NUREG-0754

Impact of the 1979 Accident at Three Mile Island Nuclear Station on Recreational Fishing in the Susquehanna River

Manuscript Completed: January 1981
Date Published: March 1981

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ABSTRACT

Dynamics of the recreational fishery of the Susquehanna River near Three Mile Island Nuclear Station during the postaccident year of 1979 are compared with those of the 5-year preaccident period 1974-1978. Monthly and annual fishing efforts essentially were normal during 1979. Harvests and indices of harvest success were at record low levels for 5 months (and on an annual basis) after the accident. The monthly harvest indices gradually improved with time until normal levels were attained during the sixth postaccident month (September). The depressed harvests did not result from water quality, ecological, or radiological causes attributable to the accident. Changes in angler harvest behavior and low retention rates for all the major fishery species were the major contributors to the poor harvest of 1979. Those changes were attributed to the anglers' awareness of the accident and to their concern with or perception of reduced environmental quality (of the river) and fish quality after the accident. The gradual recovery of the monthly harvest indices to normal levels followed the same general trend as the perception of threat and concern with emissions felt by the people living near Three Mile Island. Although the 1979 annual harvest was poor and most of the fishing year was disrupted (in terms of monthly harvests), recovery during the same year along with normal levels of fishing effort suggest that the accident-related effects on the fishery were temporary.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

Appreciation for review and comment on this manuscript is acknowledged: Ronald L. Ballard, Charles W. Billups, Thomas D. Cain, and Robert B. Samworth. The Technical Information and Document Control Division provided editorial, graphics, photography, and production services that led to the printed version.

IMPACT OF THE 1979 ACCIDENT AT THREE MILE ISLAND NUCLEAR STATION ON RECREATIONAL FISHING IN THE SUSQUEHANNA RIVER

EXECUTIVE SUMMARY

Roving creel surveys of the recreational fishery of the Susquehanna River in the vicinity of Three Mile Island (TMI) have been conducted on a continuous basis since in 1974. Thus, data are available for five preaccident years (1974-1978) and for the postaccident year of 1979. This paper, a followup to the initial assessment contained in NUREG-0596, assesses how the TMI event affected the fishery during the postaccident year and compares 1979 data with similar data of the five preaccident years.

The Preaccident Fishery

The recreational fishery of York Haven Pond of the Susquehanna River is a predominantly local weekend fishery. Most of the anglers consume all (or at least some) of their harvest. Most of the anglers reside within the counties bordering on or nearby the river in the vicinity of Three Mile Island.

Most fishing is done from boats for smallmouth bass, rock bass, channel catfish, and sunfishes (redbreast, pumpkinseed, bluegill). The "fishing year" on the pond extends from April through November; at other times fishing depends heavily on weather and river-flow conditions. Fishing effort, greatest during summer and early fall (June-September), peaks during June after smallmouth bass season opens. During summer, the pond is the most heavily used of the several fishing areas on the river in the TMI vicinity.

On an annual basis, estimates of catch indices and harvest indices of fishing success were correlated significantly with levels of fishing effort. Although higher total catches and harvests occurred during years of higher effort and lower catches and harvests were reported during years of lower effort, higher indices of fishing success (catch and harvest per hour of fishing effort, harvest per fishing trip, and the retention rate) occurred during years of low fishing effort, and low indices occurred during years of high effort. Of the five preaccident years, 1976 appears to have been the most unusual fishing year. The catch during 1976 was overwhelmingly dominated by one species, smallmouth bass, for which the retention rate was extremely low. As a result, 1976 was a naturally poor fishing year in terms of total harvest and the indices of harvest success.

The Postaccident Fishery

Fishing effort on York Haven Pond essentially was normal during 1979. At other nearby fishing areas on the river, fishing effort increased and was at a 5-year-high annual level at one location downstream of TMI.

With respect to catches and harvests on the pond, 1979 appears to have been an abnormal fishing year, similar to the naturally anomalous year of 1976 in its deviation from the preaccident norm. However, 1979 produced harvests and indices of harvest success at record low levels below those of 1976. For several months after the accident, the indices of harvest success were at record low levels. Nearly full recovery occurred by July, but normal values for all indices were not reached until September, 6 months after the accident. No other year had such across-the-board low retention rates for all the major fishery species of the pond. The harvest reductions might have been influenced in part by low abundance of some fish species, but the overall poor retention rates and patterns of record low monthly harvest indices that gradually improved with time following the accident cannot be explained by biological or population abundance alone.

Effects of the Accident on the Fishery

The required quality of thermal and chemical effluents was not affected by the accident. The effluents were maintained within the limitations imposed by the National Pollutant Discharge Elimination System (NPDES) authority (Commonwealth of Pennsylvania) and were within the bounds of those assessed during National Environmental Policy Act (NEPA) reviews prior to TMI Unit 2 operation. Similarly, liquid radiological releases to the Susquehanna River remained within the limitations imposed by U.S. Nuclear Regulatory Commission (NRC) technical specifications. Measurements of radioactivity in river fishes and other biota for several months following the accident showed no incremental or discernible levels that could be attributed to discharges from TMI. Dose-to-man estimates from eating river fishes that were caught after the accident were well below NRC limitations for protection of the public. Postaccident studies and assessments have confirmed the absence of ecological or population impacts to river fishes and biota attributable to the accident. Therefore, the abnormal fishing year of 1979 was not the result of of any changes in water quality, ecological balance, or level of radioactivity that could be attributed to the accident.

During 1979, about 65% of the anglers reported that they ate their harvest (or at least some of it) and 35% did not eat it (they released what they caught or gave it away). Overall during 1979 (in all creel survey areas, including the pond), 5.8% of the anglers who responded to questions reported that before the accident they ate their harvest (or some of it), but refrained after the accident. Of the anglers who released or gave away all of their catches and harvests, about 18% stated that before the accident they ate all or some of their harvests. A Pennsylvania Fish Commission waterway patrolman noted a greater than normal proportion of the fishes caught (unquantified) were returned to the pond after the accident. Such changes in angler behavior and low harvest retention were the major contributors to the record low harvest success and abnormal fishing year of 1979.

The postaccident depression in monthly fishing harvest indices and a nearly full recovery by July followed the same general trend as the perception of threat and concern with emissions felt by the general public living near TMI. Public concern was greatest during the accident, but by late July had decreased relative to levels during the accident. Ninety percent of the persons responding

to the survey said that their activities during July were unchanged by the accident or were back to normal. Recovery of the fishery harvests appears to have been related to decreasing concern and perception of threat with time following the accident. Since the anglers who use the river near TMI predominantly are local residents, it is understandable that the postaccident harvest patterns followed the same general trend as local perception of threat from the accident.

The essential components of a recreational fishery are threefold: the fish, their environment or habitat, and the anglers who depend on the fish populations. Therefore, a fishery depends on all three components and should one component be altered, the quality of the fishery also can be altered. The quality of the postaccident fishery of York Haven Pond was altered, not through accident-related alteration of the fish populations or their aquatic environment, but by changes in the fisherman component through perception of reduced environmental quality, fish quality, and changes in harvest behavior.

Although the 1979 annual harvest was poor and most of the fishing year was disrupted (in terms of monthly harvests), recovery during the same year along with normal levels of fishing effort suggest that the accident-related effects on the fishery were temporary.

IMPACT OF THE 1979 ACCIDENT AT THREE MILE ISLAND NUCLEAR STATION ON RECREATIONAL FISHING IN THE SUSQUEHANNA RIVER

INTRODUCTION

On Wednesday, March 28, 1979, at 4:00 a.m., several water pumps stopped working in the Unit 2 nuclear power plant at Three Mile Island Nuclear Station, initiating the series of events that escalated into the worst accident experienced to date by the nuclear power industry of the United States. The accident, of critical public concern because of health and safety considerations, has been the subject of much study and documentation. The major effects of the accident have been social, economic, and psychological (or mental health) stress of the people living in the region surrounding Three Mile Island (Refs. 1-6).

During the postaccident period of April-July 1979, the recreational fishery harvest from the Susquehanna River near Three Mile Island was lower than harvests had been for corresponding periods during the previous five preaccident years (Ref. 7). Reductions in the harvest did not result from impacts to the fish populations, but were attributed to the fact that fishermen behaved differently once they knew about the accident and were aware of liquid releases to the river.

The results of ichthyofaunal and fishery studies for the entire postaccident year of 1979 are complete (Ref. 8). Therefore, this paper examines dynamics of the recreational fishery during the entire postaccident year of 1979 and compares these data with similar data for the 5-year preaccident period 1974-1978. Results of other studies that monitored or assessed aspects of the nuclear station in relation to river biota and fishes (thermal, chemical, radiological discharges) and applicable results of social and psychological stress studies of the people living near Three Mile Island are discussed briefly.

METHODS AND DATA SOURCES

Recreational fishing in the Susquehanna River near Three Mile Island takes place on York Haven Pond, at the downstream sides of Red Hill Dam and York Haven Dam, and in the tailrace area of the hydroelectric station (Fig. 1). Creel surveys have been conducted at all four areas, but only the aquatic populations of the pond have received concurrent biological study because the power plant is located there and the potential exists for immediate impacts on the pond biota from plant operation. Although the four survey areas will be discussed generally, this analysis will focus on the pond fishery.

Roving creel surveys that have been conducted by boat on two weekend days and two weekdays per month since 1974 by Potter et al. (Ref. 9) and Nardacci et al. (Refs. 8 and 10-13) are the primary sources of data used in this

