LITERATURE CITED

Dobrokhotov, B. P., and Yu. S. Ravkin. 1961. Studies on bird populations in post-nesting periods by census path methods with registration strips of different widths. p. 89-90. *In* Yu. A. Isakov (ed.), Organization and methods of censusing terrestrial vertebrate faunal resources. Translated from the Russian by the Israel Program for Sci. Translations. Office Tech. Serv., U. S. Dept. Comm., Washington, D.C. 104 pp.

Emlen, J. T. 1971. Population densities of birds derived from transect counts. Auk, 88:323-341.

Fowler, D. K. 1970. The relationship of late summer post-breeding bird densities to understory volume. M.S. Thesis, Va. Polytechnic Institute and State Univ., Blacksburg. 116 pp. typewritten.

Hooper, R. G. 1967. The influence of habitat disturbances on bird populations. M.S. Thesis, Va. Polytechnic Inst. and State Univ., Blacksburg. 132 pp. typewritten.

, and H. S. Crawford. 1969. Habitat research for non-game wildlife. Trans. N. Am. Wildl. and Nat. Resources Conf. 34:201-205.

Kendeigh, S. C. 1944. Measurements of bird populations. Ecol. Monographs 14:67-106.

Kolb, H. 1965. The Audubon winter bird population study. Audubon Field Notes 19:432-434.

Williams, A. B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monographs 6:317-408.

PREDATION IN WARM WATER RESERVOIRS BY WINTERING COMMON MERGANSERS

Steven W. Miller
Present Address:
Department of Natural Resources
Bureau of Fish & Wildlife Management
Box 450, Madison, Wisconsin 53701

John S. Barclay
Zoology Department, Oklahoma State University
Stillwater, Oklahoma 74074

ABSTRACT

The impact of predation by common mergansers (*Mergus merganser* americanus) wintering on Lake Carl Blackwell (650 ha) in Payne County, Oklahoma was investigated. Parameters measured included merganser use-days, daily food consumption, and food habits; plus the standing crops of fish in the lake. There were 27,500 use-days in the winter of 1971-72 and 13,100 in the 1972-73 winter. The approximate daily food consumption was determined to be 454 g (1 pound) per merganser. Common Mergansers consumed an estimated 12.5 and 6.0 percent of the mean standing crop of fish in the winters of 1971-72 and 1972-73, respectively. Gizzard shad (*Dorosoma cepedianum*) comprised 84 percent of the mergansers' food by weight, and 25.6 and 12.6 percent of the standing crop of this fish was consumed in the respective winters. In 1971-72, 27.5 percent of the standing crop of white crappie (*Pomoxis annularis*) was consumed, as compared to 13.2 percent in 1972-73. From observations on the feeding behavior of this waterfowl it would appear that aggregations of fish are vulnerable to feeding flocks of wintering mergansers.

INTRODUCTION

This paper presents the results of a study on the impact of predation by wintering common mergansers on fish populations of Lake Carl Blackwell in northcentral Oklahoma. Predation was studied by a synthesis of data on merganser use-days, feeding habits, daily food consumption per bird, and the standing crops of fish in the lake.

Mills (1967:391), in reviewing predation on fish by animals other than fish, has suggested that future work on predation "be concerned with the habits, distribution, population density, and general biology of the predator and the relationship with its prey". The general ecology of the common merganser has not been studied extensively. The distribution and life history of this duck outside of its northern nesting area has been poorly documented.

Previous work with common mergansers has been largely confined to food habits studies. Most of these studies have examined the foods of mergansers inhabiting cold water lakes and streams (Coldwell 1939, Munro and Clemens 1936, White 1957, Salyer and Lagler 1940, Lindroth 1955, Mills 1962). Alcorn (1953), Heard and Curd (1959), Huntington and Roberts (1959), and Timkin and Anderson (1969) have reported on the food habits of mergansers collected from warm water impoundments.

