PREY-PREDATOR RELATIONS IN THE PREDATOR-STOCKING-EVALUATION RESERVOIRS[1]

by
ROBERT M. JENKINS and DAVID I. MORAIS
National Reservoir Research Program
U. S. Fish and Wildlife Service
Fayetteville, Arkansas

ABSTRACT

The method advanced for estimating prey-predator relations in reservoirs is based on fish standing crop data derived from samples collected in rotenone-treated coves in 23 reservoirs. The sampling, in August 1972 and 1973, was part of a cooperative study conducted under the auspices of the Reservoir Committee, Southern Division of the American Fisheries Society. Estimates were made of sizes of prey species which predators with various mouth sizes could swallow; lengths of all species of predators were then adjusted to equal the lengths of largemouth bass of equivalent predatory capability; and a computer program was developed to calculate biomass of prey available to predators in length classes equivalent to 1-inch length classes of bass 1- to 28 inches long. Results indicated that 50% of the populations sampled were deficient in available prey. Stocking of additional predators in these instances would be deemed inadvisable.

A major deficiency in the understanding of reservoir fish population dynamics stems from the lack of quantitative data on predator-prey relations. Most precepts for the management of southern reservoirs have rested on the findings of Swingle (1950), whose pioneering research in ponds yielded indexes of predator-prey "balance" in bass-sunfish populations. Complex, multispecies populations in large, relatively unstable reservoir environments pose problems in sampling and data analysis which have until recently defied realistic solutions.

Reporting on results of reservoir studies in Alabama, Swingle and Swingle (1968) concluded that fish population dynamics seemed to be similar in ponds and reservoirs, but that a regression formula derived to predict pond crops of bass and bluegills appeared to be useful for estimating reservoir fish crops only because of compensating errors. They recommended that the Reservoir Committee, Southern Division, American Fisheries Society, establish a central laboratory for processing data from southern reservoirs so that it would be available for development of fish population theories.

Member agencies of the Reservoir Committee, in response to a 1967 inquiry concerning needs for answers to pressing management problems, listed as top priority: "Evaluate the success of stocking walleye, striped bass, white bass and trout and their effects on other predator species." Continuing concern about the effects of stocking additional predators in reservoirs prompted members of the Committee in 1970 to begin organizing a coordinated field study of waters where periodic stocking of striped bass, walleyes, northern pike, or salmonids was in progress. Some reservoir studies (e.g., Stevens 1964; Bayless 1966; Rainwater and Houser 1975) have shown that production of prey available to predators of all sizes can limit total predator biomass. The committee concluded that immediate attention should be given to the evaluation of changes that occur in existing predator populations after other predator species are added.

The Committee launched the cooperative Predator Stocking Evaluation (PSE) in 1972 with the goals of determining harvest rates of predators by anglers, identifying environmental variables that influence the success of predator introductions, and gaining further insights into prey-predator relations. The data were collated and prepared for computer analysis by the National Reservoir Research Program.

Estimates of the significance of food chain structure, relative sizes of prey and predator, and of the various factors regulating predator production were to be sought by monthly monitoring of physicochemical attributes of the reservoirs, creel census, and annual fish sampling in coves. We are concerned in this report with the analysis of prey biomass

[1] Basic data presented in this paper are derived from a cooperative "Predator Stocking Evaluation (PSE)," conducted under the auspices of the Reservoir Committee, Southern Division, American Fisheries Society, 1972-73.

available to all sizes of predators in the PSE study reservoirs. The aim is to define the adequacy of the prey crop in August to sustain normal growth and well-being of the existing predator population during the rest of the growing season. Such definition of adequacy could provide fishery managers with a guide to the advisability of stocking predators after August, and estimates of the additional biomass of predators that could be supported, or conversely, estimates of the loss of predator biomass due to natural mortality through the fall and winter.

METHODS AND MATERIALS

An instantaneous measure of the available prey-predator relations was based on samples collected by the application of rotenone to blocked-off coves (here termed "cove samples") in August and recording fishes recovered by 1-inch (25.4 mm) length groups in terms of number and weight per unit of surface area. We applied adjustment factors derived from the Douglas Reservoir study of Hayne et al. (1968) to the biomass of major taxa (Table 1) to compensate for different distributions of major species and size groups

Table 1. Adjustment factors applied to standing crop of various size groups of principal fishes to compensate for differences in biomass recovery between cove and open water areas, based on the 1965 Douglas Reservoir rotenone sampling evaluation (Hayne et al. 1968). Values in parentheses indicate 1-inch length groups (e.g., 1.5 − 2.4 inches = 2-inch group). Biomass recovered is multiplied by the factor listed for appropriate size groups to calculate adjusted crop.

	Conversion factor		
	"Young"	*"Intermediate"*	*"Harvestable"*
Carp	(1-8″) 0.74	(9-12″) 1.22	(13″+) 1.21
Catostomids	(1-8″) 0.40	(9-12″) 0.83	(13″+) 2.52
Catfishes	(1-5″) 0.64	(6-9″) 1.62	(10″+) 1.04
White, striped bass	(1-6″) 2.00	(7-8″) 2.00	(9″+) 2.00
Sunfishes	(1-3″) 0.50	(4-5″) 1.00	(6″+) 1.22
Black basses	(1-4″) 0.50	(5-9″) 0.90	(10″+) 1.34
Crappies	(1-3″) 0.97	(4-7″) 1.38	(8″+) 2.42
Freshwater drum	(1-5″) 1.26	(6-8″) 1.38	(9″+) 2.56

between cove and open water areas. Adjustments were not made to clupeid biomass because studies on Beaver and DeGray Lakes have shown relatively good agreement between cove samples and concurrent open-water trawl estimates of the young-of-the-year crop (South Central Reservoir Investigations 1968-75 unpublished data).

We made an additional correction to account for incomplete recovery of fishes after rotenone treatment of coves, by applying mean recovery rates of major taxa of fin-clipped fishes (Table 2) to estimate biomass not recovered (Grinstead et al. 1977). These two adjustments represent concerted, long-term efforts by member agencies of the Reservoir Committee to improve the accuracy of cove sampling. The biomass data thus treated are hereinafter referred to as adjusted standing crop.

The adjustments increased the mean total standing crop estimate of the PSE sample about 80% (from 252 pounds per acre actual recovery to 451 pounds per acre adjusted standing crop). Mean adjusted crop of black bass was nearly twice the actual recovery mean (30 versus 16 pounds per acre), and mean clupeid crop was increased 33% (111 to 148 pounds per acre).

Mean sucker crop was increased from 16 to 49 pounds per acre, carp from 22 to 43, catfishes from 19 to 41, white bass from 2 to 5, sunfishes (centrarchids other than black bass and crappies) from 47 to 82, crappies from 6 to 18, and freshwater drum from 5 to 19 pounds per acre. In general, uncorrected cove samples tend to overestimate the biomass of young-of-the-year fish and underestimate that of adult fish.

Table 2. Mean recovery rate of marked fish from cove samples in 23 PSE reservoirs, 1972-73 (Grinstead et al. 1977).

