ESCAPE OF FISH OVER SPILLWAYS: MARYLAND, 1958-1960 *

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ABSTRACT

A four-pond study in Maryland indicates a great difference between ponds in loss of fish over dams. There is a strong suggestion that construction of the spillway is the important factor; fish did not spill over the older-type wooden structures as frequently as over the modern concrete ones.

A study at four ponds revealed that thousands of fish washed over the dams at two of the ponds, while at the two others there were only hundreds. Adequate explanation for the rather dramatic disparity is lacking, but speculation centers about the differences in construction of the spillways; the two high-loss dams are modern concrete structures while the low-loss dams are of the old-fashioned drop-board variety. The recent histories of the ponds coincide to some extent with the loss of fish, but not certain characteristics of their populations. Volume of flow appeared to affect escape only locally and occasionally.

The four ponds are on the Delmarva Peninsula (Figure 1) and are of the same order of size as regards area, maximum depth and average depth. The watersheds, their soils, elevations and annual rainfall are very much alike. Other observable qualities such as average temperature, length of growing season, water chemistry, fish populations, human usage, etc., are quite similar, or at least, enough so that it seems unprofitable to look in these directions for keys to the great differences in fish loss. See Table I for comparative data.

TABLE I

FEATURES PERTINENT TO SPILLWAY STUDY, FOUR MARYLAND PONDS

Physical	*Urieville*	*Wye*	*Frazier's*	*Linchester*
Area	35 acres	45 acres	40 acres	26 acres
Watershed	5020 acres	5600 acres	3060 acres	5730 acres
Maximum depth	10 feet	12 feet	5 feet	12 feet
Average depth	3 feet	4 feet	2 feet	4 feet
Water Quality				
pH (Sept. '60)	6.5	6.1	6.2	6.0
Hardness ppm $CaCO_3$ (Sept. '60)	22	18	20	14
Economic				
Neighborhood	Farmland	Farmland	Summer day camp; Farmland	Mostly farmland; few houses
Recent history	Dry for 30 years	Dry 3 years	Dry 3 months	Never dry
Usage	Fishing only	Fishing only	Swim., fishing	Swim, fish, power
Ownership	State of Md.	State of Md.	Wilmington Manor Meth. Church, Del.	F. S. Langrell
Fishing reputation	Poor	Mediocre	Mediocre	Good
Creel Census				
Fish harv. per man-hr.	0.09 in 1958	0.17 in 1959	0.43 in 1959	No census
Fish harv. per acre	1.2 in 1958	15.3 in 1959	27.3 in 1959	No census
Fishing trips per acre	3.4 in 1958	14.9 in 1959	18.1 in 1959	No census
Fish Populations				
Number of species	19	7	11	18
Age of population at spillway study	2 years	1 year	1 year	Many years
First stocked	Spring 1956	Spring 1958	Spring 1958	Many years ago

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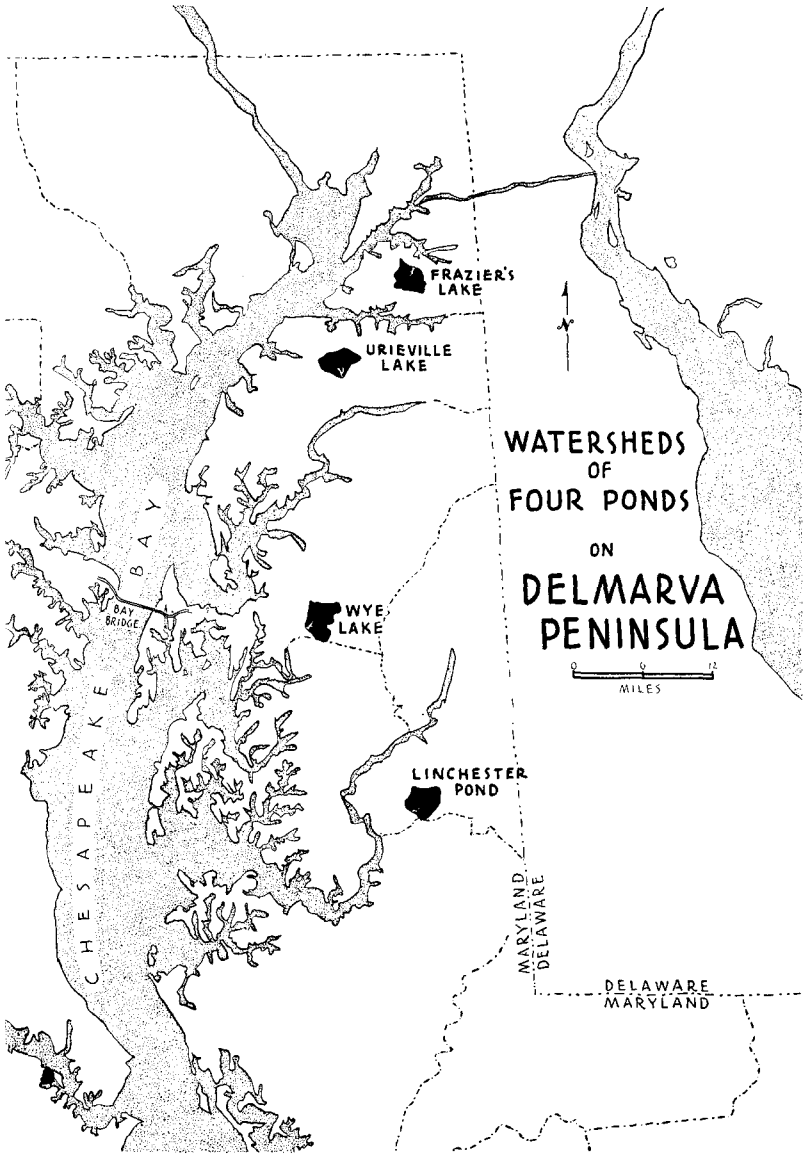

