# A Study of Toxic Hazards For Urban Subsistence and Recreational Fishermen (Year 1:1983 to 1984)

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## Table of Contents

## Abstract

A multidisciplinary study was undertaken concerning fish bioaccumulation of PCBs and pesticides as well as a human risk assessment and risk perception analysis due to the consumption of these contaminated fish by urban fishermen from the Hudson River - Upper Bay - Newark Bay system. Elevated levels of PCBs were found relevant to the U.S. Food and Drug Administration's (FDA) tolerance of two parts per million for striped bass (Mean: 3.44 ppm); white perch (Mean: 4.87 ppm); American eel (Mean: 3.3 ppm); white catfish (Mean: 4.87 ppm); bluefish (Mean: 3.45 ppm); and blue crab mixtures of muscle and hepatopancreas (Mean: 2.08 ppm). Estimates of human cancer risk were calculated for these contaminated species using different baseline data to show a 60-fold increase in the estimate of risk using the Environmental Protection Agency's (EPA) approach versus the FDA's approach. The EPA based results were judged to be more significant and thus used to quantify risk from consuming the contaminated fish caught during this project. The results show a high probability of excess cancer risk from consumption of these species over a lifetime. The relative ordering of excess risk from consumption of the species shows: white perch: white catfish> striped bass: bluefish> American eel> blue crab (mixed muscle and hepatopancreas)> blue crab (hepatopancreas alone)> blue crab (muscle alone). The fishermen survey was skewed to the Fall population consisting primarily of older (>61 yrs.), white (91%) males yet they were probably the population at most risk due to their fishing tenacity over the year. They fished often (25% daily and another 25% at least two or three times a week) and primarily for fun although they were opportunistic with 43% claiming they fished for both fun and food. Concerning risk perception it was shown that approximately an equivalent number of fishermen thought the fish were both safe to eat (45%) and unsafe to eat (55%). A majority of the participants were aware of the Public Health advisories on consumption of these fish. Those who didn't eat, did so overwhelmingly because they perceived the act as being hazardous to their health (85%) and a moderate number (20%) of the consumers thought their catch was contaminated but ate it anyway. The rejection of the health threat warnings for consumption of these fish is probably related to the message itself, the medium of transmission and the individual's response to these warnings. A paradigm is presented by which public health information concerning environmental issues might be better transmitted through environmental teaching aids for primary and secondary school teachers, multi-media public service commercials and through better communication with the environmental press which seems to be the major source of local information for fishermen on the affected drainages.

## List of Tables



## List of Maps



## List of Figures

# I. INTRODUCTION

Due to the discovery of fish contamination in the late 1970's because of a pesticide (i.e. chlordane) in the Camden, New Jersey area (Suchow et al 1978) and PCBs on the lower Hudson-Raritan estuary in the early 1980's (Belton et al 1982, 1983) the New Jersey Department of Environmental Protection (DEP) instituted commercial fishery closures as well as public health advisories for recreational fishermen (Cite 15 N.J.R. 39). This was in order to limit consumption of tainted species so as to minimize the hazards of toxicant exposure. (See Maps 1, 2 and 3). DEP recognized the potential for both social and economic repercussions from this action, but felt that by compliance with this rule the hazard to the fish consuming public of the State would be substantially decreased. This would reduce the risk of cancer and other serious health problems, and the negative economic impacts (i.e. upon commercial and recreational fishing) would be offset by the overall public health benefit.

Unfortunately, Public Health advisories are not often successful. People respond to the hazards they perceive and if their perceptions are faulty, efforts at public and environmental protection are likely to be misdirected (Slovic et al 1979). Witness the large number of people who still smoke cigarettes despite the Surgeon General's well publicized warning. For some people the long term risk of contracting cancer through continuing present behavior is acceptable since the consequence of that behavior is too far removed from their immediate experience to be real for them.

