Sediment Contamination Survey on St. Marks National Wildlife Refuge.

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ABSTRACT

A survey was conducted by the U.S. Fish and Wildlife Service to assess habitat quality on the St. Marks National Wildlife Refuge (NWR). Sediment samples were collected at 32 sites within (n=14) or adjacent (n=18) to the NWR. The survey showed only site- and use-specific contamination. Much of the area surveyed possessed little or no contaminant residues. Sediment composition (% sand/silt/clay and total organic carbon) around St. Marks NWR was comparable to coastal areas of the northeastern Gulf of Mexico. Metal contamination of sediments was not found on the refuge, but was found at 6 off-refuge sites and included moderate concentrations of copper and mercury. Polycyclic aromatic hydrocarbon (PAH) contamination was also not found on the refuge; however, off-refuge PAH contamination was slightly more widespread than metal contamination being found at 9 off-refuge sites. No organochlorine contamination was detected in samples taken on or off-refuge. Sixteen sites, including both on and off-refuge sites, were found to have relatively high concentrations of aliphatic hydrocarbons. Oil and grease contamination was found at 11 sites total, but only 1 site on the NWR. The survey objective was to provide baseline information from which to determine the need for additional monitoring and for use in developing management strategies.

KEYWORDS: St. Marks National Wildlife Refuge, sediment, contamination, copper, mercury, PAH.

Preface

This report was written primarily for scientific and management purposes. An attempt has been made to present the data in a form that is readily usable by managers who have not had formal training in ecotoxicology. The primary objective of the authors has been to make a positive contribution to the management of St. Marks National Wildlife Refuge and the coastal systems of the Gulf of Mexico.

Acknowledgments

Many people played important roles in the completion of this project. To all of them, we are most grateful. In particular we thank: Pledger Moon, Wayne Isphording, Joe White, James Burnett, Joe Reinman, and Peter Tuttle for their assistance, support and/or peer review of this document.

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INTRODUCTION

The St. Marks National Wildlife Refuge (NWR) was established in 1931 to provide wintering grounds for migratory bird species. The refuge encompasses nearly 68,000 acres of upland habitat in Jefferson, Wakulla, and Taylor counties, as well as 32,000 aquatic habitat acres in Apalachee Bay (Figure 1). St. Marks NWR is one of the oldest in the National Wildlife Refuge System. In addition to providing habitat for migratory birds, St. Marks is home to diverse plant and animal communities and Federal and State listed Threatened and Endangered plants and animals. St. Marks NWR inhabitants include southern bald eagle (*Haliaeetus leucocephalus*), red-cockaded woodpecker (*Picoides borealis*), least tern (*Sterna antillarum*), woodstork (*Mycteria americana*), American alligator (*Alligator mississippiensis*), eastern indigo snake (*Drymarchon corais couperi*), swallow-tailed kite (*Elanoides forficatus*), peregrine falcon (*Falco peregrinus tundrius*) and Florida black bear (*Ursus americanus floridanus*). The overall refuge goals include: providing winter habitat for migratory birds and waterfowl, habitat for endangered species, and habitat for all of its resident wildlife.

Managing habitat quality on St. Marks NWR is essential to the mission of the U.S. Fish and Wildlife Service (Service) and the goals of the refuge. Through management designed to promote ecological integrity, the Service strives to protect the fish, wildlife and habitat entrusted to it. For this reason, habitat quality surveys are conducted to report the status of these systems. This report describes a general sediment quality survey conducted in 1988 to reveal environmental contamination of the aquatic systems of St. Marks NWR. To this end, the Service collected 32 sediment samples on (n=14) and north (n=18) of St. Marks NWR and had them analyzed for metal, hydrocarbon, and organochlorine environmental contaminants. This survey was intended to elucidate the contamination status of the St. Marks NWR for the purpose of providing managers the information needed to contend with issues challenging habitat quality. Secondarily, the gathered data was intended to be used as baseline for future evaluations and assessments of St. Marks NWR system health.

Habitat quality of aquatic systems has been evaluated via surveys of sediment contamination (O'Connor, 1991; US NOAA, 1991; Bolton *et al.* , 1985). The challenge lies in the interpretation of ecological risk posed by sediment contamination (Long *et al.*, 1995). Many have provided numeric criteria based on reported effects of exposure as a means to estimate relative risk to living organisms (Buchman, 1999; Long *et al.*, 1995; MacDonald, 1993; Persaud, 1992; Di Toro *et al.*, 1991; Long and Morgan, 1990; US EPA, 1989).

The results of this survey were compared to the findings of Long *et al.* (1995) to estimate risk to living resources from exposure to contaminated sediments, and to assess overall aquatic ecosystem health on the St. Marks NWR. Long et al. (1995) developed Effects Range Low (ERL) and Effects Range Median (ERM) criteria for evaluating sediment contamination. Sediment contaminant concentrations exceeding the criterion ERL indicated that adverse negative effects on living resources may increase in incidence from rare to occasional. Sediment contaminant concentrations exceeding the ERM may indicate adverse effects will occur frequently.

FIGURE 1: St. Marks National Wildlife Refuge (outlined in red) on nearly 68,000 upland acres in Jefferson, Wakulla, and Taylor Counties, as well as 32,000 aquatic acres of Apalachee Bay.

MATERIALS AND METHODS

The Service adheres to standard operating procedures (SOP) to assure the quality of data that may ultimately be published as a Service report. However, during a general survey investigation, every field action is not recorded. Instead, the Service relies on instrument operation manuals, SOPs and other guidance, including State and Federal regulations, to govern its actions in the field.

Sediment sampling was chosen to evaluate habitat quality on St. Marks NWR because of the tendency of many environmental contaminants to accumulate in sediments, thus providing an established route of entry into system food webs.

Standard operating procedures for field collection of sediment samples (PCFO-EC SOP 004) are provided in Appendix A. Table 1 contains site-specific information. Thirty-two sediment samples were collected at various sites from waters on (n=14) and north (n=18) of St. Marks NWR (Figure 2). Sites 1- to 14 were collected on St. Mark NWR and sites 15-32 were collected in the more industrialized area of St. Marks River north of the NWR. The industrial area of St. Marks River hosts many stakeholders (Table 2). Sediment samples were composite 1-liter samples consisting of five 200 ml subsamples. Samples were collected using a standard ponar 316 stainless steel grab for all samples except those in water too shallow for the contaminant survey boat. Samples not taken with the standard ponar were taken with a petite ponar stainless steel grab.

Depth of sediment samples collected depended on the ponar used and type of sediment at each station (maximum depth in silt ~10 cm). Samples collected in the field were immediately put into laboratory-certified, chemically-cleaned, 1-liter amber glass jars with Teflon-lined lids and placed on ice in coolers. Samples were temporarily stored at the Panama City Field Office (PCFO) in freezers at -23^{o} C until shipment to analytical laboratories. Sediment samples were analyzed for metal, hydrocarbon (aliphatic and aromatic), and organochlorine chemical contaminants by the Geochemical and Environmental Research Group at Texas A&M University. Analytical procedures performed at the lab are further described in Appendix B. A complete list of analytes is provided in Table 3. Additional samples were analyzed for particle size and total organic carbon (TOC).

Data were compared to the Effects Range Low (ERL) and Effects Range Median (ERM) criteria of Long *et al.* (1995) to estimate risk to living resources from exposure to contaminated sediments and to assess the overall ecosystem health of the St. Marks NWR.

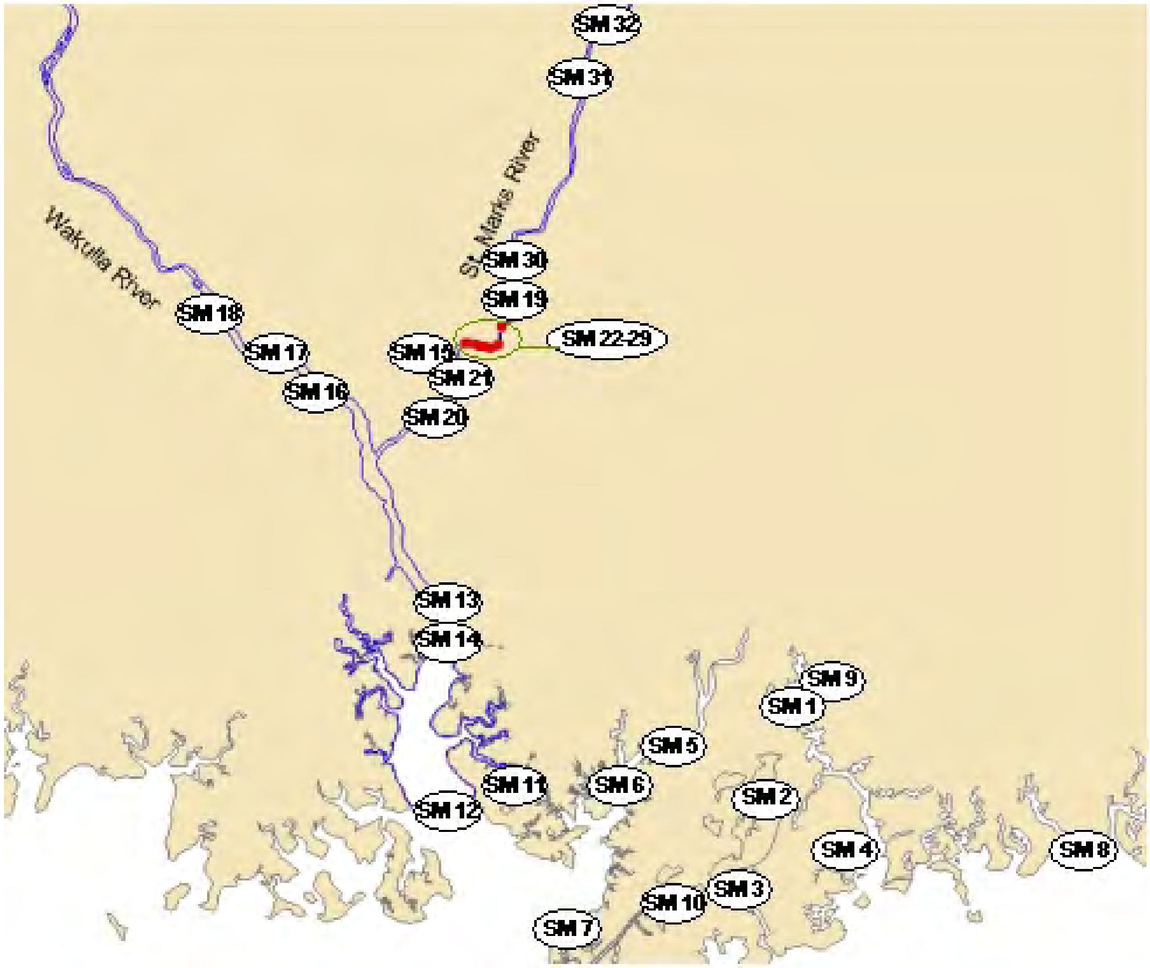

FIGURE 2: Sampling locations for the 1988 sediment quality survey on St. Marks National Wildlife Refuge.

Table 1: Sample information for sediment samples taken by the U.S. Fish and Wildlife Service on St. Marks National Wildlife Refuge in 1988: sample identification, sampling location description, latitude and longitude (degrees, minutes, hundredths of minute).

Sample ID	Location	Latitude	Longitude
SM1	East River Pool	30˚12.20	84˚08.50
SM2	Mounds Pond #1	30˚10.17	84˚09.10
SM3	Tower Pond	30˚08.83	84˚09.01
SM4	Mounds Pond #3	30˚09.75	84˚08.30
SM5	East River	30˚10.87	84˚09.82
SM6	East River below Denham	30˚10.48	84˚10.10
SM7	Boat Basin at lighthouse	30˚08.42	84˚10.42
SM8	Stony Bayou #2	30˚11.33	84˚07.10
SM9	Stony Bayou #1	30˚12.17	84˚08.30
SM10	Picnic Pond	30˚05.22	84˚09.80
SM11	St. Marks River at Buoy 27E	30˚06.25	84˚11.32
SM12	St. Marks River at Buoy 27W	30˚06.18	84˚11.55
SM13	St. Marks River at Buoy 42E	30˚07.63	84˚11.81
SM14	St. Marks River at Oliver Bayou	30˚07.63	84˚11.81
SM15	Big Boggy Bayou	30˚10.30	84˚13.06
SM16	Wakulla River below SMYC*	30˚09.59	84˚12.38

*St. Marks Yacht Club.

