day following they were hand-fed with live minnows. To distinguish the ducklings, they were marked on the upper mandible with 1 to 4 dots of red fingernail polish. Before feeding on July 5, the weights of these ducklings were: No. I (male) 6 ounces, No. II (male) 6 ounces, No. III (female) $5\frac{1}{4}$ ounces, No. IV (female) $4\frac{1}{4}$ ounces. The sex of American merganser ducklings can be determined by carefully feeling the neck. About half-way along the neck of the male there is a slight enlargement or syrinx of the windpipe.

On July 5, while the ducklings were being hand-fed, individual behaviour characteristics were noticed. My diary for the day reads as follows:

There is a noticeable difference in the behaviour of the various young.

No. I—This duckling is fairly docile but attempts to bite every chance it gets. When hand-fed it takes the fish as soon as the fish is placed between the mandibles.

No. II—Is very docile and grabs the fish and swallows them or picks them up while being held in the hand.

No. III—This duck swallows fish which are placed part way down the throat. It is the only one which peeps and it frequently does this.

No. IV—This is the smallest duckling and is extremely nervous. It takes every chance to make its escape. It does not swallow fish until they are forced well down the gullet and even then will throw its head and disgorge fish. It has continued to be nervous even when liberated in the pen.

During the feeding experiment, July 4, 1950, to June 12, 1951, these ducks consistently showed the same types of behaviour which were observed on the day after capture. No. IV was silent but always extremely nervous and would often cause the others to become panicky. Finally, on August 24, 1950, she broke the

tip off her upper mandible and we liberated her. With No. IV out of the pen, the other ducks became much tamer. Number III was more nervous than either of the males and was always a "quacker". Number II was always docile and would have become as tame as the one we raised in 1936. The other male, No. I, was never as tame as No. II. When frightened from one end of the pen to the other they always left in the order No. III, No. I, and with No. II hesitating to leave.

While there was open water in the Petitcodiac River the mergansers were retained in a pen (Fig. 3a) in the river. The pen was $10 \times 4 \times 4$ feet with a board bottom and top. The rest was screened with $1\frac{1}{4}$ -inch wire screen. From the bottom up, an 18-inch width of copper fly screen fitted tightly over the coarse screen. The fine screen was necessary to retain the smaller live fish put in the water which was kept at about 1 foot in depth. A board platform at one end acted as a roosting place above water level and the space beneath provided a hiding place when the ducks were badly frightened.

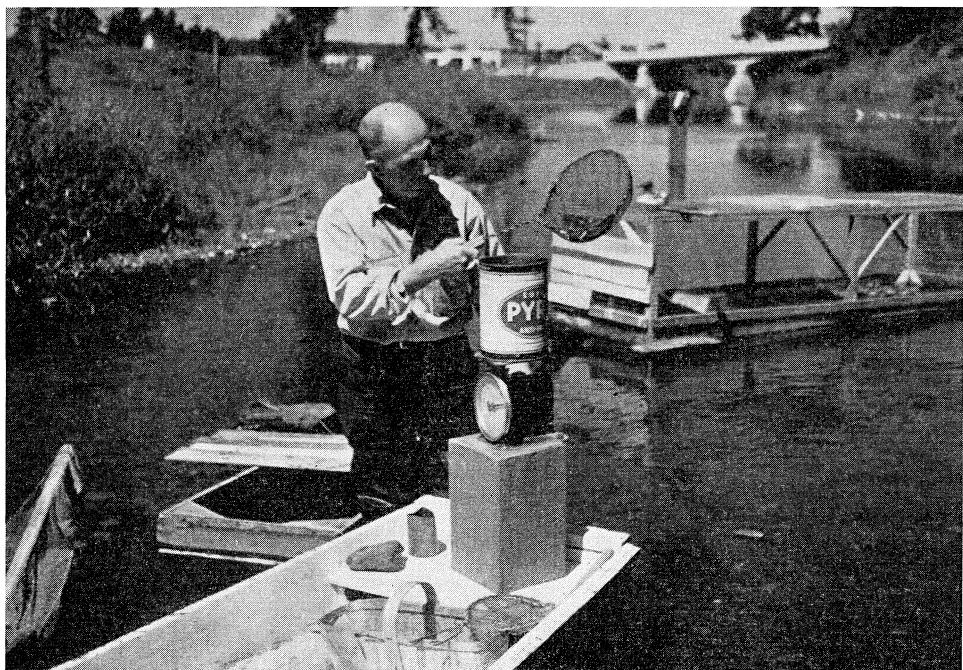


FIGURE 3a—The author weighing fish to feed the four young American mergansers reared in the pen shown in the background, during the summer of 1950.

On December 26, when ice interfered with the operation of this pen, the ducks were transferred to a winter house (Fig. 3b). This house, 12×8 feet and with an 8-foot ceiling, was built over a flowing spring. An inside pool was dug the full size of the floor. The inside duck pen was 12×4 feet and 8 feet high and of similar construction to the outside pen. Two sides of the pen had

large, screened, plastic windows. A resting platform was built at either end. A board floor over most of the space in the house not covered by the pen was used for preparing and weighing food, weighing the ducks, etc. In that part of the pool beneath the floor, supplies of live food fishes were kept in screened floating pounds.

Water from the spring ranged in temperature from 42.8° F. to 44.6° F. and was kept at a depth of about 12 inches. The pen was drained and cleaned whenever there was evidence of fouling. An underwater dish was kept full of clean gravel and sand for grit.

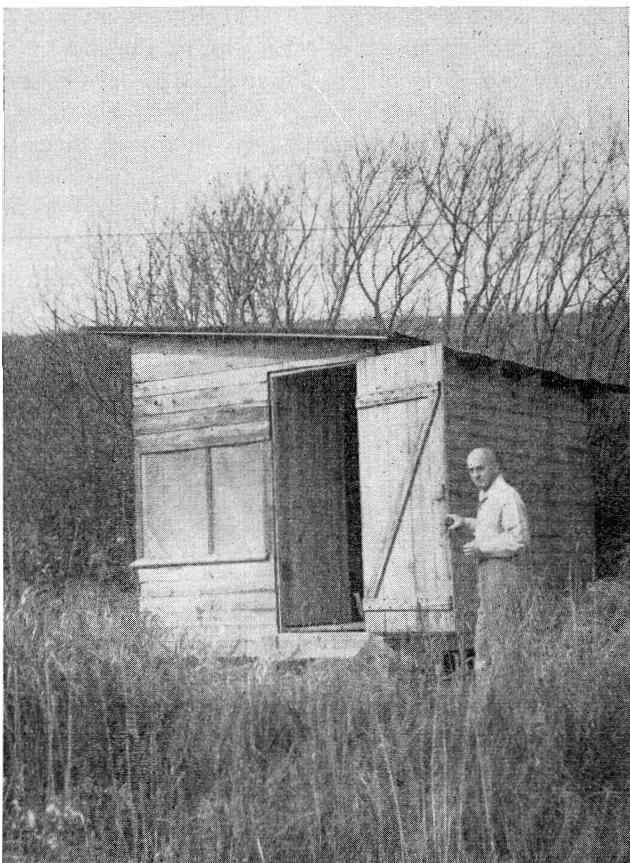


FIGURE 3b—House used in rearing the captive young American mergansers during the winter of 1950-51.

Getting food fish of the right sizes was a major task. We attempted to use stream-fishes, other than salmon and trout, such as the ducks could ordinarily get when feeding in the streams. Most of the fish were caught with a 10-foot, two-man seine from tributaries of the Petitcodiac River. Miles of fertile streams were seined and the seinings were so thorough that second trips to the same areas

yielded very few fish. Some fish were taken from the river in fyke nets and other traps. At one period in the winter 100 pounds of frozen tomcod and smelt were used. The fishes taken in nets consisted mostly of common suckers and several species of minnows. A few small eels and young metamorphosed lampreys were used.

The fish were weighed and liberated alive in the pen. To conserve the supply, only the number which the birds would readily eat was liberated at one feeding. If an excess of live fish was put in, the ducks would go on a killing spree and would not stop until every fish was killed and severely mauled. They played a sort of game of stealing fish from one another. When the water was warm, they would not eat fish which had been killed only a few hours previously. At any time of year, unlike many fish-eating birds, the mergansers would not eat a fish which was even slightly stale. When fish had been killed and not eaten it was necessary to collect and weigh them and deduct the weight from the day's total feeding. The ducks sometimes swallowed fish and then disgorged them whole or in pieces. These likewise had to be deducted. At times cut fish (large suckers and large eels) were given to the ducks but they would never eat much and sometimes regurgitated part of that which they had swallowed. Throughout their captivity the ducks were supplied with green food-grass and watercress which they ate in small quantities, but sometimes enough to give a distinct green colour to their faeces.

On June 12, 1951, after being in captivity 344 days, the 3 surviving ducks were banded and liberated on the Miramichi River near the spot where they were captured July 2, 1950.

LIFE HISTORY OF THE AMERICAN MERGANSER

DISTRIBUTION AND ABUNDANCE

The American merganser breeds across Canada south of the tree line. In eastern Canada it is a common breeding bird on many lakes and most of our streams. Each merganser brood forages over relatively large territory — several miles of a stream as a rule. Since mergansers are protected during the closed season on all ducks, and relatively few are shot during the hunting season, it seems probable that a maximum population is being carried by the available rearing areas. Many mergansers winter along our seashore, and throughout the winter they also either visit or remain on the open waters of our streams—even on small spring streams—where they can get fish.

COURTSHIP

The courtship of the merganser has been described in considerable detail by Townsend (1916). In the spring as soon as the ice leaves the rivers, fairly large flocks of mergansers congregate in the upper estuarial parts or on the lower wide areas of their rearing streams. These flocks contain mature males and females and also some immature males in the juvenile plumage. We have not

determined whether any immature females are present at that time. We have observed the kicking of jets of water by the males and their display performance of rushing about and chasing one another. Sometimes the mature males chase the full-grown immature males. Regarding fighting, Townsend states: "I have seen two splendid drakes rise up in the water breast to breast, and amid a great splashing, during which it was impossible to see details, fight like gamecocks". We think we can supply the details.

The tame young male merganser which we reared in 1936 was nearly full-grown in the fall and was only a few feet from the shore of Chamcook Lake where we were in hiding. A lone young male alighted a few yards away and the two swam toward one another. They were both hissing, a sound which we had never before heard from a merganser. They locked bills, reared up, and while treading water they vigorously flailed one another with their wings. Similar hostile activity has been described by Munro (1939) among males of Barrow's golden eye. They then separated and showed no further interest in one another. From the landing of the stranger to the separation there was a period of less than 10 seconds. The tame merganser had not seen another duck since it was a duckling so its behaviour was evidently an instinctive reaction.

After the courting concentrations have broken up, mated pairs will be found along the rivers. It appears that the adult male remains in the general vicinity of the nest until the female has started to incubate the eggs and then leaves. This, we believe, is advantageous to the species as the competitive feeding of the males on the rearing streams might be detrimental to the rearing of the broods.

NESTING TERRITORY

For the survival of birds it is necessary that the nesting territory be suitable for the rearing of their young. For the merganser the rearing stream must contain enough fish of the right sizes and the water must be clear enough so that fish can be pursued. These conditions must be determined before nesting. In the spring of the year mated pairs of mergansers will be found on streams which become turbid but we have never found them on such streams at nesting time nor with broods.

Yearling, non-breeding female mergansers tend to spend much of the summer and fall on the better rearing streams. During July and early August we have seen lone females flying among and alighting in the larger trees in the stream valleys. When doing this they quack like broody females. Since these ducks go to dead trees and stubs where nesting holes might occur, it is possible that such ducks are yearling females attempting to locate suitable nesting holes for use the following year. For Barrow's golden-eye, Munro (1939) has found that the immature females leave the water and enter nesting holes in trees. In July of 1938, on a hillside along the Margaree River we heard one of these yearling female mergansers and then watched her flying from one dead tree to another. A crow followed her and alighted nearby while she examined each

tree. When this had happened several times, the duck suddenly dashed after the crow and the last we saw of them, the duck was quacking close on the tail of the dodging crow as they disappeared around a bend in the valley. This is the only offensive move we have seen a merganser make against a potential enemy.

NESTING

In the Maritimes mergansers begin nesting in late April, even in the higher areas while there is much snow still on the ground. However, most of the nesting is done during May and early June. A few broods are not brought out until mid-July. The late broods are probably second broods when the first attempt has been a failure.

In eastern Canada the American merganser generally nests in hollow trees (Fig. 4). The same tree is often used for a number of years. Some of the cavities

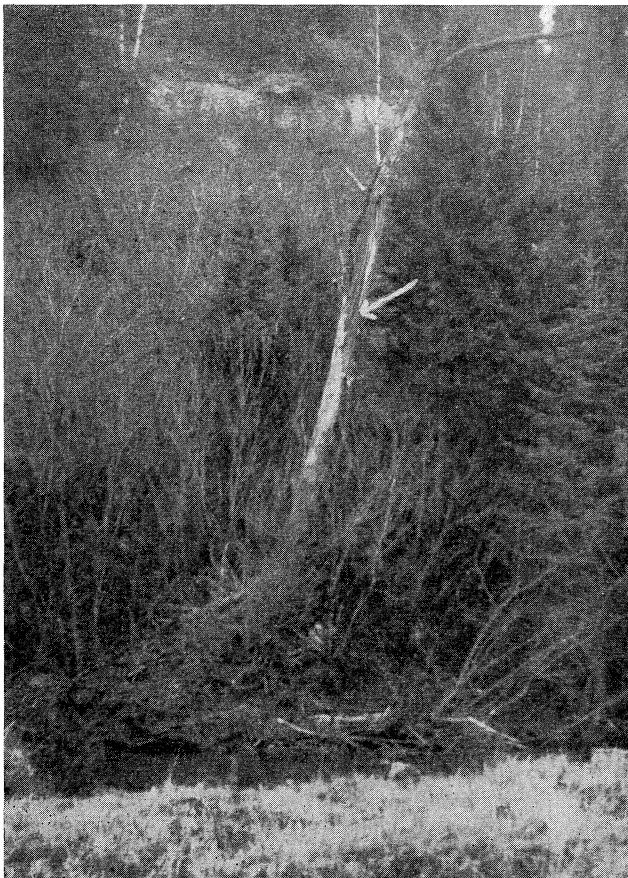


FIGURE 4—A hollow tree, along the Portage River, N.B., used as a nesting site by the American merganser. The white arrow indicates the position of the entrance to the nest.

are 50 feet or more from the ground. Nests are generally near the water of the chosen rearing areas although we have had reports of females seen leading their broods from a wooded area as much as 200 yards from the river. They sometimes nest far from the main stream and bring the young down a rivulet to the river.

On the Northwest Miramichi River a nesting tree was only a few feet from the river and the entrance to the cavity was 20 feet from the ground. This was opened and the nest, more than 4 feet below the entrance, contained 13 eggs. The nesting material was feathers, down and small pieces of decayed wood (Fig. 5). On the Pollett River a female attempted to nest between the floor and the top of a stone pier of a covered bridge. This female was poked out several times and caught by boys. She finally deserted the nest.

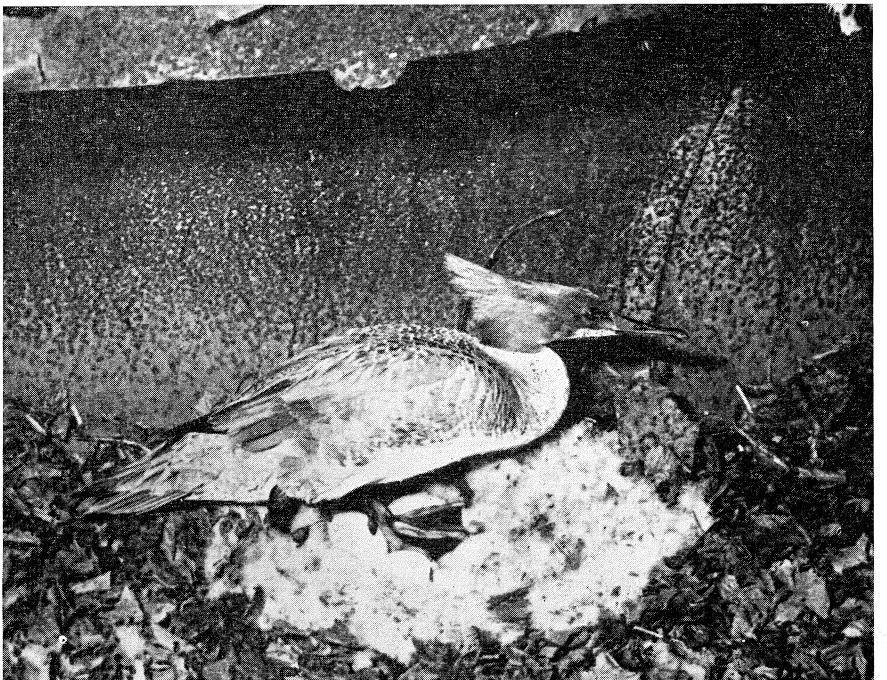


FIGURE 5—A female American merganser at her nest.
(Photo by Richard Robinson, A.R.P.S.)

Also on the Pollett, in a deep gorge, downy ducklings were seen tumbling down the rock face. The nest was probably in a rock cavity. In British Columbia, Munro and Clemens (1937) report that the merganser nests among the tree roots along banks deeply undercut by winter floods.

