TABLE 3. PARAFORMALDEHYDE POND TREATMENTS OF GOLDEN SHINERS AND GOLDFISH INFECTED WITH *GYRODACTYLUS* SP.

Trial Number	Water Temp. (°F)	Average number of gyrodactylids per fish[1]						
		Before Treatment	Days following treatment 1	2	4	5	20	40
		12.67 lbs. per acre foot[2]						
1	38	50.2	25.6	11	17			
2	38	11.2	4.6	6	13.2			
3	39	34	28	27.4	31			
4	39	34	23	24	30.1			
		22.18 lbs. per acre foot[2]						
1	39	6	3.2	1	0	0	0	0
2	40	8.1	—	—	0	0	0	0
3	40	10.3	—	—	—	0	0	0
4	40	13.7	—	—	0.2	—	—	0
5	36	31.5	—	0	—	0	0	0
6	39	51.5	—	0	—	0	0	0
7	35	71	26.5	2.4	0	0	0	0
8	42	50.7	29.4	3.2	0	0	—	—
9	42	31.2	14.8	0.3	0	0	—	—
		26.7 lbs. per acre foot[3]						
1	40	98.9	11	0.8	0	0	0	

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[1] Average count per 20 fish.
[2] Golden shiners.
[3] Goldfish.

SOME EFFECTS OF CULTURAL PRACTICES ON AQUATIC ENVIRONMENTS AND NATIVE FISH POPULATIONS

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ABSTRACT

Cultural practices which either contribute nutrient materials to the ecosystem or accelerate detrition by induced recirculation of nutrients within the system result in environmental changes which persist after the practices have been discontinued. The effects of environmental modification were found to be reflected in species structure of native fish populations. The percent of centrarchids within the total population was found to occur in direct proportion to the percent of productive bottom.

Macroinvertebrate organisms used as food by centrarchids were found to be restricted to certain bottom types. These studies confirm the conclusion of Eggleton (1933) that forces inherent in the substratum itself bend and shape all other forces and thus condition the reaction of both plants and animals. The role of submersed and floating vegetation as a substrate for invertebrate organisms is discussed.

The harvest of fish as a means of reducing lake fertility (Thomas, 1965) was found to have merit. An estimated 24,352 pounds of phosphates as PO_4 was removed in the 1,151,161 pounds of fish harvested from Lake Harris, Lake County, Florida, during a 15 month population control study. Phosphorous removed from the lake in the harvested fish would have been equivalent to removing all phosphates from 91,207 acre feet of water at a 0.1 ppm concentration.

INTRODUCTION

There has been an ever-increasing need for fishery management in culturally modified habitats since the turn of the century. The increase in human population and industrial growth, combined with the relatively recent arrival of fishery science as a practiced art, has placed many biologists in the rather awkward position of having to make decisions or recommend management practices based on incomplete or fragmentary data.

A philosophy of management and management techniques gradually evolved from the archaic conservation approach of stock and protect. The pioneers of population dynamics developed methods which can be used to determine the status and condition of fish populations. In spite of the recent achievements much work needs to be done to understand many of the vital functions within the population as it relates to the aquatic environment.

The purpose of this paper is to deal with some of the effects of cultural practices, particularly those practices which influence or modify the aquatic environment and give rise to undesirable fish populations. Eutrophication caused by sewage effluents is well documented in the literature by Hasler (1947), Ruttner (1953), and many others. For this reason, the various effects of sewage effluents will be referred to only as they relate to specific items discussed.

MATERIALS AND METHODS

Benthic invertebrates: Samples of the benthic fauna were collected with an Ekman-Birge dredge measuring 6 by 6 inches. The sampler was modified by placing a sixteen mesh per inch screen at the top to prevent the escape of the more mobile forms and to sample the column of water immediately above the sample area. The contents of each dredge sample were emptied into a container where the bottom material could be examined and the type and texture of bottom sediments recorded. The bottom sediments were then transferred to a dip net with a one millimeter mesh nylon bag. The fine mud and sand was removed by moving the bag through the lake water. The contents of the bag were transferred to a one-gallon wide-mouth jar partially filled with water. Benthic organisms were subsequently sorted from debris in a white enamel pan and placed in 95 percent alcohol.

