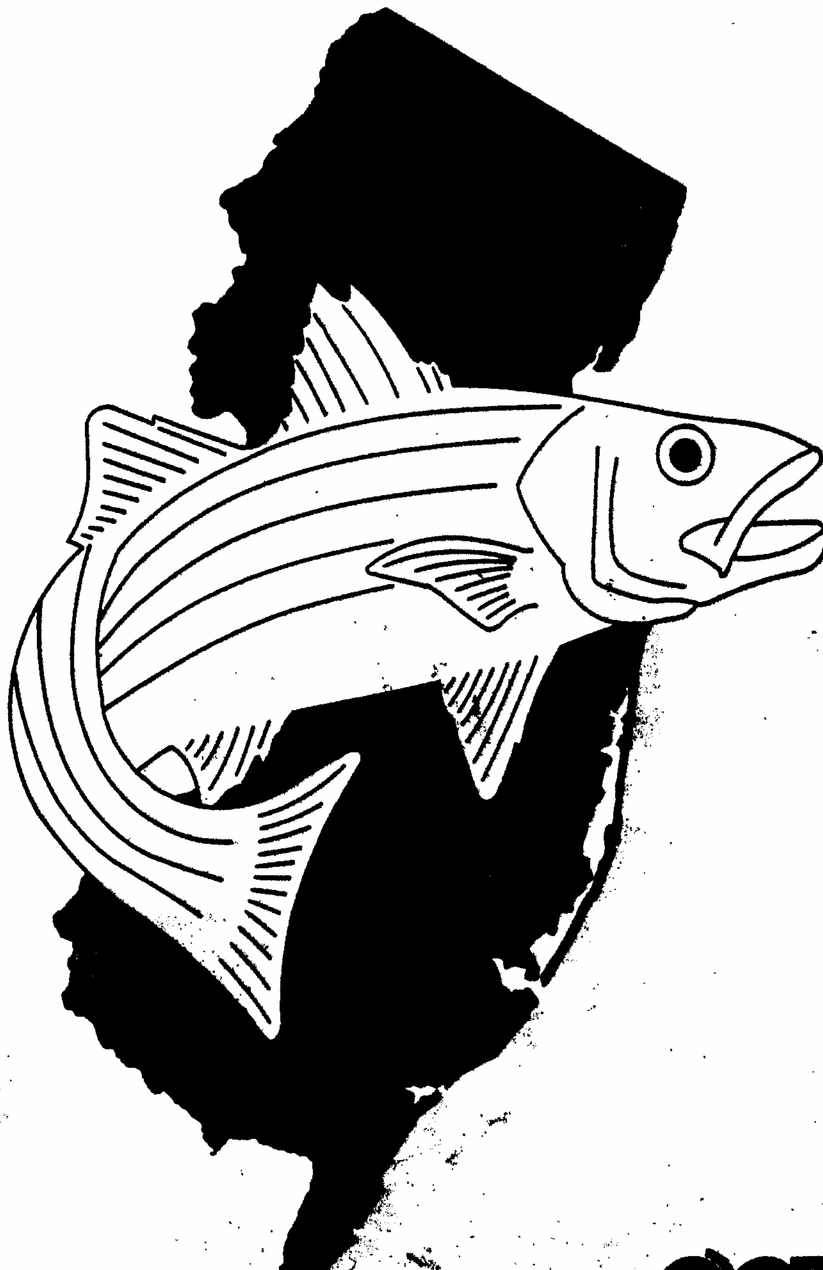
PCBs in Fish: 1975-1980
A Comprehensive Survey



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Office of Cancer and Toxic Substances Research

New Jersey Department of
Environmental Protection

PCB'S (Aroclor 1254) in Fish Tissues Throughout the State of New Jersey: A Comprehensive Survey

by
Thomas J. Belton, M.A.
Bruce E. Ruppel
Office of Cancer and Toxic Substances Research
New Jersey Department of Environmental Protection

Keith Lockwood
Division of Fish, Game and Wildlife
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EXECUTIVE SUMMARY

In 1976, stimulated by the discovery of broad range PCB contamination of fish and sediments on the upper Hudson River in New York State, DEP instituted a program to conduct a comprehensive survey of possible PCB contamination of finfish and shellfish both within the lower Hudson River and throughout the state. Since then the "PCB Project" has caught fish annually and analyzed them for Aroclor 1254, the most persistent and toxic mixture of polychlorinated biphenyls. In 1978 analysis for various organochloride pesticides was also performed after the discovery of widespread chlordane contamination in the Camden area resulted in fishing bans on the affected drainages.

The project has three main objectives: to determine the degree to which various aquatic organisms in the state are contaminated; to determine how contaminant levels in fish vary with geography and finally to assess the suitability of the fish for human consumption. The data for the PCB portion of the Project has now been analyzed. The data show that a substantial proportion of the finfish and shellfish analyzed had detectable levels of PCB's in their edible flesh (75% and 50% respectively). A small percentage, 2.4% of the finfish had levels exceeding the existing FDA action level of 5.0 micrograms of PCB in 1 gram of tissue (ug/g) or 5 parts per million (ppm). The FDA has proposed lowering the action level to 2.0 ug/g. A total of 11.1% of the finfish exceeded the proposed level. None of the shellfish had contaminant concentrations greater than the proposed 2 ug/g action level.

The data also show that those fish which are highly contaminated represent only a few species with the freshwater groups being much lower in PCB's compared to the saltwater and migratory fish. The geographical analysis indicates that some drainages and/or geographic sub-regions tend to have more highly contaminated fish than others and that the heavily urbanized, northeastern corner of the state, within the Hudson-Newark-Raritan Bay Complex is especially impacted. The Hudson River appears to be the most severely contaminated drainage within the state's water and although the mean Aroclor 1254 levels in its fish has declined since the mid 1970's the levels detected are still at or near the proposed action level of 2.0 ug/g.

A relationship is shown between Aroclor 1254 and fish lipid content for a number of species indicating a method of contaminant reduction for the consumer via fat stripping. That is, if the fatty portion of the fish is trimmed, (e.g. the belly flap, skin and lateral line) as much as 50% of the PCB's contained in the fish may be removed. It should also be noted that two of the species we have identified as having elevated PCB's; Bluefish and Striped Bass, are quite important to both the recreational and commercial fisheries in New Jersey. This fact indicates the broad range health threat associated with the contamination of fisheries and underlines the extreme sensitivity of human health to aquatic release of toxic chemicals.

And finally, now that susceptible species and critical regions have been identified, the Department's response to these problems is being carefully weighed. Continued surveillance is obviously necessary and the dissemination of information to the public on how to reduce exposure to these compounds is surely called for. The management of New Jersey's fisheries in reference to these residue levels is a topic that is being approached by all relevant parties within the Department. These deliberations will also consider the various options required to protect public health and reduce future pollution.

INTRODUCTION

The toxicity of Polychlorinated Biphenyls (PCB's) has been known for many years (1) and recent data indicates that they should be regarded as potentially carcinogenic in man (2). In the 1960's new analytical techniques showed PCB's to be ubiquitous and persistent in the environment, with the river and coastal sediments acting as transient reservoirs (3). The major factors in the dynamics of PCB distribution within surface waters are its low solubility, high specific gravity, and high affinity for solids (4). This results in PCB concentrations within the bottom sediments many times higher than the overlying waters (5). PCB's are also highly lipophilic and can bioaccumulate to high tissue concentrations within fish even when the water concentrations are below the usual detection limits for the compound. (6, 7, 8).

In 1976, stimulated by the discovery of broad range PCB contamination of fish and sediments on the upper Hudson River, in New York State (9), the New Jersey Department of Environmental Protection instituted a comprehensive program to survey possible PCB contamination of finfish and shellfish both within the lower Hudson River and throughout the State. The project was designed with three main objectives: to determine the degree to which aquatic organisms caught in the State are contaminated; to determine how PCB levels in fish vary with geography; and finally, to assess the suitability of the fish for human consumption. In keeping with this last objective, we decided to analyze only "edible fillets" of all fish caught, assuming that this would be a more appropriate indicator of health risk to New Jersey's consumers. Sampling locations were chosen to incorporate; the major drainage basins, locations containing known or suspected sources of PCB contamination, and locations important to either the commercial or recreational fisheries. Sampling was targeted at a number of indicator organisms including species of recreational and commercial importance as well as species to be used as ecological indices. Chemical analysis and calculation of concentrations, as compared to standards for Aroclor 1254, were performed on all samples after initial, broad range PCB scans indicated that this was the major Aroclor most resembling the chromatograms of our samples. Standardized composites of five fish were usually analyzed with periodic analysis of single samples for comparison purposes. The percent lipid of each sample was also determined since the lipid content of fish has often been correlated with the bio-accumulation of PCB's (10, 11, 8).

METHODS

Finfish from freshwater locations were collected by electro-fishing and gill netting. Estuarine and marine finfish were captured by the use of gill nets, otter trawls, seines, hook and line, and baited traps. Shellfish samples were collected using baited traps, bottom rakes and dredges. All samples were stored in clean, contaminant-free ice chests and kept refrigerated until processing, usually the following day. Each species collected from a particular site was processed based upon its ascending order of lipid content.

Before actual processing all finfish and shellfish were weighed, measured and speciated. Samples extracted from edible food fish consisted of a skinned edible fillet portion of the fish. The standard fillet can be defined as that portion of the fish bounded anteriorly by the pectoral fin, posteriorly by the caudal fin, and from the mid-dorsal line to the mid-ventral line, including the rib cage and belly flap. These standard fillets were either used as an individual sample from a single fish or combined with other individuals of the same species and size to form a homogenized composite sample consisting of five fish. Single samples were 100 grams in weight and composites of five fish, 500 grams. When a 100 gram sample portion was extracted from a standard fillet which exceeded 100 grams, the sample portion was taken from the anterior section of the fillet proceeding posteriorly until 100 grams was attained. Nonedible fish such as Menhaden, Killifish or fish that were too small to fillet were ground up whole in a blender, and used as whole fish samples. Composites made up of homogenized whole fish contained equal portions from all members in that composite. All bivalve shellfish, whether submitted for analysis as a single or composite sample, were homogenized as whole body samples, excluding the shell. Crab and lobster samples consisted of the edible meat portions with the hepatopancreas analyzed separately. Processed samples were packaged in contaminant free aluminum foil, labelled, and stored frozen until analysis.

Field storage of all collected samples was in contaminant free containers and wet ice. Lab surfaces and preparation equipment were continually scrubbed and rinsed with pesticide grade hexanes, between sample processing.

