REPORT OF FINDINGS

SYNOPTIC SURVEY OF TOTAL MERCURY IN RECREATIONAL FINFISH OF THE GULF OF MEXICO

TONY LOWERY, PH.D. AND E. SPENCER GARRETT III

NOAA Fisheries
Office of Sustainable Fisheries
National Seafood Inspection Laboratory
Pascagoula, MS

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Robins, C. Richard, G. Carleton Ray, and John Douglass. A Field Guide to Atlantic Coast Fishes. New York: Houghton Mifflin, 1986.

Shipp, Robert L. Dr. Bob Shipp's Guide to Fishes of the Gulf of Mexico. Mobile, AL: Dauphin Island Sea Laboratory, 1986.

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EXECUTIVE SUMMARY

The “Synoptic Survey of Total Mercury in Recreational Finfish of the Gulf of Mexico” evaluated selected finfish as potential “indicator” species for their efficacy to identify mercury hot spots in marine and estuarine waters. The metric used for the basis of the evaluation was the total mercury concentration in the meat of the fish, versus fish length. In all, 1,660 individual fish were sampled and analyzed (1,076 estuarine fish, 385 reef fish, and 190 pelagic fish). For estuarine waters, spotted seatrout and hardhead catfish are recommended for further evaluation as “indicator” species. Tampa Bay’s spotted seatrout and sand seatrout appeared to have elevated total mercury concentrations versus length relationships compared to the other three estuaries sampled (Mobile Bay, Matagorda Bay and Galveston Bay). Mobile Bay’s hardhead catfish appeared to have elevated total mercury concentrations versus length relationships compared to the other three estuaries sampled (Tampa Bay, Matagorda Bay, and Galveston Bay). There was no difference identified between the total mercury concentration versus length relationships of fish from Gulf rigs off the Louisiana Coast and Gulf reefs off the Florida Coast. However, additional sampling for Cobia, blackfin tuna, little tunny, yellowfin tuna and gag grouper is necessary to complete the comparison. The pelagic fish samples did not identify a difference between the total mercury concentrations versus length relationships of fish from Southern Texas versus Southern Florida. Again, additional sampling is necessary to complete the comparison. Scatter plots and regressions on 23 recreational finfish are presented in this report. Protocols used to complete this survey are also provided.

INTRODUCTION

The purpose of the "Synoptic Survey of Total Mercury in Recreational Finfish of the Gulf of Mexico" (Survey) was to compare the total mercury concentrations of recreational finfish from the U.S. Gulf of Mexico and its adjacent estuaries. The Gulf States, EPA, and NOAA have sampled the fish in these waters for total mercury levels for decades. These data have been used for the generation of geographically specific fish consumption advisories to protect public health where needed.[1] However, the labor-intensive nature of the Cold Vapor Atomic Absorption total mercury analyses[2,3] and associated analytical costs prohibited the processing of large numbers of samples. Given that there are several marine and estuarine waters that need to be evaluated along the Gulf Coast, coupled with the cost of the Cold Vapor Atomic Absorption analyses, carrying out surveys at the level necessary to detect hot spots were not economically feasible in the past. However, faster, less expensive, and better analytical methods have been developed (i.e., Direct Mercury Analyses[4] based on thermal decomposition, amalgamation, and atomic absorption spectrometry), causing the cost of processing large numbers of samples for total mercury to drop dramatically. This expense reduction has made the evaluation of Gulf Coast waters' mercury status possible and hot spots can now be detected.

The question now becomes, can surveyors use a limited number of indicator finfish species in a systematic way to identify mercury hot spots that may not have been identified to date? Ideally, these indicator fish species would be available for collection by the types of fishing gear used by existing State and Federal sampling programs. Likewise, the length versus total mercury concentration relationships would be fairly strong. Last, but not least, these indicator fish species would need to demonstrate that their length versus total mercury concentrations relationships do clearly vary, based on where they are collected. Based on these criteria, a set of fish species were selected, sampled, and analyzed in order to evaluate which, if any, would be suitable indicator species for identifying mercury hot spots. The protocols, methods, and findings of this Survey are included in this report.

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[1] EPA Gulf of Mexico Program. The Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico. 2000., Public Health Focus Team. Stennis Space Center, MS. 71 pp.

[2] U.S. EPA. 1991. Mercury in tissues by cold vapor atomic absorption spectroscopy. Method 245.6. U.S. Environmental Protection Agency, Washington, D.C., U.S.A.

[3] U.S. EPA. 1994. Mercury in solid or semisolid waste (manual Cold Vapor technique). Method 7471A. U.S. Environmental Protection Agency, Washington, D.C., U.S.A.

[4] U.S. EPA. 1998. Mercury in solids or solutions by thermal decomposition, amalgamation, and atomic absorption spectrophotometry. Method 7473. U.S. Environmental Protection Agency, Washington, D.C., U.S.A.

BACKGROUND

The primary impetus for conducting this Survey came from the Gulf States Marine Fisheries Commission and Council (GSMFCC) for Federal assistance in addressing the mercury in fish issue in the Gulf of Mexico.[5] The GSMFCC became aware that there was insufficient mercury data for recreationally caught seafood species in a large number of the estuaries and sections of open waters along the U.S. Coast.[6] The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) conducted a similar Survey[7] in seafood species (including mercury) back in the 1970s that was used to establish public health safeguards for commercially harvested seafood species. Drawing on this experience and analytical expertise, NOAA's National Seafood Inspection Laboratory (NSIL) designed the Survey, and entered into an inter-agency agreement[8] with EPA's Gulf of Mexico Program (GMPO) to augment the funding necessary to carry out the Survey. Contracts were entered into with the following State Agencies to piggy-back the Survey's finfish sample collections onto existing finfish sampling programs or otherwise augment sample collection activities: Alabama Department of Conservation and Natural Resources' Marine Resources Division's Fisheries (Fisheries Independent Monitoring Program), Florida Fish and Wildlife Conservation Commission (Fisheries' Dependent Monitoring Program and Fisheries Independent Monitoring Program), Louisiana Department of Wildlife and Fisheries' Marine Fisheries Division (Finfish Program), Texas Parks and Wildlife's Coastal Fisheries Division (Fisheries Independent Monitoring Program). NOAA Fisheries (NSIL and NMFS Pascagoula Fisheries Laboratory) and NOAA Research (Texas Sea Grant) also collected samples for the Survey. NSIL carried out the Survey management, sample collection coordination, sample tracking, sample storage, total mercury analyses, data management, quality assurance (QA), data analyses, and generated this report of findings. The Survey dovetailed with the White House's Office of Science Technology and Policy 2004 Report's recommendation to increase Federal methylmercury research efforts in and along the U.S. Gulf of Mexico Coast, with the intent of applying lessons learned to other U.S. Coasts.[9]

The rationale and purpose behind the design of the Survey was to determine whether the Survey would be useful to collect information for the design of larger follow up surveys prior to expanding large amounts of resources. It would be useful to know which, if any, finfish species would be good indicators for identifying areas with elevated mercury content compared to other

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[5] Gulf States Marine Fisheries Commission. 2002. Methylmercury in Marine Fish: A Gulf-Wide Initiative. Ocean Springs, MS. 18 pp.

[6] EPA Gulf of Mexico Program. The Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico. 2000., Public Health Focus Team. Stennis Space Center, MS. 71 pp.

[7] Hall, R.A., E.G. Zook, and G.M. Meaburn. 1978. National Marine Fisheries Service Survey of Trace Elements in the Fishery Resource. NOAA Technical Report NMFS SSRF-721. 315 pp.

[8] Interagency Agreement: Synoptic Survey of Total Mercury in Recreational Finfish of the Gulf of Mexico. 2002. Agreement Number DW13945924. EPA Gulf of Mexico Program, Stennis Space Center, MS. DOC, NOAA, NMFS, National Seafood Inspection Laboratory, Pascagoula, MS.

[9] White House Office of Science and Technology Policy. Methylmercury in the Gulf of Mexico: State of Knowledge and Research Recommendations. 2004. National Science and Technology Council Committee on the Environment and Natural Resources. Interagency Working Group on Methylmercury. 19 pp.

areas (i.e., hot spots). It would also be useful to know how various finfish species responded to being associated with hot spots (e.g., would all the species be elevated, or only certain species?). It would also be beneficial to know which finfish species could be easily collected in large enough numbers to support larger Gulf-wide surveys in identifying hot spots. Theoretically, pending the outcomes of the Survey, a small number of finfish species could be collected as indicator species from a large number of water bodies. These species' mercury concentrations could be utilized to identify hot spots for the purpose of issuing specific recreational fishing advisories.

The Survey's intent was to assess the logistics of collecting a limited set of recreationally caught finfish species, and evaluating their usefulness in identifying mercury hot spots. The Survey was designed to collect mercury data on a representative set of recreational finfish species from a limited set of U.S. Gulf of Mexico estuaries and sections of the open Gulf and consisted of three phases: 1) estuarine sampling, 2) rigs and reefs sampling, and 3) migratory pelagics sampling. Details on each of these phases are provided in the following sections. The Survey analyzed total mercury concentrations present in the muscle tissue of 1,660 individual finfish from the U.S. portion of the Gulf of Mexico and adjacent estuarine waters.

ESTURINE SAMPLING

Estuaries

Because of the large number of estuaries on the U.S. Coast of the Gulf of Mexico (31), the following criteria were used to select the estuaries to be included in the Survey. NOAA's Ocean Service's (NOS) National Status and Trends Mussel Watch Project has been monitoring chemical contaminant hot spots in oysters, mussels, clams, etc. for U.S. estuaries since 1986.[10, 11] The Mussel Watch Project has data for mercury concentrations in Eastern oysters (*Crassostrea virginica*) from all of the U.S. Gulf of Mexico estuaries and many sub-basins. The Mussel Watch Project's Eastern oyster data for the U.S. Gulf Coast was reviewed to identify estuaries with elevated mercury concentrations in its oysters and estuaries with non-elevated mercury concentrations in its oysters. The criteria was based on the higher oyster mercury concentrations (>0.3 ppm), Tampa Bay, FL and Matagorda Bay, TX were selected for inclusion in the Survey. The mercury concentrations for Mobile Bay, AL and Galveston Bay, TX had some of the lower concentrations (>0.1 ppm). As a result, Mobile and Galveston Bays were selected for inclusion in the Survey. The assumption is that the oyster mercury concentrations provide a surrogate organism for mercury availability in these estuarine ecosystems, and that its availability would influence the mercury concentrations in the estuaries' resident finfish.

Matagorda Bay was also selected for the Survey because it contains a well studied mercury superfund site in its Lavaca Bay sub-basin.[12] Previous sampling of red drum and black drum mercury concentrations were observed to be elevated near that site.[13] Therefore, Matagorda Bay presented the Survey with an opportunity to partly evaluate sub-basin influences on the distribution of finfish with elevated mercury concentrations within an estuary. To accomplish this partial evaluation, finfish were not collected from the Lavaca Bay portion of Matagorda Bay in order to determine if finfish with elevated mercury concentrations appeared in the other portions of Matagorda Bay.

Estuarine Species

Ten estuarine finfish species were selected for sampling during the Survey. These species tend to be estuarine residents and based upon consultations with the State Agencies' sampling program staffs, these species' adults and juveniles are abundant in the estuaries of the Gulf Coast with the exception of Tampa Bay's Atlantic croaker and Southern flounder. These Survey species are listed in Table 1. Most of the U.S. Gulf Coast is within the Louisianan Biogeographic Province

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[10] National Oceanic and Atmospheric Administration (NOAA). 1998 (on-line). "Chemical Contaminants in Oysters and Mussels" by Tom O'Connor. NOAA's State of the Coast Report. Silver Spring, MD: NOAA.
URL: http://state_of_coast.noaa.gov/bulletins/html/ccom_05/ccom.html

[11] Sericano, J.L. 2000. The Mussel Watch approach and its applicability to global chemical contamination monitoring programmes. International Journal of Environment and Pollution (IJEP), Vol. 13, No. 1/2/3/4/5/6.

[12] EPA. 1994. National Priority List Site Narrative for ALCOA (Point Comfort)/Lavaca Bay ALCOA (Point Comfort)/Lavaca Bay Point Comfort, Texas Federal Register Notice: February 23, 1994.

[13] ALCOA Alumina and Chemicals, L.L.C. 2000. Final Baseline Risk Assessment Report ALCOA (Point Comfort)/Lavaca Bay Superfund Site.

whose estuaries support similar sets of finfish species that have similar temperature regimes and other considerations. Tampa Bay is located in an area that transitions from the Louisianian Biogeographic Province to the Caribbean Biogeographic Province. As a result of its location, Tampa Bay supports most of the species that are usually associated with the Louisiana Biogeographic Province. Atlantic croaker and Southern flounder abundances are not high enough to support Gulf-wide surveys such as this Survey. However, these two species are very abundant in the U.S. Gulf Coast estuaries to the north and west of Tampa Bay, and were included in the Survey with Gulf flounder being substituted for Southern flounder and Atlantic croaker being omitted from Tampa Bay's set of species to be collected.

Table 1. Estuarine species sampled: Of the 1,170 samples targeted, 1,076 were collected. Approximately 120 samples were collected for each specie (nearly 30 samples per specie per estuary)

Catfish:	Gafftopsail catfish, hardhead catfish
Drum:	Atlantic croaker*, red drum, sand seatrout, Southern Kingfish, spot, spotted seatrout
Mullet:	Striped mullet
Flounder:	Gulf flounder**, Southern flounder*

* Not present in adequate numbers for Tampa Bay
**Substituted for Southern Flounder in Tampa Bay

The sample design called for the collection of both juveniles and adults, of the selected species (Table 1), to obtain the range size necessary to evaluate fish length versus mercury concentration (in muscle tissue) relationships per species and across estuaries. A detailed description of the sampling protocol, tissue extraction, sample tracking, and analyses are provided in Appendix 24. Fish body length measurements and muscle tissue were collected from ten each of ten small, medium, and large individuals of a given species which resulted in a total of 30 individual fish being sampled for a given species per estuary. The size ranges were based on a review of reference texts.[14,15,16,17] Since four estuaries were sampled, this resulted in 120 individual fish tissues being collected for the Survey, per each of the ten species being collected (with the exception Tampa Bay, see Table 1). In total 1,170 tissue samples and corresponding fish lengths were the target number for the field sampling. Of the 1,170 samples targeted, 1,076 samples were actually collected since some species were more difficult than others to collect in the size ranges called for by the sample design (i.e., small, medium, large, see Appendices 26-45 for specific size brackets in centimeters and measuring instructions). The results of the total mercury analyses data are presented in Appendices 1-10 with graphical presentations in Figures 1-10.

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[14] Hoose, H.D. and R.H. Moore. 1998. Fishes of the Gulf of Mexico. Texas A&M Press, College Station, TX. 422 pp.

[15] Shipp, R.L. 1986. Fishes of the Gulf of Mexico. KME Seabooks, Mobile AL. 256 pp.

[16] Walls, J.G. 1975. Fishes of the Northern Gulf of Mexico. T.F.H Publications, Inc. Ltd, Neptune City NJ. 432 pp.

[17] Robins, C.R., G.C. Ray, J. Douglas and R. Freund. Atlantic Coast Fishes. Houghton Mifflin Comp. Boston New York. 354 pp.

Estuarine Results

The following species clearly exhibited elevations in their muscle tissues' total mercury concentrations versus length (TML) relationships: 1) hardhead catfish, 2) sand seatrout, 3) spotted seatrout, and 4) Southern kingfish. The other species tissues' TMLs were inconclusive with elevations that were not clearly identifiable. In terms of being candidates as indicator species for identifying hot spots, spotted seatrout and hardhead catfish were collected in sufficient numbers in the four estuaries, while sand seatrout and Southern kingfish were not. Spotted seatrout and hardhead catfish appear to be good candidates for follow-up estuarine hot spot surveys. The spotted seatrout are primarily fish eaters (piscivores), and their TMLs are most likely reflecting the classic bioaccumulation through the food chain scenario (e.g., big fish eating smaller fish, etc.). Conversely, hardhead catfish are primarily scavengers and their TMLs may be reflecting the scavengers' ability to feed on larger fish that have died (e.g., little fish eating larger dead fish, etc.).

Sub-basin Hot Spots

Matagorda Bay's (non-Lavaca Bay) finfish TLMs were not elevated. This suggests that sampling at the estuary level (i.e., basin level) has the potential to miss hot spots depending on where the samples are collected within the basin (e.g., if samples were not collected from the portion of the estuary that has the hot spot, then the samples may not identify the hot spot). Additional sampling and analyses from the Lavaca Bay portion of Matagorda Bay would be necessary to confirm the need for sub-basin sampling in follow-up estuarine hot spot surveys.

Use of Mussel Watch's Oyster Data

The Mussel Watch oyster data's utility as a surrogate for identifying hot spots at the estuary level, appears to have been successful for the classic bioaccumulation scenario believed to be reflected by the TMLs of the spotted seatrout and sand seatrout. Tampa Bay was identified as elevated based on its oysters' mercury concentrations (0.3 ppm), and that spotted seatrout and sand seatrout had elevated TMLs compared to the other estuaries. Matagorda Bay's oysters were elevated (0.3 ppm), and Matagorda Bay's Lavaca Bay is known to contain an industrial mercury superfund site. Galveston Bay's oysters' mercury levels were not elevated (<0.1 ppm) nor were its spotted seatrout and sand seatrout compared to the other estuaries. Mobile Bay's oysters were also not elevated for mercury (<0.1 ppm), while its spotted seatrout and sand seatrout were not elevated compared to the other estuaries. Therefore, use of the Mussel Watch oyster data as an aid in identifying hot spots appears to be supportable.

The Mussel Watch oyster data did not work well as an aid in identifying Mobile Bay as containing a scavenger based hot spot. Therefore, based on this very limited set of evaluations, the oyster mercury data appears to have aligned itself more closely with the classic piscivorous bioaccumulation TMLs than to the scavenger TMLs. As a result, identifying scavenger based hot spots may prove more difficult and may require hardhead catfish sampling as the primary means of identification.

