FISHERY MANAGEMENT PLAN

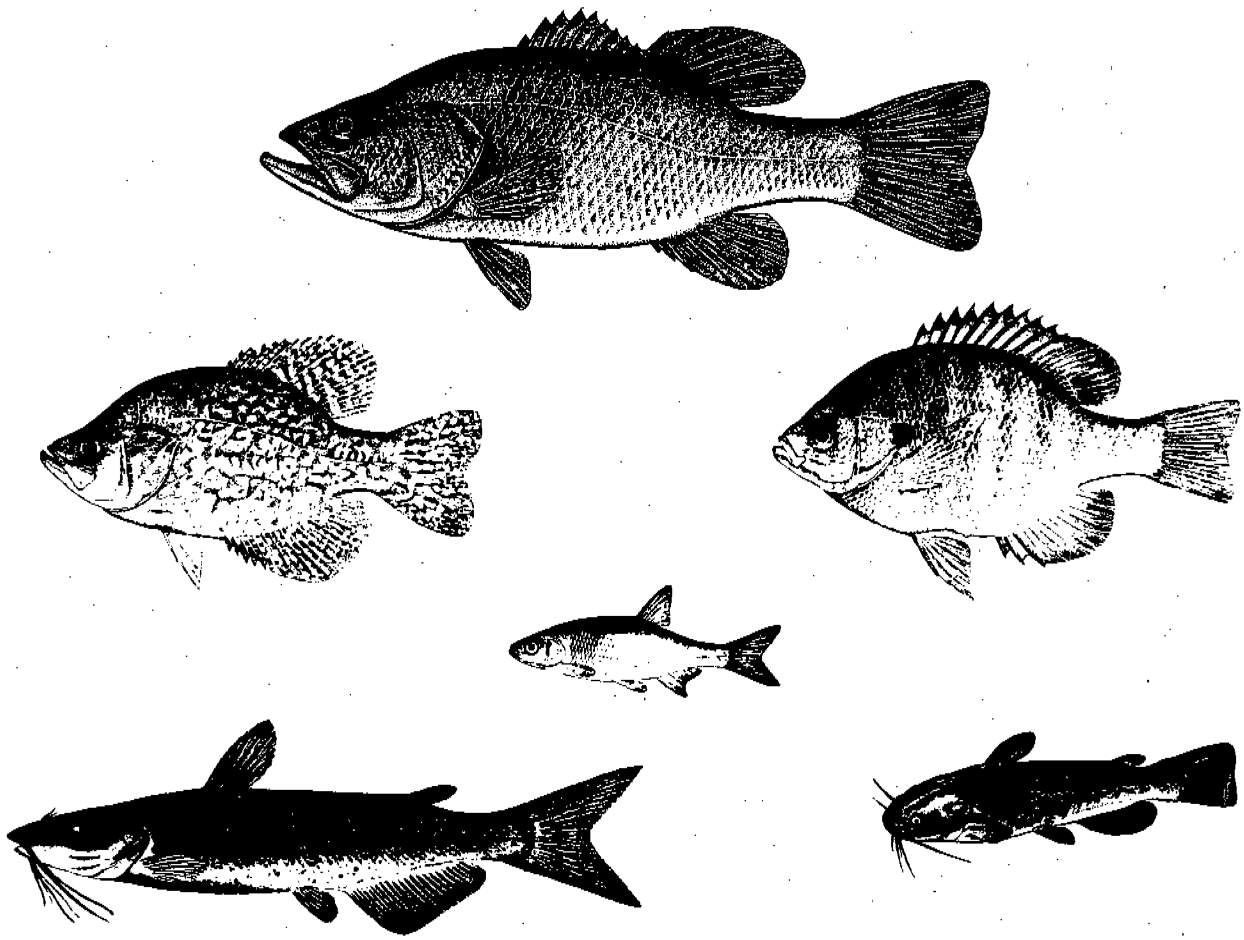
FOR LAKE O'NEILL

CAMP PENDLETON, CALIFORNIA

AFF-1-FRO-9305

PREPARED FOR:

ENVIRONMENTAL AND NATURAL
RESOURCE MANAGEMENT OFFICE
MARINE CORPS BASE
CAMP PENDLETON



PREPARED BY:

BRIAN C. CATES, FISHERY MANAGEMENT BIOLOGIST
THOMAS A. SHAW, FISHERY BIOLOGIST

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
COASTAL CALIFORNIA FISHERY RESOURCE OFFICE
ARCATA, CALIFORNIA

JULY 1993

FISHERY MANAGEMENT PLAN

FOR LAKE O'NEILL

CAMP PENDLETON, CALIFORNIA

AFF-1-FRO-9305

PREPARED FOR:

ENVIRONMENTAL AND NATURAL
RESOURCE MANAGEMENT OFFICE
MARINE CORPS BASE
CAMP PENDLETON

PREPARED BY:

BRIAN C. CATES, FISHERY MANAGEMENT BIOLOGIST
THOMAS A. SHAW, FISHERY BIOLOGIST

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
COASTAL CALIFORNIA FISHERY RESOURCE OFFICE
ARCATA, CALIFORNIA

JULY 1993

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Marine Corps Base, Camp Pendleton, California, maintains a natural resource program for protecting, conserving, and managing fish and wildlife resources under their jurisdiction. Providing quality recreational opportunities for military personnel and their families is an important component of Natural Resources management activities on the Base. Although active wildlife management programs for promoting wildlife related activities exist, fishery related efforts have been minimal.

The Environmental and Natural Resources Management Office has recognized the need for coordinated, scientifically based fishery management planning and has funded the U.S. Fish and Wildlife Service (USFWS) through its Coastal California Fishery Resource Office to begin developing fishery management options for selected Base waters. Lake O'Neill is the largest body of water on Camp Pendleton and offers the potential of significant recreational opportunities easily accessible to Base personnel. This potential makes it the logical choice as the first place to develop a "quality" fishing experience to complement its other values.

The specific purposes of USFWS activities on Lake O'Neill are to describe the past and current fishery resources of the lake, the suitability of the lake for fish, the impact of Base water level manipulation practices, and provide a plan (options) to improve its recreational fishing value. The appropriateness of USFWS involvement on Camp Pendleton are delineated through the authorizations granted by the Sikes Act (P.L. 86-797) as amended and the Fish and Wildlife Coordination Act (P.L. 85-624) as amended. The work is also consistent with the USFWS Recreational Fisheries Policy.

STUDY AREA

Camp Pendleton is located along the southern California coastline approximately 84 kilometers (km) north of San Diego (Figure 1). The boundaries of the Base enclose about 50,586 hectares of a variety of habitats including; costal strand, salt water estuary/fresh water marsh, riparian woodland, coastal sage scrub (≈35,000 acres), oak woodland/savannah, annual and perennial grassland, and chaparral. Coastal plain areas of southern California exhibit a subtropical climate characterized by warm, dry summers, moderate winters, and frequent fog. Temperatures are moderate, with an average monthly maximum temperature of 23 degrees centigrade(°C) (73.4 degrees fahrenheit (°F)) . The coldest month is January and the warmest is September. Temperatures are rarely freezing and few days exceed 32 °C (89.6 °F). Precipitation averages 34.5 centimeters (cm) (13.6 inches) per year, with most (84%) occurring between November and March. January is the wettest month, while July is the driest (Figure 2).

Lake O'Neill is a manmade impoundment of about 50 surface hectares located on Fallbrook Creek. It first stored water in 1883 when it was part of Rancho Santa Margarita, a large cattle ranch. Water in the lake was used to raise crops and support livestock. The lake obtained its waters from two sources; Fallbrook Creek and diversions from the Santa Margarita River.

The U.S. Government acquired the "Rancho" (and its associated water rights) during the 1942-1943 period for a military installation. Since that time, Lake O'Neill has primarily been utilized as a storage site for water utilized for ground water recharge and recreation. Full capacity of the lake is about 1.63 million cubic meters (1200 acre feet) and can be characterized as a shallow, eutrophic type water, with a high shoreline to volume ratio. Maximum depths occur near the dam. Following dredging near the dam in 1992, the minimum pool elevation will be at an elevation of 28.3 meters with dead pool storage of about 17% of capacity (200 acre feet). At capacity, the maximum depth would be about 3 meters. Surface water temperatures range from about 5° C (41° F) in the winter, to 30° C (86° F) in summer, although comprehensive year-round data is lacking.

The shallow waters of the lake, especially in the upper end, are conducive to the growth of aquatic vegetation along the shoreline and in other areas. Considerable growths of cattail (*Typha sp.*), water lily (*Nuphar sp.*, *Nymphaea sp.*) and burrhead (*Echinodorus sp.*) are present. A map of the lake, aquatic plant distribution, and significant study areas is shown in Figure 3.

Lake O'Neill and vicinity is an important recreational area on Camp Pendleton. It offers fishing, bird watching, camping, picnicking, boating, jogging, and other recreational opportunities. During the winter drawdown, the exposed mudflats of the lake attract many shorebirds because of its available food supply and protected inland location. Winter storms sometimes force shorebirds inland and the lake offers a safe haven. Some waterfowl may nest and rear young in the lake area but their numbers are unquantified. The lake also provides habitat for other bird species and numerous mammals.

Fish species known to be present include: Largemouth bass (*Micropterus salmoides*); Black Crappie (*Pomoxis nigromaculatus*); Brown bullhead (*Ictalurus nebulosus*); Green sunfish (*Lepomis cyanellus*); and Golden Shiners (*Notemigonas crysolencas*).

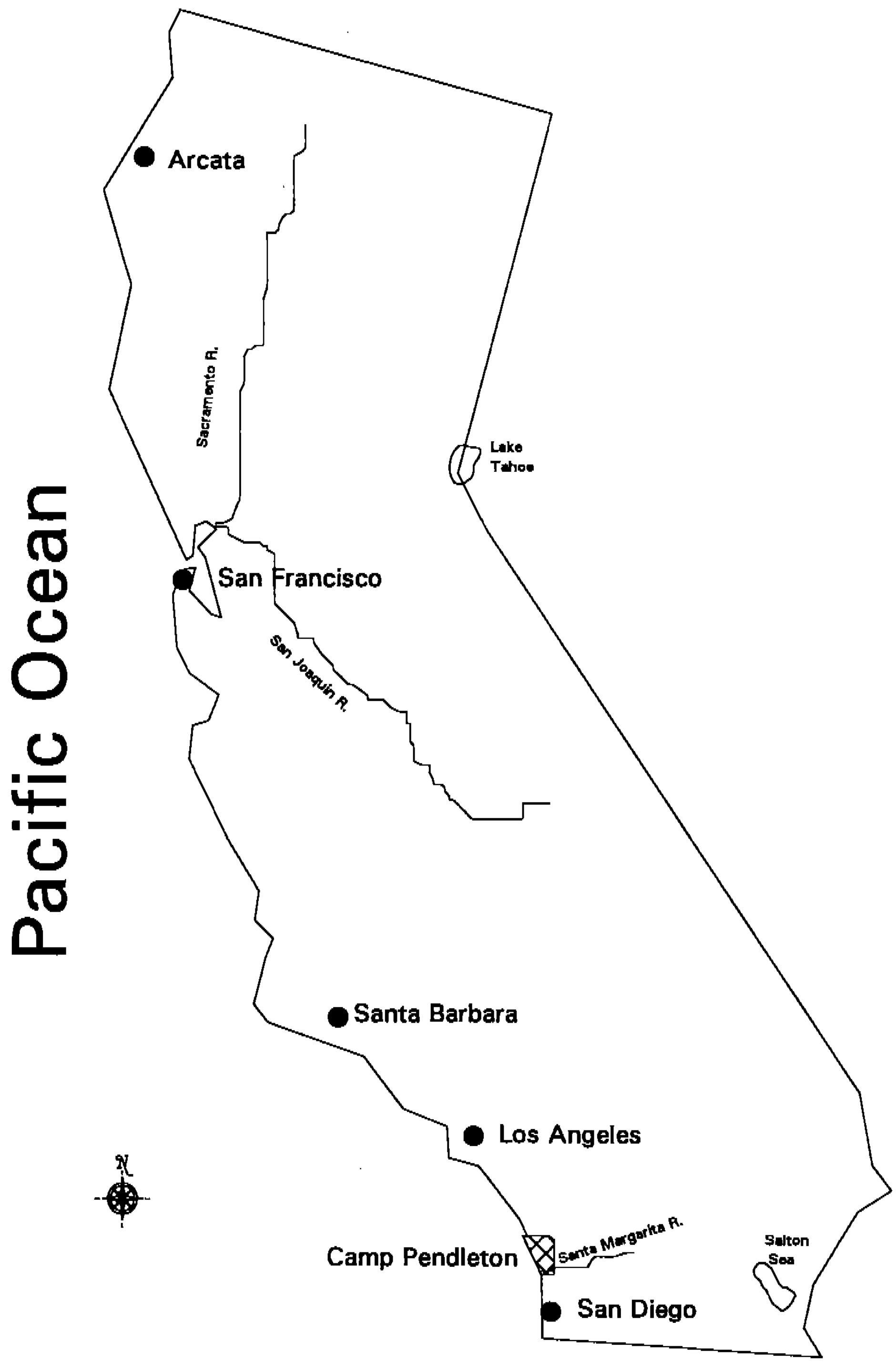


Figure 1. Location map of Camp Pendleton, California.

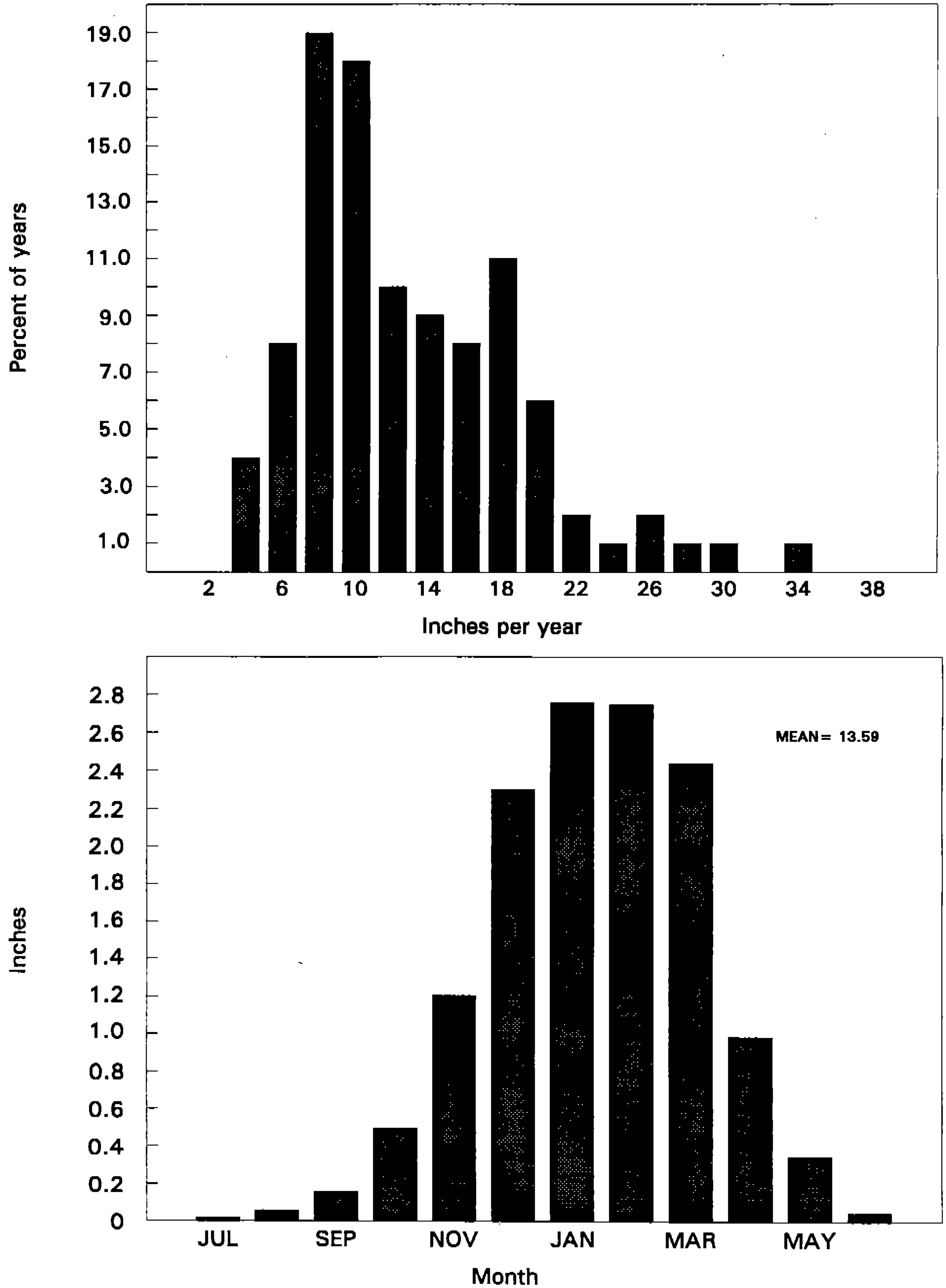


Figure 2. Lake O'Neill precipitation 1876-1990.

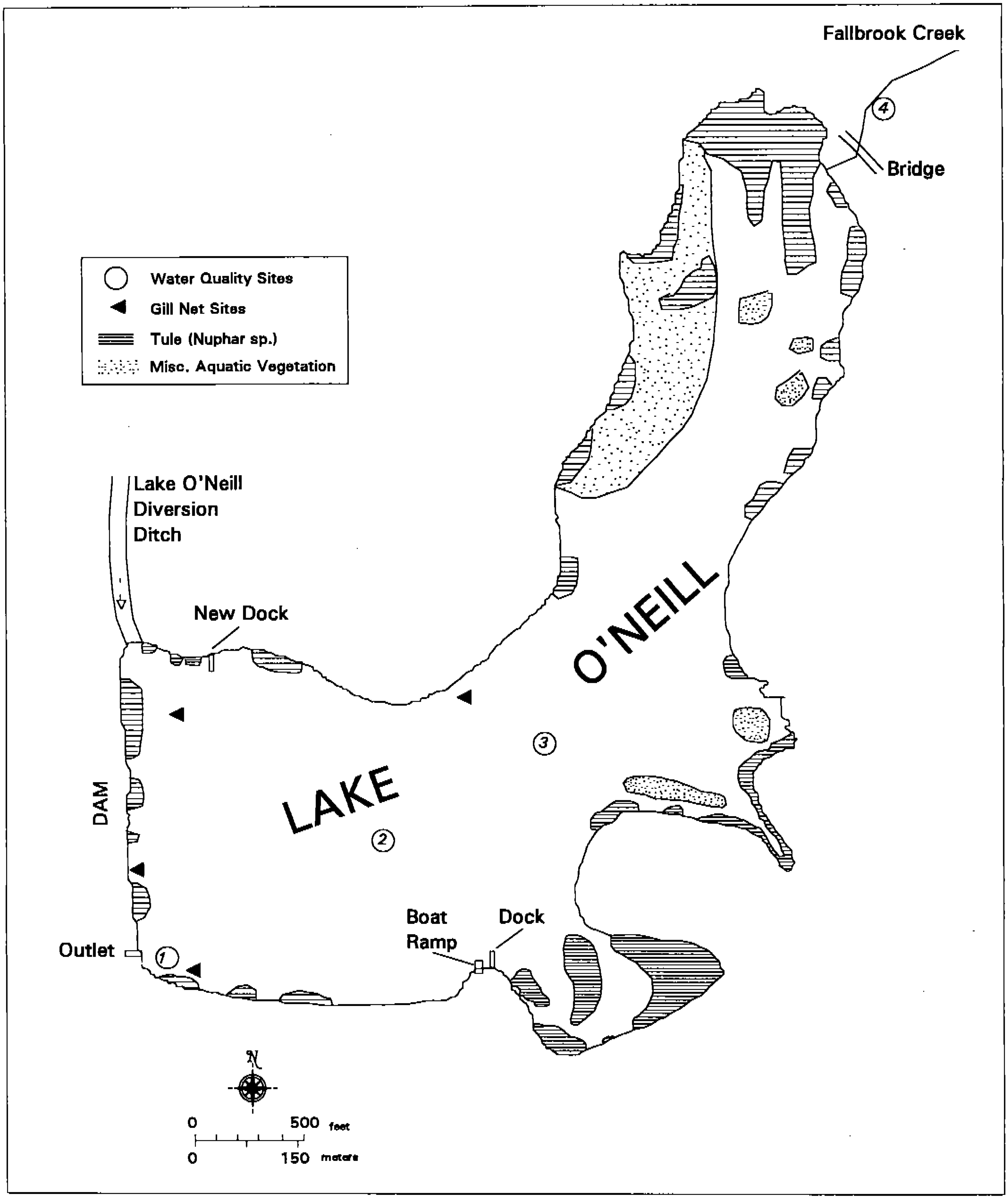


Figure 3. Lake O'Neill, showing sample sites and areas of aquatic vegetation.

