1983

The Effects of limited food availability on the striped bass fishery in Lake Mead

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CHAPTER 32

THE EFFECTS OF LIMITED FOOD AVAILABILITY ON THE STRIPED BASS FISHERY IN LAKE MEAD

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INTRODUCTION

The original range of striped bass (*Morone saxatilis*) was along the Atlantic Coast. They were introduced into the lower Sacramento River in 1879 and are now also found along the Pacific Coast [1]. A landlocked striped bass fishery was established in Santee-Cooper Reservoir, South Carolina, in 1954, and they have since been introduced into numerous other reservoirs, including Lake Havasu, Lake Mead and Lake Powell on the Colorado River.

Striped bass were introduced into Lake Mead in 1969 in response to declines in the largemouth bass (*Micropterus salmoides*) fishery that occurred during the 1960s and in order to further utilize the forage base of threadfin shad (*Dorosoma petenense*). Natural reproduction of striped bass was documented in 1973 [2], and a highly successful fishery developed during the late 1970s. Striped bass comprised 40.1% of the total angler catch in 1979 [3].

The development of the striped bass fishery in Lake Mead was not without cost. A stocking program of rainbow trout (*Salmo gairdneri*) and other salmonid species was started in 1969. This was also initiated to utilize the surplus threadfin shad production. The trout fishery was considered good from 1970 to 1975, when they comprised 13 to 19% of the total angler catch. This declined to 1% in 1976, despite increased stocking [2]. Food habit studies conducted during this period revealed that rainbow trout occurred in 23% of the striped bass stomachs. The decline in the trout fishery was attributed primarily to predation by striped bass [2]. The occurrence of other gamefish species in striped bass stomachs was low, but threadfin shad comprised 50% of their diet [2]. Striped bass are noted for their voracious appetites and their ability to exploit shad in limnetic areas of reservoirs. This resulted in over exploitation of shad in Santee-Cooper Reservoir, South Carolina [4].

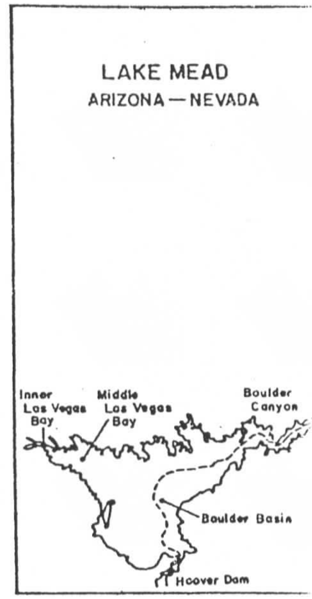
Shad production is closely linked to phytoplankton productivity because of their planktivorous feeding habits. Phytoplankton productivity in Lake Mead declined considerably after Lake Powell was formed in 1963 [5], and most of the reservoir is now oligotrophic-mesotrophic [6]. Shad in Lake Mead are, therefore, extremely vulnerable to possible over exploitation by striped bass. The purpose of this paper is to describe how rapid growth of the striped bass population altered the relative abundance of threadfin shad and how food limitation may be a factor in limiting future success of the fishery.

LAKE MEAD DESCRIPTION

Lake Mead was formed in 1935 by the construction of Hoover Dam and occupies a 183 km reach of the Colorado River on the Arizona-Nevada border. Morphometric characters of Lake Mead are given in Table I. Major reaches consist of Gregg, Temple, and Virgin Basins, collectively referred to as the Upper Basin, and Boulder Basin referred to as the Lower Basin (Figure 1). There are also two large embayments, the Overton Arm of Virgin Basin, which receive discharges from the Muddy and Virgin Rivers, and Las Vegas Bay, a large bay of Boulder Basin, which receives secondary-treated sewage effluents from Las Vegas metropolitan area via Las Vegas Wash. The Upper Basin has been classified as oligotrophic, Boulder Basin as mesotrophic and Las Vegas Bay as mesotrophic-eutrophic [6].

