50-247

Redirect - Rebuttal Testimony of

Dr. C. P. Goodyear and Dr. J. S. Mattice

Effect of Indian Point Unit 2 Chlorination on the Aquatic Biology of the Hudson River

March 1, 1973

Reference:

Testimony of Dr. John P. Lawler (5 February 1973): "Effect of Indian Point Unit 2 Chlorination on the Aquatic Biology of the Hudson River."

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Effect of Indian Point Unit 2 Chlorination on the Aquatic Biology

In his rebuttal testimony, Dr. John P. Lawler concluded that the staff short-term and chronic toxicity limits for chlorine releases did not apply to the Indian Point situation because the staff analysis included data pertaining to fish not found at Indian Point. He presented data for five fish which he said were common to the Hudson River at Indian Point and stated that these data were the only ones relevant to the discussion of Indian Point chlorine releases. A model developed by Quirk, Lawler and Matusky Engineers (Q.L.&M.) and calibrated using field data obtained by Q.L.& M. from Indian Point 1 was used to show that chlorine concentrations predicted by the model were not above safe concentrations if Indian Point 1 was operating and were not above toxic levels for the five fish species.

The purpose of limiting effluent releases to the aquatic environment is the protection of that environment from major detrimental modification. Ideally, this would involve not only complete knowledge of all local species reactions to proposed levels of all releases alone and in combination, but also of the role of each vulnerable organism in the ecosystem and the changes in the community which would result if that species were depleated or eliminated. There is no effluent or ecosystem for which this knowledge exists. Chlorine releases are certainly not an exception.

Given that the ideal situation does not apply to chlorine, there are four approaches that can be taken: (1) set no limits; (2) consider only the limited information that is derived from studies of species found at the site and set limits to protect them; (3) use all known information in an attempt to gain a general idea of safe levels; or (4) prohibit releases. The first and fourth approaches above are untenable for ecological and economic reasons, respectively. The second approach above assumes that tolerance of species which have not been studied will be similar to those which have been investigated. This is a very poor assumption. If 50% mortality is considered to be the end point in toxicity tests, some organisms can withstand a dose more than two orders of magnitude higher than other organisms when exposures are equal (See Figure 1). Of course, the more limited the data both in numbers of species and in terms of phylogenetic inclusion the more tenuous the extrapolation. The remaining approach has the advantage, especially given the extreme limitation of present data, of crossing phyletic lines as well as having the greater possibility of erring on the side of safety. It does not guarantee protection of a given ecosystem. Most of the points plotted indicate the concentration-duration which yields 50% mortality. The recommended limits are below these points, but may not be completely without sublethal effects on, for example, reproduction. This is not to imply that this is the best solution or even a very satisfactory one. It is, however, the best stopgap method of protecting the acquatic community while minimizing economic penalties as much as possible. As more and more data becomes available the limits may change. The short duration toxicity threshold in Figure 1 was revised in December of 1972 and several data points have been added since. Some of these points have a direct bearing on the conclusions to be drawn from the OL&M model predictions.

In his redirect-rebuttal testimony Dr. Lawler reached the opposite conclusion regarding which of the two methods should be used to set limits at Indian Point. Results derived from studies of five fish species were compared to the "staff curve" (Figure 1) to indicate the lack of applicability to the Indian Point situation. His argument is vulnerable in the respects discussed below.

Despite Dr. Lawler's statement, that the fathead minnow and black sucker are common species in the Indian Point area, they are not listed as such in the "Raytheon Company Final Report," for the period June 1969 through October 1971. During that period, the highest number in either a seven minute bottom or surface trawl or beach seine for each of the other three species was one. More often there was less than one each. No largemouth bass were found in any trawl samples. For these collections (maximum of one or more of the five species) the total fish caught ranged from 29 to over 400. The mean catch was over 200.

At least three of these fish (yellow perch, white sucker, fathead minnow) are rather ubiquitous in occurrence indicating a probable resistance to changes of environmental conditions. It is unlikely that all of the more sensitive (less widespread) species are so resistant. Despite this, see point 62 of Figure 1. Anadromous species moving upriver to spawn are probably under considerable stress resulting from osmotic and ionic balance problems and might be expected to be less able to cope with toxic chemicals. Eggs and larvae of both fish and invertebrates may also be more sensitive. Extrapolation from notably resistant fish to protection of a whole ecosystem lacks logic.

Consideration of only fish data also is rather shortsighted. While changes in the environment are most easily recognized especially by the layman when they concern fish or other "real animals," the fish populations are supported by the lower trophic levels. Collapse of one of the lower levels could in the end have drastic effects on both the fish species composition as well as standing crop. Fish, especially young fish, are generally plankton feeders (Heubach, Toth and McReady, 1963; Rogers, 1967; Mathur and Robbins, 1971; Siefert, 1972). Zooplankton, and at least some phytoplankton are among the most sensitive organisms to chlorine (See Figure 1).

Figure II includes the data points from the literature which concern organisms present at Indian Point. Included are common genera for which species names at Indian Point are lacking. Numbers 1-48 were included in the previous staff chlorine figure. Numbers above 48 include data which became available later. It would be difficult to support any limits set on the basis of the five fish species discussed previously even if they did represent prevalent species. The data presented in Fig. I and II probably do not represent true chlorine sensitivities in the Indian Point situation because synergistic effects such as those expected with temperature (Hegre, 1972) were not investigated.

Figures III a&b, which have been modified from one presented in the testimony of Dr. Lawler shows the relationship between the chlorine concentrations at various points in the Indian Point Plant and discharge plume and the revised short-term toxicity curve suggested by the staff. It is assumed here that the model proposed by Dr. Lawler is both reasonable and conservative with respect to the Indian Point situation. Also shown are some of the more critical points from Figure II. From this figure it is possible to determine

that there will be mortality resulting from the concentrations even without additional complications which might result from such variables as temperature. Given the uncertainty resulting from the large number of species and sensitive life stages for which no information is available, and the importance of these species not only to the local ecosystem but to a larger area along the East Coast (e.g. anadromous forms), the Staff cannot discount the possibility of detrimental consequences of chlorine releases by IP No. 2.

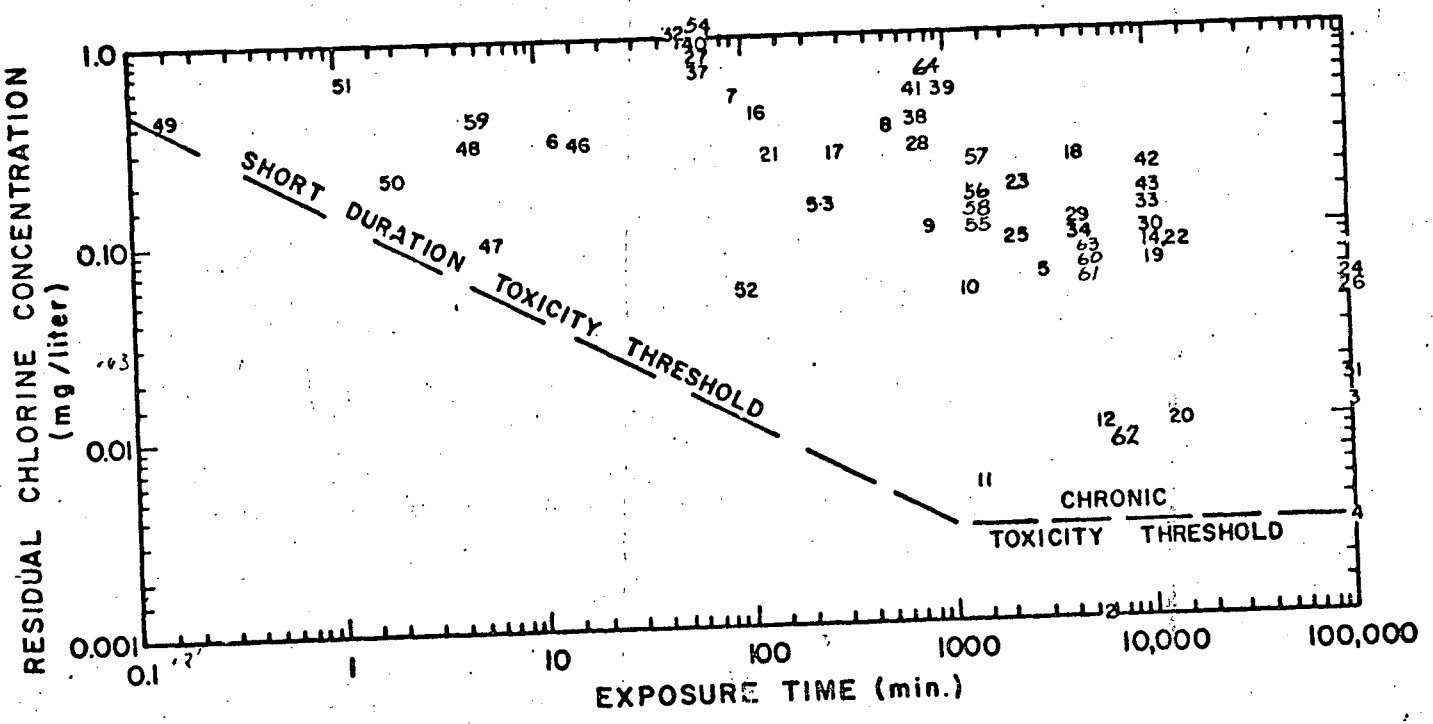

Figure 1. Summary of residual chlorine toxicity data.

Key to Fig. 1. Exposures of aquatic organisms to total residual chlorine

All concentrations were measured

Species	Point No.	Effect end point[a]	Reference
Protozoa	1	Lethal	Hale, 1930
Cladoceran	2	Lethal (4 days)	Biesinger, 1971
Scud	3	Safe concentration	Arthur, 1971
	4	Safe concentration	Arthur and Eaton, 1972
Trout fry	5	Lethal (2 days)	Coventry et al., 1935
	6	Lethal (instantly)	Coventry et al., 1935
Brook trout	7	Median mortality (90 min)	Pyle, 1960
	8	Mean survival time 8.7 hr	Dandy, 1967
	9	Mean survival time 14.1 hr	Dandy, 1967
	10	Mean survival time 20.9 hr	Dandy, 1967
	11	Mean survival time 24 hr	Dandy, 1967
	12	67% lethality (4 days)	Dandy, 1967
	13	Depressed activity	Dandy, 1967
	14	7-day TL50	Arthur, 1971
	44	Not found in streams	Tsai, 1971
Brown trout	45	Not found in streams	Tsai, 1971
Fingerling rainbow trout	17	Lethal (4 to 5 hr)	Taylor and James, 1928
Rainbow trout	15	Slight avoidance (10 min)	Sprague and Drury, 1969
	16	Lethal (2 hr)	Taylor and James 1928
	18	96-hr TL50	Basch, 1971
	19	7-day TL50	Merkens, 1958
	20	Lethal (12 days)	Sprague and Drury, 1969
Chinook salmon	21	First death 2.2 hr	Holland et al., 1960
Coho salmon	22	7-day TL50	Arthur, 1971
	23	100% kill (1–2 days)	Holland et al., 1960
	24	Maximum nonlethal	Holland et al., 1960
Pink salmon	25	100% kill (1–2 days)	Holland et al., 1960
	26	Maximum nonlethal	Holland et al., 1960
Fathead minnow	27	TL50 (1 hr)	Arthur, 1972
	28	TL50 (12 hr)	Arthur, 1972
	29	96-hr TL50	Zillich, 1969
	30	7-day TL50	Arthur, 1971
	31	Safe concentration	Arthur and Eaton, 1972
White sucker	32	Lethal (30–60 min)	Fobes, 1971
	33	7-day TL50	Arthur, 1971
Black bullhead	34	96-hr TL50	Arthur, 1971
Largemouth bass	35	7-day TL50	Arthur, 1971
	37	TL50 (1 hr)	Arthur, 1972
	38	TL50 (12 hr)	Arthur, 1972
Smallmouth bass	36	Not found in streams	Tsai, 1971
	39	Median mortality (15 hr)	Pyle, 1960

[a]TL50: median tolerance limit.