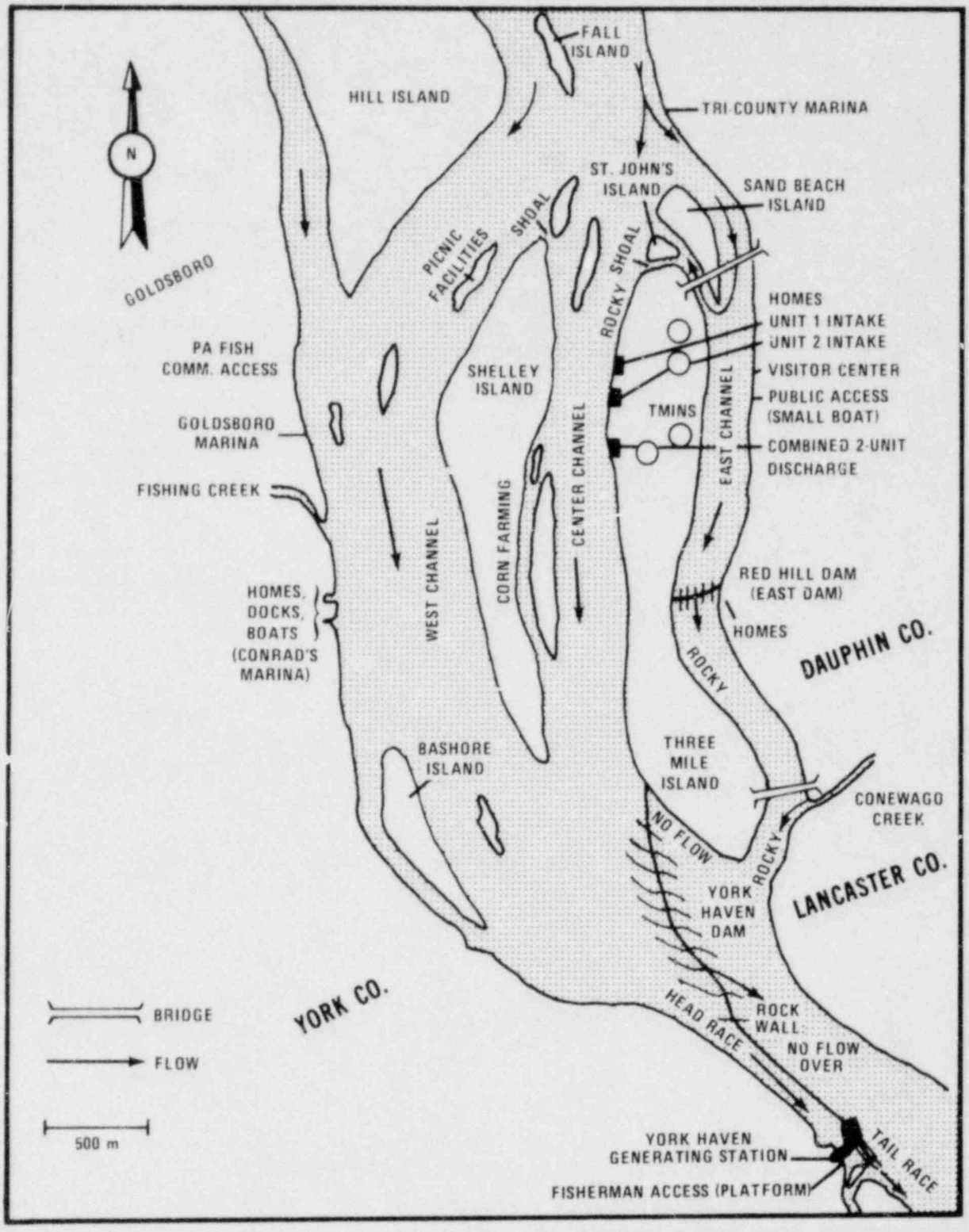

Figure 1 York Haven Pond of Susquehanna River and locations of Three Mile Island, dams that form the pond, and facilities that contribute to use of water resources of the pond

assessment. Therefore, data are available for five preaccident years (1974-1978) and for the postaccident year of 1979. On each survey date, angler interviews were conducted during three 4-hour periods: 0900-1300 hours, 1301-1700, and 1701-2100. The data obtained are considered to be incomplete, since they represent statistics for the time-fished-until-interviewed for each angler, rather than the results of completed fishing trips. The data collected were statistically treated and expanded to obtain annual estimates of fishing effort, catch, and harvest.

THE RIVER AND RECREATIONAL USES

Three Mile Island is located on an 8,800 acre-foot (10.8×10^6 m^3) pond of the Susquehanna River that is formed behind the York Haven Dam and the Red Hill Dam at river mile 55 (Fig. 1). York Haven Pond is bounded by the dams at the south and a riffle area near Fall Island and Hill Island at the north. The river is wide [~1.75 mi (2.8 km)] and shallow [~5-10 ft (1.5-3 m)] and composed of three channels. At flow rates of about 20,000 cfs (556 cms) or greater, water passes over Red Hill Dam, over the center portion of York Haven Dam, and through the York Haven Generating Station (hydroelectric) at the extreme south end of the pond. At flow rates less than about 20,000 cfs (usually during summer and early fall), the total river flow passes through the head race channel leading to the hydroelectric station, with no flow over either dam (Ref. 7).

Drawdown can be as much as 2-3 ft (0.6-0.9 m) within a few hours of increased power generation at the hydroelectric station (personal communication, Warren Singer, Waterway Patrolman, Pennsylvania Fish Commission).

York Haven Pond (also known as Lake Frederic) is unique to the Susquehanna River because of the many wooded islands that contain cottages used for vacation and weekend recreation. Three islands have public picnic facilities. Access to the islands is by boat from several marinas and access facilities located on the east and west banks of the river (Figs. 1-3). As a result, boating (including water skiing) is the largest form of recreation on York Haven Pond. Boater use becomes heavy during the summer months. The Pennsylvania Fish Commission access in Goldsboro presently has parking space for 50 vehicles on a macadam surface, but usually accommodates about 180 vehicles with boat trailers and about another 180 vehicles without trailers during summer weekends. As a result, the access is to be enlarged to about 300 parking places to accommodate summer use (personal communication, Warren Singer).

Recreational fishing also occurs on the reservoir, primarily by boat anglers. Some bank fishing occurs, but most anglers fish by boat. By comparison, however, the boat anglers are far outnumbered by the recreational boaters (nonfishermen) on the reservoir (personal communications, Warren Singer and Herman George, proprietor, Goldsboro Marina).

In addition to its use for production of electricity (hydroelectric and baseload nuclear-fueled generation), York Haven Pond provides a variety of recreational uses including power boating, water skiing, picnicing, island cottage use, and recreational fishing. The values of fishing are but a part of the overall recreational "yield" of the pond aquatic system.

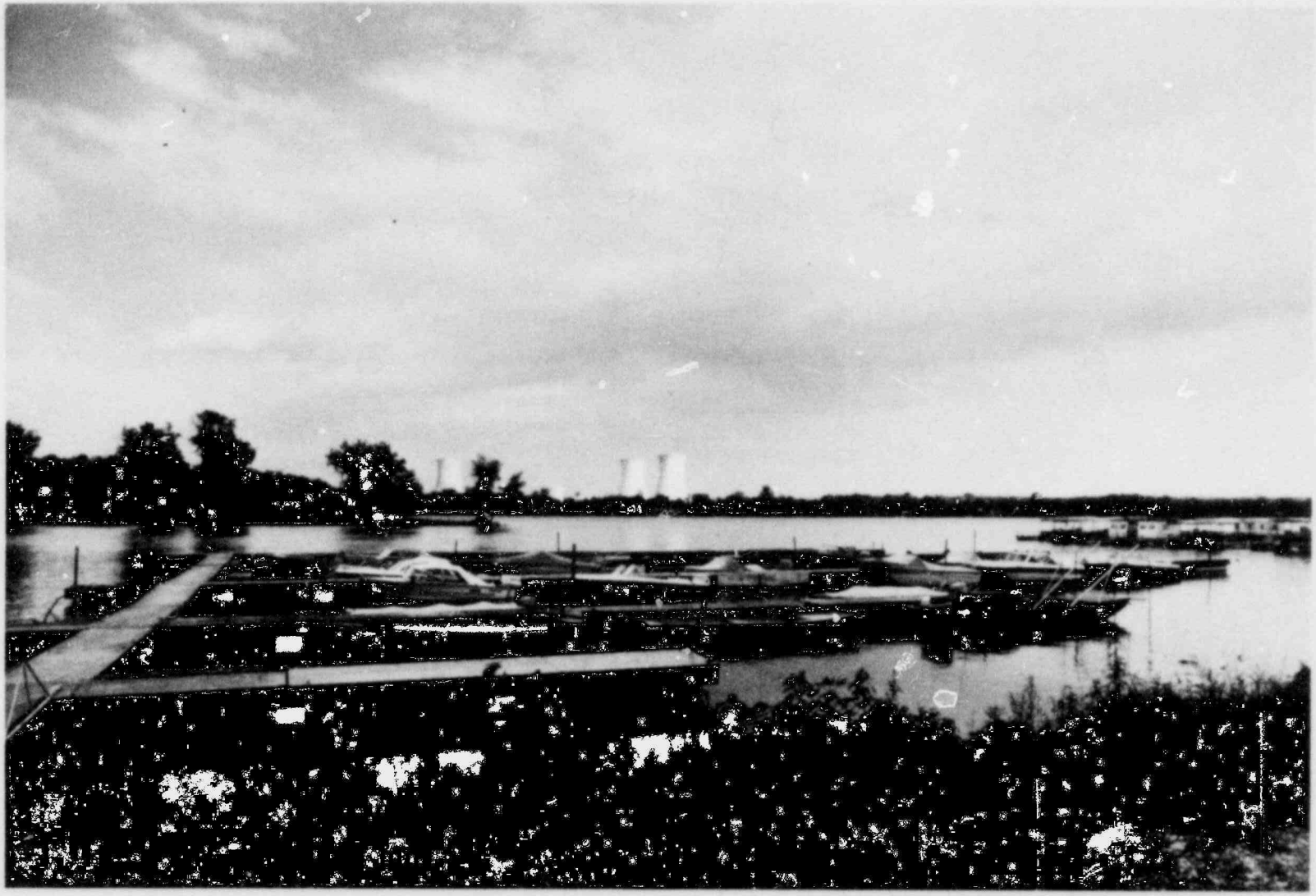

Figure 2 Golsboro Marina (capacity 100-110 boats) on the west bank of York Haven Pond d[illegible] west of Three Mile Island Nuclear Station. In the center of the picture are the Unit 2 containment building and two natural-draft cooling towers approximately 1 mile away.