Table I. Morphometric Characteristics of Lake Mead from Paulson, Baker and Deacon [7].

Parameter	Lake Mead
Maximum operating level (m)	374.0
Maximum depth (m)	180.0
Mean depth (m)	55.0
Surface area (km^2)	660.0
Volume ($m^3 \times 10^9$)	36.0
Maximum length (km)	183.0
Maximum width (km)	28.0
Shoreline development	9.7
Discharge depth (m)	83.0
Annual discharge (1977) ($m^3 \times 10^9$)	9.3
Storage ratio at maximum operating level (years)	3.9



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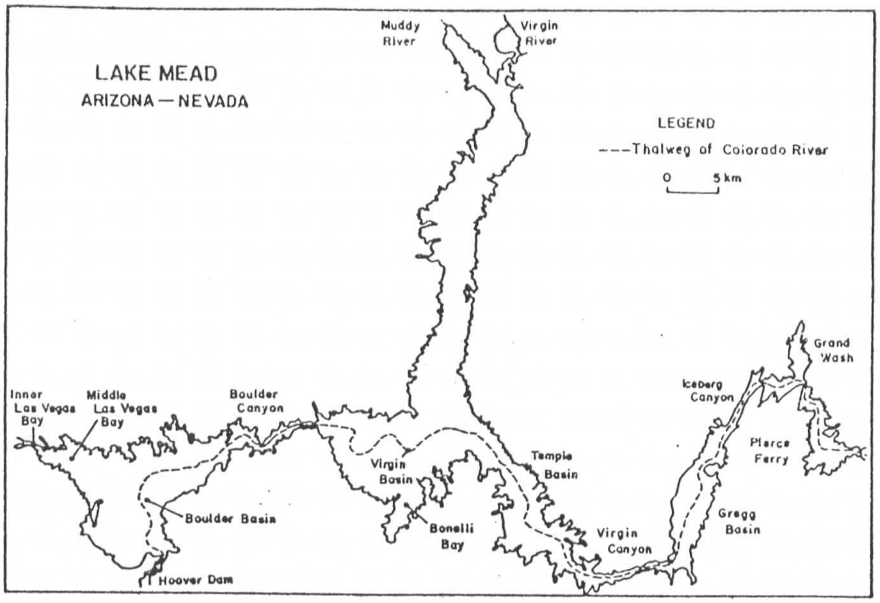

Figure 1. Map of Lake Mead.

The higher trophic state of Boulder Basin and Las Vegas Bay is due to high nutrient loading from Las Vegas Wash. Approximately 60% of the total phosphorus load to Lake Mead in 1977-78 was derived from the Las Vegas Wash inflow [8]. An advanced wastewater treatment plant is being constructed in Las Vegas. Phosphorus loading to Las Vegas Bay will decrease substantially in the future if the plant is operated to specifications. This will probably result in reduced phytoplankton growth in the Las Vegas Bay and Boulder Basin.

METHODS AND DATA SOURCES

Echo-sounding surveys have been made frequently in Lake Mead as part of water quality investigations conducted by Dr. James E. Deacon, University of Nevada, Las Vegas (UNLV) and by the Lake Mead Limnological Research Center (UNLV). Echo-sounding transects were run at various locations in Lake Mead at an approximate speed of 5 mph for 5-15 min at least monthly during 1972, 1974-75, and 1980. A Furuno (FM-22A) recording echo-sounder was used in the surveys. This instrument sounds at a frequency of 50 KHz and the transducer has a 28° beam angle.

Data on striped bass were derived from Nevada Department of Wildlife Job Progress Reports [3,9].