The above method has one significant source of error in that there is the possibility that some of the smaller organisms could escape from the bag as the fines were flushed. Since the larger macroinvertebrates were the principle concern, the time saved was considered to be more desirable than preserving the entire sample in formalin because the movement of living organisms made the task less tedious and made possible a greater number of samples per unit of work time.

CLASSIFICATION OF BOTTOM TYPES

Any classification of lake soils or sediments cannot help but reflect a lack of study of this very important portion of the acquatic enviroment in the past. Because of the endless variety of sediments and the number of combinations, classification of bottom types does not lend itself to a table of organization that can be used elsewhere without introducing a possibility of error in interpretation.

The classification used here is modeled after Davis (1946) and Roelofs (1944).

Homogeneous sediments:

Sand: Predominantly sand, sometimes with some organic materials. No attempt was made to differentiate grain size or the effect of size.

Calcareous gyttja: Finely divided, amorphous particles of calcium carbonate from the leaves of submersed aquatic plants; semi-suspended or soup-like in consistency; grayish in color; very little or no H_2S; effervesces freely in 0.1 N H_2SO_4.

Heterogeneous sediments:

Soft muck: Finely divided, amorphous organic matter with some fibrous materials; varies in consistency from soft to semi-suspended; black in color; very little or no H_2S.

Firm muck: Same as above except for consistency and color; compacted and resisted bite of dredge; black to gray in color; no odor; firmness suggests lower lake levels at sometime in the past.

Fibrous peat: Fibrous portions of plant remains; some parts readily distinguishable; varied from pale green to straw in color; finely divided particles of organic matter in varying amounts.

Pulpy peat: Fibrous portions of plant remains; parts not distinguishable; finely divided particles more abundant, sometimes as much as one-half; varies in color from yellow-brown to brown; often semi-fluid.

Liver mud: Gel-like, very colloidal; usually with H_2S odor.

Detritus: Fragments of wood, limbs, other coarse plant matterials which have not decayed.

Litter: Fragments of herbaceous portions of higher plants which have not decayed, parts distinguishable; contains abundant forage for scavenger organisms.

COMBINATIONS OF THE ABOVE AS INDICATED (TABLE 1).

Productive zone: The productive zone as it is used here includes the portion of the lake bottom capable of supporting or producing macroinvertebrate organisms. Samples of the bottom materials were taken at one-foot depth intervals with a 6 by 6 inch Ekman-Birge dredge along designated transect lines between two distinguishable landmarks. The offshore boundary of the productive zone was marked with one-gallon plastic jugs. The location of each jug was determined by triangulation with two transits and subsequently plotted on a map of the lake drawn to scale on graph paper. The size of the productive areas was then calculated by graphic subdivision. With the exception of Lake Apopka, all productive areas referred to herein were determined by the Polk County Arthropod Control Unit. The productive area of Lake Apopka was found to follow the perimeter of the lake except for one area of approximately 400 acres. The productive area was determined by planimeter.

Fish population studies: All fish population studies referred to herein were made by the Florida Game and Fresh Water Fish Commission. The method employed in these studies does not differ from routine population studies. Since the results of the population samples show no significant difference over the past five years, it is believed that they are sufficiently accurate for the purpose of this paper.

Chemical samples were made with 1 ppm rotenone (Nox-Fish) in a measured one-acre plot. Chemical distribution was accomplished with a venturi type boat bailer attached to the cavitation plate of the outboard motor.

A 230-Volt AC electro-shocker was used to supplement chemical samples in some lakes (Table 3) and as a singular method in two small lakes.

The fish were collected by dip net, measured in one-inch intervals and weighed to the nearest one-tenth of a pound. Combining the data of chemical samples with the electro-fishing samples appear to compliment each other because chemical samples tend to yield greater quantities of forage species while electro-fishing yields a greater quantity of bass.

INVERTEBRATES AND LAKE SEDIMENTS

The invertebrate fauna of five Florida lakes of similar geologic origin were grouped according to significant categories under each bottom type with the numbers of organisms per square meter (Table 1). It was evident that benthic organisms were confined to rather well-defined bottom types and that productive capacity varied with the degree of sedimentation. There was some indication that the physical texture or firmness of the substrate was one of the determining factors, if not the most important. Much more work needs to be done in this regard to determine whether or not this observation was real or apparent. These data do, however, clearly illustrate the effects of aging and the substrate requirements of certain invertebrates used as food by fishes.