METHODS

Hydrology/Water Quality

Santa Margarita River discharge data was obtained from U.S. Geological Survey (USGS) water supply publications dating back to 1960. The current USGS gauge (#11046000) is located at Ysidora near the Basilone Road Bridge. This site is below the diversion to Lake O'Neill and has been in operation since 1980. The previous gauge site was 10 km (6.2 miles) downstream and the records are not equivalent to post 1980 data.

Data on Lake O'Neill ditch diversions from the Santa Margarita River and Fallbrook Creek discharges were obtained from the Camp Pendleton Environmental and Natural Resources Management Office. That office also maintains precipitation, air temperature, and some water quality records used in this report.

Water quality data for Lake O'Neill and Fallbrook Creek was obtained by sampling at four sites (Figure 3). Water samples were taken at each site between 1250 and 1400 hours on January 13, 1992. Due to the shallow depth (<1.6 m (5 feet)) of the lake at this time, samples were taken at a depth of 0.5 m (1.5 feet) by simply lowering and opening the collection bottle. One sample site (#4) was located in Fallbrook Creek in a pool just above the culvert inlet into the lake. The sample depth in that location was 0.15 m (0.5 feet). Water samples were immediately taken to the Quality Assurance Laboratory in San Diego for analysis. Each sample was tested for a variety of factors, including hardness, nitrate-nitrogen, ammonia-nitrogen, total phosphate, total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), alkalinity, etc. A complete list of specific analyses requested and the analysis methods utilized by the lab are shown in the lab report (Appendix A).

Temperatures and dissolved oxygen (D.O.) levels were taken by USFWS personnel utilizing a YSI Model 51B probe. A Cole-Parmer DSPH-1 portable meter was used to measure pH.

Biological Collections

Fish sampling was accomplished by use of gill nets. Each net was 1.8 m (6 feet) high and 38.1 m (125 feet) long with 5 panels, each 7.6 m (25 feet) long. The stretched mesh size was different in each panel; 2.5 centimeters (cm) (1 inch), 3.8 cm (1.5 inches), 5.0 cm (2 inches), 6.4 cm (2.5 inches), and 7.6 cm (3 inches). Each net had a weighted bottom line and a floating top. The end of the net with the smallest mesh was secured to the shore and stretched (perpendicular to the shore) into the lake.

Two gill nets were fished each night on January 9-10, 1992. One net was fished on the night of January 13, 1992. Because of the shallowness of the lake, the nets effectively reached from the bottom to the surface. Net sample sites are shown in Figure 3. Nets were fished from just before dark (≈1700 hours) until about 0830 each morning.

Nets were retrieved in the morning starting at the end farthest from the shore. Fish were removed from the mesh, identified to species, and for a subsample, scales were taken and fork lengths measured to the nearest millimeter (mm). Live fish were released back into the lake. Scales were cleaned and scale impressions were made by pressing scales against acetate sheets with a heated hydraulic press. A microfiche card reader was used to magnify the scale image for visual interpretation.

RESULTS AND DISCUSSION

Water Management

Lake O'Neill receives inflow from three sources; Fallbrook Creek, a small creek from Urine Pond, and through the diversion ditch from the Santa Margarita River. Prior to 1983, it received treated sewage effluent from Urine Pond. The basic water right as adjudicated in United Stated versus Fallbrook Utility District, et. al. (U.S. District Court Southern District of California No. 1247-SD-C) is stipulated as 1100 acre feet plus 100 for dead storage. Additionally, water may be taken from the river throughout the irrigation season, in quantities sufficient to off set seepage and evaporation losses for the purpose of keeping the lake filled to capacity.

Water is diverted from the river via the Lake O'Neill ditch, generally between November and the end of March. The rate of withdrawal may not exceed 0.57 m^3 per second (20 cfs). Water entering the ditch can either enter the lake or be diverted into groundwater recharge basins. Peak river diversions usually occur January through March, when an average of 84% of the total river diversions since 1962 have been taken. Very little water is typically taken May through November, and December diversions have only occurred five out of the last thirty years. Since the early 1960's water from Fallbrook Creek has amounted to more than 50% of the total flows into the lake (Figure 4).

The lake, typically, is full by April and remains near capacity until about mid-November, when the outlet valve at the dam is opened and water is allowed to drain. Prior to dredging it usually took about three weeks to reach minimum pool (100 acre feet). The water released gradually recharges the groundwater supply below the floodplain downstream of the lake. Following the fall and winter rains, the river begins flowing again after normally being dry from July to October (Figure 5). Although average monthly flows indicate water is available during the June to October period, this is generally not the case, and is a result of unusual flows in some years. High flow events in the river can carry substantial amounts of debris and silt downstream, as a result, it is common practice to avoid diverting water into Lake O'Neill during the initial high flow days. Despite this practice, a considerable amount of silt has accumulated in the ditch on the "delta" where the ditch enters the lake. The dredging effort in 1992 was aimed at removing the silt accumulation in the lake to improve depth and storage characteristics.

Most of the lake has a relatively flat topography with finegrained bottom sediments. This provides little structural habitat for fish until lake levels reach near capacity. Structural habitat complexity for fish increases as the tule patches and other aquatic vegetation becomes wetted. A large part of the upper lake is enveloped with aquatic vegetation. Nearly all of this vegetation is exposed and dried following the yearly drawdown of water levels. At the time of our survey, most aquatic vegetation had been dried out making it difficult to identify its true distribution in the lake. At capacity pool evaluation, the vegetation likely covers more surface area of the lake than shown in Figure 3. It is not clear if a similar pattern of draining and refilling the lake has been followed each year. Base records do indicate that a flood in 1978 washed out the diversion weir in the Santa Margarita River. Until the weir was rebuilt in 1982, the Base lost the ability to divert water into the lake. From 1978 to 1983, the lake was kept at capacity because they were still discharging second stage effluent from Urine Pond into the lake. Base authorities did not want to drain the lake with only effluent entering and no way to dilute it with river water. A pipeline was completed in 1983, which diverted effluent away from Lake O'Neill. Since that time, the normal drain/fill pattern has apparently resumed.

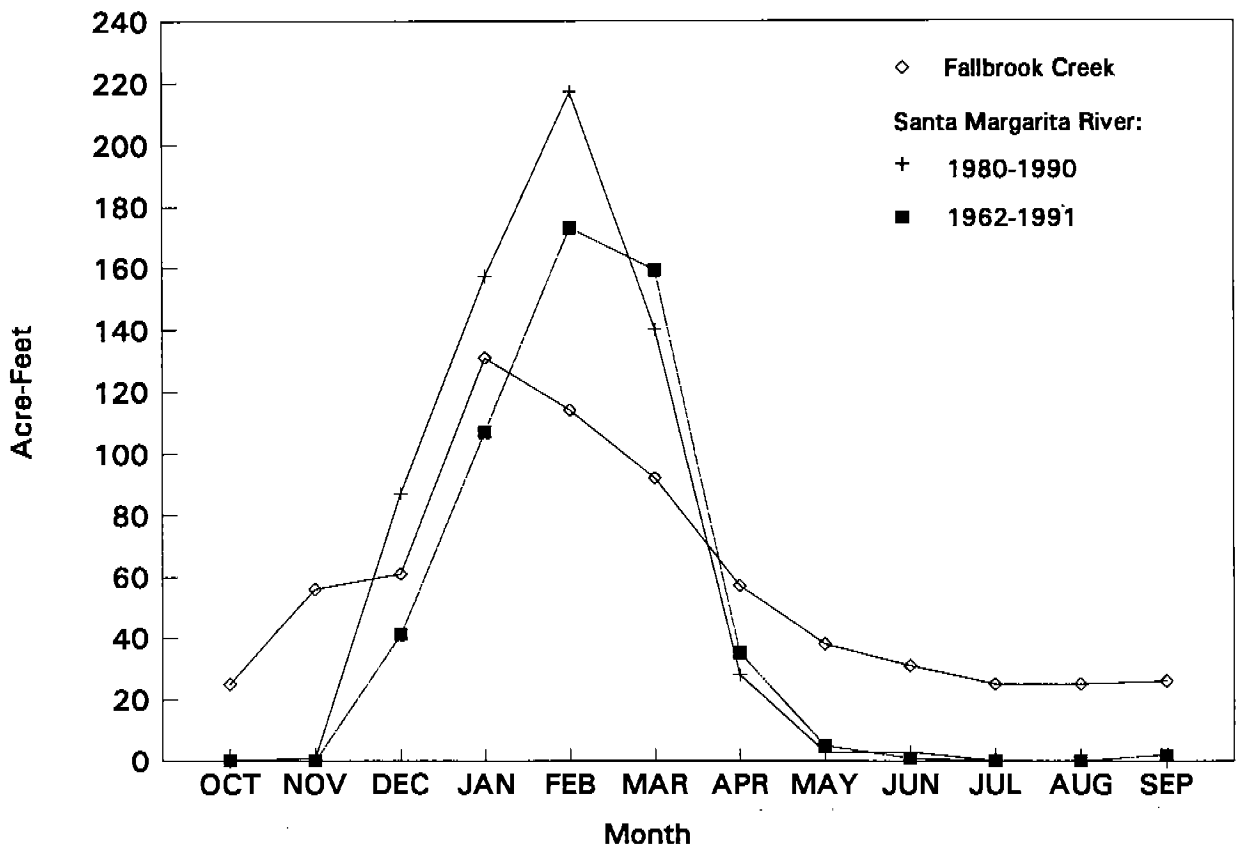


Figure 4. Average monthly discharge of Fallbrook Creek and Santa Margarita River diversions into Lake O'Neill.

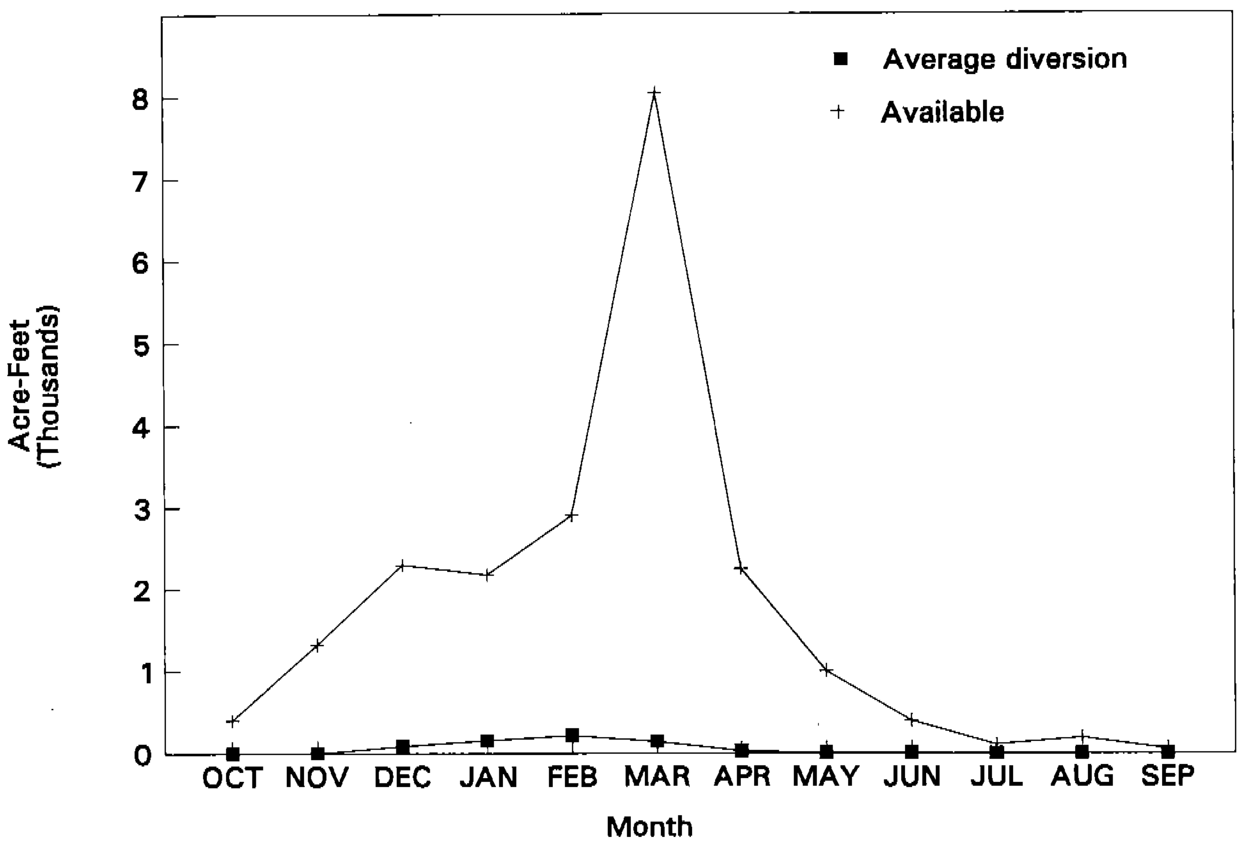


Figure 5. Average diversions of Santa Margarita River water to Lake O'Neill, 1980-1990 versus water remaining in river after flows have reached the USGS discharge station at Basilone Road.

Water Quality

Water quality data concerning the Santa Margarita River, in the area of Camp Pendleton, is limited but some data has been collected near the USGS gauge at Basilone Road by the California Department of Water Resources. Samples were taken from that site beginning on December 11, 1980, and ending on June 10, 1981. Samples were taken on five dates during this period and partial listing of the results are shown in Table 1. Nothing significant is indicated by this information.

The results of water quality testing from samples taken at Lake O'Neill and Fallbrook Creek on January 13, 1992 are shown in Table 2. Water temperatures observed at all sample sites were suitable for trout and warmwater fish; however, more extensive temperature data is needed to determine the full period of time trout might survive in the lake. Information taken in the past by Base personnel indicate surface and subsurface temperatures in July approach 30° C (86 °F), well above trout tolerance limits and temperatures in May reach 25° C (77 °F). Trout can tolerate temperatures in the neighborhood of 26° C (79 °F), but prefer 10° to 16° C (50° to 61° F) (Piper, et. al., 1982). Preferred temperatures for largemouth bass (24° to 29° C) (75° to 84° F), bluegill (16° to 27° C) (61° to 81° F) , black crappie (18° to 29° C) (64° to 84° F), and channel catfish (21° to 27° C) (70° to 81° F) indicate Lake O'Neill summer temperatures should be favorable (Reininger, 1984).

Dissolved oxygen (D.O.) is critically important in determining the suitability of waters for fish. The sampling in January 1992, indicated D.O. levels were high at that time (Table 2). With the exception of the Fallbrook Creek sample, D.O. levels were supersaturated considering the water temperatures at that time. This may have been due to wave action, high photosynthetic activity, or erroneous measurements. Base records from 1970 indicate D.O. levels may drop below 5 milligrams per liter (mg/L) in July, although this apparently varied with locality. Areas near Fallbrook Creek had D.O. levels near zero, while other areas had levels between 7 and 8.4 mg/L. Some areas with a 1.98 m depth had very low D.O. levels but this was not consistent. More data is needed, especially in the late summer/fall period. Reduced D.O. levels have the potential to constrict the available habitat and also kill fish, there apparently is some potential for this in Lake O'Neill.

At the time of our January sampling, the dredging at minimum pool levels had not been completed as planned. Although active dredging was not taking place on the days we were present, the recent dredging may have released bottom nutrients and other substances into the water column that could influence testing results. This should be considered when interpreting the January sampling.

The pH levels observed in the lake (6.0) and Fallbrook Creek (6.9) are questionable since the meter was apparently malfunctioning at other sites. Historically, the infrequent pH measurements made by Base personnel in the lake have been 7.2 - 9.4, averaging 8.5 for 41 measurements identified during the period 1952-1987. Most of these measurements were made in the fall, although two measurements were made in January 1952 (9.0) and January 1972 (8.3). We also found reference to measurements taken on January 16-17, 1985 when Lake O'Neill measurements of pH, temperature, and D.O. averaged 8.2, 10.1° C, and 15.2 respectively. These measurements are comparable to those noted in the Santa Margarita River in 1980-81 (Table 1).

The Environmental Protection Agency (EPA) recommends that the pH range be 6.5-9.0 to protect aquatic life (as quoted in MacDonald, et. al., 1991). Emergence of some aquatic insects declines below pH 6.5 and a decline in pH can also increase the mobility of heavy metal contamination. Since the pH measurements taken during January 1992 differ considerably from past data, we

Table 1. Partial list of water quality measurements taken by the California Department of Water Quality in the Santa Margarita River, at Basilone Road (1980-1981)

DATE	Streamflow (cfs)	Temperature (°C)	pH	DO *	Hardness *	Nitrate-N	T-Phosphate-P *
12/11/80	20	15.5	8.2	9.9	-	0.00	0.15
01/15/81	18	18.0	8.5	9.5	320	0.16	0.12
02/24/81	18	20.0	8.5	8.7	320	0.47	0.12
03/18/81	23	18.5	8.5	8.4	310	0.54	0.18
06/10/81	5	28.5	8.6	8.1	310	-	-

* measured in mg/L

Table 2. Water quality data for Lake O'Neill and Fallbrook Creek, January 13, 1992.

Measurement	Units	Sample Sites #1	#2	#3	#4
Sample Time:		1250	1320	1335	1400
Total Depth	meters	1.2	1.5	1.5	0.2
Surface Temp.	°C	6.0	6.0	6.0	4.0
0.5 m Temp.	°C	5.5	6.0	6.0	NS
1.0 m Temp.	°C	5.0	6.0	6.0	NS
Surface D.O.	mg/L	14.2	14.7	15.0	10.8
0.5 m D.O.	mg/L	12.8	14.6	15.0	NS
1.0 m D.O.	mg/L	11.4	13.8	15.0	NS
Sample pH		6.0	NS	NS	6.9
T-Alkalinity	mg/L	150	173	195	230
Bicarbonate	mg/L	150	173	195	230
BOD	mg/L	5.3	6.7	5.6	<3.0
COD	mg/L	65	62	55	44
Hardness	mg/L	246	243	275	336
Ammonia-N	mg/L	1.05	0.97	0.88	0.14
Nitrate-N	mg/L	0.3	0.3	0.3	<0.2
O-Phosphate-P	mg/L	<0.2	<0.2	<0.2	<0.2
T-Phosphate-P	mg/L	0.30	0.32	0.37	0.27
TDS	mg/L	538	544	544	668
Silica	mg/L	23.1	18.6	22.0	19.7
Sulfate	mg/L	128	130	126	183

believe more tests are necessary. The one-time nature and questionable results of the pH samples taken in this study are not sufficient to determine if a change in pH has occurred.

Due to the one-time nature of sampling and the recent dredging of the lake, it is difficult to ascertain the significance of the other water chemistry results (Table 2). The levels of ammonia-nitrogen and nitrate-nitrogen in the lake averaged 0.97 mg/L and 0.30 mg/L, respectively. The literature is somewhat vague on the significance of these levels of concentration to fish, but they appear to be in moderate supply. Excessive levels of ammonia can be toxic to fish but ammonia toxicity should not be a problem in receiving waters with pH below 8.0 and ammonia-n less than 1.0 mg/L (Sawyer and McCarty, 1978).

The level of nitrate-n is below the area of concern. Recommended maximum drinking standards for nitrate-n are 10 mg/L and the world average for unpolluted freshwater is 0.30 mg/L (McDonald, et. al., 1991). Data from Base files indicates that nitrate levels may once have been much higher but data concerning sampling technique, testing methods, etc., are lacking to fully evaluate the validity of past testing. Phosphates represent important nutrients in aquatic systems and can often be a limiting factor. The EPA suggests that phosphate should not exceed 0.025 mg/L for any lake or reservoir, where streams enter the lake it should not exceed 0.050 mg/L (McDonald, et. al., 1991). Heavy algal blooms have been observed in lakes where phosphate concentration exceeds 0.03 mg/L (Bell, 1990).

Phosphate levels in the lake samples during USFWS collections were 0.30-0.37 mg/L. The concentration in Fallbrook Creek was 0.27 mg/L and may represent an important contributor of phosphate into Lake O'Neill. The elevated levels of phosphate seen in Lake O'Neill indicate eutrophic conditions but may be much reduced from past loadings. Sampling during 1972-1987, at various points in the lake, yielded concentrations from 1.9 to 9.0 mg/L in infrequent samples. We could find no information on the past analysis methods used or their accuracy.

Fish Population

Lake O'Neill has maintained a varying assemblage of fish species since at least 1950. The earliest Base records indicate on September 21, 1951 the area near the hospital was seined by military personnel and 80 bass were removed and replanted in 12 area lakes. The next day Lake O'Neill was "Blue-Stoned" with 181 kilograms (kg) of copper-sulfate, presumably to control aquatic vegetation and/or algae.

On December 17, 1953 the lake was treated with 5% Derris root and 95% rotenone. According to Base memos, 19,051 kilograms of dead fish were removed, including; 17,236 kg of carp (*Cyprinus carpio*), bass, golden shiners, catfish, bluegill, green sunfish, and crappie. During the months prior to the treatment, 982 largemouth bass, 1,600 bluegill, 763 bullheads, 800 green sunfish, 107 carp, 2,450 golden shiners, 23 crappie, and an estimated 1 million mosquito fish (*Gambusia affinis*) were seined from the lake and transported to other Base waters or destroyed. Judging from field notes, the lake apparently contained a mix of bass age classes with fish ranging from 3-61 cm in length. On many occasions bass in the 51 cm range were captured.