The homogenized fish samples were extracted and quantified by gas chromatography at the New Jersey Department of Health Laboratory. They used the U.S. Environmental Protection Agency's Methods (12) with slight modifications in the initial tissue preparation and extraction section. Seven grams of tissue were soxhlet extracted for six hours in a 3:1 hexane-acetone mixture. The extract was then partitioned with acetonitrile which was again extracted with hexane and then isolated on a florisil column. Final elutate was then concentrated and characterized by gas chromatography and quantified by comparison with an Aroclor 1254 standard. A Tracor Model 222 gas chromatograph was used with an electron-capture detector. EPA quality assurance guidelines were followed and a percent recovery was calculated using known concentrations of standards after every twelve samples were run.

Fish normally exhibit contagious spatial distributions (clumped) and fish monitoring data is nearly always log-normal or negative binomial (16). As a result data for fish-distribution investigations must be transformed prior to analyses, and if no suitable transformation can be found non-parametric analyses must be used. FDA however, does not attempt any spatial-watershed analysis but a fish-lot analysis of an existing composite of tissue (not per fish) and they use the arithmetic mean in all summations (Elizabeth Campbell, FDA, personal communication). To compare our data with FDA, we used arithmetic means but utilized non-parametric tests elsewhere as the level of analysis required.

RESULTS

Quantification of the PCB results for selected species are shown in Tables Ia. and Ib. The levels shown are arithmetic means to make them comparable to the existing and proposed FDA Action Levels of 5.0 and 2.0 ug/g respectively. For all other parametric statistical analyses the data was normalized through log-transformation. Generally, it was found that over 75% of the finfish and 50% of the shellfish analyzed (i.e. defined here as sessile, filter-feeding organisms) contained detectable levels of Aroclor 1254 greater than 0.1 ug/g. Only 2.4% of the finfish and none of the shellfish had PCB levels above the existing FDA action level of 5.0 ug/g. However, 11.1% of the finfish had contaminant levels greater than the proposed action level of 2.0 ug/g.

The results in Tables Ia. and Ib. show that the freshwater species are much lower in Aroclor 1254 contamination than the saltwater species. The main contamination problem appears to reside in the euryhaline, estuarine, and true marine fishes, many of which are migratory and use the estuaries as important spawning and nursery areas.

Saltwater species with elevated Aroclor 1254 levels include Striped Bass (Monrone saxatilis), Bluefish (Pomatomus saltatrix), Atlantic Sturgeon (Acipenser oxyrhynchus), White Perch (Morone americana) and American Eel (Anguilla rostrata).

It is likely that substantial PCB uptake occurs in those coastal areas where industrial pollution is the most severe. Supporting this hypothesis are studies of different land-use areas showing that PCBs occur more frequently in urban soils where the most commonly encountered PCB is Aroclor 1254 (13).

It should be noted that besides being a coastal state, with resident populations of fresh and saltwater fish, New Jersey is very diverse geologically, encompassing both low lying coastal rivers and back bays as well as upland river and lakes. In order to perform a statewide analysis, this heterogeneity of habitat required the break up of locations into indicative sub-regions, based on a number of criteria including; common drainage basins, shared embayments, similar lake regions, and contiguous offshore areas (see Table II and Maps 1 and 2). Comparison of the results between sub-regions allowed us to estimate whether contamination of each species was a localized phenomenon or a problem common to the entire range of fish as delineated by our survey (see Table III).

We tested for differences in Aroclor 1254 concentrations within species across these different geographic sub-regions using a non-parametric test on untransformed data, the Kruskal-Wallis one-way analysis of variance by ranks test (14). The null-hypothesis being that there were no significant differences in PCB concentration between geographic sub-regions for a given species. The results of this test can be interpreted in four ways: (see Table IV).

1. Species which differ in PCB concentration by sub-region but which show minimal concentrations of the contaminant (less than 1 ppm).

2. Species which differ by PCB concentration by sub-region and which show elevated concentrations of PCB's in flesh for a large percentage of the samples (greater than 2 ppm).

3. Species which do not differ in PCB concentration by sub-region but which show minimal levels of contaminant.

4. Species which do not differ in PCB concentration by sub-region and which show elevated levels of PCB's in their flesh.

Groups one and three probably do not pose a significant public health threat at the present time, therefore we concentrated on groups two and four for more detailed levels of analysis. It should be noted that the small population size in some of our samples made comparisons invalid statistically for some regions and species, but where appropriate, trends are indicated. Overall, the results indicate that only three species show elevated levels of Aroclor 1254 and also vary by geographic sub-region. They are White Perch, American Eel and Bluefish. Conversely, four species show elevated levels of Aroclor 1254 and do not differ by geographic sub-regions. They are Striped Bass, Atlantic Menhaden, Atlantic Sturgeon and White Catfish.

Samples were also analyzed for percent lipid since the lipophilic tendencies of PCB's has been demonstrated as a prime correlation factor in bioaccumulation. The analysis required log-transforming both the PCB and percent lipid results for all species, and then performing the Kolmogorov-Smirnof, Goodness-of-Fit test (14) on each distribution to determine whether the transformation has normalized the data in order to satisfy the basic assumption for regression analysis. We then chose those species which demonstrated a normal distribution for both transformed variables and performed a linear regression on the two parameters within species (see Figure 1-4). The results indicated that four species had a demonstrated relationship by direct significance ($P<0.05$) (White Perch and Carp) or by a high coefficient of determination (r^2) (Bluefish and Striped Bass), the latter indicating a possible interdependence of the variables which would probably become significant if the sample size was increased.

Lastly, a temporal comparison of the data for species caught on the Hudson River, (see Table V) indicates that there has been a substantial decrease in the contamination of fish by Aroclor 1254 since the mid-seventies. If should be noted that the majority of the fish caught in 1981 were still elevated in Aroclor 1254 concentrations and most were quite close to the proposed FDA action level of 2 ppm.

DISCUSSION

The Aroclor 1254 data indicates that a substantial proportion of the finfish and shellfish analyzed had detectable levels of PCBs in their flesh, but that a much smaller percentage had levels exceeding both proposed and existing FDA action levels. The general absence of action level concentrations of Aroclor 1254 in shellfish (bivalves) may be related to the observation that selective uptake occurs in these organisms and also, they tend to accumulate lower chlorinated isomers in their tissues (17). We should also expect that the Aroclor 1254 results are going to be low estimates of the total PCBs in fish since other agencies such as FDA and New York DEC routinely analyze their samples for more than one Aroclor and usually find that if A-1254 is present than there may be others present in fairly large amounts.

Regional Analysis

It is obvious from the data that different species in New Jersey are not uniformly affected by PCB contamination. Freshwater species are much less contaminated than euryhaline, estuarine, and true marine species. It has also been shown that the contamination problems may be dependent upon where the fish are caught (see Maps 3, 4 and 5). The statistical results indicate two groups of highly contaminated fish, one of which shows significant differences by sub-region and another which does not. This simple, dichotomous result however may be misleading. It should be subject to further interpretation based on an analysis of sampling bias. Sampling bias may entail catches skewed to certain drainages, preferential migratory ranges for some species, and the predominance of point and nonpoint sources of PCBs to certain drainages, (e.g., the Hudson River).

An indication of this is seen in the Striped Bass results which show elevated levels of PCB's with no significant difference between sub-regions. The data shows that one-quarter of the sampling sites had greater than 3 ug/g PCB's in tissue, and over one half were greater than the proposed FDA action level of 2 ug/g. We also found that 5 out of 8 of our sampling sites were greater than 1 ug/g in tissue. We could therefore expect that the highly contaminated nature of the Striped Bass population, regardless of location, indicates a rather widespread problem with this particular species. The sampling effort however was primarily centered on the Hudson-Raritan Estuary because Striped Bass in New Jersey, tend to use the Hudson River as a preferred spawning ground and nursery area in their anadromous-migration runs. This, coupled with the fact that the Hudson River is considered to be one of the most PCB contaminated rivers in the country (18), helps to explain the overall contamination of this species. This source, the Hudson-Raritan, may also account for the elevated levels for Striped Bass at some offshore sites, but this is difficult to prove since, once out at sea, mixing with the Chesapeake Bay schools will probably occur. The results for this species should reflect contamination of Northeastern New Jersey and specifically, the Hudson River. The same argument should also apply to the Atlantic Sturgeon results which are also indicative of the Hudson-Raritan Estuary and probably, reflect local contamination problems.

The White Catfish show consistently elevated levels of PCB's and vary less from drainage to drainage, probably reflecting a more widespread contamination problem. In order to test the power of this result, we removed the high Hudson River value from the data set and performed the regional analysis again to see if this would change our result. The non-significance remained, thus reinforcing our conclusion of widespread contamination for this species within the sub-region samples. The similar finding for Atlantic Menhaden was much less certain because of the small number of analyses performed, the lack of Hudson River samples, and the concentration of the high PCB values being found on the Newark Bay-Passaic River drainage.

In addition, we found that the results for some of the species showing significant differences by sub-region were skewed by the high values of a small proportion of the sample. For example, the White Perch show significant differences between sub-regions, their highest level of contamination was found on the Hudson River and three out of the eleven sub-regions samples showed elevated levels of Aroclor 1254 in their flesh. However, if the high Hudson River value is removed from the data set and the regional analysis is run again, we find that this species shows no significant difference between sub-regions. Only 2 out of the 10 regions have elevated values. This effectively reduces the contamination problem associated with this species to the Hudson River and the Raritan Bay, which is at the mouth of the Hudson, and points to the former as a possible source of the contamination.

Conversely, the Bluefish becomes more significantly different if the Hudson River is taken out of the analysis and thus indicates that this species probably reflects true differences by sub-region and a more widespread contamination problem. Contaminated sources include the Hudson River, Newark Bay, and Upper Coastal Bay/Rivers area and offshore Site #1. (Sandy Hook to Spring Lake). American Eel also seem to vary from drainage to drainage, and appear to be more indicative of true differences by sub-region at consistently elevated levels. Contaminated sources include Newark Bay, Raritan River and Bay, Lower Coastal Bays/Rivers, and the lower Delaware.

We may therefore interpret the results of our regional analysis in three ways; one, those samples associated with the PCB-laden Hudson River; two, those samples differing in concentration by geographic sub-region: and three, those samples not differing in concentration by geographic sub-region. This first categorization is further justified by the fact that two species (Blue Claw Crab and Summer Flounder) which normally exhibit minimal levels of the contaminant, elsewhere in the state, are both elevated in Aroclor 1254 on the Hudson River and that all species, whether they vary by sub-region or not, usually show their highest level of contamination in this drainage.

In summary, the results of the geographical analysis indicate that White Catfish appear to represent the only species with wide-range Aroclor 1254 bioaccumulation for the drainages sampled. Bluefish and American Eel show elevated levels of Aroclor 1254, but the results are dependent upon the drainage within which they are caught and typically indicate the heavily industrialized Hudson-Raritan estuary as the major source of contamination. Finally, the Striped Bass, White Perch, and Atlantic Sturgeon show elevated levels of Aroclor 1254 which primarily reflect association with and contamination from the Hudson River.