Taxa	*Percent recovered*	*Taxa*	*Percent recovered*
Gars	56		
Bowfin	20		
Clupeids	75		
Pickerels *(Esox)*	63		
Carp	60		
"Minnows" and silversides	50		
Catostomids	66		
Flathead catfish	79		
Other catfishes	53		
White bass	82		
Black basses	60		
Crappies	61		
Other sunfishes	54		
Darters	50		
Yellow perch	43		
Walleye	63		
Freshwater drum	60		

Fishes considered as predators were gars; pickerels; pikes; bowfins; flathead catfish; white, blue, and channel catfish >10.4 inches in total length; white and striped bass; white perch; black basses; crappies; saugers; and walleyes.

Taxa considered as prey included clupeids; cyprinids; catfishes <10.5 inches long; catostomids <10.5 inches; white and striped bass, black basses, and crappies <6.5 inches; sunfishes; darters; silversides; yellow perch; and freshwater drum <10.5 inches.

We derived estimates of the sizes of the various prey species that predators with various mouth sizes could swallow, using as a base the calculations of Lawrence (1958) on the relation between mouth size of largemouth bass, by inch-groups, and the maximum body depth of various prey species. Comparable mouth sizes of other predator species in proportion to black basses of equal length were then estimated and a set of formulas derived to express curvilinear "prey size-predator size" relations for the major taxa. The basic predator size-group classification was then set equal to the largemouth bass-prey relation for calculation. Factors used to convert major predators to largemouth bass total length equivalents were: longnose gar, 2.6 (i.e., a 26-inch gar = 10-inch bass); spotted gar, 2.3; bowfin and flathead catfish, 1.0; other catfishes and crappies, 1.5; white and striped bass and white perch 1.3; and walleye 1.7.

Regressions expressing biomass of prey taxa available to predators in 1-through 28-inch length groups were then developed. For example, sizes of clupeids (Y) available to successive 1-inch groups of predators (largemouth bass equivalents) (X) is expressed by $Y = 0.0141X^2 + 0.1668X + 1.0972$.

A computer program was developed for calculating the ratio of available prey (AP) biomass to predator (P) biomass (AP/P) for predators from 1 + to 28 inches long, by 1-inch length groups, on a cumulative basis. The 28-inch equivalent represents the largest predators that would ordinarily be expected to occur in reservoirs (e.g., 28-inch largemouth bass, 36-inch striped bass, 73-inch gars). Logarithmic plots of these data were drawn to portray the relative adequacy of the prey crop in relation to various sizes of the predator crop (see later figures). Copies of the AP/P program may be obtained from the National Reservoir Research Program in WATFIV language for the IBM 370/155 computer, or in BASIC for the H-P 9830A calculator.

The mean available AP/P ratio thus described is essentially similar to the Y/C ratio defined by Swingle (1950) as the total weight of "forage" fishes small enough to be eaten by the average-sized adult carnivore, divided by the total weight of the species that feed principally upon other and smaller fishes. Swingle found that the Y/C ratio changes with changes in predation pressure and harvest rate, but remained constant, within limits, in "balanced" populations. Fish populations in ponds reflected by the ratio were categorized by Swingle as follows: Y/C = 0.02 to 0.5, severely overcrowded with carnivores, inefficient; 0.5 to 4.8, balanced; >4.8, overcrowded with forage fish, unbalanced.

We established a minimum desirable AP/P ratio of 1:1 in August, on the basis of the following assumptions:

1) Ecological growth efficiency is 0.20 (Steele 1974); i.e., 5 pounds of prey is required to produce 1 pound of predator.
2) Inasmuch as about 40% of the growing season remains after mid-August, 40% of the annual food requirement is needed to maintain desirable predator growth to the end of the growing season.
3) About 20% of the prey required is produced after mid-August (this value is supported by estimates of shad production in Beaver Lake, 1968-73 [Houser and Netsch 1971; and unpublished data, South Central Reservoir Investigations]).
4) The other 20% of prey required is represented by the AP/P ratio of 1:1 (5 x .20 = 1).

Although 26 reservoirs were included in the 2-year study, Lakes Eucha and Spavinaw, Oklahoma, were omitted from the present summary because cove samples were taken in the fall, and Woods Reservoir, Tennessee, because no cove sampling was done in 1973.

ANALYSIS OF AP/P RATIO

Adjusted available-prey (AP) standing crops in the 23 study reservoirs for 1972 and 1973 (Table 3) indicate that an average of about 52% of the available prey in August is

Table 3. Adjusted mean standing crop (pounds per acre) of available prey and predators in 23 reservoirs, based on cove sampling in August 1972 and 1973. The left number of each hyphenated pair represents 1972, and right 1973.

	Available prey			*Predators*	
Reservoir	*Clupeids*	*Sun-fishes*	*Total*	*Black basses*	*Total*
Jordan (Ala.)	360-232	112-75	520-348	82-95	114-107
Mitchell (Ala.)	208-47	71-40	330-106	33-26	71-39
Beaver (Ark.)	223-165	38-53	276-241	10-14	32-49
Bull Shoals (Ark.)	11-139	41-116	66-361	7-41	27-130
Greeson (Ark.)	9-6	27-57	67-81	24-21	48-36
Jackson (Ga.)	32-25	544-415	731-500	54-30	118-71
Sinclair (Ga.)	117-23	75-68	223-114	26-16	75-40
Deep Creek (Md.)	0-0	13-22	81-85	5-3	17-14
Barnett (Miss.)	459-223	95-91	595-355	68-37	229-139
Enid (Miss.)	49-56	17-21	105-119	35-38	75-110
Grenada (Miss.)	36-46	1-13	84-161	20-32	108-255
Okatibbee (Miss.)	274-120	66-46	371-170	37-30	156-41
Sardis (Miss.)	110-72	33-33	213-159	30-58	63-198
Badin (N.C.)	98-102	162-145	352-358	24-24	71-82
Gaston (N.C.)	122-196	73-97	242-356	33-39	95-84
Canton (Okla.)	33-141	1-3	51-174	8-10	28-38
Keystone (Okla.)	172-526	47-58	267-678	3-8	41-94
Cherokee (Tenn.)	205-775	103-183	324-989	36-58	66-184
Dale Hollow (Tenn.)	53-8	30-26	99-38	17-12	26-21
Watauga (Tenn.)	1-1	24-33	40-55	8-16	41-92
Bastrop (Tex.)	1-6	118-95	129-107	43-70	83-93
Cypress Springs (Tex.)	68-352	81-147	196-525	41-39	172-118
Spence (Tex.)	63-98	27-48	94-152	18-13	43-42
Mean	131	80	254	30	84

composed of clupeids, 31% sunfishes, and 17% other species. Although variability between and within reservoirs is great, the overriding importance of clupeids as potential prey is evident in most of the reservoirs. Many food studies have confirmed the dominance of clupeids in the diets of predators in southern reservoirs.

The mean predator crop of 84 pounds per acre was composed of black basses, 36%; channel, white, and blue catfishes, 28%; crappies, 21%; white bass, 5%; gars, 3%; flathead catfish, 2%; and others 5%. Black basses, catfishes, and crappies made up 85% of the predator crop and also accounted for 85% of the mean total catch of 16 pounds of predators per acre by anglers (Campbell et al. 1977). About 20% of the August mean predator crop was harvested annually (Table 4). High percentages of the crops of striped bass and walleyes estimated to have been harvested may be a reflection of underrepresentation of these species in cove samples.

