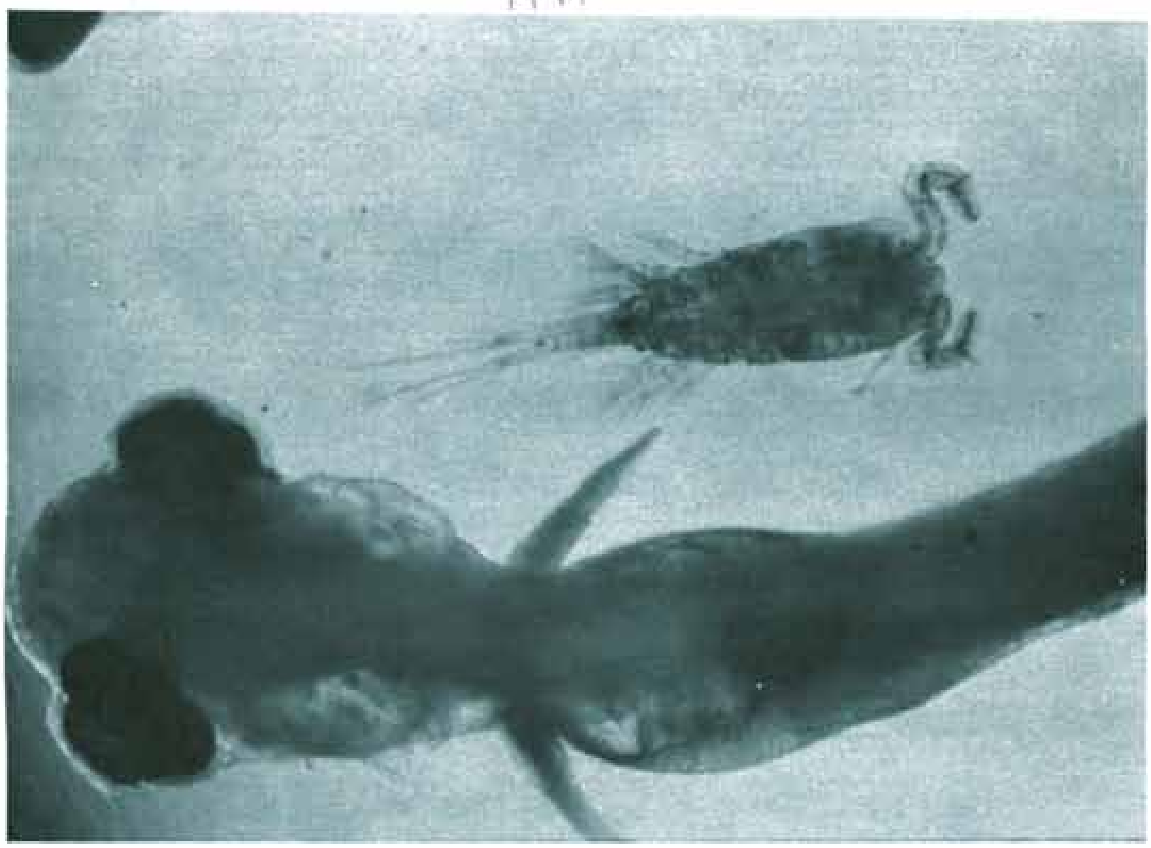
LAKE POWELL
POST-IMPOUNDMENT INVESTIGATIONS

ANNUAL PERFORMANCE REPORT

1977



LAKE POWELL
POST-IMPOUNDMENT INVESTIGATIONS

Annual Performance Report
January 1977 - December 1977

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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 January 1 through December 31, 1977. 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. 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). 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 fourth consecutive year, fingerlings raised from cultural experiments were stocked in the reservoir. Striped bass interaction with its environment and contribution to the creel has been studied since initial introduction in 1974.

THREADFIN SHAD STUDY

Job I

Background

The most important prey species in Lake Powell is the threadfin shad. Shad were first introduced into Lake Powell in 1968 and subsequently became established as the predominant food item in the diet of all major game species (Hepworth) and Gloss 1976, et al. 1975a, 1975b). Shad are typically pelagic and are 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 and 1977 was used to determine shad population level indices and monitor monthly and yearly population dynamics.

Striped bass, a large pelagic predator, were introduced into Lake Powell in 1974 to better utilize the dense population of shad. Established game species tend to be restricted to littoral zones and generally do not occupy pelagic regions of Lake Powell. Shad abundance determined for 1976 and 1977 will be used as a baseline for future comparisons in determining population changes and impacts of an expanding striped bass population on threadfin shad abundance. Additional information on shad spawning periodicity has been collected.

Methods

Trawling was carried out with a 28-foot steel hulled work boat. Two Marco W0650 hydraulic winches powered by Vickers hydraulic pumps were run directly from the boat's inboard gasoline 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 20.4 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 trawl mouth, functioned to hold the net open while fishing. Galvanized wire rope cables (1/8 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 standard 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 volume of water sampled was 8,178.44 m^3, and 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, midway up lake, and near the Colorado River inlet (Figure 1). Wahweap Bay was sampled two nights per month, with Bullfrog and Hite 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 bouys, permanently fixed in position, were used to mark trawl transects.

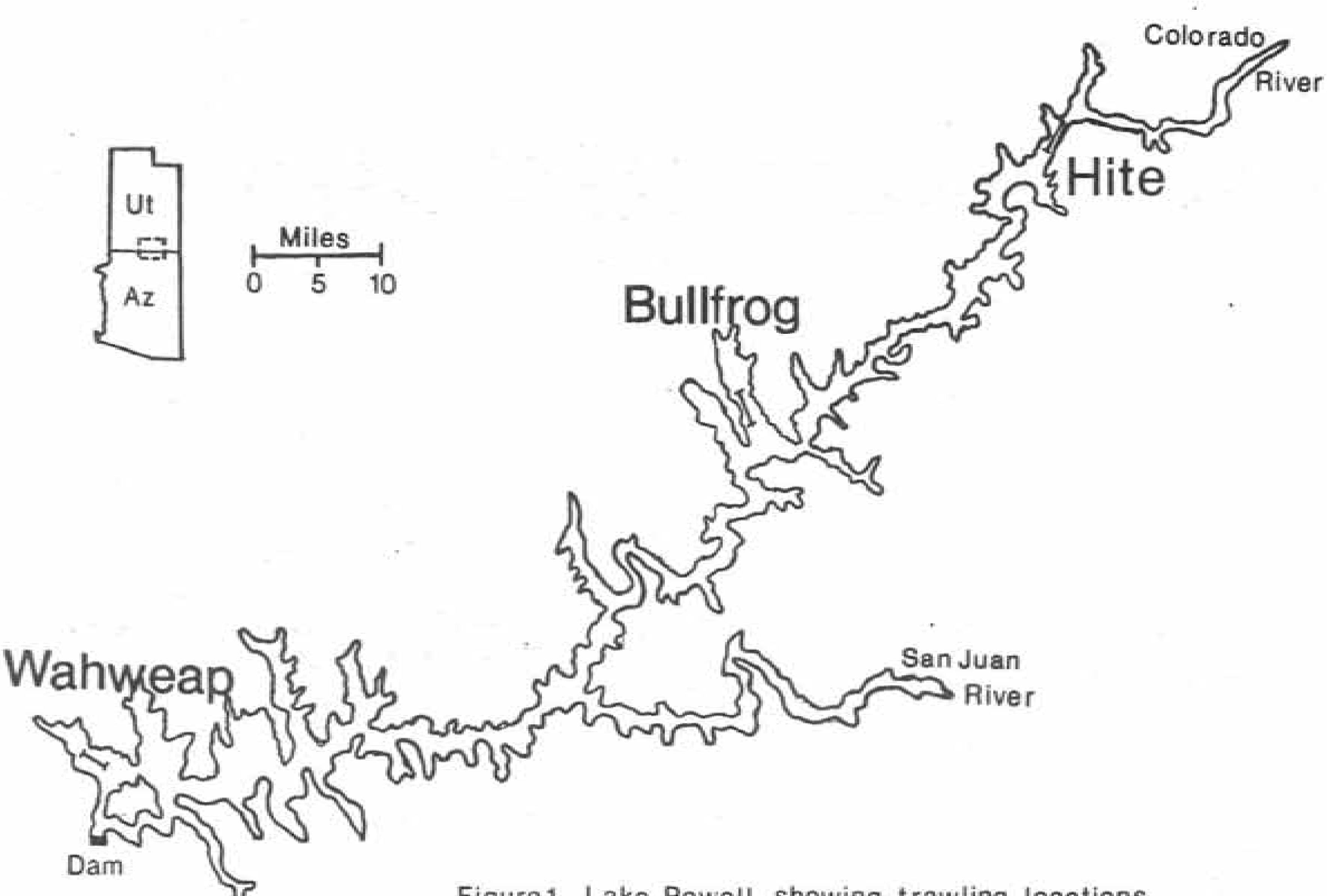


Figure 1. Lake Powell, showing trawling locations.

One sonar transect was run each sample night before trawl samples were taken. The boat was operated at an idle speed of 800 RPM for a period of eight minutes, while sonar transects were run over the trawling course. Number and biomass of shad captured per standard tow were compared with echograms showing fish trace density in the epilimnion.

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). Larvae were designated as shad smaller than 25 mm. All shad collected in the trawl were immediately preserved in a 10 percent formalin solution. Number of fish, weight of catch, average total length, and range were determined for each haul.

Results

The first indication of threadfin shad spawning activity during 1977 was the capture of larval shad on May 19, near Dark Canyon and the inlet of the Colorado River. Surface temperature at that time was 64 F. Shad were observed spawning in the upper San Juan arm on May 22. Spawning was first observed at Bullfrog on May 29 (63 degrees F) and at Wahweap on May 31 (66 degrees F). Spawning systematically progressed from the inlet down lake toward the dam. Spawning was last observed on June 14 (76 F) at Bullfrog.

Average length of shad captured per standard tow increased with time at all sampling locations (Figure 2). The length of the smallest fish captured per tow constantly increased with time at all sampling locations (Figure 2). The length of the smallest fish captured per tow constantly increased after July 18 at Hite, while size of the smallest fish captured at Bullfrog showed a slight decrease after that date (Figure 2). The smallest fish captured at Wahweap stayed relatively constant throughout the sampling season.

