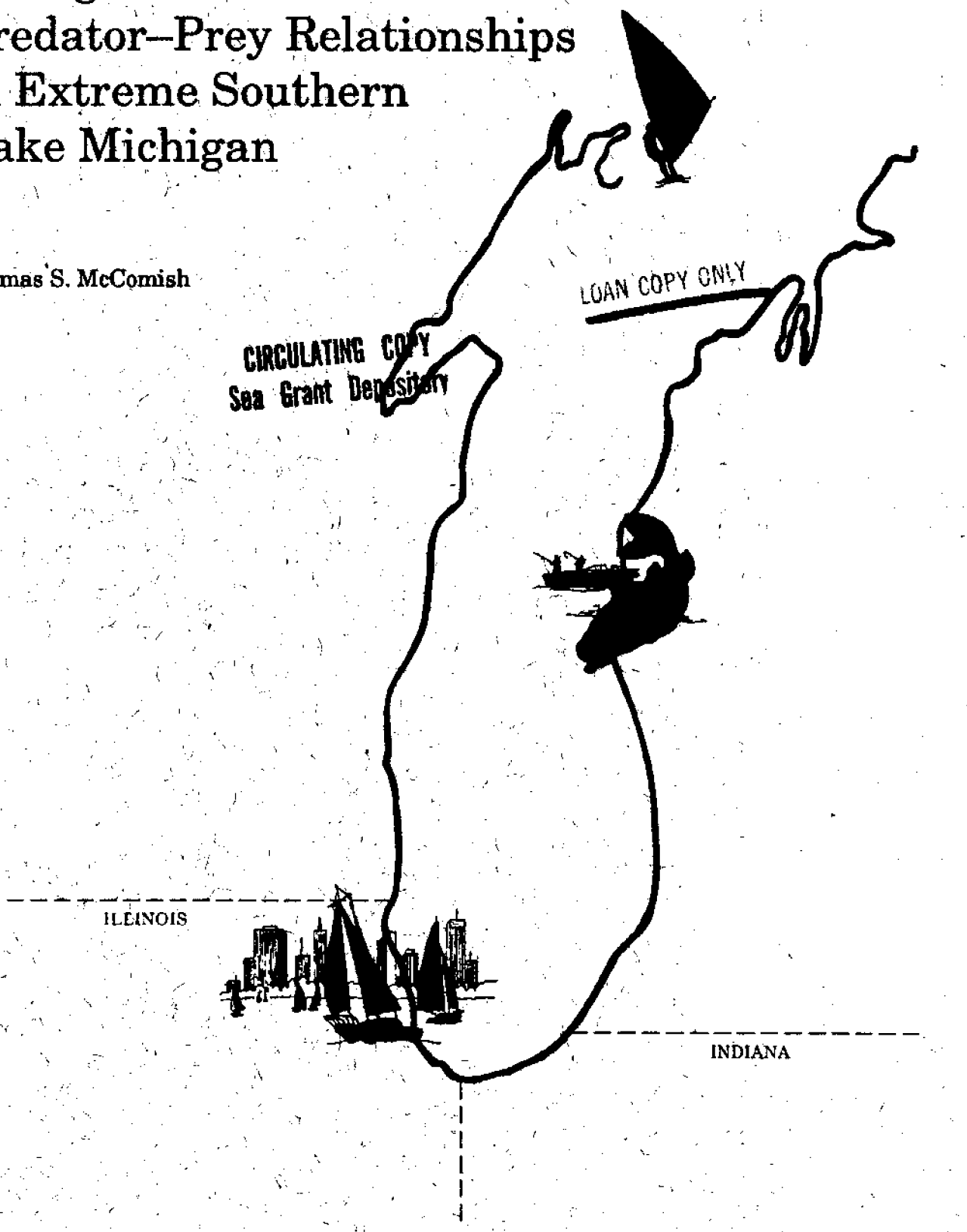
Changes in Salmonine Predator–Prey Relationships in Extreme Southern Lake Michigan

Thomas S. McComish



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CHANGES IN SALMONINE PREDATOR-PREY RELATIONSHIPS IN EXTREME SOUTHERN LAKE MICHIGAN

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TABLE OF CONTENTS

ABSTRACT

Salmonine predator-prey relationships were investigated for extreme southern Lake Michigan waters in and near Indiana from April to September of 1984 to 1986. Results were compared to a 1970 salmonine diet study for the same area and to major potential forage fish available.