Observations by DEP personnel indicated that the health warnings concerning fish for the drainages in the Camden, N.J. area were being ignored and that substantial numbers of fishermen were seen leaving the affected drainages with fish in hand, ostensibly for consumption. In 1981, DEP wishing to assess the effectiveness of the Camden fishing closure from 1978, undertook an anthropological investigation on the affected drainages in collaboration with the Rutgers University Department of Human Ecology in order to survey awareness of and attitudes toward the fishing ban by fishermen as well as their personal appraisal of the possible public health threats from eating such a contaminated resource. We wished to investigate as Miller (1983) has stated "whether policy decisions (i.e. fishing advisories in this instance) are signs of aggressive and straight-forward progress toward the resolution of real problems or weakly conceived ad-hoc responses perhaps motivated by a preoccupation with technical compliance to the law." And if the latter was true, ways in which the policy-makers might change the implementation of these actions in order to attain a more postive response from the affected public.

The initial approach was to use a "participant observer" technique (Pausewang 1973) in which the questioner takes on the guise of a co-participant in the activity (i.e. a fisherman) in order not to frighten off prospective interviewees who may already have a negative attitude towards the State and its regulators. Findings in the Camden survey (Roundy et al 1981) showed that although the number of fishermen was small, the apparent trends were fairly strong and therefore tentatively indicative (See Table 1). The data indicated a large number of people fishing in restricted waters for both recreational purposes (i.e. fish were either not removed from the fishing site or not used for human consumption) and subsistence purposes (i.e. fish were taken home for use in family kitchen, in some cases providing a major part of the diet based upon the number of fish taken, frequency of fishing, and replies to informal questioning of the fishermen). We also found that fishermen at more affluent, suburban sites were predominantly white, fished for recreation and were aware of the fishing bans. Less affluent fishermen at urban sites were more diverse ethnically with approximately half of them being black, half consuming the fish (most consumers were black), and less likely to be aware of the ban.

Therefore an implication, based on these preliminary findings, was that some of the local fishing populations were consuming potentially dangerous quantities of toxic fish and thus were exposed to long-term health risks. Furthermore, there was the suggestion that those people most likely to eat their catch were unaware of the known and advertised hazards or unwilling or unable to reduce their exposure to a long-term risk. We had identified a toxicological hazard, but one which could be observed or ignored by the fishermen based on elements of cultural preference, economic status, and environmental perceptions.

It was at this point that the 1982 PCB based fishing closures and advisories (See Maps 2 and 3) were implemented and we observed the same lack of concern for the toxic hazard by many shore fishermen within the Hudson River-Newark Bay Complex. We felt it would be interesting to study this larger, more ethnically diverse population in the same manner as the Camden study. We therefore applied to the Hudson River Foundation (HRF) for research monies and were funded for the first year of a two year study.

Our objectives were to quantify the degree of hazard faced by the urban fishing population in the study areas and to determine if locally acceptable methods existed to mitigate this hazard while simultaneously allowing the satisfaction of subsistence and recreational demands. Unlike many other fishermen surveys however (Stoffle et al 1983, Heatwole and West 1983, Va. 1979a, Va. 1979b), we would not only attempt to define fishermen activity and catch success but would also attempt to: 1) quantify toxic risk by actual analysis of food fish for PCBs and pesticides, 2) ascertain fishermen perception of resource safety and regulator competence, and 3) try to define better ways of communicating toxicological information to fishermen and the public at large.

We would be performing the investigations in an area called the worst case for toxic hazards in the world (Hudson-Raritan Estuary Project, January 1980). The results would be applicable for studying other potentially reclusive urban populations desiring access to a known degraded resource. We could therefore imply better approaches to more safely open up this resource, making it useful for both recreational and consumption purposes, and increase the multiplicity of uses of aquatic resources possible in crowded urban areas.

As the second year of our study was not funded, however, what is reported here concerns only the first year of research. Essentially, the biotic sampling was completed, however the manpower intensive, slow and methodical anthropological component required two years for its completion, hence is not fully reported. In spite of this, the information attained is scientifically valid and intrinsically interesting although somewhat less in breadth than the final results we had intended on reporting.