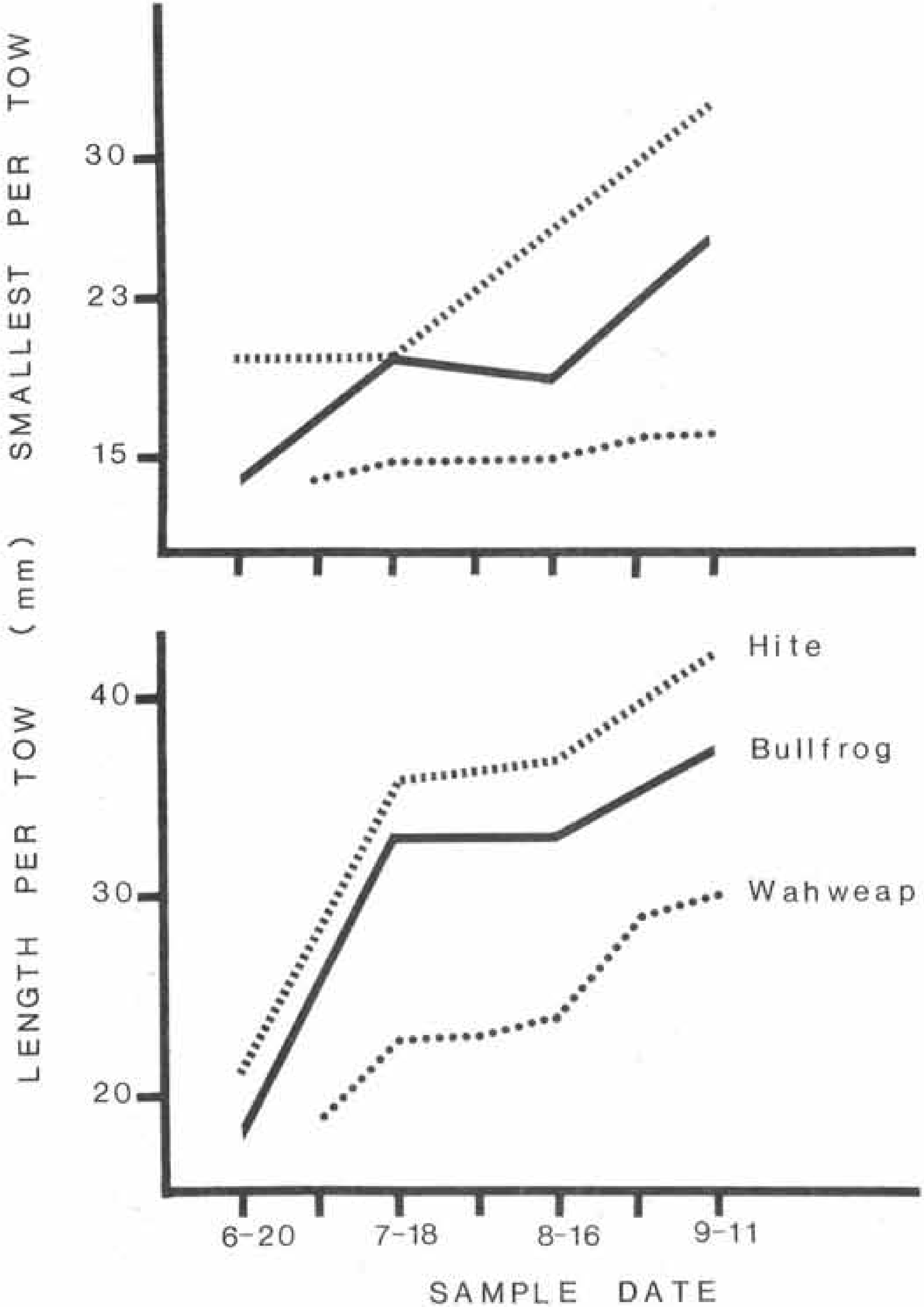


Figure 2. Average length and length of smallest shad (mm) captured per standard tow by area and sample night, Lake Powell, 1977.

Average number of shad captured per standard tow in Wahweap Bay was greater in 1977 than in 1976 (Table 1). Comparative samples for 1977 showed a 15-fold increase in shad numbers in August and a 7-fold increase in September over values collected in 1976.

Comparison of different lake areas in 1977 showed shad numbers were of about the same magnitude at Wahweap and Bullfrog but considerably greater at Hite (Table 1). Peak densities of shad at Hite reached 461 per 1000 m^3. Densities at Wahweap and Bullfrog peaked at 138 and 115 shad per 1000 m^3, respectively. However, when results were plotted (Figure 3) trends at Bullfrog and Hite were similar despite differences in total numbers. Data showed a peak abundance in July as young-of-the-year shad became large enough to capture in the trawl. Numbers subsequently declined in August and rebounded in September, reaching a smaller secondary peak. Shad numbers at Wahweap followed the same general pattern, with the main difference being a sharp decline in September.

Average shad biomass per standard tow closely followed results of number of shad captured. At Bullfrog and Hite there were two distinct peaks in biomass with the higher September peak indicating growth of shad with time (Figure 4). Biomass at Hite was consistently greater reaching a peak of 2276 g per tow. The biomass peak at Bullfrog was considerably less at 274 g per tow. A distinct peak was not evident at Wahweap but remained quite constant at levels less than 100 g per tow.

Discussion

Most authors believe that threadfin shad spawn more than once a year. Kimsey (1958) and Kimsey et al. (1957) reported two major spawning peaks for shad in California ponds in 1955 and in Lake Havasu, California-Arizona in 1956. Hida and Thompson (1962) found evidence which indicated shad spawned from June

Table 1. Average number of threadfin shad captured per standard tow and estimated number of shad per 1000 m^3 by lake area, Lake Powell, 1976-1977.

Shad per standard tow	June	July	August	September
Wahweap				
1976	----	----	50	12
1977	0	1,131	798	84
Bullfrog				
1977	11	945	530	691
Hite				
1977	790	3,773	3,187	3,691

Shad per 1000 m^3	June	July	August	September
Wahweap				
1976	----	----	6	1.5
1977	0	138	98	10
Bullfrog				
1977	1	115	65	84
Hite				
1977	97	461	390	443

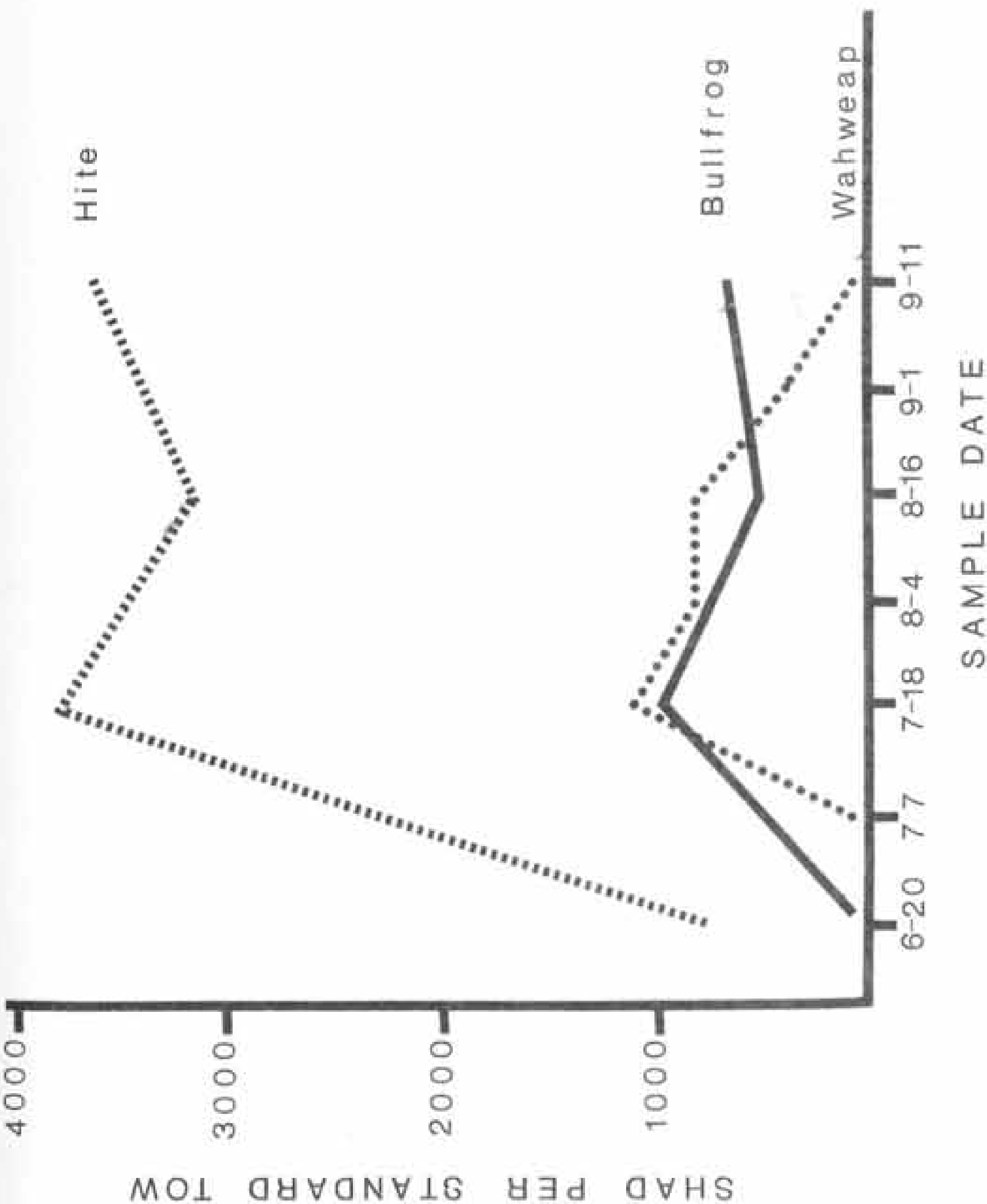


Figure 3. Average number of shad captured per standard tow by area and sample night, Lake Powell, 1977.

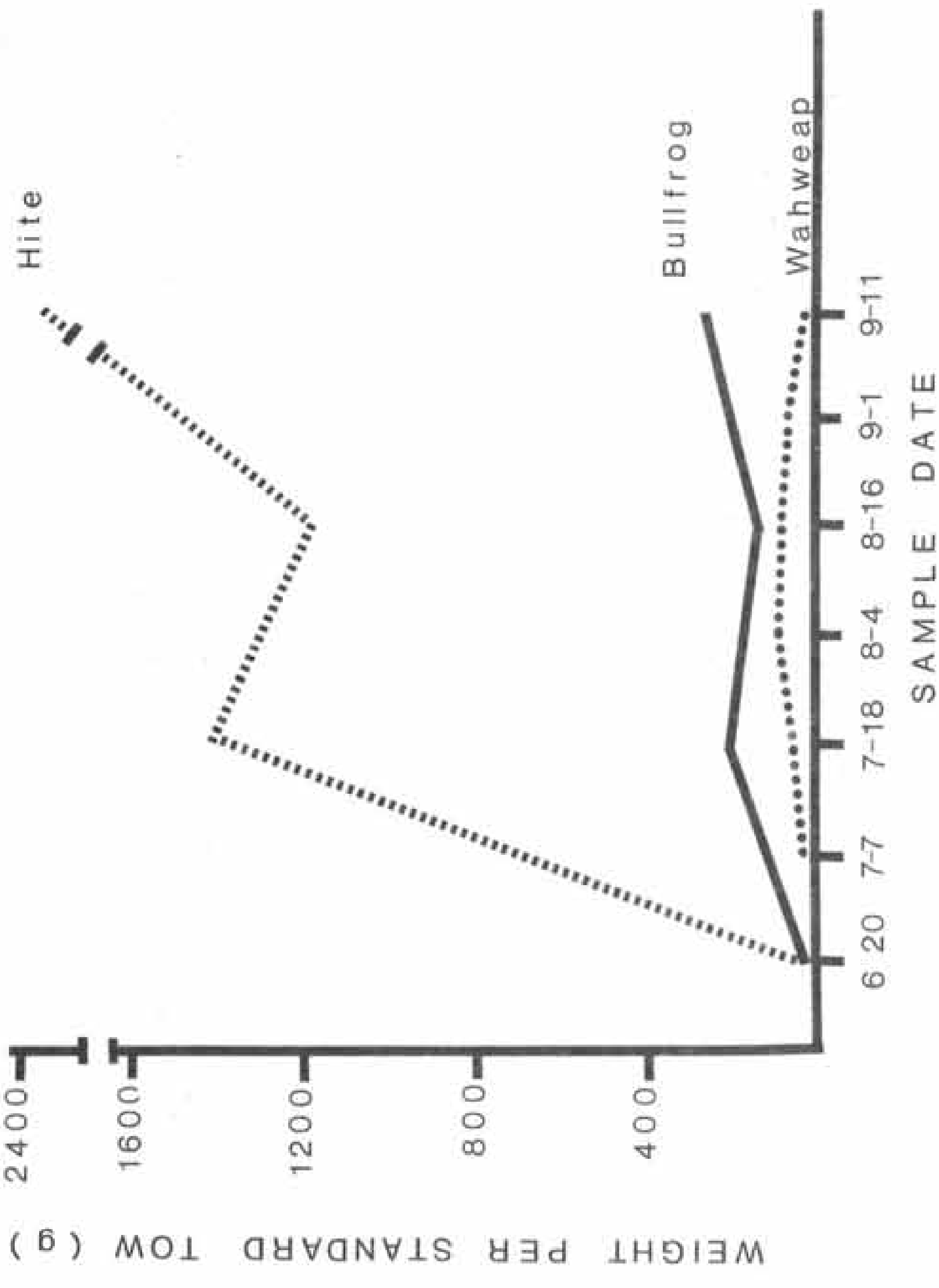


Figure 4. Average biomass (g) of shad captured per standard tow by area and sample night, Lake Powell, 1977.

through September in Hawaii. Shelton (1964) showed evidence of a second complement of ova developing in spawned female shad in central Arizona lakes but only in part of the population of shad two years and older. He further demonstrated that shad from different age-groups spawned at different times. Fish of age groups III-IV had a spawning peak about April 10, while age-group I fish had a spawning peak in late May, more than a month later.

