numbers or absent altogether, yet being abundant within the drainage, cannot acclimate themselves to withstand the high temperatures evident in this lake.

The circulation of water in Wilkes Reservoir precludes any stagnation or chemical stratification from occurring.

ACKNOWLEDGMENTS

I wish to thank Mr. Joe E. Toole, Project Leader, Texas Parks and Wildlife Department, for his guidance and counseling throughout this study. I also wish to thank Fish and Wildlife Technicians Will P. Fisher, Jr., Wayne C. Griffing, and William C. Hankins, Jr., for their help in collecting field data and conducting fish parasite examinations.

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THE EFFECTS OF THE LAKE CATHERINE STEAM ELECTRIC PLANT EFFLUENT ON THE DISTRIBUTION OF FISHES IN THE RECEIVING EMBAYMENT

By SAMMY W. BARKLEY and CARL PERRIN

Arkansas Game and Fish Commission, Little Rock, Arkansas

ABSTRACT

In 1967 the Arkansas Power and Light Company and the Arkansas Game and Fish Commission cooperated in a joint project to determine any changes in the stratification, flow pattern, and basic water quality in the lower end of Lake Catherine and in the Ouachita River below Remmel Dam as affected by the increased cooling water output and water temperature resulting from the construction of a new power unit proposed for the Lake Catherine Steam Electric Station, Hot Spring County, Arkansas. A follow-up study of the project was conducted in the summer of 1970 to obtain post-installation data to be compared to that information recorded previously in 1967. In connection with this project, nine gill netting samples were made during the period February 25, 1970 to January 16, 1971 to determine the effects of the plant effluent on the distribution of fishes within the receiving embayment.

Using five nets of varying mesh sizes, set overnight in predetermined locations, a total of eight hundred and forty-seven (847) fish were collected weighing eight hundred and twenty-six and seven tenths (826.7) pounds.

A seasonal migration of fishes was evident as a greater poundage of fishes was collected in winter samples than in summer. Individual species were graphed to show dominant fishes during winter and egress of particular species in summer.

A direct correlation could not be made between fishes present in the bay and water temperatures. The maximum water temperature was 90°F. The average temperature in the effluent receiving bay in the summer of 1970 was 84°F which is very near the optimum growth temperature for most of the native warmwater species of fish in Lake Catherine.

An obvious relationship was noted between the availability of food and dissolved oxygen concentrations to the abundance of fishes within the receiving embayment.

INTRODUCTION

With new and enlarged steam electric generation plants being constructed, additional information is needed on their effect on the environment. While considerable amount of study has been devoted to heated effluents in streams, little is available on the effect of heated effluents in lakes. Proposed expansion of the Lake Catherine Steam Electric Station which would more than double the plant's output of condenser cooling water by means of a new power unit dictated the need for an investigation of the effects of the steam plant effluent on the distribution of fishes within the effluent receiving bay.

The Arkansas Power and Light Company and the Arkansas Game and Fish Commission cooperated in a joint project initiated in the summer of 1967 and repeated in 1970. The major objective of the study was to determine any changes in the stratification, flow pattern, and basic quality in the lower end of Lake Catherine and in the Ouachita River below Remmel Dam as affected by the increased cooling water output and water temperature resulting from the additional unit.

The study consisted of daily vertical temperature and oxygen profiles at seven horizontal transects on the lower end of the reservoir, including the effluent receiving bay. Weekly chemical analyses were also conducted at each transect with determination of carbon dioxide, total alkalinity, and pH. Two continuous recording thermometers were positioned at the plant's intake structures and within the effluent bay to maintain constant temperature records.

In connection with the 1970 phase of the project, gill netting samples were made within the effluent bay to determine the relative abundance and movement of fishes into and out of the area and correlate the findings to the water quality data.

DESCRIPTION OF STUDY AREA

The Lake Catherine Steam Electric Station, located near Jones Mill in Hot Spring County, Arkansas, utilizes condenser cooling water from the lower end of Lake Catherine, a 2000-acre reservoir (Figure 1).

The newly constructed power unit has a subsurface intake fifty feet below the normal power pool elevation in the main channel of the reservoir adjacent to the intake for the other units which is located at a depth of only thirty-two feet. With all units in operation, the plant has an output of 711 million gallons per day.

The effluent of all units is discharged through two separate surface outlets into an isolated thirty acre bay with a maximum depth of thirty feet. By way of a narrow channel, the water discharge flows into one of the major bays of the lake located adjacent to the dam.