The relationship between common merganser predation and the number of young Atlantic salmon (*Salmo salar*) has received considerable attention in the Maritime Provinces of Canada (Elson 1962, White 1957, Erskine 1972, Huntsman 1941). Salyer and Lagler (1940) and White (1957) concluded that common mergansers select for trout and salmon when on streams supporting these fishes. Elson (1962) and White (1957) have reported increased Atlantic salmon smolt production following merganser control. Elson (1962) found that controlling mergansers from an undisturbed population density of one per 2.5 ha of stream to one per 20 ha resulted in a five fold increase in the production of smolts on the Pollett River, New Brunswick over production without control. Further observations by Elson, based on a consumption of one pound of fish per day per merganser, revealed that the food requirement of mergansers using the Pollett River was greater than the number of salmon parr the river could support.

Game fish appear to be an insignificant food component of common mergansers in warm water impoundments (Timkin and Anderson 1969, Heard and Curd 1959, Huntington and Roberts 1959). Forage fish, primarily gizzard shad, were the principal species consumed by mergansers in the above studies. Huntington and Roberts (1959) found mergansers generally selected a prey species in realtion to its abundance in New Mexico reservoirs. The above studies suggested that predation upon forage and coarse fish may be beneficial to game fish populations in warm water reservoirs. However, there have been no published accounts on the proportion of fish consumed by mergansers using warm water reservoirs.

This research was supported by an Environmental Protection Agency Traineeship in Aquatic Ecology administered through the Oklahoma State University Reservoir Research Center, T. C. Dorris, Director. We also wish to thank the Oklahoma Cooperative Wildlife and Fisheries Units, and the Zoology Department, Oklahoma State University for their additional support.

STUDY AREA

Lake Carl Blackwell is a 650 ha turbid reservoir located nine kilometers west of Stillwater, Payne County, Oklahoma. Physical descriptions and the ecological history of the lake are given in Leonard (1950). The lake was im-

pounded in 1937 and waterfowl originally used the lake for feeding and resting. The lake gradually deteriorated to its present turbid condition and is now used by waterfowl primarily for resting. Common mergansers were reported on the lake as early as 1940 (Baumgartner 1942), but their subsequent numbers and dates of occurrence have not been recorded on a yearly basis. Lake Carl Blackwell was chosen for this study because common mergansers consistently use it for wintering, a substantial amount of biological information about the lake has accumulated for many years, and the lake was readily accessible.

METHODS

Numbers of common mergansers using Lake Carl Blackwell were determined by direct counting of visible birds during the winters of 1971-72 and 1972-73, and expressed in use-days. A merganser use-day (Elson 1962) was defined as one merganser counted on the lake for one day, and we assumed that mergansers counted on the lake were also feeding on the lake. Counts were made at least three days each week during the period in which mergansers were present on the lake each winter. For those days on which no counts were made, the average of the two embracing counts was considered the use-days for each of those days. Summation then gave the total number of use-days for a given period of time. Total yearly use-days times the mean daily food consumption per bird estimated the total predation, in quantity of fish consumed, by mergansers on the fish populations. Total predation was apportioned among the major prey species by multiplying the proportion that each prey species comprised of the mergansers' diet by the total consumption for each winter. In addition to estimating predation pressure, observations on the feeding behavior of common mergansers on Lake Carl Blackwell were recorded.

Stomach analyses of common mergansers were conducted in order to estimate the relative species composition of the prey while on the lake. Forty-three common mergansers were collected from Blackwell for food habits study; 29 during the 1971-72 winter and 14 during the 1972-73 winter. The esophagus and stomach contents were removed from each bird and preserved in formalin until analysis. Identifiable food items were recorded by species, and total length measurements were taken for all sufficiently intact fishes or estimated from parts. Results were combined with the results of Heard and Curd (1959) for a better representation of the mergansers' food habits on Lake Carl Blackwell. The combined results were converted from a numbers to weight basis using the mean length of individuals for each species and the live weights for that particular mean length derived from Carlander (1969) and unpublished data for Lake Carl Blackwell (D.W. Toetz, Oklahoma State University, Stillwater, personal communication). The forage ratio of Hess and Swartz (1940) was used to relate the consumption of prey to its availability in the lake.