Shad spawning in Lake Powell began in early May in the extreme upper reservoir and continued down lake. This proogressive spawning pattern was similar to that described by Netsch et al. (1971) in Beaver Reservoir, Arkansas. At Beaver Reservoir the shad popultion peaked four-eight weeks after spawning, then numbers decreased rapidly due to mortality. Occasionally, secondary peaks followed due to continued spawning. At Lake Powell, the population peaked in mid-July, approximately six weeks after spawning began. At all sampling areas, numbers then decreased and later increased again (Figure 3). Continued spawning definitely occurred at Wahweap and Bullfrog as shown by larval occurring in trawl catches in August and September. Smallest shad captured per tow at Wahweap was consistently near 15 mm, which was about the smallest fish that could be captured in the trawl. Larval shad were taken less often at Bullfrog indicating a weaker continued spawn than at Wahweap (Figure 2). Prolonged spawning was not noted at Hite, size of the smallest fish steadily increasing after July. Anderson (1973) found that density dependent factors including crowding and nutritional conditions affected spawning of gizzard shad (Dorosoma cepedianum). Strong year classes of shad were produced from low density populations of adult shad and weak year classes from high density adult populations. Heidinger and Imboben (1974) demonstrated that young-of-the-year shad introduced into a shad-free environment could mature and successfully spawn the same year. The high density shad population at Hite, in relation to other lake areas, possibly inhibited a secondary spawn. Secondary complements of eggs either failed to develop and/or later developing younger females failed to produce a substantial secondary spawning peak.

Numbers of shad captured correlated well with fish traces observed in the epilimnion on sonar echograms (Figures 5, 6, and 7). Traces became consistently more numerous as the sampling season progressed. At Wahweap no traces were observed on the June 20 echograms, and no fish were captured in the trawl (Figure 5). On July 18 scattered traces were observed, and 187 shad were captured per tow. During September echograms showed dense groupings of traces at all locations; however, trawl results were not consistently higher. It has been shown that as shad grow their ability to avoid capture in a trawl increases (Alfred Houser, personal communication). Sonar echograms in August and September represented mostly juvenile and adult shad. The adults were rarely captured, and juvenile catch decreased as size increased. Trawl catches were probably biased toward smaller individuals in late summer. However, decreased trawl catch in numbers and increased density of sonar fish traces may not be totally inconsistent. Fewer but larger fish may cause denser fish traces on sonar in comparison to more numerous but smaller fish. Biomass was generally highest in September, while shad numbers were below previous peaks (Figures 3 and 4). Trawling depth may also have been a factor contributing to reduced catch in September. Maximum depth of the standard tow may not have been deep enough to sample fish in the 10-12 m range (35-40 ft) as shown by sonar.

Comparative trawl samples for 1976 and 1977 showed a stronger year class of shad in Wahweap Bay (Table 1). Others have noticed relatively large differences in year class strength of shad (Bryant and Houser 1968,

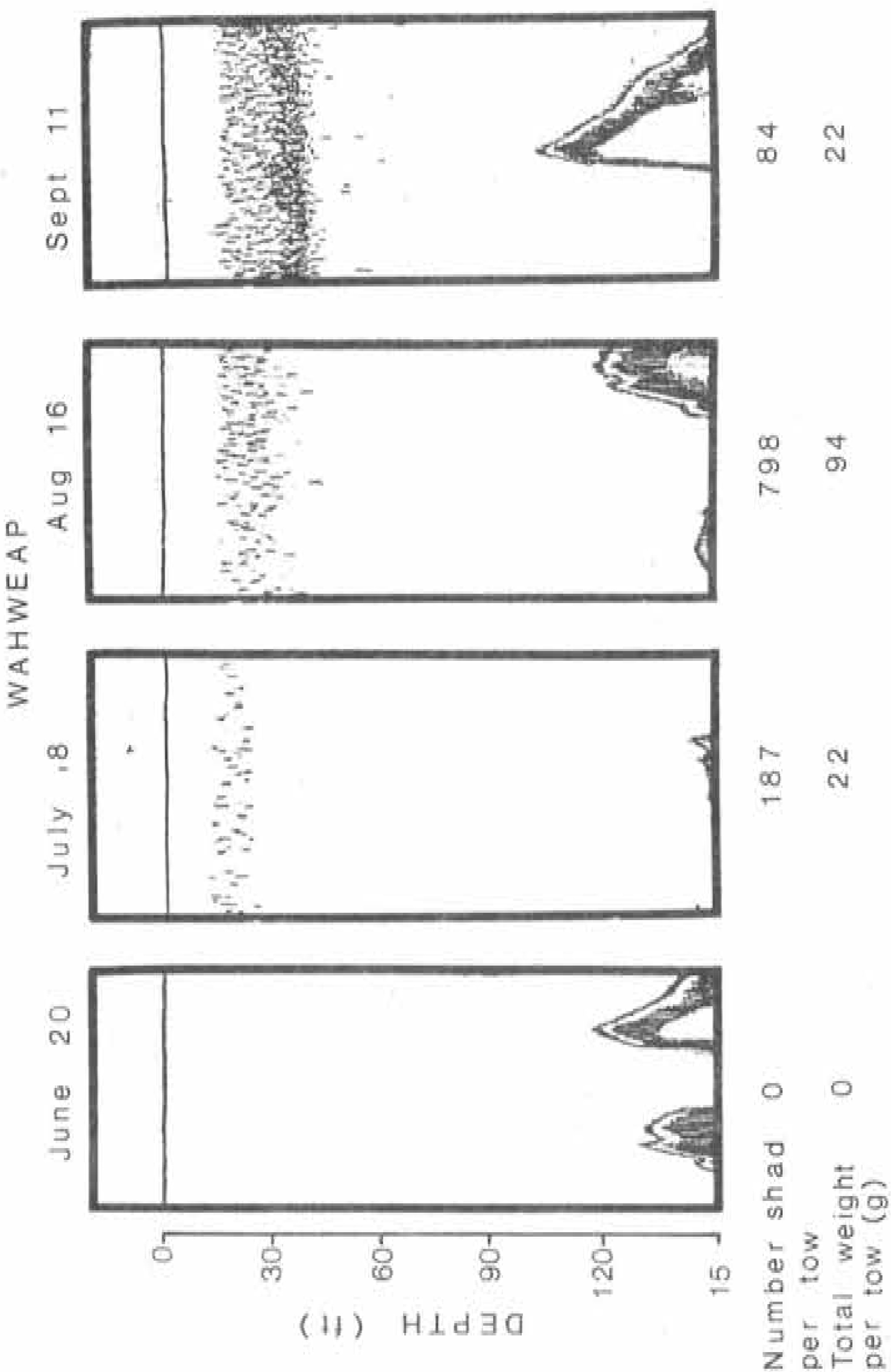
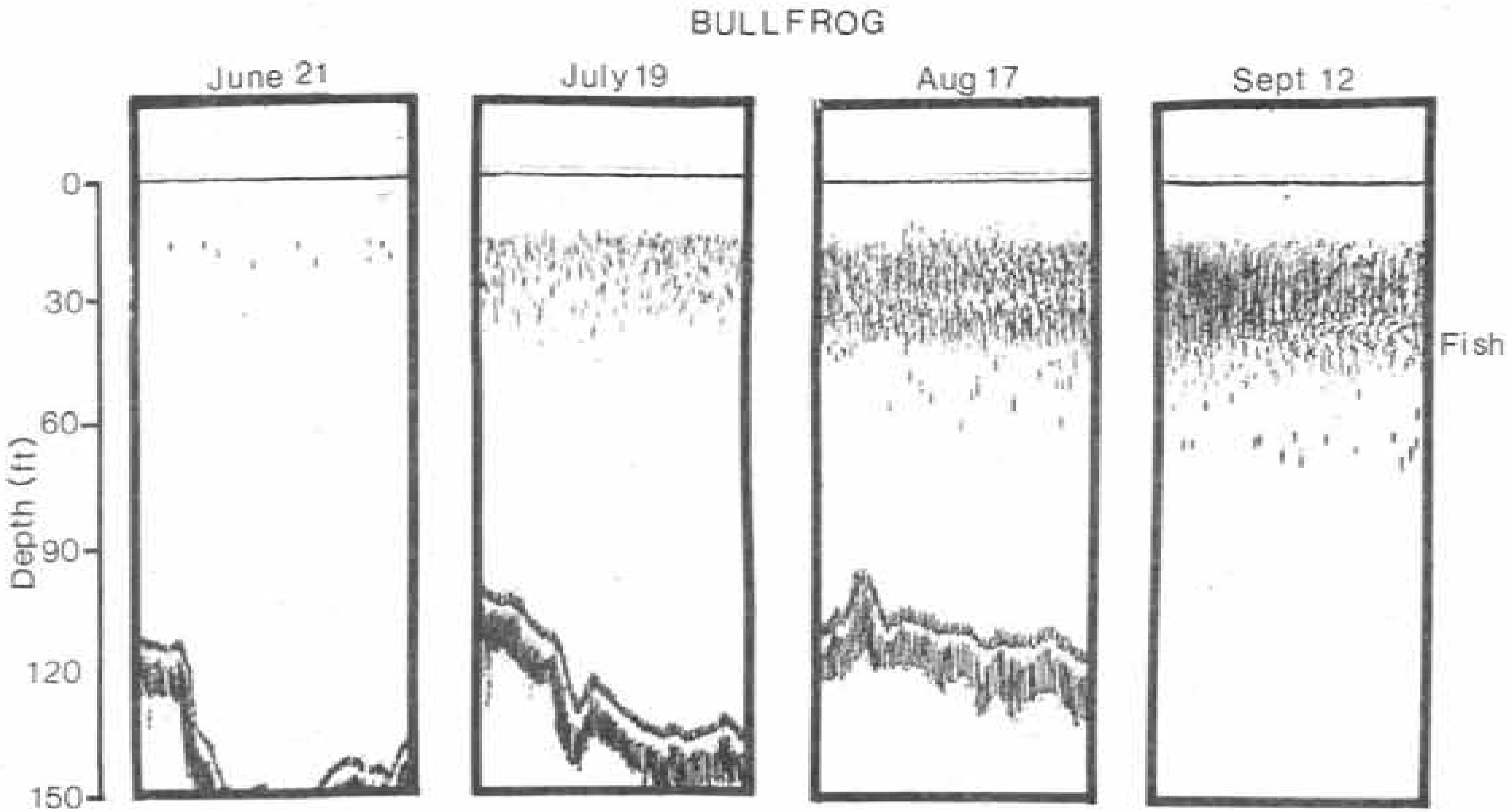


Figure 5. Average number of shad captured per standard tow compared to sonar echograms, Bullfrog Bay, 1977.



