SHORT TERM EFFECTS OF THE TOLEDO BEND PROJECT ON SABINE LAKE, LOUISIANA*

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ABSTRACT

Hydrological and biological parameters are presented for Sabine Lake, Louisiana, before and after the completion of Toledo Bend Reservoir. Salinity and temperature regiments, species composition, and abundance are presented for June 1967 through May 1969. Selected species are compared to decreasing and increasing reservoir discharges. Occurrence and abundance of marine animals are related to altered salinity levels demonstrating possible effects on the total marine animal community. Commercial Penaeid shrimp landings from Sabine Lake for 1962 through 1971 are presented and discussed.

INTRODUCTION

During recent years there has been considerable upsurge in the construction of reservoirs within many river basins. This has been true especially in the southeastern section of the United States. Justification for these projects include: water preservation, flood control, irrigation, navigation, improved water supply, drainage, hydroelectrical power, and the creation of recreational facilities to appease the increasing demand of the public. Generally, reservoir projects have met with these justifications and in most cases have been considered successful by the public. The objective of this study was to present some of the short term environmental and biological changes that may be associated with reservoir construction.

The Sabine River Authority of Louisiana was created by Act 261 of the Louisiana Legislature in 1950. Act 261 was amended in 1959 and shown as Louisiana Revised Statutes Title 38, Section 2321, et. seq. as amended. The voters of the State of Louisiana, on November 8, 1960, passed Amendment No. 8 to the Constitution of the State of Louisiana. It is now shown as Article 14, Section 45, which ratified the creation of the Sabine River Authority and gave it constitutional status.

The Sabine River Authority of Texas was created by the 51st Legislature of the State of Texas in 1951. Public Law No. 252 was passed during the first session of the 82nd Congress.

On October 14, 1963, the Federal Power Commission issued an order granting Sabine River Authorities of both States joint operation authority to dam the Sabine River on the boundary line between the State of Louisiana and the State of Texas. Thus the Toledo Bend Project was underway.

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MATERIALS AND METHODS

Three trawl sampling stations were selected in Sabine Lake. These were: Coffee Ground Cove (15), Johnson's Bayou (16), and Blue Buck Point (17) (Figure 1). Biological and hydrological samples were taken monthly at each of these locations from November 1966 through May 1969. Sampling gear consisted of a 16 foot flat otter trawl. The hood and throat portion of the trawl were made of ¾ inch bar nylon webbing. The tail was constructed of ¼ inch bar pressed-nylon webbing. Sampling was continuous over 10 minute periods at a trawling speed of approximately 3 knots. A 25 foot inboard-outboard boat was used for taking all samples.

Salinity and temperature readings were taken with a Backman RS5 induction salinity meter at a depth of one foot below the surface.

Trawl samples were placed in plastic containers, iced, and transported to the Lake Charles office of the Louisiana Wild Life and Fisheries Commission for analysis. All fishes, crustaceans, and molluscs were measured to the nearest 5 millimeters. When more than 50 of one species were taken at a station, only 50 were randomly selected for measurement; the remaining number were counted.

Toledo Bend Reservoir

The Toledo Bend Dam site is located on river mile 156.5 measured north from Sabine Lake (Figure 2). The dam site is located geographically in Newton County, Texas, and in Sabine Parish, Louisiana. The reservoir extends 65 miles north to Logansport, Louisiana, and is relatively long and narrow with arms branching out at the various tributaries on both sides of the reservoir. The maximum width at pool level is approximately 15 miles. The Sabine River has a drainage area above its mouth of 9,703 square miles. The drainage area above the Toledo Bend Dam is 7,157 square miles (Sabine River Authority, 1970).

The elevation at normal reservoir pool is 172.0 feet. At this level the storage in the reservoir is 4,477,000 acre-feet. Total surface acreage is 181,600 acres with an average depth of 60 feet. The shoreline measurement is approximately 1,200 miles (Forest and Cotton, 1958).

Construction of the reservoir was completed in the fall of 1967. The spillway consists of 11 radial gates with spillway crest at elevation 145.0 feet. There are nine 8-foot gate piers and one 10-foot by 10-foot sluiceway through a 20-foot gate pier.

