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POLYCHLORINATED BIPHENYLS (PCB'S) IN STRIPED BASS, *MORONE SAXATILIS* (WALBAUM) OF BUZZARDS BAY AND THE ACUSHNET RIVER

A Thesis

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(Master of Science)

by

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POYCHLORINATED BIPHENYLS (PCB'S) IN STRIPED BASS, MORONE SAXATILIS (WALBAUM) OF BUZZARDS BAY AND THE ACUSHNET RIVER

Tom Frank Rusek

Southeastern Massachusetts University, 1989

ABSTRACT

Polychlorinated biphenyl levels (PCB-Aroclor 1254) were measured in edible muscle fillets of 123 striped bass (Morone saxatilis) acquired from three localities in southeastern Massachusetts coastal waters. Muscle samples from 20 striped bass taken from the Acushnet River contained a mean PCB concentration of 22.3 ug/g (S.E.= 3.79) and a geometric mean of 16.5 ug/g (S.E.= 0.199), the only site to contain a mean concentration over the government regulated tolerance limit of 2 ug/g. Muscle samples from 48 striped bass from South Dartmouth contained a mean PCB concentration of 1.12 ug/g (S.E.= 0.195) and a geometric mean of 0.90 (S.E.= 0.064), while 37 striped bass fillets from Westport contained a mean PCB concentration of 0.58 ug/g (S.E.= 0.144) and a geometric mean of 0.43 ug/g (S.E.= 0.074).

The PCB levels in striped bass were not normally distributed, but skewed to the right and leptokurtotic and analyses of the data were performed on Log10-transformed values.

PCB concentrations found in striped bass were negatively correlated with the distance from the Acushnet River. PCB levels were not significantly correlated with weight, fork lengths or seasons. However, there appeared to be an overall trend of increasing PCB levels from July through September followed by a decrease in concentration levels from October through November when each locality was analyzed separately.

Eighty-five percent of all striped bass taken were females. The only significant correlation between sex and PCB concentration was observed in the Acushnet River where females contained 4 times the PCB levels of their male counterparts.

BIOGRAPHICAL SKETCH

Tom Frank Rusek, known to his colleagues and to his friends as Tommy, was born on February 12, 1951 in Adams, Massachusetts. After receiving a Bachelor of Arts Degree in Biology at North Adams State College in 1973, he was employed as a Laboratory Technician at The General Electric Company in Pittsfield, Massachusetts. At G.E. he was responsible for performing a wide range of evaluation tests on dielectric fluids (transformer oil, PCB fluids and silicone) using established techniques and instrumentation.

In 1980, Tommy received his Bachelor of Arts Degree in Chemistry from North Adams State College. He accepted a position at The Dow Chemical Company in Midland, Michigan as an Analytical Chemist in the Health and Environmental Science (Toxicology) Division. While there, Tommy acquired the experience necessary to pursue a career in Environmental Toxicology. He developed skills in analytical procedures for the extraction of chemical herbicides from various solid and liquid matrices utilizing Gas Chromatography and High Performance Liquid Chromatography. He also co-authored a publication entitled "The Metabolism and Kinetics of Radiolabeled (^{14}C) Ethylene Carbonate in Rat".

After three years at Dow, Tommy was accepted at Southeastern Massachusetts University in the fall of 1984 to pursue his goal of a Master of Science Degree in the fieldof Marine Biology. Upon completion of his thesis, Tommy Frank Rusek

hopes to utilize his academic and professional experiences in the field of Environmental Marine Toxicology.

DEDICATION

I would like to dedicate this thesis to my mother, Mrs. Blanche Rusek for her prayers and understanding, to my father, Mr. Frank Rusek who in his own way guided me toward the completion of this thesis, and to my family for their prayers.

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Special thanks go to Joe Battaglia for his moral support, invaluable help, long hours gill netting striped bass in the Acushnet River and for the many adventures we had, to Kenny Oliveira for his help in gill netting and as co-inventor of the Oliveira-Rusek apparatus and to Paul Marshall for his assistance in photography.

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INTRODUCTION

BIOLOGY OF STRIPED BASS: The striped bass Morone saxatilis (Walbaum) is an anadromous fish whose range extends from the St. Lawrence River, to Florida and into the Gulf of Mexico. The Pacific coast now has a flourishing population after being introduced in California during the late 1800's. They can be found in fresh or slightly brackish waters, in coastal salinities of 31 to 33 ppt and in higher salinity offshore areas. They are active over a temperature range from 21^{0}C (70^{0}F) down to 6-8^{0}C (43-46^0 F) (Bigelow and Schroeder 1953).

Striped bass do not venture far from their spawning grounds until two years of age, but after this period they are capable of extensive journeys. They are generally considered to be an inshore fish, although they can be found offshore when migrating. Striped bass that originate from the Chesapeake Bay follow the shoreline northward and eastward at least as far as southern New England in the spring. They return westward and southward in autumn. Numbers of migratory striped bass in Buzzards Bay are greatest in May, October and in November. Schooling fish move along the coast in either direction but they may remain in the same general location for weeks or throughout the summer months (Bigelow and Schroeder 1953).

There is evidence, from the reported capture of juvenile bass, that isolated spawning areas exist as far north

as the Annapolis and the Shubenacadie Rivers of Nova Scotia (Ray, Jessop et al. 1984). Spawning in New England rivers would be expected to occur from June to July although evidence of spawning activity has not been reported in recent years (Bigelow and Schroeder 1953). The St. Lawrence River has an indigenous, non-migrating population. Merriman collected three juvenile striped bass (7.1, 7.6 and 8.5 cm long) in the Parker River, Massachusetts in August, 1937 (Merriman 1941).

In early times striped bass entered and spawned in any river where proper conditions existed along the greater part of the Atlantic coast. Eventually, cities were built, dams were constructed and pollution increased to the point where one river after another became unsuitable for spawning.

Where spawning does occur, larger fish (15 lbs. and up) tend to frequent the enclosed bays, small estuaries and river mouths. Outside the breeding season, however, many smaller sizes run up into these sheltered areas while the larger fish may be found inshore as well as offshore. Striped bass are known to migrate far upstream in the larger rivers in New England and it is likely that they remain year round. These northern wintering fish may represent small resident year round populations or those that just occasionally spend a winter (Bigelow and Schroeder 1953).

Striped bass are known to migrate up the Hudson River to Albany, New York, a 160 mile journey. They also make lengthy excursions in the Delaware River, the Connecticut

River, the Marshfield River of northern Massachusetts and the St. Lawrence River (Bigelow and Schroeder 1953).

CHEMISTRY OF POLYCHLORINATED BIPHENYLS: Polychlorinated biphenyls (PCB's) are a class of chemical compounds that were first synthesized in 1881 but were not prepared for commercial use until 1930. The unique chemical and physical properties of PCB's have resulted in their use in many applications. Their characteristics include; low vapor pressure (high boiling points), low water solubility, miscibility with most organic solvents, resistance to combustion (high flash and fire points) as well as to acid and base hydrolysis and oxidation, remarkable chemical stability, high dielectric constant and chemical resistivity and high lipid solubility (Eisenberg, Mallman and Tubiash 1980; Rule 1977; Ahmed 1976).

PCB's are formed by means of a substitution process. Chlorine atoms are substituted at hydrogen positions in a biphenyl structure utilizing ferric chloride as the catalyst and producing hydrogen chloride as a by-product.

```
    3            2          2'           3'
     C=========C             C=========C
    /          \            /          \
 4 C        /    C-------C     \        C 4'
   \\      /    //        \\     \      //
    C---------C             C---------C
    5   /       6          6'       \   5'
       /                             \
      /                               \
    Cl_x      x + y = 1 to 10        Cl_y
```

Chloination on the biphenyl (as depicted above) can range from one to ten atoms. They can be identified by a four digit numbering code as in the Monsanto formulated Aroclor 1254. Aroclor is a trade name for various PCB mixtures produced exclusively by Monsanto Corporation, Sauget, Illinois. In this case the first two digits (12) indicate that the mixture is a biphenyl containing twelve carbons while the next two digits (54) indicate the percent chlorine by weight contained on the biphenyl. Monsanto has made available PCB mixtures that range from 21 to 68% chlorine with the possibility for 209 chlorobiphenyl congeners. Polychlorinated biphenyls seldom appear as pure compounds, but rather as mixed congeners. For example, Aroclor 1254 contains 48% congeners of 5 chlorines, 21% congeners of 4 chlorines and 23% congeners of 6 chlorines. (Eisenberg, Mallman and Tubiash 1980; Weaver 1982).

PCB's are thermally and chemically stable compounds. These properties, along with their ease of absorption and concentration as they proceed up the trophic levels of the food web, make them readily available to organisms.

HISTORY OF PCB USE AND ITS DISPOSAL: Prior to 1971, typical PCB uses included; pesticide extenders, coolant insulation fluid in electrical transformers and capacitors, flame retardants in association with asbestos for insulation, lubricants, gasket sealers, brake linings, floor tiles, recycled paper and paper products, waxes, asphalt, adhesives as laminates in the fabrication of safety glass, ceramics, additives in paints and varnishes, putties and caulking compounds, washable wall coverings, upholstery materials and printing inks. In 1970, the United States Department of Agriculture banned the use of PCB's in pesticides but other uses and unrestricted disposal were allowed to continue. Since 1971, the use of polychlorinated biphenyls has been closely monitored by the federal government due to their potential toxic effects on living organisms (Eisenberg, Mallman and Tubiash 1980; Rule 1977; Ahmed 1976).

The cumulative use of PCB's in the United States was 620,000 tons (564 million kg.) until domestic production ceased in 1977. Of this 620,000 tons, 24% is confined to landfills and dumps, 6% has been degraded by incineration, 10% (62,000 tons) has escaped into the environment and 60% is still in use (Rule 1977; Weaver 1982).

Estuarine and nearby coastal waters of the United States are still receiving a substantial quantity of these PCB's. These chemicals are constantly being released into these waterways through leaching from nearby landfills and waste disposal sites. Sediments can accumulate PCB's

through adsorption, and eventually release them into the marine ecosystem where they are transferred to the food web. In turn, the higher food web organisms concentrate PCB's from water, sediment and from the lower food web biota (Eisenberg, Mallman and Tubiash 1980; Rule 1977).

The late 1970's and early 1980's witnessed an era of close inspection by Federal and State legislation concerning the eventual elimination of polychlorinated biphenyls from the environment. Today, Federal and State Agencies closely monitor the levels of PCB's in terrestrial, aquatic and marine ecosystems, some on a yearly basis. In 1973, the Food and Drug Administration established limits for the amounts of PCB's present in food as a result of contamination. The tolerance limit set for finfish at that time was 5.0 parts per million (ppm) on a wet weight basis. That tolerance limit has since been lowered to 2.0 ppm as of August 20, 1984 (Gadbois and Maney 1983).

BIOCONCENTRATION OF PCB'S: The process of bioconcentration of a substance has been adequately demonstrated in many organisms. Detectable levels of PCB's have been found in marine life ranging from plankton and small shrimp to oysters, clams and fish (Linko et al. 1974; Gustafson 1970; Vreeland 1974; Courtney and Denton 1976; Califano et al. 1982; Pizza and O'Connor 1983).

Plankton is an important link in the incorporation of polychlorinated biphenyls into aquatic food chains. Absorp-

tion of PCB's by planktonic organisms allows these substances to remain in the water column for a longer period of time before sinking to the bottom sediments. Linko et al. (1974) worked in the Turku Archipelago in the Baltic Sea with plankton samples consisting mostly of Copepod zooplankton. These plankton samples were found to contain PCB levels resembling levels seen in Baltic herring, a local fish that feeds on plankton in the pelagic zone of the sea (Linko et al. 1974).

Shrimp, that had been previously free of PCB's (more accurately, below detectable limits) were exposed to water containing 10 ppb of Aroclor 1254 for a period of 48 hours. They were found to have accumulated 1.30 ppm in their systems; a concentration factor of 130 (Gustafson 1970).

Oysters, in a similar experiment, were exposed to 10 ppb of Aroclor 1254 for 96 hours. They were found to contain 33 ppm PCB's, a concentration factor increase of 3300 (Gustafson 1970).

Five month old oysters (*Crossostrea virginica*) were tested in a continuously flowing system for their concentration ability. Chlorobiphenyl concentrations of 5.5, 17 and 60 parts/10^{12} resulted in a mean concentration factor of 18,000 (in wet weight of oyster) (Vreeland 1974).

The suspension feeding hard clam, *Mercenaria mercenaria* was exposed to 1.25 and 12.5 parts (Aroclor 1260)/10^9 in sea water for a period of 21 days. Results showed that for the 1.25 ppb exposure level the maximum mean concentration fac-

tor was 1.8 x 10^3 for its visceral mass after 18 days and showed little change in PCB content after 3 months in clean water. At the 12.5 ppb exposure level, even though there was a significant decrease in the PCB residue in the foot after a month, the visceral mass level remained unchanged after 6 months (Courtney and Denton 1976).

Schimmel et al. (1974) found that the fry of sheepshead minnows (Cyprinodon variegatus) accumulated Aroclor 1254 at concentration factors ranging from 16,000 to 32,000 times that present in the water. This was comparable to the adults whose concentration factors ranged from 11,000 to 32,000 times (Schimmel et al. 1974).

Channel catfish (Ictalurus punctatus) were found to bioconcentrate Aroclors 1248 & 1254 at doses of 5.8 and 2.4 ug/l, respectively. After continuous exposure for 7 days to these dose levels via a flow-through diluter, the accumulated concentrations of Aroclors 1248 & 1254 were 56,370 and 61,190 times that present in the water, respectively (Mayer et al. 1977).

Young of the year striped bass, after being exposed to 1 ug/l of Aroclor 1254, accumulated 96,000 times the original concentration in 1 day (Califano et al. 1982).

Polychlorinated biphenyls can bioconcentrate from food sources as well as direct uptake from water. Pizza and O'Connor (1983) worked with young-of-the-year striped bass that were administered a nominal dose (500ng-PCB/feeding) of

roclor 1254 in natural food by gavage. Results showed a 50% assimilation rate in 7 hours from the gut.

BIOMAGNIFICATION OF PCB'S: The process of biomagnification of a substance along the food chain is evident in many avian and terrestrial organisms. Substantial amounts of PCB's have been detected in migrating waterfowl (Kim and Pastel 1984).

Migrating waterfowl have proven to be good indicators of pollution of North American waterways. Birds, with their locomotive capabilities, are exposed to a wide range of environmental contaminants particularly through their diet. High levels of pesticides and PCB's may cause problems for these aquatic birds as well as for the hunters, and their friends and families who eat them.

Levels of PCB's were measured in subcutaneous fat and in breast muscle of 63 waterfowl collected in New York State (1979-1980) by Kim and Pastel (1984). Mean PCB levels equalled 7.5 ppm in fat and 1.3 ppm in breast muscle. This is above the FDA tolerance limit of 3.0 ppm in fat for domestic poultry. The mean PCB levels show these birds unfit for human consumption because of the association of fat with the muscle while preparing it for consumption (Kim et al. 1984).

Fish-eating birds accumulate large concentrations of PCB's. The white-tailed eagle has been found to contain as much as 14,000 ppm of PCB's while peregrine falcons taken

off the coast of California contained up to 2,000 ppm of PCB's in their lipid tissue (Gustafson 1970).

ACUTE AND CHRONIC EFFECTS OF PCB'S: Phytoplankton abundance is related to nutrient availability, light, rate of mixing, grazing and pollution. O'Connors et al. (1978) exposed liters of phytoplankton cultures to dose levels of 1 to 10 ppb of Aroclor 1254. Reduced growth rates of sensitive species were observed as well as destroyed algal cultures with 10 ppb. Other cultures exhibited cells with clumped cytoplasm as well as misshapen nuclei and chloroplasts. Large diatoms were found to be more sensitive to PCB's than smaller algae. PCB pollution of coastal waters could diminish as well as contaminate primary food chains and eventually reduce harvestable fish because of a reduction in phytoplankton size (O'Connors et al. 1978).

Chronic effects of polychlorinated biphenyls are readily seen in the earliest life stages of fish development. Those stages are most susceptible to the effects of chemical pollution. Polychlorinated biphenyls can be absorbed through the gastrointestinal and respiratory tracts and through the skin. They are initially stored in the liver and muscle tissues then are redistributed primarily to lipid tissues (Weaver 1982).

Hansen et al. (1976) worked with channel catfish (*Ictalurus punctatus*) fingerlings feeding them a diet of 20 ppm Aroclor 1254 for 20 weeks. Even though no mortalities

ere observed, catfish total weight gain was halved while iver weights were higher when compared to controls. There 'as no change in the PCB body burden of treated fish after ;6 days of PCB-free feed (Hansen et al. 1976).

Mauck et al. (1978) exposed brook trout (Salvelinus :ontinalis) eggs to Aroclor 1254 at dose levels ranging from).43 to 13 ug/l for 10 days before hatching and the fry for 118 days after hatching. Findings included significant mortality after 48 days (vs. control) at 13 ug/l. After 118 days fry backbone development was impaired by Aroclor 1254 exposure at 1 ug/l. One week after hatching, fry that were exposed to 0.43 ug/l had accumulated 1.6 ug/g Aroclor 1254 residues while those exposed to 13 ug/l had accumulated 14 ug/g Aroclor 1254 residue, producing concentration factors of 3700 and 1100, respectively. After 118 days of exposure to Aroclor 1254, surviving fry had accumulated from 40,000 to 48,000 times the water concentration. These concentration factors were seen in fry having accumulated 284 ug/g whole body residues (Mauck et al. 1978).

Young-of-the-year striped bass taken from the Hudson River (1.3 to 2.7 ug/ml water concentrations) showed high liver-weight/body-weight ratios, low liver DNA and muscle protein concentrations, poor bone quality and poor swimming stamina when compared to fish from less polluted environments (Buckley et al. 1985).

The chronic effects of PCB's are frequently seen in wildlife. For example, in brown pelicans that reside on the

Anacapa Islands off the California coast, no young were hatched (1969) from 300 pairs of nesting birds because the shells of most of the eggs laid were so fragile that a dent occurred when they were handled. There are two possible causes of this egg shell thinness: a low calcium reserve in the bird and/or the inability of the bird to deliver the needed calcium to its oviduct where the egg shell is formed. The calcium level in the avian biosystem and the calcium reserve in the secondary bone structure are controlled, in part, by the hormone, estrogen. Calcium reserves are formed in association with a high estrogen level. Chlorinated hydrocarbons such as PCB's have the ability to activate enzymes in the liver which transform estrogen into a more water soluble compound that is readily eliminated from the birds' body. Therefore, when estrogen levels are low, calcium levels are also reduced. PCB's are more effective than DDT (a pesticide) in this type of enzyme-induction activity. This lack of calcium results in poor egg shell production (Gustafson 1970).

Polychlorinated biphenyls, at higher levels, can also be toxic to many mammals. A collaborative effort between researchers has resulted in obtaining malignant liver tumors in rats after dosing these animals with 100 ppm of Aroclor 1260 over a period of 21 months (Kimbrough et al. 1975, cited by Ahmed 1976).

Reproductive deficiencies caused by PCB's were investigated by Linden et al. (1974). Rats exposed to 20 ppm

Aroclor 1254 had fewer pups per litter than controls in the F_{1b} and F_2 generations. At levels of 100 ppm, mortality was increased in F_{1b} offspring while mating performance also decreased. At 500 ppm Aroclor 1260, litter size as well as survival decreased in the F_1 generation (Linder et al. 1974).

James Allen (1974) along with a group of researchers at the University of Wisconsin School of Medicine, conducted exposure tests on female rhesus monkeys. Monkeys were fed a regular diet plus 25 ppm of Aroclor 1248 for 2 months. Results indicated severe symptoms of facial swelling and skin eruptions within one month and one animal died as a result of PCB poisoning two months after removal from the experimental diet (Allen 1974).

Humans have metabolic pathways and systems similar to monkeys. The metabolized PCB's are excreted in bile, urine and in milk, whereas, the unmetabolized PCB's are excreted via feces, urine, hair and milk. The higher the degree of chlorination on the PCB molecule, the more readily it is retained in the lipid tissue. This retention can induce liver microsomal enzymes (Weaver 1982; Safe 1982).

In 1968, a severe form of skin disease was diagnosed in Japanese families who consumed rice oil contaminated with Kanechlor 400 (equivalent to Aroclor 1248). The average amount of PCB's consumed amounted to 2 grams (2000mg) with symptoms appearing at 0.5 grams (500mg). The disease became known as " Yusho syndrome " characterized by the swelling of

the upper eyelids, visual impairment, acne-like formations and an increased pigmentation of the skin. By the end of 1982 there were a total of 1788 patients. (Gustafson 1970; Masuda 1985; Weaver 1982).

Polychlorinated dibenzofurans (PCDF'S) were also consumed at an estimated concentration of 2-8 ppm. PCDF'S are also known to be a harmful class of pollutant generated by the pyrolysis of commercial PCB mixtures. Similarities between PCDF isomers present in Yusho oil and those in Japanese PCB mixtures have been isolated (Buser et al. 1978). The PCB's of these two samples had the same chlorine content and both were used in heat exchange systems for a long period of time.

In 1979 a similar mass poisoning from consumed cooking oil occurred in central Taiwan called "Yu-Cheng". By the end of 1983 there were a total of 2060 patients (Masuda 1985).

Symptoms of the Yusho and of the Yu-Cheng poisonings observed in their early stages were very similar. Chronic symptoms of the Yusho poisoning still observed today include dermal and mucosal abnormalities which were the most prevalent in the early stages. They since have gradually improved. There are, however, other general internal symptoms that have become prominent in recent years (Masuda 1985).

As of 1982, 112 Yusho patients have died; 35.4% from malignant cancers (stomach, liver, lung and breast cancer). Cancer mortality rate for the normal population is 21.1%,

therefore, the large mortality associated with PCB's in these instances may be premature (Masuda 1985; Safe 1984).

Also, as of 1982, the Yu-Cheng poisoning death total stands at 24; 5% from hepatoma, liver cirrhosis and other liver ailments (Masuda 1985).

PCB contents in liver and in adipose tissue of 64 patients who died were 0.1 and 2.5 ppm, respectively, on the average. The average concentrations of PCB's in blood after 5 years was 6.7 ppb (N= 41). These PCB concentrations were only 2 or 3 times that observed in normal persons (Masuda 1985).

A community study was conducted in Triana, Alabama by Kreiss et al. in 1979. The mean blood PCB level of 458 local fish eaters tested was 22.2 ug/l (geometric mean= 17.2 ug/l). Results showed that males of every age group contained higher PCB levels than females (geometric mean= 23.5 ug/l vs 13.7 ug/l, males vs females; $P< .0001$) and that these levels of PCB's were positively associated with high serum cholesterol levels and with elevated diastolic pressure (Kreiss et al. 1981).

