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HYDROGRAPHIC AND ECOLOGICAL EFFECTS OF ENLARGEMENT OF THE CHESA--ETC(U)
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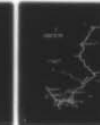
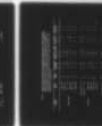
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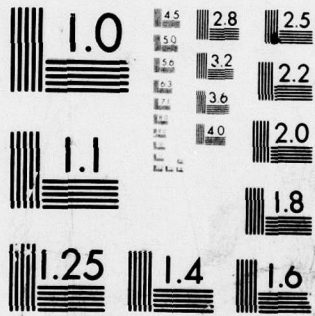
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C & D CANAL ECOLOGICAL SURVEY
 Tagging to Determine Use of C & D Canal by Fish

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6 Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal. **Final Report**
Appendix IX. Delaware Fish Migration.

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We wish to thank Mr. Carl Morris, Port Penn, Delaware for his valuable assistance in catching fish for us to tag and for prevailing on fishermen to return tags. We are indebted to Captain Thomas White, University of Delaware, for his fishing ability which enabled us to capture large numbers of striped bass for tagging. Thanks also goes to Mr. Robert Beck, Delaware Department of Natural Resources, Division of Fish and Game, for his help in making arrangements for some tagging operations and for securing tags from fishermen.

CONCLUSIONS

1. The upper Chesapeake Bay and western part of the C&D Canal is the major spawning area for striped bass found in Delaware Bay.
2. Striped bass found in Delaware waters contribute to the sport and commercial fisheries from Norfolk, Virginia to Portland, Maine.
3. The C&D Canal is an important waterway in the migrations of American shad and hickory shad.
4. The C&D Canal is used by local resident species to move between the Delaware River and upper Chesapeake Bay area.

INTRODUCTION

Tagging of fish was conducted as part of the biological survey to determine the ecological impact of enlarging the Chesapeake and Delaware Canal.

Tag and recapture data was sought to determine how fish used the canal in their migrations and movements; and to gain some knowledge of the geographic distribution of fish that spent some part of their life cycle in the Canal area. Through marking and tagging, an attempt was made to obtain a population estimate of white perch, Morone americanus, and striped bass, Morone saxatilis, present in part of the Canal at a specific time.

MATERIALS & METHODS

Fish tagging started in April 1971 and continued through May 1973. Most tagging in the Canal area was done in April and May of each year when large individuals of most species were present. During 1971, fish were tagged in the summer and fall around the Canal area. Winter tagging was confined to Delaware Bay, where striped bass were available in large numbers.

Tagging a fish consisted of measuring the fork length to the nearest half centimeter, placing a Petersen disk tag or a Carlin tag in the musculature under the dorsal fin, recording fish length and tag number, and releasing the fish immediately. Petersen tags were used on fish considered large enough to carry them without ill effect, and this size varied with species. Carlin tags were used on smaller fish. On each tag there was the word "reward", an address where to send the tag, and information to be returned with the tag. There was a \$1.00 reward given for each tag returned by the fisherman.

During the first week of May 1972, white perch caught in the Canal were marked rather than tagged so that a population estimate might be obtained for part of the Canal using the Jolly-Stochastic method of mark and recapture. Marking consisted of injecting a specified colored latex pigment into the fish and at the base of the caudal fin and forcing the pigment out into the fin along the fin rays where it was easily observable. This procedure was used because many individuals could be marked in a short time, different stations and dates would be identifiable, and it was an inexpensive

method.

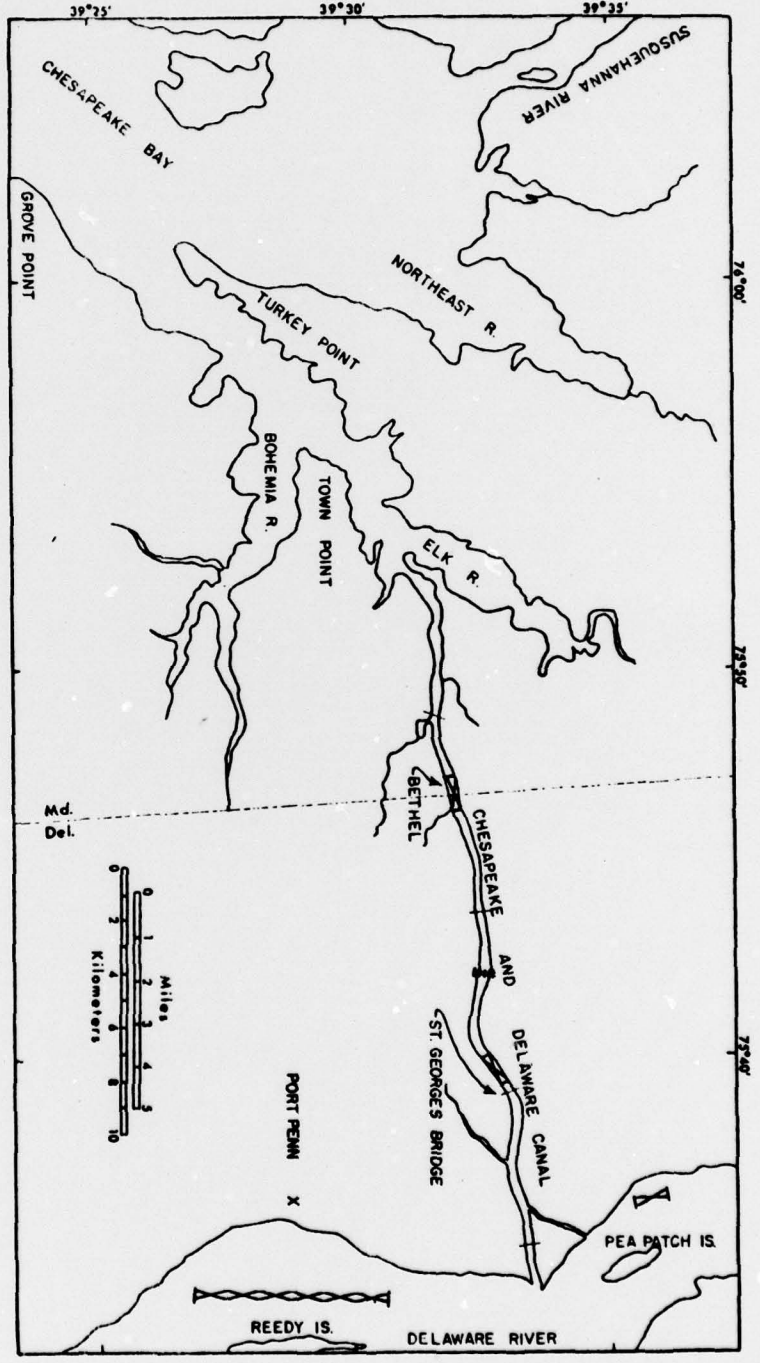
Fish for tagging were captured by means of (1) drift gill nets with 3 1/2 inch to 5 1/2 inch stretch mesh webbing; (2) a 30 foot otter trawl with 3 inch stretch mesh webbing in the wings and body, 2 inch webbing in the cod end, and 1 inch liner in the cod end; and (3) a 40 foot seine with 1/2 inch stretch mesh webbing.

All gill netting was done in the Delaware River west of Reedy Island between the Appoquinimink River and Canadas Beach, just above Port Penn. The primary area fished was between Augustine Beach and Canadas Beach (Figure 1). The reason for choosing this area for gill netting was that it was the best area near and south of the Canal where the primary target species, American shad, Alosa sapidissima, could be caught. Fish captured by gill net were removed within a few minutes after hitting the net, tagged, and released immediately.