Obviously, a substantial fish population existed in the lake prior to the 1953 rotenone treatment, including large bass. We could not locate any records indicating the specific water management schemes employed at that time. Beginning in January 1954 some of the fish, removed from Lake O'Neill to other waters, were returned to the lake. The documented history of fish planting into the lake since 1954 is incomplete, however, the information available indicates that many introductions have occurred (Table 3). These fish came from other Base waters, California Department of Fish and Game (CDFG), Chino

Table 3. Fish stocking history of Lake O'Neill.

YEAR	Month	Species	Number	Size
1954	January	Bass	32	8"-16"
	March	Bass	37	Breeders
	April	Bass	405	1"-4"
	June	Bass	600	fingerling
	June	Bass	9	6"-14"
	April	Bluegill	208	1"-4"
	April	Crappie	20	1"-3"
1957	Unknown	Largemouth Bass	8500	unknown
	Unknown	Redear Sunfish	156	unknown
1963	July	Bass	1000	unknown
1968	July	Bass	652	fingerling
	August	Sunfish	900	Adult
	May	Largemouth Bass	2525	fingerling
1973	December	Channel Catfish	6600	unknown
1985	Summer/fall	Bluegill	4000	1"-4"
	Summer/fall	Largemouth Bass	1000	1"-8"
	Summer/fall	Catfish	1000	2"-3"
	Summer/fall	Largemouth Bass	1125	6"-8"
1991	June	Channel Catfish	1500 ≤	≥1 per pound
	August	Channel Catfish	1500 ≤	≥1 per pound
1992	June	Channel Catfish	1000 ≤	≥1 per pound
	August	Channel Catfish	1000 ≤	≥1 per pound

Fisheries Base, USFWS hatcheries, and, more recently, private suppliers. Lake O'Neill was again treated with rotenone (454 liters, Pro-nox-fish) in early November 1956. Marine personnel reported the removal and disposal of 25,401 kg of carp, 1,814 kg of catfish, and 227 kg of bluegill. At this time, they also treated the Santa Margarita River and its tributaries from the Fallbrook border downstream to the brackish water of the lower river. The lake was restocked in 1957. During June 1960, the drainage ditch (presumably Lake O'Neill ditch) was dredged. According to a file letter by hospital personnel, many fish, including large and small bass, dace, bluegill, crappie, and "sunperch" were rescued by one person alone. Other fish, including over 75 catfish, were given to cooks, or observed dying. Small carp fry were also seen.

In November 1960 approximately 2,300 perch, sunfish, catfish, shiners, and bass were removed from the lake to other Base waters. Apparently about 850 catfish were buried or given away. Although the file does not indicate why fish were removed, they do indicate "it is planned to restock Lake O'Neill when normal water level is achieved."

Some largemouth bass were received from CDFG in 1963, but no other stocking is evident from records until 1968. Apparently a Fish and Wildlife Management Plan for Camp Pendleton was developed cooperatively between Camp Pendleton, CDFG, and USFWS sometime between 1965 and 1968, although a copy of the final plan could not be located for this report. A letter to the Base from CDFG in 1965 refers to a draft plan recommending the introduction of channel catfish, but suggests that fish not be stocked until arrangements are made for maintenance of water in the lake.

The lake was apparently treated on December 14-15, 1967. No bass were seen, but thousands of bluegill, 8-10 cm in length and 3 brown bullheads were observed. Fish from CDFG and USFWS were planted in the lake in 1968. Small bass (13-20 cm) were observed and reported caught out of the lake in the fall of 1968, although there were few reports of many fish being caught except for catfish.

During October 1969 Base officials, CDFG, and USFWS made plans to rotenone the lake in the fall of 1970. The purpose of the treatment was to eliminate the large population of intermediate sized sunfish and bluegills. Largemouth bass were to be restocked in February 1971. We could not find any further record of a treatment taking place or of the restocking. We did find reference of a fisherman catching four bass, all over 1.8 kg on November 29, 1970. This may indicate that no treatment had taken place.

During 1970 the Base began an active effort to inventory its lakes and ponds which lasted until the fall of 1973. These efforts provided information on fish species present, their length and age characteristics, and some of the water quality measurements presented earlier in this report. Most of the inventory efforts in Lake O'Neill took place in 1973.

Seining was done in the lake on January 23, 1973 in low water conditions. Bass, bluegill, redear sunfish (*Lepomis microlophus*), and golden shiners were caught. Gill net sampling took place in late June, July, and August. Base personnel and CDFG also utilized an electro-fishing boat to sample the lake on October 15, 1973. The length frequency data resulting from these sampling efforts are illustrated in Figures 6-9. The data displayed in these figures indicate that largemouth bass and redear sunfish grew to a reasonable size in Lake O'Neill and some were able to survive the annual drawdowns. Two age classes of bass are evident in Figure 6, although a middle age class was not evident. Several age classes of bluegill and redear sunfish are indicated by the length frequency data (Figure 7-8). Scales taken from redear sunfish and

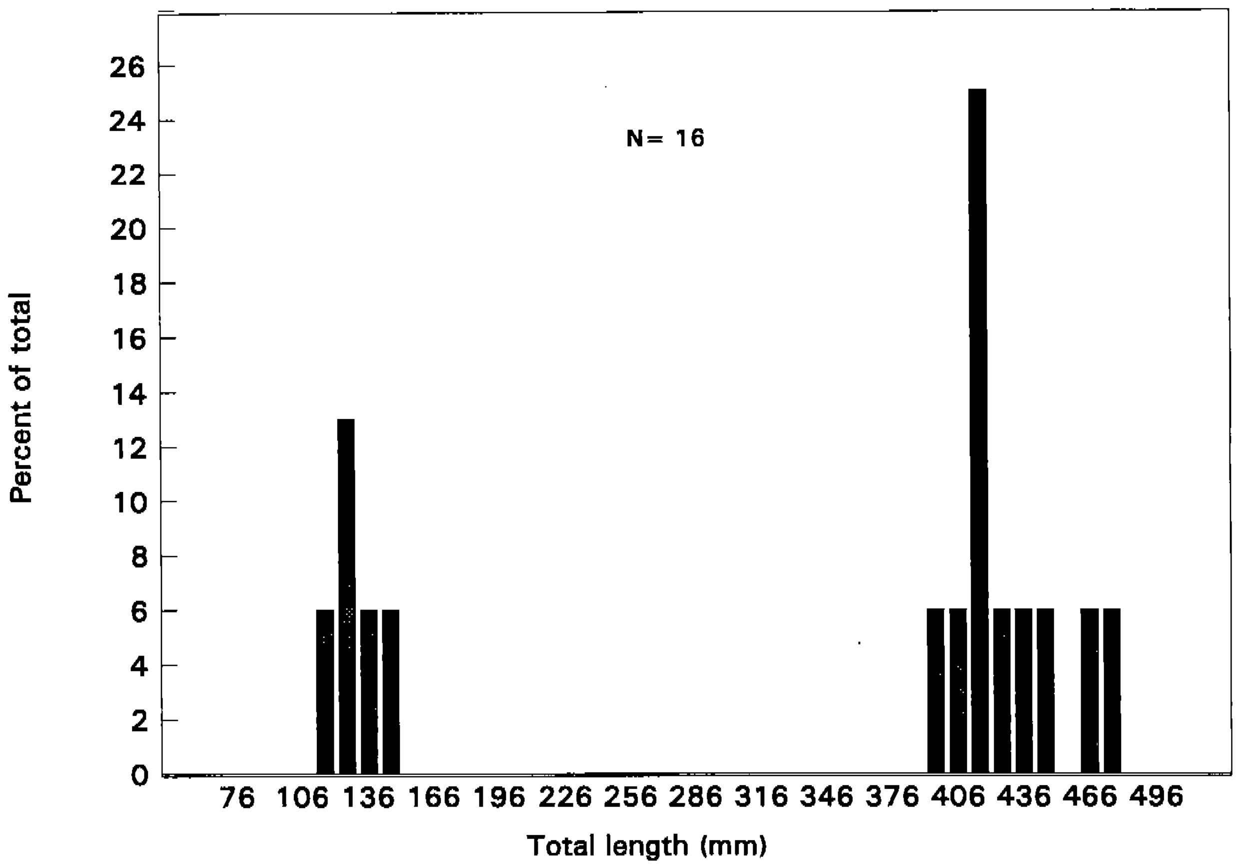


Figure 6. Length frequency histigram of largemouth bass captured by electrofishing in Lake O'Neill, October 1973.

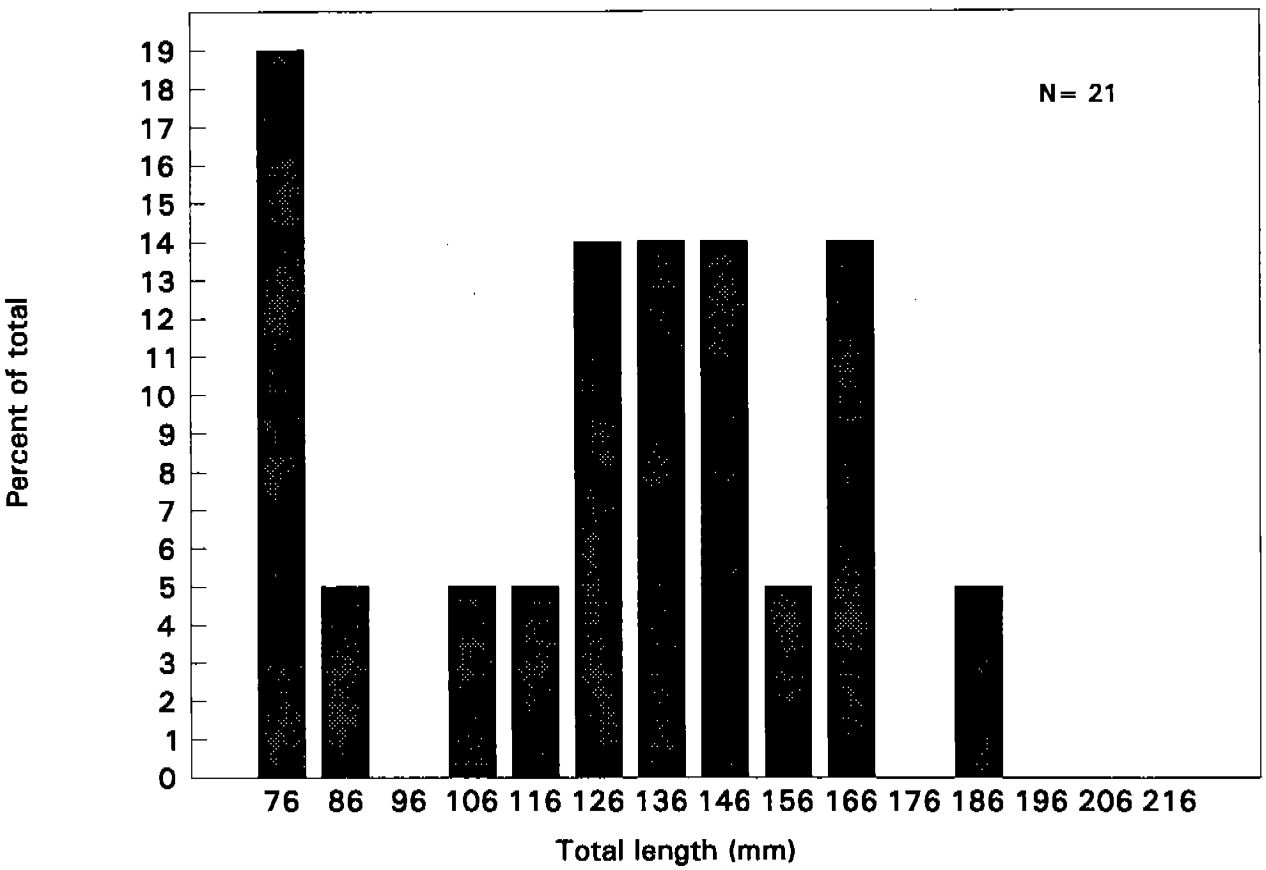


Figure 7. Length histogram of bluegill captured by seining in Lake O'Neill, January 1973.

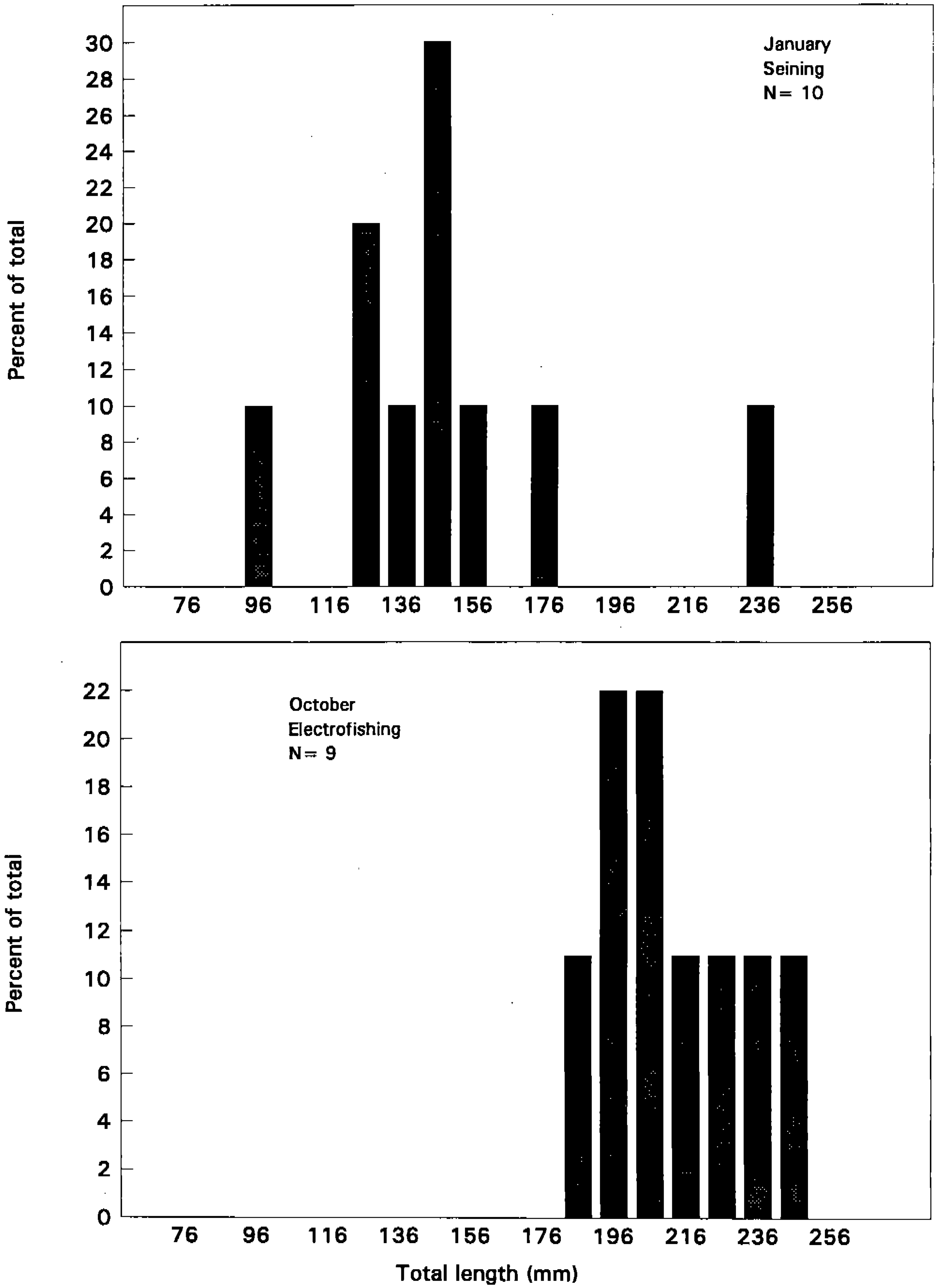


Figure 8. Length frequency histogram of redear sunfish captured by seining and electrofishing in Lake O'Neill, 1973.

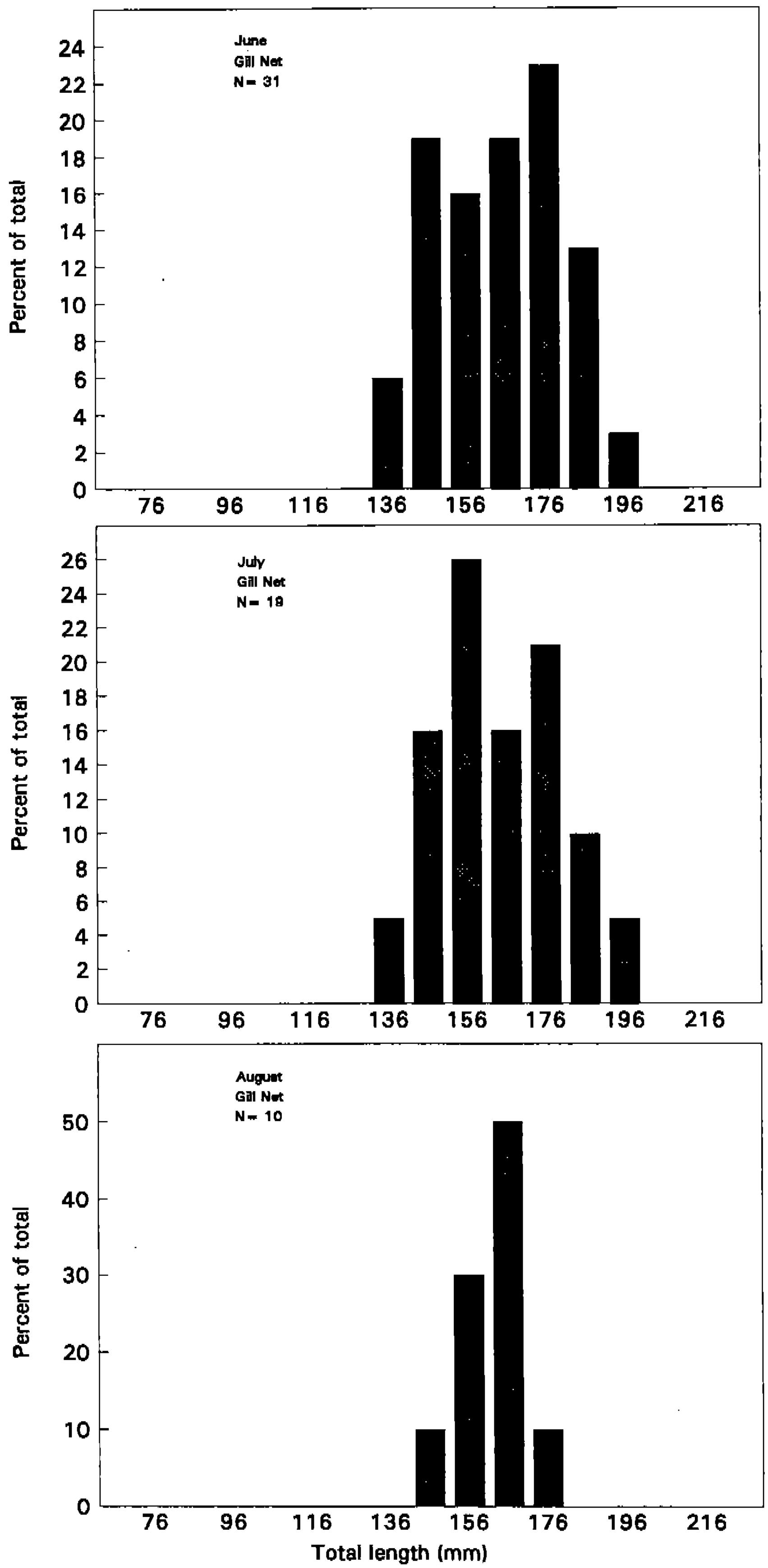


Figure 9. Length frequency histogram of golden shiners captured by gill net in Lake O'Neill, 1973.

bluegill were aged. Length at age data for redear sunfish (Figure 10) and bluegill (Figure 11) indicate the relative growth rates for each of these species, although sample sizes were small. These rates are about average for these species in California.

Judging from the quantities of fish recovered following chemical treatments prior to the 1970's, it appears to have taken only a relatively short period of time for fish populations to recover. Possible reasons for this include; only partial treatment effectiveness; fish re-populating from the Santa Margarita River, the Urine Pond and/or Fallbrook Creek; "rouge stocking"; and high productivity of the lake.

When the weir controlling the diversion of water from the Santa Margarita River washed out in 1978, the Base lost the ability to fill the lake. Instead of draining the lake, it was left full until after the weir was reconstructed in 1982. By all accounts, a significant fish population built up until the lake was once again drained in 1983. Unfortunately, no biological data was collected during this time to indicate fish growth rates and species composition.