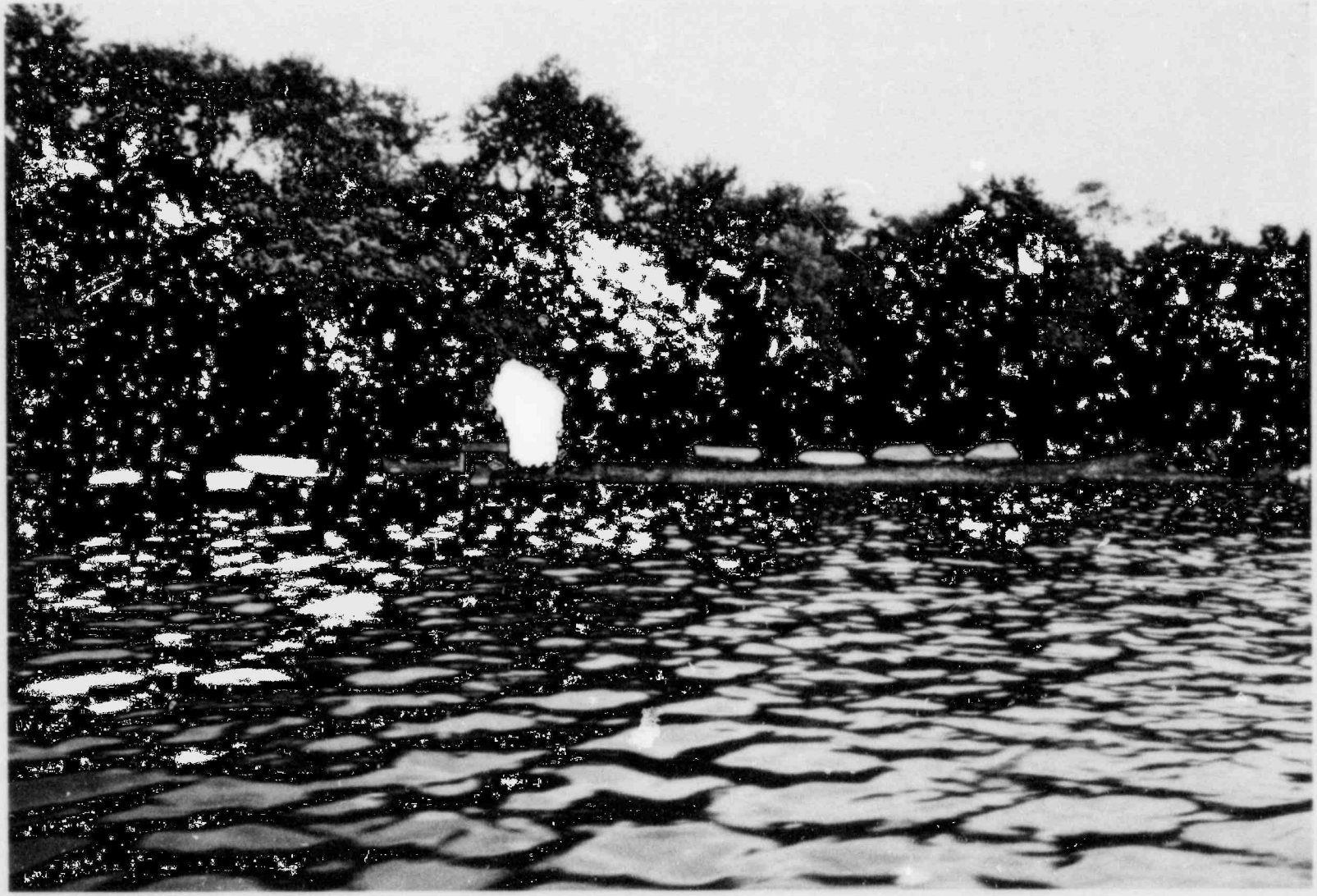

Figure 3 A public access for small boats located off highway 441 on the east bank of York Haven Pond opposite Three Mile Island Nuclear Station

DESCRIPTION OF THE PREACCIDENT FISHERY

Fishes and Fishing Locations

The recreational fishery of the Susquehanna River is a warm-water fishery. The species caught in greatest numbers overall (in 1977 and 1978, respectively) were: smallmouth bass (32% and 42% of the total for all survey areas); channel catfish (28% and 24%); walleye (10% and 11%); rock bass (10% and 9%); sunfishes (10% and 5%); carp (7% and 4%); and suckers (1% and 1%). The bulk of the harvests on the pond during 1977 and 1978, respectively, were: smallmouth bass (44% and 61%); channel catfish (25% and 13%); sunfishes (15% and 14%); rock bass (15% and 9%); and others. The total annual estimates of recreational fishing during 1974-1979 for all four survey areas are shown in Table 1 and for the York Haven Pond in Table 2.

Smallmouth bass, rock bass, and sunfishes (predominantly bluegill, pumpkinseed, and redbreast) have been caught in greater numbers in the reservoir than below either dam or in the tailrace, although smallmouth bass frequently are taken in all survey areas. Walleye are commonly taken below the dams and at the tailrace area, but have been insignificant portions of pond catches during creel surveys. Channel catfish have been relatively low in catches in the east dam, but common in other areas surveyed, with the most caught in the tailrace area. The pond has accounted for approximately 36% and 31% of all fishes caught in the vicinity during 1977 and 1978, respectively, for 29% and 40% of the total anglers, and 29% and 44% of the total hours fished. Overall, smallmouth bass catches have been greatest during May-June, rock bass during May, channel catfish during July, walleye during May, and sunfishes during June-July.

Good fishing (by boat) apparently also exists near the nuclear station discharge structure for channel catfish [many greater than 20 in. (51 cm) long], with catches of walleye and muskellunge also. People fish there primarily at night. Fishing continues through the year, except for winter months during ice conditions (personal communication, William Snider, Waterway Patrolman, Pennsylvania Fish Commission). Catches of channel catfish near the discharge are consistent with their relative abundance along the west shore of TMI, as determined during biological studies.

Fishing localities within York Haven Pond also are indicated by the places where anglers recapture tagged fishes. Recaptures have occurred throughout the pond including the head race channel of the hydrostation. Overall, more recaptures have occurred to the north of Three Mile Island Nuclear Station near Fall Island and Hill Island and around the center channel islands upstream of the nuclear station. The best smallmouth bass fishing in the pond occurs in the area between Hill and Shelley Islands and upstream to the riffle area near Fall Island (personal communication, Warren Singer). Several recaptures have occurred near the west shore in the west channel and in the center channel downstream of the power plant. Few recaptures have occurred in the east channel and in the lower pond near the confluence of the center and west channels. The concentration of recaptures in specific areas could be related both to availability of fishes and nearness to access facilities (Fig. 1).

Table 1 Estimates of total annual fishing effort and indices of catch and harvest for all creel survey areas in the Three Mile Island vicinity during 1974-1979

	Fishing effort			Catch and harvest indices						
Year	Total anglers	Total hours fished	Mean hours fished per angler	Total fish caught	Total fish kept	Retention rate, %	Mean catch per hour	Mean harvest per hour	Mean catch per angler	Mean harvest per angler
1974*	10,837	19,940	1.84	15,714	7,044	45.0	0.79	0.35	1.45	0.65
1975	11,287	21,220	1.88	16,253	8,578	52.7	0.77	0.40	1.44	0.76
1976	12,265	21,341	1.74	19,992	6,623	33.4	0.94	0.31	1.63	0.54
1977	7,791	14,773	1.90	12,089	5,431	44.2	0.82	0.36	1.55	0.69
1978	14,089	27,992	1.99	27,976	9,490	33.9	1.00	0.34	1.99	0.67
1979	13,962	24,546	1.76	29,396	7,306	24.9	1.20	0.30	2.11	0.52

*1974 survey period was May-December; all other years were January-December.

Table 2 Estimates of total annual fishing effort and indices of catch and harvest for York Haven Pond during 1974-1979

	Fishing effort			Catch and harvest indices						
Year	Total anglers	Total hours fished	Mean hours fished per angler	Total fish caught	Total fish kept	Retention rate, %	Mean catch per hour	Mean harvest per hour	Mean catch per angler	Mean harvest per angler
1974	3,890	7,656	1.97	6,086	2,793	45.9	0.79	0.36	1.56	0.72
1975	3,104	5,837	1.87	5,121	2,653	51.8	0.88	0.46	1.65	0.85
1976	4,403	8,135	1.85	8,049	2,495	31.0	0.98	0.30	1.82	0.56
1977	2,275	4,491	1.97	4,381	2,226	50.8	0.98	0.50	1.92	0.98
1978	5,579	12,166	2.18	8,704	3,342	38.4	0.72	0.28	1.56	0.60
1979	4,119	7,861	1.91	7,556	2,009	26.6	0.96	0.26	1.84	0.49

*1974 survey period was May-December; 1976 was March-November; all other years were March-December.

Fishes originating in York Haven Pond also have been caught by anglers in other Susquehanna River locations because of fish movements out of the pond, both downstream over the York Haven Dam and upstream beyond Fall Island (Refs. 8, 12, and 13). Smallmouth bass, rock bass, and walleye are the fish that most frequently move out of the pond. Downstream movements have been rare and confined to within 1-2 mi (1.6-3.2 km) of the York Haven Dam; upstream movements have been for ~62 mi (100 km) and greater in distance. Upstream movements (as indicated by angler recaptures of fishes tagged in the pond) primarily have been within the Susquehanna River proper, but movements into tributaries (Swatara Creek, Juniata River, West Branch Susquehanna River, Chenango River system) also have occurred. Upstream angler captures of smallmouth bass and rock bass have occurred principally in the river between Fall Island and Harrisburg. Most walleye captures have been in the river near Sunbury, Pennsylvania, about 65-66 mi (105-107 km) upstream of York Haven Pond. A few walleye have been taken in the Susquehanna River and the Tioughnioga River in New York State, at upstream distances of 266 mi (428 km) and 291 mi (468 km), respectively.

The Anglers

During 1977 and 1978, about 75-78% of anglers who fished in the TMI area resided in York and Dauphin counties in Pennsylvania. By creel survey area fished, the angler residence tended to reflect proximity and access to the river. Of the anglers who fished at the hydrostation tailrace, 70-71% resided in York County, on the west bank of the river, where the hydrostation is located (Fig. 1). East dam anglers were primarily from Dauphin County (68-70%), where the east dam is located. Anglers who fished at the York Haven Dam resided in York, Dauphin, Lancaster, and Lebanon counties with no single county overwhelmingly represented. York Haven pond anglers resided predominantly in York (26-36%), Dauphin (38-41%), and Cumberland (13-15%) counties. At least nine other Pennsylvania counties were represented by anglers fishing in the vicinity. A few out-of-state anglers were noted. In another study of the fishery downstream of the York Haven Dam during 1977-1978, 75% of the anglers who fished at the hydrostation were reported to live within 10 mi (16 km) and 92% were reported to live within 20 mi (32 km) of that fishing location (Ref. 14).

Of the anglers interviewed during the studies at Three Mile Island, 65-74% reported that they ate their harvest (or at least some of it), 17-26% released all they caught, and 3-9% gave away their harvests.

On an annual basis during the preaccident study period, between 64% and 80% of the anglers who fished on York Haven Pond fished on weekend days rather than on weekdays.

These data suggest that the recreational fishery of the Susquehanna River near Three Mile Island is predominantly a local weekend fishery, and that most of the anglers eat all (or at least some) of their take.

Monthly and Seasonal Fishing Effort

The "fishing year" in the Three Mile Island vicinity extends primarily from April through November on the pond. Some fishing occurs before April and after November, depending on weather and river-flow conditions. Fishing effort on the pond, in terms of number of anglers and number of hours fished, is greatest during the summer months (June through September) and peaks in June after the smallmouth bass season opens (Figs. 4 and 5).

Fishing effort on the pond relative to the total for all four creel survey areas, is greatest during summer and early fall, and peaks in September when approximately 50% of the total fishing effort is expended on the pond (Figs. 6 and 7). During the spring and fall months, fishing effort on the Pond is relatively low, and anglers concentrate in areas with easy access such as the hydrostation tailrace (reached by auto, Fig. 1). During summer and early fall, river flow decreases and does not overtop the dams, resulting in low water levels below the dams and a decrease in fishing there. Favorable weather and calm flow conditions on the pond at that time permit its use by boat anglers. During the period of maximum fishing on the pond (June-September), the month of August shows the least variability in relative fishing effort, suggesting its consistent use and popularity then. During fall, the relative effort on the pond is highly variable, probably dependent on weather conditions.

The mean number of hours fished per angler (or the length of an average fishing trip) on the pond is greatest during the period from summer to early fall, and peaks during August (Fig. 8). Longer fishing trips then correspond with favorable weather and river conditions for boating.

The estimates of hours fished per angler were determined from interviews of anglers who still were actively fishing. The actual time spent fishing until the completion of a fishing trip, therefore, would be longer than the estimates shown in Tables 1 and 2. The mean time spent fishing by the few anglers interviewed who had completed their trips was 3.24 hr (Ref. 8).