Hudson River Drainage

The Hudson River data show a marked decrease in the concentrations of Aroclor 1254 in fish, between 1975 and 1981. This probably reflects a number of factors, including the curtailing of the production of PCB's in the mid-1970's and the enforcement of effluent discharge limitations for these compounds. In spite of this, the past widespread uses of PCB's, the massive quantities temporarily held in environmental storage by sediments, and the amounts still in industrial use all testify to the continuing, long-range threat associated with these compounds.

Recent reports by NYDEC also indicate that the total amount of PCBs in fish caught in New York waters has declined since the mid-seventies although the reduction seems to be differential with the lighter, more biodegradable and volatile chlorinated biphenyls being lost relative to A-1254 which actually appears to be increasing over time. This seems to justify our initial decision to monitor the Aroclor least likely to be degraded over the years, resulting in a more significant and long term health threat.

Lawler, et al. (19), estimated in a sediment transport model that between 32 and 54 metric tons of PCB's will be transported into the Hudson River estuary during the next 20 years, if no remedial action is taken to remove contaminated sediment from the vicinity of the transformer manufacturing plant at Ft. Edwards, N.Y. It is at this site that most of the upper river contamination originated. Stainken et al. (17) have also matched the types and amounts of PCBs found in the sediments and biota at the mouth of the Hudson estuary with upper Hudson River samples indicating possible downstream transport of these substances. PCBs may enter surface waters in other ways, including precipitation (20), landfills, and sewage (21). Bopp (23) estimates that sewage effluent may account for as much as 25% of the PCBs presently deposited in the New York Harbor area. He also notes that approximately one-half of the PCB's from high deposition areas have been removed via maintenance dredging (mostly in NY Harbor) and the dumping of these dredged sediments in the NY Bight constitutes a significant input of PCBs to the nearshore coastal environment. This dump site also coincides with our "Offshore Site I Region" and may be instrumental in some of the high values we found in that area. Bopp, also estimates that 76,000 kg of PCB's are presently associated with sediments in the tidal Hudson alone. So although, the reduction in PCBs within fish may have occurred, we must assume that the low level, broad contamination of Aroclor 1254 on this drainage and others, continues to persist. Continued vigilance will be necessary to monitor any changes in uptake of these compounds for many years to come.

Lipid Content

A relationship between PCB concentration and percent lipid was demonstrated for four species based on log-transformed data in a linear regression model. The reduction of this relationship to only four species is probably dependent upon two factors. First of all, we performed the regression on only those species whose variables (PCB and % lipid) showed normalcy under the Goodness-of-Fit test. Unfortunately, this eliminated a number of species, including two of the more lipid-rich (Eel and Menhaden), neither of which showed normalcy under transformed or non-transformed data. A probable second reason for this reduction is that we analyzed for edible fillets of muscle tissue and that different species tend to store lipids in different places. For example, the fat content in fishes can vary between species, within species, and between organs within a single animal as well. This is dependent upon a variety of factors including; genetic predispostion, food source, season, sexual stage, geographic area of capture, age and size of fish, etc., (23). It is also known that pelagic fish use muscle tissue for storing lipids much more often than benthic species which may use liver (e.g., Catfish) and/or bone marrow (e.g., Flatfish) (24). This may explain why both species of catfish in our analysis showed no significant relationships between these variables whereas almost all of the significant species were mid-water fish.

It could be argued that by not using a whole body analysis, we may have lessened the chance of showing many species with any significant rate of contamination. However, we felt that the public health threat would be better demonstrated in association with "edible portion" analysis.

Blue Claw Crab

We did perform one organ analysis for one species, the Blue Claw Crab. This was in line with our Hazard Assessment objective, in as much as a report from NYDEC (unpublished) indicated elevated cadmium concentrations in the hepatopancreas of these organisms. Usage of this organ for flavoring, in meat sauce seemed to be a common practice in some households. In light of this, we decided to evaluate the residue levels in this organ relative to crab muscle tissue. Composites of muscle tissue and hepatopancreas from crabs, caught in the summer of 1981, at Shooter's Island, in Newark Bay, were analyzed (Region IV). This area historically, had shown nothing but background to minimal levels of Aroclor 1254 in crabs, for almost all of our analyses. For the 1981 samples, muscle tissue again showed non-detectable levels (<0.1 ppm), but the hepatopancreas had 3.5 ppm of Aroclor 1254. This example highlights the extremely complex nature of health risk assessment as it pertains to dietary intake. In most instances, Blue Crab muscle tissue will usually be relatively free of PCBs but due to differing cultural traditions, varying modes of preparation, and the organ dependent differences in bioaccumulation, this generally innocuous organism may prove a health risk to certain individuals. This species therefore, will hereafter be analyzed for both muscle tissue and hepatopancreas, and may be subject to reclassification into the elevated concentration group dependent upon the method of cooking preparation utilized. The relevance of soft-shell crab consumption must also be evaluated, since the hepatopancreas is eaten along with the rest of the animal.

Another important observation, concerning the fact that PCB's are usually associated with the lipid rich tissues, is that exposure to these substances can be reduced in a number of ways, such as fat-trimming while filleting the fish and altering cooking techniques so as to allow fat to run-off from the food tissue. It has been shown that removal of the fat-rich belly flap, skin and lateral line of a fish, as well as broiling, rather than frying, can reduce the exposure to PCB's from a contaminated fish by up to 50% (25).

Finally, it should be noted that two of the species we have identified as having PCB problems, Bluefish and Striped Bass, are quite important to both the recreational and commercial fisheries in New Jersey (see Tables VI and VII). This fact indicates a broad range health threat associated with the contamination of fisheries, and emphasizes the extreme sensitivity of human health to aquatic release of toxic chemicals. The Department of Environmental Protection will continue to monitor fish within state waters. It will respond to the problem of PCB contamination by continuing to expand its geographical and temporal data base, by releasing fishing advisories when appropriate, by disseminating specific information to the public on how to reduce exposure to these compounds, and by closing fisheries and/or drainages if increased bioaccumulation occurs. The Department will also continue its efforts to assess, identify and reduce the sources of PCB's to our environment.

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APPENDIX A

Tables and Maps

TABLE Ia

FRESHWATER SPECIES

STATISTICS FOR PCB AND % LIPID RESULTS

FOR SPECIES COMBINED FROM ALL SAMPLING LOCATIONS

	PCB (ug/g)			% Lipid/gm Tissue		
Species	Mean(N)+	Median	Range	Mean(N)	Median	Range
Black Crappie	0.36(8)	0.24	(0.1-1.14)	0.39(10)	0.31	(0.01-1.33)
Brown Bullhead	0.80(16)	0.40	(0.1-3.2)	1.52(36)	1.1	(0.14-9.07)
Carp	0.63(21)	0.44	(0.14-2.0)	1.88(37)	1.52	(0.03-8.07)
Chain Pickerel	0.22(1)	0.22	(0.22)	0.17(16)	0.15	(0.01-0.61)
Golden Shiner	0.80(8)	0.21	(0.11-2.58)	1.10(16)	0.72	(0.39-5.52)
Largemouth Bass	0.28(15)	0.24	(0.1-1.0)	0.44(34)	0.31	(0.1-1.45)
Pumpkinseed Sunfish	0.16(5)	0.14	(0.11-0.26)	0.69(18)	0.45	(0.02-5.02)
Rock Bass	0.37(4)	0.2	(0.11-0.95)	0.73(4)	0.39	(0.18-1.94)
Smallmouth Bass	0.35(2)	0.35	(0.25-0.44)	0.59(6)	0.4	(0.16-1.54)
Yellow Perch	0.37(4)	0.22	(0.1-0.94)	0.30(10)	0.23	(0.09-0.83)

—

\+ Arithmetic mean for samples higher than the detectable limit (0.1 ppm).

N = Number of samples analyzed (composites and/or single fish) as required by FDA analytical procedures.

No analyses performed.

TABLE Ib

SALTWATER SPECIES

STATISTICS FOR PCB AND % LIPID RESULTS

FOR SPECIES COMBINED FROM ALL SAMPLING LOCATIONS

Species	PCB (ug/g) Mean(N)+	Median	Range	% Lipid/gm Tissue Mean(N)	Median	Range
White Perch	1.86(36)	0.53	(0.1-17.9)	1.37(19)	1.25	(0.39-3.29)
Atlantic Sturgeon	2.35(9)	1.9	(0.88-5.25)	•	•	•
American Eel	1.52(39)	0.91	(0.11-9.5)	9.01(51)	9.09	(0.66-23.9)
Striped Bass	2.75(54)	1.58	(0.12-31.4)	2.18(6)	2.13	(0.85-3.37)
Weakfish	0.56(35)	0.35	(0.1-1.94)	0.68(3)	0.43	(0.36-1.25)
Winter Flounder	0.40(4)	0.38	(0.25-0.57)	•	•	•
Atlantic Menhaden	0.87(9)	0.33	(0.17-3.44)	4.87(4)	4.7	(0.61-9.46)
Bluefish	1.23(126)	0.80	(0.1-11.0)	1.11(3)	1.09	(1.0-1.23)
Summer Flounder	0.60(16)	0.43	(0.1-1.47)	0.56(1)	0.56	(0.56)
Blue Claw Crab	0.36(30)	0.23	(0.1-2.7)	0.44(1)	0.44	(0.44)
Mummichog	1.28(1)	1.28	(1.28)	2.76(2)	2.76	(2.37-3.15)
White Catfish	2.07(12)	0.90	(0.16-10.5)	1.99(12)	1.64	(0.66-4.64)

+ Arithmetic mean for samples higher than the detectable limit (0.1 ppm).

N = Number of samples analyzed (composites and/or single fish) as required by FDA analytical procedures.

• No analyses performed.