Estuarine Sampling Inferences

Based on the results of the aforementioned portion of the Survey, the following is a suggested strategy for designing follow-up surveys for the U.S. Gulf estuaries. The Mussel Watch's oyster mercury data should be evaluated to identify estuaries and sub-basins, where the oyster mercury concentrations appear elevated. Spotted seatrout and hardhead catfish muscle tissue and body lengths would be collected in accordance with the sampling protocols in Appendix 24 from these estuaries and sub-basins. Comparison of these estuaries' and sub-basin's TMLs for their spotted seatrout and hardhead catfish would be used to confirm mercury hot spots.

Figure 1. Hardhead catfish fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 120) combined (see Appendix 1 for data).

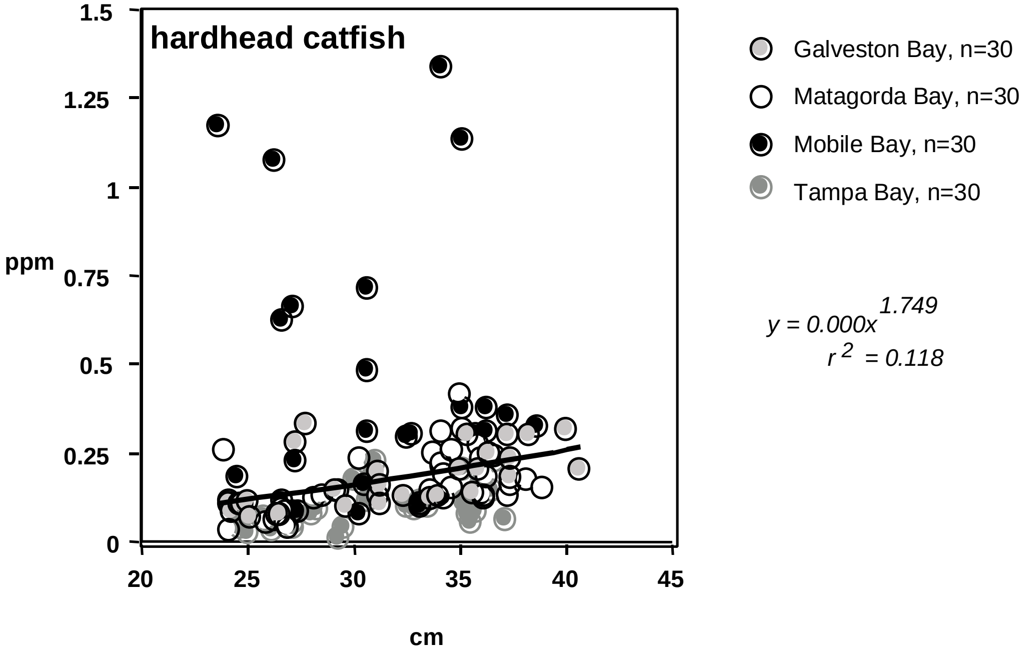


Figure 2. Gafftopsail catfish fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 87) combined (see Appendix 2 for data).

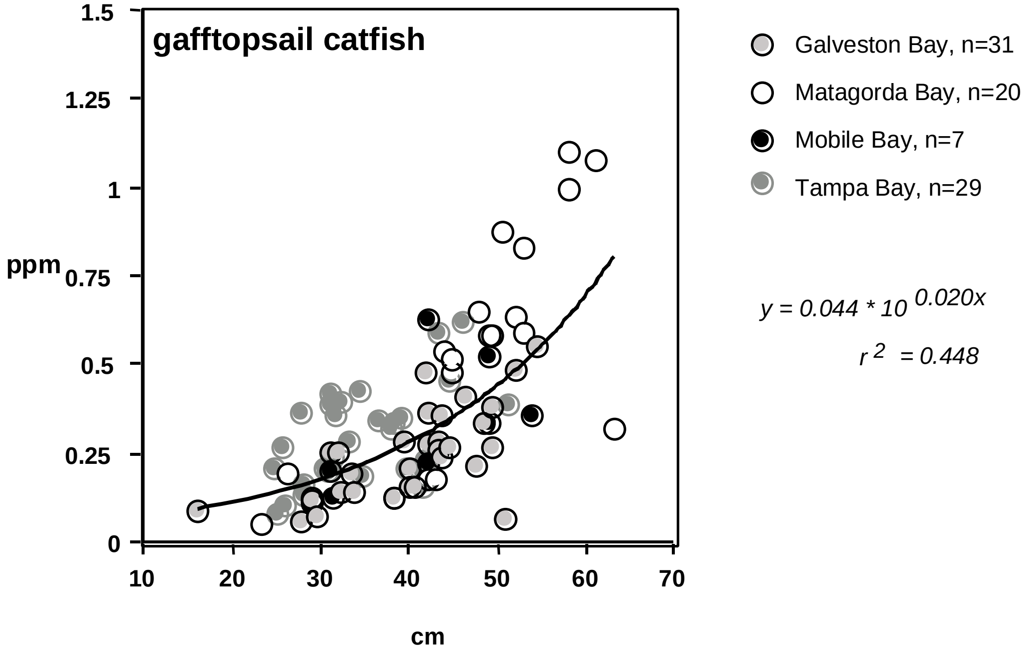


Figure 3. Atlantic croaker total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 60) combined (see Appendix 3 for data).

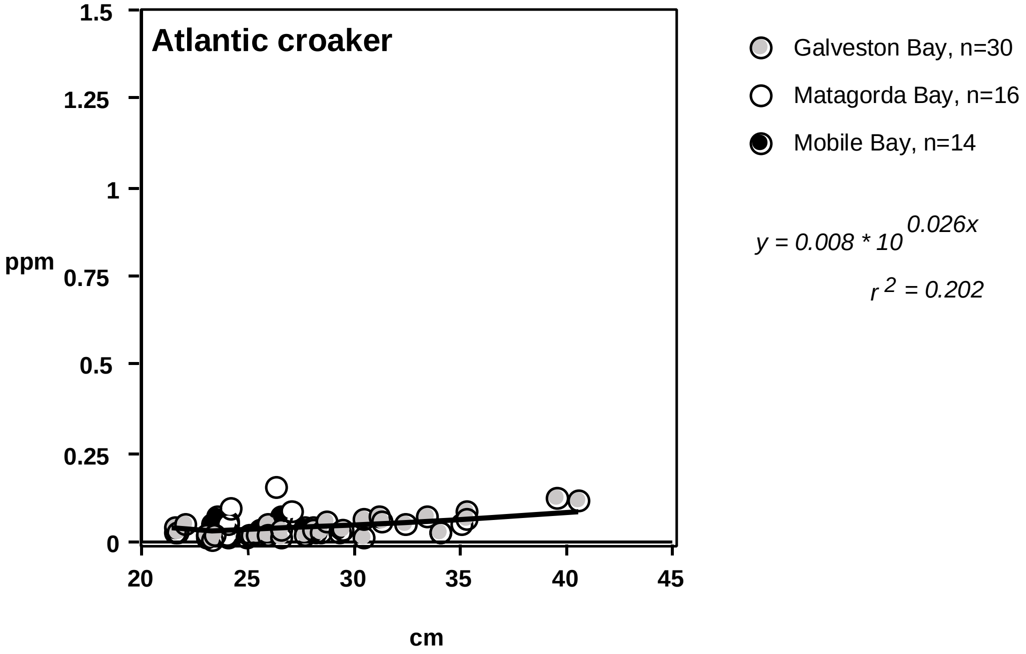


Figure 4. Spot total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 118) combined (see Appendix 4 for data).

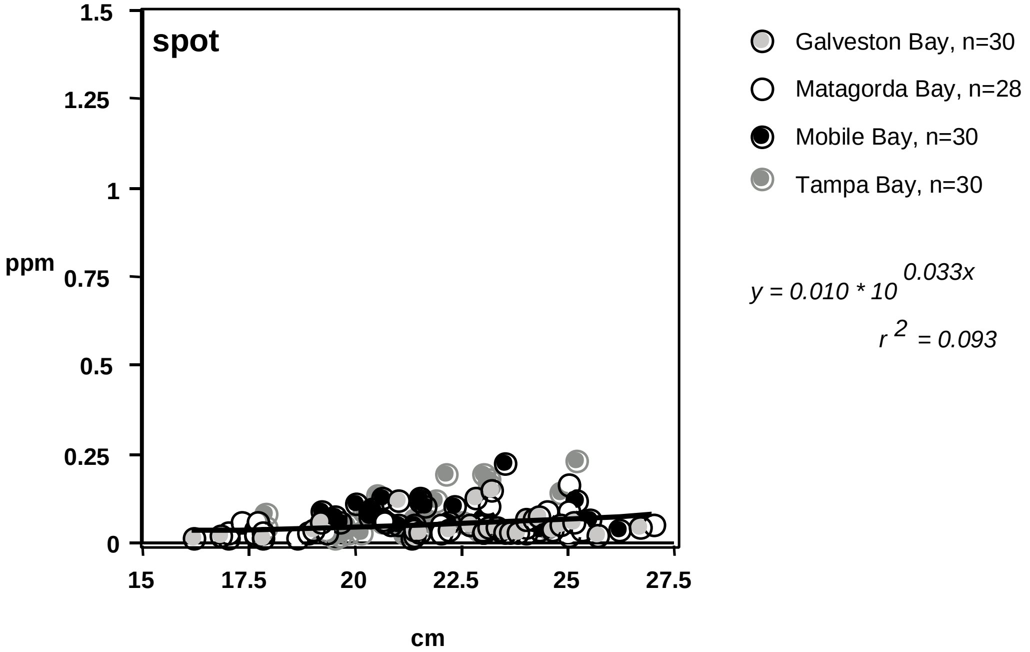


Figure 5. Southern kingfish total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 81) combined (see Appendix 5 for data).

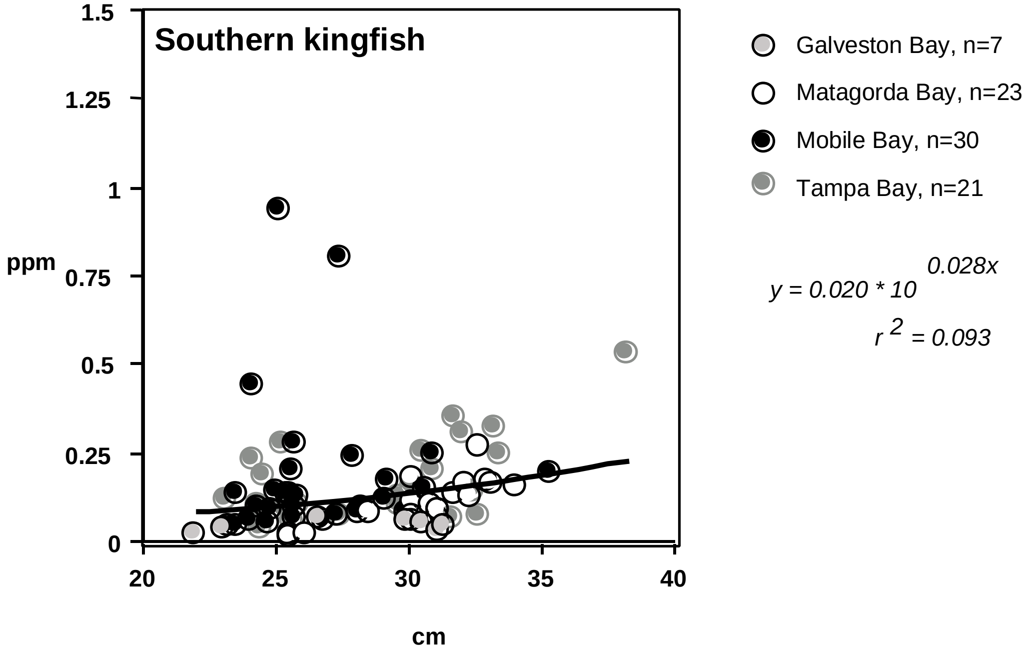


Figure 6. Sand seatrout total length (cm) vs. total mercury concentration (ppm) regression solid line) and scatter plot for all data (n = 94) combined (see Appendix 6 for data).

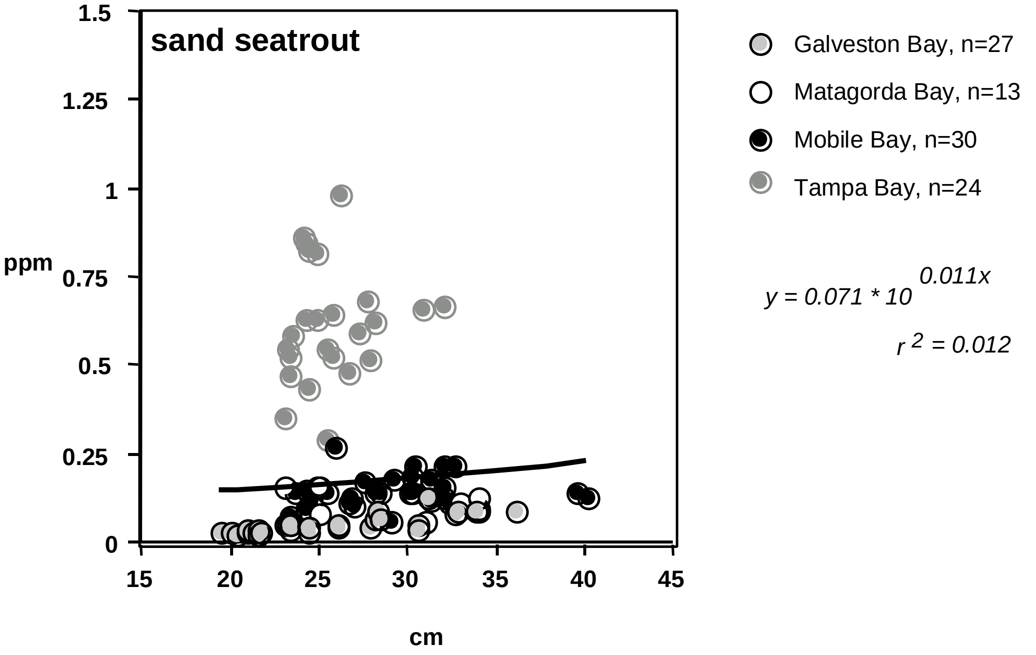


Figure 7. Spotted seatrout total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 117) combined (see Appendix 7 for data).

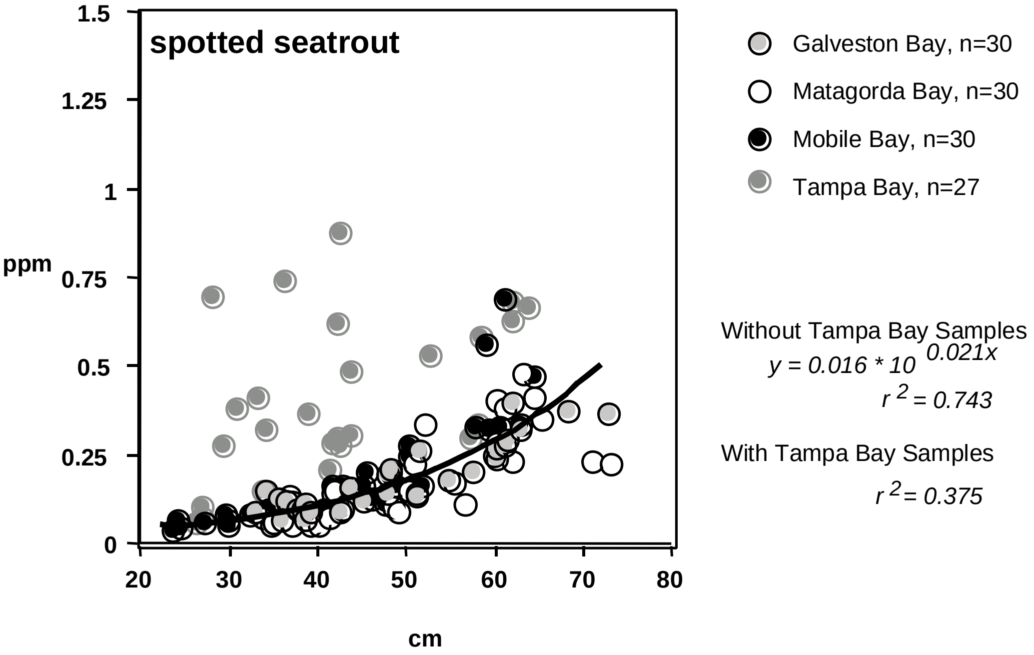


Figure 8. Red drum total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 115) combined (see Appendix 8 for data).

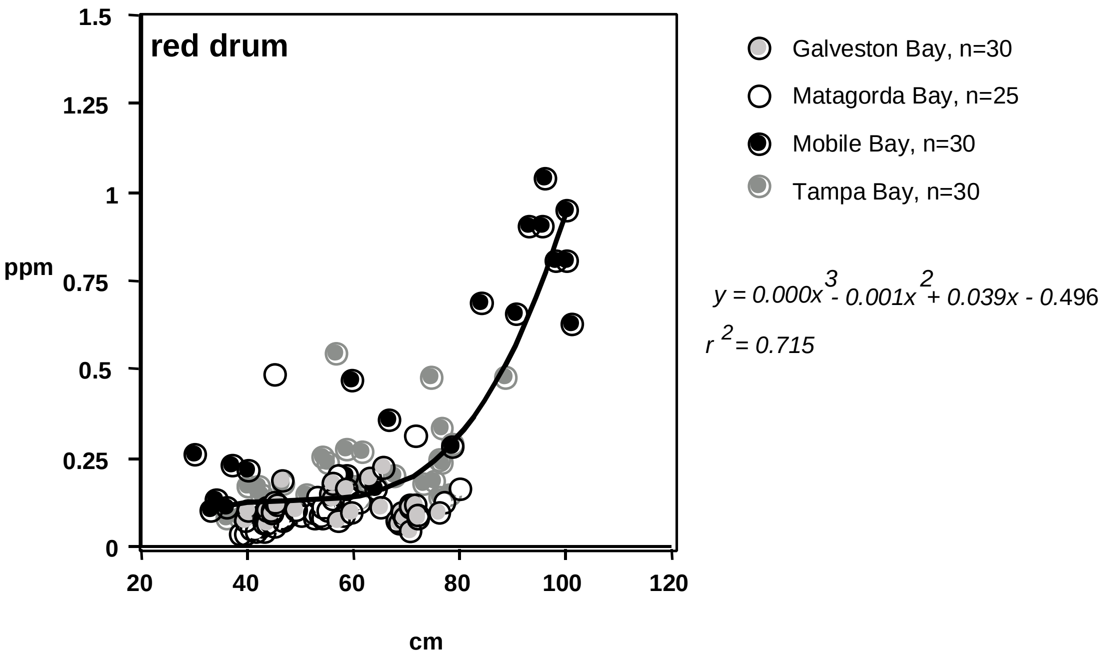


Figure 9. Striped mullet fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 120) combined (see Appendix 9 for data).