Monthly and Seasonal Indices of Catch

The mean number of fish caught per angler-hour of fishing effort peaks during May and declines in June, after which a slow steady increase occurs until a secondary high is reached during late summer and early fall (Fig. 9). The number of fish caught per angler (or the average catch per fishing trip) increases to a spring peak in May, declines in June, and then rises to an annual maximum during August (Fig. 10). Although the fish caught per hour peaks at about the same level in spring and fall (Fig. 9), the fish caught per fishing trip is highest in August due to the annual peak then in the length of an average fishing trip (Fig. 8).

The catch of fishes by anglers on the pond relative to the total catch by anglers fishing at all four creel survey areas is lowest during spring and late fall and highest during August and September (Fig. 11). This summer peak coincides with the distribution of fishing effort on the pond then, along with the longer fishing trips and catches per trip.

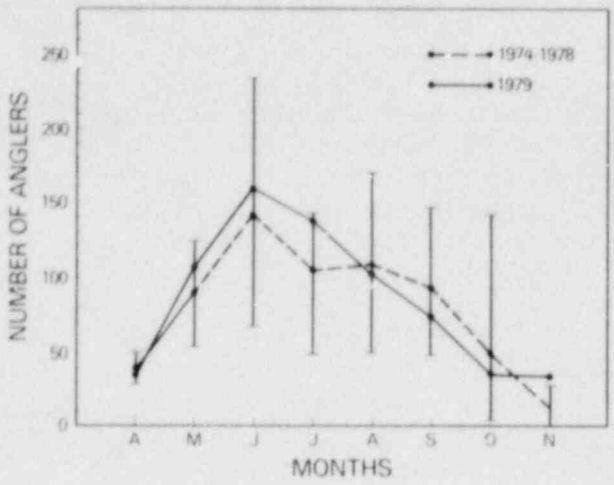

Figure 4 Number of anglers interviewed on York Haven Pond during the months of April through November 1979 (solid line) and 1974 - 1978 (broken line), showing the mean and range for each preaccident month

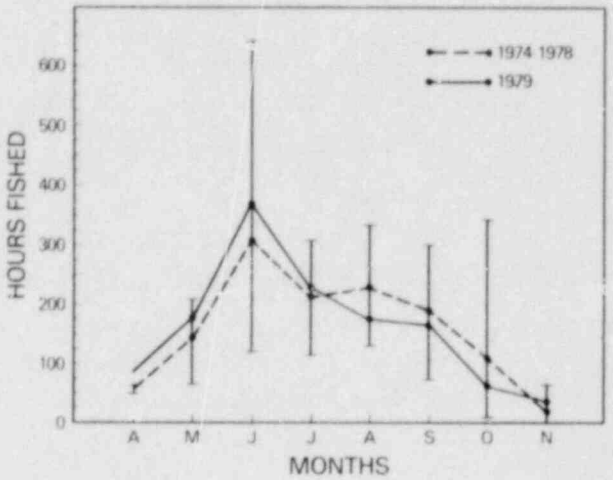

Figure 5 Number of hours fished by anglers interviewed on York Haven Pond during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

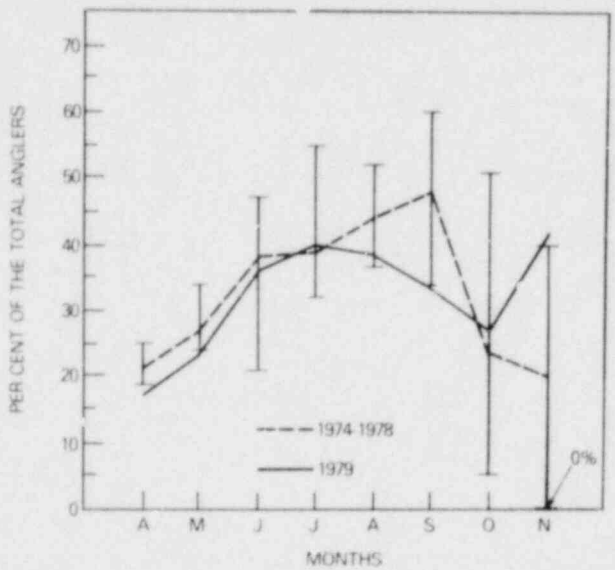

Figure 6 Number of anglers onterviewed on York Haven Pond expressed as a percentage of the total anglers at all four creel survey areas near Three Mile Island during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

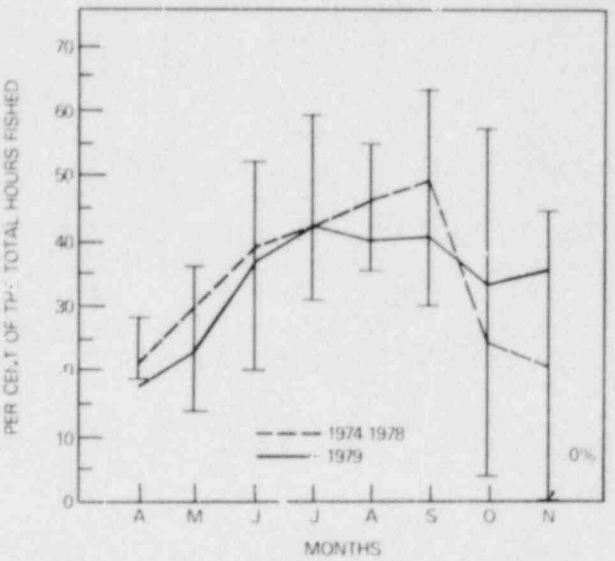

Figure 7 Number of hours fished by anglers interviewed on York Haven Pond expressed as a percentage of the total hours fished at all four creel survey areas near Three Mile Island during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

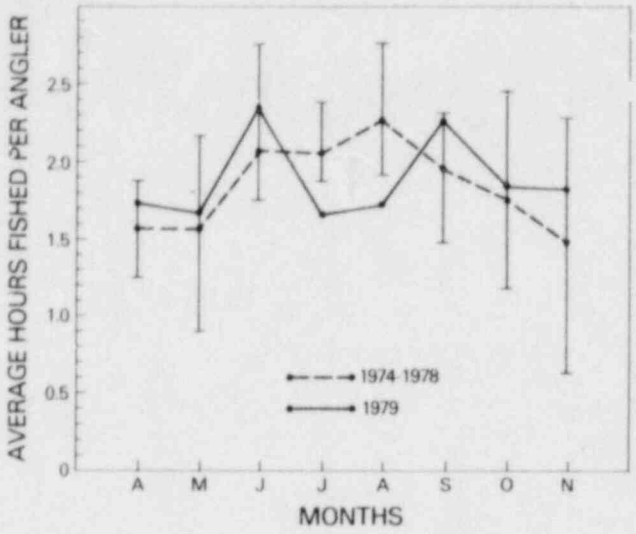

Figure 8 Mean number of hours fished per angler (or per fishing trip) on York Haven Pond during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

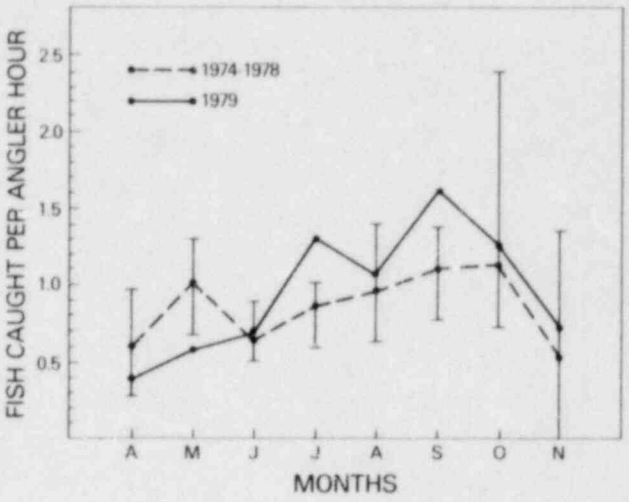

Figure 9 Mean number of fish caught per angler hour of fishing effort on York Haven Pond during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

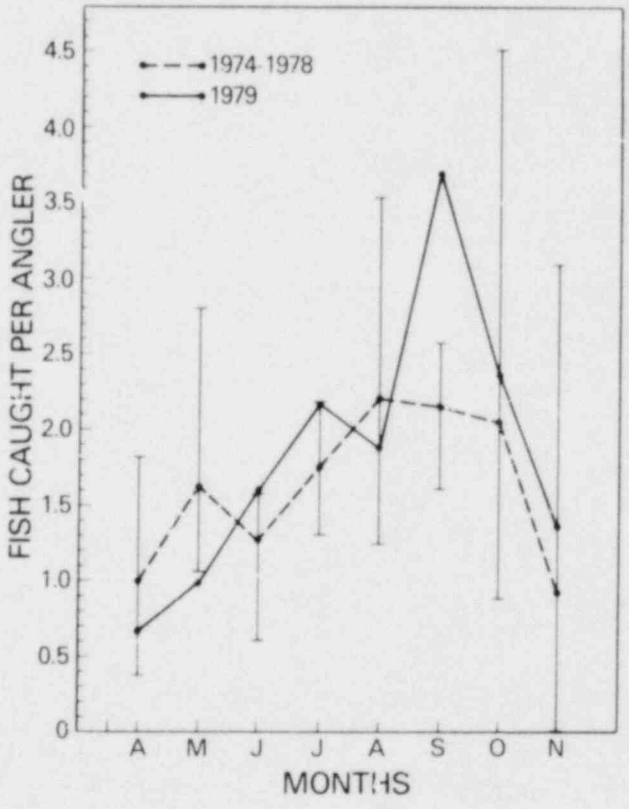

Figure 10 Mean number of fish caught per angler (or per fishing trip) on York Haven Pond during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