RESULTS

Striped Bass

The introduction of striped bass into Lake Mead in 1969, with successful natural reproduction in 1973, resulted in rapid growth of the population during the 1970s. Nevada Department of Wildlife creel census data show that the annual angler catch increased from approximately 1500 in 1973 to over 400,000 in 1979 (Figure 2). There was a major change in the Lake Mead fisheries with angler effort for striped bass increasing from 15.5 to 51.5% between 1978 and 1979. This was reflected in the percentage composition of the total catch for striped bass which increased from 4.1 to 40.1% for the same time period [3]. However, there was a slight decline in the total catch of striped bass in 1980 (Figure 2).

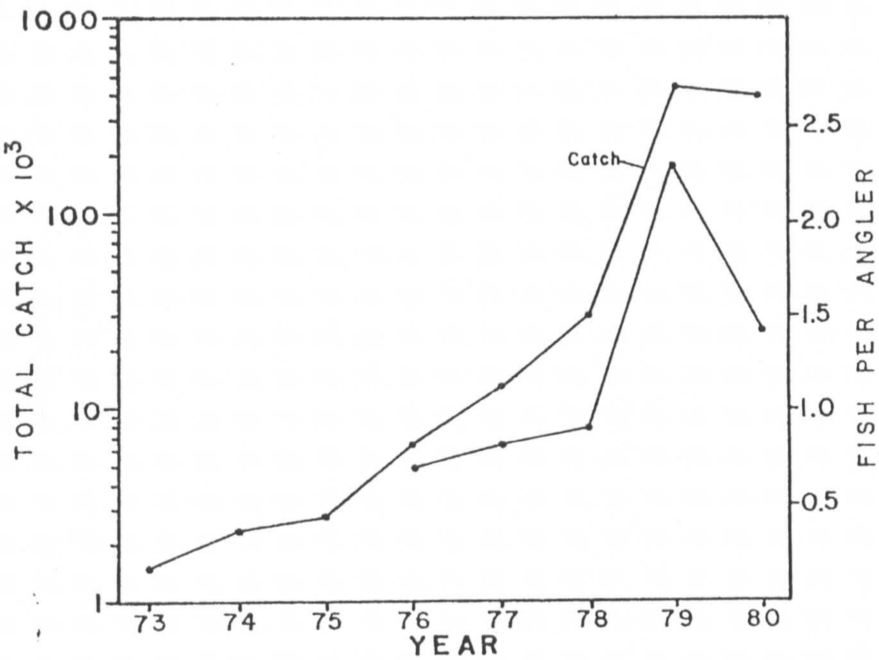

Figure 2. Total Angler Catch and Fish Per Angler for Striped Bass 1973-80 [3,9].

At this time, fishermen complained that the incidence of large striped bass in the catch was decreasing and that a large percentage of the fish caught were emaciated and in poor condition [10]. There was a marked decline in the overall condition factor (Figure 3) of striped bass in 1980, substantiating complaints from fishermen. The poor overall condition factor in 1980 was not related to a shift in the size range of fish in the catch as the condition factors of

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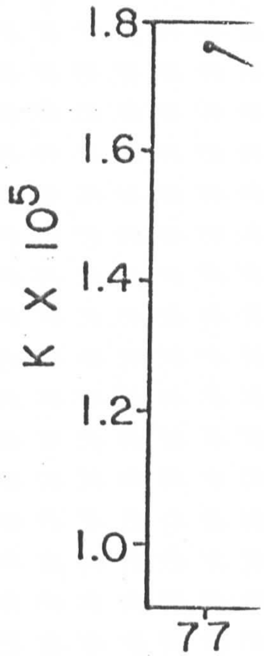