Kortright (1943) gives the number of eggs as ranging from 6 to 17 with the usual number between 9 and 12, and the incubation period as 28 days. We have observed that 8 to 12 ducklings is the usual number found in a single brood. Bent (1925) states that the young remain in the nest for 1 or 2 days.

LEAVING THE NEST

The idea that the ducklings of tree-nesting ducks are carried from the nest cavity to the water is still quite generally believed and it is quite possible that the female could do this. Mr. Percy Tozer, a fish warden on the Little Southwest Miramichi River, described with considerable detail how he had seen a brood of golden-eyes "flying down" from a nesting hole to the ground in late spring. He stated also that after the mother duck had led the ducklings through the grass some 30 feet she flew back, picked up a straggler in her bill and flew with it to join the rest of the brood. A cook at a salmon fishing cabin on the Miramichi River, where a duck nested many times in a stone chimney, stated that in several years he had seen the female carry a single duckling from the chimney but that he did not know how the rest of the brood got to the river. He said that he did not know whether the female was a merganser or a whistler. We give these merely as examples of oral reports.

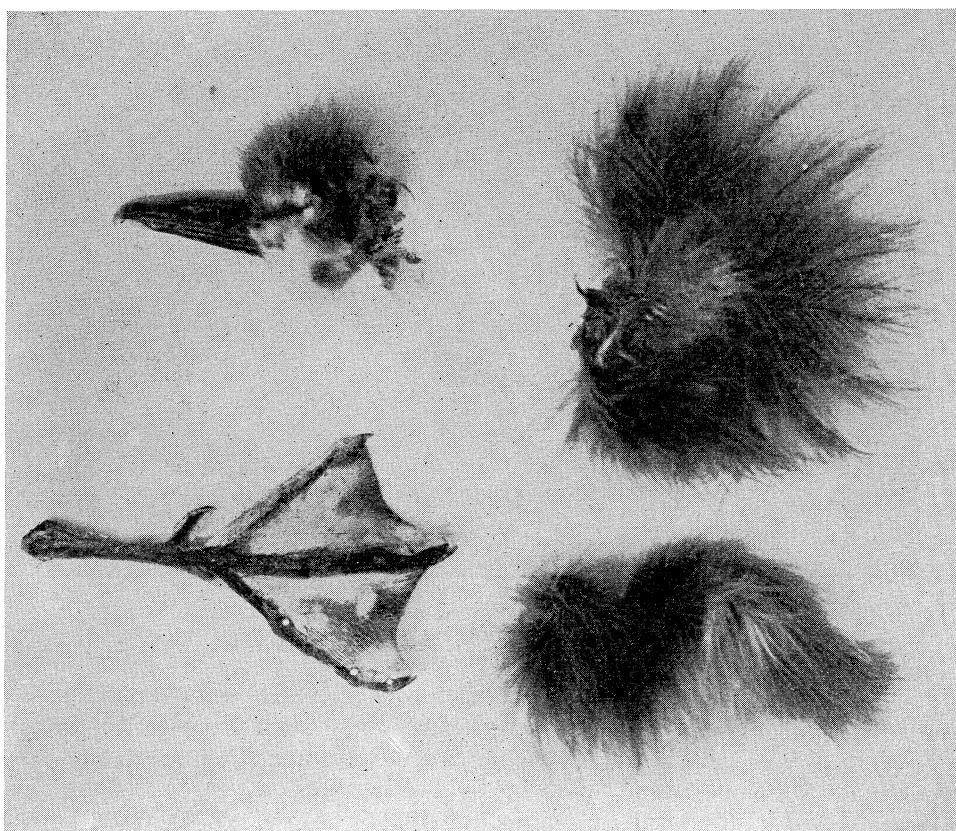


FIGURE 6.—Body parts of a day-old American merganser duckling, showing the sharp hook on the upper mandible (top left), the large fan-like tail (top right), the well-developed gauzy "flight" feathers of the wing (bottom right) and the sharp recurved claws on the large foot (bottom left). These features enable the duckling to get from the nesting hole to the level ground easily and safely.

There are many authentic records (Bent, 1925) of the ducklings of tree-nesting ducks tumbling and fluttering unhurt from the nesting hole and being led to the water by the female. Kortright (1943) states that the departure of young mergansers from the nest does not differ essentially from that of other tree-nesting ducks. For the golden-eye, Brewster (1900) says—"all used their wings freely, beating them continuously as they descended. They did not seem to strike the water with much force."

We have never seen ducklings leaving a nesting hole but we have examined well-developed ducklings from merganser eggs and ducklings which had just recently come from the nest. They are well equipped for the job of leaving the nest. Unlike older ducks, the new ducklings have sharp recurved claws and a sharp-edged hook on the upper mandible (Fig. 6). They have well-developed wings with downy and gauzy "flight" feathers (Fig. 6) and breast muscles large enough to give some power to the wings. As a further protection against injury on landing they have thick down on the breast and even the skin on the breast is remarkably tough for such a young bird. Also for such small ducks they have large feet and a large fan-like tail (Fig. 6) which undoubtedly act as parachutes to slow down their descent. After descent and until the young are nearly two months old, the feet, wings, and the breast muscles grow at a slower rate than the rest of the bird.

An interesting observation was made during the stomach analyses of six ducklings which we judged had been out of the nest only a few hours. Each gizzard of the six contained, at the pylorus, a wad of several gauzy feathers. Such wads are regularly found in the same location in grebes but other than these feathers we have rarely found even a single feather in the stomach of a merganser. The structure of these feathers is the same as the wing feathers of the ducklings.

REACTION TO DANGER

When the duck has ducklings less than a week old she will attempt to lead them away from danger by swimming stealthily along the shore. If danger seems still present she will hide with them beneath bushes or other cover or she may become immobile with them among emergent stones at the stream's edge. Sometimes she will lead the ducklings several feet away from the water and go with them beneath an upturned stump or a cover of vegetation. If a brood of ducklings is startled they will scuttle over the water, half running, half swimming with even the youngest ducklings maintaining a fast clip for some minutes. The older ducklings can do this for a longer period. The dam may fly ahead a few yards, alight on the water, and swim to lead the young away from danger. Most other ducks will try to lead an intruder away from their brood but we have never seen the American merganser make any attempt at decoying. When the brood is hard pressed by a pursuer the female will leave and the brood will disperse and go into hiding either along the shore or into vegetation several yards from the water. In a few minutes the dam will return quacking

and fly by the hiding place. This may be repeated several times. Finally, when there is no apparent danger she will alight and call them from hiding. Sometimes after the female has passed the hiding place, ducklings will come from hiding and scurry or swim in the direction taken in the last flight of the dam. There must be some difference in the quack which means "stay" and that which means "come" but we have not detected it. Only once have we seen evidence of a mistake in the call and that time all the ducklings came out while we were standing in clear view. The older ducklings, nearly ready to fly, escape by a method which is best described as "running on the water" and when badly frightened will use their wings. At a distance, the commotion caused by a flock resembles the spray and waves from a speeding motor boat.

CHANGE IN RANGE

Many, if not most, of the broods are brought directly to the main river but while the ducklings are small some broods may remain on upper reaches of the smaller tributaries. As the young get larger they tend to use the larger parts of the stream. The reason for this movement may be either the reduction of suitable food fish on the upper areas or that the areas which are safe for small ducklings are not safe for the larger ducklings. Sometimes the large ducklings will make short forays from the river into small tributaries and, if disturbed by anyone approaching from the river, they will endeavour to reach the river by swimming under water. Generally by mid-August when the ducklings are well-grown all the broods are on the main streams and have deserted or been deserted by the moulted females. At this time the broods tend to gather and form larger flocks, which may range for miles up and down the river. However, there is a definite tendency for them to drop down stream as the season progresses, and presumably as food fishes in the upper areas become scarce. In some cases they may go to the estuary or to lakes if accessible.

These larger flocks tend to use areas which have not previously been fished. When the adult females are with the broods they tend to keep the ducklings away from any place frequented by people. Such a place generally has a good population of young salmon and other fishes (White, 1939). Later the flocks of juveniles will sometimes feed almost fearlessly over such an area and, even though frightened away, will persist in returning until the food fishes are reduced to a level which makes the area no longer attractive to the birds.

SURVIVAL OF DUCKLINGS

In our association with mergansers we have been impressed with the independence of the newly-hatched duckling. It breaks out of the egg and climbs out of the nest-cavity which may be 6 feet or more down in a hollow tree. It flutters to the ground and makes its way to the stream. Even if left without a mother it can grow to maturity. We know of no other bird of which the newly hatched is so self-reliant.

The ability of the ducklings to survive without parental care was demonstrated on the experimental section of the Pollett River which for some years has been systematically patrolled to control predation by fish-eating birds. In early June a female American merganser brought a brood of 10 recently-hatched ducklings to the river and on the second day after their appearance the female and 9 of the ducklings were shot. One of these ducklings escaped. From time to time the faecal splashes of a duckling were seen on rocks along the river and on several occasions during the summer H. W. Coates, who was patrolling this section, saw the lone duckling always in the same general area. This duckling dived and went into hiding at the first sign of danger. Early in September it was finally shot. At this time it was well-grown and with flight feathers well-developed.

On the upper part of the Pollett River where only two patrols were made during the year, four downy ducklings were left motherless in June. On August 30, 4 were shot in the same area where the ducklings had been left. Their behaviour was different to that of other ducklings of similar size. When approached they did not scuttle away but attempted to hide by remaining motionless beside large emergent boulders. These ducklings had made a normal growth.

It is not often that one finds motherless young along the rivers as the ducklings apparently find and join another brood. When a young duckling becomes separated from the brood it will, at least for a short time, utter a high-pitched peep which is audible, under favourable conditions, at a distance of 200 yards. Flocks of ducklings containing young of 2 or more different broods are often found with a single female. When descending the lower Renous River of New Brunswick by canoe, each of 2 females, on a river length of a mile or more, were observed to have 3 downy ducklings. About 4 miles down stream another female had 20 ducklings. From the great difference in the sizes of the 20 ducklings it was evident that they were from several different broods, possibly from the females up the river.

MOULTING

Underyearling ducks which we reared were moulting some body feathers most of the time but there was no moult of the wing feathers.

Adult females, which have had broods, moult between late August and the last of September. At this time, there is a full moult of the wing feathers and the ducks are flightless. A few yearling females have been taken on our streams in this flightless condition but it appears that most of the yearlings leave the streams for this moult. During this flightless stage the females are extremely shy and go into hiding at the first sign of danger. During our collecting of ducks for food studies we were able to collect some of these females when, with aid of field glasses, we had seen them go into hiding at distances of more than 200 yards.

Details of moulting and other plumages are excellently portrayed in colour by T. M. Shortt (in Kortright, 1943).

In the Maritimes both the mature and yearling males begin to leave the streams by mid-June and few remain as late as mid-July. They go to sea and complete their molts and we have not found them again on our streams until late autumn.

Some mergansers which winter in our area lose patches of breast feathers which have frozen to the ice while the ducks were roosting on the ice along open runs of the streams. The down is not lost with the feathers. In the spring these patches can be recognized by the presence of light yellow pin-feathers and later by the new feathers on the breast.

ENEMIES

Mergansers in the Maritimes seem to be fairly free from attack by enemies. They are generally successful in bringing most of their broods through to the flying stage. Munro and Clemens (1937) also note that in contrast with "the hazards which beset the young of other duck species—it is remarkable how few are the casualties occurring in (merganser) families". They state also that "on coast streams where the young are preyed upon by bald eagles the mortality sometimes may be excessive".

Eagles are present on some of our salmon streams in the Maritimes but it appears that they are a menace to the mergansers only on streams which have long shallow areas which have to be negotiated by flightless ducks. When on water over 3 feet in depth, mergansers seem to have little fear of eagles.

In our area, owls, especially the barred owl, are probably the worst enemy of the mergansers. On the upper waters of the Northwest Miramichi where, throughout the day, barred owls were observed along the river, most of the female mergansers had "broken" broods. At Apple River in September of 1936 our tame merganser was struck at twilight by a barred owl when we were nearby and only quick intervention saved the duck's life. On the Bartibog River in September of 1950, we saw a barred owl make an unsuccessful attack on a flightless young male merganser. This duck was sitting on the exposed top of a large boulder in a pool. The owl flew along the stream and alighted in a tree opposite the duck. The duck did not move. Then the owl swooped from the tree at the duck. When it was about 4 feet away the duck made a quick dive from the boulder. The owl flew down the river and in about 5 seconds the duck came to the surface. It showed no further concern about the attack.

With the aid of binoculars we were observing a brood of mergansers preening themselves on a stony beach. An osprey came and hovered almost directly over them and plunged for a fish only a few feet off the beach. The ducks did not show the slightest concern. It was evident that they recognized the osprey as a harmless hawk.

On June 14, 1951, we observed a mink running along the bank and keeping abreast of a brood of scuttling ducklings. This is the only indication we have that any mammal might prey upon mergansers.

Climbing predators, such as the marten, now rare in the Maritimes, and the raccoon, might destroy mergansers' nests. In 1952 when observers were searching for nests on the Pollett River they found raccoons occupying most of the likely nesting trees.

The attacks that loons make on ducks, coots, and other birds which visit the lakes occupied by breeding loons, have been recorded by Taverner (1934) and others.

In August of 1952, we watched an attack on 3 half-grown mergansers on Eden Lake in Nova Scotia. A loon harassed the ducklings from under water for a distance of about 300 yards. The ducks would scuttle over the water for short periods, stop and dodge and then continue their flight. Using 8-power binoculars we saw 2 loons when we first noticed the ducklings but did not see a loon again until the ducklings had gone ashore. Then a loon came up and swam near the shore. During the long chase the ducks appeared to become tired. The loon must have breathed during the chase but with the ripple on the water we did not see its head come to the surface.

On July 11 of the following year when driving along the same lake we found a loon herding a flock of half-grown mergansers along the shore. The ducks kept in water too shallow for the loon to attack from beneath and where they would be able to run ashore. When we approached the ducks made a short dash toward deep water but returned immediately and scuttled away close to the shore. In spite of our nearness the loon seemed reluctant to leave. It is interesting to note that the loon attempts to prevent mergansers from feeding in waters where the loon rears its young.

RESTING AND ROOSTING

The resting and roosting places of the flightless ducks are generally situated where the ducks can make a quick escape to water at least 2 feet in depth. The only exceptions to this are resting places sometimes used during daylight, where there is clear visibility in all directions such as exposed sand or gravel bars on the larger rivers. The night roosts of both adult and young ducks are always near deep water. Absence of good roosts appears to limit the areas which the younger broods can occupy.

When collecting ducks throughout the Maritimes we made use of this roosting habit. If the good roosting places had no traces of faecal splashes on them, it was an indication that no ducks were present in the area. When splashes were present on the steep beaches or exposed rocks, the freshness and pattern of the splashes indicated approximately when they were made and the number of ducks in the flock.

FLIGHT

The merganser is a strong flier. Along the winding Nashwaak River its speed has been measured from a car at about 45 miles per hour. When above tree level it appears to fly faster. In their take-off from the surface of the water, the direction in which they start and the ease with which they rise depend on the direction and speed of the wind. When there is no wind, they may or may not paddle for a short distance on the water. With a moderate wind they can rise from the water at an angle of about 45 degrees. The females are able to gain height faster than the adult males, the latter being generally very fat and relatively heavy birds. If there is a noticeable wind they take off into the wind. When collecting mergansers for food analyses, or during merganser control experiments on our streams, the shooters take advantage of this habit and approach the ducks against the wind.

The female merganser has a flight control almost comparable to that of a pigeon. When searching for nesting sites the females manoeuvre among the branches of trees. In the winter pen where we reared mergansers, the ducks got considerable exercise by flying. In this $12 \times 4 \times 8$ -foot space, the two males would fly between resting platforms at either end. The female, however, would generally fly from a platform toward the ceiling at the other end, then turn near the ceiling and fly back to the same shelf.

DIVING AND SWIMMING

When not frightened, the swimming of the merganser is like that of other ducks. When searching for fish with its eyes submerged it swims rather slowly but if a fish is sighted in shallow water, the duck swims with considerable speed. When frightened, flightless ducks, both young and fully-grown, are able to swim on the surface with remarkable speed. However, it is beneath the surface that the merganser best shows its adaptation to its mode of life. We have made observations on the underwater swimming and feeding of a tame common loon and its underwater swimming is almost identical with that of our tame and our captive mergansers. Swimming slowly on the surface both the loon and merganser appear to paddle the feet like a domestic duck. When they go under water the legs immediately take a different position which seems almost like "shifting gears". The legs are then at right angles to the sides of the body and for rapid swimming they use a powerful frog-stroke having an action similar to that of a good swimmer's legs when swimming the breast stroke. The tarsi of the legs of both the loon and merganser are extremely flattened to reduce resistance when brought forward and the ankle relaxes. When swimming under water the webs of the merganser's feet (Fig. 7) are brought simultaneously through a 90° angle for a full stroke. The webs are slightly cupped and at the end of the full stroke beneath the duck's tail they produce an effect simulating jet propulsion. When mergansers are fleeing on the surface or when with heads

submerged, chasing a fish, we believe that they use this frog stroke. When pursuing a dodging fish the strokes on either side are varied to change the course. They can turn quickly.

Bent (1925) states: "It can sink quietly down into the water like a grebe or dive quickly with a forward curving plunge, clearing the water for a foot or more as it does so.

