Ecosystem Management Report

A Comparison of Mercury in Estuarine Fish: Florida Bay and Indian River Lagoon

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Mission

"To protect, conserve and manage Florida's environment and natural resources."

Notice

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Abstract

This study evaluates mercury in fish in relation to health advisory criteria in two Florida estuaries. Three hundred sixty-seven economically important gamefish were collected from the Indian River Lagoon in Martin and St. Lucie Counties and Florida Bay. Fish species collected were spotted seatrout, snook, gray snapper, jack crevalle, mayan cichlid, black drum, gafftopsail catfish, pompano, redfish, sheepshead, southern flounder and spadefish. Edible filets from these species were analyzed for mercury content.

Statistical analysis indicated that location was the most significant factor affecting mercury levels. With the exception of jack crevalle and gafftopsail catfish, mercury in fish from the Indian River averaged less than the Florida Limited Consumption Advisory. Tissue samples from several species of fish caught in eastern Florida Bay contained higher levels of mercury than did samples of those species collected in other areas. A significant portion of the estuarine fish collected in eastern Florida Bay, including spotted seatrout, exceed the 1.0 mg-Hg/Kg US Food and Drug Administration's "no consumption" health advisory criterion. Mercury levels were elevated in jack crevalle from all areas. Estimates of the percentage of fish within an area that may exceed applicable state and federal fish consumption advisory levels are presented.

Recommendations include the following:

1. Florida Department of Health and Rehabilitative Services should evaluate the consumption advisory status for several estuarine fish, especially those from eastern Florida Bay.

2. FDEP should continue to determine the spatial distribution of mercury contamination in Florida estuarine fish.

3. Efforts to define the underlying cause for the observed high levels of mercury in eastern Florida Bay should be continued.

4. Additional research is advised to determine the causes behind inter-species variation in mercury concentration.

Resumen

Este estudio es para evaluar que relacion tiene el mercurio encontrados en los peces contra el criterio de dos estuarios de la Florida, para establecer esta relacion se colectaron trescientos sesenta y siete especie de peces economicamente importantes de la Laguna Indian River, en los condados de Martin y San Lucie y de la Bahia de la Florida, entre ellos se encontraban, truchas, pargo gris etc. y muchas otras especies de agua dulce que se filetearon para determinar el contenido de mercurio.

Los analisis estadisticos indicaron que la localizacion donde se encontraron estos peces, jugo un papel muy importante para determinar el nivel de mercurio, con la excepcion de “Jack Crevalle” y “Gafftopsail Catfish”, el mercurio que se encontro en los peces de la Laguna Indian River, tenian un average menor que los limites de consumo recomendados por la Florida. Muestras de la carne de algunos peces encontrados en la region Este de la Bahia de la Florida contenia mayor nivel de mercurio que los peces en otras regiones. Una porcion significante de los peces estuarinos collectados en la region Este de la Bahia de la Florida, incluyendo la trucha de mar manchada, excedia el 1.0 mg-Hg/Kg considerado por la agencia de Alimentacion y Droga, como peligrosos para el consumo humano. El nivel de mercurio estaba elevado en todos los Jack Crevalles que se encontraron en todas las areas. Se ha producido un porcentage de peces en el area que puede ser que exceda los limites establecidos por la agencia estatal y federal como daninos para el consumo humano.

Recomendaciones:

1. La agencia Estatal de Servicios a la Salud y Reabilitacion (HRS) debe evaluar la rcomendacion para el consumo de algunas especies de peces que se encuentran en el area Este de la Bahia de la Florida.

2. El Departamento de la Proteccion Ambiental (FDEP) debe continuar determinando la contaminacion de mercurio en los peces del area de la Florida.

3. Continuar con los esfuerzos para investigar la causa del alto nivel de mercurio en los peces en la Bahia de la Florida.

4. Se recomienda estudios adicionales para determinar las causas de la concentracion de mercurio en las especies estudiadas.

Acknowledgements

We thank Tom Atkeson of Florida Department of Environmental Protection (FDEP), Governor's Task Force on Mercury Contamination, for his support and technical guidance during this study; Jay Concannon, Chris Christopher and Dale Evans, St. Lucie county commercial fishermen, for training in the use of gill nets, donation of fish specimens, loan of their nets, and sharing their knowledge of fishing in the Indian River Lagoon; Jim Whittington and Kraig Krum of the Tequesta office of the Florida Marine Research Institute for their assistance in collecting snook by beach seine; Tim Fitzpatrick and Julio Arrecis of the Florida Department Environmental Protection Central Analytical Laboratory; Jerry Lorenz and Chris Harrington of the Audubon Society at Plantation Key for sampling assistance; Dewitt Smith, Mike Robley, Bill Loftus and Daniel Foxen at Everglades National Park for requesting fish collections and providing Federal permits; Florida Marine Patrol, Merritt Island, for donation of confiscated gill nets; Don Breheny, Jeff Christian, Greg Kuklinski, Ward Parker and Peter Teichert, local fishermen, for donation of fish specimens; Brad Rieck and Mark Yanno, U. S. Fish and Wildlife Service, for spearing fish in the Fort Pierce inlet; Dr. Robert Muller of Florida Marine Research Institute, Dr. Alan Steinman of the South Florida Water Management District and Jeffrey Stein of the Florida State University Department of Statistics for guidance and direction in applied statistics. We thank the following for improving this document with their review and criticism: Tom Atkeson, Toni Edwards, George Henderson, Bob Muller, Eric Pluchino, and Bob Rutter of the Florida Department of Environmental Protection, and Alan Steinman of the South Florida Water Management District. We thank Nora Delosantos of the Florida Department of Environmental Protection for translation of the abstract into Spanish.

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Appendices available only upon request.

Introduction

This investigation into the nature of mercury contamination in estuarine gamefish was an approved FDEP Surface Water Ambient Monitoring Program Special Monitoring Project, executed in response to requests by research staff at the Everglades National Park. Activities were carried out with the support of the Governors Task Force on Mercury.

Two Florida estuarine areas were selected for comparison: northern Florida Bay and the Indian River Lagoon in St. Lucie and Martin Counties. The conditions in the Indian River and Florida Bay estuaries differ with respect to connection to areas containing mercury contaminated fish. Although previous data indicate that some species common in the Indian River may contain significant levels of mercury (Strom, 1989), the Indian River in Martin and St. Lucie counties receives minimal direct runoff and is well flushed through two major inlets. Conversely, Florida Bay is contiguous to areas of the Everglades known to contain fish with high levels of mercury (Lodge, 1994; Hand and Friedemann, 1990). The purpose of this report was to evaluate mercury in fish concentrations with respect to existing health advisory criteria and to test the null hypothesis that no difference exists between mercury levels in fish caught from different areas.

