Lake Powell Postimpoundment Investigations

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LAKE POWELL
POSTIMPOUNDMENT INVESTIGATIONS

Annual Performance Report
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INTRODUCTION

This report is submitted as a progress report for fisheries investigations conducted on Lake Powell by the Utah Division of Wildlife Resources from January 1 through December 31, 1978. The project was funded, in part, by Federal Aid to Fish and Wildlife Restoration, Project Number F-28-R. Fisheries 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. Current work has 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 pressure and success. Largemouth bass (Micropterus salmoides) and black crappie (Pomoxis nigromaculatus) remained the dominant species creeled. Annual netting surveys were conducted to assess annual trends in game fish population dynamics. Bass numbers remained high, along with plentiful numbers of walleye (Stizostedion vitreum vitreum). 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.

Experimental striped bass culture was conducted to develop techniques for raising fry to fingerling size suitable for stocking in Lake Powell. For the fifth consecutive year, fingerlings raised from cultural experiments were stocked in the reservoir. Striped bass interaction with its environment and contribution to the creel have been studied since initial introduction in 1974.

THREADFIN SHAD STUDY

JOB 1

Background

Threadfin shad are the most important forage fish in Lake Powell. Shad were first introduced into Lake Powell in 1968 and subsequently became the predominant food item of all major game species (Hepworth and Gloss 1976; May et al. 1975a and 1975b). Shad are typically pelagic and not readily sampled with conventional entrapment gear. The major objective of this study was to develop, through midwater trawling, an adequate system for sampling threadfin shad. Data collected in 1976, 1977 and 1978 were used to determine shad population indices and monitor monthly and annual population fluctuations. Additional information was obtained on shad spawning periodicity.

Striped bass, a pelagic predator, were introduced into Lake Powell in 1974 to utilize the dense shad population. Previously established game fishes generally were restricted to the littoral zones of Lake Powell. Threadfin shad population data collected in 1976, 1977 and 1978 will form a baseline for future comparisons in determining possible impacts of the expanding striped bass population on threadfin shad abundance.

Methods

Trawling was performed with an 8.53 m (28 ft) steel-hulled work boat. Two Marco W0650 hydraulic winches powered by Vickers hydraulic pumps were run directly from the boat's inboard engines. Dual controls made it possible to run both winches in tandem or individually. 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 net tapering from 20.3 cm (8 in) in the throat to 0.32 cm (1/8 in) at the cod end. A pair of depressors and hydrofoils, attached at the corners of the mouth, functioned to hold the net open while fishing. Galvanized wire rope cables (0.48 cm dia.; 3/16 in) running from each winch were used in deploying and retrieving the trawl.

A standard tow was developed and used to permit consistent sampling and replication. During each tow, the boat was operated at 1,100 rpm's (1.6 m/sec or 3.6 mph) while 60.96 m (200 ft) of cable was played out and immediately retrieved. The average volume of water sampled was 8,178.44m^3 (288,597 ft^3), and the maximum depth fished was about 10.7 m (35 ft). The oblique tow allowed equal sampling of the water column from the surface to maximum depth, rather than sampling shad from any one depth. For consistency, sampling was done at night when shad were distributed in a dense and uniform pattern in the epilimnion, rather than grouped in schools as found during the day (Houser and Dunn 1967; Netsch et al. 1971). Sample nights were selected during the period between new moon and first quarter to ensure dark nights and eliminate variability caused by moonlit nights.

Three trawling transects were selected to sample lake areas near the dam (Wahweap) midway uplake (Bullfrog) and near the Colorado River inlet (Hite) (Fig. 1). Wahweap Bay was sampled two nights per month and Bullfrog and Hite were sampled one night per month. Wahweap, Bullfrog and Hite were sampled on consecutive nights to allow comparison under approximately similar times and conditions. Four standard tows were made per sample night. Lighted buoys, permanently fixed in position, were used to mark trawl transects.

One sonar transect was run each sample night before trawl samples were taken. The boat was operated at an idle speed of 800 rpm's for a period of eight minutes, while sonar transects were run over the trawling course.

The trawl selectively captured larval and juvenile shad with adults taken infrequently. Larval and juvenile shad were differentiated by total length after criteria presented by Barnes (1977). Larval shad were designated as shad smaller than 25 mm (1 in) while juveniles were between 25 mm and 50 mm (2 in). All shad collected were immediately preserved in a 10% formalin solution. Number of fish, weight of catch, average total length and range were determined for each haul.

Monthly temperature profile data were collected using an ARA Model FT-2 electronic thermometer. Temperature profiles were made at each of the three regular trawling locations. Temperatures were measured at one-foot intervals between the surface and 100 feet.

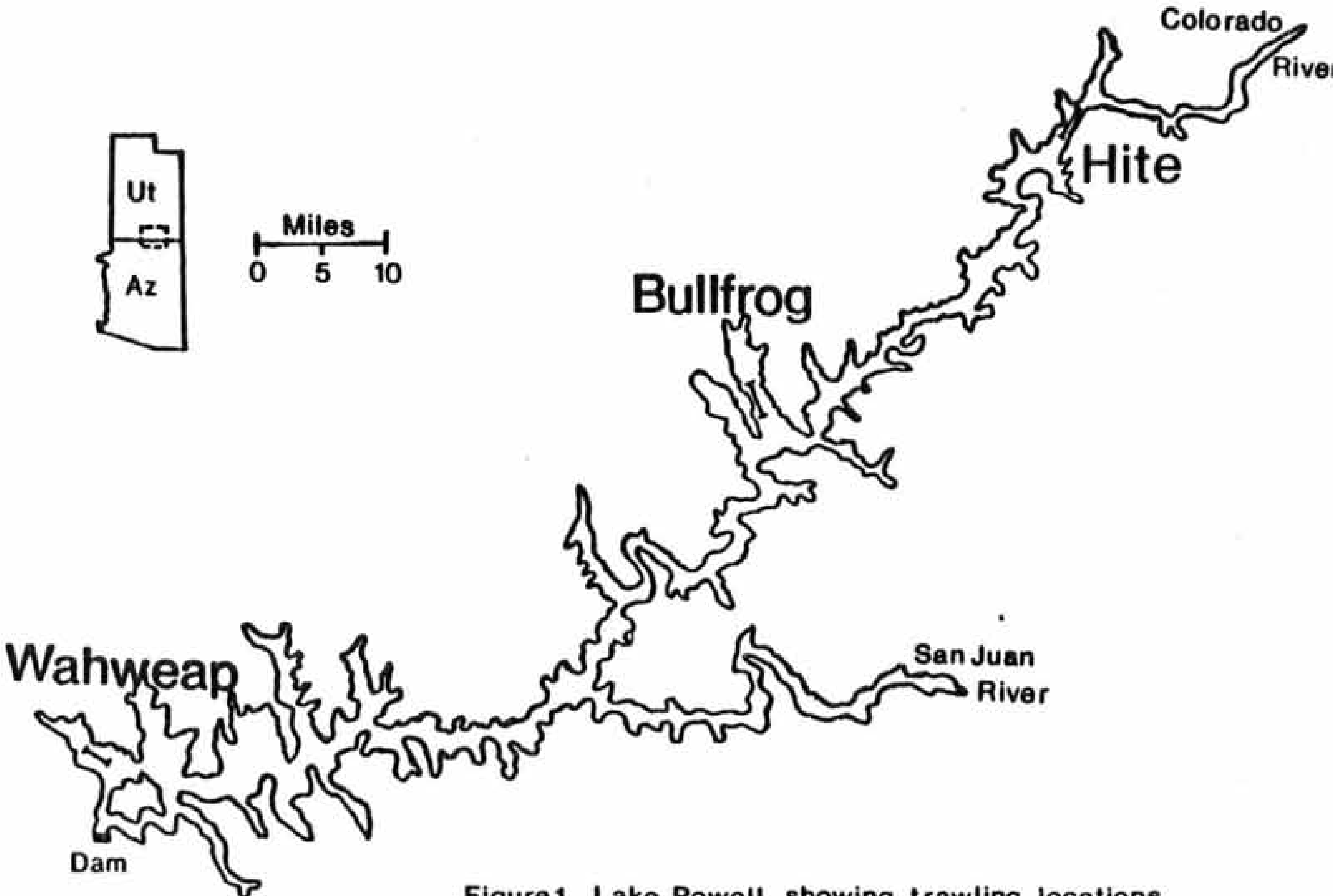

Figure 1. Lake Powell, showing trawling locations.

Results

Shad were first observed spawning at Wahweap on 15 May 1978 and at Bullfrog on 29 May 1978. A very heavy spawning run was observed at Bullfrog on 7 June 1978. No spawning observations were made at Hite. At least a few adults continued to spawn at all three locations until August 1978.

Larval shad were first collected at Wahweap on 5 July and at Bullfrog on 6 July 1978. No collections were made at Hite until 3 August 1978 because of vast quantities of driftwood flushed downstream with the high spring runoff. Larval shad were collected at Wahweap and Hite through the first week of October. No larval shad were found at Bullfrog after the first week of September.

Young-of-the-year shad populations peaked at Wahweap in August, Bullfrog in September and probably October at Hite (Figs. 2, 3 and 4). Peak densities were 257 y-o-y shad/1,000 m^3 at Wahweap, 324 y-o-y shad/1,000 m^3 at Bullfrog and 660 y-o-y shad/1,000 m^3 at Hite, representing increases of 40-180% above the 1977 maximum populations.

Changes in biomass generally followed monthly population trends (Table 1). Monthly biomass values at Bullfrog and Wahweap were well above last year while values at Hite showed a slight increase.

Discussion

Hepworth et al. (1978) reported that during the spring of 1977, shad spawning began near Hite and proceeded downlake towards Wahweap.