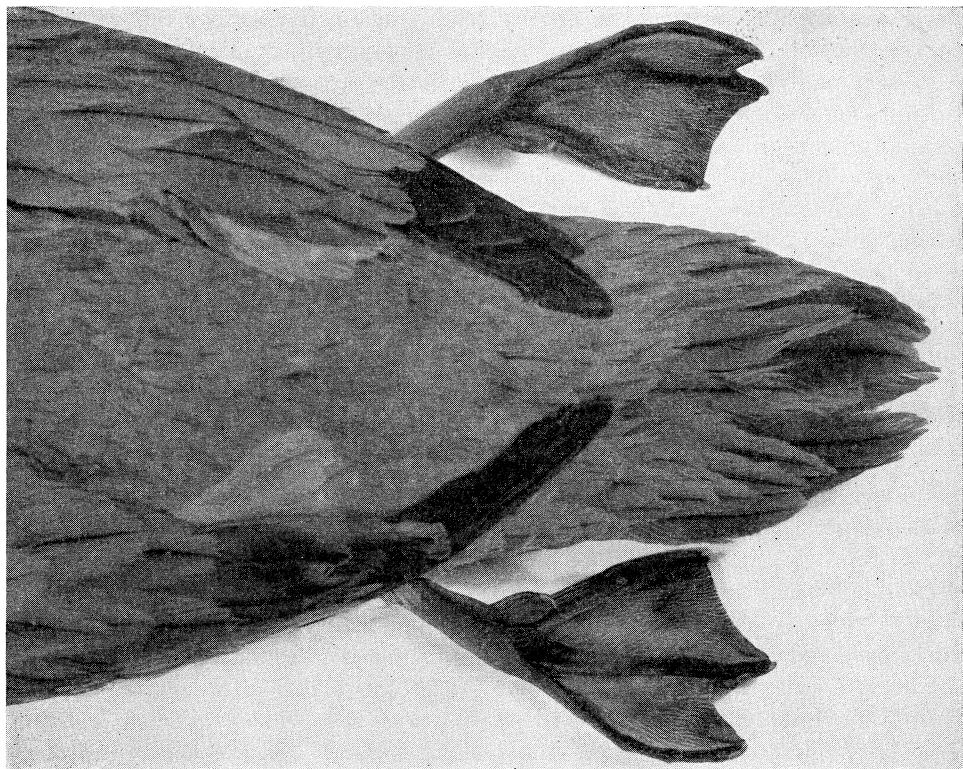


FIGURE 7—The position of the feet of the American merganser for underwater swimming.

The rapidity with which the species can dive from the air is remarkable. While in full flight it plunges into the water, swims below the surface for a distance and then suddenly emerges and continues its flight".

We believe that the American merganser is incapable of quietly sinking into the water like the loons and grebes. A wounded merganser, like many other ducks, will often come to the surface with only the head and a part of the back showing but we have never observed this at other times. Nor have we ever seen a merganser dive under the water "while in full flight" or dive from the surface in a manner which might be interpreted as "clearing the water". Ordinarily when diving the merganser causes little commotion on the water's surface.

METHODS OF FEEDING

Many birds are adapted for feeding upon some special organism and often the organism is fairly immune from capture by other predators.

Most salmon parr frequent swift rapids and it is doubtful that, here, any bird is capable of diving from the air to first locate and then capture parr. However, the American merganser fishes there successfully by swimming on the water but with its eyes and most of its head below the surface. When the duck sees a fish it pursues the fish by remaining on the surface but with head submerged and swims, even in an irregular course, with amazing speed. When it is in pursuit, a long cone of spray may be formed over it. After a chase in this manner, which usually lasts only a few seconds, the duck will submerge and generally come to the surface quickly and swallow the salmon parr. Sometimes there is a delay of 5 seconds or more before the duck surfaces. Judging from observations on the feeding of our tame merganser, this delay occurs when the fish has gone under a stone. When lively fish were thrown to our tame merganser in parts of a stream where visibility was good, we have seen fish go under stones. When the tame duck saw a fish go into hiding it would probe beneath the stone with its bill and often get the fish.

The adult merganser will dive to hunt fish when feeding in deep water or where the colour or turbidity of the water provides poor visibility. Also, when feeding from openings in the ice in winter, they dive beneath the ice.

Flocks of 20 or more full-grown mergansers on shallow lakes or wide expanses of the larger rivers often drive fish by forming a long line. The line parallels the shore of the river, or on the more open waters of shallow lakes it is concave. With much splashing made by their wings, the flock advances for 100 feet or more, evidently confusing and concentrating the fish. Then suddenly the ducks dive and catch fish. This method of fishing is co-operative and even when the flock is large, is fairly orderly. At the height of the fall migration at Long Point Bay, Lake Erie, our repeated observations show flocks will fish and then fly over the line of ducks ahead and resume fishing. On the weedy-bottomed shallow areas of the impounded waters of the Rideau Canal in eastern Ontario, we have seen single flocks of 70 or more mergansers using this driving method. In the Maritimes, fishing guides have told us about mergansers driving over the salmon spawning beds and they have thought that the ducks were chasing the large salmon. On November 6, 1952, on the Cains River we collected mergansers from a large flock which had recently fed over an extensive spawning ground and their stomachs contained mostly sexually-mature male parr which, at spawning time, are always present with the large salmon. In September, 1951, on a wide shallow expanse of the Southwest Miramichi River, we watched a large flock of mergansers driving fish. Their stomachs contained freshly-ingested salmon parr, suckers and redfin shiners.

When food fishes become scarce in the mergansers' stream, the surviving fish are those which have taken refuge beneath stones, generally in the shallow

water. When this occurs, flocks of full-grown mergansers will search the shallows and probe beneath stones with their bills (White, 1939b).

When there is sufficient food available in the feeding area, the flocks have feeding periods and resting periods. There is usually a period of 2 hours or more at midday when they rest on beaches or other places above the water level. Their most active period of feeding is just before twilight and if fish are available they fill their gullets. Nearly all mergansers shot at twilight were well filled with freshly-caught fish. Frightened mergansers will often disgorge the food from their gullets, but at twilight they will stand considerable chasing without disgorging.

UNUSUAL FEEDING

When some foods become readily available mergansers may, for a short time, take a food which is not ordinarily found in their stomachs.

On August 13, 1951, 6 ducklings of a rather late brood were collected on the lower Lahave River of Nova Scotia. These ducklings had been feeding in rather quiet water, and their stomachs contained 28 spiders—a food rarely found in any other samples.

On August 4, 1951, on the Economy River in Nova Scotia, a flock of two broods of 12 well-grown ducks was confined to a 7-mile length of stream by an impassable falls above and the muddy waters of Minas Basin below. We searched the length of the stream but could find neither fish nor ducks. Finally the flock was located at the head of tide. These ducks were feeding almost entirely upon very small eels. They had an average of 62.7 eels per stomach. Ordinarily in streams where eels are abundant they are only a minor item in the merganser's food. We do not know the conditions which made such numbers of eels available to the ducks.

SWALLOWING FISH

Observations on a tame loon showed that it would capture and swallow one fish after another while submerged, but we have never seen a merganser swallow a fish while under the water. Both our tame and our captive mergansers would come to the surface to swallow fish. All our observations were made in water 2 feet or less in depth. In deeper water observations indicate that fish may be swallowed while the duck is submerged (Sayler and Lagler, 1940).

We believe that the merganser's method of swallowing large fish has not been reported by other observers. Herons, bitterns and cormorants which we have reared all stretched their necks when swallowing large fish. A merganser can swallow a large fish and still retain the neck in the sigmoid shape. There is only a slight neck stretching when a merganser is getting about the first 3 inches of a large fish into the gullet. Then with the neck in a fairly tight sigmoid shape the duck will reach out about an inch at a time with the mouth free around the fish, clasp the fish with the bill and pull the fish inch by inch into the body.

The mechanism involved is illustrated by a skinned specimen (Fig. 8) in which, in lieu of a suitable fish, we inserted a 1-inch square stick into the gullet. The gullet is attached to the ventral surface of the muscular part of the neck just back of the head but from there on it is attached to the right side and has its greatest diameter at the posterior curve of the neck. This attachment and construction of the gullet allows the fish to be pulled straight in from the mouth through the gullet to the proventriculus. When the duck reaches with the bill for a hold on the fish, the anterior part of the fish is evidently held by the circular muscle of the gullet. This method of ingestion resembles that of the snake rather than ordinary swallowing by birds.

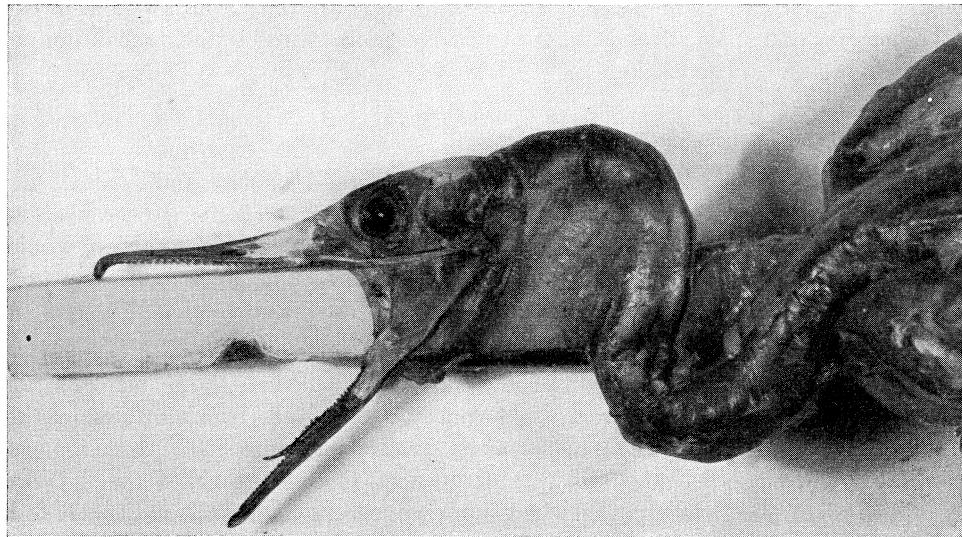
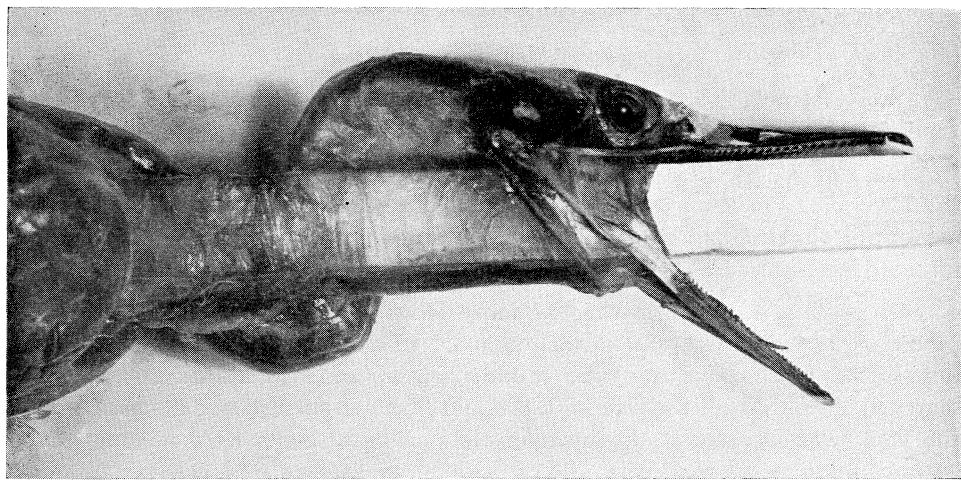


FIGURE 8—The skinned head and neck of an American merganser; right side above, left side below. A stick inserted through the mouth into the gullet illustrates how a large fish can be swallowed while the neck retains its S-shape.

SIZE OF FISH EATEN

The size of the fish taken by mergansers depends upon the size of the ducks and the availability of the fish. Ducklings 2 or 3 days old feed mostly upon insects but when they do take fish, the fish range from 1 to 2 inches in length. Our observations showed that when there was a choice of sizes at any particular time, the ducks tended to take the larger fish up to the limit of a size which they could readily swallow. This was noticeable when live fish of different sizes were liberated in the water for the captive mergansers. In the winter, on Michigan trout streams it has been suggested that trout, being the larger fish, were selected by mergansers (Sayler and Lagler, 1940). Stomach analyses show that full-grown male ducks tend to feed upon much larger fish than the smaller females. Suckers over 11 inches long are commonly taken by the males. The largest we have found was a sucker slightly over 12 inches long from the stomach of a large immature male. The large head of suckers limits the size taken. We have found eels up to 16 inches in the males. Coldwell (1939) reports finding one 22 inches in length. Sayler and Lagler (1940) report that a male merganser disgorged a brown trout $14\frac{1}{2}$ inches long and 15 ounces in weight. When the fishes in the feeding area have been severely reduced in numbers, even the full-grown ducks may revert to feeding upon the sizes taken by downy ducklings. This was shown by stomach analyses of ducks and observations on the fish populations on the Keswick and Coverdale Rivers (see page 00) and the Stewiacke River (see page 00 and Table XI).

FOOD CONSUMPTION

The American merganser feeds almost exclusively upon fish and its ability to consume great amounts of food has long been recognized. Audubon (1840-44) stated: "Digestion takes place with great rapidity, insomuch that some (mergansers) which I have fed in captivity devoured more than 2 dozen of fishes about 4 inches in length, 4 times daily, and yet always seemed desirous of more". The merganser's rate of digestion is in keeping with its ability to catch and swallow fish. The head bones of suckers are very hard, yet we have occasionally found in merganser gullets the tail half of a large sucker in a fairly fresh state but the head bones found in the gizzard nearly digested. The muscular gizzard of an adult male may contain a full teaspoon of gravel ranging in size from fine sand to larger than peas. The harder bones of fishes probably also act as grit. Considerable digestion of the flesh takes place in the proventriculus before the food enters the gizzard.

The tame male merganser which we had in 1936 weighed 41 ounces on November 23. During a 19-day period (November 12 to 30) while it was being retained in a tank at the Atlantic Biological Station it consumed 18.75 pounds (300 ounces) of fish (White, 1937). Its daily consumption ranged from 6.25 ounces to 24.25 ounces with an average of 15.8 ounces which is 38.5 per cent of its weight. On November 26 between 9 a.m. and 5 p.m. it consumed small pollock and small herring totalling 24.25 ounces which was 59 per cent of its weight.

During their captivity from July 5, 1950, to June 11, 1951, the ducklings which we reared consumed 682.6 pounds of fish or 221.4 pounds per duck (Table I). For a 10-day period before being weighed on October 31, the average daily consumption for the 3 ducks was 40.8 ounces. On October 31 their total weight was 127.5 ounces (Table III). This gives a daily consumption equal to 30.1 per cent of their weight, somewhat less than for the 1936 bird.

Table I gives the details of the feeding of our captive mergansers. Ducklings averaging almost 6 ounces at capture consumed a total of 71.5 pounds of fish food per bird or 9.5 ounces per bird per day to reach their maximum weight or full growth as immature birds in late October. Throughout the winter to mid-June and during their immature state each bird ate a total of 149.8 pounds or 10.9 ounces per day. Heaviest feeding was at the rate of 15.6 ounces per bird per day based on a weekly average, and occurred during the month of March when the birds were immature.

The food consumption of a merganser in the wild has been estimated at "one third to one half its body weight daily" (Sayler and Lagler, 1940). The ducks, which we reared in captivity, reached their maximum weight in October (Table III) although at times during the remainder of their captivity they consumed larger daily quantities of fish (Table I).

Table II shows, for consecutive periods, the conversion efficiency, i.e. the gain in weight for every 100 ounces of fish eaten. Conversion of food by the young ducklings was fairly high whereas that of the well-grown juveniles was low. Increased activity due to the start of flying in September plus the observed development of a heavy infestation of nematode worms may account, in large part, for the loss of weight after the October period when the birds reach the full-grown immature state. Comparison of the weights of our captive birds (Table III) with the average weights for wild birds (see Section "Description of mergansers") shows the former to be on the average 10 ounces lighter at comparable stages in development.

FOOD OF AMERICAN MERGANSER

MATERIALS

Since the purpose of this investigation has been to contribute information on the effect of the mergansers on the production of Atlantic salmon, most of the mergansers collected for stomach analyses have been taken on salmon-rearing areas. We have previously reported on food studies of the mergansers taken on the Margaree River (White, 1936, 1937, 1939a and b).

* A large number of the stomachs were secured from mergansers killed on streams during experiments which involved merganser control. In addition, collecting trips were made to most areas of the Maritimes. Here we made observations on the character of the habitat, the fishes present and other conditions.

Such observations proved to be very important since analyses of stomach contents showed a close relationship between the food of the merganser and the character of the immediate habitat in which they had been feeding.

The first mergansers used in our study were collected in 1932 but the first collection of any size was made in 1935. Since then collections have been made yearly up to 1954. The largest was made in 1951 in various parts of the Maritimes. Relatively few empty stomachs (i.e. gullet, proventriculus and gizzard) have been found. Of the stomachs examined, 949 contained identifiable food organisms. Eight hundred and eighty-seven were from American mergansers,

TABLE IA.—Food consumption of captive American mergansers, 1950-51.
Duckling and juvenile stages.