PCB's AND FINFISH: As a result of the above mentioned toxic effects of polychlorinated biphenyls on organisms along with their concentrating ability in lipid tissues of animals, much emphasis has been focused on conducting surveys of commercially and economically important animals.

One of the more important organisms that falls into this class is the striped bass (Morone saxatilis).

A national PCB survey was conducted from the fall of 1979 to the winter of 1981 of targeted finfish in the key areas of the Pacific Ocean, the Gulf of Mexico and the Atlantic Ocean coastal waters of the United States. In all, 88 samples of striped bass were sampled for polychlorinated biphenyls. Values ranged from 0.01 to 4.00 ppm with a mean value of 0.56 ppm (Gadbois and Maney 1983).

Maryland's Department of Health and Mental Hygiene is presently engaged in PCB analysis as applied to finfish and shellfish from the Chesapeake Bay. Of 80 fish sampled in 1976, the mean level of PCB (Aroclor 1254) was 0.20 ug/g while the level of PCB (Aroclor 1260) showed a mean of 0.34 ug/g in 66 samples. In 44 samples of striped bass, the mean level of PCB (Aroclor 1254) was 0.23 ug/g (range= N.D.-0.58 ug/g) while the level of PCB (Aroclor 1260) showed a mean of 0.24 ug/g (range= 0.22-0.26 ug/g) in 4 samples.

Finfish sampled in 1980 gave similar results. Of 24 finfish, the mean level of PCB's (total) was 0.248 ug/g (range= 0.003-1.45 ug/g) while in striped bass the level of PCB's (total) ranged from 0.003 to 0.380 ug/g in 8 fish sampled (all means reported here are arithmetic means) (Eisenberg, Mallman and Tubiash 1980; Eisenberg and Topping 1981).

PCB'S AND NEW YORK STRIPED BASS: Two General Electric Company plants located in the Fort Edward-Hudson Falls area of New York manufacture electrical capacitors in which PCB's were used as insulating fluids. These plants are located on the Hudson River (40 miles north of Albany) and local fish have been found to contain PCB's over the government regulated level (2 ppm) (Sloan and Horn 1985).

In 1980, the New York State Department of Environmental Conservation established a program to survey the Hudson River fish for polychlorinated biphenyls on a yearly basis (Sloan and Horn 1985).

The value of the annual commercial catch of the striped bass industry on the Hudson River was estimated at 1.2 million dollars prior to the ban placed on the commercial fishery in 1976 due to the elevated PCB levels found. The annual take of striped bass by sportsmen exceeds this amount. Therefore, the disruption of this commercial fishing industry has had serious economic consequences.

In 1976, the Environmental Protection Agency conducted water and sediment analyses for PCB's in the vicinity of Fort Edward, New York, near one of the General Electric plants. Water samples collected directly south of the plants' waste-water discharge pipes showed PCB values of 2.2 to 3.1 parts per billion (ppb) while nearby sediments contained 540 to 2,980 ppm (Ahmed 1976).

Total PCB content (wet weight) of striped bass obtained from the lower Hudson River estuary between 1980 and 1982

was found to be over 5 ppm in all sized fish. Fish that were greater or equal to 18 inches (total length) exhibited a range of 5 to 7 ppm PCB's and fish that were greater or equal to 24 inches (total length) exhibited a range of 9 to 10 ppm PCB's (Horn, Sloan and Brown 1983).

Similar tests conducted from 1983 to 1985 for striped bass (Morone saxatilis) are as follows:

1983: fish (greater or equal to 18 in. total length)
Mean= 4.8 ppm total PCB content from 129 fish.

fish (greater or equal to 24 in. total length)
Mean= 3.8 ppm total PCB content from 20 fish
(Horn, Sloan and Brown 1983).

1984: fish (greater or equal to 18 in. total length)
Mean= 4.8 ppm total PCB content from 167 fish.

fish (greater or equal to 24 in. total length)
Mean= 6.7 ppm total PCB content from 38 fish
(Horn and Sloan 1984).

1984: (Marine waters: New York Harbor, West and East Long Island) (Sloan and Horn 1985).

fish (greater or equal to 18 in. total length)
*Geometric Mean= 2.65 ppm, Mean= 4.34 ppm, N= 113.

fish (greater or equal to 24 in. total length)
Geometric Mean= 4.09 ppm, Mean= 5.62 ppm, N= 20.

1985: fish (greater or equal to 18 in. total length)
Mean= 6.19 ppm total PCB content from 408 fish.

fish (greater or equal to 24 in. total length)
Mean= 7.26 ppm total PCB content from 194 fish
(Sloan and Horn 1986).

1985: (Marine waters: New York Harbor, West and East Long Island) (Sloan, Horn et al. 1986).

fish (greater or equal to 18 in. total length)
Geometric Mean= 2.21 ppm, Mean= 2.69 ppm, N= 444.

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* To reduce the significance of outlier fish on the mean, data were transformed (log10) and a geometric mean calculated.

fish (greater or equal to 24 in. total length)
Geometric Mean= 2.45 ppm, Mean= 2.93 ppm, N= 320.

fish (greater or equal to 30 in. total length)
Geometric Mean= 2.93 ppm, Mean= 3.76 ppm, N= 89.

: fish (greater or equal to 18 in. total length)
Mean= 6.54 ppm total PCB content from 331 fish
(Sloan, Horn et al. 1987).

To view these results in another perspective, out of a
.gal of 79 striped bass taken during the summer of 1984
from the marine district of New York that were greater or
1 to 18 inches in total length, the probability that
les would exceed the 2 ppm government tolerance limit
polychlorinated biphenyls was over 90% (Sloan and Horn
).

BURDEN IN THE ACUSHNET RIVER: Buzzards Bay is a New
Eng and estuary, only 30 miles long and 10 miles wide posi-
tion ed between Cape Cod and the southern borders of
Massachusetts.

The waters of this area serve as an habitat for many
marine fishes such as winter flounder, scup, tautog, blue-
fish and striped bass. The bay contains over 18,000 acres
productive shellfish growing areas where thousands of
bushels of clams, scallops and oysters are harvested annu-
ally. These fisheries account for over 10 million dollars
annual commercial landings and have a considerable recre-
ational impact (EPA Region I Workplan 1985).

New Bedford fronts on the Acushnet River estuary, New
Bedford Harbor and Buzzards Bay. ~~Part of this city's econ-~~
Part of this city's economy

is based on the electronics capacitor manufacturers loed on the banks of the Acushnet River estuary. The major industries of New Bedford utilized approximately 900,000 kg a year of PCB's from 1973 to 1975. Polychlorinated biphenyls were used extensively in the manufacture of electrical capacitors from 1947 to 1978 by the Aerovox corporation which is located near the head of the Acushnet River. Specifically, PCB Aroclors 1242, 1252 and 1254 were utilized until 1972. (At its production peak, Aerovox utilized approximately 500,000 kg of PCB's on an annual basis. of this, over 77,000 kg of PCB's were contained in capacitors and diatomaceous earth disposed of in the New Bedford landfill.) Soil samples on Aerovox property ranged in PCB content from 24,000 ppm (2.4%) to 190,000 ppm (19%) inside the outlying fence and seaward, respectively (Kolek and urvels 1981; Weaver 1984; Weaver 1982).

1947 started

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Another electronic capacitor manufacturer, Cornell-Dubilier Electronics Corporation, also contributed to the PCB problem from 1941 to 1977. Representative PCB mixtures included; Aroclor 1242 (prior to 1971), Aroclor 1016 (from 1971 to 1977) and Aroclor 1254.

1941

Between the years of 1971 and 1975, Cornell-Dubilier utilized over 1.4 million kg of Aroclor 1016 and approximately 10,000 kg of Aroclor 1254. Between Jan. 1971 and Jan. 1976, approximately 122,000 kg of Aroclor was sent to the New Bedford landfill in the form of capacitors and absorbent material. Soil analyzed on the Cornell-Dubilier

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million dollars in annual commercial landings, not to mention the large annual take of fish by sportsmen.

New Bedford shoulders an enormous responsibility of providing wholesome and safe products as food items for human consumption. Although most of the commercial fisheries are offshore, the presence of polychlorinated biphenyls in New Bedford harbor poses a public relations problem to the fishing industry as well as some degree of a real threat to public health.

REASONS FOR STRIPED BASS STUDY AND PROBLEMS: Striped bass is a migratory commercial fish that frequents the Buzzards Bay area. The ability of these fish to accumulate PCB's in their lipid tissues makes them a candidate for concern.

Due to the high levels of water column and core sediment concentrations of PCB's, there exists a serious potential for an incoming fish, such as the striped bass, to increase its concentrations of polychlorinated biphenyls beyond the government indicated tolerance limit set for finfish (2 ppm).

This project monitored *Morone saxatilis*; to determine its safety and wholesomeness as a food item due to the possibility of high PCB contamination, to help evaluate the conditions of the aquatic environment in and around New Bedford harbor and to provide a basis for assessing the magnitude of PCB contamination in the Acushnet River estuarine waters. PCB's in striped bass of the Buzzards Bay area represent a

significantly more complex issue than the levels of pollutants in most other marine organisms due to the fact that the variability may be related to size, place of origin (Hudson River, Chesapeake Bay), proximity to the Acushnet River dischargers and the duration of exposure to PCB's in the Buzzards Bay area. Consequently, in order to meaningfully assess the problem, substantial numbers of fish need to be assayed and the sampling regime must account for the various sources of variability.

MATERIALS AND METHODS

Preliminary assay striped bass (*Morone saxatilis*) samples were collected over night on November 14-15, 1985 at Round Hill Point, South Dartmouth, Massachusetts via gill net (mesh size= 6.35 cm (2.5 in.) mesh stretched). Of over 200 striped bass taken, 37 bass were saved, but only 18 were extracted and analyzed (MSFA85-1 to MSFA85-18). Subsequent fish (MSJL86-38 to MSNO86-148) were collected during the following year (July to November, 1986) utilizing either a 300 ft. gill net (mesh size= 8.89 cm (3.5 in.) mesh stretched) or by hook and line (Table 2). Acushnet River samples (20 fish) were collected between Routes 6 and 195 via gill net, whereas South Dartmouth (48 fish) samples were collected off Round Hill Point, and Westport (37 fish) samples were taken at Gooseberry Point and Hen and Chickens via hook and line. A scientific collecting permit (#9006) was obtained from the Massachusetts Division of Marine Fisheries for the acquisition of undersized striped bass. Division employees aided in the collection of the preliminary samples. Concentrations of PCB's in striped bass from all localities sampled are listed in Table 2.

As soon as possible after capture, fish were stored at temperatures below $7^{0}C$ ($45^{0}F$) and upon completion of preliminary measurements, fillets with skins intact were wrapped in either aluminum foil or polyethylene bags and frozen in a Gibson Food Freezer at -15 to $-20^{0}C$. Preliminary data in-

cluded measurements of total length (cm), fork length (cm) and weight (grams). Scale samples for age determination were taken and the sex, date and location of the catch were recorded (Table 1).

EXTRACTION AND CLEANUP PROCEDURES: Each fish fillet was analyzed in accordance with procedures outlined in the Pesticide Analytical Manual- Vol. #1 (for foods and feeds), extraction and cleanup sections 212.3a [high moisture products (greater than 75% water) with less than 5% sugar], section 211.13f (fish) and section 211.14d (Florisil column cleanup).

Prior to analysis, all glassware was washed with Alconox and rinsed in distilled water twice followed by two rinses of acetone.

Reagents and chemicals included: acetonitrile (analytical grade), petroleum ether (analytical grade), hexane (pesticide grade), saturated salt solution, distilled water, Florisil (60-100 mesh; activated @ 650^{0}C and stored at 130^{0}C) and sodium sulfate (anhydrous and stored at 130^{0}C).

For the extraction procedure, 20-40 grams of fish sample (edible portion of fillet including the skin) was weighed and added to a blender along with 200ml of acetonitrile for homogenization. After blending at slow speed for a few seconds and at high speed for one minute, the sides of the blender were scraped free of caked sample material using

ı clean glass rod. Blending was then resumed for one ıinute, first at low speed for a few seconds, then at high ;peed.

After homogenization, the entire contents of the ›lender were poured through a Buchner funnel (containing No. 515 VWR paper) into a 500ml filter flask attached to an as-›irator. The sample was allowed to drip through the fil-ter paper until completion. The extract was then poured into a graduated cylinder and the volume recorded (this is volume "F" in the adjusted wet weight calculations). The extract was transferred to a 1 liter separatory funnel along with 100ml of petroleum ether and vigorously shaken for 90 seconds while venting periodically. After shaking, 10ml of saturated salt solution was added to the separatory funnel followed by approximately 600ml of distilled water that had been used to rinse the filter flask and the graduated cylin-der. Distilled water was added (using approximately 350ml in the filter flask and 250ml in the graduated cylinder) in order to rinse both pieces of glassware. The separatory funnel was then shaken for 35 seconds while being held in a horizontal position. After shaking, the phases were allowed to separate and the lower aqueous phase was drained. If an emulsion persisted, another 10ml of saturated salt solution was added after draining as much of the lower phase as pos-sible without losing any emulsified material. Any water that was released was then drained. An additional 100ml of distilled water was then added to the separatory funnel,

followed by careful opening of the stopcock and gentle swirling for 5 seconds. The lower phase was discarded and the procedure repeated a second time with 100ml of distilled water. The lower phase was again drained while the upper phase was collected in a glass stoppered graduated cylinder and the volume recorded (this is volume "P" in the adjusted wet weight calculations).

For the cleanup procedure, a column was constructed by placing a glass wool plug at the base of a glass chromatographic column and by adding 20 grams (4.5 in.) of Florisil and then approximately 1/2 inch of sodium sulfate. The column was then rinsed with enough petroleum ether to enter the bulbous upper part of the glass apparatus while adjusting the flow rate on the column to approximately 5ml/min (or 1ml/12 secs). Excess petroleum ether was allowed to drain, but 1/2 inch of the solvent was left to cover the top of the column to prevent it from drying out. Before placing the extract on the column, sodium sulfate (3-5ml) was added to the glass-stoppered graduated cylinder. The graduated cylinder was then inverted and clumping of the sodium sulfate was noted. If clumping was observed more sodium sulfate was added at increments of 2-3ml (not exceeding 10ml) until alleviated. The extract and the sodium sulfate were allowed to stand between 10 and 30 minutes before putting the extractant on the column. A 10ml concentrator tube containing 5 glass beads (0.07 ml/bead) was connected to a 500ml Kuderna-Danish flask and placed under the glass col-

umn. The extractant was then poured onto the column while care was taken not to let the column go to dryness and noting the flow rate. Three aliquots (10ml) of petroleum ether were added to the empty glass-stoppered graduated cylinder for rinsing purposes before being placed onto the column. After the last 10mls of petroleum ether rinse disappeared from the top of the column, an additional 170mls of petroleum ether was added to the column. All the petroleum ether from the column was collected in the Kuderna-Danish flask.

For sample concentration, the Kuderna-Danish (K-D) flask concentrator tube was removed from the column and a three ball snyder column was placed on top of the K-D flask. The snyder column was then rinsed with a small amount of petroleum ether before placing the entire K-D flask assembly on a steam bath previously set at 75^{0}C (as the concentration proceeded, the temperature was progressively raised to 85^{0}C). The assembly was then secured with rubber bands to a wooden apparatus (Oliveira-Rusek Apparatus) that held the K-D assembly in place over the steam bath. As the petroleum ether began to boil, the apparatus was closely observed to insure that the vapors were passing freely around the balls in the snyder column in order to avoid vapor pressure build up in the K-D flask and to avoid bumping. The sample was concentrated to 5 to 10ml before removing the entire K-D assembly from the steam bath. After removal, the snyder column was rinsed with 1-2ml of petroleum ether and the concen-

trator tube was disconnected from the K-D flask when cooled. The total volume of the sample in the concentrator tube was brought to 10ml with hexane, capped with a ground glass stopper and the contents mixed. After mixing, the diluted sample was placed into an air-tight container and stored in a refrigerator until analyzed. Prior to Gas Chromatography analysis, the sample was further evaporated (in a hood) to 2-5ml, noting the final volume, for detection purposes.

PCB QUANTIFICATION AND QUALITY CONTROL: Samples were analyzed utilizing a Hewlett Packard 5890 Gas Chromatograph equipped with a Hewlett Packard 5970 Series Mass Selective Detector and a Hewlett Packard 59970 MS Chem Data Station. Separation was achieved on a Supelco (Supelco, Inc., Bellefonte, PA) Fused Silica SPB-5 Capillary Column (30M length, 0.25mm I.D., 0.25um df). Injection volume= 2ul, carrier gas= helium, oven temperature was 45^0C held for 2 minutes and programmed at 5^0C/min to 185^0C and 2^0C/min to 220^0C, injector temperature= 190^0C, detector temperature= 250^0C. Total PCB'S were calculated by comparing the combined areas of 6 major peaks found in the sample to their corresponding peak(s) in the Aroclor 1254 standard. Aroclor 1254 has been found in high abundance in the area sampled. Area counts of these peaks were obtained with an integrator. A chromatogram of a typical fish sample (MSSE86-89) and of Aroclor 1254 Standard (STD5450 at 50 ug/ml) is depicted in Figure 3.

Standards of Aroclor 1254 were obtained from Ultra Scientific Company (Hope, RI) in ampules containing 2ml of 100 ppm. The original standard was subsequently diluted to: 50 ug/ml, 25 ug/ml, 10 ug/ml and 1 ug/ml with hexane to accommodate the samples to be analyzed. A calibration curve of Aroclor 1254 standards is shown in Figure 2 (Response= 2066 * (amount) + 1269, R^2 = 0.996, Detection Limit= 0.1ug/ml).

Duplicate samples of fish were spiked with 2ml of 100 ppm Aroclor 1254, extracted and analyzed to obtain an extraction efficiency (percent recovery) for the procedure. Blanks were also extracted and analyzed to insure minimal carry over from repetitive extractions. To comply with good quality control practices; a total of 19 blanks were intermittently dispersed through the series of fish extractions, duplicate injections of each fish extract were made on the Gas Chromatograph to insure precision greater than 90% and duplicate fillets and spiked samples were extracted. Also, for the duplicate sample extractions approximately 60 grams of edible tissue was homogenized in a Waring blender, weighed out in 25-30 gram portions and subsequently extracted, and analyzed.

Several fillets were also subdivided into inside and outside portions (skin included), extracted and analyzed. To insure each fish fillet was homogeneously represented in the extraction, approximately 25 grams of edible portion (muscle and skin) was cut in 4 or 5 parallel strips along the fil-

let. The skin portion of the fillet was included in the sample to be extracted.

Data were statistically treated by analysis of variance (ANOVA) that allowed separation of the effects of size, season and location in regard to polychlorinated biphenyl contamination of Morone saxatilis. For comparisons of locality, seasonality and sex / PCB relationships a One Factor ANOVA was utilized. Contingency tables were also used for sex ratio / locality relationships. For comparisons within groups, the Scheffe F-test (a posteriori) was utilized.

CALCULATIONS:

$$\text{Standard (D)} = \frac{\text{Vol. Inj (ul) x Standard Conc. (ng/ul)}}{\text{Total peak areas per peak(s) of interest}}$$

$$\text{Sample (ug/g)} = \frac{\text{[Tot. peak areas per spl. x Standard (D)] / 1000}}{\text{Vol. inj. (ul) x } \dfrac{\text{Adjusted Biomass (Ga)}}{\text{Final vol. of sample (ml) x 1000}}}$$

$$Ga = \frac{(S)}{} \times \frac{(F)}{(T)} \times \frac{(P)}{100}$$

$$T = (S) \times (0.785) + (200-1) \quad \text{where } 0.785 = \frac{\text{Dry weight}}{\text{Wet weight}}$$

Ga = Adjusted Biomass or grams of sample placed on the Florisil column (takes into account fluid losses).

S = Grams of fish tissue originally blended.

F = Volume of extract after blending fish sample (ml).

T = Total volume after adjustments (ml).

P = Volume of extract to be placed on Florisil column (ml).

RESULTS

METHOD RELIABILITY: Spiked fillets yielded an extraction efficiency of 51.1 (Standard deviation= +/- 9.59)% for the method utilized. This mean recovery is reasonable for the method utilized. All results reported in this study were not corrected for percent recovery.

When fillets with similar weights (25-30 grams) were extracted in duplicate, the mean coefficient of variation between the resulting PCB concentrations was 8.31. When different weights (25-30 vs. 35-40 grams) were extracted in duplicate, the mean coefficient of variation between the resulting PCB concentrations was 19.2 (Table 4).

When inside vs. outside fillet portions were extracted, the outside fillets contained on an average 4.3 times the PCB concentration of the inside fillets (Range= 7.3X to 1.1X) (Table 4).

AGE MEASUREMENTS: For age determination of striped bass, a group of scales were removed from the left side of the body above the lateral line between the two dorsal fins. Scales were impressed onto a plastic slide and read via a Bausch & Lomb slide projector. Each fish was subsequently aged by counting the annular rings. Age determinations obtained from this study are listed in Table 2 along with the estimates obtained for an age-growth curve by Mansueti (1961) who aged striped bass tagged in 1957-1958 in Maryland

waters. The age range for striped bass appropriated in this study was 2 to 6 years with 3, 4 and 5 year old fish (94%) predominating. Of the 123 striped bass caught in this study, 52% were age 4 fish (Table 9). The Acushnet River yielded 70% striped bass age 3 and 4 with 4 year old fish accounting for 40% and 3 year old striped bass accounting for 30% of the total. Striped bass ranged from age 2 to age 5. In the South Dartmouth locality 92% of the fish were age 4 and 5 with 67% of these being age 4. The range was from age 3 to age 6. In Westport 92% of the striped bass caught were age 4 and 5 with a range of age 3 to age 6. Of this 92%, 57% were fish of age 4 and 35% were fish of age 5. Striped bass taken at Round Hill Point (Fall 1985) were comprised of 3 and 4 year old fish (94%) of which 78% were age 3 (range: age 2 to age 4). Fish taken by hook and line (South Dartmouth and Westport localities) amounted to 85 fish of which 96% were age 3, 4 and 5. Of this total 92% were ages 4 and 5 (Table 9).

WEIGHT / LENGTH RELATIONSHIPS: Weight vs. fork length data are presented in Figure 4. The coefficient of determination (R^2)= 0.847 for fish from the three major localities and Round HIll preliminary samples [Weight= 8.89 X (length) - 2932.691]. The fork length ranged from 337mm (13.25 inches) for the smallest fish to 673mm (26.5 inches) for the largest while the weight ranged from 591 grams (1.3 lbs.) to 4711 grams (10.4 lbs).