Although stocking of rainbow trout (Oncorhynchus mykiss) and other fish continued in other Base waters, there is no information concerning further stocking or active fishery management efforts in Lake O'Neill from 1974-1982. In 1979, technical assistance and fish planting activities provided by the USFWS to Camp Pendleton were discontinued due to budget limitations and changing priorities. Further stocking by CDFG was discontinued because Base waters were not open to the general fishing public and state funds were lacking. As a result, fish stocking since that time has been sporadic and paid for by the Environmental and Natural Resources Management Office at Camp Pendleton. The fish come from private hatcheries and the supply has not been dependable. Channel catfish are the primary fish being obtained. The catfish bought in 1991 and 1992 qualified as "catchable" size, with a minimum weight of at least 454 grams (1 pound) as a contract stipulation.

Apparently, no fish sampling activities have occurred since 1973, with the exception of the limited sampling done as part of this study. The Base files do contain some recommendations for fisheries management in a memo from Lieutenant Colonel Roger S. Grischkowsky, USMCR, Reserve Counterpart Training, dated January 22, 1985. Although he makes recommendations for Camp Pendleton as a whole, there are specific recommendations concerning Lake O'Neill.

He recommended changing the drawdown pattern of the lake, the size of the minimum pool, aquatic weed control, made stocking recommendations, and encouraged increasing recreational sport fishing. Many of his recommendations would be valid at this time and will be discussed later in this report.

USFWS sampled Lake O'Neill with gill nets during the period January 9-14, 1992. A total of five nets were set during this time (Figure 3). The total catch consisted of 240 black crappie, 79 brown bullheads, 17 golden shiners, 16 largemouth bass, 6 bluegill, 3 green sunfish, and 1 channel catfish. Mean lengths and other data obtained from these fish are shown in Table 4. Length frequency histograms of species with more than ten fish captured are shown in Figures 12-13. Black crappie, the most abundant fish captured, were all small, averaging only 117 mm. Scale samples taken from each species (except catfish, which lack scales), were difficult to analyze. It does appear some fish were more than one year old. These fish either survived the yearly drawdowns of the lake or came from elsewhere.

Scales taken from largemouth bass do not show clear distinctive differences in growth patterns throughout the year, however length frequency patterns shown in Figure 12 indicate at least three age classes are present, probably representing fish up to three or four years old. Several year classes of

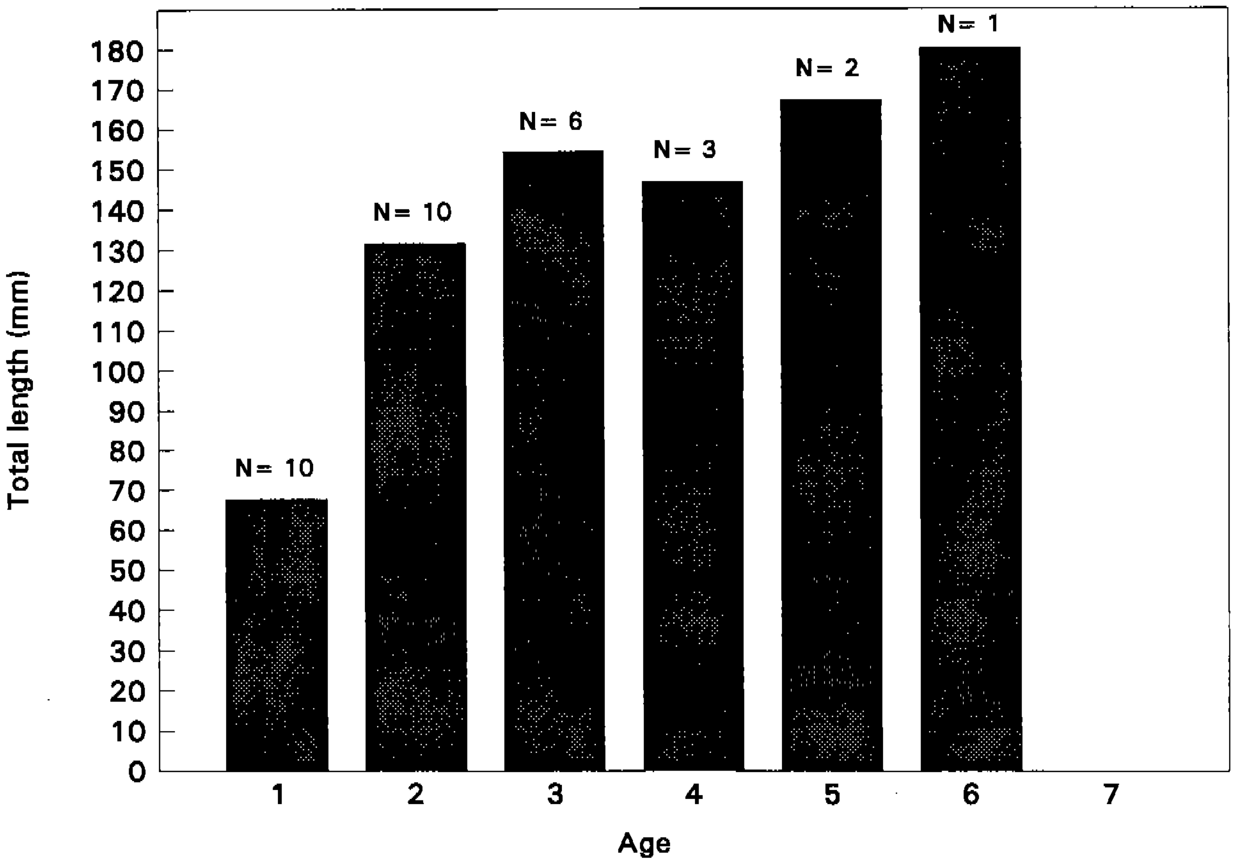


Figure 10. Length at age information for redear sunfish captured by seining in Lake O'Neill, January 1973.

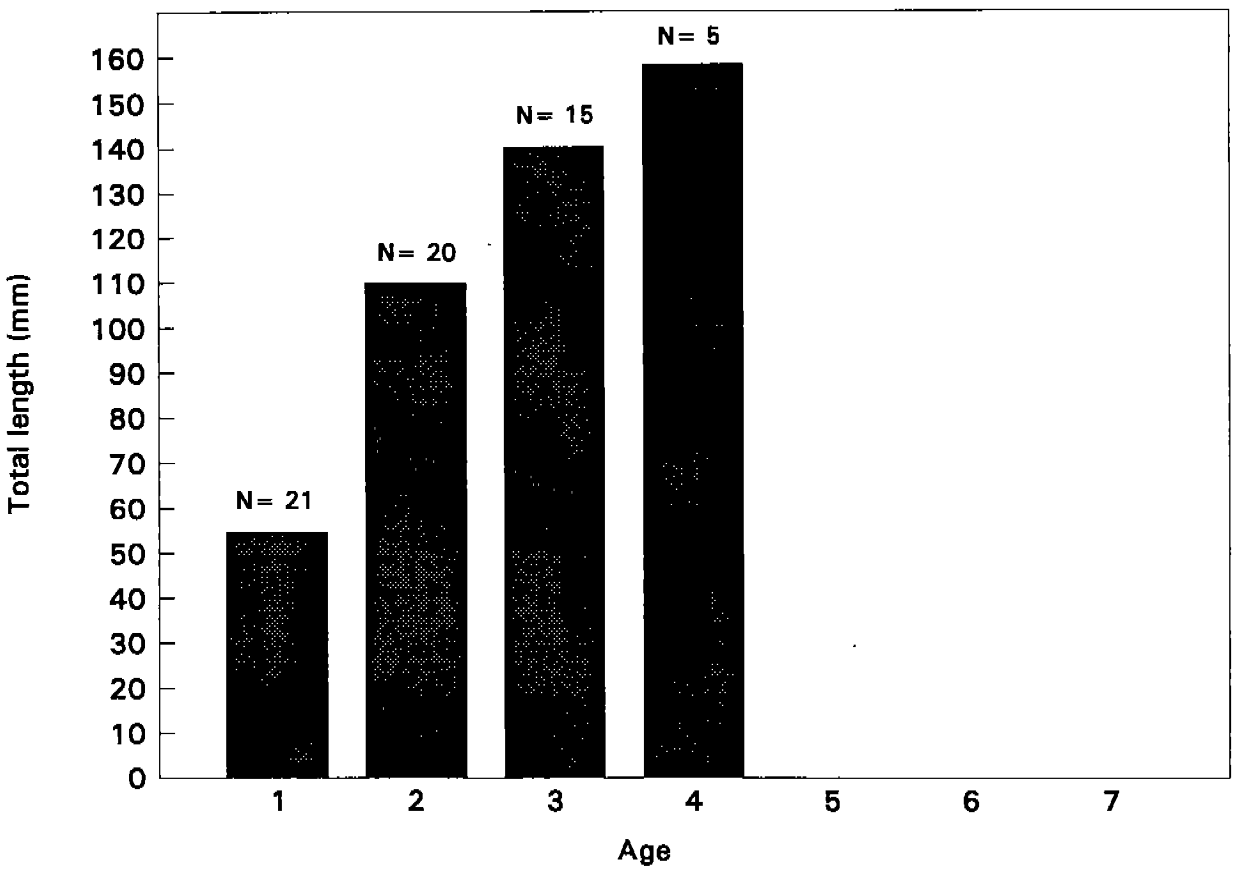


Figure 11. Length at age information for bluegill captured by seining in Lake O'Neill, January 1973.

Table 4. Mean length of fish captured by gill nets in Lake O'Neill during January 1992.

Species	# Sampled	Mean Length (mm)	Range (mm)	Standard Deviation
Largemouth bass	15	243	112-380	66.0
Black crappie	101	117	101-140	8.0
Brown bullhead	78	103	83-220	21.6
Channel catfish	1	122	-	-
Bluegill	6	97	70-118	19.7
Green sunfish	3	100	77-113	20.0
Golden shiner	15	127	115-142	11.9

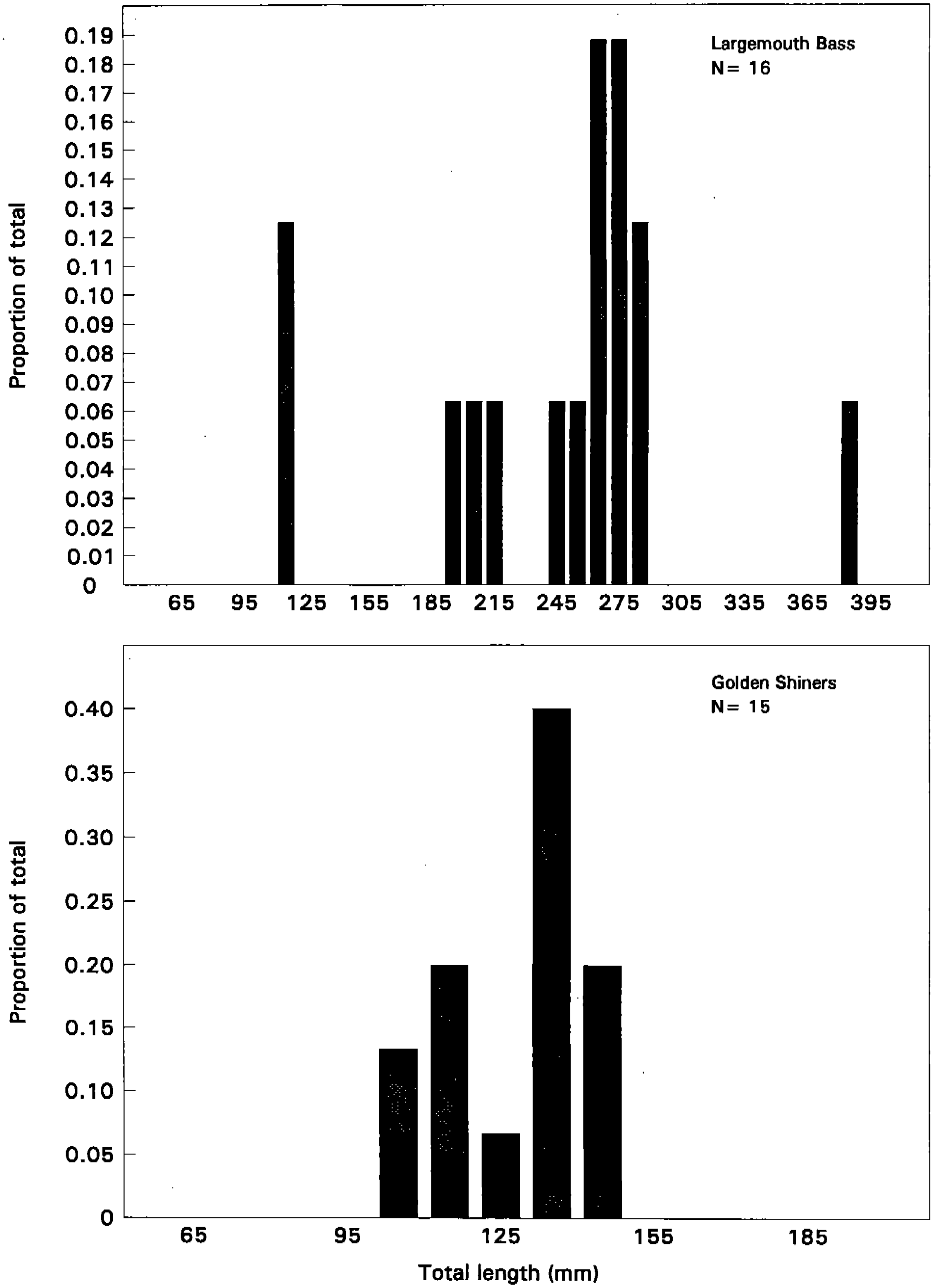


Figure 12. Length frequency histograms of largemouth bass and golden shiners captured by gill nets in Lake O'Neill, January 1993.

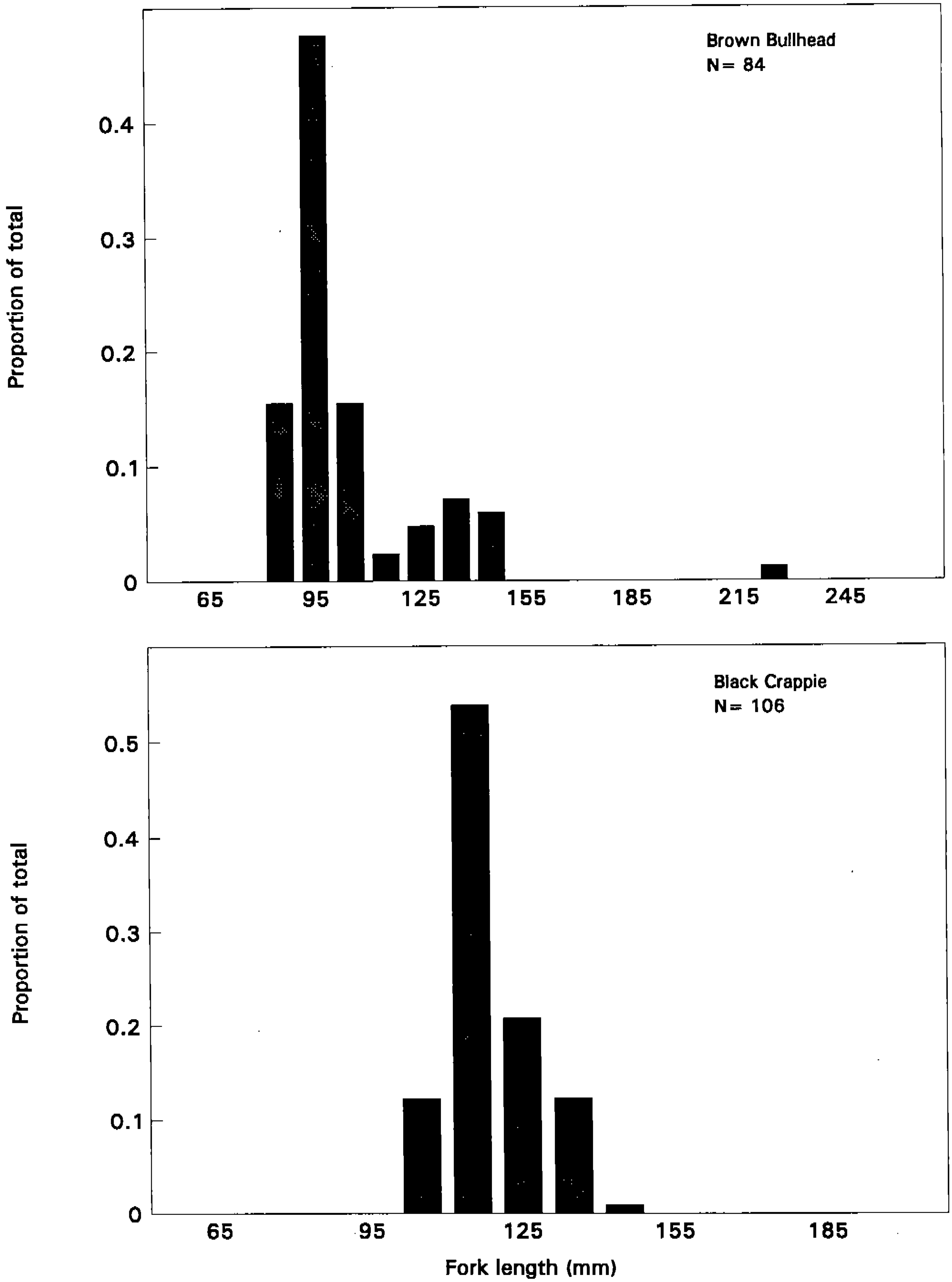


Figure 13. Length frequency histograms of brown bullhead and black crappie captured by gill nets in Lake O'Neill, January 1992.

brown bullheads, bluegill, green sunfish, and golden shiners also appear to be present, as indicated by a combination of lengths observed, and/or scale analysis. Black crappie appear to be represented by only one year class.

The most abundant species present, indicated by gill net sampling, were black crappie, followed by brown bullheads. The drawdown of the lake has greatly concentrated these fish in the remaining shallow waters of the lake, where it is likely they are heavily preyed upon by the many white pelicans and other fish eating birds observed during our sampling effort. It is unknown how many fish may be flushed out of the lake when it is lowered in the winter or if the lowering influences species composition.

The history of Lake O'Neill indicates, despite its frequent drawdowns and chemical treatments to reduce fish populations, it has (since at least the 1950's) always provided some fishing opportunities. The lake was very productive in the 1950's and 1960's. Each record of drawdowns or treatments indicates many thousands of kilograms of fish were present. Large bass, some up to 61 cm (24 inches), have been reported. Interestingly, the records indicate carp, presumably Cyrinis carpio, were very abundant up until at least the 1957 treatment of the lake and Santa Margarita River. Unverified reports of carp fry in the Lake O'Neill ditch in 1960 are the last reported sightings of carp in the lake area. None have been noted since that time nor were any captured during the 1992 gill net sampling. Given the fact that carp are usually very difficult to eradicate from a system once they have been introduced, and water is still being diverted from a river where they occurred, it is odd that carp are apparently still absent. The lack of carp is a positive sign in regards to the potential for developing and maintaining game fish populations in the lake.

Recreational Fishery

Many Base waters, including Lake O'Neill, are open to sport fishing. Currently, the Base fishing permit costs $ 3.00. The permit and a California State fishing license are required for active duty service personnel, Base employees, and retired military personnel to fish on the Base. Children, under the age of 16, may fish Base waters with a no-fee permit. State seasons and limits also apply to Base waters. A summary of Camp Pendleton fishing regulations is shown in Appendix B.

We could not locate any estimates of angler use, effort, or catch of fish from Lake O'Neill. Base authorities indicate that angling effort regularly occurs. In 1992, a total of 1088 permits were issued on the Base (Dave Boyer, personal communication).

Money collected through the sale of fishing permits is utilized to support Base fish and wildlife management including the purchase of channel catfish for stocking.

RECOMMENDATIONS

Water Manipulation

The current pattern of late fall drawdowns of Lake O'Neill is not conducive to development of healthy fish populations. Because of this, year round fishing in the lake cannot be considered a quality recreational experience. Although the stocking of catchable channel catfish is popular with anglers, it provides only a short term benefit and is expensive.

Base records indicate as long ago as the 1960's, biologists had recommended changes in the drawdown and refill pattern for Lake O'Neill. A 1985 memo, from Lt. Col. Grischkowsky, recommended a minimum pool of 300 acre feet and an overlap of the draining and filling period to enhance fish populations. Had the Base acted on these recommendations, the fish population and recreational value of Lake O'Neill would probably be greater at this time.

The current annual drawdown to about 100 acre feet (200 acre feet after drawdown) is not adequate to sustain a viable fishery. The exact level needed is unknown, but most recommendations for maintaining fish populations in ponds usually suggest that lowering the levels to 40% or more of capacity can help maintain fish populations and be useful in controlling aquatic vegetation (Vanicek and Miller, 1973; Lewis and Miller, 1980). The potential impacts of drawdowns to fish populations can be significant, but variable, depending on local conditions. For example; a fall drawdown resulting in a 35% decrease in surface area at Ridge Lake, Illinois, reduced a bluegill population from over 50,000 to under 20,000; a decrease of 69% in surface area reduced the bluegill population to 5,000-10,000 [(Bennett, et. al., 1969) as noted in Russell, et. al., 1974]. Fish in shallow lakes, similar to Lake O'Neill, are likely more severely impacted by significant drawdowns than those in deep lakes.