Table 1 (continued): Sample information for sediment samples taken by the U.S. Fish and Wildlife Service on St. Marks National Wildlife Refuge in 1988: sample identification, sampling location description, latitude and longitude (degrees, minutes, hundredths of minute).

Sample ID	Location	Latitude	Longitude
SM17	Wakulla River at Shell Island	30˚09.83	84˚12.67
SM18	Wakulla River 2 miles from mouth	30˚10.43	84˚13.74
SM19	St. Marks River above power plant	30˚10.30	84˚11.09
SM20	St. Marks River at East Side	30˚09.49	84˚12.10
SM21	St. Marks River at fuel docks	30˚09.60	84˚11.97
SM22	St. Marks River at Canal Marina	30˚09.74	84˚11.69
SM23	St. Marks River at turning basin S	30˚09.68	84˚11.61
SM24	St. Marks River at marina	30˚09.73	84˚11.60
SM25	St. Marks River at turning basin N	30˚09.72	84˚11.57
SM26	St. Marks River at new marina N	30˚09.82	84˚11.63
SM27	St. Marks River at fuel loading	30˚09.95	84˚11.58
SM28	Power Plant at discharge	30˚10.02	84˚11.60
SM29	Power Plant at fuel load	30˚10.10	84˚11.53
SM30	Power Plant at intake	30˚10.25	84˚11.58
SM31	St. Marks River below Newport Bridge	30˚12.19	84˚10.38
SM32	St. Marks River above Newport Bridge	30˚12.53	84˚10.25

Table 2: Previous and current industrial interests on St. Marks River north of the St. Marks National Wildlife Refuge in the vicinity of sampling sites 15-32: name of industry and National Pollution Discharge Elimination System (NPDES) permit number.

Industry	NPDES Permit Number
McKenzie Service Co.	FL0042161
St. Marks Refinery, Inc.	FL0035220
Tenneco Oil Company	FL0035581
Sam O. Purdom Generating Station/ City of Tallahassee	FL0025526
Wastewater Treatment Facility/City of St. Marks	FL0040835
Murphy Oil Company	FL0032433
St. Marks Powder, Inc./Olin Corporation	FL0002518

Table 3: Chemical analytes measured in sediment samples taken on St. Marks National Wildlife Refuge, 1988.

Metals	Polycyclic Aromatic Hydrocarbons	Aliphatic Hydrocarbons	Organochlorines and Pesticides
*Silver	*Napthalene	n Dodecane	Hexachlorobenzene
Aluminum	*Fluorene	n Tridecane	a, b, g and d-BHC
*Arsenic	*Phenanthrene	n Tetradecane	Oxychlordane
Boron	*Anthracene	Cyclohexane	Heptachlor
Barium	*Fluoranthrene	Pentadecane	a, g-Chlordane
Beryllium	*Pyrene	Cyclohexane	t-Nonachlor
*Cadmium	*Benz(a)anthracene	n Hexadecane	Toxaphene
*Chromium	*Chrysene	n Heptadecane	*Total PCBs
*Copper	Benzo(b)fluoranthrene	Pristane	*DDT analytes
Iron	Benzo(k)fluoranthrene	n Octadecane	Dieldrin
*Mercury	Benzo(e)pyrene	Phytane	Endrin
Magnesium	*Benzo(a)pyrene	n Nonadecane	cis-Nonachlor
Manganese	Dibenzo(a,h)anthracene	n ecosane	Mirex
Molybdenum	Benzo(g,h,i)perylene	Total AHs	Dicofol
*Nickel	*Total PAHs		Dicamba
*Lead			Dichloprop
Selenium			Silvex
Strontium			2,4-D
Thallium			2,4,5-T
Vanadium			2,4-DB
*Zinc			Pentachlorophenol

* Sediment Quality Guidelines available from Long et al. 1995.

RESULTS

Distribution of sediment composition profiles is provided in Figure 3. The distribution of percent total organic carbon (TOC) across sampling stations is presented in Figure 4. All sediment composition data, including total sample weight and percent moisture, are provided in Appendix B.

Potential problem areas were determined using the numerical, effects-based sediment quality guidelines of Long *et al.* (1995, Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments). Assignment of possible risk levels from exposure to metals (Figure 5), polycyclic aromatic hydrocarbons (PAHs, Figure 6), or organochlorines (Figure 7) were based on these numeric sediment quality guidelines. A given analyte exceeding the guidelines indicated that the sediment concentration was occasionally or frequently associated with adverse effects on living resources. Although many chemical analytes are reviewed in the Long *et al.* publication, additional measured analytes do not have associated sediment criteria (Table 3). Therefore, complete tables of the analytical results are presented in the appendices (metals, Appendix C; PAHs, Appendix D; organochlorines, Appendix E).

For each of the above analyses, tables are provided to show specific analytes that may constitute a problem in given areas. The areas of possible concern are further described by site, analyte, concentration, effects range low (ERL), and effects range median (ERM). Sediment concentrations equal to or exceeding the criteria provided in the Long *et al.* (1995) publication indicate occasional (ERL) or frequent (ERM) association with adverse effects on living resources. Tables containing ERL and ERM guidelines are presented for metals (Table 4), polycyclic aromatic hydrocarbons (Table 5), and organochlorines (Table 6).

Areas with relatively high concentrations of aliphatic hydrocarbons (Figure 8) or oil and grease (Figure 9) were divided into groups possibly needing further investigation, but not necessarily indicating risk from exposure. Risk assessment for these contaminant categories was omitted because there are no sediment criteria currently available for these classes of chemicals. Areas recommended for further evaluation were based on sediment concentrations that were high relative to other sites in the survey. Tables summarizing these sites are shown for sediment aliphatic hydrocarbons (Table 7) and oil and grease (Table 8). Full analytical results for aliphatic hydrocarbons and oil and grease are presented in Appendix F.

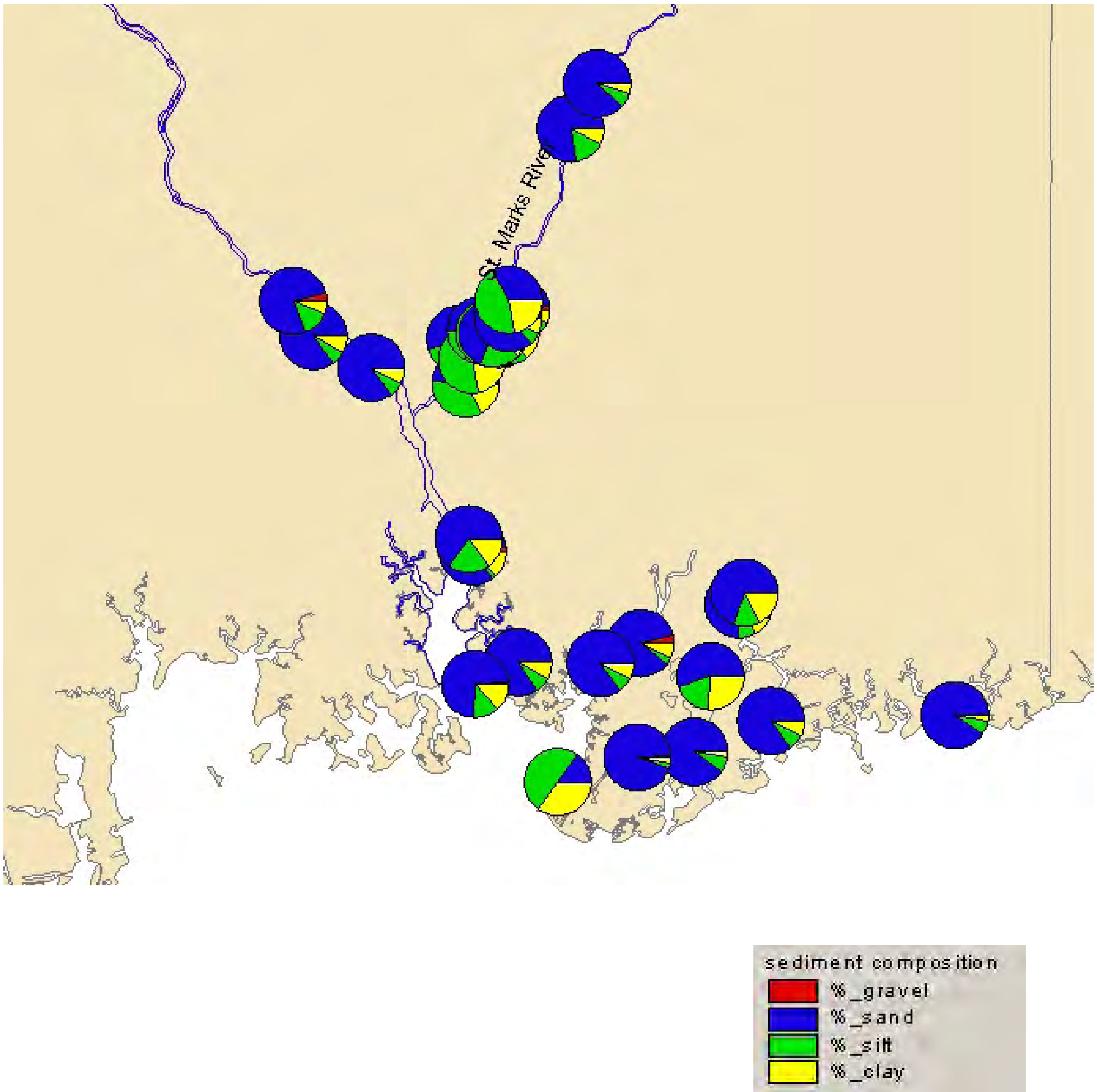

Figure 3: Sediment composition distribution for sediment samples taken on St. Marks National Wildlife Refuge, 1988.

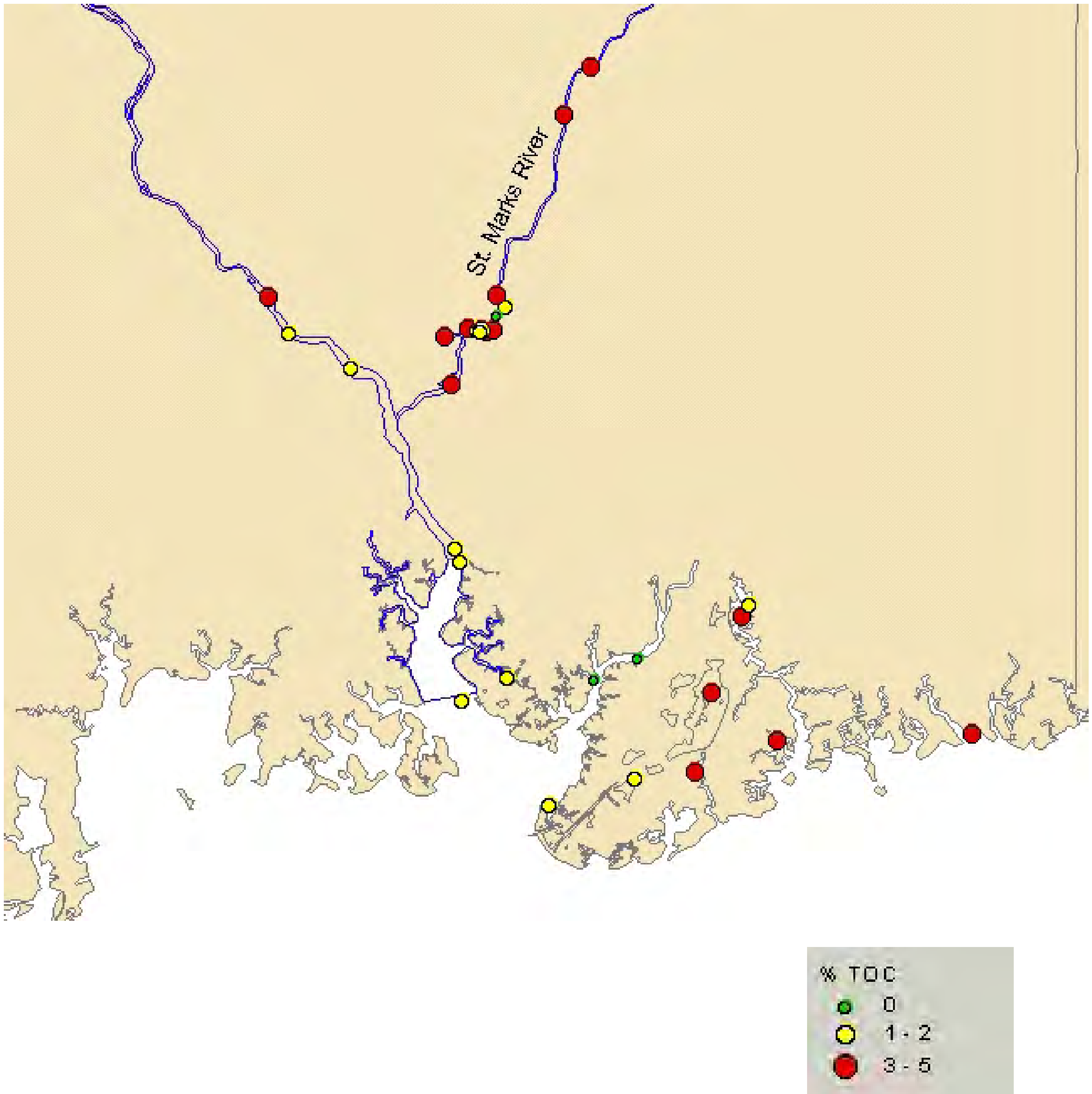

Figure 4: Total organic carbon (TOC) for sediment samples taken on St. Marks National Wildlife Refuge, 1988.