Many problems concerning undesirable changes in native fish populations appear to begin with changes in the invertebrate fauna as a result of sedimentation of organic matter. Eggleton (1933) recognized the restrictive nature of bottom types as concerns the production of benthic invertebrates. He concluded that forces inherent in the substratum itself bend and shape all other forces and thus condition the reaction of both plants and animals.

As mentioned above, the substrate appears to be the cause of failure of most invertebrate forms as fertility increases. Water quality plays a vital role in cases of moderate and gross pollution but the substrate governs the nature of the invertebrate fauna after pollution sources have been removed. As an example, the diminution of the invertebrates in Lake Apopka, according to local opinion, was the result of pollution. Upon checking the productive area around the perimeter of the lake, only 7 percent of the 30,000 acres was found to have been productive. In two instances, the invertebrate fauna was greater in number and diversity near pollution sources than similar sample areas four miles distant. Of equal or greater importance was the fact that the invertebrate fauna thrived where a suitable substrate was present.

During normal conditions or when a lake is not required to assimilate large quantities of nutrients as a direct introduction or as an induced recirculation from within, the filter feeding chironomid larvae and oligochaetes appear to be capable of consuming much of the moribund algae as it slowly sinks to the lake floor. Algae thus combined in the feces of the above contributes to a reduction of semi-suspended organic matter. The significance of great quantities of organic detritus on the lake bottom is found in the work of Berczid (1961) where the abundance of various species was found to be related to the nature of the sediments. Larvae counts in Hungarian lakes decreased with the increase in plant detritus as it did with an increase in hydrogen sulphide or an increase in the number of snails present.

Provost and Branch (1959), in their study of chironomids in lakes of Polk County, Florida, found the algal concentration in the intestines of *Glyptotendipes paripes* was 2,500 times greater than that of the surrounding water and that the algal content of *Chironomus decorus* was greater by 100 times. Usinger and Kellen (1955) found that chironomid larvae caused a significant reduction of algal cells in sewage disposal beds. Of equal importance is the fact that the retention time of food items in the intestine of chironomids appears to be rather brief, according to Walsche (1951), and that food was consumed in proportion to individual size while defecation interval appeared to be related to phytoplankton densities.

It is evident from the above that in addition to serving as a food source for many forage species of fish, they also perform a useful if not vital function in prolonging the useful life of a basin. Although the role of the shads in this regard has not been studied, presumably, their role in the ecosystem would accomplish a similar function.

MACROINVERTEBRATES AND VEGETATION

The role of the substratum in the production of benthic invertebrates can also be demonstrated by comparing the production of invertebrates in eel grass, *Vallisneria neotropicalis,* in Lake Panasoffkee with that of the calcareous gyttja of the lake floor approximately 10 yards outside the vegetation zone (Table 2). In addition to furnishing a substrate compatible to the needs of the macroinvertebrate fauna, the submersed aquatic plants served as a suitable substrate for the periphyton which served as a food source for the invertebrate fauna. Fragments of vegetation in early stages of decay (litter) supported approximately one-third more organisms than did the living plants. Equally significant is the fact that the only noticeable difference in the lake bottom of the vegetation zone and the area immediately adjacent to the vegetation zone was the presence of litter which formed a suitable substrate for benthic organisms.

Floating vegetation such as the water hyacinth, *Eichhornia crassipes*, and the water lettuce, *Pistia stratiotes*, also support a considerable amount of invertebrate forage which can be used as a food source in lakes where the invertebrates of the benthos are scant or lacking. These plants do cause a considerable obstruction to navigation because of their fast growth capabilities. Their use as a suitable substrate for invertebrate forage may be more a topic of academic interest than of a practical nature.

The numbers of invertebrates in the water hyacinth of Lake Apopka were 25 times more productive than that of the moderately firm bottom while plants over semisuspended organic muds were 238 times more productive than the bottom muds. The water lettuce in Lake Panasoffkee had a similar capacity in production of invertebrates over organic muds similar to that of Lake Apopka above. The numbers were 61 times greater than that of the bottom muds but with less species diversity than the hyacinth.

RESPONSE OF CENTRARCHIDS TO ENVIRONMENTAL CHANGES

Any discussion of changes in percentage of composition of native fish populations as they adjust to natural environmental changes or habitat modification caused by cultural practices should be prefaced with a summary of the relationship between the fish population and the aquatic resources which sustains it.