MATERIALS AND METHODS

During the period February 25, 1970 to January 16, 1971 nine gill netting samples were conducted in the steam plant bay using the following nets: 1-100 ft., 1-inch mesh gill net; 1-100 ft., 1½-inch mesh gill net; 1-200 ft., 2-inch mesh gill net; 1-100 ft., 3-inch mesh trammel net; and 1-100 ft., 3½-inch mesh trammel net.

Four samples were made during fall and winter months; five samples were made during summer months. Sample dates were as follows: February 25, 1970; June 11, 1970; June 25, 1970; July 16, 1970; August 6, 1970; August 27, 1970; October 15, 1970; November 24, 1970; and January 16, 1971.

Nets were set in late evening at locations shown in Figure 2 each time they were used. The following morning, netted fishes were sorted, weighed, and measured into two inch size groups.

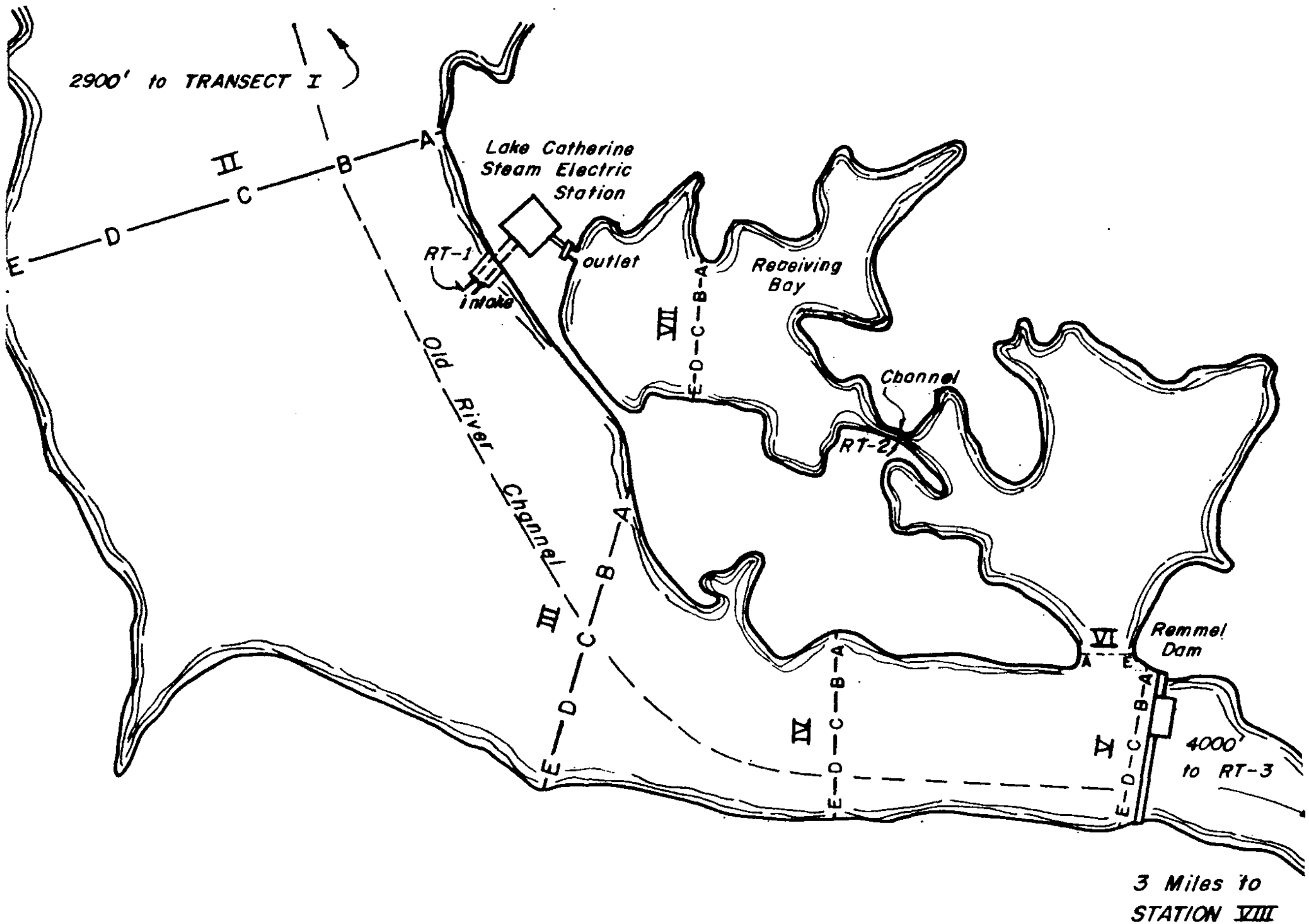


Figure 1 - Lake Catherine Study Area

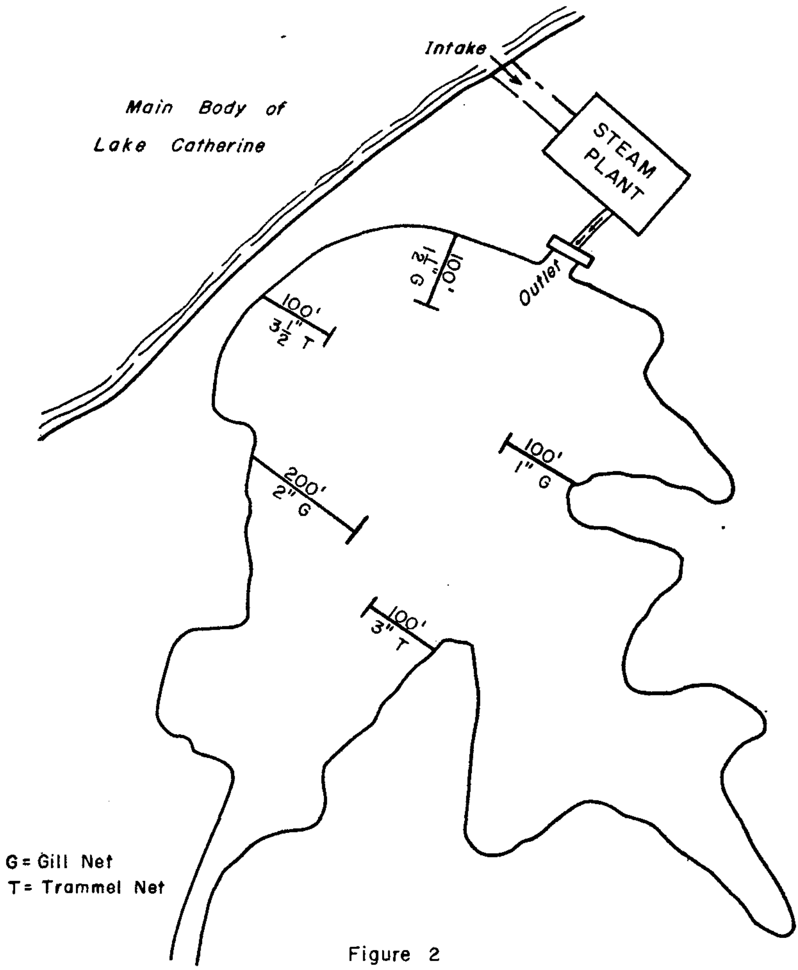


Figure 2

GILL NETTING STATIONS IN THE EFFLUENT RECEIVING BAY OF LAKE CATHERINE

RESULTS

A total of eight hundred and forty-seven (847) fish were collected weighing eight hundred and twenty-six and seven tenths (826.7) pounds.

A tabulation of the pounds of predator fishes, pounds of non-predator fishes and total pounds of fishes collected on each sample date is listed below:

Date	*Total*	*Predator*	*Non-predator*
February 25	168.7	40.1	128.6
June 11	61.6	36.8	24.8
June 25	73.4	65.4	8.0
July 16	20.4	16.8	3.6
August 6	37.0	22.8	14.2
August 27	88.9	73.5	15.4
October 15	104.7	80.8	23.9
November 24	166.2	77.4	88.8
January 16	105.8	29.4	76.4
Total		443.0	383.7

A graphic presentation of the poundage of fishes netted is shown in Figure 3; numbers and poundage of selected fishes collected per sample date is graphed in Figure 4.

Seasonal Migration—Figure 3 illustrates the definite migration of fishes into and out of the steam plant bay during different seasons of the year. Although four of the nine samples were made in fall and winter months, they accounted for over sixty-six percent of the total pounds of fish netted.

