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August 1979

A STUDY OF THE MERCURY CONCENTRATIONS

OF FISH OFF THE SOUTH AND WEST COASTS

OF PUERTO RICO

Wendy R. Beavis

Susan M. Heckman

José Manue! Lopez, Ph.D., Supervisor

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?This work was done at he Center for Energy and Environment Research

under the aupices of Oak Ridge Astciated Universes summer student

arcipation prota.

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ABSTRACT

commercially important fish and invertebrates were col~

lected 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

2 low of .007 ppm (ug/g) in Strombue gigae ("conch" ox ?carrucho")

to 1.47 ppm in Centropomue undeoimalie ("snook" or "robalo")

?There appeared to be a positive relationship between the size

of the organism and the anount of mercury present: the larger

the organism, the higher the mercury concentration. Some of

the

ganisms, in particular Centropomus undecimalie, 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

v,

Der.

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INTRODUCTION

Since the Minamata Bay pofsonings in Japan (N.A.S.-N.A-E., 1973) public concern about mereury poisoning has sparked research and quality controls on the mercury levels of edible fish. Sources of mercury pollution are a concern in areas where com- nercial 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. Ramfrez Barbot, (1979) spent year sampling the fish populations of Guayantlla Bay on the south const of Puerto Rico where a power plant and other industries are ?mown to contribute trace metals to the environment. our study was undertaken in an attempt to supplement his re~ search and to look at another part of the island's ecosysten for comparison purposes

our sampling area included Mayaguez Bay on the west coast of Puerto Rico which, although not known to be as polluted as Guayanilla Bay, is a commercial harbor and has several industrial attractions such as a tuna proc:

ing facility on its northern shore. We also sampled frequently on a clean and much fished reef about eight miles off shore and took sampling trips to the south coast and to Desecheo Island, where we fished on clear off-shore reefs. With this study and the previous work done in Guayanilla we hope to formulate a more complete picture of the mercury concentration of fish in south and west coasts of Puerto Rico, with an eye to controlling human consumption of possible toxic materials.

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LITERATURE REVIEW

Mercury occurs naturally in aquatic environments. Its natural concentration in sea water has been estimated to be 0.1 ug/l (ppb) (N.A.S.-N.A.E., 1973). Tt is a non-essential non-beneficial element and is potentially toxic. It is ace cumulated by organisms far more rapidly than it can be eliminated, and a fish may contain a concentration of mercury 10,000 times that of the surrounding water (McKim 1974). This toxic magni- fication can be carried to man, who must limit his intake of fish with high concentrations of mercury. The National Academy of Science and National Acadeny of Engineering suggested in the publication Water Quality Criteria, 1972 (N.A.S.-N.A.E. 1973) shat the concentration of mercury in fish for human consumption shoulé not exceed 0.5 ppm (ug/g). This limit was adopted by U.S. Food ond Drug Administration. There is still an active concern in the literature that this is not low enough for human safety. Recently, however, U.S. F.D.A, released a "Revised

Action List for Poisons or Deleterious Substance:

* where the

action level for mercury was established at 1.0 ppm (NPI 1978). Clearly, not enough is known about the dangers of mercury in

lower concentrations.

Mercury occurs in several forms. Microorganisms have the ability to convert inorganic and organic forms of mercury to highly toxic methyl or dimethyl mercury, making any form of mercury @ potential hazard to the environment. The methylation process takes place in and on the sediment where benthic organisms

are most active. From the ingestion of sediment, detritus, or

---Page Break---

?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,

that the water temperature may have a significant effect on the mercury concentration in fish (Cember, Curtis, Blaylock, 1978). This was not considered in our study and may be of interest. Also, it has been shown that controls on mercury discharges have effected a decrease of the mercury content of fish in an area (Armstrong and Scott, 1979).

the problem of trace metals (in particular, mercury) being contributed to the environment by man may be dealt with onty by {dentification of dangerous levels in the environment,

ing the source, and elimination of contaminants. It is only the first step of this procedure that this study deals with, with hopes that further work will be done if indicated

by our results.

PROCEDURES

Field Method

Sampling trips were made throughout June, July, and the beginning of August, 1979, Within Mayaguez Bay trawl nets were used, both in the day and at night. At Tourmaline reef off-shore and on trips further afield collection was made by spearfishing and hook and line. All samples were stored on

ice, transported to the lab, and frozen.

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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 for identi-fication. The specimens were counted, measured and 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 Gigested with concentrated sulfuric and nitric acid in a 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.