TABLE II

Fish Sampling Sub-Regions*

1. Hudson River
2. Hackensack River
3. Passaic River
4. Newark Bay
5. Raritan River
6. Raritan/Sandy Hook Bays
7. Upper Coastal Bay/Rivers
8. Lower Coastal Bay/River
9. Maurice River
10. Delaware Bay
11. Delaware River (Upper)
(Assunpink Cr. to Pequest River)
12. Delaware River (Lower)
(Crosswick Cr. to Newton Cr.)
13. Southern Inland Lakes
14. Central Inland Lakes
15. Northeast Inland Lakes
16. Northwest Inland Lakes
17. Offshore Site I
(Sandy Hook to Spring Lake)
18. Offshore Site II
(Bayhead to Barnegat Inlet)
19. Offshore Site III
(Little Egg Inlet to Wreck Inlet)
20. Offshore Site IV
(12 miles off Cape May Canal)

*See Maps I and II

TABLE III

Mean PCB Results for Each Species by Geographic Sub-Regions (ug/g) (N)+

Species	Region Numbers 1	2	3	4	5	6	7	8	9	10
Brown Bullhead					1.76(2)		0.92(1)			
Carp		0.81(2)	0.43(4)		0.32(2)					
Golden Shiner					K(1)		0.23(1)		0.11(1)	
L. Bass		0.19(1)	0.36(2)	0.25(1)	0.18(5)		K(2)	K(1)		
P. Sunfish		0.13(2)	0.15(1)	0.26(1)			K(3)	K(1)		
W. Catfish	10.5(1)				1.15(1)				0.34(1)	
S. Bass	3.49(19)			3.65(13)	1.56(8)	0.83(2)	0.4(1)			
W. Perch	12.6(3)	0.68(8)	0.11(1)		1.16(13)		0.1(1)	K(2)	3.21(1)	
A. Eel		0.34(2)	1.03(2)	1.96(3)	2.40(11)	1.15(2)	0.29(6)	3.49(2)		
A. Sturgeon	1.61(2)			1.49(3)		3.37(4)				
A. Menhaden			2.34(1)	3.44(1)		0.6(1)		0.29(2)		
Bluefish	3.44(4)			1.63(14)	0.66(7)	0.98(10)	1.5(2)	0.24(1)		0.28(3)
Weakfish				0.24(1)		0.47(8)		0.12(2)	0.2(1)	0.39(2)
B.C. Crab	1.07(4)	0.488(7)		0.18(6)	0.13(3)	0.16(7)	0.2(2)	K(1)	K(1)	
B. Crappie				0.785(2)	0.21(3)					
Chain Pickerel					K(1)		K(1)	K(1)		
Rock Bass					0.2(2)					
Smallmouth Bass					0.25(1)					
Yellow Perch					K(2)			K(1)		
S. Flounder	1.47(2)			0.14(1)	0.96(1)	0.56(7)	0.8(1)	0.3(1)		
W. Flounder						0.40(4)				

K = Below the detection limit for PCB in Tissue (0.1 ppm).

\+ Arithmetic mean for samples higher than the detectable limit (0.1 ppm).

N = Number of samples analyzed (composites and/or single fish) as required by FDA analytical procedures.

TABLE III (continued)

Mean PCB Results for Each Species by Geographic Sub-Regions (ug/g) (N)

Species	Region Numbers 11	12	13	14	15	16	17	18	19	20
Brown Bullhead		0.61(7)	K(3)	0.18(1)	0.46(3)	0.2(1)				
Carp		0.77(10)	K(3)	K(1)	0.44(1)					
Golden Shiner		0.14(1)	0.45(1)	0.13(1)	1.78(3)	K(1)				
L. Bass		0.24(1)		K(3)	0.22(2)	K(2)				
P. Sunfish			K(1)	K(1)	0.11(1)	K(1)				
W. Catfish		1.46(9)	3.54(1)			0.29(1)				
S. Bass		0.99(2)					2.24(6)	2.12(2)		
W. Perch		0.76(6)		K(1)	K(1)	0.20(1)				
A. Eel		1.67(6)	0.64(1)	0.2(1)	0.19(1)					
A. Sturgeon										
A. Menhaden		0.23(4)								
Bluefish							1.44(8)	0.96(22)	0.67(15)	
Weakfish							0.75(7)	0.82(5)	0.72(5)	0.37(4)
B.C. Crab		0.12(1)								
B. Crappie			0.27(2)	K(1)	K(2)					
Chain Pickerel		K(1)	K(4)	K(5)		K(1)				
Rock Bass	K(1)					K(1)				
Smallmouth Bass	K(2)		K(1)			0.44(1)				
Yellow Perch			0.94(1)	K(1)		0.18(1)	0.19(3)		K(4)	
S. Flounder		K(1)								
W. Flounder										

TABLE IV

Results Matrix* of Significant or Non-Significant Differences in A-1254 Concentration between Geographic Sub-Regions versus the Relative Mean Concentration of This Compound for That Species.

I Significantly Different Minimal Concentrations	II Significantly Different Elevated Concentrations	III Non-Significant Different Minimal Concentrations	IV Non-Significant Different Elevated Concentrations
Blue Claw Crab	White Perch	Weakfish	Striped Bass
	American Eel	Br. Bullhead	Atl. Menhaden
	Bluefish	Carp	Atl. Sturgeon
		G. Shiner	Wh. Catfish
		Large Bass	
		Pump. Sunfish	
		Bl. Crappie	
		Ch. Pickerel	
		Rock Bass	
		Sm. Bass	
		Yell. Perch	
		Sum. Flounder	
		Wtr. Flounder	

* Based on Kruskal-Wallis Statistic and Arithmetic Means

TABLE V

TEMPORAL COMPARISON OF

MEAN HUDSON RIVER * PCB (UG/G) RESULTS FOR 1975-76 AND 1981

Species	1975-76 (ug/g (N)+	1981 (ug/g) (N)
Striped Bass	3.49(19)	1.33(9)
Bluefish	3.44(4)	1.78(2)
White Perch	12.6(3)	1.15(3)
American Eel	--	3.28(6)
Atlantic Sturgeon	1.6(2)	1.98(1)
Weakfish	--	1.24(2)
White Catfish	10.50(4)	1.89(2)
Blue Claw Crab	1.07(4)	--
Atlantic Menhaden	--	0.3(2)

*Sites pooled included

1. Alpine, N.J.
2. George Washington Bridge
3. Ellis Island (Upper Harbor)
4. Robbins Reef (Lower Harbor)

+Number of composites analyzed

-- = none analyzed

TABLE VI

COMMERCIAL FISHERY STATISTIC FOR NEW JERSEY (1976)

	Species	Recreational Total # Caught 1979*	Commercial Landing (lbs.) 1976	Commercial Dollar Value/LB 1976
1.	Summer Flounder	5,142,000	5,647,000	$2,341,000
2.	Bluefish	4,948,000	1,280,000	145,000
3.	Winter Flounder	1,434,000	147,000	26,000
4.	Weakfish	1,372,000	5,709,000	556,000
5.	Atlantic Mackerel	969,000	1,852,000	151,000
6.	Striped Bass	30,000	137,000	102,000

*Statistics Compiled by U.S. Department of Commerce
Current Fisheries Statistics

TABLE VII

A. MARINE RECREATIONAL FISHERIES IN N.J. * (1979)

		Total Fish Caught
1.	Summer Flounder	5,142,000
2.	Bluefish	4,948,000
3.	Winter Flounder	1,434,000
4.	Weakfish	1,372,000
5.	Atlantic Mackerel	969,000
6.	Striped Bass	30,000

B. Percentage of Fishermen Affirming Species Groups Sought in Mid-Atlantic Region+

		Percentage
1.	Bluefish	25.59
2.	Summer Flounder	15.61
3.	Weakfish	10.50
4.	Striped Bass	10.49
5.	Winter Flounder	7.85
6.	White Perch	3.39
7.	None	32.62

* Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1979. U.S. Dept. of Commerce, Current Fishery Statistics Number 8063. December, 1980.

+=972,000 Participants in the Marine Recreational Fishery in N.J. for 1979.

FIGURE 1

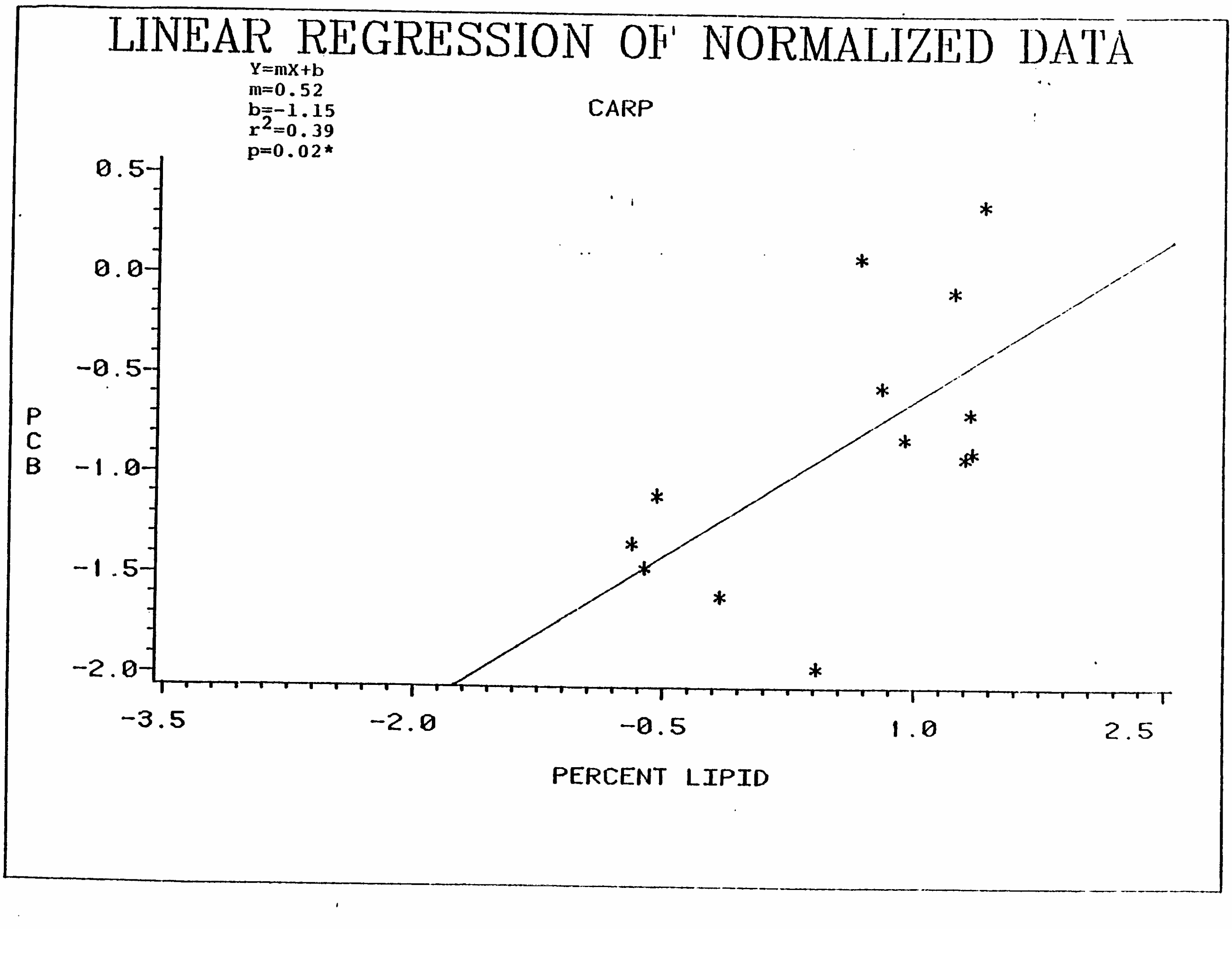

LINEAR REGRESSION OF NORMALIZED DATA
Y=mX+b
m=0.52
b=-1.15
r2=0.39
p=0.02*
CARP
PCB
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-3.5
-2.0
-0.5
1.0
2.5
PERCENT LIPID