Maintaining a higher minimum pool need not interfere with the amount of water diverted from the river to maintain Base water rights. The scenario we envision would include a partial drawdown to 50% of capacity, then as diversions begin from the river, releases to ground water recharge below the dam would resume. Releases would be monitored to determine when the yearly ground water recharge needs are met. At that time, the lake would be filled. Although such a plan would require some additional flow monitoring by Base personnel, we believe it would be minimal and yield substantial benefits to the recreational values of Lake O'Neill, especially when combined with our other recommendations. We believe the risk of not being able to refill the lake is minimal given the amount of water that is usually available but not utilized in the Santa Margarita River (Figure 5). Additionally, it should be recognized that the Lake O'Neill waters used for ground water recharge represent only a portion of the recharge waters and our recommendation only changes the timing of recharge and not the amounts. Many variations of possible diversion/drawdown patterns exist beyond what we suggest such as postponing the drawdown to the latest possible time period to deter predation by fish and wildlife or to not drain the lake but to continue to divert allocated water and allow excess water to spill over (this would not only protect the existing fish populations, but would allow a water exchange). Base personnel more familiar with the diversion pattern should develop their own standard operating procedure with the critical features being that the lake minimum pool should not be allowed below 50% of capacity and the drawdown should not take place earlier than October due to the impacts of possible dissolved oxygen depletion. It is also important to have relatively stable water levels by the end of March to promote successful fish spawning.

Aquatic vegetation may increase in the lake at higher minimum pool levels, but the 50% drawdown should help to dry some weedbeds in the upper portion of the lake. Maintaining steep banks at a 3:1 or 4:1 ratio along the shoreline and the recent dredging should reduce potential aquatic plant problems if water is at least 1 meter in depth or turbid. We recommend that aerial photography of the lake occur each year in late summer to track trends in the growth and spread of aquatic vegetation.

Various methods can be used to reduce aquatic vegetation, should it become a problem. However, we feel that at current levels the vegetation is not a large problem and can provide good habitat for the fish species present.

The decomposition of aquatic vegetation during late summer and fall may lead to oxygen depletion in areas below the thermocline. This depletion can be toxic to fish and sampling needs to be done to identify if it is a problem in Lake O'Neill. If excessive oxygen depletion is noted mechanical, chemical, and biological control methods are available and can be used to counter the problem. The existence and severity of the problem should be determined, then effective countermeasures can be developed. Technical assistance from USFWS biologists and/or CDFG personnel should be available to identify to Base authorities an appropriate fish and/or aquatic vegetation control method and needed permits.

If nutrient inputs into the lake are high, the sources, such as Fallbrook Creek, will have to be examined and controlled before aquatic vegetation problems can be overcome. Although we are not aware of any contaminate problem in Lake O'Neill, it would probably be advisable to take samples of sediments, water, and fish tissue for analysis (fecal coliform, heavy metals, hydrocarbons, and organochlorine scan) before encouraging intensive harvests.

Other advantages of a higher minimum pool include improving angler access (avoidance of crossing extensive mud flats), visual esthetics of the Base, and improving the predator/prey ratios. Drawdowns have the effect of putting fish prey species in close contact with predators which may be beneficial in avoiding the over abundance of prey like black crappie which tend to stunt their growth when populations levels get too high.

Fish Screens

During the next drawdown period the ditch below the outlet should be checked for escaping fish. If significant numbers of fish are seen the Base should consider screening the outlet.

Ideally the inlet ditch should be screened to prevent the entrance of undesirable fish species into Lake O'Neill. Evidence in Base records indicates that a screen might have been present but did not function well due to the debris load carried by the river. We believe a working screen would be beneficial but is not as critical as other factors in developing the fishery. An example of a working fish screen is provided in Appendix C. In Alabama, a steel grate (horizontal with 3 inch gaps) is inserted into the inflow and outflow canals.

Fish Management

Warmwater fish are the most appropriate fish for management activities in Lake O'Neill. Largemouth bass are a premier sportfish in California and are already present in Lake O'Neill, although their numbers do not appear to be high. According to Base records reviewed in this report, they have the potential of growing to a large size in the lake. Channel catfish represent another significant sport species following annual stocking.

It also appears black crappie and brown bullheads are present and likely represent the primary prey for predatory bass. Other Centrarchids such as bluegill and green sunfish also represent food items for bass and additional targets for recreational fishing. Golden shiners are also a food item for bass and other species and are often used as bait by anglers.

In an ideal situation a fish manager would like to have an isolated lake with a simple assemblage of predator and prey species. In the case of Lake O'Neill outside fish from the Santa Margarita River will likely continue to invade lake waters. This complicates management of the lake because of intra- and inter-specific competition among fish species.

Managers frequently prefer to stock largemouth bass and one or more types of prey fish such as bluegill. Crappie are not normally stocked in small ponds and lakes because they tend to overpopulate and they spawn before bass limiting their function as bass forage. This overpopulation results in too many small sized fish not appealing to fishermen and detrimental to bass reproduction (various authors as cited by Gablehouse, 1983).

Crappie are popular with fishermen because of their preference for concentrating around structures. This allows their locations to be identified by anglers and provides the opportunity to catch many fish. They are also a hardy, tolerant fish which probably explains why they are present in the lake. Given a productive environment and population control, black crappie can grow to their potential as the largest of the "panfish". They have a preference for aquatic vegetation and drawdowns of the type recommended for Lake O'Neill would help control their population by concentrating them with predators (bass).

Rather than suggest a chemical treatment of the lake to eradicate all fish, then restock with largemouth bass and bluegill or redear sunfish, we believe the resident population of bass and crappie along with the other species present could develop into a substantial recreational fishery. Once the level of drawdown is reduced to 50% of capacity, bass, crappie, and other fish will do better. Largemouth bass fingerlings should be planted the first year to bolster the present population. Generally an accepted rate of stocking largemouth bass is 50 bass fingerlings per surface acre in unfertilized ponds in conjunction with 500 bluegill fingerlings (Vanicek and Miller, 1973; Dillard and Novinger, 1975). Bass stocked in ponds with established populations of fish may represent wasted effort (various authors as cited in Newburg, 1975), therefore, we do not recommend bass stocking after the first year of improved habitat conditions. Although fingerling bass are expensive, they could be purchased. Currently, two registered aquaculturists, Valley Fish Farms and Widman Fish Farm, Imperial County, raise and sell largemouth bass. Fingerling bass cost $2.50/each for 80-100 mm fish ($.50 apiece less if over 200 fish are purchased). Larger bass are more expensive. Stocking approximately 1,000 fingerlings could be sufficient to take advantage of the lightly populated habitat during the first year. Bass greater than 7.6 cm (3") long would be of a size to begin feeding on fish. Stocking these fish by early summer should be suitable.

In order to maintain a sufficient predator base to keep down the population of crappie and other prey species a minimum largemouth bass length limit of 38 cm (15") or greater should be established. The reasoning for this regulation would be to maintain high densities of small bass (less than 38 cm (15")) to effectively reduce densities of young panfish. This should reduce intra-specific competition and allow prey survivors to attain sized preferred by anglers (D.W. Gablehouse, Jr., 1985). Over time this should provide a higher quality crappie, bluegill, bullhead fishery and provide a sustained fishery for large sized bass. After a few years, this size limit could be changed to a protected slot limit (30.5 cm (12") - 38 cm (15")) if the bass population is high. The small fish (< 30.5 cm (12")) and those over 38 cm (15") could still be harvested. We expect that high prey abundance will dampen the reproductive success of bass necessitating continuance of the 38 cm (15") minimum size. Adjusting the daily creel limit of 5 may not effectively reduce total harvest, but it should be considered if fishing becomes intense. Even a one fish limit might not be effective biologically. Generally it appears that creel limits distribute the total catch among more fishermen, but will not affect the total harvest significantly (Newburg, 1975). We do not recommend changing the catch limits for bass or other fish at this time.

Based on past data and our water quality information, the lake could support a winter/spring catchable trout fishery, probably from December into March, although we do not have good temperature data to know the exact length of favorable conditions. These fish would not survive the summer temperatures in the lake. Adding trout to the already stressed fish populations during the winter drawdown period does not seem advisable, especially when other Base waters may be more suitable. Winter access to the water is poor due to extensive mudflats.

Channel catfish are a popular fish in Lake O'Neill and stocking should be continued. Although our sampling effort was brief there did not appear to be much survival into the winter period. Hopefully this is due to a high catch rate. The catch rate of these fish as well as others in the lake should be monitored. Monitoring would determine if a sufficient number of channel catfish are harvested compared to the cost of stocking. Unlike the other fish present, we do not believe channel catfish will spawn successfully in the lake due to predation by other species and lack of dark secluded undercut banks, logs, etc., they prefer. They offer a good trophy fishery and may survive to reach a large size in the lake if the severe drawdowns are eliminated.

Habitat Manipulation

Largemouth bass, black crappie, and bluegill have a high preference for aquatic vegetation and underwater structures (Mosher, 1984) (Reininger, 1984). This is probably not a severe problem in Lake O'Neill until the winter drawdown period. Under the current drawdown pattern no aquatic vegetation or other structures exist for fish cover in the minimum pool area. We recommend cover structures be placed in the minimum pool area to provide protection for fish and substrate for food items. These structures would also serve as focal points for fishermen. The current fisheries literature indicates evergreen tree structures provide the best combination of cover type, fish preference, angler accessibility, and cost effectiveness (Johnson and Lynch, 1988; Masher, 1984).

Used Christmas trees have proven to be very effective structures when arranged in circles of three or more with branches overlapping 0.1 meter. Structures placed in depths of about four meters had the best results if the metalimnion was below that point (Lynch and Johnson, 1988). Even though maximum depths in Lake O'Neill will be under four meters during the drawdown, structures should be beneficial. Although the evergreen trees need to be replaced after several years (Johnson and Lynch, 1988), they are very inexpensive (tree collection after Christmas) and easy to construct. The Sport Fishing Institute has produced "Guide to the Construction of Freshwater Artificial Reefs" (Phillips, 1991), which details many inexpensive designs, mostly geared to bass, panfish, and channel catfish. A copy of this booklet is attached (Appendix D).

We believe the addition of 5-10 evergreen tree structures in the deep end of the lake may be beneficial to fish and anglers, especially during the proposed minimum pool period. Many used Christmas trees should be available on the Base and construction cost would be less than $5.00 per structure if volunteer labor is used. A concrete block is required for each tree to keep it upright on the bottom.

Because of the shallow depths in the lake, even at full pool, location of the structures in the deep end is not critical, although they should not be any closer than about 50 meters from each other. It would be advantageous to have some close to shore so they can be fished by bank anglers.

Fishing Access

Except for the extensively vegetated areas in the upper end of the lake, bank access at full pool appears sufficient. The two docks offer some access to deeper water, as do the boat rentals. A higher minimum pool will allow more winter access to the lake due to reduced mudflat areas. At the higher minimum pool, winter boat access might be possible. The Base should consider building a handicap fishing dock or platform near the dam for year-round access. It should be close to one or more of the recommended evergreen cover structures. Lake O'Neill fishing might offer good therapy for disabled or otherwise handicapped people coming to the nearby hospital, if sufficient access were developed.

Monitoring and Program Evaluation

Although we believe our recommendations, if followed, will result in a much improved recreational fishery in Lake O'Neill, adequate monitoring and evaluation are an essential part of any fishery management plan. An analysis of angler use and catch by Base personnel should yield valuable information concerning the status and recovery of the fish population and cost/benefit ratio of the channel catfish stocking program. A census program may also identify the level of angler satisfaction with the fishery.

Several approaches are feasible to collect this data. Because the Base issues permits to fish Lake O'Neill, an opportunity exists to incorporate an angler survey form into the permit process. The data collected from the form would include; number of anglers, hours fished, fish of each species caught, fish size, type of fishing (boat vs. shore), angler satisfaction level, etc.

Better information could be collected through consistent and accurate creel census conducted throughout the fishing season. A random sampling of days during the season is acceptable if fishing days are stratified into "high use" and "low use" days (eg. weekends and holidays, vs. weekdays). The expansion, done on a weekly basis for days not covered, will be statistically accurate if the information collected for the days covered each week is complete. The more fishing days covered, the smaller the standard error and variance of the harvest estimates.

A creek checker must count the effort at regular time intervals during legal fishing hours. The time interval should be shorter than the average angler day. A two hour interval is a good starting point. At the appropriate hour, the creel checker counts the number of people actually fishing. Separate counts for bank fishermen and boat fishermen are kept. For example:

1) Time interval is 2 hours. 2) Legal fishing is 6 a.m. to 8 p.m.

Count Times	Angler Count
0700	20
0900	25
1100	15
1300	5
1500	10
1700	30
1900	15
	120

120 total anglers counted x 2 hour time interval = 240 angler hours for the day.

The count for each hour represents the average effort for the hour before and the hour after the count.

During the time between the counts, the creel checker surveys the fishermen. Data from "completed efforts", that is, fishermen who are finished fishing at that time, is preferred. Specific information needed is: date and time of day of interview, where did they fish (boat or bank), how many hours did they fish (nearest 5 minutes), numbers and species of fish caught, numbers and species of fish kept, lengths of fish caught and lengths of fish kept (this is most important in the bass/bluegill/crappie fishery), and weights of fish kept. All creeled fish should be marked by the checker (caudal punch or clip). If the angler is checked again, only the time and fish caught since he resumed fishing will be counted. The creel checker should contact as many fishermen as possible during this time. In the above example, if there was 120 hours of effort but only 20 hours accounted for by creel census the daily harvest estimate will have a large variance and standard error.

Collected data should be analyzed for catches per angler hour per day and total catch per week. This should be done for each species caught, by boat and bank angler, by keeping stratified days separate to expand for days not covered. The weekly totals can then be summed.

Biological sampling of the fish population would be another useful tool in determining if progress is being made toward management objectives. The aquatic vegetation and shallowness of the lake influence the type of sampling gear that can be used, additionally, the cost and level of expertise required to effectively sample fish is important. In the case of Lake O'Neill, we believe passive gear, such as gill nets (similar to those used in this study), fished at permanent sites, in a specific yearly time period, and under rigid deployment specifications can reduce much of the random variability among gill net samples. Long-term standardized sample schedules for lakes about the size of Lake O'Neill are utilized by Texas Parks and Wildlife Department for long-term sampling of fish communities (Nielsen and Johnson, 1983). They would recommend five net sites in permanently selected sites at various locations in the reservoir during May. We believe this would be suitable in Lake O'Neill. Relative abundance of each species and length frequencies of fish would be useful in determining if black crappie, largemouth bass, and other fish are increasing in size as desired. Sampling sites should be established at full pool levels and after cover structures have been established.

Some water quality monitoring is desirable and the Base should consider monitoring phosphate and other nutrient levels in Fallbrook Creek just above the reservoir site. Samples from a permanent site should be taken monthly to determine if the creek is inputting excessive amounts of nutrients into the lake.

A second water quality monitoring station should be established in the "deep" water near the dam. The primary purpose of this station would be to monitor water temperature and oxygen profiles on a semimonthly basis from August through October. Samples should be taken just before dawn when oxygen demand is highest. This sampling should take place for several years to see if problems exist that need correction.

SUMMARY OF RECOMMENDATIONS

Water Manipulation:

1. Strategy 1:
   Partial drawdown to 50% capacity, then as diversions begin from the river, releases to ground water recharge below the dam would resume. Releases would be monitored to determine when and what amount the yearly ground water recharge needs are met. At that time, the lake would be filled.

   Strategy 2:
   Postpone draining to the latest possible time period to deter predation by fish and wildlife.

   Strately 3:
   Do not drain the lake, but continue to divert allocated water from the Santa Margarita River and allow the excess water to spill over. This strategy would not only protect the existing fish populations, but would allow a water exchange.

2. The lake minimum pool should not be allowed below 50% of capacity and the drawdown should not take place earlier than October due to possible dissolved oxygen depletion.

3. Aerial photography of the lake should occur each year in late summer to track trends in the growth and spread of aquatic vegetation.

4. If excessive oxygen depletion is noted, mechanical, chemical, and biological control methods can be used.

5. It would be advisable to take samples of sediments, water, and fish tissue for analysis (fecal coliform, heavy metals, hydrocarbons, and organochlorine scan) before encouraging intensive harvests.

Fish Screens:

1. The inlet ditch should be screened with a working screen or steel grate to prevent the entrance of undesirable fish species into Lake O'Neill.

2. The outlet should be screened to prevent the loss of desirable fish.

Fish Management:

1. The resident population of bass and crappie along with the other species present could develop into a substantial recreational fishery.

2. Largemouth bass fingerlings should be planted the first year to bolster the present population.

3. In order to maintain a sufficient predator base to keep down the population of crappie and other prey species a minimum, largemouth bass length limit of 15" or greater should be established.

4. Adding a put and take trout fishery to the already stressed fish population during the winter drawdown period does not seem advisable. Winter access to the water is poor due to extensive mudflats.

5. Channel catfish are a popular fish in Lake O'Neill and stocking should be continued.

Habitat Manipulation:

1. Cover structures should be placed in the minimum pool area to provide protection for fish and substrate for food items.

2. The addition of 5-10 Christmas tree structures in the deep end of the lake may be beneficial to fish and anglers, especially during the proposed minimum pool period.

3. It would be advantageous to have some cover structures close to shore so they can be fished by bank anglers.

Fishing Access:

1. The Base should consider building a handicap fishing dock or platform near the dam for year-round access.

2. A higher minimum pool will allow more winter access to the lake due to reduced mudflat areas.

Monitoring and Program Evaluation:

1. Adequate monitoring and evaluating by Base personnel or USFWS are essential for a successful fishery management plan.

2. An analysis of angler use and catch by base personnel should yield valuable information concerning the status and recovery of the fish population and cost/benefit ratio of the channel catfish stocking program.

3. Information could be collected through consistent and accurate creel census conducted throughout the fishing season.

4. Biological sampling (e.g. standardized gill net sampling, seining, electrofishing) would be a useful tool in determining if progress is being made toward management objectives. Sample sites should be established at full pool level and after cover structures have been established.

5. The Base should consider monitoring phosphate and other nutrient levels in Fallbrook Creek just above the reservoir site. Samples should be taken monthly to determine if the creek is imputing excessive amounts of nutrients into the lake.

6. A second water quality monitoring station should be established in the "deep" water near the dam for the monitoring of oxygen and temperatures from August through October. Samples should be taken just before dawn when the oxygen demand is the highest.

ACKNOWLEDGEMENTS

This report could not have been completed without the help and support of the Marine Corps and the Environmental and Natural Resources Management Office at Camp Pendleton. A special thank you goes to Slader Buck for background information and logistical support. Thanks are also due to David Wills now with Lower Columbia River Fisheries Resource Office, Vancouver, WA for his field assistance and to Joseph Polos, Bruce Halstead, and Pauline Locher for help and assistance in producing the final document.

DISCLAIMER

Mention of trade names or commercial products in this report does not constitute endorsement by USFWS.

REFERENCES

Bell, M.C. 1990. Fisheries Handbook of Engineering Requirements and Biological Criteria. Corps of Engineers, North Pacific Division. Portland, Oregon.

Dillard, J.G. and G.D. Novinger. 1975. Stocking Largemouth Bass in Small Impoundments in Black Bass Biology and Management. H. Clepper, editor. The Sport Fishing Institute. 534 p.

Gablehouse, D.W., Jr. 1983. An Assessment of Crappie Stocks in Small Midwestern Private Impoundments. FW-9-P-2. Kansas Fish and Game Commission. Emporia, Kansas.

Gablehouse, D.W., Jr. 1984. Length Limits in A Guide to the Management of Community Sport Fisheries. T. Mosher, editor. Kansas Fish and Game Commission.

Johnson, D.L., and W.E. Lynch, Jr. 1988. White Crappie and Bluegill Use of Artificial Structures Constructed of Evergreen Tree, Brush, and Stakes. Project F-57-R, Study 10. Ohio Cooperative Fish and Wildlife Research Unit. Columbus, Ohio.

Johnson, D.L., and L.A. Nielson. 1983. Fisheries Techniques, American Fisheries Society. Bethesda, Maryland.

Lewis, G.W., and J.F. Miller. 1980. Identification and Control of Weeds in Southern Ponds. Cooperative Extension Service, University of Georgia.

Lynch, W.E., Jr., and D.L. Johnson. 1988. Bluegill and Crappie Use of Nearshore Structure. Ohio Department of Natural Resources, Division of Wildlife Final Report. Evaluation of Fish Management Techniques. Federal Aid in Fish Restoration Project, F-57-R, Study 10.

MacDonald, L.H., A.W. Smart, and R.C. Wissman. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. EPA 910\9-91-001, Region 10, EPA. Seattle, Washington.

Mosher, T.D. 1984. in A Guide to the Management of Community Sport Fisheries. T. Mosher, editor. Kansas Fish and Game Commission.