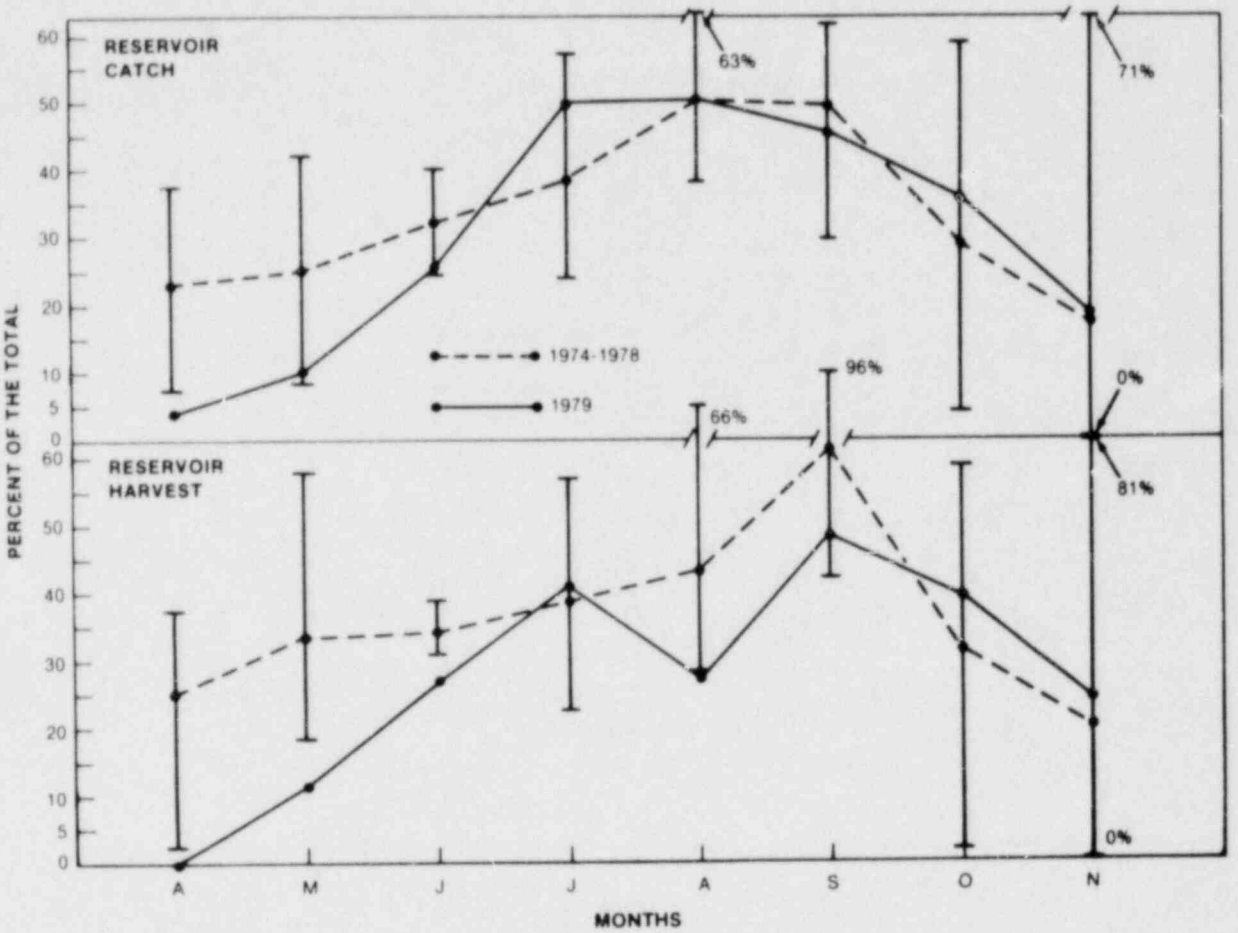

Figure 11 Catches and harvests of York Haven Pond expressed as a percentage of the totals (in numbers of fish) for all four creel survey areas near Three Mile Island during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

Monthly and Seasonal Indices of Harvest

The mean number of fish harvested (those fish actually kept) per angler-hour of fishing effort peaks during May and October, with minimum numbers kept during April and August (Fig. 12). The mean number of fish harvested per fishing trip is fairly constant throughout the fishing year (especially during summer and early fall); the maximum occurs in October (Fig. 13).

The retention rate (percentage of the fish caught that are kept) for the pond is fairly constant during spring, decreases to an annual minimum during summer, and increases to a maximum during fall (Fig. 14). The progressively decreasing rate during the summer might be related to increased catches of small (and legally undersized) fishes spawned during the previous spring. Even though the retention rate for the pond is low during summer, the actual fishes harvested from the pond relative to the total for all four creel survey areas reaches an annual maximum then (Fig. 11), since the bulk of the summer fishing effort is on the pond.

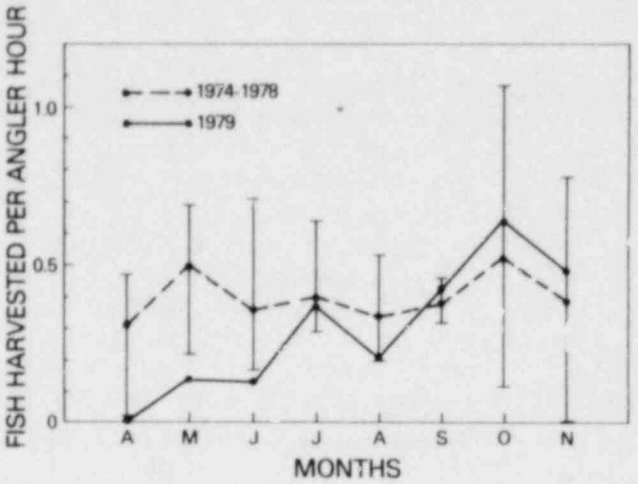

Figure 12 Mean number of fish harvested per angler hour of fishing effort on York Haven Pond during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

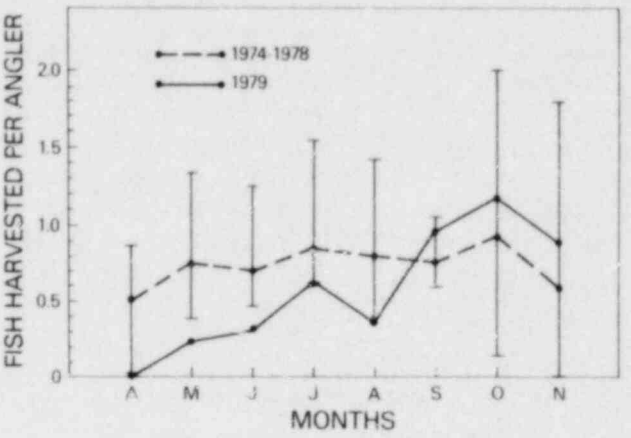

Figure 13 Mean number of fish harvested per angler (or per fishing trip) on York Haven Pond during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

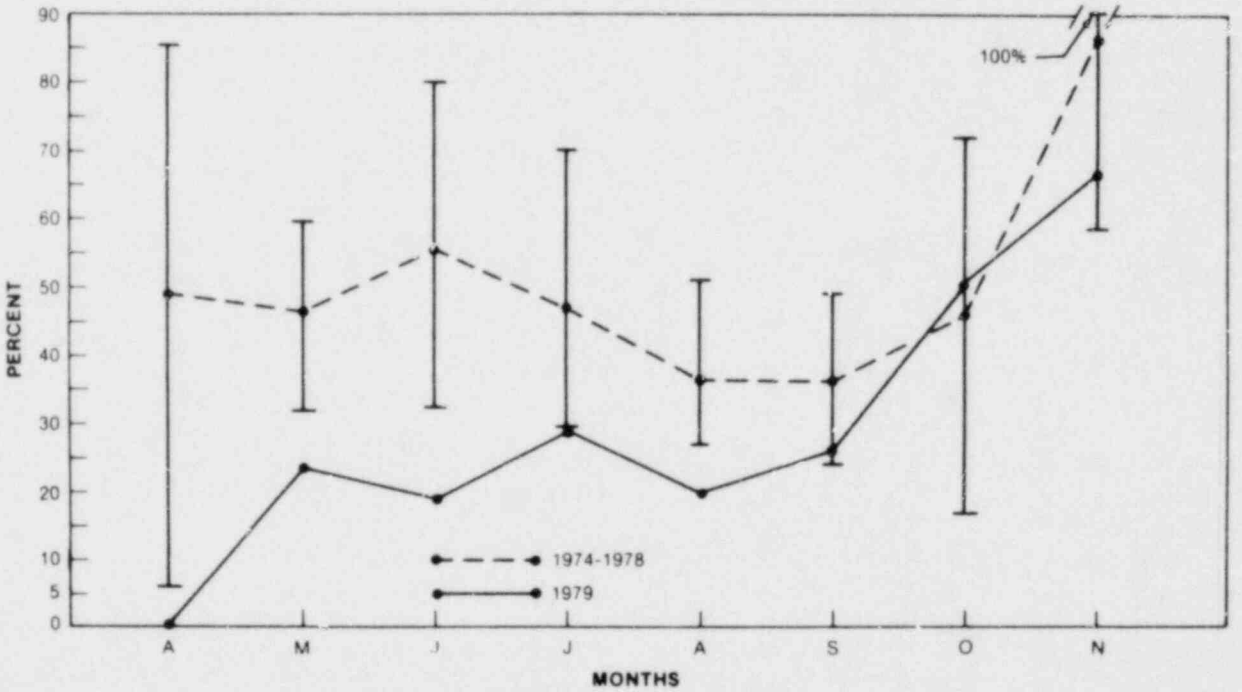

Figure 14 Mean retention rate (percent by number of the fish caught that were kept) for York Haven Pond during the months of April through November 1979 and 1974 - 1978, showing the mean and range for each preaccident month

Annual Effort, Catch, and Harvest

On an annual basis, the preaccident indices of catch and harvest appear correlated generally with levels of annual fishing effort. The plots of these data in Figs. 15 and 16 suggest increasing levels of annual catches and harvests with increasing fishing effort and generally decreasing trends in catch and harvest per effort and in the retention rate with increasing fishing effort. All of the plots suggest nearly linear relationships if the data points for 1976 are excluded. The indices for 1976 appear to have been influenced primarily by a large annual catch and a small proportionate harvest (retention rate = 16.9%) of smallmouth bass. No other preaccident year was so dominated by the catch of one species and with so low a retention rate. These data suggest that during 1976 there was either an unusual abundance or a high proportion of small or legally undersized [< 9 in., (229 mm)] smallmouth bass. Length frequency data for pondwide captures of smallmouth bass by electrofishing in 1976 (Ref. 11) showed a normally high proportion (83%) of fish smaller than legal size and a 5-year pondwide low level of catch per effort for smallmouth bass by electrofishing (5.9 bass/collection). The large annual catch by anglers in 1976 suggests that small fish returned by anglers could have been recaptured, perhaps several times, resulting in a low harvest rate. It appears that, overall, 1976 was the most unusual or anomalous fishing year of the five preaccident years.

Correlation analysis (Ref. 15) was used to test for associations between catch and harvest and the levels of annual fishing effort. Analyses were performed for the five preaccident years, and for all years 1974-1979 (Table 3) and for those same periods exclusive of 1976 (Table 4). Statistical significance is assigned at the 5% ($P \leq .05$) level.

The estimated total annual catches during the 5- and 6-year periods are correlated directly and significantly with the annual estimates of fishing effort (Tables 3 and 4). Similarly, the annual harvests have been correlated with fishing effort. Removal of the data point for the anomalous fishing year of 1976 from the analysis resulted in a large improvement in the correlation coefficient (r) and in the attainment of significance for the preaccident period (Table 4 compared with Table 3). The addition of the postaccident data point (1979) to the analysis resulted in very low coefficients and no significant correlations. These data suggest that higher annual catches and harvests occur during years of higher fishing effort, and lower returns occur during years of lower effort. The annual catches appear to have fluctuated more than the harvests (Table 2). This is most evident for 1977 compared with 1978, during which the effort nearly tripled, the catch doubled, and the harvest increased by only 50% (Table 2). During 1978, however, the catch and harvest of smallmouth bass increased by factors of 2.7 and 3.5, respectively, compared with 1977, and those of other major species generally decreased or remained nearly unchanged.