Sabine Lake

Sabine Lake is a relatively large brackish water lake containing 55,858 acres and a volume of 300,776 acre-feet (Barrett, 1970). The lake is located on the Louisiana-Texas state line at the southwestern corner of Cameron Parish, Louisiana, and the eastern edge of Jefferson County, Texas. It is a relatively shallow lake, averaging six to seven feet in depth. The main tributaries entering the lake are the Sabine River, Neches River, and Intracoastal Waterway, all of which enter at the north end. Several smaller bayous enter along the southeastern edge of the lake. The most prominent of these are Johnson's Bayou, Madam Johnson's Bayou, and Green's Bayou. The channel to the Gulf is Sabine Pass, located at the extreme southwestern end of the lake.

Historically, Sabine Lake provided the livelihood for a small fleet of commercial shrimpers operating from Texas and Louisiana. Listed in Table 1 are shrimp landings from the lake for the period 1962 through 1971. Several net fishermen and crab fishermen operate in the lake seasonally. The lake is estuarine, and its true value lies in its importance as a nursery area for juvenile shrimp, crabs, and finfishes (Perret *et al.*, 1971). Extensive recreational use is tenerated by the sport fishermen from the surrounding Louisiana and Texas counties.

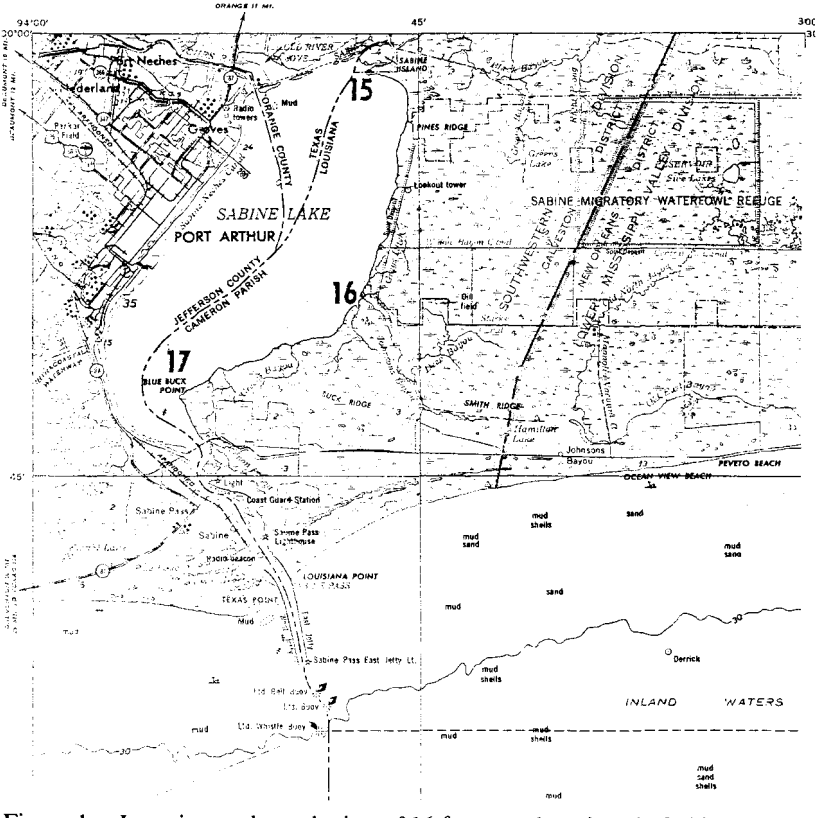

Figure 1. Location and numbering of 16-foot trawl stations in Sabine Lake, Louisiana.

