CEER-M-42 August 1979 - A STUDY OF THE MERCURY CONCENTRATIONS OF FISH OFF THE SOUTH AND WEST COASTS OF PUERTO RICO

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ABSTRACT

Commercially important fish and invertebrates were collected on the south and west coasts of Puerto Rico, primarily in and around Mayaguez Bay. The edible flesh was analyzed for mercury. The concentrations of total mercury ranged from a low of .007 ppm (ug/g) in Strombus gigas ("conch" or “carrucho") to 1.47 ppm in Centropomus undecimalis ("snook" or "robalo"). There appeared to be a positive relationship between the size of the organism and the amount of mercury present: the larger the organism, the higher the mercury concentration. Some of the organisms, in particular Centropomus undecimalis, showed higher concentrations of mercury than the safety limit of 0.5 ppm recommended by the N.A.S., ALE, and the U.S.F.D.A., and higher than the action limit of 1.0 ppm established by the government.

INTRODUCTION

Since the Minamata Bay poisonings in Japan (N.A.S.-N.A.E., 1973), public concern about mercury poisoning has sparked research and quality controls on the mercury levels of edible fish. Sources of mercury pollution are a concern in areas where commercial fishing takes place, and it is to identify these sources and measure the effects of human pollution on fish populations that studies like ours are begun. Our contemporary, José A. Ramírez Barbot (1979), spent a year sampling the fish populations of Guayanilla Bay on the south coast of Puerto Rico where...

A power plant and other industries are known to contribute trace metals to the environment. Our study was undertaken to supplement previous research and to examine another part of the island's ecosystem for comparison purposes. Our sampling area included Mayaguez Bay on the west coast of Puerto Rico. This location, despite not being as polluted as Guayanilla Bay, is a commercial harbor and houses several industrial sites, including a tuna processing facility on its northern shore. We also frequently sampled a clean, heavily fished reef about eight miles offshore and took sampling trips to the south coast and Desecheo Island, where we fished on clear offshore reefs. With this study and the previous work done in Guayanilla, we hope to compile a more comprehensive picture of mercury concentration in fish along the south and west coasts of Puerto

Rico, aiming to control human consumption of potentially toxic materials.

LITERATURE REVIEW

Mercury naturally occurs in aquatic environments. Its natural concentration in seawater is estimated to be 0.1 ug/l (ppb) (N.A.S.-N.A.E., 1973). It is a non-essential, non-beneficial element and is potentially toxic. Organisms accumulate it far more rapidly than they can eliminate it, and a fish may contain a concentration of mercury 10,000 times that of the surrounding water (McKim 1974). This toxic magnification can reach humans, who need to limit their intake of fish with high mercury concentrations. The National Academy of Science and National Academy of Engineering suggested in their publication, Water Quality Criteria (1972), that the concentration of mercury in fish for human consumption should not exceed 0.5 ppm (ug/g). This limit was adopted by the U.S. Food and Drug Administration. However, there is still active concern in the literature that this limit is not low enough for human safety. Recently, the U.S. F.D.A released a "Revised Action List for Poisons or Deleterious Substances" where the action level for...

The standard for mercury was established at 1.0 ppm (NPI 1978). Clearly, we do not know enough about the dangers of mercury at lower concentrations. Mercury occurs in several forms. Microorganisms are capable of converting both inorganic and organic forms of mercury into highly toxic methyl or dimethyl mercury, making any form of mercury a potential hazard to the environment.

The methylation process occurs in and on the sediment where benthic organisms are most active. Through the ingestion of sediment, detritus, or the benthos, fish and other larger organisms accumulate the highly toxic methylmercury (ALS.-N.A-E., 1973). Recent studies have suggested relationships between mercury concentration and environmental factors. In particular, it has been indicated that water temperature may significantly affect the mercury concentration in fish (Cember, Curtis, Blaylock, 1978). This aspect was not considered in our study and could be of interest for future research.

Additionally, it has been shown that controls on mercury discharges have led to a decrease in the mercury content of fish in a certain area (Armstrong and Scott, 1979). The issue of trace metals, particularly mercury, being introduced into the environment by humans can only be addressed by identifying dangerous levels in the environment, determining the source, and eliminating contaminants.

This study only deals with the first step of this procedure, with the hope that further work will be conducted if our results indicate a need.

PROCEDURES

Field Method: Sampling trips were conducted throughout June, July, and the beginning of August, 1979, within Mayaguez Bay. Trawl nets were used both during the day and at night. At Tourmaline reef off-shore and on trips further afield, collection was done by spearfishing and hook and line. All samples were stored on ice, transported to the lab, and then frozen.