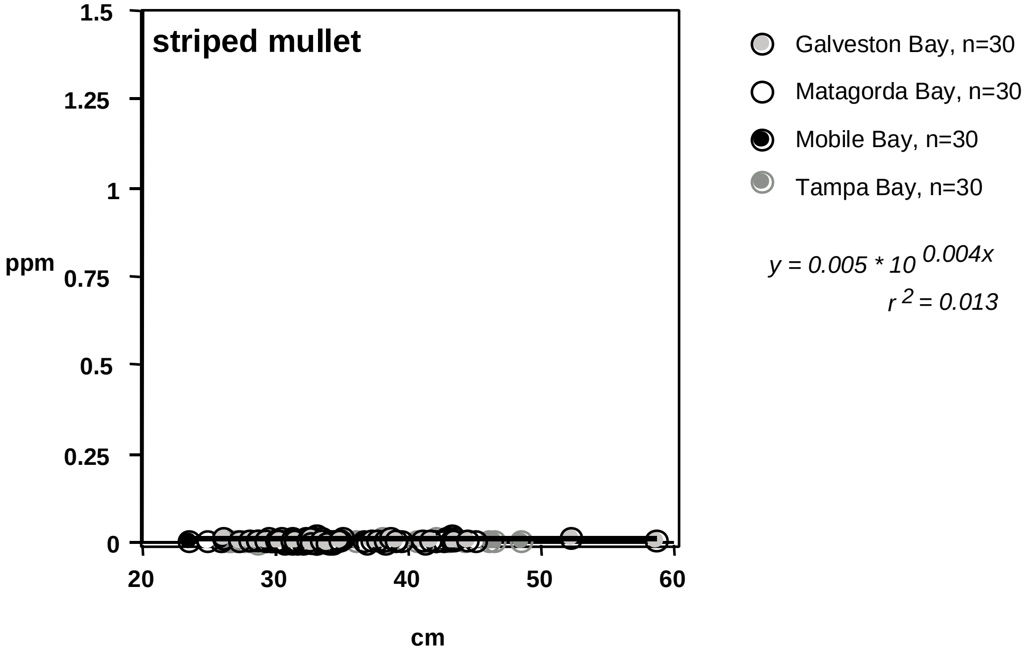
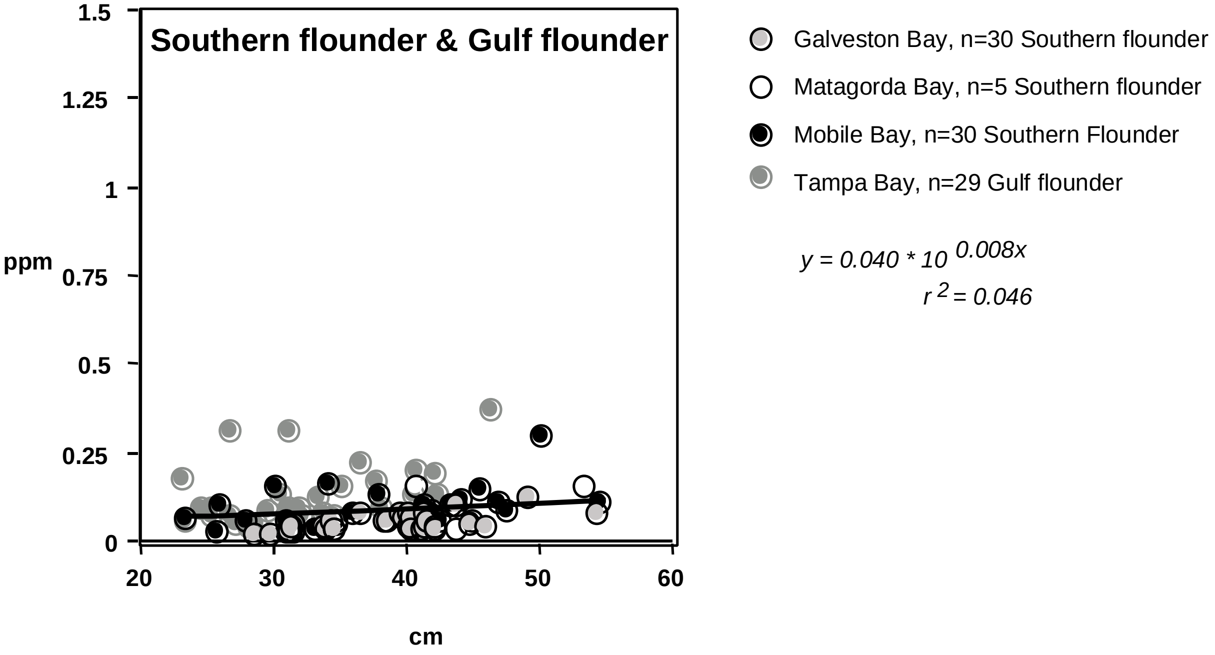


Figure 10. Southern flounder and Gulf flounder total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 120) combined (see Appendix 10 for data).



Rigs and Reefs Sampling

Given that fish mercury concentrations are likely to vary from reef to reef, and that there are thousands of reefs in the Gulf, this Survey did not attempt to evaluate individual reefs. Evaluating even a small percentage of the Gulf reefs would require an immense effort that is currently beyond the resources of this Survey. Therefore, an alternative strategy was employed in an attempt to effectively apply the Survey resources to the investigation.

Reef species (e.g., snapper, grouper, triggerfish, etc.) tend to remain in the vicinity of home reef structures. However, they can and do move from structure to structure in a non-migratory pattern. Generally, unless there is a major oceanographic event (e.g., hurricane, hypoxic bottom water intrusion, etc.), the reef species tend to remain in the same general area. As a result, the reef species' mercury concentrations are likely to be heavily influenced by the mercury available to them via the food webs associated with the reef ecosystems in their general area. Therefore, it would be very difficult to attribute the mercury concentration in a given species sample to any single site. Portions of the Gulf may in general be more contaminated than others and may have higher mercury concentrations in their reef fishes.

One known source of mercury that may (yet to be determined) become available to these reef species is barite based drilling mud from oil and gas drilling platforms in the Gulf. Barite based drilling mud contains mercury in very low concentrations (currently < 1 ppm). However, the mercury in the barite may remain locked up in the barite's crystalline matrix (barite is a mineral) and may not be available for methylation and bio-magnification through the food chain into the reef finfish. Conversely, if the mercury is being released from the barite, then it is plausible that it could contribute to elevated mercury concentrations in reef species collected in the vicinity of the rigs. This possibility has been used to suggest that reef species caught off rigs by recreational fishermen may be higher in mercury than those caught from areas without rigs. In order to provide some insight on the rigs vs. reefs issue, reef finfish samples were collected from areas that have had a great deal of offshore drilling (i.e., Gulf waters South of Grand Island, LA). Likewise, reef finfish samples were collected from areas that have had no offshore drilling (i.e., Southwestern FL).

Table 2. Rigs and Reefs Species to be sampled:
385 of the 420 samples targeted were collected.

Triggerfish:	gray triggerfish
Groupers:	gag
Snappers:	Red snapper, lane snapper, gray snapper, vermillion snapper
Jacks:	Greater amberjack

The sample design called for the collection of juveniles and adults of the selected species (Table 2), in order to obtain a range of sizes necessary to evaluate fish length versus mercury concentration (in muscle tissue) relationships per species and across estuaries. A detailed description of the sampling protocol, tissue extraction, sample tracking, and analyses are provided in Appendix 24. Body length and muscle tissue were collected from ten small, ten medium, and ten large individuals of a given species for a total of 30 individual fish sampled for a given species, per area type (reefs or rigs). The size ranges were based on a review of the finfish reference text.[18,19,20,21] Since two types of sites were sampled, this resulted in 60 individual fish tissues being collected for the Survey per each of the seven species being. In total 420 tissue samples and corresponding fish lengths were the target number for the field sampling. Of the 420 samples targeted, only 385 were actually collected as some species were more difficult than others to collect in the size ranges called for by the sample design (i.e., small, medium, large, see Appendices 46-59 for specific size brackets in centimeters and measuring instructions). The results of the total mercury analyses data are presented in Appendices 11-17 with graphical presentations in Figures 11-17.

Rigs and Reefs Results

The Rigs and Reefs species TMLs (Figures 11-17) suggest that there is no general pattern of Rigs samples being higher than Reefs samples for this set of samples. However, this does not rule out the possibility of hot spots occurring in the vicinity of specific rigs or reefs. The gag grouper samples are difficult to interpret as only 9 samples were collected from the Rigs. However, the gag grouper samples TMLs are highly variable indicating that further study is warranted.

Rigs and Reefs Inferences

Based on the strength of their TML regressions and their abundance, the red snapper and greater amberjack appear to be good hot spot candidates. However, further testing of their utility as hot spot indicators would need to be evaluated by collecting them from known reef or rig hot spots and comparing those TMLs to those obtained here.

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[18] Hoose, H.D. and R.H. Moore. 1998. Fishes of the Gulf of Mexico. Texas A&M Press, College Station, TX. 422 pp.

[19] Shipp, R.L. 1986. Fishes of the Gulf of Mexico. KME Seabooks, Mobile AL. 256 pp.

[20] Walls, J.G. 1975. Fishes of the Northern Gulf of Mexico. T.F.H Publications, Inc. Ltd, Neptune City NJ. 432 pp.

[21] Robins, C.R., G.C. Ray, J. Douglas and R. Freund. Atlantic Coast Fishes. Houghton Mifflin Comp. Boston New York. 354 pp.

Figure 11. Greater amberjack curved fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 60) combined (see Appendix 11 for data).

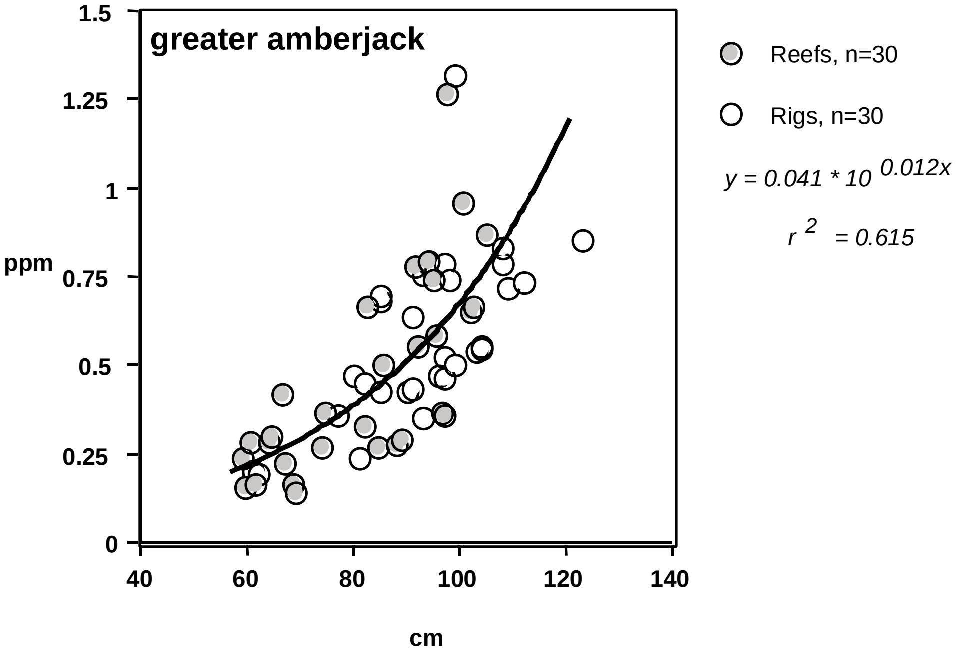


Figure 12. Gag grouper total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 39) combined (see Appendix 12 for data).

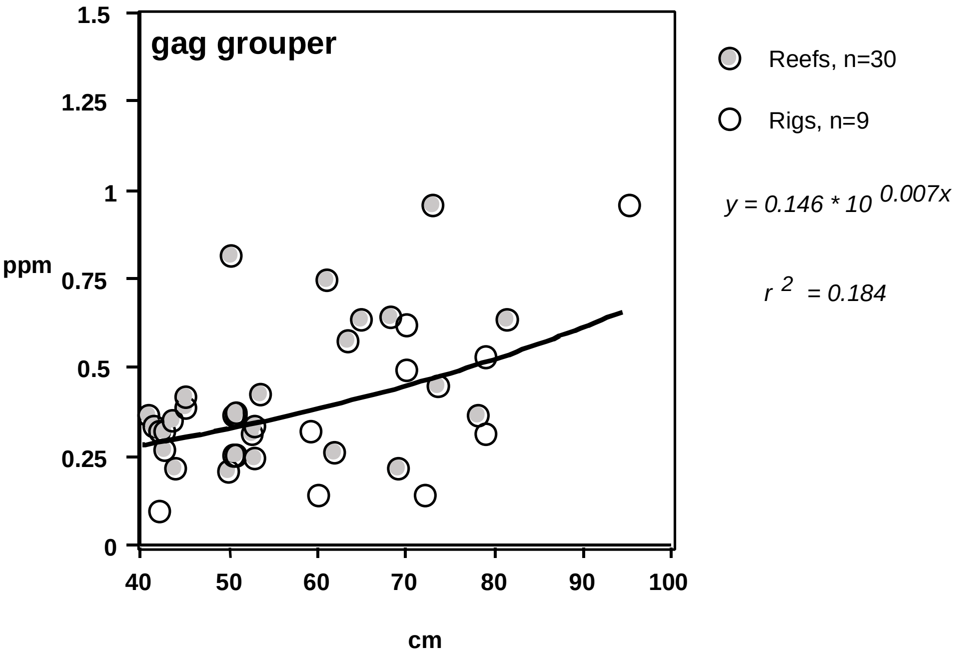


Figure 13. Gray triggerfish total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 60) combined (see Appendix 13 for data).

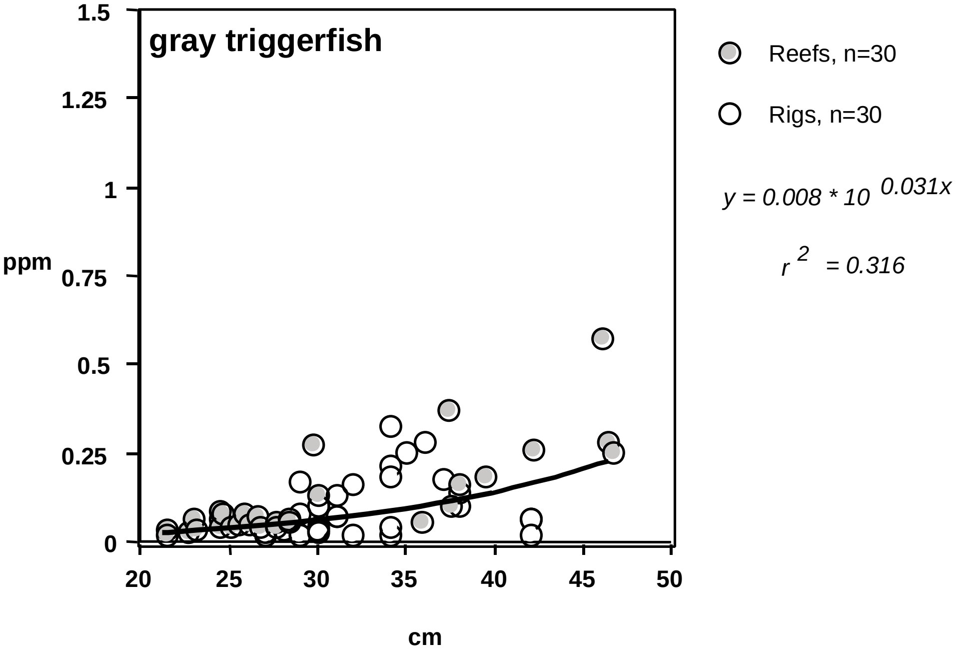


Figure 14. Gray snapper total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 60) combined (see Appendix 14 for data).

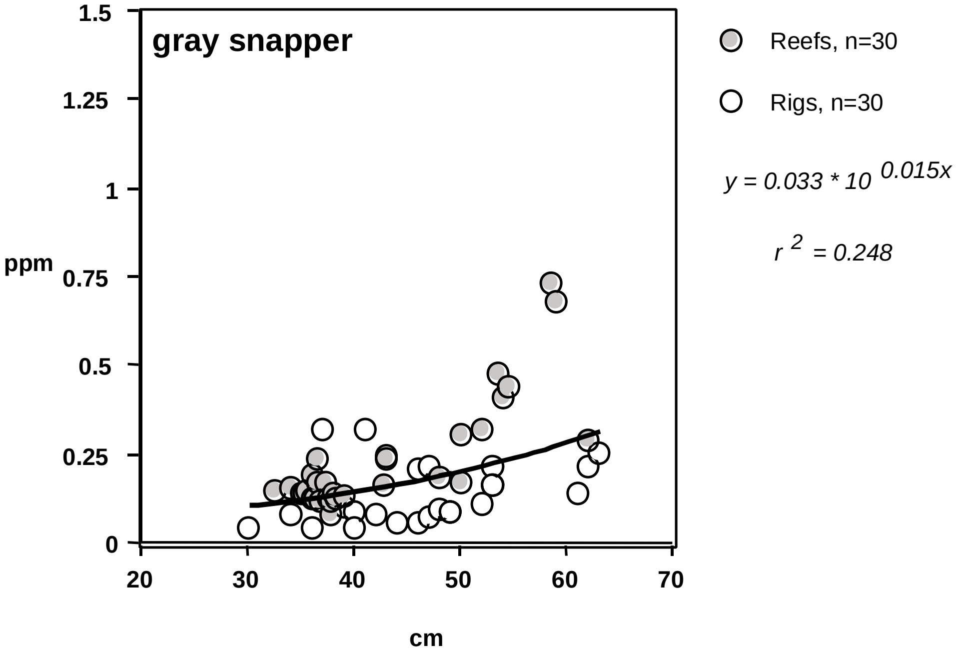


Figure 15. Lane snapper total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 45) combined (see Appendix 15 for data).