	June 21	July 19	Aug 17	Sept 12
Number shad per tow	11	945	530	690
Total weight per tow (g)	<1	225	144	274

Figure 6. Average number of shad captured per standard tow compared to sonar echograms, Bullfrog Bay, 1977.

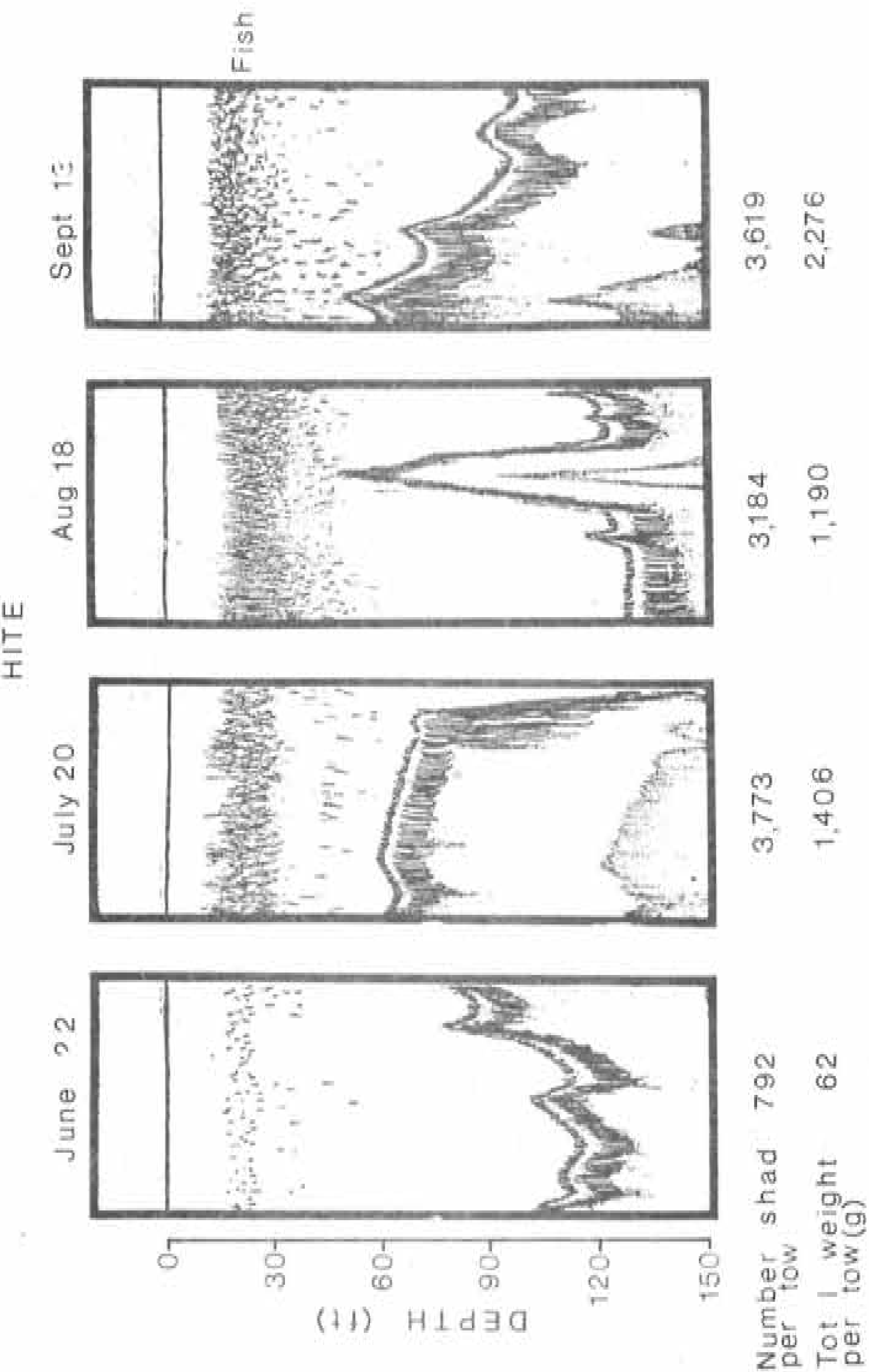


Figure 7. Average number of shad captured per standard tow compared to sonar echograms, Hite, 1977.

Johnson 1970, McConnell and Gerdes 1964). Sampling for several consecutive years at established reservoir locations in Lake Powell should better define fluctuation patterns in shad populations.

Lake Powell shad were found to grow throughout the summer. Young-of-the-year commonly reached 30-45 mm by early September (Figure 2). Kersch (1970) stated that shad grew approximately one inch per month for the first three months. However, Johnson (1970) documented a short shad growing season limited to early summer in central Arizona lakes. He thought factors such as food supply and intraspecific competition also influenced growth rate. Lake Powell shad attained a maximum length of 176 mm as adults. Others have reported maximum lengths of 136 mm in Lake Havasu (Kimsey et al. 1967), 172 mm in Pena Blanca (McConnell and Gerdes 1964), 164 mm in Lake Pleasant (Haskell 1959), and 172 mm in Roosevelt Lake (Beers and McConnell 1966).

Recommendations

Consistent trawl sampling should be continued to document trends in shad population dynamics. Work should be continued during the next project segment at established sampling sites near Wahweap, Bullfrog, and Hite. Several years data would be valuable in establishing what degree of fluctuations might be expected in shad year class strength before increasing striped bass numbers become an influencing factor.

The standard trawling tow should be investigated to better determine fishing depths being utilized. Vertical distribution of shad as determined by sonar and trawl samples can be related with temperature profiles to define a preferred range of habitation. Maximum trawl depth needed to produce most consistent catches during all seasons and weather conditions should be determined and employed.

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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. The unique nature of the reservoir's location in a remote canyon area with largely restricted access resulted in most use occurring at the four major marinas located at Wahweap, Bullfrog, Hall's Crossing, and Hite. Interviews were obtained at boat ramps and dock facilities as anglers returned from the lake. Censusing at these limited access areas provided 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. 1974; May and Hepworth 1976; Hepworth et al. 1976 and 1977). A report describing trends and changes in fishing since impoundment will be published separately. Past experience has shown that approximately 85 percent of total fishing pressure occurs from April through September. Current plans include conducting a comprehensive creel census during these months.

Methods

Scheduled creel census at Wahweap, Bullfrog, Hall's Crossing, and Hite were conducted on an average of 20 days per month. Sample days were selected randomly and stratified by weekend-holidays and week days. Wahweap was sampled between 8 and 10 days per month, and Bullfrog, Hall's and Hite combined were sampled 7 to 13 days per month. Fishermen were interviewd as they returned to the boat ramp and dock facilities. All returning anglers were asked questions pertaining to number and species caught, time fished, and number of anglers per party.

Both National Park Service (NPS) and project data were used to determine pressure estimates (Hepworth et al. 1976). Periodic boat trailer counts were made throughout the creel census season to supplement the NPS method of estimating monthly boat use. Three trailer counts were made at random hours selected within a given creel census day and compared to the single trailer count made by the NPS on the same day.

Results

Total fishing pressure for the period April through September was 76,684 angler days (Table 2). Most angling pressure occurred between April and June, during which 58,730 angler days were recorded. Angling pressure at Wahweap represented 46.4 percent of estimated pressure while Bullfrog, Hall's and Hite had a combined total of 53.6 percent.

Length of the mean boating day was 7.19 hours (Table 3). Monthly differences in length of trip by access area ranged from 4.57-8.50 hours. Average time fished per boating trip was 3.3 hours.

Utah and Arizona residents made up the majority of the anglers using the lake (Figure 8). Utah and Colorado anglers frequented the upper lake areas at Bullfrog, Hall's and Hite, while Arizona and California were represented more strongly at Wahweap.

A total of 4,025 interviewed anglers caught 6,304 fish in 16,932 hours for a catch rate of .37 fish per hour (Table 4). Fishing was best in April (0.47 fish per hour) then gradually declined through the warmer summer months. Average catch rates for bass and crappie were 0.12 fish per hour and 0.18 fish per hour, respectively. The upper lake area had the highest catch rate,

Table 2. Total estimated fishing pressure in angler days, by access area, Lake Powell, April-September, 1977.

Month	Wahweap	Bullfrog	Hall's	Hite	Total	Percent
April	8,801	6,155	3,059	3,705	21,720	28.3
May	11,604	6,549	2,796	2,303	23,252	31.1
June	7,615	1,212	983	3,948	13,758	17.2
July	3,765	541	439	992	5,737	7.5
August	931	985	387	1,238	3,532	4.5
September	2,861	1,912	849	3,063	8,685	11.4
Total	35,577	17,354	8,504	15,249	76,684	

Table 3. Mean length of boating day (hr) on Lake Powell by access area and month, April-September 1977.

Month	Wahweap	Bullfrog	Hall's	Hite	Mean
April	7.05	6.86	7.85	6.36	7.13
May	7.66	7.13	7.31	5.84	7.24
June	7.49	6.61	6.86	5.50	7.18
July	7.22	5.67	8.50	5.60	7.01
August	8.02	7.11	7.20	8.00	7.78
September	7.29	6.24	6.74	4.57	6.93
Mean	7.47	6.88	7.41	5.97	7.19