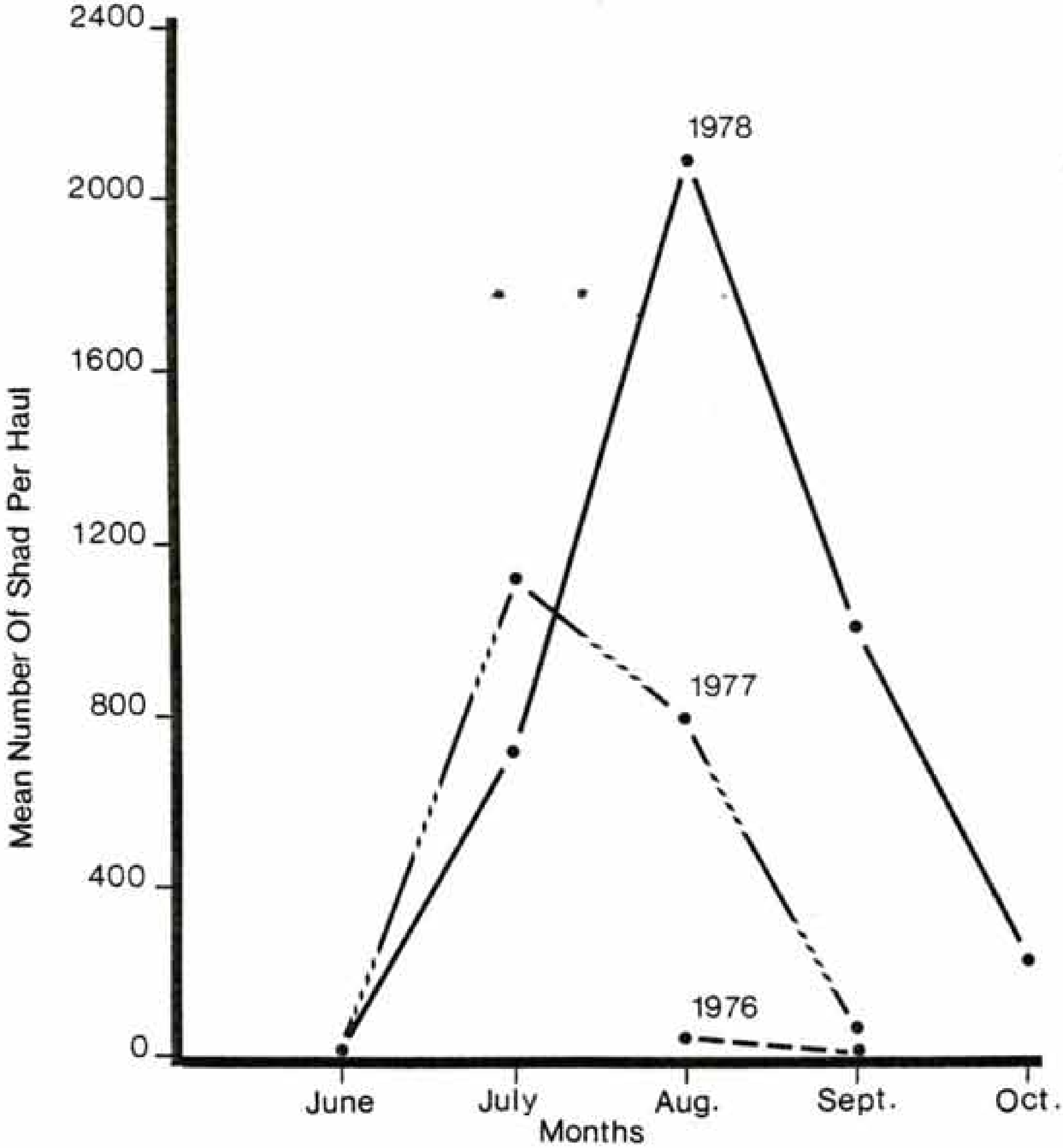

Figure 2. Mean number of young-of-the-year shad captured per trawl haul in Wahweap Bay.

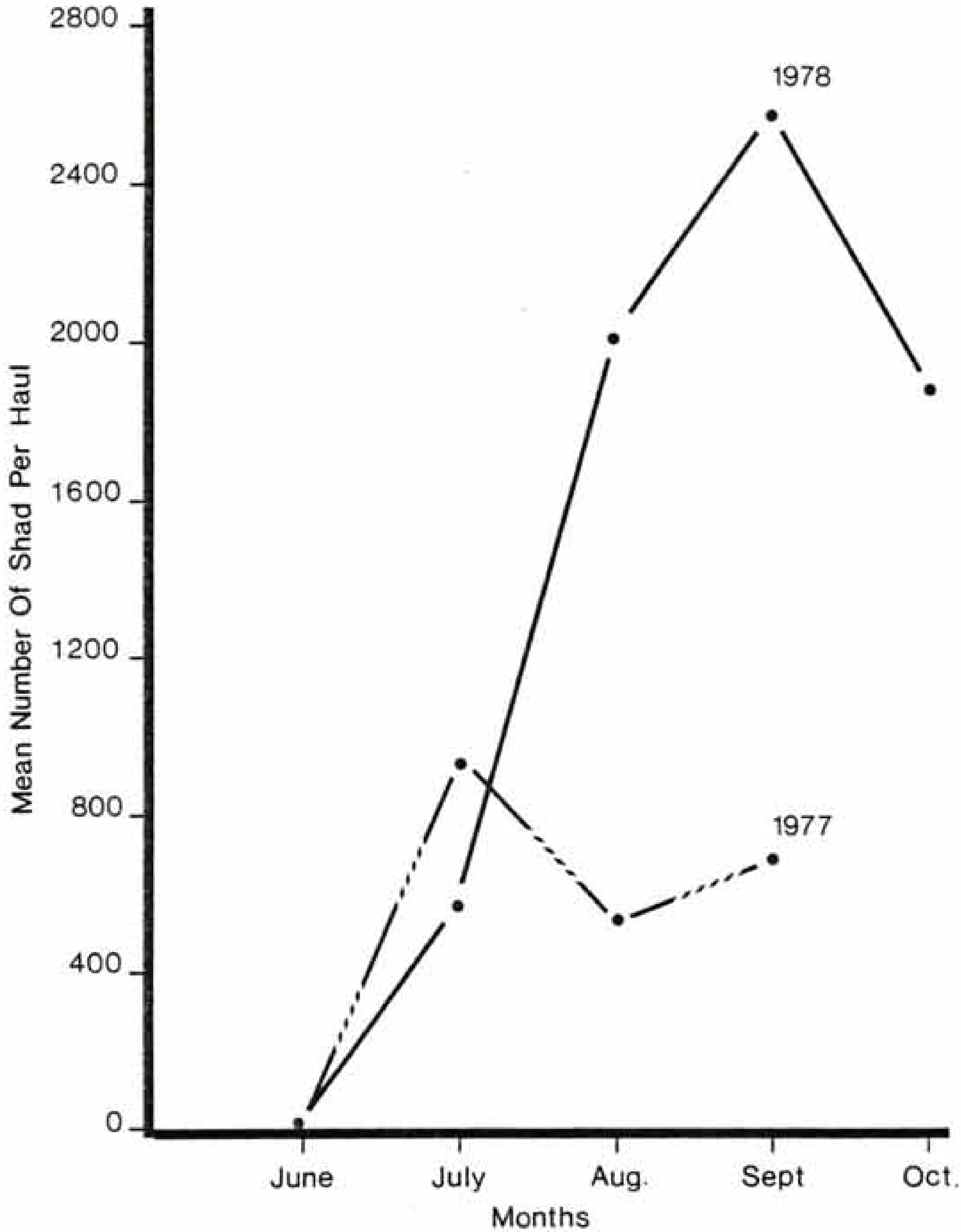

Figure 3. Mean number of young-of-the-year shad captured per trawl haul in Bullfrog Bay.

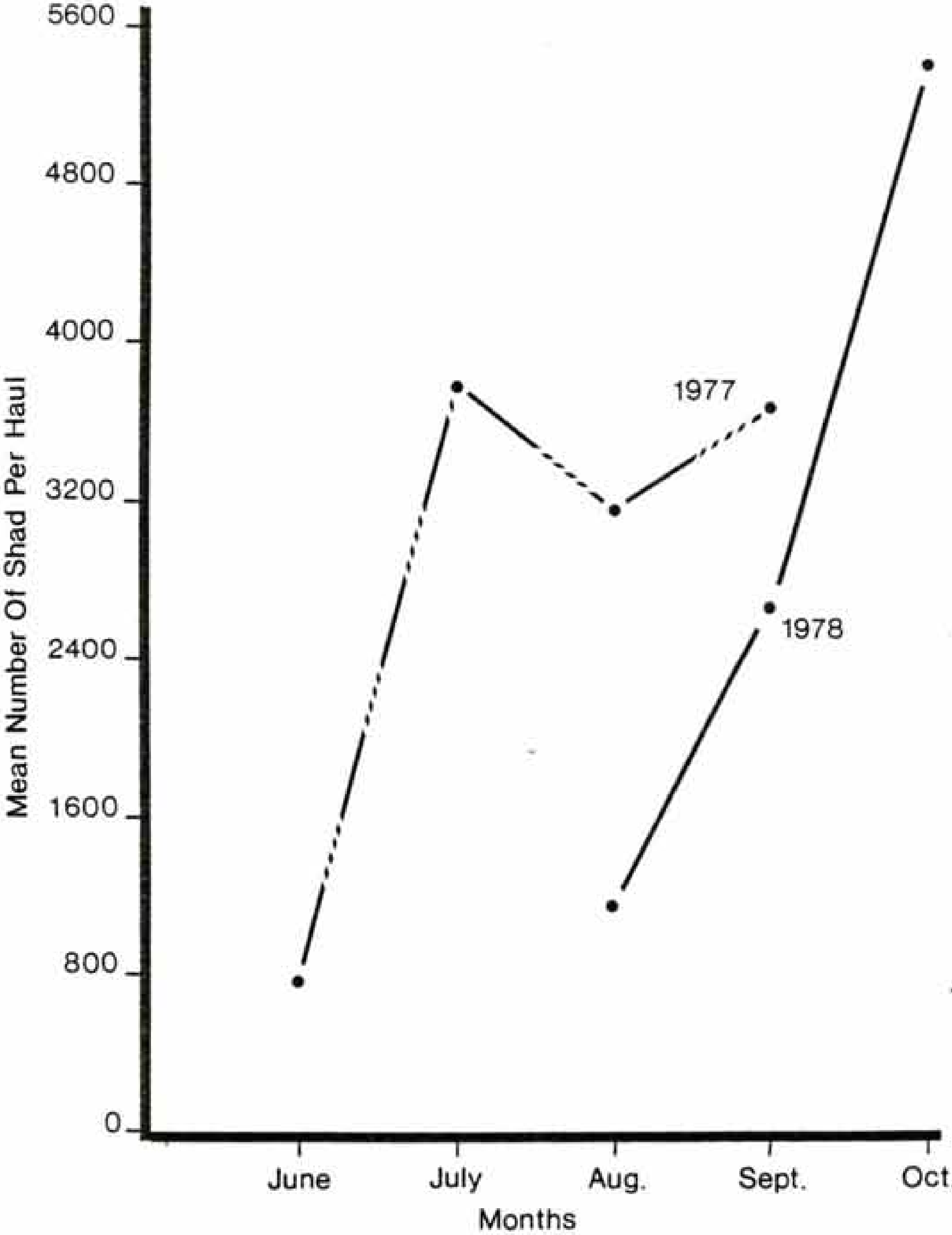

Figure 4. Mean number of young-of-the-year shad captured per trawl haul at Hite.

Table 1. Mean biomass (g) per trawl tow of young-of-the-year threadfin shad collected between June and October 1978.

Sample Site	Mean Biomass/Tow				
	J	J	A	S	O
Wahweap	0	36.6	382	165.1	77.9
Bullfrog	0	64.0	675	881.4	738.5
Hite	-	-	514[a]	1,188	2,761

[a]The average biomass per tow, including adults, was 3,639 g (8.02 lbs).

Spawning usually began several weeks earlier in the upper end of the reservoir. Netsch et al. (1971) told of a similar spawning pattern on Beaver Reservoir, Arkansas. The spawning sequence on Lake Powell in 1978 was uncertain. Spawning was observed earlier at Wahweap than Bullfrog and no observations were made at Hite. Water temperatures were approximately 10 F higher at Wahweap during May and June 1978 than during the same period of 1977 (Table 2). Surface temperatures at Bullfrog and Hite were similar both years.

Table 2. Surface temperatures at the three trawling sites during May and June of 1977 and 1978.

Sampling Location	May		June	
	1977	1978	1977	1978
Wahweap	48	58	54	65
Bullfrog	54	58	63	62
Hite	53	54	64	66

Hida and Thompson (1962) found that threadfin shad spawned from June through September in Hawaii. In 1978, Lake Powell threadfin shad spawned from mid-May through early September. Larval shad were collected at Wahweap from 5 July-2 October 1978, at Bullfrog from 6 July-30 August 1978, and at Hite from 3 August-4 October 1978.

In 1977, the maximum population was found in July at all three sample sites (Hepworth et al. 1978). During 1978, the population peaks proceeded from Wahweap to Hite. Hite was very turbid from the runoff until late July when the lake level started to drop. The high turbidity may have severely reduced the plankton resulting in little or no survival of young shad until the water began to clear.