Figure 1

The study started as a result of complaints by anglers and local residents that many fish were spilling over the dam at Urieville Lake, a State-owned pond newly constructed at an old abandoned pond site. Although we felt the complaints grossly exaggerated the situation, it was decided to investigate the matter carefully and estimate the extent of the loss. Louder's paper (1958) on spillway escape appeared about this time, which not only helped stimulate the study but gave a strong indication of what to expect as regards amount of fish, season of maximum loss, etc.

METHODS AND RESULTS

A fence of heavy lumber and half-inch hardware cloth was built across the tailrace of the dam thus creating a permanent catch-box. Fish were removed from the box with a fine-mesh seine and were then fin clipped and returned above the dam. This was done at irregular intervals—every three or four days during high-loss periods, about once a week during low-loss periods.

In the first month of the study, April 1958, 517 fish washed over the dam—many more than had been anticipated. The bulk of these fish were largemouth bass,* and most of these were legal-size, catchable fish.

In the following month, 1,632 fish were found in the catch-box, including 512 largemouth. In addition, there were some repeater fish—those whose clipped fins indicated they had been over the dam once before. These fish promptly lost another fin and were returned to the lake. However, no fins were clipped for three-trippers as we were reluctant to handicap fish to that extent. By the end of operations (Oct. 31) 2,967 fish had left the lake via the spillway. Of these, 1,131 were largemouth bass. Lengths and weights of fish were not recorded except for bass, which were sorted as legal (9 inches) or sublegal. The pond was drained shortly after termination of the project and lengths and weights taken at that time were the basis for estimating that 918 pounds of fish went over the dam at least once. On a per-acre basis, this amounts to 19 pounds of bass, 3 pounds of bluegills and 4 pounds of crappies. The standing crop of these species, when the lake was drained, amounted to 3,990 pounds. By the acre: 11 pounds of largemouth, 32 pounds of bluegill and 71 pounds of crappies. Clearly, the loss of fish, especially bass, was significant.

These unexpected results prompted further study and a three-pond project was inaugurated in 1959. Because we thought it possible that the high spillover was due to the fact that we returned all fish to the lake, thus maintaining the population pressure, we planned that at two of the lakes, Frazier's and Linchester, the fish would not be returned, while at the third, Wye Lake, the fish would be treated as at Urieville. We chose Wye Lake as the one to have its fish returned because we felt the angling public were more concerned about loss of fish at Wye since it was State owned. Hindsight now tells us that we should have paired the lakes differently; dam construction, the impoundments' recent history and handling of spilled fish all correlate with the number of fish escaping over the spillways. However, a detailed examination of loss by months (Table II) indicates this fault was not too serious; if population pressure was an important factor in the spillover we could reasonably have expected a steadily increasing number of fish washing over the dam as the season progressed. This was not the case, however, as the loss of fish decreased generally as the season wore on.

The catch-box at Linchester was operated for only nine weeks because the pond was drained in late May. However, the period during which it operated coincided with the maximum loss at the two high-loss ponds so there is little doubt that, even if we had a full season's data from Linchester, it would retain its rank as a low-loss pond.

Table II gives the number of fish going over the spillways at the four ponds in 1958-1959. It can be seen that the categorization of high and low loss is very clear cut.

* Names of fishes used in this article follow recommendations of American Fisheries Society, Special Publication No. 2, 1960.