FREQUENCY DISTRIBUTION OF PCB LEVELS: Frequency distributions of PCB's in striped bass were obtained from all localities combined as well as from each individually. For all localities combined, PCB levels proved to be not normally distributed but skewed to the right (g_1= +3.357) and leptokurtotic (g_2= +10.991). Due to the non-normality of the distribution, all data were Log10-transformed. Negative log10 values were corrected by the addition of 1 to each PCB concentration prior to the transformation. Geometric means were calculated to reduce the significance of outlier fish on the arithmetic mean. After the transformation, skewness and kurtosis were reduced (g_1= 1.673, g_2= 1.947) but were significantly different from a normal distribution ($P< 0.001$).

The South Dartmouth locality showed a similar deviation from normality of skewness and kurtosis after Log10-transformation ($P< 0.001$). After Log10-transformation, the Westport locality showed a significant deviation from normality for skewness ($P< 0.01$) but a non-significance for kurtosis ($P< 0.50$). The Acushnet River locality showed non-significance for both skewness ($P< 0.40$) and kurtosis ($P< 0.50$) and no transformation was necessary (Table 3).

LOCALITY / SIZE RELATIONSHIPS: Considering the three localities and the preliminary Round Hill samples, there was a significant difference in lengths of fish sampled [$F(3,119)$=

29.9; P= 0.0001] (Table 5; Figure 5). Within locality groups significant differences in length were observed between the Acushnet River fish (Mean= 461mm, 18.1in) and both Westport (Mean= 532mm, 21.0in) and South Dartmouth fish (Mean= 518mm, 20.4in), and between Round Hill fish (Mean= 432mm, 17in) and both South Dartmouth and Westport fish (P< 0.05).

LOCALITY / PCB CONCENTRATION RELATIONSHIPS: The geometric mean PCB concentration for the Acushnet River was 16.5 (Standard error= 0.199) ug/g, for South Dartmouth 0.90 (Standard error= 0.064) ug/g, for Wastport 0.43 (Standard error= 0.074) ug/g and for Round Hill 0.35 (Standard error= 0.069) ug/g (Table 3).

When all localities including the preliminary samples taken at Round Hill Point in 1985 were taken into account, there was a significant correlation found [F(3,119)= 133.412; P= 0.0001] between PCB concentration and locality (Tables 6 & 7; Figure 6). Within groups there was a significance difference only between the Acushnet River and each of the other localities including the Round Hill fish (P< 0.05).

Striped bass from Round Hill Point taken in the fall of 1985 were included in this comparison even though they correspond to the same general locality as do the South Dartmouth fish taken in 1986. This was to emphasize the differences in PCB concentrations from a unique group of

fish not necessarily from a different location (Tables 6 & 7; Figure 6).

SEASONALITY / PCB CONCENTRATION RELATIONSHIPS: Seasonal separations were by monthly intervals (JUL-86, AUG-86, SEP-86, OCT-86 and NOV-86). Preliminary specimens caught during the Fall 1985 were placed in a category (NOV-85) of their own.

When analyzed separately, the Acushnet River, South Dartmouth and Westport localities yielded no significant seasonal effects of PCB concentration [$F(2,17)= 0.183$; $P= 0.8346$], [$F(2,45)= 0.046$; $P= 0.9554$] and [$F(3,33)= 1.288$; $P= 0.2947$], respectively (Figures 7, 8 and 9).

SEX / PCB CONCENTRATION RELATIONSHIPS: A total of 123 striped bass were taken from all localities and 85% of these were females (104 females vs. 19 males). The proportion of females was consistent among localities (Table 9).

No significant correlation of sex and PCB concentration was observed for striped bass when all localities including preliminary Round Hill bass were pooled [$F(1,121)= 0.612$; $P= 0.4355$]. The Acushnet River locality alone yielded a significant correlation between sex and PCB concentration [$F(1,18)= 6.948$; $P= 0.0168$] with females having a higher PCB concentration than males, 25.2 ug/g and 6.03 ug/g, respectively (Figure 10).

Sex ratio and locality relationships in this study were compared using contingency tables. The results showed no significant relationship between these two parameters [G Statistic= 0.928, Total Chi-Square= 0.972, Chi-Square (.05,3)= 7.815, P= .8081].

Contingency tables were also used when striped bass from this study were pooled and compared to 199 striped bass (females= 130, 65%) taken in the Rhode Island study (Gibson and O'Brien 1987). Sex ratio and locality relationships showed a significant difference between the two areas [G Statistic= 14.965, Total Chi-Square= 14.148, Chi-Square (.05,1)= 3.841, P= .0002].

When similar comparisons were made with 676 striped bass taken by Merriman (1941) in Long Island and New England waters where females comprised 90.3% of the catch, sex ratios were not significant [G Statistic= 3.225, Total Chi-Square= 3.536, Chi-Square (.05,1)= 3.841, P= .06].

TAGGED FISH DATA: A small female striped bass was recovered (spaghetti tag #19803) on September 21, 1986 off Westport, Massachusetts. This bass was originally captured using net gear and tagged at Croton, New York in the Hudson River on April 24, 1986. Results for this fish (MSSE86-85) showed PCB levels to be below the detectable range.

DISCUSSION

Polychlorinated biphenyls are highly lipophilic compounds that tend to accumulate in organisms through the integument (including the gills) and through dietary sources (Califano et al. 1982; Pizza and O'Connor 1983). As a result, PCB concentrations in fish depend on exposure time in contaminated waters, diet, and the water PCB concentration itself (Schimmel et al. 1974; Mauch et al. 1978; Mayer et al. 1977; Bruggeman et al. 1981; Pizza et al. 1983).

A fish such as Morone saxatilis present in a high PCB area such as the Acushnet River estuarine area can accumulate these compounds in, among other tissues, their skeletal muscles (edible fillets). The "inner" fillet contains white skeletal muscles in the form of epaxial and hypaxial myomeres located along the dorso- and ventro-lateral body wall, respectively. The "outer" fillet contains the skin and the same white muscles as the inner fillet along with a narrow band of red skeletal muscle near the surface between the epaxial and hypaxial musculature medial to the lateral line. This red muscle has a high fat content (Groman 1982). When inside vs. outside fillets were extracted and analyzed the outside fillet contained PCB concentrations up to 7 times (Mean= 4.3X, Range= 1.1 to 7.3X) that of the inner fillet.

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Westport along with the Round Hill bass ($P < 0.05$) (Tables 6 & 7; Figure 6).

Sediment and water analyses conducted by other investigators yielded PCB concentration levels highest in the inner harbor area (Area I). Sediment concentrations ranged from 1000+ ug/g near discharge sites to 2.4 ug/g Aroclor 1254 farther down river. Outer harbor (Area II) sediments ranged from 0.3 to 78 ug/g (Farrington et al. 1983; Weaver 1982). Likewise, water concentrations between the hurricane barrier and Route 195 causeway contained PCB's from 63-675 ng/l surface levels to 50-476 ng/l bottom levels (Farrington et al. 1982). With the heavy concentrations present in the Acushnet River, striped bass can bioaccumulate PCB's to levels found in this study.

The Acushnet River locality was the only site to contain mean PCB concentrations over the government regulated tolerance limit of 2 ug/g for edible portions of finfish. The mean concentration was 16.5 ug/g (not corrected for percent recovery). The arithmetic mean was 22.3 ug/g with a range of 3.2-58.4 ug/g. It is reasonable that the presence of major discharge sites in the Acushnet River accounts for these elevated PCB levels in striped bass.

Of 48 striped bass taken at South Dartmouth, only 4 bass were found to contain PCB concentrations in excess of 2 ug/g while at the Westport site, 3 of 37 fish contained PCB's over the regulated tolerance limit. The fish from these sites appear to be sufficiently isolated from the

Acushnet River and suffer less PCB contamination. Preliminary striped bass taken at Round Hill Point in the fall of 1985 contained no fish over 2 ug/g and had a geometric mean concentration of 0.35 ug/g (Tables 2 & 3).

Kolek and Ceurvels (1981) found elevated concentrations of PCB'S in fish caught inside the hurricane barrier. Levels ranged from 5.5 ppm (windowpane flounder) to 730 ppm (American eel) for bottom dwelling fish. Striped bass caught just outside the hurricane barrier (Fairhaven side) had PCB concentrations from 0.4-3.0 ppm.

As the distance from the Acushnet River increases, PCB concentrations decrease. South Dartmouth concentrations fall to a mean of 0.90 ug/g. The arithmetic mean was 1.12 ug/g (Tables 2 & 3). This is a representative sample of 48 striped bass from Area III. Bottom dwelling fish in this area contained PCB concentrations ranging from N.D. to 5.6 ppm as reported by Kolek and Ceurvels (1981). The next largest sample of 37 striped bass from Westport (Gooseberry Point and Hen & Chickens) contained a geometric mean concentration of 0.43 ug/g PCB's, about half the concentration of South Dartmouth striped bass from Area III. The arithmetic mean was 0.58 ug/g (Tables 2 & 3).

A similar situation exists in the Hudson River, New York where two manufacturing plants discharged PCB contaminated effluent into the river near Fort Edward-Hudson Falls. Local fish have been found to contain PCB concentrations

well in excess of the government regulated tolerance level of 2 ppm (Sloan and Horn 1985; Ahmed 1976).

Sloan and Horn (1986) analyzed a total of 408 striped bass collected in 1985 over 18" in length from the Hudson River for polychlorinated biphenyl contamination. Upper estuary PCB concentrations from 70 striped bass had a geometric mean of 8.52 ppm (arithmetic mean= 10.2 ppm). Lower estuary concentrations from 338 striped bass showed a mean of 3.77 ppm (arithmetic mean= 5.36 ppm). PCB levels in striped bass decline from the upper estuary waters of the Hudson River (near the discharge sites) to lower estuary waters at the mouth of the river. Sloan, Horn et al. (1986) have shown that striped bass from waters off the east end of Long Island, particularly in the fall, are less contaminated than those taken from western waters near the Hudson River mouth. In 1985, 444 striped bass were analyzed for PCB concentrations from the marine district of New York State. In the New York City harbor area, a total of 90 fish greater than 18" showed a mean PCB concentration of 2.78 ppm (arithmetic mean= 3.54 ppm). From western Long Island Sound, 179 striped bass (greater than 18") had a mean PCB concentration of 2.32 ppm (arithmetic mean= 2.77 ppm). From eastern Long Island Sound, 175 striped bass had a mean PCB concentration of 1.83 ppm (arithmetic mean= 2.17 ppm). The Long Island Sound north shore bass had lower PCB concentrations than did the Atlantic south shore bass. As the distance from the

mouth of the Hudson River increases the PCB concentrations in the fish decrease.

Rhode Island (1985) results showed a mean PCB concentration of 1.94 ppm (arithmetic mean= 2.58 ppm) from 49 striped bass. This is similar to the eastern Long Island Sound results from New York. In 1986, 51 striped bass showed a mean PCB concentration of 1.48 ppm (arithmetic mean= 2.36 ppm) (Gibson and O'Brien 1987).

Preliminary striped bass acquired during the Fall of 1985 at Round Hill Point contained mean PCB levels of 0.35 ug/g from 18 fish analyzed (Table 3). A gill net was utilized to catch these bass which were mostly females in their third year and most likely part of the 1982 year class from the Chesakeake Bay. Since all of these fish were caught so late in the season (overnight on Nov. 14-15), they were most likely migrating south from northern areas well away from the Acushnet River estuary rather than resident Buzzards Bay fish. This could account for the low PCB concentrations detected in these fish relative to other South Dartmouth specimens. Merriman (1941) reported striped bass migrations beginning in late October in the south shore waters of Long Island. These migrations peaked during the first 10 days of November.

The fact that the striped bass are such a highly migratory species poses an interesting problem for the Acushnet River specimens. The Buzzards Bay area of Massachusetts is part of the striped bass summer feeding grounds. The bass

in the Acushnet River may be a group of fish up from the Chesapeake Bay feeding for the summer months, a locally resident non-spawning but overwintering group or, more likely, a mixture of the two. At least to some degree striped bass are quite non-migratory during the summer and early fall months.

There is some evidence that striped bass have spent the entire summer in the Niantic and the Thames Rivers of Connecticut. One striped bass was seined, tagged and released in June in the Niantic River only to be recaptured on three more occasions (July, September and October) in the same river (Merriman 1941).

SEASONALITY / PCB CONCENTRATION RELATIONSHIPS: When analyzed separately each individual location including the preliminary Round Hill striped bass showed no significant seasonal effects of PCB concentration (Figures 7, 8 & 9).

Gibson & O'Brien (1987) reported no significance of PCB's between seasons within years and between years (1982-86) from striped bass taken in Rhode Island waters.

Sloan, Horn et al. (1987) reported a seasonal increase of PCB's in Hudson River striped bass taken in 1986. Upper estuary PCB concentrations from 38 fish ranged from 11.3 ppm (ppm= ug/g) in the spring (May-June) to 16.5 ppm from 36 fish in the summer (July-September). Lower estuary concentrations ranged from a mean of 3.98 ppm from 204 spring fish

(March-May) to a mean of 6.26 ppm from 53 fall fish (October-November).

The Acushnet River locality striped bass showed a steady but non-significant increase of PCB concentrations from July to September (Figure 7). These results suggest a summer resident group of striped bass in the Acushnet River accumulating PCB's from the environment.

Striped bass taken from South Dartmouth showed an increase in PCB levels during July and August and a decrease in October (Figure 8). This trend of decreasing PCB levels in October suggest late season mixing of local summer feeding striped bass with northern migrators. This mixing would tend to lower mean PCB levels in the late fall month of October.

The Westport locality showed similar non-significant trends (Figure 9). Striped bass showed a steady increase of PCB levels form July to September. October fish contained less PCB contamination while November striped bass contained still lower levels of PCB's. Late season (October & November) mixing of local summer feeding striped bass with migrating striped bass tend to decrease mean PCB levels in these months.

SEX / PCB CONCENTRATION RELATIONSHIPS: Of all striped bass taken in this study, 85% were females (104/123). This dominance continued within each of the individual localities (78-88%) (Table 9). Contingency table results yielded no

significance when sex ratios were compared to each locality including the preliminary Round Hill striped bass (P= .8081).

Interestingly, Gibson & O'Brien (1987) reported 65% female (130/199) striped bass taken in Rhode Island waters from 1982-86. Contingency table comparisons were made of pooled striped bass taken in this study and the Rhode Island striped bass. Sex ratio and locality relationships showed a significant difference between the two areas (P= .0002). This difference may be due to the influence of the Hudson River stock or perhaps to a tendancy for male fish to migrate shorter distances.

Merriman (1941) reported 90.3% females from 676 striped bass taken in Long Island and New England waters from April to November, 1936 & 1937. Contingency tables showed no significant differences (P= .06) in sex ratios when compared to pooled localities in this study at the 95% confidence level. However, these near-significant results could be attributed to differences in sample size (676 vs. 123 in this study), size range (250-1100mm vs. 337-673mm in this study) or age differences (2-12 vs. 2-6 in this study). The possibility of an increase in Hudson River male striped bass can not be ruled out due to the results reported by Gibson & O'Brien (1987).

The only significance with regard to sex and PCB concentration was seen in the Acushnet River fish where 17 females contained 25.2 ug/g PCB's while 3 males contained 6.03

g/g PCB's (P< 0.05) (Table 8; Figure 10). Since the males ere only represented by 3 fish a more substantial number of ıales was needed to make any reliable conclusions.

Round Hill Point males were the only group to contain ıigher PCB concentrations than females (0.65 ug/g vs. 0.33 ıg/g). This was largely due to one male (of 4) containing ι.3 ug/g PCB (Table 9).

ORIGINS OF STRIPED BASS: Buzzards Bay striped bass probaɔly represent a mixture of Chesapeake Bay, Hudson River and possibly Delaware River stocks. These fish migrate from their home waters, after spawning in the spring, to feeding grounds of the Cape Cod area. This mixture could also contain a locally resident non-spawning but overwintering group of striped bass. Our data shows no evidence of a bimodal frequency distribution of PCB levels that could have been useful in distinguishing fish originating from Chesapeake Bay from those of Hudson River origin.

SAFETY AND WHOLESOMENESS OF BUZZARDS BAY STRIPED BASS: The mean PCB concentration of striped bass obtained from the Acushnet River was 16.5 ug/g (arithmetic mean= 22.3 ug/g). Of the 20 fish taken from inside the hurricane barrier (Area I) all had PCB concentrations over the government regulated tolerance limit of 2 ug/g for edible portions of finfish. Levels of PCB's in other finfish caught inside the hurricane barrier by Kolek and Ceurvels (1981) ranged from 5.5 ppm to

730 ppm for bottom dwelling fish. Based on the FDA guideline, finfish including striped bass taken from this area are not wholesome and are unsafe for human consumption.

As the distance from the Acushnet River increases, PCB concentrations decrease. Of 48 striped bass taken at South Dartmouth, the mean PCB level was 0.90 ug/g (arithmetic mean= 1.12 ug/g) with only 4 bass containing levels over 2 ug/g. Kolek and Ceurvels 1981) found PCB levels ranging from 0.4-3.0 ppm (Mean= 1.65 ppm) for 8 striped bass taken just outside the hurricane barrier. The area from the hurricane barrier to South Dartmouth (Areas II & III, see Figure 1) represents a high (PCB) risk region and any fish obtained from this area are questionable as to their safety and wholesomeness as food.

Westport had a mean PCB level of 0.43 ug/g (arithmetic mean= 0.58 ug/g) from 37 striped bass taken with 3 fish exceeding 2 ug/g. This region (Area IV) is classified as a questionable (PCB risk) area for the safety and wholesomeness of edible fish.

TAGGED FISH: A small tagged female striped bass (MSSE86-85) was recovered on September 21, 1986. Results showed that this bass in its fourth year contained PCB levels below the detectable range (<0.1 ug/g). The fish was 477mm (18.8") total length at tagging and grew 82mm (3.2 in.) to 559mm (22") at recapture, a period of 5 months.

This striped bass was captured by net gear and tagged ı Croton, New York in the lower estuary of the Hudson ıver. Hudson River striped bass are known for containing :B concentrations well in excess of the government regu- ıted level (Sloan and Horn 1985; Ahmed 1976; Sloan and Horn 986).

If this striped bass contained elevated levels of PCB's n release after tagging, a period of 5 months might be nough time to have PCB's excreted sufficiently to reach on-detectable levels. Niimi et al. (1983) studied biologi- al half-lives of PCB congeners in the muscle of rainbow rout (Salmo gairdneri) at 11 +/- 10^0C and found that the average $T_{1/2}$ for most congeners in fish muscle was 76 days while the $T_{1/2}$ in whole fish was estimated to be 40-350 days for some tetrachloro- and pentachloro-biphenyls examined. It is possible, however, that species differences and tem- perature effects could result in more rapid elimination of PCB's in our specimen.

Califano et al. (1980) worked with larval striped bass and found that elimination rates of Aroclor 1254 were less than 1% after 24 hours and 18% after 48 hours. Aroclor 1254 was also lost slowly from spot, an estuarine fish, after be- ing placed in PCB-free water. After 84 days, elimination was 73% in whole fish (Hansen et al. 1971).

When Hudson River striped bass migrate from riverine nursery areas to the lower estuary and marine waters, they show a significant reduction in PCB body burden. This is

due to the reduced intake of PCB's from both water and food in coastal regions as compared to that in the riverine area (Pizza and O'Connor 1983).

The fish grew 3.2" in a period of 5 months. Mansueti (1961) found the difference between 4 and 5 year old striped bass in Maryland waters to be 3.5 inches (18.4" to 21.9" fork length) while Merriman (1941) found this same age difference to be 3.2 inches (17.7" to 20.9" fork length). Although this is a reasonable rate of growth, the bass appeared in an emaciated state at its time of capture. The stress caused by the spaghetti tag in its abdomen possibly accounted for this state. The mobilization of muscle lipids in a stressful situation could possibly depress muscle PCB levels without necessarily removing the PCB's from the body.

CONCLUSIONS

1. Fish from the Acushnet River site were the only fish found to contain a mean PCB concentration over the government regulated tolerance limit of 2 ppm (ug/g). Striped bass taken from this area were all found to be unsafe and unwholesome for food consumption. Other sites tested contained lower PCB concentrations overall. However, a number of bass taken from these sites contained concentrations over 2 ppm on an individual basis. It was established that PCB concentrations found in striped bass were negatively correlated with the distance taken from major PCB discharge sites.

2. Frequency distribution of PCB levels in striped bass was not normally distributed but skewed to the right and leptokurtotic and analyses of the data were performed on Log10-transformed values which better represented a normal distribution.

3. Very low and non-significant correlation coefficients were obtained when fork lengths were compared to PCB concentrations for all localities including the preliminary Round Hill samples.

4. There was a significant difference in fork length of fish from the different sampling methods. Striped bass taken via gill nets were found to be significantly different in size from bass taken via hook & line. PCB concentrations are more affected by the locality the fish were collected

from than by size. We suspect that only when localities are far enough removed from a pollution source does the importance of size increase.

5. When analyzed separately, each individual locality yielded no significant seasonal effects of PCB concentration, however, there appeared to be an overall trend of increasing PCB concentrations from July through September followed by a decrease in concentrations from October through November.

6. Of all striped bass taken, 85% were females. The only significant correlation between sex and PCB concentration was observed in the Acushnet River where females contained 4 times the PCB levels of male *Morone saxatilis*.

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TABLE 1. Preliminary data for Striped Bass.