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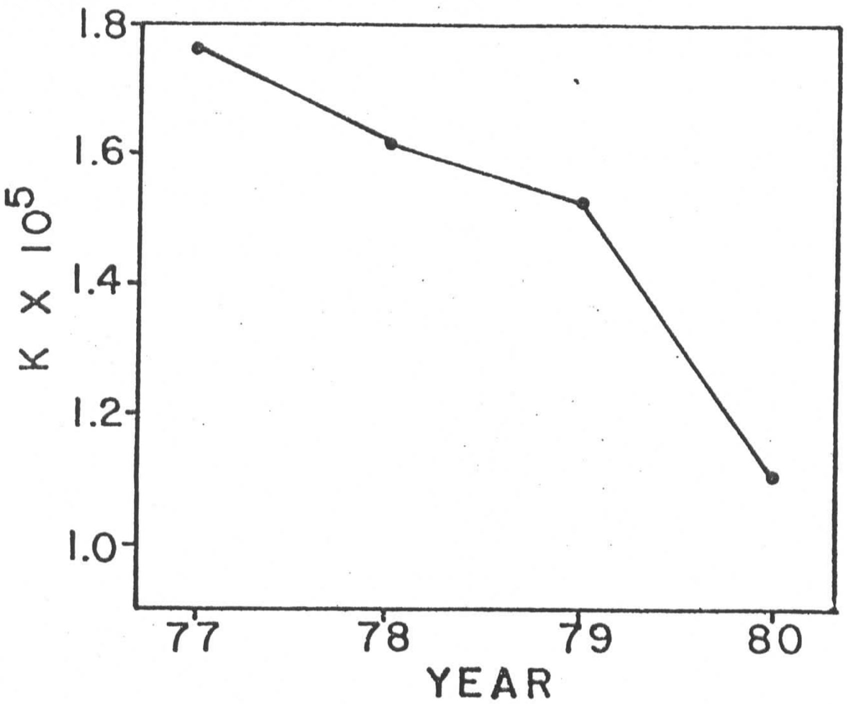


Figure 3. Striped Bass Condition Factor, 1977-80 [3,9].

Annual die-offs of striped bass, in the size range of 56-71 cm, occurred regularly in the spring of 1976-79 [11]. These fish were mainly males, and, because the die-offs occurred after spawning, it was suspected that they resulted from post-spawning stress. The Nevada Department of Wildlife initiated an investigation in 1980 to determine the actual cause for the annual die-offs; however, there was no evidence of a die-off in 1980. Striped bass were nonetheless collected in July for autopsy. The autopsies revealed that "...Lake Mead striped bass appear thin, had few parasites, and few skeletal abnormalities; however, over half (57%) of the fish had liver abnormalities" [11]. These findings, plus the poor condition factor, indicated that a nutritional problem existed and that food may have become limiting.

Threadfin Shad

Echo-sounding conducted during the early 1970s revealed that threadfin shad schools were extremely abundant throughout the epilimnetic waters of Lake Mead. This was indicated by the high density of inverted cones on the echograms presented in Figure 4. Mid-water trawling conducted by the Nevada Department of Wildlife [2] and fish trapping [12] confirmed that these inverted cones were due primarily to large schools of threadfin shad. Netsch, Kersh, Houser and Kilambi [13] have also recorded similar echograms for threadfin shad in Beaver Reservoir, Arkansas.