Index trawling data reveal changes in the forage fish populations that have taken place in extreme southern Lake Michigan from 1973 to 1984-86. The yellow perch population has expanded over 90-fold while a seventy-one percent decline in alewives has occurred. The bloater population has also undergone rapid increases in density.

The index trawling data also show the forage base available for consumption by salmonine predators in 1973 was numerically dominated by alewives followed by rainbow smelt and yellow perch. By 1984-86, the yellow perch were numerically dominant followed by rainbow smelt and bloater, with alewives accounting for less than one percent.

Predator-prey relationships of major salmonine predators reveal the continuing importance of the alewife as the major food, although it is now numerically the least abundant of the major potential forage fish species. In 1970, coho salmon consumption was predominately alewives but in 1984-86 that was reduced to forty-nine percent. Chinook salmon consumed only alewives in 1970 but yellow perch, rainbow smelt, and bloater accounted for more than half their diet in 1984-86. In 1970, lake trout ate ninety-three percent alewives and six percent rainbow smelt. By 1984-86 the diet of alewives was reduced almost in half and rainbow smelt consumption increased dramatically. Yellow perch and bloater were also added to the diet. Steelhead consumed forty-eight percent of their diet in alewives while yellow perch and rainbow smelt accounted for the balance in 1984-86.

Changes in the density of major forage fish available to salmonine predators has resulted in diet shifts but the alewife remains the major preferred forage species. Even though the yellow perch now dominates the potential forage base of extreme southern Lake Michigan, it is not consumed in proportion to its density. Future salmonine management decisions must consider the importance of the alewife population dynamics as a major impacting factor.

INTRODUCTION

Salmonine predator-prey relationships in extreme southern waters of Lake Michigan in Indiana and in nearby waters were investigated from April to September during 1984-86. Results of the diet evaluation were compared to similar research completed for the same sample area in 1970. Insight into changes was obtained by comparing food consumed by coho salmon, chinook salmon, lake trout, and steelhead trout with the forage fish base available as potential food.

This project was part of the Great Lakes Sea Grant Network Project initiated by the University of Wisconsin Sea Grant Institute. Funding was provided by Illinois-Indiana Sea Grant and Ball State University. The project was a coordinated effort to learn more about salmonine diets in the Great Lakes with a focus on what food was consumed as the alewife population declined in Indiana waters of the lake.

The fish population of Lake Michigan is currently a management dependent system dominated by introduced species (Stewart et al. 1981). The introduced salmonine predators are the management key to maintaining balance with other exotic and native fishes (Smith 1968). The introduced alewife appears to be central to the continued success of the salmonine predators. The alewife has been serving as the major forage fish consumed by salmonids both in Indiana waters of Lake Michigan (McComish and Miller 1976) and elsewhere in the lake (Smith 1968). Stocking success and high growth rates of the stocked salmonids has largely been a result of the abundant alewife forage base (Edsall et al. 1974). To underscore the importance of alewives, Stewart et al. (1982) warned that forage for salmonids in Lake Michigan is finite and excessive salmonid stocking could result in high mortality or poor growth of the salmonids.

The research reported here provides important insight to the interrelationships between the salmonids and their forage base. Continued successful management of the Lake Michigan sport fishery depends in a large measure on the understanding of the dynamics of the lake system and its major fish stocks. This report details information on predator-prey dynamics that is essential to continued wise management of the Lake Michigan fishery resource.

METHODS

Salmonine predator-prey interactions were investigated by monitoring forage fish densities at depths ranging from about 10 to 30 ft. in index trawl zones. Those data were compared to forage fish consumed by salmonid predators caught by sport fisherman. The bottom trawl used to sample the forage fish population was a 16 ft. headrope, 19 ft. footrope semi-balloon type constructed of 1.5 inch stretch meshes in the body and fitted with a 0.5 inch stretch mesh cod liner. The trawl was towed at an average speed of about 3.5 mph. All trawling was completed at night in order to minimize trawl avoidance. A total of 24 10-minute tows were completed each month during June, July, and August.

The cooperation and assistance of charter boat captains and their personnel was outstanding in providing large numbers of salmonids. The fish were brought to on-shore fish cleaning stations where stomachs were collected and data were recorded. Contents of stomachs were preserved in formalin for later analysis in the laboratory. Items in each stomach were identified, counted, and measured, and data were recorded on summary forms.