Indian River Lagoon

The Indian River Lagoon is an elongated estuarine waterbody separated from the Atlantic Ocean by barrier islands. Its estuarine character is maintained by connection to the Ocean through widely spaced inlets. Before the late 1800's, these inlets were often closed by shifting sand and the lagoon became predominately fresh water. When inlets re-opened the Indian River became brackish again. Since European-descended settlers began maintaining inlets, the lagoon has remained estuarine.

In pre-Columbian times, the watershed of the lagoon was narrow and well-defined. Since the 1900's the size of the drainage basin has been drastically increased by the construction of drainage systems. These canals lowered ground water, created arable lands and reduced flooding. The present-day watershed consists of 717 thousand acres (Woodward-Clyde, 1994c), most of which is developed for agricultural use.

Due to topography, most of the watershed drainage bypasses the Indian River, flowing out inlets to the ocean. The majority of the drainage from the St. Lucie River watershed enters the Indian River immediately opposite and exits the St. Lucie Inlet. The Jensen Beach and Stuart causeways located north of this juncture serve to limit mixing. The other major source of drainage entering the Lagoon is Taylor Creek (C-25) in Ft. Pierce. The mouth of Taylor Creek enters the Indian River nearly due west of the Ft. Pierce Inlet. Much of the Taylor Creek discharge flows out of the inlet, being confined on the north and south by the two U.S. Route A1A causeways in Ft. Pierce.

There are no major point-source discharges to this part of the lagoon. Therefore, direct point and non-point pollution sources are minimal. The quality of water and seagrass communities is generally good (Woodward-Clyde, 1994d; Woodward-Clyde, 1994e).

Florida Bay

Florida Bay is a large, mostly shallow basin straddling the southern tip of the Florida peninsula. Before massive drainage projects which commenced around 1900, Florida Bay received copious seasonal flows from the Everglades region. Florida Bay continues to receive drainage from the Everglades and South Florida albeit in reduced amounts. Watershed runoff enters the bay via surficial (streams, sloughs etc.) and sub-surface (groundwater) pathways. The Biscayne Aquifer underlying South Florida is highly porous (Davis and Ogden, 1994). Severe degradation of the Florida Bay ecosystem has been attributed to disruption of the natural water cycle (Lodge, 1994).

Artificial changes to the hydrology of South Florida began before the turn of the century. In 1948, the creation of the Central and Southern Florida Flood Control Project gave the U.S. Army Corps of Engineers responsibility for construction and oversight of water management throughout the Kissimmee-Okeechobee-Everglades Basin. Initial focus was on flood protection, drainage and water supply. The resultant widespread modifications of hydrology allowed a burgeoning population in Southeast Florida that presently exceeds 4 million (Science Subgroup, 1993). Southwestern peninsular Florida is by comparison largely undeveloped. Most of southwestern Florida is protected from development, being part of Everglades National Park.

For the purposes of this study, Florida Bay was arbitrarily divided into eastern and western sections. This division was based on the premise that upland drainage from the more extensively urbanized areas of Southeast Florida would more likely be impacted by pollution sources (Lodge, 1994). The C-111 canal and Taylor Slough discharge surficial waters directly into eastern Florida Bay.

Sampling Locations

Sample sites were assigned Storet station numbers. Location maps are presented in Figures 1 and 2, with keys to those maps presented in Tables 2 and 3, respectively.

Table 2

Key to Indian River Lagoon Station Locations (Figure 1)

Map ID	Storet Station	Location Description
1	27020448	S of Linkport (Harbor Branch) on W side of River
2	27020523	Starvation Cove near north shore
3	27020539	middle of Ft. Pierce turning basin
4	28010098	downstream C-23 spillway
5	28010110	W side of River under St. Lucie Nuke powerline
6	28010206	Bear Point cove
7	28010211	N of mouth of Little Mud Creek
8	28010241	W side of River at Martin/St.Lucie county line
9	28010242	Big Mud Crk at St.Lucie Nuke emergency intake
10	28010243	S end of Herman’s Bay at FPL tower
11	28010244	Cove S of Nettles Island
12	28010245	mangrove shoreline N of Holiday Out resort
13	28010246	W shore River opposite Nettles Island
14	28010247	E shore River W of fire station
15	28010248	1st mosquito culvert N or Jensen Beach Cswy
16	28010249	#5 marker, N side of Big Mud Creek
17	28010250	W shore River 1 mi S St. Lucie Nuclear powerline
18	28010251	Rocky Point cove on S side St. Lucie inlet
19	28010252	N side Big Mud Creek opposite St.Lucie Nuke
20	28010253	W shore of River under St.Lucie Nuke powerline
21	28010254	Bessie Cove
22	28010255	S of Sewall’s Point
23	28010256	near ruins of boathouse N of FIT campus
24	28010257	St. Lucie River near Martin Memorial hospital
25	28010269	off Fairwind Cove docks
26	28010270	Middle Cove
27	28010271	mouth of Hidden River at C-23 canal
28	28010272	Indian River at Eden
29	28010273	Indian River at Jensen Beach causeway
30	28010526	Queens Cove
31	28010796	Ft. Pierce inlet at Dynamite Point

Table 3.