Laboratory Method: After transportation to the lab, the samples were separated and identified with the help of the Cornelia Hill staff, in particular, Leida Luz Cruz. Randall (1968) and Bohike and Chaplin (1968) were used as references.

The following text was used as references for identification:

The specimens were counted, measured, weighed, and separated by species and size. Fish were grouped by 3.0 cm increments, and crabs were separated into 10-gram groups. The edible flesh and muscles were removed for analysis of total mercury content. When prominent, the eggs were also removed for analysis. For each size group, duplicates of two-gram samples (wet weight) were used for the mercury analysis.

The two-gram samples were weighed into BOD bottles, then digested with concentrated sulfuric and nitric acid in an 80°C water bath. Excess potassium permanganate was added to oxidize the mercury present to the mercuric form (Hg**) and the sample was further heated at 80°C for an hour before cooling. Hydroxylamine hydrochloride was added to clear excess permanganate, and stannous chloride was added to reduce the mercury to the metallic form just before analysis.

The instrument used was a Mercury Analyzer System, Model MAS 50, from Perkin Elmer Corporation, Coleman Instruments Division. It is sensitive to 0.01 micrograms of mercury. The percent transmittance (#1) was given for each sample.

Calculations: The absorbance can be calculated from the percent transmittance by using Beer's Law: A=log 1/T. The samples were analyzed together with a series of standards of mercury. These were graphed with a Linear Regression that was used to determine the final concentration of the element in the different samples. The final concentration of mercury was determined by the formula: Final concentration = (concentration - blank) x volume of sample / weight of sample. The final concentration was given in micrograms of mercury per gram of sample, or ppm.

Graphs comparing fish size to mercury concentration were made for the more common species using linear regression analysis and a t-test was used to compare results from different stations.

Results: In 1,122 organisms sampled of 45 different species, the mean mercury concentrations found varied from .007 ppm (ug/g) to 1.47 ppm. The only

Fish found to exceed the U.S. Food and Drug Administration action limit of 1.0 ppm were Scarus coeruleus (a large parrotfish) from Tourmaline, and several Centropomus undecimalis from the Guanajibo river mouth, with concentrations up to 1.9 ppm in some fish. The Centropomus (or snook) are a concern because they are considered excellent for eating and were acquired from fishermen who were selling them for food. Centropomus ensiferus from the Añasco River area also surpassed the 0.5 ppm safety limit recommended by the National Academy of Science and the National Academy of Engineering. Other than these fish, all samples were below the limit established by the U.S.F.D.A., but variations among species, sampling areas, and size occurred at lower mercury concentrations. Unfortunately, not all the samples were readily comparable between sampling sites. Stations on a reef did not yield the same type of fish that were collected in bay stations, and different collection techniques such as trawl nets vs. fishing in these different areas made direct comparisons between species and size groups impossible in many cases. A t-test was done for comparison of the following: Añasco vs. Mayaguez, Tourmaline and Punta Ostiones reefs vs. Desecheo Island, Añasco and Mayaguez vs. Desecheo, Añasco and Mayaguez, Tourmaline and Punta Ostiones, and Desecheo, Tourmaline to Ostiones vs. Añasco and Mayaguez. It was found that $P < 0.05$ for the two bay stations and the bay stations vs. the island. For the other three comparisons, it was found that $P < 0.01$. It can therefore be assumed that there is less mercury found in the fish at Añasco than the fish in Mayaguez Bay; and less mercury in the fish around Desecheo Island than in the bay stations. For the others compared, there is no significant difference in the mercury content. It is well known that mercury is accumulated by most organisms faster than it can be eliminated. Most species, for which three or more size groups could be established, showed an increase in mercury levels with size.

The food web and the level of mercury accumulated demonstrate that lower levels of mercury are found in organisms lower in the food web. Some commercial, edible, and valuable fish were shown to have mercury concentrations not only above the 0.5 ppm safety limit recommended by the National Academy of Science and the National Academy of Engineering, originally established by the U.S.P.D.A., but also exceeded the action limit of 1.0 ppm recently set by the U.S.F.D.A. These fish were being sold for human consumption, and an effort should be made to effect some control and educate the public about the dangers of mercury poisoning from fish. Stations closer to centers of human population yielded more mercury in the fish populations, indicating that pollution from a human source could cause higher mercury levels in fish in these areas. The tuna canneries on the north shore of Mayaguez Bay are possible mercury sources. Since the areas closer to shore are often where the highest amount of commercial and private fishing takes place, it is desirable to control sources of mercury pollution and educate the public, once again, about the dangers involved.