SPECIMEN NUMBER	WEIGHT GRAMS	LENGTH FRK MM (INCH)	LENGTH TOT MM (INCH)	SEX
MSFA85-1	908	457 (18)	483 (19)	MALE
MSFA85-2	899	483 (19)	508 (20)	FEMALE
MSFA85-3	925	432 (17)	457 (18)	FEMALE
MSFA85-4	1015	445 (17.5)	470 (18.5)	FEMALE
MSFA85-5	1024	438 (17.25)	464 (18.25)	MALE
MSFA85-6	1171	483 (19)	508 (20)	FEMALE
MSFA85-7	761	406 (16)	432 (17)	FEMALE
MSFA85-8	867	419 (16.5)	445 (17.5)	FEMALE
MSFA85-9	701	400 (15.75)	425 (16.75)	FEMALE
MSFA85-10	952	445 (17.5)	470 (18.5)	FEMALE
MSFA85-11	829	419 (16.5)	445 (17.5)	FEMALE
MSFA85-12	1492	495 (19.5)	533 (21)	FEMALE
MSFA85-13	1044	432 (17)	457 (18)	FEMALE
MSFA85-14	810	406 (16)	432 (17)	FEMALE
MSFA85-15	998	432 (17)	457 (18)	FEMALE
MSFA85-16	713	406 (16)	432 (17)	MALE*
MSFA85-17	695	381 (15)	406 (16)	FEMALE
MSFA85-18	787	394 (15.5)	419 (16.5)	MALE
MSFA85-19	1086	457 (18)	483 (19)	MALE
MSFA85-20	1014	457 (18)	483 (19)	FEMALE
MSFA85-21	2005	546 (21.5)	584 (23)	FEMALE
MSFA85-22	870	406 (16)	432 (17)	FEMALE
MSFA85-23	1150	470 (18.5)	495 (19.5)	FEMALE
MSFA85-24	988	445 (17.5)	476 (18.75)	FEMALE
MSFA85-25	993	432 (17)	464 (18.25)	FEMALE
MSFA85-26	1358	495 (19.5)	521 (20.5)	FEMALE
MSFA85-27	1014	445 (17.5)	470 (18.5)	FEMALE
MSFA85-28	1044	438 (17.25)	464 (18.25)	FEMALE
MSFA85-29	936	445 (17.5)	470 (18.5)	FEMALE
MSFA85-30	921	406 (16)	438 (17.25)	FEMALE
MSFA85-31	904	419 (16.5)	445 (17.5)	MALE
MSFA85-32	1169	457 (18)	483 (19)	FEMALE
MSFA85-33	678	394 (15.5)	419 (16.5)	FEMALE
MSFA85-34	1372	483 (19)	508 (20)	FEMALE
MSFA85-35	979	438 (17.25)	470 (18.5)	MALE
MSFA85-36	979	438 (17.25)	464 (18.25)	FEMALE
MSFA85-37	839	413 (16.25)	445 (17.5)	FEMALE
MSJL86-38	1250	457 (18)	483 (19)	FEMALE
MSJL86-39	1737	546 (21.5)	559 (22)	FEMALE
MSJL86-40	1872	521 (20.5)	552 (21.75)	FEMALE
MSJL86-41	1942	533 (21)	572 (22.5)	FEMALE
MSJL86-42	1588	508 (20)	533 (21)	FEMALE
MSJL86-43	1636	508 (20)	540 (21.25)	FEMALE
MSJL86-44	1443	489 (19.25)	508 (20)	MALE
MSJL86-45	1430	483 (19)	502 (19.75)	FEMALE
MSJL86-46	1574	514 (20.25)	533 (21)	FEMALE

ABLE 1. Cont. Preliminary data for Striped Bass.

PECIMEN NUMBER	WEIGHT GRAMS	LENGTH FRK MM (INCH)	LENGTH TOT MM (INCH)	SEX
SJL86-47	1606	521 (20.5)	546 (21.5)	FEMALE
SJL86-48	1745	527 (20.75)	552 (21.75)	FEMALE
SJL86-49	1581	514 (20.25)	533 (21)	FEMALE
SJL86-50	1351	483 (19)	508 (20)	FEMALE
SJL86-51	921	419 (16.5)	432 (17)	FEMALE
SJU86-52	1376	483 (19)	508 (20)	FEMALE
SJL86-53	1084	457 (18)	470 (18.5)	FEMALE
SJL86-54	1798	533 (21)	552 (21.75)	FEMALE
SAU86-55	983	432 (17)	451 (17.75)	FEMALE
SAU86-56	1073	445 (17.5)	470 (18.5)	FEMALE
SAU86-57	765	406 (16)	432 (17)	FEMALE
SAU86-58	1318	476 (18.75)	495 (19.5)	FEMALE
SAU86-59	1036	445 (17.5)	470 (18.5)	FEMALE
SAU86-60	607	337 (13.25)	356 (14)	FEMALE
SAU86-61	1385	483 (19)	508 (20)	FEMALE
SAU86-62	2354	559 (22)	584 (23)	FEMALE
SAU86-63	1743	533 (21)	546 (21.5)	FEMALE
SAU86-64	1367	495 (19.5)	521 (20.5)	FEMALE
SAU86-65	1068	457 (18)	476 (18.75)	MALE
SAU86-66	1545	521 (20.5)	546 (21.5)	FEMALE
SAU86-67	2174	565 (22.25)	584 (23)	MALE
SAU86-68	1380	483 (19)	502 (19.75)	MALE
SAU86-69	591	375 (14.75)	394 (15.5)	MALE
SAU86-70	758	400 (15.75)	425 (16.75)	FEMALE
SAU86-71	2468	584 (23)	610 (24)	FEMALE
SSE86-72	1495	521 (20.5)	552 (21.75)	FEMALE
SSE86-73	1928	552 (21.75)	584 (23)	FEMALE
SSE86-74	2113	572 (22.5)	610 (24)	FEMALE
SSE86-75	1445	502 (19.75)	533 (21)	MALE
SSE86-76	1623	540 (21.25)	565 (22.25)	FEMALE
SSE86-77	1522	514 (20.25)	552 (21.75)	MALE
SSE86-78	2061	572 (22.5)	610 (24)	FEMALE
SSE86-79	1880	572 (22.5)	610 (24)	FEMALE
SSE86-80	2265	565 (22.25)	597 (23.5)	FEMALE
SSE86-81	1861	552 (21.75)	584 (23)	FEMALE
SSE86-82	1845	546 (21.5)	584 (23)	FEMALE
SSE86-83	1877	552 (21.75)	584 (23)	FEMALE
SSE86-84	1365	489 (19.25)	533 (21)	MALE
SSE86-85	1769	533 (21)	559 (22)	FEMALE
SSE86-86	1550	508 (20)	533 (21)	FEMALE
SSE86-87	1518	508 (20)	533 (21)	FEMALE
SSE86-88	1274	464 (18.25)	489 (19.25)	MALE
SSE86-89	1551	495 (19.5)	521 (20.5)	FEMALE
SSE86-90	1508	514 (20.25)	546 (21.5)	FEMALE
SSE86-91	1121	476 (18.75)	502 (19.75)	FEMALE
SOC86-92	1105	457 (18)	470 (18.5)	MALE
SOC86-93	1152	495 (19.5)	508 (20)	FEMALE

TABLE 1. Cont. Preliminary data for Striped Bass.

SPECIMEN NUMBER	WEIGHT GRAMS	LENGTH FRK MM (INCH)	LENGTH TOT MM (INCH)	SEX
MSOC86-94	1046	457 (18)	483 (19)	FEMALE
MSOC86-95	1310	495 (19.5)	521 (20.5)	FEMALE
MSOC86-96	1532	521 (20.5)	546 (21.5)	FEMALE
MSOC86-97	1546	514 (20.25)	540 (21.25)	FEMALE
MSOC86-98	1252	483 (19)	495 (19.5)	FEMALE
MSOC86-99	2189	597 (23.5)	622 (24.5)	FEMALE
MSOC86-100	1563	521 (20.5)	552 (21.75)	FEMALE
MSOC86-101	1612	533 (21)	559 (22)	FEMALE
MSOC86-102	1691	559 (22)	584 (23)	FEMALE
MSOC86-103	1244	483 (19)	508 (20)	MALE
MSOC86-104	2241	597 (23.5)	622 (24.5)	FEMALE
MSOC86-105	2577	622 (24.5)	648 (25.5)	MALE
MSOC86-106	2644	610 (24)	635 (25)	FEMALE
MSOC86-107	2832	622 (24.5)	648 (25.5)	FEMALE
MSOC86-108	1476	495 (19.5)	521 (20.5)	FEMALE
MSOC86-109	1579	521 (20.5)	546 (21.5)	FEMALE
MSOC86-110	1359	514 (20.25)	540 (21.25)	FEMALE
MSOC86-111	1320	476 (18.75)	508 (20)	FEMALE
MSOC86-112	1270	483 (19)	508 (20)	FEMALE
MSOC86-113	1655	514 (20.25)	552 (21.75)	MALE
MSOC86-114	997	438 (17.25)	470 (18.5)	FEMALE
MSOC86-115	1118	457 (18)	489 (19.25)	FEMALE
MSOC86-116	1426	508 (20)	540 (21.25)	FEMALE
MSOC86-117	1184	457 (18)	483 (19)	FEMALE
MSOC86-118	1277	476 (18.75)	508 (20)	FEMALE
MSNO86-119	1765	508 (20)	533 (21)	FEMALE
MSNO86-120	1780	521 (20.5)	546 (21.5)	FEMALE
MSNO86-121	1801	546 (21.5)	565 (22.25)	FEMALE
MSNO86-122	2308	584 (23)	610 (24)	FEMALE
MSNO86-123	1586	502 (19.75)	527 (20.75)	MALE
MSNO86-124	1385	470 (18.5)	495 (19.5)	FEMALE
MSNO86-125	1098	445 (17.5)	464 (18.25)	FEMALE
MSOC86-126	1642	533 (21)	-	FEMALE
MSOC86-127	1557	521 (20.5)	-	FEMALE'
MSOC86-128	2095	572 (22.5)	-	FEMALE
MSJL86-129	1133	489 (19.25)	-	FEMALE
MSJL86-130	2039	572 (22.5)	-	FEMALE
MSAU86-131	1359	521 (20.5)	-	FEMALE
MSAU86-132	1416	495 (19.5)	-	FEMALE
MSAU86-133	1557	495 (19.5)	-	FEMALE
MSAU86-134	1076	483 (19)	-	FEMALE
MSAU86-135	1670	521 (20.5)	-	FEMALE
MSJL86-136	1925	521 (20.5)	-	FEMALE
MSJL86-137	1133	438 (17.25)	-	MALE
MSJL86-138	1993	540 (21.25)	-	MALE
MSJL86-139	1925	521 (20.5)	-	FEMALE
MSJL86-140	2492	584 (23)	-	FEMALE

ABLE 1. CONT. Preliminary data for Striped Bass.

SPECIMEN NUMBER	WEIGHT GRAMS	LENGTH FRK MM (INCH)	LENGTH TOT MM (INCH)	SEX
MSJL86-141	2039	533 (21)	-	FEMALE
MSJL86-142	1631	495 (19.5)	-	FEMALE
MSJU86-143	1586	495 (19.5)	-	FEMALE
MSAU86-144	1529	521 (20.5)	-	FEMALE
MSAU86-145	1586	508 (20)	-	FEMALE
MSJL86-146	4711	673 (26.5)	-	FEMALE
MSJL86-147	1699	527 (20.75)	-	FEMALE
MSAU86-148	2010	559 (22)	-	FEMALE

TABLE 2. Catch dates, localities, age determinations and PCB concentrations (ug/g) of striped bass.

SPECIMEN	CATCH DATE	LOCALITY	MANSUETI 1961[a]	PRESENT STUDY	PCB'S
MSFA85-1	11/15/1985	ROUND HILL	4+	4+	0.7
MSFA85-2	11/15/1985	ROUND HILL	4+	3+	0.6*
MSFA85-3	11/15/1985	ROUND HILL	3+	3	1.2
MSFA85-4	11/15/1985	ROUND HILL	3+	3+	N.D.
MSFA85-5	11/15/1985	ROUND HILL	4+	4+	1.3
MSFA85-6	11/15/1985	ROUND HILL	4+	3+	N.D.
MSFA85-7	11/15/1985	ROUND HILL	3+	3+	N.D.
MSFA85-8	11/15/1985	ROUND HILL	3+	3	N.D.
MSFA85-9	11/15/1985	ROUND HILL	3+	3	N.D.
MSFA85-10	11/15/1985	ROUND HILL	3+	3+	0.8
MSFA85-11	11/15/1985	ROUND HILL	3+	3	0.1
MSFA85-12	11/15/1985	ROUND HILL	4+	3+	0.3
MSFA85-13	11/15/1985	ROUND HILL	3+	3	0.5
MSFA85-14	11/15/1985	ROUND HILL	3+	3	N.D.
MSFA85-15	11/15/1985	ROUND HILL	3+	3	0.3
MSFA85-16	11/15/1985	ROUND HILL	3+	4	0.3**
MSFA85-17	11/15/1985	ROUND HILL	2+	2+	0.8
MSFA85-18	11/15/1985	ROUND HILL	3+	3+	0.3
MSFA85-19	11/15/1985	ROUND HILL	4+	4+	N.A.
MSFA85-20	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-21	11/15/1985	ROUND HILL	4+	5	N.A.
MSFA85-22	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-23	11/15/1985	ROUND HILL	4+	4+	N.A.
MSFA85-24	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-25	11/15/1985	ROUND HILL	3+	4+	N.A.
MSFA85-26	11/15/1985	ROUND HILL	4+	3+	N.A.
MSFA85-27	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-28	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-29	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-30	11/15/1985	ROUND HILL	3+	4+	N.A.
MSFA85-31	11/15/1985	ROUND HILL	3+	4+	N.A.
MSFA85-32	11/15/1985	ROUND HILL	3+	5+	N.A.
MSFA85-33	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-34	11/15/1985	ROUND HILL	4+	4+	N.A.
MSFA85-35	11/15/1985	ROUND HILL	3+	4	N.A.
MSFA85-36	11/15/1985	ROUND HILL	3+	3+	N.A.
MSFA85-37	11/15/1985	ROUND HILL	3+	2+	N.A.
MSJL86-38	7/10/1986	WESTPORT	3+	4+	0.5*
MSJL86-39	7/15/1986	SO. DART.	3+	5	0.8
MSJL86-40	7/15/1986	SO. DART.	3+	4+	1.0
MSJL86-41	7/15/1986	SO. DART.	4+	4+	0.7
MSJL86-42	7/15/1986	SO. DART.	4+	4+	0.7
MSJL86-43	7/15/1986	SO. DART.	4+	4+	1.7
MSJL86-44	7/16/1986	SO. DART.	4+	4+	1.1
MSJL86-45	7/16/1986	SO. DART.	4+	4+	0.8

TABLE 2. Cont. Catch dates, localities, age determinations and PCB concentrations (ug/g) of striped bass.

SPECIMEN	CATCH DATE	LOCALITY	MANSUETI 1961	PRESENT STUDY	PCB'S
MSJL86-46	7/29/1986	SO. DART.	4+	4+	1.3
MSJL86-47	7/29/1986	SO. DART.	4+	4+	0.4
MSJL86-48	7/29/1986	SO. DART.	4+	4+	0.4
MSJL86-49	7/29/1986	SO. DART.	4+	4+	0.2
MSJL86-50	7/29/1986	SO. DART.	4+	4+	1.6*
MSJL86-51	7/24/1986	ACUSHNET R.	3+	3+	10.1
MSJL86-52	7/24/1986	ACUSHNET R.	4+	4+	13.6
MSJL86-53	7/31/1986	ACUSHNET R.	3+	4+	35.6
MSJL86-54	7/31/1986	ACUSHNET R.	4+	4+	6.7
MSAU86-55	8/02/1986	ACUSHNET R.	3+	3+	25.5
MSAU86-56	8/02/1986	ACUSHNET R.	3+	3+	46.5
MSAU86-57	8/02/1986	ACUSHNET R.	3+	2+	6.9
MSAU86-58	8/02/1986	ACUSHNET R.	4+	3+	41.2
MSAU86-59	8/02/1986	ACUSHNET R.	3+	3+	4.3
MSAU86-60	8/02/1986	ACUSHNET R.	2+	2+	14.2
MSAU86-61	8/04/1986	ACUSHNET R.	4+	3+	47.3
MSAU86-62	8/05/1986	SO. DART.	5+	5+	2.1
MSAU86-63	8/05/1986	SO. DART.	4+	5	0.4
MSAU86-64	8/05/1986	SO. DART.	4+	4	1.5
MSAU86-65	8/05/1986	SO. DART.	4+	5	1.1
MSAU86-66	8/05/1986	SO. DART.	4+	4+	0.5*
MSAU86-67	8/05/1986	SO. DART.	5+	5+	1.0*
MSAU86-68	8/06/1986	ACUSHNET R.	4+	4+	4.7*
MSAU86-69	8/06/1986	ACUSHNET R.	2+	2+	3.2*
MSAU86-70	8/02/1986	ACUSHNET R.	3+	2+	17.4
MSAU86-71	8/02/1986	ACUSHNET R.	5+	4+	58.4
MSSE86-72	9/21/1986	WESTPORT	4+	4+	N.D.
MSSE86-73	9/21/1986	WESTPORT	4+	4+	2.7
MSSE86-74	9/21/1986	WESTPORT	5+	5	1.1
MSSE86-75	9/21/1986	WESTPORT	5+	5+	0.3
MSSE86-76	9/21/1986	WESTPORT	4+	4+	N.D.
MSSE86-77	9/21/1986	WESTPORT	5+	5+	N.D.
MSSE86-78	9/21/1986	WESTPORT	5+	4+	N.D.
MSSE86-79	9/21/1986	WESTPORT	5+	5+	1.0
MSSE86-80	9/21/1986	WESTPORT	5+	4+	3.9
MSSE86-81	9/21/1986	WESTPORT	4+	4+	1.3
MSSE86-82	9/21/1986	WESTPORT	4+	5+	2.3
MSSE86-83	9/21/1986	WESTPORT	4+	4+	0.3
MSSE86-84	9/21/1986	WESTPORT	4+	5	N.D.
MSSE86-85	9/21/1986	WESTPORT	4+	4+	N.D.
MSSE86-86	9/21/1986	WESTPORT	4+	5	1.1
MSSE86-87	9/24/1986	ACUSHNET R.	4+	5	28.9
MSSE86-88	9/24/1986	ACUSHNET R.	4+	4+	10.2
MSSE86-89	9/24/1986	ACUSHNET R.	4+	5	40.1
MSSE86-90	9/29/1986	ACUSHNET R.	4+	4+	12.0
MSSE86-91	9/29/1986	ACUSHNET R.	4+	4+	19.9

E 2. Cont. Catch dates, localities, age determinations and PCB concentrations (ug/g) of striped bass

IMEN	CATCH DATE	LOCALITY	MANSUETI 1961	PRESENT STUDY	PCB'S
86-92	10/04/1986	SO. DART.	4+	4+	1.1
86-93	10/04/1986	SO. DART.	4+	4+	0.6*
86-94	10/04/1986	SO. DART.	3+	4+	0.5*
86-95	10/04/1986	SO. DART.	4+	4	0.2
86-96	10/04/1986	SO. DART.	4+	4+	6.5
86-97	10/04/1986	SO. DART.	4+	4+	1.7
86-98	10/04/1986	SO. DART.	4+	4+	0.4
C86-99	10/04/1986	SO. DART.	5+	4+	0.9
C86-100	10/04/1986	SO. DART.	4+	4+	0.3
C86-101	10/04/1986	SO. DART.	4+	5	1.2
C86-102	10/04/1986	SO. DART.	5+	5	0.4
C86-103	10/04/1986	SO. DART.	4+	4+	1.2
C86-104	10/04/1986	SO. DART.	5+	5	1.0*
C86-105	10/04/1986	SO. DART.	6+	6	0.9*
C86-106	10/13/1986	WESTPORT	5+	5+	N.D.
C86-107	10/13/1986	WESTPORT	5+	6	N.D.
C86-108	10/13/1986	WESTPORT	4+	4+	1.3*
C86-109	10/13/1986	WESTPORT	4+	4+	N.D.
C86-110	10/19/1986	SO. DART.	4+	4+	0.3
C86-111	10/19/1986	SO. DART.	4+	3+	0.2
C86-112	10/19/1986	SO. DART.	4+	3+	N.D.
C86-113	10/19/1986	SO. DART.	5+	5	N.A.
C86-114	10/19/1986	SO. DART.	3+	4	N.A.
C86-115	10/19/1986	SO. DART.	3+	4+	N.A.
C86-116	10/19/1986	SO. DART.	4+	4+	N.A.
C86-117	10/19/1986	SO. DART.	3+	3+	N.A.
C86-118	10/19/1986	SO. DART.	4+	4	N.A.
NO86-119	11/11/1986	WESTPORT	4+	4+	0.5
NO86-120	11/11/1986	WESTPORT	4+	5	0.4
NO86-121	11/11/1986	WESTPORT	4+	4+	N.D.
NO86-122	11/11/1986	WESTPORT	5+	5	N.D.
NO86-123	11/11/1986	WESTPORT	5+	5+	N.D.
NO86-124	11/11/1986	WESTPORT	4+	4+	0.3
NO86-125	11/11/1986	WESTPORT	3+	3+	0.2
OC86-126	10/04/1986	SO. DART.	4+	4+	7.4
OC86-127	10/04/1986	SO. DART.	4+	4+	0.3*
OC86-128	10/04/1986	SO. DART.	5+	4+	0.8
JL86-129	7/22/1986	SO. DART.	4+	4+	0.8*
JL86-130	7/22/1986	SO. DART.	5+	5+	1.1*
AU86-131	8/03/1986	SO. DART.	4+	5	N.D.
AU86-132	8/03/1986	SO. DART.	4+	5	1.4
SAU86-133	8/31/1986	SO. DART.	4+	4+	0.7*
SAU86-134	8/31/1986	SO. DART.	4+	3+	1.4**
SAU86-135	8/31/1986	SO. DART.	4+	4+	N.D.

TABLE 2. CONT. Catch dates, localities, age determinations and PCB concentrations (ug/g) of striped bass.

SPECIMEN	CATCH DATE	LOCALITY	MANSUETI 1961	PRESENT STUDY	PCB'S
MSJL86-136	7/04/1986	WESTPORT	4+	4+	N.D.
MSJL86-137	7/12/1986	WESTPORT	4+	4+	0.5*
MSJL86-138	7/12/1986	WESTPORT	5+	5+	1.1
MSJL86-139	7/12/1986	WESTPORT	4+	4+	0.6
MSJL86-140	7/12/1986	WESTPORT	5+	5+	N.D.
MSJL86-141	7/12/1986	WESTPORT	4+	4+	0.3
MSJL86-142	7/12/1986	WESTPORT	4+	4+	N.D.
MSJL86-143	7/12/1986	WESTPORT	4+	4+	N.D.
MSAU86-144	8/31/1986	SO. DART.	4+	4+	0.8
MSAU86-145	8/31/1986	SO. DART.	4+	4+	2.2*
MSJL86-146	7/12/1986	WESTPORT	6+	6+	1.6
MSJL86-147	7/04/1986	WESTPORT	4+	4+	0.3*
MSAU86-148	8/31/1986	SO. DART.	5+	5+	1.9

@ Estimated from age/growth curve of Mansueti 1961.
* Mean of 3 injections.
** Mean of 4 injections.
N.A. Samples not analyzed.
N.D. Not Detected. Detection Limit = 0.1 ug/g.