## II. METHODS

### 1. Fish Tissue Analysis for PCBs and Pesticides

Estuarine and marine finfish were captured by the use of gill nets, ottertrawls, seines, hook and line, and baited traps. Blue crab samples were collected by use of dip-nets and commercial style crab pots. All samples were stored in clean, contaminant-free ice chests and kept refrigerated until processing, usually the following day. All storage containers, packaging, work surfaces, utensils, and anything that came in contact with the samples was thoroughly scrubbed, rinsed with pesticide grade acetone or hexanes and finally rinsed with distilled water. The immediate work surfaces and utensils were washed and rinsed with acetone or hexanes and distilled water between each individual sample, during sample processing. Each species collected from a particular site was processed based upon its ascending order of lipid content.

Before actual processing, all finfish and crabs were weighed, measured and speciated. The blue crabs were measured across the shell lengthwise from point to point. Each individual crab specimen was sexed, and a notation was made regarding missing body parts, and shell condition (i.e., soft, hard, etc.) The samples excised from edible finfish consisted of a fillet portion of the fish with the skin left on. This standard fillet was 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 combined with other individuals of the same species and size to form a composite sample consisting of five fish or used as individual samples from single fish based on sampling success. For the blue crab the thoracic body cavity was opened from the ventral surface and the hepatopancreas completely removed using a small lab spoon. All the edible white meat was then removed. This included, the thoracic, claw, leg and tail meat. All other body parts and organs were discarded. The white meat and the hepatopancreas tissue was then processed separately and/or combined as recommended by the U.S. Food and Drug Administration (FDA 1978).

The fish and crab tissue was then thoroughly homogenized in a blender. Single samples were 100 grams in weight, while composites of five fish (100 gm/fish) were 500 grams. When a 100 gram sample portion was taken from a standard fillet which exceeds 100 grams, the sample portion was cut from the anterior section of the fillet proceeding posteriorly until 100 grams was attained. Processed samples were packaged in contaminant free aluminum foil, labeled, and stored frozen until analysis. Field storage of all collected samples was in contaminant free containers filled with wet ice.

All field sampling procedures followed the U.S. Environmental Protection Agency's guidelines (EPA 1978) and all processing methods followed the Food and Drug Administration protocols (FDA 1978).

The homogenized fish samples were extracted and quantified by gas chromatography at the New Jersey Department of Health laboratory. A Tracor model 222 gas chromatograph was used with an electron capture detector. The USEPA's methods (EPA 1980a) for PCB and pesticide analysis were used 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. The final extract was then concentrated and characterized by gas chromatography and quantified by comparison with the appropriate internal standards. Quality assurance followed EPA recommended guidelines (EPA 1978) and included spiking muscle tissue of each species with appropriate standards, as well analyzing replicate and blind control samples. The percent recovery for spiked samples internal standards ranged from 80 to 120 percent.

## 2. Risk Assessment

Evidence for human carcinogencity of PCB is limited (EPA 1980b), but data are available which indicate that PCB is an animal carcinogen. Results of bioassays conducted by the National Cancer Institute in which Aroclor 1254 was fed to Fischer 344 rats provide suggestive, but inconclusive evidence of hepatocellular lesions and gastrointestinal carcinomas (NCI 1978). Kimbrough, et al (1975) fed Aroclor 1260 to female Sherman rats over the animal's entire lifetime and found significant numbers of hepatocellular carcinomas and neoplastic nodules in the dosed animals compared to controls.

Tissue concentrations of PCB in fish and crabs collected in New Jersey waters were used to estimate lifetime cancer risks from consumption of these organisms. Risks were estimated using the multistage model for carcinogenesis as fit by the computer program GLOBAL82 (Crump 1980) to bioassay data for rats exposed to Aroclor 1260 (Kimbrough, et al 1975).

## 3. Fisherman Survey

The Fishermen Survey was carried out in two discrete phases. First, a combination of visual observations and informal interviews were used to assess the fishing population and its variability. Based upon our Camden experience (Roundy et al 1981) and suggestions of the nature of the shoreline fishing populations in the New York-Newark Bays area, we expected to be dealing with a population leery of formal surveys and distrustful of outsiders. Therefore, in our early work we emphasized techniques common in cross-cultural anthropological fieldwork, including observation from a distance, participant observation, informal open-ended interviews, and note taking delayed until after respondent contacts were completed (Pausewang 1973). Via these methods, we received general answers to questions on the demographic characteristics of the fishing population (i.e. race/ethnicity, age, sex, size of group, home neighborhood), regularity and frequency of individuals' fishing behavior, range of fishing through the region for individuals, species caught, and final disposition of the catch (i.e. how distributed if removed from site, how much consumed, at what rate per person, how prepared).