Newburg, H.J. 1975. Review of Selected Literature on Largemouth Bass Life History, Ecology and Management. Investigational Report No. 335, Minnesota Department of Natural Resources.

Phillips, S.H. 1991. A Guide to the Construction of Freshwater Artificial Reefs. A.D. Mills, editor. Sport Fishing Institute. 24 p.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish Hatchery Management, USDI, Washington, D.C.

Reininger, B. 1984. Alternative Fish Species and Strains for Fishery Development and Enhancement. Federal Aid Report F-73-R-6, Idaho Department of Fish and Game.

Russell, C.D., S.M. Born, P.D. Uttormark, S.A. Smith, S.A. Nichols, J.O. Peterson, D.R. Knauer, S.L. Serns, D.R. Winter, and T.L. Wirth. 1974. Survey of Lake Rehabilitation Techniques and Experiences. Technical Bulletin No. 7S. Department of Natural Resources, Madison, Wisconsin.

Sawyer, C.N., and P.L. McCarty. 1978. Chemistry for Environmental Engineering, 3 rd Edition. McGraw-Hill Book Company, New York.

Vanicek, C.D., and A.W. Miller. 1973. Warmwater Fish Pond Management in California. USDA, Soil Conservation Service, # M7-N-23056, Portland, Oregon.

APPENDICES

APPENDIX A.

QUALITY ASSURANCE LABORATORY
6605 NANCY RIDGE DRIVE
SAN DIEGO, CALIFORNIA 92121
(619) 552-3636

U.S. FISH & WILDLIFE SERVICE
ATTN: BRIAN CATES
1125 16TH ST., ROOM 209
ARCATA, CA 95521

DATE OF REPORT	JANUARY 22, 1992
DATE RECEIVED	JANUARY 13, 1992
SAMPLING DATE	JANUARY 13, 1992
DATE OF FINAL REVIEW	JANUARY 21, 1992
ANALYZED BY	MF KL NC JM PL
SAMPLE TYPE	4 WATER
PROJECT NAME	LAKE O'NEILL

ANALYSES RESULTS

ANALYSIS	PREP/ANALYSIS METHOD	UNITS	LOG NUMBER: SAMPLE ID:	515-92A 1	516-92A 2	517-92A 3	518-92A 4
T-ALKALINITY	STD 2320-B	MG/L		150	173	195	230
BICARBONATE	STD 2320-B	MG/L		150	173	195	230
BOD	STD 5210-B	MG/L		5.3	6.7	5.6	<3.0
COD	STD 5220-D	MG/L		65	62	55	44
HARDNESS	STD 2340-B	MG/L		246	243	275	336
AMMONIA-N	STD 4500-C	MG/L		1.05	0.97	0.88	0.14
NITRATE-N	EPA 300	MG/L		0.3	0.3	0.3	<0.2
ORTHO-PHOSPHATE-P	EPA 300	MG/L		<0.2	<0.2	<0.2	<0.2
T-PHOSPHATE-P	STD 4500-B5,E	MG/L		0.30	0.32	0.37	0.27
TDS	STD 2540-C	MG/L		538	544	544	668
SILICA	3010/6010	MG/L		23.1	18.6	22.0	19.7
SULFATE	EPA 300	MG/L		128	130	126	183

PETER SHEN
LABORATORY DIRECTOR

PS/ft

QUALITY ASSURANCE LABORATORY
QUALITY CONTROL DATA REPORT

JANUARY 21, 1992

U.S. FISH AND WILDLIFE SERVICE
LOG #515-92A THROUGH 518-92A

DATE EXTRACTED:	JANUARY 10, 1992-	CALCIUM, MAGNESIUM
	JANUARY 14, 1992-	SILICA
	JANUARY 15, 1992-	BOD, T.PHOSPHATE
DATE ANALYZED:	JANUARY 14, 1992-	NITRATE, O.PHOSPHATE
	JANUARY 15, 1992-	COD, AMMONIA, T.PHOSPHATE, SILICA
	JANUARY 16, 1992-	SULFATE
	JANUARY 20, 1992-	BOD

ANALYSES	PREP/ANALYSIS METHOD	LCS % RECOVERY	SPIKE %RECOVERY	DUPLICATE RPD
BOD	STD 5210-B	99%		<1%
COD	STD 5220-D	102%	102%	3%
AMMONIA	STD 4500-C	105%	101%	<1%
NITRATE	EPA 300	97%	95%	5%
O.PHOSPHATE	EPA 300	94%	94%	7%
T.PHOSPHATE	STD 4500-B5E	99%	103%	<1%
SILICA	3010/6010	110%		2%
SULFATE	EPA 300	96%	93%	4%

LISA MACCLELLAN
QA/QC DIRECTOR

QUALITY CONTROL TERMINOLOGY

•LCS - LABORATORY CONTROL STANDARD. REPORTED AS % RECOVERY OF AN INDEPENDENT STANDARD CARRIED THROUGH ALL SAMPLE PREPARATION PROCEDURES TO VERIFY METHOD PERFORMANCE. ACCEPTALBE RANGE IS 80%-120% RECOVERY.
•SPIKE - ENVIRONMENTAL SAMPLE IS MATRIX SPIKED WITH METHOD COMPOUNDS AND % RECOVERY OF CONCENTRATION SPIKED INTO SAMPLE IS CALCULATED. REPORTED AS % RECOVERY. ACCEPTABLE RANGE FOR "NORMAL MATRIX SAMPLE" IS 75%-125% RECOVERY.
•SURROGATES - COMPOUNDS REPRESENTATIVE OF A GROUP OF COMPOUNDS. SURROGATES ARE SPIKED INTO ENVIRONMENTAL SAMPLES AND % RECOVERY OF CONCENTRATION SPIKED IS CALCULATED AND REPORTED. ACCEPTABLE RANGE VARIES DEPENDING ON SAMPLE MATRIX AND ANALYSIS METHOD.

APPENDIX B.

NATURAL RESOURCES OFFICE
Marine Corps Base
Camp Pendleton, California 92055

11015
BF5/SGB/sgd
13 Jun 84

From: Director
To: Fishermen

Subj: CAMP PENDLETON FISHING REGULATIONS

1. The following information is provided to help you have an enjoyable fishing experience. Please read it carefully. This sheet provides only a brief summary of Camp Pendleton regulations. IT IS YOUR RESPONSIBILITY TO KNOW THE CURRENT CALIFORNIA DEPARTMENT OF FISH AND GAME FISHING REGULATIONS AS WELL AS PARAGRAPH 6105 OF BASE ORDER P5000.2F.

2. Personnel Authorized Fishing Privileges

a. Active duty military stationed on Camp Pendleton, Naval Weapons Station, Fallbrook, and Camp Pendleton Mountain Warfare Training Center, Bridgeport.

b. Retired military personnel.

c. Dependents of active duty and retired military. Dependents under 12 years of age must be accompanied by an adult.

d. Bona fide house guests of active duty or retired military who are NOT house guests for the purpose of fishing.

e. Civilian employees at Camp Pendleton, Naval Weapons Station, Fallbrook, or Camp Pendleton Mountain Warfare Training Center, Bridgeport.

f. Youth Groups. Permission must be obtained from the Director, Natural Resources Office.

g. Members of the general public are authorized surf-fishing privileges within an annual quota.

MEMBERS OF THE GENERAL PUBLIC ARE NOT ALLOWED FRESHWATER FISHING PRIVILEGES ON CAMP PENDLETON.

3. Licenses. All persons 16 years of age and older shall have in their immediate possession a current California Department of Fish and Game fishing license AND a Camp Pendleton fishing permit.

4. Check-out. All persons must call the Duty Warden, 725-3360, prior to going fishing to insure that the area is open. You need not call if you wish to fish in Lake O'Neill. Checking in from fishing is not required.

5. Available Areas.

a. Freshwater inland fishing is authorized ONLY at the following locations:

Lake O'Neill
Pulgas Lake
Case Springs, Pond No. 1
Witman Pond also called Case Springs No. 2 or "Little Case"
Ysidora Basin Infiltration Ponds
Santa Margarita Rive
Santa Margarita Slough (This area is CLOSED to fishing 1 April-1 September)
Las Flores Slough-from the I-5 bridge west to the ocean. Fishing is NOT allowed in Las Flores Marsh.
Broodmare Pond commonly called "Horse Lake" (GC 705820)
Pilgrim Creek Pond (GC 715820)

With the exception of Lake O'Neill, all freshwater lakes are located within training areas. The availability of these areas is based on military training requirements.

b. Surf-fishing, clamming and diving for fish mollusks and crusteceans is available in the following areas:

(1) The beach area extending from the southern boundary of San Onofre State Beach to the northern bank of the Santa Margarita River. This is open to military and civilian personnel.

(2) The waterfront extending from the Santa Margarita River on the north to the northern groin of the Del Mar Boat Basin, excluding the recreation beach. This is open only to military personnel, their dependents and bona fide house guests.

(3) Fishing from the northern jetty is permitted during daylight hours only.

(4) Clamming is also permitted for military personnel on San Onofre Beach.

(5) PLEASE PAY PARTICULAR ATTENTION TO THE FOLLOWING:

(a) Access to the northern beaches is authorized only through the Aliso or Las Flores underpasses and the Stuart Mesa overpass. Parking will be authorized in posted parking areas only. Operation of private motor vehicles is prohibited westerly of Interstate 5 except en route to and from approved camping or parking areas. Foot traffic will be limited to the valley and the beach frontage only. No civilian vehicles or civilian foot traffic will be allowed on the bluff areas.

(b) Swimming or surfing is prohibited in the surf-fishing area. This, however, does not apply to licensed fishermen using underwater breathing apparatus who must display proper flags and buoy.

6. Fishing hours

a. Freshwater - one hour before sunrise to one hour after sunset.

b. Saltwater - Fin fish - may be taken anytime day or night.

- Marine invertebrates (clams, crabs, shrimp, lobster, etc.). Check CDFG regulations.

If an area is not being used for military training or closed for other reasons, it is available for fishing.

7. Method of Take

a. Freshwater - Hook and line ONLY. One closely attended rod and line, or one hand line. Other methods are allowed for frogs and crayfish. Persons interested in taking bullfrogs and/or crayfish should consult California Fish and Game regulations on legal methods of take.

b. Saltwater - Consult CDFG regulations.

8. Species/Seasons

a. Freshwater

Species	Open-Season	Limit	Minimum Length
Black bass (includes large and small mouth bass)	All year	5	None
Trout	All year	5	None
Crappie, Sunfish (includes Bluegill)	All year	None	None
Catfish	All year	20	None
Bullhead	All year	None	None
Bullfrog	1 July - 30 Nov	12	None
Crayfish	All year	None	None

b. Saltwater. The variety of fin fish and marine invertebrates (clams, crab, shrimp, lobster etc.) available off Camp Pendleton are too numerous to list here. Anglers should consult current CDFG regulations for information on season length, limit, minimum length and methods of take

9. Violations. It is illegal to do any of the following. If observed by a Game Warden, you will be ISSUED A CITATION. Numbers in parenthesis refer to Title 14, California Administrative Code.

Fishing without a valid California fishing license in your immediate possession (700.0).

Refusal to show fishing licenses, fishing equipment or fish on demand. Fish and Game Code, Sec 2012

Freshwater fishing with more than one pole in the water (2.05).

Fishing with methods other than hook and line (1.14).

Having or attempting to take over the daily bag and possession limit (1.17).

Freshwater fishing at night (3.00).

Use of lights to take fin fish (2.15).

Paul L. V. Campo

PAUL L. V. CAMPO

APPENDIX C.

SELECTION CHARTS

OVERSHOT TURBINE:

Upstream View

SCREEN SIZE DIA. B	LENGTH A	CAPACITY (CFS)	C	D	APPROX. SHIP.WT.LBS.
18	30	2.0	30	14	175
18	36	2.8	30	14	185
18	48	4.5	30	14	215
22	36	3.8	34	16	195
22	48	6.1	34	16	230
22	60	8.4	34	16	330
30	48	9.5	42	21	355
30	60	13.3	42	21	380
30	72	16.2	42	21	430

UNDERSHOT TURBINE:

Upstream View

SCREEN SIZE A. B	LENGTH A	CAPACITY (CFS)	C	D	APPROX. SHIP.WT.LBS.
18	30	2.8	30	8	220
18	36	3.5	30	8	245
18	48	4.5	30	8	265
22	36	5.7	34	10	350
22	48	7.6	34	10	380
22	60	9.5	34	10	410
30	48	14.3	42	12	440
30	60	18.1	42	12	480
30	72	21.9	42	12	520

"A" (FRAME LENGTH) IS WEIR SLOT LENGTH LESS 1/2" FOR CLEARANCE.

TYPICAL SPECIFICATIONS:

All material used in the construction of self-powered rotary fish screens shall be of Stainless Steel. Type 304, except as herein noted.

The screen frame shall not have any void spaces between the opening width and screen width. The frame length shall be '." less than the weir length to allow for fitting.

The Overshot Turbine Model drive shall operate by the passage of water through an intake over a stationary divider plate, with the flow of the stream to furnish the motive power to turbine wheels which rotate the screen drum.

The Undershot Turbine Model shall operate by the passage of water through an intake which drives an internal paddle wheel. The internal paddle wheel furnishes the motive power to operate a planetary gear system which rotates the screen drum.

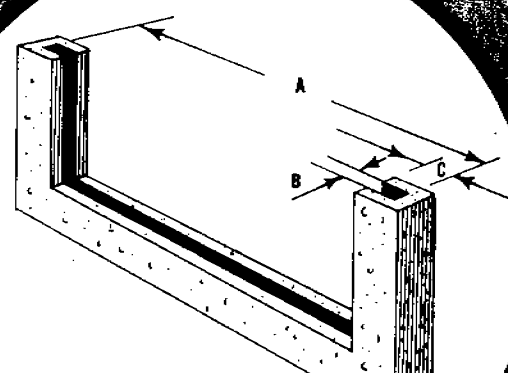
All bearings used shall be of polypropylene construction of the water lubricated type. All gears used shall be of brass or polypropylene construction.

The intake shall be furnished with neoprene seal guards

The self-powered rotary fish screen shall have a screen drum incorporating inverted "Vee" openings, and be delivered fully assembled, ready for installation.

Overshot Model

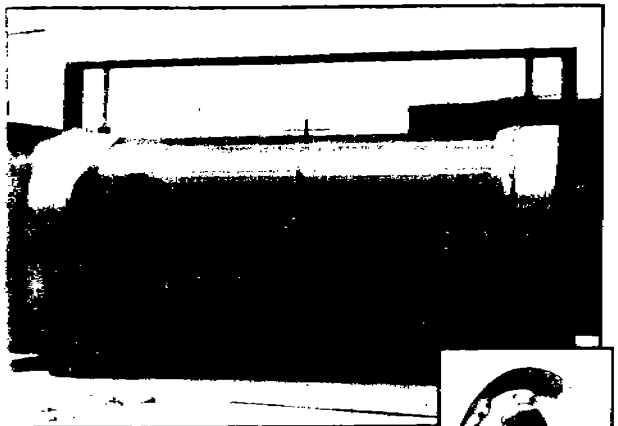
SUGGESTED TYPE OF WEIR



When ordering include: water volume, overall weir length (A), slot width (B) and depth (C). Allowance in your specifications will be made at the factory to simplify installation.

INC.

...YNE INC.
...X 189
...SBURG, CA 95448-0189
... (.7) 433-3813
X (.7) 433-3712



Undershot Model

Planetary
Gear Drive

FEATURES AND ADVANTAGES:

- WATER-POWERED
- SELF-CLEANING
- EASY INSTALLATION
- DESIGN ENGINEERED FOR LOW MAINTENANCE
- STAINLESS STEEL CONSTRUCTION FOR LONG LIFE
- PROTECTS CROP FISH
- EXCLUDES PREDATOR FISH

The AQUADYNE Aqua Screen is designed to provide screening action simply and effectively with a minimum of maintenance. While protecting valuable crop fish, and excluding undesirables, the screen will pass all floating waste material from a stream without clogging by flushing the waste material downstream. An added bonus is the increased areation of the water.

The AQUADYNE Aqua Screen is designed for use in federal, State, and private fisheries, as well as raceways, diversion streams and farm fish-out ponds. A key part of the design is adaptability to any installation wherever screening is required.

Each unit is custom manufactured to suit your requirements, and is delivered fully assembled and ready to install.

OVERSHOT TURBINE OPERATION (See Illustration)

The steady, self-cleaning operation of the AQUADYNE overshot Aqua Screen is accomplished by the passage of water through an intake divider. The flow of the stream turns the turbine wheel, which rotates the screen, operating on the principal that water flow plus head equals power. Debris is carried over the screen and is washed downstream.

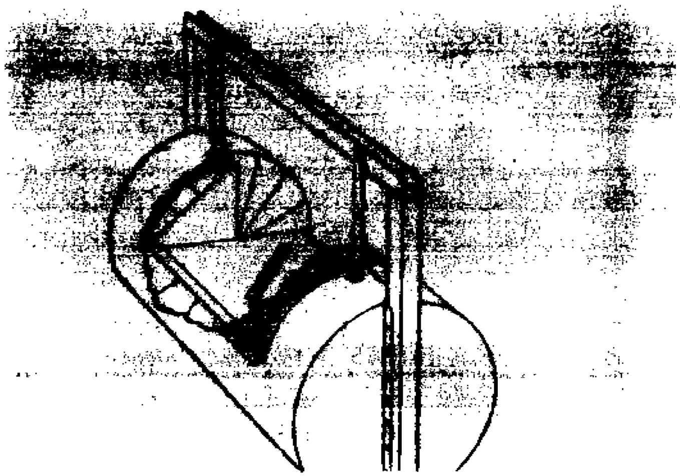
Installation is quick. Slide the Screen Frame into the Weir slots and lower to proper depth.

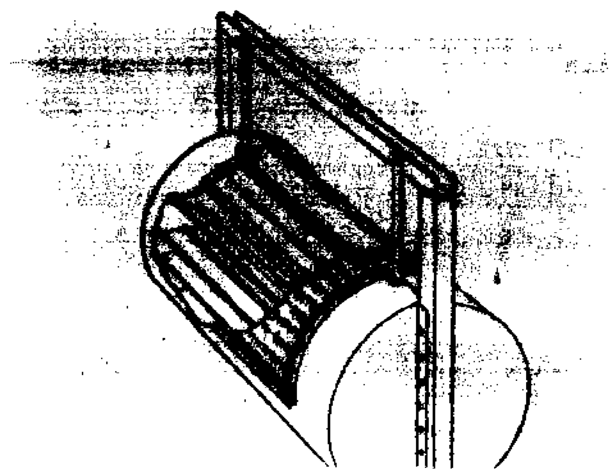
Use of Stop Logs (2" boards) under the unit will maintain proper height. The potential energy (head) or difference in elevation between the water intake and the outflow should be about half the screen diameter, or more; the intake being the higher elevation. Refer to selection chart for required head.

The flow of the stream provides an economical power source which operates the Aqua Screen. The rotating drum turns approximately 14 times per minute when installed with the proper amount of head. This same power source also relieves you of constant cleaning chores, guaranteeing low-cost, low-maintenance operation.

UNDERSHOT TURBINE OPERATION (See Illustration)

Passage of water through an intake and against an internal paddle wheel drive mechanism provides the motive power for the Undershot Turbine. Kinetic energy rather than potential energy is utilized and consequently less differential head is required for operation of the Undershot Turbine. A planetary gear train is driven by the internal paddle wheel drive mechanism which causes the screen-cylinder to rotate in the direction of water flow to pass floating debris downstream similar to the Overshot Model. Refer to selection chart for required head.





APPENDIX D.

A GUIDE TO THE CONSTRUCTION OF

FRESHWATER ARTIFICIAL REEFS

SPORT FISHING INSTITUTE

BASS

Anglers For Clean Water, Inc.