Key to Fig. 1 (continued)

Species	Point No.	Effect end point[a]	Reference
Yellow perch	40	TL50 (1 hr)	Arthur, 1972
	41	TL50 (12 hr)	Arthur, 1972
	42	7-day TL50	Arthur, 1971
Walleye	43	7-day TL50	Arthur, 1971
Miscellaneous fish	46	Initial kill 15 min	Truchan, 1971
	47	Erratic swimming (6 min)	Truchan, 1971
Cyclotella nana	48	0 growth	Hegre, 1971
Skeletonema costatum	49	50% growth	Hegre, 1971
Asterionella japonica	50	50% growth	Hegre, 1971
Detonula confervacea	51	50% growth	Hegre, 1971
Rainbow trout	52	100% lethal in plant effluent	Michigan Water Resources Commission, 1971
Daphnia magna	53	0 recovery	National Water Quality Lab, 1971
Acartia tonsa	54	16% dead or moribund	Gentile 1972
Skeletonema costatum	54	24 hr TL 50	Hegre 1971
Chaetoceros decipiens	56	24 hr TL 50	Hegre 1971
Asterionella japonica	57	24 hr TL 50	Hegre 1971
Chaetoceros didymum	58	24 hr TL 50	Hegre 1971
Skeletonema costatum	59	adverse effect on growth	Hirayama and Hirano (1970
Pimephales promelas	60	Partial kill 96 hr	Zillich, 1972
	61	lethal in 96 hr	Anonymous, 1971
	62	lethal in 120 hr	Anonymous, 1971
Ictaluris melas	63	96 TLm	Arthur, 1971
Perca flavescans	64	12 hr TLm	Arthur, 1971

References for Fig. 1

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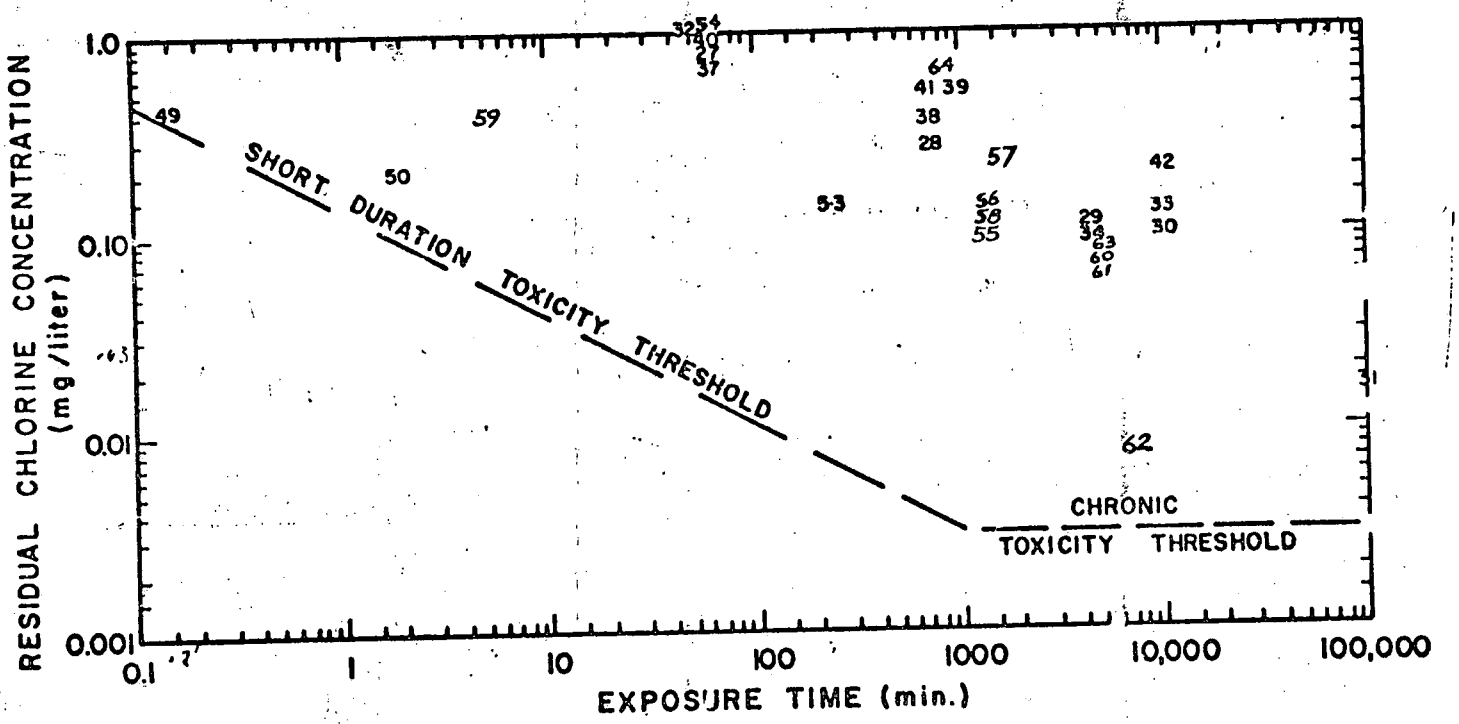

Figure 2. **Summary of residual chlorine toxicity data** for organisms found at Indian Point

Fig 3a. CUMULATIVE AVERAGE CHLORINE CONCENTRATION vs. TIME
UNIT #2 WITHOUT UNIT #1

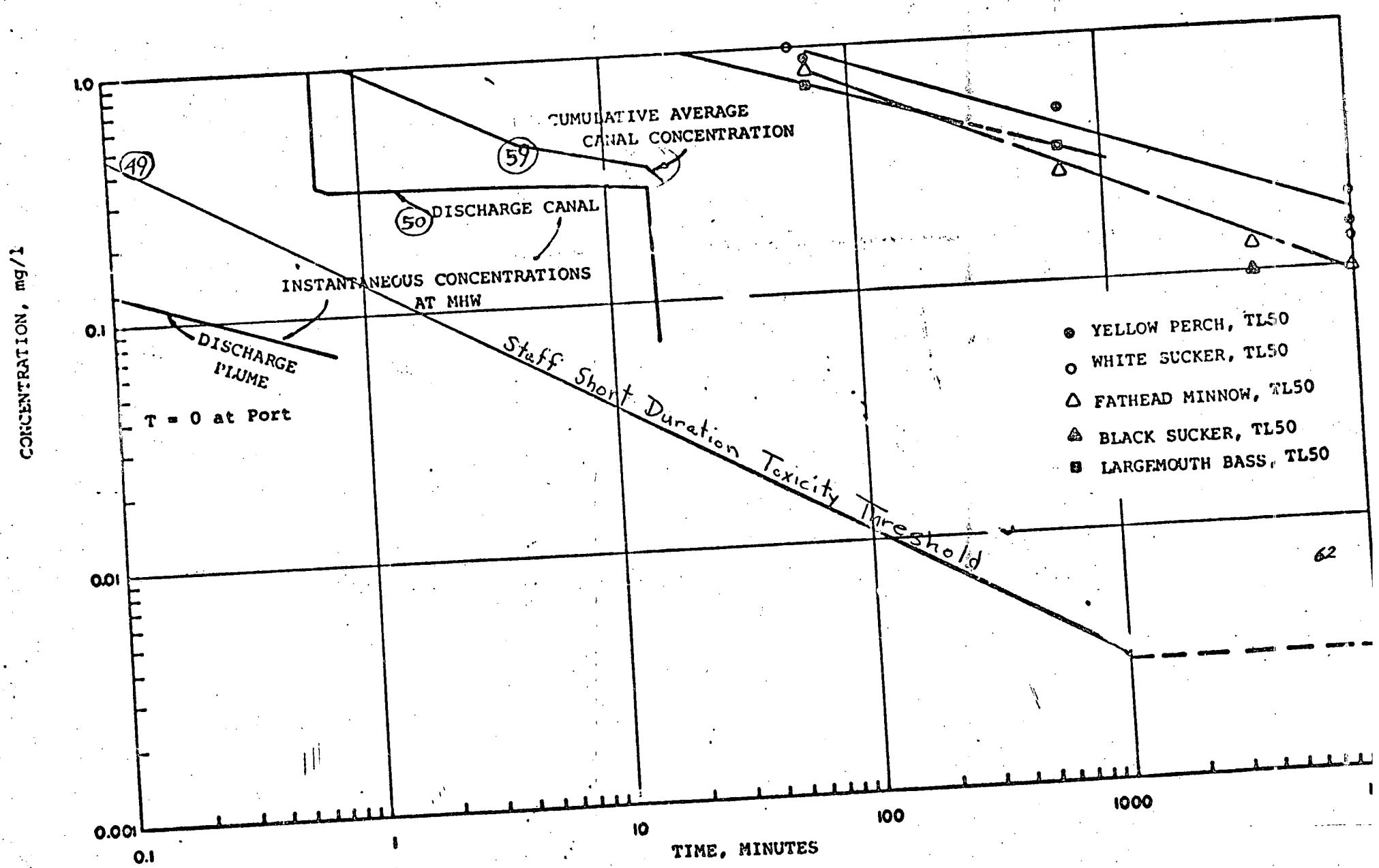

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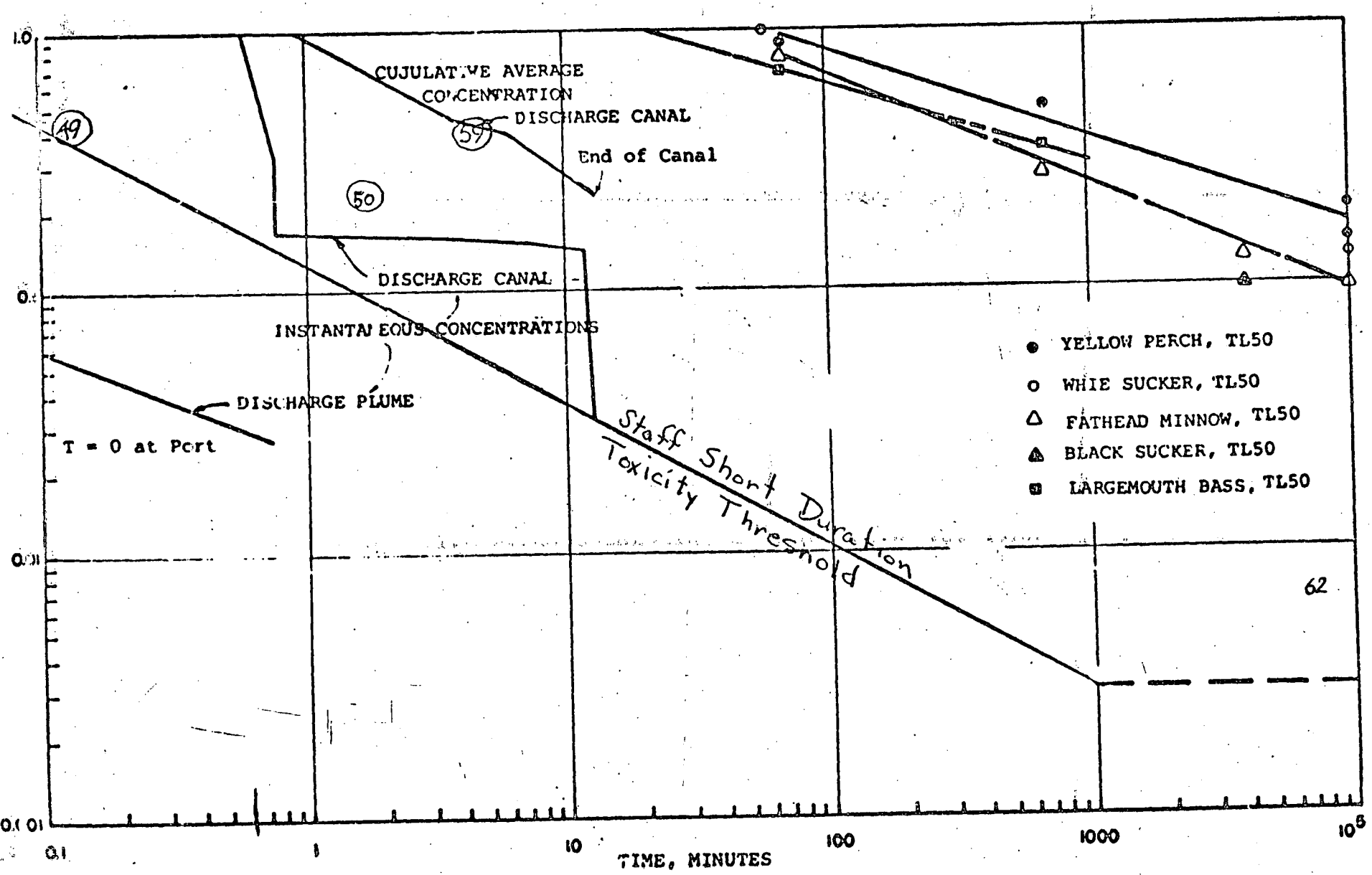
Fig. 3b CUMULATIVE AVERAGE CHLORINE CONCENTRATION VS. TIME
UNIT #2 CHLORINATION WITH UNIT #1 OPERATING



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Redirect - Rebuttal Testimony of

Dr. C. P. Goodyear

Origin of the Striped Bass Stock of the Middle Atlantic Coast

March 1, 1973

Reference:

Testimony of Dr. John P. Lawler (5 February 1973): "Contribution of the Hudson River to the Middle Atlantic Striped Bass Fishery."

Origin of the Striped Bass Stock of the Middle Atlantic Coast

In his rebuttal testimony, Dr. Lawler stated that the purpose of his testimony was to refute the conclusion that the Hudson River contributes 80% of the striped bass population in the Middle Atlantic region. To this end, he propounds the thesis that the Chesapeake and Delaware Bay systems are the major sources of the striped bass stock which is taken by commercial and sport fisheries in the Middle Atlantic region. The Staff had examined this hypothesis before the issuance of the FES for I.P. 2 and had concluded that data were available to reject both areas as major sources of the Mid-Atlantic stock. The following discussion is presented to clarify the Staff's position and the information which has led to the Staff's conclusion. This discussion follows the outline presented below.