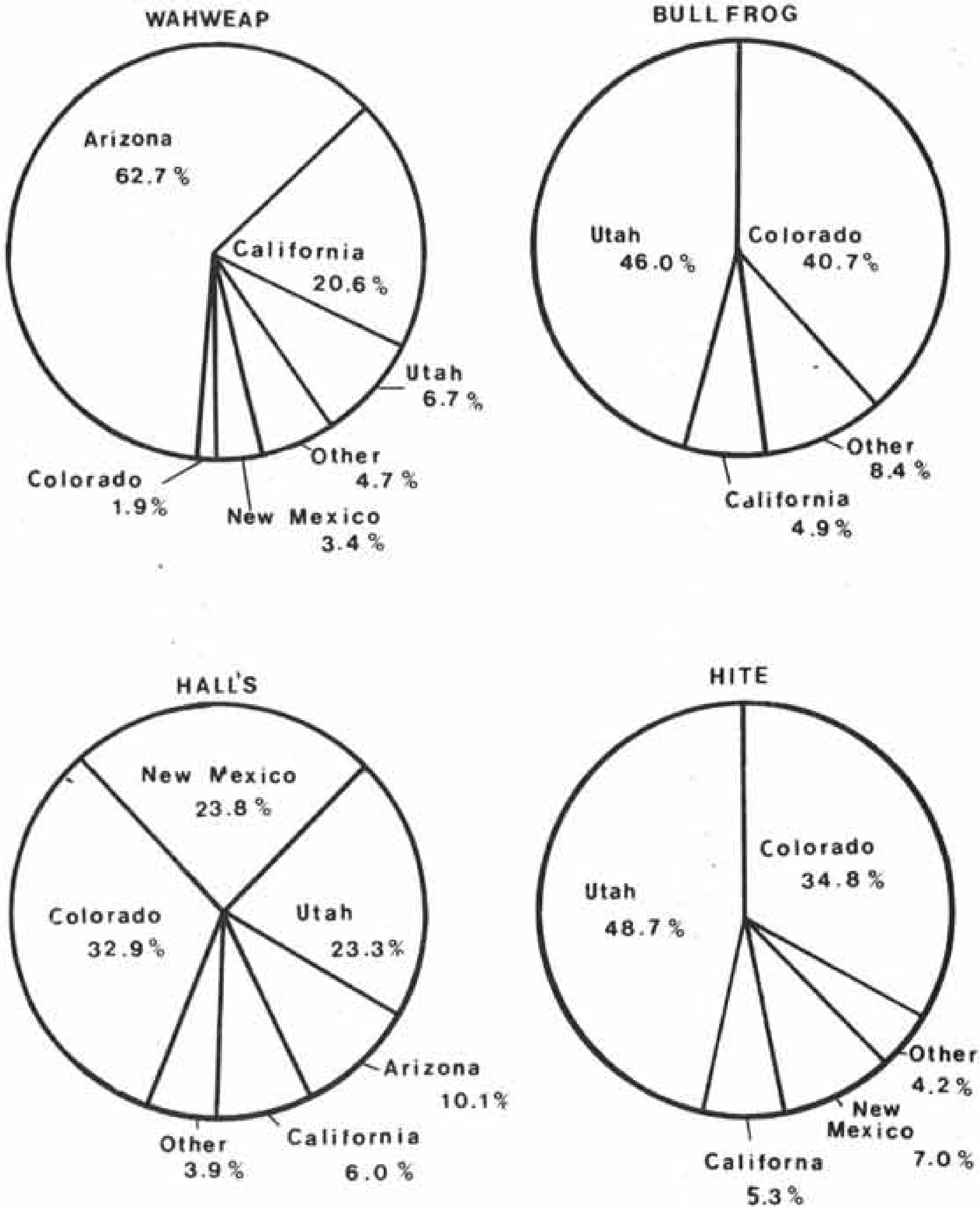

Figure 8. Residence of anglers using Lake Powell by percent for each access area April-September, 1977.

Table 4. Mean number of fish harvested per hour by species and month, Lake Powell, April-September 1977.

Species	April	May	June	July	August	September	Mean[b]
Largemouth bass	0.13	0.12	0.12	0.08	0.06	0.08	0.12
Black crappie	0.30	0.17	0.06	0.02	0.03	0.01	0.18
Bluegill	0.03	0.02	0.02	0.03	0.09	0.01	0.03
Channel catfish	0.01	0.03	0.11	0.04	0.11	0.07	0.04
Rainbow trout	t[a]	t	t	t	t	t	t
Walleye	t	t	t	t	t	t	t
Striped bass	t	t	t	t	t	t	t
Total	0.47	0.34	0.31	0.17	0.29	0.17	0.37

[a]t = Less than 0.01 fish per hour.
[b] = Total fish divided by total hours.

Table 5. Fish harvest per hour by species and access area, Lake Powell, April-September 1977.

Species	Wahweap	Bullfrog	Hall's	Hite	Mean[b]
Largemouth bass	0.09	0.11	0.16	0.17	0.12
Black crappie	0.13	0.20	0.24	0.21	0.18
Bluegill	0.02	0.03	0.02	0.07	0.03
Channel catfish	0.05	0.02	0.02	0.06	0.04
Rainbow trout	t[a]	t	0.00	0.00	t
Walleye	t	0.00	0.00	0.00	t
Striped bass	t	0.00	0.00	0.00	t
Total	0.29	0.36	0.44	0.51	0.37

[a]t = Less than 0.01 fish per hour.
[b] = Total fish divided by total hours.

with Hite exhibiting a total of 0.51 fish per hour (Table 5). Wahweap had the lowest rate at 0.29 fish per hour. Crappie and bass made up more than 80 percent of all species in the catch (Table 6). Channel catfish (Ictulurus punctatus) were important in the catch at Wahweap and Hite. Walleye and striped bass appeared in the creel at Wahweap.

Discussion

Catch rates for bass and crappie during 1977 were the lowest recorded for Lake Powell (Tables 7 and 8). Possible explanations of declining fishing success include reduced reservoir storage level due to the 1977 drought, weak year classes spawned in 1974 or 1975, unfavorable weather conditions during prime fishing months of April and May, lack of available waterdogs (a popular live bait used at Lake Powell), and lower overall productivity resulting from general reservoir aging. Because of the multitude of factors contriburing to fishing success, it becomes impossible to single out any one particular reason for a reduction in catch. It is also apparent that game fish population size does not necessarily reflect magnitude of catch rate because of numerous contributing variables (La Faunce et al. 1964). However, catch rates do measure quality of fishing and establish a means of comparing years, seasons, locations, and different fisheries. The possibility of continued declines or low rate of success should be watched closely.

Poor fishing was also reflected in lower angling pressure and a reduced boating day in 1977. Time spent on the lake in 1977 was down a total of 13,601 angler days for the same period, April-June, 1976. Mean length of the boating day also dropped from 8.0 hours in 1976 to 7.2 hours in 1977.

Channel catfish were more important in the catch than in previous years. From 1974 to 1976 channel catfish comprised an average of 3.5 percent of the angler's creel. In 1977 catfish increased to 10.4 percent of the

Table 6. Percent species composition of fish harvested by access area, Lake Powell, April-September, 1977.

Species	Wahweap	Bullfrog	Hall's	Hite	Mean
Largemouth bass	29.7	29.8	35.7	34.0	32.0
Black crappie	43.4	57.0	52.0	40.1	49.1
Bluegill	6.1	8.1	5.3	14.3	7.3
Channel catfish	17.0	4.9	7.0	21.6	10.4
Rainbow trout	0.8	0.2	0.0	0.0	0.3
Walleye	1.9	0.0	0.0	0.0	0.6
Striped bass	0.9	0.0	0.0	0.0	0.3

Table 7. Catch rate of largemouth bass by month and year, Lake Powell, 1971-1977.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mo. Ave	Weighted Ave
1971	.10	.28	.41	.43	.40	.27	.34	.30	.26	.16	.25	.11	.28[a]	.36[b]
1972	.11	—	—	.22	.17	.23	.17	.14	.14	—	—	—	.17	.17
1973	—	—	.18	.14	.13	.22	.10	.07	.11	—	—	—	.14	.14
1974	—	—	—	.19	.18	.18	.09	—	.21	—	—	—	.17	.17
1975	—	—	.25	.25	.27	.32	.35	.10	.09	—	—	—	.23	.26
1976	—	—	—	.23	.23	.20	—	—	—	—	—	—	.22	.23
1977	—	—	—	.13	.12	.12	.08	.06	.08	—	—	—	.10	.12

[a] Average of the monthly catch rates.

[b] Total fish caught divided by total hours.

Table 8. Catch rate of black crappie by month and year, Lake Powell, 1971-1977.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mo. Ave	Weighted Ave
1971	.28	.32	1.12	.71	.63	.42	.13	.11	.04	.28	.31	.08	.37[a]	.52[b]
1972	.24	—	—	1.14	.55	.27	.17	.04	.05	—	—	—	.35	.35
1973	—	—	.59	.40	.44	.16	.08	.02	.02	—	—	—	.24	.24
1974	—	—	—	.38	.29	.11	.03	—	.05	—	—	—	.17	.17
1975	—	—	.09	.30	.37	.14	.05	.02	.01	—	—	—	.14	.24
1976	—	—	—	.33	.26	.07	—	—	—	—	—	—	.22	.22
1977	—	—	—	.13	.12	.12	.08	.06	.08	—	—	—	.10	.18

[a]Average of the monthly catch rates.

[b]Total fish caught divided by total hours.

catch. With the slow bass and crappie fishing, anglers apparently turned to a more readily caught fish.

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INDEX TO ANNUAL FISH POPULATION TRENDS

Job III

Background

A standardized annual netting program was initiated in 1971. Data were collected each year at approximately similar times and locations using the same number and style of nets. Standardized sampling was thought to provide information on gross changes and trends occurring in the fishery. Results have generally shown large populations of largemouth bass and walleye. In addition, electrofishing as a sampling technique, has been partially evaluated as a means to supplement gill netting data. Current plans are to concentrate electrofishing effort towards sampling young-of-the-year game fishes to gather trend data on recruitment.

Methods

Standardized gill-net sampling was conducted in March at Padre Bay, Cha Canyon, Rincon, and Red Canyon. Ten experimental diving gill nets were fished for three consecutive days at each station. All nets were set perpendicular to shore in similar rock and rubble habitat. Data from all captured fish were recorded by species, number, length, and weight.

The electrofishing boat was constructed on a 28 foot fiberglass hull equipped with an 85 hp outboard. The electrofishing unit included a Rotating Field Electro Shocker (RF-10) manufactured by Cofelt Electronics Company, Inc., powered by an Onan 7500 watt generating plant designed for 0-240 volt output at 0-25 amps. Five electrodes mounted from a front boom were variably pulsed at an adjustable rate of one to ten electrodes per second. Best results were obtained at 150-200 volts DC at a sequence of ten pulses per second.

Electrofishing was begun in June and continued through September. Sampling locations were chosen at Bullfrog Bay, Hall's Creek, Rincon, and Knowles Canyon, in similar areas of shallow rock and rubble habitat. Electrofishing was most effective in shallow water with small indentations and coves where fish could be cornered by the shocking boat.

Because of varying water levels, weather conditions, and uneven shoreline configuration, a timed rather than a linear transect was used. This allowed flexibility to move to new locations as water levels and shoreline structure changed. Fishing time was recorded only while the electrode units were switched on. Each transect was sampled one night per month. All fish captured were recorded by species, numbers, and length and returned to the lake.

Results

Annual netting - Netting in 1977 produced a total of 515 fish in 117 nets for a catch rate of 4.4 fish per net (Table 9). Catch was comprised primarily of bass and walleye, representing 42.1 and 26.6 percent of the total, respectively. Other important species included carp (Cyprinus carpio) (10.1 percent), crappie (5.8 percent), and rainbow trout (Salmo gairdneri) (6.0 percent). Netting success was lowest at Padre Bay which produced only 89 fish (17.3 percent). The largest catch of bass occurred at Cha Canyon, where 104 were taken and the lowest at Padre Bay, where 9 bass were caught. A total of 137 walleye were captured from all areas combined. Walleye were taken frequently at all stations, with the exception of Cha Canyon where only four walleye were netted.

Mean bass length was 354 mm, ranging from 194-506 mm (Figure 9).

Table 9. Number of fish caught by species and netting location, Lake Powell, March 1977.