Key to Florida Bay Station Locations **(Figure 2)**

Map ID	Storet Station	Location Description
1	28040001	Trout Creek
2	28040002	creek to Joe Bay
3	28040003	Boggies off Blackwater Sound
4	28040004	Long Pass btwn Little Blackwater and Long Sounds
5	28040005	McCormack Creek at Lake Monroe
6	28040006	creek on NE side of Long Sound
7	28040007	mouth of Glades Canal in Manatee Bay
8	28040008	Manatee Creek in Long Sound
9	28040009	inside Mud Creek off Alligator Bay
10	28040010	Lake 5 in Taylor River
11	28040011	Lake 1 in Taylor River
12	28040012	Little Madeira Bay slightly E of entrance channel
13	28040013	dredge hole W of Flamingo entrance channel
14	28040014	Flamingo entrance channel mouth
15	28040015	Snake Bight channel
16	28040016	SW side of Murray Key
17	28040017	shoal NE of marker #5 W of Flamingo
18	28040018	Tarpon Creek between Coot and Whitewater Bays
19	28040019	Slagle Ditch N of marker 5 W of Flamingo
20	28040020	Coot Bay N of Flamingo on Wilderness Waterway
21	28040021	near Cormorant Pass N of Whitewater Bay
22	28040022	off dock at East Cape Sable Park