Netsch et al. (1971) reported that young-of-the-year shad populations peaked 4-8 weeks after spawning commenced. This phenomenon was observed in Lake Powell in 1977 (Hepworth et al. 1978). In 1978, young-of-the-year shad populations did not peak until 10-12 weeks after strong spawning runs were observed. Reasons for this change are not evident at the present time.

Young-of-the-year threadfin shad densities increased from Wahweap to Hite. The young-of-the-year shad populations were up 40-180% above the population peaks in 1977. By sampling location, Bullfrog had the lowest population change in 1977 and the greatest population expansion in 1978. Hite had the greatest population increase in 1977 and the lowest in 1978. Wahweap was intermediate both years. This pattern of population fluctuation follows that reported for gizzard shad. Anderson (1973) found that spawning was affected by density dependent factors including crowding and nutritional conditions.

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MEASUREMENT OF FISHERY HARVEST, PRESSURE AND SUCCESS

Job II

Background

Angler use and success rates at Lake Powell have been estimated annually since 1964 (Stone 1965, 1966, 1967, 1971 and 1972; Stone and Rathbun 1968 and 1969; Rathbun 1970; Gloss et al. 1974; May and Hepworth 1976; Hepworth et al. 1976, 1977 and 1978). Angler pressure, as well as total recreational use, has increased dramatically since the mid-1960's. Catch rates have varied over the years with good fishing shortly after impoundment and peaks in success again in 1971 and 1975. Gustaveson et al. (in press) reviewed the fishing success and pressure at Lake Powell from 1964-76.

Methods

A total of 106 man-days were spent on a scheduled creel census from March through September 1978. Previous study has shown the majority (over 80%) of the total annual fishing pressure at Lake Powell occurs from March through September (May and Hepworth 1976). The creel census was conducted at the four major access points on the lake--Wahweap, Hall's Crossing, Bullfrog and Hite. Virtually all anglers gained access to the lake at one of these locations. Weekends and holidays comprised 50% of the sample days with weekdays accounting for the remaining 53 census days. Wahweap was censused 4-10 days per month, Bullfrog 2-6 days per month, Hall's Crossing 2-4 days per month and Hite 1-3 days per month. The census was conducted during the afternoon when most fishermen were returning. Census clerks interviewed fishermen as they returned to boat launching ramps. Due to the isolated nature and limited access of Lake Powell, fishing by nonboating fishermen was negligible. Data recorded during each interview included the number and species of fish caught, length of boat trip, actual time spent fishing, number of anglers per boat and the residence of anglers. Total lengths and weights of selected samples of largemouth bass, black crappie and striped bass were also recorded.

Estimates of angler pressure were based upon National Park Service (NPS) data (counts of empty boat trailers at launching ramps and docking facilities). Census clerks also made counts of empty boat trailers on census days for comparison with NPS figures. The final estimate of angler pressure was calculated by adjusting NPS monthly use estimates following Hepworth et al. (1977).

The estimate of angler pressure was based upon (1) the total (fishing and nonfishing) number of boat trips, (2) the percentage of total trips which were fishing trips, and (3) the mean number of anglers per fishing boat. The latter two parameters were estimated directly from monthly summaries of data obtained during angler interviews. The number of total boat trips was estimated by adjusting monthly NPS use figures by a factor determined from random counts of empty boat trailers made by Division of Wildlife Resources (DWR) personnel. The NPS use figure for a given month was simply the sum of daily 1 pm "instantaneous" counts of empty boat trailers at launching ramps and docking facilities. An estimate of the monthly sum of daily random instantaneous counts was derived from the NPS monthly sum of 1 pm counts:

- Daily random counts = daily 1 pm counts X adjustment factor.

The adjustment factors (mean ratio of random counts by DWR: 1 pm counts by NPS) were 0.98, 0.92, 0.90 and 0.80 for Wahweap, Hall's, Bullfrog and Hite, respectively. The number of total boat trips for a given month was then estimated:

$$\text{Total boat trips} = \text{daily random counts} \times \frac{12 \text{ hours}}{\text{Mean length of boat trip.}}$$

The final estimate of the angler trips for the month was then:

$$\text{Angler trips} = \text{total boat trips} \times \frac{\text{fishing trips}}{\text{total trips}} \times \text{mean no. of anglers/fishing boat.}$$

Results

The estimated angling pressure for March through September 1978 was 207,403 angler trips (Table 3). The average boat trip was 7.0 hours long. The mean length of time spent fishing per trip was 3.1 hours. The average number of anglers per fishing boat was 2.4.

Anglers who gained access to the lake at Wahweap accounted for 98,464 angler trips or 48% of the estimated pressure during the census period. Successively less fishing pressure occurred at Bullfrog (68,816 angler trips), Hall's Crossing (24,267 angler trips) and Hite

(15,496 angler trips). Most of the angling activity occurred in April, May and June. Mean length of time spent fishing, percentage of total boats which reported angling and estimated pressure decreased during the warmer summer months.

Table 3. Estimated fishing pressure (angler trips) by access area and month, Lake Powell, March-September 1978.

Month	Wahweap	Bullfrog	Hall's	Hite	Total	Percent
March	8,265	2,332	2,450	3,604	16,651	8.0
April	20,403	23,789	5,260	6,765	56,217	27.1
May	27,253	14,424	5,257	810	47,744	23.1
June	14,320	12,137	6,117	1,626	34,200	16.5
July	11,433	3,333	3,122	443	18,331	8.9
August	7,469	3,834	1,373	947	13,623	6.6
September	9,321	8,967	688	1,301	20,277	9.8
Total	98,464	68,816	24,267	15,496	207,043	

The majority of anglers censused at Wahweap came from either Arizona (64%) or California (17%) (Fig. 5). Colorado or Utah was the residence of most of the anglers interviewed at the three other access areas (Hall's Crossing, Bullfrog and Hite).

Of the 3,152 boats checked by census clerks, 934 or 29.6% reported angling activity. A total of 8,932.25 hours was expended by 2,447 fishermen who caught 2,076 fish for an overall catch rate of 0.23 fish/hr). The catch rate was highest for anglers censused at Hite (0.49 fish/hr) and successively lower at Hall's Crossing (0.25 fish/hr), Bullfrog

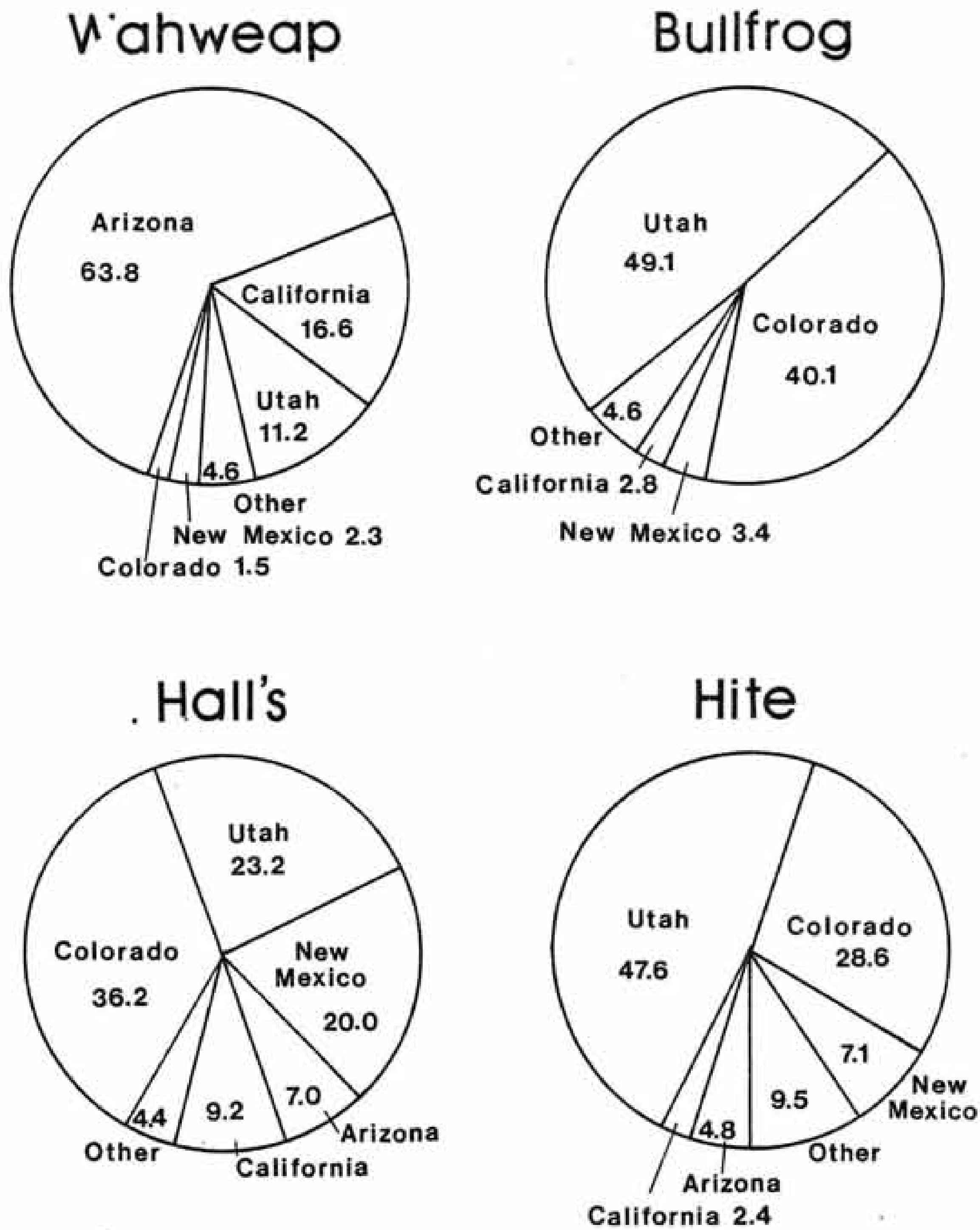

Figure 5. Residence of anglers censused at Lake Powell, March-September 1978 by access area.

(0.21 fish/hr) and Wahweap (0.21 fish/hr) (Table 4). Fishing was best during the late spring and early summer (Table 5). The highest fishing success rate occurred in July when the limited number of anglers on the lake experienced relatively high catch rates for channel catfish and bluegill as well as having some success catching largemouth bass and black crappie. Largemouth bass and black crappie were caught most often. Catch rates for bass ranged from 0.07 fish/hr (Bullfrog) to 0.24 fish/hr (Hite). The best catch rate for crappie was recorded for anglers at Hall's Crossing (0.13 fish/hr) and the lowest at Wahweap (0.06 fish/hr). When the four access areas were combined, the catch rates for bass and crappie during the 1978 census were both 0.09 fish/hr. The mean length (TL) of largemouth bass creeled during April and May was 341.7 mm (S.D. = 73.4, n = 232). Black crappie caught during the same period averaged 292.9 mm TL (S.D. = 51.1, n = 342). Limited numbers of striped bass, rainbow trout and walleye were also creeled by anglers in 1978, most of them taken by anglers at Wahweap.

Table 4. Catch rates (fish/angler hour) by species and access area, Lake Powell, March-September 1978.