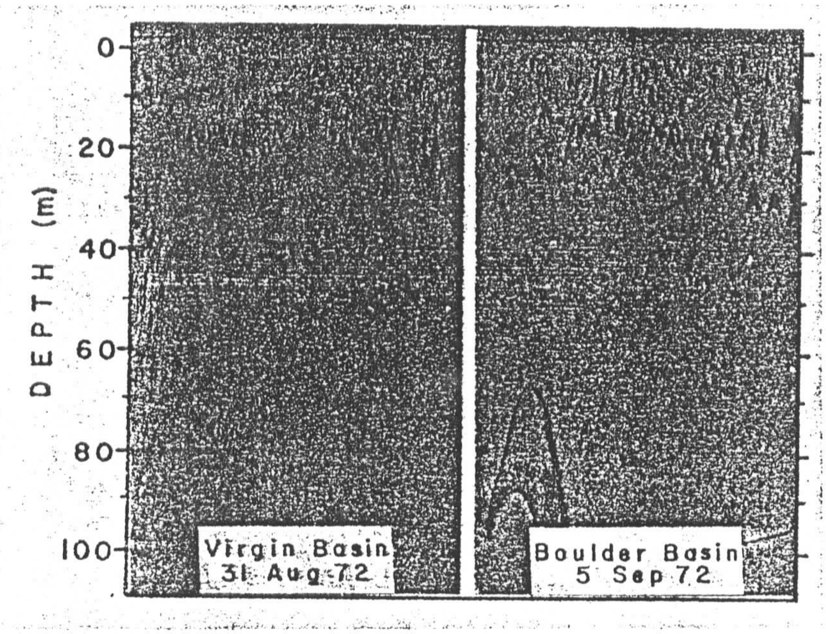
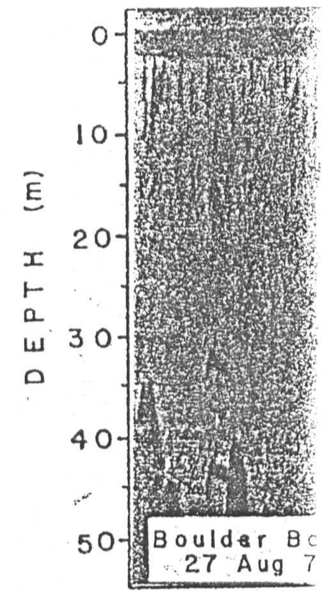


Figure 4. Echograms from Virgin and Boulder Basins, 1972.

Although it was not possible to determine absolute abundance of threadfin shad from the echograms, it was still evident that shad were numerous in 1975 (Figure 5). Echo-sounding surveys were not conducted during 1976-79, but those made during 1980 (Figure 6) showed that threadfin shad schools were nearly absent in limnetic areas of Lake Mead. This was surprising since threadfin shad are primarily limnetic in their distribution [13,14]. Scattered schools were still observed in the littoral areas, and they were fairly abundant in parts of Las Vegas Bay near the sewage inflow (Figure 7). Again, no quantitative estimate of the population can be made, but it is apparent that there was a major decline in threadfin shad abundance in the limnetic areas sometime during the late 1970s. The decline in threadfin shad was not due to a winter kill as Lake Mead temperatures rarely fall below 12°C which is above their critical minimum temperature of 9°C [15].



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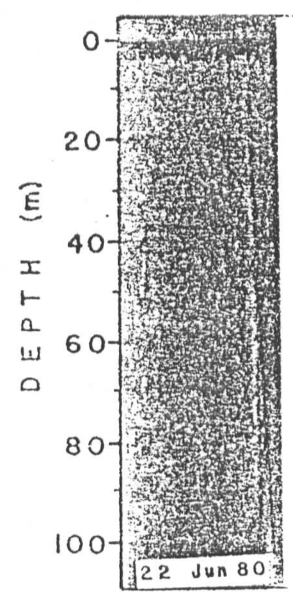

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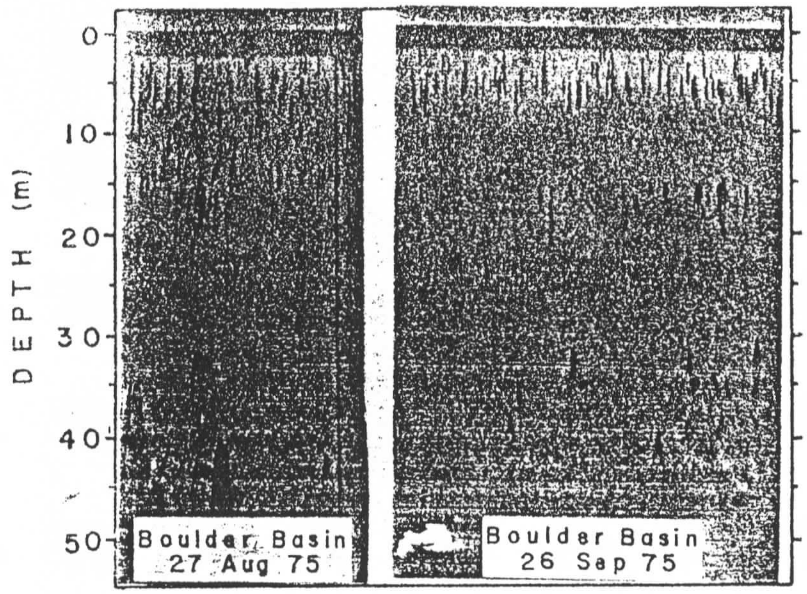