STUDY AREA

Trawling to sample forage fishes was completed in established sample zones to the east and west of Michigan City, Indiana (Figure 1). Stomach samples from salmonine predators were collected at sites in the Michigan City and Gary/Hammond areas with most at Michigan City. The lake bottom slopes gently toward offshore areas slowly increasing in depth and reaching a maximum of about 60-70 feet at locations near the state line. The substrate is varied but consists mainly of a sand, clay, and shale mixture. Little structure exists on the bottom but sharp crevice-like depressions oriented from near shore toward off shore are common west of Michigan City especially in the Kintzele Ditch area.

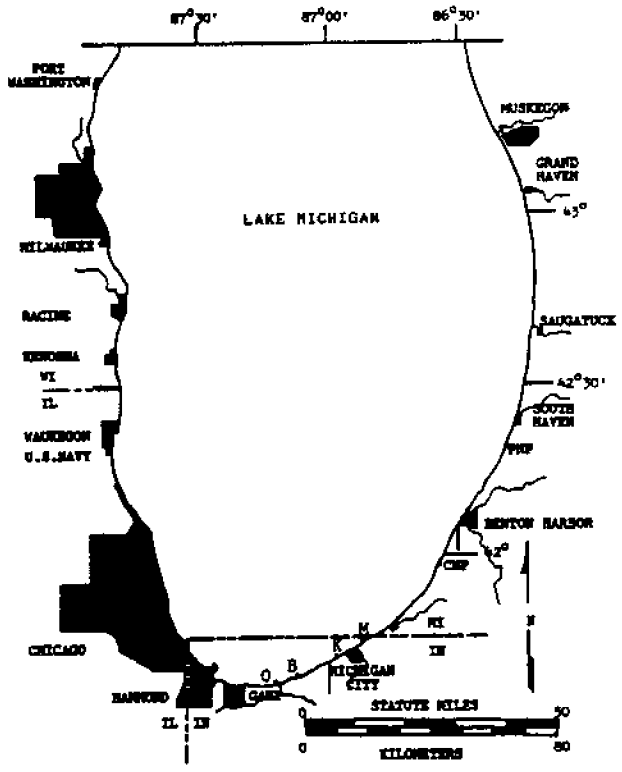

Figure 1. Established trawling zones (O, B, K, M) in Indiana waters of Lake Michigan.

RESULTS AND DISCUSSION

Salmonine Predators Sampled

Large numbers of salmonine stomachs were collected for analysis in 1984-86 (Figure 2). The numbers of stomachs examined by species were as follows: 1013 coho salmon, 1190 chinook salmon, 1482 lake trout, and 762 steelhead. On the average, 50% of all stomachs had food present.

The number of salmonine stomachs sampled in the small-scale 1970 study included 47 coho salmon, 48 chinook salmon, and 71 lake trout (McComish and Miller 1976). No steelhead were available for diet analysis. Food was present in 61% of the total stomachs examined.

The sizes of fish sampled for stomachs in 1970 ranged from 10 to 29 inches and in 1984-86 from 12 to 43 inches (Table 1). Most fish were 20 inches in total length or larger.

Table 1. Size of salmonine predators sampled comparing 1970 to 1984-86.

Predator Species	Length Range (inches)	
	1970	1984-86
Coho salmon	18 - 23	12 - 35
Chinook salmon	10 - 27	12 - 43
Lake trout	17 - 29	16 - 35
Steelhead		20 - 39