Species	Wahweap	Bullfrog	Hall's	Hite	Mean[b]
Largemouth bass	0.10	0.07	0.08	0.24	0.09
Black crappie	0.06	0.11	0.13	0.11	0.09
Channel catfish	0.04	0.02	0.04	0.02	0.03
Bluegill	t	0.02	t	0.12	0.02
Rainbow trout	t	t	0.00	0.00	t
Walleye	t	t	t	0.00	t
Striped bass	t	0.00	t	0.00	t
Total	0.21	0.21	0.25	0.49	0.23

[a]t = Less than 0.01 fish per angler hour.

[b]Mean = Total catch divided by sum of angler hours.

Table 5. Catch rates (fish/angler hour) by species and month, Lake Powell, March-September 1978.

Species	March	April	May	June	July	August	Sept.	Mean[b]
Largemouth bass	0.09	0.09	0.09	0.08	0.11	0.04	0.11	0.09
Black crappie	0.03	0.16	0.08	0.06	0.04	t[a]	0.02	0.09
Channel catfish	0.01	0.01	0.02	0.07	0.11	0.15	0.06	0.03
Bluegill	0.01	0.02	0.02	t	0.07	0.00	0.00	0.02
Rainbow trout	t	t	0.00	t	0.00	0.00	0.00	t
Walleye	t	t	t	t	t	0.00	0.00	t
Striped bass	0.00	0.00	t	0.01	0.01	0.00	t	t
Total	0.14	0.28	0.21	0.23	0.34	0.19	0.19	0.23

[a]t = Less than 0.01 fish per angler hour.

[b]Mean = Total catch divided by sum of angler hours.

Discussion

The methods used for estimating angling pressure have varied over the history of Lake Powell. The sampling design and effort expended during the annual creel censuses have changed, with scheduled censuses of 3-12 months during a given year. Consequently, comparisons of angling pressure estimates between past and present years are difficult. The NPS, however, has estimated total recreational boat use since 1966. Using the NPS estimates and the information obtained from interviews of anglers during census months (percentages of the total recreational boats which reported angling and ratio of fishing to nonfishing boats), an index of annual angling pressure was calculated (Fig. 6). This index showed a decrease in annual angling pressure at Lake Powell for the first time since 1973.

The decrease in angling pressure was also documented by the estimates of pressure during the actual census periods of 1977 and 1978. The same methods (Hepworth et al. 1977) have been used to estimate pressure since 1976, so comparisons may be made between the estimated pressures for the census months of 1977 and 1978. The 1977 estimate of angling pressure for April through September was 224,598 angler trips (Table 6). (This figure is higher than that reported by Hepworth et al. 1978 due to a mathematical error in their calculations.) The estimate for the same period in 1978 was 190,392 angler trips—a decrease of 15.3% for the six-month period. Total recreational boat use, however, has continued to rise (Fig. 6).

One reason for the drop in angling pressure in 1978 was probably the relatively poor fishing success experienced by most anglers in 1977 and 1978 (Fig. 7). The 1978 catch rates for bass, crappie and all species combined were the lowest ever recorded for Lake Powell anglers. The low catch rates during the past two years reflect a decrease in the absolute numbers of fish vulnerable to angling, a change in the anglers' effectiveness in catching those fish, or a combination of the two. Decreases in the absolute number of game fish may result from poor spawning success and recruitment (weak year classes), a decline in overall reservoir productivity associated with aging, displacement by competing species of fish, or overfishing. Angler effectiveness and success also depend upon a number of variables, including weather conditions, fish behavior and angler skill and technique.

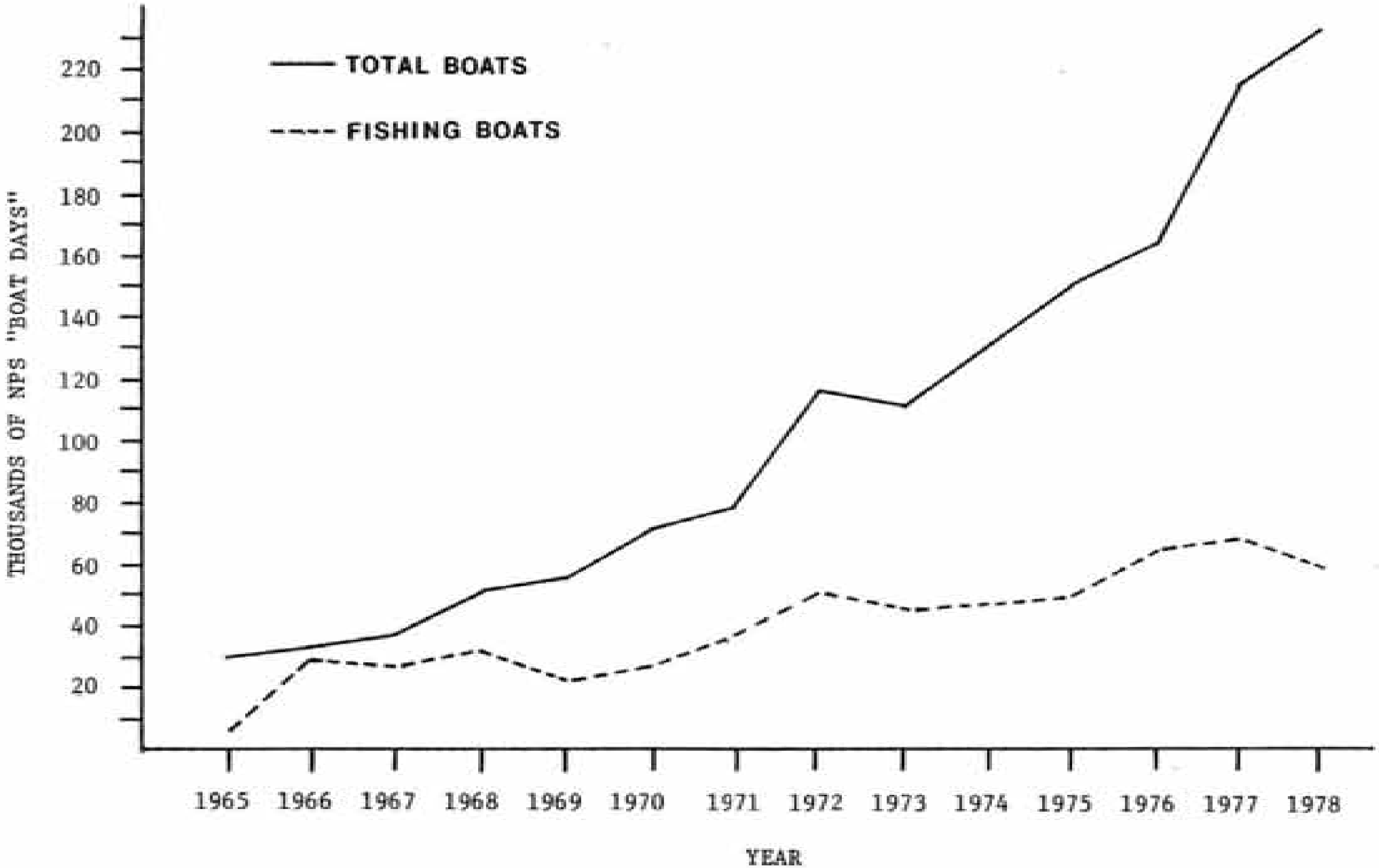

Figure 6. Indices of total recreational boat use and angling pressure, Lake Powell, 1965-78.

Table 6. Corrected estimates of fishing pressure (angler trips) by access area and month, Lake Powell, April-September 1977.

Month	Wahweap	Bullfrog	Hall's	Hite	Total	Percent
April	9,432	15,458	7,822	9,317	42,029	18.7
May	33,900	17,554	8,418	7,089	66,961	29.8
June	25,316	6,023	4,099	9,283	44,721	19.9
July	13,383	3,915	1,104	4,480	22,882	10.2
August	10,394	3,072	1,772	2,280	17,518	7.8
September	8,953	6,721	3,827	10,986	30,487	13.6
Total	101,378	52,743	27,042	43,435	224,598	100.0

Since annual netting data from 1971-78 (see Job III) provide an index of the numbers of largemouth bass, factors other than those affecting the absolute numbers of catchable-sized bass are influencing angler catch rates. Spearman's rank correlation coefficient (Snedecor and Cochran 1971) showed no significant correlation (5% level) between annual netting catch rates and angler catch rates from 1971-78. Although angler success has been relatively low for the past several years, there was also no significant correlation between success and reservoir age as measured by the above test. Analysis of the species composition of the average anglers' creel also failed to provide any obvious clues as to the cause(s) for the decline in angler catch rates (Fig. 8). The composition of the catch has not changed appreciably since the early 1970's.

Angler success is most likely affected by a combination of the factors mentioned above, with certain variables becoming more important than others in a given year. Nonetheless, the steady decline in catch rates since 1975 warrants continued attention and efforts to more clearly define probable causes.

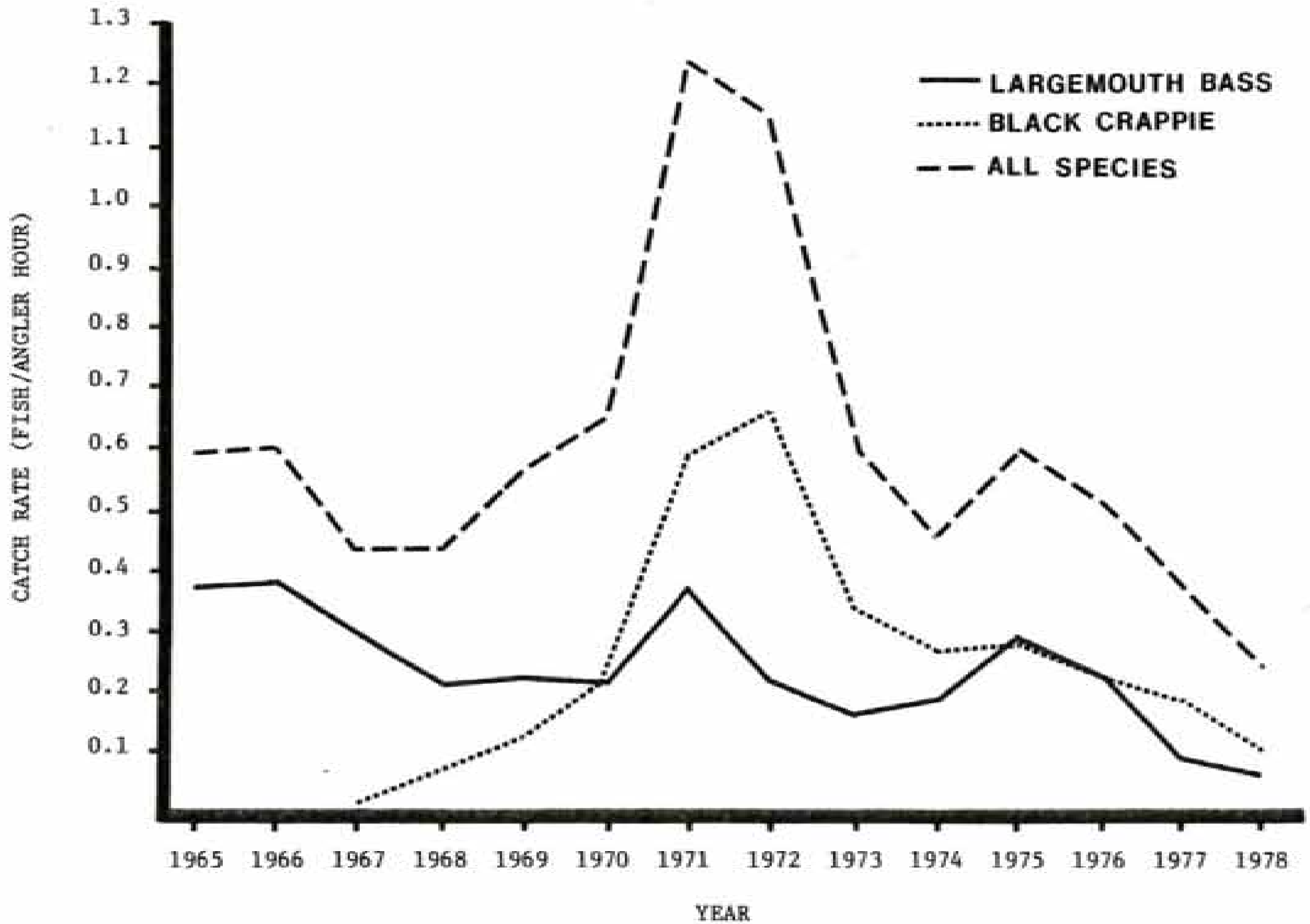

Figure 7. Mean catch rates for all species, largemouth bass and black crappie during April, May and June 1965-78, Lake Powell.

