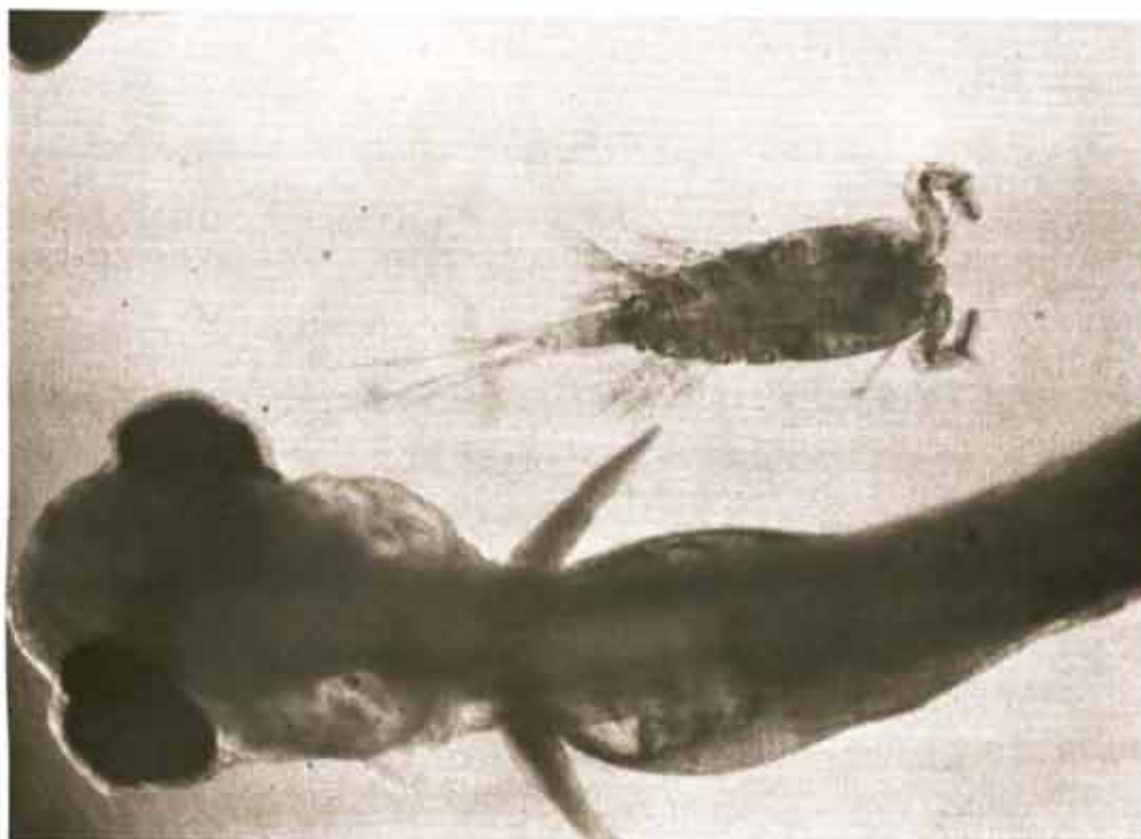


LAKE POWELL POST-IMPOUNDMENT INVESTIGATIONS

ANNUAL PERFORMANCE REPORT

1976



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**STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE RESOURCES**

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LAKE POWELL
POST-IMPOUNDMENT INVESTIGATIONS

Annual Performance Report
January 1976-December 1976

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INTRODUCTION

This report is submitted as a progress report for fishery investigations conducted on Lake Powell by the Utah Division of Wildlife Resources from February 1 through December 31, 1976. The project was funded, in part, by Federal Aid to Fish and Wildlife Restoration, Project Number F-28-R. Fishery investigations on Lake Powell began in July 1963, shortly after impoundment, and have continued to the present. Much of the initial work included physical and chemical descriptions of the reservoir and life history work on game species as sport fisheries developed. Most current work included evaluations of established fisheries, population studies of threadfin shad (Dorosoma petenense), and creation of a striped bass (Morone saxatilis) fishery. A regular creel census program was conducted to measure the magnitude and nature of sport fishing harvest, pressure, and success. Largemouth bass (Micropterus salmoides) and black crappie (Pomoxis nigromaculatus) remained the dominant species creeled. Annual trend netting surveys were conducted in March to assess available fish stocks in relation to catch from other years. Bass numbers remained high, along with plentiful numbers of walleye (Stizostedion vitreum vitreum) that have yet to be exploited by fishermen. A study of threadfin shad was begun to better understand the nature of this important forage species that has become the dominant food item for most of the reservoir's game species. Of primary importance will be evaluation of the impact of striped bass introductions on threadfin shad abundance. Experimental striped bass culture was

conducted to develop techniques for raising fry to fingerling size, suitable for stocking in Lake Powell. For the third consecutive year, fingerlings raised from cultural experiments were stocked in the reservoir. Striped bass introductions were evaluated both biologically and as a sport fishery.

THREADFIN SHAD STUDY

Job I

Background

The most important prey species, at present, in Lake Powell is the threadfin shad. Shad were introduced in 1968 and very little direct information on their status in Lake Powell has been collected. A limited amount of data concerning distribution characteristics and population dynamics was gathered after introduction and presented in annual performance reports (Gloss et al. 1970; Gloss et al. 1971). Information collected on shad utilization as food by Lake Powell fishes indicates that all major game species utilize shad to a great extent in their diets (Hepworth and Gloss 1976; May and Thompson 1974; May et al. 1975). However, little is actually known as to actual shad densities, distribution, and fluctuations on a yearly or seasonal basis. A primary reason for the lack of information is that threadfin shad inhabit mid-water zones where typical sampling with conventional entrapment gear has proven inadequate. A primary objective of the study was to develop, through mid-water trawling, an adequate system for sampling threadfin shad in Lake Powell. Data collected by trawling will be used to determine population level indices and monitor seasonal and yearly fluctuations. Also, changes in threadfin shad population levels resulting from introduction of striped bass will be evaluated. Other pertinent information relating to threadfin shad life history in Lake Powell will be collected as needed.

Methods

Trawling gear was assembled and installed aboard the Steel Clipper. Field trials were undertaken during June, 1976. After considerable experimentation, consultation, and practical experience, effective trawling was achieved. The trawl was designed after that described by von Geldern (1972). It measured 3.05 m (10 ft) square at the mouth, 15.24 m (50 ft) long, with bar mesh tapering from 20.4 cm (8 in) in the throat to 0.32 cm (1/8 in) at the cod end. Galvanized wire rope cables, attached to hydraulic winches, were used in deploying and retrieving the trawl. Two sets of depressors, of different weights, were used interchangeably to obtain different fishing depths.

A standard tow that readily captured young-of-the-year threadfin shad was designed and used to allow easy replication and consistent sampling. During each tow, the boat was operated at 1100 rpm (1.6 m/sec or 3.6 mph), while 45.72 m (200 ft) of cable was played out and immediately retrieved. Average time required per tow was 9.17 minutes. Average volume of water sampled was 8178.44 m³ and maximum depth fished was 9.1 m (30 ft) using the steel depressors. Each standard tow constituted an oblique tow or double diagonal tow. The water column from the surface to maximum depth was equally sampled. The oblique tow sampled shad in the upper 9.1 m of the water column rather than shad at any one depth. For consistency, sampling was done at night when shad were thought to be most randomly scattered throughout the upper layers of the water column (Netsch et al. 1971).

Data was collected in Wahweap Bay during August, September, and part of October, 1976. Sampling was conducted on four different nights

during August and September, and on two nights in October. Four standard tows were made per sample night. Nights were classified as either moonlit or dark to evaluate the effect of relative darkness. Sample catches were largely limited to young-of-the-year threadfin shad. Parameters measured included mean number of fish per haul and mean lengths. Sample nights were considered experimental treatments. Statistical comparison of means from two or more sample nights was made by analysis of variance. Items of particular interest for evaluation were the effect of moonlight on the number and size of fish captured. Bias incorporated into estimates from larger fish being able to detect and escape the trawl was also of interest.

Results and Discussion

An average of 50.06 shad ($6.12 \text{ per } 1000 \text{ m}^3$) were captured per tow in August and averaged 31.86 mm total length (Table 1). In September the average catch declined to 12.37 ($1.51 \text{ per } 1000 \text{ m}^3$) but average length increased to 51.92 mm. Decreased catch indicated that total numbers declined due to natural mortality and/or avoidance of the trawl increased as the fish grew. Number of threadfin shad in Wahweap Bay compared favorably with shad reported in other waters. Houser and Bryant (1967) reported a population estimate of 5.93 young-of-the-year threadfin shad per 1000 m^3 in August and 2.02 in September for Beaver Reservoir, Arkansas. For Bull Shoals Reservoir, Arkansas, they reported 6.6 and 3.43 shad per 1000 m^3 for July and September, respectively.

Preliminary investigations showed relative darkness of sample nights affected results of trawling operations. Average length of shad

captured among dark nights was compared using a one-way analysis of variance (Table 2). Differences between sample nights were found to be statistically significant. Since larger mean lengths were found later in the year, it was obvious that the significant size difference measured was the mean increase in total length as the year class grew. It was also apparent that the threadfin shad spawning season was quite long because many size ranges of shad were observed throughout the summer. Shad just beyond larval size (15 mm) were captured until the end of August. However, mean length of shad compared among samples from moonlit nights was not significantly different (Table 3). Average lengths remained low, indicating that only smaller fish were being sampled while larger individuals were able to avoid the trawl. Therefore, shad were more randomly selected on dark nights and better sampling was obtained since both large and small shad-of-the-year were collected. Mean number of shad per tow was quite uniform within a given night. Despite a sample size of only four tows per night, sample ranges were small and the coefficients of variation were all under 0.51 (Table 4).

The echo sounder was important in analyzing the distribution of threadfin shad. Daytime observations produced echograms showing occasional large schools of fish with a random scattering of individual fish above the thermocline. One drawback of the echo sounder was that it did not function properly at trawling speed due to high prop noise and air bubbles. An echogram can be produced before or after trawling runs to determine the relative distribution of fish in the trawling area.

Table 1. Mean number of threadfin shad captured per standard tow during trawling operations on Lake Powell, 1976.

Date	Number of tows	Mean catch per standard tow	Mean length	Shad per 1000 m ³
August	16	50.06	31.86	6.12
September	8	12.37	51.92	1.51

Table 2. Analysis of variance table comparing mean length of shad captured per standard tow on dark, moonless nights.

Source	df	SS	MS	F
Among nights	5	5,543.86	1,108.77	30.17 ^a
Error (within nights)	17	624.82	36.75	
Total	22	6,186.68		

^aF (5, 17, .01) = 4.56

Table 3. Analysis of variance table comparing mean length of shad captured per standard tow on moonlit nights.

Source	df	SS	MS	F
Among nights	2	687.86	343.93	3.57 NS ^a
Error (within nights)	6	577.77	96.295	
Total	8	1265.63		

^aF (2, 6, .01) = 10.9

Table 4. Average catch per standard tow of young-of-the-year threadfin shad on dark, moonless nights, 1976.