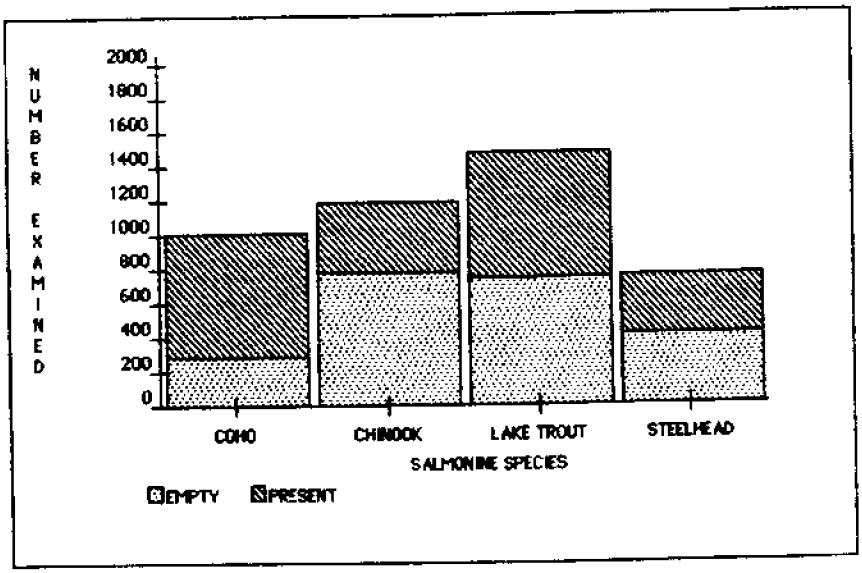

Figure 2. Salmonine stomachs collected in 1984-86 showing the number empty and with contents.

Potential Forage Fishes

Changes in the numerical abundance of major potential forage fish were noted in a comparison between 1973 and 1984-86. Adult fish, here defined as age one or older, were separated from the total trawl catch for sample periods from June through August of each year. Total annual catch was compared by year with similar sampling effort each year.

The major potential forage fish species available as a food source to larger predator fish included alewives, yellow perch, rainbow smelt, bloaters, trout-perch, and spottail shiners. Although these species comprise the potential forage base, salmonine predators ate almost exclusively yellow perch, rainbow smelt, alewives, and bloaters.

Trawling on index zones revealed significant changes in relative abundance between 1973 and 1984-86 (Figure 3). The yellow perch population expanded very rapidly from only 286 captured in 1973 to 25,990 in 1986 — over a 90-fold increase. Rainbow smelt increased from a low of 306 in 1973 to a high of 2,888 in 1984 but then declined to just under 900 in 1986. The alewifecatch

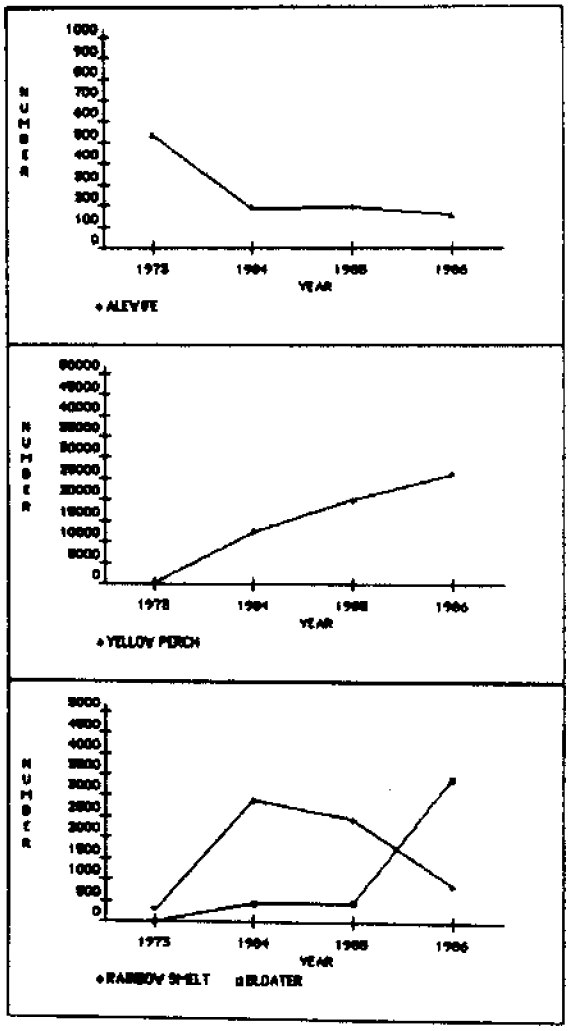

Figure 3. Annual trawl catch of alewives, yellow perch, rainbow smelt, and bloaters comparing 1973 to 1984-86.

dropped dramatically from 532 fish captured in 1973 to just over 150 in 1986 — a 71% decline. The bloater catch increased from only one fish in 1985 to a peak of over 3,400 in 1986. These data reveal marked and dramatic changes in the major forage fish species populations important as food for salmonine predators.

Other potential forage species were not important to the salmonine predators. Spottail shiners were essentially unchanged at about 1,500 fish for the 1973 and 1984-86 periods. Trout-perch declined about 90% from 1973, when over 800 were captured, to fewer than 80 in 1986. Trout-perch population levels were very low in 1984-86 as indicated by the index samples thereby limiting their availability as forage. Spottail shiners were not expected to be important forage for salmonines due to their close association with shallow near shore water.