TABLE II

NUMBER OF FISH PASSING OVER SPILLWAY, BY MONTHS AND BY SPECIES, FOUR MARYLAND PONDS, 1958-1959

(Recautpred fish not included. Numbers in parenthesis are percentage of largemouth which were of legal size.)

URIEVILLE LAKE, 1958

Month	*Largemouth bass* No.	% Legal	Bluegill	*Black* Crappie	Others *	Totals
April	461	(63%)	24	27	5 WP	517
May	512	(28%)	158	962		1,632
June	112	(42%)	186	1		299
July	9	(22%)	108	58		175
Aug.	0	(0%)	47	5		52
Sept.	4	(50%)	129	30	14 Pk	177
Oct.	33	(30%)	63	14	5 Pk	115
TOTALS	1,131	(44%)	715	1,097	24 Others	2,967

WYE LAKE, 1959

Mar. (1 wk)	0	(0%)	16	..		16
April	429	(15%)	36	..		465
May	2,459	(3%)	172	..	1 Pk, 1 BB	2,633
June	474	(2%)	127	..		601
July	1,205	(1%)	191	..	1 Pk, 1 YbS	1,398
Aug.	295	(1%)	509	..		804
Sept.	24	(4%)	80	..		104
Oct.	13	(0%)	161	..		174
TOTALS	4,899	(3%)	1,292	..	4 Others	6,195

FRAZIER'S LAKE, 1959

Mar. (2 wks)	0	(0%)	0	0		0
April	0	(0%)	8	0	1 Pk	9
May	1	(100%)	2	0	2 WP	10
June	0	(0%)	0	0	2 Carp	2
July	0	(0%)	22	1	1 GS	24
Aug.	0	(0%)	2	0	1 Carp	3
Sept.	2	(0%)	71	0	2 WP, 17 Pk	92
Oct. (2 wks)	0	(0%)	44	0	1 YbS, 35 Pk	80
TOTALS	3	(33%)	149	6	62 Others	220

LINCHESTER POND, 1959

Mar. (2 wks)	0	(0%)	0	0	1 EO	1
April	0	(0%)	2	5	2 Pk, 3 GS, 2 EO, 1 YP, 1 WC, 1 Eel, 9 Minn	26
May (3 wks)	0	(0%)	1	0	2 EO, 1 Eel, 3 Minn	7
TOTALS	0	(0%)	3	5	26 Others	34

*ABBREVIATIONS:

WP—White perch
Pk—Pumpkinseed
BB—Brown bullhead
GS—Golden shiner
EO—Creek Chubsucker
YP—Yellow perch
wks—weeks
WC—White crappie
YbS—Redbreast sunfish
Minn—Unidentified minnows

The 1959 results were even more surprising than those from the 1958 project, so, figuratively, we rubbed our eyes incredulously and planned to look again in 1960. We repeated the work on Wye and Frazier's Lakes and got confirming results (Table III), so we have now concluded that the tremendous difference in loss of fish from pond to pond is real and not just a whim of chance.

TABLE III

NUMBER OF FISH PASSING OVER SPILLWAY, BY MONTHS AND BY SPECIES, TWO MARYLAND PONDS, 1960

(Recautpred fish not included. Numbers in parenthesis are percentage of largemouth which were of legal size.)

WYE LAKE, 1960

Month	Largemouth bass No.	% Legal	Bluegill	Black Crappie	Others*	Totals
Mar. (2 wks)	0	(0%)	151	..	.....	151
April	2,696	(4%)	3,731	..	98 Ale, 3 BB	6,528
May	971	(2%)	1,235	..	338 Ale	2,544
June	408	(1%)	187	..	3 Ale	598
July	38	(0%)	135	..	29 Ale	202
Aug.	71	(1%)	539	..	52 GS, 1 Pk	663
TOTALS	4,184	(3%)	5,978	..	524 Others	10,686

FRAZIER'S LAKE, 1960

Mar. (3 wks)	0	(0%)	0	0	.....	0
April	0	(0%)	4	4	4 GS, 2 Pk	14
May	1	(0%)	9	4	5 GS, 9 Pk, 3 WP, 8 Carp	39
June	0	(0%)	0	0	.....	0
July	0	(0%)	17	0	6 Pk	23
Aug.	0	(0%)	9	..	8 BB, 1 Pk	18
TOTALS	1	(0%)	39	8	46 Others	94

*ABBREVIATIONS:

WP—White perch
GS—Golden shiner
Pk—Pumpkinseed
Ale—Alewife
BB—Brown bullhead
wks—Weeks

When fish escapement is put in terms of weight (Table IV) the picture does not change materially. Total weights, except at Urieville, were calculated from large samples weighed and measured when the catch boxes were fished.