The concentration of threadfin shad, *Dorosoma petenense,* within the effluent bay during winter months provides an available food source and undoubtedly attracts most of the predator fishes into the area. Threadfin shad are sensitive to low temperatures, with high mortalities usually occurring at 45°F (Parsons and Kimsey, 1954). The effluent receiving bay prevents the shad from winter kill and may be one of the main reasons for their increase in the fish population of Lake Catherine over the last few years.

The migration pattern is demonstrated best by catches of non-predator fishes as shown in Figure 3. This is particularly true of spotted suckers, *Mintrema melanops,* which were all but absent in summer samples yet most abundant in winter netting samples (Figure 4).

Predator fishes exhibit a similar pattern with the exception of higher than expected catches on June 25 and August 27. On June 25, several large schools of shad were observed in the bay when the nets were being set; consequently, the high poundage of predator fishes collected on this date consisted mostly of white bass (Figure 4) which had moved into the area to feed on the schools of shad. On August 27, large numbers of dead and dying shad were found in the collection bay; as a result, the predator fishes collected on this date were represented primarily by an extremely high poundage of adult catfishes (Figure 4) all of which had been feeding on the dying shad.

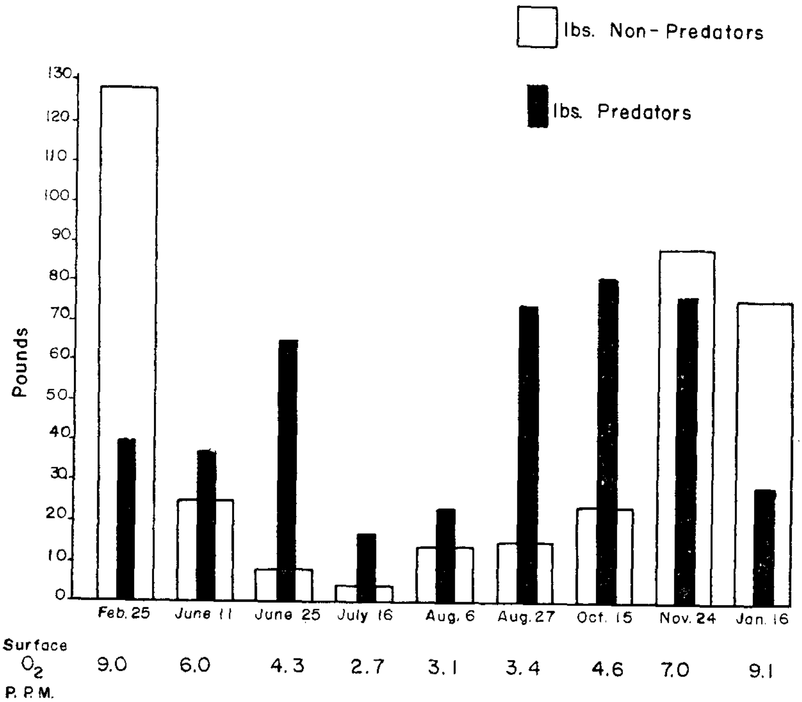
The poundage of predator fishes collected in the January 16, 1971 sample was much lower than had been expected. However, a winter drawdown of about six feet caused the water at the upper end of the channel leading into the effluent bay to be very shallow. This may have discouraged the migration of the larger predator fishes into the bay.

Temperature—The general pattern of fishes avoiding the steam plant bay during certain times in the summer could not be correlated with water temperatures.

The daily increase in water temperature from the steam plant intake to the outlet channel of the receiving bay averaged 13°F in 1970 with

Figure 3

Poundage of Predator and Non-Predator Fishes Collected in Lake Catherine Steam Plant Bay 1970-71



a maximum daily increase of 15°F. The temperature in the effluent bay was lower than the surface temperature in the main lake during the early part of the summer. By mid summer these temperatures were about the same, but during the latter part of the summer water temperatures in the bay were slightly higher than at the surface in the main lake. This was a result of the gradual increase of intake temperatures during the summer.