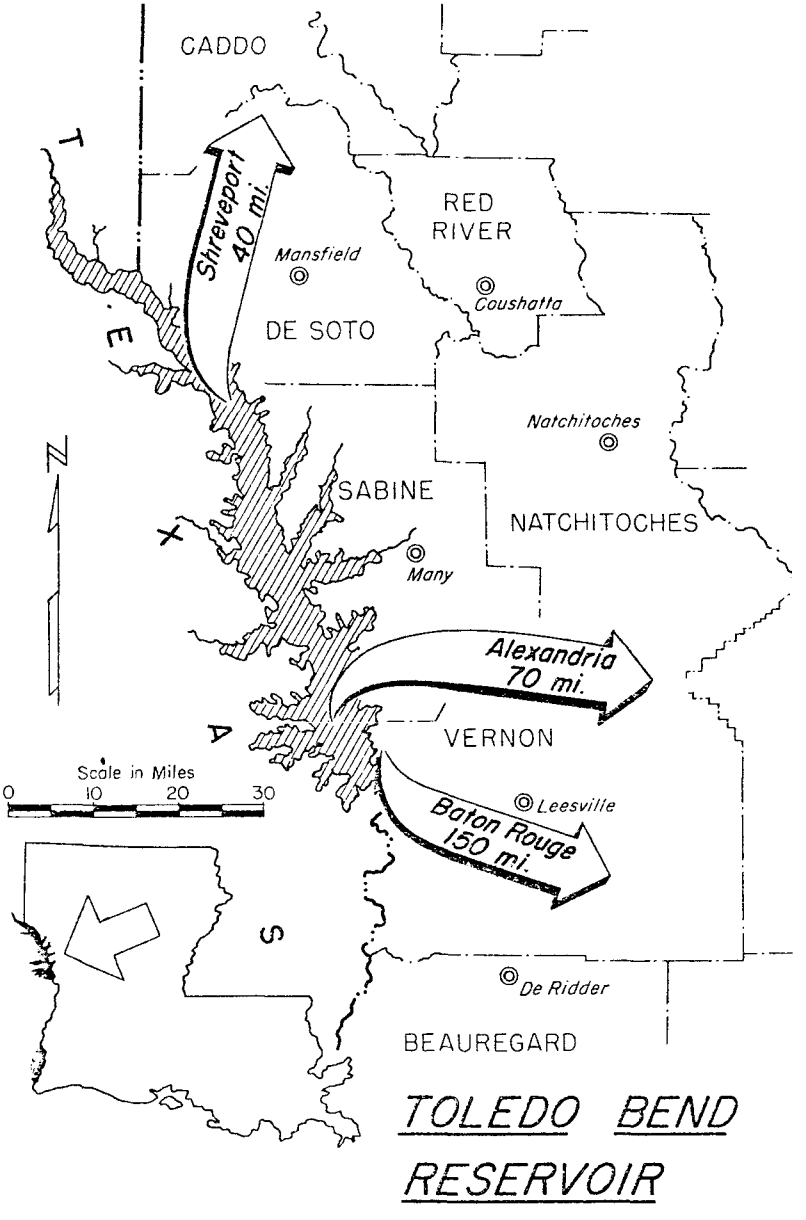

Figure 2. Geographical location of Toledo Bend Reservoir.

Table 1. Total Shrimp Landings in Pounds (Heads-off)* for Sabine Lake and Louisiana from 1962-1971.

Year	Total Catch Sabine Lake	Total Catch Louisiana
1962	261,121	29,656,139
1963	853,431	57,089,316
1964	160,572	40,395,113
1965	352,980	43,381,476
1966	55,030	43,347,516
1967	15,109	51,261,367
1968	51,287	47,231,681
1969	67,771	57,202,014
1970	20,703	59,484,393
1971	27,463	66,021,992

*Source - U. S. Department of Commerce, National Marine Fisheries Service, Gulf Coast Shrimp Data.

RESULTS AND DISCUSSIONS

Hydrology

The Sabine River flow had a marked effect on the salinity profile of Sabine Lake. During the fall of 1967, the main flow of the Sabine River was restricted to a total discharge of 100 cubic feet per second. This was done to bring the water level behind the dam to pool stage (172.0 feet elevation). Prior to October of 1967, river discharges for a period of 43 years reported a monthly average discharge of 8,271 cfs for the Sabine River (Perret *et al.*, 1971).