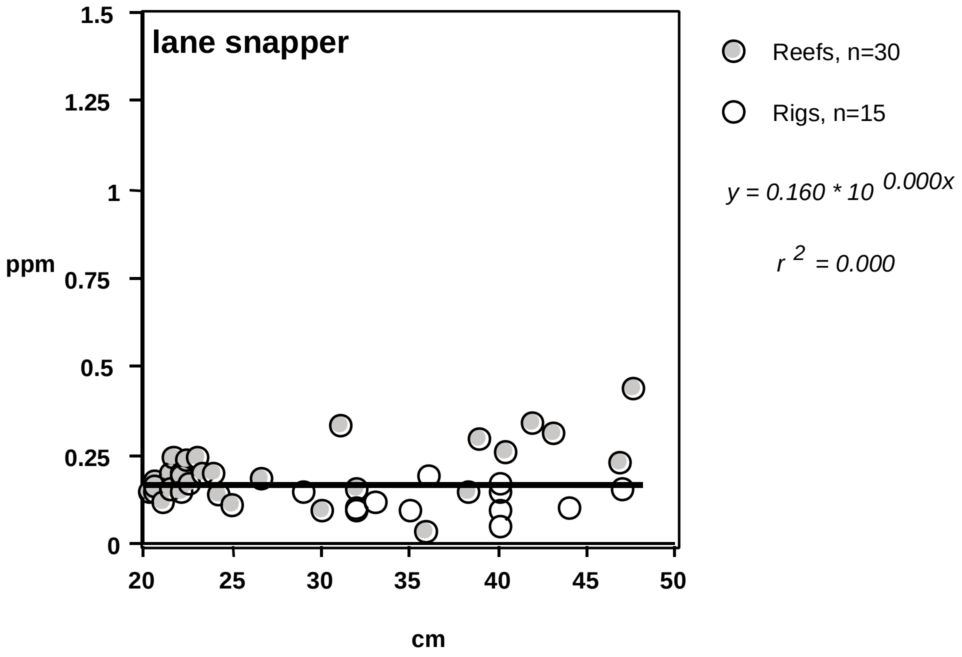


Figure 16. Red snapper total length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 60) combined (see Appendix 16 for data).

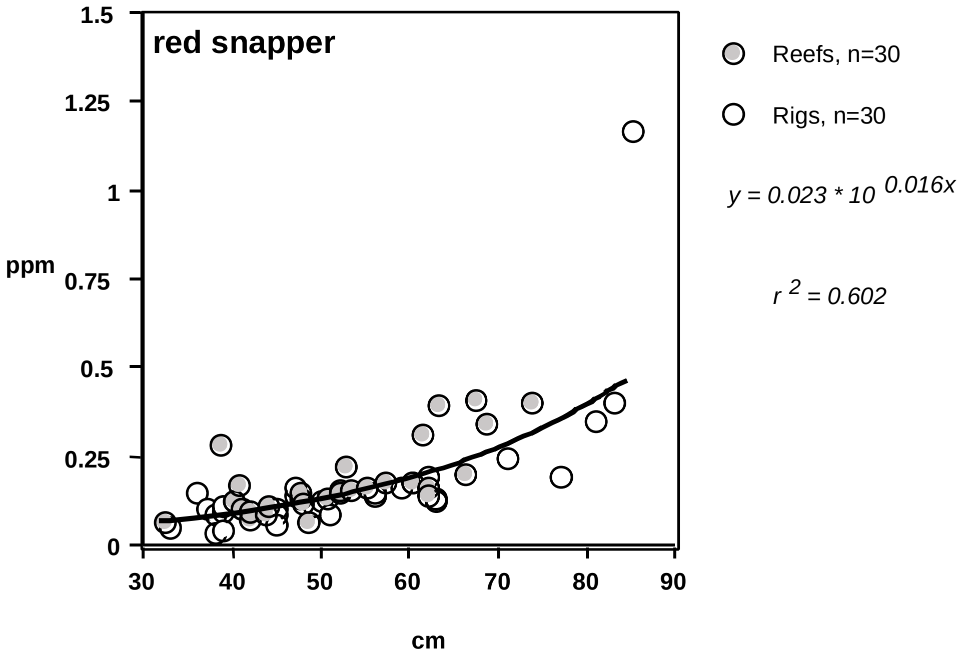
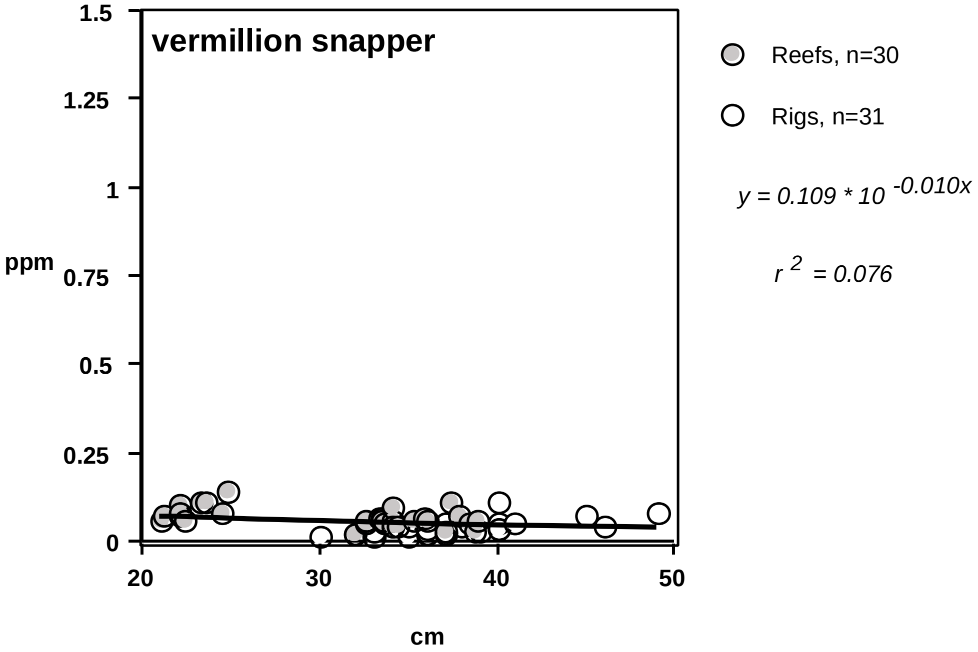


Figure 17. Vermillion snapper total length (cm) vs. total mercury concentration (ppm regression (solid line) and scatter plot for all data (n = 61) combined (see Appendix 17 for data).



Migratory Pelagic Sampling

Gulf migratory pelagics (e.g., tunas, mackerels, cobia, etc.) tend to move from Southern latitudes to Northern latitudes along the Gulf coast from winter to summer, and reverse summer to winter. This results in a Western Gulf migratory pelagics group that migrates from off Southern Texas to off Louisiana, Mississippi, Alabama and back; and an Eastern Gulf migratory pelagics group that migrates from off Southern Florida to off Louisiana-Mississippi-Alabama and back. These migratory pelagics' mercury levels represent an overall indication of the availability of mercury in their food chain which covers a large geographic area.

Due to their migrations over large sections of the Gulf, these migratory pelagics are unlikely candidates to identify hot spots. However, they may provide a means in comparing the Western versus the Eastern pelagic groups' mercury levels. Since these groups are feeding from different sides of the Gulf, some differences may occur. Therefore, for the purpose of this Survey, a representative set of migratory pelagics species (Table 3) were collected off Texas' Southern Gulf Coast and off Florida's Southern Gulf Coast for comparative purposes. This information may be useful in determining whether the Gulf States' fish consumption advisories concerning these interstate migratory species can be coordinated.

Table 3. Migratory pelagic species sampled: 190 of the 480 samples targeted were collected. Approximately 60 samples were collected for each specie (i.e., 30 Western Gulf, 30 Eastern Gulf)

Tunas:	little tunny, yellowfin tuna, blackfin tuna
Mackerels:	king mackerel
Cobia:	cobia
Dolphin:	Dolphin*

*dolphin are not interstate migratory species per se, but were included here as it is an important pelagic species.

The sample design of the Survey called for the collection of juveniles and adults of the selected species (Table 3) in order to obtain the range of sizes necessary to evaluate fish length versus mercury concentration (in muscle tissue) relationships per species and across estuaries. A detailed description of the sampling protocol, tissue extraction, sample tracking, and analyses are provided in Appendix 24. Body length and muscle tissue were collected from ten small, ten medium, and ten large individuals of a given species for a total of 30 individual fish being sampled for a given species per side of the Gulf (Eastern or Western). The size ranges were based on a review of the finfish reference text.[22,23,24,25] Since two areas were sampled, this resulted in 60 individual fish tissues being targeted for collection for the Survey per each of the ten species being collected. In total 480 tissue samples and corresponding fish lengths were the target number for the field sampling. Of the 480 samples targeted, 190 samples were actually collected as these species were more difficult to collect in the size ranges called for by the sample design than previously thought (i.e., small, medium, large, see Appendices 60-71 for specific size brackets in centimeters and measuring instructions). The results of the total mercury analyses data are presented in Appendices 18-23 with graphical presentations in Figures 18-23.

Migratory Pelagic Results

The migratory pelagic samples' TMLs (Figures 11-17) suggest that there are no major differences between the Western group and Eastern group. However, additional sampling will be required to complete this comparison. Other than king mackerel, the Survey had difficulty collecting enough samples in the specified size ranges for the other migratory pelagics.

Migratory Pelagic Inferences

As previously mentioned, migratory pelagics are not good candidates as hot spot indicators because they travel up and down the Gulf Coast. Additional effort will be required to collect enough samples to complete the desired comparisons.

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[22] Hoose, H.D. and R.H. Moore. 1998. Fishes of the Gulf of Mexico. Texas A&M Press, College Station, TX. 422 pp.

[23] Shipp, R.L. 1986. Fishes of the Gulf of Mexico. KME Seabooks, Mobile AL. 256 pp.

[24] Walls, J.G. 1975. Fishes of the Northern Gulf of Mexico. T.F.H Publications, Inc. Ltd, Neptune City NJ. 432 pp.

[25] Robins, C.R., G.C. Ray, J. Douglas and R. Freund. Atlantic Coast Fishes. Houghton Mifflin Comp. Boston New York. 354 pp.

Figure 18. King mackerel curved fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 59) combined (see Appendix 18 for data).

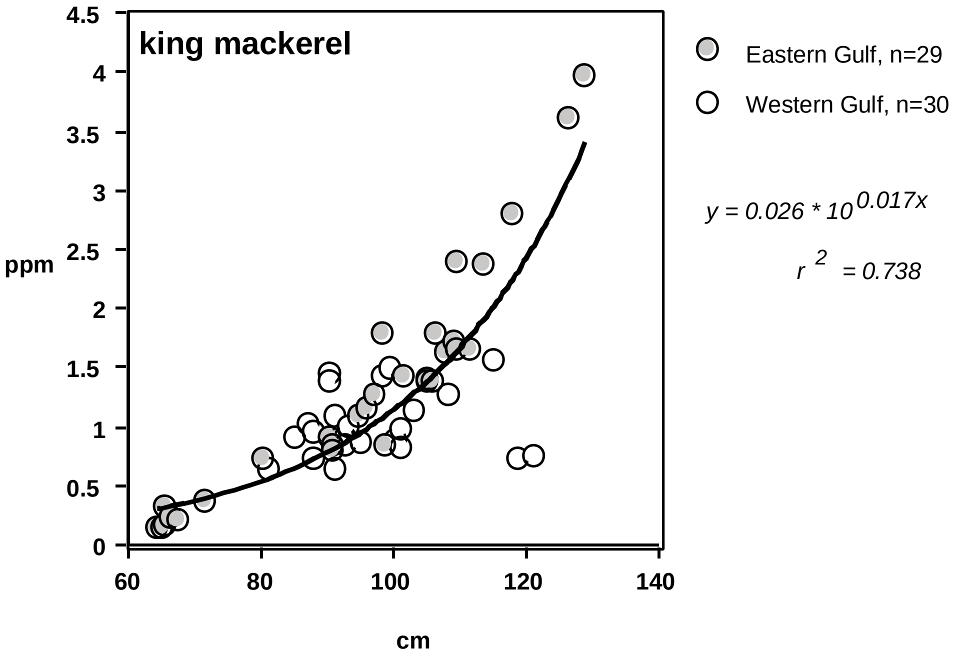


Figure 19. Cobia curved fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 8) combined (see Appendix 19 for data).

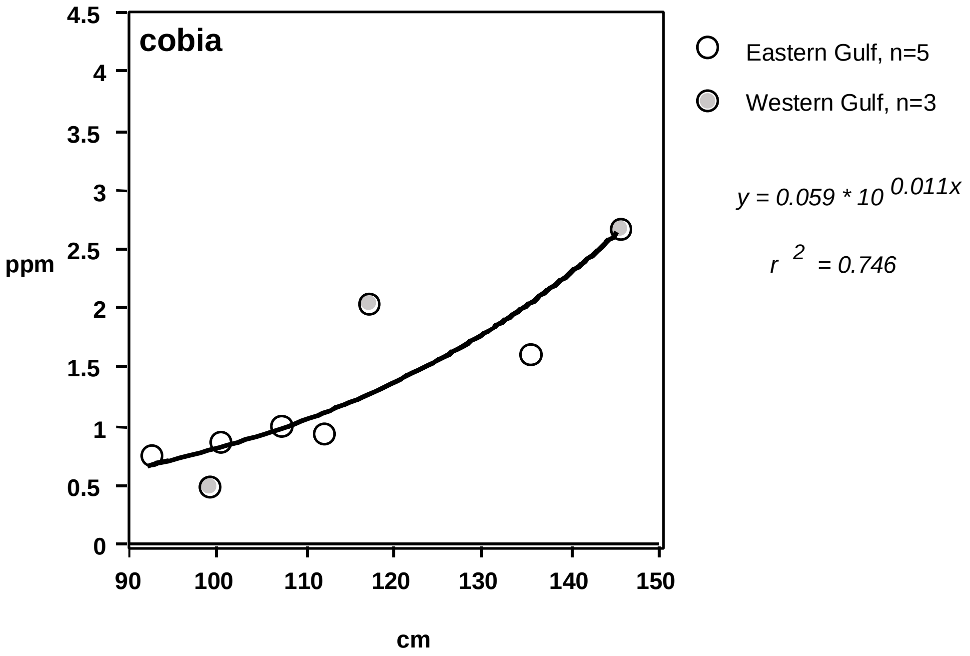


Figure 20. Dolphin curved fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 47) combined (see Appendix 20 for data).

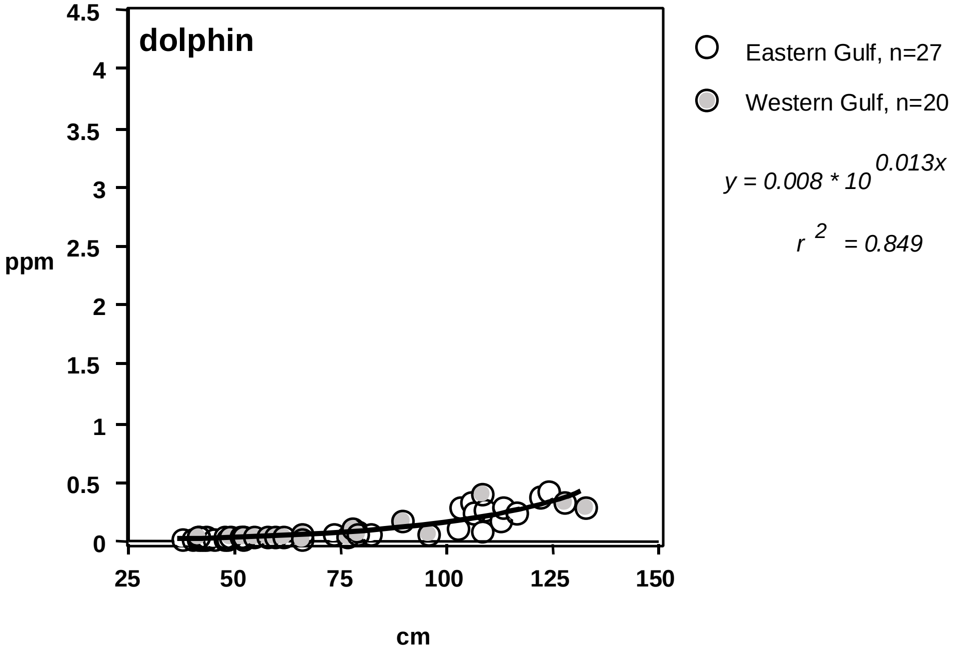


Figure 21. Blackfin tuna curved fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 32) combined (see Appendix 21 for data).

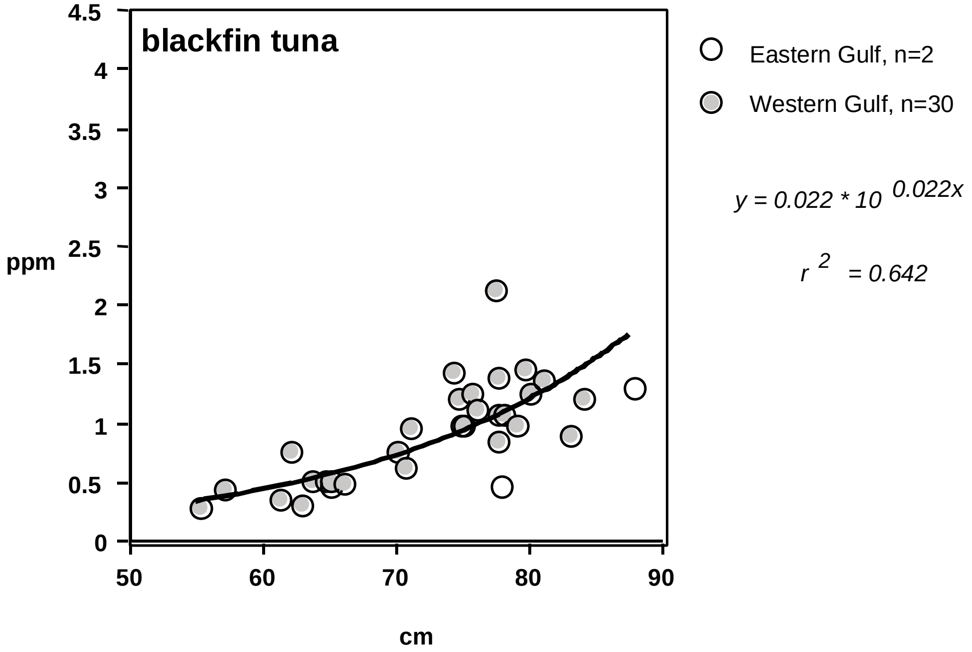


Figure 22. Little tunny curved fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 40) combined (see Appendix 22 for data).