I. Description of fishery

- A. Geographic region
- B. Commercial landings
- C. Sport landings
- D. Distribution and Movements of the Mid-Atlantic stock

II. Origins of the Mid-Atlantic stock

- A. South of Chesapeake Bay
- B. Chesapeake Bay
  1. Tagging studies
  2. Age at recruitment to coastal stock
  3. Conclusion
- C. Contribution of Delaware
- D. Contribution of Hudson
  1. Importance as spawning ground
  2. Tagging studies

DESCRIPTION OF THE FISHERY

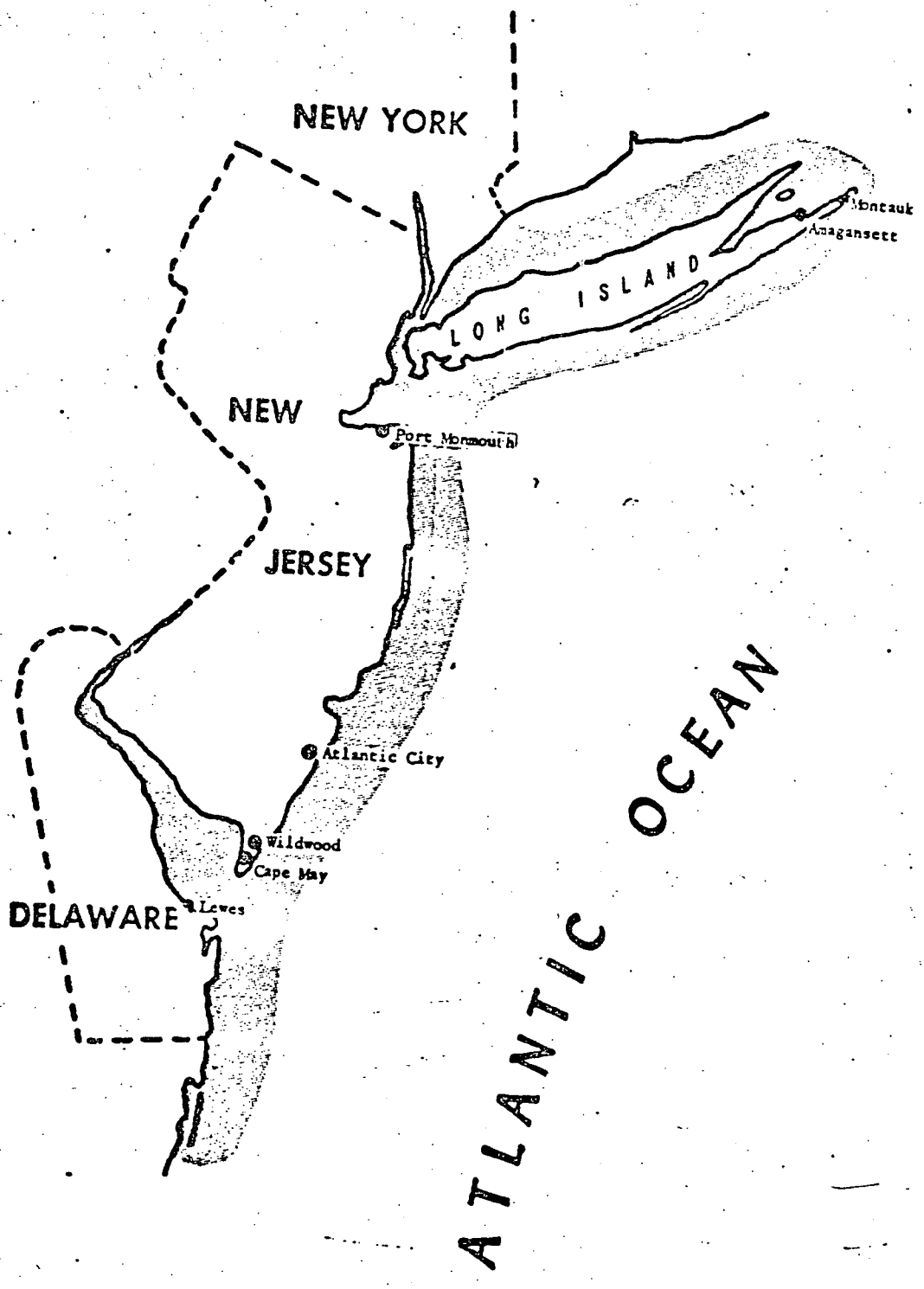
A. Geographic region

In its analysis, the Staff used the definition of the Middle Atlantic Region which was consistent with the definition used by other authors and with the area considered the Middle Atlantic Region as summarized in the commercial catch statistics (Koo, 1970). This region is illustrated in Figure 1 and consists of 3 states: New York, New Jersey, and Delaware.

Within this region, there are 2 major spawning and nursery areas which are known to be utilized by striped bass for reproduction. These 2 areas are the Hudson River and the Delaware Bay system. From the standpoint of location, striped bass produced in the Hudson River would be expected to contribute to stock in New Jersey, New York and Connecticut, whereas striped bass produced in the Delaware Bay would contribute mostly to New Jersey and Delaware. From a strict geographic standpoint, one cannot determine the relative proportion of the catch in New York which is composed of Delaware Bay fish, nor coversely can one likewise tell the proportion of the Delaware catch which is composed of Hudson-derived stock.

B. Commercial landings

Commercial landings for this area were summarized by Koo in a recent publication. Some of the data which he tabularized is presented in Tables 1, 2, and 3. These data indicate that the landings in Delaware over the last 10 years of the data presented represent only a small proportion of the total Middle Atlantic catch - something on the order of 4%. If it is assumed that the N.J. catch from the Delaware Bay is equivalent to the Delaware catch from the Delaware Bay, then the total catch in the Delaware Bay system would represent something on the order of 7.5 to maybe 15% of the total Middle Atlantic catch over the last 10 years. Thus, the catch of striped bass on the N.J. coast and



MIDDLE ATLANTIC STATES

TABLE 1. Striped bass landings, earlier records (in thousands of pounds).

	New England Region						Middle Atlantic Region					Chesapeake Region			South Atlantic Region				Combined
Year	Maine	N. H.	Mass.	R. I.	Conn.	Total	N. Y.	N. J.	Penn.	Del.	Total	Md.	Va.	Total	N. C.	S. C.	Ga.	Total	Total
1887	–	–	20	11	46	77	115	615	15	116	861	1,140	505	1,645	500	182	11	693	3,276
1888	–	–	32	13	50	95	98	739	59	116	1,012	1,123	779	1,902	560	251	11	822	3,831
1889	–	–	25	80	39	144	212	306	24	110	652	–	–	–	526	11	13	550	–
1890	–	–	–	–	–	–	208	328	23	107	666	1,366	529	1,895	568	12	9	589	–
1891	–	–	–	–	–	–	205	298	25	95	625	1,265	483	1,748	–	–	–	–	–
1897	–	–	–	–	–	–	116	287	10	129	542	935	576	1,511	845	10	9	864	–
1898	25	1	13	102	14	155	82	274	–	–	–	–	–	–	–	–	–	–	
1901	–	–	–	–	–	–	72	354	13	48	487	824	528	1,352	–	–	–	–	–
1902	16	2	28	50	40	136	–	–	–	–	–	–	–	–	1,175	10	3	1,188	–
1904	–	–	–	–	–	–	53	66	6	40	165	721	451	1,172	–	–	–	–	–
1905	4	–	21	32	19	76	–	–	–	–	–	–	–	–	–	–	–	–	–
1908	2	1	5	34	2	44	45	53	7	53	158	640	504	1,144	510	5	9	524	1,870
1920	–	–	–	–	–	–	–	–	–	–	–	1,040	380	1,420	–	–	–	–	–
1921	–	–	–	–	–	–	95	70	–	5	170	–	–	–	–	–	–	–	–
1923	–	–	–	–	–	–	–	–	–	–	–	–	–	–	447	–	–	447	–
1925	–	–	–	–	5	–	–	–	–	–	–	1,414	821	2,235	–	–	–	–	–
1926	–	–	–	–	5	–	87	64	–	46	197	–	–	–	–	–	–	–	–
1927	–	–	–	–	4	–	–	–	–	–	–	–	–	–	507	–	1	508	–
1928	–	–	8	44	4	56	–	–	–	–	–	–	–	–	–	–	–	–	–
1929	–	–	19	23	2	44	155	41	–	10	207	1,292	290	1,582	246	–	–	246	2,079

1,177,400

TABLE 2. Striped bass landings by region, 1930-66 (in thousands of pounds).

Year	New England	Middle Atlantic	Chesapeake	South Atlantic	Total
1930	89	205	1,653	457	2,404
1931	90	135	1,116	327	1,668
1932	42	52	1,028	507	1,629
1933	61	40	833	–	(1,369)[1]
1934	–	–	642	362	(1,097)
1935	22	62	1,302	–	(1,951)
1936	–	–	2,383	768	(3,621)
1937	450	405	3,016	713	4,584
1938	301	311	2,869	523	4,004
1939	285	446	2,692	340	3,763
1940	147	382	1,839	540	2,908
1941	–	–	2,089	–	(3,213)
1942	219	419	3,286	–	(4,464)
1943	216	514	–	–	(5,186)
1944	341	799	4,545	540	6,225
1945	317	782	3,664	610	5,373
1946	406	963	3,699	–	(5,772)
1947	119	413	4,063	–	(5,299)
1948	151	758	5,102	–	(6,715)
1949	162	902	4,542	–	(6,310)
1950	167	897	5,834	797	7,695
1951	265	981	4,140	702	6,088
1952	179	1,141	3,413	647	5,380
1953	193	1,023	3,106	757	5,079
1954	184	636	3,059	1,122	5,001
1955	106	629	3,466	736	4,937
1956	98	473	3,145	764	4,480
1957	80	701	2,788	597	4,166
1958	95	479	4,422	1,097	6,093
1959	120	746	6,446	872	8,184
1960	211	870	6,687	783	8,551
1961	397	1,252	7,262	551	9,462
1962	682	1,259	5,923	747	8,611
1963	582	1,474	6,496	737	9,289
1964	632	2,022	5,189	717	8,560
1965	531	1,533	5,162	486	7,712
1966	843	1,429	6,150	654	9,076

[1] Figures in parentheses are extrapolated by adding the mean of two adjacent years for the missing statistic.

TABLE 3. Striped bass landings by state, 1930-66 (in thousands of pounds).

Year	Massachusetts	Rhode Island	Connecticut	New York	New Jersey	Delaware	Maryland	Virginia	North Carolina
1930	27	60	2	66	37	102	1,228	425	457
1931	48	39	4	64	18	52	635	481	327
1932	31	7	4	32	12	8	434	594	507
1933	20	39	2	19	9	12	314	519	–
1934	–	–	–	–	–	–	333	310	362
1935	5	16	+	37	8	17	928	375	–
1936	–	–	–	–	–	27	1,864	520	768
1937	121	317	13	132	241	32	2,011	1,005	713
1938	82	210	9	139	147	25	1,714	1,155	523
1939	63	213	9	184	243	20	1,729	964	339
1940	76	64	8	169	172	41	1,180	659	540
1941	–	–	–	–	–	–	1,223	865	–
1942	98	95	18	266	95	59	2,508	778	–
1943	100	73	25	317	160	37	–	–	–
1944	191	122	17	504	257	39	2,681	1,864	–
1945	186	95	27	301	418	63	1,545	2,119	609
1946	161	217	19	482	–	–	1,615	2,084	–
1947	55	52	11	244	60	109	2,338	1,725	–
1948	78	63	10	356	41	361	2,650	2,452	–
1949	72	81	9	626	21	255	2,629	1,913	–
1950	47	112	7	517	109	271	3,038	2,796	797
1951	132	112	22	626	140	215	2,336	1,804	702
1952	125	51	11	486	536	120	2,172	1,242	647
1953	105	82	6	482	435	106	2,303	803	757
1954	68	116	+	439	51	146	2,108	951	1,122
1955	72	34	+	506	35	88	2,572	894	736
1956	71	26	1	395	50	28	2,150	995	764
1957	56	23	1	553	132	16	1,859	929	597
1958	51	41	3	398	59	22	3,105	1,317	1,096
1959	81	31	8	538	196	12	4,349	2,097	872
1960	129	77	5	731	114	25	4,409	2,278	782
1961	210	167	20	910	276	66	5,408	1,854	550
1962	589	61	32	657	494	108	3,979	1,944	747
1963	480	71	30	673	753	48	3,749	2,747	736
1964	522	75	35	995	996	31	3,300	1,889	714
1965	467	60	–	740	761	32	2,949	2,213	484
1966	585	250	–	1,050	315	64	3,347	2,803	653

the coastal areas of N.Y. and in the Hudson River represent something on the order of 90% of the total Mid-Atlantic catch. As a consequence, the Mid-Atlantic commercial catch statistics represent mostly N.Y. and N.J. landings, particularly in recent years.

C. Evaluation of sport catch

In order to evaluate the relative sizes of the sport and commercial landings, the Staff examined the proportion of tagged striped bass which were recaptured by each of the 2 fisheries. For example, Schaefer (1968) summarized tagging data for fish captured and tagged on the outer coast of Long Island for 2 periods, 1954-56 and 1961-64. Data from fish tagged during the first of the 2 periods indicated that the commercial fishing accounted for 68% of the total recaptures (Table 4). During the latter period, commercial fishing accounted for 44% of striped bass less than 6 pounds in weight and for 32 1/2% of striped bass greater than 6 pounds in weight. These figures are derived from the data presented in Tables 5 and 6 but differ in the respect that only fish taken by the sport and commercial fishing effort are included. This same procedure is applied to other studies summarized herein, such that the proportion of fish recaptured by commercial fishermen is estimated by the following equation:

$$\% = \frac{\text{\# returns from commercial fishermen} \times 100}{\text{\# returns from sport fishermen} + \text{\# returns from commercial fishermen}}$$

The data presented in Table 7 represent the recaptures of fish tagged in Great South Bay (Alperin, 1966) during the period 1956-1961, although most of the fish which were tagged in this study represent tagging done during 1960 and 1961. Of the 242 fish which were recaptured by the fishing industry, 182 were taken by sport fishermen and 60 were taken by the commercial fishermen. Thus the commercial fishing effort accounted for 24.8% of the striped bass, that were recaptured by the fishery.

Tagging studies conducted in New Jersey waters show similar results. This information is derived from data presented by Hamer (1971) in a report concerning the migratory patterns of the New Jersey striped bass. Table 8 presents a summary of returns of 88 striped bass adults which were tagged in the Maurice River in 1961. The total return of 41 out of 88 fish tagged represents 46.5% of the total number of fish which were tagged. The tagged fish were recaptured in about equal numbers by both the sport and commercial fishermen; however for this study more tagged fish were recaptured by the commercial fishery in Delaware Bay than by any other fishery in any other area. Overall, the commercial fishery took slightly over 51% of the total recaptures where the type of fishery was known. However, it should be pointed out, the fish were tagged with Petersen tags, which increase the susceptibility of tagged fish to commercial fishermen using certain types of gear, specifically gill nets.

Other data summarized by Hamer in the same report are presented in Table 9. These data represent recaptures of 111 bass tagged in the Mullica and Great Egg Harbor Rivers in N.J. during winters of the period 1955-1957, however 16 of the 17 recaptures were fish tagged during Jan., Feb., and March of 1957 and all of the recaptures which are included were made before 1960. Fishery data were available for only 9 of the 17 recaptures but indicate some 33% of the recaptured fish were taken by the commercial fishery.