With a lowered river discharge, salinities in Sabine Lake reached abnormally high salinity levels; Figures 3, 4, and 5 show that salinity levels for each of the three stations for the year prior to May 1968 were in every case above 5 ppt and in several cases above 15 ppt. The yearly average salinity for these stations for the period May 1967 through May 1968 was in each case above 10.0 ppt. This is considered several ppt higher than what may be normally expected as the average level. Immediately after the opening of the discharge gates of May 17, 1968, a drastic change occurred. The average daily discharges, as reported by the Toledo Bend Authority, are shown on Figures 3, 4 and 5. The initial discharge rate for May (17th through 31st) was in excess of an average of 9,000 cfs. This was approximately the same rate that was reported for the following month of June. These initial discharges resulted in a salinity drop of approximately 50% for all stations from the May and June average. A continued high discharge rate prevailed throughout the study. This resulted in the salinity level being maintained below 5 ppt for all but one of the 36 readings taken one year after May 17, 1968. Barrett (1971) also reported lower salinity values after May 1968. By comparison, the average salinity for all samples for one year after May 17 was 2.4 ppt. Te average salinity for the one year period prior to May 17 was 11.7 ppt.

Biology

Sabine Lake serves as a nursery area for many of the marine organisms inhabiting the near offshore Gulf waters. Many of these species are euryhaline (Gunter, 1956). Several species, however, require a relatively high salinity level for optimum growth and survival.

A total of 50 species representing 31 families were collected. Thirty-three of the 50 soecies identified are considered commercially important (Lyles, 1965).

Table 2 lists the total catch of each species one year prior to the opening of the dam and one year after the opening. Sixteen species that were taken one year prior to May 17, 1968, were not collected the year following. These were: threadfin shad (*Dorosoma petenense),* striped anchovy (*Anchoa hepsetus*), pigfish *(Orthopristes chrysopterus*), spotted sea trout (*Cynoscion nebulosus*), star drum *(Stellifer lanceolatus*), sheepshead (*Archosargus probatocephalus*), Atlantic cutlassfish (*Trichirus lepturus*), southern harvestfish (*Peprilus alepidotus*), striped mullet (*Mugil cephalus*), hogchoker (*Trinectes maculatus*), blackcheck tongue fish (*Symphurus plagiusa*), gulf toadfish (*Opsanus beta*), American oyster (*Crassostrea virginica*), roughneck shrimp (*Trachypenaeus constrictus*), mud shrimp (*Alpheus heterochaelis*), and the net clinger (*Acetes americanus*). The failure to capture a particular species after May 17, 1968, may have been a result of gear selectivity and/or chance, and not necessarily the effect of the lowered salinity level, but a trend toward reduction of estuarine-dependent species was apparent.

Eight species of fish and one species of molluscs that were not taken during the one year sampling period prior to May 17, 1968, did occur in the samples after this period. These were: alligator gar (*Lepisosteus spatula*), ladyfish (*Elops* saurus), naked goby (*Gobiosoma bosci*), Spanish mackerel (*Scomberomorous maculatus*), bumper (*Chloroscombrus chrysura*), gulf killifish (*Fundulus grandis*), gizzard shad (*Dorosoma cepedianum*), tidewater silverside (*Menidia* beryllina), and the freshwater mussel (*Edilus spatula*). Here again, the occurrence of one or more of these species may be due to the gear selectivity and/or the chance factor.

Forty-two species of fish and shellfish were collected in Sabine Lake for the one year period prior to May 17, 1968. During the one year study after the opening of the Toledo Bend Dam, 35 species of fish and shellfish were collected in the lake.

There were 22,705 animals collected during this two year period. The average monthly catch of organisms in Sabine Lake was 339.0 animals per tow for the year prior to the opening. The average catch for the year after May 17, 1968, was slightly lower at 318 per tow.

One species, however, sustained the second year's catch comparable to the first year. The bay anchovy (*Anchoa mitchilli*) increased from a total catch of 1,273 taken for one year prior to May 17, 1968, to 5,268 taken for a one year period after May 17, 1968. If we disregard the bay anchovy, the catches are as follows: for the one year prior to May 17, 1968, 301.7 animals per sample; the catch for the following year was lowered considerably to 158.5 animals per sample. This was an abundance loss of 53%. The most noticeable species decrease occurred in the Penaeid shrimp population. Figure 6 presents the normal seasonal peaks as they generally occurred each spring and summer prior to May 17, 1968. After the opening of Toledo Bend Dam, a substantial decrease in abundance occurred for both the brown shrimp (*Penaeus aztecus*) and white shrimp *(P. setiferus*). Only for a short period during the summer months of July through September 1968 were these two Penaeid shrimp species present in any number. There was an abundance loss of 66% for the Penaeid shrimp after May 17, 1968.