Table 4. Two-year mean adjusted predator standing crops in August and estimated percent of crop harvested annually by anglers in the PSE study reservoirs, 1972-73.

Predators	*Number of reservoirs in which predators occurred*	*Predator crop*	
		Pounds per acre	*Percent harvested*
Black basses	23	30.2	19
Channel, white, and blue catfishes	23	23.1	9
Crappies	23	17.8	31
White bass	14	6.0	22
Gars	17	3.4	<1
Flathead catfish	17	2.2	18
Striped bass	10	1.0	100
Walleye	9	1.2	83
Pickerels	9	1.9	8
Bowfin	4	14.0	1
Total predators	23	84.0	20

Table 5. Classification of the study reservoirs according to whether the AP/P ratio for each predator length group, 1 to 28 inches, was greater or less than 1:1 in cove samples, August 1972-73.

AP/P greater than 1:1	*AP/P less than 1:1*
Jordan	Deep Creek
Mitchell	Enid
Greeson	Grenada
Sinclair	Okatibbee
Barnett	Sardis
Gaston	Badin
Keystone	Canton
Dale Hollow	Cherokee
Bastrop	Watauga
Beaver in 1972	Beaver in 1973
Bull Shoals in 1972	Bull Shoals in 1973
Jackson in 1973	Jackson in 1972
Cypress Springs in 1973	Cypress Springs in 1972
Spence in 1973	Spence in 1972

Mean ratios of available prey to adult predators for the 46 annual samples averaged 2.5:1, and ranged from 0.2:1 (Watauga Lake, 1973) to 8.0:1 (Lake Jackson, 1972). More than 75% of the samples (35) fell within Swingle's Y/C definition of "balanced populations," 0.5-4.8. Six of the 11 samples classified as unbalanced would be considered "overcrowded with forage fishes" by Swingle's criteria.

Results of the cumulative AP/P ratio analysis provide a different perspective. The cumulative AP/P ratio fell below 1:1 at some point in 50% of the samples (Table 5), and the existing populations were considered as deficient in available prey for some size groups of predators. Stocking of additional predators in these instances would be considered inadvisable, as either survival of the stocked predators would be low, or the survivors could adversely affect some size groups of existing predator populations. Only five of the reservoir samples would be classified as deficient in prey by Swingle's Y/C criterion.

INTERPRETATION OF AP/P PLOTS

Plotting of AP/P values by 1-inch groups on a cumulative basis affords a simplified portrayal of a complex predator-prey relationship. The plot is cumulative to account for the ability of large predators to ingest prey from the smallest present to the largest they can swallow. For example, the AP/P plot for Lake Sinclair, Georgia (Figure 1), shows that about 6 pounds of prey per acre is available to 1 pound of 3-inch predators. That same 6 pounds of prey is included in the 40 pounds of prey available to 10-inch predators and in the 115 pounds available to 19-inch predators. The minimum AP/P ratio in Sinclair, 1.86, occurred at the 10-inch predator size group, indicating that prey availability was well above the minimum desirable for all predator sizes. The calculation implies that about 5 more pounds of 3-inch predators per acre, or 20 more pounds of 10-inch predators could have been sustained by the existing prey base (horizontal distance from data point to 1:1 ratio line).

Interpretation of the calculated AP/P ratio is further illustrated by a plot of values derived from August cove samples in Lake Greeson, Arkansas (Figure 2). The total cumulative predator crop for 1972 was 48 pounds per acre, of which 24 pounds was black bass and 10 pounds was striped bass. Maximum predator length was 20 inches (black bass equivalent). Total available prey per acre was 67 pounds (AP/P ratio = 1.4). Although the available prey crop was more than adequate for predators less than 11 inches long, it was near the minimum desirable ratio of 1:1 for larger predators. Total predator harvest in 1972 was 12 pounds per acre, including 4 pounds of striped bass.

In 1973 total predator crop decreased 12 pounds per acre and total available prey crop increased 14 pounds per acre. Total black bass crop held at 21 pounds per acre, but striped bass crop declined from 10.0 to 0.2 pounds per acre. The AP/P ratios were higher in 1973 than in 1972 throughout the length range of predators, generally >2:1. Total predator harvest in 1973 dropped from 12 to 4 pounds per acre, and included only a trace of striped bass. The results suggest that maximum predator carrying capacity was approached in 1972, but that high predator harvest in that year, coupled with other factors, reduced the total predator crop in 1973 and increased the AP/P ratio. Stocking of predators shorter than 6 inches would have been considered advisable in both years; however, the probability of success would have been greater in 1973 because the competition from larger predators was reduced.

An example of overrunning of the food supply and later adjustment of the predator crop is afforded by data from Cypress Springs Lake, Texas (Figure 3). Cumulative predator-prey values for 1972 indicate ratios of less than 0.5:1 for predators less than 15 inches long, indicating a severe shortage of prey in the third year of impoundment. The August adjusted predator crop per acre totaled 172 pounds, including 60 pounds of catfishes, 46 pounds of bowfins, 41 pounds of black basses, and 19 pounds of crappies. In the following August, AP/P cumulative ratios exceeded 2:1 as the predator crop per acre decreased by 54 pounds, including declines of 31 pounds in catfishes, 12 pounds in bowfins, and 6 pounds in crappie. Black bass crop declined only 1 pound per acre. Stocking of additional predators would have been inadvisable in 1972, but advisable in 1973. An estimated 36 pounds of predators per acre was harvested by anglers in 1973, including 18 pounds of