FIGURE 2

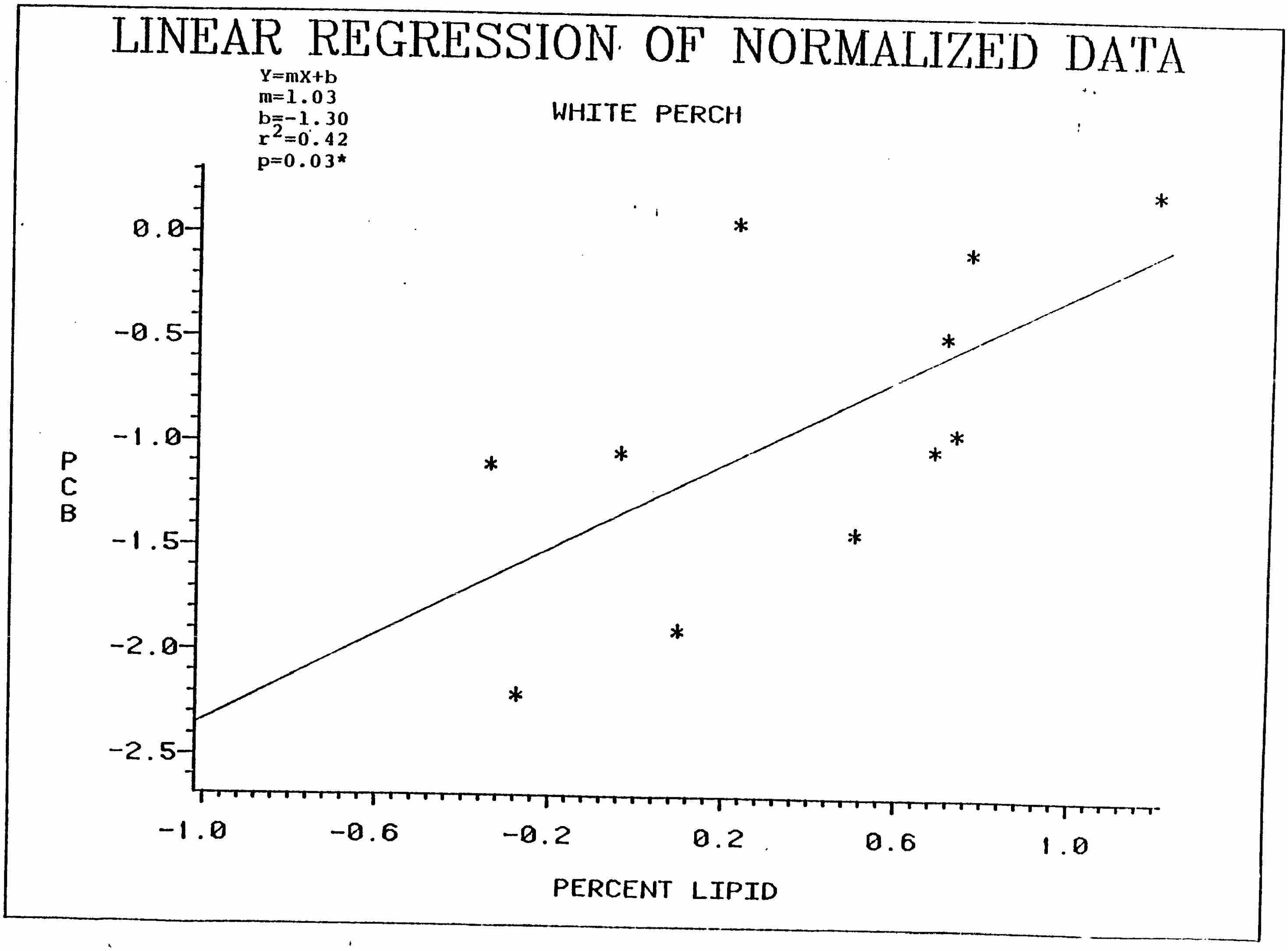
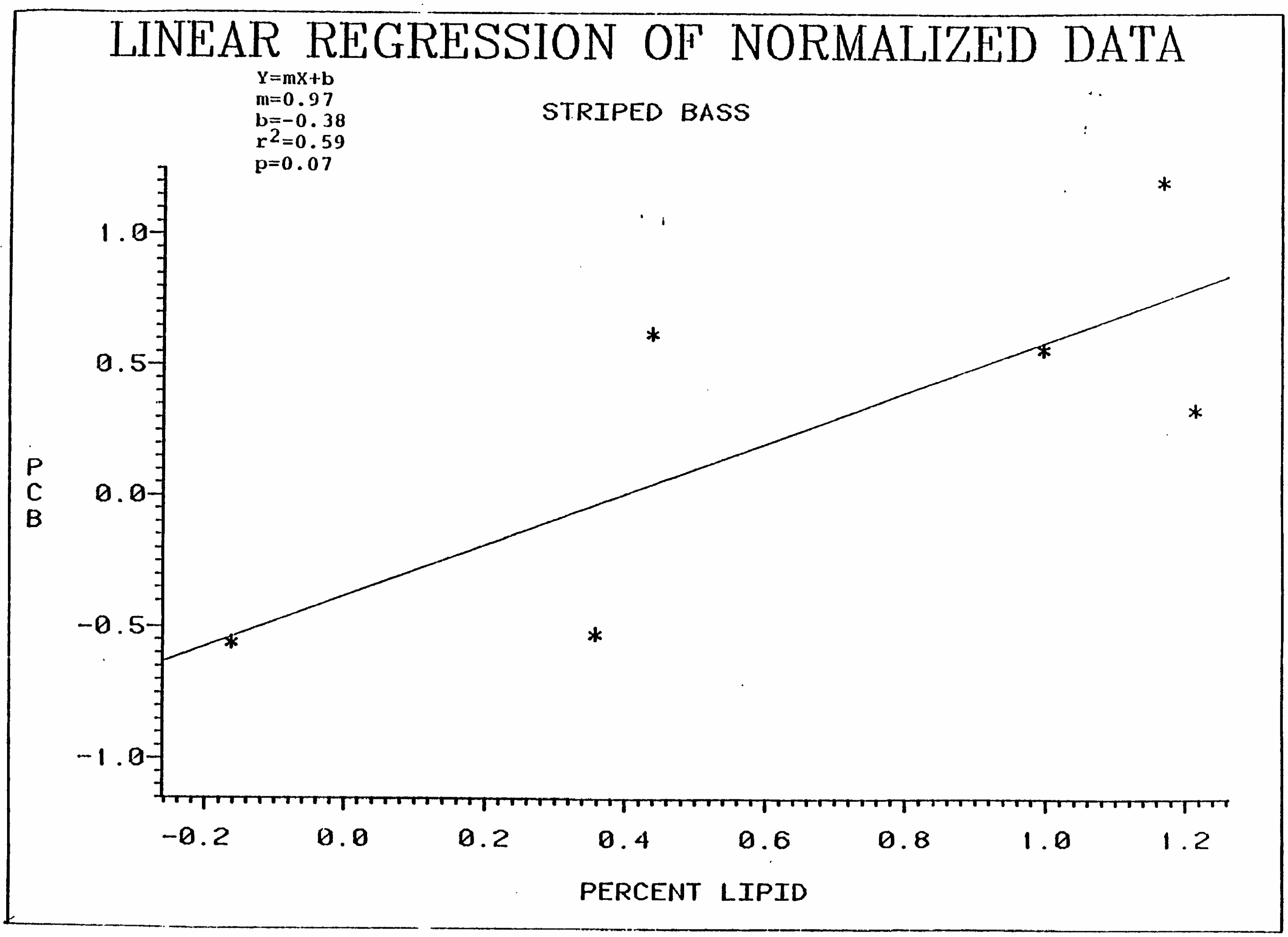
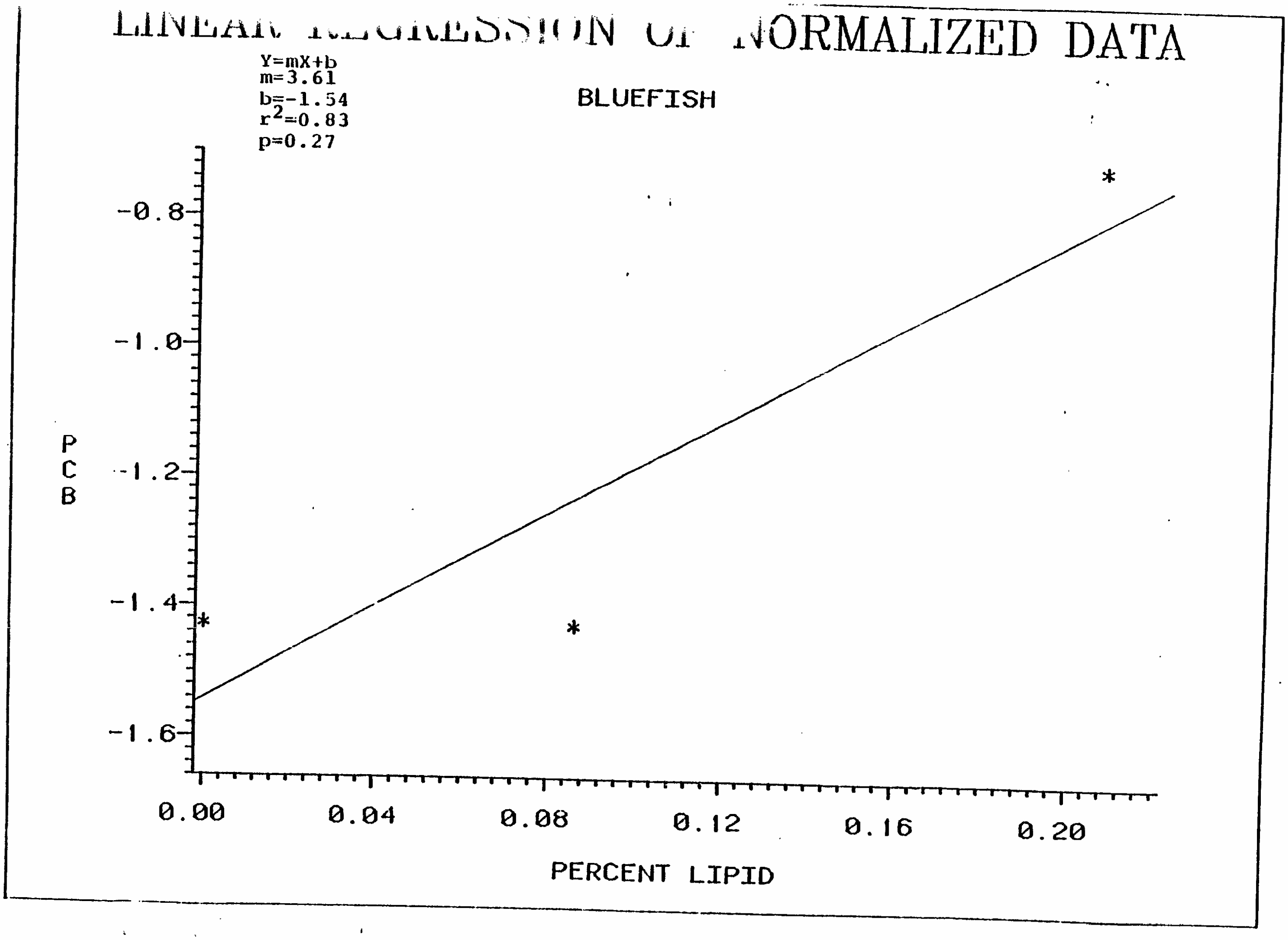

