



Prepared in cooperation with the
NATIONAL PARK SERVICE

**Fish and Aquatic Invertebrate Communities in
Waterways, and Contaminants in Fish, at the
Barataria Preserve of Jean Lafitte National
Historical Park and Preserve, Louisiana, 1999-2000**

Science Investigations Report 04-XXXX

**U.S. Department of the Interior
U.S. Geological Survey**



United States Department of the Interior

U.S. GEOLOGICAL SURVEY

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Paul Conzelmann, National Park Service
Gulf Coast Network (I&M Prog.) Coordinator
635 Cajundome Blvd., Abdalla Hall Room 124
Lafayette, La. 70506

April 20, 2004

Dear Paul,

Enclosed please find a copy of the report "Fish and aquatic invertebrate communities in waterways, and contaminants in fish at the Barataria Preserve of Jean Lafitte National Historic Park and Preserve, Louisiana, 1999-2000" for your review and comments. The report contains data on fish and aquatic invertebrate communities at JELA/Barataria Unit, as well as exploratory contaminant analyses in fish tissue. I emphasize the exploratory aspect of the contaminant analyses. The focus of the work was the aquatic community structure and their potential use in assessing water-quality. A companion report on quality of water and bottom sediment at the Barataria Unit is currently at the printer. It is available as a .pdf file at our home page: la.water.usgs.gov.

The role of the wetlands at the Barataria Preserve in transforming mercury into bioavailable forms is complex. The roles and accompanying rates may differ depending on whether undisturbed conditions prevail or if perturbations such as river diversions dominate. The introduction of river water with sulfates and nutrients into organic marshes may facilitate the methylation of mercury, but much is unknown and unstudied. We are looking, within and outside the USGS for opportunities to work in-depth on this topic.

Comments and reviews can be sent to me at the following address:

US Geological Survey
3535 S. Sherwood Forest Blvd., Suite 120
Baton Rouge, Louisiana 70816

It is my sincere pleasure to work on science issues in National Parks, and especially the floating marshes of the Barataria Unit. I look forward to hearing from you. Please call me at 225-298-5481 ext 3219 if you have questions.

Chris Swarzenski
Hydrologist (Ecol)



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By Christopher M. Swarzenski, Scott V. Mize, Bruce A. Thompson¹,
and Gary W. Peterson²

U.S. GEOLOGICAL SURVEY
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¹ Coastal Fisheries Institute, Louisiana State University

² Coastal Ecology Institute, Louisiana State University

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Baton Rouge, Louisiana

2004

U.S. DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS, DATUMS, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
acre	4,047	square meter (m ²)
acre	0.004047	square kilometer (km ²)
square foot (ft ²)	929.0	square centimeter (cm ²)
square foot (ft ²)	0.09290	square meter (m ²)
Volume		
ounce, fluid (fl. oz)	0.02957	liter (L)
pint (pt)	0.4732	liter (L)
quart (qt)	0.9464	liter (L)
gallon (gal)	3.785	liter (L)
cubic inch (in ³)	0.01639	liter (L)
Mass		
ounce, avoirdupois (oz)	28.35	gram (g)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows: °F = 1.8 (°C + 32).

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD88). Horizontal coordinate information is referenced to the North American Datum of 1927.

Abbreviated water-quality units:

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given in micrograms per gram (µg/g).

micrometer (µm)

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By Christopher M. Swarzenski, Scott V. Mize, Bruce A. Thompson¹, and Gary W. Peterson²

Abstract

Fish and aquatic invertebrate communities in waterways of the Barataria Preserve of Jean Lafitte National Historical Park and Preserve, Louisiana, were surveyed from 1999 to 2000. An inventory of fish in the Barataria Preserve was established, and concentrations of selected organochlorine pesticides, polychlorinated biphenyls, and trace elements; iron; and manganese in fish tissue for selected species were determined. The fish and aquatic invertebrate sampling completed for this study indicated that abundant and diverse communities are present in the Barataria Preserve.

Thirty-two species of fish were identified in the Barataria Preserve during this survey. The total number of species identified in a single sampling ranged from 20 to 26. Most of the fish sampled are designated as intermediate in their tolerance to poor water quality. Three species of fish designated as tolerant (common carp, *Cyprinus carpio*; golden shiner, *Notemigonus crysoleucas*; and yellow bullhead, *Ameiurus natalis*), and one as intolerant (lake chubsucker, *Erimyzon sucetta*), were identified.

In November 1999, the average total weight of all fish collected from a single site was about 35,000 grams; in May and July 1999, the average total weight was between 9,000 and 10,000 grams. The contribution of spotted gar (*Lepisosteus oculatus*) to the total weight of the electroshocked fish averaged between 38 and 41 percent among the three sample periods. Members of the sunfish family (Centrarchidae) contributed between 18 and 28 percent of the total weight. For each sampling period, 60 to 83 percent of the total weight from the sunfish family was contributed by bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*).

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Aquatic invertebrates were sampled at three sites. Most aquatic invertebrates identified were freshwater species, but some were brackish-water and marine species. About 234,000 organisms were identified and enumerated from the richest-targeted habitat (RTH, floating rafts of aquatic plants). Individuals from 84 genera belonging to 51 families were identified. Diptera (true flies) was the most diverse group. Malacostraca (crustaceans) especially Amphipoda (scuds and sideswimmers), were the most abundant (36 percent). Total abundance and taxa richness of aquatic invertebrates were comparable during the March and July sampling in 1999, but were lower in samples collected from the same habitat at all three sites in April 2000. About 106 individuals were identified and enumerated from the depositional-targeted habitat (DTH, bottom material). Individuals from 7 genera belonging to 9 families were identified. Diptera was the most diverse group, and Annelida, especially tubificid worms, were the most abundant organisms identified (52 percent). Total abundance and composition of aquatic invertebrate communities differed between RTH and DTH at all three sites in April 2000.

Organic compounds in whole fish, and trace elements, iron, and manganese in filets, were analyzed in bowfin (*Amia calva*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and common carp (*Cyprinus carpio*). Organic compounds were not detected. Mercury was detected in filets of all four species. Highest concentrations of mercury were detected in filets from bowfin and largemouth bass. Mercury concentrations increased with increasing weight in the three predatory fish species (bowfin, bluegill, and largemouth bass), but were much lower, relative to weight, in the omnivore, common carp. Chromium concentrations were detected in tissue of the two larger fish, bowfin and common carp and bowfin. Cadmium and lead were not detected in any samples.

Mercury concentrations for larger predatory fish caught in Preserve waterways may reach levels of concern if frequently consumed by humans. The process of mercury accumulation appears to be natural, and not related to a local source problem. Mercury concentrations in comparable fish tissue at some other sites in coastal Louisiana were higher per unit wet weight of fish.

Introduction

The Barataria Preserve of Jean Lafitte National Historical Park and Preserve is a healthy 20,600-acre wetland ecosystem about 10 mi southwest of New Orleans, Louisiana (fig. 1). Proximity to a large metropolitan area and easy access to water make the Preserve a popular center for fishing; however, the abundant aquatic resources of the Preserve have not been systematically surveyed and tabulated prior to this study. To effectively manage these resources, information is needed about fish and aquatic invertebrate communities, as well as concentrations of selected contaminants in fish tissue.

Figure(s) /
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Many natural and anthropogenic factors influence water quality in the Barataria Preserve and may affect aquatic resources. In other studies, the U.S. Geological Survey (USGS) analyzed physical properties and selected major ions, trace elements, nutrients, and organic compounds of surface water and bottom material within the Barataria Preserve (Garrison, 1982; Swarzenski, 2004). These studies demonstrated that water with differing quality was entering the study area from several sources, including Lake Salvador, Segnette Waterway, and Bayou Villars. Stormwater runoff from suburban areas was also entering the Preserve. Bottom sediments contained some organic pollutants and some trace elements. DDT concentrations appeared to decrease over time, but PCB concentrations remained constant or increased. Concentrations of organic compounds and trace elements in surface water and bottom material (Swarzenski, 2004) were below levels at which the Canadian Council of Ministers of the Environment (1999) determined impairment of aquatic resources could occur.

Large-scale projects are being developed to restore the coastal wetlands (Barataria-Terrebonne National Estuary Program, 1994). One strategy is the diversion of freshwater from the Mississippi River across the levees into the wetlands to mimic the natural springtime overbank flooding that occurred before the levees were constructed. The Davis Pond diversion, located about 4 mi northwest of the Preserve, was scheduled to begin operation in 2001, and would result in a seasonal influx of nutrient- and sediment-rich water. As the Davis Pond diversion introduces Mississippi River water into the Park and Preserve, the fish and aquatic invertebrate communities in the Preserve may change in response to the change in water quality.

During 1999-2000, the USGS, in cooperation with the National Park Service, conducted a survey of fish and other aquatic communities in waterways of the Barataria Preserve to provide data essential to the effective management of these resources. Major objectives included (1) compiling an inventory of fish in the Preserve; (2) describing aquatic invertebrate and algal communities; (3) collecting data on concentrations of selected organochlorine pesticides, PCB's, and trace elements; iron; and manganese in fish tissue; and (4) compiling a list of submerged aquatic vegetation (SAV) observed in the waterways.

Purpose and Scope

This report describes fish and aquatic invertebrate community composition in waterways of the Barataria Preserve of Jean Lafitte National Historical Park and Preserve. Concentrations of selected contaminants in tissue and whole organism samples of four fish species commonly caught in waters of the Barataria Preserve and consumed by humans are presented. A list of SAV species observed during the survey also is presented, in appendix 1. Samples to determine algal populations in surface water of the Preserve were collected, but these data were not generated because of inconsistencies in sample processing and preservation between sampling periods. This survey will provide data on conditions in Preserve waterways prior to the diversion taking effect.

Description of Study Area

The Barataria Preserve includes swamp forests and large expanses of freshwater peat marsh, with interconnected canals and other waterways. The terrain is relatively flat; water flow is sluggish and bidirectional. The water in the canals and bayous is low in suspended sediment and high in dissolved organic compounds (Garrison, 1982). The bottom material consists of soft clays and silts with a high proportion of organic matter (Garrison, 1982; Skrobialowski, 2001). The Preserve is located in Barataria Basin, a low-lying interdistributary basin flanked by the Mississippi River to the east and a former distributary of the Mississippi River, Bayou Lafourche, to the west (fig. 1). The west side of the Barataria Preserve adjoins Lake Salvador.

There is a continuum from fresh to saltwater in Barataria Basin. Salinity of surface water in the basin varies and is determined by the mixture of marine water from the Gulf of Mexico and freshwater runoff from precipitation and local drainage. Direct inflow from the Mississippi River is limited and occurs through a diversion structure that crosses the

flood control levees. Canals, lakes, and bayous connect the Gulf of Mexico to the most inland parts of the basin. There is no structural impediment to flow of water and material. An excellent description of Barataria Basin is given by Conner and Day (1987). They discuss the physical environment and climatic forcing factors, and provide profiles of all estuarine habitats and communities in this subtropical estuary.

Approach and Methods

Fish samples were collected along canal banks. Their habitat consisted of overhanging wax-myrtle (*Myrica cerifera*) shrubs sometimes reaching into the water, SAV, and occasional tree stumps or logs. The SAV at three sites were identified (app. 1). The SAV provides shelter for species such as golden topminnow (*Fundulus crysotus*), western mosquitofish (*Gambusia affinis*), and banded pygmy sunfish (*Elassoma zonatum*), as well as the early life-history stages of many of the larger species such as spotted gar (*Lepisosteus oculatus*) and largemouth bass (*Micropterus salmoides*) (Ross, 2001). Aquatic invertebrates were sampled from rafts of floating vegetation or the soft bottom sediments.

Fish and aquatic invertebrates were sampled and SAV noted at Tarpaper Canal near Keyhole 6 (site 1, fig. 2), Pipeline Canal west of Crown Point (site 2), and North Twin Canal (site 3), following techniques established by the National Water-Quality Assessment (NAWQA) Program (Meador and others, 1993; Cuffney and others, 1993). Sites 2 and 3 were on or near sites for which contaminant data on bottom material was known (Swarzenski, 2004). At sites 4 and 6, only fish were sampled. Fish were sampled in mid-May, late July, and early November 1999 to determine seasonal variations and community structure. Aquatic invertebrates were sampled in mid-March and late July 1999, and again in mid-April 2000, also to assess seasonality in communities. In contrast to fish, aquatic invertebrates were sampled in April 2000 rather than in November 1999. Fall sampling, originally planned for late September, was delayed until early November. It was decided that fish collections would not be affected by the delay, but that invertebrate communities could be depauperate that late in the year, and not representative. Hence, invertebrate sampling was postponed until the following spring.

At sites 1-3, fish were surveyed on both banks of a reach of canal (transects A and B) with a boat-mounted electroshocker. Site 1 was 800 m in length, site 2 was 700 m, and site 3 was 500 m. The same transects were sampled each time at each site. During fish collection, the boat was maneuvered slowly along the bank. The hull served as the

Figure(s) 2
near here

cathode. A pole-mounted anode ring covered with small-mesh netting was manually swept through and under the diverse microhabitats. This net and two additional nets were used to capture the fish, which were put into buckets filled with canal water. After both sides of a reach were electrofished, the fish were identified, weighed, length measured, physical deformities noted, and then released back into the canal. These data were used to tabulate fish species and individual numbers.

To determine if smaller fish species and early life-history stages were efficiently sampled by electrofishing, two additional sites (sites 4 and 6) were sampled during each trip using a seine 10 ft in length, with 3/16-in. mesh. For each trip, three to four seine hauls were made along a short length of canal in shallow-marsh (site 4) or swamp-forest (site 6) habitat. Site 4 also was sampled in mid-May at two randomly selected points with a 1-m² drop-net sampler. Fish species collected using these techniques were compared with those collected by electrofishing to evaluate sampling efficiency.