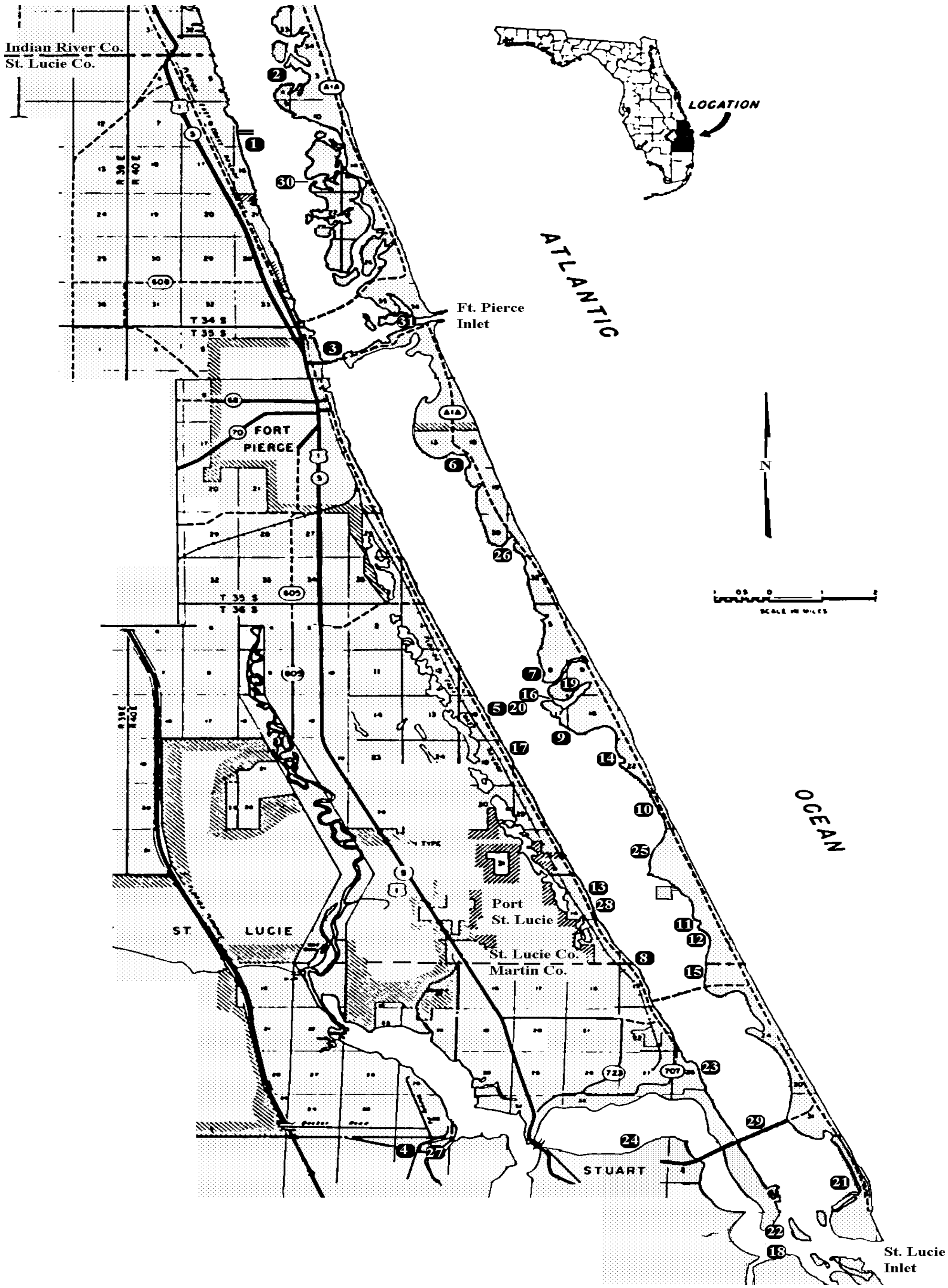


Figure 1. Indian River Lagoon Fish Collection Sites

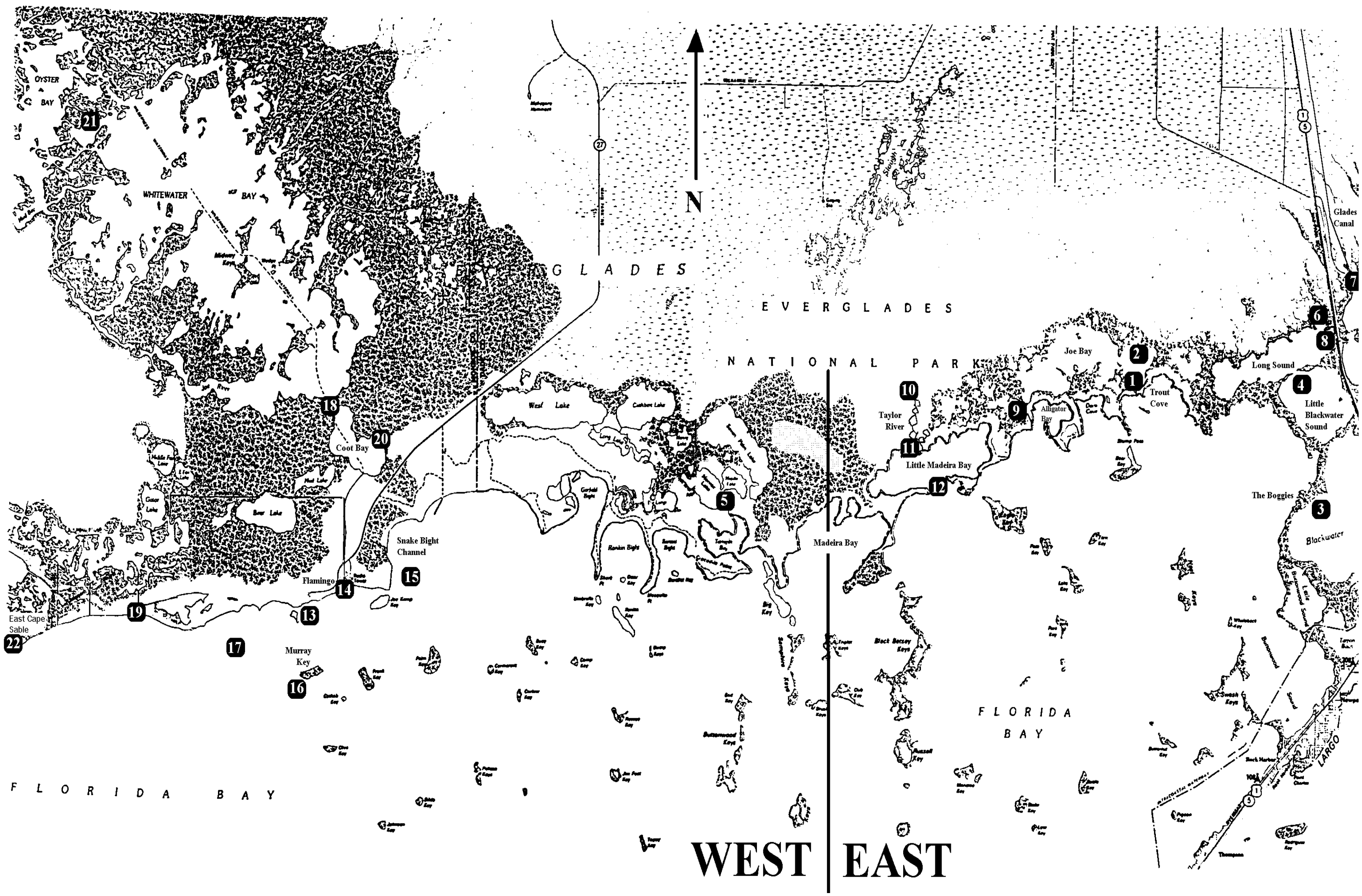


Figure 2. Florida Bay Fish Collection Sites

Methods

Fish were placed on ice immediately after collection and were processed within twelve hours of collection. Total length, standard length, sex, stage of gonad ripeness and weight were recorded (Nielson and Johnson, 1983). Unusual conditions and/or stomach contents were also noted. Specimens were filleted with a stainless steel knife on a polyethylene cutting board. The cutting board and knife were rinsed between fish. For fish less than two pounds the sample consisted of an entire filet; for larger fish an approximately eight ounce portion was removed from the front top part of the filet. The sample filet was rinsed with deionized water before being placed in a sixteen ounce Whirlpac® bag. Each tissue sample was assigned a unique log number.

The samples were maintained at 1? to 4? C. until delivered to an FDEP laboratory for analysis. All samples were analyzed by cold-vapor atomic absorption spectrophotometry utilizing standard procedures (FDEP, 1992). Samples collected from the Indian River in 1989 were analyzed at the Southeast District Laboratory in Port St. Lucie. Samples collected during 1993-94 were analyzed at the FDEP Central Laboratory in Tallahassee. To minimize contamination or loss during transport to the Central Laboratory, the labeled sample bags were placed together inside a sealed Ziploc® bag. This bag was then packed in ice inside a large plastic garbage bag which lined a shipping cooler. Upon delivery to the Central Lab, samples were frozen until analyzed.

Analysis of data was facilitated by Minitab® statistical software. The study area was divided into three geographical zones (Figures 1 and 2): the Indian River Lagoon and Eastern and Western Florida Bay. Where data from more than ten fish of one species were available from within a given geographical area, a normal logarithmic or square root data transformation was employed to approximate normality (Gilbert, 1987). Assumption of normality was accepted when $P > 0.10$ utilizing the Ryan-Joiner (similar to Shapiro-Wilk) W-test (Blackwood, 1995; Ryan and Joiner, 1976). Results of these analyses for normality are presented in Appendix B. For each set of species data so qualified, Minitab®'s cumulative normal distribution probability function was used to estimate the percentages of fish that may exceed health advisory criteria. Results are graphically presented in the form of pie charts. for differences between sets of single-species data collected from different geographical areas. In those incidences where significant differences were indicated by the t test, such differences were confirmed with the nonparametric Mann-Whitney U test. Where significant differences were detected, the range of difference between groups of data is given. This range is the 95% Mann-Whitney confidence interval, and is accompanied by the Mann-Whitney P value (Conover, 1971).

All fish collected were analyzed. No analytical data were discarded. Fish consumption advisory levels used in this report are presented in Table 1.

Table 1.

Mercury in Food Fish Consumption Alert Levels

Mercury in EdiblePortion of Fish mg/Kg wet weight	Consumption AdvisoryType	Acronym	Regulating Agency
0.5	Limited Consumption Advisory Level	LCA	Florida HRS
1.0	No Consumption Level	USNCA	USFDA
1.5	No Consumption Level	FNCA	Florida HRS

Results and Discussion

Raw data are presented in Appendix A. In the following tables, "N" refers to the number of fish analyzed in each group. Values presented are arithmetic means; the value in parentheses following each value is the standard deviation (where N>2).

Black Drum (*Pogonias cromis*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
Western Florida Bay	1	0.2	3629	49.5