Calcutations

?The absorbance can be calculated from the percent transmittance by using Beer's Law: A=log 1/T. The samples were

---Page Break---

analyzed together with a series of standards of mercury.

These were graphed with a Linear Regression that was used

to Cetermine the final concentration of the element in the

different samples. The final concentration of mercury was

determined by the formula:

Final cone.« (cone.-blank) ¥ volume of sample

?grane of sample

?The final concentration was given in micrograms of mercury

Per gram of sample, oF ppm.

Graphs comparing fish size to mercury concentration

wore made for the more comuon 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 aifferent species, the

ean morcury concentrations found varied from .007 ppm (ug/s)

to 1.47 ppm. The only fish found to exceed the U.S. Food and

Drug Administration action Limit of 1.0 ppm were Seamus

coeruleus (@ large parrotfish) from Tourmaline, and several

Contropomus undeotnal

from the Guanajibo river mouth, with

concentrations to 1.9 ppm in some fish, The Centropomua

(or snook) are a concern because they are considered excellent

for eating and were acquired from fisherman who were selling

then for food. Controponue enatferue from the Aflasco 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

---Page Break---

the Limit established by the U.S.F.D.A., but variations among species, sampling areas, and size occurred at lower

mercury concontration

Unfortunately, not all the samples were readily comparable between sampling sites. Stations on a reef did not yield the sane 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 be- tween species and size groups impossible in many cases. A

trtest was done for comparison of the following: Aflasco ve.

Mayaguez, Tourmaline and Punta Ostiones reefs vs. Desecheo

Istand, Afiasco and Mayaguez ve. Desecheo, Afasco and Mayaguez

urmatine and Punta Ostiones, and Desecheo, Tourmaline

ta Ostiones vs. Aiasco 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 Afasco 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 éifference in the mercury content.

It is well known that mercury {s 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 an increase in

size. These were Baliet

vetula, Bothue sp., Callinectes

SD, Contropomus undectmalie, Cephalopholiea futva, Cynosoion

---Page Break---

janaieensie, Diapterus sp., Larimus breviceps, Lutjanue

synagrie, Ophioseton aduetue, Panutirue argus, Peneaus 8P-»
Selene vomer, Symphumue aravak, and Trichivus lepturus. Some
of the species tested showed a decrease in mercury levels

with an increase in size, These were Epinophelus guttatua,

Epinephelue etriatuo, Petmometopon eruentatun, and Potydactyiue
sp. (see graphs). The other species analyzed were not graphed
as there were not enough size groups for each.

?The minimum number of points used for graphing was three which may allow for too great an error. The fact that the points esed were mean concentrations regardless of station,

there m

be some fluctuations in the graphs that are not attributable to size increase only. (The graphs were done by means of Linear regression analysis and best fit line.) onty the large fish had concentrations approaching or exceeding potentially dangerous levels. We also observed a correlation between diet and mercury concentration. Grazers and other organisms lower on the food chain (such as conchs, lobsters, or shrimp) generally exhibited lower mercury concentrations than carnivorous or predator species.

In some specimens we were able to analyze the gonads as well as the edible flesh and found less mercury in the gonads.

?The gonads were not free from mercury, however, and

pecially

in very large fish (in particular, Centroponue) the mercury concentration of the gonads was high enough (see table) to warrant concern about future generations of fish continually exposed to high levels of mercury.

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CONCLUSIONS AND RECOMMENDATIONS

?here is a positive relationship between size and mercury concentration with a few exceptions, since larger fish denon-strated significantly higher levels of mercury. This has been found by other researchers in the field. There is also an apparent correlation between an organism's niche in the food web and the level of mercury accumulated in 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 Acadeny of Science and the National Academy of Engineering and originally established 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 nade 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 to educate the public, once

again, of the dangers involved.

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our results were generally similar to those of the research done in Guayanilla Bay by José A. Ramfrez Barbot (979). The same relationship between fish size and mercury concentrations was observed. Similar results were found for the sane species in both studies. Centroponus undeoinatie, 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 mereury in other components of the environment surrounding the fish sampled. Not only water and sediment, ané food sources, but also temperature records may be both interesting ané beneficial to a study of this kind.