Aquatic invertebrate communities were sampled from richest-targeted habitat (RTH) and depositional-targeted habitat (DTH) (Cuffney and others, 1993) at sites 1-3. The RTH selected was the floating rafts of aquatic plants, primarily water-hyacinth (*Eichornea crassipes*), along the banks of the waterways. In coastal Louisiana freshwater areas, floating rafts of vegetation are considered preferred habitat not only for invertebrates in the water column but also for some invertebrates more typically found in bottom sediment (Sklar, 1985). Within each reach, the underside of five rafts was scooped using a 0.25-m², fine-mesh (425- μ m), wire-rim net, and the scooped material was composited in a 19-L bucket. Invertebrates were carefully picked out of the vegetation, preserved in a 10-percent formalin solution, and shipped to the NWQL for enumeration and taxonomic identification. Rare and large organisms were preserved separately. DTH, sampled only in April 2000, was fine-grained material from the waterway bottom. At each of the three sites, five samples were collected with a petite Ponar sampler with a surface area of 0.24 m² (a combined surface area of 1.2 m²), and composited for analysis. Invertebrates in bottom material retained by a 425- μ m sieve were removed, preserved in a 10-percent formalin solution, and shipped to the NWQL.

Bowfin (*Amia calva*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and common carp (*Cyprinus carpio*), in consultation with the Natural Resource Manager of Jean Lafitte National Historical Park and Preserve, were selected for contaminant analyses. Two species were collected and submitted for analyses in July, and two additional species were collected and submitted for analyses during the November trip. The largest individuals of the targeted species that were collected at sites 1-3 were analyzed for selected chemicals. This number varied

depending on the catch from electrofishing. Whole fish were homogenized, composited, and analyzed for organochlorine pesticides and PCB's. Skin-off fish fillets were composited and analyzed for trace elements, iron, and manganese. Samples were chilled and sent to the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado.

Acknowledgments

The authors thank Sandee Dingmann and David Muth of the National Park Service for their assistance with all aspects of the survey.

Fish and Aquatic Invertebrate Communities

Water quality greatly influences the composition and relative abundances of aquatic communities including fish and invertebrates. Aquatic communities can be useful indicators of water quality (Karr, 1981; Barbour and others, 1995). Chemical and physical surveys of water quality may not always detect problematic water quality, since they are subject to continuously fluctuating conditions. Frequent sampling may be needed to detect poor water-quality. In contrast, fish and aquatic invertebrates have life cycles that span months to years and integrate water-quality conditions over long periods. In an area where habitat quality is good and remains stable, the presence and relative abundances of taxa can be used to evaluate water quality and determine whether an optimal community composition (high biotic integrity) is present along a given reach of waterway. Of the two aquatic communities, fish live longer, often surviving several years; invertebrates generally have lifespans of less than a year.

For aquatic communities to be useful as indicators of biotic integrity and water quality, the optimal community composition in a given physiographic area should be well documented. A pristine or minimally affected area in an environmental setting similar to the proposed study area must first be identified (Karr and Chu, 1997). This pristine area is sampled for several successive years so that seasonal and inter-annual variations of individuals and species can be documented. Taxa and relative abundances at the study site(s) then are compared to those from the reference site. In the absence of data from reference sites, routine monitoring over several years can help determine the stability of the communities. For this study, fish and aquatic invertebrates were sampled in a manner that would permit these data being included in long-term assessments of water quality and biotic integrity in the Preserve.

Fish

In the Barataria Preserve, there were small variations in the number and taxa of fish sampled during the three trips. The fish sampling completed for this study indicated that abundant and diverse communities are present in the Barataria Preserve. With the exception of the common carp, all fish collected are native to Barataria Basin. Fish were most abundant in November 1999. Specific conductance, an important influence on aquatic community composition, increased in Preserve waterways from 1,000-3,000 $\mu\text{S}/\text{cm}$ to 4,000-6,000 $\mu\text{S}/\text{cm}$ during the study (fig. 3).

Figure(s) 3
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During this survey, 16 families, comprising 32 species of fish, were identified in the Barataria Preserve. They are listed, along with ecological affinity and pollution tolerance where that information was available, in table 1. Fish in the Barataria Preserve during the study were similar to those found in freshwater swamps and low-salinity marshes of coastal Louisiana (Conner and Day, 1987). Of the 32 species identified, 22 had freshwater affinities. All life-history stages of many of the species were present. The total number of species found during a single sampling event ranged from 20 to 26. Seining added from 1 to 2 species to the total during each sampling event. The total was lowest in July 1999, when only two of the three sites were sampled. This also is a stressful period of the year in terms of high water temperature and low dissolved-oxygen concentrations (fig. 3). Two to four species were unique to each of the three sampling periods.

Catfish (Family Ictaluridae) were not found in the July 1999 sampling. Bowfin (*Amia calva*) were abundant in the November sampling, were observed but not caught in the May sampling, and were not observed or caught during the July sampling. Seven members of the sunfish family (Centrarchidae) were identified in the Barataria Preserve during this study. Sixteen species belonging to the sunfish family are found in freshwater systems in Louisiana.

Most of the fish collected in the Barataria Preserve for this study are classified as intermediate in their tolerance to poor water quality (table 1). Only three species identified during this study are designated as tolerant: the common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*) and yellow bullhead (*Ameiurus natalis*). Small numbers of lake chubsucker (*Erimyzon sucetta*) were collected in the May and November samples. This species is classified as intolerant of poor water quality (Barbour and others, 1999).

Table(s)
 nearby

Table 1. Ecological affinity, trophic guild, and relative pollution tolerance of fish species identified at the Barataria Preserve, Jean Lafitte National Historical Park and Preserve in May, July, and November 1999.

[Y, fish identified during sampling period; N, fish not identified during sampling period; Ys, fish captured only by seine; --, not known]

Fish species by family ¹		Ecological affinity ¹	Trophic guild ²	Relative pollution tolerance ³	Sampling date (1999)		
Scientific name (common name)	May 17-19				July 26-28	November 1-3	
FAMILY							
Genus species							
LEPISOSTEIDAE (gars)							
<i>Lepisosteus oculatus</i> (spotted gar)	Freshwater	Piscivore	Intermediate	Y	Y	Y	
AMIIDAE (bowfins)							
<i>Amia calva</i> (bowfin)	Freshwater	Piscivore	Intermediate	Y	N	Y	
ANGUILLIDAE (freshwater eels)							
<i>Anguilla rostrata</i> (American eel)	Catadromous	Piscivore	Intermediate	Y	N	N	
CLUPEIDAE (herrings)							
<i>Brevoortia patronus</i> (gulf menhaden)	Estuarine/marine	--	--	N	Y	Y	
<i>Dorosoma cepedianum</i> (gizzard shad)	Freshwater	Omnivore	Intermediate	Y	Y	Y	
<i>Dorosoma petenense</i> (threadfin shad)	Freshwater	Omnivore	Intermediate	N	N	Y	
ENGRAULIDAE (anchovies)							
<i>Anchoa mitchilli</i> (bay anchovy)	Estuarine/marine	--	--	Y	Y	Y	
CYPRINIDAE (carps and minnows)							
<i>Cyprinus carpio</i> (common carp)	Freshwater	Omnivore	Tolerant	Y	Y	Y	
<i>Notemigonus crysoleucas</i> (golden shiner)	Freshwater	Omnivore	Tolerant	Y	Y	Y	
CATOSTOMIDAE (suckers)							
<i>Erymizon sucetta</i> (lake chubsucker)	Freshwater	Insectivore	Intolerant	Y	N	Y	
ICTALURIDAE (bullhead catfish)							
<i>Ameiurus natalis</i> (yellow bullhead)	Freshwater	Insectivore	Tolerant	N	N	Y	
<i>Ictalurus furcatus</i> (blue catfish)	Freshwater	Piscivore	Intermediate	Y	N	N	
<i>Ictalurus punctatus</i> (channel catfish)	Freshwater	Piscivore	Intermediate	Y	N	Y	
BELONIDAE (needlefish)							
<i>Strongylura marina</i> (Atlantic needlefish)	Estuarine/marine	Insectivore/Piscivore		Y	N	N	
CYPRINODONTIDAE (toothcarps)							
<i>Cyprinodon variegatus</i> (sheepshead minnow)	Estuarine	Omnivore	Intermediate	Ys	N	N	
FUNDULIDAE : (killifish and topminnows)							
<i>Fundulus chrysotus</i> (golden topminnow)	Freshwater	--	--	Y	Y	Y	
<i>Fundulus grandis</i> (Gulf killifish)	Estuarine	Piscivore	--	N	N	Ys	
<i>Fundulus pulvereus</i> (bayou topminnow)	Estuarine	--	--	N	Ys	N	
<i>Lucania parva</i> (rainwater killifish)	Estuarine	--	--	Y	Y	Y	
POECILIIDAE (livebearers)							
<i>Gambusia affinis</i> (western mosquitofish)	Freshwater	Insectivore	Intermediate	Y	Y	Y	
<i>Heterandria formosa</i> (least killifish)	Freshwater	--	--	Y	Y	N	
<i>Poecilia latipinna</i> (sailfin molly)	Freshwater	--	--	Ys	Y	Y	
ATHERINIDAE (silversides)							
<i>Menidia beryllina</i> (inland silverside)	Estuarine	--	--	N	Y	N	
ELASSOMIDAE (pigmy sunfish)							
<i>Elassoma zonatum</i> (banded pygmy sunfish)	Freshwater	Insectivore	Intermediate	Y	N	Y	

Table 1. Ecological affinity, trophic guild, and relative pollution tolerance of fish species identified at the Barataria Preserve, Jean Lafitte National Historical Park and Preserve in May, July, and November 1999.—Continued
[Y, fish identified during sampling period; N, fish not identified during sampling period; Ys, fish captured only by seine; --, not known]

Fish species by family ¹	Ecological affinity ¹	Trophic guild ²	Relative pollution tolerance ³	Sampling date (1999)		
				May 17-19	July 26-28	November 1-3
CENTRARCHIDAE (sunfish)						
→ <i>Chaenobryttus (Lepomis) gulosus</i> (warmouth)	Freshwater	Piscivore	Intermediate	Y	Y	Y
<i>Lepomis macrochirus</i> (bluegill)	Freshwater	Insectivore	Intermediate	Y	Y	Y
<i>Lepomis microlophus</i> (redeer sunfish)	Freshwater	Insectivore	Intermediate	Y	Y	Y
→ <i>Lepomis miniatus</i> (redspotted sunfish)	Freshwater	--	--	Y	Y	Y
<i>Lepomis symmetricus</i> (bantam sunfish)	Freshwater	Insectivore	Intermediate	Y	Y	Y
<i>Micropterus salmoides</i> (largemouth bass)	Freshwater	Piscivore	Intermediate	Y	Y	Y
<i>Pomoxis nigromaculatus</i> (black crappie)	Freshwater	Piscivore	Intermediate	Y	N	Y
MUGILIDAE (MULLETS)						
<i>Mugil cephalus</i> (striped mullet)	Estuarine/marine	--	--	Y	Y	Y
TOTAL				26	20	25
Exclusive to sampling period				4	2	3

¹ Fish species by family taxonomic nomenclature (scientific names and common names) follow Robins and others, 1991.

² Trophic guild based on Appendix C of Barbour and others, 1999.

³ Relative pollution tolerance based on Appendix C of Barbour and others, 1999.

The total number of species found during each sampling trip was similar, but the number of individuals and the total weight of fish sampled was much higher in November 1999 (table 2). In May and July, the total weight of electroshocked fish from a single site averaged between 9,000 and 10,000 g; in November, the average weight of all fish from a single site was about 35,000 g. The number of individuals for most species and families increased by 3 to 5 times in November. Catfish were an exception, with both the number of individuals and the average weight per individual decreasing in November collections. The higher specific conductance at this time could be a factor (fig. 3). The contribution of spotted gar (*Lepisosteus oculatus*) to the total weight of the electroshocked fish averaged 38 to 41 percent among the three sample periods. Members of the sunfish family contributed between 18 and 28 percent to the total fish weight. Bowfin (*Amia calva*) and common carp (*Cyprinus carpio*) contributed almost 25 percent of weight in November; their relative contribution to total weight was less in the two earlier sampling periods. The average weight per individual for most species was lowest in July.

Table(s) 2
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Table 2. Abundance, weight, length, and weight distribution of dominant fish sampled at the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, in May, July, and November 1999.
[NA, not applicable]

Dominant fish	1 May 15-17				2 July 26-28				1 November 1-3			
	Number of individuals	Average weight per individual (grams)	Average length per individual (mm)	Contribution to total sample weight (percent)	Number of individuals	Average weight per individual (grams)	Average length per individual (mm)	Contribution to total sample weight (percent)	Number of individuals	Average weight per individual (grams)	Average length per individual (mm)	Contribution to total sample weight (percent)
CLUPEIDAE (herrings) Gizzard shad, <i>Dorosoma cepedianum</i>	5	180	194	3	2	54	90	1	21	137	204	3
CYPRINIDAE (carps and minnows) Common carp, <i>Cyprinus carpio</i>	1	1,106	331	4	1	2,041	410	11	5	3,665	498	17
LEPISOSTEIDAE (gars) Spotted gar, <i>Lepisosteus oculatus</i>	20	570	377	39	20	349	402	38	92	473	394	41
ICTALURIDAE (bullhead catfish) (3 species total)	12	631	270	26	0	NA	NA	NA	4	321	238	1
CENTRARCHIDAE (sunfish) (7 species total)	189	28	79	18	231	23	70	28	790	31	92	23
AMIIDAE (bowfins) Bowfin, <i>Amia calva</i>	0	NA	NA	NA	0	NA	NA	NA	6	1,015	366	6
MUGILIDAE (mullets) Striped mullet, <i>Mugil cephalus</i>	11	234	207	9	23	173	181	22	28	294	225	8
May 15-17												
Total weight, in grams, of above categories		28,871				18,307				104,588		
Total weight, in grams, of all fish collected		29,550				18,343				104,809		
Average weight of fish collected, in grams per meter of shoreline sampled		7.2				6.1				26.2		
July 26-28												
November 1-3												

¹ Three sites sampled.