FishAmerica Foundation

Published by
The Sport Fishing Institute
April 1991

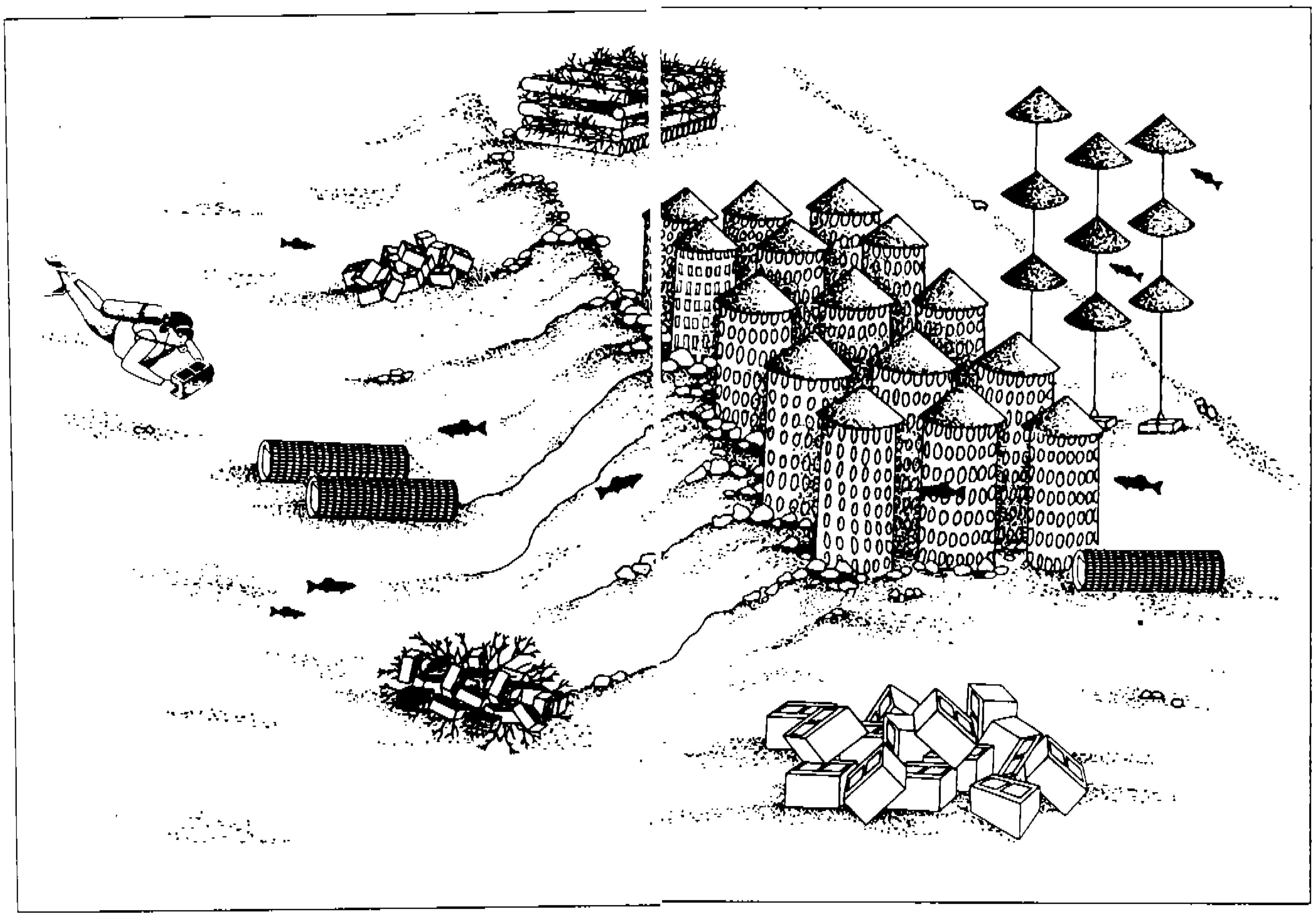
ACW Publication 8156-22

I. Introduction

Fishermen have known for years that bass, crappie and panfish are usually found near cover such as submerged logs, trees, brush, rock outcroppings, boathouses, and docks. Fishery biologists have been able to imitate natural cover for fish by creating artificial cover, commonly referred to as artificial reefs. Artificial reefs have been used to improve fishing success in lakes, ponds and reservoirs for over 50 years.

Reefs are a valuable management tool, especially in older reservoirs, where natural cover (trees and shrubs), that was submerged when the impoundment was flooded, deteriorates. Cover contributes to healthy fish communities by providing substrate for food organisms, safety from predators and, in some cases, spawning habitat. Many of you who are veteran anglers in the bass and panfish haunts may more closely identify with the term "structure," instead of "cover." In this pocket manual the term "cover" will be used synonymously with "structure."

The purpose of this manual is to present proven methods for building freshwater artificial reefs. The manual is intended to illustrate: types of materials for reef construction, the cost of reef construction, and methods to construct reef habitat. The manual is intended for use by fishery resource managers, and by angling groups and civic associations interested in undertaking properly designed and constructed freshwater artificial-reef projects.



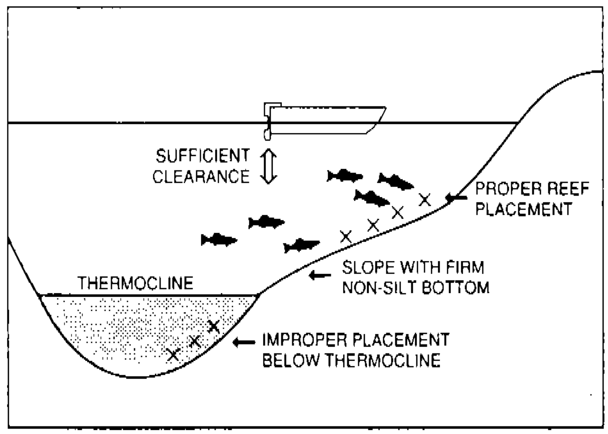
II. Project Planning

It is vital that any reef project follow a carefully thought-out plan of action. The materials presented in this manual enable reef sponsors to develop a specific plan of action to follow in a reef deployment project. While a plan does not ensure success, it can provide a rational decision-making process from project conception to actual reef deployment. Listed below are suggestions for planning a reef project:

- Determine the objective of the reef project. What species and age classes are to be targeted? Do these species respond to structure? Is the reef intended for dock, shore, boat or disabled fishermen? Is the reef really needed?
- Contact personnel with the state natural resource agencies and/or Federal agency in charge of artificial-reef development. Permits may be required for the reef. Your state natural resource agency is also a valuable source of reef development information and should be a cooperator in the project.
- It is important that communication lines be opened to as many fishermen as possible to get their input and volunteer labor into the project.
- Organize a group of dedicated volunteers who are willing to set time aside to work on the project.
- Determine how much fishing pressure the reef will receive. This information is invaluable for determining the need, size and location of the reef.
- Determine what resources are available to undertake the project: financial, manpower, transportation, materials. It is strongly advised that before any individual, civic organization, or fishing club begins an artificial reef project that the appropriate state/federal natural resource agency and/or department of fisheries be contacted. They will often be of great help in undertaking reef projects and in many instances may be willing project participants.
- Take necessary safety precautions. An integral part of any artificial reef project is safety. All individuals involved in reef material fabrication and deployment should be equipped with appropriate safety equipment, such as a personal flotation device (when on a boat or barge), safety eyeglasses or shield, heavy duty gloves and any other equipment required to prevent injury. Also, reef materials should always be deployed by at least two able-bodied persons; never work alone.

III. Proper Placement of a Reef

Proper placement of the artificial reef is as important as selecting a good material and design. Simply put, the reef must be located where cover is lacking, where it will be utilized by



the targeted species of fish and where it will be accessible to fishermen. In some cases, placement may help in segregating various water users (i.e. skiers, anglers) and reduce conflicts.

A. *Bottom Type*

The reef location site should have a firm substrate such as sand, stone, or clay. Soft bottoms, characterized by silt and mud, are not recommended for reef placement as heavier reef materials may eventually subside and disappear. A long stick can be used as a probe to test the bottom; or better yet a diver can be used to test bottom hardness. If there is a dive club in your area, inquire if they would like to volunteer and participate in the project. It is very important that artificial reefs are not placed directly on productive bottom habitat such as natural shoals or existing submerged trees or brush.

B. *Clearance*

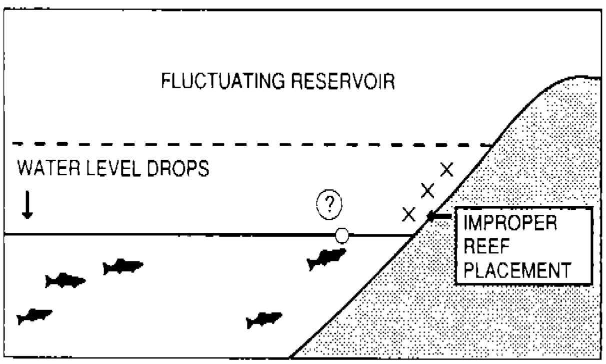
Reef placement must not pose a hazard to boat and skier traffic. Reefs should be located out of boating lanes and at a sufficient depth to allow for safe boat passage. The agency or individual with regulatory authority over the body of water must be contacted to determine permit requirements. This may be a state, federal, or private entity. In navigable waters, reefs should be clearly marked with permanent buoys as required by the U.S. Coast Guard. Some states may also have requirements for permits or buoys. For these reasons it is imperative to check with your appropriate state or federal natural resource agency before placement of reef material in public waters.

C. *Permits*

IN SOME BODIES OF WATER A PERMIT MAY BE REQUIRED FROM STATE OR FEDERAL AGENCIES TO CONSTRUCT AN ARTIFICIAL REEF. PLEASE CONTACT YOUR STATE NATURAL RESOURCE AGENCY AND INCLUDE THEM IN THE INITIAL PLANNING PROCESS.

D. *Depth of Reef Placement*

Fish are found at different water depths depending on the season of the year and corresponding water temperature. Seasonal water temperature changes and water level fluctuations can make the optimal depth of reef placement difficult because the reef may only be inhabited by fish part of the year. A reef placed in shallow water (less than 10 feet) will be inhabited in the



spring, but will go unused by adult game fish throughout most of the summer and early fall. For example, adult largemouth bass spawn in shallow water in the late spring (depending on latitude) and move into deeper water (15-20 feet) early in the summer and even deeper water as water temperatures rise through the summer.

If you have ever swam in a lake in the summer, you may have noticed that at some depth there is a sudden drop in water temperature. In the late spring through early fall many lakes and reservoirs have a warmer upper layer and colder lower layer. The portion of the water column dividing the warmer upper waters and the cooler lower waters is referred to as the thermocline. The concept of the thermocline is important because warm-water fish such as bass, crappie and bluegill prefer the warmer waters of the upper layer above the thermocline. The colder waters lying below the thermocline often suffer from declining oxygen levels as the season progresses and becomes less hospitable to most fish species. If a reef is placed below the thermocline in the colder lower layer, it may go unused. This is especially important for species such as crappie, which are found near the thermocline throughout the summer.

There are several methods you can use to properly place artificial reef materials where they will be inhabited by fish throughout most of the warmer months:

- Generally, do not place a reef deeper than 30 feet or shallower than 10 feet. There are circumstances where reefs may be placed in water shallower than 10 feet to provide fishing opportunities for bank fishermen. Also some reservoirs, especially in the western states, have widely fluctuating water levels. Be sure to contact your appropriate state/federal natural resource agency to help you determine the proper depth of placement.
- Find out the depth where fish are caught throughout the year; this can be achieved by asking local fishermen, and will be easy if you are a member of a fishing club.
- If possible, the reef units should be placed on a gradient line going from shallow to deeper water. The deepest portion of the reef should be slightly deeper than the late summer depth of the thermocline. The placement of the reef structure in rows will ensure that as water temperatures warm (and in reservoirs where water levels decline) and fish move, reef materials will continue to be inhabited.
- Consult with your state fishery biologist.

Most states have regional and/or local offices where many of these questions can be answered.

IV. Construction Techniques

Productive artificial reef habitats must display several general physical properties:

- Provide maximum structural complexity to provide hiding places and attachment surfaces for food organisms (periphyton).
- Have sufficient weight for stability so that the reef stays as placed.
- Be made of non-toxic materials that do not deteriorate in a short period of time.
- Be placed so as to optimize public awareness and use.

The number of fish attractors installed in a given water body should not be too large nor should they be placed in habitat where cover is already abundant. Discuss the concept of over-harvest potential in the target populations with your state fisheries biologist. Some fisheries experts feel the installations of fish attractors in some instances may accentuate overharvest problems by increasing angling success.

Researchers have found that the installation of several smaller reefs are preferable to one large unit because many small reefs provide more surface area and structural diversity for food organisms. Several smaller reefs also serve to spread fishing effort over a larger area, reducing angler conflicts.

As noted earlier, artificial reef projects in reservoirs can become complicated because of rising and falling water levels. This is especially true in western states where reservoirs are drawn down to allow for storage of spring melt-off. At low pool, reefs may become exposed; posing a navigational hazard or being vulnerable to vandalism. Certain types of reefs, such as tire modules, may be impractical in reservoirs with fluctuating levels because their weight and bulk make removal very difficult. Keep in mind that innovative reef design and construction can overcome the problem of fluctuating reservoirs.

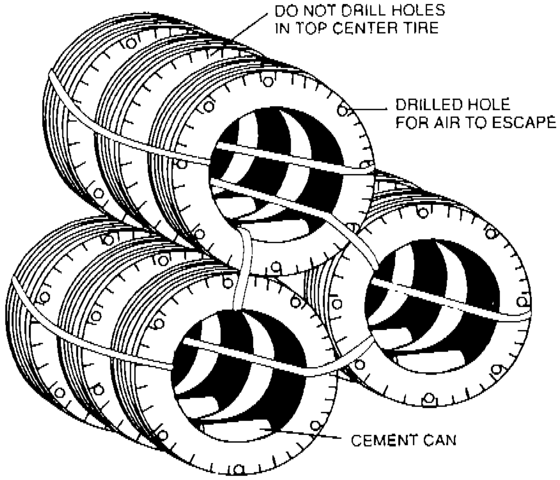
V. Specific Materials

It is important to select a durable, productive reef material for a successful reef project. The following pages illustrate some better known and successful artificial reef designs. Information is also provided on the cost of materials (prices will vary), as well as tips on how to construct, transport and secure reef materials in their intended locations. The reefs pictured and described have proved to be effective if properly constructed and placed. Diagrams are provided to assist the reader in constructing and deploying the reef.

1. Tires

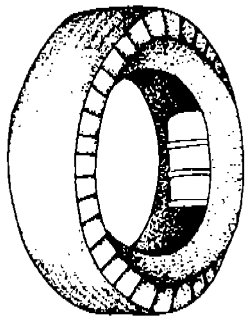
TARGET SPECIES -- Catfish, largemouth bass, panfish, walleye

MATERIALS — Used tires are easily located. Tire stores are usually more than happy to donate tires to a reef project. Concrete is needed as ballast for the tires and 1/4-inch dark-color polypropylene rope is needed to tie the tires together.

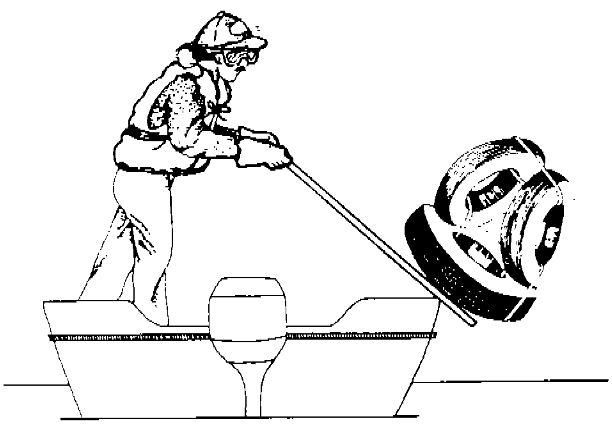


CONSTRUCTION TECHNIQUES — Tire units can be constructed in several ways. Remember the more voluminous the unit, the more it will weigh. As with all reefs, sufficient clearance must be allowed so that boat traffic can proceed safely. While high-profile, more complex reefs provide better fish habitat, keep in mind the difficulty of construction and deployment.

To construct the nine-tire nodule pictured in the diagram, three tires are fastened together to form a nine-tire pyramid configuration. To assure



stability, one No. 10 can (3-lb. coffee can) filled with cement should be placed inside each tire between the sidewalls. It is important that holes be drilled in the tires near the top to allow air escapement. However, holes should not be drilled in the middle tire of the top assembly. The trapped air in the desired space will cause the unit to lie in the desired position on the bottom.



DEPLOYMENT AND SECURING — Tire units require a barge or large, stable work boat for transportation. To deploy, tire units may be placed on plywood boards. Levers can then be used to lift up the board and slide the unit into the water. This should be done in a deliberate manner to assure that the unit does not flip over. Anchors are not required for this reef because of the concrete ballast.

COSTS —

Tires: no cost

Polypropylene rope: $.04-05/foot, or strapping material

Concrete: $4.00 per 80-pound bag

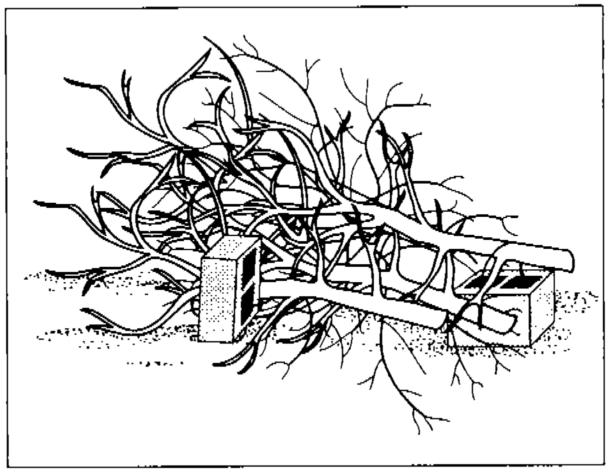
2. **BRUSHPILES**

TARGET SPECIES — Largemouth bass, crappie. bluegill, other panfish

MATERIALS — Green trees and brush material

are long lasting and therefore preferable. Hardwood such as oak is also recommended. Cedar trees have commonly been used with good results.

CONSTRUCTION TECHNIQUES — Brushpiles should be built to provide high-profile and structural diversity. It is important to remember that the more complex in design the brushpile reef; the more habitat it provides. Brushpiles need thicker branches to ensure integrity, sturdiness and



longevity. Brushpiles made of thinner branches have a short submerged life because of their fragility. Probably the best technique involves the construction of a frame made out of sturdy wood, such as ironwood, or other hardwood such as oak or cherry. A metal frame can also be used. Brush can also be bundled, tied and weighted with a concrete block.

DEPLOYMENT AND SECURING — While placement of brushpiles on ice has been used, it is not recommended because it can cause the material to disperse at ice-out. It is important to secure the brush with use of concrete blocks.

COSTS —

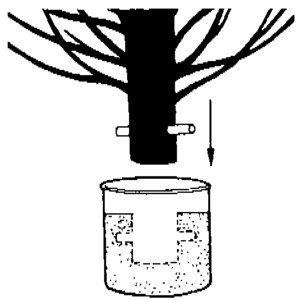
Concrete block: $.89 per block

Polypropylene rope: $.04-.05 per foot

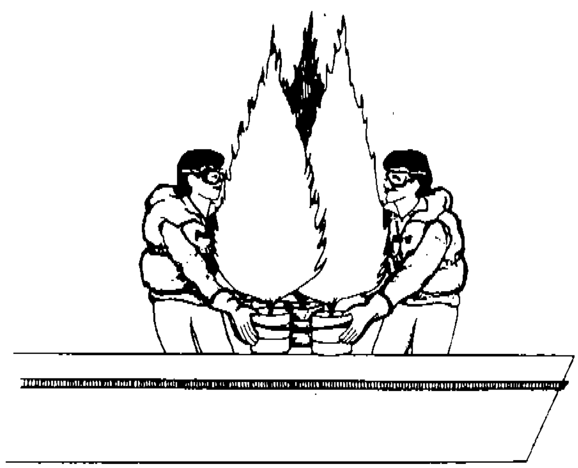
3. **CHRISTMAS TREES**

TARGET SPECIES — Largemouth bass, crappie, panfish

MATERIALS — Christmas trees, although not



particularly durable, are plentiful during the Christmas holidays at no cost. It is important to get trees that have not been chemically treated with flame retardant. Concrete in 5-gallon containers can be used for ballast. Dark-color polypropylene rope is needed to tie the trees into bundles. Metal pins are needed to secure the trees in the cement-filled cans. (Note: Though inexpensive, Christmas-tree structures are not particularly durable due to early decay.)



CONSTRUCTION TECHNIQUES — The trees can be ballasted by drilling a 3/8-inch horizontal hole in the bottom of a Christmas tree and forcing a length of 1/4-inch steel bar stock into the hole. The tree is then placed into a 5-gallon can and filled to three-quarters capacity with concrete. Trees tied together in groups of three or more are more stable than single trees. Dark-color polypropylene rope should be used to tie the trees together.

DEPLOYMENT AND SECURING — The trees are ballasted by the concrete base, so further anchoring is not required. Trees will be cumbersome, so a barge or large raft is required for deployment. Groups of trees can also be towed out to the site. Trees should either be set on the bottom in rows or placed in mounds.

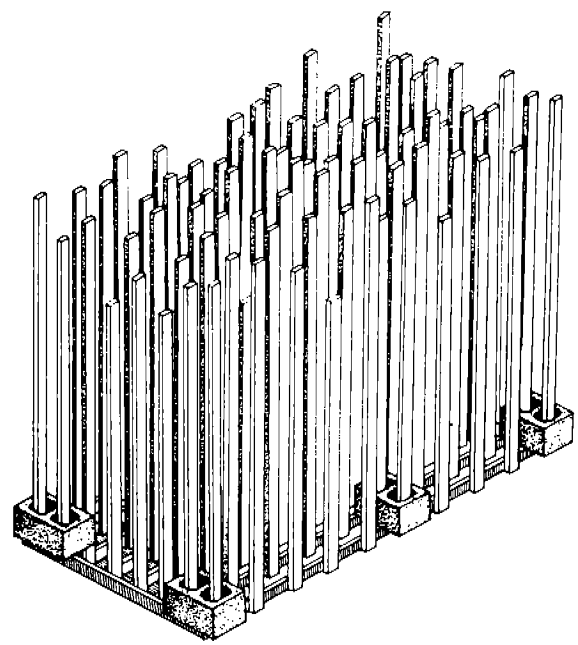
COSTS —
Trees: Donated
Concrete: $4.00 per 80-lb. bag
5-gallon can: Donated
1/4-inch rebar: $2.25 per 10 feet

4. **STAKE BEDS**

TARGET SPECIES — Largemouth bass, crappie, panfish

MATERIALS — A lumberyard can provide the stakes necessary to construct the beds. To weigh down the stake bed, 40-pound cement construction blocks are needed. These can be found at a building materials store.