Movs importantly, however, we need to pinpoint the sources of mercury pollution and implenent some form of

control. Traditionally, it has been known that tuna have

part:

larly high mercury concentrations. The presence of

the tuna cann

es on the northern shore of Mayaguez Bay

that have been releasing their effluent into the bay for years

is certainly suspect ae a mercury pollutant. Before we actually

endanger the fish populations and the people who eat them, we

should take care to regulate the amount and kinds of waste we

contribute to our environment. In this area, mercury may be

of particular concern as it so directly affects the fish that

are necessary to the economy.

---Page Break---

TABLE 1

SUMMARY OF MERCURY CONTENT

OF FISH AND INVERTEBRATE ORGANISMS

---Page Break---

EAN CONC.

secies stze__STATION (ug/g) _STA._DEV._n

dewithoetracton Tourmaline

quedricornie 15-18 em Reef 0303 0011 1

Aoanthoetracion Tourmaline

potygoniue 21-24 em ? Reet 0126 0015 1

Anchoa Tyotepte 3-6 em Ahasco 0612 0.0 10

fntotmemia suwinoweneie 27-30 em Tourmaline wt 0356 1

Balieves vetute 480 0076 4

21-24 em Tourmaline 0346 0081 1

2h-27 cm Tourmaline 0387 0.0 1

27-30 cm Tourmaline 0382 0008 1

33-36 cm Tourmaline 0802 0027 1

Bothus sp. 0998 0177 2

3-6 om Arasco 0513 0087 8

Mayaguez 0450 0015 "

BS em 482 0062 20

6-3 cm Afasco 0988 0037 18

9-12 om Anasco -1782 0027 3

12-15 em Mayaguez 21298 0051 1

Callinectes sp. <1130 0872 86

0-10 g ? Anasco 02h 0007 52

Mayaguez 0189 +0006, 5

ows - 0217 0013 57

10-20 9 ARasco 0318 -0010 7

30-40 9 Anasco 0921 0189 4

Mayaguez 0543 0037 2

B0-W0g = 0732 0226 6

40-50 9 Anasco 1064 0157 7

Mayaguez 0560 0 1

0-509 = 0817 0157 8

50-60 9 Anasco 1008, 0073 3

60-70 g Anasco 3052 0169 1

70-80 9 Atasco 1263 0210 2

80-90 9 © Anasco 0822 0024 2

---Page Break---

species

size

STATION

MEAN CONC.

(ua/a) STA. ev. in

- 1.4702 7132 4

- 3015 015 2

9.53 ka Guanajibo 1.0520 £1635 1

11.79 ko Guanajibo 1.6106 A158 1

13.61 ko Guanajibo 1.3124 0048 1

gonads Guanajibo 0.2119 0093 1

15.88 kg Guanajibo 1.9048 0391 1

gonads Guanajibo 9.3910 0052 1

73 0362 2

30-33 em Anasco 13 0308 1

33-36 cm ARaseo 7853 0054 1

35.2. cm Desecheo 0305 000 ?

0 1013 0595 9

15-18 cm Tourmaline 0424 0008 1

18-21 em Tourmaline 1829 0137 1

Desecheo, 0912 0055 1

1Bahem = 1371 0192 2

21-2h cm Tourmaline .14K6 0091 1

Desecheo 0629 0022 5

2i-zh em +1038 013 6

2-27 em Desecheo 0835, 0054 1

chaetodiptenue Saber 21-2h em Tourmaline .0678 0010 2

chtoroacenbmie

3-6 cm Mayaguez 0324 0.0 6

18-21 cm Tourmaline 0564 0006 1

1527 0034 10

6-9 em Afasco 0551 0018 4

9°12 cm Mayaguez an 0016 4

12-15 cm Mayaguez 1658 0.0 1

15-18 em Mayaguez 276 0.0 1

Digpterue sp. 0328 0051 "

3-6 cm Mayaguez 0298 0008 7

6-9 em Mayaguez 0269 0033 1

9-12 em Mayaguez 0325 0.0 5

12-15 em Mayaguez 0339 0009 1

---Page Break---

MEAN CONC.