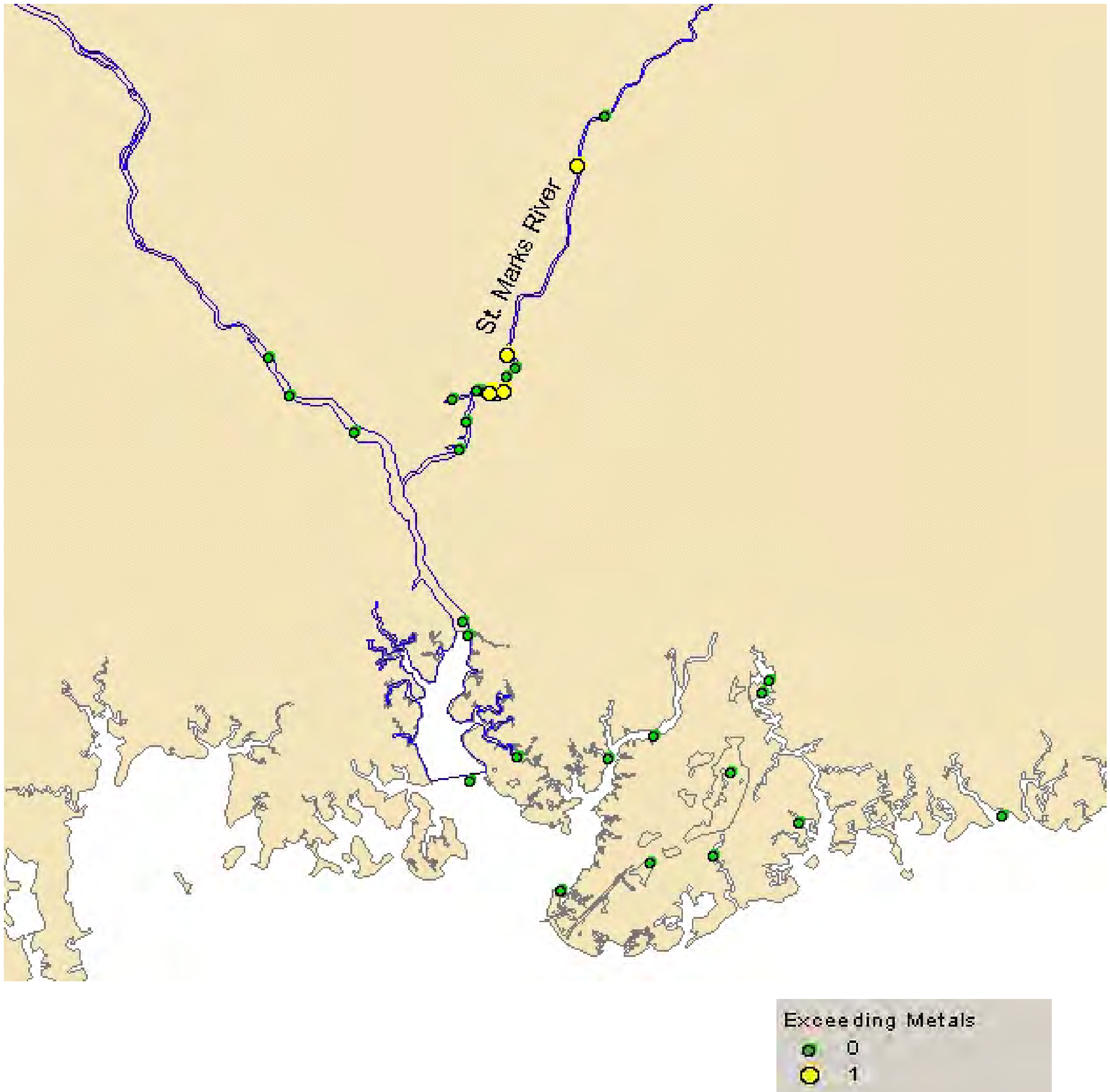

Figure 5: Number of metal analytes in sediment samples taken on St. Marks National Wildlife Refuge, 1988, exceeding Long *et al.* (1995) sediment quality guidelines.

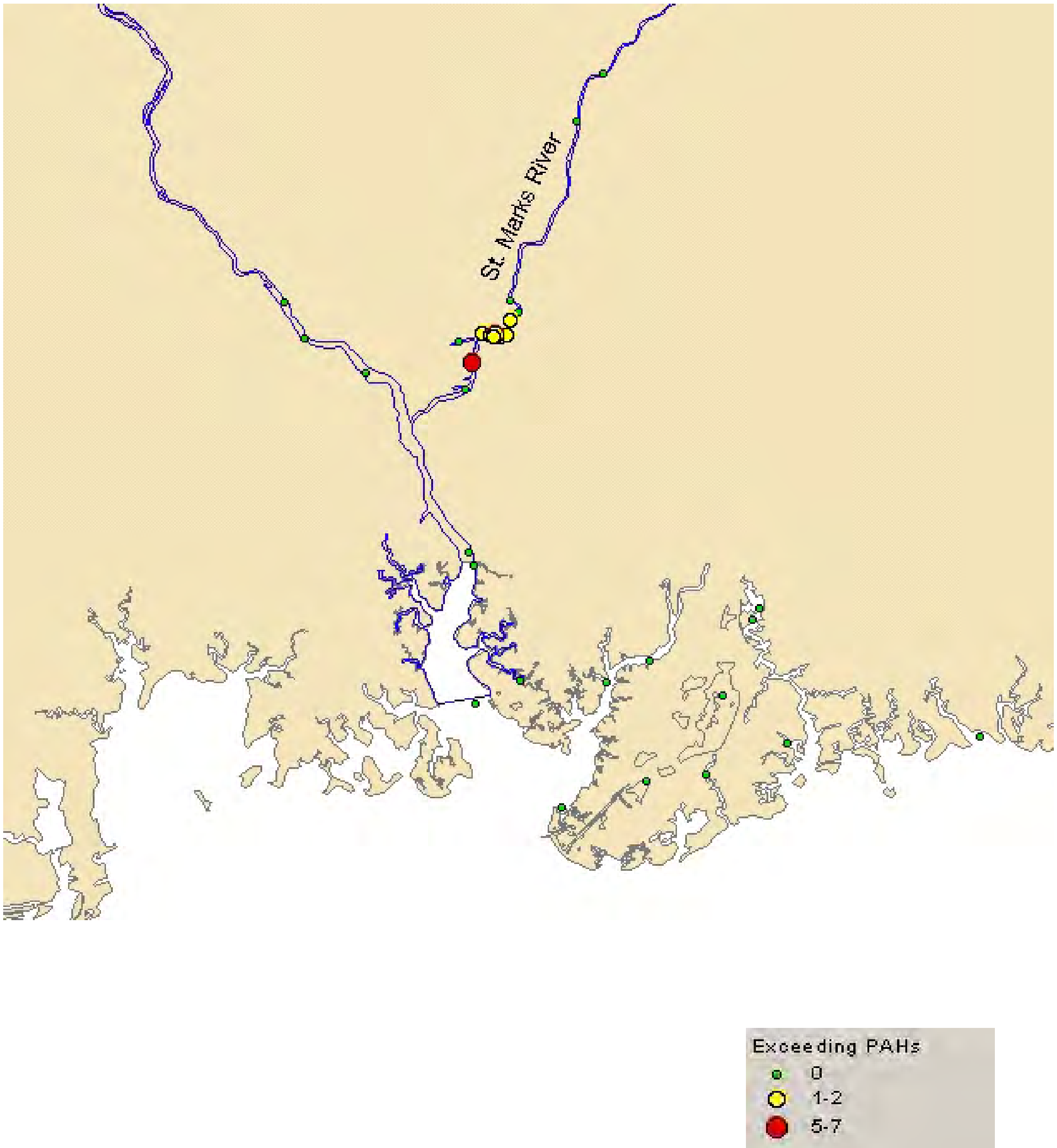

Figure 6: Number of polycyclic aromatic hydrocarbons analytes in sediment samples taken on St. Marks National Wildlife Refuge, 1988, exceeding Long *et al.* (1995) sediment quality guidelines.

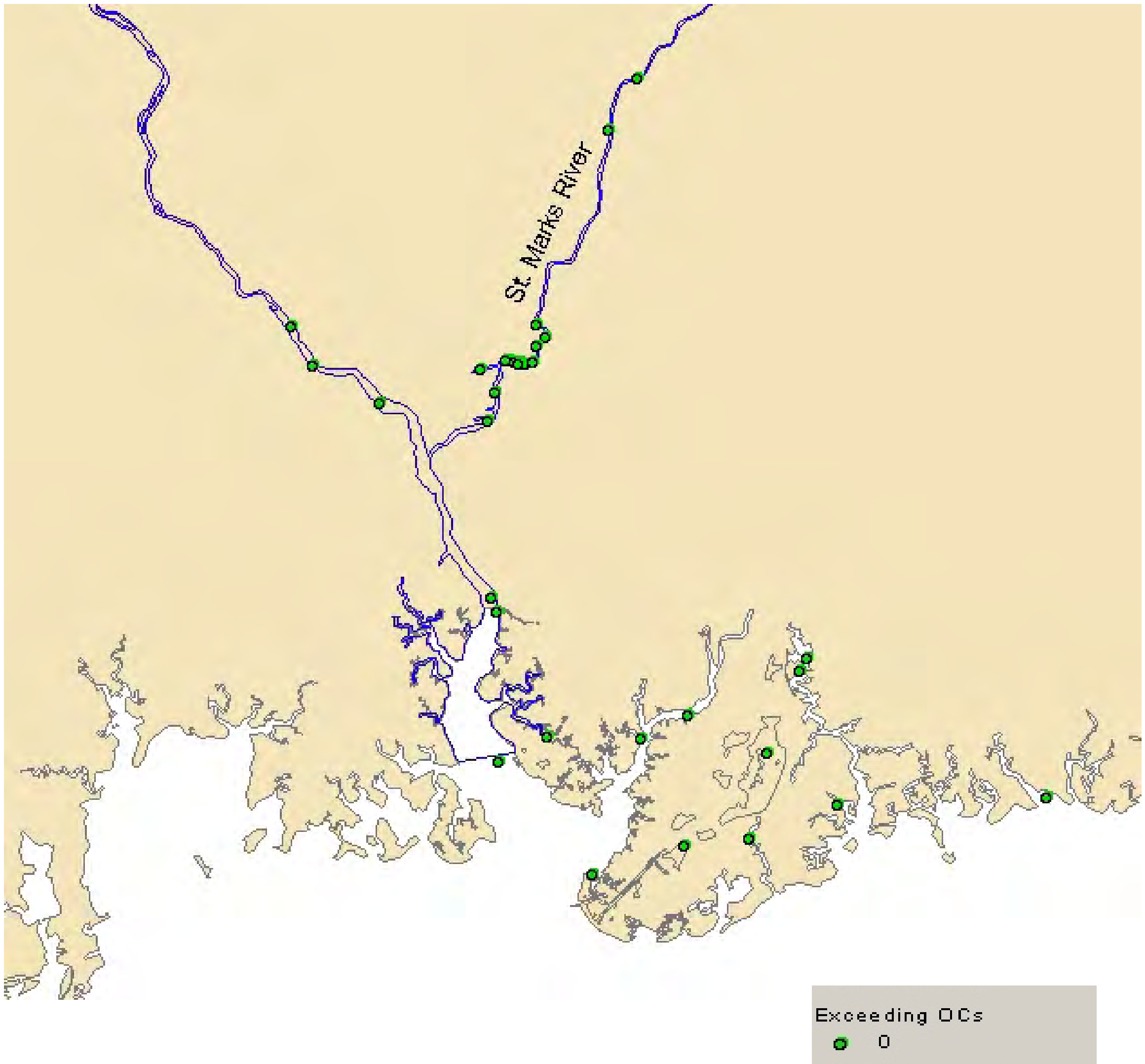

Figure 7: Number of organochlorine analytes in sediment samples taken on St. Marks National Wildlife Refuge, 1988, exceeding Long *et al.* (1995) sediment quality guidelines.