TABLE IV

ESTIMATED POUNDS OF FISH GOING OVER SPILLWAY, BY SPECIES, FOUR MARYLAND PONDS, 1958-1960

(Recaptured fish not included)

	Largemouth Sublegal	Largemouth Legal	Largemouth Total	Bluegill	Black Crappie	Others	Total	Pounds P/Acre
Urieville Lake, 1958 35 Acres	110	560	670	110	140	3	920	26
Wye Lake, 1959 45 Acres	380	160	540	100	–	1	640	14
Wye Lake, 1960 45 Acres	450	120	570	1,400	–	100†	2,100	47
Frazier's Lake, 1959 40 Acres	½	½	1	13	1	12	27	11/16
Frazier's Lake, 1960 40 Acres	*	–	*	3	1	18†	22	9/16
Linchester, 1960 26 Acres	–	–	–	*	*	3	3	2/16

* Less than ½ pound.

† Estimated.

WATER FLOW

The tables indicate that the greatest loss is in the spring of the year, especially May. Peak flows of water, which usually occur in the spring, may be an important factor in fish loss. (Of the bass leaving Wye Lake in July, '59, 82 percent left during the high water from a single heavy storm.) Data is not available for comparing rainfall of the four watersheds, but since the lakes are

so close together, it is almost certain there were only minor differences. Therefore, it seems that water flow fails to account for the differences in fish loss beween the two types of ponds, although it probably explains much of the day-to-day variation at any individual pond. In 1960 the field men were instructed to record recent weather and water flow on their data sheets. Their notations for Wye Lake appear in Table V; it will be seen that there is only a fair correspondence between water flow and fish escapement. (Compare entries for April 6 and 19, May 10, June 29 and July 13.)

TABLE V

WEATHER AND WATER-FLOW COMMENTS ON FIELD-MEN'S DATA SHEETS, SPILLWAY STUDY AT WYE LAKE, MARYLAND, 1960

Date		*No. Fish in Catch Box (Includes Recaptures)*	*Remarks*
Mar.	18	0	"Catch box installed Mar. 15. Water exceptionally high."
	24	0	(No comment)
	31	154	(No comment)
April	6	1,999	"Heavy rain for 2 days. Water 7 inches high over spillway."
	7	1,520	"Water about 1 inch above normal."
	12	74	"Water level normal. No rain since 7th."
	14	585	"Water level normal. Great numbers of LMB in catch box."
	19	1,391	"Water level normal. No rain during this period."
	22	274	"No rain this period. Normal flow."
	26	511	"Flow normal over last period."
	28	140	"Very light rainfall 2 nights previous."
May	3	82	"No rise in flow of water."
	6	121	"No rain, flow normal."
	10	1,241	"Heavy rains over week-end caused 3-inch raise in level."
	13	304	"Water flow above normal due to previous rains."
	18	462	"Light rain but did not raise lake level."
	25	572	"Flow normal. Few small showers preceding."
June	8	215	"Screens were out previous week due to extra heavy rains."
	15	367	"Level high one night due to heavy rain."
	23	153	"Light rains during past week."
	29	27	"No rain during this period."
July	5	16	"Recent weather hot and dry."
	13	27	"Heavy rains over week-end brought water level up approximately 4 inches, but no increase of fish over spillway."
	21	7	"Catch box out 3 days due to trash. No rain since replaced."
	27	179	"Very little rain over this period."
Aug.	3	65	"Lake up 12 inches due to extra heavy rain, catch box overflowed due to trash."
	10	17	"Catch box overflowed part of time. Trash on screens."
	16	140	"Catch box overflowed. Duckweed and trash on screens."
	24	149	"Catch box overflowed. Duckweed and trash on screens."
	30	324	"Impossible to keep screen clean. Part of box removed."

POND HISTORIES

Urieville Lake was built in 1955 by the Maryland Department of Game and Inland Fish jointly with the Maryland State Roads Commission when Highway 213 north of Chestertown was improved. The new road forms the dam, and the water covers the site of an old pond which had fallen into disrepair about 30 years ago. After the new pond was constructed, adult largemouth and bluegills were planted (see Table VI) and fishing began in the spring of 1956. Fishing was not very good that year and many complaints were heard. Most of these were from people who had seen fish going over the dam and were sure that all the fish had washed downstream. In November of 1958, after the spillway study had ended, the pond was drained and 5,600 pounds of fish of 19 species were recovered (see Table VII).