Then, from this population of informally observed and interviewed individuals a sample was investigated in greater depth. This transition from informal to formal investigation is usually a difficult process, but it can be achieved as the researchers become identifiable and their presence in the fishing area accepted. Sample members' fishing behavior was then questioned in detail utilizing questionnaires of ninety eight questions developed from investigator hypotheses and from respondent feedback during the informal part of the investigation.

We expected that the State's attempts to persuade people to alter their fishing or fish consumption patterns were likely to fail unless they were based on an understanding of what people already knew and believed about the risk. (Evidence of the need for cultural or cross cultural understanding in the successful planning of health-related behavior modification can be seen internationally in such works as Chen, 1970a, 1970b, 1972, 1975, and 1978; Prince et al, 1965; and Spruyt et al, 1976). This is especially true for low probability risks that take a long time to appear such as environmental carcinogenesis. An important component of the questionnaire then was whether people fishing in the waters under study were aware of any risk, how they perceived this risk, and why they continued to fish in spite of the risk.

Guiding the selection of questions was the body of existing knowledge about preventive health behavior (Ajzen and Fishbein, 1980; and Rosenstock, 1974). There was also research showing that people often acknowledge the existence of a risk, but find ingenious ways of believing that this does not apply to them (Kates, 1962; and Weinstein, in press). Discovering and then confronting these misbeliefs is necessary for changing risky behaviors. In our first year of study we tested approaches to fishermen and specific questions on these themes. Formal questioning commenced in Year 1 and will be completed in the second year of our fieldwork.

All questions were pretested in the field. Although open-ended questions are sometimes difficult to analyze, that is not a significant problem for the present study. Our goal was to describe the beliefs of respondents, not to provide numerical measurements of specific attitudes (a particular problem for open-ended questions). For this goal, the interview format we have chosen maximizes cooperation while not attempting to achieve unnecessary and probably illusory precision.

Finally, besides gathering information from people who see their fish as a consumable resource, we were also in contact with people who saw access to the waterfront as a desirable resource. For them, the goal of fishing is waterside recreation and not food. The resultant data therefore aids in assessing the size, distribution, source, and demographic characteristics of this population as well.

## III. RESULTS

### 1. Fish Tissue Analysis for PCBs and Pesticides

During this survey we captured 13 different species of fish including the six named in New Jersey's public health advisories of 1982 as being contaminated by PCBs; Striped Bass, Bluefish, American Eel, White Catfish, and White Perch. Besides these we also caught and analysed some other fish from these drainages which could either be used as a human food source (as indicated by the fishermen survey portion of this study) or else was an important forage fish (prey) for the other species caught (See Table 2). They included Menhaden, Alewife Herring, American Shad (Juvenile), Killfish, Blueback Herring, Atlantic Tomcod and Winter Flounder. In addition to edible flesh (i.e. muscle and skin) we performed some limited analyses of other organ tissues including fish liver and crab hepatopancreas as well as fish roe and crab sponge (eggs) (See Table 3). This information was relevant since it is known that some groups in the study area may eat these tissues (Kneip et al 1979, Heatwole Personal Communication) or use them in some aspects of food preparation for flavoring (Davidson 1979, Ross 1978, Sarvis 1968).

Essentially we found that striped bass showed a mean PCB concentration of 3.49 ppm (Range: 1.3-9.34 ppm), white perch a mean of 4.87 ppm (Range: 1.57-9.69 ppm), American eel a mean of 3.3 ppm, (Range: 1.53-7.01 ppm), white catfish a mean of 4.87 ppm (Range 4.26-5.48 ppm) blue crab (combined muscle-hepatopancreas) a mean of 2.08 ppm (Range: 0.85-4.72 ppm) and bluefish with a mean of 3.45 ppm (Range: 1.51-5.44 ppm).