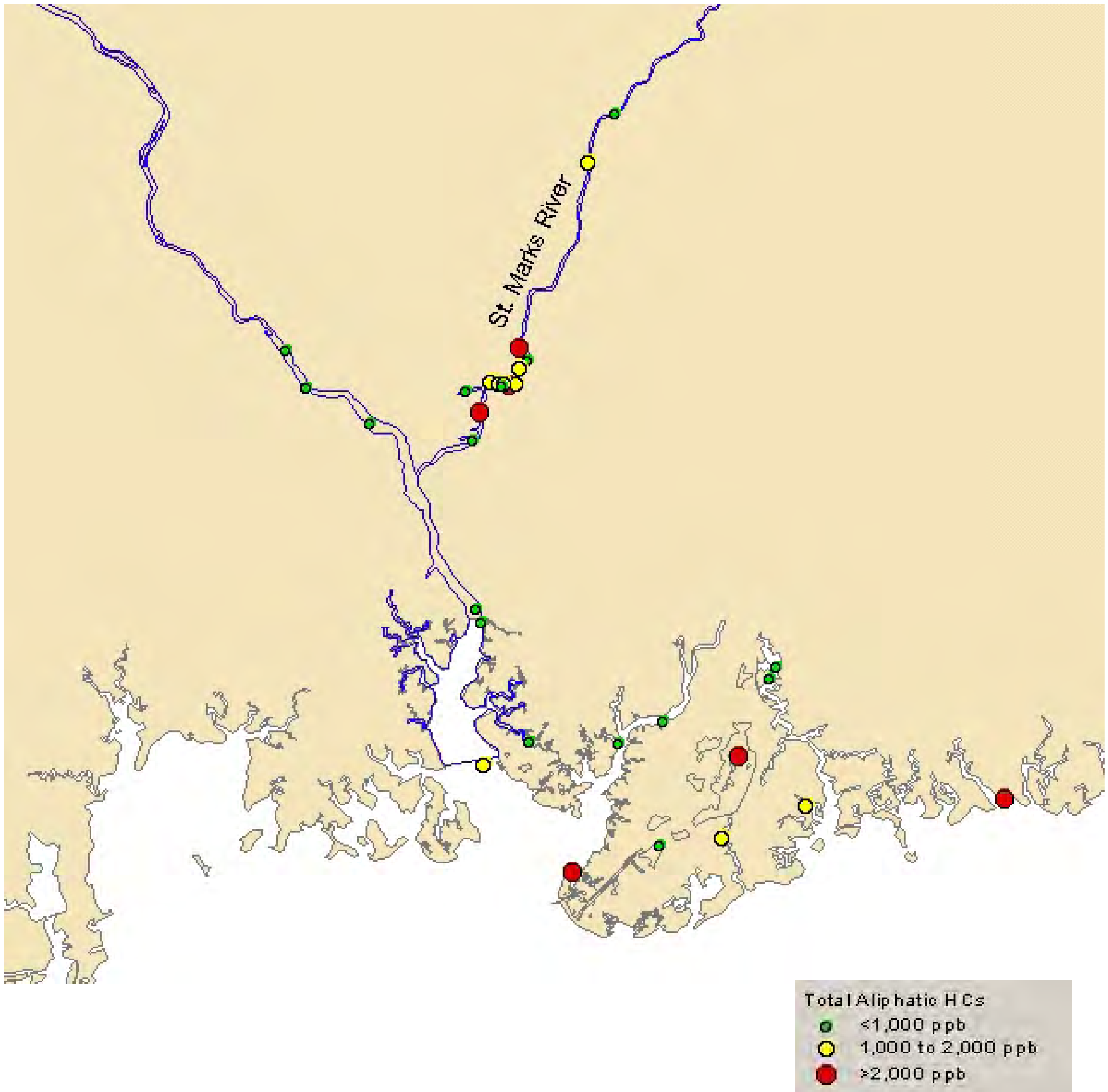

Figure 8: Relative aliphatic hydrocarbon analyte levels in sediment samples taken on St. Marks National Wildlife Refuge, 1988.

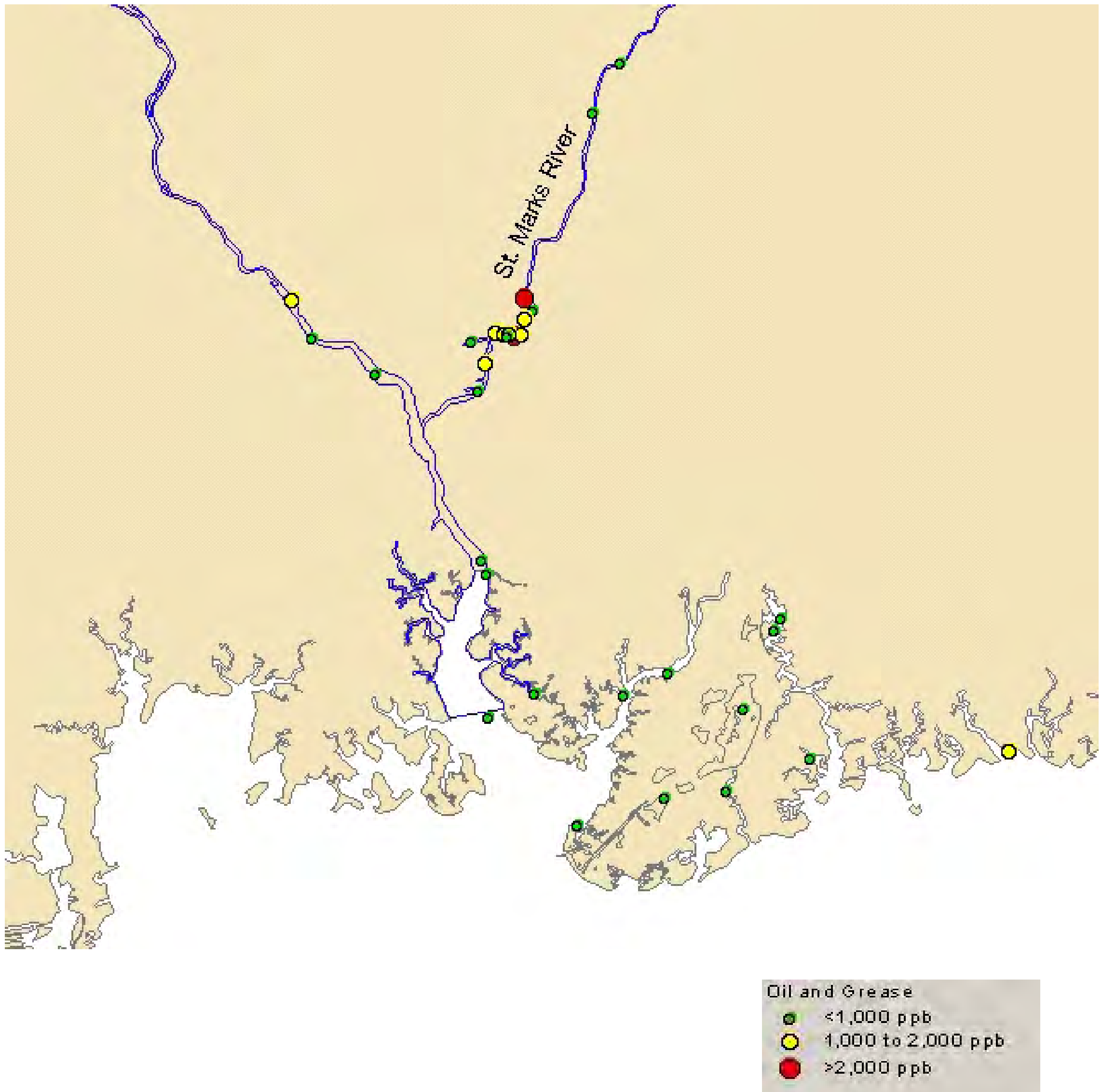

Figure 9: Relative grease and oil levels in sediment samples taken on St. Marks National Wildlife Refuge, 1988.

Table 4: Specific information on sites with metal analytes equal to or exceeding recommended sediment quality guidelines (Long *et al.* 1995): site, analyte, sediment concentration (ug/kg, ppb, dry weight), effects range low (ERL), and effects range median (ERM).

Site	Analyte	Sediment Concentration	ERL	ERM
SM28	Copper	39.3	34.0	270
SM24	Mercury	0.16	0.15	0.71
SM25	〃	0.16	〃	〃
SM27	〃	0.15	〃	〃
SM30	〃	0.16	〃	〃
SM31	〃	0.17	〃	〃

Table 5: Specific information on sites with polycyclic aromatic hydrocarbon analytes equal to or exceeding recommended sediment quality guidelines (Long *et al.* 1995): site, analyte, sediment concentration (ug/kg, ppb, dry weight), effects range low (ERL), and effects range median (ERM).

Site	**Analyte**	**Sediment Concentration**	**ERL**	**ERM**
SM21	Phenanthrene	292	240	1,500
″	Anthracene	643	85	1,100
″	benz(a)anthracene	468	261	1,600
″	Chrysene	877	384	2,800
″	Total PAHs[1]	4,269	1,700	9,600
SM22	Total PAHs[1]	1,992	1,700	9,600
SM23	Total PAHs[1]	3,583	1,700	9,600
SM24	Total PAHs[1]	2,190	1,700	9,600
SM25	Total PAHs[1]	2,500	1,700	9,600
SM26	Total PAHs[1]	2,565	1,700	9,600
SM27	Fluorene	429	19	540
″	Phenanthrene	1,786	240	1,500
″	Anthracene	357	85	1,100
″	Fluoranthrene	1,643	600	5,100
″	Pyrene	1,286	665	2,600
″	Chrysene	500	384	2,800
″	Total PAHs[1]	8,571	1,700	9,600
SM28	Total PAHs[1]	2,208	1,700	9,600
SM29	Chrysene	399	384	2,800
″	Total PAHs[1]	2,822	1,700	9,600

[1]- Total sum of analyzed PAHs.

Table 6: Specific information on sites with organochlorine analytes equal to or exceeding recommended sediment quality guidelines (Long *et al*. 1995): site, analyte, sediment concentration (ug/kg, ppb, dry weight), effects range low (ERL), and effects range median (ERM).

Site	Analyte	Sediment Concentration	ERL	ERM
None	-	-	-	-

Table 7: Specific information on sites with relatively high concentrations of total aliphatic hydrocarbon analytes for the St. Marks National Wildlife Refuge sediment quality survey, 1988: site, analyte, sediment concentration (ug/kg, ppb, dry weight), possible need for further evaluation (possible), and probable need for further evaluation (probable).

Site	**Analyte**	**Sediment Concentration**	**Possible**	**Probable**
SM2	Sum Total Alipahtic	3,770	1,000	2,000
SM3	Hydrocarbons	1,166	″	″
SM4	″	1,306	″	″
SM7	″	3,842	″	″
SM8	″	4,056	″	″
SM12	″	1,073	″	″
SM21	″	2,423	″	″
SM22	″	1,504	″	″
SM23	″	1,398	″	″
SM24	″	2,470	″	″
SM25	″	1,729	″	″
SM26	″	1,832	″	″
SM27	″	2,350	″	″
SM29	″	1,149	″	″
SM30	″	2,475	″	″
SM31	″	1,141	″	″

Table 8: Specific information on sites with relatively high concentrations of combined oil and grease analytes for the St. Marks National Wildlife Refuge sediment quality survey 1988: site, analyte, sediment concentration (ug/kg, ppb, dry weight), possible need for further evaluation (possible), and probable need for further evaluation (probable) .