Species	Padre Bay	Cha Canyon	Rincon	Red Canyon	Total	Percent of Catch
Largemouth bass	9	104	46	58	217	42.1
Walleye	46	4	36	51	137	26.6
Black crappie	2	3	17	8	30	5.8
Bluegill	0	2	2	1	5	1.0
Green sunfish	1	0	4	6	11	2.1
Channel catfish	5	2	7	9	23	4.5
Carp	13	2	13	24	52	10.1
Flannelmouth sucker	0	3	0	1	4	0.8
Rainbow trout	11	12	6	2	31	6.0
Brown trout	0	0	1	1	2	0.4
Striped bass	2	0	0	0	2	0.4
Yellow bullhead	0	0	0	1	1	0.2
Total	89	132	132	162	515	

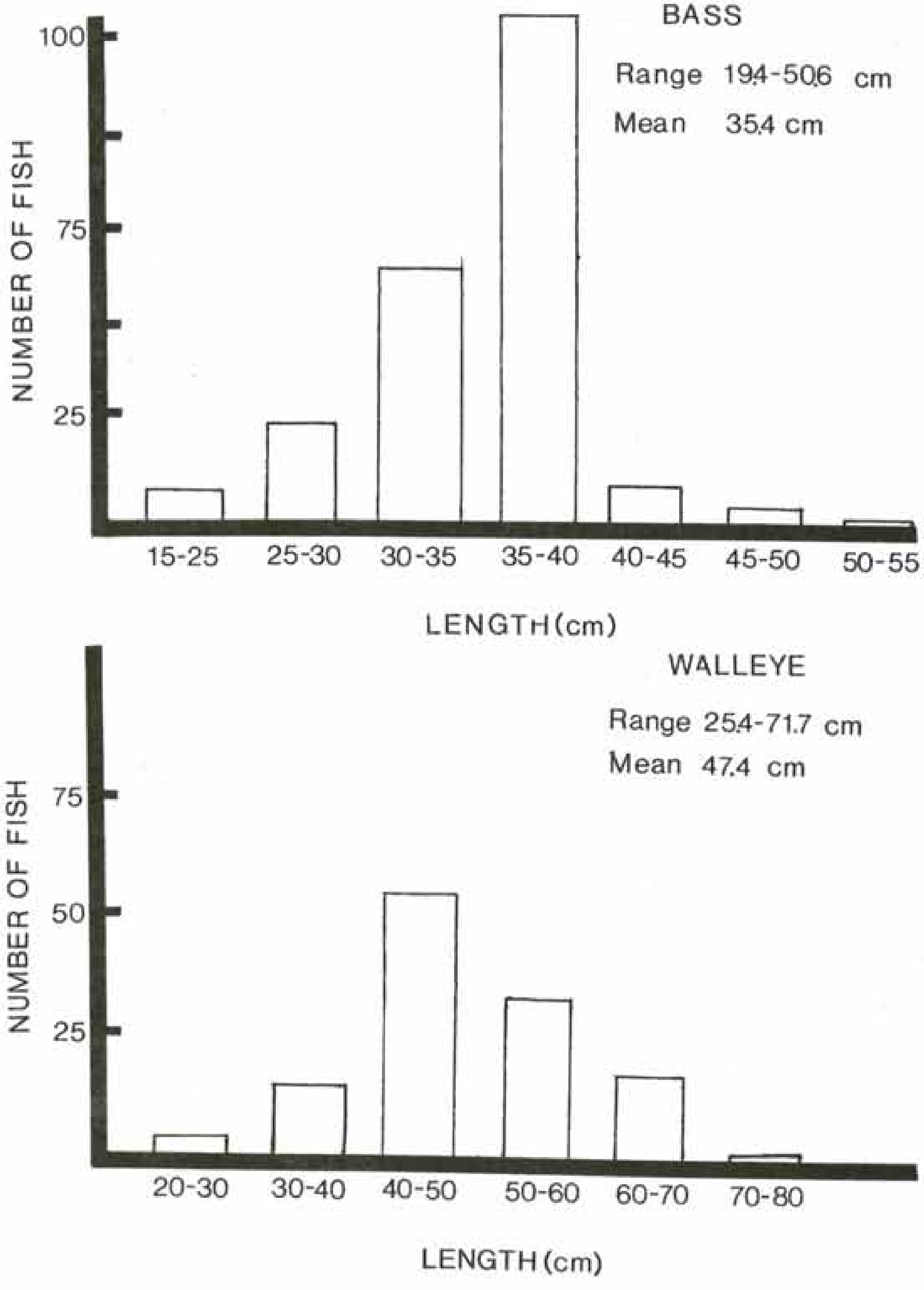

Figure 9. Length frequenty distribution of bass and walleye in annual netting, Lake Powell, 1977.

Approximately 92 percent of all bass were within the range of 250-400 mm total length. Walleye total lengths ranged from 254-717 mm, with a mean of 474 mm. Approximately 88 percent of all walleye were within a range of 300-600 mm.

Electrofishing - A total of 1,340 fish were collected by electrofishing (Table 10). Green sunfish (Lepomis cyanellus) and bluegill (Lepomis macrochirus) represented 77.4 percent of the catch. Bass and crappie made up 13.1 percent of the total. Bullfrog and Knowles Canyon transects had the highest catch per unit effort at 178.5 and 144.4 fish per hour, respectively (Table 11). Numbers captured per hour increased as the season progressed. Values for all stations sampled in June were well under 100 fish per hour, while values recorded for September were all over 280 fish per hour. Increases in young-of-the-year bass were also apparent (Table 12). Bass-of-the-year were found only at the Rincon in June but were numerous at all areas by September.

Discussion

Catch rates for largemouth bass and walleye decreased for the second consecutive year of annual netting (Table 13). Evaluation of bass catch by sample area (Table 14) showed the decrease primarily resulted from lower catch at Padre Bay and the Rincon. Walleye catch declined at all four locations in 1977 and at three of the four locations in 1976 (Table 15). Nevertheless, bass and walleye continued to dominate the total annual catch. Both species combined have consistently made 68.4-82.9 percent of the catch for the period 1972-1977. There was nothing to indicate that either bass or walleye were displaced by expansion of other species. Although 1977 bass and walleye catch rates were low, values remained within previously established ranges. Continued decreases in catch would justify more cause for concern.

Table 10. Lake Powell electrofishing results by number, species, and transect area, June through September, 1977.

	Bullfrog	Hall's	Knowles	Rincon	Total	Percent
Largemouth bass	52	34	17	22	125	9.4
Crappie	15	19	12	3	49	3.7
Green sunfish	126	205	195	135	661	49.9
Bluegill	177	40	121	26	364	27.5
Carp	42	17	15	23	85	6.4
Channel catfish	10	12	7	7	35	2.6
Yellow bullhead	1	1	2	1	5	0.4
Walleye	0	0	0	1	1	0.1
Total	423	328	371	218	1,340	
Fish per hour[a]	178.5	125.7	144.4	99.5	137.6	

[a] Total fish divided by total hours effort

Table 11. Fish per hour of electrofishing, by month and transect area, Lake Powell, 1977.

Month	Bullfrog	Hall's	Knowles	Rincon
April	43.5	----	----	----
May	14.7	----	----	----
June	20.3	57.0	38.0	47.4
July	178.1	----	----	----
August	360.6	146.4	249.2	95.2
September	638.2	403.4	539.6	286.3

Table 12. Young-of-the-year bass per hour of electrofishing, by month and transect area, Lake Powell, 1977.

Month	Bullfrog	Hall's	Knowles	Rincon
April	0.0	----	----	----
May	0.0	----	----	----
June	0.0	0.0	0.0	17.7
July	9.38	----	----	----
August	28.7	8.9	3.4	3.3
September	43.9	36.1	10.4	6.3

Table 13. Catch rate (fish per net) and percent of catch by species and year, annual gill netting, Lake Powell, 1971-1977.

Species	1971 Catch rate	1971 % of catch	1972 Catch rate	1972 % of catch	1973 Catch rate	1973 % of catch	1974 Catch rate	1974 % of catch	1975 Catch rate	1975 % of catch	1976 Catch rate	1976 % of catch	1977 Catch rate	1977 % 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
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
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
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
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
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
Carp	1.14	28.6	0.79	7.8	0.32	7.3	0.34	5.4	0.36	4.4	0.38	7.3	0.44	10.1
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
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
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
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
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
All species	3.98		10.10		4.24		6.31		8.02		6.15		4.44	

Table 14. Bass per net by sampling area from annual netting, Lake Powell, 1971-1977.

Date	Padre Bay	Cha Canyon	Rincon	Red Canyon	Mean[a]
1971	0.7	----	----	2.2	1.7
1972	5.4	6.3	6.9	4.7	5.8
1973	1.7	4.3	3.3	1.4	2.7
1974	5.0	5.3	4.1	1.8	4.0
1975	2.5	7.9	3.5	4.1	4.5
1976	1.7	3.2	4.3	1.6	2.7
1977	0.3	3.5	1.7	1.9	1.9
Mean[a]	2.4	5.0	3.9	2.5	3.4

[a] Total fish divided by total nets.

Table 15. Walleye per net by sampling area from annual netting, Lake Powell, 1971-1977.

Date	Padre Bay	Cha Canyon	Rincon	Red Canyon	Mean[a]
1971	0.3	----	----	0.3	0.3
1972	3.4	0.1	0.3	0.9	1.1
1973	0.1	0.2	0.3	0.9	0.4
1974	0.8	0.9	0.7	1.9	1.1
1975	2.5	0.4	2.9	2.8	2.2
1976	1.9	0.2	2.1	4.2	2.1
1977	1.5	0.1	1.3	1.7	1.2
Mean[a]	1.5	0.3	1.3	1.8	1.3

[a] Total fish divided by total nets.

Electrofishing should be a valuable addition to data obtained from annual gill net sampling. In the past two years of netting, only four bass less than 200 mm were collected. Length of bass collected by summer electrofishing ranged from 46-553 mm and averaged 60 mm. Bryant and Houser (1971) found that electrofishing was the only method, other than cove rotenone samples, which collected all age groups of bass in significant number for population estimates. Others also found electrofishing to be less size selective than netting (Novotny and Priegel 1974, Young 1975, Sullivan 1956).

Young-of-the-year bass were captured by electrofishing from June through September (Table 12). Numbers sampled generally increased as young bass grew and became more vulnerable to sampling. Approximately 57 percent of all bass young-of-the-year were collected in September. Vincent (1971), when estimating fish populations in stream situations, suggested a sampling effort great enough to obtain at least 150 fish per transect. Adequate sample sizes would be of major importance in developing reliable indices of annual bass recruitment.

Recommendations

Scheduled electrofishing should be conducted during summer months to follow progress of annual bass recruitment and possibly other game species. In late summer or fall, an annual recruitment index should be developed by a concerted sampling effort when fish-of-the-year attain a suitable size for efficient collection.

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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 method used to establish inland fisheries with continued stocking generally necessary to maintain populations because of unsuccessful natural reproduction (Bailey 1973). An experimental culture pond facility for striped bass 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. Completed work has included studies on plankton responses to fertilization, evaluation of stocking densities, food habit studies, and timing of fry introduction for optimum water temperature and food availability (Hepworth et al. 1977 and 1976, May and Hepworth 1976, Gloss et al. 1974). Total pond production was thought to be largely determined by mortality experienced the first 1-2 weeks after stocking fry. Stocking fry into ponds with plankton blooms in the wrong stage of development resulted in inadequate food supplies and high predation on fry. Primary objectives for 1977 were to continue studies designed to determine when ponds should be filled and fertilized in relation to time of fry arrival from donor agencies.

Methods

Fry shipments from California were scheduled for mid-May. Fertilization and filling of ponds was scheduled according to planned fry arrival. Previous results indicated that spring weather conditions and water temperatures at the culture location in southern Utah were best suited for high fry survival and fast growth during May, rather than earlier dates when fry are generally available from the east coast.

Ponds were divided into three treatments, each replicated twice. Treatments included:

(1) filling and fertilizing ponds 40 days in advance of fry arrival.

(2) filling ponds 40 days in advance and fertilizing 24 days before fry arrival.