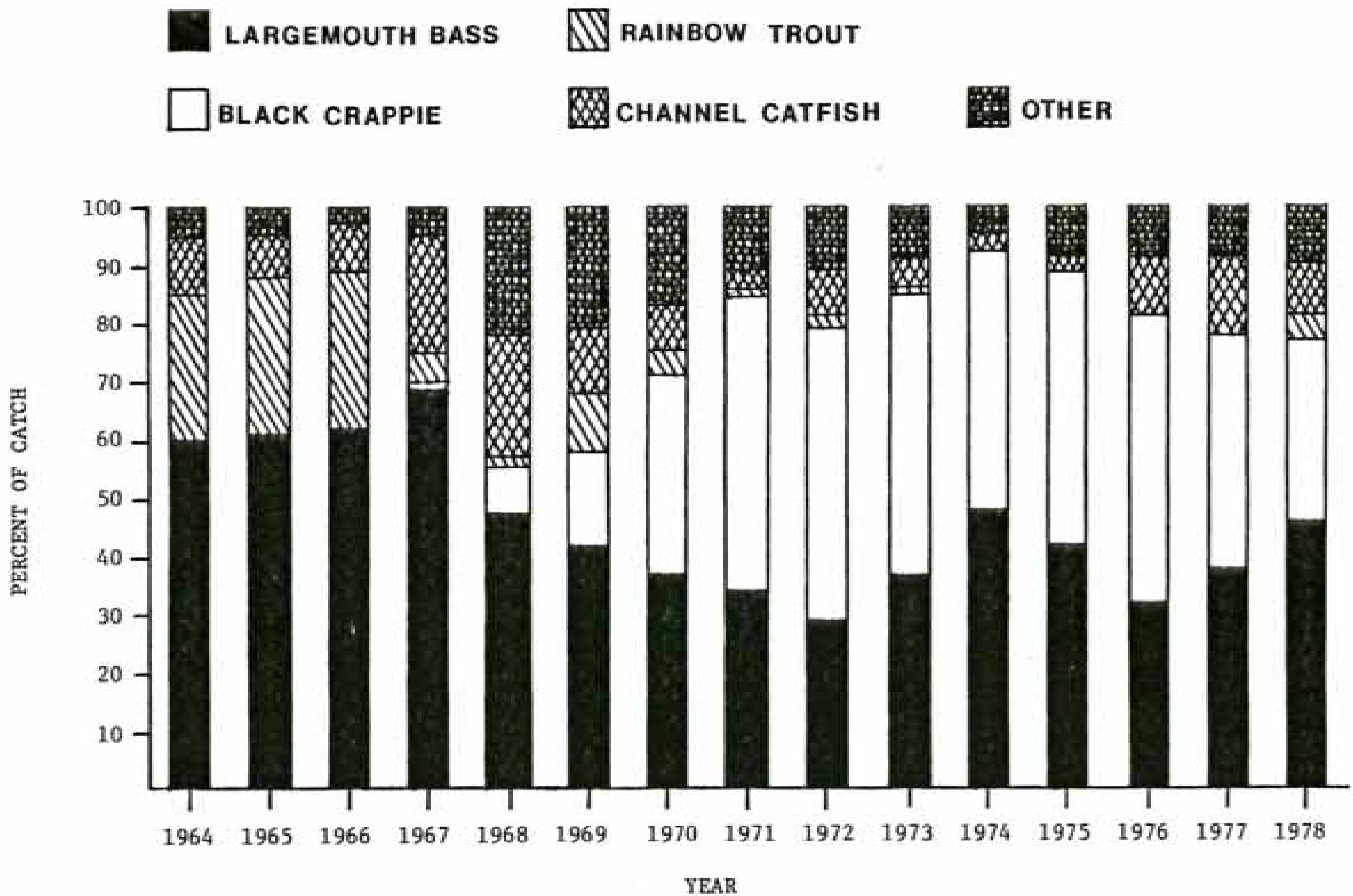

Figure 8. Species composition by percent of the average Lake Powell angler's creel 1964-78.

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INDEX TO ANNUAL FISH POPULATION TRENDS

Job III

Background

Logistical problems usually preclude estimates of absolute numbers of fish in large reservoirs. In such instances, catches from a standardized program of gill netting may provide indices of relative abundance (Moyle 1950; Gooch 1977). A program of annual standardized gill-net sampling has been conducted at Lake Powell since 1971 (Gloss et al. 1974; May and Hepworth 1976; Hepworth et al. 1976, 1977 and 1978) to monitor gross changes in population densities or species composition. In general, past gill-net catches have been dominated by largemouth bass and walleye, with walleye showing an increase in relative numbers since the early 1970's.

Since gill nets are selective with respect to size and species of fish (Lagler 1968), a program of electrofishing was initiated in 1977 to obtain information on the segments of the Lake Powell fisheries which were poorly sampled by gill nets; e.g., young-of-the-year game fish. Standardized annual sampling by electrofishing may also provide an indication of future year-class strength and information on recruitment.

Methods

Gill-net sampling was conducted during March 1978 at Padre Bay, Cha Canyon, Rincon and Red Canyon (Fig. 9). Gangs of ten 30.48 m (100 ft) experimental gill nets (mesh sizes 25, 38, 51 and 76 mm) were fished for three consecutive days at each station. On occasion, only nine nets were used per set due to equipment loss. Nets were set perpendicular to the shoreline in rock and rubble habitat. Fish were removed at 24-hour intervals, measured to the nearest millimeter (TL) and weighed to the nearest 5 g. Scales were taken from selected specimens of all game fish species for future age and growth analysis.

The electrofishing boat was a 8.5 m Yukon Delta with fiberglass hull. An Onan 7.5 kw generator provided electrical power for the lighting system and a Coffelt Model RF-10 electroshocker. Five 1.8 m cables which hung from a front-mounted boom served as positive electrodes. The negative electrode consisted of two 4.6 m cables trailing from both sides of the boat. Output voltage of the electroshocker was 150-200 v dc, which was sequenced to the five positive electrodes so that each electrode was pulsed one time per second. The sampling crew consisted of a driver and one or two netters. Sampling began after dusk and continued for two to six hours. Similar shoreline habitat was electrofished at each station. All captured fish were measured to the nearest millimeter (TL) and released at the station of capture. The time during which the electroshocker was in operation was recorded and a catch rate (fish/hour of electrofishing) was calculated for each species. Largemouth bass less than 175 mm TL and black crappie

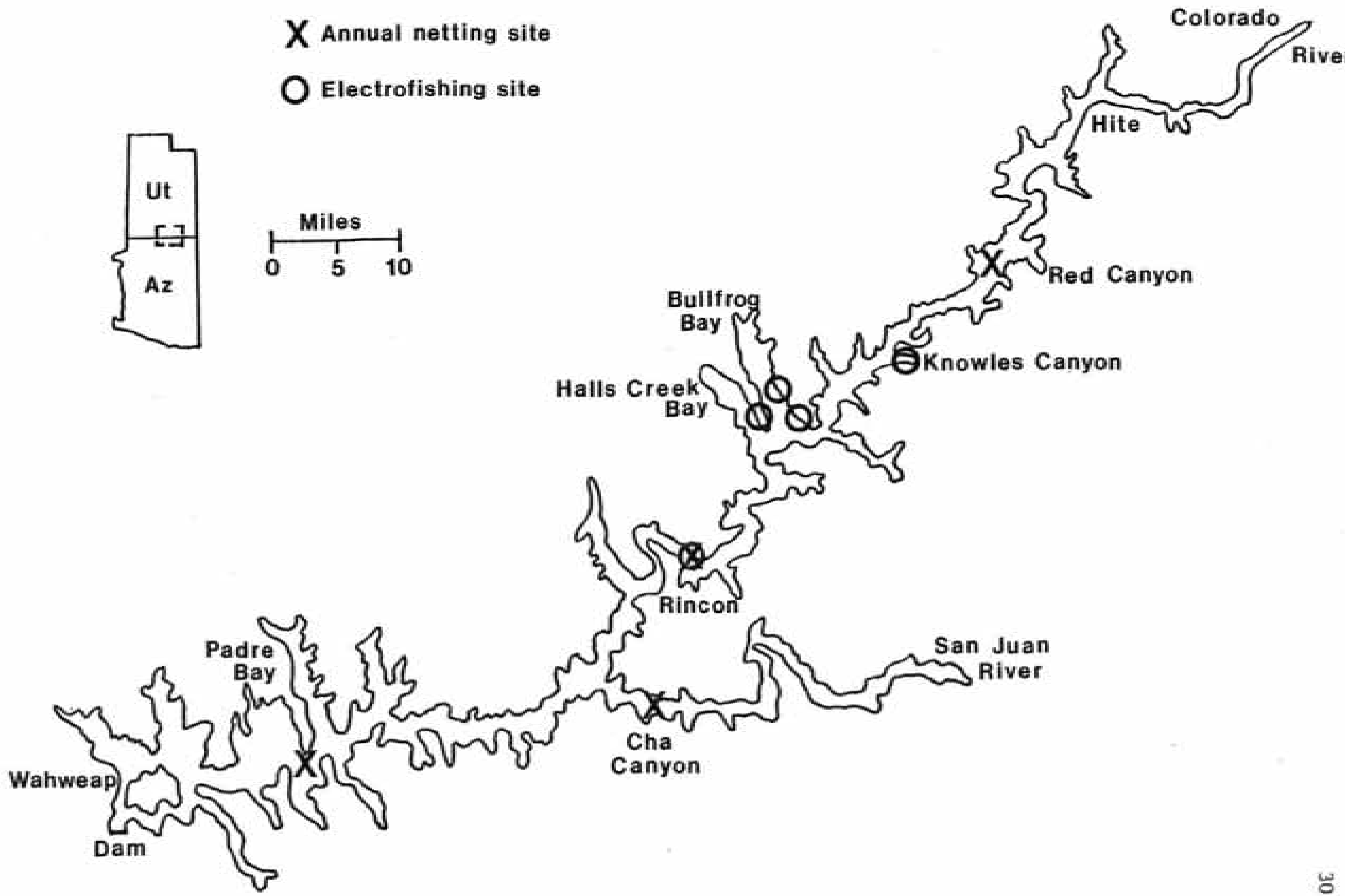

Figure 9. Lake Powell showing electrofishing and annual netting locations.

less than 125 mm TL were considered young-of-the-year. Five stations--Rincon, Hall's Creek Bay, Crappie Cove (Bullfrog Bay) Bass Rock (Bullfrog Bay) and Knowles Canyon (Fig. 9)--were electrofished three nights each. Each station was sampled at approximately one week intervals from mid-August to mid-September.