The PCB data for other tissue types in this primary fish group also revealed that typically the liver and eggs are usually contaminated with PCBs at higher levels than those found in the flesh (See Table 3). For example whereas the white perch showed a mean concentration of 4.86 ppm in the edible muscle tissue, the liver showed more than twice that level of contamination (i.e. 10.02 ppm) and the roe or eggs had almost an equivalent amount (i.e. 4.15 ppm) as the muscle tissue.

With respect to the blue crab a differential analysis of the muscle tissue (mean=0.13 ppm), hepatopancreas (6.52 ppm) and egg sponge (1.65 ppm) revealed starkly different levels of PCB contamination. Also, since all of these different crab tissues are considered edible food, the U.S. Food and Drug Administration (FDA) has recommended to NJDEP to include in our analysis some samples of combined muscle meat and hepatopancreas in order to better define the actual exposure of someone who eats both tissue types. The results indicate that whereas lump meat alone does not exceed the FDA tolerance the combined muscle-hepatopancreas mixture does (mean=2.08 ppm, Range 0.85-4.72 ppm).

Concerning the limited analyses for the secondary fish group we found that some species showed elevated levels of PCBs whereas others did not (See Table 3). The two species from this group most often utilized for human consumption as identified by our fishermen survey showed only trace quantities of PCBs in their edible flesh (i.e. Winter Flounder = 0.23 ppm, Tomcod 0.25 ppm). This finding concurs with other studies on this drainage (Belton et al 1982, Sloan and Armstrong 1981). However, some of the forage fish from this second group which are utilized as prey by the primary groups of species showed elevated levels of PCBs in this flesh thereby elucidating possible food-chain implications for contaminant transport through the system.

Finally, the analyses of our samples for the organochloride pesticides chlordane, DDT (and its metabolites) and alpha BHC, failed to identify elevated levels of any of these compounds relevant to any established action level (FDA 1980) promulgated by the Food and Drug Administration (i.e. chlordane = 0.3 ppm; DDT (and its metabolites combined) = 5.00 ppm; and alpha BHC = 0.5 ppm). However the finding of substantial quantities of these compounds in fish in addition to PCBs is relevant because of the possible additive and/or synergistic health effects of these substances. That is, due to their similar chemical properties and the fact that they will all accumulate in human fat tissue at proportionately the same rate over time these chlorinated hydrocarbons and their toxicities may all respond in an additive fashion. It is for these reasons that the quantified risk assessment based on PCB contamination alone may be a conservative, low estimate of the expected increase in cancer risk by these fishermen due to the consumption of these fish.

2. Risk Assessment

Table 7 presents tissue levels of PCB in various organisms, with corresponding doses to consumers calculated assuming consumption rates of 15.7 and 36.8 grams per day, representing the 90th and 99th percentiles of fish consumption rates of 25,000 surveyed residents of the great lakes states (Cordle, et al, 1982). PCB doses range from .034 to 1.31 ug/kg body wt./day for 15.7g consumers, and from .079 to 3.06 ug/kg/day for 36.8g consumers. The smallest and largest doses for both levels of consumption are associated with blue crab muscle tissue and white perch respectively.

Human cancer risk estimates for consumption of PCB contaminated seafood have been produced using results from both the NCI (1978) and Kimbrough (1975) studies. The FDA used the NCI results to conclude that heavy consumption (36.8 g/day) of fish contaminated at the 2 ppm level over a lifetime would result in 7.2 cancers per 100,000 in the population of consumers (FDA 1979). EPA, in the ambient water quality criteria document for PCB used the Kimbrough study to develop "safe" levels of PCB in water. Using EPA's results, lifetime daily consumption of 36.8 grams of fish contaminated with 2 ppm PCB would result in approximately 450 cancers per 100,000. The approximate 60-fold difference between these two results reflects the choice of bioassay, and illustrates the dependence of risk estimation methods on the underlying data. Since the NCI bioassay results were inconclusive, this report concurs with EPA and risks are based on the Kimbrough (1975) results.

Risk estimates in Table 8 were produced using the multistage model fit to the combined hepatocellular carcinoma and neoplastic nodule data from the Kimbrough study with GLOBAL82. The methods of dose conversion and risk estimation follow the EPA Carcinogen Assessment Group (CAG) procedures closely (Anderson, et al 1983).