(3) filling and fertilizing 24 days in advance of fry arrival.

Ponds 1 and 5 were assigned the first treatment, ponds 2 and 3 the second treatment, and ponds 4 and 6 the third treatment. Initial fertilization rate was 2500 lb alfalfa hay per acre with supplemental additions of either hay or inorganic 20-20-20 fertilizer added as needed to keep plankton densities high (Table 16). Plankton samples were taken every four days for quantitative and qualitative comparisons. Dissolved oxygen samples were taken during morning hours from all ponds at 1-3 day intervals to determine time needed for ponds to recover from oxygen depletions caused by initial fertilization.

On May 22 shipment of 1 million 2-day old striped bass was received from California. Ponds were stocked at an estimated rate of 100,000 fry per acre. Fry were tempered and stocked after dark and held in seran cloth baskets for observation. At 6 days of age, baskets were tilted and fry were released into open ponds. A small number of fry were retained in one seran basket in each pond for observation and collection of fish samples. Survival, growth, and food habits of fry were compared to amounts and kinds of

Table 16. Striped bass culture pond fertilization schedule, 1977.

Item	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6
Initial application of alfalfa hay						
Rate per acre (lb)	2500	2500	2500	2500	2500	2500
Total (lb)	1000	1000	2500	2750	7750	9750
Supplemental additions						
Total alfalfa (lb)	650	350	1450	1300	3750	2650
Total inorganic 20-20-20- (lb)	15	15	30	30	30	50

zooplankton in each pond. Samples of fry were taken from baskets every other day between 10 and 20 days. Ponds were treated for aquatic insect control on April 29 and May 11 at the rate of 5 gal diesel fuel per acre.

Use of Diuron 80 percent active ingredient (3-(3, 4-Dichlorophenyl)-1, 1-Dimethyluria to control aquatic weeds was evaluated in pond 1. Pond 1 was selected because fry survival was poor, and there was little danger of sacrificing a large crop of fish. Diuron was applied at the rate of 0.6 lbs per acre for three consecutive days (June 14-16) just as weeds were becoming noticeable. Striped bass, age 25 days, were held in a seran basket for observation and pond oxygen levels were taken daily. Control of weed growth was determined by visual observations.

Results

A total of 142,731 fingerling striped bass were produced in 6 ponds for an average of 14,417 fish per acre (Table 17). Ponds 4 and 6, treated by fertilizing and filling 24 days before stocking, contributed 98.0 percent of total production. The remaining ponds, treated by filling and/or fertilizing at earlier dates, produced only 2.0 percent of the total number of fingerlings raised. Total production was the highest in four years of raising striped bass at the Glen Canyon facility and was attained from the smallest shipment of fry. Fry were the progeny of one 27 lb female. Survival from fry to fingerling averaged 14.27 percent.

Plankton blooms corresponded with pond treatments, appearing successively according to time of fertilization (Figure 10). Ponds 1 and 5 bloomed about the end of April, ponds 2 and 3 bloomed in early May while ponds 4 and 6 did not bloom until late May, shortly after fry were stocked.

Pond oxygen depletions lasted 12-16 days after fertilization and nauplii copepod densities reached 100 per liter within 12-32 days after fertilization

Table 17. Production of fingerling striped bass by culture pond treatment, 1977.

Treatment	Estimated number fry stocked		Results		
	Per acre	Total	Total fingerling production	Percent survival	Production per acre
Fertilized and started filling 40 days before fry arrival.					
Pond 1	100,000	50,000	0	0	0
Pond 5	100,000	300,000	1,143	0.38	369
Started filling 40 days before fry arrival. Fertilized 24 days in advance.					
Pond 2	100,000	50,000	34	0.07	85
Pond 3	100,000	100,000	1,653	1.65	1,653
Fertilized and started filling 24 days before fry arrival.					
Pond 4	100,000	100,000	28,558	28.56	25,962
Pond 6	100,000	400,000	111,343	27.84	28,549
Total	100,000	1,000,000	142,731	14.27	14,417

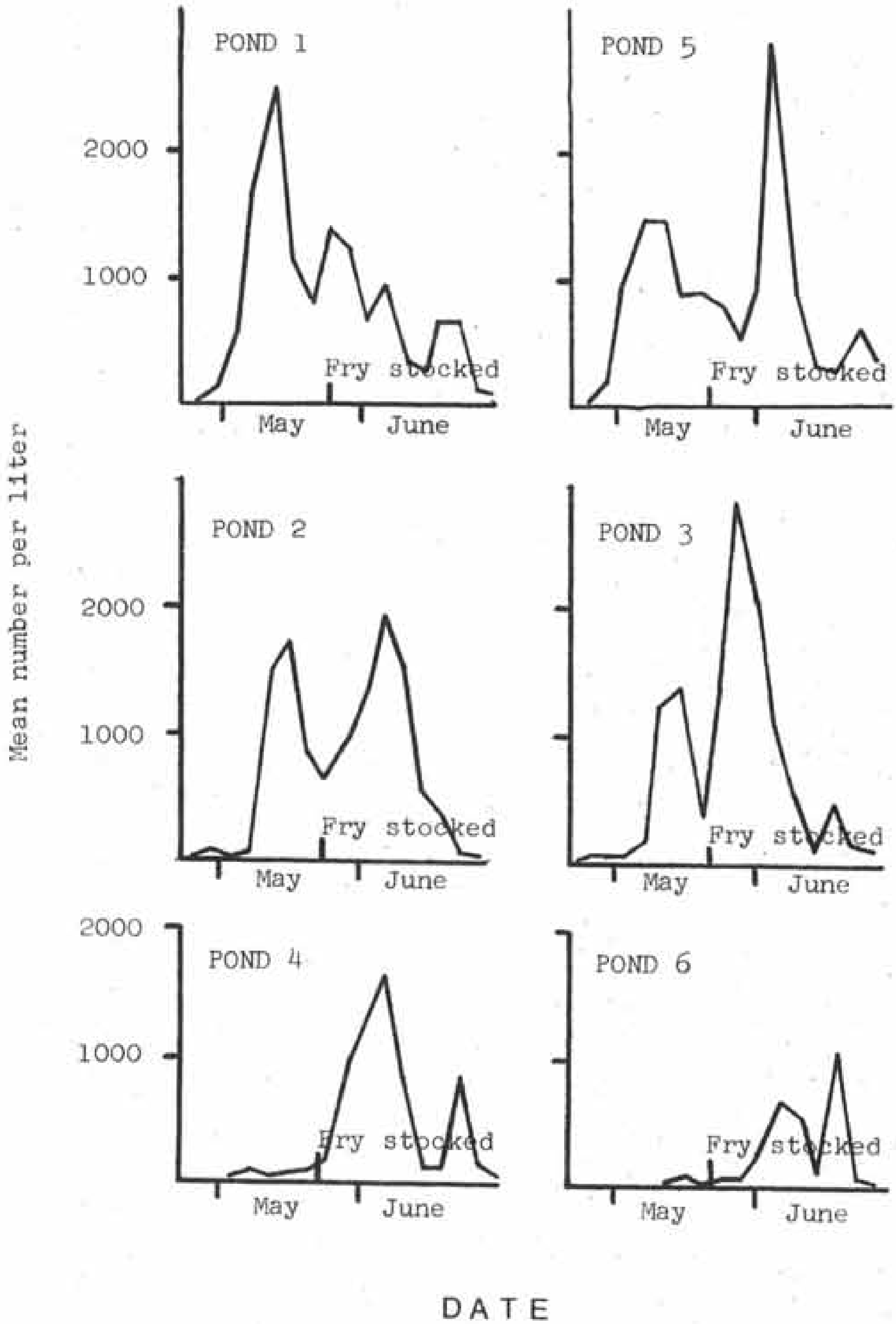

Figure 10. Comparison of plankton abundance among striped bass culture ponds, 1977.

(Table 18). The copepod population in pond 2 developed fastest, attaining values of 100 per liter 2 days before oxygen levels reached saturation at 8 ppm. Copepods developed slowest in pond 6, requiring 16 days after full oxygen recovery to reach a value of 100 per liter. Ponds filled prior to fertilization had a reduced time interval between oxygen recovery and copepod development compared to ponds filled and fertilized simultaneously.

Complete mortality of fry held in seran baskets in ponds 1 and 2 occurred before age 20 days, while survival in other ponds was excellent. Food consumption, as measured by mean number of copepods per stomach, was 15.7, 8.9, 6.3, and 0.5 for fish in ponds 3, 6, 4, and 5, respectively (Table 19). Frequency of empty stomachs was greatest in pond 5. Best average growth at age 20 days was 13.1 mm total length in pond 6. Averages attained in ponds 4, 3, and 5 were 12.6, 12.2, and 7.9 mm, respectively.

Control of undesirable aquatic weeds in pond 1 was obtained 3-6 days after treatment with Diuron. However, oxygen levels dropped to as low as 1.0 ppm and remained below 3.0 ppm for 10 days after application. Despite low oxygen levels, some striped bass held in seran baskets survived the treatment and were eventually removed at 45 days of age.

Discussion

Development of the aquatic community in culture ponds occurs by a succession of smaller to larger organisms with time. Successful culture of striped bass fingerlings appears to be dependent upon correct timing of fry introduction into fertilized ponds. Size selective food requirements and vulnerability of fry to predation limit success obtained by introducing fry into different stages of pond development. Stocking of fry into ponds shortly before plankton populations bloom assures the presence of proportionally higher numbers of smaller organisms that might serve as

Table 18. Time required after pond fertilization for dissolved oxygen to reach saturation and nauplii copepod abundance to reach 100 per liter, compared to times when striped bass fry were stocked.

Item	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6
Date fertilized	4-12	4-28	4-28	4-28	4-12	4-28
Days after fertilization required for oxygen to reach saturation at 8 ppm	12	14	15	14	14	16
Days after fertilization required for copepods to reach 100 per liter	19	12	20	28	20	32
Days between oxygen recovery and copepod plankton bloom of 100 per liter	7	-2	5	14	6	16
Days after fertilization when fry were stocked	40	24	24	24	40	24

Table 19. Growth and feeding of striped bass fry, age 10-20 days, held in seran baskets in each culture pond, 1977.

Item	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6
Growth, mean total length (mm)						
10 days	5.6[a]	5.8[a]	6.9	6.2	5.9	6.4
20 days			12.2	12.6	7.9	13.1
Food consumed, mean number of copepods per stomach (Sample of 8 fish taken at age 10, 12, 14, 16, 18, and 20 days).			15.7[a]	6.3[a]	0.5	8.9
Percent empty stomachs based on total sampled			12.5[a]	16.7[a]	58.3	18.7
Copepod density in pounds, mean number per liter (Samples taken on 3 days between age 10 and 20 days).	539	1,482	1,107	858	1,228	383

[a]Fry failed to survive.

food and fewer large organisms that could be predaceous. Stocking before blooms peak also assures better use of plankton production and more economical use of fertilizer. Ponds producing best results in 1977 had distinctly lower standing crops of plankton, indicating that fish were cropping off production (Figure 10).

Reasonable success was obtained in two out of six ponds during the current year, representing about half of the total surface acres available for pond culture. Overall production remains well below the facility's potential capacity. Since 1974, when pond culture was first undertaken, all ponds exceeding production of 25,000 fingerlings per acre have had a history of being stocked before plankton populations bloomed. More successful ponds were all stocked in May or early June. Best results in 1974 and 1976 were obtained when ponds were drained because of unsuccessful first attempts and refilled only one or two days before a second stocking. Other culturists have reported similar experiences. North Carolina, Alabama, and Oklahoma (pers. comm. C. R. Guier, 1976; M. Powell, 1976; and J. L. Harper, 1976, respectively) indicated having best results when ponds were filled shortly before stocking fry. North Carolina and Alabama stocked fry into partially filled ponds and completed filling after introduction.