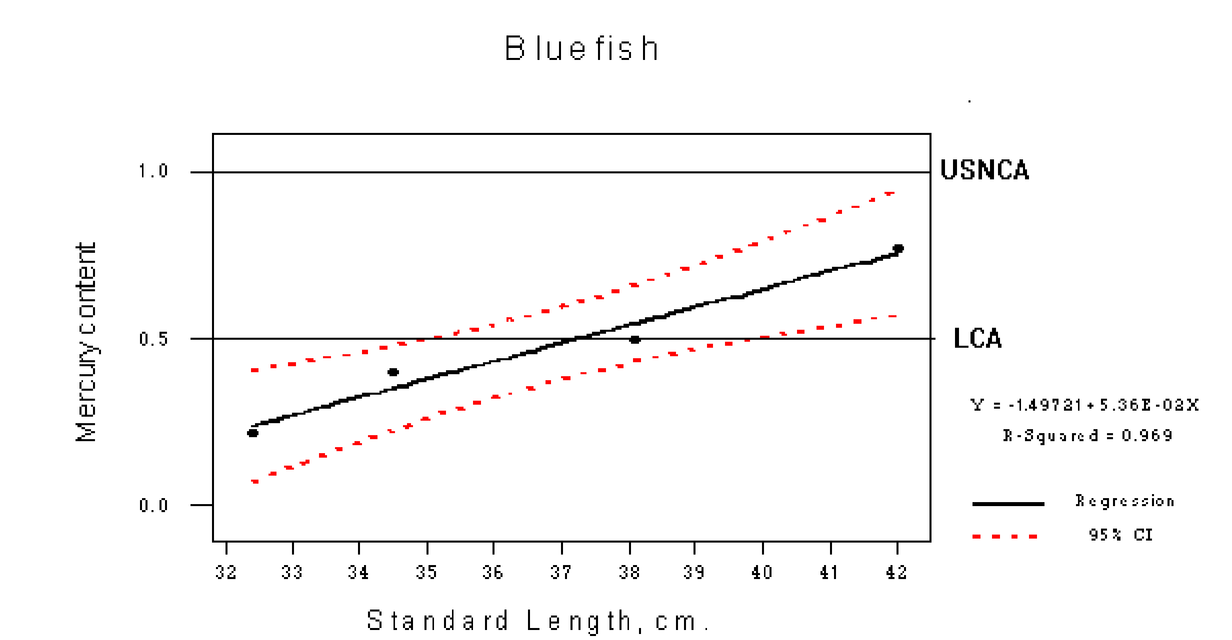
Blue Crab (*Callinictes sapidus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
Indian River	1	0.1	390	NA

Bluefish (*Pomatomus saltatrix*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	5	.514 (.220)	1180 (686)	38.4 (5.2)
Indian River	4	0.472 (0.230)	907 (365)	36.8 (4.2)
Western Florida Bay	1	0.68	2268	45

Figure 3. Mercury Content versus Standard Length for Indian River Bluefish.



Indian River bluefish showed a strong positive relationship between mercury content and standard length.

Common Snook (*Centropomus undecimalis*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	46	0.412 (0.160)	3752 (2535)	61 (12)
Indian River	37	0.396 (0.162)	4167 (2628)	64 (12)
Florida Bay All	9	0.478 (0.138)	2044 (991)	51 (8)
Eastern Fla. Bay	4	0.515 (0.158)	1725 (1058)	48 (9)
Western Fla. Bay	5	0.448 (0.131)	2298 (969)	54 (7)

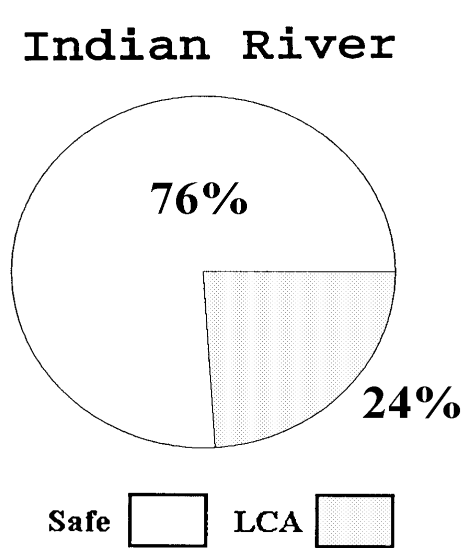


Figure 4. Estimate of mercury content distribution in Common Snook (square root transform).

Gafftopsail Catfish (*Bagre marinus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	6	0.582 (0.123)	990 (523)	35 (7)
Indian River	4	0.588 (0.157)	1295 (288)	39 (3)
Western Fla. Bay	2	0.570 (0.042)	382 (83)	28 (2)

The few gafftopsail catfish collected averaged over the LCA. A previous study documented levels of mercury exceeding the LCA in gafftopsail catfish in southeast Florida estuarine waters (Brim et al., 1993).

Gray Snapper (*Lutjanus griseus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	95	0.242 (0.147)	374 (163)	23.5 (3.4)
Indian River	33	0.205 (0.065)	440 (242)	26.7 (4.6)
Florida Bay All	62	0.261 (0.160)	339 (80.3)	22.5 (2)
Eastern Fla. Bay	36	0.353 (0.129)	372 (79.1)	23.3 (2)
Western Fla. Bay	26	0.134 (0.1)	293 (56.6)	21.4 (1.5)

Snapper from eastern Florida Bay contained 0.08 - 0.19 mg/Kg more mercury ($P<0.0001$) than those from the Indian River. There was no difference between the weight of fish from eastern Florida Bay and the Indian River, although the length of fish from the latter were 1 - 5 cm longer ($P=0.0015$).

Similarly, eastern Florida Bay snapper contained 0.16 - 0.26 mg/Kg more mercury ($P<0.0001$) than those from western Florida Bay. However, snapper from eastern Florida Bay were larger. Gray snapper caught in western Florida Bay were from 1 to 3 cm (0.4 - 1.2 in) shorter ($P=0.0005$) and weighed from 43 to 122 grams (0.1 - 0.3 lb) less ($P=0.0002$) than those obtained from eastern Florida Bay.

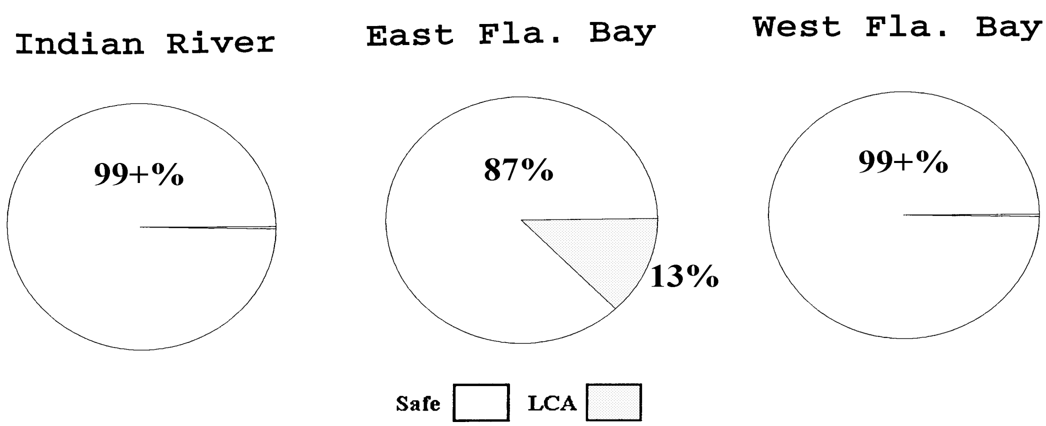


Figure 5. Estimate of mercury content distribution in Gray Snapper by geographical area (natural log transform).