These data reflect several important facts. The proportion of the total catch of striped bass made by commercial fishermen ranged from a high of some 68% to a low of 24.5% (by numbers). Most of the recaptures included in this series of data were made during the late 1950's or early 1960's and represent the distribution of recaptures according to the fishery for that period. These data would indicate that the total landings of striped bass taken by the combined sport and commercial fishing industries would range from approximately 2 to 4 times the commercial catch.

TABLE 4. RETURNS FOR STRIPED BASS TAGGED AT WESTHAMPTON BEACH ACCORDING TO MANNER OF RECOVERY

Manner of recovery	Number	Per cent
Sport fishing		
Trolling	4	8.0
Casting	2	4.0
Unknown	10	20.0
Sub-total	16	32.0
Commercial fishing		
Gill net	20	40.0
Haul seine	9	18.0
Pound net	1	2.0
Fyke net	1	2.0
Unknown	3	6.0
Sub-total	34	68.0
Total	50	100.0

TABLE 5. RETURNS FOR SMALL* STRIPED BASS TAGGED AT GREAT SOUTH BEACH ACCORDING TO MANNER OF RECOVERY

Manner of recovery	Number	Per cent
Sport fishing		
Casting	7	21.2
Trolling	4	12.1
Still-fishing	4	12.1
Sub-total	15	45.4
Commercial fishing		
Haul seine	9	27.3
Gill net	3	9.1
Sub-total	12	36.4
Miscellaneous		
Found dead or dying	6	18.2
Total	33	100.0

* Fish less than 6 pounds or 600 millimeters.

TABLE 6. RETURNS FOR LARGE* STRIPED BASS TAGGED AT GREAT SOUTH BEACH ACCORDING TO MANNER OF RECOVERY

Manner of recovery	Number	Per cent
Sport fishing		
Casting	22	32.8
Trolling	13	19.4
Still-fishing	5	7.5
Spearing	2	3.0
Sub-total	42	62.7
Commercial fishing		
Haul seine	6	9.0
Gill net	6	9.0
Otter trawl	4	6.0
Pound net	1	1.5
Jacking	1	1.5
Unknown	2	3.0
Sub-total	20	29.8
Miscellaneous		
Found dead or dying	5	7.5
Total	67	100.0

* Fish 6 pounds or 600 millimeters or larger.

TABLE 7. RETURNS FOR STRIPED BASS TAGGED IN GREAT SOUTH BAY ACCORDING TO MANNER OF RECOVERY

Manner of recovery	Number	Per cent
Sport fishing		
Trolling	28	10.0
Casting	54	19.2
Spearing	1	0.4
Other and unknown	99	35.2
Sub-total	182	64.8
Commercial fishing		
Seine	21	7.5
Trawl	7	2.5
Pound net	1	0.4
Gill net	20	7.1
Other and unknown	11	3.9
Sub-total	60	21.4
Miscellaneous		
Project seining	33	11.7
Tagging mortality	2	0.7
Natural mortality	2	0.7
Unknown	2	0.7
Sub-total	39	13.8
Total	281	100.0

TABLE 8 Summary of tag returns by major waters and fisheries.

Water Area	FISHERY							
	Sport		Comm.		Unknown		Total	
	No.	%	No.	%	No.	%	No.	%
Maurice River	8	9.1	3	3.4	-	-	11	12.5
Delaware Bay and tributaries	6	6.8	12	13.6	4	4.5	22	24.9
Chesapeake Bay and tributaries	1	1.1	3	3.4	-	-	4	4.5
Ocean	2	2.3	-	-	-	-	2	2.3
Unknown	-	-	-	-	2	2.3	2	2.3
	17	19.3	18	20.4	6	6.8	41	46.5

TABLE 9 Summary of tag returns, by state and fishery, of 111 striped bass tagged while wintering in the Mullica and Great Egg Harbor Rivers.

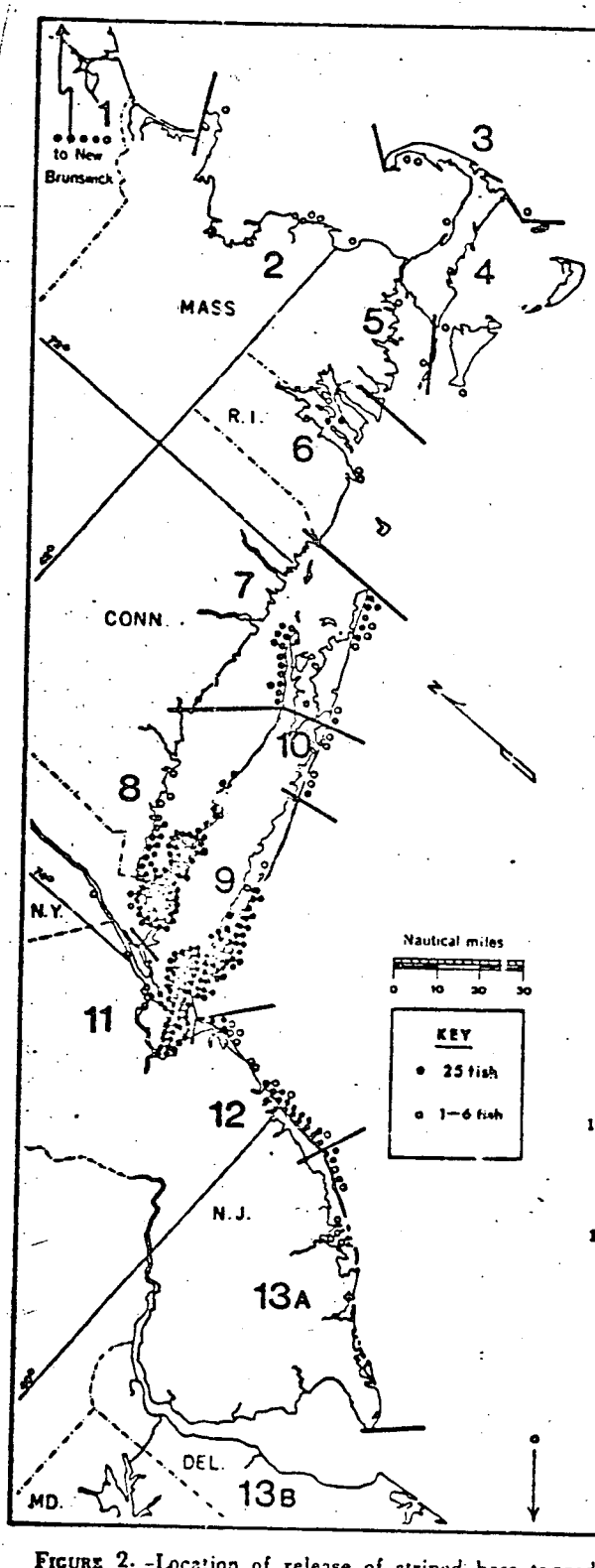
	Sport		Comm.		Unknown		Total	
	No.	%	No.	%	No.	%	No.	%
New Jersey	3	2.7	1	.9	1	.9	5	4.5
Long Island, N.J.	2	1.8	2	1.8	3	2.7	7	6.3
Rhode Island	1	.9	0	-	1	.9	2	1.8
Massachusetts	0	-	0	-	3	2.7	3	2.7
	6	5.4	3	2.7	8	7.2	17	15.3

It should be pointed out that there are several sources of error inherent in this type of analysis. For instance, the extrapolations from these data assume that the proportion of returns of fish recaptured by the commercial and sport fishermen is the same. This presumption is likely to be invalid. It seems probable that the response exhibited by commercial fishermen would be less than that shown by sports fishermen; however, since non-response by the 2 groups has not been estimated for this area, it is not possible to evaluate the importance of this factor.

In summary, it would appear that the sport catch is somewhat larger than the commercial catch, but it does not appear likely that the total sport catch could exceed the commercial catch by a factor of 30 as estimated by Schaefer for N.Y. waters for 1965. However, this conclusion is particularly sensitive to the ratio of the sport to commercial fishing effort and the size of the sport catch which occurs in the West portion of Long Island Sound and New York Bay; these areas were not adequately represented in the studies which were utilized in deriving commercial vs. sport fishing ratios.

D. Distribution and movement of the Mid-Atlantic Stock

It would appear that there are 2 fairly distinct stocks which are exploited by the striped bass fishermen which inhabit the N.J.-N.Y. area. The first of these, which is best illustrated by using the distribution of the fish which were tagged by the Long Island League of Salt Water Sportsmen during the period 1959-63, as presented by Clark (1968) and reproduced here as Figure 2. Areas 8 and 11, which include the western portion of Long Island Sound and the N.Y. Harbor area are generally believed to be supported by reproduction in the Hudson River and perhaps to a lesser extent areas 9 and 12, which include the upper N.J. coast and the lower out coastal region of Long Island. Fish from this general area, tend to move into the Hudson in the winter and back into the



1. NORTH COAST: The coast north from Cape Ann, Massachusetts, to New Brunswick, Canada.

2. MASSACHUSETTS BAY: The coast south from Cape Ann to the northern tip of Cape Cod.

3. EAST CAPE: The coast from the northern tip of Cape Cod to Monomoy Point, Cape Cod.

4. SOUTH CAPE: Vineyard Sound from Monomoy to Woods Hole including Martha's Vineyard and Nantucket.

5. BUZZARDS BAY: From Cuttyhunk around Buzzards Bay and west to the Rhode Island border.

6. RHODE ISLAND: The Rhode Island shore and Narragansett Bay and tributaries (including those with headwaters in Massachusetts).

7. EAST SOUND: The north shore of Long Island Sound from the Rhode Island border west to New Haven Harbor; the south shore of Long Island Sound from Mattituck east to Montauk Point and west to Shinnecock Inlet.

8. WEST SOUND: The north shore of Long Island Sound from New Haven Harbor west to Hell's Gate, and the south shore of Long Island Sound east to Mattituck.

9. SOUTHWEST LONG ISLAND: From Rockaway Inlet east to Mastic Beach, including south shore bays except Jamaica Bay.

10. SOUTHEAST LONG ISLAND: Mastic Beach east to and including Shinnecock Inlet.

11. NEW YORK BAY: West of Rockaway, including Jamaica Bay, greater New York Harbor and the Hudson River: Staten Island and east along the south shore of Raritan Bay to Leonardo.

12. NORTH JERSEY: Sandy Hook Bay from Leonardo east to and including Sandy Hook and the northern New Jersey shore south to but not including Barnegat Inlet.

13. SOUTH COAST: Barnegat Inlet south to Chesapeake Bay.
   A. SOUTH JERSEY: The Atlantic shore of New Jersey from Barnegat Inlet south to Cape May.
   B. DELAWARE BAY: Delaware Bay and the outer coast from Cape Henlopen south to Ocean City, Maryland, including tributary streams.
   C. CHESAPEAKE BAY: All of Chesapeake Bay and tributary streams.

FIGURE 2.—Location of release of striped bass tagged by the Long Island League of Saltwater Sportsmen, 1959–63. (Tagging locations outside chart boundaries indicated at border.)

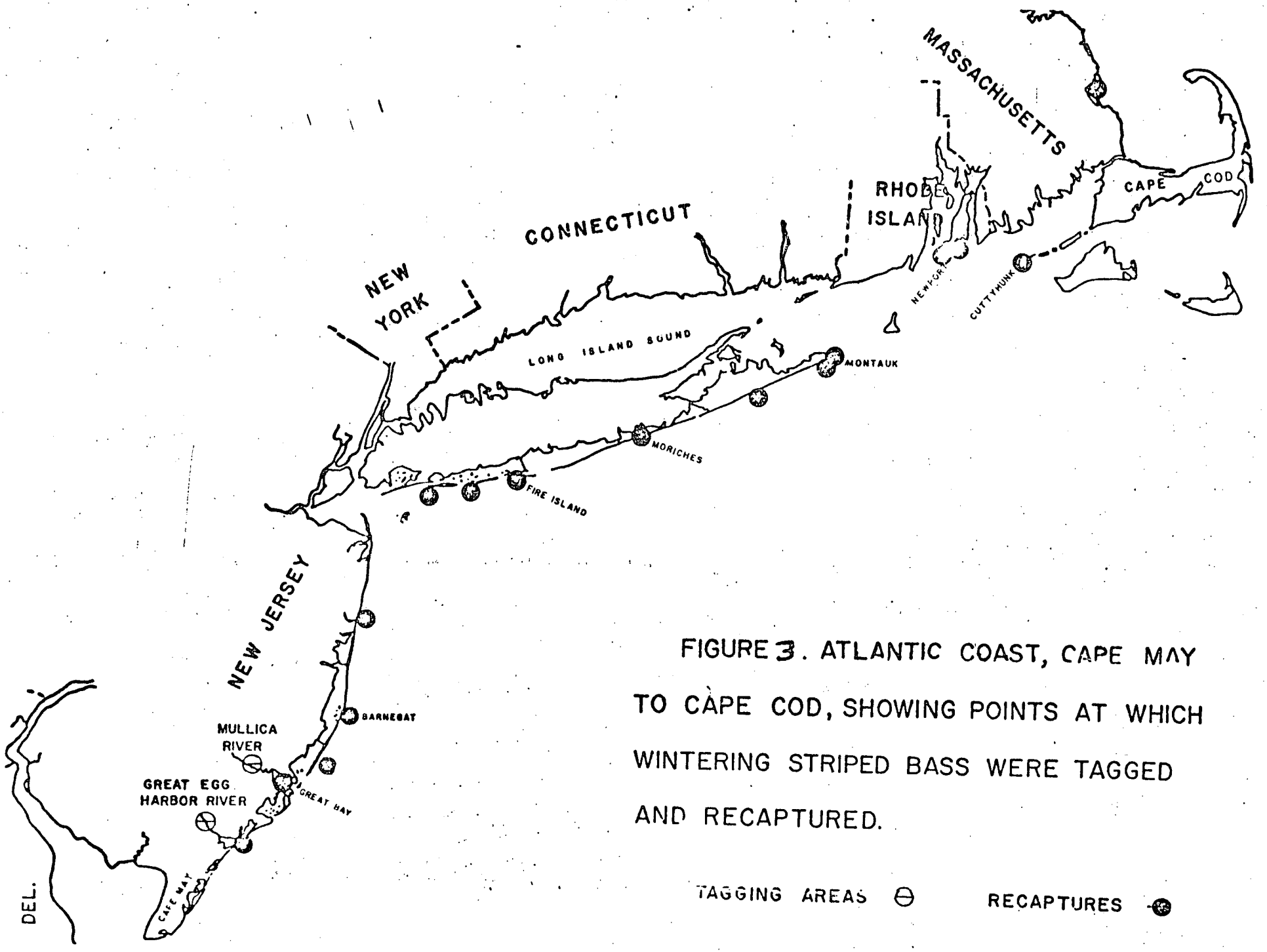


FIGURE 3. ATLANTIC COAST, CAPE MAY TO CAPE COD, SHOWING POINTS AT WHICH WINTERING STRIPED BASS WERE TAGGED AND RECAPTURED.

various regions in the spring, but do not apparently make large-scale migrations either to the south or to the north. However, it should be pointed out that the data upon which these conclusions are based consist of tag returns of bass mostly within the 10-18 inch range and that these fish are normally less mobile than are the older individuals as was reported in the FES.