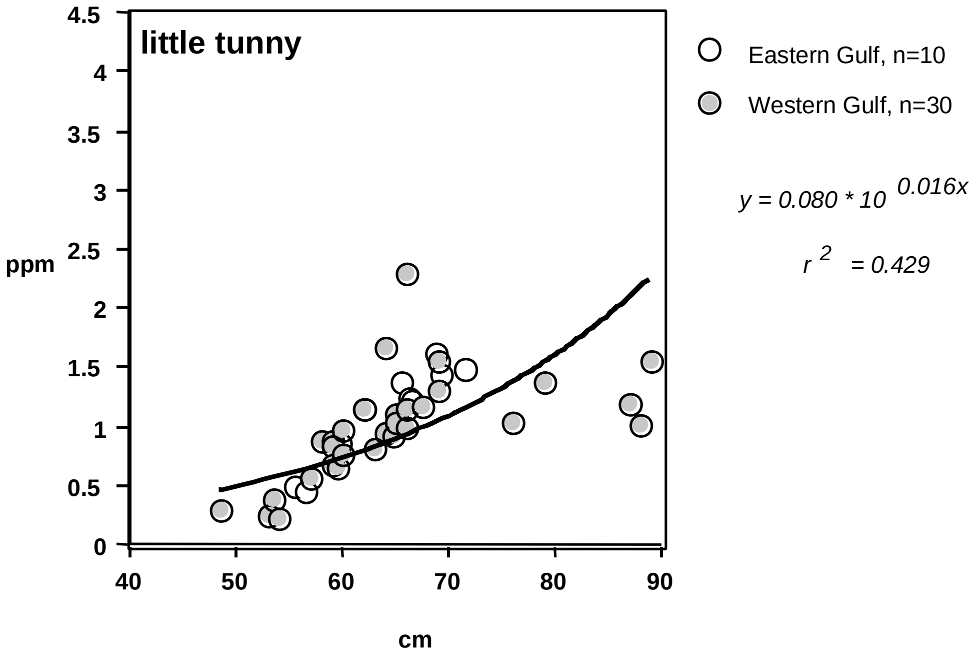
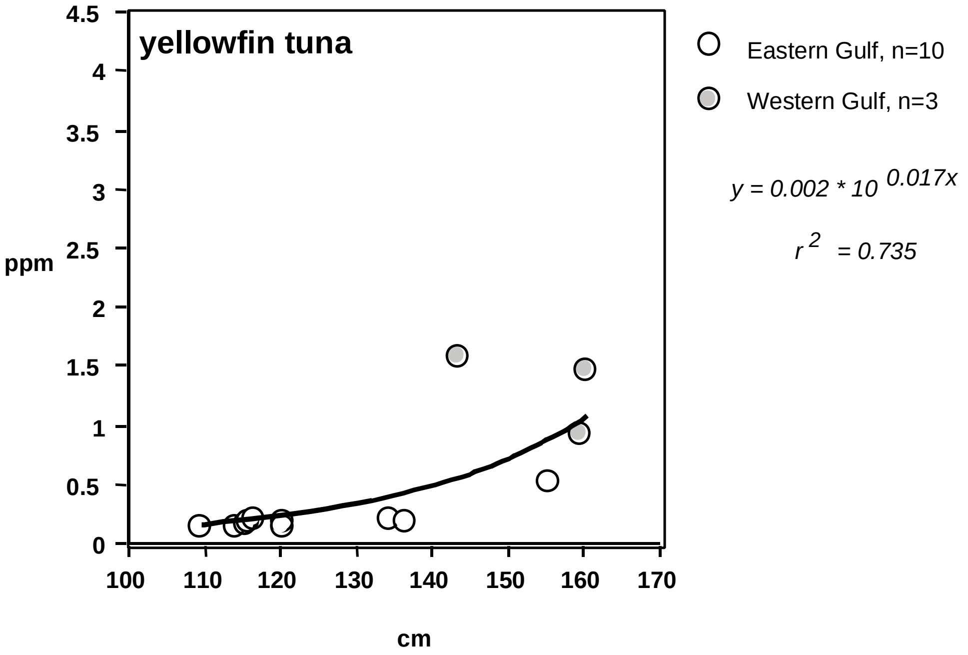


Figure 23. Yellowfin tuna curved fork length (cm) vs. total mercury concentration (ppm) regression (solid line) and scatter plot for all data (n = 13) combined (see Appendix 23 for data).



Appendix 1. Hardhead catfish length vs. total mercury concentration

Galveston Bay hardhead catfish Fork Length (cm)	Galveston Bay hardhead catfish Total Mercury (ppm)	Matagorda Bay hardhead catfish Fork Length (cm)	Matagorda Bay hardhead catfish Total Mercury (ppm)	Mobile Bay hardhead catfish Fork Length (cm)	Mobile Bay hardhead catfish Total Mercury (ppm)	Tampa Bay hardhead catfish Fork Length (cm)	Tampa Bay hardhead catfish Total Mercury (ppm)
23.9	0.1151	23.7	0.2671	23.5	1.1788	24.5	0.0482
24.1	0.0940	24	0.0412	24	0.1235	24.5	0.0738
24.4	0.1162	25.7	0.0586	24.3	0.1890	24.8	0.0318
24.6	0.1121	26.1	0.0669	26.1	1.0838	25.6	0.0729
24.8	0.1225	26.5	0.0980	26.5	0.1214	26	0.0379
25	0.0733	26.6	0.0574	26.5	0.6287	26.5	0.0827
26.2	0.0849	26.6	0.0919	27	0.0937	26.9	0.0478
26.3	0.0864	26.7	0.0488	27	0.6719	26.9	0.0638
27.1	0.2884	28	0.1249	27.1	0.2299	27.8	0.0803
27.6	0.3407	28.3	0.1366	27.2	0.0917	28.1	0.0997
28.9	0.1533	29.1	0.1524	30.1	0.0819	29.1	0.0158
29.5	0.1029	30.1	0.2405	30.3	0.1689	29.3	0.0470
30.9	0.2071	33.5	0.1480	30.4	0.3188	29.8	0.1787
31	0.1323	33.6	0.2596	30.4	0.7200	30.4	0.1181
31.1	0.1145	33.9	0.2255	30.5	0.4911	30.7	0.1848
31.1	0.1652	34	0.3164	32.3	0.3036	30.8	0.2369
32.2	0.1354	34.1	0.1935	32.6	0.3098	32.3	0.1077
33.4	0.1304	34.5	0.2665	33	0.1139	32.7	0.0993
33.8	0.1343	34.5	0.1593	33	0.1026	32.9	0.1245
34.8	0.2080	34.8	0.4236	33.9	1.3437	33.3	0.1025
35.2	0.3112	35	0.3236	34	0.2189	35	0.2098
35.5	0.1426	35.7	0.2763	34.1	0.1251	35.1	0.1195
35.7	0.2135	35.8	0.2419	35	0.3867	35.2	0.1226
36.2	0.2534	36	0.1370	35	1.1431	35.2	0.0851
37.1	0.3072	36.1	0.1875	35.6	0.3068	35.3	0.0593
37.2	0.1894	36.4	0.2469	36	0.1280	35.6	0.0928
37.2	0.2430	37.1	0.1331	36.1	0.3147	35.8	0.1663
38.1	0.3103	37.2	0.1636	36.1	0.3801	36.3	0.1483
39.8	0.3263	38	0.1818	37.1	0.3610	36.5	0.2321
40.4	0.2130	38.7	0.1618	38.5	0.3277	37	0.0699

Appendix 2. Gafftopsail catfish length vs. total mercury concentration

Galveston Bay gaftopsail catfish Fork Length (cm)	Galveston Bay gaftopsail catfish Total Mercury (ppm)	Matagorda Bay gaftopsail catfish Fork Length (cm)	Matagorda Bay gaftopsail catfish Total Mercury (ppm)	Mobile Bay gaftopsail catfish Fork Length (cm)	Mobile Bay gaftopsail catfish Total Mercury (ppm)	Tampa Bay gaftopsail catfish Fork Length (cm)	Tampa Bay gaftopsail catfish Total Mercury (ppm)
16	0.0925	23	0.0518	31.0	0.2040	24.6	0.2122
27.5	0.0572	26.1	0.1919	31.3	0.1307	24.8	0.0802
28.8	0.1297	28.7	0.1140	41.9	0.2277	25.4	0.2716
28.9	0.1240	38	0.1312	41.9	0.6298	25.9	0.1044
29.5	0.0731	42	0.1816	48.8	0.3408	27.6	0.3649
31	0.2565	43	0.1787	48.9	0.5249	28	0.1685
31.9	0.2537	43.8	0.5418	53.8	0.3615	28	0.1381
32	0.1442	44.6	0.4835			30.2	0.2138
33.3	0.1971	44.7	0.5187			30.7	0.2058
33.6	0.1397	47.6	0.6546			30.8	0.3901
38	0.1315	48.8	0.5825			30.8	0.4228
39.2	0.2859	49.2	0.5864			31.2	0.2422
39.8	0.1592	50.5	0.8787			31.6	0.3597
39.8	0.2114	51.9	0.6369			32.1	0.3965
40.5	0.1592	52.7	0.8323			32.9	0.2822
41.6	0.4781	52.8	0.5907			34.3	0.4313
42	0.3653	58	0.9958			34.5	0.1868
42.1	0.2806	58	1.1064			36.4	0.3442
43.1	0.2836	61	1.0780			37.7	0.3239
43.1	0.2664	63	0.3205			38.2	0.3375
43.5	0.3574					38.9	0.3529
43.6	0.2442					39.6	0.2082
44.3	0.2685					41.1	0.2088
46.3	0.4135					41.5	0.1563
47.5	0.2177					41.7	0.2297
48.3	0.3387					43.2	0.5960
49.1	0.2707					44.5	0.4593
49.1	0.3867					46	0.6230
50.7	0.0690					51	0.3928
52	0.4869						
54.3	0.5549						

Appendix 3. Atlantic croaker length vs. total mercury concentration

Galveston Bay Altantic croaker Total Length (cm)	Galveston Bay Altantic croaker Total Mercury (ppm)	Matagorda Bay Altantic croaker Total Length (cm)	Matagorda Bay Altantic croaker Total Mercury (ppm)	Mobile Bay Altantic croaker Total Length (cm)	Mobile Bay Altantic croaker Total Mercury (ppm)	Tampa Bay Altantic croaker Total Length (cm)	Tampa Bay Altantic croaker Total Mercury (ppm)
21.4	0.0293	23	0.0262	23	0.0170		
21.5	0.0438	24	0.0582	23.2	0.0545		
21.6	0.0331	24	0.0181	23.5	0.0758		
21.9	0.0540	24	0.0567	23.5	0.0370		
23	0.0262	24.1	0.0951	23.5	0.0260		
23.2	0.0102	25	0.0211	23.5	0.0339		
23.3	0.0261	26	0.0416	23.9	0.0334		
25.1	0.0250	26.2	0.1576	24	0.0199		
25.3	0.0193	27	0.0872	24.8	0.0160		
25.8	0.0560	28	0.0453	25.4	0.0355		
25.8	0.0207	35	0.0543	26.4	0.0756		
26.4	0.0161			27.6	0.0482		
26.5	0.0383			28.1	0.0275		
27.6	0.0250			29.2	0.0341		
27.9	0.0406						
28.3	0.0320						
28.6	0.0579						
29.3	0.0346						
30.3	0.0166						
30.3	0.0654						
31.1	0.0723						
31.2	0.0578						
32.3	0.0542						
33.3	0.0731						
34	0.0281						
34	0.0317						
35.2	0.0893						
35.2	0.0711						
39.4	0.1250						
40.5	0.1242						

Appendix 4. Spot length vs. total mercury concentration

Galveston Bay spot Total Length (cm)	Galveston Bay spot Total Mercury (ppm)	Matagorda Bay spot Total Length (cm)	Matagorda Bay spot Total Mercury (ppm)	Mobile Bay spot Total Length (cm)	Mobile Bay spot Total Mercury (ppm)	Tampa Bay spot Total Length (cm)	Tampa Bay spot Total Mercury (ppm)
16.2	0.0155	17	0.0135	23.3	0.0082	17.9	0.0426
16.8	0.0202	17	0.0287	25.8	0.0065	17.9	0.0806
17.8	0.0126	17.3	0.0583	29.1	0.0095	19.1	0.0349
19	0.0387	17.6	0.0359	29.5	0.0090	19.1	0.0444
19.2	0.0589	17.6	0.0279	29.5	0.0098	19.5	0.0177
21	0.1176	17.6	0.0207	29.6	0.0067	19.6	0.0475
21.3	0.0148	17.7	0.0637	29.8	0.0090	19.6	0.0256
21.4	0.0239	17.8	0.0287	30	0.0068	19.8	0.0338
21.4	0.0390	18.6	0.0192	30.3	0.0101	19.8	0.0516
21.5	0.0323	18.9	0.0329	30.5	0.0082	20.1	0.0339
22.2	0.0364	19.3	0.0313	30.7	0.0105	20.2	0.0904
22.7	0.0512	20.7	0.0577	32.1	0.0147	20.5	0.1361
22.7	0.0525	22	0.0564	32.1	0.0092	20.6	0.0575
22.8	0.1252	22	0.0320	32.7	0.0187	21.1	0.0270
23	0.0292	23	0.0590	32.9	0.0216	21.1	0.0415
23	0.0340	23	0.0532	33	0.0222	21.4	0.0708
23.1	0.0429	23.1	0.1036	33.1	0.0055	21.5	0.0646
23.2	0.1490	24	0.0492	33.2	0.0063	21.6	0.0503
23.3	0.0489	24	0.0321	33.2	0.0079	21.8	0.0632
23.5	0.0331	24	0.0431	33.4	0.0087	21.9	0.1177
23.6	0.0280	24.5	0.0897	34	0.0084	22	0.0536
23.8	0.0292	25	0.0555	34.2	0.0040	22.1	0.1977
24	0.0675	25	0.1651	34.3	0.0084	22.5	0.0598
24.2	0.0713	25	0.0671	34.6	0.0084	22.9	0.0353
24.3	0.0746	25	0.0218	35	0.0118	23	0.1947
24.6	0.0391	25	0.0878	36.5	0.0105	23.1	0.1817
24.8	0.0521	25.3	0.0398	38	0.0080	23.1	0.1671
25.1	0.0579	27	0.0506	42.7	0.0141	24.5	0.0469
25.7	0.0207			43.2	0.0262	24.8	0.1430
26.7	0.0490			43.3	0.0131	25.2	0.2328

Appendix 5. Southern kingfish length vs. total mercury concentration

Galveston Bay Southern kingfish Total Length (cm)	Galveston Bay Southern kingfish Total Mercury (ppm)	Matagorda Bay Southern kingfish Total Length (cm)	Matagorda Bay Southern kingfish Total Mercury (ppm)	Mobile Bay Southern kingfish Total Length (cm)	Mobile Bay Southern kingfish Total Mercury (ppm)	Tampa Bay Southern kingfish Total Length (cm)	Tampa Bay Southern kingfish Total Mercury (ppm)
21.8	0.0273	25.4	0.0217	23.1	0.0563	23	0.1266
22.9	0.0440	26	0.0269	23.4	0.1438	24	0.2371
26.5	0.0771	28.4	0.0915	23.4	0.0516	24.2	0.1106
29.8	0.0691	30	0.1896	23.9	0.0656	24.3	0.0488
30.4	0.0574	30	0.1172	24	0.4480	24.4	0.1963
31	0.0368	30	0.0802	24.2	0.1064	25.1	0.2885
31.2	0.0553	30	0.0686	24.6	0.0606	25.2	0.1009
		30.7	0.1125	24.7	0.0988	25.5	0.0660
		31	0.0750	24.9	0.1535	25.7	0.1165
		31	0.1006	25	0.9485	27.3	0.0801
		31	0.0963	25.3	0.1440	29.5	0.1100
		31.6	0.1459	25.4	0.1455	29.5	0.1348
		32	0.1732	25.4	0.0304	30	0.1638
		32.2	0.1360	25.5	0.2079	30.4	0.2622
		32.5	0.2749	25.6	0.1060	30.8	0.2089
		32.8	0.1810	25.6	0.0779	31.5	0.0734
		33	0.1721	25.6	0.2830	31.6	0.3625
		33.9	0.1620	25.7	0.1364	31.9	0.3129
				26.7	0.0681	32.3	0.1479
				27.2	0.0860	32.5	0.0845
				27.3	0.8114	33.1	0.3287
				27.8	0.2475	33.3	0.2572
				28	0.0899	38.1	0.5399
				28.1	0.1090		
				29	0.1308		
				29.1	0.1793		
				29.8	0.0879		
				30.5	0.1564		
				30.8	0.2526		
				35.2	0.2023		