Fish were caught by trawl for tagging during regular fish survey cruises and also on special tagging cruises. Areas fished on the survey cruises are given in the fish survey part of the report (Appendix VII), and special tagging areas were (1) in the C&D Canal near St. Georges Bridge and Bethel, Maryland, and (2) in the Delaware Bay from Big Stone Beach to Broadkill Beach (Figure 3). Fish captured were placed in a running water live tank, tagged, and released.

Seining for fish to tag was done on Reedy and Pea Patch Islands. Seining was also tried in the C&D Canal; however, bottom conditions there did not permit it. Fish captured were placed in 10 gallon plastic containers partially filled with water, tagged, and released immediately.

Figure 1. Principal areas in and around the Chesapeake and Delaware Canal where fish were caught for tagging.



RESULTS AND DISCUSSION

Table 1 gives the overall numerical information from tagging operations. The lack of returns from Carlin tags is thought to be due to the fact that fish tagged with these were too small to enter into any fishery for recapture. Since only one return has been received for Carlin tags, fish tagged with this type will not be discussed. There were no recaptures for spot (Leiostomus xanthurus), weakfish (Cynoscion regalis), black drum (Pogonias cromis), and carp (Cyprinus carpio). Only two of these species, spot and carp, were tagged with a fair number of Petersen tags. Two possible reasons for lack of spot recaptures might be a high mortality from tagging, or a high natural mortality. In the case of carp, there is not a big fishery for them so minimal recaptures could be expected. It was hoped that a few would be recaptured by sport fishermen or ourselves to see if they remained in the vicinity of capture.

Table 2 gives recapture information for Petersen tags broken down into type of fishing. Further results and discussion of the species listed in Table 2 is given by species.

STRIPED BASS (Morone saxatilis)

The general migration pattern for mid-Atlantic striped bass is that they migrate northward up the Atlantic coast after spawning in the spring, and then move southward in the fall to overwinter in estuaries and coastal areas of the mid-Atlantic region. Small

TABLE 1. Numbers of fish tagged and recaptured by tag type as part of ecological study of the Chesapeake and Delaware Canal.

SPECIES	NUMBER TAGGED		NUMBER RECAPTURED		PERCENT RECAPTURED		
	CARLIN PETERSEN	CARLIN PETERSEN	CARLIN PETERSEN	CARLIN PETERSEN	CARLIN PETERSEN	CARLIN PETERSEN	
STRIPED BASS	1971	55	127	0	27	0	21.3
	1972	6	518	0	44	0	8.5
	1973	0	889	0	222	0	25.0
WHITE PERCH	1971	398	451	1	23	0.2	5.1
	1972	20	64	0	7	0	10.9
AMERICAN SHAD	1971		154		25		16.2
	1972		100		13		13.0
	1973		34		4		
HICKORY SHAD	1971		43		13		30.2
	1972		23		10		43.5
	1973		94		11		11.7
CHANNEL CATFISH	1971		20		0		0
	1972		15		5		33
WHITE CATFISH	1971		3		1		33
	1972		10		0		0
ALEWIFE	1971		2		0		0
	1972		11		1		9.1
GLIZZARD SHAD	1971	2	11		1		9.1
	1972		16		0		0
YELLOW PERCH	1971		2		2		100

Table 1, continued.

SPECIES		NUMBER TAGGED		NUMBER RECAPTURED		PERCENT RECAPTURED	
		CARLIN PETERSEN		CARLIN PETERSEN		CARLIN PETERSEN	
SPOT	1971	107	133	0	0	0	0
WEAKFISH	1971	46	7	0	0	0	0
BLACK DRUM	1971	15	8	0	0	0	0
CARP	1971		25		0		0
	1972		20		0		0

TABLE 2. Numbers of fish tagged with Petersen tags as part of ecological study of the Chesapeake and Delaware Canal, and recaptures by type of fishing.

SPECIES	NUMBER TAGGED	NUMBER RECAPTURED		PERCENT RECAPTURED		
		SPORT	COMMERCIAL	SPORT	COMMERCIAL	TOTAL
STRIPED BASS	1971	10	17	7.9	13.4	21.3
	1972	11	33	2.1	6.4	8.5
	1973	23	199	2.6	22.4	25.0
Fish larger than 50 centimeters						
HICKORY SHAD	1971	8	0	32.0	0	32.0
	1972	3	1	23.1	7.7	30.8
	1973	1	1	4.8	4.8	9.5
SHAD	1971	1	12	2.3	27.9	30.2
	1972	3	7	13.0	30.4	43.5
	1973	3	8	3.2	8.5	11.7
WHITE PERCH	1971	19	6	12.3	3.9	16.2
	1972	1	12	1.0	12.0	13.0
	1973	2	2	5.9	5.9	11.8
CHANNEL CAT-FISH	1971	0	23	0	5.1	5.1
	1972	0	7	0	10.9	10.9
WHITE CAT-FISH	1971	0	0	0	0	0
	1972	3	2	20	13	33
YELLOW PERCH	1971	0	1	0	33	33
	1972	0	0	0	0	0
YELLOW PERCH	1971	0	2	0	100	100
	1972	2	2	0	0	0

Table 2, continued.

SPECIES	NUMBER TAGGED	NUMBER RECAPTURED		PERCENT RECAPTURED	
		SPORT	COMMERCIAL	SPORT	COMMERCIAL
ALEWIFE	1971	0	0	0	0
	1972	0	1	0	9.1
	1973	0	0	0	0
GIZZARD SHAD	1971	0	1	0	9.1
	1972	0	0	0	0
	1973	0	0	0	0

juvenile fish, or those under 30 centimeters do not make extensive migrations, but remain in or near their natal estuary. (Nichols, 1966; and Massmann and Pacheco, 1961).

Striped bass tagged at Reedy Island in the spring are thought to be fish coming up the Delaware River to spawn in the C&D Canal spawning area or possibly in the Delaware River. Most fish tagged here were over 45 centimeters (four years or older) because the gill net used was primarily for shad and had 5½ inch stretch mesh. As described in the general migration pattern for adult fish, recaptures show (Figure 2) that the fish moved northward up the coast after spawning. Of the 15 fish recaptured (Table 3), 67% of them were recaptured north of Delaware Bay. The other five fish were recaptured in the Chesapeake and Delaware Bays near the C&D Canal spawning area (Figure 3), three within 12 days of release, and two one year later. These latter two recaptures give evidence to support the theory that striped bass return to the same spawning grounds on succeeding years (Nichols, 1966). Fish tagged near Reedy Island in the summer and fall were two and three years old. Out of the 17 fish recaptured (Table 3), 94% were caught in the Chesapeake and Delaware Bays (Figure 3). The other fish was recaptured at Saco River, Maine, the following June. It seems that juvenile striped bass remaining in the vicinity of the canal during the summer and fall, stay in the general bay area at least through the following spring spawning season. This observation agrees with the generalized migration pattern for striped bass.

Figure 2. Northeast Atlantic Coast showing points of striped bass recapture.