Results

Annual netting. A total of 792 fish were captured in 116 nets (Table 7). The highest catch rate occurred at Red Canyon (254 fish or 8.5 fish/net), while the lowest was found at Padre Bay (163 fish or 5.8 fish/net). Walleye and largemouth bass accounted for over 80% of the total catch. Crappie, channel catfish and carp each comprised about 5% of the total. Although largemouth bass and walleye made up the majority of fish netted at all stations, the catch of these two species varied greatly between individual stations. Only six walleye were netted at Cha Canyon, while 136 bass were taken there. Conversely, at Padre Bay, bass made up only 10% of the catch and walleye accounted for 71%. About a third of the fish netted at Rincon and Red Canyon were bass; walleye made up about one half of the catch at these two stations. Crappie made up from 0.6% (Padre Bay) to 11% (Cha Canyon) of the catch at individual stations. Rainbow trout were netted at Cha Canyon and Padre Bay. Striped bass were also taken in limited numbers at Padre Bay.

Table 7. Number and catch rate (in parentheses) of fish caught in gill nets, Lake Powell, March 1978. Catch rates are in fish per net.

Species	Padre Bay	Cha Canyon	Rincon	Red Canyon	Total	Percent of Catch
Largemouth bass	15 (0.5)	136 (4.9)	67 (2.2)	85 (2.8)	303 (2.6)	38.7
Walleye	109 (3.9)	6 (0.2)	93 (3.1)	122 (4.1)	330 (2.8)	42.1
Black crappie	1 (t[a])	21 (0.8)	5 (0.2)	11 (0.4)	38 (0.3)	4.9
Bluegill	0 (0.0)	3 (0.1)	1 (t)	1 (t)	5 (t)	0.6
Green sunfish	1 (t)	1 (t)	1 (t)	9 (0.3)	12 (0.1)	1.5
Channel catfish	7 (0.3)	7 (0.3)	13 (0.4)	7 (0.2)	34 (0.3)	4.3
Carp	13 (0.5)	10 (0.4)	3 (0.1)	13 (0.4)	39 (0.3)	5.0
Flannelmouth sucker	1 (t)	0 (0.0)	0 (0.0)	2 (t)	3 (t)	0.4
Rainbow trout	6 (0.2)	7 (0.3)	0 (0.0)	0 (0.0)	13 (0.1)	1.7
Brown trout	1 (t)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)	0.1
Striped bass	9 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	9 (t)	1.1
Yellow bullhead	0 (0.0)	1 (t)	0 (0.0)	4 (0.1)	5 (t)	0.6
Total	163 (5.8)	192 (6.9)	183 (6.1)	254 (8.5)	792 (6.8)	

[a]t = Less than 0.1 fish per net.

Electrofishing. A total of 1,829 fish were captured in 15 nights of electrofishing (11.5 hours actual shocking time) for an overall catch rate of 159 fish/hr. Green sunfish and young-of-the-year largemouth bass were captured most often, making up 40 and 34% of the total sample, respectively (Table 8).

The highest catch rates for both y-o-y bass and y-o-y crappie occurred at Crappie Cove in Bullfrog Bay. The lowest catch rates for both of these groups occurred at Knowles Canyon--green sunfish and bluegill making up the majority of the sample there. Relatively high catch rates for y-o-y bass and y-o-y crappie were recorded for Hall's Creek Bay (bass = 61 fish/hr; crappie = 21 fish/hr) and Bass Rock in Bullfrog Bay (bass = 58 fish/hr; crappie = 29 fish/hr). The catch rate of y-o-y bass at Rincon was intermediate (49 fish/hr) while the catch rate for y-o-y crappie was relatively low there (7 fish/hr). Several juvenile and adult bass were also captured during electrofishing at Hall's Creek Bay and at Bass Rock.

Discussion

Annual netting. The 1978 annual netting catch rates for bass and walleye both showed an increase over the 1977 rates (Fig. 10 and Table 9). This increase was evident at all sample stations. The species composition of the catch was similar to that of past years and demonstrated the same trends--bass and walleye making up the majority of the catch and walleye continuing to show an increase in numbers. There

Table 8. Number and mean catch rate (in parentheses) of fish caught by electrofishing, Lake Powell, August-September 1978. Catch rates are fish per hour of electrofishing.

	Rincon	Hall's Creek Bay	Bass Rock	Crappie Cove	Knowles Canyon	Total	% of Total Catch
Young-of-the-year largemouth bass	118 (49.3)	182 (61.2)	159 (58.4)	91 (80.1)	79 (35.5)	629 (54.5)[a]	34.4
Age 1 and older largemouth bass	- -	5 (1.7)	17 (6.2)	- -	- -	22 (1.9)	1.2
Young-of-the-year black crappie	17 (6.6)	66 (21.0)	79 (29.4)	42 (36.3)	10 (4.7)	214 (18.6)	11.7
Green sunfish	92 (37.8)	261 (86.8)	160 (59.6)	32 (28.1)	178 (77.9)	723 (62.7)	39.5
Bluegill	22 (9.2)	43 (14.7)	50 (18.6)	15 (13.8)	75 (31.9)	205 (17.8)	11.2
Channel catfish	- -	11 (3.8)	4 (1.5)	2 (1.9)	- -	17 (1.5)	0.9
Red shiner	- -	5 (1.6)	1 (0.4)	- -	5 (1.8)	11 (1.0)	0.6
Yellow bullhead	6 (2.6)	1 (0.3)	1 (0.4)	- -	- -	8 (4.0)	0.4
All species	255 (111.7)[a]	574 (186.2)	471 (138.3)	182 (145.4)	347 (150.9)	1,829 (158.6)	

[a]Total fish divided by total hours of electrofishing.

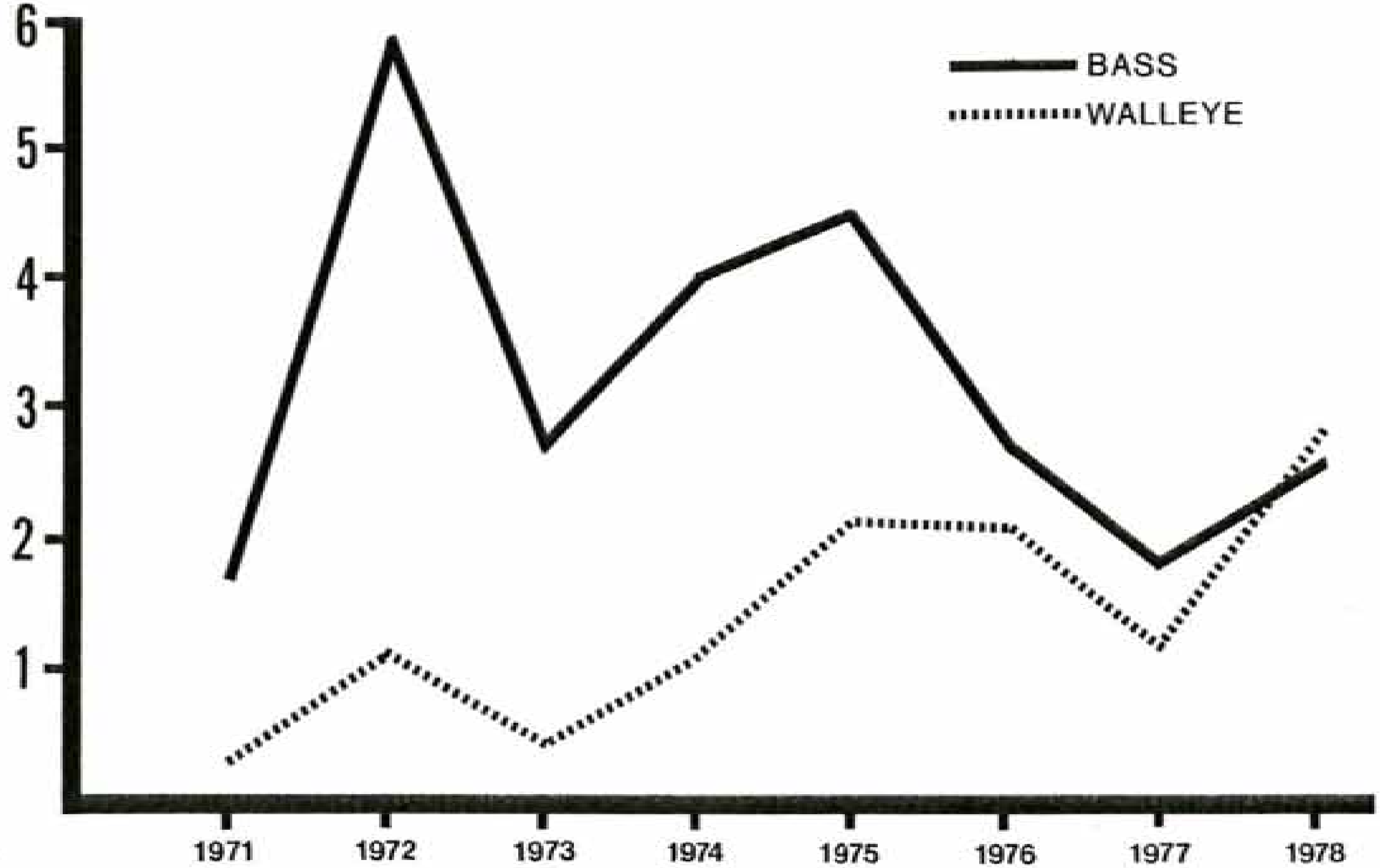

Figure 10. Catch rates (fish/net) of largemouth bass and walleye from annual netting 1971-78, Lake Powell.

Table 9. Catch rate and the percentage of the catch by species and year, annual gill netting, Lake Powell, 1971-1978.

Species	1971		1972		1973		1974		1975		1976		1977		1978	
	Catch Rate	% of Catch	Catch Rate	% of Catch	Catch Rate	% of Catch	Catch Rate	% of Catch	Catch Rate	% of Catch	Catch Rate	% of Catch	Catch Rate	% of Catch	Catch Rate	% of 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	1.85	42.1	2.61	38.3
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	1.17	26.6	2.84	41.7
Black crappie	0.12	3.1	0.67	6.6	0.12	6.1	0.27	4.2	0.36	4.5	0.27	4.3	0.26	5.8	0.33	4.8
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	0.09	2.1	0.04	0.6
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	0.09	2.1	0.10	1.5
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	0.20	4.5	0.29	4.3
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	0.44	10.1	0.34	4.9
Flannelmouth 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	0.03	0.8	0.03	0.4
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	0.26	6.0	0.11	1.6
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	0.02	0.4	0.01	0.1
Striped bass	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.02	0.4	0.08	1.1
Yellow bullhead	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	0.2	0.04	0.6
All Species	3.98		10.10		4.24		6.31		8.02		6.15		4.44		6.82	

was a statistically significant correlation (5% level) between the catch rate for walleye and the time since the annual netting program began, according to Spearman's rank correlation coefficient (Snedecor and Cochran 1971). Although the catch rate for walleye has been increasing and exceeded that of bass for the first time in 1978, there was no indication that the expanding walleye population has adversely affected populations of largemouth bass or any other species. Bass gill-net catch rates have remained relatively stable and Spearman's rank correlation coefficient showed no statistically significant correlations between the catch rate of bass and reservoir age or walleye catch rates.