Appendix 6. Sand seatrout length vs. total mercury concentration

Galveston Bay sand seatrout Total Length (cm)	Galveston Bay sand seatrout Total Mercury (ppm)	Matagorda Bay sand seatrout Total Length (cm)	Matagorda Bay sand seatrout Total Mercury (ppm)	Mobile Bay sand seatrout Total Length (cm)	Mobile Bay sand seatrout Total Mercury (ppm)	Tampa Bay sand seatrout Total Length (cm)	Tampa Bay sand seatrout Total Mercury (ppm)
19.4	0.0283	23	0.1555	23.4	0.0561	23	0.3535
20	0.0309	23	0.0493	23.4	0.0734	23.2	0.5477
20.3	0.0263	25	0.0816	23.6	0.1395	23.4	0.5262
20.9	0.0325	25	0.1543	24.2	0.0956	23.4	0.4699
21	0.0351	31	0.0638	24.3	0.1513	23.5	0.5845
21.3	0.0318	33	0.1145	24.6	0.1187	24.1	0.8628
21.5	0.0387	34	0.0907	24.8	0.1615	24.2	0.6300
21.5	0.0240	34	0.0997	25.4	0.1416	24.2	0.8501
21.7	0.0332	34	0.1273	25.9	0.2680	24.4	0.8280
23.2	0.0496			26.6	0.1105	24.4	0.4363
23.4	0.0387			26.8	0.1247	24.8	0.6271
23.4	0.0552			27	0.1025	24.9	0.8171
24.4	0.0307			27.5	0.1705	25.4	0.5444
24.4	0.0482			28.1	0.1456	25.4	0.2906
26	0.0422			28.4	0.1401	25.8	0.5279
26.1	0.0512			29.1	0.0581	25.8	0.6474
27.8	0.0480			29.2	0.1814	26.2	0.9832
28.1	0.0683			30.1	0.1438	26.7	0.4790
28.3	0.0905			30.2	0.1452	27.3	0.5909
28.4	0.0709			30.2	0.1855	27.7	0.6862
30.5	0.0548			30.4	0.2165	27.9	0.5191
30.6	0.0383			31.3	0.1183	28.2	0.6209
31.2	0.1295			31.3	0.1809	30.8	0.6619
32.6	0.0803			32	0.1301	32	0.6647
32.8	0.0874			32	0.2166		
33.8	0.0882			32.1	0.1590		
36.1	0.0911			32.4	0.1097		
				32.7	0.2180		
				39.5	0.1451		
				40.2	0.1315		

Appendix 7. Spotted seatrout length vs. total mercury concentration

Galveston Bay spotted seatrout Total Length (cm)	Galveston Bay spotted seatrout Total Mercury (ppm)	Matagorda Bay spotted seatrout Total Length (cm)	Matagorda Bay spotted seatrout Total Mercury (ppm)	Mobile Bay spotted seatrout Total Length (cm)	Mobile Bay spotted seatrout Total Mercury (ppm)	Tampa Bay spotted seatrout Total Length (cm)	Tampa Bay spotted seatrout Total Mercury (ppm)
32.8	0.0914	33.7	0.0785	23.6	0.0398	26.2	0.0640
34	0.1539	34.6	0.0564	24	0.0712	26.8	0.1058
35.4	0.1260	34.9	0.0634	24.3	0.0428	26.8	0.0784
35.7	0.0662	35	0.0601	27.1	0.0628	28.1	0.6951
36.5	0.1212	36.3	0.0767	29.5	0.0817	29.3	0.2791
37.5	0.0965	36.8	0.1343	29.7	0.0658	30.6	0.3845
38.3	0.0957	37.1	0.1239	29.8	0.0566	33.2	0.4128
38.6	0.1107	37.1	0.0519	32.2	0.0811	33.6	0.1486
38.6	0.0645	39.2	0.0560	34.3	0.0953	34	0.3254
39	0.0903	39.9	0.0496	40.6	0.1003	36	0.7459
42.4	0.0934	41.2	0.0770	41.5	0.1640	38.9	0.3698
43.7	0.1585	41.4	0.1431	41.6	0.1054	41.3	0.2075
45.2	0.1232	41.9	0.1486	42	0.1022	41.5	0.2823
47.7	0.1955	42.8	0.0958	42.7	0.1683	42	0.6243
47.9	0.1415	48.4	0.1031	45	0.1674	42.2	0.2987
48.2	0.2110	49	0.0916	45.5	0.2053	42.5	0.8784
51.1	0.1464	50.3	0.1501	46	0.1258	42.5	0.2755
51.2	0.1383	50.8	0.2244	47.4	0.1164	43.5	0.3052
51.5	0.2666	52	0.3355	48.1	0.2001	43.6	0.4869
54.6	0.1827	55.2	0.1713	48.7	0.1656	50.8	0.2630
57.3	0.2043	56.5	0.1100	50.1	0.2773	52.7	0.5337
59.9	0.2465	60	0.4058	50.1	0.2469	57	0.2979
60	0.2369	60	0.2826	51.6	0.1654	58.1	0.3410
60.2	0.2699	61	0.3832	57.7	0.3291	58.4	0.5879
60.9	0.2804	62	0.2323	59	0.5634	61.8	0.6823
61.2	0.2927	63	0.4800	59.3	0.3253	61.8	0.6309
61.9	0.4009	64.3	0.4106	60.4	0.3341	63.8	0.6646
62.8	0.3249	65.1	0.3503	61	0.6924		
68.3	0.3783	70.8	0.2303	62.8	0.3370		
72.7	0.3665	73	0.2249	64.4	0.4693		

Appendix 8. Red drum length vs. total mercury concentration

Galveston Bay red drum Total Length (cm)	Galveston Bay red drum Total Mercury (ppm)	Matagorda Bay red drum Total Length (cm)	Matagorda Bay red drum Total Mercury (ppm)	Mobile Bay red drum Total Length (cm)	Mobile Bay red drum Total Mercury (ppm)	Tampa Bay red drum Total Length (cm)	Tampa Bay red drum Total Mercury (ppm)
39.4	0.0768	38.5	0.0377	30	0.2605	35.9	0.0818
40	0.1021	39.4	0.0412	32.7	0.1058	38.2	0.0796
43.4	0.0713	40.1	0.0499	34	0.1348	39.8	0.1738
43.5	0.1076	41.5	0.0484	36	0.1161	40	0.1694
44.1	0.1079	43	0.0680	36.6	0.2306	41.6	0.1753
44.2	0.0946	44	0.0792	39.8	0.0535	42.5	0.1505
44.6	0.1246	44.6	0.4853	40	0.2161	43.7	0.0753
45.1	0.1210	44.7	0.0609	40.1	0.0542	44.3	0.1208
46.1	0.1909	46.4	0.0750	42.3	0.0904	46.5	0.1805
48.8	0.1051	50	0.0873	43	0.0477	50.6	0.1496
55.2	0.1512	52.1	0.0851	43.1	0.1120	54	0.2583
55.7	0.1337	52.3	0.1003	46.5	0.0838	54.7	0.2417
55.7	0.1769	53	0.1447	47.2	0.0906	56.1	0.5462
57	0.0771	53.2	0.0873	56.8	0.1973	57.2	0.1534
58.5	0.1659	53.8	0.1018	58.3	0.1415	58.1	0.2800
59.2	0.0980	54	0.0815	58.5	0.1993	60	0.1757
62.6	0.1974	54	0.1122	59.1	0.4767	60.9	0.1424
64.9	0.1127	55	0.1063	59.2	0.1338	61.5	0.2720
65.5	0.2248	56.8	0.2064	63.7	0.1688	67.3	0.2065
67.7	0.0752	57.9	0.0886	66.2	0.3574	72.6	0.1827
68.5	0.0649	59	0.1422	78.5	0.2864	74.5	0.4839
69	0.0973	60.9	0.1275	83.7	0.6908	74.6	0.1847
69.2	0.0846	71.5	0.3147	90.2	0.6573	76	0.1393
70.1	0.1193	77	0.1309	92.8	0.9109	76	0.2492
70.2	0.1138	80	0.1622	95.4	0.9077	76.4	0.3398
70.4	0.0462			96	1.0437	76.5	0.2401
71.5	0.1232			98	0.8079	77.7	0.1473
71.6	0.0826			99.8	0.9513	77.7	0.1936
72	0.0871			100	0.8132	78.4	0.2958
75.7	0.0990			100.8	0.6308	88.2	0.4825

Appendix 9. Striped mullet length vs. total mercury concentration

Galveston Bay striped mullet Fork Length (cm)	Galveston Bay striped mullet Total Mercury (ppm)	Matagorda Bay striped mullet Fork Length (cm)	Matagorda Bay striped mullet Total Mercury (ppm)	Mobile Bay striped mullet Fork Length (cm)	Mobile Bay striped mullet Total Mercury (ppm)	Tampa Bay striped mullet Fork Length (cm)	Tampa Bay striped mullet Total Mercury (ppm)
26	0.0118	24.7	0.0068	23.3	0.0082	25.9	0.0057
27.1	0.0067	29.4	0.0182	25.8	0.0065	26.3	0.0077
28	0.0046	30.3	0.0172	29.1	0.0095	26.5	0.0073
28.5	0.0055	30.5	0.0056	29.5	0.0090	27	0.0070
28.6	0.0078	30.5	0.0013	29.5	0.0098	27.6	0.0058
29.2	0.0059	31.1	0.0129	29.6	0.0067	27.9	0.0073
29.9	0.0064	31.2	0.0038	29.8	0.0090	28	0.0059
30	0.0082	31.4	0.0074	30	0.0068	28.6	0.0033
30.1	0.0104	31.5	0.0075	30.3	0.0101	29.1	0.0084
31.1	0.0049	31.5	0.0046	30.5	0.0082	29.4	0.0059
31.2	0.0092	31.6	0.0041	30.7	0.0105	32.3	0.0070
31.3	0.0098	31.9	0.0062	32.1	0.0147	33.4	0.0064
32.4	0.0111	32	0.0024	32.1	0.0092	33.6	0.0097
32.5	0.0138	32.2	0.0050	32.7	0.0187	34	0.0055
32.6	0.0042	33	0.0031	32.9	0.0216	34.3	0.0098
33.3	0.0079	33	0.0022	33	0.0222	34.3	0.0075
33.8	0.0039	33.4	0.0160	33.1	0.0055	35.9	0.0079
34.8	0.0087	34	0.0051	33.2	0.0063	37.9	0.0164
37.2	0.0086	34	0.0024	33.2	0.0079	38.5	0.0047
37.6	0.0087	34.2	0.0047	33.4	0.0087	40.5	0.0086
38.2	0.0074	34.6	0.0052	34	0.0084	41	0.0086
38.5	0.0175	36.8	0.0011	34.2	0.0040	41.2	0.0090
39	0.0094	38.2	0.0028	34.3	0.0084	41.6	0.0053
41	0.0098	39	0.0055	34.6	0.0084	41.9	0.0072
41.5	0.0082	39.4	0.0055	35	0.0118	42	0.0120
43.2	0.0063	41.2	0.0022	36.5	0.0105	43	0.0109
43.3	0.0111	41.9	0.0086	38	0.0080	44.2	0.0077
44.3	0.0085	42	0.0044	42.7	0.0141	46	0.0078
52.1	0.0133	42.5	0.0047	43.2	0.0262	46.4	0.0080
58.5	0.0090	45	0.0052	43.3	0.0131	48.3	0.0100

Appendix 10. Southern and Gulf flounder length vs. total mercury concentration

Galveston Bay Southern flounder Total Length (cm)	Galveston Bay Southern flounder Total Mercury (ppm)	Matagorda Bay Southern flounder Total Length (cm)	Matagorda Bay Southern flounder Total Mercury (ppm)	Mobile Bay Southern flounder Total Length (cm)	Mobile Bay Southern flounder Total Mercury (ppm)	Tampa Bay Gulf flounder Total Length (cm)	Tampa Bay Gulf flounder Total Mercury (ppm)
28.4	0.0219	31.1	0.0315	23.1	0.0704	23	0.1776
29.6	0.0263	34.5	0.0614	25.5	0.0338	23.2	0.0570
31	0.0316	40.5	0.1576	25.8	0.1051	24.4	0.0954
31.1	0.0440	43.5	0.0358	27.8	0.0575	25.2	0.0972
33.5	0.0422	53.1	0.1551	29.9	0.1593	25.2	0.0752
33.7	0.0396			30.7	0.0619	26.5	0.3135
34.2	0.0569			30.8	0.0334	26.6	0.0759
34.3	0.0374			31.3	0.0549	26.9	0.0500
34.4	0.0358			31.3	0.0292	28	0.0422
36.4	0.0840			31.4	0.0493	28.6	0.0564
38.1	0.0601			33	0.0352	29.3	0.0903
38.4	0.0574			33.7	0.0443	30.4	0.1374
39.3	0.0809			34	0.1667	30.7	0.0770
39.6	0.0697			34.5	0.0531	30.9	0.0982
40	0.0820			35.7	0.0823	31	0.3149
40	0.0477			37.7	0.1368	31.8	0.0989
40.1	0.0427			40.1	0.0637	32	0.0726
40.2	0.0682			40.2	0.0515	33.1	0.1312
40.2	0.0401			40.4	0.0506	33.6	0.0793
41	0.0359			41.1	0.1022	34.4	0.0730
41.2	0.0861			41.7	0.0908	35	0.1615
41.2	0.0443			42.4	0.0630	36.4	0.2276
41.3	0.0604			43.1	0.1026	37.6	0.1758
41.9	0.0455			44	0.1200	38	0.0991
41.9	0.0386			44.8	0.0636	40.4	0.1376
43.5	0.1024			45.3	0.1485	40.5	0.2053
44.5	0.0518			46.8	0.1149	42	0.1982
45.8	0.0457			47.4	0.0921	42.2	0.1372
49	0.1312			49.9	0.2993	46.2	0.3790
54.1	0.0820			54.4	0.1109		

Appendix 11. Greater amberjack length vs. total mercury concentration

Reefs **greater amberjack** Curved Fork Length (cm)	**Reefs** **greater amberjack** Total Mercury (ppm)	**Rigs** **greater amberjack** Curved Fork Length (cm)	**Rigs** **greater amberjack** Total Mercury (ppm)
59.2	0.2387	61	0.2047
59.5	0.1591	62	0.1919
60.4	0.2833	77	0.3641
61.5	0.1692	80	0.4702
64.1	0.2870	81	0.2393
64.7	0.2995	82	0.4502
66.5	0.4230	85	0.6819
67	0.2280	85	0.6966
68.4	0.1619	85	0.4296
69.2	0.1421	90	0.4288
73.9	0.2738	91	0.4369
74.7	0.3678	91	0.6394
82	0.3306	93	0.7578
82.4	0.6698	93	0.3513
84.6	0.2722	94	0.7898
85.4	0.5037	96	0.4765
87.9	0.2774	97	0.5252
89.1	0.2917	97	0.7905
91.4	0.7802	97	0.4642
92	0.5564	98	0.7445
94	0.7982	99	0.5008
95	0.7441	99	1.3168
95.7	0.5877	103	0.5388
96.7	0.3660	104	0.5547
97	0.3628	104	0.5499
97.5	1.2680	108	0.7870
100.6	0.9622	108	0.8308
102.1	0.6554	109	0.7208
102.5	0.6716	112	0.7361
105.1	0.8678	123	0.8530

Appendix 12. Gag grouper length vs. total mercury concentration

Reefs **gag grouper** Total Length (cm)	**Reefs** **gag grouper** Total Mercury (ppm)	**Rigs** **gag grouper** Total Length (cm)	**Rigs** **gag grouper** Total Mercury (ppm)
40.7	0.3705	42	0.0972
41.4	0.3390	59	0.3209
42	0.3201	60	0.1441
42.5	0.2680	70	0.4947
42.7	0.3218	70	0.6258
43.5	0.3566	72	0.1428
43.9	0.2201	79	0.5294
44.9	0.3873	79	0.3173
45.1	0.4189	95	0.9615
49.7	0.2123		
50	0.8146		
50.4	0.2550		
50.4	0.3680		
50.7	0.3709		
50.7	0.3756		
50.8	0.2592		
52.5	0.3184		
52.8	0.2482		
52.9	0.3354		
53.5	0.4282		
60.9	0.7495		
61.9	0.2661		
63.4	0.5815		
64.7	0.6383		
68	0.6463		
69	0.2157		
72.8	0.9577		
73.4	0.4540		
78.1	0.3678		
81.2	0.6362		

Appendix 13. Gray Triggerfish length vs. total mercury concentration

Reefs gray triggerfish Total Length (cm)	Reefs gray triggerfish Total Mercury (ppm)	Rigs gray triggerfish Total Length (cm)	Rigs gray triggerfish Total Mercury (ppm)
21.4	0.0376	27	0.0254
21.4	0.0258	27	0.0298
22.6	0.0327	28	0.0402
22.9	0.0669	29	0.1742
23.1	0.0409	29	0.0858
24.4	0.0671	29	0.0239
24.4	0.0893	29	0.0261
24.4	0.0448	30	0.1051
24.6	0.0805	30	0.1035
25	0.0486	30	0.0482
25.5	0.0527	30	0.0368
25.8	0.0852	30	0.0334
26.1	0.0553	31	0.1385
26.5	0.0731	31	0.0734
26.7	0.0424	31	0.0731
27.6	0.0618	32	0.0252
27.6	0.0428	32	0.1666
28.3	0.0653	34	0.3333
28.4	0.0628	34	0.2203
29.7	0.2801	34	0.1886
30	0.1387	34	0.0222
35.9	0.0592	34	0.0490
37.4	0.3723	35	0.2582
37.5	0.1039	36	0.2832
38	0.1631	37	0.1834
39.4	0.1845	38	0.1083
42.1	0.2637	38	0.1422
46	0.5772	42	0.0706
46.4	0.2856	42	0.0703
46.7	0.2565	42	0.0239

Appendix 14. Gray snapper length vs. total mercury concentration

Reefs gray snapper Total Length (cm)	Reefs gray snapper Total Mercury (ppm)	Rigs gray snapper Total Length (cm)	Rigs gray snapper Total Mercury (ppm)
32.5	0.1480	30	0.0472
34	0.1553	34	0.0814
34.9	0.1465	36	0.0439
35.1	0.1408	36	0.1422
35.4	0.1508	37	0.3214
35.8	0.1317	39	0.1023
35.9	0.1957	40	0.0909
36.2	0.1247	40	0.0489
36.3	0.1721	41	0.3228
36.4	0.2393	42	0.0864
36.7	0.1235	43	0.2476
37.2	0.1717	44	0.0596
37.5	0.1275	46	0.2136
37.6	0.0805	46	0.0616
37.7	0.1239	47	0.2149
38	0.1441	47	0.0727
38.1	0.1246	48	0.0988
38.9	0.1334	49	0.0885
42.7	0.1683	49	0.0885
43	0.2369	52	0.1155
47.8	0.1874	53	0.1663
49.9	0.1752	53	0.2182
49.9	0.3048	53	0.1625
52	0.3259	61	0.1442
53.3	0.4823	62	0.2160
53.8	0.4119	63	0.2531
54.5	0.4429		
58.5	0.7332		
59	0.6830		
62	0.2936		