The indices of catch per hour showed good correlations with fishing effort only for the preaccident years exclusive of 1976 (Table 4); catch per angler (or per fishing trip) has not been correlated significantly with fishing effort. In several analyses, the harvest per hour has been correlated indirectly and significantly with fishing effort. The retention rate correlated indirectly and significantly with fishing effort only when the anomalous year 1976 was not included in the analysis. These data suggest that during

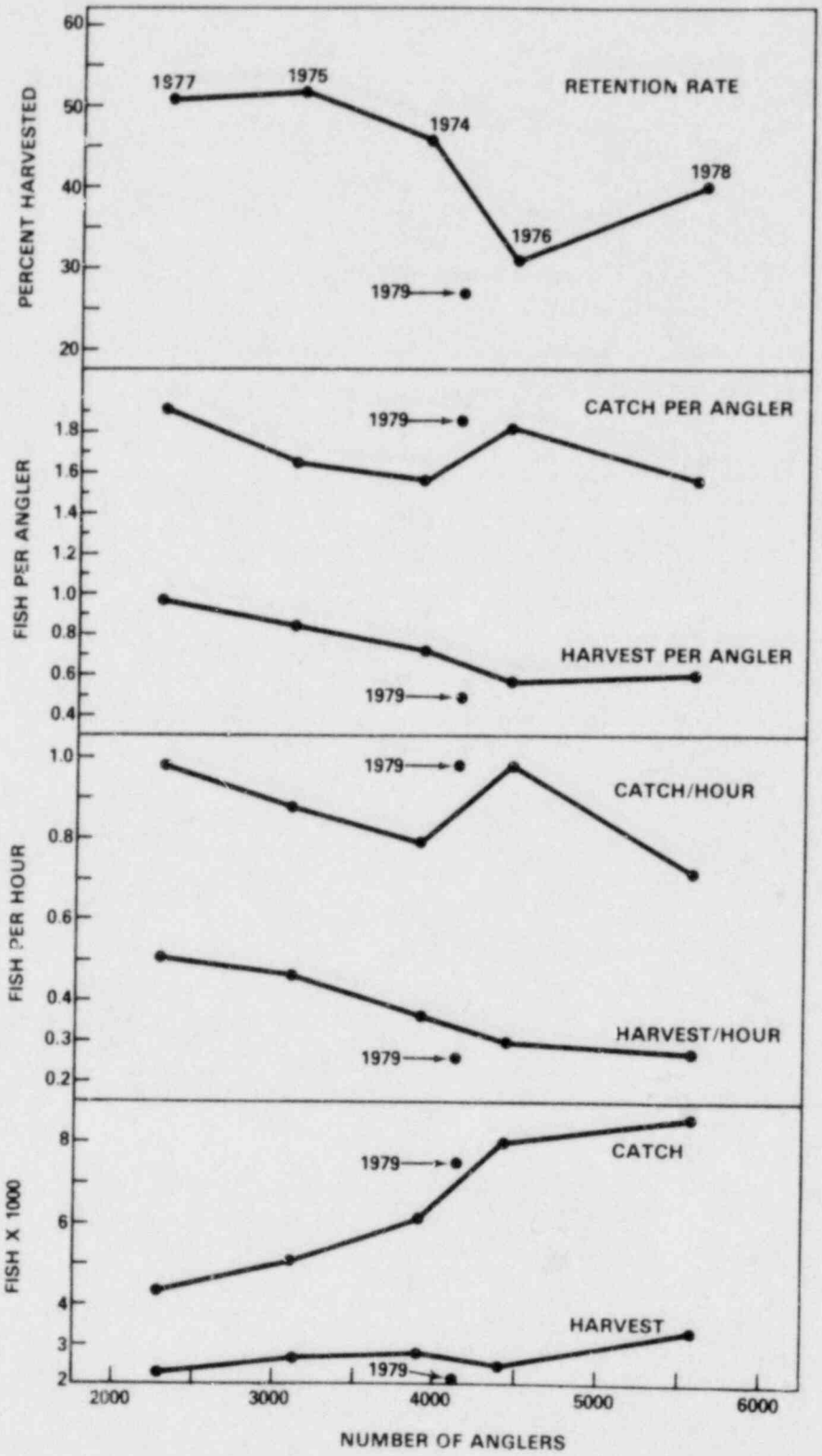

Figure 15 Comparison of the annual indices of catch and harvest with annual levels of fishing effort (in terms of number of anglers) for York Haven Pond during the preaccident period of 1974 - 1978, with the data points for the postaccident year of 1979 indicated separately

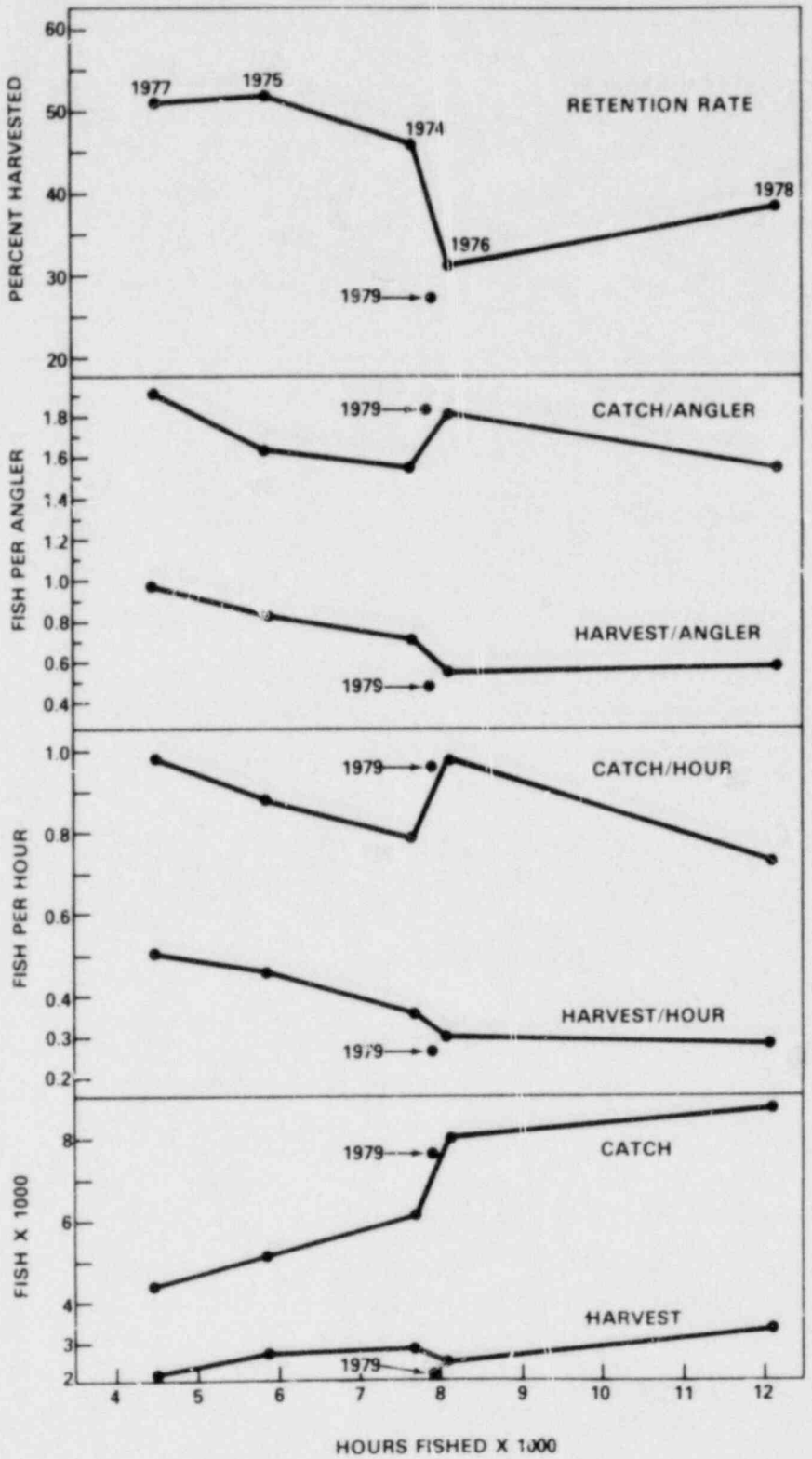

Figure 16 Comparison of annual indices of catch and harvest with annual levels of fishing effort (in terms of number of hours fished) for York Haven Pond during the preaccident period 1974 - 1978, with data points for the postaccident year 1979 indicated separately

Table 3 Results of correlation analyses performed between the estimates of annual fishing effort (total hours fished and total number of anglers) and several annual indices of catch and harvest for York Haven Pond during the preaccident years (1974-1978) and all years combined (1974-1979)

Index	Total hours fished			Total anglers		
	r	r^2	P	r	r^2	P
Total catch						
1974-1978	0.919	0.845	<.05*	0.964	0.929	<.01*
1974-1979	0.896	0.803	<.05*	0.952	0.906	<.01*
Total harvest						
1974-1978	0.906	0.821	<.05*	0.853	0.728	>.05**
1974-1979	0.701	0.491	>.05	0.616	0.379	>.05
Catch/hour						
1974-1978	-0.737	0.543	>.05	-0.659	0.434	>.05
1974-1979	-0.684	0.468	>.05	-0.585	0.342	>.05
Harvest/hour						
1974-1978	-0.899	0.808	<.05*	-0.956	0.914	<.05*
1974-1979	-0.798	0.637	>.05**	-0.876	0.767	<.05*
Catch/angler						
1974-1978	-0.627	0.393	>.05	-0.603	0.364	>.05
1974-1979	-0.572	0.327	>.05	-0.524	0.275	>.05
Harvest/angler						
1974-1978	-0.826	0.682	>.05**	-0.913	0.834	<.05*
1974-1979	-0.706	0.498	>.05	-0.812	0.659	<.05*
Retention rate						
1974-1978	-0.655	0.429	>.05	-0.752	0.566	>.05
1974-1979	-0.513	0.263	>.05	-0.626	0.392	>.05

* = Correlations significantly different from zero.

** = Correlations not significantly different from zero, but nearly so.

Table 4 Results of correlation analysis performed between the estimates of annual fishing effort (total hours fished and total number of anglers) and several annual indices of catch and harvest for York Haven Pond during the preaccident years (1974-1978) exclusive of 1976, and during all years combined (1974-1979) exclusive of 1976

	Total hours fished			Total anglers		
Index	r	r^2	P	r	r^2	P
Total catch						
1974-1978	0.999	0.998	<.01*	0.993	0.986	<.01*
1974-1979	0.944	0.891	<.05*	0.966	0.933	<.01*
Total harvest						
1974-1978	0.975	0.951	<.05*	0.989	0.978	<.05*
1974-1979	0.715	0.511	>.05	0.656	0.430	>.05
Catch/hour						
1974-1978	-0.933	0.870	>.05**	-0.963	0.927	<.05*
1974-1979	-0.797	0.635	>.05	-0.769	0.591	>.05
Harvest/hour						
1974-1978	-0.96[a]	0.939	<.05*	-0.980	0.960	<.05*
1974-1979	-0.812	0.659	>.05	-0.871	0.759	>.05**
Catch/angler						
1974-1978	-0.725	0.526	>.05	-0.795	0.632	>.05
1974-1979	-0.621	0.386	>.05	-0.634	0.402	>.05
Harvest/angler						
1974-1978	-0.953	0.908	<.05*	-0.977	0.955	<.05*
1974-1979	-0.533	0.284	>.05	-0.625	0.391	>.05
Retention rate						
1974-1978	-0.971	0.943	<.05*	-0.953	0.908	<.05*
1974-1979	-0.535	0.286	>.05	-0.605	0.366	>.05

* = Correlations significantly different from zero.