The bulk of the catch in Sabine Lake was composed of six species: bay anchovy, largescale menhaden (*Brevoortia patronus*), Atlantic croaker *(Micropogon undulatus*), spot (*Leiostomus xanthurus*), white shrimp and brown shrimp. These six species composed 93% of the catch from Sabine Lake during this study. In the case of the bay anchovy, there was an increase of 242% after May 17, 1968. Perret *et al.* (1971) found the bay anchovy to be the most abundant species present in samples from the Louisiana coast. Norden (1966) in his study of the fish populations of Vermilion Bay showed that the bay anchovy was the most abundant species collected in a three year period. Three of the remaining species, Atlantic croaker, spot, and largescale menhaden, showed no

substantial changes during this study. This might be expected, as previous studies (Gunter, 1945, 1956; Gunter, Christmas, Killebrew, 1964; Reid, 1954; Perret *et al.,* 1971) have shown that certain species are capable of withstanding considerable salinity variances.

The reduction in catch for the brown shrimp and white shrimp can be directly attributed to the operational procedures on the Toledo Bend Dam. Formerly, higher discharges occurred during spring and tapered off during summer. Now, however, high winter river discharges are retained until mid-May, at which time releasing takes place. Thus, instead of increasing salinities during late May and throughout the summer, a near freshwater condition exists. This has been devastating to the brown and white shrimp populations.

Hopefully, in future projects of this type, more consideration will be given to fishery resources of the lower basins, to keep production losses at a minimum.

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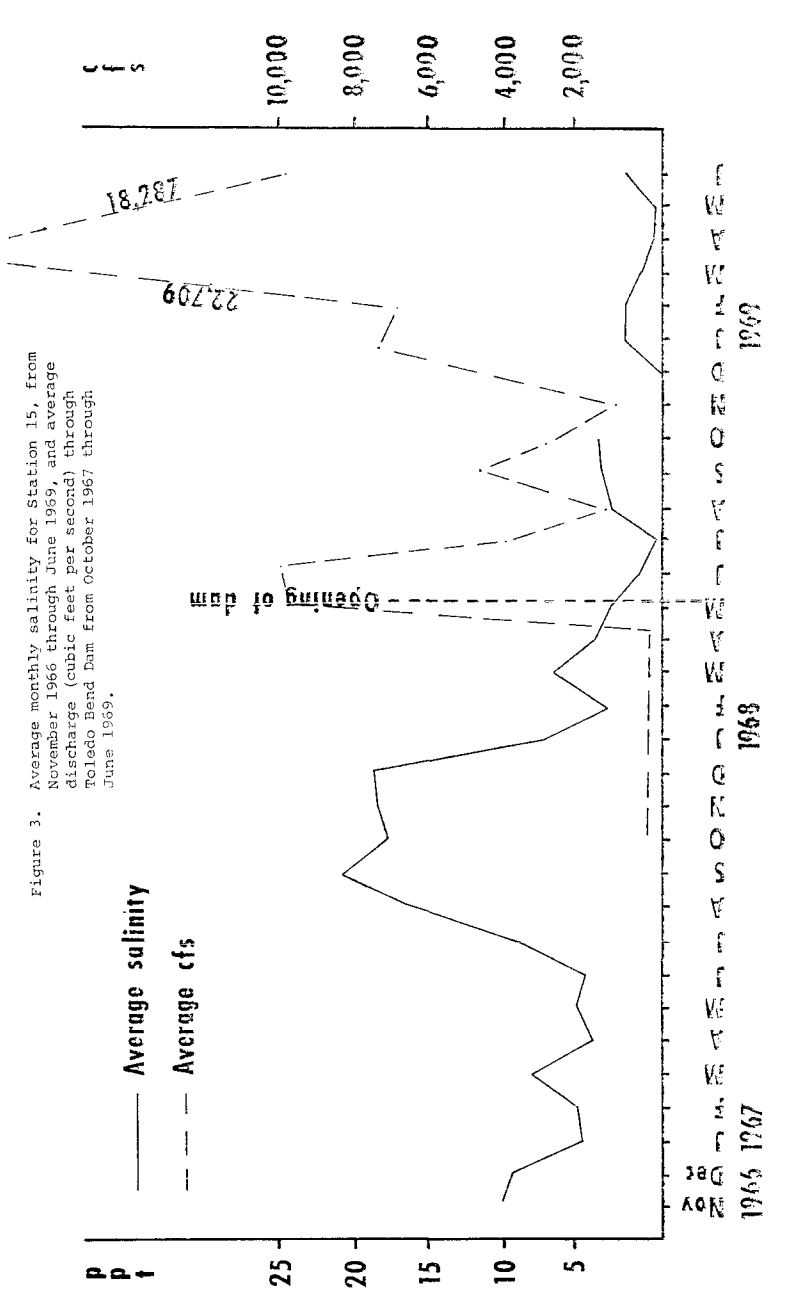