Appendix 15. Lane snapper length vs. total mercury concentration

Reefs lane snapper Total Length (cm)	Reefs lane snapper Total Mercury (ppm)	Rigs lane snapper Total Length (cm)	Rigs lane snapper Total Mercury (ppm)
20.3	0.1496	29	0.1475
20.5	0.1823	32	0.1077
20.5	0.1533	32	0.1008
20.6	0.1690	33	0.1223
21	0.1181	35	0.1008
21.4	0.2014	36	0.1927
21.5	0.1583	40	0.0993
21.6	0.2450	40	0.1522
22	0.2054	40	0.0503
22.1	0.1929	40	0.1740
22.1	0.1481	44	0.1025
22.4	0.2423	47	0.1557
22.5	0.1765		
23	0.2479		
23.3	0.2038		
23.8	0.1993		
24.2	0.1428		
24.9	0.1156		
26.5	0.1883		
30	0.0998		
31	0.3365		
32	0.1569		
35.8	0.0407		
38.2	0.1498		
38.8	0.3008		
40.4	0.2646		
41.8	0.3420		
43	0.3146		
46.8	0.2314		
47.6	0.4453		

Appendix 16. Red snapper length vs. total mercury concentration

Reefs red snapper Total Length (cm)	Reefs red snapper Total Mercury (ppm)	Rigs red snapper Total Length (cm)	Rigs red snapper Total Mercury (ppm)
32.2	0.0661	33	0.0560
38.6	0.2884	36	0.1468
40.1	0.1311	37	0.1063
40.2	0.1309	38	0.0344
40.7	0.1717	38	0.0913
40.9	0.1078	39	0.1137
41.8	0.0756	39	0.1017
42	0.0947	39	0.1107
43.8	0.0916	39	0.0453
43.9	0.1134	41	0.1082
47.5	0.1360	45	0.0940
47.6	0.1494	45	0.1037
47.8	0.1187	45	0.0580
48.6	0.0712	47	0.1460
50.6	0.1332	47	0.1672
52	0.1485	49	0.1129
52.7	0.2259	50	0.1289
53.2	0.1559	51	0.0914
55.1	0.1632	52	0.1565
57.1	0.1816	56	0.1406
60.1	0.1797	56	0.1524
60.3	0.1837	59	0.1682
61.5	0.3171	62	0.1989
62.1	0.1637	63	0.1319
62.1	0.1427	63	0.1316
63.3	0.3943	71	0.2503
66.2	0.2047	77	0.1952
67.3	0.4100	81	0.3562
68.7	0.3445	83	0.4079
73.7	0.4042	85	1.1717

Appendix 17. Vermillion snapper length vs. total mercury concentration

Reefs vermillion snapper Total Length (cm)	Reefs vermillion snapper Total Mercury (ppm)	Rigs vermillion snapper Total Length (cm)	Rigs vermillion snapper Total Mercury (ppm)
21	0.0597	30	0.0151
21.2	0.0763	32	0.0205
22	0.0752	33	0.0152
22	0.1019	33	0.0271
22.1	0.0853	35	0.0137
22.4	0.0618	35	0.0479
23.3	0.1100	36	0.0262
23.6	0.1143	36	0.0244
24.5	0.0820	36	0.0417
24.8	0.1431	37	0.0472
32.5	0.0494	37	0.0432
32.5	0.0614	37	0.0505
33.3	0.0643	37	0.0270
33.5	0.0663	37	0.0346
33.5	0.0590	37	0.0558
33.6	0.0512	37	0.0232
34	0.0490	38	0.0458
34	0.0599	39	0.0301
34.1	0.0956	40	0.1100
34.1	0.0429	40	0.0496
34.4	0.0422	40	0.0415
35.3	0.0595	40	0.0391
35.9	0.0692	41	0.0524
36	0.0582	45	0.0779
37.1	0.0326	46	0.0444
37.4	0.1110	49	0.0809
37.8	0.0761		
38.4	0.0530		
38.7	0.0282		
38.9	0.0592		

Appendix 18. King mackerel length vs. total mercury concentration

Western Gulf king mackerel Curved Fork Length (cm)	Western Gulf king mackerel Total Mercury (ppm)	Eastern Gulf king mackerel Curved Fork Length (cm)	Eastern Gulf king mackerel Total Mercury (ppm)
79.5	0.5946	63.9	0.1495
81	0.6449	64.9	0.1586
85	0.9285	65.2	0.3348
86.5	0.6055	65.2	0.1916
86.8	1.0422	66.1	0.2401
87.5	0.7531	67.4	0.2374
87.8	0.9757	71.1	0.3756
90	1.4711	80.2	0.7425
90	1.4017	90	0.9213
91	0.6632	90.5	0.8627
91	1.1022	90.5	0.8029
92	0.9428	94.5	1.1027
92.5	0.9240	95.6	1.1651
92.5	0.8473	97	1.2868
93	1.0042	98.2	1.7915
95	0.8897	98.6	0.8606
98	1.4416	101.1	1.4506
99.1	1.5050	104.9	1.4008
99.9	0.8946	105.6	1.3925
101	0.8279	106.2	1.8100
101	0.9840	107.5	1.6490
102	1.4512	108.9	1.7240
103	1.1547	109.2	2.4019
105	1.4197	109.4	1.6623
107	1.2858	111.1	1.6771
107.2	0.9898	113.2	2.3893
108	1.2830	117.6	2.8058
115	1.5743	126.2	3.6136
118.5	0.7447	128.5	3.9945
121	0.7697		

Appendix 19. Cobia length vs. total mercury concentration

Western Gulf cobia Curved Fork Length (cm)	**Western Gulf cobia** Total Mercury (ppm)	**Eastern Gulf cobia** Curved Fork Length (cm)	**Eastern Gulf cobia** Total Mercury (ppm)
99	0.4944	92.3	0.7654
117	2.0394	100.2	0.8841
145.5	2.6849	107.1	1.0171
		111.8	0.9394
		135.2	1.6300

Appendix 20. Dolphin length vs. total mercury concentration

Western Gulf dolphin Curved Fork Length (cm)	**Western Gulf dolphin** Total Mercury (ppm)	**Eastern Gulf dolphin** Curved Fork Length (cm)	**Eastern Gulf dolphin** Total Mercury (ppm)
41	0.0560	37.5	0.0349
41.5	0.0499	39.8	0.0185
49	0.0457	41.4	0.0272
51.5	0.0518	41.6	0.0246
52	0.0387	42.4	0.0224
52	0.0355	42.9	0.0206
54.5	0.0398	43.2	0.0405
57.5	0.0442	45.2	0.0287
59.5	0.0374	47.4	0.0267
61.5	0.0381	47.7	0.0368
65.5	0.0660	48.1	0.0257
65.9	0.0311	51.8	0.0283
76.2	0.0362	73.2	0.0618
77.8	0.1160	78.6	0.0897
79	0.0730	81.8	0.0639
89.5	0.1926	90.9	0.1921
95.7	0.0744	102.4	0.1122
108	0.4057	103.4	0.2906
127.8	0.3466	105.8	0.3338
132.5	0.2935	106.2	0.2481
		108	0.0844
		108.6	0.2760
		112.7	0.1702
		113.1	0.2859
		116.2	0.2484
		121.7	0.3902
		123.8	0.4250

Appendix 21. Black tuna length vs. total mercury concentration

Western Gulf black tuna Curved Fork Length (cm)	**Western Gulf black tuna** Total Mercury (ppm)	**Eastern Gulf black tuna** Curved Fork Length (cm)	**Eastern Gulf black tuna** Total Mercury (ppm)
55.2	0.2980	87.7	1.3005
57	0.4519	77.8	0.4680
61.1	0.3505		
62	0.7765		
62.8	0.3200		
63.5	0.5221		
64.5	0.5278		
65	0.4662		
65	0.5086		
66	0.4898		
70	0.7591		
70.5	0.6256		
71	0.9598		
74.1	1.4328		
74.5	1.2055		
74.8	0.9867		
75	0.9843		
75.5	1.2668		
76	1.1370		
77.3	2.1360		
77.5	0.8578		
77.5	1.3895		
77.6	1.0868		
78	1.0803		
79	0.9989		
79.5	1.4669		
80	1.2670		
81	1.3690		
83	0.8909		
83.9	1.2248		

Appendix 22. Little tunny length vs. total mercury concentration

Western Gulf little tunny Curved Fork Length (cm)	**Western Gulf little tunny** Total Mercury (ppm)	**Eastern Gulf little tunny** Curved Fork Length (cm)	**Eastern Gulf little tunny** Total Mercury (ppm)
48.5	0.2955	55.4	0.4930
53	0.2470	56.5	0.4615
53.5	0.3916	59.7	0.8491
54	0.2235	62	1.1539
57	0.5571	65.3	1.3739
58	0.8743	66.2	1.2349
58.8	0.8698	66.4	1.2275
59	0.8245	68.7	1.6295
59	0.6826	69.1	1.4506
59.5	0.6458	71.4	1.4951
60	0.7665		
60	0.9755		
61.8	1.1380		
63	0.8078		
63.8	0.9361		
64	1.6688		
64.6	0.9146		
65	1.0931		
65	1.0445		
65.8	0.9815		
66	1.1500		
66	2.2999		
67.5	1.1623		
69	1.5496		
69	1.3164		
76	1.0253		
79	1.3837		
87	1.1902		
88	1.0219		
89	1.5608		

Appendix 23. Yellowfin tuna length vs. total mercury concentration

Western Gulf yellowfin tuna Curved Fork Length (cm)	**Western Gulf yellowfin tuna** Total Mercury (ppm)	**Eastern Gulf yellowfin tuna** Curved Fork Length (cm)	**Eastern Gulf yellowfin tuna** Total Mercury (ppm)
143	1.5980	109	0.1656
159	0.9501	113.5	0.1685
160	1.4944	114.9	0.1924
		115.5	0.2082
		116.2	0.2180
		119.8	0.1975
		119.9	0.1687
		134	0.2369
		136.1	0.2131
		155.1	0.5447

Appendix 24. Survey Protocols

Purpose

This appendix documents the protocols used in completing the “Synoptic Survey of Total Mercury in Recreational Finfish in the Gulf of Mexico.” This appendix provides the protocols that were followed and are recommended for similar surveys.

Record Binders

All hardcopies of forms/records related to the Survey must be maintained in large three ring record binders. There will be one master record binder kept for each geographic location. The Survey Field Coordinator and Sample Custodian will maintain separate copies of record binders. The logs and spreadsheets contained in these binders will be the primary means by which the Survey manages sample collections in the field, the shipment and receipt of the samples, and tracking of the samples once received at the analytical laboratory.

Sampling Binders

The sampling binders contain the Sampler’s manually recorded information about the samples. If the Sampler’s laboratory has an equivalent system to record the desired information, that system may be used instead of the Sampling Binders provided by the analytical laboratory, if approved by the Field Coordinator.

The first page of the sampling binders will contain a trip log where sampling trip information is recorded. The trip log shall contain the following data fields: 1) trip date; 2) Sampler’s name; 3) Sampler initials; 4) Sampler’s affiliation; 5) vessel used; and 6) collection gear used. The trip data sheet will have 25 data rows to accommodate multiple trips required to collect the set of samples for the geographic location.

The backsides of the binder pages will contain: 1) line drawings and photographs of the species to be collected, 2) information on how to identify the desired species, versus similar looking species, using key characteristics, and 3) instructions on how to measure the species and how to extract the tissue sample. The identification information and measuring instructions for a given species will be printed on the backside of the previous page in order for the identification, measurement, and extraction information for a given species to be visible along with the species data recording spreadsheet.

A separate binder will be dedicated for each geographic location being sampled (see appendices 25-71 for examples). There will be one data recording spreadsheet page for each species in each binder. The species pages will be laminated and the data will be recorded using permanent ink pens and block lettering. Several permanent ink pens will be provided with each binder.

The individual specie spreadsheet’s data rows will be pre-printed with the species name, size category, geographic location, and sequence number (1 through 30) for the set of samples to be collected. The individual species pages (i.e., spreadsheets) will be divided into three fish size category sections: small; medium; and large. On each data row of the spreadsheet, the range of acceptable lengths in centimeters will be pre-printed. There will be 10 data rows (i.e., lines) within each fish size category section. There will be multiple data columns for each data row.

These columns will be labeled: 1) length of the fish being sampled; 2) longitude and latitude of location from which the fish was caught; 3) date of capture; and 4) initials of sampler. Alternatively, the samplers may enter this data into electronic spreadsheets setup in the same way as the data sheets.

Monitoring Sampling Effort

The Field Coordinator will monitor the progress of the sampling effort via scanned images of the hardcopy binder pages or electronic spreadsheets (FAX-ed or e-mailed by the Onsite Sampling Coordinator) to assure legibility and completeness of the recorded data. The Field Coordinator is responsible for monitoring: 1) sample collection progress, 2) onsite Sampling Coordinator's adherence to the instructions of the Survey Protocols, 3) scheduling sample shipments, and 4) assure that the data collected is useable and legible.

Sampler Training

The Field Coordinator will train each Sampler to ensure they understand how to follow the sampling protocol, data recording protocol, sample handling, etc. The Samplers will be accompanied by the Field Coordinator on their first sampling trip if possible.

Sampling Kit

The sampling kits and high efficiency coolers will be delivered to each Sampler personally by the Field Coordinator during his/her training trips to the Samplers' laboratories.

The following items will be contained in each Sampler's sampling kit:

1. handheld GPS
2. 3 meter long measuring tape
3. a plastic L bracket (approx. 6 inch, by 6 inch, by 3 inch) to duct tape to the deck or rail for use as a place to butt the nose of the fish to in order to get consistent length measurements,
4. 3 black permanent ink pens
5. phone numbers to the Field Coordinator
6. pre-labeled Fedex box to ship binder to Data Manager
7. pre-printed Fedex label to ship the cooler to Sample Custodian
8. binder with per species for geographic area being sampled: species identification information, measuring instructions, tissue extraction instructions, data recording spreadsheets, and sample labels,
9. one medium sized high efficiency ice cooler
10. small Ziplock bags for tissue samples
11. medium Ziplock bags to group small Ziplock bags per species for freezing
12. large Ziplock bags to group medium Ziplock bags per geographic location for transport
13. one stainless steel fillet knife
14. one box of Wet Wipes to clean fillet knife and hands between samples
15. one roll of duct tape to tape the bracket down on the ends to make it lay flat
16. one roll of paper towels to clean hands and work area
17. backpack for carrying supplies in field

Sampler’s Management of Samples

The strategy for managing the samples and their associated data follows: Each geographic location to be sampled (e.g., estuary, section of open Gulf waters) will have a limited set of species that will be sampled. For each species being sampled for a given geographic location the sampler should attempt to collect 10 samples from 10 different individual fish for each of three fish size categories (i.e., 10 small, 10 medium, 10 large). Each fish sampled will have the following information recorded in the sampling binder or equivalent spreadsheets: 1) date, 2) length of fish measured, 3) latitude and longitude of capture, and 4) sampler’s initials. The information will be recorded on pre-printed laminated plastic spreadsheets for the given species and geographic location using waterproof ink pens. Information on the trip and sampler will be recorded on a separate spreadsheet page.

A single muscle tissue sample (approximately 1 inch cube of meat) is to be extracted from above the left pectoral fin of the collected individual fish using the stainless steel fillet knife provided in the sampling kit. The individual muscle tissue sample will be placed in a small ziplock bag and labeled with a provided pre-printed label that corresponds to the sample binder’s (or equivalent) spreadsheet data row. The small ziplock bags for a given species will be stored in an ice slurry in the field. Alternatively, the whole fish may be placed on ice and brought back to the laboratory, and the muscle tissues extracted and placed into the small ziplock bags at the laboratory.

At the Sampler’s laboratory, prior to placement in a freezer for storage, the small ziplock bags containing samples for a given species will be placed into a medium ziplock bag to group the samples for the given species and given geographic location. The medium ziplock bags will be labeled with provided pre-printed labels indicating geographic location and species. The medium ziplock bags will be placed in a single large ziplock bag labeled with a provided pre-printed label indicating the geographic location. As new muscle tissue samples are collected during the course of the Survey, their information will be entered into the sample binder and the samples are to be placed into a labeled small ziplock bag, and placed in the appropriate medium and large ziplock bags according to their species and geographic location. The large ziplock bag, and enclosed medium ziplock bags, and muscle tissue containing small ziplock bags are to be stored in the Sampler’s laboratory freezer and shall be maintained in a hard frozen state during additions of any new samples (the samples are not to be allowed to thaw and be re-frozen).

Sample Shipment

The initial shipment of samples for a given geographic location will contain the bulk of the samples for the given geographic location (e.g., 312 of the 330 Mobile Bay samples). Subsequent shipments will be to fill in samples not provided in the initial shipment (e.g., multiple shipments of smaller quantities of samples may come in to fill out the Mobile Bay sample quota). At the Field Coordinator's discretion, after reviewing the status of the sample collection, and confirming the availability of the Sample Custodian to receive a shipment, the Onsite Sample Coordinator will be instructed to Fedex overnight the frozen samples. These samples must be packed in the coolers with dry ice along with a hardcopy list of samples contained in the cooler, and be shipped to the Sample Custodian. Alternatively, the Field Coordinator may arrange to have the analytical laboratory’s staff pick up and transport the frozen samples (packed in the coolers with dry ice) to the analytical laboratory. The Field Coordinator will give the Sample Custodian notice that a shipment is on the way along with the expected delivery date and time. Both the Field

Coordinator and Sample Custodian will be on standby to receive and check-in the samples. The Sample Custodian will be responsible for checking on the arrival of Fedex deliveries.

Receipt of Main Shipment of Samples

Attending to incoming samples and ensuring that they stay frozen is the Sample Custodian and Field Coordinator's highest priority. All other tasks will cease as soon as the samples arrive and are not to be resumed until the samples have been logged-in and placed in cold storage. Upon receipt of the samples, the Sample Custodian and Field Coordinator will jointly open the cooler, log in the samples and place them in an ultra-low freezer as quickly as possible. The Sample Custodian and Field Coordinator will log-in each shipment by cross checking the received samples against the hardcopy list of samples accompanying the shipment and previously obtained copies of the Sampler Binder or equivalent data pages.