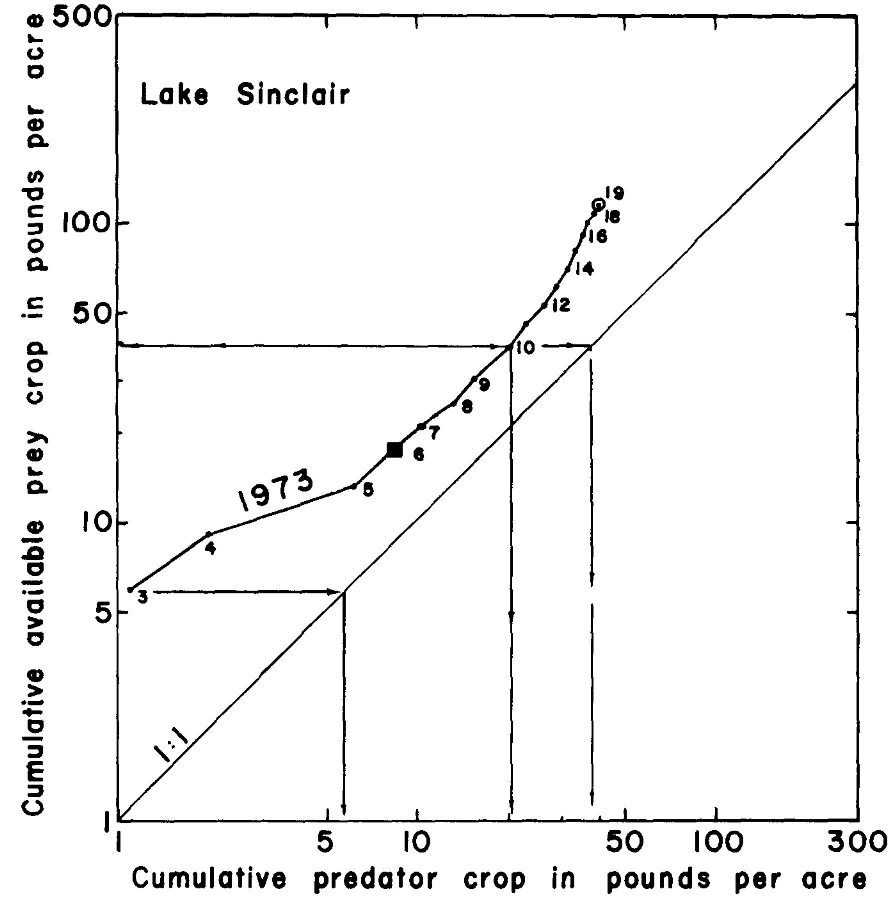

Figure 1. Explanatory logarithmic plot of cumulative AP/P ratio, Lake Sinclair, Georgia, August 1973. Numbered points indicate cumulative biomass of predators (horizontal-axis) at inch-groups 3 through 19, plotted against biomass of available prey (vertical-axis). For example, the cumulative biomass of predators less than 10.4 inches equaled 20.7 pounds per acre; the cumulative biomass of prey available to those predators equaled 38.6 pounds per acre. The AP/P ratio at that point was 1.86. The open circle at 19 indicates the total AP/P ratio, 114.3/40.5 = 2.82. The largest predators in the sample were in the 19-inch length group (black bass "equivalent"). The solid square indicates the cumulative AP/P value for predators shorter than 6.5 inches. The 1:1 slope represents the minimum desirable AP/P ratio.

crappies, 10 pounds of black bass, 5 pounds of catfish, 2 pounds of walleyes, and 1 pound of bowfins.

Data for a longer period (1972-75) are available from Beaver and Bull Shoals Lakes (Figures 4 and 5). The AP/P ratios in 28,000-acre Beaver Lake were similar during the 4 years, with one exception. In 1973, a shortage of prey occurred for predators <4.5 inches; otherwise, the ratio remained above 2:1. Total predator crops during the period were

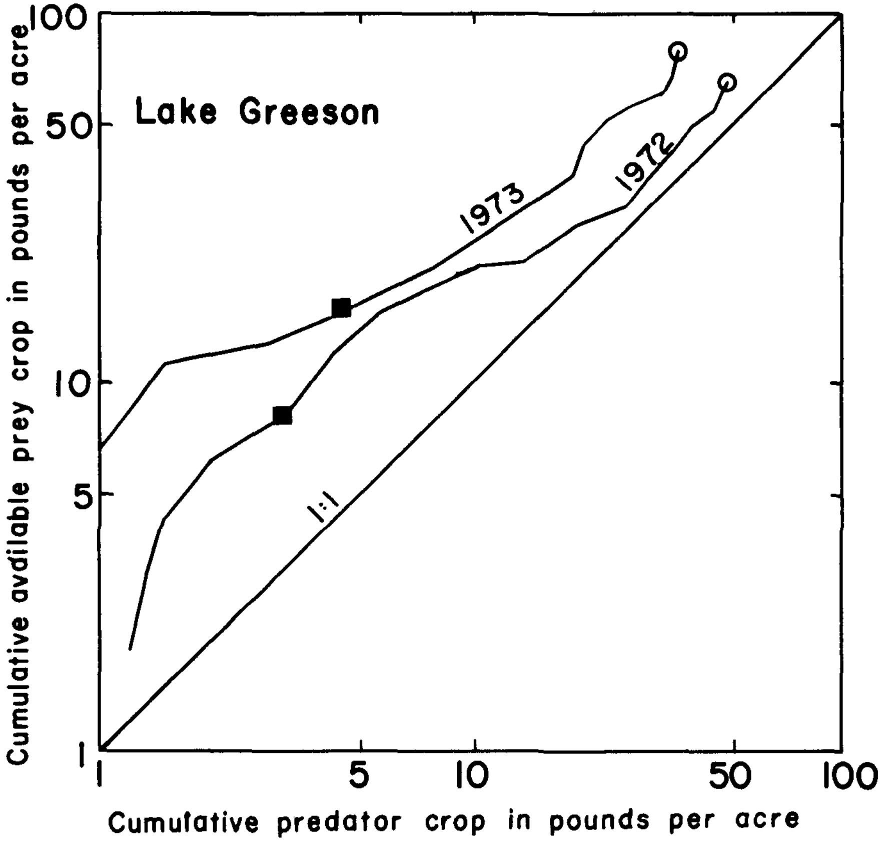

Figure 2. Logarithmic plot of the cumulative AP/P ratio in Lake Greeson, 1972-73, based on adjusted August cove samples. Solid squares represent predators in the 6-inch length group; open circles represent the total AP/P ratio.

relatively stable, ranging from 32 to 50 pounds per acre. Stocking of striped bass since 1968 has resulted in a successful fishery; harvests ranged from 5,000 to 14,000 pounds per year in 1971-75. (The largest fish caught in 1975 weighed 24 pounds.)

In contrast, AP/P ratios in Bull Shoals Lake during 1972-75 (Figure 5) were more erratic; a severe shortage of prey for smaller predators occurred in 1973, and lesser shortages in 1974 and 1975. Lake levels rose 35 feet in early 1973, nearly doubling the surface area and fostering an explosion in production of young predators. In August 1973, when the crop of young predators (<6.5 inches) equaled 82 pounds per acre (including 52 pounds of white bass and 20 pounds of black bass), only 54 pounds of prey was available. High natural mortality of young predators took a heavy toll during the remainder of the year. In August 1974, the crop of young predators was only 9 pounds per acre, and total predator crop had decreased from 130 pounds to 57 pounds per acre—a reduction approximately equaling the young-of-the-year predator crop in 1973.

Stocking of striped bass in Bull Shoals in 1970 and 1973 did not result in establishment of a substantial fishery through 1975, as it had in Beaver. Comparative success in the two reservoirs must be linked to relative adequacy of the prey base for small predators as revealed by the AP/P analysis.