Date	No. hauls	Mean (standard deviation)	Range	Coefficient of variation
8-17	4	56.0 (17.24)	35-107	0.30
8-24	4	68.5 (8.44)	46- 86	0.12
8-26	4	21.0 (3.85)	14- 32	0.18
9-15	4	9.0 (4.66)	0- 18	0.51
9-24	4	15.8 (2.39)	12- 22	0.15

Threadfin shad spawning information was collected in conjunction with trawling operations. The first observed spawning of shad occurred on May 19 at Bullfrog Marina with a water temperature of 69 F. The peak of the spawning period was about June 6 with the last observed spawning on June 21. Unconfirmed reports indicated that spawning occurred two weeks earlier at Hite near the inlet of the Colorado River. Spawning was not observed at Wahweap but was estimated to have occurred two weeks later than the Bullfrog observation. Additional life history information will continue to be collected during the next project segment.

The pelagic nature of the black crappie was also noted. During night trawling operations in August, 53 crappie fry and 5 adults were captured. The capture rate was 15 shad to 1 crappie. Crappie fry averaged 12 mm in length with a range of 7-15 mm. Crappie fry or young were not taken in September. Adult crappie were taken occasionally but not in significant numbers.

Recommendations

Better sampling could be achieved in several ways. Variability among tows within nights can be reduced by increased sampling. Sampling for the next segment should be modified from four to six tows per night. Catch rates among sample nights should measure natural mortality of shad as it occurs with time. Experimental error enters the estimate from such variables as wind, weather, moon phase, and changing ability of shad to escape the trawl as they become larger. Future sampling should take into account lunar cycles to avoid bias from this source. Influence from other variables will be assumed to be negligible.

Trawling operations should be conducted weekly during the next segment to determine seasonal changes in abundance and biomass. Sampling should also be conducted in different reservoir areas to better determine horizontal distribution. Data will be collected during the next segment to measure seasonal and annual changes in the shad population and the impact of striped bass introduction on shad abundance.

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MEASUREMENT OF FISHERY HARVEST, PRESSURE, AND SUCCESS

Job II

Background

Creel census has been conducted annually on Lake Powell since 1964. Because of the unique nature of Lake Powell's location and inaccessability to automobiles, censusing has been accomplished at the four major access areas of Wahweap, Bullfrog, Hall's Crossing, and Hite. The program has been designed to obtain estimates of fishing harvest, pressure, and success. Results for individual years are available in annual performance reports (Stone 1965, 1966, 1967, 1971, and 1972; Stone and Rathbun 1968 and 1969; Rathbun 1970; Gloss et al. 1970, 1971, and 1973; May and Hepworth 1975; Hepworth et al. 1976). A report describing trends and changes in the fishery since impoundment is being prepared and will be published separately. Current plans are to conduct a comprehensive creel census every other year. During these years a regular scheduled census will be conducted March through September. Past experience has shown that approximately 90 percent of fishing use occurs within these months. During interim years, a less comprehensive interview program will be conducted only during the period of intensive angling. Although sampling was restricted to the reduced schedule during 1976, program work included evaluation of creel techniques used to estimate pressure.

Methods

Lake Powell project personnel conducted a scheduled creel census at the four major access areas (Wahweap, Bullfrog, Hall's Crossing,

and Hite) during April, May, and June. A total of 20 days per month were devoted to the creel program. Sample days were selected on a random basis with Wahweap being censused 10 days, Bullfrog 6 days, Hall's Crossing 3 days, and Hite 1 day. Fishermen were interviewed at boat ramps as they returned from the lake.

Project personnel also conducted a study of the method utilized by the National Park Service (NPS) to estimate monthly boat use; the objective being to determine the feasibility of using NPS data to calculate fishing pressure estimates. Each census day, three boat trailer counts were made at random hours selected throughout the day. These data were compared to the single 1 pm trailer count made by the NPS on the same days. Means were used to compare data and determine patterns in pressure not measured by the NPS single daily count.

The NPS reports monthly boat use as a total summation of counts made each day. It is assumed that all users are on the lake at 1 pm and recorded by a count at that time. No adjustments or expansions are applied to the data, as monthly total boat trips are estimated strictly by total enumeration. This method is an underestimate simply because some boaters arrive after 1 pm and others leave before 1 pm and are not taken into consideration by the NPS count. Possibly, a better value may be obtained by using NPS and Division of Wildlife Resources (DWR) data combined. Data can be applied to formulas estimating pressure by expanding instantaneous counts over a defined

period of time. For example:

1. Total NPS trailer counts for a month = 6,000; giving an underestimated NPS boat use total of 6,000 boat trips per month.
2. $6,000 \text{ total boat count} \div 30 \text{ counts/month} = 200 \text{ instantaneous boats per count.}$
3. $200 \text{ boats/count} \times 12 \text{ hours/day} \times 30 \text{ day/month} = 72,000 \text{ boat hours/month.}$
4. $72,000 \text{ boat hours/month} \div 8 \text{ hours/trip (from DWR creel data)} = 9,000 \text{ boat trips per month.}$

This second estimate is likely to be high because all trailer counts were made at 1 pm, a probable time of high use. Assuming DWR randomized daily counts show the actual hourly average for a day to be 10 percent lower, a correction factor could be applied. By reducing all NPS boat trailer counts by 10 percent an even better estimate could be obtained:

5. $200 \text{ instantaneous boats/count} \times .10 \text{ reduction factor} = 180 \text{ instantaneous boats/count.}$
6. $180 \text{ boats/count} \times 12 \text{ hours/day} \times 30 \text{ days/month} \div 8 \text{ boat hours/trip} = 8,100 \text{ boat trips per month.}$

This last estimate of 8,100 boat trips lies intermediate between the known low value of 6,000 obtained by simply summing observed use each day and the high value of 9,000 obtained by using daily counts in the same manner that randomized counts would be used in standard fishing pressure formulas.

Results and Discussion

Results show that randomized counts made by project personnel were consistently lower than NPS counts (Table 5). Difference between means derived from all counts was 10.3 percent. On the average, it appears that a 1 pm count occurs at a time of high use and when used as an instantaneous count and expanded, gives an overestimate of actual pressure.

Length of the average boating trip, as determined by creel interviews, was 8.0 hours for the three month period (Table 6). During May, the average trip was 8.9 hours, but decreased to 7.0 hours in June.

Using the above procedure, total fishing pressure for the three months censused was 72,331 angler days (Table 7). The greatest fishing pressure occurred during April and May, with 39.0 percent and 39.4 percent, respectively. Wahweap accounted for the majority of the angling effort with 42.6 percent of the total pressure. Bullfrog, Hall's Crossing and Hite had a combined total of 57.4 percent.

The majority of anglers using Lake Powell were from Utah and Arizona (Table 8). As could be expected, most anglers censused at Wahweap were from Arizona (77 percent). The upper portion of the lake (Bullfrog, Hall's Crossing, and Hite) accounted for most of the Utah anglers censused (84 percent). Bullfrog registered an increased use by Utah anglers in 1976. Approximately 10 percent more Utahns were censused than in 1975 (43.3 percent in 1975 to 53.6 percent in 1976). A similar increase was noted for Hall's Crossing which rose from 25.9

Table 5. Comparison of mean sample trailer counts taken by the National Park Service and the Division of Wildlife Resources from similar dates on Lake Powell, April through June, 1976.

Location	NPS		DWR		Percent difference
	No. counts	Mean	No. counts	Mean	
Wahweap	30	298	90	280	- 6.0
Bullfrog	18	236	54	196	-16.9
Hall's Crossing	9	71	27	56	-21.1
Hite	3	81	9	52	-35.8
All areas	60	234	180	210	-10.3

Table 6. Mean length of boating day (hours) on Lake Powell by access area and month, April-June, 1976.

Location	April	May	June	Mean
Wahweap	7.0	8.0	7.0	7.3
Bullfrog	8.5	9.6	7.0	8.4
Hall's Crossing	9.1	8.9	7.0	8.3
Hite	7.4	9.0	7.0	7.8
Mean	8.0	8.9	7.0	8.0

Table 7. Total estimated fishing pressure in angler days, by access area, Lake Powell, April-June, 1976 (percent of total pressure is given in parentheses).^a

Month	Wahweap	Bullfrog	Hall's	Hite	Total
April (39.0)	8,760	10,998	3,954	4,542	28,244
May (39.4)	15,921	9,042	3,224	277	28,464
June (21.6)	6,095	6,181	1,902	1,445	15,623
Total (100.0)	30,776 (42.6)	26,211 (36.3)	9,080 (12.7)	6,264 (8.4)	72,331

^aEstimates were determined by applying Division of Wildlife Resources creel census data to adjusted National Park Service monthly boat use figures.

Table 8. Residence of anglers on Lake Powell by percent, determined for each access area, April-June, 1976.

State	Wahweap	Bullfrog	Hall's	Hite
Utah	7.0	53.6	34.1	37.3
Arizona	77.0	4.2	9.3	30.0
Colorado	2.3	33.7	29.3	23.7
California	8.3	4.3	3.7	0.0
New Mexico	2.3	0.2	17.3	5.0
Other States	3.1	4.0	6.3	4.0

percent Utah anglers in 1975, to 34.1 percent in the 1976 creel census. Colorado anglers primarily frequented the upper portion of the lake (28.9 percent) while Wahweap had only 2.3 percent Colorado use.

A total of 1,114 interviews over the three month creel census program produced a total of 3,136 anglers, who spent 11,670 hours and caught 5,887 fish (0.51 fish per hour, Table 9). Fishing was best in April and May when the average catch rate was 0.58 and 0.54, respectively. Average catch rate for bass was 0.23 fish per hour, while crappie were taken at 0.22 fish per hour. Hite had the best catch rate of all the access areas with an average of 0.60 fish per hour (Table 10). Crappie were the predominant species harvested during spring and early summer by Lake Powell anglers (Table 11). Approximately 47 percent of all fish checked by creel clerks were crappie. Bass harvest was a close second at 42.3 percent. Walleye appeared in the creel at Wahweap and Hite, making up 0.5 percent and 3.1 percent of the total creel, respectively. Bullfrog and Hall's Crossing produced the best crappie catches as indicated by both catch rates and percent of total catch. Bass harvest appeared best at the extreme ends of the lake with Hite and Wahweap having the best results.

Recommendations

Pressure estimates at Lake Powell should continue to be made by incorporating NPS boat use data. Under a practical work load, project personnel were able to make only 60 counts per month. The NPS, located at each access area, made 120 counts per month. Since NPS counts are made each day, a good measure of the variability among days is obtained and the possibility of error from this source is

Table 9. Fish harvested per hour by species and month, Lake Powell, April-June, 1976.

Species	April	May	June	Total
Largemouth bass	0.23	0.23	0.20	0.23
Black crappie	0.33	0.26	0.07	0.22
Bluegill	0.02	0.04	0.03	0.04
Channel catfish	t ^a	0.01	0.06	0.02
Rainbow trout	t	t	0.01	t
Walleye	0.00	t	0.01	t
Striped bass	0.00	t	t	t
Total	0.58	0.54	0.38	0.51

^a t = less than 0.01 fish per hour.

Table 10. Mean number of fish harvested per hour by species and access area, Lake Powell, April-June, 1976.