Standing crop estimates of fishes in Lake Carl Blackwell (Table 1) were obtained from four cove and shoreline rotenone samples in late summer 1971 (unpublished data, J. N. Johnson, Oklahoma State University, Stillwater). These estimates provided an approximation of the quantity and composition of the prey potentially available to wintering mergansers on Blackwell. However, these estimates taken at the end of the summer are probably greater than the standing crops during the winter period in which mergansers were present on the lake.

Six common mergansers were live captured by nightlighting and used to establish a mean daily rate of food consumption. Results obtained corresponded to other published accounts. These data were used in conceptualizing the relationship between common mergansers and the standing crops of fish.

RESULTS

Common mergansers were present on Lake Carl Blackwell from 27 November 1971 to 10 March 1972, and from 20 November 1972 to 7 March 1973. Total use-days for each year was 27,500 and 13,100 respectively. Ice covered the lake completely for three weeks during the 1972-73 winter and was probably the main reason for less merganser use in that period. Ice never completely covered the lake during the 1971-72 winter.

There was no evidence of mergansers leaving Blackwell as if to feed elsewhere, nor was there evidence of mergansers arriving from other areas to feed on the lake. Lake Carl Blackwell is the largest reservoir in the Stillwater, Oklahoma area, and fluctuations in merganser numbers on the lake were assumed to be due to migratory movements rather than daily feeding activities of mergansers on the lake or in the general region of Blackwell. Thus, the two years of population counts probably give a reasonable approximation of the amount of use (hence, an estimated degree of predation pressure) that Lake Carl Blackwell received from common mergansers.

Common mergansers on Lake Carl Blackwell were observed to feed in a cooperative feeding manner. Cooperative feeding consists of coordinated flock movements by fish eating birds, and flock movements suggest that the birds are following fish (Bartholomew 1942). Huntington and Roberts (1959) have reported this feeding behavior for mergansers wintering on Elephant Butte Reservoir, New Mexico. Thus, this behavior is probably typical of mergansers wintering on large reservoirs.

Table 2 shows the similarity between the food habits results in this study, and Heard and Curd (1959). Gizzard shad was the most important food item in both studies. No whole identifiable drum (*Aplodinotus grunniens*) remains were found in this study, but otoliths were recovered which indicated that drum were utilized to some extent. No white crappie were recovered in this study as compared with Heard and Curd, but this may be due to our smaller sample size. Converting the combined results (Table 2) to a weight basis (Table 3) showed gizzard shad to comprise, by weight, 84 percent of the mergansers' food on Blackwell. Computed forage ratios (Table 4) were found to be greater than two for gizzard shad and white crappie, and one or less for all other fishes.

The daily food requirement of the common merganser has been estimated at 454 g (1 pound) (Salyer and Lagler 1940, White 1957). Our six captive mergansers averaged 240 g daily (range 227-261), equivalent to 20 percent of the mean body weight. The six mergansers were allowed essentially no activity other than swimming and all lost weight while in captivity. Body weights in captivity were approximately 400 g below the weights at capture. Assuming that normal weight, wild common mergansers would also consume 20 percent of their body weight daily, we multiplied this value by 1500 g, the mean capture weight of all mergansers. Daily consumption would thus equal 300 g. Considering the added metabolic cost of flying and of a wild existence over that of a captive one, we concluded that 454 g is a plausible daily consumption for a free-ranging common merganser.

Sincock (1962:217) stated that "the average food consumption per bird (waterfowl) per day could be estimated, in dry weight, as 10 percent of the wet body weight". Thus, for a 1500 g common merganser the daily dry weight consumption of fish would be 150 g. Assuming that live organisms are two-thirds or more water (Odum 1971:32), the daily wet weight consumption of fish would be approximately 454 g per merganser.

Predation was interpreted as a flow of fish (x1) from the environment (the lake) to the mergansers (x2), expressed as $x1 \xrightarrow{F12} x2$, where $F12=\theta 12x2$. For one merganser $\theta 12$ is the mean daily rate of food consumption (454 g), and

x2 is the number of mergansers preying upon the fish population for some period of time, or, as in this case, the number of use-days for a wintering period. The amount of fish consumed for a given number of use-days is F12. It follows that total consumption is equivalent to 12,474 kg for 1971-72 and 5,942 kg for 1972-73. This is a consumption of 12.5 and 6.0 percent of the mean, late summer standing crop of fish in Lake Carl Blackwell for the respective winters. When predation was divided among the prey species it became evident (Table 5) the mergansers consumed a large percentage of the standing crop of shad and white crappie in 1971-72. However, predation was reduced by approximately one-half in 1972-73 probably because of ice cover during that winter.