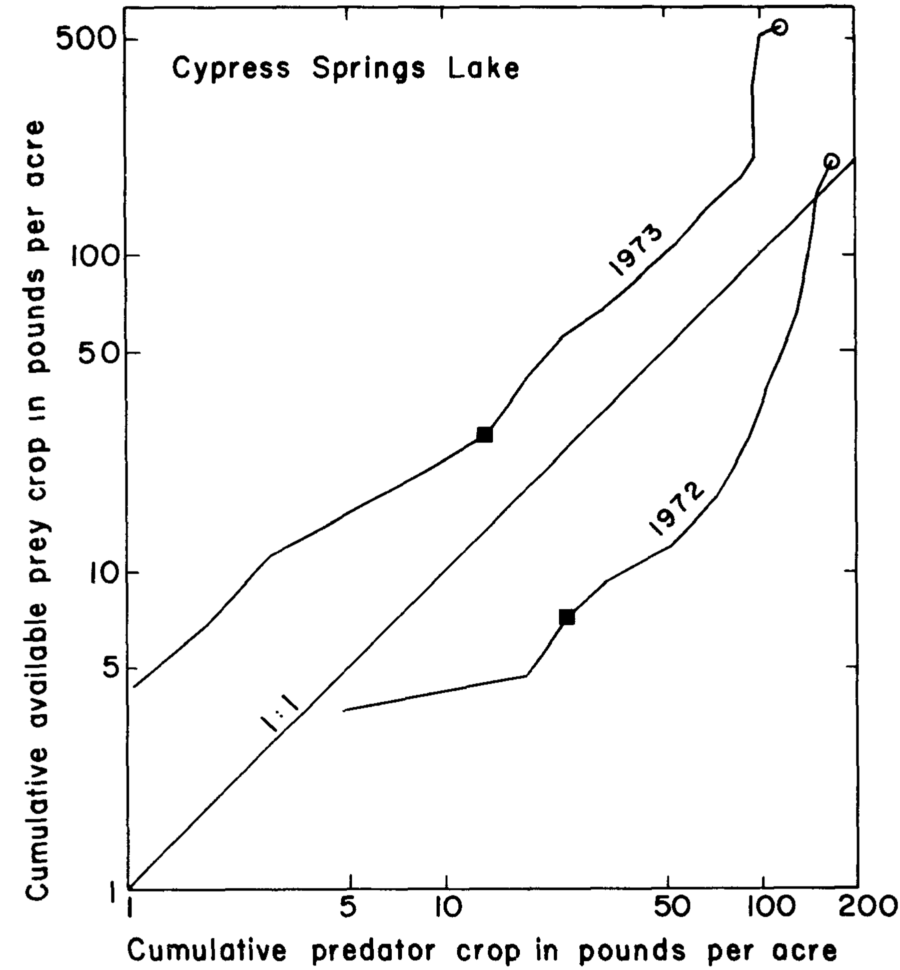

Figure 3. Logarithmic plot of the cumulative AP/P ratio in Cypress Springs Lake, Texas, 1972-73, based on adjusted August cove samples. Solid squares represent predators in the 6-inch length group; open circles indicate the total AP/P ratio.

PREY DEFICIENT RESERVOIRS

Of the 23 study reservoirs, 9 were deficient in available prey in both 1972 and 1973 (Table 5, right hand column). Five of these are shallow, relatively turbid, flood control impoundments—Enid, Grenada, Okatibbee, and Sardis Lakes in Mississippi, and Canton Lake in Oklahoma. In Enid, Grenada, and Sardis (Figure 6), 45 to 70% of the total predator crop was made up of crappies and catfishes and it is possible that these species were sustained by consumption of benthos rather than fish. However, the need for more available prey has been recognized by Mississippi biologists (Schultz 1975), and new species are being introduced.

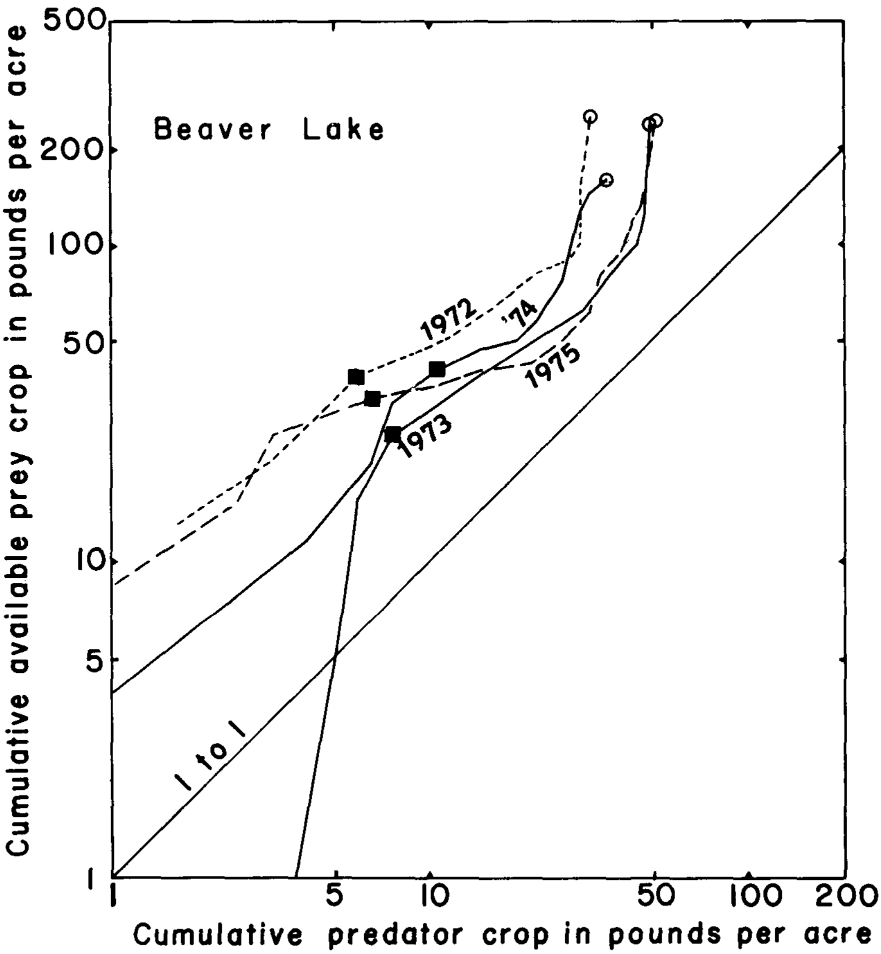

Figure 4. Logarithmic plot of cumulative AP/P ratios in August for Beaver Lake, Arkansas, 1972-75. Solid squares indicate cumulative biomass of predators <6.5 inches, total length; open circles indicate total AP/P.

Annual harvest of predators from Enid, Grenada, and Sardis ranged from 1.6 to 9.6 pounds per acre; the average of 4.4 pounds per acre was only one-fourth of the mean for all PSE reservoirs. Higher harvests might help alleviate the existing predator imbalance.

An overrunning of the available food supply, followed by predator crop readjustment (a fairly common occurrence in young reservoirs), apparently took place in 5-year-old Lake Okatibbee (Figure 7). Predator crop dropped from 156 to 41 pounds per acre from 1972 to 1973, and AP/P ratios in 1973 were >1:1 for predators >7.4 inches. In Canton Lake, available prey was deficient in 1972 for predators <8.5 inches. Prey biomass tripled in 1973 and was deficient only for predators <5.5 inches.

Striped bass stocked in Okatibbee, Sardis, and Canton were not taken in cove samples nor recorded in the sport fish harvest. However, previous introductions of white bass in Enid and Grenada, and walleyes in Canton were successful in establishing reproducing populations.