Three basic and fundamental factors appear to determine and control the character and composition of fish populations in natural environments. They are: bottom type and the invertebrate organisms associated with each, the ratio of the area of productive bottom to that of the unproductive muds, and certain dynamic functions within the population itself. Each of these factors is important and fundamental in evaluating changes in population structure or composition but neither is any more important than its relation to the whole.

The effects of cultural practices on native fish populations in the past have been measured by percentage of composition, both as number and weight. These parameters yield an immediate value for appraisal but the results can be misleading if used as a singular basis of evaluation. The organization of fresh water fish communities, according to Larkin (1956), is characterized by the breadth of each level of the food chain rather than by a height of a pyramid of numbers. This factor alone requires that fish populations be considered as a part of the total environment rather than an idependent entity. With the exception involving acute or chronic toxicity, any significant change in population composition is likely to have its origin in the biologic system which produces and sustains the fish population. Studies of invertebrate faunas, as do fishery studies, tend to relate only to certain chemical and physical characteristics of interest to the investigating agency involved. Consequently, changes in fish populations and benthic invertebrates caused by cultural practices are only partially understood. This is particularly true of the relationship between benthic invertebrates and fish populations because most food studies record only the organisms consumed by a particular fish without giving an account of the benthic organisms from which they had been selected.

Hynes (1960) depicts a lake as a nutrient trap. This characteristic alone suggests that conditions will be ever changing as the lake ages. The gradual accumulation of cellulose fractions of phytoplankton and higher plants form an amorphous mass in the deeper portions of the lake least affected by wave action and currents. These deposits remain unnoticed until the rate of sedimentation exceeds the ability of the detritus and filter feeders to affect consolidation.

Shelford (1911a, 1911b, 1913) demonstrated the temporal nature of lakes in his study of population succession taking place in the pondlike depressions between the transverse ridges formed by glaciation near

Lake Michigan. Pioneer species of plants and animals were replaced by more tolerant forms as the ponds aged; and, as the aging process continued, these forms were replaced by even more tolerant forms. The response of plants and animals to an ever-changing environment demonstrates the applicability of Newton's Law to aquatic phenomena. Each action is indeed followed by an equal and opposite reaction.

Many of the coarse species are confined to trophic levels very much different from that of the centrarchids. This is particularly true of the gizzard and threadfin shad. The food chain of the shads is simple, short and efficient while the food chain of the centrarchids is complex and less efficient because of the greater number of steps between primary productivity and the adult. When environmental conditions preclude the conversion of phytoplankton into animal tissue of sufficient size and number to assure adequate production of forage species, no matter of management will produce a worth-while fishery.

Hubbs (1934) suggested that the ecological role of the shad appeared to be that of a connecting link between the plankton and the carnivorous fishes. Because of its complex food habits, the black crappie, *Pomoxis nigromaculatus,* is perhaps the best example of the environmental requirements of the centrarchids. Reid (1950), in his study of the food habits of the black crappie in Lake Orange, Florida, reported the diet of juveniles was predominantly entomostraca and that fish occurred with increasing frequency as the size of the crappie approached 100 millimeters standard length. Reid considered the plankton - shad - crappie food chain to be the most important in the lake. While the food chain that sustains the adult crappie population was important, the food chain that carried the juvenile crappie to a sufficient size to utilize the smaller shads was of equal or greater importance because the remainder of the centrarchid population would be dependent upon the same food source. In view of the fact that lakes with as much as 80 percent shad fail to produce more than token crappie populations or other centrarchids, it would appear that fertility would be of lesser importance than the amount of area capable of supporting invertebrate forage used as food by centrarchids. With regard to food resources, Allen (1960) concluded that the effect of food supply is directed toward determining the total quantity of fish in the population, considered as a function of both number and individual size.

There was a positive relationship between the percent of centrarchids in the total population and the percent of productive lake bottom (Table 3). The correlation coefficient of the sum of least squares (Snedecor, 1950) was 0.966. The effect marginal vegetation in older lakes and the greater diversity of species in younger lakes makes further statistical treatment of these data of questionable value.

RECIRCULATION OF NUTRIENTS AND THEIR REMOVAL

Because of the nature of biologic systems, each natural function and cultural practice has side effects which ultimately prove detrimental to the aquatic environment. As the nutrient elements of dead plants and animals return to the ecosystem, the fractions resistant to decomposition are added to the residues of previous cycles. Even the production of oxygen so vital to the ecosystem is not without cost. Gotass *et al.* (1955) found that one pound of algal protoplasm was produced with each 1.65 pounds of photosynthetic oxygen and, in spite of this benefit, an algal residue remained.