The second group of striped bass which inhabit the area tend to migrate north and south along the outer coast from N.J. to Massachusetts. The distribution of exploitation of this portion of the stock is represented by Figure 3, which shows the recapture locations of representatives of this migratory portion of the stock which were tagged in the Mullica and Great Egg Harbor Rivers. A considerable quantity of tag and recapture data both for this study and various others shows a substantial migratory element of the Mid-Atlantic striped bass stock, which moves northward in the spring and southward in the fall. It is this portion of the Mid-Atlantic stock which may be largely derived from nursery or spawning areas other than the Hudson River and is the subject of most of the following discussion.

ORIGINS OF THE MIDDLE ATLANTIC STOCK

A. Spawning areas south of the Chesapeake

Areas south of the Chesapeake are not generally believed to be important for contributing to the Mid-Atlantic stock. This concept is apparently derived originally from the studies by Merriman (1941), who performed fairly detailed analyses of the growth rate of striped bass living in the areas south of the Chesapeake as compared to the growth rate in the Chesapeake and in the N.Y. and New England areas. He concluded the basis of his studies that the fish which were present in Connecticut exhibited rates of growth that were significantly lower than those exhibited by fish known to reproduce in the Albemarle-Pamlico Sound systems. These data have not been contested by other investigators and an examination of the growth rate information available for fish in the various

areas indicates that Merriman was quite accurate in his deduction (Table 10).

B. Contribution from the Chesapeake

Prevailing opinion has been for many years that the Chesapeake system provides the largest proportion of the stock to Middle Atlantic states. In its initial cursory review before the issuance of the DES, the Staff tentatively adopted this hypothesis; however, in reevaluating the initial analysis in response to the Applicant's comments on the DES, the Staff examined the data base upon which the conclusion of the Chesapeake origin of the Middle Atlantic stock of striped bass is based. As a consequence of this evaluation, the Staff was forced to a conclusion that the hypothesis of a Chesapeake origin of the Middle Atlantic stock was not consistent with the data available.

This conclusion is based primarily on 2 separate pieces of information which are derived from tagging studies which have been conducted in Chesapeake Bay. Specifically, the proportion of 2-year-olds which have been found to leave the Bay is very small, and secondly, the total number of fish which are known to leave the Bay is a very small proportion of the total stock in the Chesapeake and is too small to account for the Middle Atlantic fishery.

1. Tagging studies

The tagging studies conducted in the Chesapeake which have been examined by the Staff are summarized in Table 11. These data demonstrate the very small proportion of the Chesapeake stock which leaves the Bay. Overall, 1.5 percent of the stock tagged in the Chesapeake have been recaptured outside this system. Furthermore, only about half of those recaptures outside the Chesapeake occurred within the area of the Middle Atlantic fishery. Thus it could be concluded that the contribution of the Chesapeake stock should be approximately 0.75% of the total stock of the Chesapeake (by numbers).

Table 11. Summary of Recapture of Striped Bass Tagged in the Chesapeake and Recaptured Elsewhere.

Author	# tagged	Age of tagged fish	# recaptured	% of fish recaptured outside Ches. Bay	Age of fish outside Bay
Chapoton & Sykes (1961)	206	IV - XVIII	27	55.6% (15 fish)	all V
Grant, Burrell, Richards, & Joseph (1971)	Winter 1968 3195	I - 757, II - 2345, III - 83, IV - 6, V+ - 3, unknown - 1	487	0.2% (1)	V
	Summer-Fall 1968 2439	I - 841, II - 1531, III - 57, IV - 8, V+ - 2	408	0.2% (1)	unknown
	Winter 1969 2891	I - 143, II - 2044, III - 665, IV - 23, V+ - 14, unknown - 2	231	0.0% (0)	-----
Hollis & Davis (1955)	457	up to XI	80	2.5% (2)	unknown
Mansueti (1956)	31	II - 10, III - 18, IV - 3	11	0.0% (0)	------
Mansueti (1961)	1103	II and III	418	0.7% (3)	IV - 1, V - 1, unknown - 1
Mansueti & Murphy (1961)	104	VIII - 1, all rest II and III	14	0.0% (0)	--------
Massmann & Pacheco (1961)	2429	I - 1378, II - 610, III - 281, IV - 50, V+ - 107, unknown - 3	675	1.8% (12)	II - 1 (< 12")

Author	# tagged	Age of tagged fish	# recaptured	% of fish recaptured outside Ches. Bay	Age of fish outside Bay
'ichols & Miller (1967)	8973	winter tagging: II & III - 86% spawning season: II & III - 60% feeding season: II & III- 95%	3345	1.5% (52) (winter tagging - 1.6%, spawning season - 1.3%, feeding season - 1.2%)	III - 88%, none younger than II
'earson (1938)	305	II and III	89	0.0% (0)	———
laney, Woolcott, : Mehring (1954)	unknown	II	20	0.0% (0)	--------
'ladykov & Wallace (1952)	2869	II and III, 2% V+	958	3.1% (30)	II - 1, all rest - III+
'hitney (1961)	1354	II and III	179	0.6% (1)	unknown
TOTAL	26,356		6,942	1.5% (105)	% younger than III = 0.03% (2)

A second and very important point which was dedeuced from the tag and recapture data of fish tagged in the Chesapeake is that fish of 1- and 2-year-old age groups simply do not leave the system. In fact, no 1-year-old striped bass have been tagged in the Chesapeake and thereafter recovered as 1-year-olds on the Atlantic coast. Of the 2-year-olds tagged in the Chesapeake, only 2 fish could be identified by the Staff has having been recaptured outside the Chesapeake as 2-year-old striped bass. This represents 2 fish out of nearly 7000 recaptured striped bass, for a total contribution of some 0.03% of the total striped bass population of the Chesapeake. In other words, it would appear that only 3 out of 10,000 2-year-old striped bass in the Chesapeake migrate out of the Chesapeake to enter the fishery along the Atlantic coast.

2. Age at recruitment to Middle Atlantic stock

It was the latter set of data which forced the Staff into re-examining the hypothesis that the source of the Middle Atlantic stock was from the Chesapeake. This concept seems to have originated with the 1934 year class, which was studied in some detail by Merriman, who published his results in 1941. The importance of the 2-year-olds can be seen from the following quotation from Merriman's discussions.

> . . . The decline in the average weight of the striped bass making up the annual catches by seine at Point Judith from 1930 to 1936 is quite striking, the drop in this period being from an 8-pound average to a 2-pound average (see fig. 7). . . The sharp drop in average weight in 1936 was primarily due to the appearance of the 1934 dominant year-class in the commercial catch. The tremendous numbers of 2-year-olds in this year is well shown in fig. 8. (p. 12-13)

> The peaks at 1936 and 1937, however, are no doubt reasonably accurate indications of the increased abundance in those years. In 1936 the enormous numbers of striped bass that appeared along the Atlantic coast were mainly made up of fish 2 years old, the age at which this species first makes its appearance in the commercial and sport fishermen's catch in Long Island and New England waters. In 1937 a large proportion of the population along the Atlantic coast was composed of 3-year-old. (p. 10)

> Fish 2 years old and older were sufficiently abundant to give ample material for growth-rate studies in Long Island and New England waters, particularly on the members of the dominant 1934 year-class. Figure 17 shows length-frequency curves of all striped bass measured in Connecticut waters from April through October 1936 and 1937. The prominent peaks that characterize these two curves are mainly made up of the 2-year-olds in 1936 and the 2- and 3-year olds in 1937, and they give some idea of the relative abundance of the members of the 1934 year-class. (p. 25)

> . . . evidence from samplings of the striped bass population from commercial fishermen's nets in northern waters indicates that the 2-year olds in 1936 comprised over 85 percent of the stock available at this time (see fig. 8) and that the members of this year-class continued to dominate the population in 1937 in spite of the fast rate of depletion of fish of this age due to the highly intensive fishery (see figs. 5, 6, 7, and 8). Evidence from other samplings of the stock in northern waters in the summer of 1937 shows that the 2-year-olds of 1937 are apparently represented too strongly in the length-frequency curve for this year (see fig. 17). It is difficult to account for the large proportion of 2-year-olds in the lower graph in figure 17, but it is clear that they were not relatively as abundant in 1937 in all northern waters (see fig. 5). (p. 26)

On the basis of these observations and the assumption that the 2-year-old fish which were captured in the N.Y.-New England area were from the Chesapeake, Merriman concluded the following:

> . . . Assuming the fishing intensity to be about the same in New York and Maryland, it is therefore reasonable to expect that this means that about one-tenth of each year's production of young in Chesapeake Bay reach New York. However, since immigrants from Chesapeake Bay are also taken in New Jersey and southern New England (unpublished material of V. C. Vladykov, p. 46), it is probable that somewhat more than one-tenth of the annual production of young leave Chesapeake Bay near the time that they become 2 years old, at the beginning of their third summer, and before they are old enough to be of any great value to the Chesapeake Bay fishery. (p. 52)

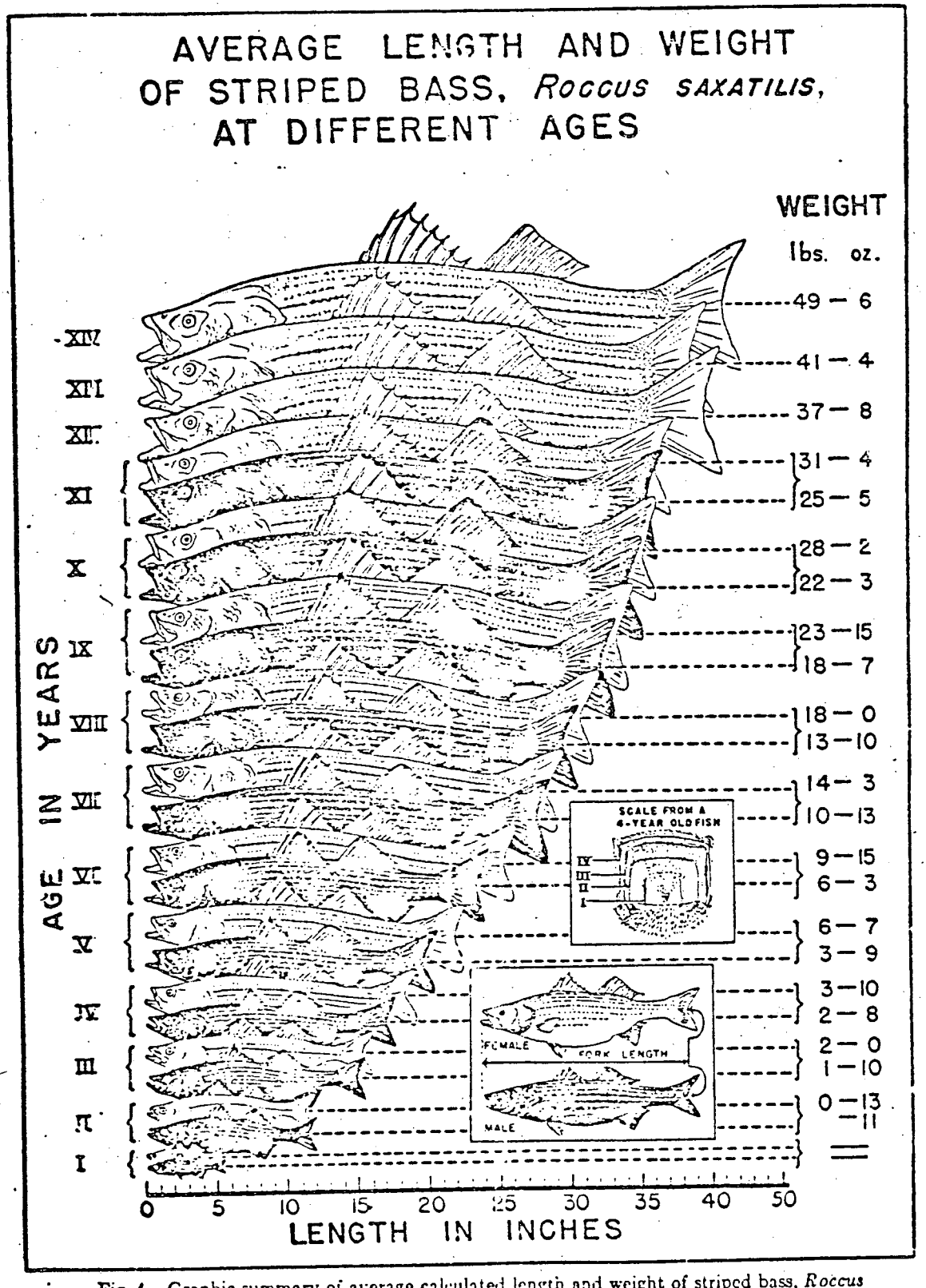


Fig. 4.—Graphic summary of average calculated length and weight of striped bass, *Roccus saxatilis*, at different ages, based on fish tagged in 1957 and early 1958 in Chesapeake Bay, Maryland.