TABLE 3. Polychlorinated biphenyl concentration statistical parameters for all localities and Round Hill bass (non-transformed data). Concentrations in ug/g are not corrected for extraction efficiency or for experimental precision.

Statistical Parameter	Acushnet River	South Dartmouth	Westport	Round Hill
Fish Analyzed	20	48	37	18
Geometric Mean	16.5	0.90	0.43	0.35
Std. Error Geometric Mean	0.199	0.064	0.074	0.069
Arithmetic Mean	22.3	1.12	0.58	0.40
Std. Dev.	16.97	1.349	0.874	0.420
Std. Error	3.79	0.195	0.144	0.099
Variance	287.90	1.819	0.764	0.176
Coef. Var.	75.97	121.01	149.742	105.021
Maximum	58.4	7.4	3.9	1.3
Minimum	3.2	<0.1	<0.1	<0.1
Range	55.2	7.4	3.9	1.3
t-95%	7.94	0.392	0.291	0.209
95% Upper	30.28	1.506	0.875	0.609
95% Lower	14.39	0.723	0.292	0.191
Skewness	g_1= 0.659	g_1= 3.479	g_1= 2.104	
Transformed	N.A.	g_1= 1.43	g_1= 1.16	
Kurtosis	g_2= -0.861	g_2= 12.856	g_2= 4.501	
Transformed	N.A.	g_2= 3.433	g_2= 0.544	

LE 4. Duplicate extraction results of striped bass fillets with similar weights, different weights and inside versus outside fillets.

LETS WITH SIMILAR WEIGHTS (25-30 GRAMS):

SAMPLE NUMBER	EXTRACTION WEIGHT	PCB CONTENT	COEFFICIENT OF VARIATION
MSAU86-70	25.21 grams	17.4 ug/g	21.7
MAAU86-70	25.11 grams	11.2 ug/g	
MSSE86-89	25.16 grams	44.2 ug/g	0.79
MSSE86-89	25.16 grams	44.9 ug/g	
MSSE86-90	25.22 grams	12.0 ug/g	2.44
MSSE86-90	24.69 grams	12.6 ug/g	

MEAN COEFFICIENT OF VARIATION= 8.31

LETS WITH DIFFERENT WEIGHTS (25-30 / 35-40 GRAMS):

MSAU86-71	25.30 grams	52.1 ug/g	0.38
MSAU86-71	36.40 grams	52.5 ug/g	
MSSE86-87	25.14 grmas	28.9 ug/g	36.3
MSSE86-87	36.48 grams	61.9 ug/g	
MSSE86-88	25.04 grams	10.2 ug/g	20.9
MSSE86-88	37.08 grams	15.6 ug/g	

MEAN COEFFICIENT OF VARIATION= 19.2

SIDE VERSUS OUTSIDE FILLETS:

SAMPLE NUMBER	INSIDE FILLET PCB CONTENT	OUTSIDE FILLET PCB CONTENT	DIFFERENCE FACTOR
MSAU86-70	3.4 ug/g	24.8 ug/g	7.3
MSSE86-87	41.5 ug/g	45.2 ug/g	1.1
MSSE86-89	8.6 ug/g	43.0 ug/g	5.0
MSOC86-126	1.6 ug/g	6.2 ug/g	3.9

MEAN DIFFERENCE FACTOR= 4.3

TABLE 5. One Factor ANOVA: X1: Locality X2: Fk Length (inches). All localities and Round Hill bass.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-ratio
Among groups	3	262.328	87.443	29.861
Within groups	119	348.466	2.928	p=.0001
Total	122	610.794		

Group	Count	Mean	St. Dev.	St. Error
Acushnet	20	18.138	2.237	0.5
Westport	37	20.959	1.889	0.311
Round Hill	18	17	1.263	0.298
So. Dartmouth	48	20.401	1.443	0.208

Comparison	Mean Difference	Scheffe F-test
Acushnet vs. Westport	-2.822	11.769*
Acushnet vs. Round Hill	1.138	1.395
Acushnet vs. So. Dartmouth	-2.264	8.234*
Westport vs. Round Hill	3.959	21.61*
Westport vs. So. Dartmouth	0.558	0.742
Round Hill vs. So. Dartmouth	-3.401	17.237*

* Significant at 95%

TABLE 6. One Factor ANOVA: X1: Locality X2: Log(1+x)PCB Concentration. All Localities and Round Hill bass.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-ratio
Among groups	3	18.42	6.14	133.412
Within groups	119	5.477	0.046	p=.0001
Total	122	23.897		

Group	Count	Mean	St. Dev.	St. Error
Acushnet	20	1.243	0.354	0.079
Westport	37	0.154	0.186	0.031
Round Hill	18	0.129	0.123	0.029
So. Dartmouth	48	0.278	0.184	0.027

Comparison	Mean Difference	Scheffe F-test
Acushnet vs. Westport	1.089	111.474*
Acushnet vs. Round Hill	1.114	85.172*
Acushnet vs. So. Dartmouth	0.966	95.33*
Westport vs. Round Hill	0.025	0.056
Westport vs. So. Dartmouth	-0.123	2.299
Round Hill vs. So. Dartmouth	-0.149	2.093

* Significance at 95%

TABLE 7. One Factor ANOVA: X1: Locality X2: PCB Concentration (non-transformed). All localities and Round Hill bass.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-ratio
Among groups	3	7777.034	2592.345	55.225
Within groups	119	5586.076	46.942	p=.0001
Total	122	13363.11		

Group	Count	Mean	St. Dev.	St. Error
Acushnet	20	22.335	16.968	3.794
Westport	37	0.584	0.874	0.144
Round Hill	18	0.4	0.42	0.099
So. Dartmouth	48	1.115	1.349	0.195

Comparison	Mean Difference	Scheffe F-test
Acushnet vs. Westport	21.751	43.616*
Acushnet vs. Round Hill	21.935	32.368*
Acushnet vs. So. Dartmouth	21.22	45.143*
Westport vs. Round Hill	0.184	0.003
Westport vs. So. Dartmouth	-0.531	0.042
Round Hill vs. So. Dartmouth	-0.715	0.047

* Significant at 95%

TABLE 8. One Factor ANOVA: X1: Sex X2: Log(1+x)PCB Concentration. Acushnet River locality.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-ratio
Among groups	1	0.664	0.664	6.948
Within groups	18	1.72	0.096	p=.0168
Total	19	2.384		

Group	Count	Mean	St. Dev.	St. Error
Male	3	0.809	0.218	0.126
Female	17	1.32	0.319	0.077

Comparison	Mean Difference	Scheffe F-test
Male vs. Female	-0.51	6.948*

* Significant at 95%

TABLE 9. Mean PCB concentrations, Standard Deviations, Ranges and age parameters for both sexes in each locality and Round Hill bass (ug/g).

SEX	ACUSHNET RIVER	SOUTH DARTMOUTH	WESTPORT	ROUND HILL	
Male	N = 3	N = 6	N = 6	N = 4	
Mean	6.03	1.07	0.32	0.65	
Std.Error	1.737	0.038	0.163	0.205	
Range	3.2-10.2	0.9-1.2	<0.1-1.1	0.3-1.3	
% Male	15	12	16	22	
Female	N = 17	N = 42	N = 31	N = 14	
Mean	25.2	1.12	0.64	0.33	
Std.Error	3.948	0.220	0.165	0.101	
Range	4.3-58.4	<0.1-7.4	<0.1-3.9	<0.1-1.2	
% Female	85	88	84	78	
					TOTALS
Age 2	4	0	0	1	5
Age 3	6	3	1	14	24
Age 4	8	32	21	3	64
Age 5	2	12	13	0	27
Age 6	0	1	2	0	3
Totals	20	48	37	18	123

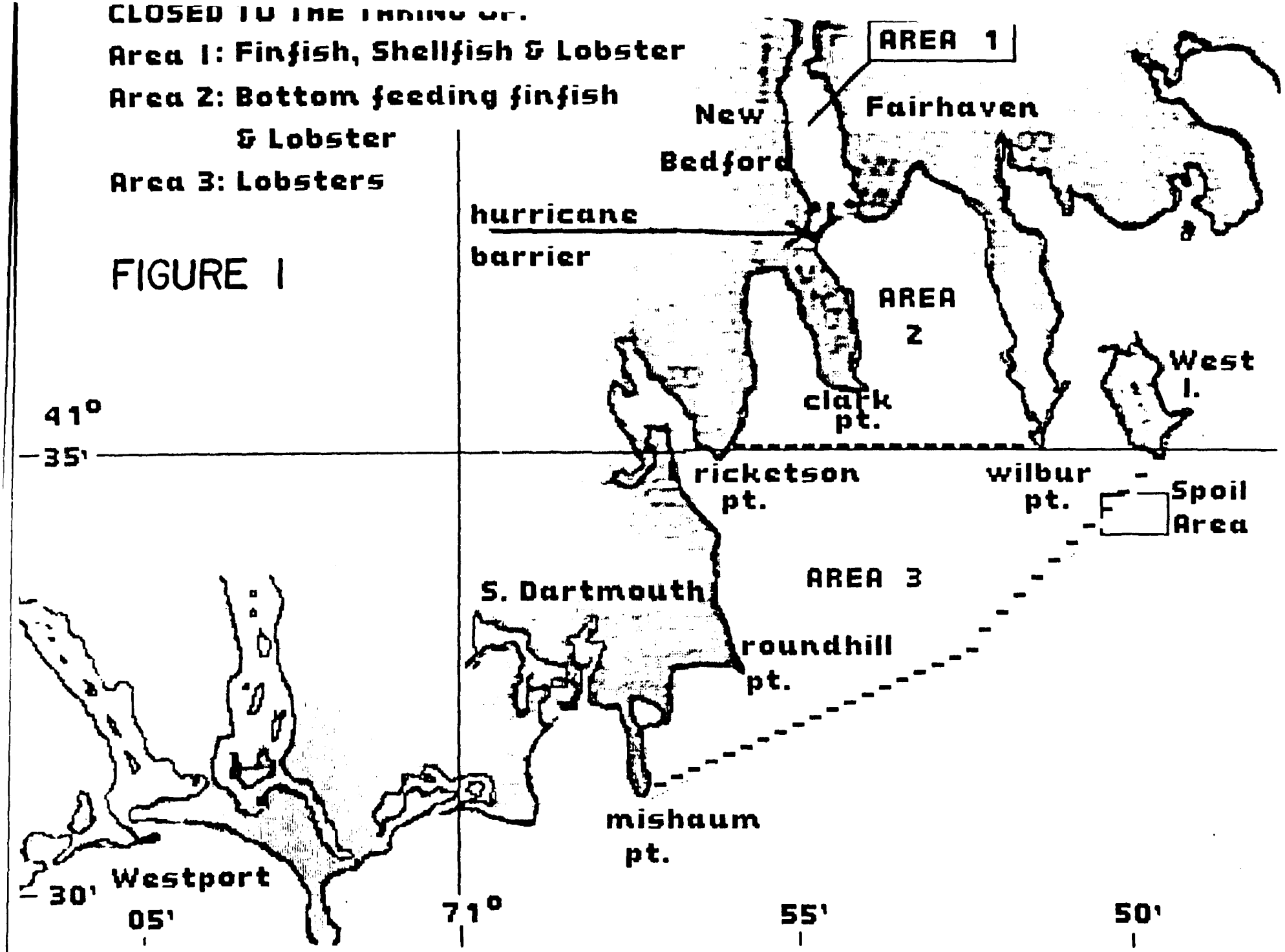
CLOSED TO THE TAKING OF:

Area 1: Finfish, Shellfish & Lobster

Area 2: Bottom feeding finfish & Lobster

Area 3: Lobsters

FIGURE 1



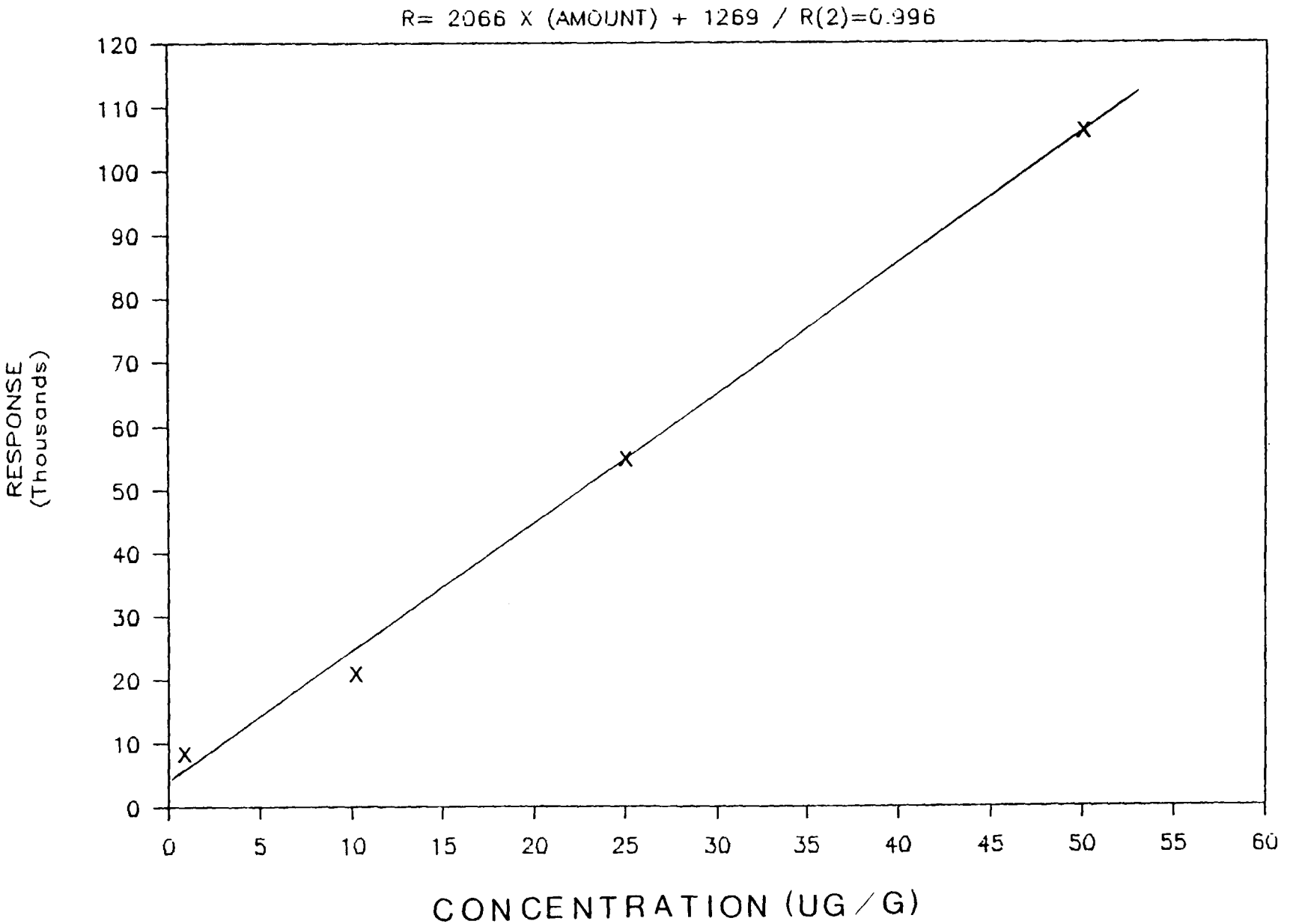
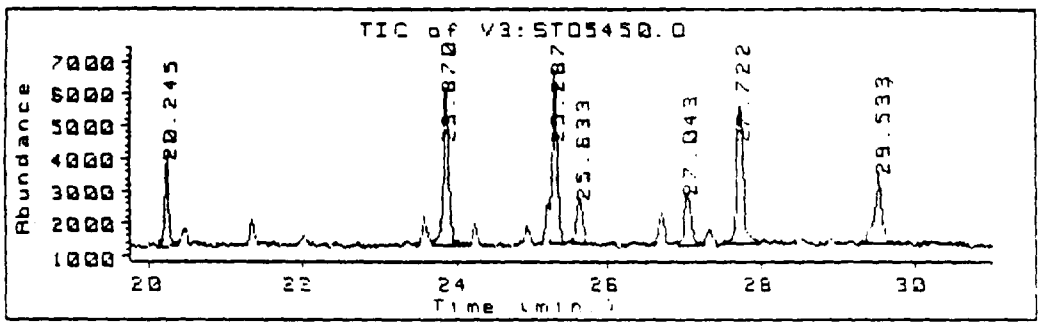
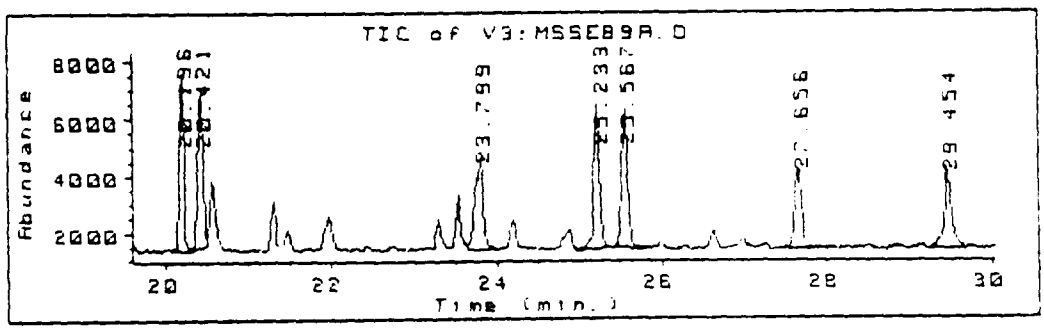

R= 2066 X (AMOUNT) + 1269 / R(2)=0.996
RESPONSE (Thousands)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
5
10
15
20
25
30
35
40
45
50
55
60
CONCENTRATION (UG/G)

FIGURE 2

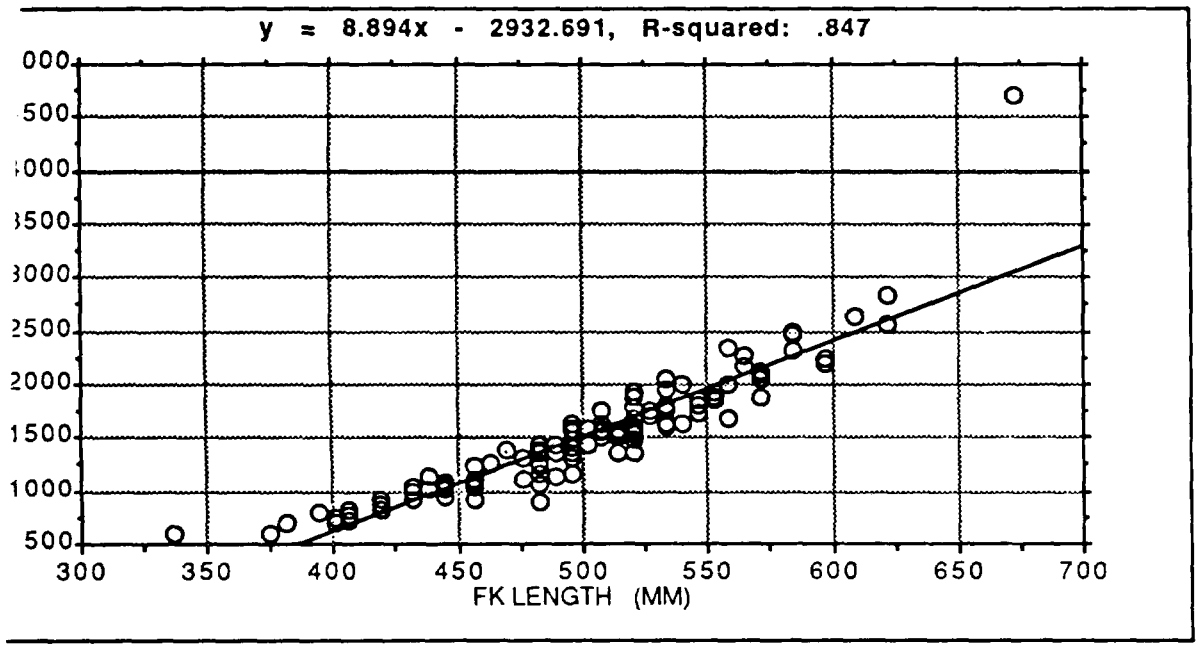
FIGURE 3





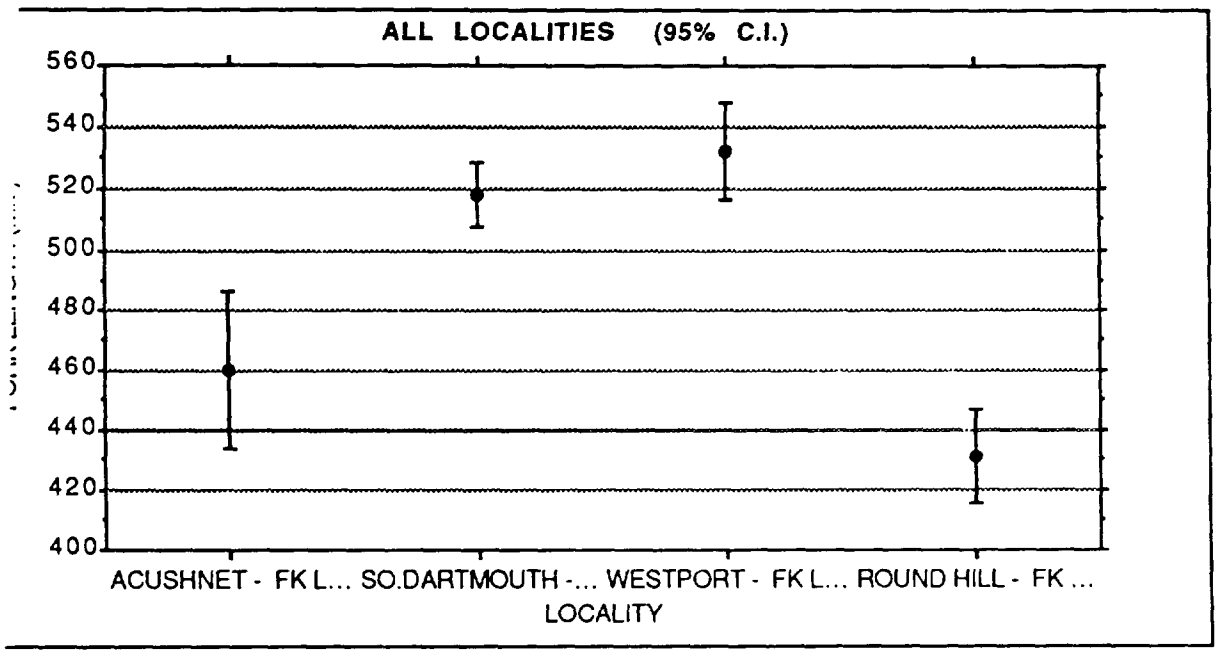
CHROMATOGRAM OF PCB-AROCLOR 1254 STANDARD AND FISH SAMPLE (MSSE86-89).