Differences in the composition of the catch between stations were again evident in 1978. As in past years, few bass were caught at Padre Bay while walleye were relatively abundant there. The opposite continued to hold true for Cha Canyon in 1978, where bass were abundant and walleye scarce. The highest overall catch rate again occurred at Red Canyon in 1978. Species other than bass and walleye were relatively rare in the gillnet catches and exhibited no obvious changes in relative abundance.

Electrofishing. The 1978 electrofishing catch rates for y-o-y bass were higher at all stations than those recorded in 1977 (Table 10). Young-of-the-year crappie were also caught at a higher range in 1978 at all stations except Knowles Canyon. This suggests that there was a relatively stronger year class of both bass and crappie in 1978. Observations during other sampling and reports from anglers support such a hypothesis.

Table 10. Young-of-the-year bass and crappie per hour of electrofishing for August-September 1977 and 1978, Lake Powell.

Location	Y-O-Y Bass		Y-O-Y Crappie	
	1977	1978	1977	1978
Rincon	4.8	49.3	1.5	6.6
Hall's Bay	22.5	61.2	13.7	21.0
Bass Rock	----	58.4	----	29.4
Crappie Cove	36.3	80.1	6.4	36.3
Knowles Canyon	6.9	35.5	8.2	4.7

Factors other than relative abundance may influence the catch rates obtained by electrofishing and gill netting. Some of these include fish behavior, shape and structure of fish, weather conditions during sampling and operator skill and experience. Although concerted effort has been made to keep sampling variability to a minimum by standardizing sampling stations, sampling dates and technique, some uncontrolled variables will inevitably remain. The use of two different gears (electroshocker and gill nets) should provide a fuller and more accurate picture of any population changes. Additionally, electrofishing provides a means of following population dynamics of bass and crappie prior to the time that they become vulnerable to other types of gear or to the angler.

Recommendations

1. Continue standardized sampling of fish populations by electrofishing and gill netting.

2. Test the feasibility of other methods (beach seining, transect counts of fish using SCUBA gear) for sampling segments of the fishery still inadequately sampled, particularly adult crappie.

3. Design a gill-net study of seasonal, special and length-frequency distribution of walleye in Lake Powell. Current test netting reflects walleye distribution only during the spawning period.

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STRIPED BASS CULTURE

Job IV

Background

An experimental culture station for striped bass rearing research was constructed near Glen Canyon City, Utah and completed in 1973. Striped bass production began in 1974 and has been conducted annually. Objectives of the 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. Completed work has included studies on plankton responses to organic and inorganic fertilization, evaluation of stocking densities, food habit studies, timing of fry introductions in relation to water temperature and food availability, and time of pond filling and fertilization in relation to fry arrival from donor agencies (Hepworth et al. 1978, 1977 and 1976; May and Hepworth 1976; Gloss et al. 1974).

Primary objectives for 1978 were (1) to evaluate optimum age for release of fry from tempering baskets; and (2) to evaluate aquatic weed control using potassium permanganate as a shading agent.

Methods

Fertilization and filling of ponds were scheduled around planned fry arrival. Previous results indicated that spring weather conditions and water temperatures at the culture facility were best suited for fry survival and growth during May. Fry are generally available from California Fish and Game at this time and have been received in the past around 20 May. Fry arrival was scheduled for 20 May 1978 and pond preparation was geared for that date.

All ponds were fertilized at the rate of 2,679 kg/ha (3,000 lbs/acre) with alfalfa hay (Table 11). Pond filling began 29 April 1978, 21 days before expected fry arrival. During this preparation period, the ponds were monitored for oxygen and plankton development. Oxygen was sampled daily until saturation was reached. Plankton samples were taken every four days to identify types and sizes of plankton blooms. Ponds that were slow to develop an adequate bloom were administered supplemental doses of 20-20-20 inorganic fertilizer to stimulate plankton growth.

On 23 May 1978, shipment of 1.25 million fry was received from California. Ponds were stocked at an estimated rate of 308,625 fry per hectare (125,000/acre). Fry were tempered and stocked after dark into seran cloth baskets for observation. Ponds similar in plankton abundance and development were treated differently as to time of release to determine which age at time of release was more conducive to fry survival. Fry in Ponds 1, 2, and 5 were released from the baskets at seven days of age, while fry in Ponds 3, 4, and 6 were released at 12 days of age. A small number of fish were retained in baskets in each pond for observation and sampling. Fish were sampled at four-day intervals for food habit determinations from age nine days to age 31 days. Sample fish were taken from the basket and also from the pond when possible.

Fuel oil treatments for aquatic insect control were made before fry arrival, before fry release from tempering baskets, when insects were observed to be increasing and prior to harvest. Ponds were treated at 46.75 l/ha (5 gal/acre) with a mixture of diesel fuel, gasoline and motor oil as described by Harper (1977).

Table 11. Fertilization rates of culture ponds, 1978.

Pond	Ponds of Hay Initially Applied at 3,000 lbs/acre	Pounds of Hay Added as Supplemental Fertilizer	Pounds of Inorganic Fertilizer
1	1,200	200	10
2	1,200	200	5
3	3,000	600	25
4	3,300	400	10
5	9,300	500	25
6	11,700	950	25

The use of potassium permanganate as a shading agent to retard aquatic weed growth was evaluated by treating Ponds 1 and 3 with a 3 ppm concentration on 12 June 1978. The dry chemical was placed in burlap bags and disseminated by towing the bag around the pond. Ponds 2 and 4 were treated with 1.5 ppm potassium permanganate on 22 June 1978 followed by a similar dose on 26 June. On 1 July 1978, Pond 1 was treated with 4 ppm and Pond 3 was treated with 6 ppm.

Supplemental feeding was attemped in Ponds 4 and 5. Feeding was begun when fish were 28 days old and 15-20 mm long. Initial feeding rate was 4.5 kg/ha/day (5 lbs/acre) using an equal mixture of ground beef liver and Silver Cup salmon starter. The liver mixture was fed for the first two days and then Silver Cup was fed for the remainder of the time. The amount of Silver Cup was increased to 8.9 kg/ha/day (10 lbs/acre) when fish were 33 days of age. Supplemental feeding began in Pond 2 on 27 June 1978, when plankton counts indicated food supplies were critically low. Fish were started feeding on Silver Cup alone and fed 8.9 kg/ha/day (10 lbs/acre).

Results

Finglering production reached a record high of 254,290 striped bass (Table 12). The 3.28 ha (8 acre) facility produced an average of 78,383 fingerlings per hectare (31,747/acre). Of the estimated 1,200,000 fry stocked 21% survived, overshadowing the previous high survival rate of 14% achieved in 1977. Production success was attributed to timing of fry introductions to coincide with the beginning of the nauplii copepod plankton bloom. Successful ponds were characterized by fry introduction before the copepod count reached 100 per liter (Figure 11). The nauplii copepod count in unsuccessful ponds exceeded 100 per liter before fry introduction. Oxygen depletions due to pond fertilization were overcome 11-16 days after filling began. Nauplii copepod abundance reached 100 per liter 23-35 days after filling.

Table 12. Production of fingerling striped bass, 1978.

Pond	Surface Acres	Estimated Number Stocked	Percent Survival	Production per Acre	Total Harvested
1	0.46	100,000	0.20	441.30	203
2	0.43	50,000	57.0	65,930.23	28,350
3	0.95	175,000	0.02	38.95	37
4	0.73	150,000	46.0	93,835.62	68,500
5	2.60	300,000	42.0	48,692.31	126,600
6	2.84	425,000	7.0	10,774.65	30,600
Total	8.01	1,200,000	21.0	31,746.57	254,290

Fry released from tempering baskets at seven days of age had an average production of 94,696 per hectare (38,354/acre) compared to 86,126 per hectare (34,883/acre) for fry released at 12 days of age. Fish retained in tempering baskets for food habits and growth studies were found to be slow-growing and in poor condition compared to fish collected directly from the same pond.

Air breathing hemipterans were effectively eliminated in Ponds 1-4 by fuel oil treatments. The larger size of Ponds 5 and 6 made it impossible to cover the entire pond with an oil film; therefore, insect control was less effective. Aquatic insects were not a problem this year with the exception of gill-breathing Odonata larvae which were unaffected by the fuel oil treatment.

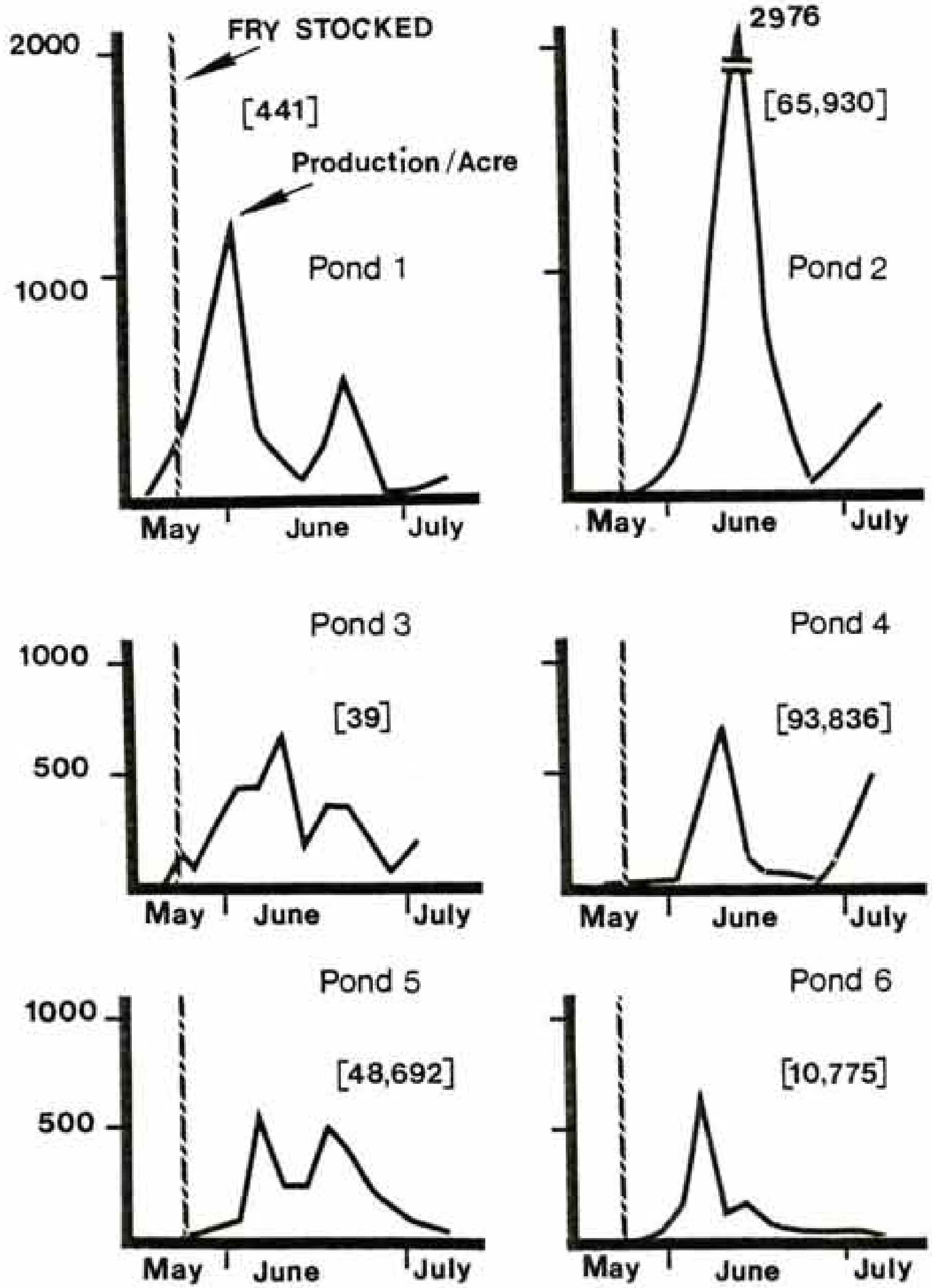

Figure 11. Timing of fry introduction in relation to stage of nauplii copepod abundance. Production of fingerlings per acre listed for each pond.