Current pond preparation techniques produce optimum conditions for stocking fry that last about one week, although weather and water temperatures cause some variability. Best time for fry introduction occurs after oxygen recovery from effects of fertilization and before copepod densities reach 100 per liter. Evaluation of pond treatments indicated that a wider range of days between oxygen recovery and plankton blooms could be expected if ponds were fertilized and filled at the same time, rather than filled and subsequently fertilized (Table 18).

Aquatic insects have likely contributed to poor results in some ponds for the past two years. Surface breathing Hemipterans were particularly abundant in 1976 but held under control during 1977 by periodic application of diesel fuel. However, diesel fuel did not affect gill breathing Odonata larvae that became abundant in ponds 2, 3, and 5 shortly after plankton populations peaked. Fingerling production from ponds that had dense insect populations at time of fry introduction was poor while survival of fry in control baskets in the same ponds was usually good. Seran baskets apparently restricted the entrance of insects and protected fry from predation.

Other factors affecting fry in seran baskets were relative densities of fish and pond oxygen levels. Lower food consumption and slower growth observed in pond 5 was a result of a greater density of fry held in the basket (Table 19). Despite efforts to retain similar numbers of fry in all baskets, the basket in pond 5 was more crowded. Loss of fry in pond 1 was attributed to an oxygen depletion caused by supplemental additions of fertilizer. Fry were lost after fertilizer was added in an attempt to reverse declining plankton levels.

Recommendations

Ponds should be filled and fertilized no earlier than 24 days before fry arrival. Different pond preparation techniques and fertilizers should be considered to lengthen the optimum period during which fry can be successfully introduced. Faster reacting fertilizers would reduce time of oxygen depletions, and fry could be stocked well before insects colonize ponds. Other ways that insect predation might be reduced should be investigated. Possible beneficial results from holding fry in protective seran baskets longer than the normal 6 day period should be assessed.

Investigation of possible mechanical or chemical control of aquatic weeds needs to continue. Problem weeds have spread to all ponds and not only make harvest difficult but result in increased loss of fish that become stranded and impossible to locate when ponds are drained.

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EVALUATION OF STRIPED BASS INTRODUCTION

Job V

Background

Striped bass have been stocked annually into Lake Powell since 1974. Most fish were stocked at the south end of the reservoir, in Wahweap Bay. Bullfrog Bay, located approximately mid-way up lake, was stocked in 1976 and again in 1977. Sampling of the striped bass population was designed to supply data on survival, growth characteristics, and food preferences. Data on distribution and development of a sport fishery was largely collected as part of the regular creel census program (Job II). To date, striped bass have shown excellent growth and high utilization of threadfin shad in their diet. Returns to the creel have been largely incidental to angling for other species.

Methods

Collections of striped bass from Lake Powell were largely made by gill netting. A few young-of-the-year 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. Various sizes and numbers of gill nets were set monthly to collect adequate samples of all age groups of striped bass present in the lake. Most nets were set near locations where striped bass were first introduced.

Lengths, weights, stomachs, and scales were collected from all striped bass. Stomach contents were preserved in 10 percent formalin for later examination. Analysis of stomach contents will be completed and more fully evaluated during the next project segment. Scales were taken from below the lateral line and posterior to the pectoral fin. Scale imprints were made in acetate cards with a heated press and examined for aging with a microprojector. Scale characteristics were compared to growth of introduced striped bass of known age. Complete age and growth analysis from scale computations will be completed during future project segments.

Inspection of potential spawning areas near the Colorado and San Juan inlets were made in late May and early June. Limited sampling with gill nets and electrofishing equipment was conducted to find mature striped bass.

Results

More than 138,000 striped bass were introduced into Lake Powell during July 1977 (Table 20). Some 86,000 were stocked at Wahweap by truck and 52,000 were stocked at Bullfrog by airplane. The total number of striped bass introduced since 1974 was 338,473 or approximately two fish per surface acre.

Complete netting results for the current project segment produced a total of 191 striped bass (Table 21). The majority of the fish were collected near Wahweap and Warm Creek at the extreme southern end of the reservoir. Two striped bass were collected in Padre Bay during annual netting studies (Job III), and 10 were collected in Bullfrog Bay. Limited sampling made in attempt to collect mature fish at areas near the Colorado and San Juan River inlets failed to produce any striped bass. Several mature females were collected in Wahweap and Warm Creek in April.

Sampling with beach seines and small mesh gill nets indicated good survival of 1977 year-class fish stocked at Wahweap. Fingerling striped bass were taken in nearly all seine hauls made in Wahweap Bay. Survival of fish stocked at Bullfrog, however, was questionable since only five fingerlings were collected in repeated seine and gill-net sampling.

Table 20. Stocking record of striped bass introductions 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
Total	266,518	71,955	338,473

Table 21. Monthly gill net catch of striped bass, Lake Powell, 1977.

Month	1974	1975	1976	1977
	Number collected by year class			
Jan.	0	0	3	—
Feb.	0	0	0	—
March	0	2	0	—
April	9	60	3	—
May	0	1	3	—
June	3	8	2	—
July	0	0	12	0
Aug.	2	0	7	0
Sept.	4	4	7	4
Oct.	2	0	10	6
Nov.	0	0	1	0
Dec.	26	8	0	4
Total	46	83	48	14

Average growth of striped bass was plotted in Figure 11. Respective Total lengths at ages I-III were 248, 409. and 580 mm. Striped bass collected in December, nearly completing their fourth year of growth, averaged 635 mm total length. Average length of 1977 year class striped bass increased from 50 mm as fingerlings stocked in July to 207 mm by December.

Discussion

Growth of striped bass at Lake Powell compared favorably with reported growth from other waters (Table 22). Average lengths for Lake Powell striped bass ages I-IV generally exceeded growth at other areas. Values for Lake Powell were determined from known age fish collected near January 1 rather than back calculated averages based on the scale method. Averages may differ somewhat in the future when age-growth analysis is completed using the total sample of fish made available by the scale technique. Comparison of scale characteristics to actual growth has shown Lake Powell striped bass to form distinct annual growth marks for the first three years.

Maturity of striped bass was determined by relative size of gonads and formation of ripe eggs. Males generally matured by age III. Although the majority of age III females were immature, several mature individuals were collected in April. By December, ovaries in age III+ females had greatly enlarged, and it appeared that most females would be mature by spring at age IV.

Cursory examination of striped bass stomachs showed a continued heavy reliance on threadfin shad in the diet. Analysis of stomach samples collected during 1977 will be completed during the next study segment.

Development of a sport fishery for striped bass continued to be restricted to the southern end of the reservoir. Striped bass were still taken incidental to other species. Wahweap was the only location where striped

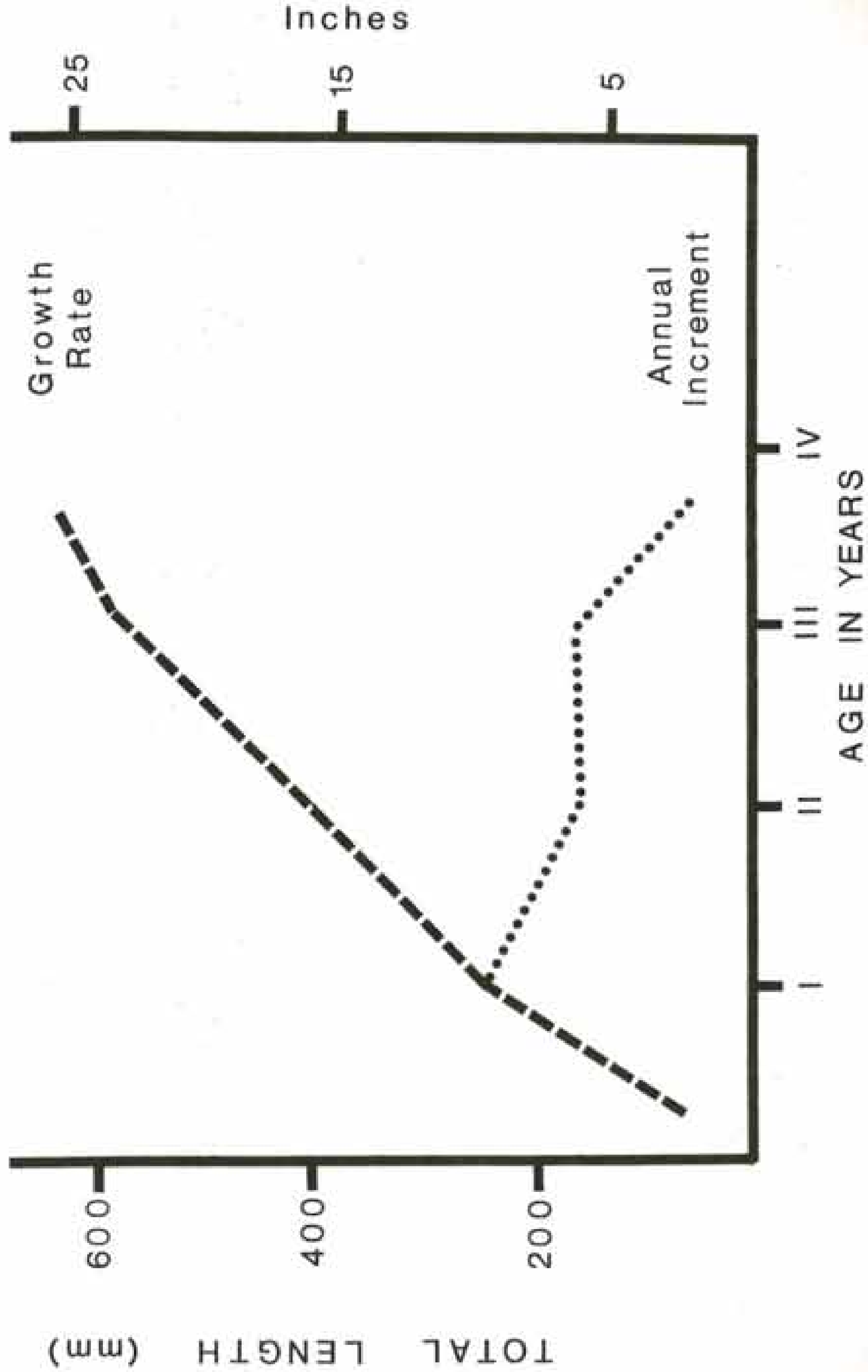

Figure 11. Average growth of Lake Powell striped bass, 1974-1977.

Table 22. 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	248	174	190	112	120	218	145	133	—	280
II	409	463	470	266	266	401	318	312	399	473
III	580	609	648	413	416	505	408	415	516	584
IV	635[a]	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]Value taken from fish age III+, nearly age IV.

bass were recorded by the regular creel census program (see Job II). Efforts to establish a population of striped bass in the Bullfrog area by airplane stocking has not been as successful as hoped. Numbers of age 0 and age I striped bass found at Wahweap and Bullfrog per sampling effort seem directly related to stocking technique. Increased stocking loss may have resulted from over crowding during airplane flights to Bullfrog or from actual air drops.

Recommendations

Airplane stocking of striped bass in Bullfrog Bay should be reevaluated. Other techniques or means of transportation should be explored.

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