Figure 3. Average monthly salinity for Station 15, from November 1966 through June 1969, and average discharge (cubic feet per second) through Toledo Bend Dam from October 1967 through June 1969.

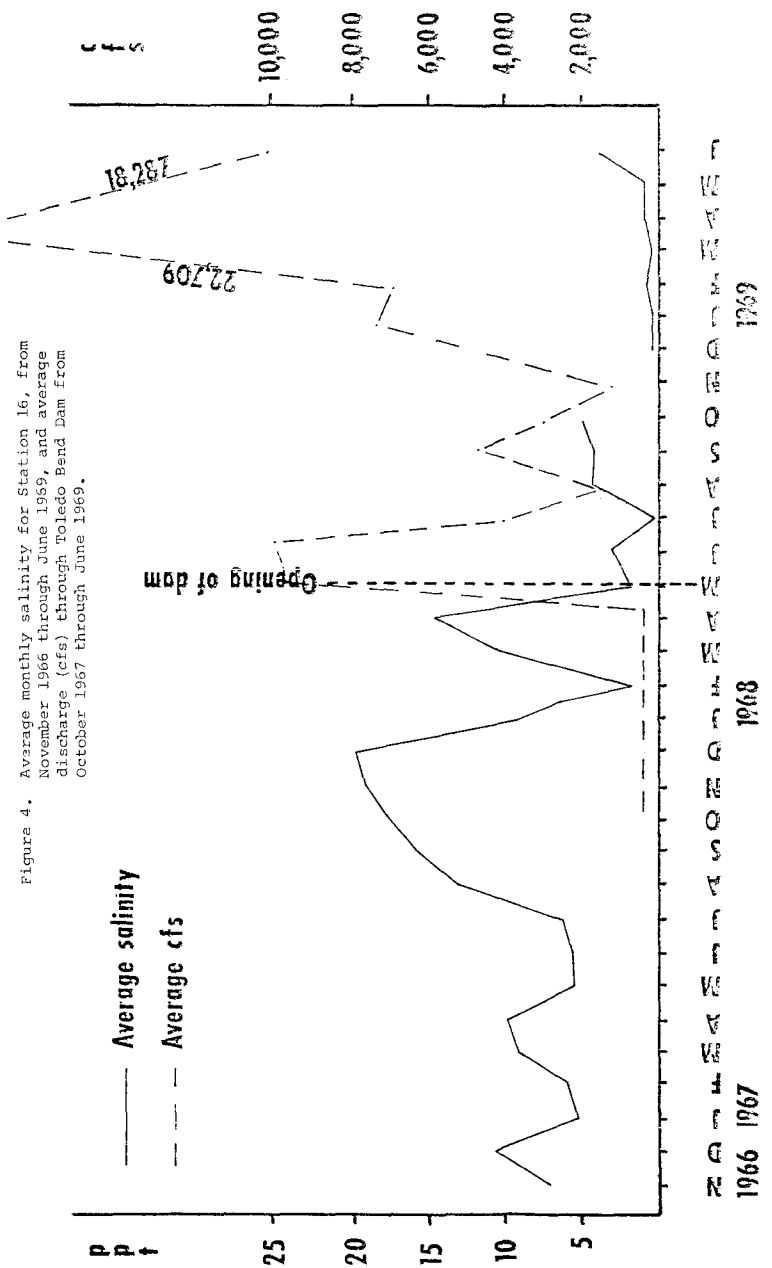

Figure 4. Average monthly salinity for Station 16, from November 1966 through June 1969, and average discharge (cfs) through Toledo Bend Dam from October 1967 through June 1969.