(Data based on food consumption of 4 mergansers to August 24th, thereafter 3 mergansers)

Periods	Weekly		Daily (one bird)	Remarks
	(all birds)	(one bird)		
	oz.	oz.	oz.	
July 5- 8.....	44.0	11.0	2.8	Ducks weighed and measured.
9-15.....	98.0	25.5	3.6	
16-22.....	141.0	35.2	5.0	
23-29.....	164.0	41.0	5.9	
30- 5.....	165.5	41.4	5.9	
Aug. 6-12.....	191.0	47.7	6.8	
13-19.....	240.0	60.0	8.6	
20-26.....	217.0	60.0	8.6	
				Ducks weighed and measured.
Sept. 27- 2.....	168.0	56.0	8.0	Heavy rain. Female duck No. 4 broke bill and was released Aug. 24.
3- 9.....	180.0	60.0	8.6	
10-16.....	220.0	73.3	10.5	
				Heavy rain. Ducks nervous.
				Ducks weighed and measured.
17-23.....	326.0	108.7	15.5	Ducks now have full flight feathers and are flying. They are restless and vigorous.
				First heavy frost. Ducks are restless and vigorous.
Oct. 24-30.....	244.0	81.3	11.6	
1- 7.....	234.0	78.0	11.1	
8-14.....	301.0	100.3	14.3	
15-21.....	244.0	81.3	11.6	
22-28.....	265.0	88.3	12.6	
29- 4.....	286.0	95.3	13.6	Ducks weighed and measured.
Total.....	3,728.5 (233.0 lb.)	1,144.3 (71.5 lb.)		

Av./bird/day, July 5 to Nov. 4 (121 days) = 9.45 oz. (268 grams)

TABLE IB.—Food consumption of captive American mergansers, 1950-51.

Immature stage.

(Data based on food consumption of 3 mergansers)

Periods	Weekly		Daily (one bird)	Remarks
	(all birds)	(one bird)		
Nov.	oz.	oz.	oz.	
	203.0	67.7	9.7	Heavy rain.
	283.0	94.3	13.3	Heavy rain and snow.
	296.0	98.7	14.1	Heavy rain. Pen moved.
Dec.	220.0	73.3	10.5	Ducks nervous. Green vegetation fed.
	279.0	93.0	13.3	Heavy rain. Pen moved.
	266.0	88.7	12.7	Heavy rain. Pen moved.
	317.0	105.7	15.1	Ducks nervous.
Jan.	205.0	68.3	9.8	
	312.0	50.7	7.2	Transferred ducks to winter house. Carpentry upset ducks.
	207.0	69.0	9.9	Carpentry and high water.
	197.0	65.7	9.4	Ducks weighed and measured.
Feb.	204.0	68.0	9.7	
	210.0	70.0	10.0	
	182.5	60.8	8.7	High water due to rain and ice jam.
	241.0	80.3	11.5	
Mar.	250.0	83.3	11.9	Started feeding frozen smelt and tomcod.
	325.0	108.3	15.5	Ducks active.
	303.0	101.0	14.4	
	294.0	98.0	14.0	
Apr.	328.0	109.3	15.6	Started feeding fresh suckers.
	246.0	82.0	11.7	Ducks flying a lot.
	183.0	61.0	8.7	
	240.0	80.0	11.4	Ducks weighed.
May	235.0	78.3	11.2	
	231.0	77.0	11.0	
	161.0	53.7	7.7	
	176.0	58.7	8.4	
June	195.0	65.0	9.3	
	182.0	60.7	8.7	
	155.0	51.7	7.4	Ducks weighed.
	175.0	58.3	8.3	Ducks vigorous but underweight.
Total.....	51.0	17.0	2.4	Ducks liberated.
	7,192.5 (449.5 lb.)	2,397.5 (149.8 lb.)		

Av./bird/day from Nov. 5 to June 11 (219 days) = 10.93 oz. (310 grams)

Total for all stages.. (682.6 lb.)

60 from red-breasted mergansers and 2 from hooded mergansers. A few of the analyses of stomach contents which have been reported in previous papers are included here.

PRESERVATION OF MATERIAL

Since the merganser has a rapid digestion, only a small percentage of the fish found in them—generally only those in the gullet—can be identified to species without recourse to a study of bones or scales. For identification of the fishes we have depended largely upon bones. We had found that when specimens were preserved in formalin, it was very difficult to clean the hardened flesh off the fish bones used for the specific identifications. The best success was obtained by preservation with salt. Stomachs were removed from the ducks, tied, labelled and put into jars with sufficient salt to assure a concentrated solution. If putrefaction has not started before salting they will keep for a number of years.

TABLE II.—Food conversion by captive American mergansers during the duckling and immature stages.

Period	Food	Gain in weight	Conversion efficiency
			oz.
July 5–Aug. 3.....	622.0	49.25	7.9
Aug. 4–Aug. 21.....	527.5	30.75	5.8
Aug. 22–Sept. 8.....	469.0	22.25	4.7
Sept. 9–Oct. 31.....	1,999.0	27.00	1.4

STOMACH ANALYSES

When the specimens were to be used, single stomachs were opened and the contents washed with water. Any well-preserved fish specimens from the gullet were identified and measured. The remaining food was generally sufficiently soft so that vigorous agitation in water would free the bones. Sometimes it was necessary to cook the contents slightly before agitating. Most of the flesh could then be decanted off leaving the bones and grit. The residue was then usually treated with chlorine water. This finished the cleaning of the bones and also removed unpleasant odours. The bones being lighter than the gravel were decanted and, to remove fine material, sometimes screened. Then, under a dissecting microscope, the bones used for specific identification were sorted out.

For identification of the fishes we have assembled a reference collection of bones from identified specimens (White, 1953). Except for a few rare species, this collection contains diagnostic bones of various sized fishes of all the species

which frequent the fresh waters of the Maritime Provinces. Head and shoulder bones are the most durable and have been depended upon mainly for determining the identifications and sizes of the fish.

Reference will frequently be made to the number of fish found in a stomach. This number includes all individuals represented, whether whole fish, partly digested fish, or bones from which the flesh had been digested. In most instances the approximate length of the fish was recorded, but excepting for very small ducklings we have made few references to volumetric proportions. Since we were primarily interested in the numbers of salmon and competitor and enemy species which are being taken by the ducks, we have based food percentages on the numbers, the "numerical percentage". Another index used is the "incidence" or "percentage occurrence" of a food species, that is, the percentage of the stomachs which contain it. This index indicates whether or not the organism is a regular food. A 50 per cent occurrence may be considered high.

Analyses showed that the mergansers' stomachs contained 29 species of fish (Table IV), in most areas not more than 14 of these were being taken by the ducks.

Since there are relatively few species of fishes in the fresh waters of the Maritime Provinces, little difficulty has been experienced in making the specific identifications of the fish remains found in the stomachs. Insects, generally from downy ducklings, have been identified in most cases to families.

FOOD OF DUCKLINGS

Except in the case of the very young ducklings, insects constitute an insignificant part of the American merganser's food. When the young begin feeding they feed entirely upon insects, catching most of them beneath the surface, but they soon start to catch small fish, some as small as 20 mm. (0.8 inches) in length. Within the first 10 or 12 days of feeding or when they weigh about 3 ounces they generally graduate from insects to a predominantly fish diet. Ducklings when they are small take small fish and as they increase in size they take the larger sizes. These changes in diet may be influenced by the type of habitat and the varying abundance of insects and fish of suitable sizes. As an illustration of these changes in diet with size the results of analyses of 118 stomachs of ducklings ranging in average weight from 1.6 to 9.6 ounces and collected from 6 different areas are presented in Table V. Stomachs were from birds of single or mixed broods.

NORTHWEST MIRAMICHI RIVER

The Northwest Miramichi is a large branch of the Miramichi River system. The lower part is in the Pennsylvanian Carboniferous formation with the upper part draining large wooded areas of volcanic Paleozoic formations. The Tomogonops branch reaches into the lime-bearing Ordovician area which has little effect upon the character of the waters of the main stream.

TABLE III.—Record of weights and lengths of captive American mergansers. Length was measured from tip of bill to tip of tail feathers not including downy or hair-like ends.

Date	Duck No. 1 ♂			Duck No. 2 ♂			Duck No. 3 ♀			Duck No. 4 ♀		
	Weight	Gain in weight	Length									
1950	oz.	oz.	in.									
July 5.....	6.0	11.25	6.0	11.25	5.25	10.5	4.25	9.75
Aug. 3.....	19.0	13.0	17.5	17.5	11.5	17.25	19.0	13.75	17.0	15.25	11.0	16.5
Aug. 22.....	26.0	7.0	21.0	28.0	10.5	21.0	24.25	5.25	19.25	23.25	8.0	19.25
Sept. 9.....	37.5	11.5	22.5	39.0	11.0	22.5	24.0	-0.25	19.5			
Oct. 31.....	46.0	8.5	24.0	50.5	11.5	24.5	31.0	7.0	21.0			
1951												
Jan. 10.....	45.0	24.0	47.0	24.0	32.0	1.0	21.0			
Feb. 16.....	30.0			
Apr. 8.....	40.5	41.5	32.5			
June 2.....	40.5	24.0	42.0	24.5	29.0	21.5			

TABLE IV.—List of the fishes found in the stomachs of mergansers taken on the fresh and estuarine waters of the Maritime Provinces of Canada.

LAMPREYS
1. Sea lamprey, <i>Petromyzon marinus</i>
HERRINGS
2. Alewife, Gaspereau, <i>Pomolobus pseudoharengus</i>
3. American shad, <i>Alosa sapidissima</i>
SALMON
4. Atlantic salmon, <i>Salmo salar</i>
TROUT
5. Eastern brook trout, <i>Salvelinus fontinalis</i>
SMELTS
6. American smelt, <i>Osmerus mordax</i>
EELS
7. American eel, <i>Anguilla rostrata</i>
SUCKERS
8. White sucker, <i>Catostomus commersoni</i>
DACES
9. Blacknose dace, <i>Rhinichthys atratulus</i>
10. Redbelly dace, <i>Chrosomus eos</i>
MINNOWS
11. Golden shiner, <i>Notemigonus crysoleucas</i>
12. Common shiner, <i>Notropis cornutus</i>
13. Blacknose shiner, <i>Notropis heterolepis</i>
CHUBS
14. Fallfish, <i>Semotilus corporalis</i>
15. Creek chub, <i>Semotilus atromaculatus</i>
16. Lake chub, <i>Couesius plumbeus</i>
FRESHWATER CATFISHES
17. Brown bullhead, <i>Ameiurus nebulosus</i>
PICKERELS
18. Chain pickerel, <i>Esox niger</i>
KILLIFISHES
19. Banded killifish, <i>Fundulus diaphanus</i>
CODFISHES AND HAKES
20. Atlantic tomcod, <i>Microgadus tomcod</i>
21. Burbot, <i>Lota lota</i>
STICKLEBACKS
22. Threespine stickleback, <i>Gasterosteus aculeatus</i>
23. Ninespine stickleback, <i>Pungitius pungitius</i>
24. Fourspine stickleback, <i>Apeltes quadracus</i>
PERCHES
25. Yellow perch, <i>Perca flavescens</i>
BLACK BASSES
26. Smallmouth bass, <i>Micropterus dolomieu</i>
SUNFISHES
27. Pumpkinseed, <i>Lepomis gibbosus</i>
BASSES
28. White perch, <i>Morone americana</i>
SCULPINS
29. Freshwater sculpin, <i>Cottus cognatus</i>

TABLE V.—Food of American merganser ducklings, based on stomach contents.

Date	Ducklings		Food				Remarks on fish food
	Number	Av. weight	Insects ^a		Fish		
	oz.	no.	vol. %	no.	vol. %		
TOBIQUE RIVER	6 ^b	1.6	6	100	0	0	
	4	2.0	23	50	2	50	1 sucker (45 mm.); 1 minnow (30 mm.)
	4 ^c	9.6	0	0	24	100	10 salmon parr (40-90 mm.); 2 suckers (80 mm.); 12 minnows (45-90 mm.)
POLLETT RIVER	5	2.0	21	75	1	25	1 trout fry (35 mm.)
	4	3.0	4	20	10	80	10 minnows (30-70 mm.)
	12	3.75	16	5	25	95	11 trout and 14 minnows (30-100 mm.)
LITTLE SOUTHWEST MIRAMICHI RIVER	5	2.2	593	65	9	35	1 salmon fry and 8 minnows (20-35 mm.)
	6	5.5	0	0	11	100	1 salmon yearling and 10 minnows (60-80 mm.)
	14 ^d	2.1	474	..	30	..	4 salmon fry and 26 minnows (av. 45.5 mm.)
RENOUS RIVER.	25 ^e	3.4	92	..	55	..	5 salmon fry, 1 trout fry, 7 suckers and 42 minnows (av. 55.0 mm.)
	8 ^f	5.3	18	..	11	..	1 salmon fry, 6 suckers and 4 minnows (av. 67.2 mm.)
	6	4.2	1	..	34	..	11 salmon fry, 6 suckers, 24 minnows, 5 elvers.
NORTHWEST MIRAMICHI RIVER	14	5.2	134	..	46	..	5 salmon fry and 1 parr, 4 trout fry, 24 minnows.
	5	6.5	55	100	34 salmon fry (35-70 mm.), 2 trout fry, 19 minnows.

^a Included caddisflies and larvae, mayflies and nymphs, backswimmers, Diptera adults and larvae, water striders, craneflies, dragonfly nymphs. Over 93% were mayflies.

^b Probably out of nest only a few hours.

^c Probably three weeks old.

^d 7 to 9 inches long.

^e 9 to 10 inches long.

^f 10 to 11 inches long.

The river water is soft, ranging as low as pH 6.3 during high water periods. Although the stream is not rich, it produces good populations of salmon parr. There are 10 fishes which are common resident species of the flowing water and a number of others which inhabit weedy backwaters mostly along the lower part of the river. These include pearl dace, finescale dace, golden shiner, brown bullhead, killifish, yellow perch, ninespine stickleback and brook stickleback. Only two specimens of these species occurred in the 838 fish found in mergansers of all sizes collected from this river.

Since 1950, an experiment in merganser control has been in progress on the Northwest Miramichi. A total of 133 stomachs of American mergansers were taken from this stream system from 1949 to 1953. Ninety-six were from adult and well-grown young taken below the falls at Dam Camp about 35 miles up the river. Analyses are shown for 4 of the 5 years' collections in Table VI. Twenty were from downy ducklings (see Table V). Eleven were adults from the upper part of the stream system (see Table XIV), while 6 were adults from a tributary, the Sevogle (see Table VIII).

The very high and consistent percentages of stomachs containing salmon (72 to 88) show that salmon parr is the main food of the mergansers on the Northwest Miramichi. The numerical percentage for salmon parr ranges from 33 to 69 with an average of 50. The parr in the stomachs average larger than the other species, mostly minnows, so the volume for salmon would be higher than for all other fish. A merganser from the 1952 collection contained 34 salmon parr, the maximum for a single stomach from our entire stomach collections.

In most streams where the white sucker occurs, it has rated high both in occurrence and numerical percentage in the food but on this branch of the Miramichi it is relatively low. The blacknose dace, a small minnow, rates higher here than in most of the streams where it occurs. The threespine stickleback rates relatively high in the 1951 collection. This is largely due to the stomach contents of ducks collected at the mouth of the Tomogonops River. Five stomachs from this area contained 41 of the 55 sticklebacks.

SOUTHWEST MIRAMICHI RIVER SYSTEM

The Southwest Miramichi River, one of the larger rivers of the Maritime Provinces, has a drainage basin of some 500 square miles. The lower part of the watershed is Pennsylvanian Carboniferous formation but part of the upper drainage area is lime-bearing Paleozoic formations. This river has a good production of fish and is one of the few streams in which crayfish occur. Results of the analyses of the stomach contents of American mergansers taken here are shown in Table VII.

From the *Main Southwest Miramichi River* in August, 1949, and September, 1951, 35 mergansers were collected on a 16-mile stretch between the villages of Boiestown and Doaktown. These ducks contained remains of 170 salmon parr. Twelve ducks were well-grown young taken August 29, 1949. They contained 37 salmon, averaging 3 per duck, giving a numerical percentage of 55.2 and a percentage occurrence of 100. The remaining 23 ducks were taken September 3, 1951. They contained 133 salmon (5.9 per duck) with a numerical percentage of 34.4 and percentage occurrence of 82.6. The difference in the numerical percentages for salmon in these two lots was caused by the 1951 collection which had 4 ducks containing 134 threespine sticklebacks. This species of fish is ordinarily a minor food of the American merganser but it is commonly taken by the red-breasted merganser. This last collection was unique also in the number of insects occurring in full-grown young and adults. They contained 28 large insects and 2 small crayfish. The total volume of these was only a small fraction of the food in the stomachs. The insects were mostly stonefly and dragonfly nymphs.

The *Renous River* is a large branch which enters the Main Southwest Miramichi at the head of tide water. It is mostly in the Pennsylvanian formation although some tributaries flow through the granitic Devonian. It is a fairly rich stream.

In the section on ducklings we have dealt with the food the downy ducklings have taken on the Renous (Table V). Ten yearling and 2 mature female mergansers were collected on the lower 20 miles of this stream. Eleven of the 12 ducks contained salmon parr, an incidence of 91.7 per cent. Parr constituted 41.2 per cent of the fishes taken. Common shiners were second in abundance, being 26.8 per cent. One duck had taken 3 sticklebacks. Insects in these ducks consisted of 5 caddisfly larvae and 1 stonefly.