Table 12—*Length distribution of tagged striped bass for each tagging area (length data were not available for 141 tagged fish)*

Length group (inches)	Number of fish tagged in each area									Total
	Area 1–5	Area 6	Area 7	Area 8	Area 9	Area 10	Area 11	Area 12	Area 13	
5–6	–	–	–	3	2	–	11	–	–	16
7–8	–	–	3	17	2	5	22	1	–	50
9–10	1	–	3	58	17	3	76	15	4	177
11–12	8	4	34	161	73	4	204	27	23	538
13–14	18	6	73	469	200	3	375	60	13	1,217
15–16	62	18	188	792	310	15	495	123	37	2,040
17–18	62	21	118	398	224	8	271	197	50	1,349
19–20	26	4	53	167	156	3	133	53	6	601
21–22	17	6	33	71	71	1	52	27	4	282
23–24	3	4	12	28	43	–	18	18	1	127
25–26	1	–	10	14	15	–	5	15	–	60
27–28	2	–	5	8	14	–	1	11	–	41
29–30	–	–	5	8	3	–	–	2	–	18
31–32	1	–	1	1	3	–	–	2	–	8
33–34	–	–	–	3	–	–	–	4	–	7
35–47	1	1	–	2	3	–	–	–	–	7
Totals	202	64	538	2,200	1,136	42	1,663	555	138	6,538

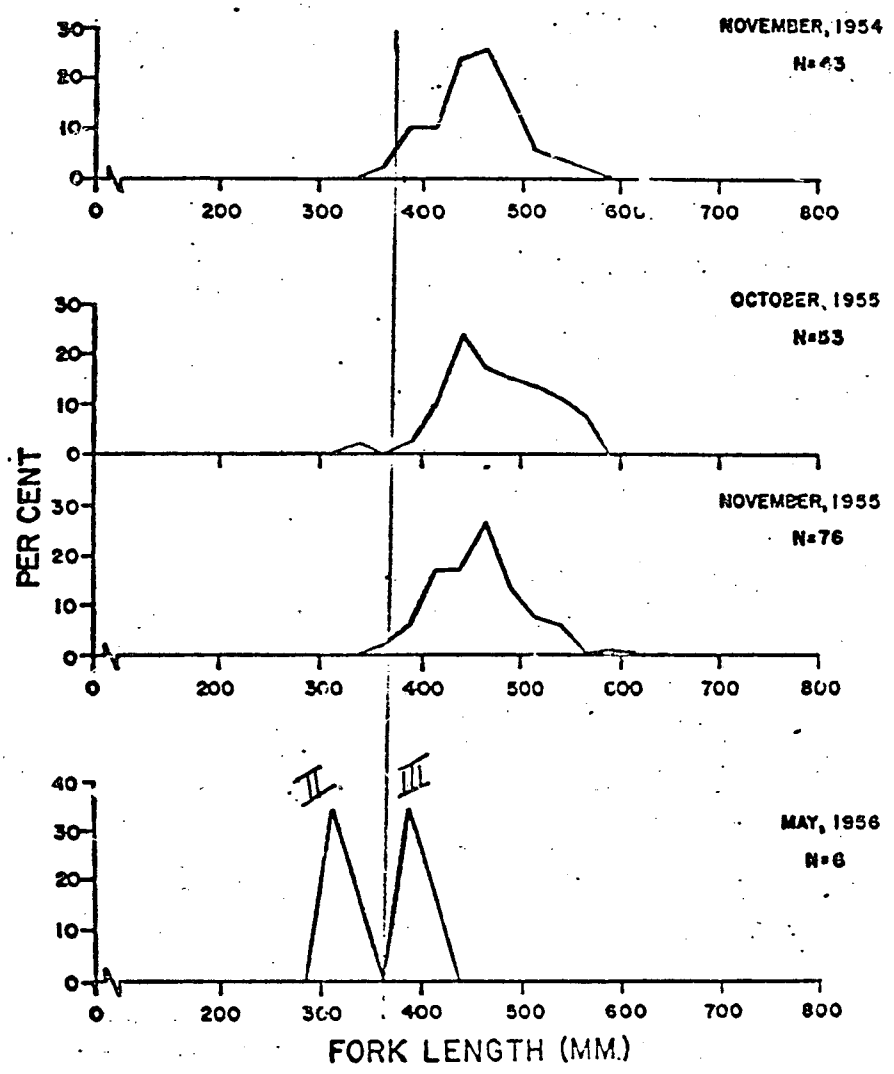


Figure 5 · Monthly length-frequency distribution for striped bass tagged at Westhampton Beach in 1954, 1955 and 1956.

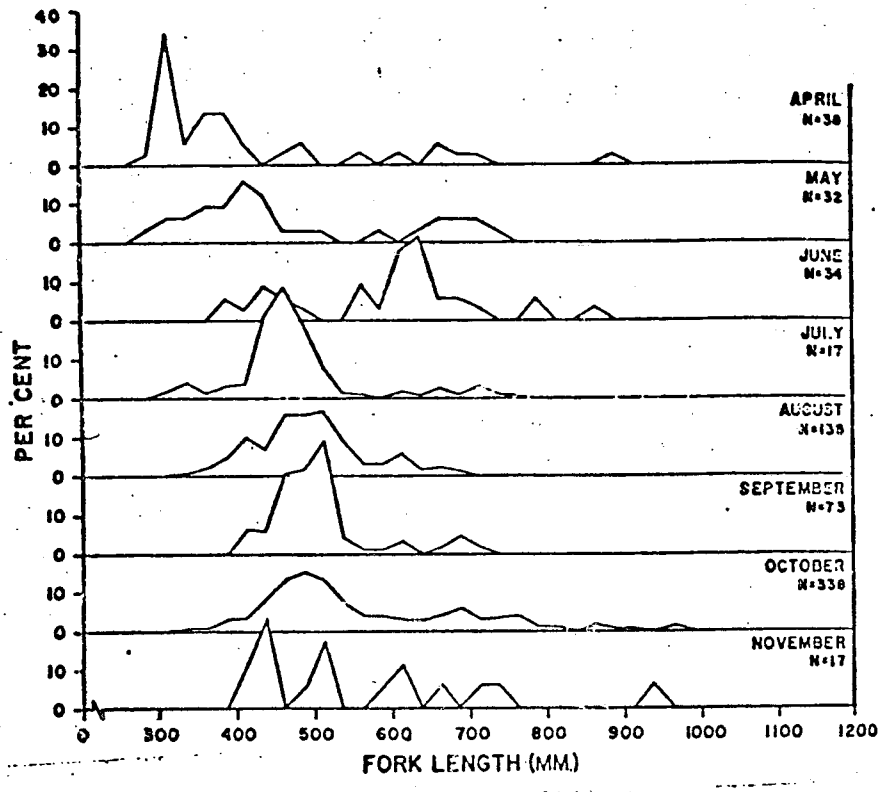
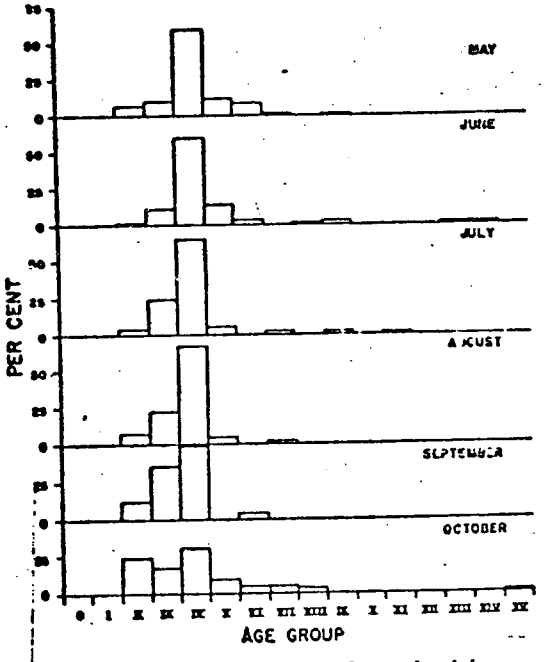
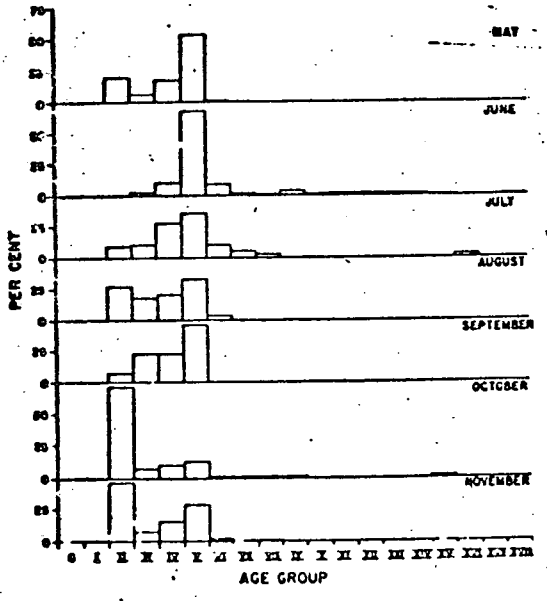


Figure 6 Monthly length-frequency distribution for striped bass collected at Great South Beach in 1964.



Monthly age-frequency distribution for striped bass collected at Great South Beach in 1962.



Monthly age-frequency distribution for striped bass collected at Great South Beach in 1963.

Figure 7.

TABLE 13. LENGTH-FREQUENCY DISTRIBUTION OF STRIPED BASS TAGGED IN GREAT SOUTH BAY

Fork length in millimeters	Season and year tagged							Total	Percentage by group
	June-October 1956	July-October 1959	May 1960	June 1960	July-November 1960	May 1961	June 1961		
200–224	..	..	1	..	..	..	..	1	61.9*
225–249	..	..	2	2	..	..	..	4	
250–274	..	..	41	26	..	2	..	69	
275–299	2	2	108	110	1	7	10	240	
300–324	1	8	65	95	2	18	49	238	
325–349	15	8	12	16	21	33	126	231	
350–374	5	22	14	1	45	27	118	232	
375–399	7	13	37	2	24	34	54	171	
400–424	3	6	52	1	18	27	42	149	34.5
425–449	..	..	63	2	1	26	37	129	
450–474	..	6	40	2	..	9	25	82	
475–499	..	4	52	4	1	4	6	71	
500–524	..	..	71	..	..	1	3	75	
525–549	..	..	50	1	1	4	2	58	
550–574	1	..	54	..	..	7	1	63	
575–599	..	..	25	3	..	6	1	35	
600–624	..	..	11	1	..	7	1	20	3.6
625–649	..	..	11	..	..	8	1	20	
650–674	..	..	8	..	..	4	2	14	
675–699	..	..	4	..	..	2	..	6	
700–724	..	..	3	3	..	1	..	7	
725–749	..	..	..	..	..	1	..	1	
750–774	..	..	..	..	..	..	..	..	
775–799	..	..	..	..	..	..	..	..	
800–824	..	..	1	..	..	..	..	1	
Total	34	69	725	269	114	228	478	1,917	100.0

* Below size that may be taken legally.

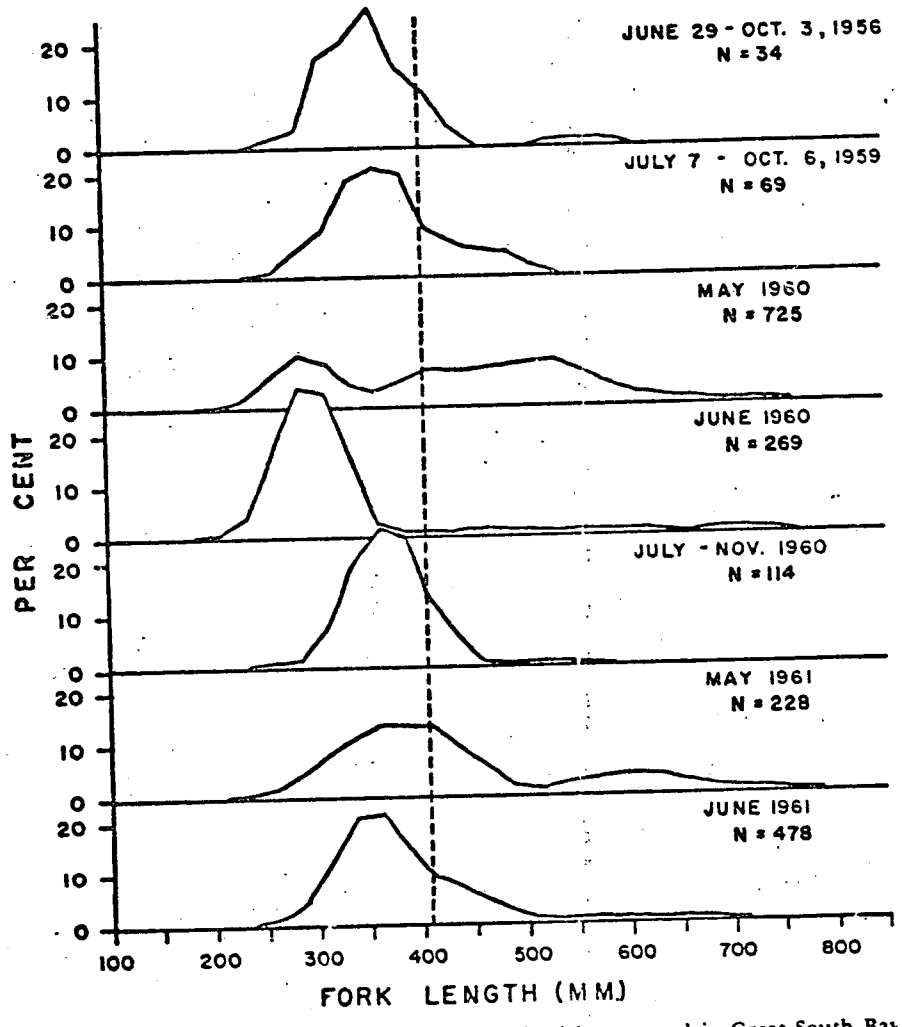


Figure 9 Length-frequency distributions of striped bass tagged in Great South Bay from 1956 to 1961; data smoothed by moving average of three.