Since the study had only one dose group besides the controls, the fitted model was essentially one-hit. Consequently, the risk estimates and their corresponding 95% upper confidence limits set an upper bound on cancer risk if low dose linearity is assumed (Anderson, et al 1983). The carcinogenic potency for this data was estimated as 4.78254 (1/(mg/kg/day)).

The estimates in Table 8 should be interpreted very cautiously only as indicators of possible cancer risks. The large uncertainties inherent in low dose extrapolation and the lack of data on segregation of PCB isomers in fish tissue warrant this conclusion (Dr. Robert McGaughy, CAG, personal comm).

3. Fisherman Survey

Initial reconnaissance by both automobile and boat revealed only a few locations where fishermen could gain access to the water. Most of the shoreline was private property with heavy industry and railroads predominating. Much of it was also in deterioration with abandoned piers and derelict buildings effectively separating the urban public from the water. This has been caused by a number of technological changes during the past 25 years in how cargo is handled. Most importantly the onset of "Containerization" or the shipping of goods in huge metal boxes has caused a shift from the conventional bulk cargo and finger pier operations on the Hudson River to the larger container facilities of Port Elizabeth and Port Newwark on Newark Bay (Moss 1976). In spite of this however we did find eleven fishing sites where fisherman were clustered (See Map 4). These included municipal and state parks, a fishing pier erected by the state and a number of illegal (or restricted access) sites such as railroad bridges and abandoned finger piers.

The clustering of fishermen in a few places made us reconsider certain aspects of our experimental design. It meant that we did not have to cover many miles of waterfront each day but could stratify our sampling times and days across these locations achieving a maximum return on our field time per unit effort. Clustering also made us reconsider the utility of a "participant observer" approach. Since we would be highly visible to a number of prospective survey participants simultaneously it would obviously occur to them that we were there for other reasons besides fishing. Therefore, in order to forestall any negative, suspicious reactions from the fishermen we decided to alter our approach and maintain a high profile where our field surveyors identified themselves as members of a Rutgers University research team. This more visible and explicit interviewing approach allowed us to develop and pretest a much longer questionnaire than we had previously planned when our clandestine method precluded our taking notes on the dock.

We therefore expanded the short questionnaire used on the Camden study to attain more detailed information and then pretested or informally questioned prospective participants to see if the types of questions were easily understandable, ambiguous, superfluous and also to see if their attention span would flag. By the fall of 1983 we had developed a questionnaire of 98 questions which most people didn't mind answering and whose import was apparent. We also narrowed our prime observation and interview sites to six locations where fishing activity was the greatest and most representative of the totality of local fishing.

The level of fishing at these combined locations varied seasonally (See Figure 1) with two peak activity periods taking place across the year. The first peak was in the spring with a second occurring in the latter part of the summer while the fall and winter showed a steady decline in activity. As the first year of formal questioning did not begin until September of 1983, the following results are skewed to this fall fishing population which is empirically different from the range of fishermen seen during other parts of the year and less in number (36 fishermen interviewed) due to the onset of winter weather which curtailed most fishing activity.

Essentially, fall fishermen were older, more dedicated fishermen but fewer in number than the fair weather crowds of spring and summer. As far as risk assessment is concerned they may actually be the population at greatest risk however due to their fishing tenacity resulting in the capture and consumption of larger quantities of potentially tainted fish than the general fishing population.

The data from the questionnaire also indicated the following decreasing order of consumption: blue crab>winter flounder>bluefish>striped bass>American eel>tomcod. This ranking probably implies ease of access to fishing grounds for shoreline fishermen and ease of capture or fishing success rather than food preference. For example, crabbing and bottom-fishing (i.e. winter flounder) are fairly passive endeavors compared to angling for most of the other species which are mid-water fish. Complementary to this observation we found that many fishermen were simultaneously running crab lines and actively angling. They would stop between casts and pull a few crab traps thereby maximizing their time across the two activities.