The *Cains River* is another large branch of the Southwest entering the main river above the village of Blacksville. This stream is entirely in the Pennsylvanian formation and is a fairly rich river. Only 4 full-grown young were collected from the main part of this stream. These were shot November 6, 1952. They had recently fed over a salmon spawning area and contained 78 fish of which 57.7 per cent were salmon. Three of the ducks contained salmon giving an incidence of 75 per cent. Each duck contained both suckers and common shiners, indicating that the 2 species were a regular food.

The *Dungarvon River* is the lowest and largest branch of the Renous. This stream has been used as a "check" stream in the merganser control experiment on the Miramichi River. For this reason only two 12-inch ducklings were killed here.

STREAMS OF THE PALEOZOIC AREA OF NORTHERN NEW BRUNSWICK

There are a number of river systems in the Paleozoic area of northern New Brunswick. The Northwest Miramichi is in this area and has been dealt with separately (Table VI). From 5 other streams of the area we have a collection of 30 merganser stomachs. Food analyses are shown in Table VIII.

The *Tobique River* is a fairly large salmon stream of the Saint John River system. This stream is unique in having a run of salmon which come into fresh water as very fat fish and remain a year before spawning. A large part of this river is in the Mississippian formation and is a rich stream. We have dealt with the food of 14 ducklings from this stream up to the time that salmon constituted the main item in their food (see Section "Food of ducklings", Table V). Seven mature mergansers collected from this stream in September, 1949, and June, 1951, contained 61.5 per cent salmon parr.

The *Little Southwest Miramichi River* is similar to the Northwest Miramichi. Eight mergansers, all full-grown females taken in June of 1951 contained 71.7 per cent salmon. Suckers and lake chub ranked second in importance.

The *Sevogle River*, a branch of the Northwest Miramichi, is smaller but otherwise much like the Main Northwest (Table VI). Six well-grown young mergansers were collected from this stream on August 7, 1953. The main food item was salmon parr (51.8 per cent). The white sucker was second (21.4 per cent). Common shiner and blacknose dace were next (8.9 per cent each). A small ball of rootlets is commonly found in the gizzard of a merganser but 2 of these mergansers contained quarter-inch compact balls of very finely-shredded bark of the paper birch tree.

The *Middle River* is a small clear salmon stream emptying into Bay Chaleur. Most of its watershed is in the lime-bearing Ordovician formation. We collected 2 stomachs from this stream on June 28, 1951. They contained remains of 12 salmon and 8 blacknose dace.

The *Upsalquitch River* is a large branch of the famous Restigouche River system. We have records of the stomach contents of five $6\frac{1}{2}$ -ounce ducklings (see Table V) and 2 full-grown females, taken on June 29, 1951, from the lower 5 miles of the stream. The female which was with the ducklings contained 16 salmon parr, 1 white sucker, 3 blacknose dace and 1 freshwater sculpin. The other duck was a yearling female. It contained 15 salmon but no other fish.

TABLE VI.—Food of American mergansers in the Northwest Miramichi River. (For this and subsequent tables, No. = number of fish in stomach(s), % = percentage number of fish in stomach(s), oc% = percentage of stomachs containing the food fish = percentage occurrence or incidence.)

Fishes	1949			1951			1952			1953		
	17 stomachs			38 stomachs			30 stomachs			11 stomachs		
	No.	%	oc%									
Gaspereau.....	1	0.3	2.6	1	0.5	3.3
American smelt.....	4	1.1	2.6	8	3.6	6.7
Salmon.....	85	63.4	88.2	122	33.3	84.2	154	69.1	80.0	12	34.3	72.7
Brook trout.....	1	0.8	5.9	16	4.4	26.3	11	4.9	23.3
White sucker.....	5	3.7	23.5	37	10.1	44.7	7	3.1	13.3	6	17.1	54.5
Fallfish.....	5	3.7	17.6	10	2.7	21.1	2	5.7	17.3
Creek chub.....	1	0.5	3.3
Lake chub.....	13	9.7	35.2	10	2.7	21.1	10	4.5	16.7	2	5.7	17.3
Blacknose dace.....	19	14.2	47.1	68	18.6	47.4	12	5.4	26.7
Common shiner.....	4	3.0	17.6	40	10.9	36.8	13	5.8	20.0	10	28.6	63.6
Other minnows.....	1	0.8	5.9
Eel.....	2	0.5	5.3	1	0.5	3.3
Killifish.....	1	0.3	2.6
Sculpin.....	3	1.4	10.0
Threespine stickleback...	1	0.8	5.9	55	15.0	34.2	2	0.9	6.7	3	8.6	17.3
Totals.....	134			366			223			35		

TABLE VII.—Food of American mergansers in Southwest Miramichi River System.

Fishes	Main Southwest Miramichi R.			Renous R.			Cains R.			Dungarvon R.	
	35 stomachs			12 stomachs			4 stomachs			2 stomachs	
	No.	%	oc%	No.	%	oc%	No.	%	oc%	No.	%
Salmon.....	170	37.5	88.6	40	41.2	91.7	45	57.7	75.0	3	17.7
White sucker.....	31	6.8	57.1	5	5.2	3.3	6	7.7	100.0
Creek chub.....	12	2.7	25.7	3	3.9	25.0	2	11.8
Fallfish.....	1	5.9
Lake chub.....	2	0.4	5.7	9	9.3	41.7	1	1.3	25.0
Blacknose dace.....	16	3.5	25.7	13	13.4	41.7	4	23.5
Common shiner.....	70	15.5	62.9	26	26.8	58.3	22	28.2	100.0	7	41.2
Other minnows.....	6	1.3	11.4	1	1.0	8.3
Eel.....	1	0.2	2.9
Threespine stickleback.....	146	32.2	34.3	3	3.1	8.3	1	1.3	25.0		
Totals.....	454			97			78			17	

TABLE VIII.—Food of American mergansers in streams of the Paleozoic area of northern New Brunswick.

			No. of stomachs	Sea lamprey	Salmon	Brook trout	White sucker	Fallfish	Lake chub	Blacknose dace	Common shiner	Other minnows	Eel	Sculpin	Ninespine stickleback	Threespine stickleback	Totals
Tobique River.....	7	1	24	..	4	..	4	..	4	3	1	2	39	
Little Southwest Miramichi River.....	8	..	38	1	3	2	3	2	2	2	1	1	53	
Sevogle River.....	6	..	29	..	12	1	3	5	5	1	..	56	
Middle River.....	2	..	12	8	20	
Upsalquitch River.....	2	..	31	..	1	3	1	36	
Totals.....	25	1	134	1	16	7	6	22	10	2	1	1	1	2	2	204	
Numerical %.....	..	0.5	65.7	1.5	8.0	3.4	3.0	10.8	5.0	1.0	0.5	0.5	0.5	1.0	1.0	..	
Occurrence %.....	..	4.0	84.0	4.0	32.0	20.0	20.0	32.0	32.0	8.0	4.0	4.0	4.0	4.0	8.0	..	

TABLE IX.—Food of American mergansers in streams of southern and western New Brunswick.

Fishes	Lower Pollett River			Hammond River			Nashwaak River			Totals	
	8 stomachs			7 stomachs			33 stomachs				
	No.	%	Oc%	No.	%	Oc%	No.	%	Oc%		
Sea lamprey.....	1	1.8	12.5	1	
Shad.....	2	0.8	3.0	2	
Salmon.....	13	23.2	62.5	12	54.6	85.7	46	17.8	63.3	71	
White sucker.....	20	35.7	87.5	1	4.6	14.3	37	14.3	66.6	58	
Fallfish.....	50	19.4	60.6	50	
Creek chub.....	1	1.8	12.5	2	0.8	6.1	3	
Lake chub.....	12	21.4	37.5	8	3.1	12.2	20	
Blacknose dace.....	1	1.8	12.5	5	22.7	71.4	28	10.9	33.3	34	
Golden shiner.....	1	1.8	12.5	1	
Common shiner.....	1	4.6	14.3	66	25.6	72.7	67	
Other minnows.....	1	4.6	14.3	4	1.6	9.1	5	
Eel.....	4	7.1	50.0	2	9.1	28.6	9	3.5	18.2	15	
Killifish.....	1	1.8	12.5	6	2.3	12.1	7	
Threespine stickleback.....	2	3.6	12.5	2	
Totals.....	56			22			258			336	

STREAMS OF SOUTHERN AND WESTERN NEW BRUNSWICK

Specimens of merganser stomachs have been collected from 3 streams of southern and western New Brunswick. Stomach analyses are shown in Table IX. The streams are all fairly rich with most of their drainage in the Carboniferous formations. All the areas where ducks were collected were bordered by farm lands.

Eight ducks were collected from 1947 to 1952 on the lower *Pollett River*, below the area where the bird control experiment is being carried out (see Table XVI). This area is not affected by the experiment and is populated naturally by indigenous salmon. Fifty-six fish of 10 species were present in the stomachs of these ducks. The white sucker was their main food fish with salmon parr second. Here, as in many other streams, the salmon and sucker are the main food species.

The *Hammond River* is a small stream which joins the lower Kennebecasis waters to flow into the Bay of Fundy through the outlet of the Saint John River. Much of the drainage of this stream is on the rich Mississippian formation. Seven ducks collected from this stream in July and August, 1951, contained 22 fish of which 12 were salmon parr. Five blacknose dace were second in number. Only 4 other species occurred in the stomachs of these ducks. Besides fish these ducks contained small clusters of fish-eggs, probably those of the gaspereau. At the time the ducks were collected, eggs of this species were adhering to stones in the stream. This is the only instance where we found fish-eggs which appeared to have been eaten directly by the merganser and are not from ingested fish.

The *Nashwaak River* is of medium size, the main stream being about 60 miles long. It enters the Saint John River opposite Fredericton. The lower part is in the Pennsylvanian and Mississippian formations. The upper waters are from other Paleozoic areas. It is a rich stream and is well-populated with minnows, suckers and other fish. In the lower part where our specimens were collected the river has long stretches of slow-flowing shallows 2 to 4 feet in depth. In August and September, 1949 and 1951, 33 mergansers were collected from the lower 25 miles. Our observations indicate that every year a relatively large number of mergansers are reared on this stream. Here, the common shiner was the main food, with the highest numerical percentage and incidence. The fallfish is second in numerical percentage. This is the only stream where this large minnow, which grows to a length of a foot or more, has rated high as a merganser food item. Salmon and suckers both rate high in incidence. Salmon are third in numerical percentage, rather high for such a typical minnow-sucker habitat.

For the 3 streams of this area more salmon were taken than any other species.

SOUTHEAST MAINLAND NOVA SCOTIA

Analyses of merganser stomachs from Moser River, St. Mary River and its 2 branches, the East and West St. Mary Rivers, are given in Table X.

Moser River is a small salmon stream of the Pre-cambrian area of southeastern Nova Scotia. There are several small lakes in the drainage area which is entirely forest land. The water, like that of other streams of the Pre-cambrian area is dark in colour and has a low pH (soft water). It is not a productive stream but provides some fairly good early-summer angling for grilse and sea-run brook trout. Comparatively few species of fish occur in the stream system. Merganser broods are reared on the stream at least periodically, if not every year, as some years the local fish warden reports that he has found no broods on the stream. It is possible that this small river is not capable of producing a sufficient crop of fish every year for successful rearing of broods.

A total of 12 well-grown young mergansers collected in August, 1940 and 1942, contained mostly suckers, salmon parr and killifish. The parr ranged between 100 and 120 mm. (3.9 and 4.7 inches) in length, i.e. parr which had completed at least their second year's growth. Salmon made up 24.1 per cent of the fish eaten and had an incidence of 75 per cent. Suckers were a major food, 25.9 per cent.

The *West St. Mary River* is a branch of St. Mary River. The main part of this branch is about 35 miles long and has many feeder streams. This branch is almost entirely in the Horton Carboniferous formation but has some small branches arising in the Pre-cambrian area. It is a fairly rich stream and potentially a good salmon-rearing area. This is one of the streams on which merganser control is being tested experimentally. Fifty-nine ducks were taken during August in 1951, 1952 and 1953. Six young and 1 mature female were taken July 10, 1953, making a total of 66 specimens. All except the young of the July collection were nearly full-grown or mature. The stomachs contained identifiable remains of 674 fish and 1 small frog.

Of the 12 species of fishes eaten, the common shiner was found in the greatest number (199) with a numerical percentage of 29.5. This fish was also second in incidence, 78.8. Salmon parr were second in numbers with 152, a percentage of 22.5, and an incidence of 72.7 per cent. The white sucker was third in numerical percentage, 20.1, but first in incidence, 80.3. None of the other 13 species rated an incidence above 43.9.

These analyses show that the common shiner, salmon and white sucker are the main food fishes of the mergansers on this stream.

The *East St. Mary River*, the other main branch of the St. Mary River, is a smaller stream than the west branch being only some 24 miles in length and with numerous small branches. This stream drains Carboniferous and Devonian formations and is a potentially productive salmon stream. The salmon parr make fast growth. There are a number of small lakes in the drainage area. Seventeen merganser stomachs taken in late August, 1952, on branches not far from lake outlets were analysed. They contained remains of 176 fish. The proportions of common lake species such as golden shiners, bullheads, killifish, and yellow perch in these stomachs show a definite influence of the proximity of lakes or other still waters.

The ducks had fed to some extent on fingerling gaspereau which, at the time the ducks were killed, were present in great numbers during their seaward migration from the lakes. The number of young gaspereau must have been many times greater than all other species yet they constituted only 10.8 per cent of the fish in the stomachs. Selection for size may account for the relatively low percentage of gaspereau. The average size of the gaspereau taken was approximately 61 mm. (2.4 inches) while the average for other fishes was 93 mm. (3.7 inches). The average size for the 18 salmon parr was 109 mm. (4.3 inches). The sucker was highest in incidence (88.2 per cent) emphasizing the fact that where it occurs it is generally a staple merganser food. The golden shiner was highest in number taken with a numerical percentage of 23.9 and an incidence of 71.2 per cent. Salmon constituted only 10.2 per cent of the fish eaten but had an incidence of 64.7, high enough to indicate that, in this stream, it is a staple food.

The *Main St. Mary River* is about 12 miles long from the confluence of the east and west branches to tidewater. It is mostly slow flowing with areas of bordering bullrush beds and weedy stillwaters. It has few rapids but many good deep areas for salmon angling. It contains some salmon parr but is not a good rearing area.

Thirteen merganser stomachs taken from this area during August and September, 1950 and 1951, contained remains of 99 fish of 12 species. Four salmon parr constituted 4 per cent. Descending gaspereau fingerlings formed 41.4 per cent. Other fishes taken were mostly those found in weedy stillwaters or sluggish streams. One of the ducks contained a small frog, a rare item in the food of the American merganser.

THE MISSISSIPPAN CARBONIFEROUS AREA OF NOVA SCOTIA

Streams of the Mississippian system are fertile and have a high pH (hard water). Consequently they have a high production of fish. These streams have clear water and support relatively large populations of mergansers. From 5 rivers of this area we have analyses of 54 stomachs (Table XI).

All the tabulated streams in this area are small salmon-rearing streams and all contain brook trout. There is some variation in the character of the minnow populations. River Philip and the Maccan River apparently contain no common shiners while the Stewiacke and Maccan Rivers lack the creek chub. The blacknose dace is not recorded for River Herbert.

The numerical percentage of salmon found in the stomachs of mergansers taken during July and August of 1951 from the 5 streams varies from 62.7 per cent for River Philip to 7 per cent for the Stewiacke River. The low percentage from the Stewiacke is due, perhaps, to the salmon of sizes ordinarily taken by mergansers having been fairly well depleted and the ducks, although well grown by August 2, having reverted to feeding upon very small minnows and sticklebacks. One of the salmon was a small fry-of-the-year. The incidence of salmon was 75 per cent showing that they were a regular food. Suckers rated a numerical percentage of 20.9 and an incidence of 89 per cent.

THE PRE-CAMBRIAN AREA OF SOUTHWEST NOVA SCOTIA

The streams of southwestern Nova Scotia are largely in the Pre-cambrian formation but nearly all have branches which pass through some granite Devonian formation. All have dark-coloured soft water (the pH ranges from 4 to 6.8) and lack molluscs. The low productivity and dark colour of the water probably accounts for the relative scarcity of American mergansers which we found in this area. In 3 days of collecting (August 13 to 15, 1951) on 3 streams only 22 ducks were taken. Analyses of the stomach contents of these ducks are shown in Table XII.

The *LaHave River* is a medium-size salmon river with a number of lakes in the system. Thirteen ducks were taken on this stream. These consisted of a late brood of 6 young averaging 12 inches in length, 4 well-grown flying young, 1 immature female and 2 flightless moulting adult females.

The 6 younger ducks were taken from the lower quieter part of the stream. They contained 89 small fish ranging in length from 25 to 90 mm. (1.0 to 3.5 inches), also 37 aquatic insects and 28 small spiders. In volume the insects and spiders constituted only a small fraction of the food. The presence of sticklebacks, killifish and young suckers indicates that recently the ducks had fed in quiet water. Although the feeding area was not a good salmon rearing one, the stomachs contained 4 salmon fingerlings averaging 55 mm. (2.2 inches) in length.

The 7 large ducks which were taken farther upstream in better salmon water contained 25 fish. These consisted of 4 salmon parr averaging 75 mm. (2.9 inches), 5 suckers—90 to 250 mm. (3.5 to 9.8 inches), 1 golden shiner, 8 killifish and 5 white perch. The presence of the golden shiners, killifish and white perch indicated that some of these ducks had fed in fairly quiet waters. Mergansers in this watershed may do a considerable part of their feeding in the lakes of the system.