His conclusion in this regard stands in stark contrast to the tagging studies which have demonstrated that fish of age group II are virtually non-migratory, at least insofar as the Chesapeake is concerned. Nor can Merriman's data be explained as an aberration of normal circumstances. An examination of the tagging data which have been presented in this proceeding by Dr. Raney (October 30 testimony) shows that based on size and age data (Fig. 4) 2-year-olds would be common among fish that were tagged in the mid-Atlantic region. Similar conclusions apply to Clarke (1968) data (Table 12). Furthermore, Schaefer (1969) collected 2-year-old striped bass in the surf waters of Long Island (Figs. 5-8) and Alperin (1966) found that the predominant age category present in Great South Bay on the outer coast of Long Island was composed of 2-year-old fish (Table 13; Fig. 9). These data indicate that the stock present along the Atlantic coast of Long Island and New England receive a great proportion of its initial recruits as 2-year-olds.

3. Summary

The importance of the 2-year-old stock then becomes very clear. It is apparent from tagging data in the Chesapeake area that 2-year-old fish are not migrating out of the Bay to any significant extent. Whereas, in contrast the Mid Atlantic stock, supposedly derived from the Chesapeake, receives a major proportion of its recruits as 2-year-old fish. These two conclusions are apparentely mutally exclusive with the result that if tagging data in the Chesapeake is considered to be representative, even remotely, then the stock which is present in the Mid-Atlantic region is not derived in the main from Chesapeake production.

Not only is the age of recruitment to the Middle Atlantic stock inconsistent with the concept of a Chesapeake origin but the total proportion of tagged fish recaptured outside the Chesapeake cannot begin to account for the Middle Atlantic stock. Vladykov and Wallace (1937) discussed this situation in some detail:

. . . Are these recaptures sufficient evidence to make definite conclusions that the Chesapeake Bay rock is a migratory fish which vacates the bay in considerable numbers and visits the northern Atlantic states during the summer months? Merriman (1937, pp. 30-31) expressed such a possibility. His reasons were based on tagging results and other observations that disclosed in 1936 an exceptionally large number of 2-year-old rock present in Connecticut. The 1934 year class was also extremely abundant in Chesapeake Bay, a condition noticed in 1935. Merriman was unable to secure in Connecticut any definite information about young rock of sizes comparable to those of Chesapeake Bay in 1935. He attributed the absence of young rock in Connecticut to heavy pollutions of local rivers, which makes spawning impossible. He was then forced to the conclusion that Connecticut receives its fish from other bodies of water: "The fish two years old are probably the youngest to take any large part in the migrations." The present investigations give support to his findings that fish younger than 2 years do not undertake extensive migrations. We observed, for instance, that the 1936 year class was present in Chesapeake Bay in several rivers (Choptank, Patuxent, etc.), not only during the summer and fall months of 1936, but also during March and April of 1937. Moreover, the greater number of rock tagged by us in 1936 were fish of the 1934 year class (with two annuli)---fish about 2½ years old when tagged. All these observations seemingly corroborate Merriman's belief that the abundance of rock in Connecticut during the summer of 1936 "had as its point of origin the Chesapeake Bay area." Only further and more extensive tagging of Chesapeake rock of different sizes, especially yearlings, can definitely settle this very important question. The racial studies of rock populations from different localities along the Atlantic Coast will be of great help in the final analysis.

It is important here to point out facts in opposition to the belief that the Chesapeake Bay rock is migratory. First of all the outside recaptures of the Chesapeake tagged fish represented only a very small number, or approximately 2.5 per cent of the total recaptures. The Connecticut tagged fish recovered from Chesapeake Bay represent even a smaller amount, less than 2.0 per cent of Merriman's total recaptures (Table 8).

Tags from fish marked under the direction of the Chesapeake Biological Laboratory, and taken from bodies of water foreign to the Chesapeake, were returned promptly and very cooperatively. Perhaps all such tags recovered from fish caught outside of Chesapeake Bay were returned. If so, it is highly improbable that very large catches of rock made in different Atlantic states, from North Carolina to Maine inclusive, during 1936 and 1937, should be attributed to Chesapeake Bay fish. Evidence brought by Merriman that a large portion of the Connecticut rock was composed of the 1934 year class, which is equally abundant in Chesapeake Bay, is merely circumstantial. There is the possibility that the very prolific 1934 brood had its origin in different regions independently, due to favorable conditions for development and survival throughout the range. (p. 82-83, Vladykov and Wallace)

Assuming that the information presented in these discussions is accurate, one well might ask what is the contribution of the Chesapeake to the Middle Atlantic stock. One estimate of this contribution could be made from the recapture data of bass tagged in the Chesapeake and recaptured in the Middle Atlantic region. Thus if it is assumed that the fish which were tagged in the Chesapeake and later recaptured outside the Bay originated from spawning within that system, the contribution to the Middle Atlantic region would constitute something on the order of 0.5 - 1% of the Chesapeake stock, or by weight something on the order of 50,000 pounds. This amount would constitute only about 5% of the Middle Atlantic catch. Thus, it must be concluded that the Chesapeake does not contribute the major part of the stock of the Middle Atlantic fishery.

C. Contribution from the Delaware

In his rebuttal testimony, Dr. Lawler asserted that the Delaware Bay estuary was a major spawning area for striped bass, which inhabited the Middle Atlantic region. In its evaluation, the Staff consulted 2 principal references concerning the relative importance of the Delaware system to the production of striped bass within the last decade. The first of these 2 sources of information was a report issued by Murawsky which was commented upon by Dr. Lawler in his rebuttal testimony. However, after some study of Dr. Lawler's comments, it was not apparent to the Staff that Dr. Lawler's conclusions were consistent with the information upon which he based them. In particular, the total catch of eggs and larvae represented by the several years of sampling data summarized within Murawsky's report do not represent, at least to the Staff, a productive region for striped bass spawning.

TABLE 14 Summary of returns from juvenile striped bass tagged in the Lower Delaware River.

Released		Recaptured		
Location	Date	Location	Date	Fishery
Deepwater, N.J.	10/10/62	Del. Bay, Little Crk, Del.	11/1/62	Comm.
Deepwater	10/22/62	Big Stone Beach, Del.	12/1/62	Comm.
Deepwater	10/26/62	Del. Bay, Milford, Del.	12/3/62	Comm.
Deepwater	12/22/62	Del.Bay, Missipillion Light	12/13/63	Comm.
Deepwater	10/10/62	Kitts Hummock, Delaware	2/?/64	Comm.
Deepwater	10/13/65	C.& D. Canal, Reedy Pt., Del.	10/18/65	Sport
Deepwater	10/4/65	Ches. Bay, Rock Hall, Md.	12/16/65	Comm.
Deepwater	10/13/65	Del.Bay, Bowers Beach,Del.	2/21/66	Comm.
Deepwater	10/4/65	Del.Bay, off Dennis Crk.NJ	3/7/66	Comm.
Deepwater	10/4/65	Indian Beach, Del.	10/2/66	?
Deepwater	10/27/65	Ches.Bay off Tolchester,Md.	?	Comm.
Salem Cove, N.J.	10/1/63	Del.Bay,mouth of Maurice R.	11/22/63	Comm.
Salem Cove	10/1/63	Ches. Bay, Abbey Pt., Md.	2/11/64	Comm.
Reedy Isl.	10/4/68	Mad Horse Creek,N.J.	10/9/68	Sport

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Deepwater	10/26/62	Del. Bay, Milford, Del.	12/3/62	Comm.
Deepwater	12/22/62	Del.Bay, Missipillion Light	12/13/63	Comm.
Deepwater	10/10/62	Kitts Hummock, Delaware	2/?/64	Comm.
Deepwater	10/13/65	C.& D. Canal, Reedy Pt., Del.	10/18/65	Sport
Deepwater	10/4/65	Ches. Bay, Rock Hall, Md.	12/16/65	Comm.
Deepwater	10/13/65	Del.Bay, Bowers Beach,Del.	2/21/66	Comm.
Deepwater	10/4/65	Del.Bay, off Dennis Crk.NJ	3/7/66	Comm.
Deepwater	10/4/65	Indian Beach, Del.	10/2/66	?
Deepwater	10/27/65	Ches.Bay off Tolchester,Md.	?	Comm.
Salem Cove, N.J.	10/1/63	Del.Bay,mouth of Maurice R.	11/22/63	Comm.
Salem Cove	10/1/63	Ches. Bay, Abbey Pt., Md.	2/11/64	Comm.
Reedy Isl.	10/4/68	Mad Horse Creek,N.J.	10/9/68	Sport

Other information is available which also indicates paucity of spawning successes of striped bass in the Delaware system, in particular, a recent publication by Chittendon, whose abstract is quoted below:

> The Delaware River was historically an important spawning and nursery area for striped bass, particularly in and near tidal fresh water. Collections of fishes throughout the freshwater sections from 1963 to 1966 by techniques that included continuously fishing traps and large and small meshed seines contained no striped bass, and few specimens were collected in rotenone surveys from 1960 to 1962.
>
> Gross pollution of the tidal freshwater area has destroyed its potential as a spawning and nursery area, has resulted in the virtual extirpation of the striped bass from there and upstream waters, and is the probable cause of the decline in abundance of this species in the Delaware River. Major restoration of striped bass would occur if pollution is decreased so that the tidal freshwater section can resume its former importance as a spawning and nursery area. (Abstract, Chittenden, 1971)

The Staff also examined with interest Dr. Lawler's statements concerning the relative importance of striped bass spawning in the Maurice River, which is a tributary to Delaware Bay. The location of the recaptures of the fish tagged in the Maurice, to which Dr. Lawler is referring, is presented in Figure 10. Note that none of the recaptures of fish tagged in this river system have been recaptured north of the mouth of the Delaware and therefore could not be considered as representing the migratory stock which moves north and south along the Lond Island shore, nor does it seem to support any major fishery for striped bass outside Delaware Bay itself. Furthermore, other data presented by Hamer (1971), demonstrate that juvenile fish which have been tagged in Delaware Bay do not in fact leave the system (Table 14). In effect, the information which Hamer presented in his 1971 report show no striped bass tagged within the Delaware Bay which were later recaptured north of the Bay.

D. Contribution from the Hudson

The importance of the Hudson as a spawning area for striped bass has long been noted. In fact, Merriman commented on this very point as follows:

> . . . Areas similar to those where small bass were taken in the Hudson River in the summers of 1936 and 1937, as well as many other likely localities, have been worked with minnow seines and small-meshed trawls that were efficient enough to catch large numbers of young fish of many other species and occasionally even adult striped bass. However, the smallest striped bass taken in Connecticut waters was a small 2-year-old which measured 23 cm. (9 inches). . .
>
> . . . In 1936 the New York State Conservation Department took large numbers of juvenile striped bass in various localities on the Hudson River from Beacon downstream. A length-frequency curve of these fish is shown in figure 10. (p. 16-17)
>
> . . . There can be little doubt, therefore, that the Hudson River is a spawning area for striped bass. (p. 17)

This evidence has since been confirmed by Raney (1952), by Rathjen and Miller (1957), and by the Hudson River Fisheries Investigation (1970). Much of the recent information has been gathered by investigators under contract to the Applicant. In effect, these data show that the Hudson is in fact a major spawning area for striped bass.

Because of its location, the Hudson River should have been expected to be the predominant source of striped bass inhabiting the New Jersey Coast, New York, Connecticut, and perhaps Rhode Island and the rest of the New England area simply on the basis of the fact that each population of striped bass on the Atlantic coast appears to support a local fishery such that the degree to which one geographic area is supported by stock originating in another geographic area is apparently very small. For instance, within the Chesapeake, there seems to be no consistent relationship between the stock utilized in the Maryland portion

of the Chesapeake and that utilized within the Virginia portion. Likewise, there is no apparent relationship between landings in the Delaware and either the combined Maryland and Chesapeake catches or the Chesapeake catches or the Maryland catches. Furthermore, there is no evidence that the South Carolina stock is supported to any extent at all by the Chesapeake stock, nor is the opposite comparison significant.

With this information in mind, the Staff finds the Merriman hypothesis indefensible. It should be pointed out that Merriman's analysis was especially well done, and it is the Staff's belief that his error was one of omission as indicated in the following quotation:

ORIGIN OF THE DOMINANT 1934 YEAR-CLASS

The problem of the geographical point of origin of the dominant 1934 year-class, that age-group which has already been discussed at some length, is of particular interest. There is considerable evidence to support the conclusion that these fish were produced mainly in the Chesapeake Bay region. Thus, in the summer of 1935, when the members of this year-class were 1-year-olds and probably averaged 15-20 cm. (approximately 6-8 inches) in length, an unusually great abundance of striped bass of about this size and presumably of this age was observed and reported from Chesapeake Bay by many competent people. Truitt and Vladykov (1936) also "found that fish ranging from 21 to 25 cm. in standard length" seemed to be the most abundant age-category of striped bass in Chesapeake Bay during the early and midsummer in 1936. These fish were undoubtedly 2-year-olds at that time---members of the dominant 1934 year-class. Vladykov and Wallace (1937) also corroborate this information. On the other hand, diligent inquiry elicited no reports of yearling bass in 1935 from waters farther north. In the light of these observations it therefore seems logical to suppose that this large group of fish that were 2-year-olds in the summer of 1936, and first appeared in north Atlantic waters in that year, came in the majority from the Chesapeake Bay area and that general latitude. (See below for evidence that the dominant 1934 year-class did not come from farther south, p. 49.) From what is now known of the paucity of the spawning areas in the north, it is most unlikely that those regions north of the latitude covered by Delaware Bay contributed more than a small fraction to this dominant year-class---or for that matter, that they ever play more than a small and unimportant role in contributing to the total stock along the Atlantic coast under present conditions. Thus it becomes apparent that the striped bass fishery from New Jersey northward is almost entirely dependent for its existence on the stock of bass produced to the south, and on the migrations from the south to the north in the spring, which do not occur until bass become 2 years old or older.