Site	Analyte	Sediment Concentration	Possible	Probable
SM8	Combined Oil	1,469	1,000	2,000
SM18	and Grease	1,738	″	″
SM21	″	1,289	″	″
SM22	″	1,278	″	″
SM23	″	1,505	″	″
SM24	″	2,530	″	″
SM25	″	1,880	″	″
SM26	″	1,221	″	″
SM27	″	1,795	″	″
SM29	″	1,522	″	″
SM30	″	2,172	″	″

DISCUSSION

This report summarizes the U.S. Fish and Wildlife Service's 1988 sediment survey data and assessment of habitat quality on the St. Marks National Wildlife Refuge (NWR). The data reflect site-specific sampling at 32 sites in the aquatic environments on (n=14) and north (n=18) of the NWR. Our objective was to provide survey information from which to determine the need for additional monitoring and for use in developing management strategies.

Sediment composition on and around St. Marks NWR was comparable to other coastal areas of the northeastern Gulf of Mexico (Hemming *et al.*, 2002; Brim *et al.*, 2000; Brim, 1998). The typical sandy sediments of the Gulf coast were evident with sand fractions measuring as high as 95%. Sand fractions were also found to be as low as 15%, but most often above 65%. The silt and clay fractions were similarly variable and reciprocal to the sand fraction. Gravel was not uncommon in samples, but constituted a maximum of 5.7% of the total sediment composition by weight. Percent total organic carbon ranged from 0.2 to 4.9 which was also typical of sediments from the northern Gulf of Mexico ((Hemming *et al.*, 2002; Brim *et al.*, 2000; Brim, 1998).

Metal contamination was found in sediment samples taken just north of St. Marks NWR, but not on the actual refuge. Only 2 metals, copper and mercury, were found at concentrations expected to increase the incidence of adverse negative effects on living resources from rare to occasional (Effects Range Low, ERL, Long *et al.*, 1995). Copper exceeded the ERL at 1 site and mercury exceeded the ERL at 5 sites. No metals exceeded the Effects Range Median (ERM); therefore, frequent adverse effects were not expected from metal exposure. Metal concentrations in samples from all 6 sites were only slightly higher than the respective ERLs.

Polycyclic aromatic hydrocarbon (PAH) contamination was also not found on the actual refuge, but was somewhat more widespread than metal contamination (9 sites). Many of the PAH contaminated sites were the same as those with slight metal contamination. The PAH analytes chrysene, phenanthrene, and anthracene were most frequently in excess of the ERL; however, they were only found 3, 2, and 2 times each, respectively. Phenanthrene was detected at a concentration in excess of the ERM at a fuel loading area. Contamination in excess of the ERM may increase the incidence of adverse effects to frequent (Long *et al.*, 1995). The most common sediment guideline exceeded was the ERL guidance value for sum total PAHs. This criterion was exceeded at all 9 sites where PAH contamination was found, even at sites where no individual analytes exceeded the sediment quality guidelines. PAH contamination at these sites was not surprising in the industrial area on St. Marks River with fuel docks and marinas nearby. PAHs are fuel fractions and would be expected to be found where fossil fuels are burned and may enter the environment.

Not only were organochlorine (OC) compounds not found to exceed the sediment quality guidelines, but no OC contamination was detected in samples taken. The significance of the absence of OC residues in the sediments on and around St. Marks NWR is unclear. The reported historical use of OCs in pest management in the area makes the lack of detectable analytes noteworthy.

In the case of aliphatic hydrocarbon (AH) and oil and grease sediment contamination, sediment quality guidelines were not available. For the purpose of contamination evaluation, areas/sites were recommended for further evaluation based on relative sediment concentrations. If concentrations were moderately higher than other sites (1,000+ ppb) or higher (2,000+ ppb) than other sites surveyed, further evaluation was recommended.

AHs and oil and grease residues were the only contaminant groups found in sediment samples taken from the aquatic locations actually on St. Marks NWR. Additional contamination was found at sites just north of the refuge where metal and PAH contamination was found. Sixteen sites are recommended for further investigation due to the AH concentration of the sediments. Of those 16 sites, sediment AH contamination of 9 of the sites was considered moderately high, versus high at the remaining 7 sites. Like PAHs, AHs are fuel fractions and often occur where fuel is used or dispensed. More specifically, AHs are the lighter fuel fractions typically dominating small engine fuels. The co-occurrence of both PAHs and AHs at sites around fueling dock and marinas may be expected. AH contamination of other sites, including bayous, lakes and ponds, may have been the result of motorboat traffic due to the inefficient use of gasoline products by these 2-cycle engines. Use of the more recently available 4-cycle engines may help to lessen the level of contamination at these sites/areas.

Oil and grease contamination, based on the above describe benchmarks, was for the most part found around boat activity and fueling stations as described for PAHs. However, this type of contamination was found at a coastal bayou site on St. Marks NWR. Oil and grease use in lubrication of motorboat engines likely contributed largely to this specific contamination.

CONCLUSIONS

The sediment quality survey of the aquatic habitats of St. Marks National Wildlife Refuge (NWR) documented only site/area use-specific contamination. Much of the area surveyed possessed little or no contamination. Aliphatic hydrocarbons and oil and grease residues were the only contamination found in sediment samples taken from the aquatic environmental on St. Marks NWR. However, contamination was found at sites in the more industrialized area of St. Marks River north of the NWR.

Sediment composition on St. Marks NWR was typical of sediments in the northern Gulf of Mexico. Metal contamination was slight and limited to copper and mercury found north of the NWR. Polycyclic aromatic hydrocarbons found north of the NWR were concentrated at sites in the area dominated by fuel docks and marinas. Reported historical use of OCs in pest management in the area made the lack of detectable analytes noteworthy. Aliphatic hydrocarbons were also found at sites around fueling docks and marinas, but also at sites with motorboat traffic. Oil and grease use in lubrication of motorboat engines likely contributed largely to the area-specific oil and grease contamination.

RECOMMENDATIONS

The following recommendations are offered for consideration.

1. Implement site-specific management strategies at identified contaminated sites to include Best Management Practices (BMPs).

2. Investigate biological impacts from sediments around contaminated sites.

3. Assess the potential of adverse ecological effects from aliphatic hydrocarbon and oil and grease residues in sediments for the purpose of developing sediment quality guidelines.

4. Re-evaluate site-specific aliphatic hydrocarbon contaminated sediments pre- and post-introduction of 4-cycle motor boat engines.

5. Re-evaluate all sites on St. Marks National Wildlife Refuge for recent changes and trends in sediment contamination and habitat quality.

6. Review and update the refuge spill response plan with current environmental quality data to assure adequate protection of the aquatic habitats of St. Marks National Wildlife Refuge.

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APPENDICES

Appendix A
Standard operating procedures for field collection of sediment samples
(PCFO-EC SOP 004).

PCFO-EC SOP 004

STANDARD OPERATING PROCEDURES
SEDIMENT SAMPLING FOR CHEMICAL ANALYSES

To maintain and assure quality control, sediment samples collected for shipment to USFWS- approved analytical laboratories will be obtained and handled as follows:

COLLECTON OF SAMPLES FROM COASTAL WATERS OR LARGE RIVERS

1. **Sampling Devices** - The following devices are approved for obtaining sediment samples:
   A) Ponar grab, Standard. Manufactured from 316 stainless steel including jaws, side plates, underlip plate, screen. frame, screens and hinge pin. 583 micron mesh top screens; weight empty - 21 kg (45 lbs); sampling area 22.85 cm. x 22.85 cm (9" x 9").
   B) Ponar grab, Petite. Manufactured with 316 stainless steel including jaws, side plates, underlip plate, screen frame, screens and hinge pin. 583 micron mesh top screens; weight empty - 6.8 kg (15 lbs); sampling area 15.24 x 15.24 cm (6" x 6").

2. **Sediment Sampling Boat**-
   A) fiberglass boat with outboard motor equipped as follows:
      1) navigation and positioning capabilities including: a) loran navigation system, b) chart-printing depth recorder, c) compass, d) appropriate navigation charts.
      2) 12 volt electric winch; steel ginpole with heavy duty pulley; 100' of 1/2" braided nylon lift rope.

3. **Other Equipment and Supplies** -
   A) Stainless steel sample pan 28 x 48 x 10 cm.
   B) Pre-cleaned, chemical-free, glass 1.0 liter sample jars with screw-top lids having Teflon liners.
   C) Pre-cleaned, chemical-free stainless steel utensils.
   D) Clean insulated ice chests with ice.
   E) Permanent, glass-adhesive markers.
   F) Bound collection logbook or individual record sheets.
   G) Disposable laboratory gloves.
   H) Meters: dissolved oxygen, salinity, temperature, pH and others, as appropriate.

4. **Operational Procedures** -

A) Prior to each *collection day* the ponar sampler will be scrubbed and washed with a detergent solution, rinsed thoroughly with tap water, and then rinsed with distilled water. After each collection *field*trip the ponar will be cleaned, as above, and stored properly.

B) The daily collection plan shall provide, to the greatest extent possible, for sampling to begin at the least contaminated station, with work advancing toward the most contaminated station.

C) Sediment samples obtained at *sampling stations* will be composite samples. Each composite will consist of five individual ponar sub-samples collected 3 meters apart along a straight-line transect, with the collection boat anchored. Move from one *sub-sample position* to the next by slipping the anchor line to provide approximately 3 meters of horizontal drift.

D) Place each ponar sub-sample in the sample pan. Take approximately 150 grams - of sediment from the center of the sub-sample using appropriate utensils and place it in the collection jar designated for that station. After obtaining each sub-sample, rinse utensils, wash deck, sample pan, and the ponar sampler with seawater or river water.

Note: 150 grams *of* sub-sample collected from each *of* the 5 sub-sample positions (about 750 grams *of* sample total) should result in the sample jar being about 3/4 full. This leaves adequate space in the jar for any expansion of the sample during freezing.

E) During collection of the third ponar sub-sample, record the *station location* by loran positions and by latitude and longitude. At this time, also record all other station information (such as depth, salinity. water temperature, etc).

F) Place each sub-sample (total. n=5) in the appropriate pre-labeled, sample jar. Secure the lid and place sample on ice in a cooler.

G) After work at each *sampling station* is complete, clean the ponar. Sample pan, wash deck and utensils thoroughly and rinse with seawater or river water.

H) For field trips involving more than one day, samples will be frozen and stored in a portable field freezer.

I) After each collection day double-wrap each full sample jar with clean. heavy-duty aluminum foil, place a second identification label over the foil and store in a freezer.

J) Upon returning to the Panama City Field Office samples will be transferred to a *laboratory freezer* and held at -230 degrees centigrade (-10 Fahrenheit) until shipment for chemical analyses. Sediment samples for particle size analysis will be held at 40 °C.

Appendix B

Composition of sediment samples taken on St. Marks National Wildlife Refuge, 1988.