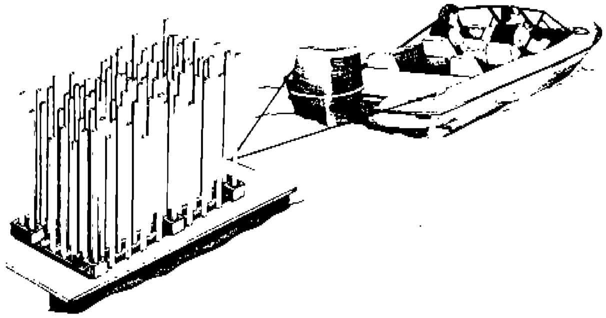
CONSTRUCTION TECHNIQUES — Fifty green sawmill stakes (4 to 7 feet long), and nine green sawmill oak lumber (2 inch by 4 inch by 8 feet



long) are required to construct a 4-foot by 8-foot stake bed. Twentypenny galvanized coated nails should be used to nail the structure together. To construct the bed, place six of the 2 by 4s six inches apart, parallel to one another. The remaining 2 by 4s are then nailed at right angles to the six boards to form the base of the bed. Stakes are then nailed into the boards 1-2 feet apart. Concrete construction blocks should be placed on each corner of the structure. Care should be taken when placing the blocks on the corners so that the bed is not damaged.

Stake beds can also be made out of PVC piping.

DEPLOYMENT AND SECURING — Stake



beds can be fabricated on shore and then towed on a pontoon boat or barge. The beds require no anchoring because of the weight provided by the concrete blocks. As with the tire units, if stake beds are put on barges, they can be shoved off by hand.

COSTS —
Oak Stakes:
2" x 4" x 8' lumber: $2.00 per piece
Nails: $.79 per lb. (2 1/2-inch galvanized)
Concrete Blocks: $.89 per block

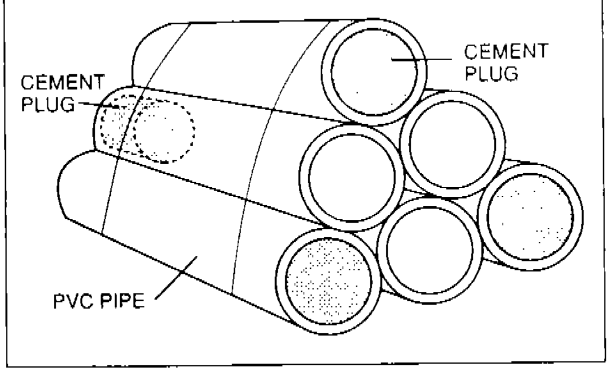
5. **PIPING**

TARGET SPECIES — Catfish, bullhead

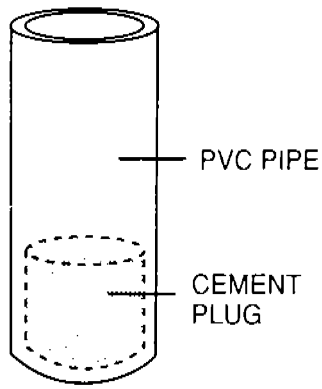
MATERIALS — Vitrified clay PVC and corrugated polyethylene pipe can be purchased at building supply stores. There are often broken pipes or seconds that can be obtained free at construction sites or from distributors.

CONSTRUCTION TECHNIQUES — Concrete and vitrified clay piping can be bundled into a pyramid shape. Plastic bundling strips may work better than polypropylene rope. PVC and corrugated polyethylene piping, because of their light weight, need to be ballasted. Pouring cement into

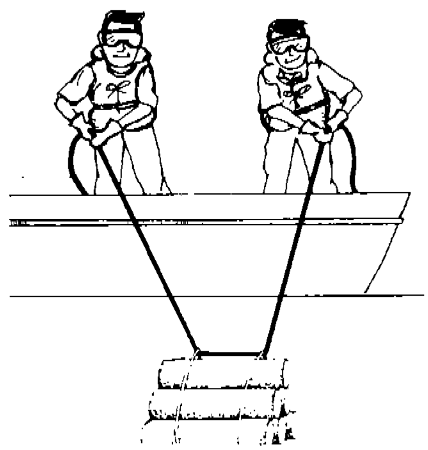
CONSTRUCTION OF PYRAMID UNIT



one end of each pipe accomplishes two functions. It provides needed ballast as well as providing a shaded hiding area preferred by catfish. Ballast can also be provided by filling the bottom middle pipe wholly or partially with cement.



DEPLOYMENT AND SECURING — Use of a barge or pontoon boat allows for fewer trips to and from the shore. However, recreational fishing boats can be used to ferry the pipes to the site. Since there is sufficient weight with the vitrified



clay pipes and the ballasted PVC and corrugated polypropylene pipe, no additional anchoring is required.

COSTS —

Vitrified clay pipe: $4.96 per 100 feet (6-inch diameter)

PVC Pipe: $4.29 per 10 feet (1-inch diameter)

Corrugated polyethylene pipe: $2.16 per 20 feet (6-inch diameter)

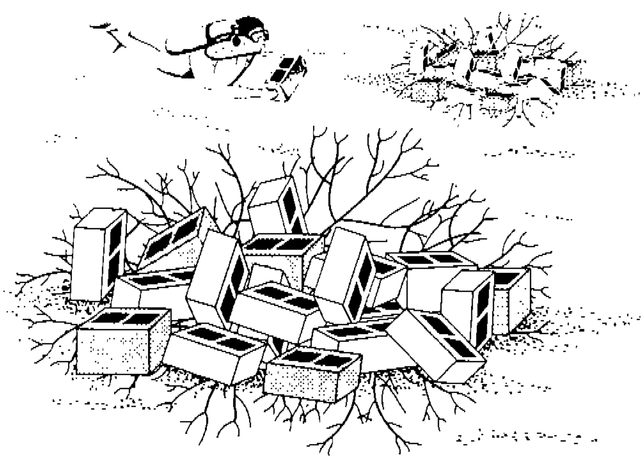
Strapping/binding material: Inquire locally

6. **CONCRETE Block/Rubble/Rock**

TARGET SPECIES — Rockpile reefs attract a variety of species including catfish, bass, panfish, and walleye. Rock reefs also serve as spawning substrate for smallmouth bass, largemouth bass, walleye and catfish.

MATERIALS — Broken concrete blocks can be obtained at building supply stores or at construction sites. Building rubble can also be obtained at a low cost, but it is important that the rubble material be free of any piping, asphalt or other toxic or hazardous substances. Quarry rock can also be used, however, this option is expensive and requires heavy equipment for transportation and deployment.

CONSTRUCTION TECHNIQUES — Piles of rock can be placed in conjunction with cinder blocks and brush to form a rock reef. Rock reefs should be made of different sizes of rock to ensure the creation of a variety of habitats. Placement of several small piles of rock is preferable



to one large pile. In the large pile many of the rocks are buried within the structure and are not usable by the majority of the reef inhabitants. Smaller reefs will result in more attachment surfaces and structural diversity for food organisms.

DEPLOYMENT AND SECURING — Because of their weight, rock reefs are more cumbersome and may require a barge and heavy equipment to transport. Repeated trips to a reef site can be made by pleasure boats with cinder block. However, keep in mind that the blocks may cause boat damage. A diver can be very helpful in stacking the blocks into a mound once they have been placed on the bottom. In northern states, rock can be placed on winter ice at the reef site. Upon ice-out, the rock will fall through the ice.

COSTS —

Cinder blocks: $.89 per block

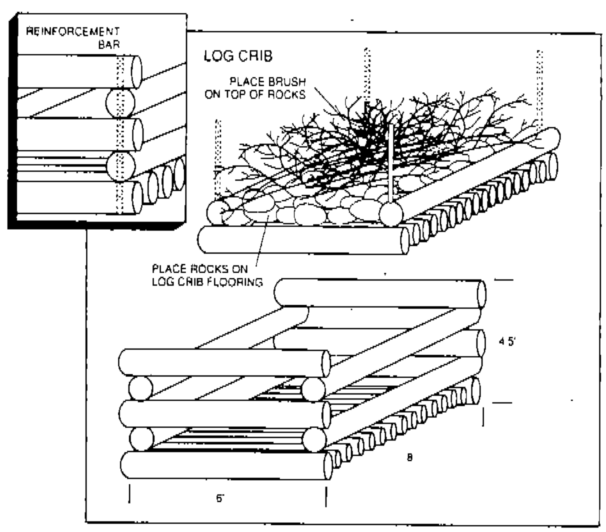
Quarry rock: Price varies locally

Building rubble: Sometimes free

7. **LOG CRIBS**

TARGET SPECIES — Walleye, bass, panfish, catfish

MATERIALS — Green oak is highly recommended because of its density and weight. If green oak is used, less rock ballast will be needed. Sapling poles can often be found in the woods, where allowable. Rebar can be bought at a building supply store.



CONSTRUCTION TECHNIQUES — (Note: this is an effective but labor-intensive reef). Two 8-foot logs 6 inches in diameter are placed 6 feet apart; two more logs are laid across the ends of the first two logs to permit an overhang of 8-12 inches. A 5/8-inch hole should be drilled in each corner where the logs overlap. A 1/2-inch piece of rebar is then inserted into the first log and bent over on the bottom side. Saplings are then fastened as a floor across the bottom row of logs. These saplings will serve as a floor for ballast rock and brush to be added later. To complete the structure, logs are laid crossways in "log cabin" fashion threaded onto the rebar until the structure reaches a height of approximately 5 feet. The logs are fastened together near the corners by the rebar which is bent over at the top and bottom. Ballast rocks and loosely piled brush are then placed into the interior of the crib. Several saplings and overhanging brush should be wired across the top of the crib to hold the interior brush in place.

If the crib is made out of dry wood, then additional ballast will be required in the form of rock or concrete block. The rock is placed in the bottom of the crib; this will require additional flooring below where the brush flooring is located.

DEPLOYMENT AND SECURING — Cribs must be built in place at extremely low water or built on a log ramp or pontoon boat and slid carefully into the water at the desired site. Because of the weight, extra care must be taken to place the crib on firm, hard bottom to avoid subsidence. In northern states, cribs can be constructed on ice. Once ice-out occurs, the crib will sink to the bottom.

COSTS —
Logs: Depends on availability
Rebar: $3.69 per 10 feet

8. PLASTICS

Structural diversity in various natural forms such as brush, logs, overhanging bank vegetation and submerged or emergent aquatic plants is highly important to adult predator fish for ambush cover. Some quantity of this structural diversity is also critical for protective cover for many juvenile and forage-fish species.

Artificial structure can be purchased ready to assemble and deploy. It can also be constructed from available materials using a little imagination and ingenuity. Some successful approaches currently in use are presented here for your project consideration.

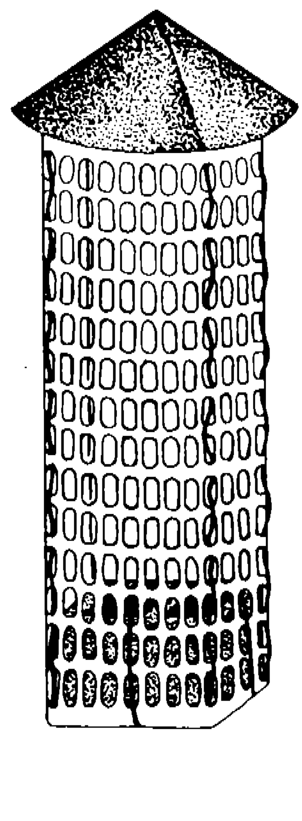
Plastic-snow fence has been used with a great deal of success in Arizona reservoirs. Fish "Condos" and "Bass Bungalows" made from it are lightweight and easily transported and deployed. The numerous openings in the snow-fencing material provide excellent escape cover for small fish.

A. *FISH "CONDOS"*

A wide variety of new and innovative plastic-reef concepts and materials have been introduced in the past 10 years. One successful reef design, used by the U.S. Forest Service's Mesa Ranger District in Arizona, is presented here as an example of the new lightweight (30 to 50 lbs.) and durable artificial reef designs being used.

TARGET SPECIES — Largemouth bass, crappie, panfish

MATERIALS — High-density polyethylene snow fence, black wire fasteners ("Zipties"), galvanized twisted wire fence stays, cement blocks for ballast. A high-denisty vacuum-formed polyethylene "hat" is required for the top.



CONSTRUCTION TECHNIQUES — A length of the snow-fence material (with 1 1/2" x 2 1/2" elongated ed holes) is formed into a 20-inch-diameter tube and held together with "Zipties." The tube is reinforced with four interwoven galvanized twisted wire fence stays to stiffen the tube and support it in its vertical position. One 16" x 16" x 4" cement block is "Ziptied" into the bottom of the upright snow-fence tube for ballast. The "hat" is "Ziptied" to the four fence stays at the top to cover and exclude predators from the interior of the tube.

DEPLOYMENT AND SECURING — Use of a barge or pontoon boat allows for fewer trips to and from the loading site. However, recreational fishing boats can be used successfully to ferry the "condos" to the deployment site. Since the cement blocks provide sufficient ballast in the condo tubes, anchoring is not required.

COSTS —

High-density polyethylene snow fence: $40-70 per 100-foot roll.

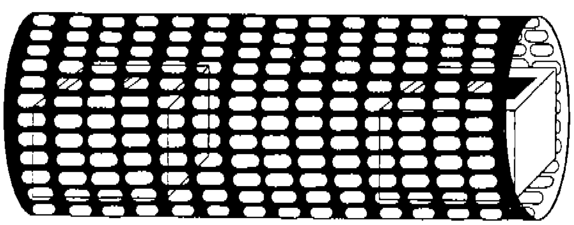
Black nylon wire fasteners (Zipties): $3.50/100 pack.

Galvanized twisted wire fence stays: $27.00/100 bundle.

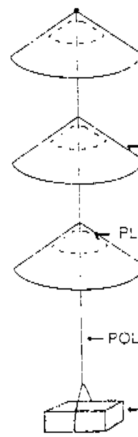
Cement blocks: $.09/each.

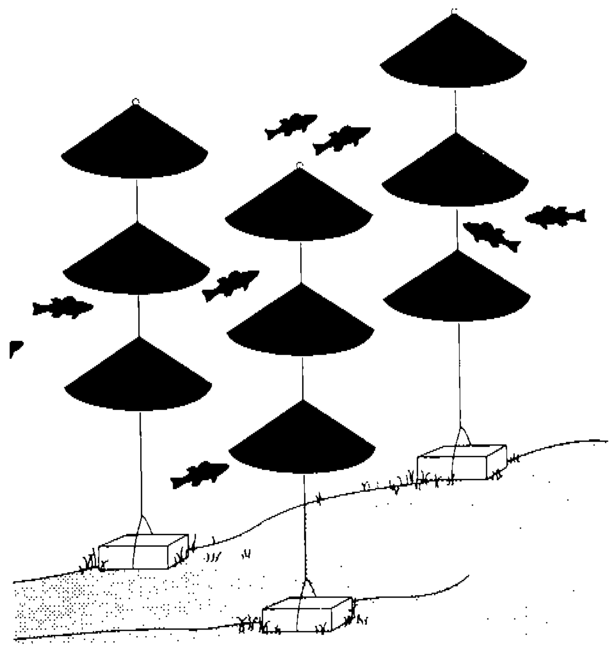
Polyethylene plastic hats: contact your local plastics manufacturer.

B. *"BASS BUNGALOWS"* — The "Bass Bungalow" is a slightly smaller diameter and slightly shorter version of the snow-fence tube used in the Fish Condo. It is rolled around and fastened to three spacer or support hoops which are nothing more than single sections cut from corrugated polypropylene pipe. The roll or tube is deployed horizontally on substrate where largemouth bass would be expected to spawn. It does not require the fence stays as stiffeners nor is it covered on either end. It does require two 4" x 8" x 16" cement blocks fastened interiorly for ballast. Its primary purpose is to provide desired escape cover for juvenile bass in the early and vulnerable stages of their life cycle.

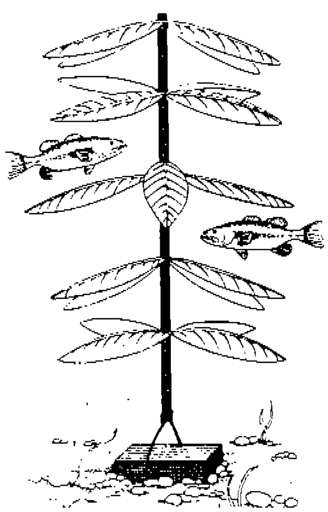


C. *"MUSHROOM HATS"* — The so-called "Mushroom Hat" is the same polypropylene plastic cover device used to cover the top of the Fish Condo. In this case it is deployed separately in a suspended but submerged configuration anchored singularly or in multiple columns at desired depths and locations. In its most simple description, the desired number of "hats" are threaded onto polypropylene rope below knots tied at the desired depths above the anchor. A block of plastic foam is threaded onto the rope immediately under the conical hat to float and suspend each hat at its desired position in the water column. Its primary purpose is to serve as ambush cover for adult predator fish near travel lanes frequented by schools of forage fish.





D. *"FISH N' TREES"** – Pradco of Fort Smith, Arkansas, markets a product known commercially as Fish N' Trees. The product functions as a submerged upright stalk with large leaf-like units every few feet which protrude in a draping horizontal position. These large leaf-like units provide the ambush cover that attracts and hides predator fish as they await their prey. The Fish N' Trees are made up of 3-foot polypropylene modular units which, when connected with fastners, make up tall plant-like units up to 28 feet long. Upright flotation and suspension in the water column is achieved through plastic foam in the stalks with some sort of anchor device needed to maintain the units in place and at the desired depths. The plant-like units can be deployed singularly or anchored in multiples to PVC frames inserted with steel rebar for ballast. These multiple units are referred to as "Fish N' Forests." These units appear to be most effective when deployed in deeper water along known migration routes of forage fish. As a general rule, these materials are sold to private parties only for use in private waters. If the materials are to be used in public waters, it is generally required that acquisition be accomplished through an appropriate state or federal agency. More information can be obtained by contacting: Plastics Research, 3601 Jenny Lind, Ft. Smith, Arkansas, 72902, 800-422-3474.



*This does not constitute a product endorsement by the Sport Fishing Institute or the Bass Anglers Sportsman Society.

VI. **Concluding Remarks**

Properly designed and constructed artificial reefs can be an invaluable asset to any fishery community. When planned and deployed with the assistance of knowledgeable biologists, these reefs can increase the available habitat for fish to spawn, feed, and hide from predators, thereby increasing the potential for a better fish community as well as better fishing. However, artificial reefs alone do not solve the entire problem of stock depletion. Anglers must continue to follow ethical fishing standards to ensure the conservation of their fisheries resources.

These standards include: (1) keep only the fish needed, (2) do not pollute – properly dispose of trash, (3) sharpen angling and boating skills, (4) observe angling and boating safety regulations, (5) respect the rights of other anglers and property owners, (6) pass on knowledge and angling skills, (7) support local conservation efforts, (8) never stock fish or plants into public water, and (9) promote the sport of angling.

Although the installation of artificial reef cover is a tool commonly used by fisheries management agencies, certain projects can also easily be accomplished by small, dedicated groups of volunteers. Artificial reef projects need not be expensive to have profound effects. Often, volunteer labor is readily available from local conservation groups, while local merchants may be willing to donate some of the materials needed for these projects. However, additional funds are often needed to supply extra materials and to cover additional expenses.

The FishAmerica Foundation is a fisheries conservation organization which can supply limited funds to volunteer groups who need them. FishAmerica was founded by members of the sportfishing industry who realized the need for an efficient way to help local groups enhance their fisheries resources. Since 1983, FishAmerica has provided over $1.5 million to 245 groups across North America that are dedicated to improving our waterways and fisheries. The Foundation has provided assistance to several artificial reef programs – both fresh and saltwater – and is looking for more high quality projects in need of assistance. If you need help with your project or would like to see if you are eligible for funding, contact FishAmerica, 1010 Massachusetts Avenue, N.W., Suite 320, Washington, DC 20001, (202) 898-0869.

For Additional Information Contact:
Sport Fishing Institute
Artificial Reef Development Center
1010 Massachusetts Avenue, N.W.
Suite 320
Washington, DC 20001
Phone (202) 898-0770

NOTES:

Anglers For Clean Water, Inc.

FishAmerica Foundation

Published by
The Sport Fishing Institute
April 1991

ACW Publication 8156-22