Species	Wahweap	Bullfrog	Hall's	Hite	Mean
Largemouth Bass	0.26	0.14	0.11	0.39	0.23
Black crappie	0.18	0.30	0.22	0.16	0.22
Bluegill	0.02	0.05	0.05	0.02	0.04
Channel catfish	0.03	0.01	0.02	0.02	0.02
Rainbow trout	0.01	0.00	t	0.00	t
Walleye	t ^a	0.00	0.00	0.01	t
Striped bass	t	0.00	0.00	0.00	t
Total	0.51	0.50	0.41	0.60	0.51

^a t = less than 0.01 fish per hour

Table 11. Percent species composition of fish harvested by access area, Lake Powell, April-June, 1976.

Species	Wahweap	Bullfrog	Hall's	Hite	Mean
Largemouth bass	51.3	26.8	26.0	64.6	42.2
Black crappie	41.0	61.9	60.1	26.0	47.3
Bluegill	2.3	10.4	10.5	3.9	6.8
Channel catfish	3.6	0.9	3.0	2.4	2.5
Rainbow trout	1.1	t ^a	0.4	t	0.3
Walleye	0.5	t	t	3.1	0.9
Striped bass	0.2	t	t	t	t

^at = less than 0.1 percent

largely eliminated from the estimates. As mentioned previously, errors made from making only one daily count can be corrected by utilizing data obtained from project creel census. Monthly NPS figures, obtained by total enumeration, can still be used as long as it is realized they represent minimum values and that actual use would be somewhat greater.

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INDEX TO ANNUAL FISH POPULATION TRENDS

Job III

Background

To understand changes that occur in fish populations, it becomes necessary to sample populations on a scheduled basis. The dynamic nature of a reservoir such as Lake Powell creates the need for annual sampling of the resource. Data collected in a standardized manner provides information on gross changes and trends occurring in the fishery. Possible changes in numbers of rough fish or game fish can be monitored and provide valuable help in future management decisions. Annual gill netting in Lake Powell has taken place during March since 1971. Variables influencing catch, such as locations and habitat fished and number and style of nets, have been held as constant as possible between years. Results have generally shown a healthy population of largemouth bass and increasing numbers of walleye. Electro-fishing, as a sample technique, is being evaluated to possibly supplement gill netting data.

Methods

Project personnel conducted standardized gill net sampling in March, 1976, at Padre Bay, Cha Canyon, Rincon, and Red Canyon. Ten experimental diving gill nets were fished for three consecutive days at each station. Each net had four 25-foot panels consisting of 1, 1 1/2, 2, and 3 inch bar mesh. All nets were set perpendicular to the shore in similar rock and rubble habitat. Catch was recorded by

species and number. Lengths and weights were taken from each fish.

Final installation and testing of the electrofishing boat and evaluation of sampling techniques was also begun. Periodic field trials were made throughout the summer and fall. Best results were obtained at night in shallow water (less than 10 feet). A new fiberglass hull was obtained for the electrofishing boat; modifications and transfer of the electrode system will soon be complete. Continued evaluation of sampling techniques will begin in early spring and proceed throughout the year. Emphasis will be placed on collecting data pertaining to numbers and size by species per unit effort, and seasonal changes in catch efficiency related to available habitat. If data justifies, a standardized sampling scheme will be developed and used to supplement data collected during annual trend netting.

Results and Discussion

The 1976 annual netting produced a total of 741 fish for a catch rate of 6.2 fish per net (F/N, Table 12). This compared to a high of 10.1 F/N obtained in 1972 and a low of 4.0 F/N in 1971. Of the 741 fish, approximately 44 percent were bass and an additional 34 percent walleye (Table 13). This year's catch contained the lowest percentage of bass since 1971 and the highest percentage of walleye captured in six years of netting. However, a comparison of bass and walleye catch rates from annual netting 1971 through 1976 showed bass numbers to be relatively stable (Figure 1). Bass numbers appeared to be fluctuating around a fixed population level with no indication of either increasing

Table 12. Number of nets set, number of fish captured, and catch rate (F/N) for standardized annual gill netting, Lake Powell, 1971 - 1976.

Date	Padre Bay			Ocha Canyon			Rincon			Red Canyon			Total		
	No. nets	No. fish	F/N	No. nets	No. fish	F/N	No. nets	No. fish	F/N	No. nets	No. fish	F/N	No. nets	No. fish	F/N
1971	18	54	3.0	-	-	-	-	-	-	31	142	4.6	49	196	4.0
1972	22	281	12.7	24	230	9.6	24	252	10.5	24	191	8.0	94	954	10.1
1973	30	128	4.3	30	165	5.5	30	139	4.6	30	105	3.5	120	502	4.2
1974	30	211	4.3	30	212	7.1	30	182	6.1	30	154	5.1	120	759	6.3
1975	30	200	6.7	30	276	9.2	30	237	7.9	30	248	8.3	120	961	8.0
1976	30	152	5.1	30	132	4.4	30	242	8.1	30	215	7.2	120	746	6.2
Total	160	1026	6.4	144	1015	7.0	144	1052	7.3	175	1055	6.0	623	4148	6.7

Table 13. Catch rate (F/N) and percent of catch by species and year, annual gill netting, Lake Powell, 1971-1976.

Species	1971		1972		1973		1974		1975		1976	
	Catch % of rate catch		Catch % of rate catch		Catch % of rate catch		Catch % of rate catch		Catch % of rate catch		Catch % of rate catch	
Largemouth bass	1.65	41.3	5.82	57.4	2.71	62.3	4.01	63.4	4.49	56.1	2.72	43.9
Walleye	0.29	7.1	1.12	11.0	0.41	9.4	1.09	17.3	2.15	26.8	2.11	34.1
Black Crappie	0.12	3.1	0.67	6.6	0.20	6.1	0.27	4.2	0.36	4.5	0.27	4.3
Bluegill	0.12	3.1	0.52	5.1	0.06	1.3	0.05	0.8	0.04	0.5	0.10	1.6
Green Sunfish	0.10	2.5	0.16	1.6	0.09	2.1	0.13	2.0	0.06	0.7	0.04	0.7
Channel catfish	0.12	3.1	0.43	4.2	0.21	4.6	0.14	2.3	0.25	3.1	0.16	2.6
Carp	1.14	28.6	0.79	7.8	0.32	7.3	0.34	5.4	0.36	4.4	0.38	6.2
Flannemouth sucker	0.18	4.6	0.28	2.7	0.21	2.5	0.17	2.6	0.08	0.9	0.08	1.3
Rainbow trout	0.24	6.1	0.31	3.0	0.10	2.2	0.08	1.2	0.19	2.4	0.25	4.0
Brown trout	0.02	0.5	0.00	0.0	0.01	0.2	0.03	0.5	0.04	0.5	0.04	0.7
All species	3.98		10.12		4.24		6.31		8.02		6.15	

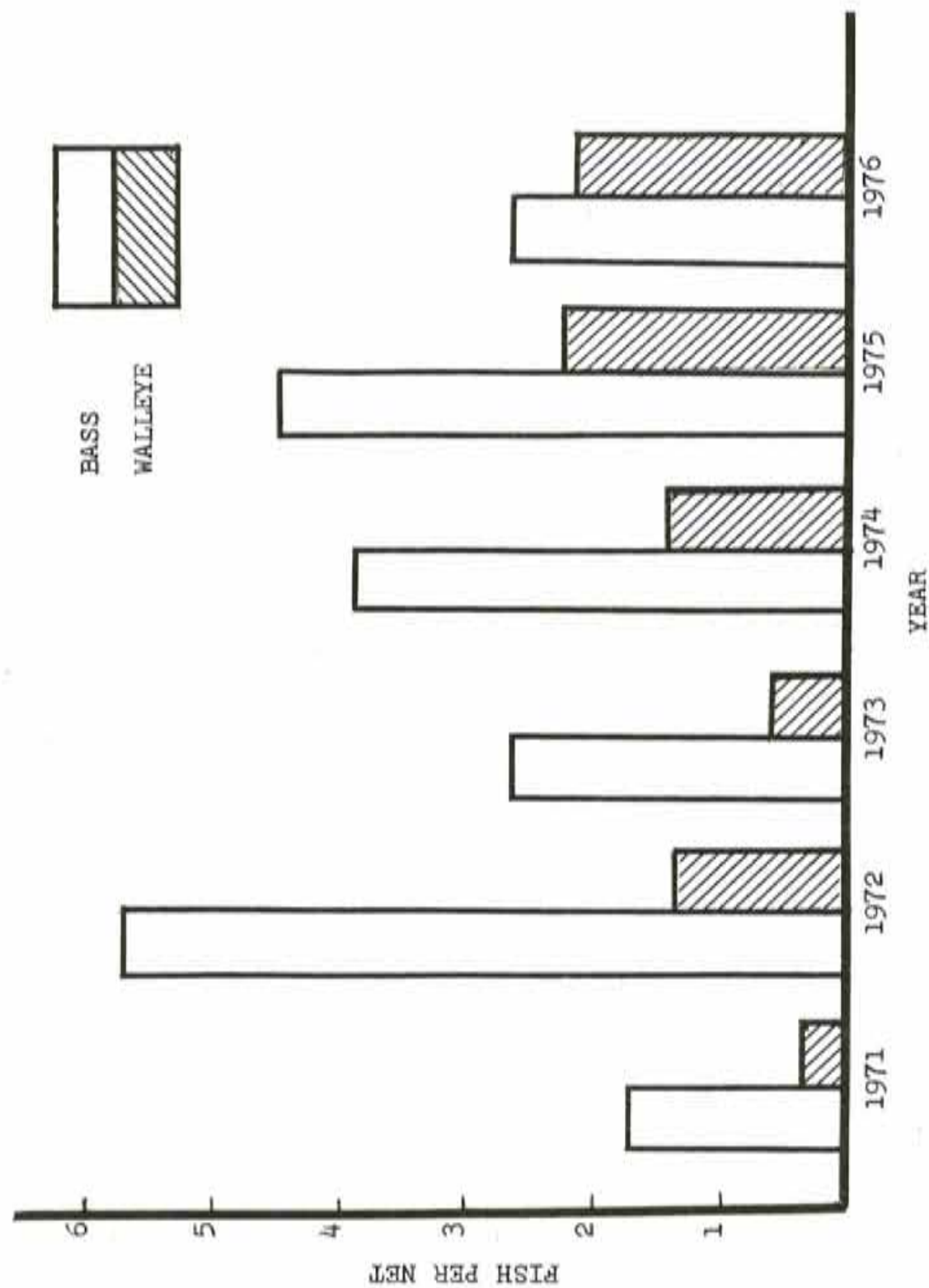


Figure 1. Number of bass and walleye per net, annual gill netting, 1971-1976.

or decreasing trends. Number of walleye per net indicated an increasing trend over the six-year study period. However, a drop from 2.15 F/N in 1975 to 2.11 F/N in 1976 could indicate a possible leveling off of walleye numbers.