Frazier's Lake (low loss) was drained in 1957 (standing crop of 458 pounds per acre, of which 350 were in carp) and stocked with bass, bluegills and striped bass (experiment) in 1958. In 1959 the spillway study was started.

TABLE VI

FISH STOCKED IN FOUR MARYLAND PONDS, BY SPECIES, 1956-1960

Pond	*Year*	*Largemouth*	*Bluegill*	*Others*
Urieville	1956	941	1,500	5,000 *
				500 **
	1957	275	0	0
	1958	200	0	0
Wye	1958	2,479	2,012	0
	1959	1,066	554	0
	1960	0	0	668 ***
Frazier's	1958	470	0	100 †
	1959	200	0	0
	1960	0	0	6 ‡
Linchester	1957	100	0	0
	1958	300	0	0
	1959	178	0	0

* Redbreast sunfish ** Smallmouth bass (fing.) *** Alewife
† Striped bass ‡ Chain pickerel

TABLE VII

STANDING CROP OF FISH IN TWO MARYLAND PONDS, 1958-1959

URIEVILLE LAKE (High Loss) Drained Nov. 1958		LINCHESTER POND (Low Loss) Drained May 1959	
Species	*Pounds*	*Species*	*Pounds*
Black crappies	2,500	Bluegills	820
Goldfish	1,200	Largemouth bass	600
Bluegills	1,100	Black crappies	570
Largemouth bass	390	Creek chubsuckers	150
White suckers	150	Pumpkinseeds	32
Creek chubsuckers	100	Chain pickerel	14
Brown bullheads	80	Golden shiners	10
Golden shiners	20	Yellow bullheads	5
Eels	15	Eels	5
Pumpkinseeds	14	Brown bullheads	3
Redbreast sunfish	4	White catfish	3
White perch	3	Yellow perch	1
Redfin pickerel	1	Mud sunfish	*
Gizzard shad	1	White crappies	*
Mudminnows	*	Pirate perch	*
Yellow perch	*	Redfin pickerel	*
Smallmouth bass	*	Tadpole madtom	*
Bluespotted sunfish	*	Eastern mudminnows	*
Tadpole madtom	*		
TOTAL	5,600	TOTAL	2,200
Pounds per acre	158	Pounds per acre	84

* Less than ½ pound.

Wye Lake (high loss), a mill pond perhaps 200 years old, was purchased by the State in 1954. Shortly after, Hurricane Hazel arrived and the control structure, which was in a bad state of repair, was washed out. Two years later construction began on a new dam and spillway, the pond lying empty during 1955, 1956 and 1957. In 1958 it was stocked with largemouth and bluegills and fishing began. In 1959 the spillway study started. Some difficulty was experienced with maintenance of the catch box at Wye Lake; floating material in the form of duckweed and old smartweed stems tended to clog the mesh during midsummer. In 1960 the problem was especially severe and during much of

August the water overflowed the catch box (see Table III), presumably carrying with it hundreds of fish. It is felt that the recorded loss of 663 fish is much too low for that month.

Linchester Pond (low loss) is an old mill pond, exact history unknown, but the mill which it powers is still operative. It has an excellent reputation for largemouth fishing. The spillway study was terminated after only nine weeks when the pond was drained because an adjacent road had to be relocated. When the study was planned it was thought the road work would not start until fall. Table VII shows the amount of fish found in the pond when it was drained.

These brief histories show some correspondence with fish loss, although the relationship is by no means convincing as there seems to be no explanation of the mechanics behind the losses. Urieville (high loss) and Wye (high loss) were dry for some time before they were reflooded, while Frazier's (low loss) was dry for no more than three months and Linchester (low loss) had not been dry at all in recent years.

Wye (high loss) and Frazier's (low loss) both started with new populations in 1958—Table VI shows the stocking each received—so their populations were in their second year when their spillway studies were conducted. Fish populations were restricted to seven species at Wye (high loss), 11 at Frazier's (low loss), 18 at Linchester (low loss) and 19 at Urieville (high loss).

The standing crop at Urieville (high loss) was twice as high per acre as at Linchester (low loss) but we have only these two lakes for comparison. However, if fishing success depends on the standing crop, then low-loss Frazier's Lake must have been much heavier populated than Urieville or Wye, for fishing was twice as good. See Table I, creel census.

DAM CONSTRUCTION

The one factor which correlates conspicuously with fish loss is the construction of the dams. The spillways of Urieville (high loss) and Wye (high loss) are concrete structures built on the upstream side of the dam in the shape of a box with the top and one side missing (Figure 2). The water spills over the top of the three sides on to a concrete apron (the bottom of the box) and then flows under a bridge and joins the stream below. This type of construction allows for such a very long spillover ledge that no emergency spillway is needed.