Sediment Composition Database for St. Marks National Wildlife Refu
Total Organic Carbon and Grain Size Analysis
Study identifier:89-4-108B

Site II	Geographical Name	% Grav	% Sand	% Silt	% Clay	Tot.Wgt grams	% Moist	TOC-I	%MstTOC	TOC-DW
SM1-0	East River Pool	0.1	75.18	7.8	16.92	956	66.8	3.51	61.87	2.89
SM2-0	Mounds #1	0.03	54.57	19.12	26.28	988	85.2	3.48	66.25	2.82
SM3-0	Tower Pond	0	90.6	6.5	2.9	773	46.8	4.15	33	3.82
SM4-0	Mounds #3	0	84.96	8.16	6.88	803	66	4.35	49.67	3.85
SM5-0	East Riv/above Afr	3.84	84.84	2.94	8.38	1218	33.4	0.66	27.73	0.38
SM6-0	East Riv/below Der	0	85.54	6.52	7.94	1180	33.7	0.59	28.38	0.31
SM7-0	Boat Basin/lighth	0	14.96	49.62	35.42	871	87.1	2.82	74.57	2.07
SM8-0	Stony Bayou #2	0.15	90.07	6.94	2.83	820	77.6	4.01	62.38	3.39
SM9-0	Stony Bayou #1	0.05	70.15	11.93	17.87	801	66.6	1.44	56.76	0.87
SM10-0	Picnic Pond	0.57	94.63	2.02	2.77	905	69.1	2.45	41.83	2.03
SM11-0	St Marks Riv/Buoy	0.03	83.47	8.36	8.14	903	52.5	2.36	38.59	1.97
SM12-0	SMR/Buoy 27W	0.93	73.12	13.09	12.87	947	63.9	1.46	49.61	0.96
SM13-0	SMR/Buoy 42E	1.93	82.42	2.3	13.35	1028	33.6	1.03	29.13	0.74
SM14-0	SMR/Oliver Bayou	0.02	64.79	20.19	15	693	53.9	2.54	57.48	1.97
SM15-0	Big Boggy Bayou	0.46	55.29	14.72	29.54	718	60.2	4.58	44.81	4.13
SM16-0	Wakulla Rv/below S	0.18	84.8	7.04	7.98	972	36.9	1.69	34.02	1.35
SM17-0	Wakulla Rv/Shell I	0.03	85.73	6.75	7.5	839	41	1.19	27.8	0.91
SM18-0	Wakulla Rv/2 mi mo	3.58	78.24	12.58	5.6	1012	67.4	5.71	81.01	4.9
SM19-0	SMR/above power pl	1.62	85.84	6.13	6.41	861	62.1	1.93	45.54	1.47
SM20-0	SMR/East Side	0.05	49.25	33.84	16.86	927	70.9	3.29	48.47	2.81
SM21-0	SMR/fuel docks	0	36	41.79	22.21	920	82.9		74.1	
SM22-0	SMR/Canal Marina	0.03	12.27	35.83	51.88	911	75.9	2.3	70.67	1.59
SM23-0	SMR/turning basin	0.81	49.46	30.92	18.82	792	76	4.29	64.96	3.64
SM24-0	smR/marina	4.36	51.37	28.33	15.94	452	75.8	3.64	68.16	2.96
SM25-0	SMR/turning basin	0.08	64.86	21.02	14.04	705	62.8	3.88	60.79	3.27
SM26-0	SMR/new marina N	0.57	32.99	39.56	26.88	806	80.9	3.08	74.21	2.34
SM27-0	SMR/fuel loading	5.68	42.76	33.93	17.63	906	86	4.42	74.86	3.67
SM28-0	Power Plant/discha	0.12	69.48	18.52	11.87	995	43.4	1.63	35.17	1.28
SM29-0	Power Plant/fuel l	0.87	85.74	5.44	7.96	910	67.4	1.1	85.59	0.24
SM30-0	Power Plant/intake	0	32.91	44.59	22.5	924	84.9	4.73	74.39	3.99
SM31-0	SMR/below Newport	0.2	77.43	14.33	8.04	778	74.8	4.76		4.76
SM32-0	SMR/above Newport	0.49	86.99	7.03	5.49	908	71.3	3.28	54.19	2.74

Appendix C

Metal analytes in sediment samples taken on St. Marks National Wildlife Refuge, 1988.

Metals Sediment Data Base for St. Marks National Wildlife Refuge, Fl

Metals and Guideline Values in Parts Per Million (ug/g) dry weight

Site ID	Geographical Name	Latitu	Longit	(meter	Silver	Aluminu	Arsenic
		Edward R. Long et al 1995 (Environ Manage					
		ERL	-		1		8.2
		ERM	-	Depth	3.7		70
SM1-M	East River Pool	30°07.3	84°08.5	1.2	<2.0	5930	1.3
SM2-M	Mounds #1	30°06.1	84°09.1	0.9	<2.0	17900	2.7
SM3-M	Tower Pond	30°05.3	84°09.0	1.2	<2.0	2720	0.55
SM4-M	Mounds #3	30°05.8	84°08.3	0.9	<2.0	1150	0.3
SM5-M	East Riv/above Afri	30°06.5	84°09.8	1.8	<2.0	2410	0.65
SM6-M	East Riv/below Denh	30°06.2	84°10.1	0.6	<2.0	3010	0.96
SM7-M	Boat Basin/lighthou	30°05.0	84°10.4	0.8	<2.0	20500	3.1
SM8-M	Stony Bayou #2	30°06.8	84°07.1	1.2	<2.0	11200	0.66
SM9-M	Stony Bayou #1	30°07.3	84°08.3	1.2	<2.0	11200	1.3
SM10-M	Picnic Pond	30°05.2	84°09.8	1.5	<2.0	3630	0.61
SM11-M	St Marks Riv/Buoy 2'	30°06.2	84°11.3	2.3	<2.0	5420	1.4
SM12-M	SMR/Buoy 27W	30°06.1	84°11.5	1.5	<2.0	6450	2.1
SM13-M	SMR/Buoy 42E	30°07.6	84°11.8	1.2	<2.0	3260	0.72
SM14-M	SMR/Oliver Bayou	30°07.6	84°11.8	1.2	<2.0	5800	1.4
SM15-M	Big Boggy Bayou	30°10.3	84°13.0	0.9	<2.0	5590	1.3
SM16-M	Wakulla Rv/below SM	30°09.5	84°12.3	0.6	<2.0	2100	0.48
SM17-M	Wakulla Rv/Shell Is	30°09.8	84°12.6	0.8	<2.0	1550	0.39
SM18-M	Wakulla Rv/2 mi mou	30°10.9	84°13.7	2.1	<2.0	2140	0.96
SM19-M	SMR/above power pla	30°10.3	84°11.0	2.7	<2.0	4990	0.8
SM20-M	SMR/East Side	30°09.9	84°12.1	2.4	<2.0	7980	1.7
SM21-M	SMR/fuel docks	30°09.6	84°11.3	4.6	<2.0	20100	4.2
SM22-M	SMR/Canal Marina	30°09.7	84°11.6	2.3	<2.0	26800	5.3
SM23-M	SMR/turning basin S	30°09.6	84°11.6	4.0	<2.0	18200	2.3
SM24-M	smR/marina	30°09.7	84°11.6	4.6	<2.0	20100	3.3
SM25-M	SMR/turning basin N	30°09.7	84°11.5	2.7	<2.0	8350	1.7
SM26-M	SMR/new marina N	30°09.8	84°11.6	2.1	<2.0	20100	3.4
SM27-M	SMR/fuel loading	30°09.9	84°11.5	2.7	<2.0	13600	4
SM28-M	Power Plant/dischar	30°10.0	84°11.6	1.7	<2.0	3140	0.93
SM29-M	Power Plant/fuel lo	30°10.1	84°11.5	4.6	<2.0	7770	1.2
SM30-M	Power Plant/intake	30°10.2	84°11.5	3.0	<2.0	17400	3.4
SM31-M	SMR/below Newport B	30°12.1	84°10.3	2.1	<2.0	9920	1.4
SM32-M	SMR/above Newport B	30°12.5	84°10.2	1.4	<2.0	7120	0.8

ife Refuge, Florida.

19(1):81-97.

Site ID	Boron	Barium	Berylli	Cadmium	Chromiu	Copper	Iron	Mercury	Magnesi
				1.2	81	34		0.15	
				9.6	370	270		0.71	
SM1-M	3	8.7	0.2	<0.4	8.2	0.5	2720	0.03	1060
SM2-M	16	14.4	0.88	<0.3	14	3.2	7140	0.066	5880
SM3-M	6.2	7.7	0.1	<0.4	4.8	0.74	985	0.03	965
SM4-M	12	6.5	0.1	<0.4	2	0.4	463	0.02	1880
SM5-M	3	4.1	0.1	<0.4	4	0.6	1320	0.02	702
SM6-M	5	7.3	0.1	<0.4	7.1	1.5	1980	0.02	1090
SM7-M	41	25.6	0.71	1	54	13	13900	0.14	10800
SM8-M	7.4	16.7	0.34	<0.4	20	0.84	2360	0.054	2220
SM9-M	6.4	9.6	0.41	<0.3	16	0.76	3370	0.04	2760
SM10-M	6.9	6.5	0.2	<0.4	7.1	1.3	2000	0.045	1310
SM11-M	11	8.8	0.1	<0.3	15	2.9	4190	0.063	2580
SM12-M	21	10.1	0.2	<0.4	22	4.4	5520	0.072	4000
SM13-M	5.4	7.3	0.1	<0.4	10	2	2360	0.04	1310
SM14-M	9.5	12.3	0.2	<0.4	22	4.5	4310	0.051	3290
SM15-M	6.7	18.6	0.3	<0.4	27	2.4	4030	0.069	1780
SM16-M	4	16.1	0.1	<0.4	10	2.3	1140	0.04	841
SM17-M	4	14.1	<0.1	<0.4	11	2.3	996	0.03	744
SM18-M	4	12.1	0.2	0.6	41	1.4	1910	0.04	855
SM19-M	5	27.4	0.2	<0.4	26	14	3370	0.11	2520
SM20-M	12	19.1	0.3	<0.3	31	12	5710	0.087	4170
SM21-M	35	33.5	0.65	0.9	71	28	13100	0.2	9520
SM22-M	17	45.2	0.79	0.5	59	31.3	15000	0.15	8080
SM23-M	36	31.3	0.49	0.6	55	17	10500	0.14	7870
SM24-M	35	41.1	0.57	0.5	66	24	12800	0.16	8910
SM25-M	12	19.9	0.3	<0.4	31	12	6240	0.16	4240
SM26-M	16	38.9	0.63	0.8	61	23.6	12400	0.25	8990
SM27-M	21	29.6	0.51	0.6	52	19	9660	0.15	10500
SM28-M	5	18.2	<0.1	<0.4	13	39.3	3050	0.04	1900
SM29-M	11	20.4	0.3	<0.4	29	12	5370	0.066	3490
SM30-M	24	36.4	0.54	0.7	63	18	11800	0.16	8170
SM31-M	4	61.2	0.34	<0.4	46	20	7340	0.17	2920
SM32-M	3	37.1	0.2	<0.3	31	4.5	4780	0.09	1510

			20.9	46.6					150
			51.6	218					410
Site ID	Mangane	Molybde	Nickel	Lead	Seleniu	Strontium		Vanadiu	Zinc
SM1-M	17	2	2	<4.0	0.2	9.3	<4.0	10	6.6
SM2-M	38.3	5	8.7	10	0.4	42.3	<4.0	20	15
SM3-M	3.5	2	1	<4.0	0.2	11.9	<4.0	5.1	3.7
SM4-M	4.1	<1.0	<2.0	<4.0	<0.1	21.1	<4.0	2.4	1.8
SM5-M	6.4	2	2	<4.0	<0.1	6.5	<4.0	5.1	4
SM6-M	11	2	<1.0	<4.0	0.2	10.5	<4.0	6.1	6
SM7-M	71.7	11	9.5	20	1.7	84.3	<4.0	26	44
SM8-M	18	2	4	<4.0	0.54	32.8	<4.0	11	5.2
SM9-M	15	3	4	<4.0	0.4	24.2	<4.0	18	5.6
SM10-M	7	3	2	<4.0	0.46	15	<4.0	6.1	5.1
SM11-M	41.9	3	3	5	0.42	42.5	<4.0	9.4	14
SM12-M	58.9	5	4	6	0.77	65.7	<4.0	12	14
SM13-M	23.6	2	2	<4.0	0.3	39.9	<4.0	6.4	6.7
SM14-M	41.9	4	3	5	0.87	46.2	<4.0	11	12
SM15-M	62	3	3	<4.0	1.6	24.7	<4.0	13	8.1
SM16-M	17	1	<1.0	<4.0	0.43	13.2	<4.0	4.3	8.6
SM17-M	15	1	<1.0	<4.0	0.65	14.3	<4.0	3.5	6.4
SM18-M	14	2	2	<4.0	3.3	32.8	<4.0	9.9	3.4
SM19-M	63.2	3	2	28	1.1	33.3	<4.0	9.3	23
SM20-M	69	4	4	10	1.3	61.7	<4.0	13	22
SM21-M	163	8.7	10	22	2.9	121	<4.0	28	49.3
SM22-M	92.6	9.9	11	20	1.6	96.2	<4.0	36.4	63
SM23-M	127	6	8	14	2.1	96.8	<4.0	26	38
SM24-M	152	7.9	9.6	18	2.9	121	<4.0	29	49
SM25-M	73	4	4.4	9	1.3	55.3	<4.0	14	25
SM26-M	115	8.1	9.6	24	2.5	98.6	<4.0	30	70.5
SM27-M	128	6.1	6.7	17	2.1	117	<4.0	21	43.9
SM28-M	33.2	3	14	8	0.44	20.7	<4.0	38.7	21
SM29-M	63.1	4	4.6	8	1.2	46.5	<4.0	13	25
SM30-M	169	8.7	10	22	2.6	100	<4.0	29	45.8
SM31-M	362	5	5.2	18	2.3	53.4	<4.0	19	42
SM32-M	213	4	4	6	1.6	28.8	<4.0	13	16

Appendix D

Polycyclic aromatic analytes in sediment samples taken on St. Marks National Wildlife Refuge, 1988.