The *Gold River* is a small stream with several small lakes in the system. Four well-grown but still flightless young were collected from a stillwater known as "The Salmon Pool" some 15 miles above the mouth of the river. The ducks were seen actively feeding on the broad shallow upper part of the pool. The presence of golden shiners, brown bullheads and ninespine sticklebacks in their food reflects the type of habitat in which the ducks were feeding. Two large freshly-caught parr (150 and 170 mm.) (5.9 and 6.7 inches) were probably taken in the pool. One of the ducks contained a small frog (body 40 mm. (1.6 inches)) (see also Table XII). Here, as in many streams, the sucker is the dominant food species.

The *Medway River* is a medium-size stream with a flow comparable to that of the Lahave but the drainage contains more and larger lakes. At the time the mergansers were collected there was a run of young gaspereau descending to the sea. The ducks were feeding largely upon this

abundant supply of food. The 5 ducks, all full-grown females, contained 39 gaspereaux but only 2 salmon parr. Killifish and white perch were also taken. As in the other 2 streams of this Pre-cambrian area, salmon is only a minor item in the food of the merganser.

MARGINAL SALMON WATERS

There are some streams or parts of streams in which a few salmon parr occur but they constitute a very small part of the fish population. Adult mergansers at times feed in these areas and broods are sometimes either raised on them or migrate into them. We have 39 stomach records from such areas (Table XIII).

The *Kennebecasis River* may be regarded as the lowest branch of the great Saint John River. The upper branches of the Kennebecasis are some of our best trout angling streams and contain considerable numbers of salmon parr. The *lower Kennebecasis River*, especially that part below the town of Sussex, is entirely in the rich Mississippian formation. It is slow-flowing and with many weedy areas. In this lower part there are such fishes as chain pickerel, black bass and two species of sunfishes. Although this area does not have the appearance of a salmon parr habitat, some salmon parr occur on the rapids. During January and February of 1952 and 1953, 6 large mergansers were taken (see Section "Winter feeding"). Also in the summer months of 1949-1953, 2 adults and 9 flying young-of-the-year were taken. These 11 birds had eaten a total of 45 recognizable fish. Four of the fish were large yearling salmon parr. The common shiner was the main food. Eighteen specimens made up 40 per cent of the fish taken. An incidence of 75 per cent indicates that this species is a regular food. Of all the habitats from which merganser specimens were collected, this is the only one which contained smallmouth bass. The ducks contained 5 of these ranging in length from 120 to 160 mm. (4.7 to 6.3 inches). They contained also a rather high percentage of eels. Pickerel are fairly common in this stream but none was found in the stomachs.

In addition to fish, the 9 young ducks contained 20 waterstriders and 4 other insects. It is rather unusual to find more than an occasional insect in such advanced young.

The *Main Petitcodiac River* flows through fertile farm land of the Pennsylvanian formation and is fed by branches arising in the rich lime-bearing Mississippian formation. Even moderate floods cause the water to become roily and thus unfit for the rearing of merganser broods. In this connection it is significant that only 2 of the 20 ducks taken in this area from 1948 to 1952 were females. Full-grown mergansers feed in the river at times when it is open during the winter but most feeding occurs in the spring and late fall. Some years salmon parr occur in small numbers but are never abundant enough to be a significant part of the fish population. Suckers and eels are abundant and constitute the greater part of the merganser's food.

The *Canaan River* is a medium-size river flowing into the long Washademoak Lake of the Saint John River system. Its drainage is almost exclusively in the Pennsylvanian formation. The mid-section, from which mergansers were collected in July of 1951, contains a large number of fish species including pickerel, yellow perch and 2 species of sunfishes. Common shiners, fallfish and suckers are the dominant species. Although we have done considerable angling and collecting on this stream the only evidence we have of the presence of salmon parr are two specimens, one from a kingfisher's pellet and one from the stomach of a pickerel.

One adult female merganser and 7 nearly full-grown young were secured from this stream. These ducks contained only 25 fish, 10 of which were common shiners. Other than minnows and killifish the stomachs contained 5 suckers. This stream has a fairly dark-coloured water but is not acid. It has a good supply of molluscs and does not become roily. Every year it produces a number of American merganser broods.

TABLE X.—Food of American mergansers in streams of the southeast mainland of Nova Scotia.

Fishes	Moser River			West St. Mary			East St. Mary			Main St. Mary		
	12 stomachs			66 stomachs			17 stomachs			13 stomachs		
	No.	%	oc%	No.	%	oc%	No.	%	oc%	No.	%	oc%
Gaspereau.....	1	1.7	8.3	19	10.8	47.0	41	41.4	38.5
Salmon.....	14	24.1	75	152	22.5	72.7	18	10.2	64.7	4	4.0	15.4
Brook trout.....	3	0.4	4.5	1	0.6	5.9
White sucker.....	15	25.9	75	136	20.1	80.3	30	17.1	88.2	18	18.2	61.5
Creek chub.....	1	1.7	8.3	69	10.2	43.9	6	3.4	1.2	1	1.0	7.7
Lake chub.....	43	6.4	31.8
Redbelly dace.....	1	0.1	1.5
Golden shiner.....	2	3.5	16.6	42	23.9	71.2	5	5.0	31.0
Common shiner.....	9	15.5	33.3	199	29.5	78.8	19	10.8	47	13	13.1	38.5
Brown bullhead.....	3	0.4	1.5	3	1.7	17.6	1	1.0	7.7
Eel.....	24	3.6	30.3	3	1.7	12.8	1	1.0	7.7
Killifish.....	14	24.1	58.3	37	5.5	38.0	23	13.1	64.7	3	3.0	15.4
White perch.....	1	1.0	7.7
Yellow perch.....	5	2.8	23.5	1	1.0	7.7
Ninespine stickleback.....	2	3.5	16.6	3	0.4	4.5
Threespine stickleback.....	4	0.6	6.2	7	4.0	23.5	10	10.0	31.0
Frog.....	1	0.1
Totals.....	58			675			176			99		

TABLE XI.—Food of American mergansers in streams of the Carboniferous area of mainland Nova Scotia.

Stream	No. of ducks	Salmon	Brook trout	White sucker	Creek chub	Lake chub	Blacknose dace	Golden shiner	Common shiner	Eel	Sticklebacks
Wallace River.....	6	7	..	8	3	3	3	..	6	1	16
Stewiacke River.....	12	8	4	24	..	21	8	3	47
Maccan River.....	7	17	..	1	4	7	3
Herbert River.....	10	18	1	26	19	5	..	1	4	21	23
River Philip.....	19	89	2	21	2	2	9	17
Totals.....	54	139	7	80	24	31	16	1	18	32	106
Numerical %.....	..	30.6	1.6	17.6	5.3	6.8	3.5	0.2	4.0	7.0	23.3
Occurrence %.....	..	83.3	9.2	63.0	20.4	31.5	18.5	1.8	18.5	31.5	61.1

TABLE XII.—Food of American mergansers in the Pre-cambrian area of southwest Nova Scotia.

Fishes	LaHave River			Gold River			Medway River		
	13 stomachs			4 stomachs			5 stomachs		
	No.	%	oc%	No.	%	oc%	No.	%	oc%
Gaspereau.....	39	86.7	100
Salmon.....	8	7.0	38.0	4	13.8	50	2	4.4	40
White sucker.....	60	52.6	77.0	9	31.0	100
Creek chub.....	1	0.9	7.7	2	6.9	25
Lake chub.....	4	3.5	15.4	6	20.7	50
Golden shiner.....	3	2.6	23.0	1	3.4	25
Brown bullhead.....	3	10.3	75
Eel.....	1	0.9	7.7
Killifish.....	23	20.2	69.2	2	4.4	20
White perch.....	5	4.4	30.8	2	4.4	20
Ninespine stickleback.....	9	7.9	38.0	2	6.9	25
Threespine stickleback.....	1	3.4	25
Frog.....	1	3.4	25
Totals.....	114			29			45		

TABLE XIII.—Food of American mergansers in marginal salmon waters.

Fishes	Lower Kennebecasis R.		Main Petitcodiac R.		Canaan R.	
	11 stomachs		20 stomachs		8 stomachs	
	No.	%	No.	%	No.	%
Sea lamprey.....	4	5.1
Salmon.....	4	8.9
White sucker.....	6	13.3	29	36.7	5	20.0
Fallfish.....	2	8.0
Lake chub.....	3	3.8
Blacknose dace.....	3	12.0
Golden shiner.....	2	5.3
Common shiner.....	18	40.0	10	40.0
Other minnows.....	2	4.4	4	5.1	1	4.0
Eel.....	7	15.6	27	34.2
Killifish.....	2	4.4	7	8.9	4	16.0
Smallmouth bass.....	5	11.1
Pumpkinseed.....	1	2.2
Tomcod.....	1	1.3
Ninespine stickleback.....	1	1.3
Threespine stickleback.....	1	1.3
Totals.....	45		79		25	

TROUT WATERS

Most of the waters from which we have collections of merganser stomachs have contained both salmon and brook trout. We have only 1 collection from an area which contains trout but no salmon. This area is the *upper part of the Pollett River* above Gordon Falls. Excepting a few eels, no fish are able to surmount the falls. Trout and blacknose dace occur above the falls. The area is largely wooded country and every year 2 to 4 merganser broods are brought up on it.

For this area we have records of the stomach contents of 28 mergansers taken in the early summer of 1948, 1950 and 1952. Twenty-one were downy ducklings (see Table V), 5 were adult females and 2 were 12-inch ducklings. The adults contained 13 trout, 90 to 150 mm. (3.5 to 5.9 inches) in length and 15 dace, 60 to 70 mm. (2.4 to 2.7 inches) in length. The two large ducklings contained 21 and 30 small seeds. In all the analyses we have rarely found a seed in a merganser's stomach.

STREAMS WITH SALMON AND TROUT DOMINANT

There are in the Maritimes many streams or parts of streams where salmon and trout are the dominant species. The reason for this dominance may be that the temperature is too low for other fishes to compete with the salmonids or that there are falls which prevent other fishes from reaching the area. Most of the streams probably contain a few eels but eels are generally found in warmer waters. Many of these streams are too small for successful rearing of merganser broods but are used as feeding grounds for the first week or more after the young have come from the nest. Where the stream is large enough to provide open reaches and pools merganser broods may be reared on the streams. Also some of these streams have open water during most of the winter and provide feeding areas for a few wintering mergansers. The analyses of merganser stomachs collected from streams or areas of streams where salmon and trout are the dominant species are summarized in Table XIV.

The upper *Northwest Miramichi River* where 11 mergansers were collected in July, 1951, is above an 8-foot falls at Dam Camp about 35 miles up the river in wooded land. All the ducks taken in this area contained salmon and trout only, 29 and 25 respectively.

The *Cheticamp River* is a small salmon stream of the Cape Breton Island part of Nova Scotia. This salmon stream heads in the Cape Breton Highlands National Park about 1,000 feet above sea level. We know of no fish other than salmon and trout in its turbulent waters. Five ducklings less than half grown collected in the lower part in June, 1936, contained 27 yearling salmon parr only.

The *North River*, very similar to the Cheticamp, heads also in the tablelands. A single merganser received from this stream was taken in the lower part in late August, 1949. It contained 3 yearling salmon parr and 2 small eels, 75 and 130 mm. (2.9 and 5.1 inches) in length.

The *Northeast Margaree River*, also in Cape Breton, is a famous medium-size, salmon river. Salmon and trout are the dominant fish but large suckers occur in some numbers in the lower 15 miles. Small suckers, killifish and sticklebacks are present in some weedy backwaters. Seventy-three mergansers collected from this stream between 1935 and 1951 contained 288 salmon and 17 trout—95.6 per cent of the fish present in the stomach contents.

The *Port Daniel River* is on the Gaspé peninsula of Quebec and is the only stream outside the Maritime Provinces from which we have received merganser stomachs. This is a small river where salmon investigations are being carried out by the Province of Quebec. Twelve stomachs collected from this stream in July, August and September, 1952, contained 36 salmon parr and 5 trout but no other food.

PONDS AND LAKES

Since this work is mostly in connection with the relation of mergansers to the production of salmon, exclusive of "land-locks", relatively few ducks have been collected from lakes or ponds. We have had only 20 stomachs from such habitats. The food found in these stomachs is listed in Table XV,

Chamcook Lake, about 1 square mile in area, is situated in southwestern New Brunswick near the Biological Station at St. Andrews. Chamcook, at least locally, is famous for the angling of land-locked or Sebago salmon and also lake trout. It contains smelt and a number of other fishes. Between 1932 and 1936, during the fall migration, 7 mergansers were collected from this lake. The ducks had fed largely upon smelt and sticklebacks and had taken some suckers and minnows. Three of the ducks were seen when they arrived at the lake and were collected after they had fed there for less than an hour. In addition, they contained recognizable remains of 1 chain pickerel, 3 white perch and 1 fish of the cod family. These fish do not occur in the fauna of this lake. We have included them in the table but not in the calculated food percentages for the lake. The nearest place where they could have taken the pickerel and perch is at a lake about eight air miles away.

The *Glades Pond* is a small pond above a dam on the Pollett River, a branch of the Petitcodiac River of southern New Brunswick. Of 6 mergansers collected on this pond, 3 were taken in December, 1949, 2 in February, 1953, and 1 in April, 1951. They consisted of 4 immature males, 1 mature male and 1 immature female. The pond is a favourite resting place for mature males. The ducks had fed largely upon suckers and eels from the pond. The males had eaten 14 suckers, ranging from 100 to 250 mm. (3.9 to 9.8 inches) in length, whereas the female had eaten only 1 sucker 35 mm. (1.4 inches) long. The female's food differed also in that she had taken 2 larval lampreys and 2 dragonfly nymphs. These ducks contained 12 eels ranging from 100 to 290 mm. (3.9 to 11.4 inches) in length. A high percentage of eels is common in the winter and early spring food of mergansers from other localities.

Long and Eden Lakes are 2 lakes in the East St. Mary River system. Long Lake is small but Eden Lake larger, 2 miles by $\frac{1}{2}$ mile. Merganser broods found on these lakes have access also to the river. The advanced broods are found in Eden Lake after they have depleted the food supply in the small Moose River which feeds this lake. Eden Lake with a narrows dividing it into 2 parts generally has, each year, 2 pairs of nesting loons, 1 pair in either part, and as pointed out previously the mergansers are obliged to feed in the shallowest water along the edge of the lake.

One adult female and 16 juveniles were collected from the 2 lakes on July 10 and 11 of 1953. There is no essential difference in the food taken except that creek chub were taken only in Eden Lake and blacknose shiner only in Long Lake. The food of the mergansers in these 2 lakes is probably typical of their food in most lakes of the Maritimes. Their feeding in such areas has no relation to salmon.

WINTER FOOD

Typical winter food of adult mergansers is shown in the stomach contents of 11 of 20 ducks taken from the *main Petitcodiac River* (see Section "Food in marginal salmon waters") during the month of March. Suckers and eels made

up the bulk of the food of the birds. Eels taken were large which may account in part for the greater number of suckers eaten. Coldwell (1939) reported mergansers feeding almost entirely upon eels during winter at an open pool in the Gaspereau River, Kings County, Nova Scotia.

Some of the upper tributaries of the *Kennebecasis River* are quite unlike the lower part which we have classed as marginal salmon water (see Section "Food in marginal salmon waters").

The Portage branch is a fertile stream which rises in the hills of Kings County of New Brunswick. At times it is flood-swept but ordinarily it is almost entirely spring-fed by the numerous springs throughout its length. Even in severe winter weather it is generally free of ice. Although it is one of the favourite angling streams of southern New Brunswick it maintains a good population of native trout. It is also a good salmon-rearing stream.

During the fishing season, the presence of anglers along the stream tends to keep mergansers from using it as a feeding ground or as a rearing place for their broods. In the closed fishing season a few mergansers visit the stream and some spend the winter there.

Six mergansers, consisting of 4 mature females and 2 immature males were collected on this stream during January and February of 1952 and 1953. These contained the remains of 78 fish. Five per cent were salmon parr, 13 per cent trout, 60 per cent freshwater sculpins, 1 per cent burbot fingerlings, 1 per cent common shiners, 1 per cent eels and 18 per cent threespine sticklebacks.

Sculpins occurred in 83.3 per cent of the stomachs examined, indicating that on this stream this fish is a staple winter food. The sculpins in the stomachs ranged from 45 to 120 mm. (1.8 to 4.7 inches) in length. Both trout and sticklebacks had an incidence of 66.6 per cent and are thus classed as staple foods. Salmon with an incidence of 33.3 per cent and burbot, common shiner and eel with an incidence of only 16.6 per cent each, rate as occasional foods.

That trout and minnows are not found in higher percentages is probably due to the fact that during the winter they hide in submerged brush, among loose rocks and other cover. This habit was discovered by electro-fishing during that season. In the winter sculpins are plentiful on the gravelly rapids. Their availability probably accounts for their dominance in the food.

UPPER ESTUARIAL WATERS

In the Maritime Provinces there are 3 periods when the American merganser frequents the upper estuarial waters of a stream system. First, in the spring of the year when the courting flocks are present the ducks sometimes use upper estuarial waters. Second, on some streams mergansers congregate in upper estuarial waters at the beginning of the spawning run of smelt. Third, when the advanced young have depleted the upper waters they often drop downstream to feed in the estuary.