DISCUSSION

The forage ratios for gizzard shad and white crappie indicates that mergansers are consuming these fish in greater proportion than would be expected on the basis of abundance along. Some factor(s) apparently made shad and crappie more vulnerable to feeding mergansers. Jester and Jensen (1971) reported that gizzard shad move to deeper water during winter and become relatively inactive at water temperatures below 14°C. White crappie also congregate in deeper or warmer water during winter (Grinstead 1965). Thus, mergansers may have selected prey on the basis of relative abundance and availability. Largely inactive, congregated fish would appear easy prey for mergansers once located.

Locating prey is probably a cooperative effort among mergansers wintering on reservoirs. Group feeding behavior has been observed to be highly organized and may be an advantage to individual birds. Aggregations of fish would have seemingly greater difficulty in eluding a group of mergansers rather than an individual. We suggest that aggregations of fish are selected by feeding groups of wintering mergansers. And, that possibly this selectivity, under special circumstances, could result in predation detrimental to a fish species (e.g. white crappie concentrated in a warm water discharge area, Grinstead 1965).

However, predation is one of a system of factors acting upon a population and it is difficult to evaluate its impact unless measured concomitantly with other controlling factors. Predation by mergansers is limited to sizes of fish which can be swallowed, girth being more critical than length (Latta and Sharkey 1966). Fish recovered from mergansers during stomach analysis had maximum total lengths of 185 mm and a mean length of 125 mm. The natural size restriction of prey means that mergansers are feeding upon only a part of prey population. Fish larger than the maximum swallowable size are unavailable to mergansers. Thus, the available quantity of prey fish in Lake Carl Blackwell was less than the standing crops listed in Table 1. Subsequently, the impact of predation (as measured by percent of standing crop consumed) would have been greater than the 25 percent for shad and crappie listed in Table 5.

The actual effect of avian predation upon fish remains to be documented (Hynes 1972). It is difficult to conclude whether or not a minimum consumption of one-fourth the standing crop is significant upon a prey species. Mills (1967) stated that predation by fish on other fish is probably more serious than predation by other animals. Errington (1946) expressed the opinion that predators of vertebrates remove a doomed surplus, and Bennett (1971) suggested that the impact of fish-eating birds is likely beneficial on most waters.

Jester and Jensen (1971) stated that despite heavy predation by common mergansers and westerns grebes (*Aechmophorus occidentalis*), gizzard shad in Elephant Butte Reservoir, New Mexico, continued to provide necessary forage for game fish populations. They suggested that adaptability and high reproductive potential maintains gizzard shad populations in most reservoirs where established population occur. Stunting of shad in Elephant Butte Reservoir was

apparently not relieved by avian predators, but was reduced by the establishment of additional fish predators into the lake (Jester and Jensen 1971).

Gizzard shad is an abundant forage fish in most of the reservoirs throughout the midwest (Carlander 1955) and would provide a large and accessible food source for mergansers. Reservoirs in Kansas and Oklahoma support large concentrations (10,000 to 35,000) of wintering mergansers each year (S. W. Miller, unpublished data). Clearly, this waterfowl is utilizing a winter habitat highly suited to its energy requirements. In Oklahoma, the number of wintering common mergansers has increased during the past thirty years concurrently with the impounding of 301,000 ha of water (Sutton 1967, Oklahoma Water Resources Board 1970). However, it is not known if the apparent increase in mergansers in Oklahoma is a result of a greater number wintering in the sate or merely a redistribution of mergansers which formerly would winter on the rivers flowing through Oklahoma or adjacent states.

In view of the large concentrations, plus an estimated daily food consumption of one pound per bird, wintering common mergansers are potentially significant predators in warm water reservoirs. Merganser predation is probably largely confined to forage fish such as gizzard shad due to the abundance and availability of these fish, and therefore is not a direct threat to game fish populations.