species SiZe___STATION (ug/g)__STA. 9EV._n

Diodon holacantiua 0166 0.0 5

6-3 om Joyuda 0159 0.0 4

9°12 em Joyuda 0172 0.0 1

Dipteotmum nad 6-9. cm Joyuda 0322 0002 1

spinephelua gut 0526 2020514

Pea. Ostiones -0470 0027 1

La Parguera -0802 0004 1

118 em = 0636 0031 2

18-21 em Tourmaline 0464 0066 3

Pea. Ostiones -0458 0024 5

18-21. = 20461 0100 8

21-24 em Pra. Ostiones 0514 0047 4

0736 0278 4

21-Th cm Pa. Ostiones -0656 0002 1

2h-27 em Pta, Ostiones .1223 0039) 2

36-39 om Pta. Ostiones .0408 0237 1

Eusinostomas so. 0459 0.0 4

3-6 cm Guanajibo ??.0380 0.0 3

6-9 em Guanajibo 0538 0.0 1

Buthyrnue 30. 30-33 cm Tourmaline 1369 0191 1

Hoeriton sp. 0623 0025 5

3-6 em Anasco 0548 0.0 2

6-3 cm Mayaguez 0757 0025 3

Havengula sp. 2128 os 7

6-3. em Mayaguez £1305 os

9-12 em Anasco 2953 0068 4

Lactophaye biaudalie 18-21 ?m Desecheo 0226 0025 1

Lactophrye trigonue 15-18 cm Tourmaline 0563, 0017 ?

larimie brevicere 1572 0815 AB

0-3 cm Anasco 0230 0.0 | (0

3-6 em Anasco. 0353 00 13

6-9 em Afasco O75 018312

Mayaguez 120 0028 2

63 em = 0993, tL)

9-12 cm Ahasco 0551 0135, 5

Mayaguez 1576 0.0 3

---Page Break---

MEAN CONC

Secies Size __ STATION (ug/g) _STA. DEV. in

Farinas Bre G12 en 1064 0135 8

15-18 cm Nasco +3361 0552 1

18-21 em ARasco 4517 ont 1

15-18 cm Pta, Ostiones .0389 0013 1

Iutganue foo Pea. Ost 1220 0091 1

Lutianue synagrie 0535 0038 7

3-6 om Mayaguez 0282 0014 3

6-9. em Joyuda nz 0047 2

Mayaguez 0677 0037 5

63 en - 0550 0074 7

9-12 em Mayaguez 0760 0010 1

ue 0614 20335 "

9°12 em Mayaguez 0837 0033 2

9-12 em Anasco 0310 0127 1

B12 em = 0824 0160 3

12-15 om Mayaguez 0315 0014 2

15-18 cm Mayaguez 016 ors 1

18-21 cm Mayaguez 0580 0015 1

21-24 em Mayaguez 0586 024 1

24-27 em Mayaguer ost 0.0 2

30-33 cm ARasco 21387 0075 1

Pamulivue ange 0322 0172 6

21-24 em 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 em 0317 0040 5

Ponoaus sp. 0512 0370 $50

0-3 cm Anasco 018 0050 200

3-6 om Afasco 0228 0056 50

6-9 em Afasco 0751 00K 236

Mayaguez 0259 0018 26

69 om = 0505 0064 262

---Page Break---

MEAN CONC:

SeciES. SIZe_STATION (ug/a)__STA. DEV. _n

Poaneaus sp. 9-12 em Masco 1129) 0031 2

Mayaguez 0506 0.0 2B

912 en - 0818 0031 35

12-15 em 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

21-2h cm Tourmaline «1231 0032 1

24-24 em Desecheo +0951 ont 3

21-26 om - 1031 013 4

2h-27 cm La Parguera ? -1300 0012 3

© 1275 1070 28

3-6 cm ARasco 3312 0.0 2

Mayaguez 0071 0008 2

3-6 om - 1692 0008 23

6-3 em Ahasco 0921 001 1

9-12 em asco ont 0925 1

Mayaguez 1350 0126 3

93-12 em - 1036 1051 4

Pomacanthus ancuatus 27-30 cm Tourmaline 0424 0392 1

Ryptioue eaponaseue tou 0042 4

9-12 em Mayaguez 0757 0025 3

12-15 em 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 em Mayaguez 1832 0028 3

Sermanus lavivertyis 36 em Joyuda +0626 0.0 2

Sphacroides testulineus 3-6 em ?Afasco 0236 0.0 2

Steliffer sp. 21486 017 7

6-3 em Anasco 1262 20055 6

9-12 em Masco <1709 0092 6

---Page Break---

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 em Atasco 0520 0072 9

Mayaguez 0392 0.0 1

63 em 0456 0072 10

9-12 em Afasco. 077 0088 19

Mayaguez 20335 0035 2

- 05m 0123 2

?Anasco +0506 oot 6

Mayaguez 0610 0008 2

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

---Page Break---

?~z

Fig 1

SAMPLING SITES ON THE WEST COAST

OF. PUERTO RICO

aon

woe

RIO ANAascO.