Jack Crevalle (*Caranx hippos*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	46	0.718 (0.563)	1251 (2150)	32.2 (13)
Indian River	22	0.734 (0.625)	2056 (2917)	39.7 (15.7)
Florida Bay All	24	0.702 (0.512)	509 (266)	26 (5)
Eastern Fla. Bay	11	1.065 (0.554)	332 (108)	22.7 (3)
Western Fla. Bay	13	0.395 (0.154)	659 (270)	28.8 (4.7)

Jacks from eastern Florida Bay weighed 159 - 1337 gm (0.4 - 2.9 lb) less (P=0.0001) and were 5 - 22 cm (2 - 9 in) shorter (P=0.0003) than those from the Indian River. Despite this size difference, jacks from eastern Florida Bay contained 0.04 - 0.81 mg/Kg more mercury (at ?=0.1, P=0.0756) than those from the Indian River.

Jack crevalle caught in western Florida Bay were 139 - 516 grams (0.3 - 1.1 lb) heavier (P=0.0028) and from 3 - 10 cm (1 - 4 in) longer (P=0.0028) than those from eastern Florida Bay. Although smaller, jacks from eastern Florida Bay contained 0.19 - 1.03 mg/Kg more mercury (P=0.0045) than those from western Florida Bay.

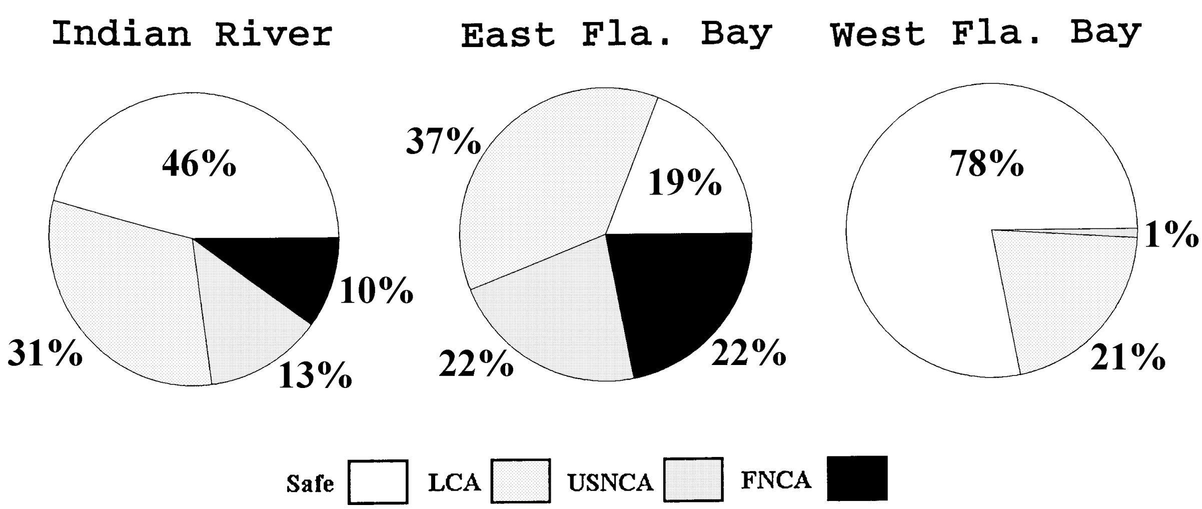
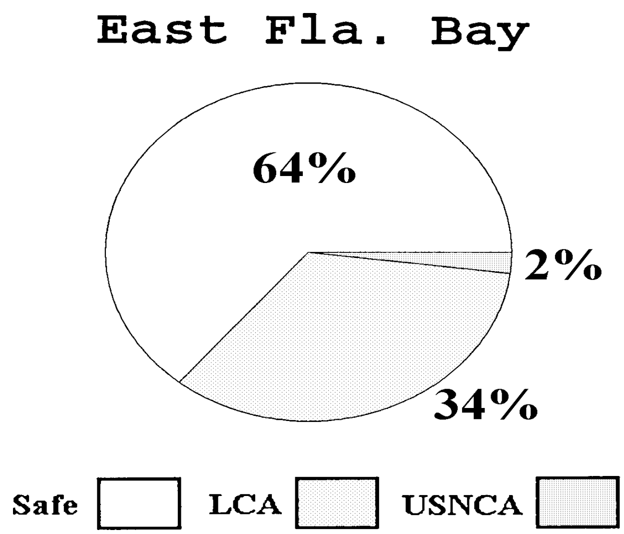


Figure 6. Estimate of mercury content distributio in Jack Crevalle by geographical area (natural log transform).

Mayan Cichlid (*Cichlasoma urophthalmus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
Eastern Fla. Bay	18	0.444 (0.234)	103 (46.5)	13.3 (2.13)

Mayan cichlids were obtained exclusively from the Taylor River chain of lakes located in eastern Florida Bay.



Pompano (*Trachinotus carolinus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
Indian River	2	0.09 (0.02)	719 (518)	28 (7.1)

Redfish (*Scianops ocellatus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	15	0.23 (0.1)	1598 (709)	42.0 (4.1)
Indian River	9	0.21 (0.11)	1646 (917)	41.6 (5.3)
Florida Bay All	6	0.262 (0.079)	1527 (231)	42.6 (1.8)
Eastern Fla. Bay	4	0.303 (0.056)	1514 (271)	42.1 (2.0)
Western Fla. Bay	2	0.18 (0.042)	1553 (208)	43.5 (1.4)