The only time that young salmon are present in any numbers in tidal waters is during the smolt run and for a short time after. This limits their time in the estuary from late May to the middle of June. We have never found the American merganser feeding on the smolts in the estuary but the red-breasted merganser is commonly found in the estuary at this time.

Every spring, as soon as the smelt begins its spawning run, hundreds of mergansers congregate in the upper estuarial waters of the *Bartibog River* and then follow the schools of smelt as the run progresses up the stream. Several times we have visited the Bartibog during this period. It contains many large boulders, some protruding as much as 3 feet above the water. Between

feeding periods the mergansers crowd the tops of the boulders for miles in and along the stream painting them with their faeces. Five mergansers collected from the upper estuary during the smelt run contained 17 smelt.

On August 27, 1949, we came down the lower 10 miles of the *Renous River* in a canoe. There were remains of old merganser faecal splashes on the protruding boulders. Fish appeared to be extremely scarce. No mergansers were seen on the river. In the estuarial waters we found a flock of well-advanced young which had just reached the flying stage. The stomachs of 5 that we collected contained 4 medium-size suckers measuring 200 to 250 mm. (7.9 to 9.8 inches) in length, also 1 blacknose dace and 1 ninespine stickleback.

On July 29, 1936, on the *Margaree River* estuary, 4 well-grown young ducks were secured from a flock of about 20. At this time the main part of the river had been fairly well depleted of fish suitable for merganser food. The stomachs of these ducks contained 1 salmon parr, 1 sucker, 3 threespine sticklebacks and 6 yearling gaspereau. Every year, during late summer, yearling gaspereau come into the Margaree estuary in large numbers.

In most areas, the feeding of the American merganser in the estuaries has little, if any, effect on the production of salmon.

DEPLETED STREAMS

Feeding experiments and stomach analyses show definitely that the American merganser requires large quantities of food. Where broods are reared annually upon streams their food supply is limited by the annual production of fish of the sizes suitable for merganser food. The merganser is an excellent "fisherman" but expends much energy in the capture of its food. To produce this energy and also for the young to make growth, they require from one-third to one-half of their weight in fish daily. They tend to take fish up to the size which they can swallow. Very young downy ducklings will take fish as small as 20 mm. (0.8 inches) but the larger ducklings and adults do not ordinarily take fish under 50 mm. (2 inches) in length. It may be that the energy acquired from such small fish is not sufficient to compensate for the energy spent in their capture. Moreover these small fish are frequently in shallow water where the larger ducks cannot successfully pursue and capture them.

When a stream has been thoroughly fished by mergansers, the fish which remain are mostly the very small ones and those which are too large for the ducks to swallow. However, a few fish of the suitable sizes will be left when the population is reduced to the point where the ducks cannot profitably search for them. Also, there are sometimes small areas which remain well stocked with fish of all sizes. These areas are at places where mergansers are constantly frightened away. Such places are along well-travelled roads, near stream-side human habitations where there is much activity, at well-travelled bridges, at swimming holes or other places where children play and at places frequented by anglers during daylight hours.

It is difficult for those who have not been intimately associated with merganser predation to appreciate how thoroughly the mergansers sometimes deplete a stream. When ordinary food fish become depleted the mergansers attempt to adapt themselves to the changed conditions.

We have collections of stomachs from 3 depleted streams and the contents of these show the feeding habits of the ducks.

The *Coverdale River* is a small salmon-rearing stream entering the muddy estuary of the Petitcodiac River. This stream is smaller than, but equally as rich as the Pollett branch where, with merganser control, a large number of salmon smolts is produced annually as well as large populations of minnows, suckers and eels. During low water many fish are readily seen when walking beside or wading in the stream.

On July 16, 1953, accompanied by 2 assistants, I made a merganser collecting trip to the Coverdale River. The water was very low and clear and some 10 miles of the stream was examined for fish and mergansers. The stream showed all signs of depletion of the fish by mergansers. Visibility to the bottom, even in the large pools, was excellent and many large suckers were seen but some medium-size suckers showed unmistakable marks of having been mauled by mergansers. These were fish which were a little too big to be swallowed by half-grown mergansers. We could find no fish of the sizes ordinarily taken. Residents reported 2 flocks, 1 of 8 and another estimated at from 25 to 40. We found the flock of 8 and collected them. The other flock had been seen that day some 10 miles below the area we covered.

The 8 mergansers consisted of the dam and 7 half-grown young. Three of the young contained remains of 3 fish, one 75 mm. (3 inches) sucker, 1 blacknose dace 60 mm. (2.4 inches), and one 200 mm. (7.9 inches) eel. Four of the stomachs contained no trace of fish. All had either a small quantity of grass-like leaves or chlorophyll stain in their gizzards. They had reverted to the downy ducklings' habit of feeding on insects, as they contained 1 dragonfly nymph, 1 waterstrider, 1 cranefly larva, and 1 mayfly nymph. The dam contained 4 suckers, 1 of which was 130 mm. (5.1 inches) in length and three 70 mm. (2.8 inches) each. Evidently the adult female was more proficient in finding the surviving small fishes.

Ordinarily, before the stream had become so badly depleted, these ducks would have moved down to larger waters, but the muddy waters and extreme tides of the lower Petitcodiac evidently barred their movement.

The 7 young were probably from 3 broods. The following year the stream was thoroughly examined for mergansers but none were found. The stream may have been so depleted that no female merganser would nest in the vicinity.

The *Keswick River* is a small salmon-rearing stream entering the Saint John River about 15 miles above Fredericton. It is in the Pennsylvanian Carboniferous formation and for the most part flows through farm land. It is a fairly rich stream. A female and 4 young, just able to fly, were collected on August 31, 1951. They contained 46 fish—3 salmon fry-of-the-year averaging 63 mm. (2.5 inches) in length, 10 suckers averaging 44 mm. (1.7 inches), 1 lake chub 45 mm. (1.8 inches), 15 blacknose dace averaging 60 mm. (2.4 inches), 13 common shiners averaging 58 mm. (2.3 inches), 2 elvers 130 mm. (5.1 inches) each, 2 fourspine sticklebacks 45 mm. (1.8 inches) each. Although these ducks contained on the average 9 fish each, the bulk would not equal that of a single fish ordinarily taken by ducks of this size. Here the depletion had extended only to the sizes of fish ordinarily taken by mature ducks and the nearly full-grown young. Both the female and flying young had evidently reverted to feeding upon very small fish such as are ordinarily taken by downy ducklings.

The *Economy River* is a small salmon-rearing stream in Cumberland County, Nova Scotia, and flows into Cobequid Bay. It is entirely in Devonian and Carboniferous formations and is thus relatively fertile. About 8 miles above tide-water there is a high falls impassable to salmon and apparently impassable for non-flying mergansers.

On August 4, 1951, the water was low and visibility into it was good. Visual examination of the stream from the falls to near the head of tide did not reveal a single fish. Local residents reported that they had recently seen a flock of a dozen or more mergansers on the stream.

Two nearly full-grown mergansers found feeding at the falls were collected. Moving downstream we saw old faecal splashes on large emergent boulders all along the stream indicating that mergansers had used it. Near the head of tide close to the settlement we found an abundance of fresh faecal splashes. Finally just at the head of tide we found the flock of 10 well-grown young. From their sizes they were evidently from 2 broods. The larger young were developed just to the flying stage but could not sustain their flight. When first seen the flock had evidently just finished a feeding period and were resting on a large emergent boulder. Nine of these ducks were collected. Most of their gullets were nearly filled with freshly ingested elvers and small eels, some of which were still alive when the ducks were shot. The elvers ranged from 65 to 110 mm. (2.6 to 4.3 inches). The largest eel was 320 mm. (12.6 inches) in length. One duck contained 125 elvers making a total volume of 50 cc.

The unusual character of the feeding of these ducks may be judged from the fact that 9 contained 625 elvers and eels which is more than 4 times the 169 found in the stomach contents of the other 878 mergansers used for this investigation.

In addition to the eels these 11 ducks from the Economy River contained 7 salmon parr, 3 lake chub, 5 fourspine sticklebacks, 7 ninespine sticklebacks and 1 tomcod. The sticklebacks and tomcod inhabit salt or brackish water. Five of the parr were in 1 of the ducks collected from the pool below the falls.

The story of these ducks appears to be as follows. The falls was a barrier to their upstream movement to the stream and lakes above and in the roily waters of Cobequid Bay they could not feed. They had depleted the supply of fish in the 7- to 8-mile section. There was no mature female with them so they had gradually ventured down where houses were on either side of the stream. Finding an abundance of small eels they persisted in feeding there even though harassed. A stream-side resident claimed that he had killed one with a stone. The amount of faecal splashes on the rocks and the statements of residents show that the ducks had been feeding there for some days. They must have consumed a very large number of eels.

Ordinarily on streams where eels are abundant they form only an occasional or minor food of the mergansers on the stream (see Table XIII and page 00).

EXPERIMENTAL SECTION OF THE POLLETT RIVER

The Pollett River is a branch of the Petitcodiac River of southern New Brunswick. It is a small river 75 to 100 feet wide rising in the Albert County hills and descending some 700 feet in 40 miles. It flows largely through Carboniferous formations and is a comparatively rich stream. Having clear water and many rapids it is an ideal stream for the rearing of young salmon. The experimental section of this stream is an 11-mile stretch between a salmon counting fence at The Glades and the upper limit at Gordon Falls above the village of Elgin. A dam below the counting fence is a barrier to the upstream migration of spawning salmon into the experimental area. In this section a study of the effects of bird control on the production of salmon has been in progress since 1947.

The stock of salmon for the experiment is dependent upon plantings of hatchery-reared salmon fry. The counting fence is maintained to determine the numbers of smolts resulting from the various plantings of fry. The young salmon make excellent growth and most descend to the sea as large 2-year smolts. With bird control the section has produced good crops of salmon parr and migrations of smolts to the sea. Coincident with bird control other fishes have

made large increases in numbers. Dr. P. F. Elson of the Fisheries Research Board of Canada is in charge of this experiment. A preliminary report has been published (Elson, 1950).

For the study of the food of the merganser on the experimental section we have analyzed the stomach contents of 120 mergansers taken during the bird control operations from 1948 to 1952. The results of analyses of 117 of those taken from 1949 to 1952 are shown in Table XVI. Three other ducks taken during December of 1948 had eaten 1 salmon, 1 trout, 4 suckers and 8 minnows.

A glance at the table will show that of the various fishes taken by the mergansers, salmon parr occurred in the stomachs in the highest percentage in 3 of the 4 years and ranged from 22.4 per cent in 1949 to 56.7 per cent in 1952. The white sucker was also high, ranging from 16.2 per cent to 32.9 per cent. Both of these fishes are high in incidence showing again that they are a regular food. The lake chub was third and the blacknose dace fourth in numbers taken.

On the experimental section for the years 1948 to 1952 counts of the numbers of salmon, suckers, chub and dace have been made annually in 7 representative sections selected along the 11-mile experimental area. To obtain the count, the sections ranging from 50 to 60 yards in length were blocked off by fine-mesh barrier nets and the fish removed with seine and electro-fishing. The same sections have been used each year. After counting, the fish all have been returned alive to the section. The numbers and percentages of the 4 dominant fishes taken during these seinings are shown in Table XVIIA.

For the same dominant fishes the numbers and percentages found in mergansers collected on the experimental section are shown in Table XVIIIB.

The mergansers were collected throughout the year and the seinings were made each year after the seaward run of salmon smolts. For more comparable data, the totals for the 4 years have been used to determine percentages for the 4 dominant fishes.

If the fish were taken at random by the mergansers, there should be a fairly close agreement between the percentages of the fishes taken in population censuses and those taken by mergansers. However, the percentage of species in stomachs (Table XVIIA) divided by the percentages of species in the streams (Table XVIIIB) gives for salmon 3.7, sucker 2.0, lake chub 0.3, blacknose dace 0.4. Giving salmon a value of 10, the result may be expressed as salmon 10, sucker 5, blacknose dace 1, lake chub 1. For the mergansers feeding on this stream, the results indicate that salmon are either selected or are more available than the other fishes. At any time in the experimental section, possibly excepting a short period after the smolt run, it is probable there were more salmon than other fishes of the sizes preferred by adult mergansers. Thus the mergansers may have selected salmon for size. For Michigan trout waters, Sayler and Lagler (1940) conclude that trout were selected because they were larger than forage fishes.

Our observations on many streams indicate that the mergansers do most of their feeding in the better parr habitats.

LIFE HISTORY AND FOOD OF THE RED-BREASTED AND HOODED MERGANSERS

RED-BREASTED MERGANSER

The red-breasted merganser (*Mergus serrator*) is known throughout the Maritime Provinces by the same names as the American merganser. The characters which distinguish this species are given in the chapter on the description of mergansers. It is found over the entire Maritimes, but it seldom

TABLE XIV.—Food of American mergansers in streams with salmon and trout dominant. The figures under each species, exclusive of numerical and occurrence percentage, are the total numbers of each fish found.

Stream	Number of stomachs	Salmon	Trout	White sucker	Eel	Killifish	Stickle- backs	Total
Upper Northwest Miramichi River.....	11	29	25	54
Cheticamp River.....	5	27	27
52 North River.....	1	3	2	5
Port Daniel River.....	14	36	5	41
Northeast Margaree River.....	73	288	17	4	2	2	6	319
Totals.....	104	383	47	4	4	2	6	446
Numerical %.....	..	85.9	10.6	0.9	0.9	0.4	1.4	..
Occurrence %.....	..	93.3	25.0	3.8	2.9	0.9	4.8	..

TABLE XV.—Food of American mergansers in ponds and lakes. Bracketed figures are for species not found in the lake and are not used in calculating percentages of food.

Fishes	Chamcook Lake		The Glades Pond		Long and Eden Lakes	
	7 stomachs		6 stomachs		17 stomachs	
	No.	%	No.	%	No.	%
Sea lamprey.....	2	4.9
Smelt.....	37	30.3
Salmon.....	1	0.8	1	2.4
White sucker.....	4	3.3	15	36.6	31	17.5
Creek chub.....	4	2.3
Lake chub.....	6	14.63	8	4.5
Blacknose dace.....	4	9.8
Common shiner.....	3	2.5	46	26.0
Golden shiner.....	5	2.8
Blacknose shiner.....	3	1.7
Other Minnows.....	3	2.5	1	0.6
Chain pickerels.....	(1)
Eel.....	12	29.3	1	0.6
Killifish.....	61	34.5
White perch.....	(3)	1	0.6
Yellow perch.....	15	8.5
Threespine stickleback.....	14	11.5	1	2.4
Ninespine stickleback.....	60	49.2	1	0.6
A cod.....	(1)
Totals.....	122		41		177	

nests on the better salmon streams and when it does the downy young are generally taken down to tidal waters. In size, feeding habits and choice of territory, this merganser is intermediate between the American and a third species, the hooded merganser. It tends to frequent the quiet waters but not such small water areas as those often used by the hooded merganser.

This duck nests on the ground. The only nest which we have found was among low bushes about 10 feet from the edge of a small boggy lake in Prince Edward Island. It tends to nest somewhat later than the American merganser and produces larger numbers of young in the broods—12 or 14 being common.

Throughout the summer of 1936, we made periodic observations on a female which appeared early in June on the tidal part of the Margaree River with 21 small ducklings. These may have been from 2 broods but we saw no other female in the vicinity.

Townsend (in Bent, 1925) makes the following statements:

Both parents are assiduous in caring for their young The young are carefully fed and guarded by their parents and the family group keeps together until the young are fully grown. The young conceal themselves while the adults do their best to entice the intruder away.

In our area the males have mostly left the rearing areas by mid-June. Of 18 adult males which we collected only 2 were taken after June 6, 1 on June 22 and 1 July 7. We have seen many broods of this merganser but have never seen a male accompanying a brood. The young are precocious and capture food for themselves. Usually the female leads her brood away from danger but we have seen no attempt to entice the intruder away.

For a food study of the red-breasted merganser we have had relatively few stomachs—only 60—and have previously reported on some of these (White, 1937, 1939 a and b).

Eleven specimens taken in 1936 from the Margaree River contained—45 salmon (43 parr, 2 fry), 17 sticklebacks, and 4 killifish. In addition they contained 3 cunners, and 2 sculpins taken from the sea. The food from the river consisted of 45 salmon and 21 other fish, i.e. 68.2 per cent salmon, 31.8 per cent other fish.

Between the years 1948 and 1950, 8 red-breasted mergansers were secured during April and May from the Petitcodiac River system. Two were from a salmon-rearing area and contained 2 salmon smolts, 4 suckers and 4 typical stream minnows.

The stomachs of 3 taken on a pond contained 3 small suckers, 34 golden shiners, 29 fourspined sticklebacks, 34 threespined sticklebacks and 1 eel.

Three ducks collected on the main Petitcodiac River contained 5 suckers, 3 golden shiners, 5 other minnows, and 5 sticklebacks. One specimen from Belle Isle Bay (Saint John River) contained 1 sucker, 3 minnows, and 1 dragonfly nymph.

Two from the tidal part of the Bartibog River contained 1 smelt, 2 killifish, 12 threespined sticklebacks, and 2 twospined sticklebacks. The only specimen from the Northwest Miramichi was taken from a backwater. This one contained 2 salmon parr, 3 small suckers, 1 golden shiner, 11 other minnows and 1 stickleback.