Table 1. Mean standing crop estimates of fishes in Lake Carl Blackwell based on four rotenone samples during late summer 1971.

Species of Fish	Mean standing Crop (kg/ha)
Gizzard shad	63.222
Carp	37.830
River Carpsucker	29.876
Freshwater Drum	10.111
Largemouth Bass	4.061
White Crappie	3.343
Bluegill	1.799
Longear Sunfish	1.251
Green Sunfish	1.043
White Bass	0.857
Flathead Catfish	0.244
Orangespotted Sunfish	0.195
All Fish	153.832

Table 2. Results of stomach analysis of common mergansers collected from Lake Carl Blackwell.

Food Item	Total Number	Percent of Total Food	Frequency of Occurrence (%)
This Study[1]			
Gizzard shad	42	81	85
Minnow	5	10	5
Unidentifiable Fish Remains	5	10	5
Heard and Curd, 1959[2]			
Gizzard shad	229	75	91
Freshwater Drum	16	5	22
White Crappie	25	8	22
Channel Catfish	2	1	4
Unidentifiable Fish Remains	32	10	40
Both Studies Combined[3]			
Gizzard shad	271	76	89
Freshwater Drum	16	4	15
White Crappie	25	7	15
Channel Catfish	2	1	3
Minnow	5	1	2
Unidentifiable Fish Remains	37	10	32

[1]20 stomachs - collected the winters of 1971-72 and 1972-73.
[2]45 stomachs - collected the winter 1957-58.
[3]65 total stomachs.

Table 3. Conversion of combined stomach analysis results (Table 2) from numbers to weight.

Food Item	Total Number	Mean Length (mm)	Weight for Mean Length (g)	Total Weight (g)	Percent of Total Food (weight)
Gizzard Shad	271	110	11.3	3062	84.2
Freshwater Drum	16	128	14	224	6.2
White Crappie	25	98	7	175	4.8
Channel Catfish	2	72	8	16	0.4
Minnow	5	70	2.5	12.5	0.4
Unidentified Fish Remains	37	–	4	148	4.1
				3637.5	100.0

Table 4. Forage ratios[1] of prey species in Lake Carl Blackwell for the common merganser.

Prey Species	Percent in Food (weight)	Percent in Lake (weight)	Ratio
Gizzard Shad	84.2	41.1	2.05
Freshwater Drum	6.2	6.6	0.94
White Crappie	4.8	2.2	2.18
All other Fish Species	4.8	50.2	0.1

[1]Computed following Hess and Swartz, 1940.

Table 5. Fish consumption by common mergansers on Lake Carl Blackwell for the winters 1971-72 and 1972-73.

Prey Species	Standing Crop (kg/ha)	Percent of Food by Weight	kg/ha consumed		Percent of Standing Crop Consumed	
			71-72	72-73	71-72	72-73
All Fish	153.832	–	19.2	9.2	12.5	6.0
Gizzard Shad	63.222	84.2	16.2	7.7	25.6	12.2
Freshwater Drum	10.111	6.2	1.2	0.6	11.9	5.6
White Crappie	3.343	4.8	0.9	0.45	27.5	13.2

LITERATURE CITED

Alcorn, J. R. 1952. Food of the common merganser in Churchill County Nevada. Condor 55:151-152.

Bartholomew, G. A. Jr. 1942. The fishing activities of double-crested cormorants on San Francisco Bay. Condor 44:13-21.

Baumgartner, F. M. 1942. An analysis of waterfowl hunting at Lake Carl Blackwell, Payne County, Oklahoma, for 1940. J. Wildl. Manage. 6:83-91.

Bennett, G. W. 1971. Management of lakes and ponds. Van Nostrand Reinhold Company, New York. 375 pp.

Carlander, K. D. 1955. The standing crop of fish in lakes. J. Fish. Res. Bd. Canada. 12:543-570.

Carlander, K. D. 1969. Handbook of freshwater fishery biology. The Iowa State Univ. Press, Ames, Iowa. 752 pp.