In order to keep the frozen samples from thawing the shipment log-in must be done quickly. Individual samples will not be removed from their small ziplock bags during log in. One medium ziplock bag will be removed from the cooler at a time by the Sample Custodian while the others are kept in the cooler. The Sample Custodian will remove the sample containing small ziplock bags and lay them out in the order of their size and number sequence. The Field Coordinator will then log them in and fill out the hardcopy Sample Receipt form (see page 39) that corresponds to the given geographic location and species of the samples.

The Sample Custodian will confirm the completed Sample Receipt Form against the laid out samples and instruct the Field Coordinator to make corrections to the Sample Receipt Form if needed. The Field Coordinator will use the Sample Receipt Form to verify that the samples have been received and, if needed, to request the Field Samplers to collect and ship additional "fill-in" samples to replace any missing, spoiled, mislabeled, or otherwise unusable samples.

After logging the samples in, the Sample Custodian will place the individual small ziplock bags back into their medium ziplock bag (i.e., species bag) and large ziplock bag (i.e., geographic location) that they were received in and place them back into the cooler, until all of the samples have been logged-in. After logging-in all the samples received, the Sample Custodian will seal the large ziplock bag containing the medium ziplock bags which contain the small ziplock bags containing the samples, and place them into a locked ultra-low freezer for storage until they are checked out for analyses.

Both the Sample Custodian and Field Coordinator will maintain copies of the Sample Receipt Forms in a Sample Receipt log (e.g., large three ring binder) for documentation and retrieval.

Receipt of Fill-in Samples

The Field Coordinator will notify the Sample Custodian of any fill-in samples being shipped. The procedure for logging in the fill-in shipments will be the same as the procedure for the initial shipment log-in, with the following modifications. Since the original large ziplock bag and medium ziplock bags have previously been shipped, logged-in, and placed in storage in an ultra-low freezer, the fill-in samples will arrive in individual ziplock bags that have been placed in unlabelled medium ziplock bags. Therefore the log-in procedure was modified to accommodate this difference in shipping preparation.

Upon receipt of a fill-in shipment, the Sample Custodian will remove the fill-in shipment's small ziplock bags from their medium ziplock bags and place the samples contained in the small ziplock bags out according to species, size, and number. The Field Coordinator will cross check the presence of the sample containing small ziplock bags against the hardcopy list of the samples that accompanied the shipment. The Field Coordinator will complete a blank Sample Receipt Form for each specie and geographic location sample received. The Sample Custodian will check the newly completed Sample Receipt Forms and instruct the Field Coordinator to make any necessary corrections.

After the fill-in samples are logged-in by the Sample Custodian and Field Coordinator they will jointly locate the ultra-low freezer containing the large ziplock and medium ziplock bags that the Fill-in samples' small ziplock bags belong in, and place the sample containing the small ziplock bags into their corresponding medium ziplock bags per species and large ziplock bag per geographic location.

An annotation that the fill-in sample(s) was placed in an ultra-low freezer in its corresponding geographic location and species bag(s) will be recorded in the "Notes" section of the fill-in Sample Receipt Form. The Sample Custodian will make copies of the fill-in Sample Receipt Form and provide copies to the Field Coordinator and Lead Chemist. The Sample Custodian and Field Coordinator will archive and maintain the copies of the fill-in Sample Receipt Form in the Sample Receipt log by stapling the fill-in Sample Receipt Form(s) to the backs of the main shipment's Sample Receipt Forms.

Upon completion of the sampling in the field, the Field Coordinator will instruct the Onsite Sampling Coordinator to ship the Sample Binder to the Data Entry Manager (or transmit the final copy of the Excel spreadsheet, if used as an alternative to the Sample Binder). Prior to shipping the Sample Binder, the Onsite Sample Coordinator will photocopy the data sheets and the Sample Binder as a backup (in case the binder is lost during shipment). After copying the Sample Binder, the Onsite Sample Coordinator will Fedex the Sample Binder to the Data Entry Manager, in the Fedex packaging provided by the Field Coordinator. The Survey's Field Coordinator will notify the Survey's Data Entry Manager that the binder has been shipped and provide the expected delivery date and time. The Data Entry Manager will inform the Field Coordinator when the binder has arrived.

Alternatively, if Excel spreadsheets are used instead of hardcopies, the Field Coordinator will acquire the Excel spreadsheets via e-mail and forward the spreadsheets to the Data Entry Manager for data entry with the total mercury data after the Chemists complete their analyses.

EXAMPLE SAMPLE RECEIPT FORM

Sample Binder Shipment

Delivered by __________
Received by __________
Receipt date__________
Receipt Time _________
Sample Custodian doing check in ___________
Field Coordinator doing check in ___________
Check-in Date _________
Check-in Time _________
Post Check-in FreezerStorage___________
Notes:

Matagorda Bay Texas Sampling (MBTS)

Southern flounder *Paralichthys lethostigma*

Sample ID & number.	Size Bracket	Present (check for yes, blank for no)	Useable (check for yes, blank for no)	Agrees with presence in sample binder
MBTS-Southern_flounder-SM-1	Small			
MBTS-Southern_flounder-SM-2	Small			
MBTS-Southern_flounder-SM-3	Small			
MBTS-Southern_flounder-SM-4	Small			
MBTS-Southern_flounder-SM-5	Small			
MBTS-Southern_flounder-SM-6	Small			
MBTS-Southern_flounder-SM-7	Small			
MBTS-Southern_flounder-SM-8	Small			
MBTS-Southern_flounder-SM-9	Small			
MBTS-Southern_flounder-SM-10	Small			
MBTS-Southern_flounder-MED-1	Medium			
MBTS-Southern_flounder-MED-2	Medium			
MBTS-Southern_flounder-MED-3	Medium			
MBTS-Southern_flounder-MED-4	Medium			
MBTS-Southern_flounder-MED-5	Medium			
MBTS-Southern_flounder-MED-6	Medium			
MBTS-Southern_flounder-MED-7	Medium			
MBTS-Southern_flounder-MED-8	Medium			
MBTS-Southern_flounder-MED-9	Medium			
MBTS-Southern_flounder-MED-10	Medium			
MBTS-Southern_flounder-LRG-1	Large			
MBTS-Southern_flounder-LRG-2	Large			
MBTS-Southern_flounder-LRG-3	Large			
MBTS-Southern_flounder-LRG-4	Large			
MBTS-Southern_flounder-LRG-5	Large			
MBTS-Southern_flounder-LRG-6	Large			
MBTS-Southern_flounder-LRG-7	Large			
MBTS-Southern_flounder-LRG-8	Large			
MBTS-Southern_flounder-LRG-9	Large			
MBTS-Southern_flounder-LRG-10	Large			

Checking out Batches for Analyses

The Sample Custodian will inform the Lead Chemist when samples have arrived and provide him/her copies of the Sample Receipt Forms. The Lead Chemist will use the copies of the Sample Receipt Forms to determine the availability of samples for analyses. To acquire a batch of samples (i.e., one medium ziplock bag) for analyses, the Lead Chemist will be required to check the batch out of the ultra-low freezer by requesting the batch from the Sample Custodian. The Sample Custodian will maintain a “Sample Check-Out Log” for the batches noting: time of check out, date of check out, batch checked out, ultra-low freezer checked out from, etc.

After the analyses have been completed, the Lead Chemist will return the non-used portions of the samples to the Sample Custodian. The Sample Custodian will verify that the correct number of sample remains have been returned, and that they are contained in the bags that they were checked out in (i.e., correct sample in correct small, medium and large ziplock bags). The Sample Custodian will assign these sample remains to an ultra-low freezer for long-term storage (other than the one used for the un-analyzed samples) and record in the “Sample Remains Log” the freezer that the sample remains were placed in. The Sample Custodian will archive and maintain this log in the Records Binder for the assigned geographical location.

Sample Remains Re-analyses

If needed, the Lead Chemist will request samples for re-analyses from the Sample Custodian. The Sample Custodian will retrieve the requested sample remains and check them out to the Lead Chemist. The Sample Custodian will use the “Remains Log” to record sample remains check out and check in transactions. The Sample Custodian will archive and maintain this log in the Records Binder for the assigned geographical location.

The Survey’s Program Coordinator will notify the Sample Custodian by written instruction when sample remains are to be disposed. Upon receiving the instruction from the Program Coordinator, the Sample Custodian will transfer the sample remains to the Laboratory Safety Officer for disposal. The Sample Custodian will record this transaction in the Remains log, and attach the written request from the Program Coordinator. The Sample Custodian will archive the Record Binders and its contents.

Lead Chemist Sample Tracking

The Lead Chemist will be responsible for the sample tracking and scheduling of analyses. The Lead Chemist will maintain a “Batch Log” to track the batches’ location, changes in location, person changing the location, and date and time of location changes to avoid miss-placing samples. The Lead Chemist and Chemists will maintain check off list(s) on a clip-board in the mercury analyses room(s) to track the batches that have been analyzed and batches being thawed for analyses. This is to avoid duplication of analyses and neglecting to analyze batches. The Lead Chemist will maintain archived hardcopies of the check off lists and Batch Log.

Chemist Sample Handling for Mercury Analyses

The Lead Chemist will check out, from the Sample Custodian, selected batches (i.e., medium ziplock bags containing samples) from the ultra-low freezer(s), where they were checked-in and placed by the Sample Custodian. The checked out batch will be thawed in one of the laboratory’s lockable refrigerators in a room other than the room where the total mercury analyses will be performed. The Lead Chemist will check out enough batches to provide the Chemist with ample samples to be analyzed during the following workday. In order to minimize microbiological degradation of the samples, the Lead Chemist will schedule the thawed samples be analyzed within two days of being checked out from the ultra-low freezers.

There will be two mercury workstations in the mercury analyses room where the samples are to be analyzed. One Chemist will be assigned to one mercury analyses workstation, while the other Chemist is assigned to the other mercury analyses workstation. Each station will have its own refrigerator, sample prep work area, and one Milestone, Inc. DMA-80 Direct Mercury Analyzer with scales and associated software interface computer (DMA).

Prior to performing the mercury analyses the Chemist will check out one batch of thawed samples from the Lead Chemist and transport that batch to their workstation's refrigerator. Only one batch of thawed samples is to be present at a mercury analyses workstation at any given time. All samples and sample prep will be restricted to the workstation of the Chemist assigned to carry out the analyses of the batch of thawed samples. At no time are the samples assigned to one Chemist to be placed into the workstation of the other Chemist.

The thawed samples will remain refrigerated at all times with the following exceptions:
1) in order to move the samples from the Lead Chemist refrigerator into the mercury analyses workstations' refrigerators, 2) in order to prepare the samples for placement into the sample boats and weighing on the DMA, 3) in order to place the samples into the DMA's autoloader,
4) while the sample is in the DMA's autoloader, 5) in order to place the non-used portion of the inter-cube back into its sample bag, or 6) in order to transport the samples back to the Sample Custodian.

The samples should not be allowed to sit outside of the refrigerator for more than 5 minutes prior to weighing them on the DMA. This is to minimize the sample losing weigh via either evaporation or moisture weeping from the tissues due to cellular disruption caused during freezing.

The Chemist will pull the small ziplock bags from one medium ziplock bag and put the small ziplock bags onto three separate trays. This is in addition to organizing and processing the samples prior to analyses.

Tray one will contain in sequence the small ziplock bags #1-#10.
Tray two will contain in sequence the small ziplock bags #11-#20.
Tray three will contain in sequence the small ziplock bags #21-#30.

The Chemist will follow the procedures for carrying out total mercury analyses as per the Milestone, Inc. DMA-80 Direct Mercury Analyzer Manual of Operation, U.S. EPA Method 7473* and Cizdziel et al, 2002**. This procedure includes entering data into the DMA spreadsheet data fields in order to identify the analyses with the sample or standard. The DMA loading sequence is as follows: a third analysis is run only on samples duplicates that are >14.9% different in their total mercury results. The requirement for running a third analyses for samples with differences >14.9% is waved for samples with both duplicates having total mercury values ≤0.009 ppm.

EXAMPLE SAMPLE RECEIPT FORM
Sample Binder Shipment

Slot Position	ID	Slot Position	ID
1.	Inst Blank (no boat)	1.	Inst Blank (no boat)
2.	Blank (empty boat)	2.	Blank (empty boat)
3.	Tuna Std	3.	Tuna Std
4.	Dorm Std	4.	Dorm Std
5.	Blank (empty boat)	5.	Blank (empty boat)
6.	Small 1	6.	Medium 6
7.	Small 1	7.	Medium 6
8.	Small 2	8.	Medium 7
9.	Small 2	9.	Medium 7
10.	Small 3	10.	Medium 8
11.	Small 3	11.	Medium 8
12.	Small 4	12.	Medium 9
13.	Small 4	13.	Medium 9
14.	Small 5	14.	Medium 10
15.	Small 5	15.	Medium 10
16.	Small 6	16.	Large 1
17.	Small 6	17.	Large 1
18.	Small 6	18.	Large 2
19.	Small 7	19.	Large 2
20.	Small 7	20.	Large 3
21.	Small 8	21.	Large 3
22.	Small 8	22.	Large 4
23.	Small 9	23.	Large 4
24.	Small 10	24.	Large 5
25.	Small 10	25.	Large 5
26.	Blank (empty boat)	26.	Blank (empty boat)
27.	Tuna Std	27.	Tuna Std
28.	Dorm Std	28.	Dorm Std
29.	Blank (empty boat)	29.	Blank (empty boat)
30.	Medium 1	30.	Large 6
31.	Medium 1	31.	Large 6
32.	Medium 2	32.	Large 7
33.	Medium 2	33.	Large 7
34.	Medium 3	34.	Large 8
35.	Medium 3	35.	Large 8
36.	Medium 4	36.	Large 9
37.	Medium 4	37.	Large 9
38.	Medium 5	38.	Large 10
39.	Medium 5	39.	Large 10
40.	Tuna Std	40.	Tuna Std

Note: These are the “ideal” loading positions. Blanks/Standards/Samples positions may be modified.

*U.S. EPA. 1998. Mercury in solids or solutions by thermal decomposition, amalgamation, and atomic absorption spectrophotometry. Method 7473. U.S. Environmental Protection Agency, Washington, D.C., U.S.A.

**Cizdziel, J.V., T.A. Hinners and E.M. Heithmar. 2002. Determination of Total Mercury in Fish Tissues using Combustion Atomic Absorption Spectrometry with Gold Amalgamation. Water, Air, and Soil Pollution 135: 355-370.

The Chemist will use one spatula exclusively for loading the DORM Standard into the DMA sample boats and will use a second spatula exclusively for loading the TUNA Standard into the DMA sample boats. The Chemist will use a third spatula for loading the tissue samples into the DMA sample boats. The knife and spatula will be cleaned by the Chemist between each sample by wiping the blades with wet wipes and drying them with paper towels. Fresh wet wipes and paper towels will be used to clean the blades between samples.

The Chemist will use a stainless steel knife to cut approximately 1/4 inch off all six sides of the sample cubes to remove the tissues that were most likely to have suffered freezer burn which could affect the weight of the tissues. The Chemist will use the tissue from the inner-cube for the DMA analyses. The preparation of the inner-cube, cutting a portion of it for placement on the DMA sample boats and weighing on the DMA, should take no longer than five minutes per sample. The portion of the inner-cube not used for the DMA analyses is to be returned to its original labeled sample bag and placed back into the refrigerator. The non-used portion of the inner-cube should not be allowed to remain out of the refrigerator for more than five minutes. This is to avoid microbiological degradation of the non-used portion of the inner-cube that would cause weight changes due to cellular disruption and associated moisture weeping from the tissues that could affect later re-analyses.

At the end of the DMA run for the three trays (i.e., small, medium, large samples for a given species and geographic location), the Chemist will place the small ziplock bags containing the remains of the inter-cube back into their medium bag and check the batch back in with the Lead Chemist who will check the sample remains in with the Sample Custodian for archiving in an ultra-low freezer other than the one used for the un-analyzed samples. The Sample Custodian will maintain a “Remains Log” of the checking in of the sample remains and location of the sample remains.

Data Transfer and Entry

After each day of analyses, the Chemists will provide copies of their DMA data sheets to the Lead Chemist. The Chemists will archive and maintain their original data sheets. The Lead Chemist will data enter the Chemist’s DMA data sheets information (total mercury ppm per sample) into an Excel spreadsheet, and provide an electronic copy of the spreadsheet to the Chemist for QA. After passing the Chemist’s QA, the Lead Chemist will provide an electronic copy of the data to the Data Entry Manager. Thereafter, the Data Entry Manager assigns one of the Data Entry Staff to data enter the samples’ corresponding data and information from the original previously shipped Sample Binder (or alternative sample spreadsheet) into the spreadsheet containing the total mercury provided by the Lead Chemist. The Data Entry Manager will provide the Lead Chemist and Field Coordinator with copies of the entered data for QA. After QA electronic copies of the spreadsheets will be provided to the Data Manager who will check the files for problems and archive the files on multiple computers and CDs. The Data Entry Manager will keep a log of the data sheets and binder’s received from the Lead Chemist and Field Coordinator and of their approval of the QA of the entered data. The Data Entry Manager and Data Manager will maintain an electronic archive of the spreadsheets.

Data Analyses

The Data Manager will provide copies of the total mercury and length spreadsheets for the various geographic locations and species to the Data Analysts. The Data Analysts will generate scatter plots of the total mercury and length data to evaluate the comparability of the species' mercury concentrations as observed from the different geographic locations. The Statistician will fit regressions to evaluate the total mercury and length data relationships per species. The Data Analyst and Statistician will provide the graphs of the scatter plots with regression lines per species with each geographic locations' data keyed for identification on the graphs.

Report Generation

The Program Coordinator will generate a draft of a Report of Findings. This Report will be Quality Assured and edited by the Laboratory Director and editorial staff.

Appendix 25. Example Trip Log Spreadsheet

Trip Log
Galveston Bay Texas Sampling

Sampler Name	Institutional Affiliation	Date of Trip	Vessel Used	Fishing Gear(s) Used	General Fishing Area(s)