Figure 5. Echograms from Boulder Basin, 1975.

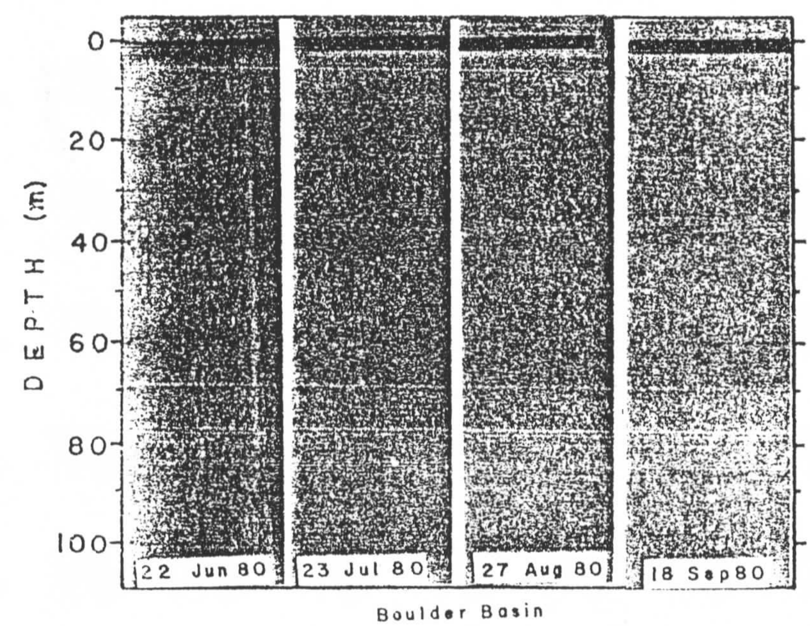

Figure 6. Echograms from Boulder Basin, 1980.

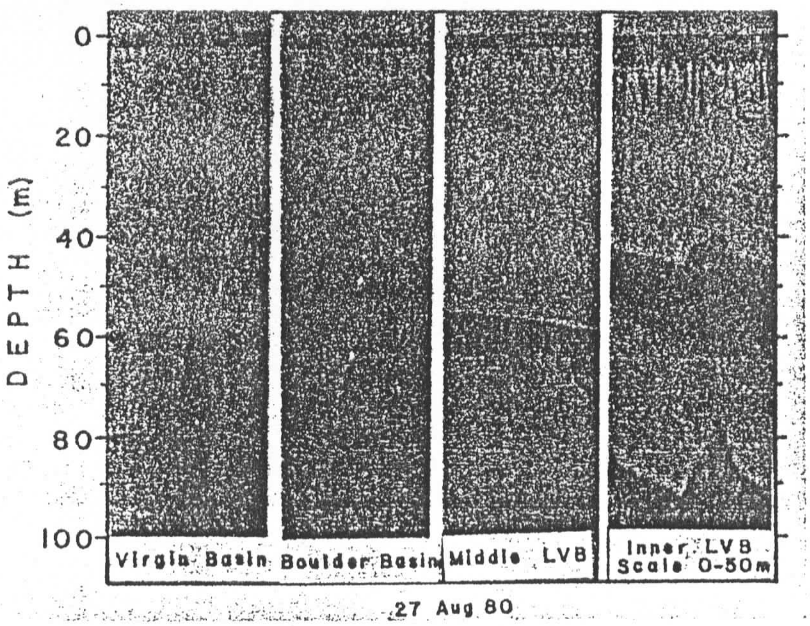

Figure 7. Echograms from Virgin Basin, Boulder Basin and Las Vegas Bay, August, 1980.