² Two sites sampled.

³ Standard length used (from tip of snout to base of tail).

All seven members of the sunfish family (Centrarchidae) found in the Barataria Preserve during this study were collected during each sampling period, with the exception of black crappie (*Pomoxis nigromaculatus*), which was not collected in July (table 3). Bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) contributed 60 to 83 percent of the total Centrarchidae weight during each sampling period (table 3). In November, redear sunfish (*Lepomis microlophus*) contributed 29 percent of the total weight (table 3).

Table(s) near here

Table 3. Abundance, weight, and weight distribution of sunfish (Family Centrarchidae) sampled at the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, in May, July, and November 1999.
[<, less than indicated value]

Sunfish species	¹ May 15-17			² July 26-28			¹ November 1-3		
	Number of individuals	Average weight per individual (grams)	Contribution to total sample weight (percent)	Number of individuals	Average weight per individual (grams)	Contribution to total sample weight (percent)	Number of individuals	Average weight per individual (grams)	Contribution to total sample weight (percent)
Warmouth, <i>Chaenobryttus gulosus</i>	7	110	14	3	20	1	27	39	4
Bluegill, <i>Lepomis macrochirus</i>	77	22	33	45	34	29	270	29	32
Redear sunfish, <i>Lepomis microlophus</i>	28	31	16	35	21	14	354	20	29
Redspotted sunfish, <i>Lepomis miniatus</i>	8	17	3	27	2	1	64	12	3
Bantam sunfish, <i>Lepomis symmetricus</i>	4	3	<1	20	2	1	8	1	<1
Largemouth bass, <i>Micropterus salmoides</i>	63	27	32	101	28	54	56	121	28
Black crappie, <i>Pomoxis nigromaculatus</i>	2	48	2	0	0	0	11	79	4
	May 15-17			July 26-28			November 1-3		
Total weight (grams)	5,318			5,198			24,285		

¹Three sites sampled.

²Two sites sampled.

Seasonal sampling of three sites (sites 1-3) using a boat-mounted electroshocker appeared to provide a good representation of fish community composition in Preserve waterways. A minimum of three sample-collection sites probably is necessary to describe fish communities. Species generally were added with each additional transect

sampled (fig. 4). Fish were most abundant, and the full complement of species for a particular trip was reached more quickly, in November; but May sampling yielded the highest number of species, and the highest number of species uniquely collected during a single sampling event. Using only a boat-mounted electroshocker may suffice to describe fish communities in Preserve waterways over time. The boat-mounted electroshocker (sites 1-3) captured 29 of the 32 species of fish found during this study. Seining at two additional sites (4 and 6) only added 3 species: sheepshead minnow (*Cyprinodon variegatus*), Gulf killifish (*Fundulus grandis*), and bayou topminnow (*Fundulus pulvereus*). The drop-net sampler (site 4) did not add to the species list. A boat-mounted electroshocker can sample larger areas more efficiently than other techniques.

Figure(s) 4
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Aquatic Invertebrates

The fish and aquatic invertebrate sampling completed for this study indicated that abundant and diverse communities are present in the Barataria Preserve. Most aquatic invertebrates identified in the Barataria Preserve were freshwater species, but some brackish-water and marine species also were collected. In April 2000, total abundance (number of organisms) and taxa richness (number of taxa) declined, and changes in community composition occurred in the RTH at all three sites, compared to March and July 1999. Abundance and composition of aquatic invertebrate communities differed between RTH and DTH habitats at all three sites.

Richest-Targeted Habitat

About 234,000 organisms were identified and enumerated from the RTH during the study. Organisms are listed in appendix 2, along with densities and total abundances for each sampling period. Individuals from 84 genera belonging to 51 families were identified. Thirty-five individuals were identified to species. Taxa identified to Order, and their respective densities for the three sampling periods, are listed in table 4. Sites having the most richness did not necessarily have the highest total abundance. Diptera (true flies) was the most diverse group (38 taxa), followed by Coleoptera (beetles; 23 taxa), and Gastropoda (snails, limpets; 17 taxa). Malacostraca (crustaceans), especially Amphipoda, were the most abundant (36 percent) followed by other noninsects (sponges, hydras, moss animals, flatworms, roundworms, leeches, and eight-legged arthropods; 19 percent) and Diptera (14 percent), especially the family Chironomidae (midges).

Table(s) 4
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Table 4. Taxa, densities, and percentages of aquatic invertebrates in richest-targeted habitat in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000.

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. --, species not collected]

Taxa	Tarpaper Canal near Keyhole 6 (site 1)						Pipeline Canal west of Crown Point (site 2)						North Twin Canal (site 3)					
	3/16/99		7/27/99		4/21/00		3/16/99		7/27/99		4/21/00		3/16/99		7/27/99		4/21/00	
	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent
PHYLUM																		
CLASS																		
ORDER																		
PORIFERA (sponges)	--	--	--	--	--	--	--	--	67	0.22	--	--	--	--	59	0.29	--	--
CNIDARIA (coelenterates)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HYDROZOA (hydras)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HYDROIDA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	59	.29	--	--
BRYOZOA (moss animals)	--	--	--	--	--	--	50	0.26	--	--	--	--	108	0.26	59	.29	--	--
PLATYHELMINTHES (flatworms)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TURBELLARIA (free-living flatworms)	212	0.86	392	0.67	--	--	101	.53	874	2.81	--	--	748	1.80	176	.87	67	0.28
NEMERTEA (proboscis worms)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ENOPLA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HOPLONERTEA	--	--	--	--	--	--	50	.26	--	--	--	--	--	--	--	--	--	--
NEMATODA (roundworms)	--	--	22,540	38.55	20	0.27	--	--	6,250	20.10	--	--	1,818	4.38	1,588	7.85	--	--
MOLLUSCA (clams, snails, and limpets)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BIVALVIA (bivalve molluscs)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VENEROIDA	--	--	--	--	--	--	--	--	--	--	--	--	3	.01	59	.29	--	--
GASTROPODA (snails, limpets)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BASOMMATOPHORA	1,348	5.45	5,106	8.73	40	.55	403	2.12	3,231	10.39	161	2.13	8,570	20.65	1,717	8.48	136	.57
MESOGASTROPODA	215	.87	395	.68	--	--	--	--	201	.65	--	--	--	--	648	3.20	--	--
ANNELIDA (segmented worms)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HIRUDINEA (leeches)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ARHYNCHOBELLA	--	--	--	--	--	--	1	.01	--	--	--	--	--	--	--	--	1	.00
RHYNCHOBELLA	72	0.29	1	.00	20	.27	4	.02	--	--	--	--	6	.01	1	.00	268	1.13
OLIGOCHAETA (aquatic worms)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TUBIFICIDA	847	3.43	12,936	22.12	--	--	1,866	9.80	2,957	9.51	--	--	2,139	5.15	941	4.65	2,419	10.19
ARTHROPODA (arthropods)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ARACHNIDA (eight-legged arthropods)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ACARI (water mites)	988	4.00	2,744	4.69	60	.82	252	1.32	1,277	4.11	--	--	1,603	3.86	1,294	6.39	67	.28
MALACOSTRACA (crustaceans)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AMPHIPODA (scuds, sideswimmers)	17,441	70.53	3,921	6.71	5,907	80.60	8,527	44.80	4,638	14.92	5,230	69.33	15,086	36.35	6,358	31.41	11,022	46.41
DECAPODA (crayfishes, shrimps)	4	.02	5	.01	5	.07	10	.05	72	.23	71	.94	7	.02	4	.02	2	.01
ISOPODA (aquatic sow bugs)	917	3.71	--	--	81	1.11	1,413	7.42	2	.01	0	.00	1,925	4.64	1	.00	1,612	6.79
MYSIDA (opossum shrimps)	80	.32	--	--	202	2.76	--	--	--	--	484	6.42	--	--	--	--	--	--
INSECTA (insects)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
COLEOPTERA (beetles)	154	0.62	6	.01	--	--	262	1.38	154	.50	25	.33	881	2.12	257	1.27	2	0.01
COLLEMBOLA (springtails)	635	2.57	--	--	--	--	101	.53	67	.22	23	.30	855	2.06	235	1.16	--	--
DIPTERA (true flies)	1,277	5.16	5,693	9.74	482	6.58	5,154	27.08	5,511	17.73	483	6.40	5,675	13.67	2,827	13.97	5,173	21.78
EPHEMEROPTERA (mayflies)	9	.04	2,951	5.05	40	.55	59	.31	5,108	16.43	46	.61	1,503	3.62	2,592	12.81	942	3.97
HEMiptERA (true bugs)	443	1.79	599	1.02	128	1.75	110	.58	70	.23	192	2.55	121	.29	184	.91	480	2.02
LEPIDOPTERA (aquatic caterpillars)	5	.02	196	.34	60	.82	50	.26	67	.22	69	.91	217	.52	--	--	134	.56
ODONATA (damselfly/dragonflies)	79	.32	793	1.36	244	3.33	621	3.26	207	.67	760	10.07	236	.57	1,122	5.54	1,423	5.99
TRICHOPTERA (caddisflies)	1	.00	197	.34	40	.55	--	--	337	1.08	--	--	--	--	60	.30	--	--
TOTAL	24,727	100.00	58,475	100.00	7,329	100.00	19,034	100.00	31,090	100.00	7,544	100.00	41,501	100.00	20,241	100.00	23,748	100.00

The largest seasonal variation in composition in RTH samples from spring (March 1999) to summer (July 1999) occurred at sites 1 and 2 (fig. 5). Malacostraca, which dominated in the spring samples at all sites (41 to 75 percent of the community), decreased in relative abundance by 10 to 68 percent in the summer samples; Amphipoda decreased by 64 percent at site 1 and by 30 percent at site 2. In contrast, other noninsects, nematodes in particular, increased in relative abundance by 38 percent at site 1 and by 20 percent at site 2 from spring to summer. Ephemeroptera (mayflies) and Trichoptera (caddisflies) also increased in relative abundance from spring to summer by 5 to 17 percent at all sites. The smallest seasonal variation in relative abundance between sampling periods was at site 3, at the marsh-swamp interface.

Figure(s) 5
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Ephemeroptera, Plecoptera (stoneflies), and Trichoptera, referred to collectively as EPT, generally are intolerant to pollution or perturbation, and are expected to decrease with water-quality degradation (Barbour and others, 1999). The percentage of EPT in a sample, therefore, can be related to water-quality conditions. Typically, aquatic invertebrates are subjected to the most stress in the summer, when water temperatures are high and dissolved-oxygen concentrations are low (Hynes, 1970). However, in the Barataria Preserve, mayflies and caddisflies in RTH samples were proportionally more abundant in July than during the other two sampling periods. Stoneflies prefer cool running waters (Hynes, 1970) and usually are not present in the waterways of southern Louisiana. No stoneflies were present in any of the invertebrate samples collected from the Barataria Preserve. Mayflies, especially *Caenis*, which is generally considered a more tolerant mayfly, composed the largest percentage of EPT at all sites in July.

Compared to the samples collected in 1999, total abundance and taxa richness of RTH decreased at all sites between RTH samples collected in the spring 1999 and 2000 (fig. 6). At sites 1 and 2, total abundance was greatest in July 1999; at site 3, however, total abundance was greatest in March 1999. Taxa richness of aquatic invertebrates in RTH samples was comparable in March and July 1999, but was lower in samples from all three sites in April 2000. Total abundance and taxa richness in April 2000 were highest at site 3. A nearby water-quality data-collection site (N-10, fig. 2) near site 3 exhibited the smallest increase in specific conductance of all sites in waterways during the study (fig. 3). Total abundance in spring samples decreased by 30 to 57 percent and taxa richness decreased by 46 to 64 percent from 1999 to 2000 (fig. 6). The largest decrease in total abundance occurred at site 3, and the largest decrease in taxa richness occurred at site 1.

Figure(s) 6
nearhere

Composition measures such as relative abundance (fig. 5) and the proportion of the five dominant taxa (fig. 7) illustrate the differences between 1999 and 2000 spring samples. Mollusca (clams, snails, and limpets), especially Gastropoda, as well as other noninsects, decreased in relative abundance at all sites except site 2, where relative abundance of Mollusca remained the same. The relative abundance of Malacostraca, particularly Amphipoda, increased by 10 to 24 percent at all sites from 1999 to 2000, with the largest increase occurring at site 2. Perturbation may increase the dominance of a few taxa (Barbour and others, 1999). The five dominant taxa (fig. 7) increased by 7 to 20 percent at all sites, with the largest increase occurring at site 2 from 1999 to 2000.