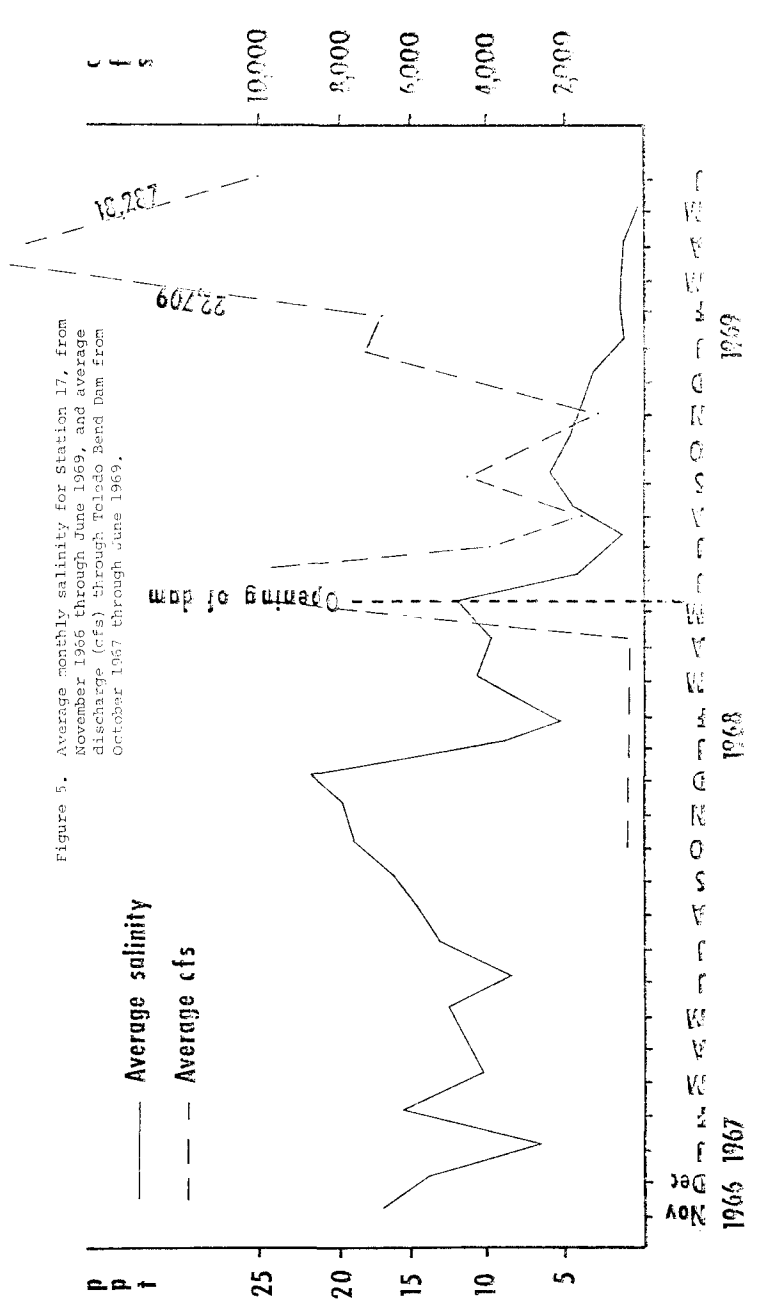

Figure 5. Average monthly salinity for Station 17, from November 1966 through June 1969, and average discharge (cfs) through Toledo Bend Dam from October 1967 through June 1969.

Table 2. Species taken in Sabine Lake, one year prior to the opening of Toledo Bend Dam, June 1967 - May 1968, and one year after, June 1968 - May 1969.