Gill nets placed at the Rincon produced the largest catch of bass, with 130 fish being netted in three days (Table 14). Cha Canyon was second with 97 fish. The largest catch of walleye occurred at Red Canyon (130 total walleye). Red Canyon's catch changed from predominantly bass in 1975 to walleye in 1976. The 1975 sample produced 124 bass and 83 walleye (only 48 bass were netted in 1976). Walleye also exceeded bass in numbers at Padre Bay (51 bass and 54 walleye) and at Red Canyon in 1974 (53 bass and 57 walleye). At other locations numbers of bass have always predominated.

When comparing mean total lengths of all bass netted since 1971, there appeared to be no difference either between areas or years netted (Table 15). The slight increase in length of fish captured at up lake locations compared to lower lake locations failed to be significant ($P = 0.05$) when analyzed by one-way analysis of variance. Mean length of bass netted in 1976 was 347 mm and ranged from 165 mm to 500 mm (Figure 2). Approximately 94 percent of all bass netted were in the range of 250 mm to 400 mm. Walleye averaged 496 mm with a range of 265 mm to 725 mm. Walleye in the size range of 400 mm to 600 mm dominated the catch (88 percent).

Table 14. Number of fish caught by species and netting location, Lake Powell, March 1976.

Species	Padre Bay	Cha Canyon	Rincon	Red Canyon	Total
Largemouth bass	51	97	130	48	326
Walleye	54	7	62	130	253
Black crapple	6	8	13	5	32
Bluegill	4	3	4	1	12
Green sunfish	1	0	4	0	5
Channel catfish	4	2	7	6	19
Black bullhead	0	0	0	3	3
Carp	11	1	17	17	46
Flannemouth sucker	1	3	2	4	10
Rainbow trout	18	11	1	0	30
Brown trout	2	0	2	1	5
Total	152	132	242	215	741

Table 15. Mean length (mm) of Largemouth bass captured in annual gill netting, 1971-1976.

Year	Padre Bay	Cha Canyon	Rincon	Red Canyon	Mean
1971	305.4	321.6	-	324.4	319.6
1972	353.6	319.1	340.5	340.3	320.5
1973	305.3	341.0	362.4	351.8	343.3
1974	282.7	310.5	337.1	338.7	311.7
1975	337.9	316.1	340.0	342.1	330.3
1976	343.3	346.6	346.3	354.4	346.7
Mean	321.0	323.5	329.4	343.6	

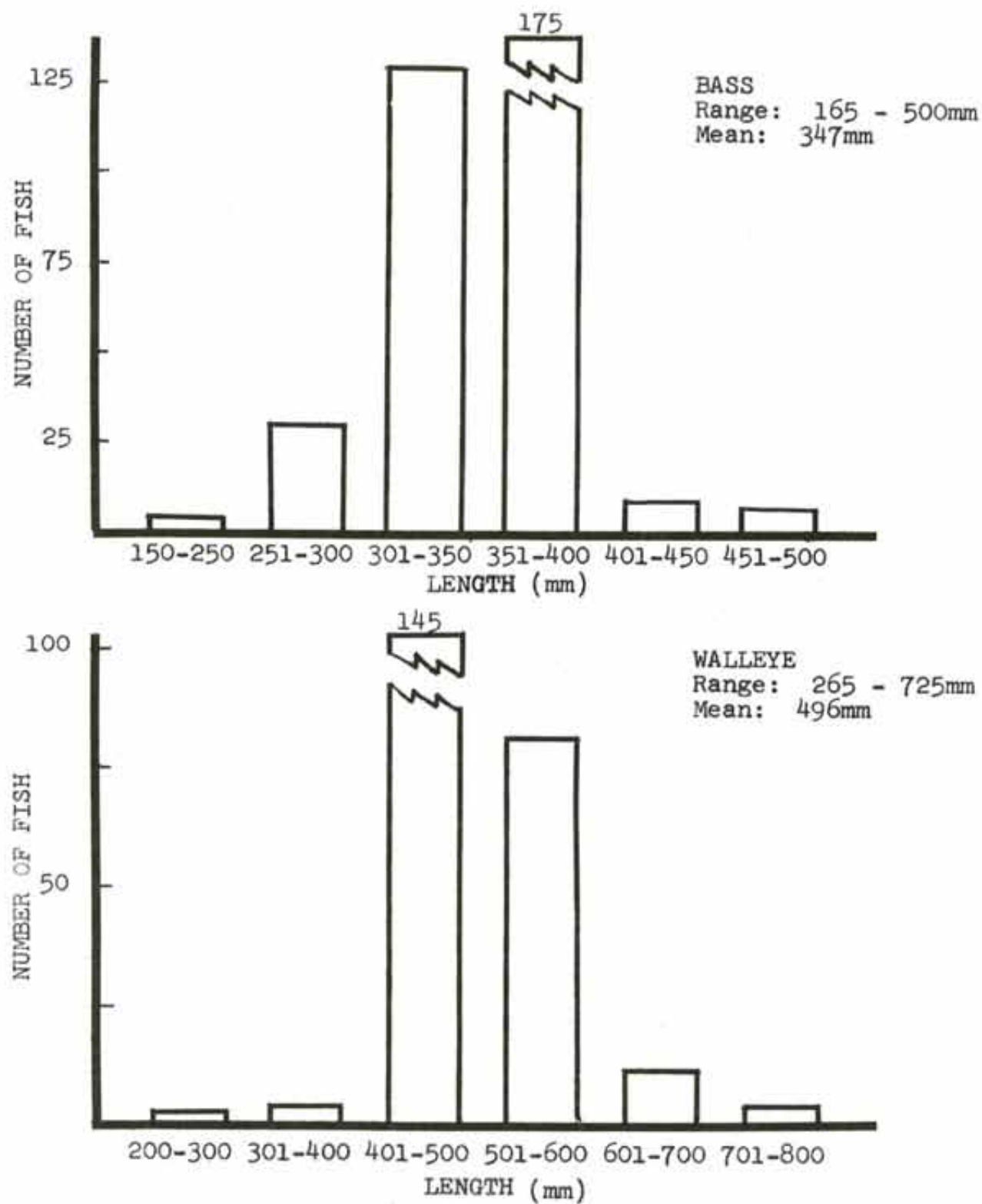


Figure 2. Length frequency distribution of bass and walleye, annual netting, 1976.

STRIPED BASS CULTURE

Job IV

Background

The establishment of a striped bass fishery in Lake Powell is a primary research and management objective of the Lake Powell study. Introduction of fingerling striped bass has been the most successful technique of establishing inland fisheries and is generally necessary to maintain fisheries because of unsuccessful natural reproduction (Bailey 1973). To provide striped bass for Lake Powell, an experimental cultural pond facility was constructed and completed in 1973. Objectives of culture studies are to evaluate variables affecting survival and growth of pond cultured striped bass and develop techniques for rearing larval striped bass to fingerling size. Initial work has included studies on plankton response to fertilization and evaluation of stocking densities of striped bass fry (Gloss et al. 1974; May and Hepworth 1976; Hepworth et al. 1976). Fry are available from donor states from approximately late March through early June. Since desirable 2 inch fingerlings can be cultured in 60 days, there is a possibility of producing two crops within a single season. Production results among ponds have been highly variable, ranging from 0 - 67,955 fingerlings per acre. Total production of a pond is thought to be largely determined by the amount of mortality experienced the first 1 - 2 weeks after stocking fry. Poorly timed plankton blooms, resulting in inadequate food supplies and high predation on fry, likely contribute to low yields. Primary objectives for 1976 were to (1) experimentally

determine when ponds should be filled and fertilized in relation to time of fry arrival and (2) determine the feasibility of producing two crops of striped bass fingerlings in one season.

Methods

Ponds were divided into three treatments, each replicated twice. Treatments included (1) filling and fertilizing well in advance of fry arrival, (2) filling well in advance of fry arrival, but fertilizing just prior to fry arrival, and (3) filling and fertilizing just prior to fry arrival. In early March, ponds 2, 4, 5, and 6 were filled. Ponds 2 and 5 were immediately fertilized. Ponds 4 and 6 were not fertilized until the end of March, approximately one week prior to stocking of fry. Ponds 1 and 3 were filled and fertilized less than one week in advance of fry arrival. Initial fertilization rates were held constant (3,750 lbs alfalfa hay per acre) with supplemental additions added as needed to keep plankton densities high (Table 16). Plankton samples were taken every four days for quantitative and qualitative comparisons. On April 3, all ponds were stocked at an estimated rate of 140,000 fry per acre. All fry were tempered and stocked after dark and held in seran cloth tempering baskets for observation. Baskets were suspended at a variety of locations in each pond. It was hoped that 2 inch fingerlings could be produced by early June and another crop started at that time.

Because of poor results obtained from the first shipment, plans to produce two crops of striped bass were cancelled and a second shipment of fry was obtained to replace initial losses. Fry from the first

shipment were used to stock ponds 2 and 5, while ponds 1, 3, 4, and 6 were stocked from the second shipment. The second shipment of fry was not received until May 17, well over a month after the first shipment. Because of the uncertainty of when more fry would arrive, water levels were maintained in unstocked ponds for most of the interval. Supplemental fertilizer was added in an attempt to hold plankton blooms at high densities (Table 16). Ponds 1 and 4 were finally drained for a short time and refilled to evaluate the effect on zooplankton numbers. Attempts were made to compare survival, growth, and food habits of newly introduced fry to amounts and kinds of zooplankton present in each pond. Emphasis of study was during the first month after stocking fry. Small numbers of fry were retained in tempering baskets in each pond to facilitate observations and collection of samples.

Subsequent to harvest of fingerling striped bass, two ponds were used to experiment with inorganic fertilizer as a means of producing zooplankton. Ponds were allowed to dry for one month. Vegetation and organic matter was removed by burning. Both ponds were filled on August 18 and fertilized at the rate of 75 lbs per acre with 20-20-20 inorganic. Additional fertilizer (20-20-20) was added each week thereafter at the rate of 10 lbs per acre, until ponds were drained on September 17. Both ponds were treated alike to determine what type of variation due to uncontrolled variables might be expected between individual ponds. Plankton samples were taken every five days for quantitative and qualitative analysis.

Table 16. Alfalfa hay fertilization schedule (total lbs) for striped bass culture ponds, 1976 (20-20-20 inorganic in parentheses).

Date	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6
March 8		1,500			10,000	
March 29				4,150		12,500
April 1	1,500	(50)	3,750			
April 25		(35)			(65)	
April 27		(15)			(35)	
May 4	500			1,250		
May 15			500			1,250
May 28				100		250
May 29				200		250
May 30				(20)		(30)
May 31			(10)			250
June 1				(20)		(30)
June 17	(4)		(10)	(10)		(26)
June 22	(5)					
June 24				(15)	(10)	(25)

Results and Discussion

Striped bass culture continued to show great variability among individual culture ponds. Production of fingerlings ranged from near zero to over 41,000 per acre (Table 17). A total of 56,044 fingerling striped bass were produced from six ponds for a mean of 5,561 per acre. However, combined totals from ponds 2, 3, and 4 contributed less than 1.0 percent of all fingerlings harvested.