DISCUSSION

The introduction and subsequent establishment of striped bass into Lake Mead in 1969 resulted in a highly successful fishery during the 1970s. However, rapid growth of their population was associated with a decline in the rainbow trout and threadfin shad populations. The decline in the trout population has already been attributed to predation by striped bass [2], and it appears that this was also the cause for the recent decrease in threadfin shad abundance in limnetic areas. Striped bass were apparently extremely efficient in utilizing the surplus shad production that existed during the early 1970s. However, over exploitation seems to have occurred sometime between 1975 and 1979. The incidence of large striped bass in the angler catch decreased in 1980, and a large percentage of the fish taken were emaciated and in poor condition.

The pattern in Lake Mead is remarkably similar to what occurred in Santee-Cooper Reservoir in 1960. The striped bass population in Santee-Cooper Reservoir increased to the point where threadfin shad could no longer sustain the predator pressure. This ultimately led to a 30 to 50% decrease in their population. Minckley [16] predicted that the

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forage base in Lake Mead and other Colorado River reservoirs was also susceptible to over exploitation by striped bass. This seemed to be compounded in Lake Mead due to low fertility and productivity that developed as a result of decreased nutrient loading from the Colorado River after Lake Powell was formed in 1963 [5]. Chlorophyll-a concentrations in Lake Mead averaged only 1.3 mg/m^3 in the Upper Basin and 3 mg/m^3 in Boulder Basin during 1977-78 [6]. In Las Vegas Bay, near the sewage inflow, chlorophyll-a concentrations averaged 7 mg/m^3 and ranged as high as 23 mg/m^3 during summer [6].

Rinne, Minckley and Bersell [17] found that the horizontal distribution and abundance of threadfin shad was directly related to chlorophyll-a concentrations in the Salt River reservoirs. Zooplankton standing crops were affected both by levels of phytoplankton productivity and threadfin shad predation and were not therefore correlated with fish abundance [17]. Average annual zooplankton standing crops in Lake Mead were generally related to chlorophyll-a concentrations during 1977-78, but there were seasonal variations in this relationship and marked differences in the response of various zooplankton groups [6]. Preliminary experiments conducted during the summer of 1981 indicate that chlorophyll-a concentrations were sufficient to maintain optimal growth and reproduction of Daphnia in Las Vegas Bay, but concentrations in Boulder Basin were not adequate (Baker unpubl. data). Wilde [18] reported that zooplankton abundance in Boulder Basin has decreased considerably since 1971. He attributed this to decreased productivity because it closely paralleled reductions in nitrate loading from the Colorado River after 1970 as well as decreases in chlorophyll-a concentrations in the inner Las Vegas Bay since 1972 [19].

Threadfin shad extensively utilize zooplankton and phytoplankton as food resources in Lake Mead [20], and it is likely that historic reductions in zooplankton abundance have influenced their populations. Echo-sounding surveys revealed that shad were still fairly abundant in Las Vegas Bay during 1980 indicating that perhaps their abundance does increase at higher levels of phytoplankton productivity. The productivity in Las Vegas Bay will probably further decline if phosphorus loading is significantly decreased by operation of the advanced wastewater treatment plant. Studies are presently being conducted to determine what levels of treatment are appropriate to protect beneficial uses. In this regard, the trophic relationships in Lake Mead should be further investigated to determine if present and future phytoplankton production is adequate to maintain shad production at levels necessary to have a productive striped bass fishery.

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