FIGURE 4

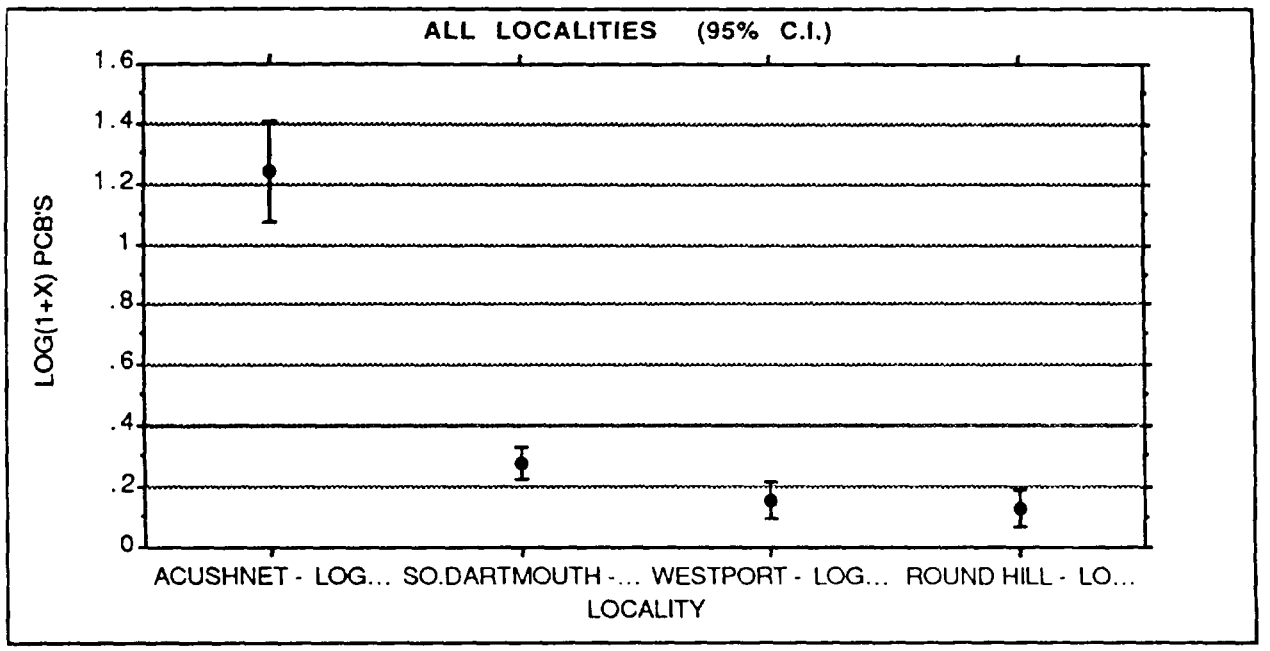


WEIGHT (GRAMS) VS. FORK LENGTH (MM) ALL LOCALITIES

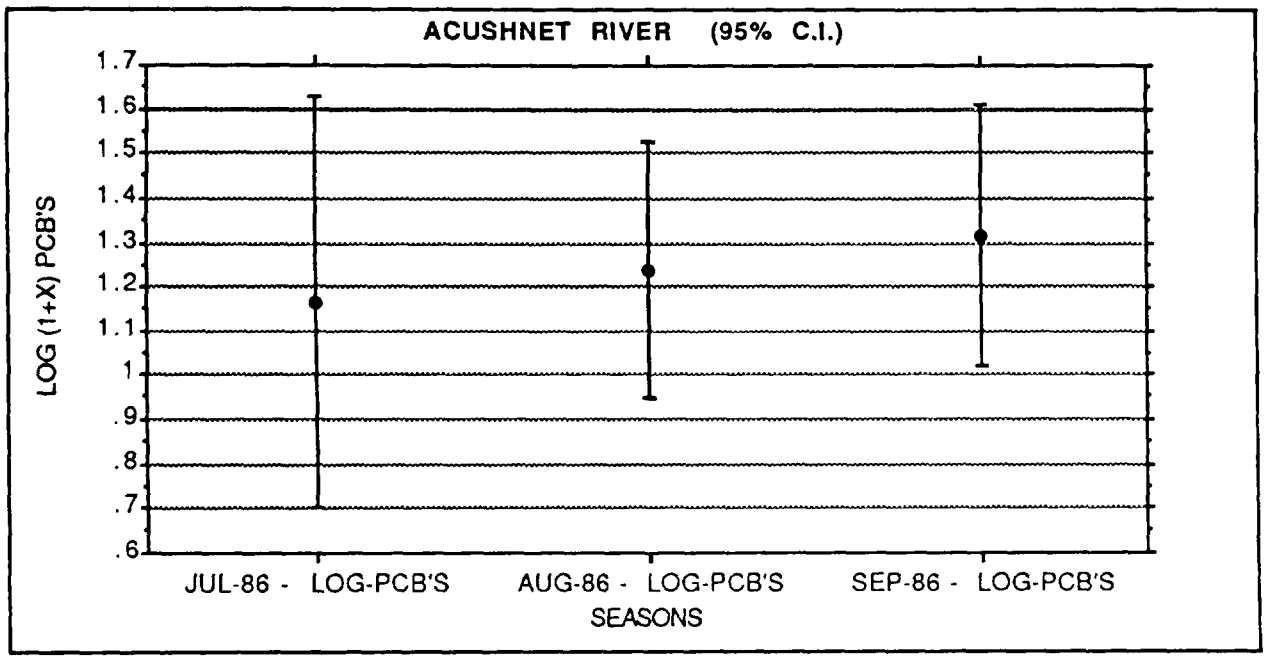
FIGURE 5



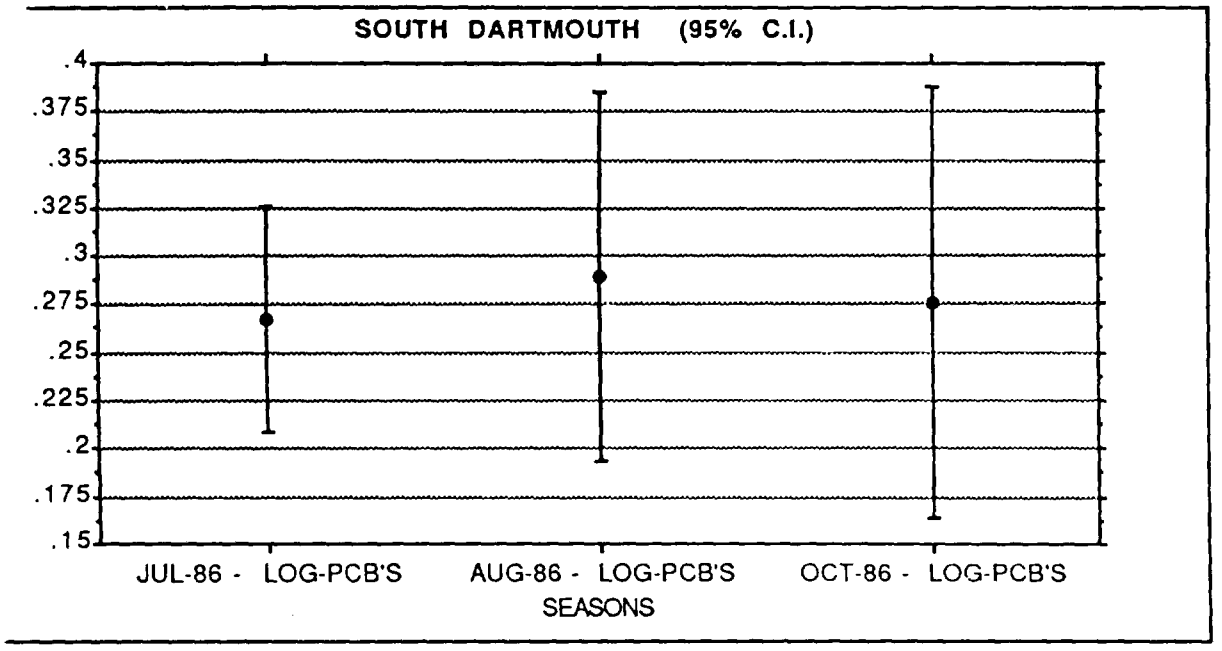
FORK LENGTH VS. LOCALITY



LOG-TRANSFORMED PCB'S VS. LOCALITY



LOG-TRANSFORMED PCB'S VS. SEASONALITY



LOG-TRANSFORMED PCB'S VS. SEASONALITY

STATEMENT FROM THE WORK SESSION

ON

"CHEMICALLY INDUCED ALTERATIONS IN SEXUAL DEVELOPMENT: THE WILDLIFE/HUMAN CONNECTION"

THE PROBLEM

Many compounds introduced into the environment by human activity are capable of disrupting the endocrine system of animals, including fish, wildlife, and humans. The consequences of such disruption can be profound because of the crucial role hormones play in controlling development. Because of the increasing and pervasive contamination of the environment by compounds capable of such activity, a multidisciplinary group of experts gathered in retreat at Wingspread, Racine, Wisconsin, USA, July 26-28, 1991 to assess what is known about the issue. Participants included experts in the fields of anthropology, ecology, comparative endocrinology, histopathology, immunology, mammalogy, medicine, law, psychiatry, psychoneuroendocrinology, reproductive physiology, toxicology, wildlife management, tumor biology, and zoology.

The purposes of the meeting were:

1. to integrate and evaluate findings from the diverse research disciplines concerning the magnitude of the problem of endocrine disruptors in the environment;
2. to identify the conclusions that can be drawn with confidence from existing data; and
3. to establish a research agenda that would clarify uncertainties remaining in the field.

CONSENSUS STATEMENT

The following consensus was reached by participants at the workshop.

1. <u>We are certain of the following:</u>

- A large number of man-made chemicals that have been released into the environment, as well as a few natural ones, have the potential to disrupt the endocrine system of animals, including humans. Among these are the persistent, bioaccumulative, organohalogen compounds that include some pesticides (fungicides, herbicides, and insecticides) and industrial chemicals, other synthetic products, and some metals[1].

- Many wildlife populations are already affected by these compounds. The impacts include thyroid dysfunction in birds and fish; decreased fertility in birds, fish, shellfish, and mammals; decreased hatching success in birds, fish, and turtles; gross birth deformities in birds, fish, and turtles; metabolic abnormalities in birds, fish, and mammals; behavioral abnormalities in birds; demasculinization and feminization of male fish, birds and mammals; defeminization and masculinization of female fish and birds; and compromised immune systems in birds and mammals.

- The patterns of effects vary among species and among compounds. Four general points can nonetheless be made: (1) the chemicals of concern may have entirely different effects on the embryo, fetus, or perinatal organism than on the adult; (2) the effects are most often manifested in offspring, not in the exposed parent; (3) the timing of exposure in the developing organism is crucial in determining its character and future potential; and (4) although critical exposure occurs during embryonic development, obvious manifestations may not occur until maturity.

---

[1] Chemicals known to disrupt the endocrine system include: DDT and its degradation products, DEHP (di(2-ethylhexyl)phthalate), dicofol, HCB (hexachlorobenzene), kelthane, kepone, lindane and other hexachlorocyclohexane congeners, methoxychlor, octachlorostyrene, synthetic pyrethroids, triazine herbicides, EBDC fungicides, certain PCB congeners, 2,3,7,8-TCDD and other dioxins, 2,3,7,8-TCDF and other furans, cadmium, lead, mercury, tributyltin and other organo-tin compounds, alkyl phenols (non-biodegradable detergents and anti-oxidants present in modified polystyrene and PVCs), styrene dimers and trimers, soy products, and laboratory animal and pet food products.

- Laboratory studies corroborate the abnormal sexual development observed in the field and provide biological mechanisms to explain the observations in wildlife.

- Humans have been affected by compounds of this nature, too. The effects of DES (diethylstilbestrol), a synthetic therapeutic agent, like many of the compounds mentioned above, are estrogenic. Daughters born to mothers who took DES now suffer increased rates of vaginal clear cell adenocarcinoma, various genital tract abnormalities, abnormal pregnancies, and some changes in immune responses. Both sons and daughters exposed in utero experience congenital anomalies of their reproductive system and reduced fertility. The effects seen in in utero DES-exposed humans parallel those found in contaminated wildlife and laboratory animals, suggesting that humans may be at risk to the same environmental hazards as wildlife.

2. We estimate with confidence that:

- Some of the developmental impairments reported in humans today are seen in adult offspring of parents exposed to synthetic hormone disruptors (agonists and antagonists) released in the environment. The concentrations of a number of synthetic sex hormone agonists and antagonists measured in the US human population today are well within the range and dosages at which effects are seen in wildlife populations. In fact, experimental results are being seen at the low end of current environmental concentrations.

- Unless the environmental load of synthetic hormone disruptors is abated and controlled, large scale dysfunction at the population level is possible. The scope and potential hazard to wildlife and humans are great because of the probability of repeated and/or constant exposure to numerous synthetic chemicals that are known to be endocrine disruptors.

- As attention is focused on this problem, more parallels in wildlife, laboratory, and human research will be revealed.

3. Current models predict that:

- The mechanisms by which these compounds have their impact vary, but they share the general properties of (1) mimicking the effects of natural hormones by recognizing their binding sites; (2) antagonizing the effect of these hormones by blocking their interaction with their physiological binding sites; (3) reacting directly and indirectly with the hormone in question; (4) by altering the natural pattern of synthesis of hormones; or (5) altering hormone receptor levels.

- Both exogenous (external source) and endogenous (internal source) androgens (male hormones) and estrogens (female hormones) can alter the development of brain function.

- Any perturbation of the endocrine system of a developing organism may alter the development of that organism: typically these effects are irreversible. For example, many sex-related characteristics are determined hormonally during a window of time in the early stages of development and can be influenced by small changes in hormone balance. Evidence suggests that sex-related characteristics, once imprinted, may be irreversible.

- Reproductive effects reported in wildlife should be of concern to humans dependent upon the same resources, e.g., contaminated fish. Food fish is a major pathway of exposure for birds. The avian (bird) model for organochlorine endocrine disruption is the best described to date. It also provides support for the wildlife/human connection because of similarities in the development of the avian and mammalian endocrine systems.

4. There are many uncertainties in our predictions because:

- The nature and extent of the effects of exposure on humans are not well established. Information is limited concerning the disposition of these contaminants within humans, especially data on concentrations of contaminants in embryos. This is compounded by the lack of measurable endpoints (biologic markers of exposure and effect) and the lack of multi-generational exposure studies that simulate ambient concentrations.

- While there are adequate quantitative data concerning reduction in reproductive success in wildlife, data are less robust concerning changes in behavior. The evidence, however, is sufficient to call

for immediate efforts to fill these knowledge gaps.

- The potencies of many synthetic estrogenic compounds relative to natural estrogens have not been established. This is important because contemporary blood concentrations of some of the compounds of concern exceed those of internally produced estrogens.

5. Our judgment is that:

- Testing of products for regulatory purposes should be broadened to include hormonal activity in vivo. There is no substitute for animal studies for this aspect of testing.

- Screening assays for androgenicity and estrogenicity are available for those compounds that have direct hormonal effects. Regulations should require screening all new products and by-products for hormonal activity. If the material tests positive, further testing for functional teratogenicity (loss of function rather than obvious gross birth defects) using multigenerational studies should be required. This should apply to all persistent, bioaccumulative products released in the past as well.

- It is urgent to move reproductive effects and functional teratogenicity to the forefront when evaluating health risks. The cancer paradigm is insufficient because chemicals can cause severe health effects other than cancer.

- A more comprehensive inventory of these compounds is needed as they move through commerce and are eventually released to the environment. This information must be made more accessible. Information such as this affords the opportunity to reduce exposure through containment and manipulation of food chains. Rather than separately regulating contaminants in water, air, and land, regulatory agencies should focus on the ecosystem as a whole.

- Banning the production and use of persistent chemicals has not solved the exposure problem. New approaches are needed to reduce exposure to synthetic chemicals already in the environment and prevent the release of new products with similar characteristics.

- Impacts on wildlife and laboratory animals as a result of exposure to these contaminants are of such a profound and insidious nature that a major research initiative on humans must be undertaken.

- The scientific and public health communities' general lack of awareness concerning the presence of hormonally active environmental chemicals, functional teratogenicity, and the concept of transgenerational exposure must be addressed. Because functional deficits are not visible at birth and may not be fully manifested until adulthood, they are often missed by physicians, parents, and the regulatory community, and the causal agent is never identified.

6. To improve our predictive capability:

- More basic research in the field of developmental biology of hormonally responsive organs is needed. For example, the amount of specific endogenous hormones required to evoke a normal response must be established. Specific biologic markers of normal development per species, organ, and stage of development are needed. With this information, levels that elicit pathological changes can be established.

- Integrated cooperative research is needed to develop both wildlife and laboratory models for extrapolating risks to humans.

- The selection of a sentinel species at each trophic level in an ecosystem is needed for observing functional deficits, while at the same time describing the dynamics of a compound moving through the system.

- Measurable endpoints (biologic markers) as a result of exposure to exogenous endocrine disruptors are needed that include a range of effects at the molecular, cellular, organismal, and population levels. Molecular and cellular markers are important for the early monitoring of dysfunction. Normal levels and patterns of isoenzymes and hormones should be established.

- In mammals, exposure assessments are needed based on body burdens of a chemical that describe the concentration of a chemical in an egg (ovum) which can be extrapolated to a dose of the chemical to the embryo, fetus, newborn, and adult. Hazard evaluations are needed that repeat in the laboratory what is being seen in the field. Subsequently, a gradient of doses for particular responses must be determined in the laboratory and then compared with exposure levels in wildlife populations.

- More descriptive field research is needed to explain the annual influx to areas of known pollution of migratory species that appear to maintain stable populations in spite of the relative vulnerability of their offspring.

- A reevaluation of the in utero DES-exposed population is required for a number of reasons. First, because the unregulated, large-volume releases of synthetic chemicals coincide with the use of DES, the results of the original DES studies may have been confounded by widespread exposure to other synthetic endocrine disruptors. Second, exposure to a hormone during fetal life may elevate responsiveness to the hormone during later life. As a result, the first wave of individuals exposed to DES in utero is just reaching the age where various cancers (vaginal, endometrial, breast, and prostatic) may start appearing if the individuals are at a greater risk because of perinatal exposure to estrogen-like compounds. A threshold for DES adverse effects is needed. Even the lowest recorded dose has given rise to vaginal adenocarcinoma. DES exposure of fetal humans may provide the most-severe-effect model in the investigation of the less potent effects from environmental estrogens. Thus, the biological endpoints determined in in utero DES-exposed offspring will lead the investigation in humans following possible ambient exposures.

- The effects of endocrine disruptors on longer-lived humans may not be as easily discerned as in shorter-lived laboratory or wildlife species. Therefore, early detection methods are needed to determine if human reproductive capability is declining. This is important from an individual level, as well as at the population level, because infertility is a subject of great concern and has psychological and economic impacts. Methods are now available to determine fertility rates in humans. New methods should involve more use of liver-enzyme-system activity screening, sperm counts, analyses of developmental abnormalities, and examination of histopathological lesions. These should be accompanied by more and better biomarkers of social and behavioral development, the use of multigenerational histories of individuals and their progeny, and congener-specific chemical analyses of reproductive tissues and products, including breast milk.

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Rose and Pabon were among ne 11 who didn't know or vouldn't even venture a guess.

But Vanessa Peterson, 19, of 'onkers knew the right answer

Schools may in fact be the answer, said Peter Iodice, director of the Westchester County Veterans Service Agency.

History teachers should focus

another day.

Staff writers Riva Shoshana and Regina Pappalardo contributed information for this report.

es indicate health risk

usefulness. The studies were done on children born 15 to 20 years ago, when PCB levels, both in food and humans, were higher than now, he said.

Yet the scientists who have done the research think Bolger is right on the facts but wrong in the interpretation.

Levels of PCBs in humans have fallen, Colborn said, but not enough to assume that the risk has disappeared. Worldwide, she said, the average concentration of PCBs in human fat is about 1 part per million, down from 1.37 a decade ago. The current average includes a range from 0.3 to 3.14 parts per million but most people fall near the average, she said.

"PCBs have come down around the world, but they're still not down below the level that the Jacobsons saw," Colborn said.

Interference with reading

The Jacobsons — Joseph and Sandra — are researchers at Wayne State University in Detroit who, in a study published in September in the New England Journal of Medicine, found significant intellectual impairment in 11-year-old children who as fetuses were exposed to 1 to 1.25 parts per million of PCBs.

The mothers of the children had eaten two or three meals of fish a month for about six years. The fish were caught in Lake Michigan, which had been widely contaminated with PCBs.

The Jacobsons found that children who were exposed to 1.25 ppm of PCBs were three times as likely to have low average IQ scores and twice as likely to be at least two years behind in reading comprehension.