Complete mortality of fry was experienced after stocking on April 3 in baskets located in recently fertilized ponds (1,3,4, and 6). All baskets located in ponds fertilized in early March contained fry in excellent condition (ponds 2 and 5). Analysis of the alfalfa hay indicated the presence of Methoxychlor, an insecticide, at a concentration of 4 ppm. Apparently the insecticide persisted inside cut and bailed hay during two years of storage and remained toxic for a short time after being introduced into the ponds. Korn and Earnest (1974) reported a 96-hour LC_{50} of 0.0033 ppm Methoxychlor for fingerling striped bass. Evidently the chemical had broken down in ponds 2 and 5 by the time fry were introduced. Additional fry for restocking were not immediately available from donor states and planned evaluation of experimental pond treatments was not possible.

Fry in ponds 2 and 5 were released from the baskets at 6 days of age. A small sample of fry was retained in one basket in pond 5 to evaluate survival, growth, and food habits. Samples of 8 - 12 fish were taken from the basket every 2 - 4 days for analysis. Water temperatures during April ranged from 50 - 60 F. Optimum temperatures

Table 17. Striped bass harvest, 1976.

Pond	Source of fry	No. released from tempering baskets	Number fingerlings produced	Fingerlings produced per acre	Percent survival
1	Cal.	60,000	16,515	41,288	27.53
2	S.C.	34,000	120	300	0.35
3	Cal.	150,000	390	390	0.26
4	Cal.	160,000	9	8	0.006
5	S.C.	410,000	5,530	1,784	1.35
6	Cal.	560,000	33,480	8,585	5.98

for striped bass fry have been reported to be 62-67 F (Shannon 1970; Bonn et al. 1975). Although fry continued to survive, little feeding activity or growth occurred until water temperatures began to increase in May. It eventually took 90 days to produce 2 inch fingerlings, compared to a normal 60-day period for ponds stocked later in the year (Figure 3). Production and survival from ponds 2 and 5 was also below normal (Table 16).

Draining and refilling ponds 1 and 4 shortly before restocking of fry caused changes in plankton populations (Figures 4 and 5). In both cases, populations of copepods developed quickly after refilling. Pond 4 had a dense population of cladocerans prior to draining, which failed to regain previous numbers after refilling. Draining and refilling appeared to have some value in reducing numbers of large plankters and repopulating ponds with smaller organisms. Pond 1 proved to be the most productive pond of the year. Like the more successful ponds in previous years, pond 1 failed to produce a plankton bloom until shortly after striped bass fry were stocked. Fry were able to grow and develop with the plankton population. Larger food items became available as fry increased in size.

Food habits of fry from age 10 to 32 days are described in Figure 6. For the first 8 days after feeding commenced, fry preferred small nauplii copepods, which made up 61.9 percent of the diet by number. Adult copepods were also important, making up 36.1 percent of the diet. As fry became larger (20 - 32 days old), adult copepods became more important in the diet (67.8 percent). Nauplii copepods, however, still

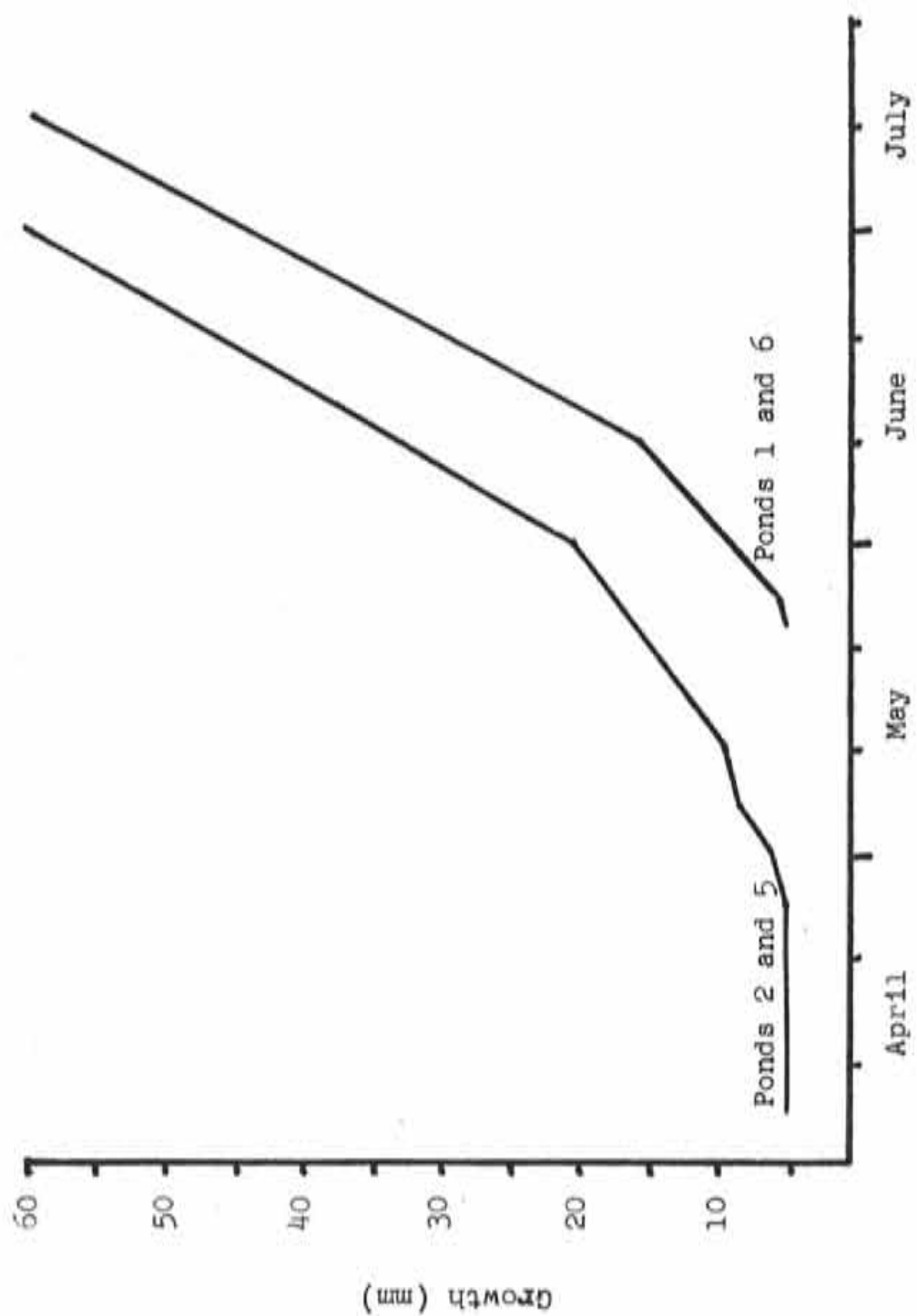


Figure 3. Growth of pond cultured striped bass comparing fry stocked in early April versus fry stocked in May, 1976.

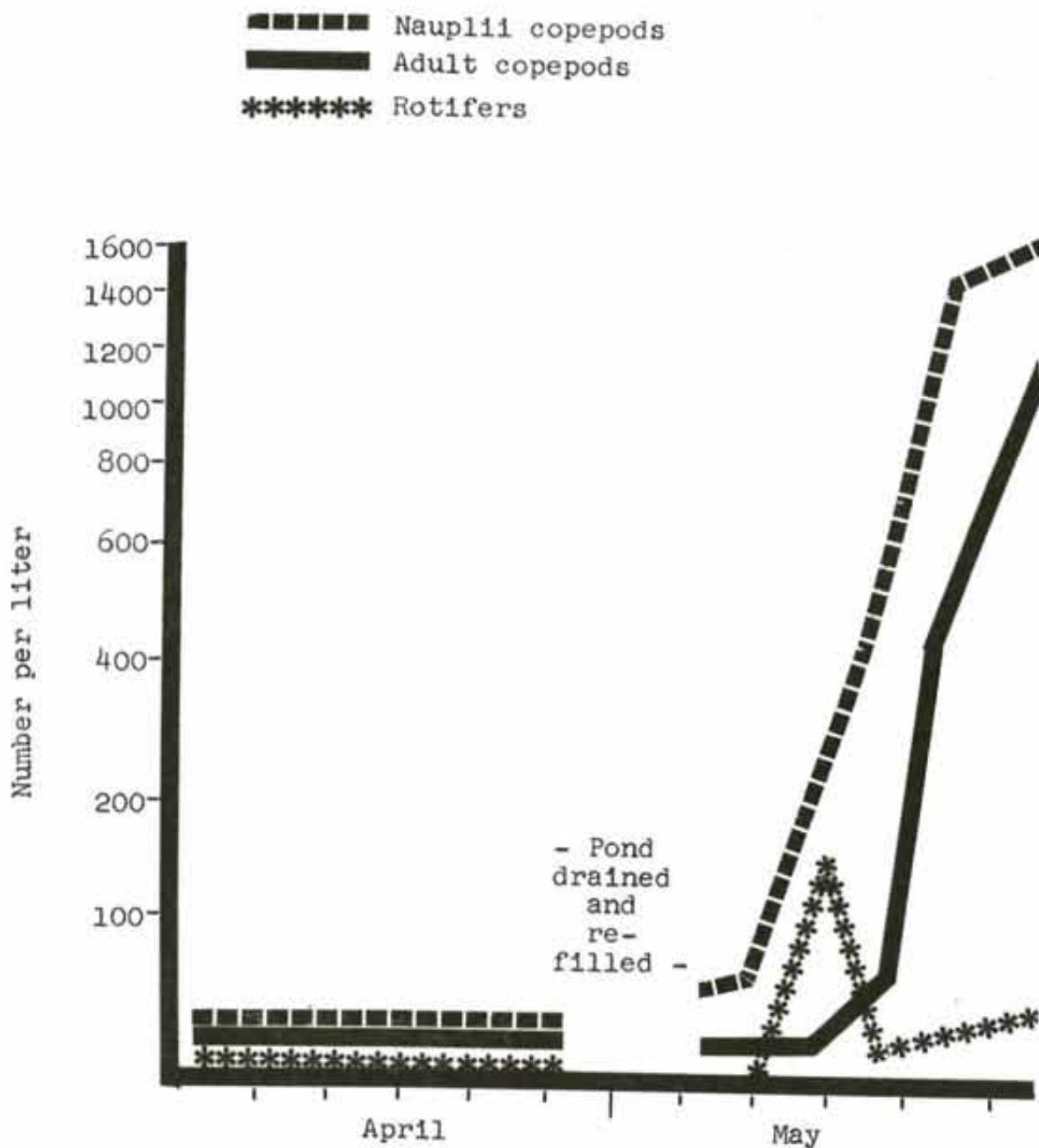


Figure 4. Changes in abundance of predominant zooplankton found in pond 1, 1976.