LINEAR REGRESSION OF NORMALIZED DATA
Y=mX+b
m=1.03
b=-1.30
r2=0.42
p=0.03*
WHITE PERCH
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
PCB
-1.0
-0.6
-0.2
0.2
0.6
1.0
PERCENT LIPID

FIGURE 3

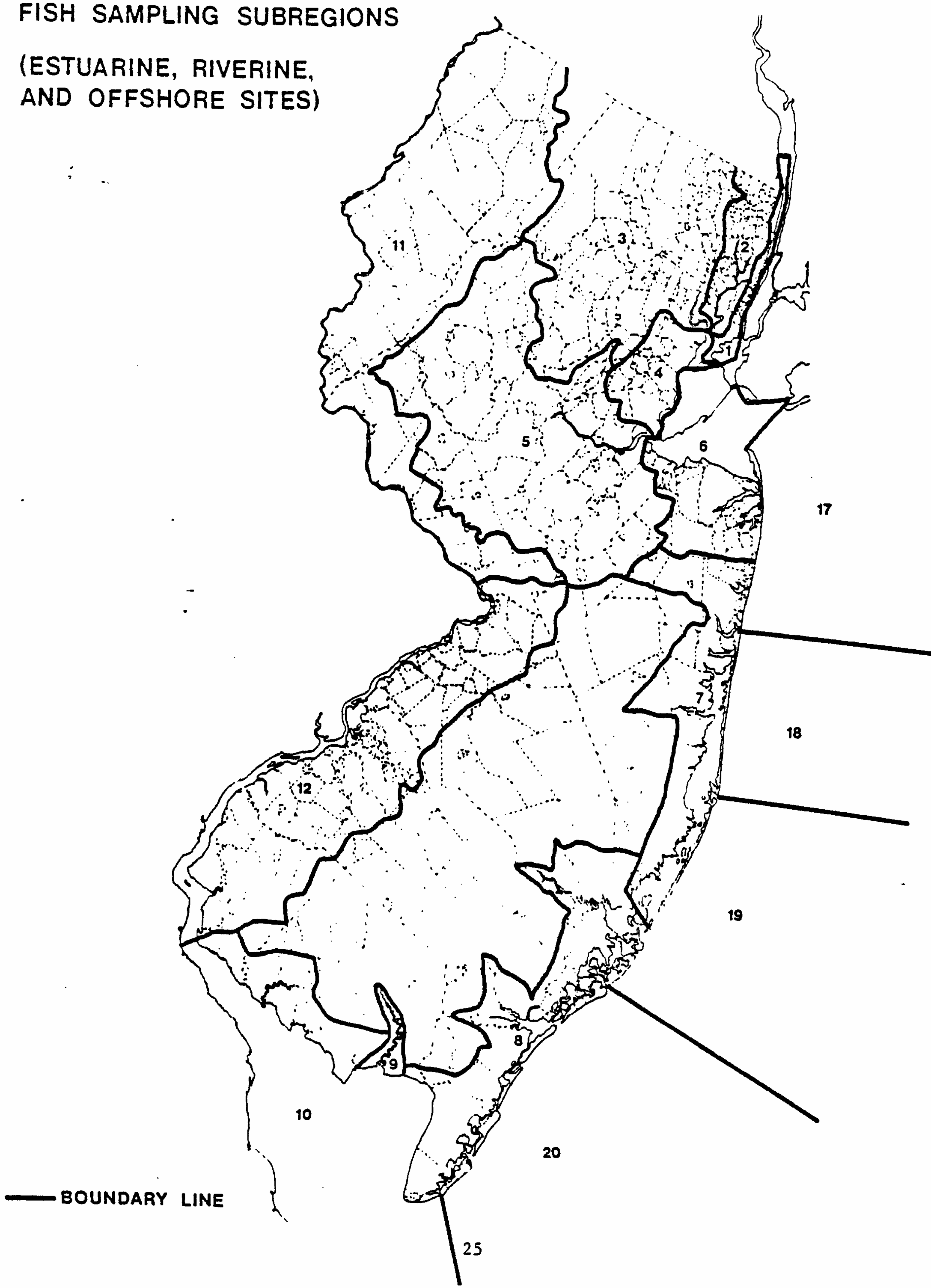


LINEAR REGRESSION OF NORMALIZED DATA
Y=mX+b
m=0.97
b=-0.38
r2=0.59
p=0.07
STRIPED BASS
1.0
0.5
0.0
-0.5
-1.0
PCB
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
PERCENT LIPID


NORMALIZED DATA
Y=mX+b
m=3.61
b=-1.54
r2=0.83
p=0.27
BLUEFISH
PCB
-0.8
-1.0
-1.2
-1.4
-1.6
0.00
0.04
0.08
0.12
0.16
0.20
PERCENT LIPID

I. NEW JERSEY FISH SAMPLING SUBREGIONS

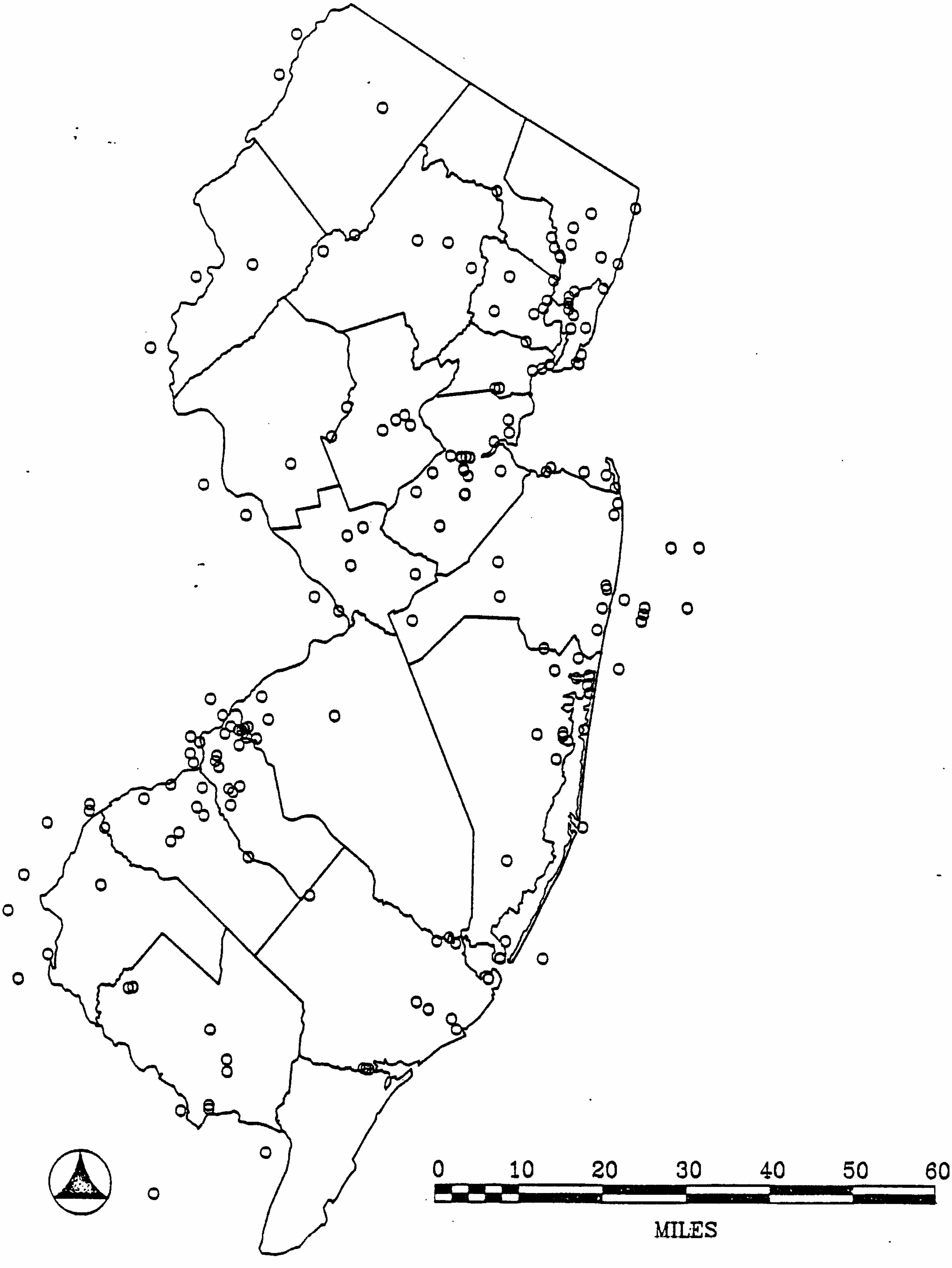
(ESTUARINE, RIVERINE, AND OFFSHORE SITES)