Figure(s) 7
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The decrease in total abundance and taxa richness, and the changes in community composition between March 1999 and April 2000, are likely due to drought conditions in southern Louisiana (Swenson and others, 2003), and the corresponding increase in salinity as measured by the specific conductance values that occurred between July 1999 and April 2000 in Preserve waterways (Swarzenski, 2004). During that time, salinity was much higher than is usual for this part of Barataria Basin (Swarzenski, 1994). Elevated salinity in Preserve waterways broke up large rafts of floating water-hyacinth (*Eichornia crassipenes*) that had clogged canals near the data-collection sites for 2 or more years, reducing the RTH in the Preserve. Sikora and Sklar (1987, p. 62) noted that seasonal changes in floating aquatic raft extent affected the abundance of aquatic invertebrates. Aquatic invertebrate communities in floating aquatic rafts in the Preserve may be influenced by the higher salinity and overall loss in habitat that occur during regional droughts.

Depositional-Targeted Habitat

Aquatic invertebrates in bottom material at the three sites were sampled only in April 2000. About 106 organisms were identified and enumerated from all the DTH samples. Individuals from 7 genera belonging to 9 families were identified (app. 3). Four individuals were identified to species. Diptera (true flies) was the most diverse group (5 taxa), followed by Malacostraca (crustaceans; 4 taxa) and Annelida (worms; 3 taxa). Together, these three groups comprised more than 94 percent of the individual aquatic invertebrates collected in DTH samples. Annelida, especially tubificid worms, were the most abundant (52 percent) followed by Diptera (26 percent, especially the family Chironomidae (midges)) and Malacostraca (16 percent). The aquatic invertebrate communities represented

in DTH samples from this survey were similar in composition to the communities found in bottom material during the earlier survey by Garrison (1982).

The total abundance and taxa richness of aquatic invertebrate communities differed between the RTH and DTH samples collected from all three sites in April 2000 (fig. 8). The RTH had substantially more individuals (38,621 aquatic invertebrates), and higher taxa richness (26 to 45 taxa) than the DTH (106 aquatic invertebrates, 3 to 7 taxa), even though roughly the same total area (about 1.2 m²) was sampled. These findings were similar to those of an earlier study of a swamp forest in Barataria Basin (Sikora and Sklar, 1987; Sklar, 1985), in which floating plant rafts contained the most abundant and diverse invertebrate communities. One possible explanation for the lower total abundance and taxa richness in DTH environments may be the low dissolved-oxygen concentrations and lack of diverse habitat and food resources in bottom sediments, compared to floating plant rafts.

Compositional differences in RTH and DTH samples collected in April 2000 from site 3 distinguish this site from the other sites in the Preserve. Noninsects, primarily crustaceans (amphipods such as scuds and sideswimmers) and annelid worms, dominated all RTH and DTH samples from sites 1 and 2 and the RTH sample from site 3. At site 3, insects (mostly midges) dominated the DTH sample (fig. 9). Crustaceans, primarily mysids (opossum shrimps) and annelids in the order Polychaeta (marine worms), which are almost exclusively marine species (Pennak, 1954), were present in April 2000 samples from sites 1 and 2. Mysids were present in RTH and DTH samples from site 1, and only in RTH samples from site 2 (table 5). Polychaets were present only in DTH samples at sites 1 and 2. The presence of mysids and polychaets in April samples was consistent with the increase in specific conductance (fig. 3) at these sites.

Figure(s) 8
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Figure(s) 9
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Table(s) 5
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Table 5. Taxa, densities, and percentages of aquatic invertebrates in richest-targeted habitat and depositional-targeted habitat in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, April 2000.

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. RTH, richest-targeted habitat; DTH, depositional-targeted habitat; --, species not collected; * Suborder]

PHYLUM CLASS ORDER	Taxa	Tarpaper Canal near Keyhole 6 (site 1)				Pipeline Canal west of Crown Point (site 2)				North Twin Canal (site 3)			
		RTH		DTH		RTH		DTH		RTH		DTH	
		Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent	Den- sity	Per- cent
	PLATYHELMINTHES (flatworms)	--	--	--	--	--	--	--	--	--	--	--	--
	TURBELLARIA (free-living flatworms)	--	--	--	--	--	--	--	--	67	0.28	--	--
	NEMATODA (roundworms)	20	0.27	--	--	--	--	--	--	--	--	--	--
	MOLLUSCA (clams, snails, and limpets)	--	--	--	--	--	--	--	--	--	--	--	--
	GASTROPODA (snails, limpets)	--	--	--	--	--	--	--	--	--	--	--	--
	BASOMMATOPHORA	40	0.55	--	--	161	2.13	--	--	136	0.57	--	--
	PROSOBRANCHIA*	--	--	--	--	--	--	2	5.13	--	--	--	--
	ANNELIDA (segmented worms)	--	--	--	--	--	--	--	--	--	--	--	--
	HIRUDINEA (leeches)	--	--	--	--	--	--	--	--	--	--	--	--
	ARHYNCHOBDELLAE	--	--	--	--	--	--	--	--	1	0.00	--	--
	RHYNCHOBDELLAE	20	0.27	--	--	--	--	--	--	268	1.13	--	--
	OLIGOCHAETA (aquatic worms)	--	--	--	--	--	--	--	--	--	--	--	--
	TUBIFICIDA	--	--	34	56.67	--	--	10	25.64	2,419	10.19	2	28.57
	POLYCHAETA (marine worms)	--	--	--	--	--	--	--	--	--	--	--	--
	TEREBELLIDA	--	--	4	6.67	--	--	5	12.82	--	--	--	--
	ARTHROPODA (arthropods)	--	--	--	--	--	--	--	--	--	--	--	--
	ARACHNIDA (eight-legged arthropods)	--	--	--	--	--	--	--	--	--	--	--	--
	ACARI (water mites)	60	0.82	2	3.33	--	--	--	--	67	0.28	--	--
	MALACOSTRACA (crustaceans)	--	--	--	--	--	--	--	--	--	--	--	--
	AMPHIPODA (scuds, sideswimmers)	5,907	80.60	8	13.33	5,230	69.33	7	17.95	11,022	46.41	--	--
	DECAPODA (crayfishes, shrimps)	5	0.07	--	--	71	0.94	--	--	2	0.01	--	--
	ISOPODA (aquatic sow bugs)	81	1.11	--	--	0	0.00	--	--	1,612	6.79	--	--
	MYSIDA (opossum shrimps)	202	2.76	2	3.33	484	6.42	--	--	--	--	--	--
	INSECTA (insects)	--	--	--	--	--	--	--	--	--	--	--	--
	COLEOPTERA (beetles)	--	--	--	--	25	0.33	--	--	2	0.01	--	--
	COLLEMBOLA (springtails)	--	--	--	--	23	0.30	--	--	--	--	--	--
	DIPTERA (true flies)	482	6.58	8	13.33	483	6.40	15	38.46	5,173	21.78	5	71.43
	EPHEMEROPTERA (mayflies)	40	0.55	--	--	46	0.61	--	--	942	3.97	--	--
	HEMIPTERA (true bugs)	128	1.75	--	--	192	2.55	--	--	480	2.02	--	--
	LEPIDOPTERA (aquatic caterpillars)	60	0.82	--	--	69	0.91	--	--	134	0.56	--	--
	ODONATA (damself/dragonflies)	244	3.33	2	3.33	760	10.07	--	--	1,423	5.99	--	--
	TRICHOPTERA (caddisflies)	40	0.55	--	--	--	--	--	--	--	--	--	--
	TOTAL	7,329	100.00	60	100.00	7,544	100.00	39	100.00	23,748	100.00	7	100.00

Contaminants in Fish

Three predators, bowfin (*Amia calva*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*), and the omnivore common carp (*Cyprinus carpio*) were selected for analyses because of their feeding habits (trophic level) and frequency of human consumption. Their biology and feeding habitats are described in detail by Ross (2001). Bowfin feed in the water column, consuming a diet mostly of fish and also large crustaceans such as crayfish. Bluegill typically feed in the water column, primarily on zooplankton, but also on terrestrial and aquatic insects. Largemouth bass also feed in the water column, consuming aquatic insects and fish (bluegill, and gizzard and threadfin shads). Bowfin also feed in the water column, consuming a diet mostly of fish and also large crustaceans such as crayfish. Common carp are bottom feeders, sifting through soft mud and detritus for food.

Whole fish analyses did not detect any organic compounds (table 6). In a concurrent study, organic compounds were not found in Preserve waterways, with the exception of the herbicide 2,4-D, which was detected at one of three sites during one of three sampling events. 2,4-D is occasionally sprayed onto floating aquatic vegetations in parts of the Preserve to keep waterways clear for boats (Swarzenski, 2004).

Table(s) 6
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Trace elements, iron, and manganese analyzed in fish filets are listed in table 7. Mercury (as total Hg) was detected in all four species, with greatest concentrations detected in largemouth bass and bowfin. Mercury concentrations increased with increasing wet weight in the three predatory fish species, but were much lower, relative to weight, in the common carp (fig. 10). Arsenic was not detected in bluegill and common carp tissue, but was detected in largemouth bass and bowfin. Chromium concentrations were detected in tissue of the two largest fish, common carp and bowfin, suggesting that weight (a surrogate for age), plays a role in accumulation of this trace element. Cadmium and lead were below detection in all tissue samples. The smallest fish, bluegill, had the highest concentrations of manganese, selenium, and strontium.

Table(s) 7
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Figure(s) 10
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Sampling for contaminants was exploratory and was limited to a few fish per analysis. In a more rigorous sampling scheme, typically filets from at least eight individuals of similar size and caught at a single location would be composited to establish age-related concentrations of contaminants. Fish would be electroshocked for the sole purpose of obtaining sufficient individuals of a single age class. Although mercury concentrations are expected to increase as fish increase in weight, the linear trend indicated in figure 10 seems to be somewhat idealized. The relation between age and tissue contaminant concentration is better quantified using larger, more robust sampling populations.

Table 6. Concentrations of selected organochlorine pesticides, and polychlorinated biphenyls in whole tissue of fish from selected waterways in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, July and November 1999.

[Values for constituents, except lipids, are measured in wet weight, recoverable, in micrograms per kilogram. <, less than indicated value]

Species:	Bluegill (<i>Lepomis macrochirus</i>)	Largemouth bass (<i>Micropterus salmoides</i>)	Bowfin (<i>Amia calva</i>)	Common carp (<i>Cyprinus carpio</i>)
Sample date:	July 28		November 1	
Number of individual fish composited:	4	3	2	2
Average fresh weight (grams):	60	279	1,389	3,815
Constituents	Concentrations			
Percent lipids, in whole fish	0.7	0.9	2.5	6.6
Aldrin	<5	<5	<5	<5
Alpha-BHC	<5	<5	<5	<5
Benzene, hexa-chloro-	<5	<5	<5	<5
Beta-BHC	<5	<5	<5	<5
Cis-chlordane	<5	<5	<5	<5
Cis-nonachlor	<5	<5	<5	<5
DCPA	<5	<5	<5	<5
Delta-BHC	<5	<5	<5	<5
Dieldrin	<5	<5	<5	<5
Endrin	<5	<5	<5	<5
Heptachlor epoxide	<5	<5	<5	<5
Heptachlor	<5	<5	<5	<5
Lindane	<5	<5	<5	<5
Methoxychlor, O, P' -	<5	<9	<5	<5
Methoxychlor, P, P' -	<5	<5	<5	<5
Mirex	<5	<5	<5	<5
O, P' -DDD	<5	<5	<5	<5
O, P' -DDE	<5	<5	<5	<5
O, P' -DDT	<5	<5	<5	<5
Oxychlordane	<5	<5	<5	<5
P, P' -DDD	<5	<5	<5	<5
P, P' -DDE	<5	<5	<5	<5
P, P' -DDT	<5	<5	<5	<5
Pentachloroanisole	<5	<5	<5	<5
Toxaphene	<200	<200	<200	<200
Trans-chlordane	<5	<5	<5	<5
Trans-nonachlor	<5	<5	<5	<5
Polychlorinated biphenyls	<50	<50	<50	<50

Table 7. Concentrations of selected trace elements, iron, and manganese in muscle (fillet) tissue of fish from selected waterways in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, July and November 1999.

[Values for constituent,s except water, are measured in dry weight, recoverable, in micrograms per gram. <, less than indicated value]

Species:	Bluegill (<i>Lepomis macrochirus</i>)	Largemouth bass (<i>Micropterus salmoides</i>)	Bowfin (<i>Amia calva</i>)	Common carp (<i>Cyprinus carpio</i>)
Sample date:	July 28		November 1	
Number of individual fish composited:	4	2	2	1
Average fresh weight (grams):	81	380	1,602	5,557
Constituents	Concentrations			
Percent water in tissue	82	80	79	79
Aluminum	<1.0	<1.0	<1.0	<1.0
Antimony	<.3	<.2	<.2	<.2
Arsenic	<.3	.6	1.4	<.2
Barium	.8	<.1	.3	.9
Beryllium	<.3	<.2	<.2	<.2
Boron	.9	.9	1.2	.7
Cadmium	<.3	<.2	<.2	<.2
Chromium	<.5	<.5	.6	.5
Cobalt	<.3	<.2	<.2	<.2
Copper	.9	.8	1	2.8
Iron	5	7	12	73
Lead	<.3	<.2	<.2	<.2
Manganese	2.4	.5	1.1	1.5
Mercury	.2	.4	1.5	.2
Molybdenum	<.3	<.2	<.2	<.2
Nickel	<.3	<.2	<.2	<.2
Selenium	3.8	1.9	.8	.8
Silver	<.3	<.2	<.2	<.2
Strontium	6.9	1	2.3	4.7
Vanadium	<.3	<.2	<.2	<.2
Zinc	24	17	14	25

In most adult fish, 90-100 percent of the total mercury present is in the form of methylmercury. This is the biologically active and toxic form of mercury. An advisory of fish consumption by humans at indicated levels of methylmercury is given in table 8. Consumption of fish with tissue methylmercury concentrations of 0.1 to 0.15 µg/g wet tissue weight (0.5 to 0.75 µg/g dry tissue weight, assuming 80 percent moisture content for fish) should be limited to less than 10 g of wet weight fillet per day. This amount is equivalent to about 1/4 of a cup of fish or one fish sandwich

Table(s) 8
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per week (table 8) (U.S. Environmental Protection Agency, 2001, p. 4). The consistent linear increase in mercury concentration with increasing fish weight at the Barataria Preserve (fig. 10) suggests concentrations for larger fish caught in Preserve waterways may reach levels of concern for humans, if frequently consumed.