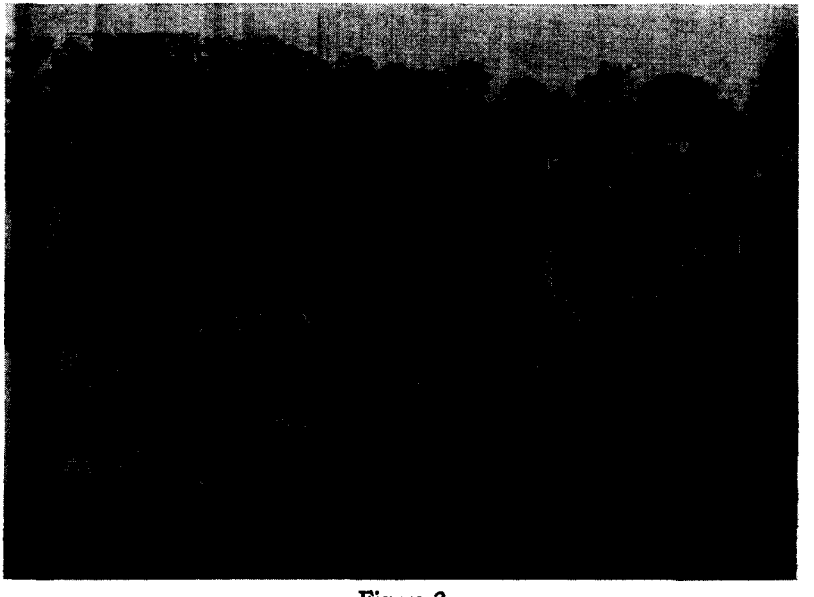

Figure 2

For instance, the box in the dam at Urieville Lakes measures 27 by 53 feet to provide a total spillover length of 107 feet. The Wye Lake spillway is 20 by 35 feet, the equivalent of a 75-foot spillway. The water flows over the dams nearly in laminar flow—because the concrete is shaped to approximate the natural curve which the bottom surface of a sheet of water would form when flowing over a lip (Figure 3a). The water flows smoothly on to the concrete apron or into the water which is backed up to both dams by the tide. (At Urieville the apron is dry at low tide.)

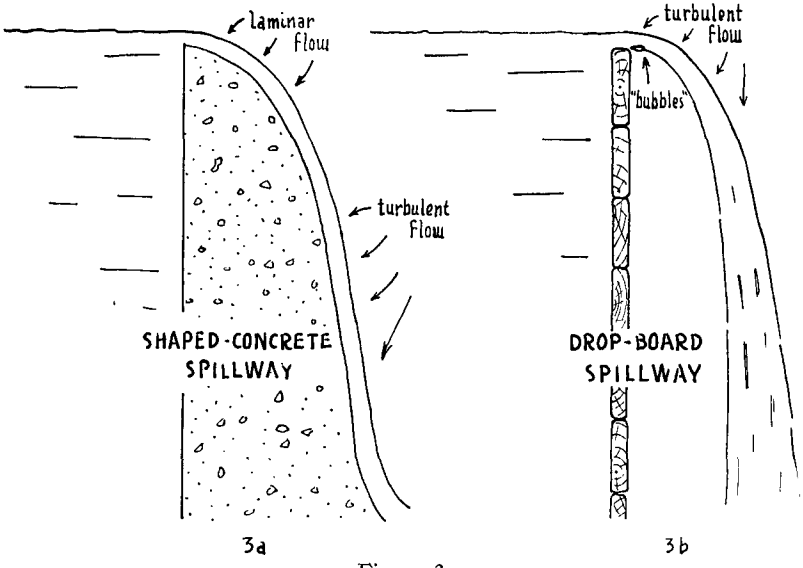

Figure 3

The control structures at Frazier's and Linchester (both low loss) are made of wood and have drop boards which hold back the water. Frazier's has a spillway width of 16 feet while Linchester's is about 18 feet. Frazier's water splashes on concrete or into water at high tide, while Linchester's splashes on a wooden platform. In neither lake is the lip of the spillway contoured.

OTHER STUDIES

Loss of fish over spillways has been studied on at least three other occasions. At Carbondale, Illinois, Darrell Louder (1958) installed a catch box made of ¼-inch hardware cloth which sieved 1/3 of the water leaving 160-acre Lake Murphysboro. He reported 3,394 fish in the catch box in three seasons, from which an estimate of 10,182 escaped fish can be made. The lake lost 47 fish per acre in 1955 (Table VIII), but its three-season average was 21 per acre—fairly close to the level of Maryland's low-loss ponds.