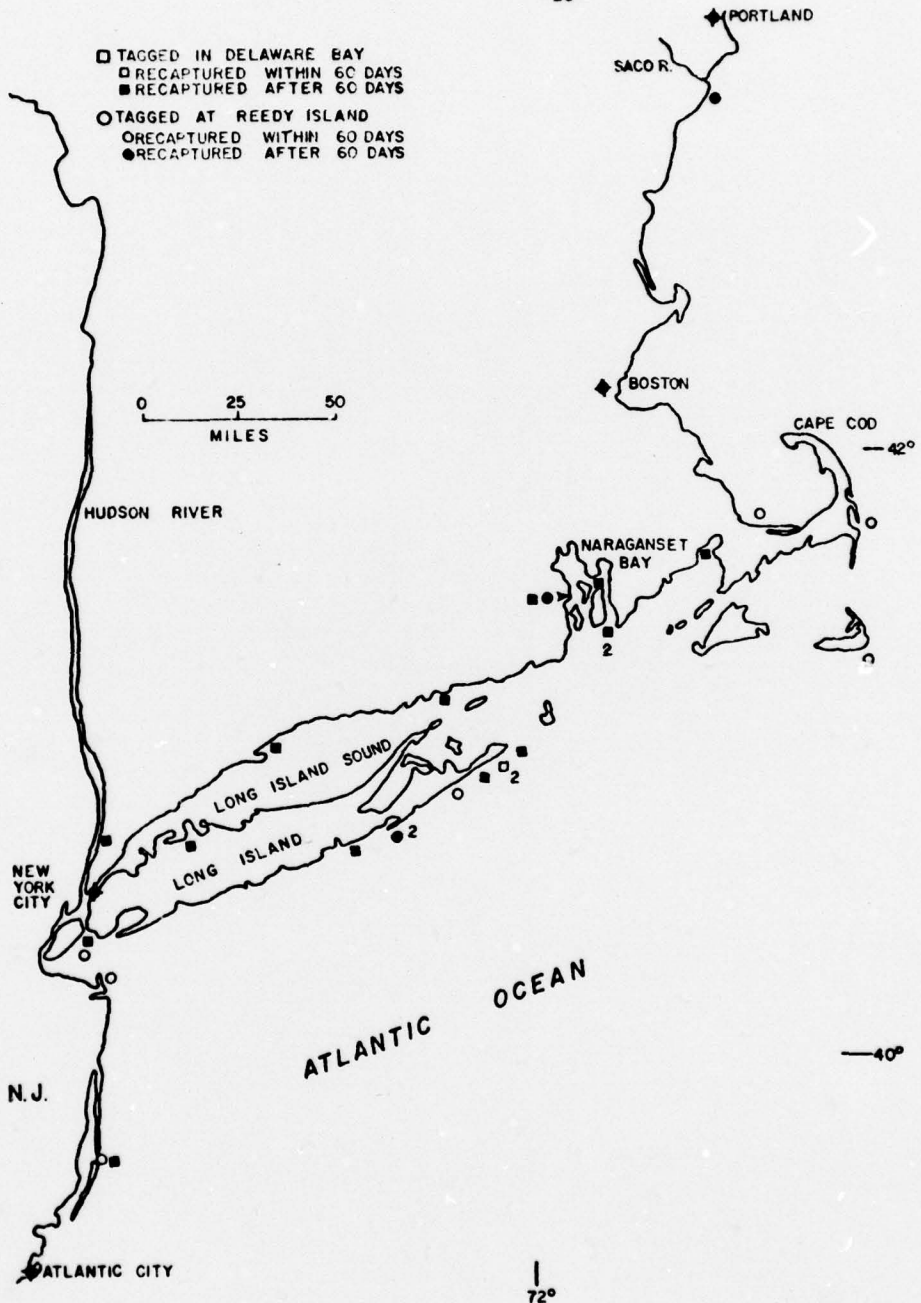


Figure 3. Delaware and upper Chesapeake Bays showing striped bass tagging areas and points of recapture.