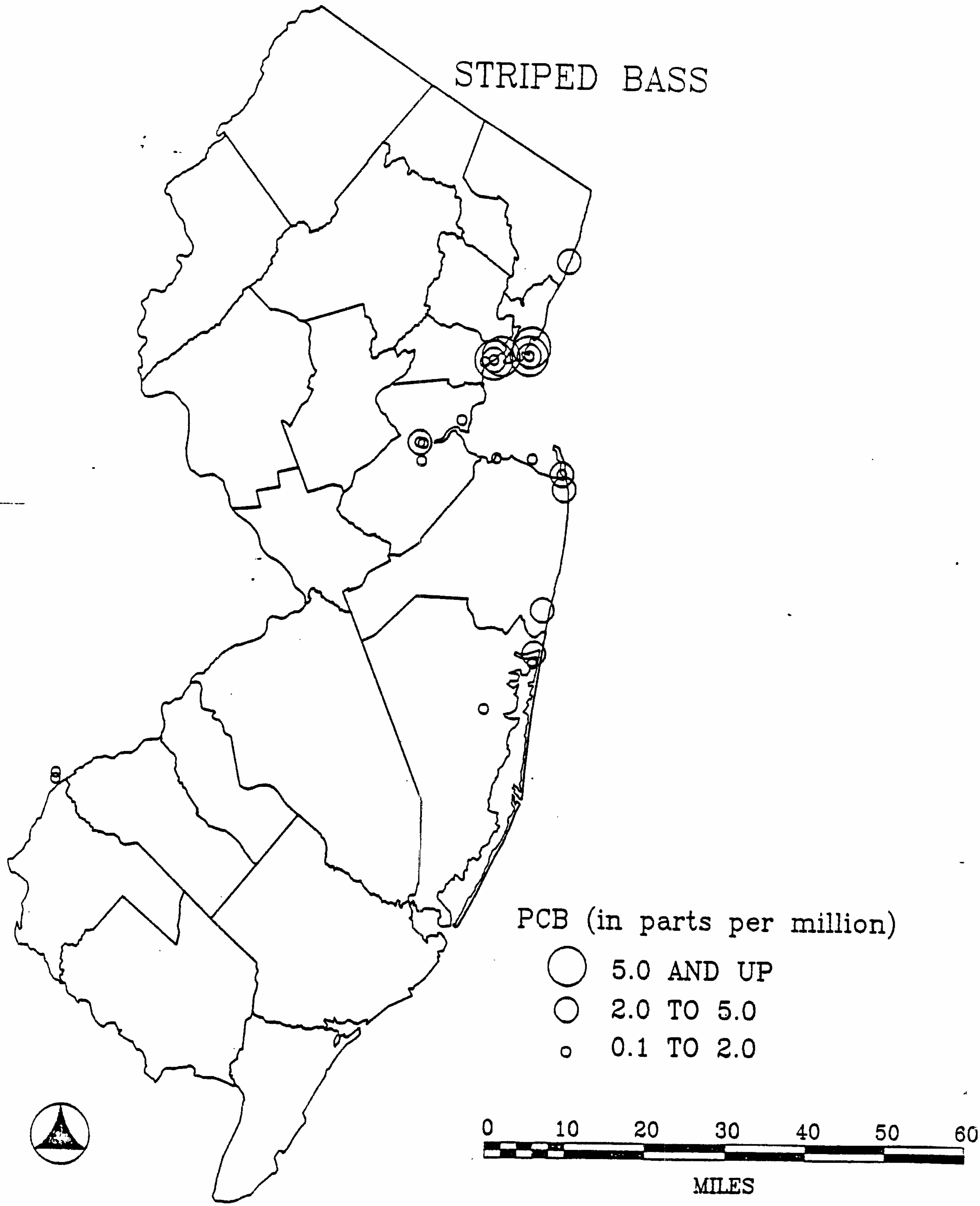
II. NEW JERSEY
FISH SAMPLING SUBREGIONS

(INLAND LAKES)