In Table 6 are summarized the study demographic characteristics as well as responses to sixteen of the more important questions from the public health-policy assessment point of view represented as percentage of total fishermen interviewed across all of the sites. Essentially most of these fall fisherman were elderly with 83% being greater than 61 years old. Racially most were white (91%), fished often (25% daily and another 25% at least two or three times a week), and fished primarily for fun although they were opportunistic with 43% claiming they fish for both fun and food. A fair (14%) to moderate (39%) amount of consumption occurred if it is assumed that fish given away by fishermen were ostensibly for eating.

Concerning the questions of consumption and risk perception there is almost an even split between those who think the fish are safe to eat (45%) and those who do not (55%). However, those who "Don't Eat!" do so overwhelmingly because they perceive the act as being hazardous to their health, and also realize that you can't tell by looking at the fish if its safe (85%) although a large amount of uncertainty exists as to any possible means of making the fish safer prior to eating (i.e. 31% yes; 38% no; 31% unsure).

Of those who "Do Eat!" their catch a fair (13%) to moderate (20%) number think the fish may be polluted somehow but eat the fish in spite of it and although the majority of them think that the water is somewhat polluted a surprising 47% believe that the waters are not polluted at all. The majority of the participants (57%) were aware of the public health ordinances although a sizeable number (43%) were not and most people didn't known who was responsible for such ordinances. A number of fishermen were also shown to store their catch away in order to eat it after the fishing season was over (53%).

We found that the fisherman's perception of the space available per fishermen at any of the angling spots approximated a normal distribution with the majority of the anglers feeling the space was just right whereas an equal amount felt the space was concurrently under-utilized or overcrowded. This is probably a reflection of the typical urban spatial perspective. Finally we found that none of our urban fishermen were members of any fishing organizations or conservation groups underlining the fact that these anglers all appear to be fishing loners except as it relates to their neighbors on the immediate dock.

## IV. DISCUSSION

### 1. Fish Tissue Analysis

In Table 4 the contaminated data shows that the primary food fish and crustacean species sought by the New Jersey shoreline fishermen are still tainted by PCBs at levels in excess of the FDA tolerance of 2 ppm (49 FR 21514). They also remain substantially high enough within the majority of samples analyzed (>50%) to warrant continued enforcement of the commercial fishery closures and high enough to ensure that recreational fisherman on the affected drainage have a high probability of eating PCB contaminated fish with subsequent long range detrimental health effects.

The six contaminated foodfish identified are also salinity tolerant to various degrees and capable of movements into or across the brackish water within the estuary. This means that with the exception of the white catfish which is a freshwater fish having a maximum salinity tolerance of 14.5 ppt (Jones et al 1978) all of the other species may move freely between the waters of the Hudson River, Upper New York Harbor and Newark Bay because of wide-ranging foraging activity or through true migratory behavior associated with spawning. (Schaefer et al 1968, Jones et al 1978, Clark 1968, Lund and Malteyos 1970).

To test the homogeneity of these contaminated fish populations we performed a two sample t-test on log transformed data for the four species caught on these drainages to see if there was a difference between single and composite sample results. The t-test results showed that there was no significant difference between these single and composite samples for striped bass ($p=0.38$), bluefish ($p=0.45$), blue crabs ($p=0.14$) and whereas

American eel was significant (p=0.0044) it may have been due to unequal sample size and uncharacteristically high obervations in one sample.

We then pooled all the data for these species and then compared the level of PCB contamination across the two geographic areas where fishermen activity was highest using a two sample Wilcoxon rank sum, test on untransformed data. (Sokal & Rohlf 1969). The results showed no significant difference between the levels of PCBs in fish from the Hudson River/New York Bay and the Newark Bay Complex at a 5% significance level; striped bass (p=0.07), American eel (p=0.94), bluefish (p=0.15), blue crab mixture (p=0.07). In addition when all of the species were combined and compared across the two regions at a 5% signficance level the general biota population was shown to similar for the two regions as well (p=0.64). We could therefore assume that the absolute level of contaminant exposure due to fish consumption for both of the bays and the river was the same and should present the same general level of risk to fishermen throughout the affected drainages if similar diets are followed.