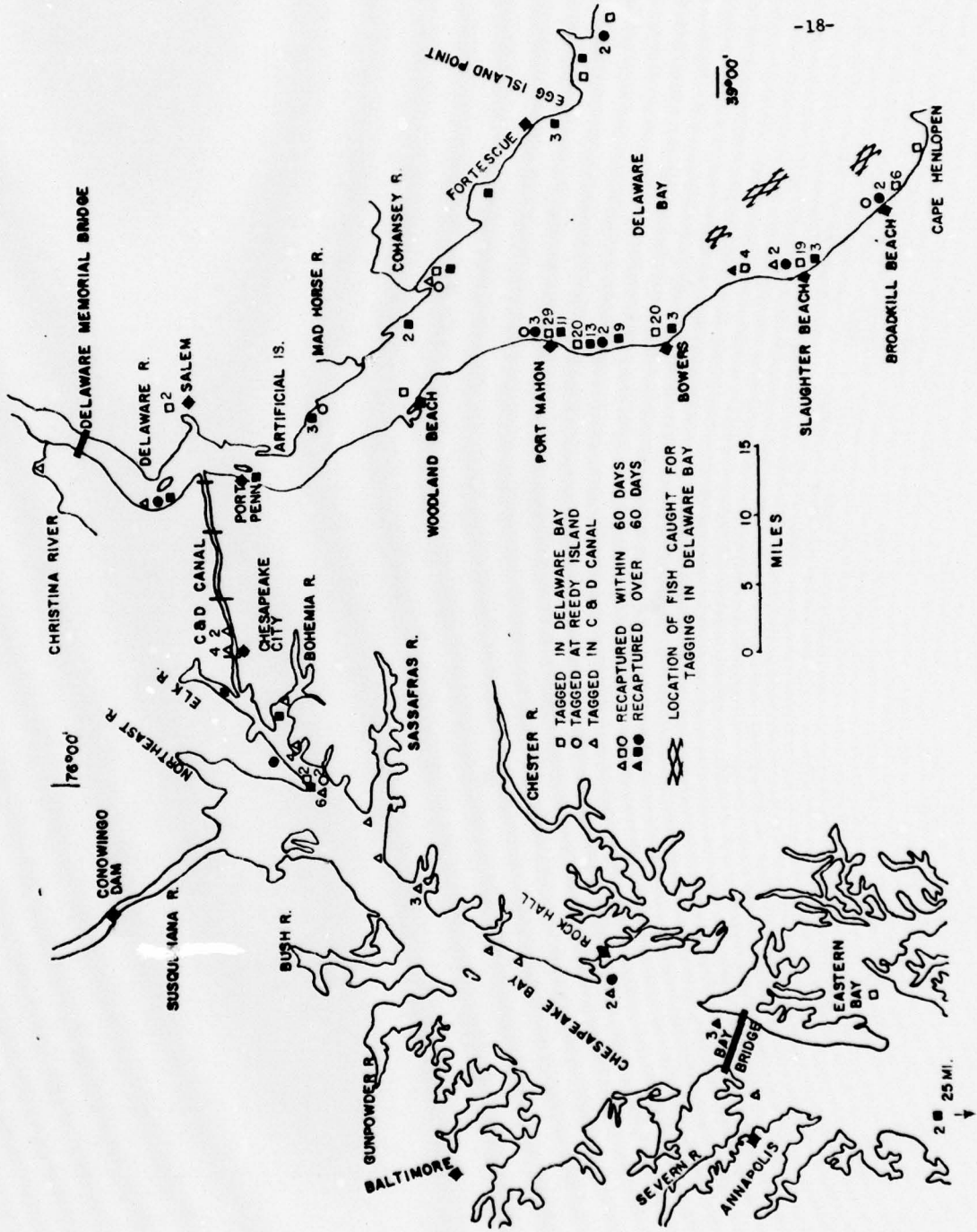


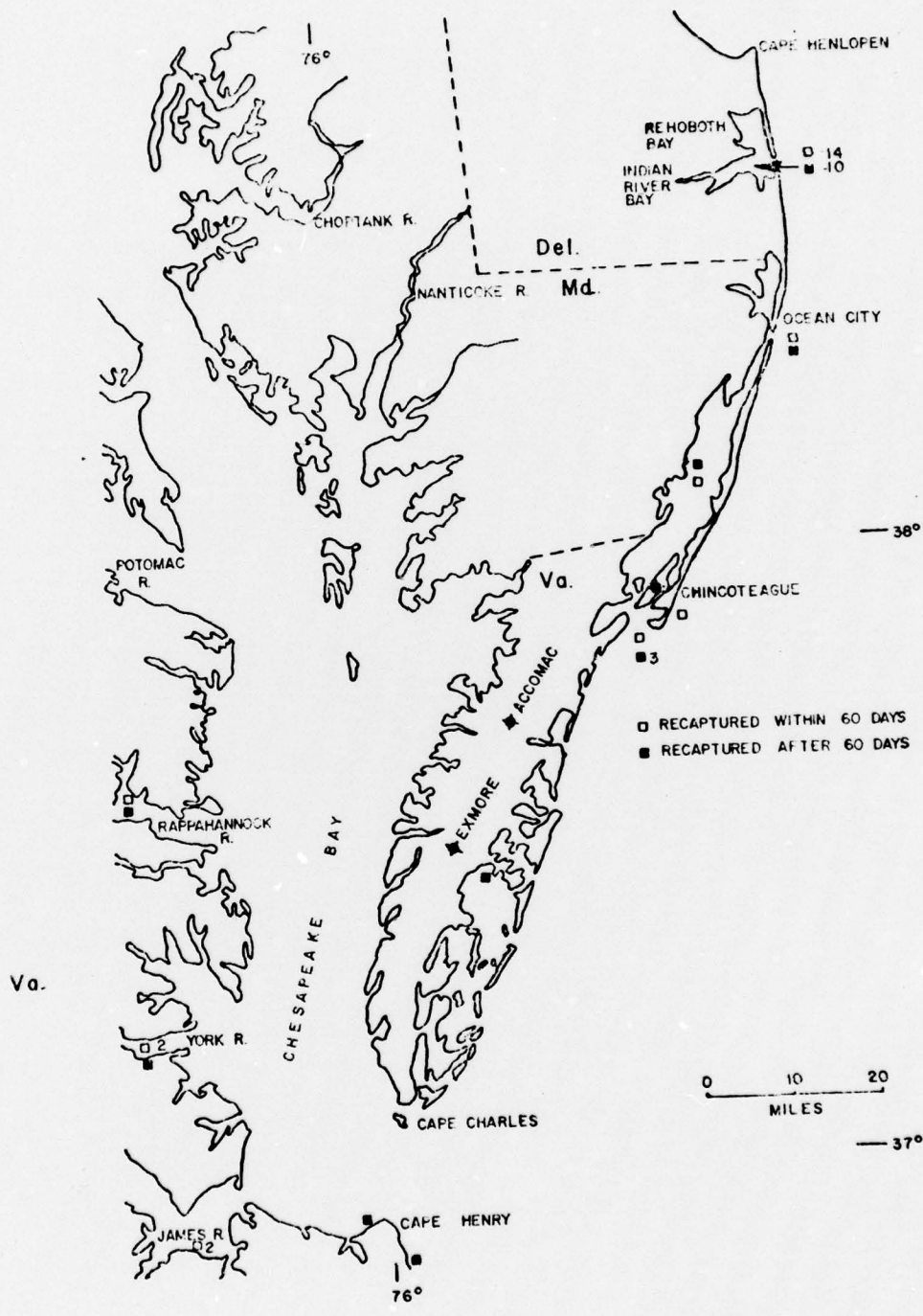
TABLE 3. Seasonal Petersen tagging data and recaptures by general area for striped bass tagged as part of ecological study of the Chesapeake and Delaware Canal. Percent recaptured by area is based on total number recaptured, not total number tagged. Chesapeake and Delaware Bay area includes all of Delaware Bay and Maryland part of Chesapeake Bay. North of Delaware Bay includes all points along the Atlantic coast northward. South of Delaware Bay includes all points along the Atlantic coast southward and also the Virginia part of Chesapeake Bay.

TAGGING LOCATION	SEASON TAGGED	NUMBER TAGGED	TOTAL NUMBER RECAPTURED IN CHESA- RECAPTURED N. RECAPTURED S.		PEAKE & DEL. BAYS OF DEL. BAY OF DEL. BAY					
			No.	%	No.	%	No.	%		
REEDY ISLAND	Spring 1971	30	8	26.7	1	12.5	7	87.5	0	0
	Summer 1971	12	3	25.0	3	100	0	0	0	0
	Fall 1971	38	14	36.8	13	92.9	1	7.1	0	0
	Spring 1972	15	5	33.3	2	40.0	3	60.0	0	0
	Fall 1972	2	0	0	0	0	0	0	0	0
	Spring 1973	29	2	6.9	2	100	0	0	0	0
	Total Spring 71-73	74	15	20.3	5	33.3	10	66.7	0	0
	Total Fall 71-73	40	14	35.0	13	92.9	1	7.1	0	0
C&D CANAL	Spring 1971	27	1	3.7	1	100	0	0	0	0
	Summer 1971	2	1	50.0	1	100	0	0	0	0
	Spring 1972	468	33	7.1	33	100	0	0	0	0
	Spring 1973	47	1	2.1	1	100	0	0	0	0
	Total Spring 71-73	542	35	6.5	35	100	0	0	0	0

Table 3, continued

TAGGING LOCATION	SEASON TAGGED	NUMBER TAGGED	TOTAL NUMBER RECAPTURED		RECAPTURED IN CHESA-PEAKE & DEL. BAYA		RECAPTURED N. OF DEL. BAY		RECAPTURED S. OF DEL. BAY	
			No.	%	No.	%	No.	%	No.	%
PEA PATCH ISLAND VICINITY	Spring 1971	1	0	0	0	0	0	0	0	0
	Summer 1971	4	0	0	0	0	0	0	0	0
	Fall 1971	1	0	0	0	0	0	0	0	0
	Spring 1973	7	0	0	0	0	0	0	0	0
DELAWARE BAY Around 38°55' by 75°12'	Winter 1971-72	33	6	18.2	6	100	0	0	0	6
	Winter 1972-73	806	219	27.2	160	73.1	16	43	19.6	219

Figure 4. Mid-Atlantic Coast and lower Chesapeake Bay showing points of striped bass recapture.



Fish tagged in the C&D Canal in the spring were mostly males two and three years old, presumably in the area for spawning. As shown in Table 3, the majority were tagged in the spring of 1972. All recaptures were from the Chesapeake and Delaware Bays area (Figure 3), and most were caught within two months after tagging. It is not known why the percentage of returns was so low for fish tagged in the canal.

A total of 13 striped bass were tagged in the vicinity of Pea Patch Island (Table 3). There were no recaptures for this area.

In February 1972, 33 fish (90% two years old) were tagged in lower Delaware Bay (Figure 3). Out of six returns, five were from Delaware Bay and the other was from the C&D Canal spawning area. This seemed to indicate that fish present in Delaware Bay in the winter stayed in the area until after spawning. However, results from 806 fish tagged in the same area in January and February 1973 indicate that this is not so for some fish. As shown in Figures 3 and 4 and Table 3, 19.6% of the recaptures were from the coastal area south of Delaware Bay. Of these recaptures, eight fish or 3.6% were caught in rivers of Virginia emptying into lower Chesapeake Bay. All these fish except one were recaptured before or during the time of spawning in the C&D Canal area. Therefore, it seems that a fair number of fish present in Delaware Bay during part of the winter do not remain there all winter and then spawn in the C&D Canal

as previously thought. It is probable that striped bass present in Delaware Bay in the winter are a mixture of several spawning stocks, and these fish work their way towards their spawning grounds as they ripen. From the recapture pattern (Figure 4), it appears that all fish migrating to the rivers of lower Chesapeake Bay to spawn do so by moving down the Atlantic coast and not through the Canal and down the Chesapeake Bay. The C&D Canal spawning stock is the dominant one; however, since 73.1% of the fish recaptured were taken in the upper Chesapeake and Delaware Bays.

deSylva (1961) concluded on the basis of meristic characters that the Delaware River probably supports a spawning population of striped bass, but that the Delaware population is supplemented by stocks from other regions, especially the James River, Virginia, and upper Chesapeake Bay. Results from the present study indicate that striped bass spawned in the C&D Canal area contribute most to the Delaware population.