Forage Base Utilized

A comparison of the forage base composition in 1973 and 1984-86 revealed major shifts in the dominant species (Figure 4). In 1973 the forage fish base utilized by salmonine predators was composed of 47% alewives, 27% rainbow smelt, and 25% yellow perch. By 1984-86, the forage base shifted dramatically to dominance by yellow perch at 83% followed by 11% rainbow smelt, 5% bloater, and less than 1% alewife.

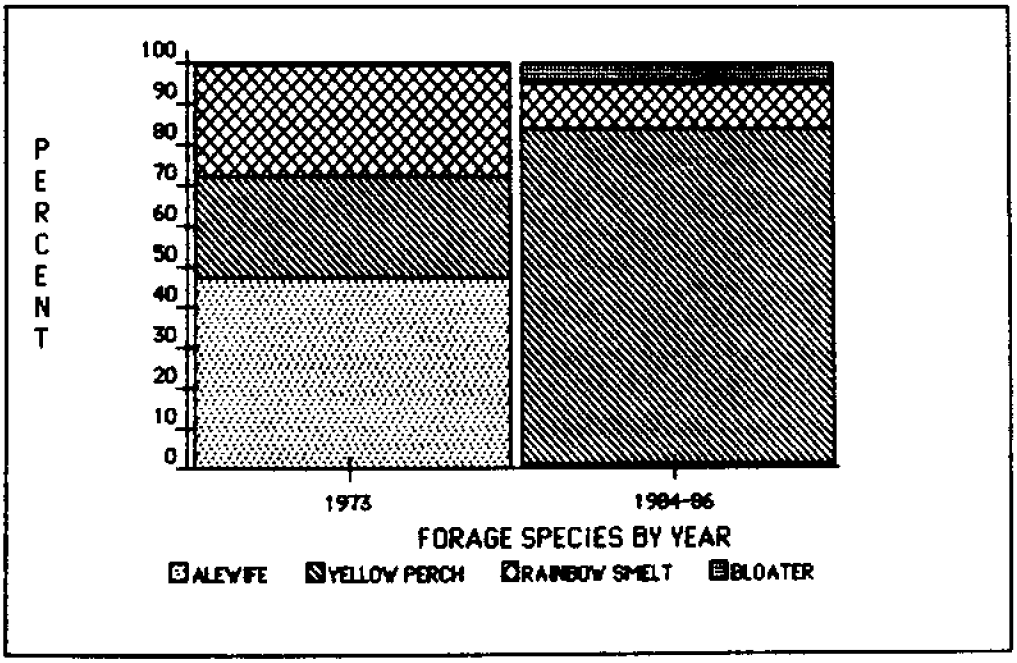

Figure 4. Percent composition of forage species comparing 1973 to 1984-86.

Diet Shifts of Salmonines

A comparison of forage fish consumed in 1970 with 1984-86 (Table 2, Figure 5) reveals the continued importance of the alewife in salmonine diets even though the alewife was about 70% less available in the potential forage base.

Diet evaluations conducted in 1970 for coho salmon revealed alewives as the single dominant forage fish consumed at 97%. By comparison, the 1984-86 diet evaluation revealed striking change due to the altered population levels of forage fish available but a continued preference for alewives. During the 1984-86 period, coho salmon ate 49% alewives followed by 23% perch and 23% smelt.

The 1970 diet studies for chinook salmon revealed that only alewives were consumed. In the 1984-86 study the salmon had a more diverse diet but again ate mostly alewives at 44% followed by 30% yellow perch, 17% smelt, and 6% bloaters.

The clearly dominant food item of lake trout in 1970 was alewives at 93% followed by rainbow smelt at 6%. In 1984-86 lake trout food habits were diversified and in some respects similar to chinook salmon. The trout consumed mainly alewives at 56% followed by 31% rainbow smelt, 8% yellow perch, and 5% bloaters.

Table 2. A comparison of percent numerical composition of prey fish in the diet of salmonine predators for 1970 and 1984-86.

Prey Fish	Predator Species						
	Coho		Chinook		Lake trout		Steelhead
	70	84-86	70	84-86	70	84-86	84-86
Alewife	97	49	100	44	93	56	48
Y. perch		23		30		8	30
R. smelt	3	23		17	6	31	21
Bloater				6		5	
Other *		5		3	1		1

* A combination of spottail shiners, sculpin, and trout-perch.