MAYAGUEZ BAY

PUNTA GUANAJIBO

JOYUDA

TOURMALINE

PUNTA OSTIONES

LA PARGUERA

DESECHEO ISLAND

---Page Break---

GRAPHS SHOWING CORRELATIONS BETWEEN

ORGANISM SIZE AND MERCURY CONCENTRATION

---Page Break---

Hg concentration ug/g

38,

16.

08,

02,

Fig 2

Bothus sp. y= 0143+ 0109 Cx?

IJ

as TS ws 155

Length in em.

---Page Break---

Hg concentration ug/g

Hg concentration ug/g

345

Fig. 2

Balistes vetula ?_y = ~.0562 + 0098 cx)

ans

Length inem.

Centropomus undecimatis.

¥ = 0525 +0506 (x)

Weight in Ko

---Page Break---

Fig 4

se

si

so

swes6 UF aUBIOM

ss sy se

(L100 + 6020 = &

sz

st

8/6n uonesnus2u0s BH

---Page Break---

264 Fig 5

25; Gynoscion jamaicensis

y= = 1276+ 0234Cx)

7s eS 3 1s

Length in em.

---Page Break---

Fig 6

14,

013,

Cephalophotis ful

or, Y¥ =-0287 + 003 x)

008,

oa, +

ss Ws 25) 255

Length in em,

Diapterus sp

040) y 2.0216 + 00120) .

Mg concentration ug/g

a5 75 Ws 35

Length inem,

---Page Break---

ig concentration ug 43

Fig 7

Epinephelus guttatus

y=.0904-002060

055+

050

pas

aoe

Se

16s. 195 225

Length incm

Spnepbetis striatus

Wg concentration 15/0

a

25 255 285 3s 345

Length in em

---Page Break---

Hg concentration wag

Fig 8

arimus breviceps y= ~.0616 + 022660)

7 0s 35 65 1S

Length in em.

228

---Page Break---

vere

Lutjanus synagris ?y=.0067 + .008¢x?

onl

03)

02,

on.

as 75 ws 135

Length in em.

---Page Break---

Fig 0

wo ur wBue7

sez sgt

Cx 9900 4 save =A

so

3109.2U09 8H

6/6n vor

---Page Break---

Fig 11

y=.0302 + 000070

a

020:

8/00,

§

vonen32009 OH

oa.

oa

35

285

255

225

Length in em.

---Page Break---

vo

Hg concentration

3B

Peneaus sp.

a

Fig 12

y= 0097 + 0047 Cx>

75 ws

Length in em.

5

---Page Break---

Fig. 13

y=.444-000860

6/6n_uonenvesv0s 8H

255

225

195.

Length in om.

---Page Break---

varg

Hg concentration

Polydactylus_sp.

y=-2036 - 0109 60

as 75 ws

Length in em,

---Page Break---

Fig. 15

ye 0015+ 228400

20-

18°

co

2d

8/6 vonenueou0> 6H

105

75

45

Length in cm

---Page Break---

Fig. 16

Symphurus_arawak

0137 + 0038¢x>

or,

3 75 0s 155 es

Length in cm,

---Page Break---

Fig 17

G60

Ee

vonesnuasucs 64

&

435

25ST

95

Length in cm

---Page Break---

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APPENDIX TABLE 1

ADDITIONAL DATA

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WATER SANPLE ANALYSIS

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SAMPLE STATION MEAN CONC. (ug/i) STA. DEV. NOTES

? Anaseo <0.001 -

8 Anasco <0.001 -

a Mayaguez <0.001 -

6 Mayaguez <0.001 -

3A Punta Guanajibo ? <0,001 -

: Punta Guonajibo ? <0.00" -

?A soyuda <0.001 -

2 Joyuda <0,001 :

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APPENDIX TABLE 2

ADDITIONAL DATA,

SEDIMENT SAMPLE ANALYSIS

STATION EAN CONC. (ug/g) STA. DEV. __NOTES

?Araseo 0679 0.0

8 nasco 0677 20243

2h Mayaguez 1787 0087

28 Mayaguez mg 0004

3A Punta Guanajibo 0423 0126

3 Punta Guanajibo ? .0745 0.0

A toyuda 1036 ork

4s Jeyuda 1018 0.0

5 Punta Ostiones 0936 0123

6 Punta Ostiones 1005 sort

7 Punta Ost iones <0.003 0.0

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