Renn (1954) found the stimulation of algal production caused by sewage, other organic wastes and their decomposition products can lead to the formation of a mass of organic matter greater than that of the original material. This result is demonstrable in the laboratory (Bartsch, 1960). From the work of Renn, and that of Gotass *et al.* above, we can assume that the control of floating and submersed vegetation or shad control can add to the accumulation of algal residues when the remains are left in the lake to decay. Although algal production resulting from the control of vegetation and shads has not been studied in Florida, an estimate of the magnitude of nutrients released to the waters can be estimated with reasonable accuracy.

An estimated 20 million pounds of gizzard shad and threadfin shad were killed in Lake Apopka during three successive treatments with rotenone beginning 1957 through 1959 (Clugston, 1963). An estimated 280,000 pounds of nitrogen and 140,000 pounds of phosphates was returned to the lake as the shads decayed (Table 4).

During the same interval, an estimated 1,180 acres of water hyacinths, *Eichhornia crassipes*, were killed by chemical treatment (Vernon Myers, pers. comm.). Nitrogen and phosphates content of the hyacinths destroyed was estimated by using two-thirds of the 150 tons per acre wet weight estimate of Penfound and Earle (1948). Since hyacinths rarely occur in mat form, the reduced tonnage of 100 tons per acre appeared to be a reasonable estimate. The dry weight was four percent of the live weight. Of this amount, the nitrogen content was 2.5 percent and phosphates was 0.2 of one percent (unpublished data). The quantity of nitrogen and phosphates returned to the water was approximately 236,000 pounds and 18,880 pounds, respectively.

The combined nutrients in the shads and water hyacinths was 516,000 pounds of nitrogen and 159,000 pounds of phosphates. Combined nutrient recirculation from the shads and hyacinths during the three-year interval amounted to 1.7 times the nitrogen and 0.88 times the phosphate estimated to have been discharged into the lake as the sewered population of Winter Garden increased from 325 in 1922 to 2,475 in 1957.

As the above suggests, the removal of fish and vegetation from a lake is as desirable as the removal of nutrient elements from treated sewage. Unfortunately, the commercial harvest of fish as a management practice has not been accepted by the public and removal of nutrients from sewage effluents is not yet within the economic capabilities of municipalities.

Thomas (1965) reasoned that the removal of nutrients from a lake in the flesh of fish was a step toward preventing eutrophication. An estimate of Thomas' Hypothesis as a potential tool is outlined below.

During the 15-month interval between April 10, 1952 and June 24, 1953, 1,151,161 pounds of game and coarse fish were harvested by commercially operated nets and 244,986 pounds of game species by sports fishermen from Lake Harris, Lake County, Florida (Freeman and Huish, no date). Nutrient materials contained in the harvested fish can be estimated applying known values of various species from other Florida lakes (Table 4). On the basis of these data, an estimated 15,580 pounds of nitrogen and 24,352 pounds of phosphates was removed from the lake during the population control study.

While this amount may not appear formidable, it does represent a significant quantity of nutrient materials which could not be otherwise removed without prohibitive costs. The significance of removing such a quantity can be illustrated in the following example:

Phosphate concentrations are known to vary between zero and three parts per million in lake waters (unpublished data), averaging about 0.1 ppm. The 24,352 pounds of phosphates bound in the 1,151,161 pounds of fish harvested during the population control study (Table 5) would be the equivalent of removing all of the phosphates from 91,207 acre feet of lake water at a phosphate concentration of 0.1 ppm. The removal of the above quantity of phosphates from the ecosystem would approximate the removal of phosphates contained in the annual untreated waste of 5,000 persons.

Nutrient materials thus removed would not cause an immediate reduction of nutrient materials in the lake water but it would serve as a deterrent to eutrophication. The extinction of a lake, according to Hasler (1947), is probably hastened by organic sedimentation to a greater degree than by inorganic processes — phytoplankton produced above settles incompletely decomposed to the bottom. Since the nutrient materials in the harvested fish do not return to the ecosystem, the rapidity of the aging process would be diminished by a reduction in phytoplankton production and sedimentation.