Table 8. Monthly fish consumption limits for methylmercury.
[Source: U.S. Environmental Protection Agency, 2001, p. 5]

Risk-based consumption limit for humans		Noncancer health endpoints	
Fish meals ¹ per month		Fish tissue concentration, micrograms per gram wet weight ²	
	16		>0.03 to 0.06
	12		>0.06 to 0.08
	8		>0.08 to 0.12
	4		>0.12 to 0.24
	3		>0.24 to 0.32
	2		>0.32 to 0.48
	1		>0.48 to 0.97
	0.5		>0.97 to 1.9
	None		>1.9

¹A fish meal is assumed to be about 227 grams wet weight; consumer weight is 70 kilograms; reference dose for methylmercury is 10^{-4} milligrams per kilogram per day.

²To convert to dry weight concentration, multiply wet weight concentration by 5; a moisture content of 80 percent was assumed for fish.

In many waters in Louisiana, mercury concentrations are sufficiently high in fish fillets to be of concern (Louisiana Department of Environmental Quality, no date; Louisiana Department of Health and Hospitals, 1998). There are 35 consumptive advisories (including a statewide coastal advisory) listed for Louisiana by the Louisiana Department of Health and Hospitals (1998). Mercury concentrations in comparable fish tissue at some other sites in coastal Louisiana were higher per unit wet weight of fish (fig. 10), indicating that mercury is not an issue specific to the Barataria Preserve, with a unique local source. Mercury concentrations in bottom material of Preserve waterways were between 0.01 and 0.03 $\mu\text{g/g}$ sediment dry weight in a recent survey at Barataria Preserve (Swarzenski, 2004). These concentrations are below levels that would raise toxicity concerns for aquatic life (Canadian Council of Ministers of the Environment, 1999).

The sources and processes by which mercury becomes available to, and accumulates in, aquatic organisms in areas where direct inputs of mercury appear to be low, such as the Preserve waterways, is not well understood. There is no apparent local source to Preserve waterways that can be mitigated or removed. Wetland environments in general

appear to play a key role because of anaerobic conditions in soils. Highly organic soils, for example the Everglades marshes or the peat marshes that make up much of the Preserve, also may be important in making mercury bioavailable. Studies of mercury cycling in wetlands (Krabbenhof and others, 1999; Gilmour, 1998) suggest that, under certain conditions, wetlands may make atmospheric mercury deposited in wetlands more readily available for biological uptake. This is because the reduction of sulfate to sulfide, which occurs in the anaerobic wetland soils containing sulfate, may facilitate methylation of mercury. Further study on this issue in the Preserve is warranted, especially in light of the Davis Pond diversion. The diversion may change the way sulfates enter Barataria Preserve wetlands, which could enhance mercury methylation rates.

Summary and Conclusions

page

Fish and aquatic invertebrate communities in waterways of the Barataria Preserve of the Jean Lafitte National Historical Park and Preserve, Louisiana, were surveyed from 1999 to 2000. An inventory of fish in the Barataria Preserve was established, and concentrations of selected organochlorine pesticides, polychlorinated biphenyls, and trace elements; iron; and manganese for selected fish species were determined. The fish and aquatic invertebrate sampling completed for this study indicated that abundant and diverse communities are present in the Barataria Preserve.

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Fish were surveyed at three sites in Preserve waterways in May, July, and November 1999. Sixteen families, comprising 32 species of fish, were identified in the Barataria Preserve during this survey. Of the 32 species, 22 had freshwater affinities. All life-history stages of many of the species were present.

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The total number of fish species found in a single sampling ranged from 20 to 26. The total was lowest in July, when only two of the three sites were sampled. Between 2 and 4 species were unique to each of the three sampling periods. A boat-mounted electroshocker was sufficient to collect most species; seining added from 1 to 2 species to the total during each sampling event. A drop-net sampler did not add to the species list.

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In November, the average weight of all fish recovered from a single site was about 35,000 grams; in May and July the average weight of all fish from a single site was between 9,000 and 10,000 grams. The number of individuals for most species or categories also increased, by about 3 to 5 times, in November. The contribution of spotted gar (*Lepisosteus oculatus*) to the total weight of the electroshocked fish averaged between 38 and 41 percent among the three sample periods. Bowfin (*Amia calva*) and common Carp (*Cyprinus carpio*) contributed almost 25 percent of fish weight in November; their relative contribution to total weight was less in the two earlier sampling periods. Members of the sunfish family (Centrarchidae) contributed between 18 and 28 percent of the total fish weight; for each sampling period, bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) contributed 60 to 83 percent of the total Centrarchidae weight. The average weight per individual for most species or categories was lowest in July.

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Most of the fish collected in the Barataria Preserve during this study are classified as intermediate in their tolerance to poor water quality. Three species designated as tolerant of poor water quality, the common carp (*Cyprinus*

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carpio), golden shiner (*Notemigonus crysoleucas*), and yellow bullhead (*Ameiurus natalis*), and one intolerant species, lake chubsucker (*Erimyzon sucetta*), were identified during the study.

Aquatic invertebrates were sampled from three sites in March and July 1999 and April 2000. Most aquatic invertebrates identified in the Barataria Preserve were freshwater species, but some were brackish-water and marine species. About 234,000 organisms were identified and enumerated from the richest-targeted habitat (RTH, floating rafts of aquatic plants) during the study. Individuals from 84 genera belonging to 51 families were identified. Thirty-five individuals were identified to species. Diptera (true flies) was the most diverse group (38 taxa), and Malacostraca (crustaceans), especially Amphipoda, were the most abundant (36 percent).

Total abundance and taxa richness of aquatic invertebrates in RTH samples were comparable during the March and July sampling in 1999, but were lower in samples collected from the same habitat at all three sites in April 2000. From 1999 to 2000, total abundance in spring samples decreased by 30 to 57 percent and taxa richness decreased by 46 to 64 percent. The largest decrease in total abundance occurred at site 3 (North Twin Canal); the largest decrease in taxa richness occurred at site 1 (Tarpaper Canal near Keyhole 6). Composition measures such as relative abundance and proportion of the five most dominant taxa illustrate the differences between 1999 and 2000 spring samples. Mollusca (clams, snails, and limpets), especially Gastropoda, as well as other noninsects, decreased in relative abundance at all sites except site 2 (Pipeline Canal west of Crown Point), where relative abundance of Mollusca remained the same. The relative abundance of Malacostraca, particularly Amphipoda, increased by 10 to 24 percent at all sites from 1999 to 2000, with the largest increase occurring at site 2. The five most dominant taxa increased by 7 to 20 percent at all sites, with the largest increase occurring at site 2.

The decrease in total abundance and taxa richness and the changes in community composition between March 1999 and April 2000 are likely due to drought conditions in southern Louisiana and the corresponding increase in salinity in waterways of the Barataria Preserve. Elevated salinity in Preserve waterways broke up large rafts of floating water hyacinth, reducing the RTH. Salinity levels in surface water were atypically high by April 2000 at all three sites.

Aquatic invertebrates in bottom material at the three sites were sampled only in April 2000. About 106 individuals were identified and enumerated from all depositional-targeted habitat (DTH, bottom material) samples.

Individuals from 7 genera belonging to 9 families were identified. Four individuals were identified to species. Diptera was the most diverse group (5 taxa), and Annelida, especially tubificid worms, were the most abundant (52 percent).

Total abundance and composition of aquatic invertebrate communities differed between RTH and DTH at all three sites in April 2000. The RTH environment had substantially more individuals (38,621 aquatic invertebrates) than the DTH environment (106 aquatic invertebrates), even though roughly the same total area (about 1.2 square miles) was sampled. Compositional differences in RTH and DTH samples collected from site 3 distinguish this site from the other sites in the Preserve. Noninsects dominated all RTH and DTH samples from sites 1 and 2, and the RTH sample from site 3. Insects (mostly midges) dominated the DTH sample from site 3. The presence of mysids (opossum shrimps) and polychaets (marine worms), which are almost exclusively marine species, were present only in samples from sites 1 and 2. This was consistent with the increase in specific conductance at these sites. Sampling of aquatic invertebrate communities may have potential for evaluating water-quality conditions and trends in the Barataria Preserve.

Three predators, bowfin (*Amia calva*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*), and the omnivore common carp (*Cyprinus carpio*) were selected for contaminant analyses. Organic compounds were not detected in any whole fish analyses. Mercury was detected in fillets of all four species sampled. The greatest concentrations of mercury were detected in bowfin and largemouth bass. Mercury concentrations increased with increasing wet weight in the three predatory fish species, but were much lower, relative to weight, in the omnivore. Arsenic was detected in bowfin and largemouth bass. Chromium concentrations were detected in tissue of the two larger fish, bowfin and common carp, suggesting that weight plays a role in accumulation of this trace element. Cadmium and lead concentrations were below detection in all tissue samples.

The consistent linear increase in mercury concentration with increasing fish weight at the Barataria Preserve suggests that mercury concentrations for larger predatory fish caught in Preserve waterways may reach levels of concern if frequently consumed by humans. The process of mercury accumulation appears to be natural, and not related specifically with Preserve waterways or a local source problem. Mercury concentrations in comparable fish tissue at some other sites in coastal Louisiana were higher per unit wet weight of fish, supporting the conclusion that mercury is not an issue specific to the Barataria Preserve. Other studies of mercury cycling in wetlands suggest that

wetlands under certain conditions may make atmospheric mercury deposited in wetlands more readily available for biological uptake. The reduction of sulfate to sulfide which occurs in anaerobic wetland soils, provided there is a source of sulfate, may facilitate methylation of mercury. The Davis Pond diversion, ^{p. 3} about 4 miles northwest of the Preserve, may change the way sulfates enter Barataria Preserve wetlands, which could enhance mercury methylation rates. As the diversion introduces Mississippi River water into the Park and Preserve, the fish and aquatic invertebrate communities in the Preserve may change in response to the change in water quality.

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Appendix 1. Submerged aquatic vegetation observed along transects of waterways sampled for fish ^{in the} Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000.

Species	Common name	Characteristic
<i>Azolla caroliniana</i>	Mosquito-fern	Free-floating
<i>Ceratophyllum demersum</i>	Coontail	Free-floating
<i>Eichornea crassipes</i>	Water hyacinth	Free-floating
<i>Utricularia macrorhiza</i>	Common bladderwort	Free-floating
<i>Cabomba caroliniana</i>	Fanwort	Rooted, floating
<i>Nymphaea odorata</i>	Water lily	Rooted, floating
<i>Hydrilla verticillata</i>	Hydrilla	Rooted, submerged
<i>Myriophyllum spicatum</i>	Eurasian water-milfoil	Rooted, submerged
<i>Vallisneria americana</i>	Tapegrass, wild celery	Rooted, submerged
<i>Potamogeton epihydrus</i>	Ribbon-leaf pondweed	Rooted, submerged, and floating-leaved
<i>Heteranthera reniformis</i>	Kidney-leaf mud plantain	Free-floating and submerged

Appendixes 2 and 3
are in Excel - will
be converted to Frame-
Maker and formatted
to USGS standards.

Appendix 2. Taxa, densities, and total number of aquatic invertebrates in richest-targeted habitat at selected sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000.