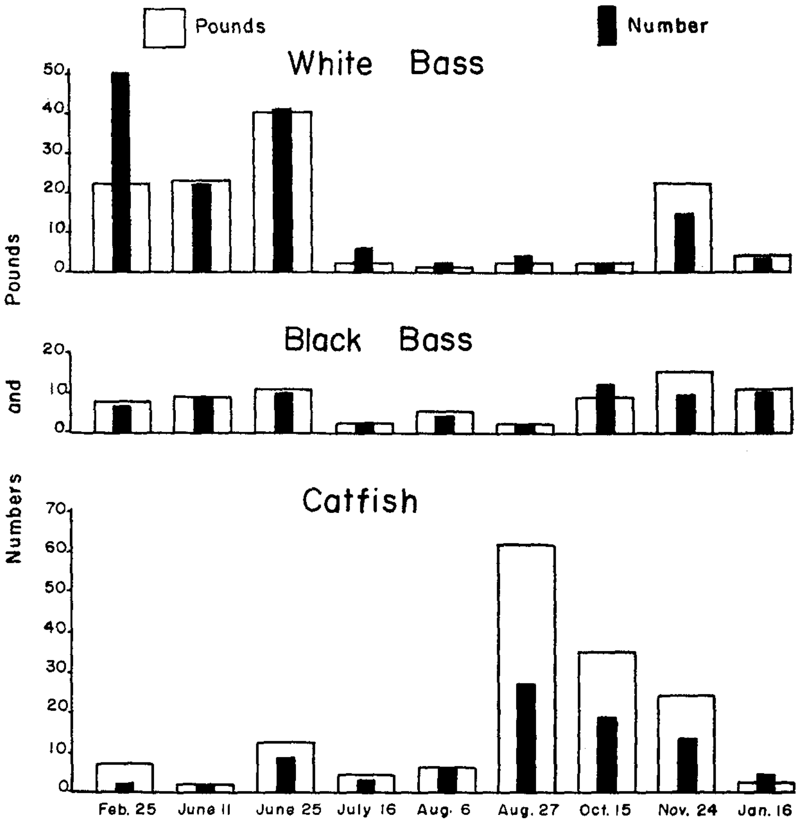
The maximum water temperature of the receiving embayment during the course of the netting samples was 90°F; the minimum water temperatures was 59°F.

Oxygen—There is an obvious direct relationship between the summer egress of fishes in the steam plant bay and dissolved oxygen concentrations. This relationship is shown in Figure 3 where the surface water oxygen concentrations in the effluent receiving bay on the dates the netting samples were made are inserted. Oxygen concentrations of February 25 and November 24 are estimations based on known oxygen concentrations in the area with similar water temperatures.

The effluent receiving embayment contains lower oxygen concentrations than other areas of Lake Catherine mainly due to the intakes' locations in the lower strata of the reservoir.

Figure 4

Numbers and Poundage of Selected Fishes Collected in Lake Catherine Steam Plant Bay 1970-71



Using dissolved oxygen as a marker, the oxygen deficient effluent water could be traced upstream at the surface and at the 10-foot level.

In 1970, the surface water at transect I was only 97% saturated with oxygen and the percent saturation declined progressively at each transect toward the effluent to 73% saturation at Remell Dam (transect V) and 49% saturation in the effluent receiving bay.

In the pre-operational phase of the study (1967), the surface waters were 100% saturated at transect IV and all other stations upstream and 58% saturated in the receiving bay.