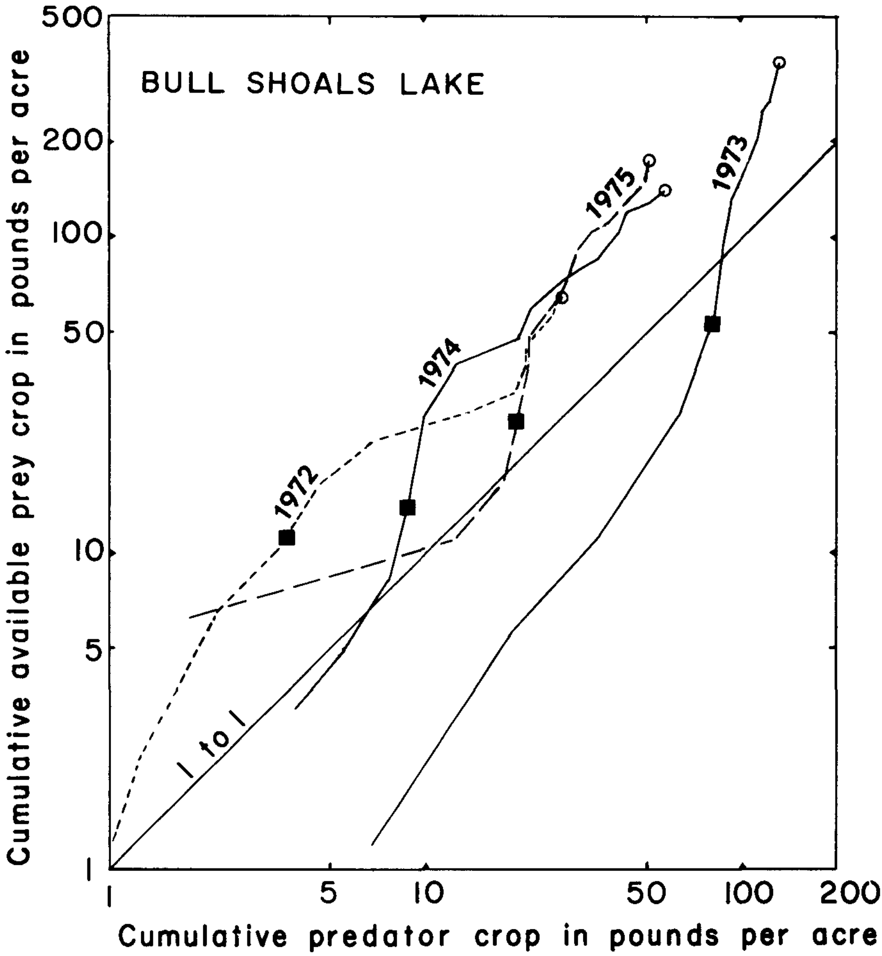

Figure 5. Logarithmic plot of cumulative AP/P ratios in August for Bull Shoals Lake, Arkansas and Missouri, 1972-75. Solid squares represent predators in the 6-inch length group; open circles indicate the total AP/P ratio.

Two eastern hydropower reservoirs—Deep Creek in Maryland and Badin in North Carolina—were deficient in prey for small predators (Figure 8). Significant harvests of introduced predators, including northern pike and walleye in Deep Creek and striped bass in Badin, suggest that adequate small prey was available in earlier years when stocking took place. However, it appears that carrying capacity for young-of-the-year predators was surpassed in 1972-73, and stocking success in those years would have been limited.

Two Tennessee hydropower reservoirs—Cherokee and Watauga—produced data from cove samples (Figure 9) and sport fish harvests that did not conform to our AP/P ratio hypothesis. Available prey were deficient for predators <9.5 inches long in 22,000-acre Cherokee Lake in both years, but striped bass (plus hybrids) stocked during 1966-72 contributed substantially to the sport fish harvest (1.1 pounds per acre in 1972 and 4.7

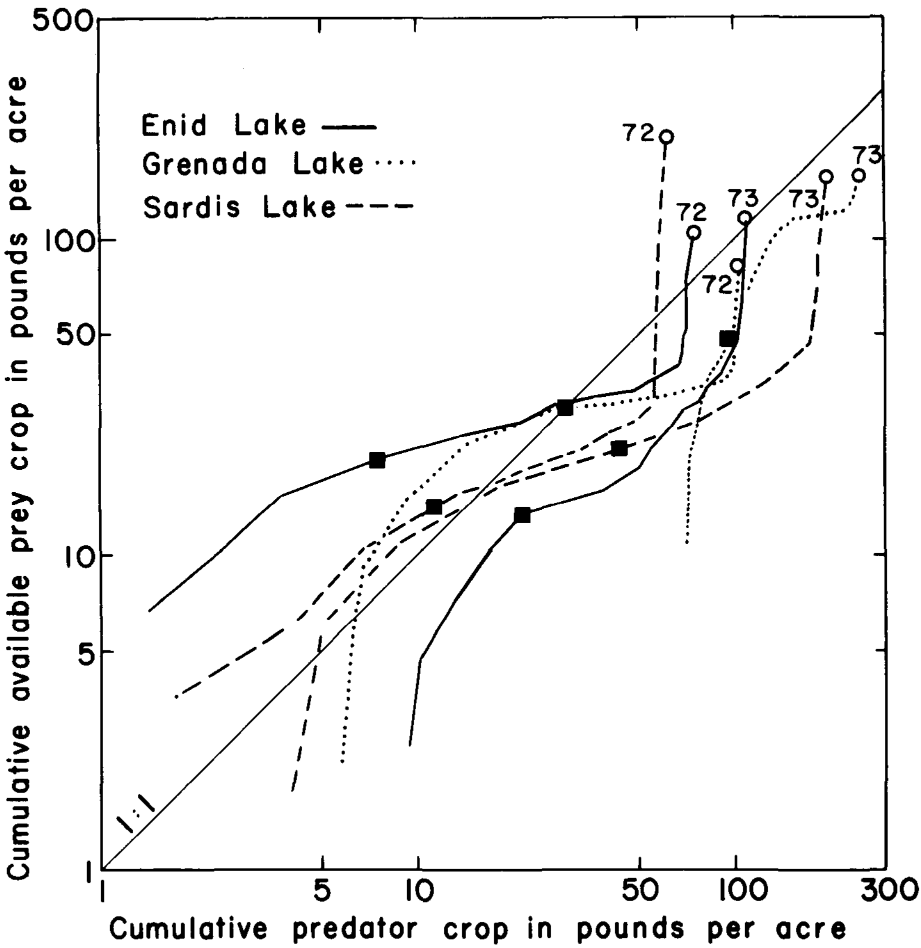

Figure 6. Logarithmic plot of cumulative AP/P ratios in August for Enid, Grenada, and Sardis Lakes, Mississippi, 1972-73. Solid squares represent predators in the 6-inch length group; open circles indicate the total AP/P ratio.

pounds in 1973). Possibly the fishery was supported by striped bass stocked in the earlier years and carrying capacity of small predators was first surpassed in 1972. Cove samples and harvest estimates in later years may show predator-prey readjustments such as occurred in Bull Shoals Lake in 1973-75 (Figure 5).

Watauga Lake AP/P ratios were equal to or slightly less than 1:1 in 1972 (Figure 9), but dropped precipitately in 1973 as total predator crop rose from 40 to 90 pounds per acre. It appears that in "normal" years (e.g., 1972) the predator crop is delicately balanced with the available prey base. If the 50 pounds per acre of predators <7.5 inches existing in August 1973 were lost through natural mortality (i.e., starvation), the fish population could have regained "balance" in 1974. Predator harvest was 13 pounds per acre in both years, suggesting that adjustments in predator crop were occurring primarily in size groups below those harvested.