Granting that the major portion of the production of striped bass takes place from the northern part of Delaware Bay south, it is of interest to determine how far south the stock contributes to the supply in northern waters, and to what extent different areas contribute to this supply. It is known that the Chesapeake Bay area is an important spawning center, and the work of V. D. Vladykov and D. H. Wallace (as yet unpublished) on tagging striped bass in connection with the survey of anadromous fishes for the State of Maryland has shown that the migration of bass out of Chesapeake Bay to the north in the spring is not an uncommon occurrence. Thus it seems well established that this general region contributes to the supply in the north and is an important center of production.

It would appear from this discussion that Merriman did not have sufficient data with which to evaluate the importance of the Hudson and therefore rejected the Hudson as a probability.

It is the Staff's belief that there are several good reasons to accept the hypothesis that the Hudson contributes the major portion of the stock to the Middle Atlantic fishery and perhaps the fishery of the New England as well. Two relatively recent and comprehensive studies of the composition and migration of striped bass which frequent this area have been conducted by Alperin (1966) and Schaefer (1968). In both studies, the bass were captured by haul seine and most were tagged and released after appropriate size data and scale samples (used for age determination) were taken. One of the important objectives of each of these studies was to determine the origins of bass occurring on the outer coast of Long Island. Such information is particularly needed to assess the extent of the contribution of the Hudson stock to the commercial and sport fisheries of the New York area. The size, age, and migration data which resulted from these studies permit evaluation of questions related to the annual variations in contributions from the Chesapeake Bay and the Hudson River to populations on the Atlantic coast of Long Island.

Sampling in the first of these two studies was concentrated in Great South Bay during the period from 1956 to 1961. In dicussing the results of this study, Alperin concluded the following:

> "The origins of the striped bass that frequent Great South Bay are not readily discernible from the information collected during this investigation. Returns from the fish tagged in 1960 and 1961 do not, however, suggest a Hudson River origin, although this river contains the nearest important spawning ground. Of the 149 tag returns from within New York waters, only three (2.0 percent) came from the main body of the Hudson. Even when

all adjacent areas were included (i.e., Jamaica Bay, Upper and Lower New York Bays, Staten Island and western Long Island Sound) the returns totalled only 11 (7.4 percent). In contrast, much higher rates of recovery in the Hudson River resulted from the small samples tagged in 1956 and 1959. Of the six returns for fish tagged in 1956, all in New York waters, one (16.6 percent) was taken in the lower Hudson River in 1958. For the fish tagged in 1959, recoveries from the Hudson River totalled four (18.1 percent) of the 22 from State waters. Also none of the striped bass tagged in 1959 were recovered south of New Jersey although some did reach New England.

"These data, meager as they are, lead to the conclusion that the fish marked in 1956 and 1959 were of more local nature and may have originated in the Hudson River, while those marked in 1960 and 1961, which appeared in great numbers, probably originated elsewhere. In the years when migrants from the South are not abundant in Great South Bay, fish of Hudson River origin may be the principal source of supply."

In comparing the results of tag returns from striped bass tagged in surf waters with the results obtained by Alperin, Schaefer commented,

"The results of the tagging conducted in the present study, however, roughly parallel those presented by Alperin for striped bass tagged in Great South Bay between 1956 and 1961. He reported that 16.6 percent and 18.1 percent, respectively, of the recoveries for fish tagged during 1956 and 1959 came from the Hudson River, but that only 2.0 percent of those for fish tagged during 1960 and 1961 came from that location. These observations prompted him to hypothesize that 'the fish marked in 1956 and 1959 were of more local nature and may have originated in the Hudson River, while those bass marked in 1960 and 1961, which appeared in great numbers, probably originated elsewhere. In the years when migrants from the south are not abundant in Great South Bay, fish of Hudson River origin may be the principal source of supply'. Although it may seem contradictory that both Raney et al. and Alperin suggested that striped bass of Hudson River stock seldom go farther east along the south shore of Long Island than Jones Beach, it should be noted that this conclusion is based solely on recovery data from fish tagged in the Hudson River which were mostly specimens of sublegal (less than 16 inches in fork length) size. It has been demonstrated by several investigators (Vladykov and Wallace, 1938, 1952; Merriman, 1941; Raney, 1952, 1957; Mansueti, 1961; Massmann and Pacheco, 1961; Nichols and Miller, 1967) that small striped bass, especially those less than 2 years old, are, for the most part, nonmigratory. With this in mind, the hypothesis of Alperin concerning the origins of the Great South Bay population seems quite plausible. Applying similar reasoning to the recovery observations of the present study, it is suggested that a rather sizeable portion of the fish tagged at Westhampton Beach between 1954 and 1956, and possibly some of those tagged at Great South Beach between 1961 and 1963, may have been of Hudson River origin.

Recent returns from tagging studies conducted by Sandy Hood Marine Laboratory personnel also indicate a contribution of Hudson stock to the coastal fishery (Fig. 11) (Clark and Smith, 1968).

Furthermore, yearling striped bass were discovered along the south area of Long Island in Great South Bay during the summer of 1964. Alperin (1966) concluded that these fish were of Hudson River origin based on their meristic characteristics. Thus, recruitment of Hudson stock to the coastal waters was confined.

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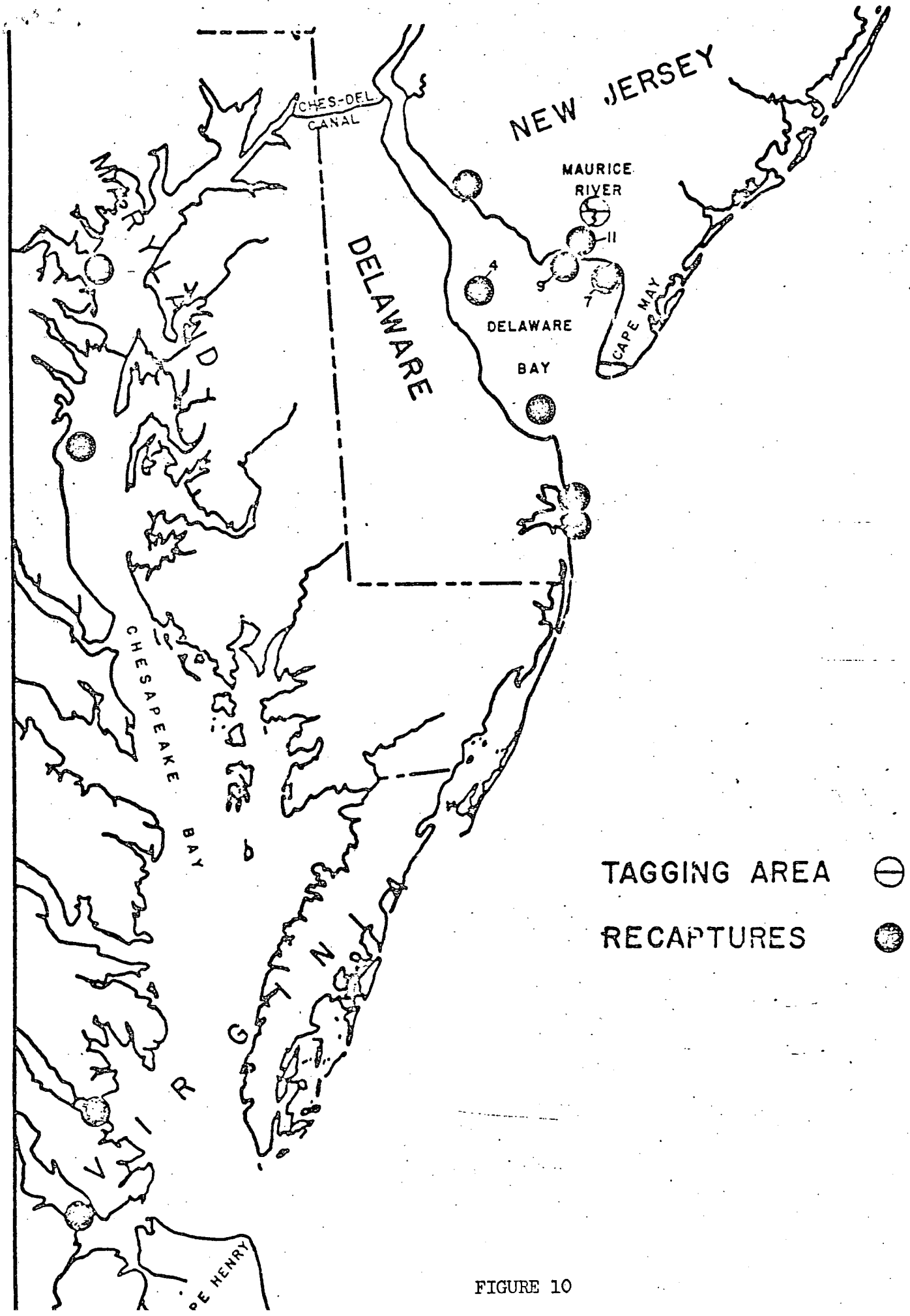
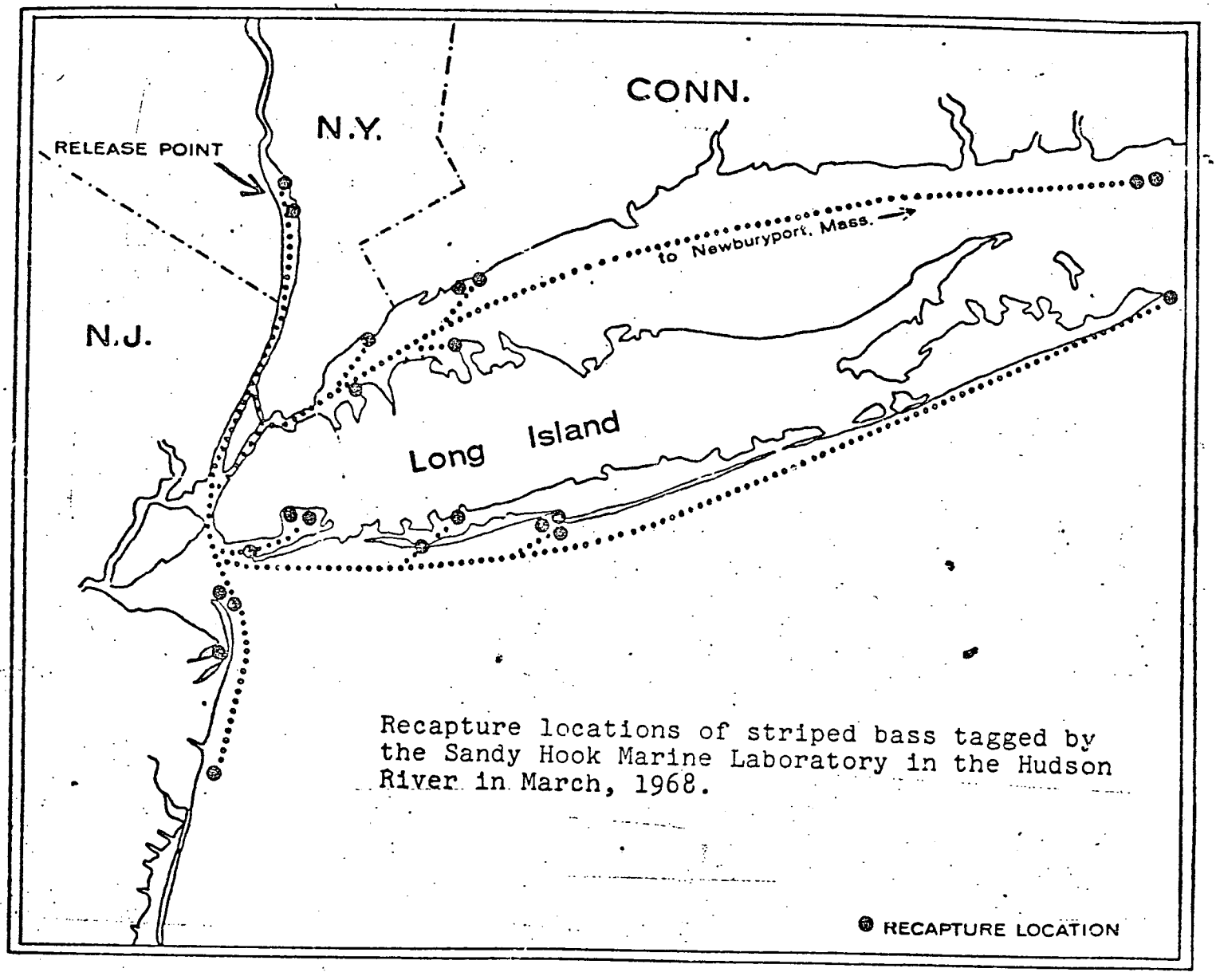

NEW JERSEY
CHES-DEL CANAL
MAURICE RIVER
DELAWARE
DELAWARE BAY
CAPE MAY
MARYLAND
CHESAPEAKE BAY
VIRGINIA
CAPE HENRY
TAGGING AREA
RECAPTURES

FIGURE 10



Recapture locations of striped bass tagged by the Sandy Hook Marine Laboratory in the Hudson River in March, 1968.

FIGURE 11

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