Our results were generally similar to those of the research done in Guayanilla Bay by José A. Ramirez Barbot (1979). The same relationship between fish size and mercury concentrations was observed. Similar results were found for the same species in both studies. Centroponus undecimalis, for example, exhibited very high levels of mercury in both studies. Anyone wishing to make further studies in this area may want to analyze for mercury in other components of the environment surrounding the fish sampled. Not only water and sediment, and food sources, but also temperature records may be both interesting and beneficial to a study of this kind. More importantly, however, we need to pinpoint the sources of mercury pollution and implement some form of control. Traditionally, it has been known that tuna have particularly high mercury concentrations. The presence of the tuna

The text seems to be a mixture of scientific data and commentary. Here's a tidied up version:

"Canneries on the northern shore of Mayaguez Bay have been releasing their effluent into the bay for years, which is certainly a suspect as a mercury pollutant. Before we actually endanger fish populations and the people who eat them, we should take care to regulate the amount and types of waste we contribute to our environment. In this area, mercury may be of particular concern as it directly affects the fish that are necessary for the economy.

TABLE 1: SUMMARY OF MERCURY CONTENT OF FISH AND INVERTEBRATE ORGANISMS

MEAN CONC. species size__STATION (ug/g) _STA._DEV._n
Tourmaline quedricornie 15-18 cm Reef 0.303 0.011 1
Tourmaline potygoniue 21-24 cm Reef 0.126 0.015 1
Anchoa Tyotepte 3-6 cm Ahasco 0.612 0 10
Intotmemia suwinoweneie 27-30 cm Tourmaline 0.356 1
Balieves vetute 480 0.076 4 21-24 cm Tourmaline 0.346 0.081 1
2h-27 cm Tourmaline 0.387 0 1
27-30 cm Tourmaline 0.382 0.008 1
33-36 cm Tourmaline 0.802 0.027 1

Species size STATION MEAN CONC (ug/g) STA. dev.
Guanajibo 1.4702 0.7132 4
Guanajibo 0.3015 0.015 2
Guanajibo 1.0520 0.1635 1
Guanajibo 1.6106 0.158 1
Guanajibo 1.3124 0.048 1
Guanajibo 0.2119 0.093 1
Guanajibo 1.9048 0.391 1
Guanajibo 0.3910 0.052 1

(The remaining part of the text is too garbled for meaningful interpretation and would need to be provided in a better format for it to be corrected.)

This text appears to be a data set or a list of information which is difficult to correct without context. The terms seem to reference geological or biological data, possibly about minerals or species, along with some kind of measurements or identifiers.

However, it's hard to make corrections or provide a coherent revision without knowing the correct format or the intended meaning of the data.

I would recommend providing more context or a sample of what the correct formatting should look like so I could provide a more accurate revision.

The text appears to be in a structured format, possibly scientific or statistical data. However, it has many inconsistencies, making it difficult to correct without proper context. Here is an attempt:

0310 0127 1 B12 cm = 0824 0160 3 12-15 cm Mayaguez 0315 0014 2 15-18 cm Mayaguez 016 hours 1 18-21 cm Mayaguez 0580 0015 1 21-24 cm Mayaguez 0586 024 1 24-27 cm Mayaguez ost 0.0 2 30-33 cm ARasco 21387 0075 1 Pamulivue range 0322 0172 6 21-24 cm Tourmaline 0373 0003 1 24-27 cm Tourmaline 0212 0009 1 27-30 cm Tourmaline 0366 0100 ? 30-33 cm Tourmaline .0346 0020 2 33-36 cm Tourmaline 0335 0034 3 Peo. Ostiones .0299, (0006 2 3336 cm 0317 0040 5 Ponoaus sp. 0512 0370 $50 0-3 cm Anasco 018 0050 200 3-6 cm Afasco 0228 0056 50 6-9 cm Afasco

MEAN CONC: SPECIES, SIZE_STATION (ug/a)__STA. DEV. _n Ponoaus sp. 9-12 cm Masco 1129) 0031 2 Mayaguez 0506 0.0 2B 912 cm - 0818 0031 35 12-15 cm Mayaguez 0564 0169 3 1234 0233 3 18-21 cm Tourmaline 1211 0025 1 18-21 cm La Parguera 1479 0088 1 - 1345, 0078 2 21-24 cm Tourmaline 1231 0032 1 24-24 cm Desecheo 0951 3 21-26 cm - 1031 013 4 24-27 cm La Parguera 1300 0012 3 1275 1070 28 3-6 cm ARasco 3312 0.0 2 Mayaguez 0071 0008 2 3-6 cm - 1692 0008 23 6-9 cm Ahasco 0921 001 1 9-12 cm asco 0925 1 Mayaguez 1350 0126 3 9-12 cm - 1036 1051 4 Pomacanthus ancuatus 27-30 cm Tourmaline 0424 0392 1 Ryptioue eaponaseue tou 0042 4 9-12 cm Mayaguez 0757 0025 3 12-15 cm Mayaguez 135 0017 1 Seamus eoemuteus 49.4 cm Tourmaline 1.226 0064 1 Seonberomorue segatie 42.2 cm Pra. Ostiones .0963, 0175 1 Selene vores 1063 0028 2 3-6 cm Mayaguez 0250 0.0 7 6-9 cm Mayaguez 21106 0.0 2 9-12 cm Mayaguez 1832 0028 3 Sermanus lavivertyis 36 cm Joyuda 0626 0.0 2 Sphacroides testulineus 3-6 cm Afasco 0236 0.0 2 Steliffer sp. 21486 017 7 6-9 cm Anasco 1262 20055 6 9-12 cm Masco 1709 0092 6