Polycyclic Aromatic Hydrocarbon (PAH) Sediment Data Base for St. Marks N
Concentrationsprovided by lab in ppm wet wt. Calculated 1. ppb (ug/g) dr
2. wet weight ppb / % dry weight of sediment (not moist percent)

Edward R. Long et al. 1995 (Environ Manage 19(1):8

ERL	ppb dry wt	70
ERH		670

Site I	Geographical Name	Latitu	Longit	Depth (meter	Tot. Wgt grams	% Moist	napthalene wet wgt ppb	dry wgt ppb
1	East River Pool	30 07.:	84 08.51		956	67	nd	nd
2	Mounds #1	30 06.	84 09.11		988	85	nd	nd
3	Tower Pond	30 05.:	84 09.11		773	47	nd	nd
4	Mounds #3	30 05.	84 08.01		803	66	nd	nd
5	East Riv/above Afri	30 06.	84 09.82		1218	33	nd	nd
6	East Riv/below Danh	30 06.	84 10.11		1180	34	nd	nd
7	Boat Basin/lightho	30 05.	84 10.41		871	87	nd	nd
8	Stony Bayou #2	30 06.	84 07.11		820	78	nd	nd
9	Stony Bayou #1	30 07.:	84 08.01		801	67	nd	nd
10	Picnic Pond	30 05.:	84 09.82		905	69	nd	nd
11	St Marks Riv/Buoy 2	30 06.:	84 11.02		903	53	nd	nd
12	SMR/Buoy 27W	30 06.	84 11.52		947	64	nd	nd
13	SMR/Buoy 42E	30 07.	84 11.41		1028	34	nd	nd
14	SMR/Oliver Bayou	30 07.	84 11.41		693	54	nd	nd
15	Big Boggy Bayou	30 10.:	84 13.06		718	60	nd	nd
16	Wakulla Rv/below SM	30 09.	84 12.01		972	37	nd	nd
17	Wakulla Rv/Shell I:	30 09.	84 12.11		839	41	nd	nd
18	Wakulla Rv/2 mi mo	30 10.	84 13.12		1012	67	nd	nd
19	SMR/above power pl	30 10.:	84 11.03		861	62	nd	nd
20	SMR/East Side	30 09.	84 12.12		927	71	nd	nd
21	SMR/fuel docks	30 09.	84 11.05		920	83	nd	nd
22	SMR/Canal Marina	30 09.	84 11.62		911	76	nd	nd
23	SMR/turning basin	30 09.	84 11.14		792	76	nd	nd
24	smR/marina	30 09.	84 11.65		452	76	nd	nd
25	SMR/turning basin N	30 09.	84 11.13		705	63	nd	nd
26	SMR/new marina N	30 09.	84 11.62		806	81	nd	nd
27	SMR/fuel loading	30 09.	84 11.53		906	86	10	71
28	Power Plant/dischar	30 10.	84 11.62		995	43	nd	nd
29	Power Plant/fuel lc	30 10.	84 11.55		910	67	nd	nd
30	Power Plant/intake	30 10.:	84 11.53		924	85	nd	nd
21	SMR/below Newport	30 12.	84 10.02		778	75	nd	nd
32	SMR/above Newport	30 12.	84 10.01		908	71	nd	nd

ational Wildlife Refuge, Florida.
y weight : ppm *1000=ppb;

1-37.

		19		240		85		600		665
		540		1500		1100		5100		2600
	fluorene		phenanthrene		anthracene		fluoranthrene		pyrene	
:	wet wgt	dry wgt	wet wgt	dry wgt	wet wg	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt
Site ID	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	10	19	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
7	nd	nd	nd	nd	nd	nd	10	78	10	78
8	nd	nd	nd	nd	nd	nd	10	45	20	89
9	nd	nd	nd	nd	nd	nd	10	30	20	60
10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
11	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
12	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
13	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
14	nd	nd	nd	nd	nd	nd	20	43	20	43
15	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
16	nd	nd	nd	nd	nd	nd	nd	nd	10	16
17	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
18	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
19	nd	nd	nd	nd	nd	nd	30	79	20	53
20	nd	nd	nd	nd	nd	nd	30	103	30	103
21	20	117	50	292	110	643	100	585	70	409
22	nd	nd	nd	nd	10	41	100	415	100	415
23	nd	nd	nd	nd	10	42	40	167	90	375
24	nd	nd	nd	nd	10	41	50	207	100	413
25	nd	nd	20	54	10	27	90	242	120	323
26	nd	nd	10	52	10	52	40	209	60	314
27	60	429	250	1786	50	357	230	1643	180	1286
28	nd	nd	30	53	10	18	90	159	130	230
29	10	31	10	31	20	61	90	276	110	337
30	nd	nd	nd	nd	nd	nd	30	199	60	397
21	10	40	10	40	nd	nd	nd	nd	50	136
32	nd	nd	nd	nd	nd	nd	nd	nd	10	35

	1,2-benzanthracene [benz(a)anthracene]		chrysene		benzo(b)fluoranthr		benzo(k)fluoranthr	
		261		384				
		1600		2800				
:	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt
Site ID	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd
3	10	19	60	113	nd	nd	nd	nd
4	nd	nd	10	29			nd	nd
5	nd	nd	10	15	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd	nd	nd
7	nd	nd	nd	nd	nd	nd	nd	nd
8	10	45	120	536	nd	nd	nd	nd
9	10	30	80	240	nd	nd	nd	nd
10	nd	nd	nd	nd	nd	nd	nd	nd
11	nd	nd	nd	nd	nd	nd	nd	nd
12	nd	nd	nd	nd	nd	nd	nd	nd
13	nd	nd	nd	nd	nd	nd	nd	nd
14	nd	nd	nd	nd	10	22	nd	nd
15	nd	nd	nd	nd	10	25	nd	nd
16	nd	nd	nd	nd	nd	nd	nd	nd
17	nd	nd	nd	nd	nd	nd	nd	nd
18	nd	nd	nd	nd	nd	nd	nd	nd
19	nd	nd	nd	nd	10	26	nd	nd
20	nd	nd	nd	nd	10	34	nd	nd
21	80	468	150	877	20	117	20	117
22	40	166	80	332	30	124	10	41
23	40	167	70	292	20	83	10	42
24	40	165	60	248	30	124	10	41
25	70	188	10	27	60	161	10	27
26	30	157	50	262	40	209	10	52
27	70	500	50	357	50	357	10	71
28	70	124	90	159	90	159	10	18
29	70	215	130	339	70	215	10	31
30	20	132	20	132	10	66	nd	nd
21	nd	nd	20	79	10	40	nd	nd
32	nd	nd	nd	nd	10	35	nd	nd

				430 1600		
ene	benzo(e)pyren		benzo(a)pyrene		1, 2, 5, 6-dibenzanthrac [dibenzo(a, h)anthrace	
	wet wg	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt
Site ID	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd
5	nd	nd	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd
7	nd	nd	nd	nd	nd	nd
8	nd	nd	nd	nd	nd	nd
9	nd	nd	nd	nd	nd	nd
10	nd	nd	nd	nd	nd	nd
11	nd	nd	nd	nd	nd	nd
12	nd	nd	nd	nd	nd	nd
13	nd	nd	nd	nd	nd	nd
14	10	22	10	22	20	43
15	nd	nd	nd	nd	nd	nd
16	nd	nd	nd	nd	nd	nd
17	nd	nd	nd	nd	nd	nd
18	nd	nd	nd	nd	nd	nd
19	nd	nd	20	53	nd	nd
20	60	206	10	34	nd	nd
21	40	234	30	175	20	117
22	80	332	30	124	nd	nd
23	70	292	90	375	170	708
24	60	248	50	207	30	124
25	70	188	130	349	140	376
26	40	209	50	262	60	314
27	50	357	60	429	40	286
28	60	106	120	212	230	406
29	80	245	90	276	70	215
30	40	265	20	132	20	132
21	nd	nd	10	40	nd	nd
32	nd	nd	20	70	nd	nd

			total	lHigh MWPAH
			4022	1700
			44792	9600
:ene				
:ne]	benzo(g,h,i)pyrene		total PAH	
	wet wgt	dry wgt	wet wgt	dry wgt
Site ID	ppb	ppb	ppb	ppb
1	nd	nd		nd
2	nd	nd		nd
3	nd	nd		150
4	nd	nd		29
5	nd	nd		15
6	nd	nd		nd
7	nd	nd		155
8	nd	nd		714
9	nd	nd		359
10	nd	nd		nd
11	nd	nd		nd
12	nd	nd		nd
13	nd	nd		nd
14	30	65		260
15	nd	nd		25
16	nd	nd		16
17	nd	nd		nd
18	nd	nd		nd
19	10	26		237
20	nd	nd		461
21	20	117		4269
22	30	124		1392
23	250	1042		3583
24	90	372		2190
25	200	538		2500
26	90	471		2565
27	90	643		8571
28	320	565		2208
29	160	491		2822
30	20	132		1589
21	10	40		476
32	nd	nd		139

Appendix E

Organochlorine analytes in sediment samples taken on St. Marks National Wildlife Refuge, 1988.

Organochlorine Compound (OC) Sediment Data Base for St. Marks National

			Edward R. Long et al 1995 (Environ				
			ERL		ppb dry wt		
			ERM				
MDL 10 ppb wet weight						HCB	
						Hexachlorobenz	
				Depth	% Moist	wet wgt	dry wgt
Site II	Geographical Name	Latitude	Longitud	(meters)		ppb	ppb
1	East River Pool	30°07.32	84°08.50	1	67	nd	nd
2	Mounds #1	30°06.10	84°09.10	1	85	nd	nd
3	Tower Pond	30°05.30	84°09.01	1	47	nd	nd
4	Mounds #3	30°05.85	84°08.30	1	66	nd	nd
5	East Riv/above Afri	30°06.52	84°09.82	2	33	nd	nd
6	East Riv/below Denh	30°06.29	84°10.10	1	34	nd	nd
7	Boat Basin/lighthou	30°05.05	84°10.42	1	87	nd	nd
8	Stony Bayou #2	30°06.80	84°07.10	1	78	nd	nd
9	Stony Bayou #1	30°07.30	84°08.30	1	67	nd	nd
10	Picnic Pond	30°05.22	84°09.80	2	69	nd	nd
11	St Marks Riv/Buoy 2	30°06.25	84°11.32	2	53	nd	nd
12	SMR/Buoy 27W	30°06.18	84°11.55	2	64	nd	nd
13	SMR/Buoy 42E	30°07.63	84°11.81	1	34	nd	nd
14	SMR/Oliver Bayou	30°07.63	84°11.81	1	54		
15	Big Boggy Bayou	30°10.30	84°13.06		60		
16	Wakulla Rv/below SM	30°09.59	84°12.38	1	37		
17	Wakulla Rv/Shell Is	30°09.83	84°12.67	1	41		
18	Wakulla Rv/2 mi mou	30°10.43	84°13.74	2	67		
19	SMR/above power pla	30°10.30	84°11.09	3	62		
20	SMR/East Side	30°09.49	84°12.10	2	71		
21	SMR/fuel docks	30°09.60	84°11.97	5	83		
22	SMR/Canal Marina	30°09.74	84°11.69	2	76		
23	SMR/turning basin S	30°09.68	84°11.61	4	76		
24	smR/marina	30°09.73	84°11.60	5	76		
25	SMR/turning basin N	30°09.72	84°11.57	3	63		
26	SMR/new marina N	30°09.82	84°11.63	2	81		
27	SMR/fuel loading	30°09.95	84°11.58	3	86	nd	nd
28	Power Plant/dischar	30°10.02	84°11.60	2	43	nd	nd
29	Power Plant/fuel lo	30°10.10	84°11.53	5	67	nd	nd
30	Power Plant/intake	30°10.25	84°11.58	3	85	nd	nd
21	SMR/below Newport E	30°12.19	84°10.38	2	75	nd	nd
32	SMR/above Newport E	30°12.53	84°10.25	1	71		

. Wildlife Refuge, Florida.