The 16 fish that were recaptured northward up the coast (Figure 2) before spawning time were probably immature females on their feeding migration. Five of the 16 fish listed in Table 3 as caught north of Delaware Bay were recaptured before or during the time of spawning in the C&D Canal area.

Both Table 2 and Table 3 indicate the high fishing mortality for striped bass, especially in 1971 and 1973 when it was 21% and 25% respectively. This mortality is even higher for fish over 50

centimeters. It is surprising that striped bass from the Delaware area can support such a high fishing mortality and still maintain their stocks at high levels of abundance. This fact emphasizes the importance of protecting all spawning and nursery areas used by fish frequenting Delaware waters. With such a high annual fishing mortality, it would take very little time to drastically reduce the population if they could not maintain their present rate of recruitment. A significant reduction in population size would be felt by sport and commercial fishermen all along the Atlantic coast and not just in the Delaware area. It is interesting to note that the majority of recaptures of fish larger than 50 centimeters (Table 2) are by sport fishermen. One reason for this is that most of these fish were recaptured along the Atlantic coast north of Delaware Bay, and the sport fishing effort and catch in this area is considerably greater than that of commercial fishing (Albert C. Jensen, personal communication).

The 468 striped bass tagged in the C&D Canal in the spring of 1972 (Table 3) were all tagged the beginning of May to try to get an estimate on the numbers of fish in part of the canal at that time. Subsequent sampling yielded no recaptures, so no population estimate could be made. The fact that there were no recaptures indicates; (1) that striped bass in the canal at spawning time are highly mobile and do not remain in a given area very long, and (2) there is a considerable number of fish present at this time.

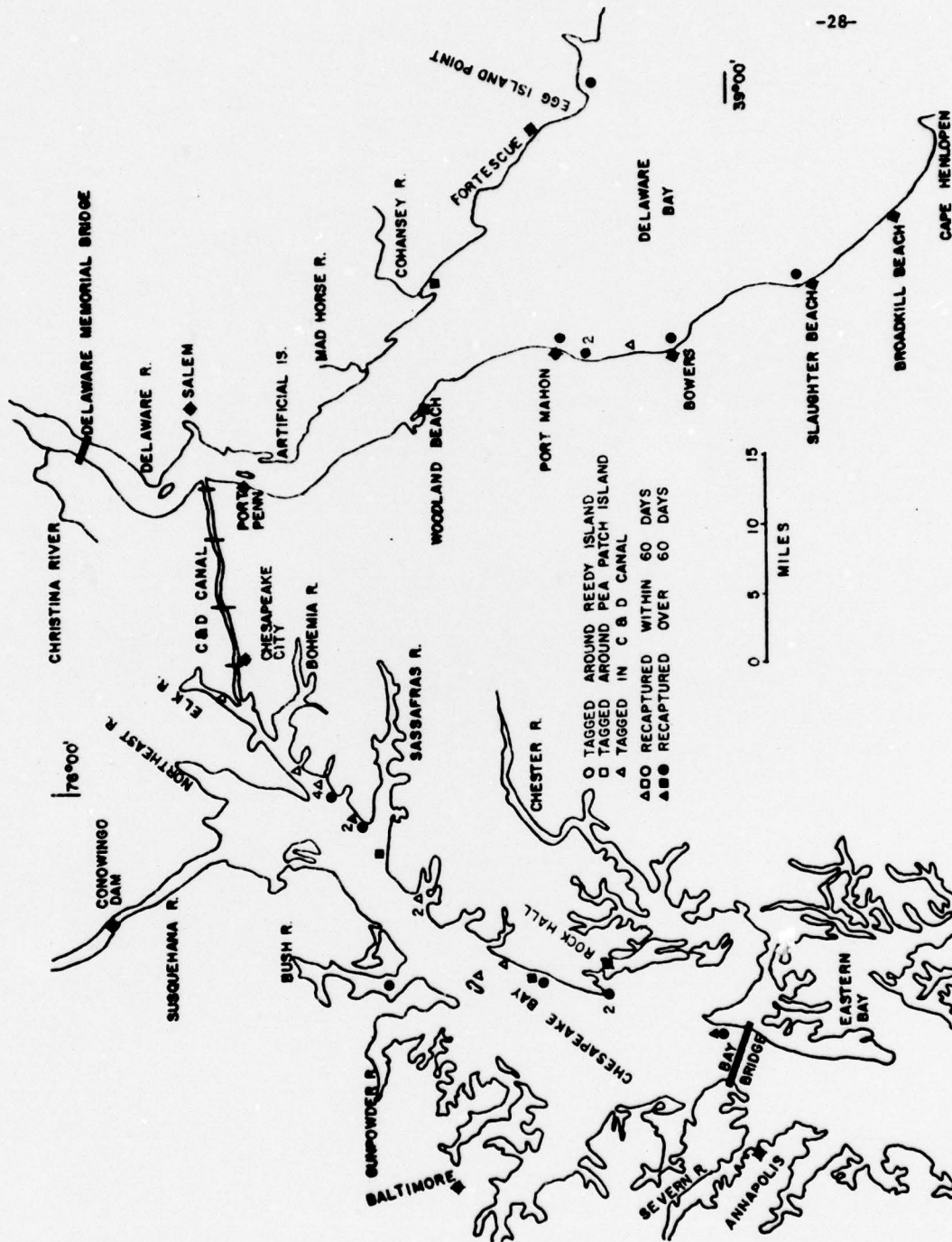
WHITE PERCH (Morone americanus)

White perch are primarily an estuarine anadromous fish, with a range from South Carolina to Nova Scotia. No real migrations are undertaken by this species, except one to reach fresh or slightly brackish water for spawning, if they live a distance from this type of area (Bigelow and Schroeder, 1953).

Out of the 15 returns for fish tagged in the Delaware River near the canal, 46.7% (seven fish) were recaptured in the Delaware Bay and River, and 53.3% (eight fish) in the upper Chesapeake Bay (Figure 5). For perch tagged in the eastern half of the canal, 50.0% (seven fish) were recaptured near the western mouth of the canal, 42.8% (six fish) in the upper Chesapeake Bay, and 7.2% (one fish) in the Delaware Bay (Figure 5). The generalized pattern indicated from these results is that some white perch move from the area around the eastern end of the canal down into the Delaware Bay and through the canal down into the upper Chesapeake Bay. There does not seem to be any seasonal pattern to their movements.

In the beginning of May 1972, 1,057 perch were marked at St. Georges Bridge and Bethel, Maryland. It was hoped that some recaptures would be made with subsequent sampling so that a population estimate could be obtained for white perch in part of the canal at that time. However, no recaptures were made in the 2,400 perch caught during tagging and subsequent sampling. Lack of returns indicates; (1) that these perch are very mobile, and (2) that there is a very large population present in the canal at this time of year when they are spawning.

Figure 5. Delaware and upper Chesapeake Bays showing white perch points of recapture.



AMERICAN SHAD (Alosa sapidissima)

The typical shad migration pattern of adult fish migrating to natal streams in the spring for spawning and then northward to the New England area for the summer and fall has been well established (Nichols and Miller, 1966).

All shad were tagged in the spring at Reedy Island. Out of the 42 fish recaptured (Table 2), 50% were caught in the upper Chesapeake Bay and Susquehanna River, 47.6% in the Delaware and Brandywine Rivers, and the tag from one fish (2.4%) was found on the beach at Sandy Hook, New Jersey. Actual recapture locations are given in Figure 6 with the exception of the tag from Sandy Hook and two recaptures in the upper Chesapeake Bay at Rock Hall. Four fish were recaptured one year after release, one at Rock Hall, two around the western end of the canal, and one in the Susquehanna River. It is not known whether these fish came up the Delaware or Chesapeake Bays to reach their spawning grounds.