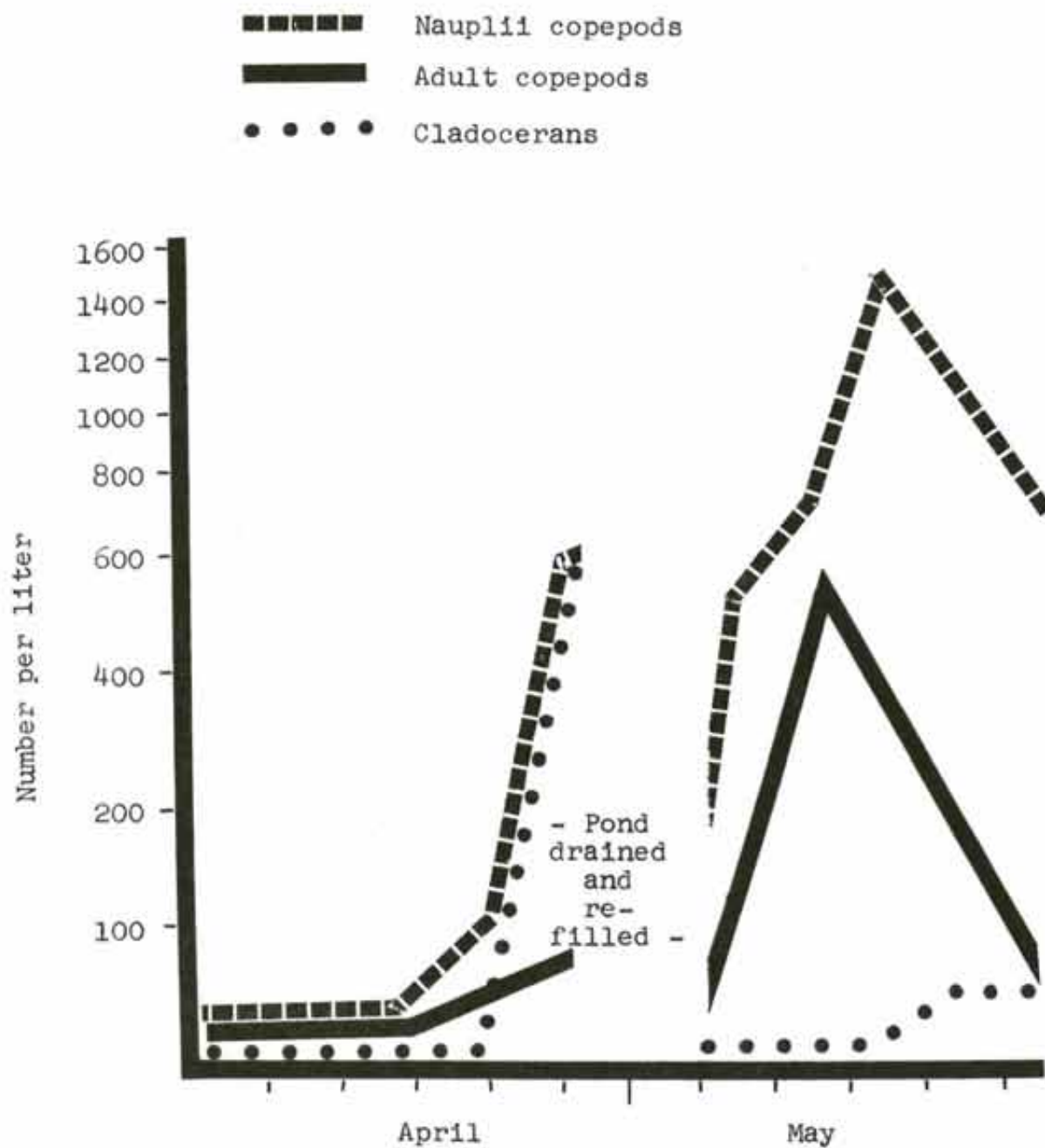
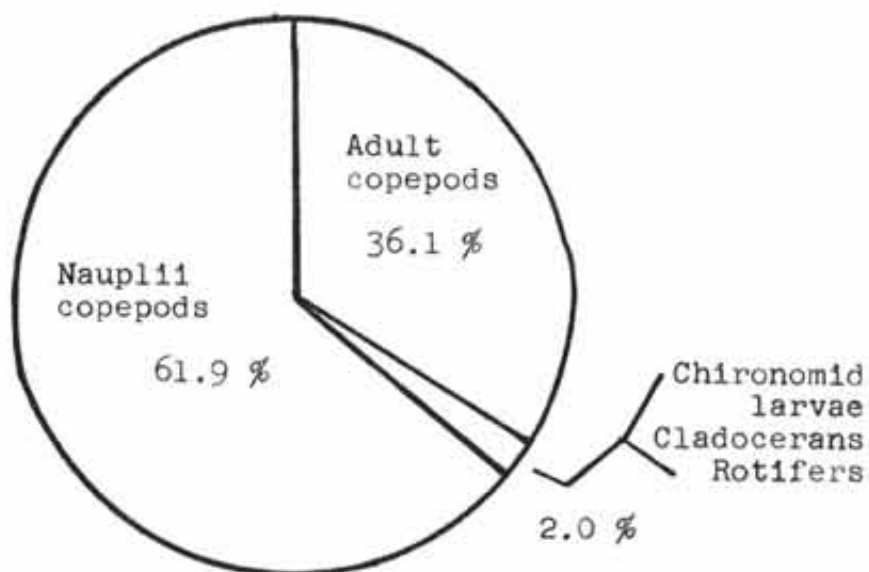
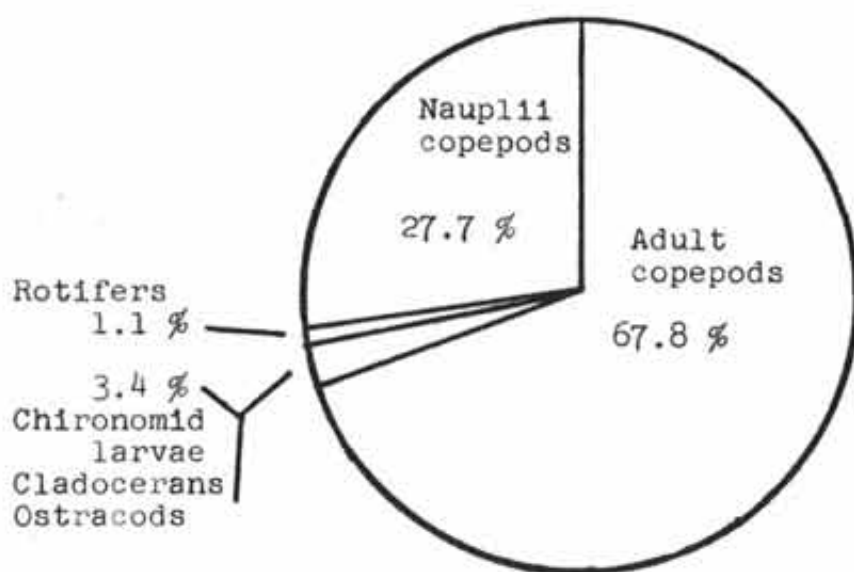


Figure 5. Changes in abundance of predominant zooplankton found in pond 4, 1976.



Age 10-18 days



Age 20-32 days

Figure 6. Food habits of striped bass fry, age 10-32 days, 1976. Values determined as a mean from all culture ponds and expressed as percent by number.

made up 27.7 percent of all food items. Rotifers, cladocerans, ostracods, and chironomid larvae were abundant, but of little importance during the first month. Rotifers were small enough to be ingested, but were apparently avoided. Other items, in general, were too large to be utilized by striped bass fry less than 32 days old. It has been noted elsewhere that copepods are an important part of the diet of small striped bass fry, while other items become more important as the fry become larger (Humphries and Cumming 1972; Harper et al. 1968).

During the first 20 days, the number of nauplii ingested by fry and rate of growth was found to be directly related to density of nauplii found in different ponds (Figure 7). In each case, growth and feeding of fry was progressively better as fry were sampled from baskets in ponds with increasingly higher standing crops of zooplankton. Pond 5, for example, had less than 50 nauplii copepods per liter. Total length of fry at age 20 days, in this case, was under 7 mm and a mean of only 1.8 nauplii were found per stomach. In contrast, pond 1 had over 1400 nauplii copepods per liter. Fry grew to 13.3 mm in 20 days and averaged 73.7 nauplii per stomach.

Early growth, food consumption, and plankton abundance was also compared to eventual pond production (Table 18). Experience from previous years has shown that general survival and condition of fry held in tempering baskets until 6 days of age indicated if a pond would finally produce a substantial number of fingerlings. Ponds 1, 5, and 6 followed expected results. Growth and survival of fry held in baskets was representative of how fish succeeded in each pond. Nevertheless,

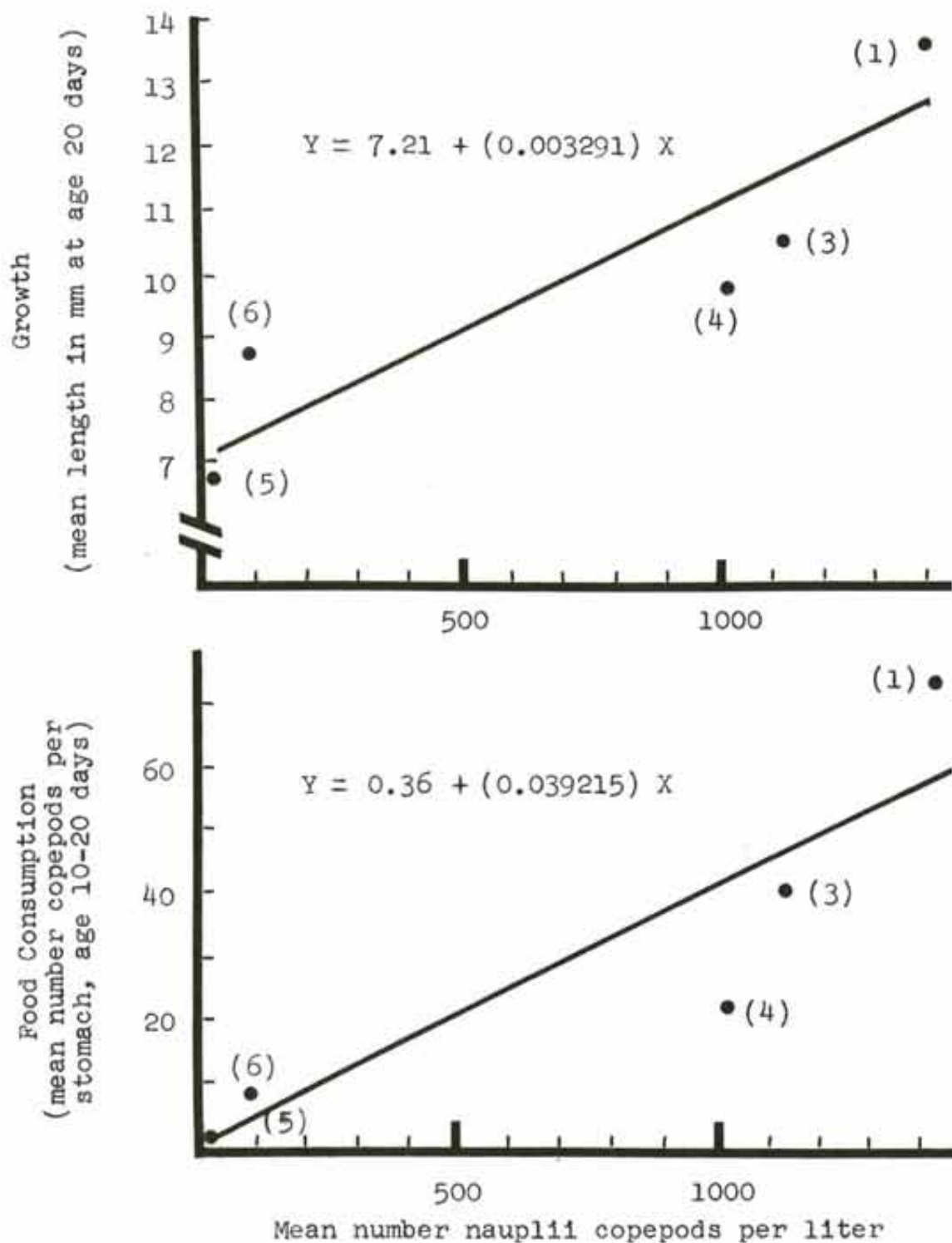


Figure 7. Relation of plankton density in culture ponds to growth and food consumption of striped bass fry, 1976. Numbers in parentheses indicate individual culture ponds.