** = Correlations not significantly different from zero, but nearly so.

year of increased total fishing pressure, on the average, an angler harvested fewer fish per fishing trip and per hour of time spent fishing than during years of lesser total pressure. The catches per trip and per hour were not correlated with fishing effort, perhaps partly as a result of an angler being able to recatch fishes that have been caught and returned previously.

Preaccident Fishery Summary

The York Haven Pond recreational fishery is predominantly a local weekend fishery and most anglers consume all or at least part of their harvest. Most fishermen fish from boats for smallmouth bass, rockbass, sunfishes, and channel catfish. Angling occurs on much of the pond, but the most frequently fished localities are in the north, northwest, and western portions, probably because fish are available there and those portions are near boat-access facilities. York Haven Pond fishes also contribute to the catches of anglers in other Susquehanna River areas, primarily upstream in the Harrisburg and Sunbury, Pennsylvania, areas because of upstream movements by smallmouth bass, rock bass and walleye.

The fishing year extends primarily from April through November. Fishing effort on the pond is greatest during the summer months of June through September. Recreational fishing takes place at several other locations on the Susquehanna River near Three Mile Island, but during the summer months York Haven Pond is the area most heavily fished. The number of fish caught per angler hour peaks during summer. The number of fish harvested per angler hour peaks during spring and fall; the number of fish harvested per angler remains fairly constant throughout the year. The retention rate of fishes caught in the pond is highest during spring and fall and at a yearly minimum during summer.

The total annual catches and harvests (number of fish of all species) have been directly correlated with total annual levels of fishing effort; greater catches and harvests occurred during years of increased effort and lesser catches and harvests during years of decreased effort. The annual indices of catch and harvest per units of effort, however, generally have been lower during years of increased effort and higher during years of decreased effort. Similar relationships between effort and harvest were found during a nationwide survey of 103 reservoirs by Jenkins and Morais (Ref. 16). Therefore, during years of increased total fishing pressure, on the average, an angler has harvested fewer fish per fishing trip and per hour of time spent fishing on the pond than during years of lesser total pressure. Catch and harvest indices estimated by other investigators for areas of the Susquehanna River downstream of TMI are similar to those reported for York Haven Pond. The mean number of fish caught per angler hour near the Brunner Island Steam Electric Station [located about 3-4 mi (5-6 km) downstream of TMI] during 1977-1978 were 0.75 and 0.61, respectively (Ref. 14), compared with the range of 0.72-0.98 for York Haven Pond during the preaccident years (Table 2). The harvest per angler hour for the Conowingo Pond [located about 40 mi (64 km) downstream of TMI] during 1977-1978 was estimated to be 0.33 (Ref. 17), compared with the preaccident range of 0.28-0.50 for York Haven Pond (Table 2).

The year 1976 appears to have been an unusual or anomalous fishing year that was out of phase with the other preaccident years. That year, dominated by a

large catch, had a very poor harvest of smallmouth bass. Correlation analyses of annual fishing effort and indices of catch and harvest for the preaccident years yielded higher coefficients and more statistically significant correlations when the data for 1976 were not included in the analyses.

It should be noted that no tests (i.e., regression) were performed to establish or estimate the dependence of catch and harvest levels upon the levels of fishing effort. It appears, however, that the level of annual fishing effort can influence the total annual catches and harvests in York Haven Pond. Harvests and indices of harvest success appear to be influenced by fishing effort and by other phenomena such as stock abundance and size (length or weight) of fish and by species preferences, fishing habits and behavior, and perceptions (as illustrated in the sections to follow) of the anglers.

DESCRIPTION OF THE POSTACCIDENT FISHERY

The Anglers

Angler residence during 1979 for all creel survey areas combined was about 80% from York and Dauphin counties, 7% from Lancaster County, and 9% from Cumberland County. York Haven Pond anglers were predominantly from York (32%), Dauphin (35%), Cumberland (17%), Lancaster (8%), and Lebanon (6%) counties. Eleven other Pennsylvania counties were represented by anglers fishing in the creel survey area. Only a few out-of-state anglers were noted. No significant changes in angler residence were noted during 1979 (Ref. 8).

Of the anglers interviewed during 1979, about 65% reported that they ate their harvest (or at least some of it), 25% released all they caught, and 10% did otherwise (released and gave away, gave away only, and other undefined uses). Overall during 1979 (all four creel survey areas), 5.8% of the anglers who responded to questions during the creel survey reported that they changed the use of their catches after the March 28 accident (Ref. 8). They reported eating their harvests (or at least part of them) before the accident, but doing otherwise after the accident. Of those anglers fishing on York Haven Pond, 5.5% reported changes in the use of their catches. Of all the anglers who reported that they released or gave away their catches and harvests, about 18% stated that before the accident they ate their harvest (or at least some of it). However, the Pennsylvania Fish Commission waterway patrolman who patrols the York County side of York Haven Pond noted a greater-than-normal proportion of the fishes caught (unquantified) were returned to the pond after the accident and throughout 1979 (personal communication, Warren Singer).

Monthly, Seasonal, and Annual Fishing Effort

Fishing effort on the York Haven Pond (in terms of number of anglers, hours fished, and hours fished per fishing trip) essentially was normal during 1979 (Figs. 4, 5, and 8). The only departure from historic trends was noted during July and August, when the mean lengths of fishing trips were 10-12% less than the lowest figures of record and 19-24% less than the monthly mean values during corresponding preaccident months (Fig. 8). The longest fishing trips of the year normally occur in the summer.

The number of anglers interviewed on the pond relative to the total for all four creel survey areas was lower than normal during April, May, and September and higher than normal for November 1979 (Fig. 6). The number of hours fished on the pond relative to the areawide total was below normal during April 1979, but within the normal range for each succeeding postaccident month (Fig. 7).

On an annual basis, the fishing effort on the pond during 1979 was within the range of values recorded during the five preaccident years (Table 2). However, during 1979, angler participation increased at other areas and was at a record high annual level at the hydrostation (Ref. 8). The low levels of relative fishing effort on the pond immediately following the accident might be attributable to increased fishing at other nearby areas. It thus appears that during 1979, angler participation in the river fishery near Three Mile Island at normal-to-high levels relative to the five preaccident years of record.

Interviews with anglers during 1980 suggest that some anglers (amount as yet unquantified) avoided fishing in the Three Mile Island area during 1979, but returned in 1980 (personal communication, George Nardacci, Ichthyological Associates, Inc.). Also, it has been noted that some boaters avoided using the pond and their island cottages during 1979, and that both cottage use and the interest in their use were reduced because of the accident (personal communication, Herman George).

Monthly and Seasonal Indices of Catch and Harvest

The numbers of fish caught per angler hour of fishing effort and the numbers of fish caught per angler (or per fishing trip) on the pond during 1979 were lower than normal only during May. During all other postaccident months, the values were either normal or above normal (Figs. 9 and 10). The catches on the pond relative to the total areawide catches were at a record low level during April, at low-normal level during May and June, and at normal levels thereafter during 1979 (Fig. 11).

The numbers of fish harvested per angler hour of effort on the pond were at record low levels during the postaccident months of April (no fish harvested), May, and June, and within historical monthly ranges thereafter (Fig. 12). The numbers of fish harvested per fishing trip were at record low values for the postaccident months of April, May, June, and August, and July figures were equal to the low value of record for that month (Fig. 13). The retention rates (percent of the catch actually kept) were record low values during each postaccident month from April through August; values for the remainder of 1979 were normal (Fig. 14). During April, no fish caught in the pond were kept by anglers; all were returned. The retention rate appeared to recover to nearly normal preaccident levels during July, but was further depressed in August, before full recovery in September. Similar July-August patterns also occurred for the indices of harvest per hour and harvest per angler. The harvests from the pond relative to the total areawide harvests were at record low values for the postaccident months of April, May, June, and August; harvest values were normal during other months (Fig. 11). A decrease in the relative harvest index from July to August occurred, similar to the other harvest indices. The reduced relative catch and harvest indices for the pond probably resulted from

a combination of depressed retention rates for the pond along with increased angler participation at the other three creel survey areas (and normal participation on the pond).

Annual Catch and Harvest

During 1979, the principal catches and harvests from the York Haven Pond are estimated as follows:

	Caught		Harvested	
Species	No.	%	No.	%
Smallmouth bass	4,958	65.6	1,180	58.8
Sunfishes	997	12.9	209	10.4
Channel catfish	751	9.9	292	14.5
Rock bass	751	9.9	292	14.5
Total: All species	7,556	100	2,009	100

The total estimated catch from the pond during 1979 fell within the range for previous years; the harvest, however, was a record low--9.7% below the minimum of record and 25.6% below the 5-year preaccident mean number of fish harvested (Table 2 and Figs. 15 and 16).

On an annual basis, both the catch per angler hour and the fish caught per trip on the pond during 1979 were within the ranges recorded for preaccident years. The annual indices of harvest per hour and harvest per fishing trip were at record low values, 7.1% and 12.5%, respectively, below the preaccident minimum values of record (Table 2). The annual retention rate (percent harvested) for 1979 also was a record low, being 14.2% less than the annual preaccident minimum. The spring and summer months are those that are most heavily fished on the pond and are those during which large catches and harvests are made. Thus, the harvest reductions that occurred during the first few postaccident months were sufficient to produce a record low level of harvest for the entire fishing year of 1979.

The 1979 annual estimates of catch and harvest relative to fishing effort are included as separate data points in Figures 15 and 16 and are added to the correlation analyses in Tables 3 and 4. Addition of the data points for 1979 reduced the correlation coefficients (r) of every test. However, several of the 6-year correlations still were significant: total catch with fishing effort; harvest per hour and harvest per angler with number of anglers (Table 3). When the 1979 data points were added to the correlation analyses for the four preaccident years exclusive of the anomalous 1976 year, all coefficients were reduced (some substantially) and only the correlations of total catch with fishing effort were significant (Table 4).

The annual indices of catch and harvest for 1979 in relation to fishing effort more closely resemble those of 1976 than any other year, but are reduced below those of 1976. This suggests that during 1979 anglers harvested fewer fish than during a naturally poor fishing year. The annual harvest for 1979 was

smaller than for the year 1977 in which the fishing effort was 43-44% less; the 1979 indices of harvest per hour, harvest per angler, and retention rate were smaller than for the year 1978 in which the fishing effort was 45-55% greater. At the intermediate levels of fishing effort expended during 1979, the harvest indices might well have been intermediate between those of the annual extremes recorded for 1977 and 1978. The year 1979 does appear to have been another anomalous fishing year similar to 1976.

The harvest indices for 1979 appear to have been influenced by large catches of smallmouth bass and moderate catches of the other major species, with low-normal retention rates for smallmouth bass (23.8%) and channel catfish (38.9%) and record low annual harvests and retention rates for rock bass (38.9%) and sunfishes (21.3%). No other year had such across-the-board low retention rates for all the major fishery species. Abundance and catch-per-effort data from biological studies suggest that smallmouth bass and sunfishes were in low abundance in 1979, and that rock bass and channel catfish were relatively abundant (Ref. 8). Like 1976, the harvest indices of 1979 were influenced primarily by low abundance, large catches, and poor harvest rates of smallmouth bass, suggesting a large return-recatch rate. The two years differed in that 1979 had much lower retention rates (15-25 percentage points) than 1976 for all the other major fishery species as well.