Louder also studied fish loss from 1,200-acre Little Grassy Lake during 1955. It was estimated at 655 fish, about 0.6 fish per acre. However, the catch box was made of one-inch wire netting which probably did not retain the majority of the small fish, so the estimated loss per acre is almost certainly a minimum.

At 1,500-acre Lake Loramie, Ohio, Clark (1942), collected fish in a catch box below one of the 11 sections of the spillway. An estimated 57,408 fish spilled over the dam in two seasons for a loss of 19 fish per acre per season. The wire netting used for the catch box was one-inch mesh so, again, the estimate is probably a minimum.

There are important size differences between these lakes and the four Maryland ponds which must be considered when comparing data. Not only do they

TABLE VIII

NUMBER OF FISH GOING OVER SPILLWAY, PER ACRE, PER SEASON, BY SPECIES, SEVEN IMPOUNDMENTS IN MARYLAND, ILLINOIS AND OHIO, 1940-1960

	Largemouth Bass	*Lepomids*[1]	*Crappies*[2]	*Clupeids*[3]	*Others*[4]	*Total Fish Per Acre*
Urieville Lake, 1958	32	21	31	–	*	85
Wye Lake, 1959	109	29	–	–	*	138
Wye Lake, 1960	91	121	–	10	*	223
AVERAGE	100	75	–	5	*	180
Frazier's Lake, 1959	*	5	*	–	*	6
Frazier's Lake, 1960	*	1	*	–	1	2
AVERAGE	*	3	*	–	*	4
Linchester Pond, 1959	–	*	*	–	1	1
Lake Murphysboro, 1954[5]	9	3	–	–	*	12
Lake Murphysboro, 1955	27	20	–	–	*	47
Lake Murphysboro, 1956	2	1	–	–	1	4
AVERAGE	13	8	–	–	*	21
Little Grassy Lake, 1955	*	*	–	*	*	1
Lake Loramie, 1940[6]	*	4	2	22	2	29
Lake Loramie, 1941	–	2	2	4	2	9
AVERAGE	*	4	2	13	2	19

* Less than ½.
1 Mostly bluegills, but also redbreast, redear, green and orangespotted sunfish and pumpkinseeds.
2 Black and white crappies.
3 Gizzard shad and alewife.
4 Various suckers, minnows and catfish.
5 From Louder (1958)
6 From Clark (1942).

differ greatly in area, but the water-flow patterns are very dissimilar. The Maryland ponds spill over their dams all year (except during very prolonged drought) while Murphysboro spilled for only 167 hours in 1954, 1,152 in 1955 and 418 in 1956. Little Grassy spilled for 885 hours in 1955 and Lake Loramie for 78 days in 1940 and 59 days in 1941.

The species composition of the fish populations do not differ as markedly as might be expected. All are typical warm-water populations, with largemouth bass, bluegills and golden shiners occurring in all seven ponds. Pumpkinseeds and black crappies occurred in five ponds each and white crappies, yellow bullheads and brown bullheads in four each.

Both Louder and Clark noted that the most common species in the lake were also the best represented in the catch box. The one Maryland pond, Urieville, where sufficient pertinent data is at hand, seems to agree, in general, with these observations. It is worth pointing out that largemouth have a tendency to be better represented in the catch box than in the lake, and, at the other extreme, goldfish, golden shiners, warmouth and, in two cases out of three, white crappies, seem to prefer to stay in the pond. Table IX has been prepared to demonstate this.†

† Linchester Pond has been omitted from Table IX because the numbers in the catch box were too small to have validity when ranked. Wye and Frazier's, of course, were not drained after their spillway studies, so we do not know how their species ranked.

TABLE IX

RANK, BY NUMBER, IN LAKE COMPARED WITH RANK IN CATCH BOX OF MOST COMMON SPECIES, FOUR PONDS IN MARYLAND, ILLINOIS AND OHIO, 1940-1958

	Rank in Lake	*Species*	*Rank in Catch Box*
Urieville Lake, Md., 1958 **	1	Bluegill	3
	2	Black Crappie	2
	3	Goldfish	*
	4	Largemouth	1
	5	Golden Shiner	*
Lake Loramie, Ohio, 1941-42 †	1	White Crappie	3
	2	Gizzard Shad	1
	3	Bluegills	2
Lake Murphysboro, Ill., 1955 ‡	1	Bluegill	3
	2	Largemouth	1
	3	Redear Sunfish	2
	4	White Crappie	*
	5	Warmouth	*
Little Grassy Lake, Ill., 1954-55 ‡	1	Gizzard Shad	1
	2	Carp	2
	3	Longear Sunfish	6
	4	Bluegill	4
	5	White Crappie	*
	6	Largemouth	3

* Did not occur in catch box.
** Rank in lake determined from draining shortly after spillway study.
† From Clark, 1942. Rank in lake from test-net data over 4-year period.
‡ From Louder, 1958. Rank in lake from data gathered by electric shocker, wire baskets and gill nets.