Analyses of stomachs from these different habitats show that in general the red-breasted merganser tends to feed in quiet weedy waters. This is indicated by the presence in their stomachs of such fishes as golden shiners, killifish and sticklebacks; species which generally occur in quiet weedy areas. Analyses also show that when on salmon-rearing waters they take salmon parr and other fishes typical of the habitat. For the Margaree River, it was concluded that when feeding on the same areas there was no difference in the feeding of the red-breasted and American mergansers (White, 1937). Munro and Clemens (1939) found the same to be true for British Columbia waters.

TABLE XVI.—Food of American mergansers in experimental section of Pollett River.

Fishes	1949			1950			1951			1952		
	39 stomachs			16 stomachs			29 stomachs			33 stomachs		
	No.	%	oc%									
Sea Lamprey.....	1	0.3	3.0
Salmon.....	53	22.4	46.1	45	42.9	68.8	107	46.3	53.8	166	56.7	79.0
Brook trout.....	12	5.1	20.5	11	10.5	25.0	2	0.9	2.5	1	0.3	3.0
White sucker.....	78	32.9	87.2	18	17.1	68.8	49	21.2	59.0	48	16.4	60.6
Fallfish.....	1	0.4	2.3	1	1.0	6.2	1	0.4	2.5
Lake chub.....	42	17.7	41.5	15	14.3	37.5	22	9.5	30.8	38	13.0	36.4
Blacknose dace.....	22	9.3	28.2	4	3.8	12.5	21	9.1	18.0	13	4.4	30.3
Other minnows.....	18	7.6	18.0	4	1.7	7.7
Eel.....	9	3.8	15.4	3	2.9	6.2	7	3.0	15.4	14	4.8	24.2
Killifish.....	1	1.0	6.2
Sculpin.....	5	4.8	6.2	1	0.4	2.5
Threespine stickleback.....	2	0.8	4.6	2	1.9	6.2	16	6.9	15.4	10	3.4	9.1
Fourspine stickleback.....	1	0.4	2.5	3	0.7	3.0
Totals.....	237			105			231			293		

TABLE XVII. A.—Numbers and percentages of the four dominant fishes taken in the experimental section of the Pollett River.

Year	Salmon parr	White suckers	Lake chub	Blacknose dace
1948.....	396	560	2,639	486
1949.....	550	391	2,645	1,117
1950.....	633	629	1,633	935
1951.....	933	326	1,270	1,335
1952.....	105	604	1,704	583
Totals.....	2,617	2,510	9,891	4,456
Per cent.....	13.4	12.9	50.8	22.9

TABLE XVII. B.—Numbers and percentages of the four dominant fishes in the stomachs of American mergansers from the Pollett River.

Year	Salmon parr	White suckers	Lake chub	Blacknose dace
1948.....	7	4	0	3
1949.....	53	78	42	22
1950.....	45	18	15	4
1951.....	107	49	22	21
1952.....	166	48	38	13
Totals.....	372	197	117	63
Per cent.....	49.7	26.3	15.6	8.4

HOODED MERGANSER

In the Maritime Provinces the hooded merganser (*Lophodytes cucullatus*) is not a common duck but occurs in some numbers along the Saint John River and in the lake district of the southwestern part of New Brunswick. Smith (1955) lists 106 sight records from August for 1949 and 167 for 1950 at Crecy Lake, a small lake in the southwestern corner of the province.

During our years of merganser collecting and stream surveying in other parts of the Maritimes we encountered the hooded merganser only on the Cains River, a branch of the Southwest Miramichi. There a flock of 7 was seen in one of the backwaters along the river.

Concerning their food on a well-stocked trout lake, Smith (1955) states: "Three of 30 hooded mergansers shot at Crecy Lake had eaten killifish but none had eaten trout".

Kortright (1943) reports that this merganser eats a certain amount of vegetation but that its food is mainly animal matter, fish, frogs, tadpoles, crayfish and aquatic insects.

Since this little merganser frequents only small ponds and weedy areas it is unlikely that it could have any effect on commercial or game fishes.

SALMON AS THE FOOD OF MERGANSERS

The results of our studies of the food of the American merganser in the different salmon streams of the Maritime Provinces have been summarized in Table XVIII. Here, we have consolidated our results on the basis of the 4 great drainage areas of the Maritimes—the Gulf Mainland, Cape Breton, Atlantic Nova Scotia and Bay of Fundy. Amounts of all fish eaten which were young salmon varied from highs of 46 to 91 per cent in the Gulf Mainland and Cape Breton drainages and from overall lows of 36 to 5 per cent in the Atlantic Nova Scotia and Bay of Fundy drainages.

TABLE XVIII.—Salmon as the food of the American merganser in areas of the Canadian Atlantic drainage.

	Merganser stomachs examined	Salmon eaten	Salmon eaten	Stomachs with salmon
	No.	No.	%	%
GULF MAINLAND DRAINAGE NORTH N.B. AND GASPÉ RIVERS (Upsalquitch, Port Daniel and Middle Rivers).....	18	79	81	78
MIRAMICHI RIVER SYSTEM.....	174	727	46	86
NORTHUMBERLAND STRAIT RIVERS (Philip and Wallace Rivers).....	25	96	51	96
CAPE BRETON DRAINAGE (Cheticamp, North and Margaree Rivers).....	79	318	91	95
ATLANTIC NOVA SCOTIA DRAINAGE (St. Mary, Moser, Lahave, Gold and Medway Rivers).....	130	202	17	62
BAY OF FUNDY DRAINAGE NOVA SCOTIAN RIVERS (Herbert, Stewiacke, Economy and Maccaan Rivers).....	40	50	5	60
PETITCODIAC RIVER SYSTEM.....	181	384	36	45
SAINT JOHN RIVER SYSTEM.....	77	93	18	49

Other fish species eaten in the Gulf Mainland and Cape Breton drainage areas were mainly blacknose dace, common shiners and white suckers except in the latter area and in the Port Daniel River of the former where trout were the second most important food item. In the Atlantic Nova Scotia area white suckers and common shiners, with lesser amounts of gaspereau and killifish, formed the bulk of the food. Sixty-six per cent of the fish eaten in the Nova Scotian rivers of the Bay of Fundy drainage area were small eels (pigmented elvers) from the estuary of the Economy River. This was exceptional feeding practice and accounts for the low of 5 per cent for salmon eaten by the birds in the area. Sticklebacks, suckers and minnows made up the remaining 30 per cent. In the Petitcodiac River system suckers, chub and eels made up 64 per cent of the food consumed. In the Saint John River mergansers had consumed 82 per cent fallfish, shiners, suckers, and dace.

Perhaps of more importance is the percentage number of birds from the various areas that had eaten young salmon. This gives the incidence or regularity with which salmon is eaten and whether it is preferred as a food item. Table XVIII shows that salmon are found in from 45 to 96 per cent of the stomachs examined from the various areas. Even in the Atlantic Nova Scotia and Bay of Fundy drainage areas where young salmon made up as little as 5 per cent of the fish-food items, 45 to 62 per cent of the mergansers had eaten some young salmon. This strongly suggests that young salmon are a preferred item and are selected by the American merganser as food. The suggestion is qualified, however, by the fact that mergansers feed by sight and need clear water—just the kind that is typically salmon and trout habitat.

Now let us apply the information on food consumption obtained from rearing the captive mergansers to full-growth (Table I) and the information on the amounts and incidence of young salmon as merganser food in the different rivers of the Maritimes (Table XVIII) to provide quantitative evidence of the effect of predation by the American merganser on salmon production. These data combined with the numbers of American mergansers recorded as killed during merganser-control operations on the Miramichi River system in 1954 by specially trained crews from the Conservation and Development Service of the federal Department of Fisheries, allow us to calculate the numbers of young salmon (parr) required to rear these birds to full-growth.

In 1954, almost 1,200 American mergansers were shot on the Miramichi River system, one of the most important salmon-producing rivers on the Canadian Atlantic coast. From Table XVIII it may be seen that 86 per cent of the birds on this system ate young salmon. Now to rear a single merganser to full growth may take as much as 72 pounds of fish (Table I) of which 46% or 33 pounds are young salmon (Table XVIII). Assuming that salmon parr average $\frac{1}{3}$ ounce in weight, the 33 pounds represent 1,584 salmon parr eaten in the rearing of each merganser to full growth. Consequently, the 1,200 birds shot on the Miramichi represent an annual consumption of over 1,900,000 salmon parr. Preliminary

data available from Dr. P. F. Elson of the Biological Station, St. Andrews, indicates these parr could represent an additional production of about 1,000,000 salmon smolts.

Estimates made for the 700 to 1,000 miles of salmon-producing waters of the Miramichi in 1951 and 1954 showed that between 1,500,000 and 1,690,000 smolts were produced annually. Potential smolts eaten as salmon parr by mergansers thus amounted to more than two-thirds the annual numbers of smolts actually produced by the river system. The comparison would undoubtedly have been even more striking if our calculations had been based, not on the numbers of birds shot, but on the entire population of birds feeding on the Miramichi River system.

PREDATOR-PREY RELATIONSHIP

The feeding of wild animals tends to exploit but not exterminate the food species. This results in an ecological condition popularly known as "the balance of nature".

Before the arrival of white man in the Maritimes, the mergansers undoubtedly harvested the yearling salmon parr from the streams. But the ducks probably left the streams when they were unable to get about a third of their weight in fish per day. This resulted in enough young salmon surviving to go to sea and produce sufficient adults to return and restock the streams. This, unwittingly, was a form of husbandry suitable to the merganser. Now, man's arrival and desire for salmon as a food and sport fish makes him a new and important predator. The balance of nature is upset. To restore the balance, control of predators becomes necessary.

It has been argued that in salmon streams, where minnows and suckers were present, mergansers created conditions for the better growth of salmon parr by reducing the population of competing fish.

Also it has been thought that with mergansers present on a stream that supports a variety of species of fishes, the minnows and suckers would be beneficial to the salmon by acting as a buffer food. However, predation by mergansers with such "buffer-fish" available, has the effect of *reducing* the numbers of salmon parr surviving. Mergansers quit the feeding grounds when the fish population reaches a certain level, say 10 per cent of the original. Suppose the original population on an area were 100 salmon, then all 10 survivors would be salmon. If, however, the original population were 90 per cent coarse fish and 10 per cent salmon and mergansers showed equal preference for all species of fish, the surviving population would consist of 9 minnows and suckers and only 1 salmon. With natural and other mortalities yet to take their toll, the likelihood of enough salmon remaining to restock this stream becomes much reduced.

It has been stated that game fishes, because they are more agile, are seldom taken by fish-eating birds (Bent, 1940). We know no evidence that non-game

fishes are more easily caught than game fishes. Stomach analyses indicate that salmon and trout are readily caught by fish-eating birds. It appears that on our streams the American merganser tends to feed more on the areas frequented by salmon parr. Regarding the winter feeding of mergansers on Michigan streams, Sayler and Lagler (1940) state: "On trout streams, trout predominate in the food and seem to be selected for size from among other, more abundant forage organisms with buffer potentialities".

STREAM PRODUCTION VERSUS STANDING POPULATION

The ability of a stream to support mergansers depends upon the stream's capacity to produce fish. This in turn is determined by the chemical and physical characteristics of the waters. A relatively infertile stream may contain a fairly good population of fish, a "standing crop" of old fish. If mergansers harvested the standing crop, such a stream might serve as a rearing area for a number of mergansers for one year and then it might be a year or more before it would be ready for another cropping.

However such streams cannot produce large numbers of mergansers every year. To support broods every year, the waters must be fertile enough to produce large annual crops of fish as food. Unfortunately we do not know the absolute fish producing capacity of the various streams, but their relative productivity is quite obvious. On the less fertile waters a small number of mergansers may range over large areas and make normal growth.

On the fertile streams, especially the salmon streams and to a lesser extent the larger trout streams, our observations indicate that the merganser population tends to utilize almost the entire annual fish production of the stream.

ECONOMIC STATUS

Our study of the American merganser has dealt principally with the relation of its feeding habits to the production of Atlantic salmon. We wish to emphasize that we make no claim that the results of this investigation are applicable to other species of fishes, or to other habitats. Throughout much of Canada this merganser breeds on lakes and its feeding there is largely confined to shallow shore waters. Only on Chamcook Lake, where the land-locked salmon occurs, did we find a salmon in the stomach of a merganser from a lake habitat.

Merganser control experiments have shown large increases in salmon parr populations following a curtailment of the merganser's feeding on the experimental areas (White, 1939; Elson, 1950). Other fish have also increased, but a larger production of parr and smolts has been maintained with no indication that the other fish, mostly minnows and suckers, have had any adverse effect on the growth of the salmon. Mergansers take some eels but these are mostly elvers and the feeding has little effect on the eel population. The large eels

take some salmon but they also feed upon elvers. Our experiments have shown definitely that large populations of parr can co-exist with large populations of eels, but not with even moderate populations of mergansers, i.e. as low as 1 per mile.

Unlike many ducks the American merganser is largely dependent upon sight to procure its food. The downy ducklings are entirely dependent upon sight to catch underwater insects and small fish. Since the ducklings have a high rate of metabolism and no reserve fat, if deprived of food they will starve within a period of 24 hours. For their survival the water of their habitat must remain relatively clear at all times. Thus in the Maritimes where lakes are not generally available on the stream systems, the areas for rearing young are limited to those streams which do not remain very turbid for more than a day or so at a time during periods of high water. Such streams are the best salmon and trout waters.

The merganser searches for fish by swimming on the surface with its eyes submerged, and it is the only fish-eating bird which habitually utilizes the parr on the swift rapids. The well-grown broods remain on the salmon-rearing waters until their fishing efforts will not yield enough fish for their requirements. This is an example of Ricker's (1952) type C (2) predation. This tends to utilize but not exterminate the salmon parr and results in an economy where enough parr survive to produce an annual supply of spawning salmon which in turn maintains an annual crop of parr for merganser food.

Man's economy is directed at producing more smolts to go to sea to furnish a larger number of catchable salmon. We have shown in this paper that the merganser is one of the most important predators on salmon. Thus the economy of the merganser is in opposition to that which man desires. We believe that man by wise control of the merganser population can maintain the balance of nature and keep salmon at maximum production levels.

Regarding merganser control we wish to emphasize that when such control is necessary it should be carried out by specially trained crews who can distinguish mergansers from other ducks. The bounty system, with its inherent abuses should never be instituted as a means of control. Moreover anything which we have reported in this study of mergansers on Maritime salmon waters should not be interpreted as indicating that a general reduction in other areas is biologically justified.

REFERENCES

- AUDUBON, JOHN JAMES. The birds of America, 1840-44.
- BENT, ARTHUR CLEVELAND. 1925. Life-histories of North American wild fowl, Order Anseres (part). *U.S. Nat. Mus. Bull.*, **130**: 1-376.
1940. Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. *Ibid.*, **176**: 1-506.
- BREWSTER, WILLIAM. 1900. Notes on the breeding habits of the American goldeneye duck or whistler. *Auk*, **17**: 207-216.
- COLDWELL, CYRIL. 1939. The feeding habits of American mergansers. *Canadian Field-Nat.*, **53**(4): 55.
- ELSON, P. F. 1950. Increasing salmon stocks by control of mergansers and kingfishers. *Fish. Res. Bd. Canada, Prog. Rep. Atl.*, No. 51, pp. 12-16.
- KORTRIGHT, FRANCIS H. Ducks, geese and swans of North America. The American Wildlife Institute, Washington, 1943.
- MUNRO, J. A. 1939. Studies of waterfowl in British Columbia, Barrow's golden-eye, American golden-eye. *Trans. Roy. Canadian Inst.*, **22**(2): 259-318.
- MUNRO, J. A., and W. A. CLEMENS. 1937. The American merganser in British Columbia and its relation to the fish population. *Bull. Fish. Res. Bd. Canada*, No. 55, 50 pp.
1939. The food and feeding habits of the red-breasted merganser in British Columbia. *J. Wildlife Management*, **3**(1): 46-53.
- RICKER, W. E. 1952. Numerical relations between abundance of predators and survival of prey. *Canadian Fish Culturist*, No. 13, pp. 5-9.
- SAYLER, J. CLARK, II, and KARL F. LAGLER. 1940. The food and habits of the American merganser during winter, considered in relation to fish management. *J. Wildlife Management*, **4**(2): 186-219.
- SMITH, M. W. 1949. Relation of rock formation to trout production. *Fish. Res. Bd. Canada, Atl. Prog. Rep.*, No. 47, pp. 3-5.
1955. Fertilization and predator control to improve trout angling in natural lakes. *J. Fish. Res. Bd. Canada*, **12**(2): 210-237.
- TAVERNER, P. A. 1934. Birds of Canada. *Nat. Mus. Canada, Bull.*, No. 72, *Biol. Series*, No. 19.
- TOWNSEND, W. C. 1916. The courtship of the merganser, mallard, black duck, baldpate, wood duck and bufflehead. *Auk*, **33**: 9-17.
- WHITE, H. C. 1936. The food of kingfishers and mergansers on the Margaree River, Nova Scotia. *J. Biol. Bd. Canada*, **2**(3): 299-309.
1937. Local feeding of kingfishers and mergansers. *Ibid.*, **3**(4): 323-338.
- 1939a. The food of *Mergus serrator* on the Margaree River, N.S. *J. Fish. Res. Bd. Canada*, **4**(5): 309-311.
- 1939b. Bird control to increase Margaree River salmon. *Bull. Fish. Res. Bd. Canada*, No. 58, 30 pp.
1953. The eastern belted kingfisher in the Maritime Provinces. *Ibid.*, No. 97, 44 pp.