All redfish collected were relatively low in mercury. Redfish from the Indian River appeared to show a relationship between weight of fish and mercury content, as per the following regression equation:

mg-Hg/Kg = 0.0361 + 0.000105 gm

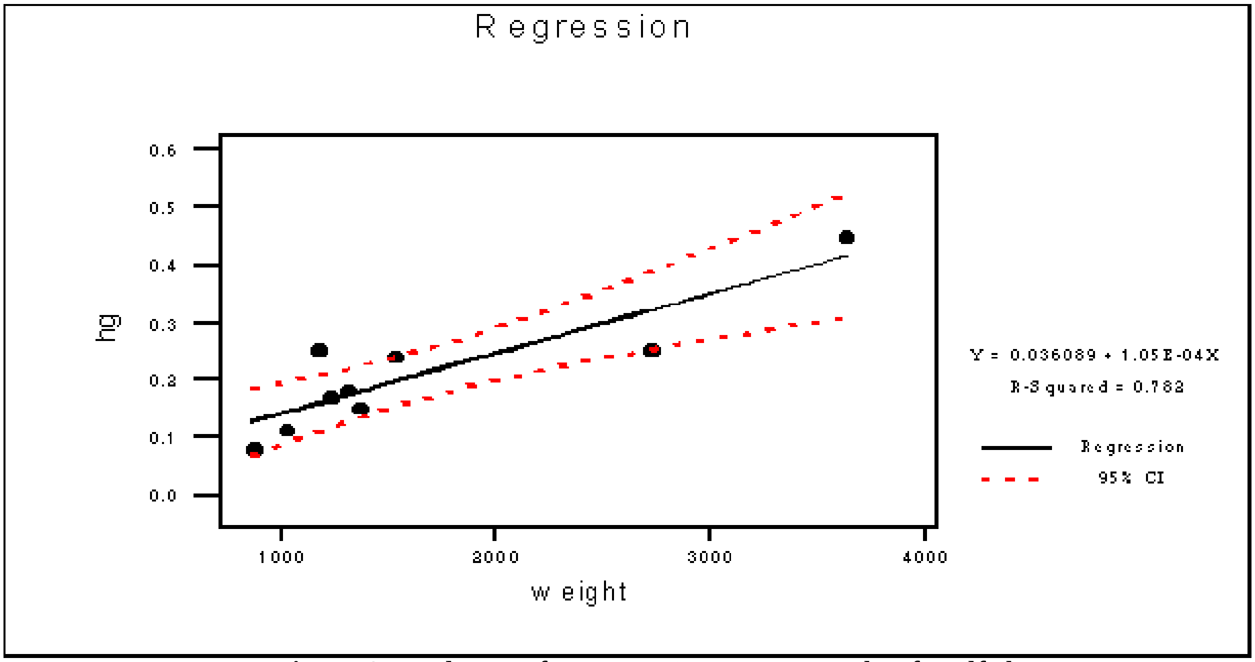


Figure 8. Relation of Mercury Content to Weight of Redfish

Sheepshead (*Archosargus probatocephalus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	21	0.2 (0.094)	646 (311)	23.8 (3.4)
Indian River	19	0.2 (0.091)	669 (312)	23.9 (3.2)
Western Fla. Bay	2	0.23 (0.16)	427 (295)	22.3 (6)

All sheepshead collected were relatively low in mercury.

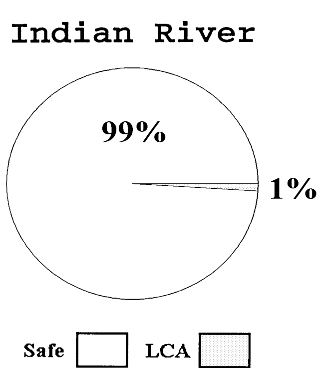


Figure 9. Estimate of mercury content distribution in Sheepshead (natural log transform).

Southern Flounder (*Paralichthys lethostigma*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	13	0.23 (0.13)	741 (662)	32.5 (7.4)
Indian River	12	0.234 (0.13)	780 (675)	33.5 (7)
Wstrn Florida Bay	1	0.16	265	22.5

All flounder collected were relatively low in mercury.

Spadefish (*Chaetodipterus faber*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
Indian River	1	0.22	1150	28.6

Spotted Seatrout (*Cynoscion nebulosus*)

Location	N	mg-Hg/Kg	Weight gm	Length std cm
All	96	0.663 (0.375)	888 (598)	36.3 (8.6)
Indian River	28	0.443 (0.167)	1265 (671)	43.4 (8)
Florida Bay All	68	0.754 (0.4)	733 (491)	34 (7.5)
Eastern Fla. Bay	51	0.921 (0.302)	826 (512)	35.5 (7.3)
Western Fla. Bay	17	0.254 (0.161)	451 (278)	29.4 (6)

Trout caught in the Indian River were from 92 - 806 gm (0.2 - 1.8 lb) heavier ($P=0.0094$) and from 3.5 to 12.5 cm (1 - 5 in) longer ($P=0.0005$) than those from eastern Florida Bay. Although smaller, spotted seatrout collected in eastern Florida Bay contained 0.35 -0.54 mg/Kg more mercury ($P<0.0001$) than those from the Indian River Lagoon.

Western Florida Bay trout weighed from 89 - 496 gm (0.2 - 1.1 lb) less ($P=0.0023$) and were from 2 to 10 cm (0.8 - 3.9 in) shorter ($P=0.0044$) than those caught in eastern Florida Bay. Spotted seatrout collected in western Florida Bay contained on average from 0.54 - 0.73 mg/Kg less mercury ($P<0.0001$) than those caught in eastern Florida Bay.

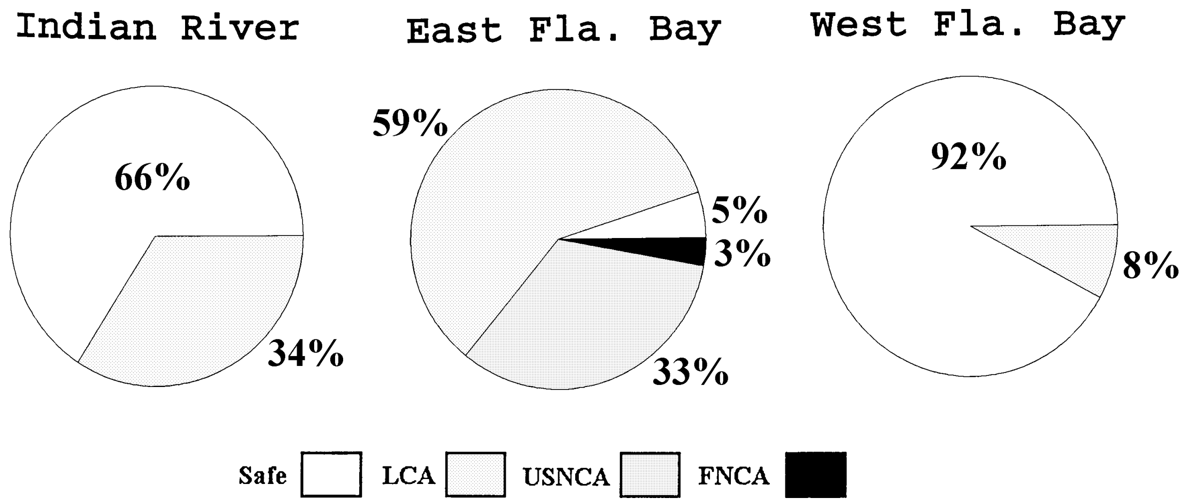


Figure 10. Estimate of mercury content distribution in Spotted Seatrout by geographical area (square root transform).