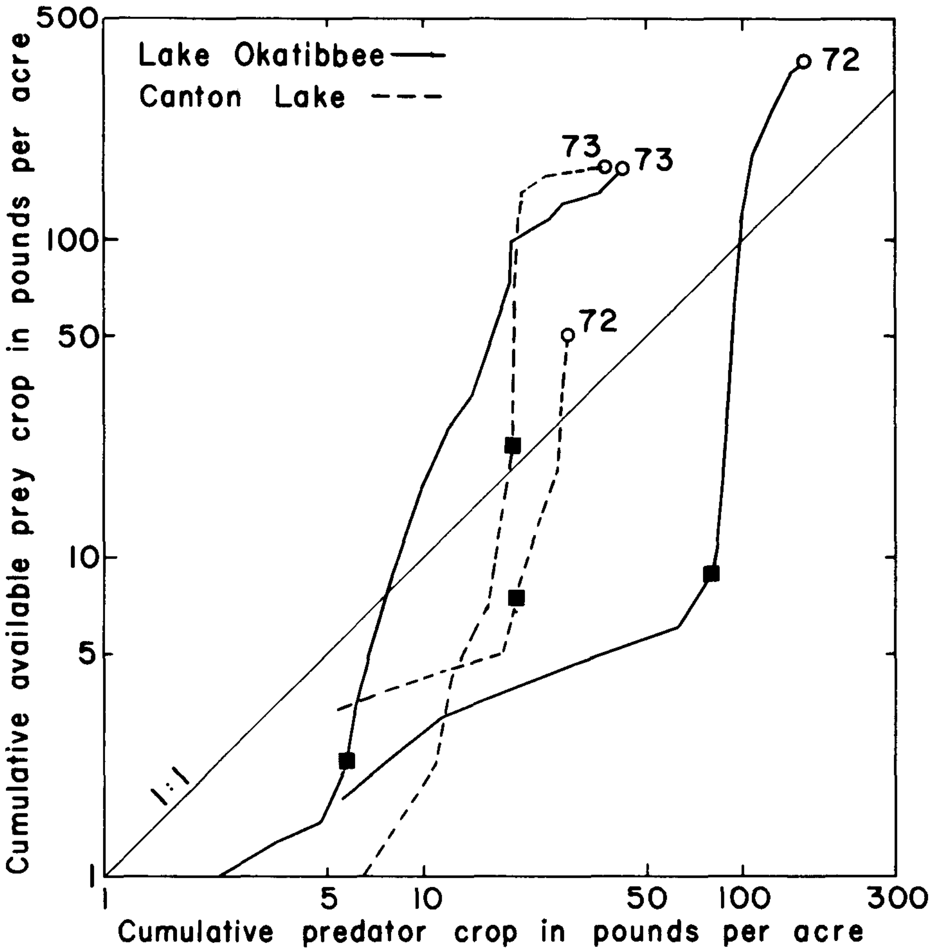

Figure 7. Logarithmic plot of cumulative AP/P ratios in August for Lake Okatibbee, Mississippi, and Canton Lake, Oklahoma, 1972-73. Solid squares represent predators in the 6-inch length group; open circles indicate the total AP/P ratio.

The assumptions and hypotheses advanced concerning prey deficiencies in the nine reservoirs discussed above emphasize the need for long-term data before more definitive conclusions can be drawn from predator-prey relationships for management purposes.

AP/P RATIO SAMPLE MEANS

Calculation of mean AP/P ratios at 2-inch length intervals for the entire sample (Figure 10) indicated that available prey was more abundant in 1973 than 1972—an increase that has been attributed to greater nutrient inflows into many of the reservoirs in 1973 (Aggus and Lewis 1977). In both years, AP/P ratios were lowest in the 8- to 12-inch predator size classes (black bass equivalent). Greatest potential competition for food apparently occurs in this size range, which includes 1- to 3-year-old predators. About 38% of the mean total predator biomass was included in the 8- to 12-inch size range, compared with 35% for all

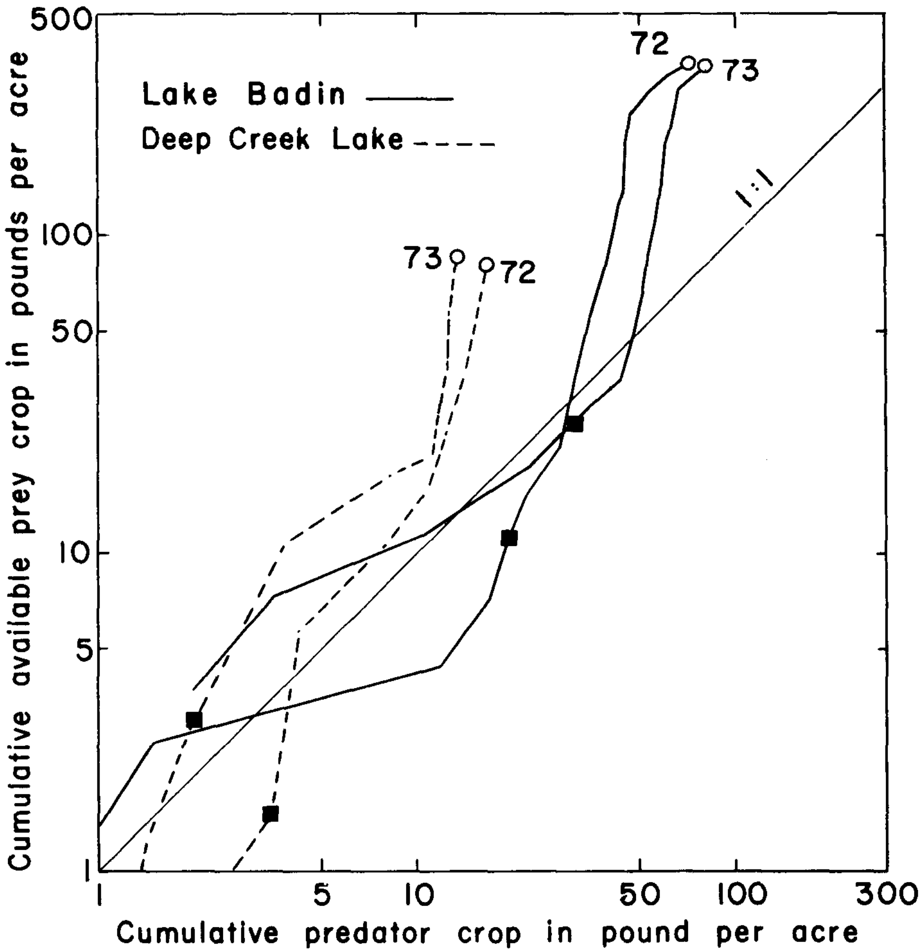

Figure 8. Logarithmic plot of cumulative AP/P ratios for Lake Badin, North Carolina, and Deep Creek Lake, Maryland, August 1972-73. Solid squares represent predators in the 6-inch length group; open circles indicate the total AP/P ratio.

larger predators and 27% for smaller predators. Most of the annual production of predators is contributed by 1- to 3-year-olds, suggesting that this size-group uses prey most effeciently and is most affected by prey shortages.

CONCLUSION

Computer simulation of available prey-predator relations in reservoir fish populations rests on a number of assumptions that are incompletely defined at present. More detailed studies are needed to improve the interpretation of biomass data from cove samples and describe predator food habits precisely. Reservoirs contain too many species which interact in too many ways for such a simulation to provide all of the answers. However, there is evidence that relatively simple prey-predator relations exist in reservoirs.