The diet evaluation of steelhead was possible only in 1984-86 since no samples were available in 1970. Again, alewives dominated the diet at 48% followed by 30% yellow perch and 21% rainbow smelt.

These diet data reveal the continued importance of the alewife in the diet of all salmonines. While the clear dominant of the 1984-86 forage fish base is the yellow perch, it is much less important as a salmonine food than the alewife. Coho salmon, chinook salmon, and steelhead all consumed relatively high overall percentages of yellow perch in 1984-86 (23-30%) but lake trout did not (8%). Bloaters were a food item of both chinook salmon and lake trout in 1984-86 but were not consumed by coho salmon or steelhead. The data seem to show that the chinook salmon has adapted best to the recent changes in the forage fish base.

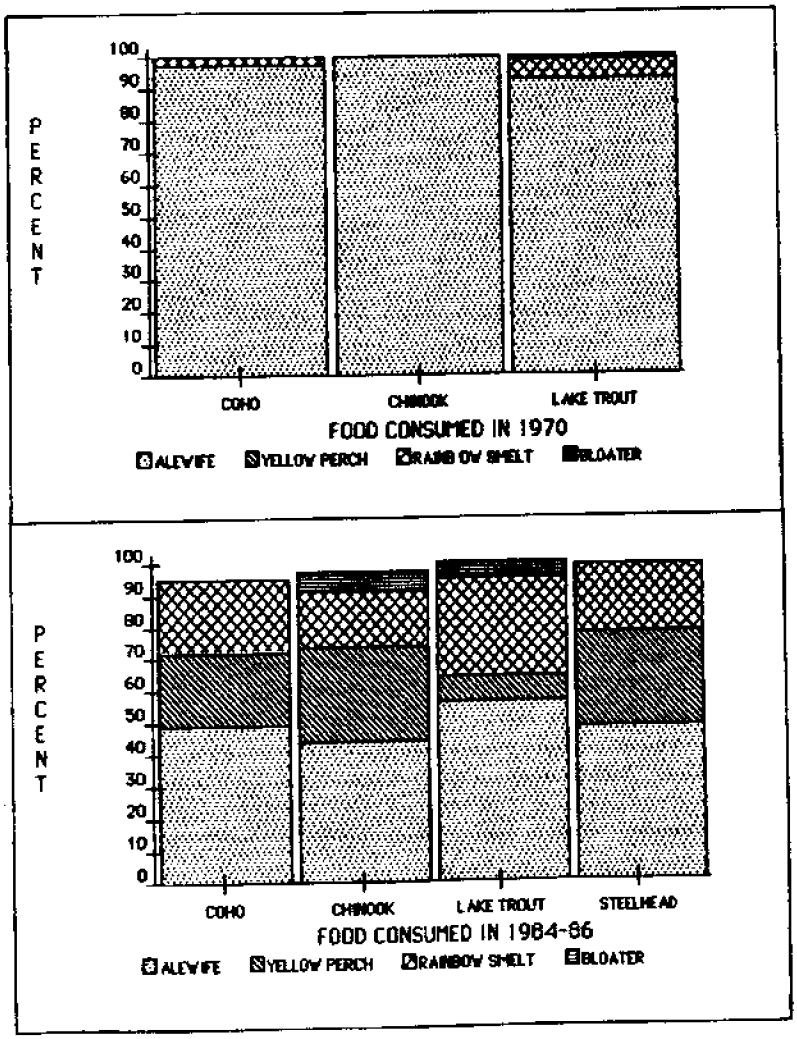

Figure 5. A comparison of percent composition of forage fish items consumed by salmonine predators 1970 and 1984-86.

Prey Fish Size Selection

Correlations between the size of prey fish consumed and size of predator salmonines for the 1984-86 period found no significant relationships due to the tendency by predators to consume all sizes of prey. Foraging theory promotes the concept that as predator fish increase in size, feeding efficiency requires larger prey. Recently published data for salmonines collected inshore in southeastern Lake Michigan from 1973-82 (Jude et al. 1987) revealed significant positive relationships for size selection of alewives and rainbow smelt. The difference between the 1984-86 results and the 1973-82 data (Jude et al. 1987) is possibly related to the dramatic changes in density of major forage species making it necessary for salmonine predators to feed on all sizes of prey regardless of preference for larger prey sizes by larger predators.