Postaccident Fishery Summary

The foregoing analyses suggest that 1979 was an abnormal fishing year on York Haven Pond with respect to catches and harvests and that it was similar to the naturally anomalous fishing year of 1976 in its deviation from the preaccident patterns. However, 1979 produced harvests and indices of harvest success at record low levels below those of 1976. The fishing effort expended during 1979 on the pond was within the range observed for previous years, but the harvest success was lower than that which might have been expected during a normal year with comparable effort. Therefore, harvest success during the 1979 fishing year appears to have been more abnormal than is evident by simply comparing the data for 1979 with those for other years of low success (as in Table 2 and Figs. 15 and 16). During the months following the accident, the levels of fishing effort and the indices of catch success were normal, except for a few deviations. However, the indices of harvest success were at record low levels with normal values not attained for all indices until September, 6 months after the accident. The harvest reduction might have been influenced in part by low abundance of some fish species, but the overall poor retention rates and the patterns of record low monthly harvest indices that gradually improved with time following the accident cannot be explained by biological or population abundance data alone.

The observed changes in angler behavior and catch retention noted above appear to have been the major contributor to the record low harvest success and abnormal fishing year of 1979. This is discussed further in the following section.

EFFECTS OF THE ACCIDENT ON THE FISHERY

Less than 1 Ci of liquid radioactive material was released to the river during and following the accident. Negligible amounts of tritium were released. The releases, although above the levels of normal operation, were within the limitations imposed by the NRC technical specifications (Refs. 5 and 18). None of the radioactive wastes in the TMI- 2 auxiliary, fuel handling, and reactor containment buildings were released during 1979. Therefore, the quantity of radioactive material in liquid effluents released as a result of the March 28 accident were not significant (Ref. 18). Beginning in early April 1979, gut tissue and flesh of a variety of finfish species were collected from the Susquehanna River and upper Chesapeake Bay and analyzed for the presence of radionuclides (Ref. 19). Aquatic vegetation, bottom sediments, and Chesapeake Bay shellfishes (blue crab and oyster) also were analyzed. Results through November 1979 indicated there was no discernible radioactivity and no apparent increment of radioactivity that can be attributed to discharges from Three Mile Island Nuclear Station. The maximum doses that a person would have received by eating fish from the Susquehanna River were calculated based on liquid releases from Three Mile Island during the period March 28-May 11, 1979 (Ref. 5). The analysis assumed a consumption rate of about 1/2 lb (0.25 kg) of fish per meal. The resulting total dose was well below NRC limitations for protection of the public.

As a result of the accident, several million gallons of treated industrial effluents were released to the Susquehanna River. Both chemical and thermal effluents were maintained within the limitations established by the NPDES-permitting authority (Commonwealth of Pennsylvania) and were within the bounds of those analyzed during impact assessments prior to TMI-2 operation. Maintenance of the required quality of nonradiological liquid effluents appears not to have been impaired as a result of the accident (Ref. 7). Since effluent limitations were not violated, impacts to aquatic biota of the river were not expected. Postaccident assessments and biological studies confirmed the absence of any ecological effects attributable to the accident (Refs. 7 and 8).

The initial postaccident assessment of the recreational fishery noted record low harvest indices for York Haven Pond through July 1979 (Ref. 7). Although statistically significant differences were not detected between the fishery parameters of 1979 and previous years, it was apparent that the recreational fishery differed following the accident from corresponding periods preceding the accident. The changes were attributed to altered fishing behavior due to the anglers' awareness of the accident and the releases of liquid industrial wastes to the Susquehanna River. Reduced harvests were not attributed to altered water quality of the river or to ecological impacts to river biota from the accident.

This assessment has examined the recreational fishery for the entire post-accident year of 1979 and defined reduced harvests beyond July and on an annual basis. Angler participation and fishing effort on the pond remained within historic levels; both, however, were increased at other nearby fishing areas on the Susquehanna River. Therefore, it appears that neither the nuclear accident nor the gasoline shortage experienced during the summer deterred anglers from fishing in the river during the postaccident months of 1979. Since the fishery there is primarily a local one [that is, most anglers live

within 20 mi (32 km) and reside in counties bordering the river], anglers do not have to travel long distances to fish. This is contrasted with the immediate and adverse effects that the accident had on tourism in the Harrisburg and south-central Pennsylvania area (Refs. 3 and 4).

The postaccident depression of monthly fishery harvest indices and the nearly full recovery by July followed the same general trend as the perception of threat felt by the populace living near (within 15 mi) of Three Mile Island. The public's concern with emissions from the nuclear station and the perception of threat were greatest during the accident, but by late July both had decreased relative to levels during the accident (Refs. 3). Similarly, 90% of the persons responding to questioning said that their activities during July 1979 were unchanged by the accident or were back to normal (Refs. 2 and 3). Most of the anglers who use the river near TMI are local residents, therefore, it is understandable that the observed changes in postaccident harvest patterns followed the same general trend as the local public's perception of threat from the accident. Additionally, however, anglers might be affected by events that threaten (or appear to threaten) only the river environment and not the general population of the site vicinity. During late July 1979, about 4,000 gallons (~15,000 l) of water were released from TMI to the Susquehanna River. Although the release posed no threat to public health or safety, it was reported to be "slightly radioactive" and this report was widely publicized by the news media around August 1. This elicited inquiries (letters and phone calls) to various Pennsylvania resource agencies from anglers concerned with radioactive waste and the safe consumption of river fish (personal communication, Larry Jackson, Area Fisheries Manager, Pennsylvania Fish Commission). The reduction in harvest indices for August after a nearly full recovery to normal levels in July might be attributable (at least in part) to the release event during late July-early August. This group-specific behavior is consistent with studies demonstrating that recreational fishermen are especially sensitive to and concerned with environmental quality (such as water pollution and stream alteration) and management problems concerned with adverse environmental conditions (Refs. 20 and 21).

The essential components of a recreational fishery are threefold: the fish, their environment or habitat, and the people who depend on the fish populations--the anglers (Ref. 22). Therefore, a fishery is dependent on all three components and if any one is altered, the quality of the fishery also can be altered. The quality of the postaccident fishery of York Haven Pond was changed, not through accident-related alteration of the fish populations or their aquatic environment, but by changes in the fisherman component when fishermen perceived reduced environmental or fish quality and changed their harvest behavior.

Perceptions of threat and altered sport fishery harvest patterns have accompanied other types of environmental events associated with aquatic contaminants. During the mid-1970s, the insecticide kepone contaminated portions of the James River in Virginia, a tributary of the lower Chesapeake Bay. Kepone residues were found in James River biota, including blue crabs, oysters, and bluefish (Ref. 23). Subsequently, commercial harvesting was closed in the James River (Ref. 24) and recreational fishing was permitted on a catch-and-release basis only (Ref. 25). During 1976, charter boat captains from the lower Maryland portion of Chesapeake Bay reported that many fishing trips had been cancelled because anglers were concerned about contaminated bluefish.

Around the Annapolis area, trip cancellations among charter boats were minimal, but several private boat fishermen at Chesapeake Beach, Maryland [more than 100 mi (~160 km) north or up-Bay from the James River], were reported to have released bluefish weighing up to 5 lb (~2.3 kg) because they were concerned about kepone contamination (Ref. 26). Problems with other aquatic contaminants such as PCBs, mercury, and mirex also have produced concern among anglers in various areas of the United States and have resulted in altered angler participation in sport fishing. Well-intentioned publicity associated with such events often has contributed to the reduction in angler participation, especially among the occasional or less-dedicated anglers (Ref. 24). A small number of New Jersey charter boat captains indicated that some anglers were reluctant to charter fishing trips as a result of adverse publicity in 1976 about fish contaminated with kepone and PCBs (Ref. 27).

These situations differ from the one at Three Mile Island in that contaminants and potential public health and environmental problems actually identified in the mid-1970s resulted in reductions in both harvest and angler participation (voluntary or mandatory). At Three Mile Island, no such health or aquatic environmental problems occurred and only harvest, not angler participation, was noticeably affected. It was noted that some anglers who normally fish on the pond avoided that area in 1979 following the accident, but to what degree they avoided it is unknown. Indices of harvest success were depressed for 5 months following the accident, but slowly improved to preaccident levels during the sixth month.

Although the 1979 annual harvest was poor and most of the fishing year was disrupted (in terms of monthly harvests), recovery during the same year along with normal (or unaltered) levels of fishing effort suggest that the accident-related effects on the fishery were temporary. Recovery appears to have been related to the local public's decreasing concern and perception of threat with time following the accident.

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NRC FORM 335 (7.77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER (Assigned by DDC): NUREG-0754

4. TITLE AND SUBTITLE (Add Volume No., if appropriate): Impact of the 1979 Accident at Three Mile Island Nuclear Station on Recreational Fishing in the Susquehanna River

2. (Leave blank)

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S): Clarence R. Hickey, Jr.

5. DATE REPORT COMPLETED: MONTH January 1981

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code):
Division of Engineering
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

DATE REPORT ISSUED: MONTH March YEAR 1981

6. (Leave blank)

8. (Leave blank)

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

13. TYPE OF REPORT: Staff Technical Report

PERIOD COVERED (Inclusive dates): 1979

15. SUPPLEMENTARY NOTES

14. (Leave blank)

16. ABSTRACT (200 words or less)

Dynamics of the recreational fishery of the Susquehanna River near Three Mile Island Nuclear Station during the postaccident year of 1979 are compared with those of the 5-year preaccident period 1974-1978. Monthly and annual fishing effort essentially was normal during 1979. Harvests and indices of harvest success were at record low levels for 5 months (and on an annual basis) after the accident. The monthly harvest indices gradually improved with time until normal levels were attained during the sixth postaccident month (September). The depressed harvests did not result from water quality, ecological, or radiological causes attributable to the accident. Changes in anglet harvest behavior and low retention rates for all the major fishery species were the major contributors to the poor harvest success of 1979. Those changes were attributed to the anglers' awareness of the accident and to their concern with or perception of reduced environmental quality (of the river) and fish quality after the accident. The gradual recovery of the monthly harvest indices to normal levels followed the same general trend as the perception of threat and concern with emissions felt by the people living near Three Mile Island. Although the 1979 annual harvest was poor and most of the fishing year was disrupted (in terms of monthly harvests), recovery during the same year along with normal levels of fishing effort suggest that the accident-related effects on the fishery were temporary.

17. KEY WORDS AND DOCUMENT ANALYSIS
Three Mile Island Accident
Recreational fishery
Susquehanna River

17a. DESCRIPTORS
Impact assessment
Catch and harvest
Perception of threat
Fisherman behavior

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT: Unlimited

19. SECURITY CLASS (This report): Unclassified

21. NO. OF PAGES

20. SECURITY CLASS (This page): Unclassified

22. PRICE: $

NRC FORM 335 (7.77)