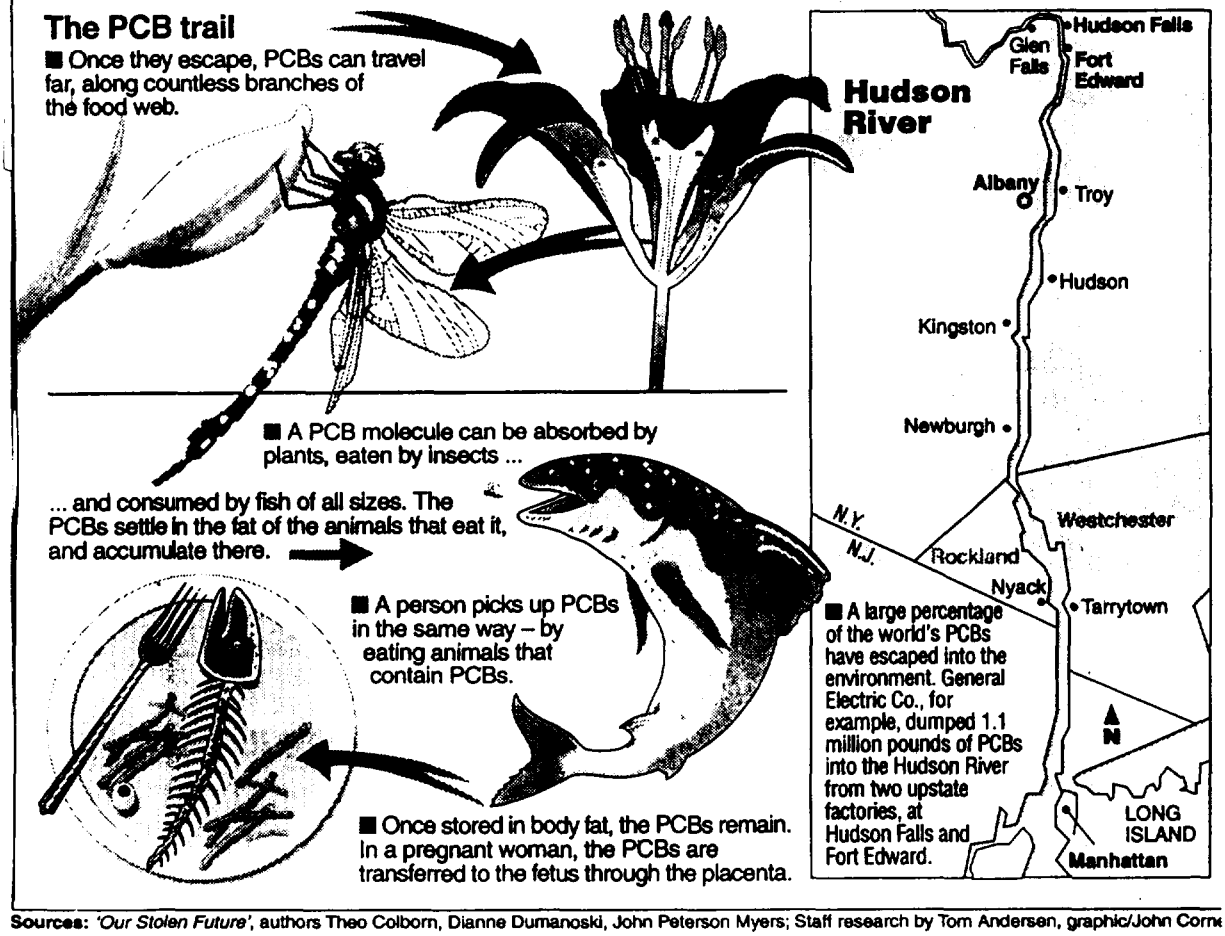
"There was a substantial increase in the proportion of children at the lower end of the normal range who would be expected to function more poorly in school," the study said. "This intellectual deficit seemed to interfere particularly with reading mastery. Eight of the 12 highly exposed children with low IQ scores were at least one year behind their peers in word or reading comprehension, and all but one were at least six months behind."

Joseph Jacobson emphasized in an interview that the intellec-

The threat from PCBs

The U.S. Environmental Protection Agency considers PCBs to be a probable carcinogen, and for years most public concern about PCBs has focused on cancer. But recent research indicates that PCBs might pose a greater threat to intellectual ability of children who were exposed to them as fetuses.

PCBs are synthetic compounds that were first developed in 1929 and manufactured in the United States by Monsanto Corp. until 1976, when they were banned. Worldwide, more than 3.4 billion pounds were produced.



Sources: *'Our Stolen Future'*, authors Theo Colborn, Dianne Dumanoski, John Peterson Myers; Staff research by Tom Andersen, graphic/John Corne

paper.

"Women who eat no fish may accumulate these compounds from other food sources, including dairy products, such as cheese and butter, and fatty meats, particularly beef and pork," their report said.

"Unlike exposure to lead or illicit drugs, which occurs predominantly in economically disadvantaged families, prenatal exposure to (PCBs) is unrelated to socioeconomic status. Although in the United States environmental concentrations of these contaminants have declined in recent years, the risk of exposure from toxic industrial waste continues because the

ment laden with PCBs poses enough risk to warrant dredging it from a stretch of the upper Hudson. General Electric would be responsible for the cleanup. The material would be disposed of in an off-site landfill.

"Much of the decision as to whether to require GE to put up the money to clean up the mess will be based on the risk assessment," said Cara Lee, environmental director of Scenic Hudson, an environmental group based in Poughkeepsie.

GE has already spent $110 million remediating its plants in Hudson Falls and Fort Edward

into the river.

GE would like the EPA to find no need to remove the vast PCB-laden sediment deposits in the river.

"We believe the evidence shows that dredging the sediments will not speed up the recovery of the fish, will not lead to decline of PCBs in fish any faster than doing what we're doing," Warshaw said.

Lee said GE would save millions of dollars if dredging is not required. It cost more than $1 million, for example, to dredge PCB site at Waukegan Harbor Ill., that was one-fortieth the size of the proposed Hudson dredging site.

"(General Electric has) 57 Superfund sites around the country," Lee said. "It seems to me that GE has successfully carried out a strategy to minimize or reduce the likelihood" of clear

Newslinks

A guide to learning more

To get more information on PCBs, including a summary report on PCB contamination in the Hudson River prepared by the Clearwater organization, visit Gannett Suburban Newspapers' World Wide Web site at http://www.nynews.com/links.htm

PCBs may pose additional threat

Staff photo/Laura Seitz

Robert Gabrielson is the last commercial fisherman in Nyack. His business has been hurt since it became illegal to fish for striped bass in the Hudson River for fear the fish were contaminated with PCBs.

Studies show low level of chemicals can cause learning defects in children

By Tom Andersen and Kathryn Winiarski
Staff Writers

In a world of health threats real and imagined, a battery of recent scientific studies and reassessments indicates that where PCBs are concerned, maybe we've been worried about the wrong thing.

The man-made chemicals have long been linked in the public mind with cancer, and the U.S. Environmental Protection Agency still considers them a probable human carcinogen.

But federal scientists reported in October that some types of PCBs pose 20 times less cancer risk than previously thought, and even the kinds of PCBs that are most likely to be absorbed in body fat pose two or three times less cancer risk than thought.

Yet numerous studies, most notably recent research conducted in Michigan, show a more immediate danger from PCBs, one widespread and insidious. The research indicates that children who as fetuses absorbed small amounts of PCBs from their mothers suffered a noticeable and long-term impairment of their intellectual abilities.

> "How do you tell people to avoid these chemicals? They're everywhere."
> **— Theo Colborn, World Wildlife Fund researcher**

"This goes well beyond cancer," said Theo Colborn, a researcher with the World Wildlife Fund in Washington, D.C., who has analyzed the effects of PCBs on human development. "If you use enough high doses of chemicals, in many cases you can cause cancer. But at ambient concentrations, if I thought my children and grandchildren

Please see PCBs, 2A

exec 4-12

Cattell pleads guil in $6M scam that

By Bruce Golding
Staff Writer

A former Kraft General F executive pleaded guilty ye day in a $6 million corp fraud scheme that author called the largest theft in W chester County history.

Claudia Cattell, 46, was promised a sentence of four to 12 years in state prison for her guilty plea to first-degree grand larceny.

No restitution will be ordered because the former Port Chester resident has already agreed to a $3.7 million civil judgment covering her share of the illegal proceeds. During questioning by County Judge Mary H. Smith, Cattell said she and a co-defendant ran a five-year overbilling and kickback scam to finance lavish lifestyles they could not otherwise afford.

For Cattell, the money financed a fleet of expensive automobiles, an Arizona ranch and a stable of thoroughbred show horses.

"I guess we wanted to h things that we shouldn't ha she said during her court app ance in White Plains.

Cattell also said she was "v sorry" and that "being in jail the past five months has sh me what I did was wrong."

Smith told Cattell that she accepting the guilty plea des

Pearl Harbor's 'infamy' seems a fadin

after 55 years, many

"I wasn't even born yet," was

realize it's inevitable.

PCBs may pose additional threat

Staff photo/Laura Seitz

Robert Gabrielson is the last commercial fisherman in Nyack. His business has been hurt since it became illegal to fish for striped bass in the Hudson River for fear the fish were contaminated with PCBs.

Studies show low level of chemicals can cause learning defects in children

By Tom Andersen and Kathryn Winiarski
Staff Writers

In a world of health threats real and imagined, a battery of recent scientific studies and reassessments indicates that where PCBs are concerned, maybe we've been worried about the wrong thing.

The man-made chemicals have long been linked in the public mind with cancer, and the U.S. Environmental Protection Agency still considers them a probable human carcinogen.

But federal scientists reported in October that some types of PCBs pose 20 times less cancer risk than previously thought, and even the kinds of PCBs that are most likely to be absorbed in body fat pose two or three times less cancer risk than thought.

Yet numerous studies, most notably recent research conducted in Michigan, show a more immediate danger from PCBs, one widespread and insidious. The research indicates that children who as fetuses absorbed small amounts of PCBs from their mothers suffered a noticeable and long-term impairment of their intellectual abilities.

> "How do you tell people to avoid these chemicals? They're everywhere."
> — Theo Colborn, World Wildlife Fund researcher

"This goes well beyond cancer," said Theo Colborn, a researcher with the World Wildlife Fund in Washington, D.C., who has analyzed the effects of PCBs on human development. "If you use enough high doses of chemicals, in many cases you can cause cancer. But at ambient concentrations, if I thought my children and grandchildren

Please see PCBs, 2A

exec to get 4-12 years

Cattell pleads guilty, accepts prison term in $6M scam that financed flashy lifestyle

By Bruce Golding
Staff Writer

A former Kraft General Foods executive pleaded guilty yesterday in a $6 million corporate fraud scheme that authorities called the largest theft in Westchester County history.

Claudia Cattell, 46, was promised a sentence of four to 12 years in state prison for her guilty plea to first-degree grand larceny.

No restitution will be ordered because the former Port Chester resident has already agreed to a $3.7 million civil judgment covering her share of the illegal proceeds. During questioning by County Judge Mary H. Smith, Cattell said she and a co-defendant ran a five-year overbilling and kickback scam to finance lavish lifestyles they could not otherwise afford.

For Cattell, the money financed a fleet of expensive automobiles, an Arizona ranch and a stable of thoroughbred show horses.

> "I guess we wanted to have things that we shouldn't have."
> — Claudia Cattell

"I guess we wanted to have things that we shouldn't have," she said during her court appearance in White Plains.

Cattell also said she was "very sorry" and that "being in jail for the past five months has shown me what I did was wrong."

Smith told Cattell that she was accepting the guilty plea despite reservations that the negotiated sentence was too lenient. Under state law, first-degree grand larceny carries a maximum prison term of 8⅓ to 25 years.

Prosecutor Kenneth C. Citarella said Cattell's sentence would be the harshest ever imposed in a grand larceny case settled before trial in Westchester.

Cattell's crime involved overbilling her employer — now known as Kraft Foods Inc. — for design work on Post cereal boxes between June 1988 and August 1993. At the time, she was working as a senior design manager in White Plains; she was fired from her $79,000-a-year job in the fall of 1993.

A company spokeswoman, Kathy Knuth, said Kraft was satisfied with the outcome of Cattell's criminal prosecution.

During her plea, Cattell implicated a co-defendant, Joseph DeVito of Valhalla, owner of the Prographics II graphic arts company, and agreed to testify against him at trial.

DeVito has pleaded innocent to grand larceny and bribery charges; he and Cattell are both due in court Jan. 30.

A third defendant, Brooklyn resident Barry Kessler, owner of Kessler Graphics in Manhattan, pleaded guilty to second-degree grand larceny earlier this year in a deal to avoid jail by testifying against Cattell and DeVito.

Pearl Harbor's 'infamy' seems a fading memory

After 55 years, many can't name the date of historic attack

By Ed Tagliaferri
Staff Writer

Today is the anniversary of the day that was supposed to live in infamy. But infamy seems to have expired a lot sooner than expected.

Yehudah Rose thought for a minute when asked if he knew the significance of Dec. 7, 1941. The 25-year-old White Plains resident had to admit that he didn't.

"I wasn't even born yet," was the reply of Thomas Pabon, 16, of the Bronx when asked the same question.

Fifty-five years after the Japanese bombed American naval bases in Pearl Harbor — propelling the United States into World War II and prompting President Franklin Roosevelt to state the date would never be forgotten — the historic event seems to have faded from the public's collective memory.

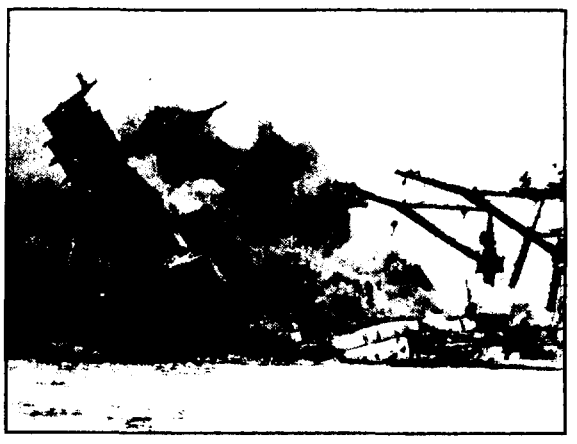
And while veterans groups are troubled by this pattern, they realize it's inevitable.

"As time goes on, people tend to forget," said Sal Sialiano, director of the Yonkers Veterans Agency, which organized a ceremony yesterday to commemorate the day at Roosevelt High School in Yonkers.

Pearl Harbor survivor Peter Sarantapoulas, 73, of Bardonia agreed.

"Unfortunately, the memory of Pearl Harbor is fading out as we've had two or three wars after that, but the over-40 crowd does

Please see PEARL, 2A



Smoke billows from the USS Arizona as it sinks in Pearl Harbor after the Japanese sneak attack on Dec. 7, 1941. The Arizona memorial, built in 1961, now stands on the site.

File photo/ The Associated Press

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Rose and Pabon were among ne 11 who didn't know or vouldn't even venture a guess.

But Vanessa Peterson, 19, of 'onkers knew the right answer

Schools may in fact be the answer, said Peter Iodice, director of the Westchester County Veterans Service Agency.

History teachers should focus

another day.

Staff writers Riva Shoshana and Regina Pappalardo contributed information for this report.

PCBs: Studies indicate children at health risk

Continued from page 1A

were being compromised, I think this is outrageous."

The cancer fear stems from laboratory work in which animals subjected to large doses of PCBs developed tumors. By contrast, the learning defects in children were triggered by tiny amounts of PCBs absorbed over a relatively short amount of time.

"It's a different concern because of the levels of exposure," said Denton Brosius, a neurobiologist who is associate director of environmental health sciences at New York Medical College in Valhalla. "Clearly, the cancer-causing part is of great concern, but we're talking here about effects that interfere with normal development and normal reproduction."

PCBs, or polychlorinated biphenyls, are a class of man-made chemicals that were widely used in manufacturing throughout much of the century. General Electric Co. used them in two factories on the Hudson River in upstate New York — in Hudson Falls and Fort Edward — and over three decades ending in 1977 disposed of 1.1 million pounds of PCBs in the Hudson.

The PCBs have contaminated fish such as striped bass, prompting the state Health Department to advise children and women of childbearing years to eat no fish of any kind caught in the Hudson. High levels of PCBs forced the state Department of Environmental Conservation to ban commercial fishing for striped bass 20 years ago, a decision that has all but wiped out commercial fishing on the river.

"I've been hanging on by my teeth," said Robert Gabrielson, president of the New York State Commercial Fishermen's Association and the only commercial fisherman left in Nyack. "There were 14 people here in Nyack in the industry when I was a young man, and 10-15 guys in Piermont. Now, it's just me."

Gabrielson said striped bass are so abundant that they have prevented fishermen from catching shad in spring.

"We take 10,000 pounds of striped bass out of the net and throw it back in the river," he said. "It's a disgrace."

None of the new research likely will change the government health warnings or result in a change in the state ban on commercial striped bass fishing.

"(The new data) means very little in terms of the difference in the risk," Dr. Nancy Kim, director of the state Health Department's division of Environmental Health Assessment, said of the revised view of the cancer risk.

And Michael Bolger, a toxicologist who is chief of the U.S. Food and Drug Administration's contaminants branch, said the research on how PCBs affect children's intellectual abilities was interesting but of limited usefulness. The studies were done on children born 15 to 20 years ago, when PCB levels, both in food and humans, were higher than now, he said.

Yet the scientists who have done the research think Bolger is right on the facts but wrong in the interpretation.

Levels of PCBs in humans have fallen, Colborn said, but not enough to assume that the risk has disappeared. Worldwide, she said, the average concentration of PCBs in human fat is about 1 part per million, down from 1.37 a decade ago. The current average includes a range from 0.3 to 3.14 parts per million but most people fall near the average, she said.

"PCBs have come down around the world, but they're still not down below the level that the Jacobsons saw," Colborn said.

Interference with reading

The Jacobsons — Joseph and Sandra — are researchers at Wayne State University in Detroit who, in a study published in September in the New England Journal of Medicine, found significant intellectual impairment in 11-year-old children who as fetuses were exposed to 1 to 1.25 parts per million of PCBs.

The mothers of the children had eaten two or three meals of fish a month for about six years. The fish were caught in Lake Michigan, which had been widely contaminated with PCBs.

The Jacobsons found that children who were exposed to 1.25 ppm of PCBs were three times as likely to have low average IQ scores and twice as likely to be at least two years behind in reading comprehension.

"There was a substantial increase in the proportion of children at the lower end of the normal range who would be expected to function more poorly in school," the study said. "This intellectual deficit seemed to interfere particularly with reading mastery. Eight of the 12 highly exposed children with low IQ scores were at least one year behind their peers in word or reading comprehension, and all but one were at least six months behind."

Joseph Jacobson emphasized in an interview that the intellectual problems they saw were not severe.

"We think it has a real effect on their ability to handle schoolwork," he said. "But they're still in normal schoolrooms — they're not in special ed."

The Jacobsons have followed their study's subjects since birth and found similar learning deficiencies in infancy and at age 4.

"What we're doing is compromising the potential of a large size of the population," Colborn said. "How do you tell people to avoid these chemicals? They're everywhere."

The Jacobsons outlined the breadth of the threat in their paper.

"Women who eat no fish may accumulate these compounds from other food sources, including dairy products, such as cheese and butter, and fatty meats, particularly beef and pork," their report said.

"Unlike exposure to lead or illicit drugs, which occurs predominantly in economically disadvantaged families, prenatal exposure to (PCBs) is unrelated to socioeconomic status. Although in the United States environmental concentrations of these contaminants have declined in recent years, the risk of exposure from toxic industrial waste continues because the amount in use in older electrical equipment and in landfills exceeds the total quantity that has escaped into the environment to date."

Bolger of the FDA, however, said that so-called market-basket studies have shown recently that food Americans buy at the grocery store does not contain PCBs in amounts worth worrying about.

Effect on the Hudson

It is unclear how the new research might affect the Hudson River. The EPA is trying to decide whether underwater sediment laden with PCBs poses enough risk to warrant dredging it from a stretch of the upper Hudson. General Electric would be responsible for the cleanup. The material would be disposed of in an off-site landfill.

"Much of the decision as to whether to require GE to put up the money to clean up the mess will be based on the risk assessment," said Cara Lee, environmental director of Scenic Hudson, an environmental group based in Poughkeepsie.

GE has already spent $110 million remediating its plants in Hudson Falls and Fort Edward since 1989 under a series of consent orders with the state DEC, GE spokesman David Warshaw said.

The company finished capping 60 acres of PCB sludge deposits near Fort Edward in 1991. It also recently finished removing more than 50 tons of PCBs from an abandoned mill south of the Hudson Falls plant. When PCB levels rose markedly in the area in 1992, inspectors found that a wood gate in the 19th century mill had collapsed. PCB-contaminated soils that had been held back by the gate were released into the river.

GE would like the EPA to find no need to remove the vast PCB-laden sediment deposits in the river.

"We believe the evidence shows that dredging the sediments will not speed up the recovery of the fish, will not lead to decline of PCBs in fish any faster than doing what we're doing," Warshaw said.

Lee said GE would save millions of dollars if dredging is not required. It cost more than $1 million, for example, to dredge a PCB site at Waukegan Harbor, Ill., that was one-fortieth the size of the proposed Hudson dredging site.

"(General Electric has) 57 Superfund sites around the country," Lee said. "It seems to me that GE has successfully carried out a strategy to minimize or reduce the likelihood" of cleanup.

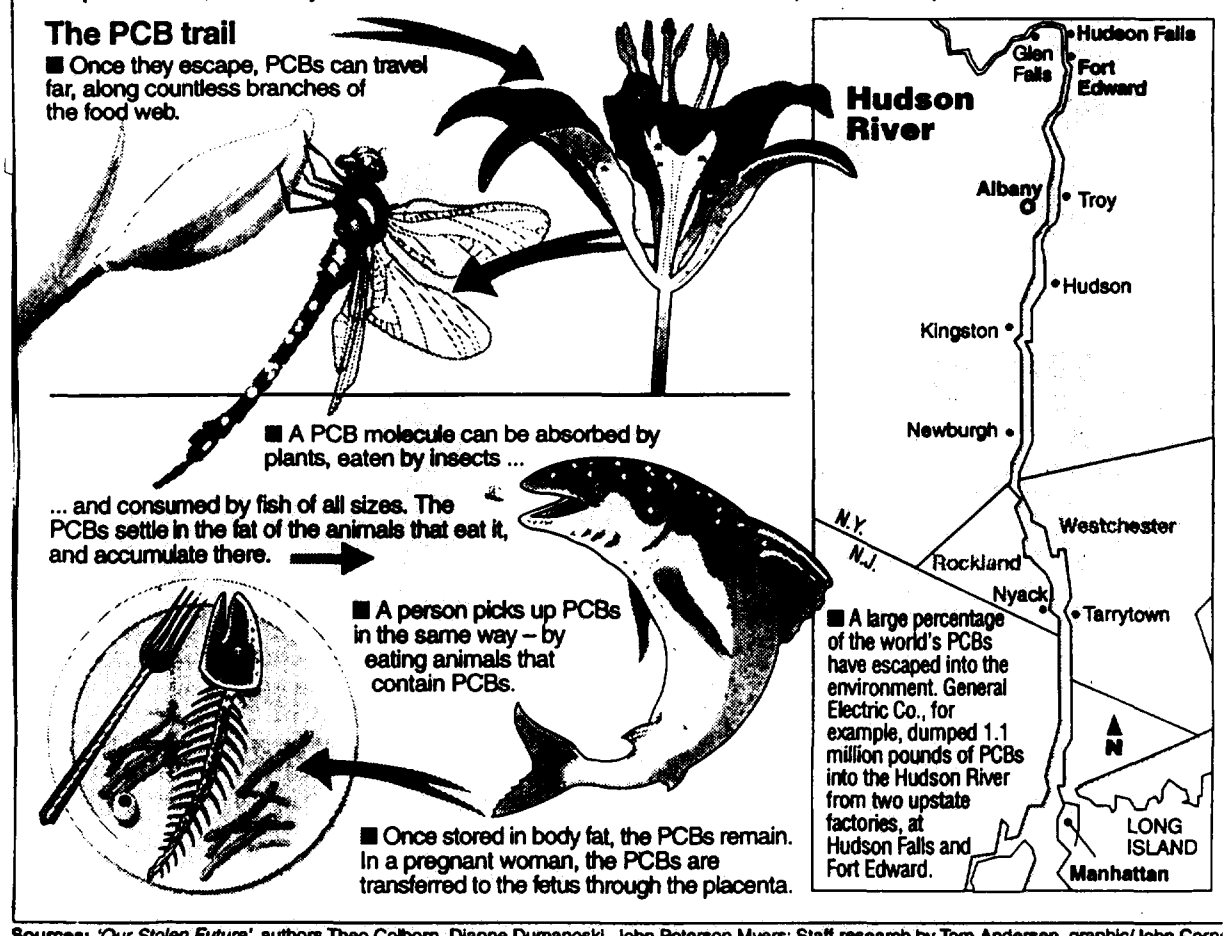
Lee, who has been involved in the study of whether to require GE to dredge the river, said she has been trying to persuade EPA to take into account the new research on how PCBs affect children.