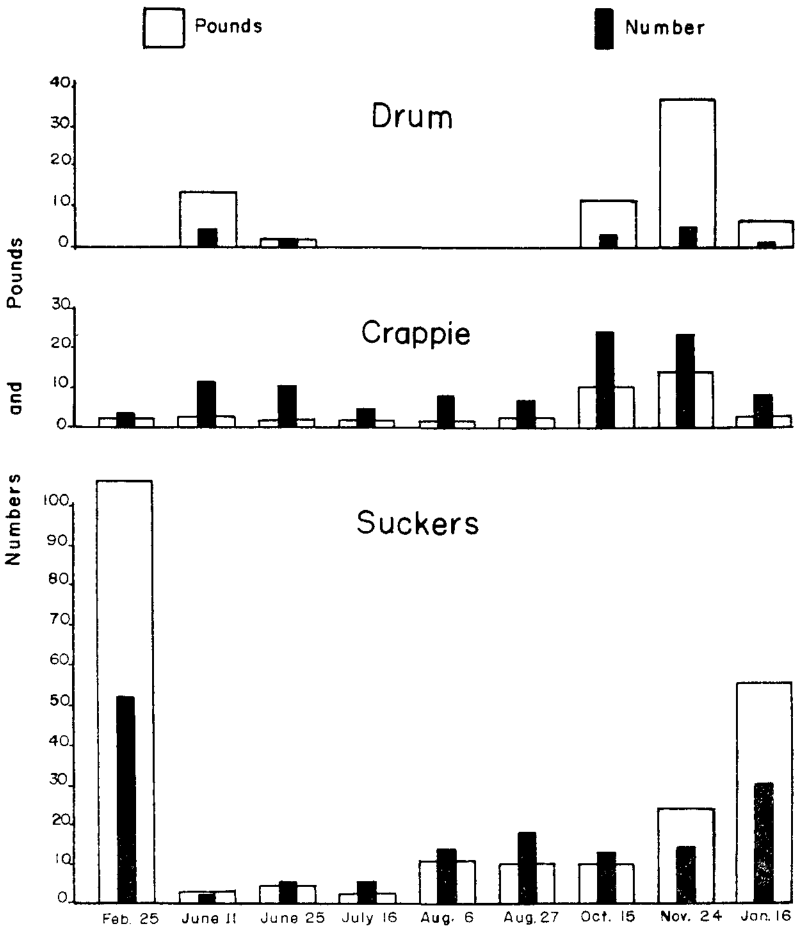
CONCLUSIONS

1. There was an obvious seasonal ingress and egress of fishes within the effluent receiving bay. A greater poundage of fishes was collected in winter samples than in summer.

2. The concentration of fishes during winter months is brought on by an abundance of threadfin shad which seek out the warm water discharge. The concentrations of shad attract predator fishes into the area and create an excellent winter fishery.

Figure 4 (cont.)

Numbers and Poundage of Selected Fishes
Collected in Lake Catherine Steam Plant Bay 1970-71



3. Other than food supply, dissolved oxygen concentration was the major factor controlling abundance of fishes within the receiving embayment. However, when an available food source occurred in the bay, numerous large predator fishes would move into the bay even at times of low oxygen concentrations.

4. A direct correlation could not be made between the distribution of fishes in the effluent receiving bay and water temperatures. The average temperature in the plant bay in the summer of 1970 was very near the optimum temperature for most of the native warmwater species of fish in Lake Catherine. However, optimum temperatures for all fishes are only a few degrees below lethal temperatures for that particular species (Mounts, 1970) and it requires only a short period of time for excessive temperatures to damage the fish population.

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FIRST REPORTED INCIDENCE OF GAS-BUBBLE DISEASE IN THE HEATED EFFLUENT OF A STEAM GENERATING STATION [1]

By DAVID J. DeMONT and ROY W. MILLER

Division of Inland Fisheries, North Carolina Wildlife Resources Commission, Raleigh, North Carolina

ABSTRACT

During the winter of 1970-71, thirteen species of warm-water fishes exhibited external symptoms of gas-bubble disease (mostly "pop-eye") in the discharge canal and cove of a steam generating station. Peak monthly incidences were 70.8, 33.3, and 23.5 percent for white bass, threadfin shad, and bluegill, respectively.

Forty-nine percent of the bluegill in excess of 4 inches were afflicted, whereas only 4.4 percent of those under 4 inches exhibited symptoms. Among the bluegill, the right eye only symptoms were more prevalent than were the left eye only symptoms at the 97.5 percent confidence level.

Dead fish, principally black crappie, observed in the discharge in February, 1971 did not exhibit external symptoms of gas-bubble disease. However, autopsies of dying black crappie revealed gas emboli in the larger vessels of the gill fragments.

INTRODUCTION

Gas-bubble disease (GBD) can occur when the blood of a fish becomes supersaturated with gases. This condition may result when a fish at equilibrium with air-saturated water is subjected to an increase in temperature, a decrease in pressure, or both. More commonly GBD develops when a fish is exposed to an environment that is supersaturated with dissolved gases.

Water can become supersaturated with gases when leaks allow the introduction of air into pumped water supplies for aquaria (Marsh and Gorham, 1905) or into gravity-fed water supplies for fish hatcheries (Harvey and Smith, 1961). Natural waters may also become supersaturated with gases. This condition, usually involving nitrogen, has been reported from springs (Marsh and Gorham, 1905; Rucker and Hodgeboom, 1953), wells (Rucker and Tuttle, 1948), streams (Harvey and Cooper, 1962) and lakes (Harvey, 1967).

If the degree of supersaturation is great enough, fishes generally exhibit external GBD symptoms which include bubbles in the integument (commonly on the head or fins) and exophthalmos ("pop-eye") caused by bubbles in the tissues behind or within the eye (Marsh and Gorham,

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