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. --, species not collected; *, Suborder; **, Subfamily; ***, Tribe]

Taxonomic Hierarchy ¹	Tarpaper Canal near Keyhole 6 (site 1)			Pipeline Canal west of Crown Point (site 2)			North Twin Canal (site 3)		
	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00
PHYLUM									
CLASS									
ORDER									
Family									
Genus species									
PORIFERA (sponges)	--	--	--	--	67	--	--	59	--
CNIDARIA (coelenterates)	--	--	--	--	--	--	--	--	--
HYDROZOA (hydras)	--	--	--	--	--	--	--	--	--
HYDROIDA	--	--	--	--	--	--	--	--	--
Hydridae	--	--	--	--	--	--	--	--	--
<i>Hydra</i> sp.	--	--	--	--	--	--	--	59	--
BRYOZOA (moss animals)	--	--	--	50	--	--	108	59	--
PLATYHELMINTHES (flatworms)	--	--	--	--	--	--	--	--	--
TURBELLARIA (free-living flatworms)	212	392	--	101	874	--	748	176	67
NEMERTEA (proboscis worms)	--	--	--	--	--	--	--	--	--
ENOPLA	--	--	--	--	--	--	--	--	--
HOPLONEMERTEA	--	--	--	--	--	--	--	--	--
Tetrastemmatidae	--	--	--	--	--	--	--	--	--
<i>Prostoma</i> sp.	--	--	--	50	--	--	--	--	--
NEMATODA (roundworms)	--	22,540	20	--	6,250	--	1,818	1,588	--
MOLLUSCA (clams, snails, and limpets)	--	--	--	--	--	--	--	--	--
BIVALVIA (bivalve molluscs)	--	--	--	--	--	--	--	--	--
VENEROIDA	--	--	--	--	--	--	--	--	--
Sphaeriidae (fingernail clams)	--	--	--	--	--	--	--	--	--
Sphaeriinae**	--	--	--	--	--	--	--	59	--
<i>Musculium</i> sp.	--	--	--	--	--	--	3	--	--
GASTROPODA (snails, limpets)	--	--	--	--	--	--	--	--	--
BASOMMATOPHORA	--	--	--	--	269	--	427	59	--
Ancylidae (limpets)	141	2,548	--	--	538	--	1,711	118	--
<i>Ferrissia</i> sp.	--	392	--	--	--	--	--	--	--
<i>Hebetancylus excentricus</i>	--	1	--	50	134	--	429	235	--
<i>Laevapex fuscus</i>	--	2	--	--	--	--	6	3	--
<i>Laevapex</i> sp.	1	--	--	--	202	--	1	294	67
Lymnaeidae (pond snails)	71	--	--	50	--	--	321	--	--
<i>Fossaria / Stagnicola</i> sp.	--	--	--	--	--	--	108	--	--
<i>Pseudosuccinea columella</i>	1	--	--	--	--	--	--	--	1
Physidae (pouch snails)	--	--	--	--	--	--	--	--	--
<i>Physella</i> sp.	1,060	1,372	40	303	1,277	161	3,746	588	67
Planorbidae (orb snails)	71	588	--	--	605	--	321	294	--
<i>Biomphalaria havanensis</i>	2	201	--	--	4	--	2	6	--
<i>Micromenetus dilatatus</i>	1	2	--	--	134	--	1,497	59	--
<i>Micromenetus</i> sp.	--	--	--	--	--	--	--	--	--

Appendix 2. Taxa, densities, and total number of aquatic invertebrates in richest-targeted habitat at selected sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000. — *Continued*

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. --, species not collected; *, Suborder; **, Subfamily; ***, Tribe]

Taxonomic Hierarchy ¹	Tarpaper Canal near Keyhole 6 (site 1)			Pipeline Canal west of Crown Point (site 2)			North Twin Canal (site 3)		
	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00
PHYLUM									
CLASS									
ORDER									
Family									
Genus species									
<i>Planorbella</i> sp.	--	--	--	--	68	--	1	61	1
MESOGASTROPODA	--	--	--	--	--	--	--	--	--
Hydrobiidae	212	392	--	--	134	--	--	647	--
<i>Amnicola</i> sp.	3	3	--	--	--	--	--	--	--
<i>Pyrgophorus</i> sp.	--	--	--	--	67	--	--	1	--
ANNELIDA (segmented worms)	--	--	--	--	--	--	--	--	--
HIRUDINEA (leeches)	--	--	--	--	--	--	--	--	--
ARHYNCHOBDELLAE	--	--	--	--	--	--	--	--	--
Erpobdellidae	--	--	--	1	--	--	--	--	1
RHYNCHOBDELLAE	--	--	--	--	--	--	--	--	--
Glossiphoniidae	71	--	20	--	--	--	--	--	134
<i>Helobdella stagnalis</i>	--	--	--	--	--	--	--	1	134
<i>Helobdella triserialis</i>	--	1	--	--	--	--	6	--	--
Piscicolidae	--	--	--	--	--	--	--	--	--
<i>Myzobdella lugubris</i>	1	--	--	4	--	--	--	--	--
OLIGOCHAETA (aquatic worms)	--	--	--	--	--	--	--	--	--
TUBIFICIDA	--	--	--	--	--	--	--	--	--
Naididae	776	12,740	--	1,866	2,957	--	2,139	941	2,419
Tubificidae	71	196	--	--	--	--	--	--	--
ARTHROPODA (arthropods)	--	--	--	--	--	--	--	--	--
ARACHNIDA (eight-legged arthropods)	--	--	--	--	--	--	--	--	--
ACARI (water mites)	988	2,744	60	252	1,277	--	1,603	1,294	67
MALACOSTRACA (crustaceans)	--	--	--	--	--	--	--	--	--
AMPHIPODA (scuds, sideswimmers)	8,542	588	423	2,778	336	207	8,665	647	672
Corophiidae	--	--	--	--	--	--	--	--	--
<i>Corophium</i> sp.	73	196	--	--	--	--	--	--	--
Crangonyctidae	--	--	--	--	--	--	--	--	--
<i>Crangonyx</i> sp.	--	--	--	--	--	--	427	--	605
<i>Synurella</i> sp.	--	--	20	--	--	--	--	--	--
Gammaridae	--	--	--	--	--	--	--	--	--
<i>Gammarus</i> sp.	1,411	--	1,634	907	--	3,664	--	--	2,823
Hyalellidae	--	--	--	--	--	--	--	--	--
<i>Hyalella azteca</i>	7,415	3,137	3,830	4,842	4,302	1,359	5,994	5,711	6,922
DECAPODA (crayfishes, shrimps)	--	--	--	--	--	--	--	--	--
Cambaridae	1	--	3	--	1	--	--	--	2
<i>Cambarillus shufeldtii</i>	--	--	--	--	68	--	--	1	--
Palaemonidae (prawns and river shrimps)	--	--	--	--	--	--	--	--	--
<i>Palaemonetes kadiakensis</i>	1	--	--	4	--	--	6	2	--

Appendix 2. Taxa, densities, and total number of aquatic invertebrates in richest-targeted habitat at selected sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000. *Continued*

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. --, species not collected; *, Suborder; **, Subfamily; ***, Tribe]

Taxonomic Hierarchy ¹	Tarpaper Canal near Keyhole 6 (site 1)			Pipeline Canal west of Crown Point (site 2)			North Twin Canal (site 3)		
	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00
PHYLUM									
CLASS									
ORDER									
Family									
Genus species									
<i>Palaemonetes paludosus</i>	2	4	2	6	3	2	1	1	--
<i>Palaemonetes</i> sp.	--	1	--	--	--	69	--	--	--
ISOPODA (aquatic sow bugs)	353	--	--	--	--	--	--	--	--
Asellidae	--	--	--	706	--	--	535	--	134
<i>Caecidotea</i> sp.	564	--	81	707	2	--	1,390	1	1,478
MYSIDA (opossum shrimps)	--	--	--	--	--	--	--	--	--
Mysidae	--	--	--	--	--	--	--	--	--
<i>Taphromysis louisianae</i>	80	--	202	--	--	484	--	--	--
INSECTA (insects)	--	--	--	--	--	--	--	--	--
COLEOPTERA (beetles)	--	--	--	--	--	--	--	--	--
Curculionidae (weevils)	76	1	--	--	74	--	323	61	--
Dytiscidae (predaceous diving beetles)	--	--	--	--	--	--	--	--	--
Colymbetinae**	--	--	--	--	--	--	--	--	--
Agabini***	--	--	--	--	--	--	--	--	--
<i>Ilybius</i> sp.	--	--	--	--	--	--	--	1	--
Matini***	--	--	--	--	--	--	--	--	--
<i>Matus</i> sp.	--	1	--	--	--	--	108	--	--
Cybistrinae**	--	--	--	--	--	--	--	--	--
<i>Cybister fimbriolatus</i>	--	--	--	--	--	--	1	--	--
<i>Cybister</i> sp.	--	2	--	2	4	2	2	--	1
Hydroporinae**	--	--	--	--	--	--	--	--	--
Bidessini***	71	--	--	--	--	--	--	--	--
Hydrovatini***	--	--	--	--	--	--	--	--	--
<i>Hydrovatus</i> sp.	--	--	--	1	69	--	3	1	--
Methilinae**	--	--	--	--	--	--	--	--	--
Celinini***	--	--	--	--	--	--	--	--	--
<i>Celina</i> sp.	--	--	--	--	--	--	--	1	--
Halplidae (crawling water beetles)	--	--	--	--	--	--	--	--	--
<i>Haliplus</i> sp.	--	--	--	--	--	--	--	1	--
<i>Peltodytes sexmaculatus</i>	--	--	--	1	--	--	--	13	--
Hydraenidae (minute moss beetles)	--	--	--	--	--	--	--	--	--
<i>Hydraena</i> sp.	--	--	--	--	--	23	108	--	--
Hydrophilidae (water scavenger beetles)	--	--	--	--	--	--	108	--	--
<i>Derallus altus</i>	--	--	--	--	--	--	3	--	--
<i>Enochrus</i> sp.	--	--	--	3	--	--	2	--	1
<i>Helobata larvalis</i>	--	--	--	--	--	--	2	--	--
<i>Paracymus</i> sp.	--	--	--	--	--	--	3	--	--
Noteridae (burrowing water beetles)	--	--	--	--	--	--	--	176	--

Appendix 2. Taxa, densities, and total number of aquatic invertebrates in richest-targeted habitat at selected sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000. -- Continued

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. --, species not collected; *, Suborder; **, Subfamily; ***, Tribe]

Taxonomic Hierarchy ¹	Tarpaper Canal near Keyhole 6 (site 1)			Pipeline Canal west of Crown Point (site 2)			North Twin Canal (site 3)		
	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00
PHYLUM									
CLASS									
ORDER									
Family									
Genus species									
<i>Hydrocanthus</i> sp.	3	2	--	2	2	--	3	3	--
<i>Notomicrus</i> sp.	--	--	--	50	--	--	--	--	--
<i>Suphisellus bicolor</i>	--	--	--	--	5	--	--	--	--
Scirtidae (marsh beetles)	4	--	--	153	--	--	215	--	--
Staphylinidae (rove beetles)	--	--	--	50	--	--	--	--	--
COLLEMBOLA (springtails)	635	--	--	101	67	23	855	235	--
DIPTERA (true flies)	--	--	--	--	--	--	--	--	--
Brachycera*	71	--	--	--	--	--	109	--	--
Ephydriidae (shore and brine flies)	--	1	--	--	--	--	--	--	67
Sciomyzidae (marsh flies)	--	--	--	--	--	--	2	--	--
Stratiomyidae (soldier flies)	--	--	--	--	--	--	--	--	67
Stratiomyinae**	--	--	--	--	--	--	--	--	--
<i>Hedriodiscus/Odontomyia</i> sp.	2	2	--	1	--	--	--	2	--
Nematocera*	--	--	--	--	--	--	--	--	--
Ceratopogonidae (biting midges, no-see-ums)	71	197	40	51	--	--	--	--	--
Ceratopogoninae**	--	--	--	--	--	--	--	--	--
<i>Bezzia/Palpomyia</i> sp.	--	393	--	50	134	--	321	588	--
Dasyheleinae**	--	--	--	--	--	--	--	--	--
<i>Dasyhelea</i> sp.	--	393	--	--	--	--	108	353	--
Chironomidae (midges)	2	3	--	13	2	--	--	--	--
Chironominae**	--	--	--	302	134	--	--	--	--
Chironomini***	71	--	--	--	--	--	641	118	67
<i>Chironomus</i> sp.	--	--	--	--	--	--	--	--	134
<i>Cryptochironomus</i> sp.	71	--	--	--	--	--	--	--	--
<i>Dicrotendipes</i> sp.	--	--	--	50	--	--	--	59	--
<i>Endochironomus</i> sp.	212	196	242	1,462	202	92	535	--	2,688
<i>Glyptotendipes</i> sp.	--	--	40	--	--	--	--	--	336
<i>Goeldichironomus</i> sp.	--	--	40	50	67	--	214	--	874
<i>Parachironomus</i> sp.	282	--	20	1,411	874	161	641	412	336
<i>Polypedilum</i> sp.	--	392	--	50	941	--	214	59	--
<i>Zavreliella</i> sp.	--	196	--	--	403	--	--	176	--
Tanytarsini***	--	--	--	--	--	--	--	59	--
<i>Micropsectra/Tanytarsus</i> sp.	71	196	--	151	--	--	--	59	--
<i>Tanytarsini</i> genus "A"	--	--	--	--	67	--	108	118	67
<i>Tanytarsus</i> sp.	--	784	--	--	67	--	1,711	59	--
Orthocladinae**	--	--	--	--	--	--	--	--	--
<i>Cricotopus trifascia</i> group	--	--	--	--	--	92	--	--	--
<i>Cricotopus</i> sp.	--	392	--	1,260	67	--	--	--	67

Appendix 2. Taxa, densities, and total number of aquatic invertebrates in richest-targeted habitat at selected sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000. —Continued

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. --, species not collected; *, Suborder; **, Subfamily; ***, Tribe]