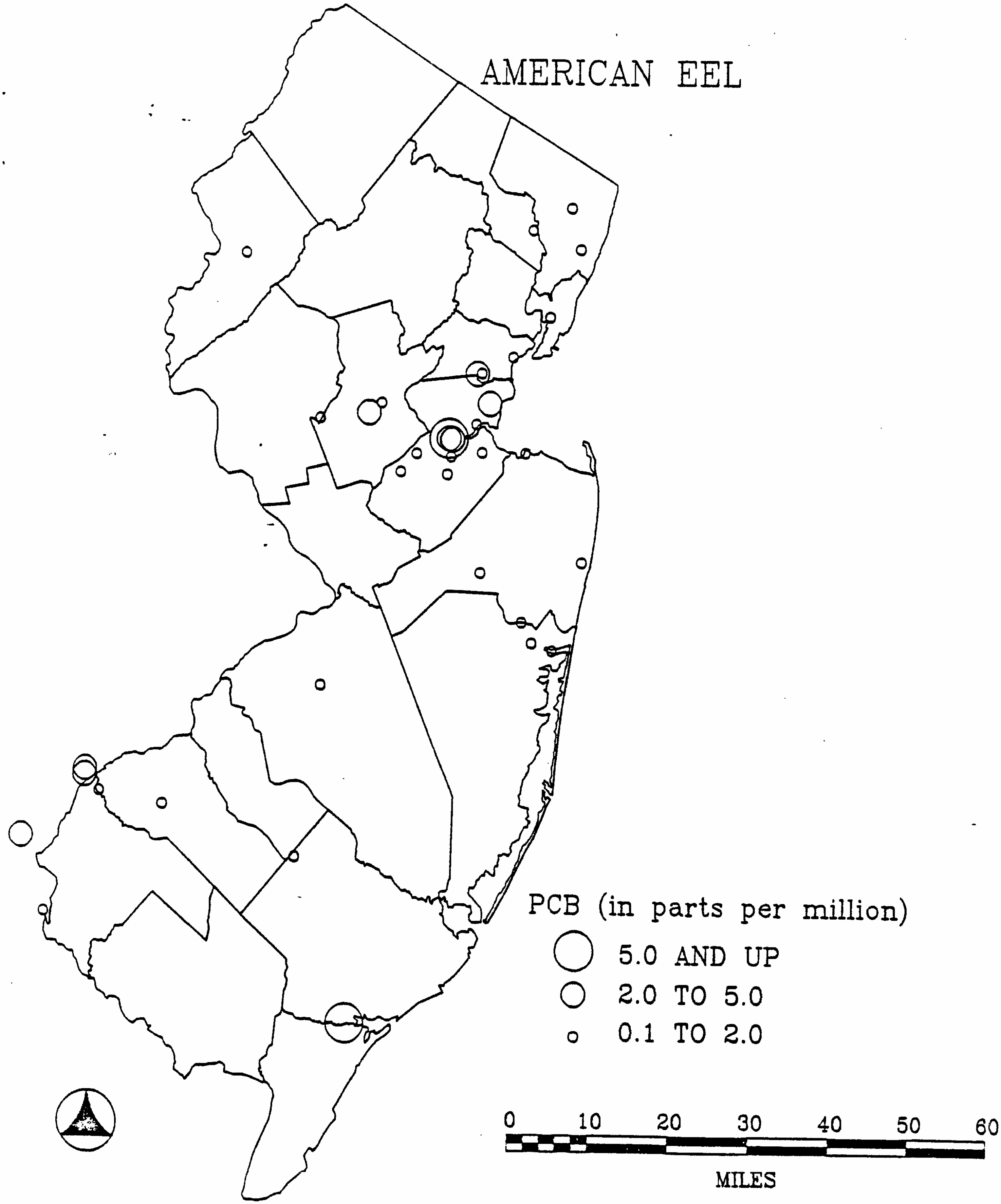
SAMPLING STATIONS



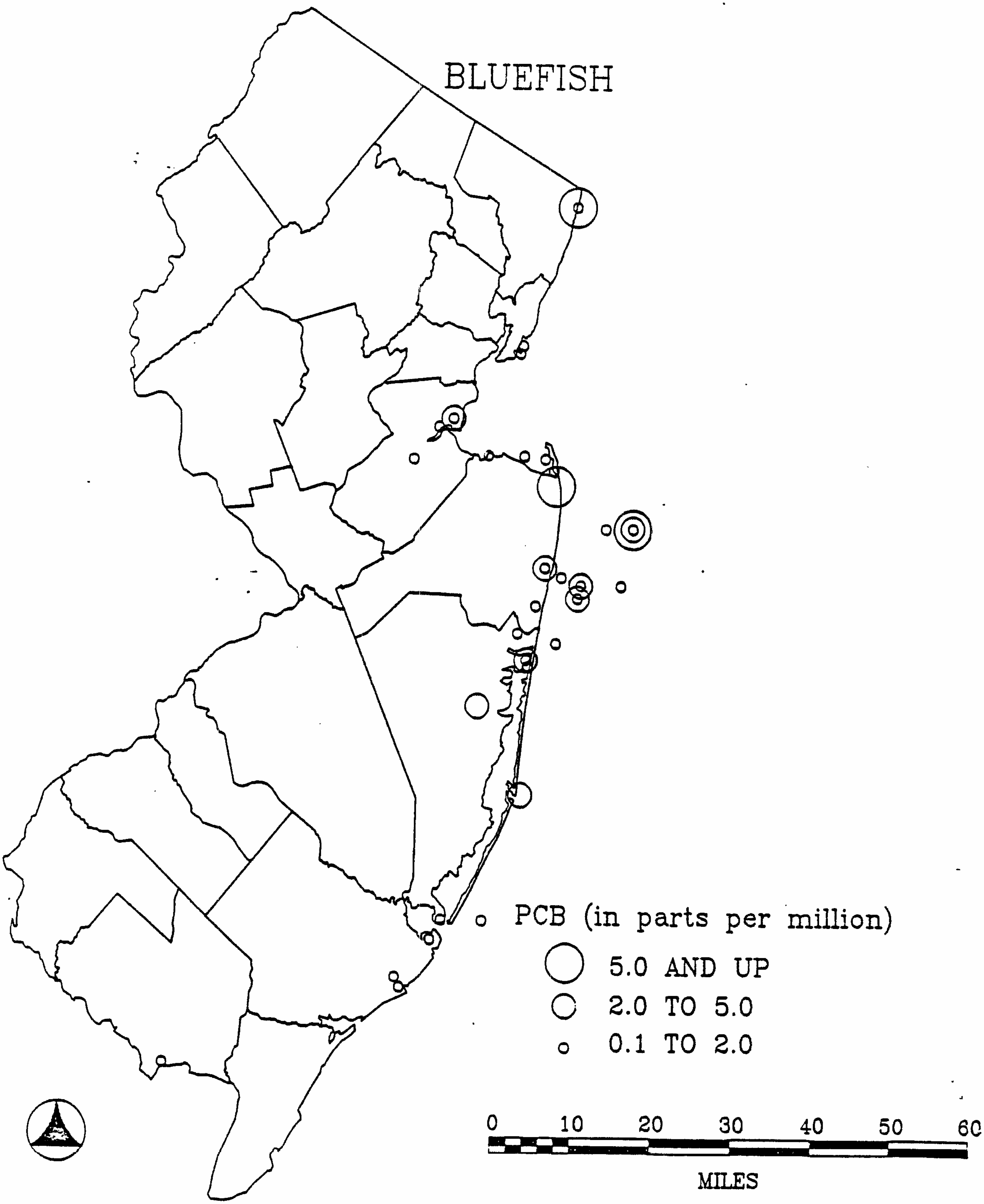
DISTRIBUTION MAP - PCB RESULTS



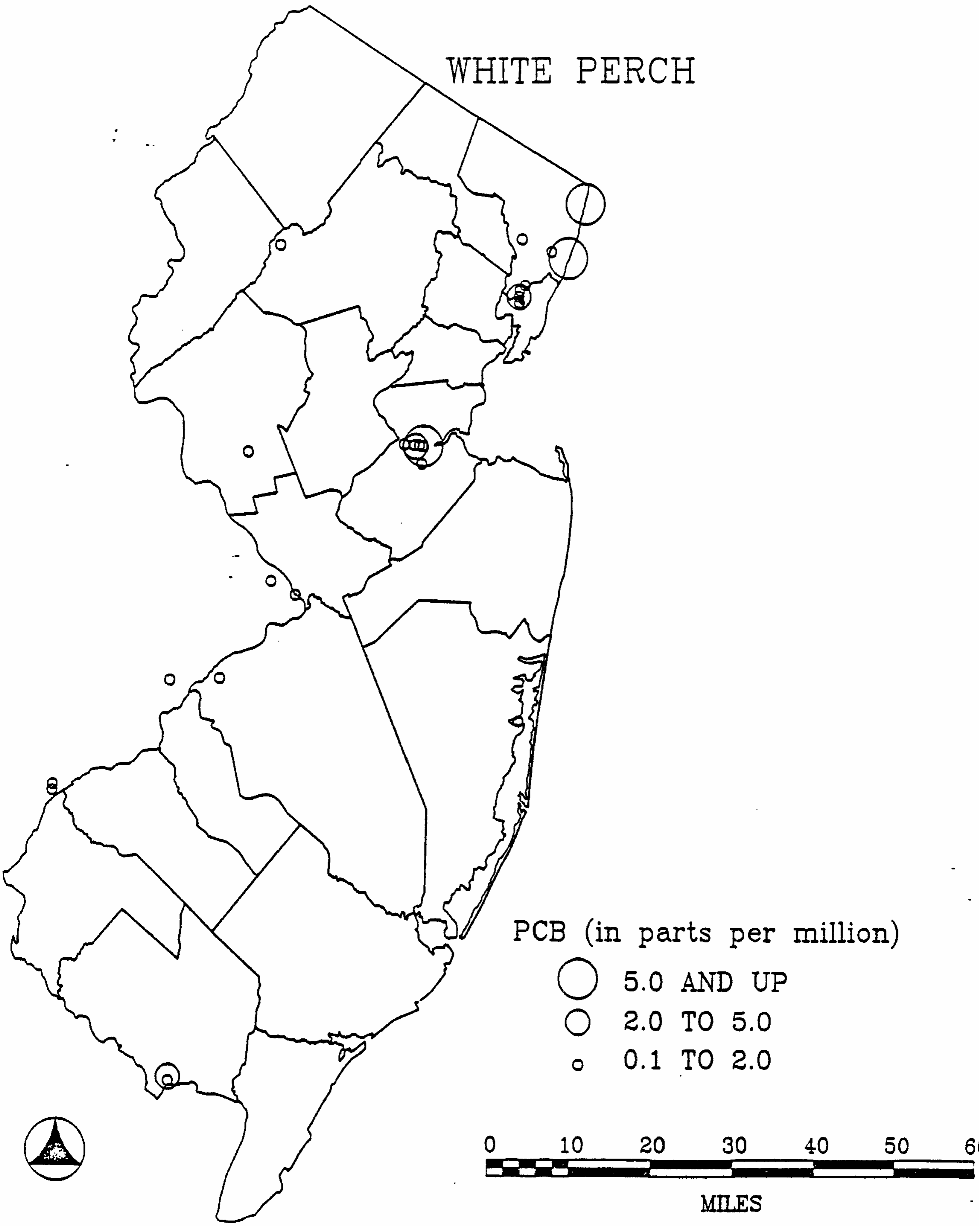
DISTRIBUTION MAP - PCB RESULTS



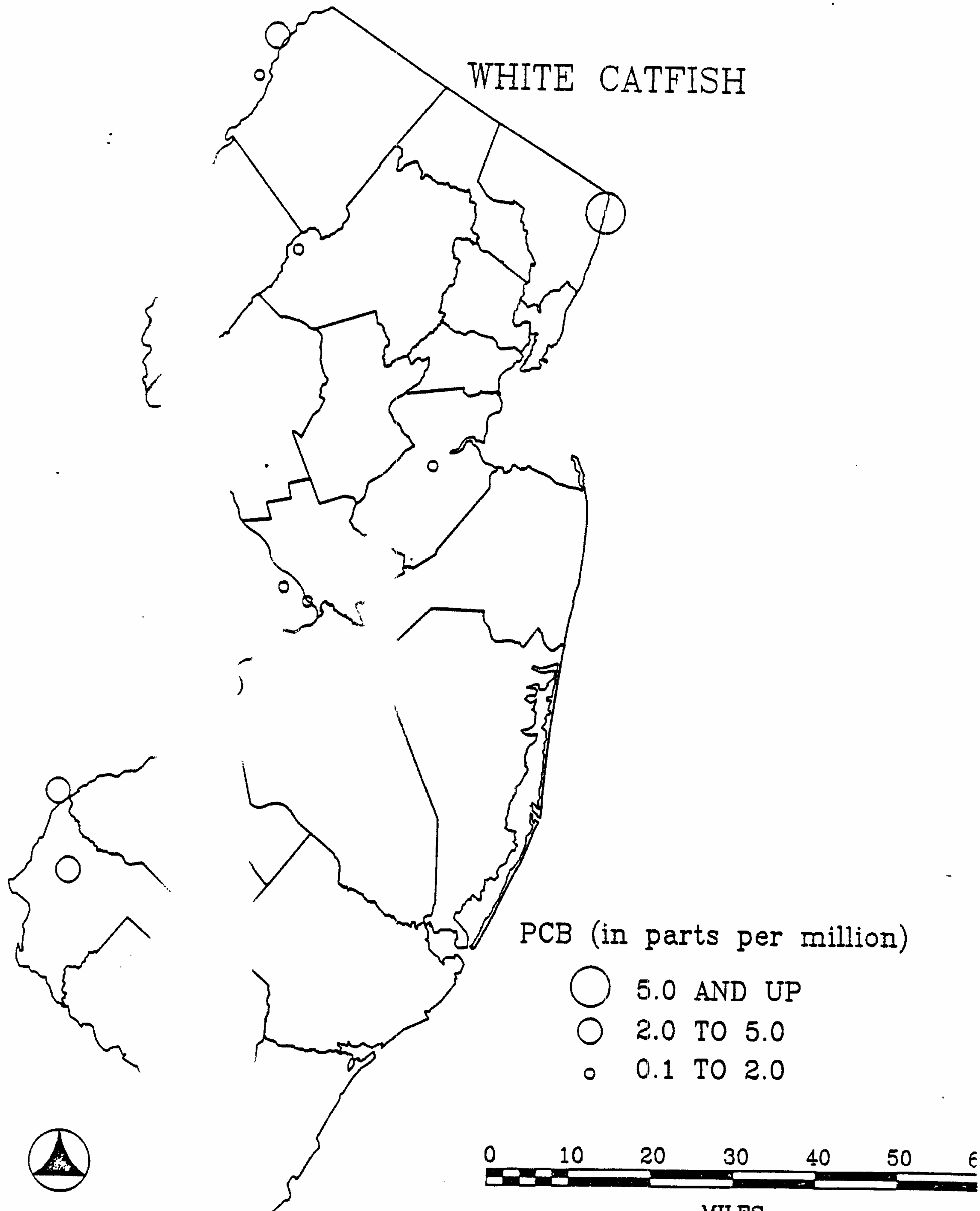
DISTRIBUTION MAP - PCB RESULTS



DISTRIBUTION MAP - PCB RESULTS



DIS' TION MAP – PCB RESULTS



APPENDIX B.

Regulatory Update

The results discussed in this report should be considered in relationship to the actions of two federal agencies which are directly involved in the regulation of PCBs in food and in the environment. They are the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA).

First, reference is made to FDA action levels or tolerances. A tolerance is the allowable background level of a given contaminant which is found to be unavoidable in a food product but is still within levels that maintain the public safety. FDA tolerances have been developed for milk products, eggs, poultry, and fish.[1] It should be noted that these action levels are only required for foods in interstate commerce. However, states have traditionally used these values as the acceptable limits for foods in intrastate trade as well. Certainly, this has been the case for fish caught, sold and consumed within a state. The expense of doing risk assessments has usually precluded any independent calculation of alternative exposure levels, and federal criteria have served for commercial and recreational fishing, both interstate and intrastate.

FDA has the authority to issue tolerances for unavoidable food contaminants, to deem food adulterated, and prohibit interstate sales, if the food contains "any added poisonous or added deleterious substances."[2] The agency is also authorized to promulgate regulations limiting the quantity of such substances that may be present.[3]

In 1973, the tolerance for PCB's in fish was established at 5 parts per million (ppm). In 1977, new data[4] showed that the incidence of PCB contamination of regulated foods had significantly declined. Fish were the only food group in which detectable levels of PCB's were still routinely found. Based on this declining incidence of PCB contamination, coupled with new toxicity data suggesting adverse health effects resulting from chronic exposure, the Food and Drug Administration proposed that the PCB tolerances should be lowered.

The FDA concluded that a reduction of the fish and shellfish tolerance from 5 to 2 ppm would better protect the public health.[5] This decision was made even though the reduction would result in an estimated loss of 0.2 percent marine fish and up to 25 percent of the freshwater fish shipped interstate. The combined loss was estimated to have a value of $8 million per year. These losses have been more recently revised downward.[6]

Evidentiary hearings were held in 1981, to review FDA's data and objections that had been raised concerning the claim that the agency had understated the amount of food loss that would actually occur with a 2 ppm tolerance level. The administrative law judge issued a decision agreeing that there was a need to reduce the tolerance. The FDA Commissioner has been sent the decision and all the associated information for review before he issues the final ruling.[7]

Recently, the Environmental Protection Agency has promulgated final regulations for polychlorinated biphenyls used in electrical equipment.[8] This final rule contains some modification from the proposed regulation.[9]

It establishes a deadline of October 1, 1985 for removal of all transformers and electromagnets, containing 500 ppm or more of PCB's, that might present an exposure risk to food or feed. It authorizes the use of all other indoor PCB containing transformers and capacitors for the remainder of their useful lives, rather than the ten year limit recommended in the proposed rule. It permits indefinite storage, for disposal, of nonleaking PCB-containing large high voltage capacitors and PCB-contaminated electrical equipment outside at qualified storage facilities. The proposed rule would have prohibited such storage after January 1, 1983. Finally, the rule omits the language in the proposal on the required extent of PCB spill cleanup. "Comments urged EPA to postpone consideration of this language, and the extent of cleanup of PCB spills will not be dealt with at this time."[10]

The "useful lives" clause and the hesitancy of EPA to address the spill cleanup language has created a situation which will undoubtedly prolong the presence of PCB's as an environmental contaminant into the coming years. These developments and their relationship to the data presented in this report obviously have implications for possible future mitigation of biotic contamination here in New Jersey.

<u>References</u>

1 - 21CFR 109.30

2 - 21 USC 342(a).

3 - 21 USC 346 et seq.

4 - 42 FR 17487, April 1, 1977.

5 - Ibid.

6 - 44 FR 38330, June 29, 1979.

7 - Personal communication, Ted Herman, FDA.

8 - 40 CFR 761 et seq.

9 - 47 FR 17426, April 22, 1982.

10 - 47 FR 37342, August 25, 1982.