COMMENTARY

In summary, we are not certain why two of our Maryland ponds lose fish in such great numbers while the other two do not. The physical and chemical set-up of the lakes is remarkably similar as are the populations of fishes. Recent history shows a correlation in that the high-loss ponds were empty for a longer time than either of the low-loss ponds, but it seems impossible to go any further with that line of thought. It is only in dam construction that we have a good, clear-cut correlation. The dams are so very different—as different as the number of fish which pass over them—that it is the most obvious place to look for an explanation.

An hypothesis which, it seems, cannot be invalidated on a *priori* grounds is that a sound is produced at the wooden dams which stimulates an avoidance reaction in fish and which is not produced at the concrete structures.

A probable source of sound is the turbulence at the lip of the spillway. Under good conditions this turbulence can be seen. It appears as small "bubbles" on the undersurface of the sheet of water at the edge of the boards where it starts its free fall (see Figure 3b). These are not true bubbles, but rather indentations in the surface such as appear behind rocks in a rapids. At flows an inch or two deep these measure up to an inch long but at a flow of eight inches they are very much elongated, appearing as streaks. I have seen these turbulence pockets not only at the wooden dams, but at a square-lipped concrete dam and at a waterfall.

In the smooth laminar flow at the shaped-concrete structures these pockets are absent, or almost so, until the water has slipped down three or four feet of spillway surface (see Figure 3a).

The "bubbles" are located so they can be seen by fish only when the fish is close to the surface and close to the dam, although their reflections probably can be seen at a somewhat greater range. However, they would not furnish a visual stimulus in turbid water or in darkness and, at best, could be seen for only a few feet. It seems that sight of the turbulence pockets may almost be ruled out as a factor in prevention of escape.

The hypothesis can be tested. I suggest a continuous-tape recording of the suspected sound at a low-loss dam and playing it back at a high-loss dam. If the recording were played on a week-on-week-off schedule it would soon become apparent whether or not the sound was warning the fish. The greatest technical difficulty of such a test would lie in recording and playing back the sound with adequate fidelity.

Another test would be possible if a replaceable lip could be made that would produce a laminar flow at a wooden dam or a turbulent flow at the concrete dams. This would have to be installed and removed easily and used on a week-on-week-off schedule. This would not prove that it is sound that repels the fish but it would show whether something about the contour of the lip was a factor in escape of fish.

I believe the findings of this study have extreme practical importance. Reservoirs of all sizes are being constructed at an increasing rate and if shape of spillway is an important factor in fish loss, it would seem prudent to learn all we can about it before building new dams.

Future researches would best be directed at answering the following questions: (1) Is shape of spillway the most important factor in fish loss as the Maryland results seem to show? If so, (2) is it sound that is the causative agent?, and (3) is escape of fish an important factor in fish management? Fish spilling over a dam may be desirable—it may be one way of keeping overabundant populations in check. On the other hand, fish that go over a dam are not available to the lake's fishermen.

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It must be obvious that this study could not have been made without competent and willing field workers. These people were furnished by the Maryland Department of Game and Inland Fish and were ably supervised by Guy S. Rogers, regional fish manager for the area. I am beholden to them.

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RESULTS OF SAMPLING THE FISH POPULATION OF AN 88-ACRE POND BY ELECTRICAL, CHEMICAL AND MECHANICAL METHODS

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A comparison of four different gear for fish sampling was conducted in the summer of 1959 as part of Maryland's federal aid to fisheries program F1OR.

The tests were made at Big Pool, an 85 acre section of the Chesapeake and Ohio Canal which is land isolated from other watered sections. It is located 15 miles west of Hagerstown, Maryland. The average depth is 5½ feet, the maximum 14 feet.

Total hardness of Big Pool water was measured as 122 p.p.m. $CaCO_3$. The pH varied from 6.8 in the swampy northern end to 7.2 in mid-lake. Turbidity measurements using LaMotte standards were from 60 to 100 p.p.m. silica. Motorboating causes unusual wave action and resultant high turbidities along the immediate shoreline. (See Figure 1.)

Age and growth analyses revealed a stunted population of carp, white perch, crappie and bluegill (Sanderson, 1960)*

* Nomenclature from American Fish. Soc. Spec. Pub. No. 2, 1960.