Table 18. Fingerling production compared to early growth, food consumption, and plankton abundance, 1976.

Item	Pond 1	Pond 3	Pond 4	Pond 5	Pond 6
Growth ^a	13.3	10.3	9.7	6.7	8.6
Food consumption ^b	73.7	41.1	25.1	1.8	9.8
Plankton availability ^c	1,473	1,182	1,043	22	97
Empty stomachs ^d	4.2	6.2	22.9	58.3	27.1
Fingerling production					
per acre	41,288	390	8	1,784	8,585
Percent survival	27.53	0.26	0.01	1.35	5.98

^aMean length (mm) at age 20 days

^bMean number of copepods per stomach. Sample of 8 fish taken at age 10, 12, 14, 16, 18, and 20 days.

^cMean number nauplii copepods per liter. Samples taken on 3 different days between age 10 and 20 days.

^dPercentage, based on total number of stomachs sampled.

ponds 3 and 4 did not follow this trend. Food consumption, growth, and survival of fry held in baskets in ponds 3 and 4 was excellent. Both ponds had large blooms of nauplii copepods when fry were stocked. Considerable numbers of fingerlings should have been produced, but neither pond did well. Pond 3 produced approximately 100 fingerlings directly from the basket, while the pond produced only 390 fish altogether. Pond 4 was even worse, producing a total of only 9 fish. Obviously, something outside the baskets adversely affected survival. Chemical and physical factors, as well as general plankton densities, were similar between ponds and baskets. The most likely explanation is that fry held in the baskets were protected from insect predation. Cursory field observations indicated that aquatic insects (Corixidae and Notonectidae) were more numerous in ponds 3 and 4 than any other ponds. Few insects were noticed in any baskets. Culture ponds were filled several months before stocking, allowing insects time to become established. Diesel fuel has been effectively used in the past to control insect populations, but this had always been done just before harvest. Application of diesel shortly before and after stocking of fry would reduce potential predation from aquatic insects (Bonn et al. 1975).

Field observations of ponds used to experiment with inorganic 20-20-20 indicated that peak blooms occurred at different times for the two ponds. Plankton counts indicated that cladocerans bloomed during the middle of the study period in pond 1 and late during the study period in pond 2. However, plankton counts showed that blooms of copepods occurred at approximately the same time, but were of different magnitudes (Figure 8). Pond 1, which had the least amount of water loss from

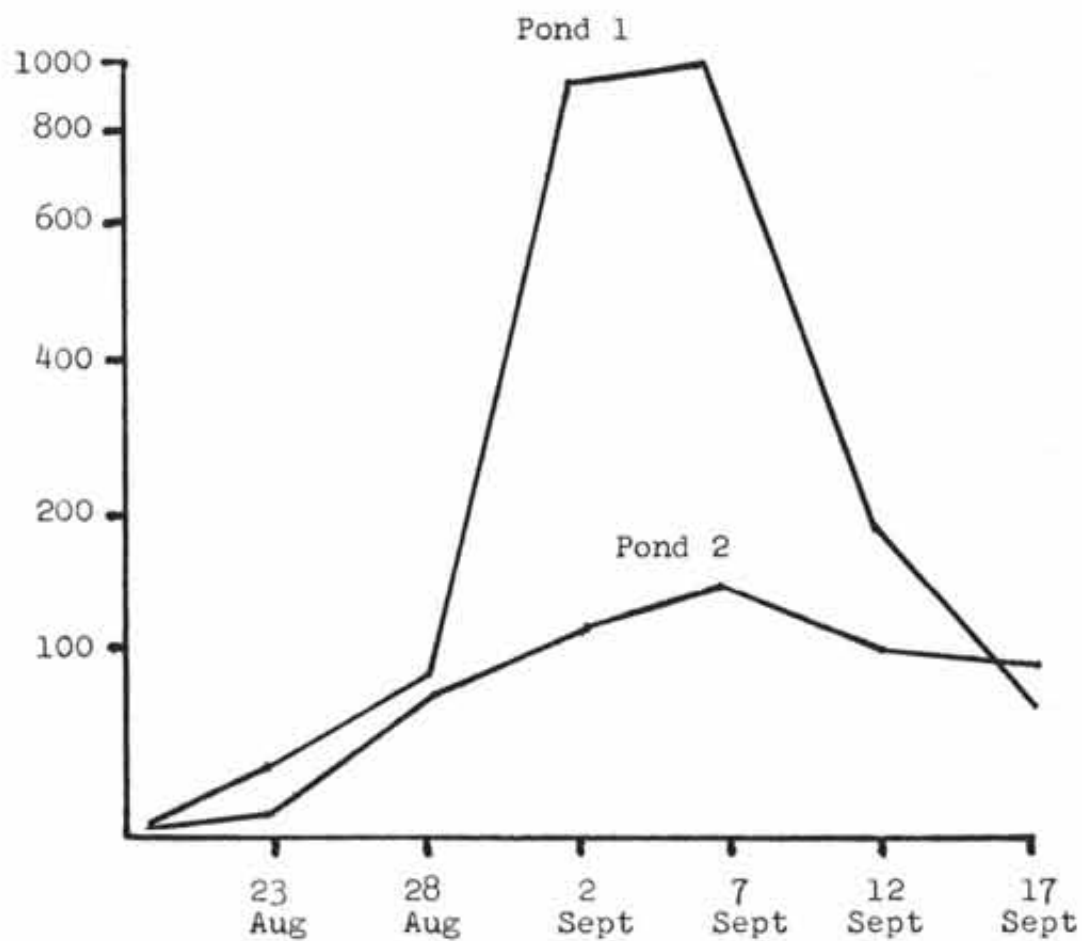


Figure 8. Changes in abundance of nauplii copepods after fertilization with inorganic (20-20-20).

seepage, produced by far the greater density of copepods. Neither pond produced a bloom of any duration, despite continued weekly fertilization. Density of nauplii copepods in pond 1 remained at levels above 500 per liter for less than one week. Pond 2 never attained a density beyond 160 per liter. In contrast, ponds fertilized earlier in the year with alfalfa hay had blooms exceeding 500 nauplii copepods per liter for periods of at least one month if ponds did not contain large numbers of fish. Ponds have been found to have more sustained blooms when organic fertilizer is used (Bonn et al. 1975).

Recommendations

Based on such poor results from stocking in April, it seems impractical to rear two crops of striped bass in one year. Higher production and better results could be expected by waiting until May and raising one crop. Seasonal weather patterns become more predictable and mild in May, which would also benefit attempts to control plankton blooms and schedule shipments of fry.

Experimentation for the upcoming year should again be designed to determine the best time to fill and fertilize ponds. Development of zooplankton blooms after fertilization is apparently a critical factor in determining success of introducing striped bass fry and needs to be further assessed. Development of aquatic insects and other large predators in ponds holding water over long periods of time should be considered and necessary precautions taken. Additional work needs to be

conducted with different fertilizers to determine reliable methods of producing sustained zooplankton blooms in as short a period after fertilization as possible.

Efforts to predict successful ponds well in advance of harvest should be continued. Having test fish in baskets is important in case of an accidental fish kill caused by a toxic chemical or oxygen depletion. Losses from other factors may be more subtle, but successful ponds are usually evident within a month after stocking. Schooling fish are often seen around the shoreline and drain boxes. If fish are not seen in a pond with estimated poor survival, it should be drained and restocked if additional fry are available. Production and consistency would be greatly improved if unsuccessful ponds could be eliminated.

Improvements in several other culture techniques need to be made. Adequate precautions need to be taken in the future to obtain alfalfa hay free from any chemical treatment. Growth of aquatic weeds made it particularly difficult to harvest fish. This problem has become worse each year since ponds were put into use. It is apparent that some chemical control may become necessary and recommended that trial techniques be investigated on an experimental basis. Also, for the first time, low oxygen levels were recorded after fertilization. Although levels returned to normal in several days and fish were not yet stocked, values initially dropped to as low as 2.2 ppm. Values lower than 4.0 ppm should be avoided (Bonn et al. 1975). Some reduction in initial fertilization rates with more fertilizer added as needed might be

warranted. Large amounts of fertilizer should not be added all at once, especially if fry have been stocked.

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EVALUATION OF STRIPED BASS INTRODUCTION

Job V

Background

Striped bass were stocked into Lake Powell each summer, 1974-1976. Fish have generally been stocked at the south end of the reservoir, in Wahweap Bay. Bullfrog Bay, located approximately mid-way up lake, was stocked for the first time in 1976. Initial sampling was designed to supply data at given levels of precision on survival, growth characteristics, and food preferences. Data on distribution and development of a sport fishery will be collected as part of the regular creel census program. To date, striped bass have shown excellent growth and high utilization of threadfin shad in their diet. Returns to the creel have largely been incidental to angling for other species. A few fishermen, however, began to pursue striped bass during summer months.

Methods

Collections of striped bass from Lake Powell have largely been made by gill netting. A few striped bass were collected with beach seines. Creel census returns and angler reports were used to describe distribution and movement from areas of original introduction. Gill nets were set each month to sample a few fish from each year class. Most nets were set near areas where striped bass were first introduced. Lengths, weights, stomachs, and scales were collected from all fish. Stomachs were preserved in 10 percent formalin and later analyzed to determine composition of food items by number, percent, and volume. Scales were

analyzed by two or more readings. Scale characteristics were compared to growth of introduced striped bass of known age. The distance between the outer-most annulus and margin of a scale was considered a full year's growth if fish were captured after December 31 and before time of annulus formation in spring. Age and growth computations were made, in part, by computer program (Maxwell et al. 1970).

Results and Discussion

Most of the 55,057 fingerling striped bass introduced into Lake Powell during July 1976 were stocked by truck in Wahweap Bay (35,752). The remaining 19,305 fish were stocked by airplane in Bullfrog Bay. This brought the total number of striped bass introduced into Lake Powell to 199,820 or 1.25 fish per surface acre (Table 19).