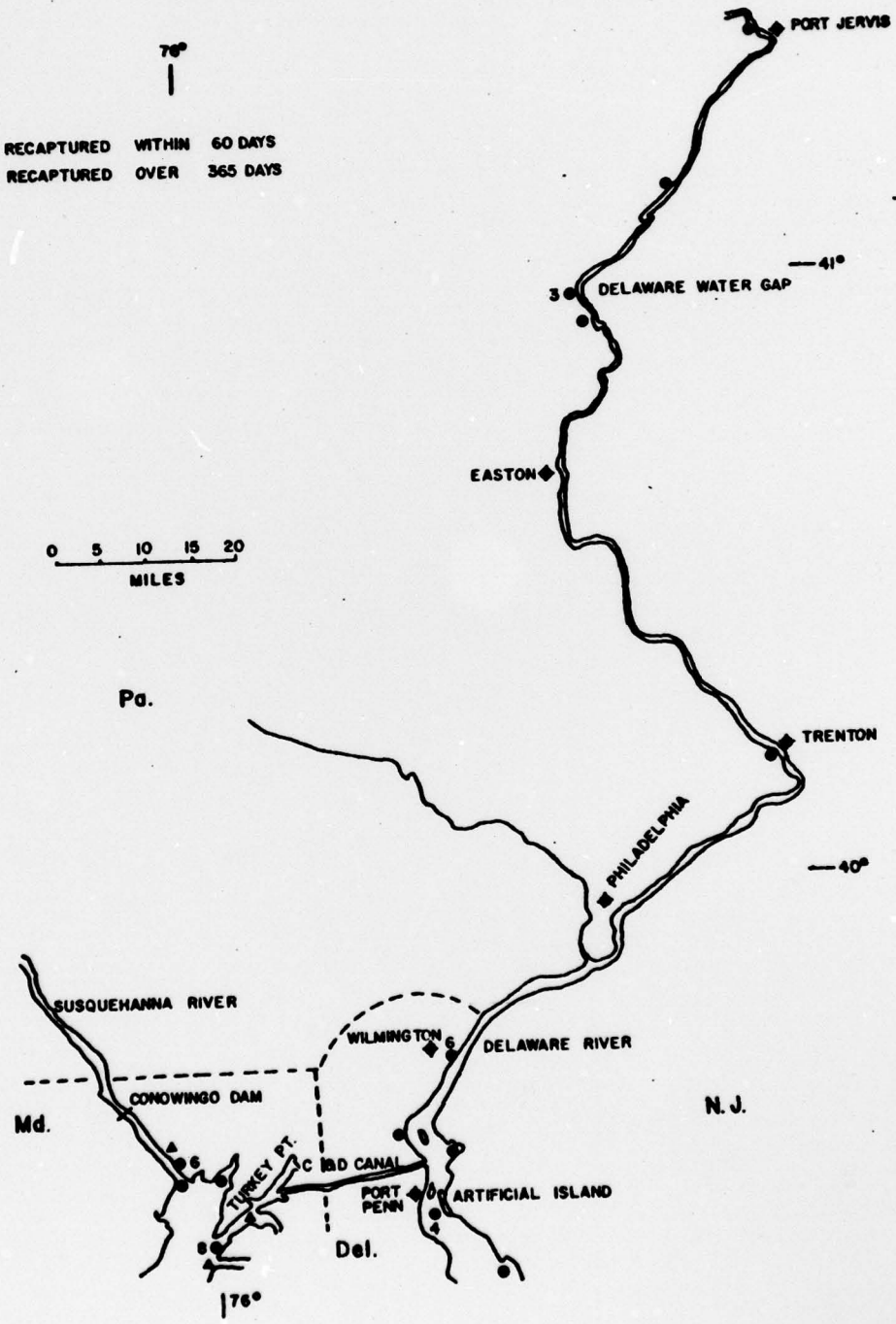
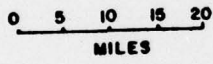
It seems that approximately half the shad coming up the Delaware River below the canal use the canal to cross over and reach spawning grounds in the Susquehanna River. Whether these fish find adverse conditions in the Delaware River and cross over to spawn in the Susquehanna or whether the Delaware-C&D Canal route is one commonly used by shad to reach the Susquehanna is not known. Since shad do get up the Delaware (Figure 6), the adverse condition factor must

Figure 6. Delaware River and C&D Canal area showing American shad points of recapture.

-31-

- RECAPTURED WITHIN 60 DAYS
- ▲ RECAPTURED OVER 365 DAYS

76°



change on a daily basis. It might be that the Delaware-C&D Canal route has become genetically imprinted in some shad using the Susquehanna River. This route is certainly shorter for fish moving down from New England than going down the coast to the mouth of Chesapeake Bay and then up the length of that bay. Whatever the reason, the C&D Canal is considered an important waterway in the migration of shad.

HICKORY SHAD (Alosa mediocris)

Information on hickory shad migrations and movements is limited; however, it is known that they migrate to brackish and fresh water areas in the spring for spawning and they also make a fall migration through these areas. It is suspected that the rest of their time is spent in coastal ocean areas (Bigelow and Schroeder, 1953).

All hickory shad were tagged in the vicinity of Reedy Island during the spring or fall. Tagging results indicate that spring run fish use the C&D Canal something like the American shad (Figure 7). Out of 31 returns for fish tagged in the spring, 67.7% (21 fish) were recaptured in the upper Chesapeake Bay and Susquehanna River, and 32.3% (ten fish) were recaptured in the lower Delaware River and upper Bay. Fall run fish evidently go through the canal area on their way to the rivers and sounds of North Carolina. All three recaptures from fish tagged in the fall were from the Neuse River, North Carolina (Figure 8). One fish tagged in the spring of 1971 was recaptured in the fall of 1972 at Great Oaks, Maryland (Figure 7), indicating that hickory shad use the same migratory route yearly.

The recapture rate for hickory shad is extremely high (Tables 1 and 2). One possible reason for this is that large adult fish may be very susceptible to fishing pressure, and only large adult fish were tagged in this study. It is doubtful that the hickory shad popu-

Figure 7. Delaware and upper Chesapeake Bays
showing hickory shad points of
recapture.