MEAN CONC. SPECIES size___STATION (ug/a) STA. DEV. __n Stronbue gigae 1.36 kg Pea. Ostiones .0074 0043 18 Symphuarue amici 0529 0260 7 3-6 cm Afasco 0303 0.0 7 6-9 cm Atasco 0520 0072 9 Mayaguez 0392 0.0 1 63 cm 0456 0072 10 9-12 cm Afasco. 077 0088 19 Mayaguez 20335 0035 2 - 05m 0123 2 Anasco 0506 6 Mayaguez 0610 0008 2

I've made an assumption that 'cm' might be the unit of measurement and 'ost' could be an abbreviation for 'ostiones' which is a species of clam. 'MEAN CONC' could be 'mean concentration'. Please provide more context for a more accurate correction.

It appears that the text you provided is a mix of technical terms, data, and figures. It seems difficult to provide a meaningful correction without understanding the context or the purpose of the text. However, I have tried to structure the text in a more readable way:

"11S em = 0558 0050, 8 15-18 cm, Mayaguez 0822 0015 1, retoniueme Lepome 065% 0103 6, 1821 cm Anasco 0356 0010 1, 212k em —Akasco 0283 2.0 1, 2-27 em ARasco 0314 0110 1, Mayaguez 0224 0.0 1, 227 em = 0269 0110 2, 27-30 cm hasco <1 0016 1, 48.8 cm Hayaguer 1948 0055 1.

Fig 1: SAMPLING SITES ON THE WEST COAST OF PUERTO RICO: RIO ANAascO, MAYAGUEZ BAY, PUNTA GUANAJIBO, JOYUDA TOURMALINE, PUNTA OSTIONES, LA PARGUERA, DESECHEO ISLAND.

GRAPHS SHOWING CORRELATIONS BETWEEN ORGANISM SIZE AND MERCURY CONCENTRATION.

Hg concentration ug/g 38, 16, 08, 02.

Fig 2: Bothus sp. y= 0143+ 0109 Cx? IJ as TS ws 155 Length in em.

Hg concentration ug/g Hg concentration ug/g 345 Fig. 2 Balistes vetula —y = ~.0562 + 0098 cx) ans Length in em.

Centropomus undecimatis. ¥ = 0525 +0506 (x) Weight in Kg.

Fig 4: se si so swes6 UF aUBIOM ss sy se (L100 + 6020 = & sz st 8/6n uonesnus2u0s BH.

264 Fig 5 25; Gynoscion jamaicensis y= = 1276+ 0234Cx) 7s eS 3 1s Length in em."

The rest of the text follows a similar pattern with figure numbers, species names, equations, and data points. Due to the lack of context or a clear question, this is the best correction I can provide. If you could provide more information about your expectations or the context, I might be able to help you better.

ACKNOWLEDGEMENTS

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APPENDIX TABLE 1
ADDITIONAL DATA
Stationvag Water Sample Analysis
Sample Station Mean Conc.

(ug/g) STA. DEV. NOTES " Anaseo <0.001 - 8 Anasco <0.001 - Mayaguez <0.001 - 6 Mayaguez <0.001 - 3A Punta Guanajibo <0.001 - Punta Guanajibo <0.001 - Joyuda <0.001 - 2 Joyuda <0.001 -

APPENDIX TABLE 2 ADDITIONAL DATA, SEDIMENT SAMPLE ANALYSIS STATION EAN CONC. (ug/g) STA. DEV. NOTES
‘Anaseo 0.679 0.0 8
Anasco 0.677 2.043 2
Mayaguez 1.787 0.087 28
Mayaguez 0.004 3A

Punta Guanajibo 0.423 0.126 3
Punta Guanajibo 0.745 0.0
Joyuda 1.036 0.0 4
Joyuda 1.018 0.0 5
Punta Ostiones 0.936 0.123 6
Punta Ostiones 1.005 0.0 7
Punta Ostiones <0.003 0.0