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TABLE 1

RELATIONSHIP BETWEEN BENTHIC INVERTEBRATES[1] AND BOTTOM TYPE IN FIVE FLORIDA LAKES

	Annelida	Chironomidae	Ceratopogonidae	Chaoborus sp.	Gastropoda	Unionidae	Hyalella azteca	Asellus sp.	Ephemeroptera	Trichoptera	Odonata	$\frac{\text{Avg. No. /m}^2}{\text{Number of Samples}}$
Sand	$\frac{832}{25}$	$\frac{47}{19}$	$\frac{422}{7}$	$\frac{86}{4}$	$\frac{603}{18}$	$\frac{108}{2}$	$\frac{652}{3}$	$\frac{43}{1}$	$\frac{99}{4}$	—	$\frac{86}{2}$	$\frac{2978}{85}$
Sand and litter	$\frac{1757}{6}$	$\frac{2166}{5}$	$\frac{43}{1}$	$\frac{283}{2}$	$\frac{202}{3}$	$\frac{87}{1}$	$\frac{109}{2}$	—	$\frac{43}{1}$	—	$\frac{43}{1}$	$\frac{4733}{22}$
Soft muck and litter	$\frac{565}{4}$	$\frac{565}{5}$	—	$\frac{43}{1}$	$\frac{2653}{2}$	—	$\frac{1159}{3}$	—	$\frac{43}{1}$	—	—	$\frac{5028}{16}$
Firm muck	$\frac{159}{4}$	$\frac{870}{5}$	$\frac{87}{1}$	$\frac{43}{1}$	$\frac{260}{3}$	—	$\frac{22}{1}$	—	$\frac{217}{1}$	—	—	$\frac{1658}{16}$
Sand and muck	$\frac{304}{1}$	$\frac{86}{4}$	—	$\frac{195}{4}$	—	—	—	—	—	—	—	$\frac{585}{9}$
Soft muck and peat	$\frac{353}{7}$	$\frac{130}{4}$	—	$\frac{221}{6}$	$\frac{130}{3}$	—	$\frac{522}{3}$	—	$\frac{43}{1}$	—	$\frac{87}{1}$	$\frac{1486}{25}$
Cal. gyttja and litter	$\frac{108}{3}$	$\frac{337}{2}$	$\frac{54}{2}$	$\frac{54}{2}$	$\frac{467}{4}$	—	$\frac{398}{3}$	—	$\frac{43}{1}$	$\frac{185}{1}$	—	$\frac{1646}{18}$
Sand and shell	$\frac{457}{2}$	$\frac{87}{1}$	—	—	$\frac{261}{1}$	—	—	—	—	—	—	$\frac{805}{4}$
Cal. gyttja and shell	$\frac{217}{2}$	—	—	$\frac{87}{1}$	—	—	—	—	—	—	—	$\frac{304}{3}$
Firm peat	$\frac{261}{1}$	$\frac{43}{1}$	—	—	$\frac{130}{1}$	—	—	—	—	—	—	$\frac{434}{3}$
Cal. gyttja	$\frac{261}{1}$	—	—	—	—	—	—	—	—	—	—	$\frac{261}{1}$

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[1] Lakes Apopka, Griffin, Henderson, Hernando, and Panasoffkee.

[2] No life was found in 21 samples of fibrous peat or in 16 samples of pulpy peat.

TABLE 2
RELATIONSHIP BETWEEN INVERTEBRATE PRODUCTION TO VEGETATION AND BOTTOM TYPE

	Lake Panasoffkee				Lake Panasoffkee		Lake Apopka	
Species	On Vegetation[1]	Cal. gyttja and litter[2]	Outside Vegetation[3]	Mid-Lake[4]	Water Lettuce[5]	Lake Bottom[6]	Water Hyacinth[7]	Lake Bottom[8]
Oligochaeta	0	0	86	258	0	43	43	43
Hirudinea	21	86	21	0	544	0	130	0
Hyalella azteca	573	430	0	0	14680	215	6503	0
Ephemeroptera	0	43	0	0	22	0	65	87
Trichoptera	64	301	0	0	43	0	0	0
Odonata	0	0	0	0	239	0	109	0
Coleoptera	0	0	0	0	87	0	174	0
Hemiptera	0	0	0	0	0	0	130	0
Chironomidae	107	602	0	0	0	0	391	174
Ceratopogonidae	21	43	0	0	0	0	0	0
Chaoborus	64	0	43	0	0	0	0	0
Gastropoda	408	430	0	0	109	0	109	0
Number/m^2	1258	1935	150	258	15724	258	7654	304