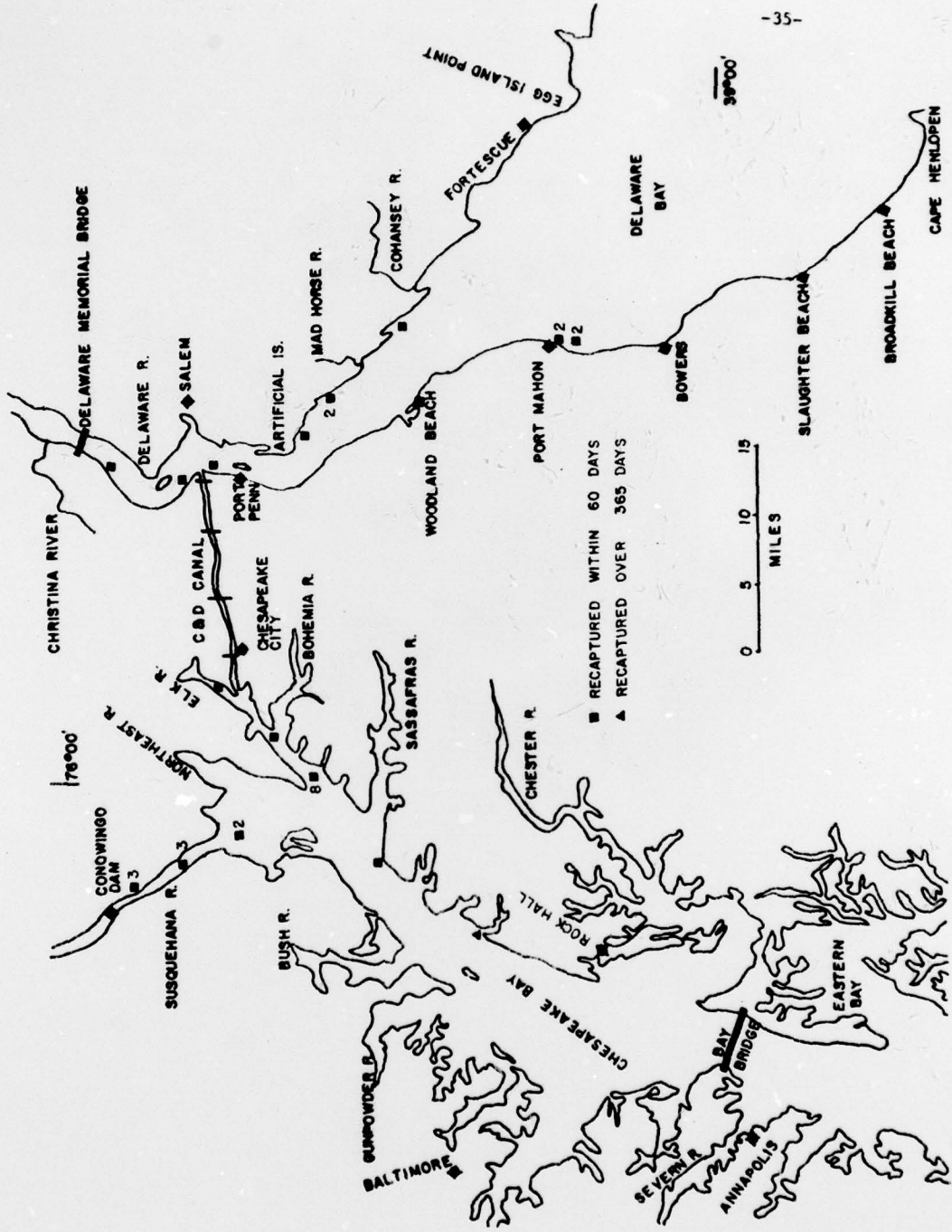
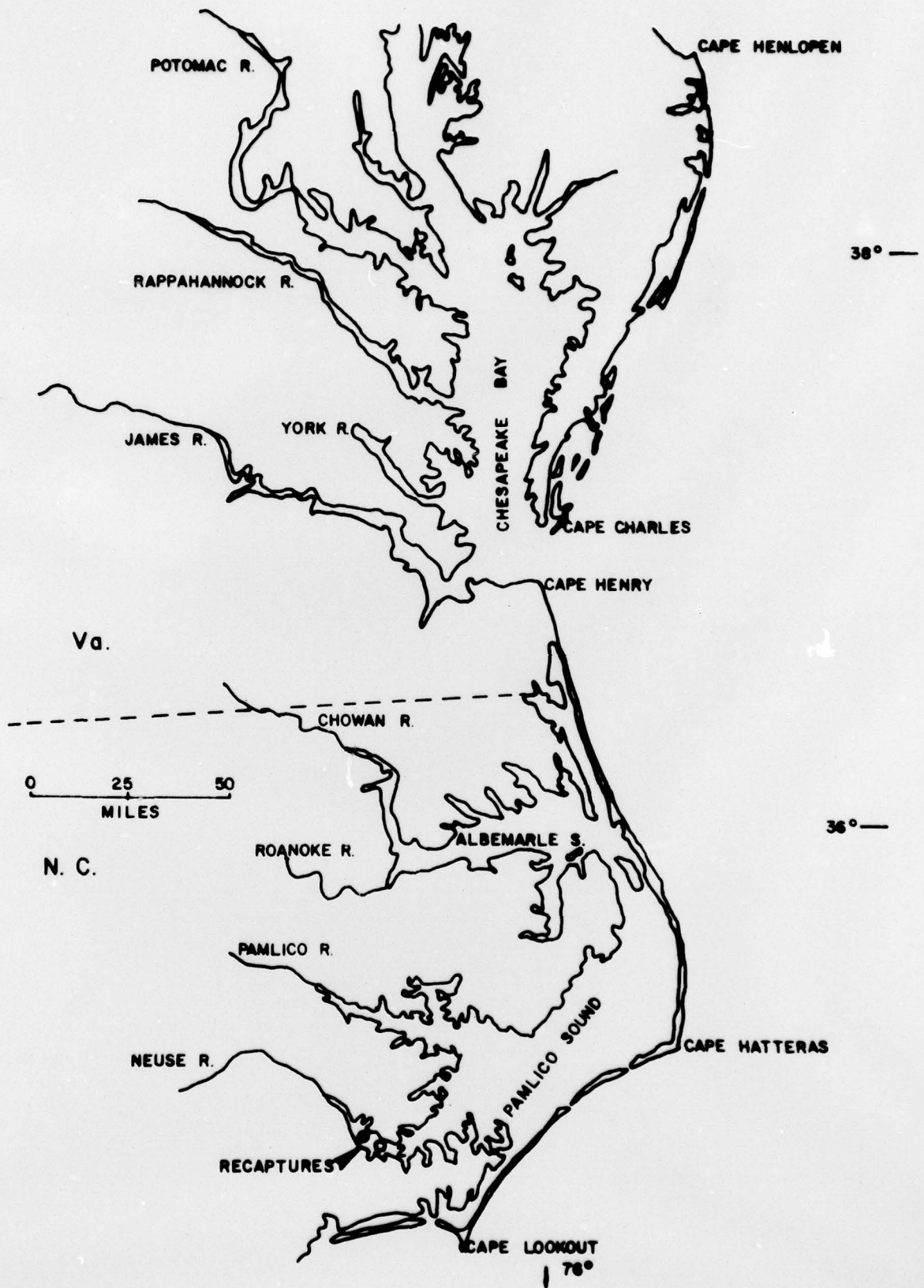


Figure 8. Atlantic coast from Cape Henlopen to Cape Lookout showing hickory shad points of recapture.



lation as a whole could withstand such a high fishing mortality and continue to maintain itself.

CHANNEL CATFISH (Ictalurus punctatus)

Being primarily a fresh water species, channel catfish movements are influenced by salinity, and this can be seen in the tagging results (Figure 9). The five fish recaptured were all caught in the upper Chesapeake area or in the canal, where salinities are normally lower than in the Delaware River.

WHITE CATFISH (Ictalurus catus)

The above statements about channel catfish also pertain to the white catfish. The single recapture out of eight fish tagged near Reedy Island was at the western end of the canal (Figure 9).

YELLOW PERCH (Perca flavescens)

Two fish were tagged just below Reedy Island, and both of these were recaptured at the head of Chesapeake Bay (Figure 10). Again, their movements were probably influenced by salinity and they used the C&D Canal as a route to move westward to an area near the Susquehanna River.

ALEWIFE (Alosa pseudoharengus)

and

GIZZARD SHAD (Dorosoma cepedianum)

About all that can be said for these species is that the one

Figure 9. Delaware and upper Chesapeake Bays showing channel catfish (Δ) and white catfish (O) points of recapture.