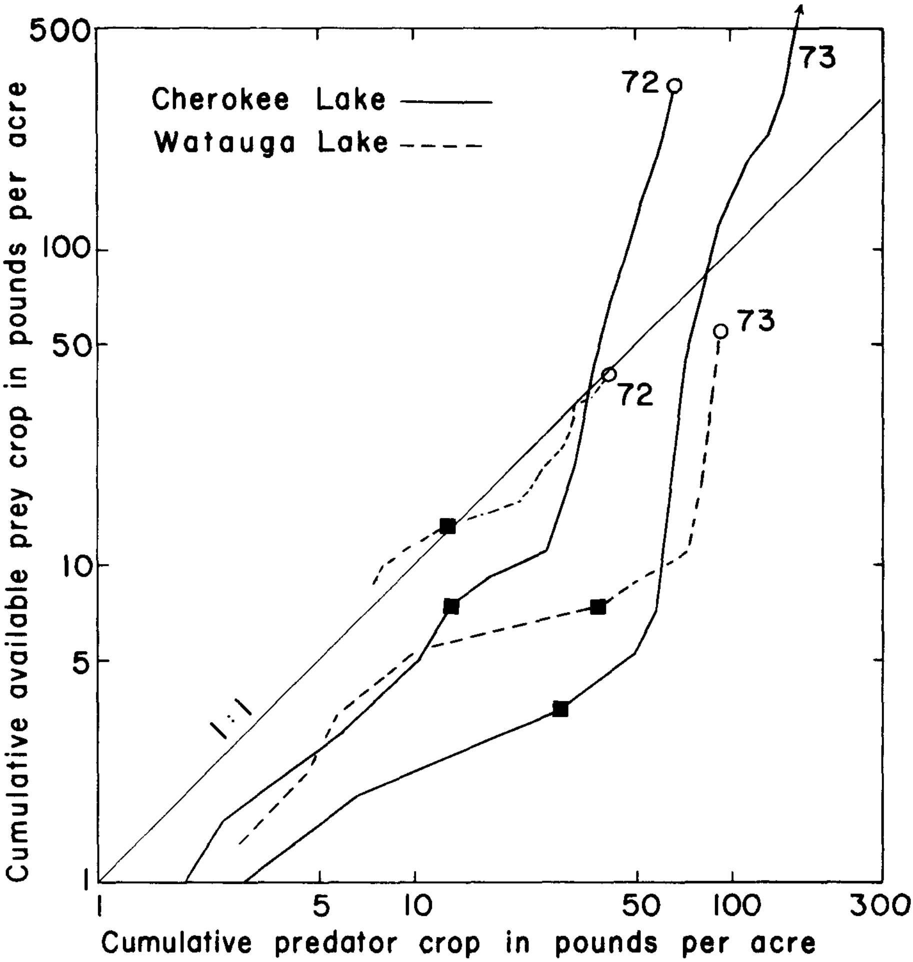

Figure 9. Logarithmic plot of cumulative AP/P ratios for Cherokee and Watauga Lakes, Tennessee, August 1972-73. Solid squares represent predators in the 6-inch length group; open circles indicate the total AP/P ratio.

Recognizing the overriding influence of environmental conditions in placing constraints on species abundance, we ascribe to the thesis that available food, and not behavior or a "space" factor, is of greatest importance in limiting predator production. Available prey is the key to differences in the success of predators, be they native or introduced. Computers now make it possible to define and combine some of these complex interspecific relationships, with realism of the results being dependent on the precision of the basic assumptions concerning food conversion efficiency and rate of prey production.

With acceptance of these assumptions, fishery managers are provided with an instantaneous measure of the adequacy of the prey base and the advisability of stocking more predators or introducing more prey species. All that is required is carefully executed cove sampling of sufficient magnitude to represent the range of habitats present (e.g.,

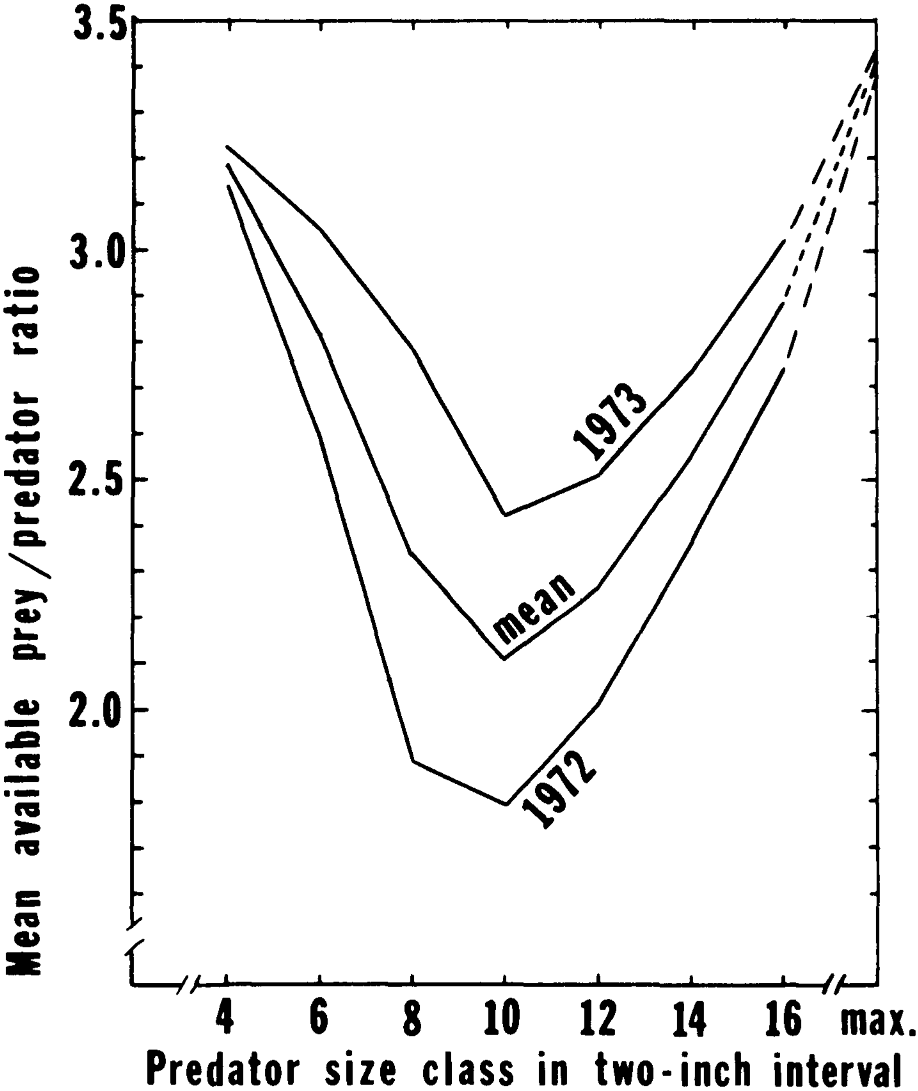

Figure 10. Average cumulative AP/P ratios arrayed at 2-inch length intervals, 4-through 16 inches, and the average total AP/P ratio ("max.") of 23 PSE reservoirs, 1972-73.

three 3-acre coves) and recording of species biomasses in 1-inch length increments. Greater precision will evolve from an expanded base of biomass data, more food studies, and long-term observations on predator harvest. Angler preferences may be further quantified and also included in the ultimate predator management model.

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