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[1] *Vegetation:* **Vallisneria neotropicalis**, depth 4 ft.; [2] Bottom type: Calcareous gyttja and litter, depth 4 ft.; [3] Bottom type: Calcareous gyttja, depth 5 ft., no litter; [4] Bottom: White, thin, soupy, calcareous gyttja, depth 9 ft., no vegetation; [5] Water lettuce (**Pistia stratiotes**); [6] Semisuspended organic detritus, depth 3 ft.; [7] Water hyacinth (**Eichhornia crassipes**); [8] Semisuspended organic detritus, depth 3 ft.

TABLE 3
RELATIONSHIP BETWEEN CENTRARCHIDS AND PERCENT OF PRODUCTIVE LAKE BOTTOM

Lake	County	Total Acreage	Percent Productive Bottom	Percent Centrarchids	Sample[2] Size	Sample[3] Method
Mirror	Polk	134	90	85.4	29	S
Deer	Polk	121	90[1]	78.8	51	SC
Eloise	Polk	1122	80	87.6	5	SC
Howard	Polk	635	75	78.5	17	SC
Cannon	Polk	338	58	55.9	7	SC
Shipp	Polk	284	47	44.0	37	SC
Idlylwild	Polk	97	15	35.0	17	S
Apopka	Orange & Lake	30000	7	16.5	-1	CN

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[1] No muck deposits were evident in sampling.

[2] Sample size — number of pounds in sample/total acreage times 100. A value of five was considered an acceptable minimum. Percent centrarchids in large lakes will require more study before sufficiently accurate estimates can be made.

[3] S - Electro-fishing; C - Chemical samples; N - Block net samples.

TABLE 4. NITROGEN AND PHOSPHOROUS CONTENT[1] OF EIGHT FLORIDA FISH

Species	Weight in Grams		Nitrogen Per cent	Phosphates Per cent	Source
	Live	Dry	Live Weight	Live Weight	
Black crappie	171.0	51.3	1.3	1.97	Lake Apopka
Bluegill	117.0	28.1	1.0	2.30	Lake Apopka
Redear	221.5	62.02	1.0	1.80	Lake Apopka
Warmouth	97.0	25.22	1.4	1.6	Lake Apopka
Gizzard shad	167.7	67.1	3.3	1.7	Lake Apopka
Golden shiner	98.0	15.68	0.6	1.4	Lake Apopka
Brown bullhead	77.7	14.76	1.37	1.5	Lake Apopka
Longnose gar	1524.1	574.1	2.6	4.9	Lake Griffin

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[1] Chemical determinations were made according to Standard Methods. 10th Edit. Amer. Pub. Health Assoc. New York. 522 pp.

TABLE 5. ESTIMATED POUNDS OF NITROGEN AND PHOSPHATES REMOVED FROM LAKE HARRIS, LAKE COUNTY, FLORIDA, FROM APRIL 1952 THROUGH JUNE 1953[1]

Species	1000 Lbs. Removed[1]	Nitrogen per 1000 Lbs. Live Weight	Phosphates per 1000 Lbs. Live Weight	Pounds Nitrogen Removed	Pounds Phosphates Removed
Black crappie[3]	87.0	11.0	19.6	957.0	1705.0
Bluegill[3]	392.25	10.0	23.0	3922.5	9021.0
Redear[3]	203.90	10.0	18.0	2039.0	3670.0
Redbreast[2]	1.80	—	—	18.0	32.4
Brown bullhead[3]	22.7	19.0	11.0	431.3	294.7
Channel catfish[2]	31.00	—	—	589.0	341.0
White catfish[2]	9.80	—	—	186.2	107.8
Longnose gar	144.10	26.0	49.0	3746.6	7060.9
Spotted gar[2]	7.50	—	—	195.0	367.5
Bowfin[3]	1.00	—	—	10.0	7.0
Gizzard shad[3]	294.30	14.0	7.0	3490.0	1745.0
	1150.35			15580.4	24352.3

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[1] From Freeman and Huish (no date).

[2] N and P unknown—lowest value in same genus used as estimate.

[3] N and P unknown—lowest known value used as estimate.

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