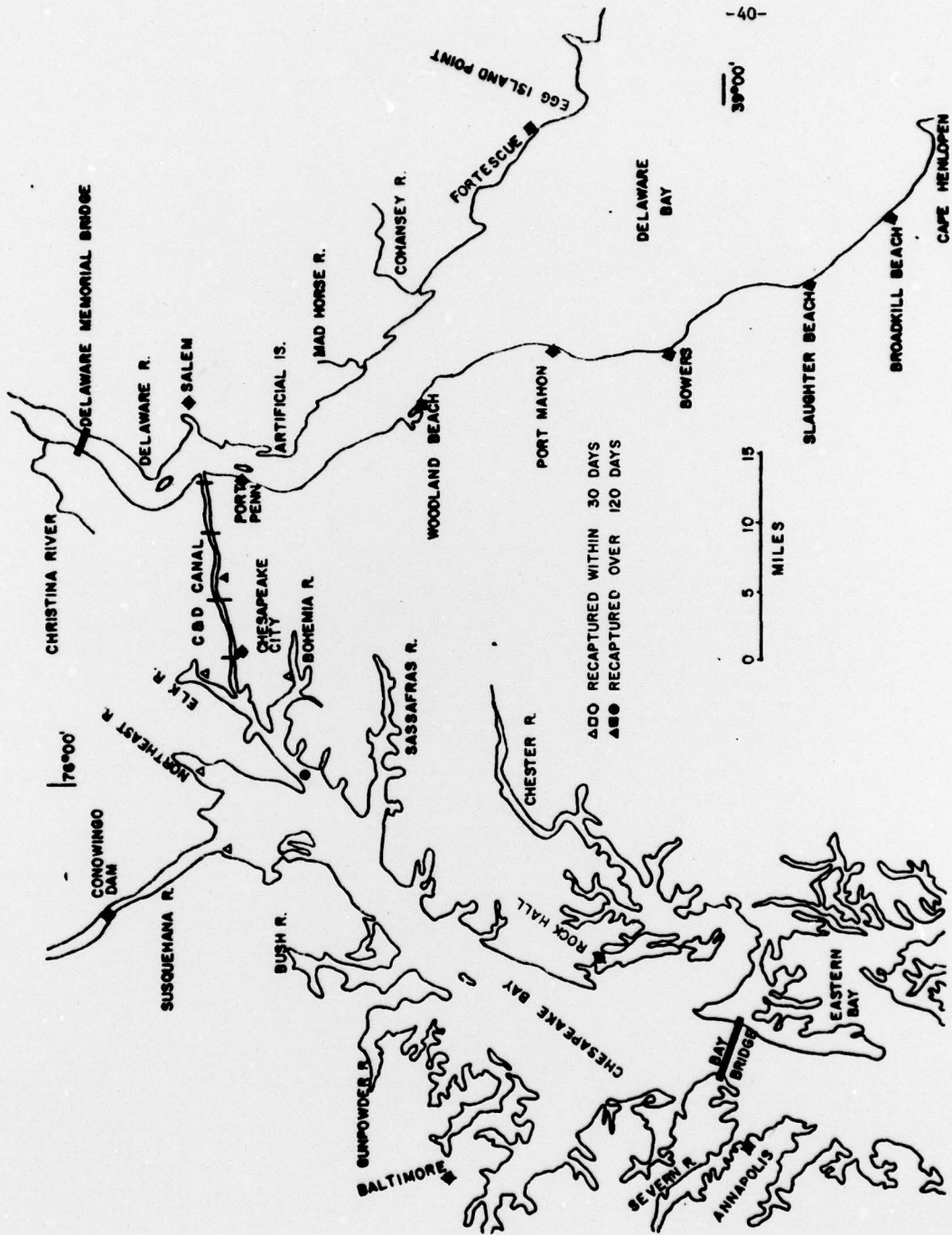
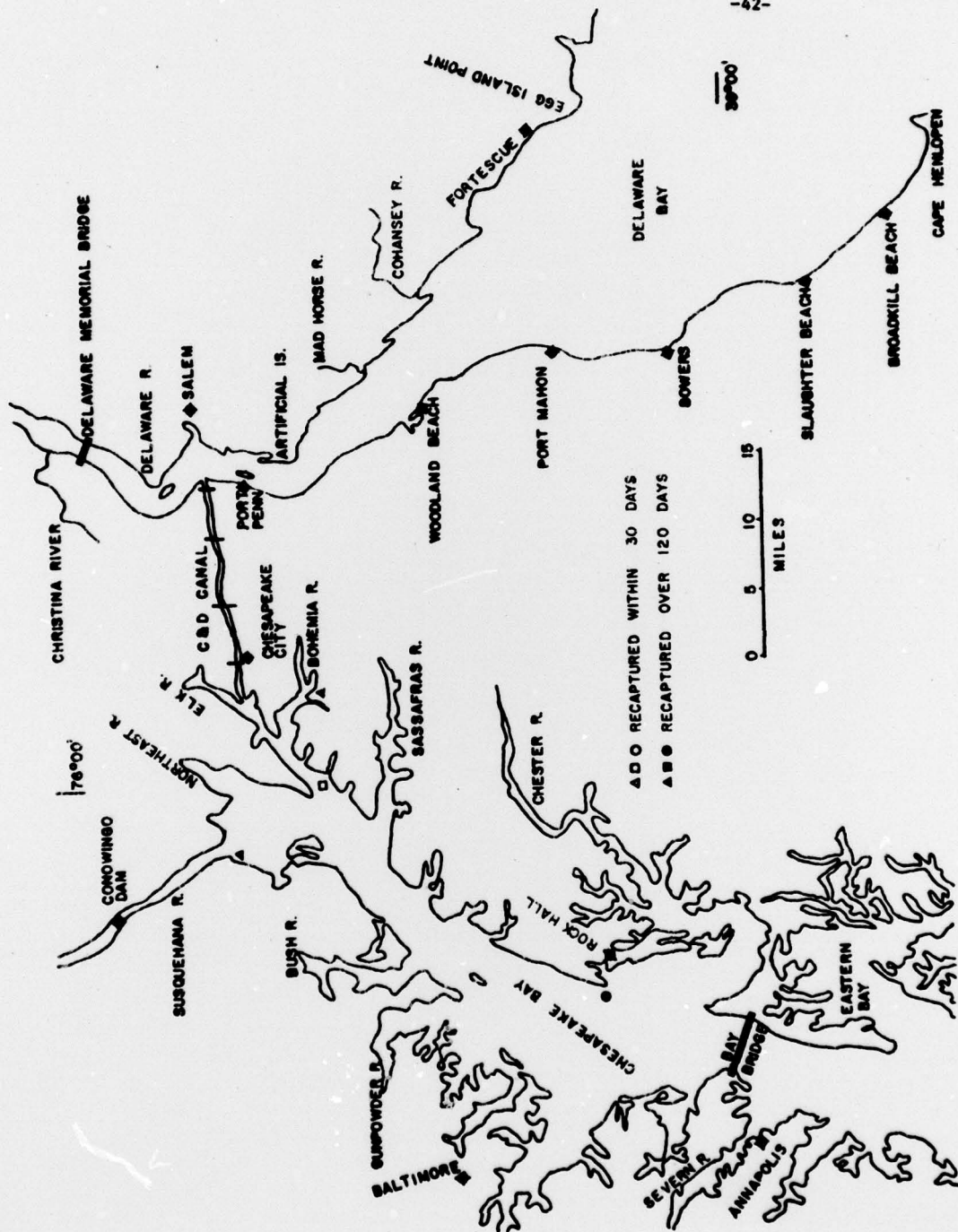


Figure 10. Delaware and upper Chesapeake Bays showing points of recapture for yellow perch (Δ), alewife (\square), and gizzard shad (\circ).



recapture for each one went west through the canal and was recaptured in the upper Chesapeake Bay.

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GLOSSARY

- Anal Fin - The fin situated medially and normally immediately behind the anus.
- Carlin Tag - A tag consisting of a strip of plastic bearing a message attached to articulated links of stainless steel wire. It is attached to the fish by two wires passing through the musculature and bones internally supporting the dorsal or anal fin and being twisted together on the other side.
- Caudal Fin - The fin on the tail.
- Dorsal Fin - The fin situated medially on the back. Sometimes more than one are present.
- Fork Length - The straight line distance from the tip of the snout to the apex of the angle formed by the caudal fin lobes.
- Petersen Tag - A tag consisting of 2 metal or plastic discs connected by a wire passing through the body of a fish, usually under the dorsal fin.