General Discussion

The mean mercury concentration for select fishes collected from each geographical zone are given in Figure 12. Where available, the mean mercury content of fish from eastern Florida Bay are higher than those for the Indian River or western Florida Bay. This difference is significant (at ?=0.05) for gray snapper, jack crevalle and spotted seatrout.

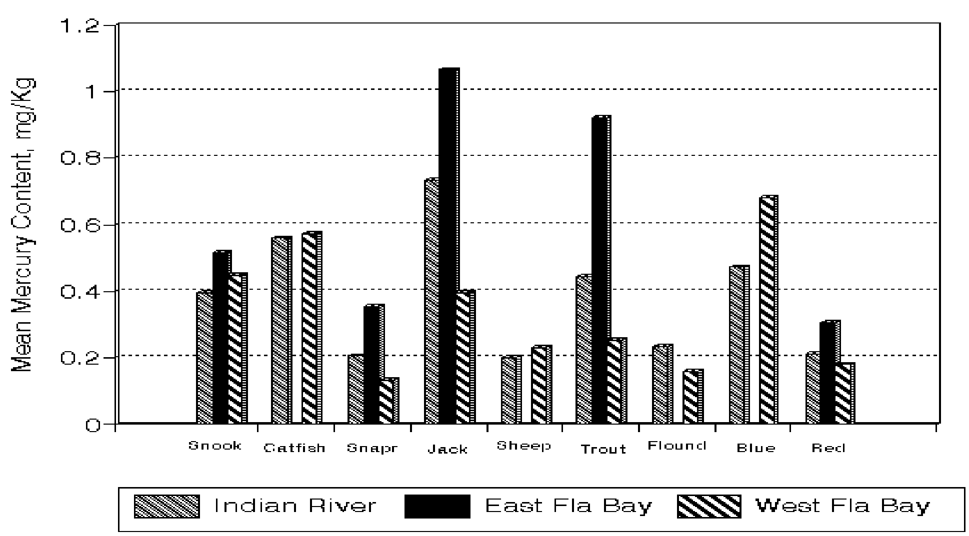


Figure 11. Comparison of Mean Mercury Content of Select Fish Species.

For comparison purposes, the number and percentage of fish from each geographical area that exceeded the relevant health advisory limits is presented in Table 4. This table should not be construed as being proportional to actual fish populations within each area. Be aware that different numbers of fish, different species, sizes of fish and total number of fish per area were collected. Nevertheless, it is clear that a greater fraction of fish collected from Eastern Florida Bay exceed advisory limits than the other areas.

Table 4
Comparison of Exceedances by Geographical Area*

Location	N	n > LCA	n > USNCA	n > FNCA
Indian River	172	39 (23%)	4 (2%)	2 (1%)
East Florida Bay	125	70 (56%)	22 (18%)	6 (5%)
West Florida Bay	70	8 (11%)	0	0

***Note:** This table reflects sampling effort. It does not represent actual mercury content of the total population of fish from a geographical area.

Conclusions

Jack crevalle from all areas and spotted seatrout from eastern Florida Bay were found (on average) to contain high levels of mercury. Based on fewer samples, bluefish and gafftopsail catfish appeared to have elevated mercury levels. Mercury levels for snook and Mayan cichlid were moderate. Levels in redfish, sheepshead, southern flounder and gray snapper (except in Florida Bay, where levels in snapper were moderate) were low. Relative mercury levels could not be determined for black drum, blue crab, pompano or spadefish since few samples were analyzed. Mercury levels in bluefish and redfish appeared to be related to the size of the fish collected, although this relationship was based on few samples. Mayan cichlids (collected exclusively from eastern Florida Bay) contained high concentrations of mercury considering their small size.

With the exception of jack crevalle and gafftopsail catfish, mercury in fish from the Indian River averaged less than the Florida Limited Consumption Advisory.Fish from eastern Florida Bay contained more mercury than the same species from other areas. Jack Crevalle, gray snapper and spotted seatrout from eastern Florida Bay contained significantly more mercury than those collected from either the Indian River or western Florida Bay.

Recommendations

1. Florida Department of Health and Rehabilitative Services should evaluate the consumption advisory status for several estuarine fish, especially spotted seatrout in eastern Florida Bay and jack crevalle in all areas.

2. Efforts by FDEP to determine spatial distribution of mercury in estuarine fish in Florida should be continued.

3. Efforts to define the underlying cause for the observed high levels of mercury in eastern Florida Bay should be continued.

4. Determine the underlying cause(s) for the observed high levels of mercury in eastern Florida Bay. The relationship between the area of elevated mercury in fish in eastern Florida Bay and nearby pollution sources should be elucidated.

5. Perform research to determine the causes behind inter-species variation in mercury concentration.

List of Acronyms

FDEP	Florida Department of Environmental Protection (formerly FDER)
FDER	Florida Department of Environmental Regulation (now FDEP)
FGFWFC	Florida Game and Freshwater Fish Commission
FLNCA	No consumption advisory level issued by State of Florida
HRS	Florida Department of Health and Rehabilitative Services
LCA	Limited Consumption Advisory level
SFWMD	South Florida Water Management District
USEPA	United States Environmental Protection Agency
USFDA	United States Food and Drug Administration
USFWS	United States Fish and Wildlife Service
USNCA	No consumption advisory level issued by USFDA

Glossary of Technical Terms

α	100(1-?)% is the confidence level for acceptance or rejection of hypotheses
mg/Kg	milligram per kilogram wet weight
P	probability that the observations are not statistically different
regression	mathematical process to evaluate the location of points to determine a straight line that best represents those points
ripe	fish reproductive organ appeared ready to release eggs/sperm
stage	term relating to reproductive status of either ‘ripe’ or ‘unripe’
standard length	length of fish measured from tip of jaw to the posterior end of the hypural bone
total length	length of fish measured from the tip of the nose to the tip of the longest caudal fin array
unripe	fish did not appear ready for mating

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