Fish stocked in 1976 adapted and grew well. Growth during the first summer followed the composite curve of previously stocked striped bass (Figure 9). Average 0 age striped bass reached 237 mm and 161 g by December. Airplane stocking of fish in Bullfrog Bay was successful as indicated by 0 age striped bass in seine and gill net samples. Striped bass at Bullfrog showed slightly faster growth than those stocked at Wahweap (Table 20). In October, fish in Bullfrog Bay averaged 22 mm longer than those collected by similar methods in Wahweap Bay (significant at $p = 0.05$, $t = 2.85$). By November, the difference was reduced to 14 mm, but was still significant ($p = 0.05$, $t = 2.57$). Only one striped bass was collected at Bullfrog during December, prohibiting further statistical comparison between the two areas.

Table 19. Striped bass stocked in Lake Powell.

Year	Total Number	Number per surface acre ^a
1974	49,885	0.31
1975	94,878	0.59
1976	55,057	0.34
Total	199,820	1.25

^aBased on surface acreage of lake at full pool (160,000 surface acres).

TOTAL LENGTH (inches)

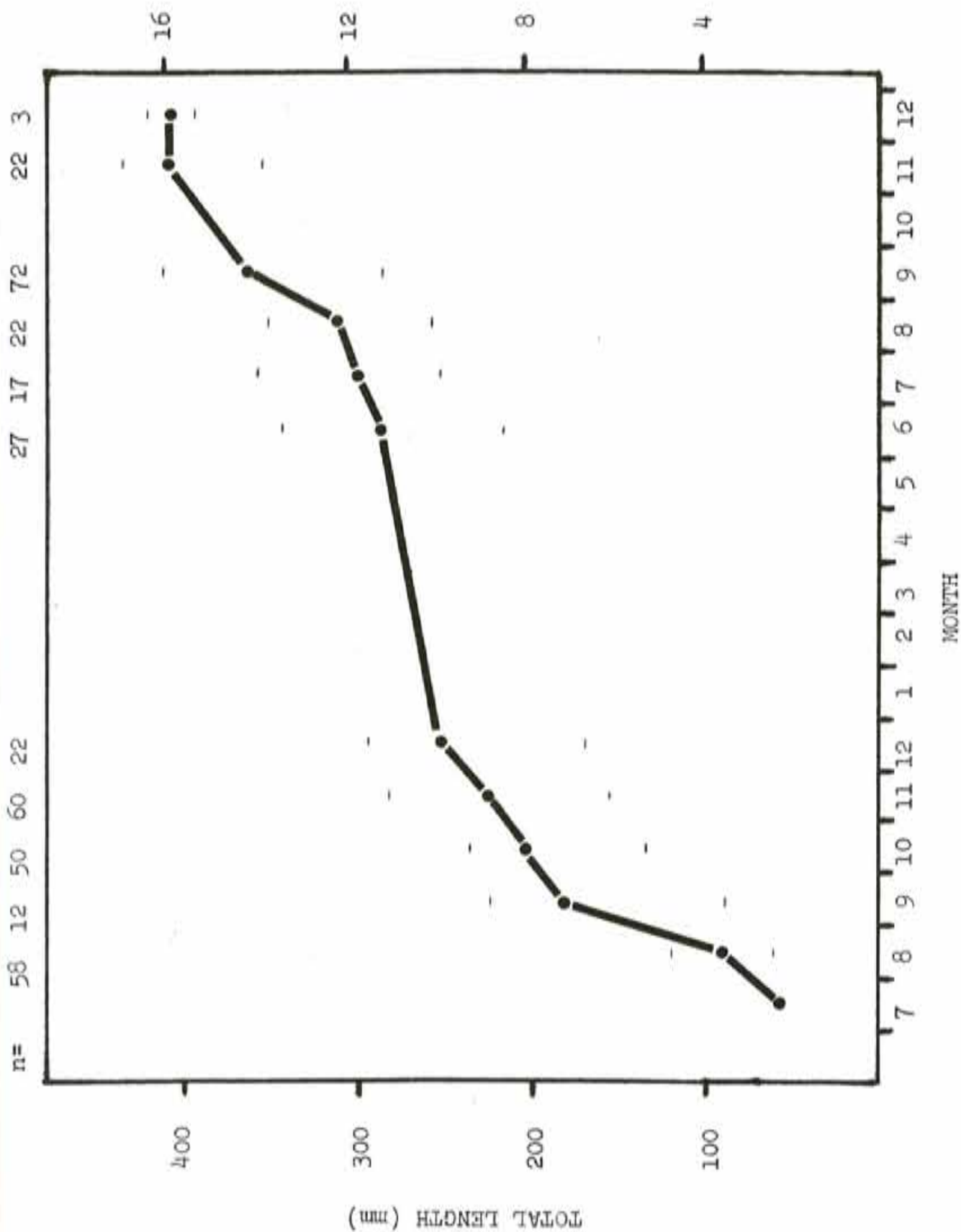


Figure 9. Composite growth of three year classes of striped bass (1974, 1975, and 1976) after stocking in Lake Powell. Dots represent sample means, bars sample range.

Table 20. Growth of young-of-the-year striped bass at Wahweap and Bullfrog Bay, 1976.

	October			November			December		
	(n)	mean length (mm)	inches	(n)	mean length (mm)	inches	(n)	mean length (mm)	inches
Wahweap	12	184	7.2	13	220	8.6	13	237	9.3
Bullfrog	14	206	8.1	9	234	9.2	1	247	9.7
Difference		22	0.9 ^a		14	0.6 ^a		10	0.4

^aSignificant at the 95 percent level.

Previously introduced striped bass continued to grow well. The largest fish observed, at an approximate age of 2-1/2 years, was 587 mm (23 in) and weighed 2,270 g (5 lbs). The average 1974 year class fish measured 444 mm (17.5 in) and weighed 991 g (2.2 lbs) at age 2 years (Table 21). The most numerous year class of striped bass, stocked in 1975, showed average growth at age 1 year to be 257 mm (10.1 in) and 204 g (0.4 lbs), nearly equalling that of the 1974 year class at the same age.

Summer was the most important growth period (Figure 9). The largest monthly growth increment for 0 age and yearling fish was during August and September which corresponded with the peak in threadfin shad biomass. Growth continued in the winter and spring but at a much slower rate than shown during summer and fall. Scale analysis indicated that annulus formation began in May with all scales showing a growth annulus by the end of June.

Older striped bass became harder to catch as shown by catch per gill net (Table 22). Catch rates fell from a high of 4.13 F/N for 0 age fish to a low of 0.69 for age II fish. Young fish remained near the stocking locations resulting in a relatively high catch rate. As the fish grew older and dispersed throughout the reservoir, the catch rate declined. Striped bass from the 1974 year class were captured in gill nets in Bullfrog Bay, and captured by anglers as far up-lake as Four-mile Canyon, a distance of 130 miles from the original stocking location. Unconfirmed reports by anglers indicated the presence of striped bass in the San Juan and Escalante River areas of the reservoir.

Table 21. Mean back-calculated total lengths at annulus for two year classes of striped bass, Lake Powell, 1976.

Length at annulus	Total length (mm)		Mean annual increment
	1974 year class	1975 year class	
I	268	257	262
II	444		182

Table 22. Return of striped bass by gill net sampling, Lake Powell, 1976.

Age Group	Number	Catch per net
0	227	4.13
I	275	3.71
II	38	0.69

Striped bass diet consisted mainly of threadfin shad. Age 0 striped bass greater than 100 mm total length averaged 1.3 shad per stomach, with insects and zooplankton being important in total number of items per stomach (Table 23). Age I fish averaged 8.8 shad per stomach with crayfish becoming important (0.1 per stomach). By age II striped bass averaged 1.9 shad and 1.5 crayfish per stomach. Number of crayfish in the diet varied with season. Crayfish were found in stomachs only in spring and summer (Table 24). Number of crayfish observed was much greater this year than reported last year. This was probably a result of older striped bass showing an increased utilization of crayfish (Table 23) rather than an increased crayfish population in Lake Powell.

Comparison of stomach contents of hook and line versus gill net caught striped bass revealed that shad importance was probably underestimated in gill net samples (Table 25). In July, striped bass were observed feeding voraciously on post-larval shad. Striped bass caught on hook and line during feeding activity averaged 160 shad per stomach. Those caught in gill nets and left over night averaged only 0.7 shad per stomach. Crayfish importance was probably overestimated in summer months because the hard carapace did not digest as readily as threadfin shad.

The beginnings of a sport fishery for striped bass developed during the study segment. Striped bass entered the creel in the spring as anglers trolling for trout and jigging for crappie made incidental catches. Striped bass were caught in early summer by bass fishermen. As bass fishing declined after spawning, number of striped

Table 23. Food habits of three different age groups of striped bass collected from Lake Powell, 1975 and 1976.

Age group	Length of striped bass (mm)	Sample size	Percent empty stomachs	Mean number of food items per stomach ^a					
				Shad	Centrar- chids	Unident- ified fish	Crayfish	Insects	Zoo- plankters
0	61-274	180	18.9	1.3	t ^b	0.3	0.0	7.4	24.0
I	195-434	147	37.4	8.8	t	0.4	0.1	0.0	0.0
II	379-498	40	52.5	1.9	0	0.1	1.5	0.0	0.0

^a Values based on total number of stomachs containing food items

^b t indicates value less than 0.1

Table 24. Seasonal food habits of Lake Powell striped bass, 1976.

ITEM	Spring (n=4)				Summer (n=67)				Fall (n=56)				Winter (n=17)			
	% OCC	% VOL	% NO.		% OCC	% VOL	% NO.		% OCC	% VOL	% NO.		% OCC	% VOL	% NO.	
FISH	85	87	91		53	28.0	49.0		98.0	99.9	81.0		75.0	85	1.0	
Shad	77	80	85		45	27.0	48.0		93.0	92.2	80.0		37.5	32	0.7	
Crappie					2	0.1	0.5									
Sunfish									2.5	4.0	0.5					
Unknown	11	7	6		8	0.9	0.5		2.5	3.0	0.5		37.5	53	0.3	
CRAYFISH	15	13	9		38	65.0	2.5									
CLADOCERANS					5	1.0	48.0		2.5	0.1	19.0		25.0	15	99.0	
ROCKS					1	5.0	0.5									
OTHER ^a					2	1.0										

^aPercentage by number not determined for other food items

Table 25. Comparison of food habits of yearling striped bass collected by gill nets versus hook and line during July, 1976, Lake Powell.

Sample Method	Sample size	Length of striped bass (mm)	Percent with empty stomachs	Mean No. shad per stomach	Mean length of shad (mm)	Total No. other items
Gill net	12	255-312	50.0	0.7	27	1 ^a
Hook and line	3	244-287	0.0	160.0	20	2 ^b

^aCrayfish

^bCrappie fry

bass caught increased. The peak of striper activity coincided with emergence of larval threadfin shad in pelagic reservoir areas.

Striped bass were observed feeding near the surface on schools of shad and could be caught with small, shad-imitating lures. Anglers were able to locate striped bass schools by sight and move from school to school. Striped bass became less visible in late summer and fall as shad grew and became more elusive. Striped bass presence could still be detected by schools of shad jumping to avoid predation. During fall and winter striped bass catches were again incidental to other fishing. Net result, however, was the extension of the sport fishery into the summer. As largemouth bass became harder to catch, anglers switched to the pursuit of striped bass.

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