Manage 19(1):81-97.

	alpha-BHC		alpha-BHC		gamma-BHC		beta-BHC		delta-I
zene									
>	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt
Site #	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	nd	nd	nd	nd	nd	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd	nd	nd	nd
7	nd	nd	nd	nd	nd	nd	nd	nd	nd
8	nd	nd	nd	nd	nd	nd	nd	nd	nd
9	nd	nd	nd	nd	nd	nd	nd	nd	nd
10	nd	nd	nd	nd	nd	nd	nd	nd	nd
11	nd	nd	nd	nd	nd	nd	nd	nd	nd
12	nd	nd	nd	nd	nd	nd	nd	nd	nd
13	nd	nd	nd	nd	nd	nd	nd	nd	nd
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27	nd	nd	nd	nd	nd	nd	nd	nd	nd
28	nd	nd	nd	nd	nd	nd	nd	nd	nd
29	nd	nd	nd	nd	nd	nd	nd	nd	nd
30	nd	nd	nd	nd	nd	nd	nd	nd	nd
31	nd	nd	nd	nd	nd	nd	nd	nd	nd
32									

BHC		oxychlordane		Hept. Epox		gamma-chlorda	rt-nonachlor		
›	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt
Site II	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	nd	nd	nd	nd	nd	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd	nd	nd	nd
7	nd	nd	nd	nd	nd	nd	nd	nd	nd
8	nd	nd	nd	nd	nd	nd	nd	nd	nd
9	nd	nd	nd	nd	nd	nd	nd	nd	nd
10	nd	nd	nd	nd	nd	nd	nd	nd	nd
11	nd	nd	nd	nd	nd	nd	nd	nd	nd
12	nd	nd	nd	nd	nd	nd	nd	nd	nd
13	nd	nd	nd	nd	nd	nd	nd	nd	nd
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27	nd	nd	nd	nd	nd	nd	nd	nd	nd
28	nd	nd	nd	nd	nd	nd	nd	nd	nd
29	nd	nd	nd	nd	nd	nd	nd	nd	nd
30	nd	nd	nd	nd	nd	nd	nd	nd	nd
21	nd	nd	nd	nd	nd	nd	nd	nd	nd
32									

			23						2	
			180						27	
	toxaphene		Total PCBs		o,p-DDE		alpha-chlorda		p,p-DDE	
>	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	
Site II	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	Site II
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	1
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	2
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	3
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	4
5	nd	nd	nd	nd	nd	nd	nd	nd	nd	5
6	nd	nd	nd	nd	nd	nd	nd	nd	nd	6
7	nd	nd	nd	nd	nd	nd	nd	nd	nd	7
8	nd	nd	nd	nd	nd	nd	nd	nd	nd	8
9	nd	nd	nd	nd	nd	nd	nd	nd	nd	9
10	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
11	nd	nd	nd	nd	nd	nd	nd	nd	nd	11
12	nd	nd	nd	nd	nd	nd	nd	nd	nd	12
13	nd	nd	nd	nd	nd	nd	nd	nd	nd	13
14										14
15										15
16										16
17										17
18										18
19										19
20										20
21										21
22										22
23										23
24										24
25										25
26										26
27	nd	nd	nd	nd	nd	nd	nd	nd	nd	27
28	nd	nd	nd	nd	nd	nd	nd	nd	nd	28
29	nd	nd	nd	nd	nd	nd	nd	nd	nd	29
30	nd	nd	nd	nd	nd	nd	nd	nd	nd	30
21	nd	nd	nd	nd	nd	nd	nd	nd	nd	21
32										32

	Dieldrin		o,p-DDD		Endrin		cis-nonachlor	
dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt
ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	nd

Total DDT
1.58
46.1

	o,p-DDT		p,p-DDD		p,p-DDT		Mirex		Dicofol	
>	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt
Site II	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
8	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
9	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
11	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
12	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
13	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
28	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
29	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
30	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
21	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
32										

Chlorophenoxy Acid Herbicid MDL 10 ppb wet weight

	Dicamba		Dichloprop		2,4-D		Silvex		2,4,5-T	
>	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt	wet wgt	dry wgt
Site II	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5										
6										
7										
8	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
9	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
10	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
11										
12										
13										
14										
15										
16										
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24										
25										
26										
27										
28										
29										
30										
21										
32										

Chlorophenoxy Acid Herbicides

	2,4-DB		PCP	
>	wet wgt	dry wgt	wet wgt	dry wgt
Site II	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd
2	nd	nd	nd	nd
3	nd	nd	nd	nd
4	nd	nd	nd	nd
5				
6				
7				
8	nd	nd	nd	nd
9	nd	nd	nd	nd
10	nd	nd	nd	nd
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
21				
32				

Appendix F

Aliphatic hydrocarbon and oil and grease in sediment samples taken on St. Marks National Wildlife Refuge, 1988.

Aliphatic Hydrocarbon Sediment Data Base for St. Marks National Wil
Concentrationsprovided by lab in ppm wet wt. Calculated 1. ppb (ug/
2. wet weight ppb / % dry weight of sediment (not moist percent)

				n dodecane		n tridecane	
		Depth		wet wg	dry wg	wet wg	dry wg
Site ID	Geographical Name	(mt)	% MS	ppb	ppb	ppb	ppb
1	East River Pool	1.2	49	nd	nd	nd	nd
2	Mounds #1	0.9	87.8	20	164	20	164
3	Tower Pond	1.2	43.4	20	35	20	35
4	Mounds #3	0.9	55.6	20	45	20	45
5	East Riv/above Af	1.8	31.6	20	29	20	29
6	East Riv/below De:	0.6	37	60	95	40	63
7	Boat Basin/lighth	0.8	81	40	211	30	158
8	Stony Bayou #2	1.2	71.4	30	105	20	70
9	Stony Bayou #1	1.2	57	20	47	10	23
10	Picnic Pond	1.5	50	40	80	30	60
11	St Marks Riv/Buoy	2.3	52.6	20	42	20	42
12	SMR/Buoy 27W	1.5	61.8	60	157	40	105
13	SMR/Buoy 42E	1.2	30.8	30	43	20	29
14	SMR/Oliver Bayou	1.2	51.8	50	104	30	62
15	Big Boggy Bayou	0.9	56.4	50	115	40	92
16	Wakulla Rv/below	0.6	31.8	50	73	40	59
17	Wakulla Rv/Shell	0.8	38.8	10	16	nd	nd
18	Wakulla Rv/2 mi m	2.1	58	40	95	30	71
19	SMR/above power p	2.7	62	60	158	40	105
20	SMR/East Side	2.4	64.2	10	28	10	28
21	SMR/fuel docks	4.6	80.6	20	103	10	52
22	SMR/Canal Marina	2.3	73.4	30	113	20	75
23	SMR/turning basin	4.0	81.4	nd	nd	nd	nd
24	smR/marina	4.6	83.4	10	60	nd	nd
25	SMR/turning basin	2.7	73.4	20	75	10	38
26	SMR/new marina N	2.1	73.8	20	76	20	76
27	SMR/fuel loading	2.7	76.6	20	85	20	85
28	Power Plant/disch	1.7	39	40	66	30	49
29	Power Plant/fuel	4.6	67.8	30	93	20	62
30	Power Plant/intak	3.0	80.2	60	303	40	202
21	SMR/below Newport	2.1	63.2	30	82	20	54
32	SMR/above Newport	1.4	50.8	30	61	20	41

dlife Refuge, Florida.
g) dry weight : ppm *1000=ppb;

e	n tetradecan		cyclohexan		pentadecane		cyclohexane	
t	wet wg	dry wg	wet wg	dry wg	wet wg	dry wg	wet wg	dry wg
Site ID	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	nd	nd	20	39	nd	nd
2	nd	nd	10	82	20	164	nd	nd
3	10	18	nd	nd	20	35	nd	nd
4	nd	nd	nd	nd	30	68	nd	nd
5	nd	nd	nd	nd	10	15	nd	nd
6	20	32	10	16	20	32	10	16
7	10	53	10	53	40	211	20	105
8	10	35	20	70	20	70	nd	nd
9	10	23	20	47	nd	nd	nd	nd
10	10	20	nd	nd	20	40	10	20
11	10	21	nd	nd	10	21	nd	nd
12	10	26	10	26	20	52	10	26
13	nd	nd	nd	nd	10	14	nd	nd
14	10	21	10	21	30	62	20	41
15	10	23	80	183	130	298	nd	0
16	10	15	10	15	20	29	10	15
17	nd	nd	10	16	nd	nd	nd	nd
18	nd	nd	10	24	60	143	nd	nd
19	10	26	20	53	40	105	nd	nd
20	nd	nd	nd	nd	40	112	nd	nd
21	10	52	30	155	50	258	nd	nd
22	10	38	10	38	60	226	20	75
23	nd	nd	nd	nd	30	161	nd	nd
24	nd	nd	10	60	60	361	nd	nd
25	10	38	nd	nd	70	263	30	113
26	10	38	10	38	70	267	nd	nd
27	20	85	10	43	90	385	nd	nd
28	20	33	30	49	50	82	40	66
29	10	31	10	31	50	155	20	62
30	10	51	20	101	50	253	30	152
21	nd	nd	10	27	30	82	nd	nd
32	nd	nd	20	41	50	102	nd	nd

e t Site ID	n hexadecane wet wg ppb	 dry wg ppb	n heptadeca: wet wg ppb	 dry wg ppb	pristane wet wg ppb	 dry wg ppb	n octadecan wet wg ppb	 dry wg ppb
1	nd	nd	120	235	nd	nd	20	39
2	10	82	240	1967	nd	nd	30	246
3	20	35	470	830	nd	nd	30	53
4	20	45	420	946	nd	nd	20	45
5	10	15	60	88	nd	nd	10	15
6	30	48	120	190	nd	nd	30	48
7	30	158	360	1895	30	158	30	158
8	10	35	910	3182	nd	nd	50	175
9	nd	nd	190	442	nd	nd	10	23
10	20	40	150	300	nd	nd	30	60
11	10	21	100	211	nd	nd	20	42
12	20	52	140	366	nd	nd	30	79
13	10	14	40	58	nd	nd	10	14
14	30	62	100	207	20	41	20	41
15	20	46	20	46	nd	nd	20	46
16	20	29	40	59	nd	nd	20	29
17	nd	nd	10	16	nd	nd	10	16
18	10	24	10	24	nd	nd	20	48
19	20	53	40	105	10	26	20	53
20	20	56	90	251	10	28	20	56
21	20	103	120	619	20	103	20	103
22	30	113	90	338	30	113	20	75
23	20	108	70	376	10	54	10	54
24	30	181	90	542	20	120	20	120
25	40	150	100	376	30	113	30	113
26	40	153	150	573	30	115	30	115
27	50	214	120	513	40	171	30	128
28	50	82	90	148	30	49	50	82
29	20	62	80	248	10	31	20	62
30	30	152	110	556	10	51	30	152
21	10	27	60	163	20	54	20	54
32	20	41	70	142	10	20	20	41

e	phytane		n nonadecan		n eicosane		Total Aliphati		oil grease	
t	wet wg	dry wg	wet wg	dry wg	wet wg	dry wg	wet wg	dry wg ppm	wet	dry wg
Site ID	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1	nd	nd	50	98	30	59		471	470	922
2	40	328	50	410	20	164		3770	70	574
3	30	53	30	53	10	18		1166	400	707
4	10	23	20	45	20	45		1306	290	653
5	nd	nd	10	15	nd	nd		205	70	102
6	40	63	40	63	30	48		714	140	222
7	80	421	30	158	20	105		3842	110	579
8	20	70	40	140	30	105		4056	420	1469
9	nd	nd	10	23	10	23		651	250	581
10	nd	nd	20	40	30	60		720	340	680
11	20	42	30	63	20	42		549	160	338
12	30	79	30	79	10	26		1073	110	288
13	nd	nd	10	14	nd	nd		188	180	260
14	20	41	20	41	10	21		768	190	394
15	nd	nd	30	69	10	23		940	420	963
16	nd	nd	20	29	10	15		367	170	249
17	nd	nd	20	33	nd	nd		98	210	343
18	nd	nd	80	190	10	24		643	730	1738
19	10	26	60	158	40	105		974	350	921
20	20	56	60	168	70	196		978	270	754
21	20	103	110	567	40	206		2423	250	1289
22	40	150	40	150	nd	nd		1504	340	1278
23	20	108	60	323	40	215		1398	280	1505
24	30	181	80	482	60	361		2470	420	2530
25	40	150	80	301	nd	nd		1729	500	1880
26	40	153	60	229	nd	nd		1832	320	1221
27	40	171	110	470	nd	nd		2350	420	1795
28	40	66	110	180	20	33		984	540	885
29	20	62	80	248	nd	nd		1149	490	1522
30	20	101	60	303	20	101		2475	430	2172
21	30	82	180	489	10	27		1141	360	978
32	20	41	110	224	30	61		813	470	955