Species Collected	June 1967 - May 1968 (Total catch 36 samples)	June 1968 - May 1969 (Total catch 33 samples)
*Lepisosteus spatula**	0	5
*Elops saurus**	0	30
*Brevoortia patronus**	330	168
*Dorosoma cepedianum**	0	1
Dorosoma petenense	2	0
Anchoa hepsetus	2	0
Anchoa mitchilli	1273	5268
*Bagre marinus**	2	6
*Galeichthys felis**	119	63
Fundulus grandis	0	1
*Caranx hippos**	1	6
Chloroscombrus chrysura	0	0
*Orthopristes chrysopterus**	1	0
*Cynoscion arenarius**	168	223
*Cynoscion nebulosus**	1	0
*Leiostomus xanthurus**	470	439
*Menticirrhus americanus**	3	2
*Stellifer lanceolatus**	4	0
*Micropogon undulatus**	3050	2837
*Pogonais cromis**	3	4
*Archosargus probatocephalus**	3	0
*Lagodon rhomboides**	12	1
*Chaetodipterus faber**	8	16
*Trichirus lepturus**	3	0
*Scomberomorus maculatus**	0	4
Gobiosoma bosci	0	4
Gobiosoma robustrum	1	1
*Prinotus tribulus**	1	7
*Peprilus alepidotus**	2	0
*Mugil cephalus**	20	0
*Menidia beryllina**	0	1
Polydactylus octonemus	88	20
*Citharichthys spilopterus**	16	7
*Paralichthys lethostigma**	12	1
Achirus lineatus	7	6
*Trinectes maculatus**	3	0
Symphurus plagiusa	3	0
Spharoides nephelus	11	1
Opsanus beta	1	0
*Crassostrea virginica**	2	0
*Rangia cuneata**	31	2
*Penaeus setiferus**	4390	499
*Penaeus aztecus**	1681	638
Acetes americanus	310	0
Trachypenaeus constrictus	1	0
*Macrobrachium ohione**	16	41
Palaemonetes sp.	6	28
Alpheus heterochaelis	1	0

*Callinectes sapidus**	146	158
Panopeus herbstii	1	1
Edilus spatula	0	5
Total catch	12,205	10,500
Total species	42	35

*Denotes commercial species (From Lyles, 1965).

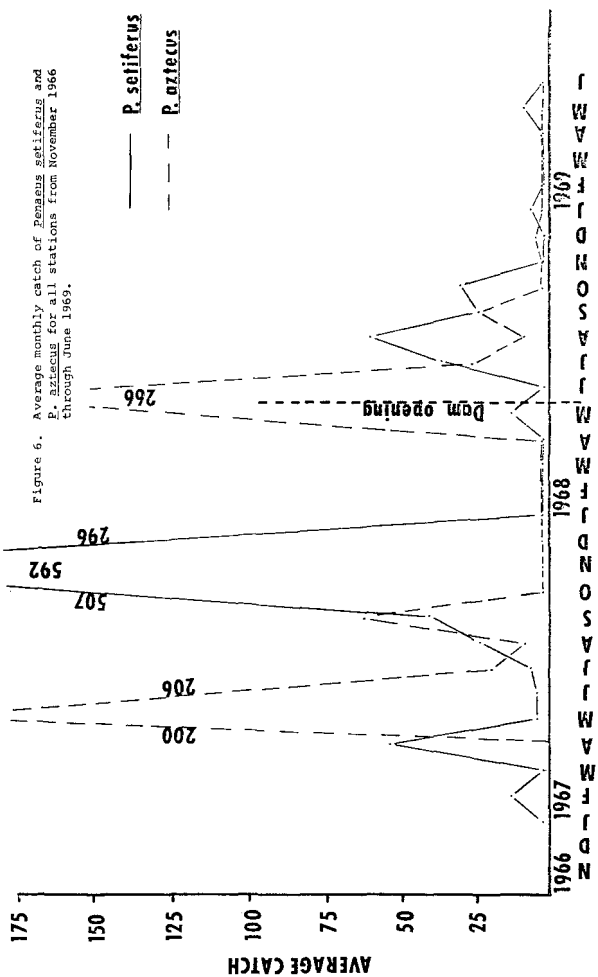

Figure 6. Average monthly catch of *Penaeus setiferus* and *P. aztecus* for all stations from November 1966 through June 1969.