## 2. Risk Assessment

Our risk assessments on the pooled data shows a fairly high level of excess cancer risk for the consumers of these PCB contaminated species. In contrast to the typical regulatory benchmark where one in a million excess risk may be acceptable our study shows that 37 persons in a population of 10,000 who hypothetically eat 15.7 grams of striped bass per day from the Hudson River or Newark Bay over a lifetime could develop some form of liver cancer (Table 8). This is clearly an excess risk and therefore explains the strong regulatory response that New Jersey followed in closing all commercial fisheries for this species on the affected drainage and issued strong advisories not to consume them for the recreational fishermen.

In fact recent studies show that consumption of contaminated fish may be one of the major exposure pathways for environmental toxins in such urban populations. For example, in a comparison of the carcinogenic risks from consuming fish vs. groundwater contaminated by organic compounds Connor (1984) showed that although we consume 100 times more water than fish, the fish pathway can be a more important source of organic carcinogens due to the high concentrations and the increased potencies of the types of carcinogens bioaccumulated by fish. They note that based on PCB concentrations the lifetime cancer risk for consumers of Hudson River striped bass may be 100 times greater than the groundwater risks. Smoking of course would increase the risk of either activity even more.

The reality, however, shows that coastal zones are composed of "public goods and services" (i.e. fish, crabs, swimmable waters, etc.) which by definition are so highly indivisible that potential consumers cannot be easily excluded from enojoying their benefits (Breton, 1966). That is, it is too labor intensive and ineffective to attempt to police these "public goods" (e.g. prevent a recreational fishermen from angling) therefore, the need arises for this type of "user survey" to better ascertain more efficient means of understanding and convincing a scientifically naive and incredulous citizenry.

3. Fisherman Survey

The unique problem of the urban angler in finding access to the resource was also noted by Heatwole and West (1983) whose study of the shore fishermen on the New York City side of the Hudson River found only eight locations or 2 percent of the City's shoreline where the majority of it's urban angling occurred. In spite of this type of limitation however a New Jersey survey done by the Division of Fish, Game and Wildlife (NJDEP 1977) showed that 29% of the salt water anglers in the state fished from piers while 57% said they fished on a Bay or Creek rather than in the Ocean itself. Another study by the Department of the Interior also noted that in 1970 12.3% of the people who live in cities of 500,000 persons or more went fishing (FWS 1972).

The finding in our survey that the bulk of the fishing population was male, elderly (83% >61 yrs) and overwhelmingly white (91.4%) was a surprise since we had originally expected the majority of these fishermen to be composed of the urban poor and ethnic minorities who would be supplementing their diets by subsistence fishing. This is obviously not the case. This finding concurs with the New York City study (Heatwole and West 1983). Their population of fishermen were 62% white, mostly middle class, blue collar and relatively young. Unlike our study they found that only 15.4% of the sample were greater than 61 years of age. This discrepancy, as previously mentioned, may be related to seasonal aspects and only further sampling will elucidate on the affects of this. The surfeit of true subsistence fishing observed during the survey may also be related to the economic conditions during the study. For example, it has been shown that on Lake Michigan (Stoffle et al 1983) during economically depressed times laid-off factory workers, the elderly, the retired and minority groups often relied upon fish catches as a basic food source. This infers that the demography of our fishing population and the level of consumption may change as the economy does.

Race or ethnicity of fisherman was variable, but a number of our fishing sites were used by locally predictable mix of races. These older male fisherman, many of whom were likely to consume their catch, were supplemented, especially in the Summer months, by school age (pre-teen and teen), predominantly male, fisherman who were much less likely to consume their catch.

Except for peak seasons during the run of a desirable fishing species or public holidays, fishing populations rarely exceeded twenty individuals at a given site at one time. Peak seasons tended to be in August and September when a combination of pleasant weather, traditional school and work vacations, and the peak of the crab season brought out large and serious fishing populations (See Figure 1).

Fishermen universally expressed a pleasure at having a site for fishermen. Complaints were heard that so few nearby sites were available or that access to them was too restrictive. Suggestions for improving existing sites included: repairs to make then cleaner and safer; better access by automobile; and provision of regular services at sites including cleaning,