Treatment with potassium permanganate at 3 ppm concentration produced and maintained a secchi disk measurement of 0.92-1.37 m (3-4.5 ft) for a 10-day period. Treatment at 1.5 ppm followed by a subsequent treatment of 1.5 ppm produced a reading of 1.22-1.83 m (4-6 ft) initially and then showed no change as a result of the second treatment. Treatments of 4-6 ppm had a negative shading effect since phytoplankton was apparently eliminated by the heavy concentration of potassium permanganate. Secchi disk readings increased from 1.22 m (4 ft) to 1.68 m (5.5 ft) in Pond 1 and to 1.98 m (6.5 ft) in Pond 3 following treatment. Lowest secchi disk readings (2-2.5 ft) were obtained in Pond 5 which was untreated. Dense weed growth occurred in all ponds since light was not sufficiently reduced to retard weed growth.

Supplemental feeding was begun 16 June 1978 in Ponds 4 and 5. Fish in Pond 4 were immediately attracted to ground liver and salmon starter and were actively feeding by 19 June 1978. Fish in Pond 5 were never observed feeding and supplemental feeding was curtailed on 21 June 1978. Supplemental feeding began 27 June 1978 in Pond 2 when plankton counts indicated food supplies were critically low. Although fish were started without ground liver, they began feeding immediately on salmon starter.

Discussion

Previous experimentation indicated that timing the fry introduction to precede the bloom of nauplii copepods was the key to successful fingerling production (Hepworth et al. 1978). Using the filling and fertilization techniques that were proven most successful last year, we achieved excellent success in four of the six ponds. The two unsuccessful ponds bloomed more quickly than the others even though all ponds were treated similarly (Figure 11). These results further substantiate the premise that timing is the key to production success.

Experimentation on optimum age of release from tempering baskets was inconclusive. Production per hectare was slightly higher on fish released at seven days compared to fish released at 12 days, although there was no statistical significance. Field observations, however, suggest releasing fish at the earlier age. A significant mortality occurred on the 11th day of holding in Pond 6 when healthy fish were trapped in dislodged patches of filamentous algae. Mortality of this nature would have less chance of occurring if holding time was reduced to the shortest possible time. Future fry releases will occur near six days of age. This will allow enough time to ensure that the fry have successfully acclimated to the pond environment without exposing them to unnecessary risks due to confinement.

Fry food habit studies indicated a selective preference for copepods and cladocerans while rotifers and ostracods were avoided. Food was first observed in stomachs of fry at 10-13 days of age (5-7 mm). There was some indication that rotifers were taken during the critical period when feeding began, but nauplii copepods were the preferred diet. Fry began eating adult copepods and cladocerans when they attained lengths of 10 mm. Comparison of stomachs from fish taken from the sample baskets and those taken directly from the pond indicated that fish confined in the baskets were forced to eat available food items (ostracods and rotifers) rather than selecting preferred items. Growth and condition of fish held in tempering baskets were poorer than fish sampled from the pond. Future studies of fish held in tempering baskets would require daily cleaning of the mesh baskets to ensure adequate water and plankton exchange.

The control of aquatic weeds by shading the pond with potassium permanganate proved ineffective. Application of 3 ppm produced a secchi disk reading of about 1 m for a 10-day period. This light reduction did not sufficiently retard weed growth. A reading of 0.46 m (18 in) or less is required for effective weed control (Harper 1977). Weed control has become the biggest challenge at the culture facility. Success of harvest depends on the absence of weed growth in the seining areas. Heavy weed growth hinders the harvest and causes serious losses of fingerlings that could otherwise be stocked into Lake Powell. Future studies will concentrate on methods of eliminating noxious weed growth by chemical and mechanical control.

Supplemental feeding was found to be of value in ponds where plankton production could not keep pace with striped bass predation. When plankton numbers were high, fry would not eat Silver Cup feed. I feel that the health and condition of the fish were maintained by supplemental feeding in Ponds 2 and 4.

Recommendations

1. Replicate the successful technique of filling and fertilizing the ponds approximately 20 days prior to planned fry arrival.

2. Apply a preemergent herbicide to the dry pond bottoms of selected ponds to evaluate the utility of this method of aquatic weed control.

3. Release fry from tempering baskets at 6-7 days of age.

4. Evaluate other methods of aquatic weed control to include: potassium permanganate shading, lining the seining areas with plastic sheets and experimenting with herbicide treatments.

5. Drain and refill those ponds that bloom prior to fry arrival.

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EVALUATION OF STRIPED BASS INTRODUCTION

Job V

Background

Striped bass have been stocked annually into Lake Powell since 1974 with approximately 80% of the fingerling stripers stocked in Wahweap Bay. Bullfrog Bay has been stocked annually since 1976. Sampling of the striped bass population was designed to supply information on survival, growth and food habits. Data on distribution and development of a sport fishery were largely collected as part of the regular creel census program (Job II). The striped bass have continued to show excellent growth and high utilization of threadfin shad in their diet. Most of the returns to the creel have been incidental although a small group of anglers are successfully fishing for striped bass in the southern end of the reservoir.

Methods

Collections of striped bass from Lake Powell were largely made by gill netting. A few young-of-the-year striped bass were caught with beach seines. Creel census returns and angler reports were used to describe distribution and movement from the original stocking areas.

Lengths, weights, stomachs and scales were collected from all striped bass. Stomach contents were preserved in 10% formalin for later examination. Stomachs were examined to determine composition of food items by number, volume and occurrence. Scales were taken from below the lateral line and posterior to the pectoral fin. Impressions of the scales were made on acetate cards with a heated press. They were read and measured with the aid of a microprojector. Scale characteristics were compared to growth of introduced known age striped bass.

Striped bass stocking procedures and times are covered under Job IV.

Results

A total of 254,290 striped bass fingerlings were stocked in Lake Powell in 1978. Wahweap Bay received 169,469 and 84,821 were planted in Bullfrog Bay (Table 13). A total of 592,763 striped bass have been planted in Lake Powell since 1974.

Catches with both beach seines and small mesh gill nets indicated good survival of the fingerlings stocked in Wahweap Bay. An average of four young-of-the-year stripers were collected per seine haul in Wahweap Bay. Sampling success was poor at Bullfrog for the second year. It is not known whether the lack of success in the Bullfrog area is the result of poor survival, migration, gear and site selectivity or a combination of all three.

The average growth of each age class is illustrated in Table 14. Mean total lengths at ages 1-4 were 261, 442, 566 and 676 mm, respectively.

Table 13. Stocking record of striped bass introduced into Lake Powell.

Year	Number Stocked Wahweap	Bullfrog	Total
1974	49,885	0	49,885
1975	94,878	0	94,878
1976	35,752	19,305	55,057
1977	86,003	52,650	138,653
1978	169,469	84,821	254,290
Total	435,987	156,776	592,763

Threadfin shad dominated the diet of 272 striped bass examined during 1977 and 1978. Shad comprised 71-100% of the diet by number and 82-100% by volume (Table 15). The lowest numbers and volumes of threadfin shad were observed in the summer and the highest in the winter. Crayfish were the second most abundant organism in striped bass stomachs followed by unidentified fishes and centrarchids, respectively.

Discussion

Growth of Lake Powell striped bass was better than most other reported populations (Table 14). The mean total lengths at ages 1-4 were 261, 442, 566 and 676 mm, respectively. Growth rates of both sexes have been combined to date. Edwards (1974) and Robinson (1960) found that males and females grow at the same rate through age four when the females began to grow faster than males.

Table 14. Comparison of growth rates of striped bass from various studies. All data converted to total length.

Age Group	Present Study Lake Powell	Lower Colo. River (Edwards 1974)		California (Robinson 1960)		South Carolina (Stevens 1957)	Maryland (Mansueti 1961)		Oregon (Morgan and Gerlach 1950)	Oklahoma (Erickson et al. 1971)
		Male	Fem.	Male	Fem.		Male	Fem.		
I	261	174	190	112	120	218	145	133	---	280
II	442	463	470	266	266	401	318	312	399	473
III	566	609	648	413	416	505	408	415	516	584
IV	676	712	768	535	620	573	500	529	620	676
V	---	790	873	606	641	658	535	595	679	742
VI	---	851	934	666	731	736	636	690	739	---

A new lake record striper was caught on hook and line in the Bullfrog area on 2 December 1978. The fish was a male, 759 mm (30 in) TL and it weighed 5,225 g (11.5 lbs). Some females from the 1974 year class could be 800 mm and weigh between 5,900 g (13 lbs) and 6,356 g (14 lbs).

Several age 4 females examined during the spring and early summer of 1978 had mature green-colored eggs. No reproduction was observed and it was not known whether eggs were reabsorbed or expelled.

Striped bass in Lake Powell fed mainly on threadfin shad. Edwards (1974) reported that stripers from lower reservoirs on the Colorado River relied on threadfin shad and threadfin shad were found in 67.3% of the stomachs containing food. Stevens (1978 Personal Communication) found clupeid fishes in 83% of all full stomachs. The stripers were so dependent on shad in Santee Cooper Reservoir that when the shad population was severely overcropped, many striped bass starved to death rather than switch to other sources of food.

During the summer months, June-August, 26% of the Lake Powell striped bass stomachs contained crayfish, 57% threadfin shad and 47% were empty. Unidentified fishes and centrarchids were found in 9% and 6% of the stomachs, respectively. The summer sample had the highest percent of empty stomachs (47%). The warmer body temperatures and increased metabolism resulted in faster digestion rates during the warmer months. The soft bodies and small bones of shad were digested rapidly compared to the heavy chitinous exoskeleton of a crayfish.

Table 15. Food habits, by season, of striped bass collected in Lake Powell during 1977 and 1978.

Food Items	Dec.-Feb., 1977 (n^a = 39)			Mar.-May, 1977-78 (n = 132)			June-Aug., 1977-78 (n = 55)			Sept.-Nov., 1977 (n = 46)		
	% by Number	% by Vol.	% Occ.	% by Number	% by Vol.	% Occ.	% by Number	% by Vol.	% Occ.	% by Number	% by Vol.	% Occ.
Crayfish	-	-	-	1	1	6	18	7	26	4	16	5
Fish												
Threadfin shad	100	100	100	88	95	76	71	82	57	96	84	92
Centrarchidae	-	-	-	-	-	-	6	3	6	-	-	-
Unidentified	-	-	-	4	1	8	5	7	9	-	-	-
Debris	-	-	-	1	1	3	t^b	1	2	t	t	3
Lepidoptera	-	-	-	6	2	1	-	-	-	-	-	-
	Empty = 2 (5.1%)			Empty = 48 (36.4%)			Empty = 26 (47%)			Empty = 8 (17%)		

[a] n = Total number of stomachs examined.

[b] t = Trace, less than 1%.

In the fall months, crayfish were found in only 5% of the stomachs containing food while threadfin shad were observed in 92%. By winter, shad comprised 100% of the striper's diet. As the water warmed in the spring, striped bass began feeding on crayfish (6% of the full stomachs), shad (76%) and unidentified fishes (8%).

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