Coldwell, C. 1939. The feeding habits of American mergansers. Can. Field Nat. 52:55.

Elson, P. F. 1962. Predator-prey relationships between fish eating birds and Atlantic salmon (with a supplement on fundamentals of merganser control). Fish. Res. Bd. Can. Bull. 133. 87 pp.
Errington, P. D. 1946. Predation and vertebrate populations. Q. Rev. Biol. 21:144-177, 221-245.
Erskine, A. J. 1972. Populations, movements and seasonal distribution of mergansers. Can. Wildl. Serv. Rep. Ser. 17. 36 pp.
Grinstead, B. G. 1965. The vertical distribution of the white crappie *Pomoxis annularis*, in the Buncombe Creek arm of Lake Texoma. M.S. Thesis. Univ. of Oklahoma. 90 pp.
Heard, W. R. and M. R. Curd. 1959. Stomach contents of American mergansers, *Mergus merganser americanus* Linnaeus, caught in gill nets in Lake Carl Blackwell, Oklahoma. Proc. Okla. Acad. Sci. 39:197-200.
Hess, A. D. and A. Swartz. 1940. The forage ratio and its use in determining the food grade of streams. Trans. N. Am. Wildl. Conf. 5:162-164.
Huntington, E. H. and A. A. Roberts. 1959. Food habits of the merganser in New Mexico. New Mexico Dept. Game and Fish Bull. 9. 36 pp.
Huntsman, A. G. 1941. Cyclical abundance and birds versus salmon. J. Fish. Res. Bd. Canada. 5:227-235.
Hynes, H. B. N. 1972. The ecology of running waters. University of Toronto Press. 555 pp.
Jester, D. B. and B. L. Jensen. 1972. Life history and ecology of gizzard shad, *Dorosoma cepedianum* (Le Sueur), with reference to Elephant Butte Lake. New Mexico State Univ. Agric. Exp. Stn. Res. Rep. 218. 56 pp.
Latta, W. C. and R. F. Sharkey. 1966. Feeding behavior of the American merganser in captivity. J. Wildl. Manage. 30:17-23.
Leonard, E. M. 1950. Limnological features and successional changes of Lake Carl Blackwell, Oklahoma. Ph.D. Thesis. Oklahoma State Univ., Stillwater. 76 pp.
Lindroth, A. 1955. Mergansers as salmon and trout predators in the River Indasalven. Rep. Inst. Freshwat. Res., Drottningholm. 36:126-132.
Mills, D. H. 1962. The goosander and red-breasted merganser as predators of salmon in Scottish waters. Scient. Invest. Freshwat. Salm. Fish. Res. Scot. Home Dept. 29:1-10.
Mills, D. H. 1967. Predation on fish by other animals. Pages 377-397. *in* S. D. Gerking, ed. The biological basis of freshwater fish production. Blackwell Scientific, Oxford. 495 pp.
Munro, J. A. and W. A. Clemens. 1936. Food habits of the American merganser (*Mergus merganser americanus*) in British Columbia. Can. Field Nat. 50:34-36.
Odum, E. P. 1971. Fundamentals of Ecology, 2nd ed. W. B. Saunders Company, Philadelphia, Pa. 574 pp.
Oklahoma Water resources Board. 1970. Oklahoma Water Resources. Oklahoma City, Oklahoma. 69 pp.
Salyer, J. C. and K. F. Lagler. 1940. Food habits of the American merganser during winter in Michigan considered in relation to fish management. J. Wildl. Manage. 4:186-219.
Sincock, J. L. 1962. Estimating consumption of food by wintering waterfowl populations. Proc. Southeastern Assoc. Game and Fish Commissioners. 16:217-221.
Sutton, G. M. 1967. Oklahoma Birds. University of Oklahoma Press, Norman. 647 pp.
Timkin, R. J. and B. W. Anderson. 1969. Food habits of common mergansers in the North Central United States. J. Wildl. Manage. 33:87-91.
White, H. C. 1957. Food and natural history of mergansers on salmon waters in the Maritime Provinces of Canada. Fish. Res. Bd. Canada Bull. 116 pp.