"There's a growing understanding of the difference between the carcinogenity factor and the impacts-on-intelligence factors," she said. "It takes way less exposure for the latter types of manifestations to show up. That's just a really critical thing for people to understand."

The threat from PCBs

The U.S. Environmental Protection Agency considers PCBs to be a probable carcinogen, and for years most public concern about PCBs has focused on cancer. But recent research indicates that PCBs might pose a greater threat to intellectual ability of children who were exposed to them as fetuses.

PCBs are synthetic compounds that were first developed in 1929 and manufactured in the United States by Monsanto Corp. until 1976, when they were banned. Worldwide, more than 3.4 billion pounds were produced.

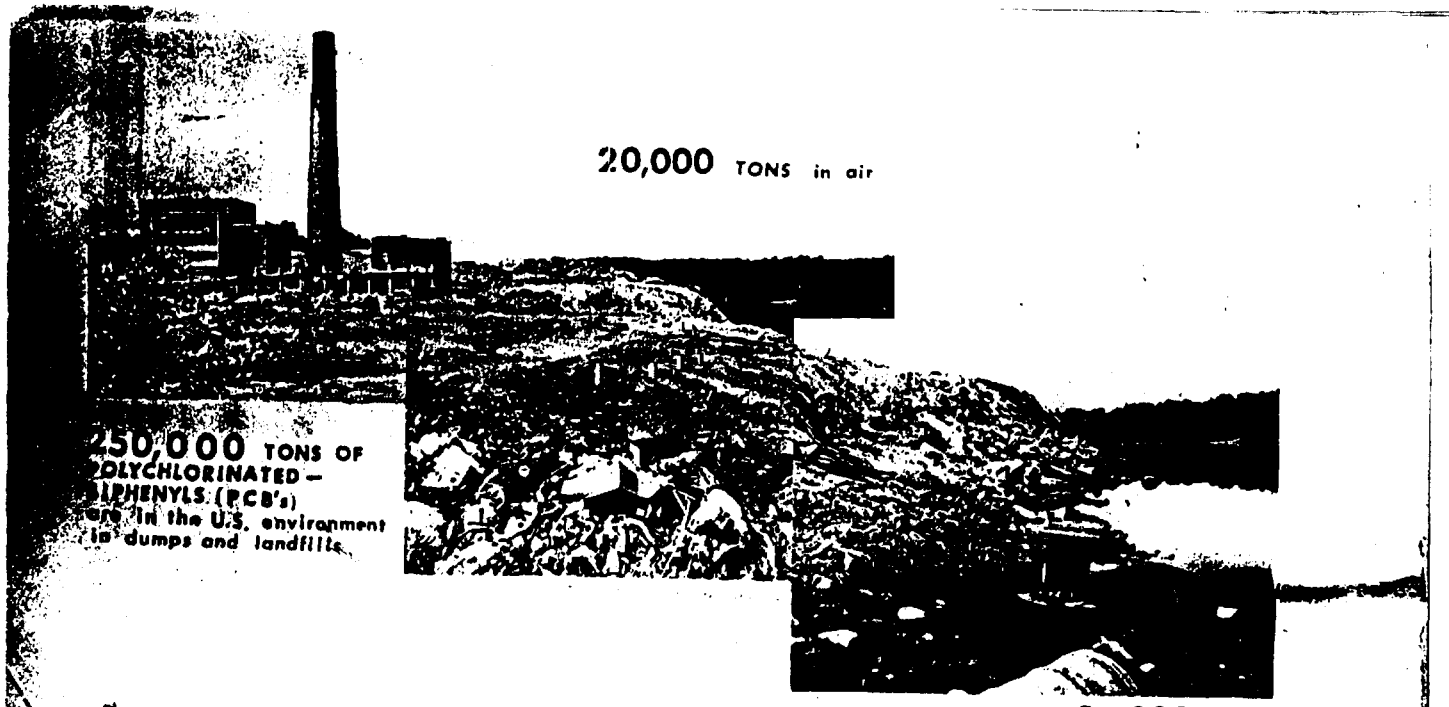


Sources: *'Our Stolen Future'*, authors Theo Colborn, Dianne Dumanoski, John Peterson Myers; Staff research by Tom Andersen, graphic/John Corn

Newslinks

A guide to learning more

To get more information on PCBs, including a summary report on PCB contamination in the Hudson River prepared by the Clearwater organization, visit Gannett Suburban Newspapers' World Wide Web site at http://www.nynews.com/links.htm



Organochlorine insecticide residues in perch and large-mouth bass on whole fish basis. Levels in ripe fish eggs would be several times this amount.

Taken from — National Pesticide Monitoring Service.

RIVERS	D.D.T. & METABOLITES	P.C.B.'S
1. Merrimac	1.97	4.39
2. Connecticut	1.60	3.40
3. Hudson	3.30	4.82
4. Raritan	1.94	4.51
5. Delaware	10.95	2.04
6. Susquehanna	.75	1.31
7. Potomac	.48	1.04
8. James	.41	.14
9. Roanoke	1.38	.10
10. Cooper	3.87	.10
11. Savannah	.76	1.18
12. St. John's	.29	.31
13. Apalachicola	2.69	.10
14. Tombigbee	10.15	.10
15. Mississippi	.46	.66
16. White	.91	.10
17. Sacramento	1.34	.10
18. San Joaquin	1.40	.10
19. Lake Superior	1.58	2.84
20. Lake Michigan	6.44	12.60
21. Lake Huron	1.52	4.02
22. Lake Erie	1.08	2.33
23. Lake Ontario	2.13	7.08

THE ASSOCIATED PRESS

A deformed frog with two extra hind legs is shown in this photo provided by the Minnesota Pollution Control Agency.

Scientists puzzled by deformed frogs

By Beth Silver
THE ASSOCIATED PRESS

HENDERSON, Minn. — Bruce Nelson was catching frogs for catfish bait last year when he realized something was horribly wrong: Some of the frogs had stumps for legs, and others had as many as four tangled hind legs.

"You see deformed things all the time in nature, but nothing like this," Nelson said.

All across Minnesota, into neighboring Wisconsin, South Dakota, and even as far away as Quebec and Vermont, scientists and locals are seeing the same kind of grotesquely misshaped limbs, along with frogs with tails, missing or shrunken eyes, and smaller sex organs.

In fact, scientists have had a hard time finding wetlands in Minnesota with no deformed frogs.

"It scares me," said Judy

FROGS/Page 6

FROGS

From Page 1

Helgen, a research scientist with the Minnesota Pollution Control Agency. "I'm at different levels of getting a chill down my spine."

Scientists aren't sure what's causing the deformities. The theories run the gamut from pesticides to parasites to radiation from ozone depletion, or some combination of factors.

What worries many around the state is whether humans are in danger, too.

"There's a reasonable assumption that if there's an external substance influencing amphibian development, it could influence human development," said David Hoppe, who is on a state-financed team of scientists researching the problem.

So far, little has been discovered. The federal Environmental Protection Agency plans to do its own study.

Students from the Minnesota New Country School in Le Sueur, in the heart of the state's farm country, first reported the deformed leopard frogs during a field trip to a wetland last year.

They reported their findings to the pollution control agency, then to state lawmakers, and finally went worldwide by putting their information and pictures of the frogs on the Internet.

"When somebody caught a frog without one leg," 13-year-old Jack Bovee told a state House committee this year, "I thought, 'Houston, we have a problem.'"

Cindy Reinitz, the teacher who has become known as "The Frog Lady" since her middle school students made the discovery, said there is at least once person with cancer in every household around the wetland. But scientists have made no direct link between the frog abnormalities and cancer.

A newly created frog hot line has received hundreds of sightings of deformed frogs, from 54 of the state's 87 counties.

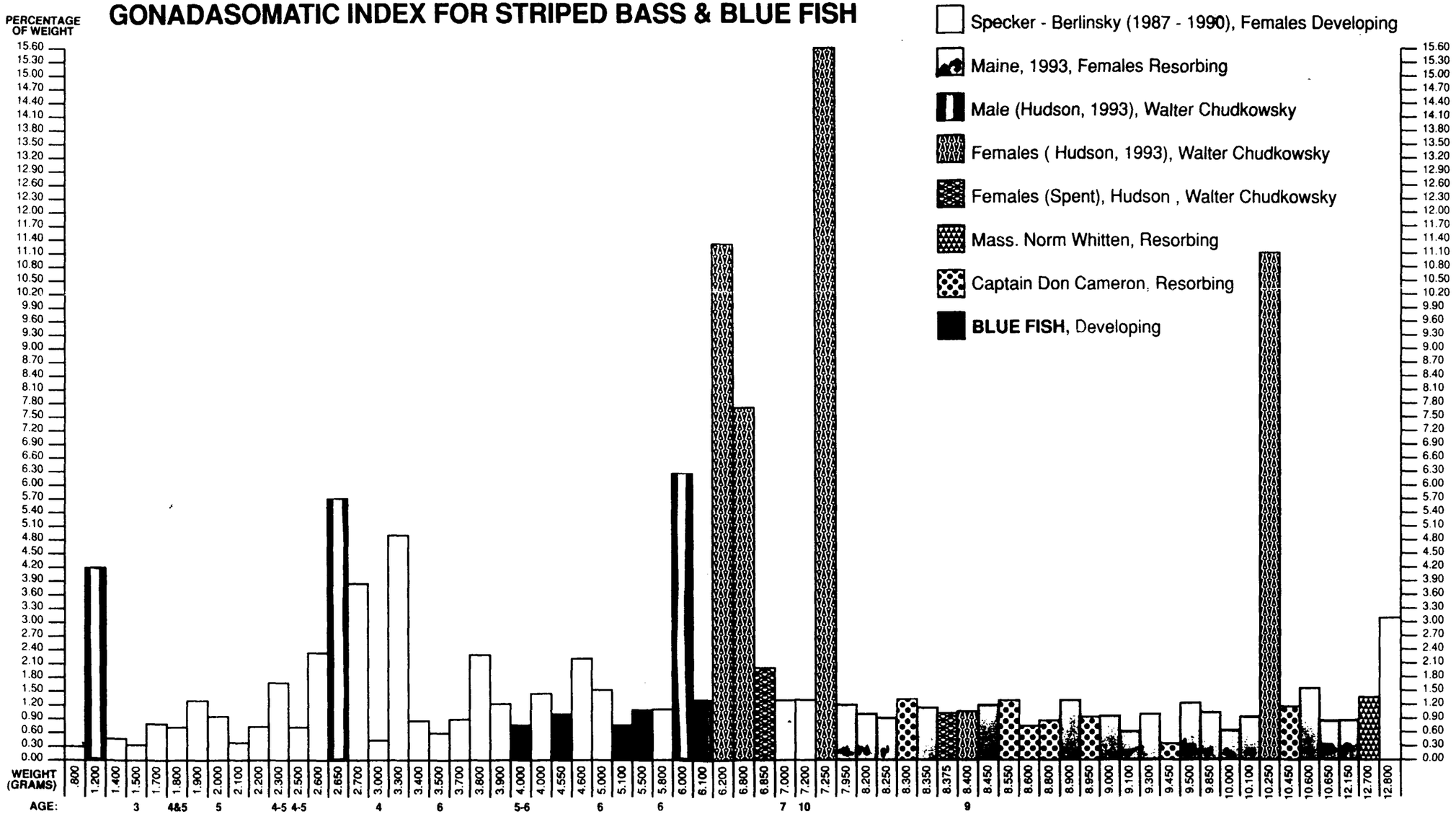
The fact that the abnormalities are widespread suggests that the problem has more than one source, said Hoppe, a herpetologist from the University of Minnesota at Morris.

His best guess is some sort of water pollution, possibly from something airborne. That could come from heavy metals, pesticides or a whole array of things that settle onto the landscape.

In researching some 10,000 frogs this summer, Hoppe said, he found that the most aquatic frogs had the worst abnormalities.

"I was very surprised, startled even," he said, "because I've seen a lot of frogs over the years and I've never seen anything like that."

GONADASOMATIC INDEX FOR STRIPED BASS & BLUE FISH



Age according to Specker - 1987

Stripers Unlimited, Inc. - P. O. Box 3045 - South Attleboro, MA 02703

G.S.I. Gonad weight as a percentage of body weight

Sports Fishing Catch
Choptank River, Md.

October 5-20, 1990

Statistics gathered by Captain Jim Price. Joseph Boone & Robert Pond aboard Captain Jim Price's Charter Boat

NO.	AGE	SAMPLE NO.	SEX	BODY WEIGHT (Kg)	BODY WEIGHT (Lbs)	BODY LENGTH TOTAL (CM)	BODY LENGTH (INCHES)	CONDITION WT. (Kg) LENGTH CUBED (mm)
1	4.5	1	M	3.06	6.75	69.22	27.250	.92
2	4.5	1	M	2.26	5.0	66.04	26.00	.79
3	4.5	1	M	2.55	5.625	64.14	25.00	.97
4	4.5	2	F	2.32	5.125	63.5	25.00	.96
5	4.5	1	M	2.10	4.625	62.87	24.75	.86
6	4.5	1	M	2.49	5.5	60.96	24.00	1.10
7	3.5	1	M	2.10	4.625	59.69	23.50	.99
8	3.5	1	M	1.42	4.25	58.42	23.0	.97
9	3.5	1	F	1.57	3.5	56.52	22.250	.88
10	3.5	1	M	1.81	4.0	56.52	22.250	1.01
11	3.5	1	F	1.81	4.0	55.88	22	1.04
12	3.5	2	M	1.40	3.09	54.61	21.5	.86
13	3.5	1	F	1.30	2.875	53.97	21.250	.83
14	3.5	1	M	1.27	2.81	52.70	20.75	.87
15	3.5	2	F, M	1.39	3.06	52.39	20.5	.97
16	3.5	1	M	1.33	2.937	51.44	20.250	.98
17	2.5	3	F	1.19	2.625	49.53	19.5	.98
18	2.5	1	1F, 2M	1.13	2.5	48.90	19.25	.86
19	2.5	1	F	1.11	2.437	46.63	18.75	1.09
20	2.5	2	1F, 1M	.93	2.06	46.35	18.25	.93
21	2.5	4	1F, 3M	.92	2.03	45.72	18.00	.93

Condition factor = weight in (Kg) length in $(Cm)^3$
C - Condition factor K) Length into girth. Condition factor weight in Kg/length in CMX3 E03.

Condition Average .942

Range .79-1.10

Striped Bass Report

Information gathered from Striped Bass caught during The Snug Harbor Fishing Tournament and by the Rhode Island Mobile Sports Fishermen.

NO.	DATE	AUTHOR	AGE	SEX	SAMPLE AREA	BODY WT. (Kg)	BODY WT. (Gm)	GONAD WT. (Gm)	G.S.I.	BODY LENGTH FL (CM)	BODY LENGTH TL (CM)	BODY WT. (Lbs)	BODY LENGTH FL (INCHES)	BODY LENGTH TL	COND. WT. (Kg) LENGTH CUBED (mm)
1	June, 1991	R. Pond	14	F	Block Island	14.33	14330	154.1	1.07	109.22	114.3	31.6	43.0	45.0	1.10
2			9	M	R.I. Surf	9.93	9930	37.0	.37	95.25	99.06	21.9M	37.5	39.0	1.15
3			9	F	Block Island	8.80	8800	71.8	.81	93.98	97.79	19.4	37.0	38.5	1.06
4			8	F	Block Island	10.02	10020	137.3	1.37	91.44	95.25	22.1	36.0	37.5	1.31
5			8	X	Block Island	8.26	8260	None	None	90.17	92.71	18.2	35.5	36.0	1.13
6			8	F	R.I. Surf	7.3	7300	62.5	.86	89.54	93.98	15.5	35.25	37.0	1.02
7			8	F	R.I. Surf	8.12	8120	67.0	.83	88.9	92.71	17.9	35.0	36.5	1.16
8			7	F	R.I. Surf	6.08	6080	57.9	.95	88.46	86.36	13.4	33.25	34.0	1.01
9			7	M	R.I. Surf	6.12	6120	27.3	.45	83.82	87.63	13.5	33.0	34.5	1.04
10			6	F	R.I. Surf	2.90	2900	37.7	.64	78.7	83.19	13.0	31.0	32.75	1.21
11			5	F	R.I. Surf	3.18	3180	31.1	.82	69.22	71.75	8.4	27.25	28.25	1.15

Aged according to Diodati length/weight chart.

Condition Average 1.12

Range 1.01-1.31

Reported relationships of gonad weight, egg number, body length and body weigth among striped bass of various ages.

NO.	YEAR	AREA	AUTHOR	GONAD WT. (9M)	TOTAL BODY WT. (Kg)	NO. OF EGGS	G.S.I.	BODY LENGTH (CM)	AGE	CONDITION
	1924	Roanoke River	W.L. Page	None	40.82	7,000,000				
1	1950	Coos Bay, Oregon	Morgan & Gerlach	None	22.68	4,775,000	None	None	None	
2	1967	Elk River	Hollis	3470	25.350	4,136,000	13.69	119.4	15	1.50E-03
3	1973	Potomac River	Holland & Yelverton	2123	19.000	4,057,059	11.117	109.0	10	1.47E-03
5-4	1967	Potomac River	Hollis	3011	25.630	3,846,000	11.75	115.6	14	1.66E-03
6	1967	Patomic River	Hollis	2142	20,140	3,257,000	10.64	108.7	12	1.57E-03
7	1973	Off Shore N.C.	Holland & Yelverton	12.53	13,600	3,715,939	9.25	98.1	9	1.44E-03
8	1973	Off Shore N.C.	Holland & Yelverton	914	12.700	3,511,038	7.2	98.7	12	1.32E-03
9	1973	Off Shore N.C.	Holland & Yelverton	663	12.200	3,304,479	5.4	95.0		1.42E-03
10-7	1904	Roanoke River, N.C.	Wortn	None	22.68	3,220,000	None	None	None	
11	1952	Chesapeake Bay	Jackson & Tiller	1319.5	9.752	2,510,346	13.5	92.1	10	1.25E-03
12	1967	Elk River, MD	Hollis	1897	11.570	2,310,000	16.40	90.9	10	1.54E-03
13	1952	Chesapeake Bay	Vladykov & Wallac	755	8.670	None	8.7	83.2	None	1.51E-03
14	1967	Elk River, Md.	Hollis	1966	11.380	2,248,000	17.28	91.9	12	1.47E-03
15	1973	Off Shore, N.C.	Holland & Yelverton	867	8.800	2,221,821	9.85	84.0		1.48E-03
16	1967	Nanticoke Rvr. Md.	Hollis	1650	14.970	2,207,000	11.16	100.3	10	1.48E-03
17	1973	Off Shore, N.C.	Holland & Yelverton	180	9.000	1,995,974	2.0	89.2	10	1.27E-03
18	1952	Chesapeake Bay	Jackson & Tiller	988	7.212	1,682,292	13.7	83.0	8	1.26E-03
19	1938	Upper Chesapeake	Pearson	None	5.897	1,337,000	None	70.0	None	1.72E-03
20	1967	Transquaking River	Hollis	543.9	4.760	1,319,000	11.43	71.1	6	1.32E-03
21	1966	Roanoke River, N.C.	Lewis & Bonner	None	6.76	1,090,000	None	73.4	10	1.71E-03
22	1973	Off Shore, N.C.	Holland & Yelverton	126	7.300	1,044,230	1.7	80.0	8	1.43E-03
23	1950	Coos Bay, Oregon	Morgan & Gerlac	None	3.990	900,000	None	None	None	None
24	1973	Off Shore, N.C.	Holland & Yelverton	67	7.700	1,067,472	.87	82.0	9	1.40E-03
25	1952	Chesapeake Bay, Md.	Jackson & Tiller	5940	5.397	856,257	11	71.26	6	1.49E-03
26	1967	Elk River	Hollis	3475	3.310	591,000	10.50	61.5	5	1.42E-03
28	1967	Elk River	Hollis	275.3	3.13	494,000	6.9	60.5		1.41E-03
29	1966	Roanoke River	Lewis & Bonner	None	3.03	454,000	None	57.0		1.64E-03
30	1966	Transquaking River	Hollis	149.7	1.36	416,000	11	52.5	4	.94E-03
31	1966	Transquaking River	Hollis	427.7	4.630	398,000	9.24	69.6	6	1.44E-03
32	1966	Transquaking River	Hollis	118	1.310	252,000	9.01	49.3	4	1.09E-03
33	1952	Roanoke River	Lewis & Bonner	None	2.01	320,000	None	52.9	4	1.36E-03
34	1941	Chesapeake Bay	Merriman	None	2.041	265,000	None	None		
35	1967	Nanticoke	Hollis	71.6	1.150	201,000	6.2	42.7	4	1.48E-03
36	1952	Chesapeake Bay, Md.	Jackson & Tiller	58.5	1.996	68239	2.9	51.2		1.49E-03
37	1904	Roanoke River	Wortn	None	1.361	14,000	None	None		
38	1952	Chesapeake Bay	Vladykov & Wallace	M89.9	1,461	Males	6.15	44.22	3-4	1.69E-03
39	1952	Chesapeake Bay	Vladykov & Wallace	M27.1	.550	Males	4.9	34.0	2 1/2	.59E-03
40	1952	Chesapeake Bay	Vladykov & Wallace							

Condition Factors Weight in Kg/Length CM3E-03

Condition factor using averages and range data .Condition Average 1.41

From Rogers and Westin-1978. Range .59- 1.72