Invertebrates Consumed

Invertebrate food items were consumed by some salmonine predators (Table 3). They were unimportant to both chinook salmon and lake trout with fewer than 1% having consumed invertebrates. Invertebrates were frequently consumed by coho salmon and steelhead. This was particularly true from April through June of 1984-86 when 75-85% of coho salmon and 85-100% of steelhead had eaten invertebrates of some kind. The major invertebrate group consumed by both salmonine predators was insects in the order Diptera (flies). Insects in the orders Coleoptera and Lepidoptera were also frequently consumed by steelhead. It should be noted that while large percentages of coho salmon and steelhead consumed invertebrates through June, after June, invertebrate occurrence was low at 0-13%. Fish consumption through June was 6-53% by coho salmon and steelhead but after June, 100% consumed fish. Thus, after June, the shift away from invertebrates to fish as prey was complete. Overall occurrence for invertebrates between April and September of 1984-86 was 75% for coho salmon and 47% for steelhead. The data reveal that invertebrates were relatively important early growth season food items for coho salmon and steelhead, but forage fish dominated the diet thereafter.

Table 3. A comparison of percent occurrence of invertebrate prey in the diet of salmonine predators for 1984-86.

Invertebrate Prey	Predator Species			
	Coho	Chinook	Lake trout	Steelhead
Invertebrates	75	T *	T	47
Amphipoda	33			5
Coleoptera	31			37
Diptera	69	T	T	39
Hemiptera	14			9
Lepidoptera	28		T	30

* T = Less than 1%.

SUMMARY AND CONCLUSIONS

Salmonine predator-prey relationships were investigated for extreme southern Lake Michigan waters in and near Indiana from April to September of 1984-86. Results were compared to the major potential forage fish available. Diet changes were noted when compared to a 1970 study for the same area (McComish and Miller 1976).

Trawling on index zones in Indiana waters of Lake Michigan revealed significant changes in the forage fish populations between 1973 and 1984-86. The major shift taking place was a 90-fold increase in abundance of yellow perch along with a 71% decline in alewives. At the same time, bloaters experienced a tremendous expansion from only one specimen captured in 1973 to over 3,400 in 1986. Consumption of the final important forage fish, rainbow smelt, fluctuated widely between 1984-86. This is characteristic of this species in the Great Lakes.

Composition of the forage base utilized by salmonine predators shifted dramatically between 1973 and 1984-86. In 1973 it was dominated by alewives at 47% followed by 27% rainbow smelt and 25% yellow perch. In 1984-86, the yellow perch population was the overwhelming dominant at 83% followed by 11% rainbow smelt, 5% bloater, and less than 1% alewife.

A comparison of food consumed in 1970 by salmonine predators (McComish and Miller 1976) with that eaten in 1984-86 revealed continued importance of the alewife in the diet even though the prey population had declined sharply. In 1970, coho salmon consumed 97% alewives. By comparison, in 1984-86 they ate 49% alewives, 23% yellow perch, and 23% rainbow smelt. Chinook salmon consumed 100% alewives in 1970 but 44% alewives, 30% yellow perch, 17% rainbow smelt, and 6% bloater in 1984-86. In 1970, lake trout ate 93% alewives and 6% rainbow smelt. By 1984-86, the lake trout diet included 56% alewives, 31% rainbow smelt, 8% yellow perch, and 5% bloaters. Although a steelhead diet analysis was not completed in the early 1970s, in 1984-86 steelhead consumed 48% alewives, 30% yellow perch, and 21% rainbow smelt.

Due to the shifts in the forage fish populations, there have been significant changes in diets of all the salmonine predators between the early 1970s and the mid-1980s. It is important to emphasize, however, that the alewife continues to be a major dietary component even though the population has declined and is less available in relation to the overall potential forage fish base.

The Lake Michigan sport fishery, composed mainly of salmonine predators, is greatly affected by the availability of alewives for food. The dominance of the forage fish populations by yellow perch did not result in it becoming the dominant forage of the salmonine predators. This underscores the importance of the wise scientific management not only of the salmonine populations but also the alewife population. Future management decisions involving the salmonine sport fishery must carefully consider the alewife population dynamics as a major impacting factor in the continued high survival and growth rates of the salmonine populations in Lake Michigan.

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