Taxonomic Hierarchy ¹	Tarpaper Canal near Keyhole 6 (site 1)			Pipeline Canal west of Crown Point (site 2)			North Twin Canal (site 3)		
	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00
PHYLUM									
CLASS									
ORDER									
Family									
Genus species									
<i>Limnophyes</i> sp.	71	--	--	--	--	--	108	--	--
<i>Nanocladius</i> sp.	141	--	--	202	--	--	--	--	--
<i>Rheocricotopus</i> sp.	--	--	--	50	--	--	--	--	--
Tanypodinae**	--	196	20	--	67	--	--	--	--
Pentaneurini***	--	--	40	--	--	--	--	--	--
<i>Ablabesmyia</i> sp.	212	--	--	--	605	--	427	353	67
<i>Labrundinia</i> sp.	--	1,176	40	--	1,478	138	214	176	336
<i>Larsia</i> sp.	--	1,176	--	--	336	--	--	118	--
<i>Monopelopia</i> sp.	--	--	--	--	67	--	--	118	--
Culicidae (mosquitos)	--	--	--	51	--	--	--	--	--
<i>Culex</i> sp.	--	--	--	--	--	--	--	--	67
Psychodidae (moth flies)	--	--	--	--	--	--	322	--	--
EPHEMEROPTERA (mayflies)	--	--	--	--	--	--	--	--	--
Baetidae	--	--	20	--	67	46	--	--	--
<i>Callibaetis</i> sp.	3	203	20	55	135	--	114	239	67
Caenidae	--	--	--	--	--	--	--	--	--
<i>Caenis diminuta</i>	6	4	--	2	--	--	--	177	--
<i>Caenis</i> sp.	--	2,744	--	2	4,906	--	1,389	2,176	875
HEMIPTERA (true bugs)	--	--	--	--	--	--	--	--	--
Belostomatidae (giant water bugs)	--	--	2	--	--	25	--	--	72
<i>Belostoma lutarium</i>	--	1	--	--	3	--	--	2	--
<i>Belostoma</i> sp.	--	--	--	--	--	--	1	--	--
Corixidae (water boatmen)	423	196	81	101	67	115	108	118	202
<i>Trichocorixa</i> sp.	18	8	--	4	--	23	6	1	--
Gerridae (water striders)	--	--	--	--	--	--	--	--	--
<i>Neogerris hesione</i>	--	--	--	--	--	1	--	--	--
Naucoridae (creeping water bugs)	--	--	20	--	--	--	--	--	--
<i>Pelocoris femoratus</i>	2	1	--	1	--	--	4	2	4
<i>Pelocoris</i> sp.	--	--	20	--	--	--	--	2	--
Nepidae (water scorpions)	--	--	--	--	--	--	--	--	--
<i>Ranatra australis</i>	--	--	--	--	--	--	1	--	--
<i>Ranatra nigra</i>	--	--	--	4	--	--	--	--	--
<i>Ranatra</i> sp.	--	--	5	--	--	5	--	59	--
Pleidae (pigmy back swimmers)	--	1	--	--	--	23	--	--	--
Veliidae (broad-shouldered water striders)	--	196	--	--	--	--	--	--	202
<i>Microvelia pulchella</i>	--	196	--	--	--	--	--	--	--
<i>Platyvelia brachialis</i>	--	--	--	--	--	--	1	--	--
LEPIDOPTERA (aquatic caterpillars)	--	196	60	50	67	69	--	--	134

Appendix 2. Taxa, densities, and total number of aquatic invertebrates in richest-targeted habitat at selected sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000. — *Continued*

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter. --, species not collected; *, Suborder; **, Subfamily; ***, Tribe]

Taxonomic Heirarchy ¹	Tarpaper Canal near Keyhole 6 (site 1)			Pipeline Canal west of Crown Point (site 2)			North Twin Canal (site 3)		
	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00	3/16/99	7/27/99	4/21/00
PHYLUM									
CLASS									
ORDER									
Family									
Genus species									
Pyrilidae	5	--	--	--	--	--	217	--	--
ODONATA (damself/dragonflies)	--	--	40	--	--	23	--	118	134
Aeshnidae (darners)	--	--	--	--	--	--	--	--	--
<i>Anax junius</i>	--	--	--	--	--	--	2	--	--
Coenagrionidae	--	588	162	605	202	719	214	823	1,215
<i>Coenagrion / Enallagma</i> sp.	--	--	21	--	--	--	--	--	4
<i>Enallagma signatum</i>	--	--	--	1	2	--	--	--	--
<i>Enallagma</i> sp.	--	3	--	5	--	8	--	118	--
<i>Ischnura posita</i>	--	--	--	--	--	--	6	--	--
<i>Ischnura ramburii</i>	--	--	--	1	--	--	--	--	--
<i>Ischnura</i> sp.	73	1	20	6	1	10	4	--	67
<i>Telebasis byersi</i>	--	--	--	--	--	--	1	--	--
Libellulidae	--	196	--	--	--	--	--	59	--
<i>Erythemis simplicicollis</i>	5	5	--	1	2	--	2	2	1
<i>Erythemis</i> sp.	--	--	--	2	--	--	--	2	--
<i>Pachydiplax longipennis</i>	1	--	1	--	--	--	7	--	2
TRICHOPTERA (caddisflies)	--	--	--	--	--	--	--	--	--
Hydroptilidae (microcaddis)	--	--	--	--	--	--	--	--	--
<i>Hydroptila</i> sp.	--	--	--	--	202	--	--	--	--
<i>Orthotrichia</i> sp.	--	196	--	--	67	--	--	--	--
Leptoceridae	--	--	--	--	--	--	--	--	--
<i>Oecetis cinerascens</i>	1	--	--	--	--	--	--	1	--
<i>Oecetis</i> sp.	--	1	40	--	68	--	--	59	--
TOTAL ABUNDANCE	24,727	58,475	7,329	19,034	31,090	7,544	41,501	20,241	23,748

¹ Aquatic invertebrate community data and taxonomy used in this report are presented in alphabetical order and are taxonomically representative (spelling and taxonomic heirarchy) of data provided by the U.S. Geological Survey National Water Quality Laboratory, Lakewood, Colorado.

Appendix 3. Taxa, densities, and total number of aquatic invertebrates in depositional-targeted habitat at selected sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 2000.

[Densities and total number of aquatic invertebrates are rounded to the nearest whole number and reported as organisms per square meter; --, species not collected; *, Subclass; **, Subfamily; ***, Tribe]

PHYLUM CLASS ORDER Family <i>Genus species</i>	Taxonomic Heirarchy ¹	Tarpaper Canal	Pipeline Canal	North Twin
		near Keyhole 6	west of Crown	Canal (site 3)
		(site 1)	Point (site 2)	
		4/21/00	4/21/00	4/21/00
MOLLUSCA (clams, oysters, squids, octopods, snails, and limpets)		--	--	--
GASTROPODA (snails, limpets)		--	--	--
PROSOBRANCHIA*		--	2	--
ANNELIDA (segmented worms)		--	--	--
OLIGOCHAETA (aquatic worms)		--	--	--
TUBIFICIDA		--	--	--
Naididae		6	--	--
Tubificidae		28	10	2
POLYCHAETA (marine worms)		--	--	--
TEREBELLIDA		--	--	--
Ampharetidae		--	--	--
<i>Hobsonia florida</i>		4	5	--
ARTHROPODA (arthropods)		--	--	--
ARACHNIDA (eight-legged arthropods)		--	--	--
ACARI (water mites)		2	--	--
MALACOSTRACA (crustaceans)		--	--	--
AMPHIPODA (scuds, sideswimmers)		--	7	--
Crangonyctidae		4	--	--
Hyalellidae		--	--	--
<i>Hyalella azteca</i>		4	--	--
MYSIDA (opossum shrimps)		--	--	--
Mysidae		--	--	--
<i>Taphromysis louisianae</i>		2	--	--
INSECTA (insects)		--	--	--
DIPTERA (true flies)		--	--	--
Ceratopogonidae (biting midges, no-see-ums)		--	--	--
Ceratopogoninae**		--	--	--
<i>Sphaeromias</i> sp.		--	--	3
Chironomidae (midges)		--	--	--
Chironominae**		--	--	--
Chironomini***		--	2	--
<i>Chironomus</i> sp.		4	10	2
Tanytarsini***		--	--	--
<i>Tanytarsus limneticus</i>		2	3	--
Tanypodinae**		--	--	--
Coelotanypodini***		--	--	--
<i>Clinotanypus</i> sp.		2	--	--
ODONATA (damselfly/dragonflies)		--	--	--
Coenagrionidae		2	--	--
TOTAL ABUNDANCE		60	39	7

¹ Aquatic invertebrate community data and taxonomy used in this report are presented in alphabetical order and are taxonomically representative (spelling and taxonomic heirarchy) of data provided by the U.S. Geological Survey National Water Quality Laboratory, Lakewood, Colorado.

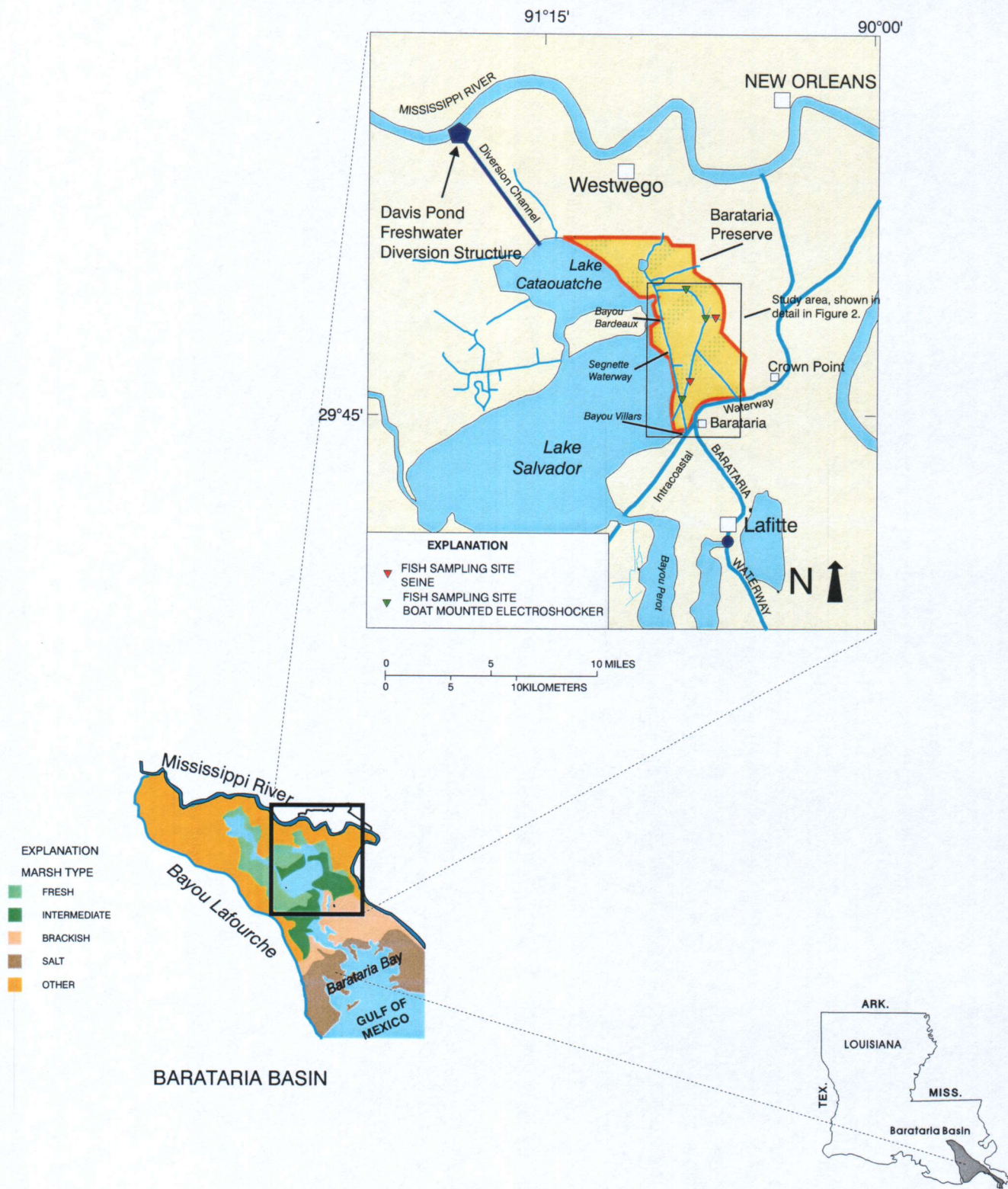


Figure 1. Location of the Barataria Preserve, Jean Lafitte National Historical Park and Preserve in Barataria Basin, Louisiana.

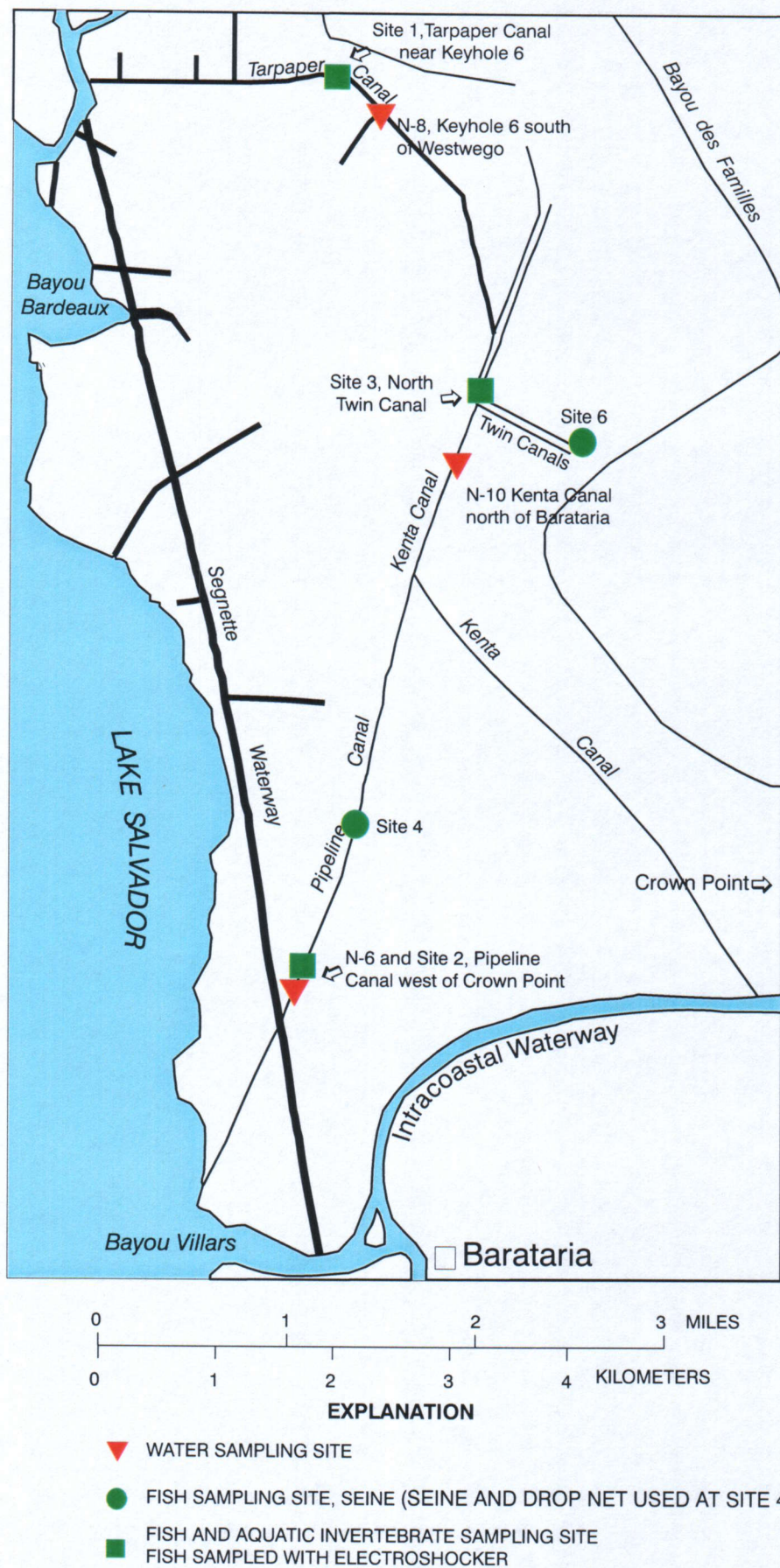
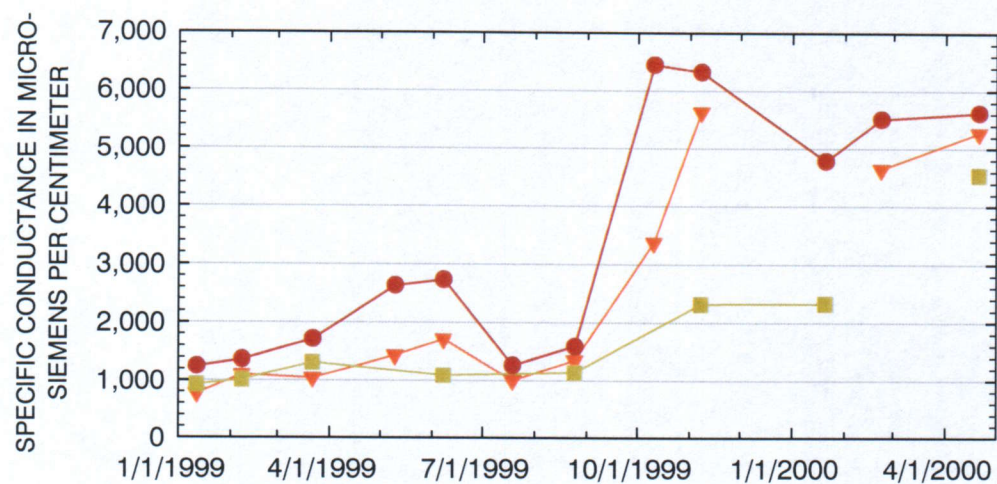


Figure 2. Sampling sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana.

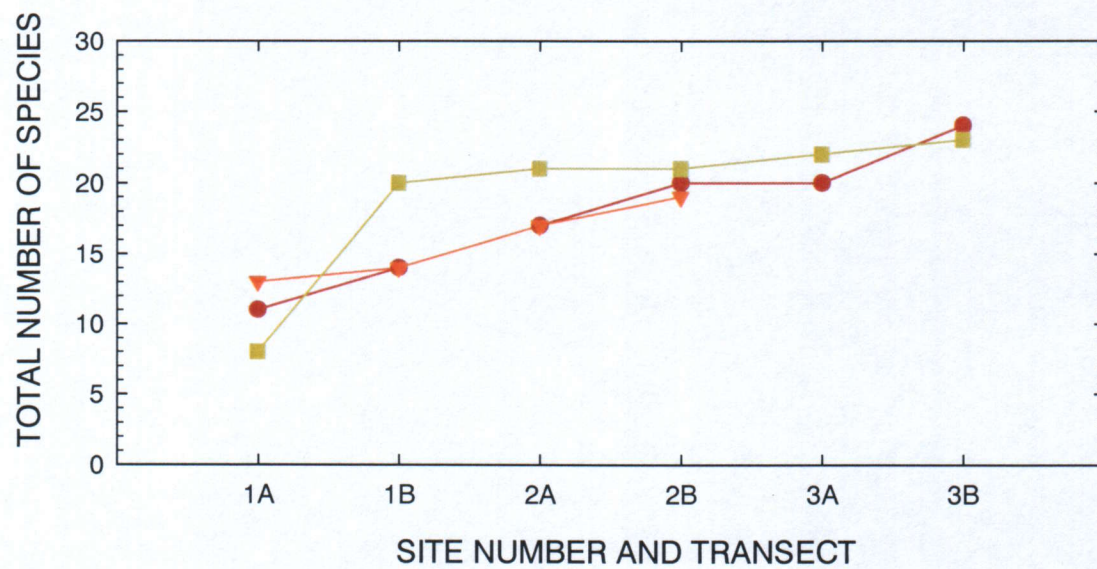


Source: Swarzenski 2003

EXPLANATION

- N-6 Pipeline Canal near Segnette Waterway
- ▼— N-8, Keyhole 6 south of Westwego
- N-10, Kenta Canal north of Barataria

Figure 3. Specific conductance at selected sites in waterways of the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, January 1999 - April 2000.



EXPLANATION

Sample trip

- May
- ▼ July
- November

Figure 4. Number of fish species collected with each additional length of waterway sampled using a boat-mounted electroshocker, 1999.

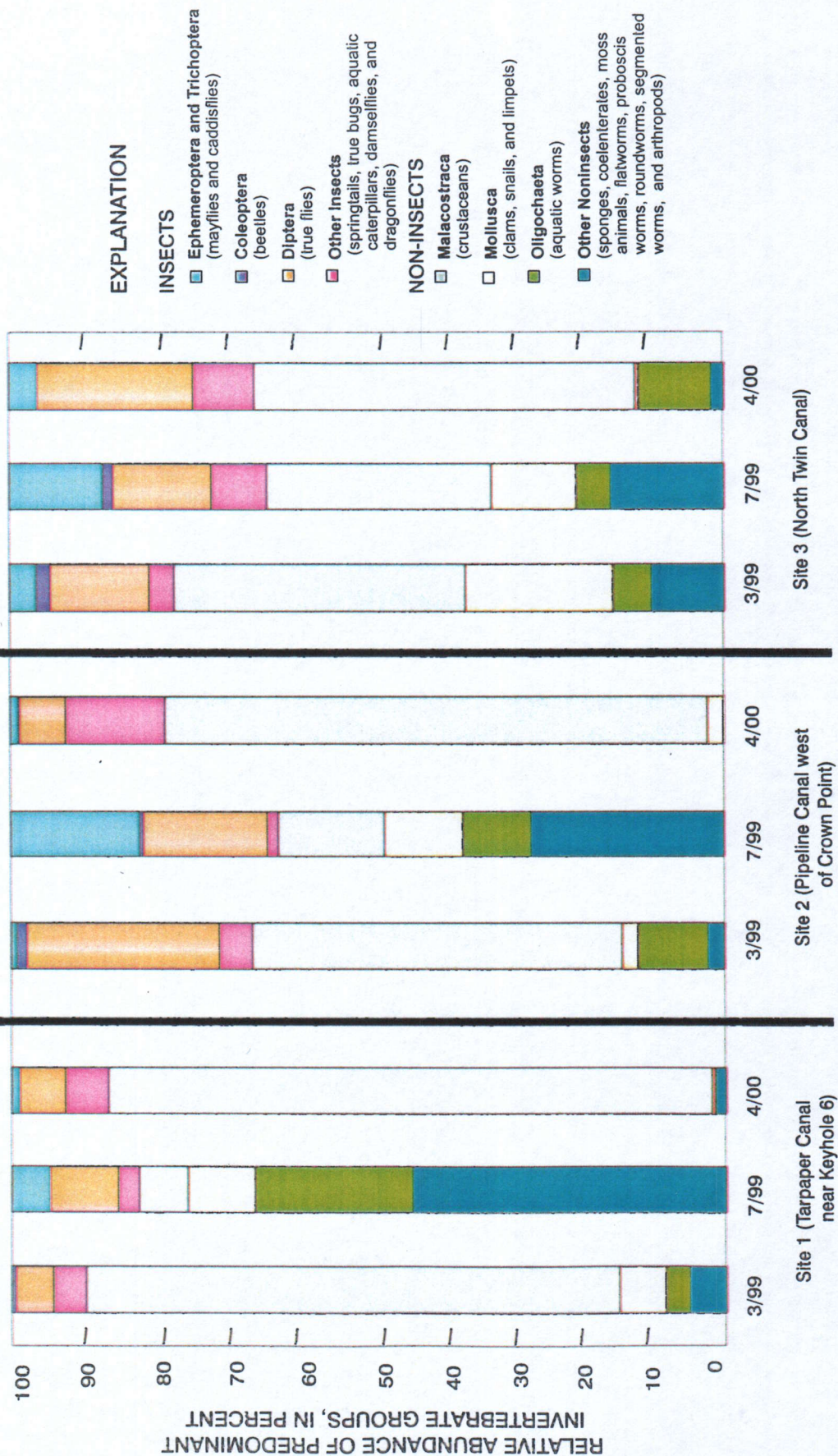
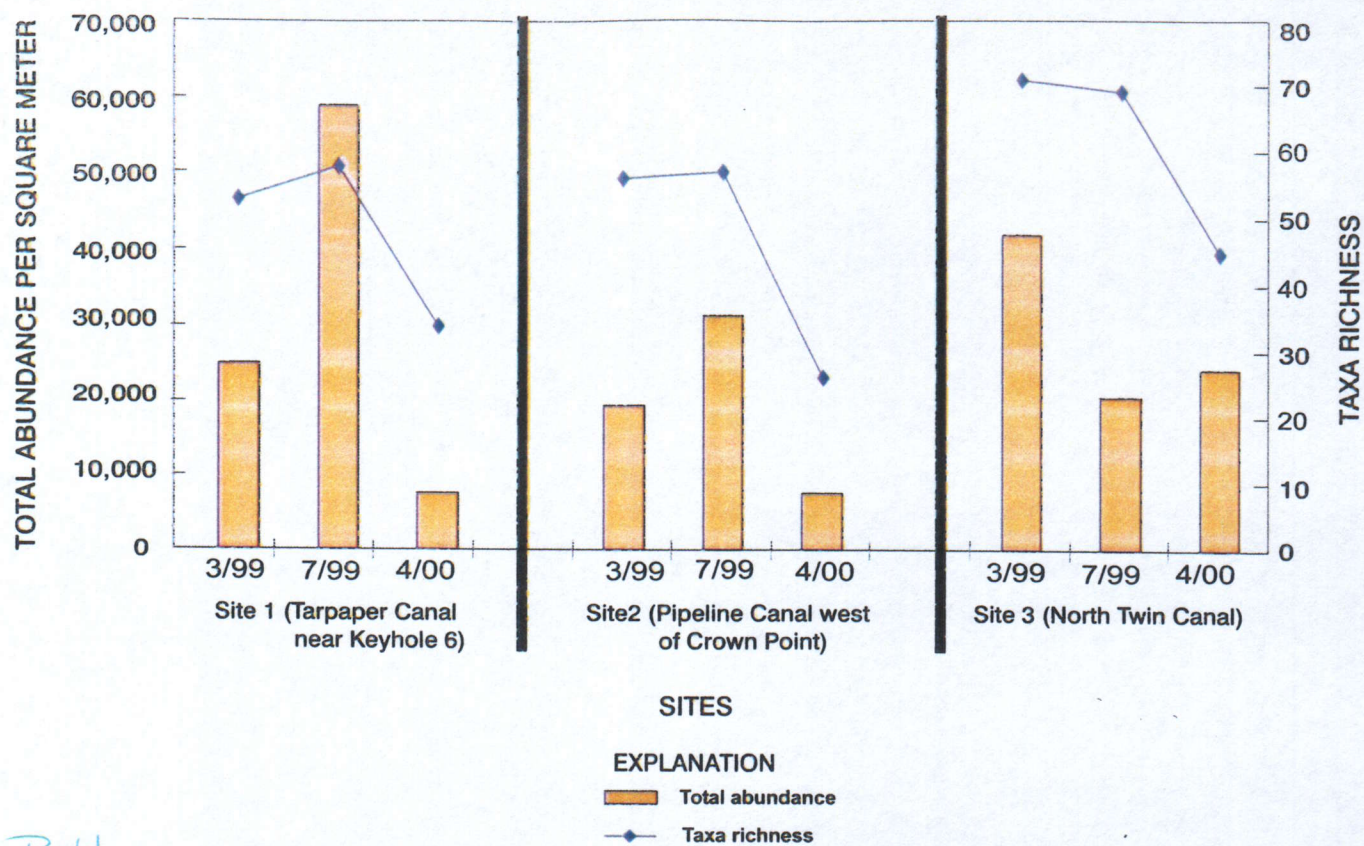
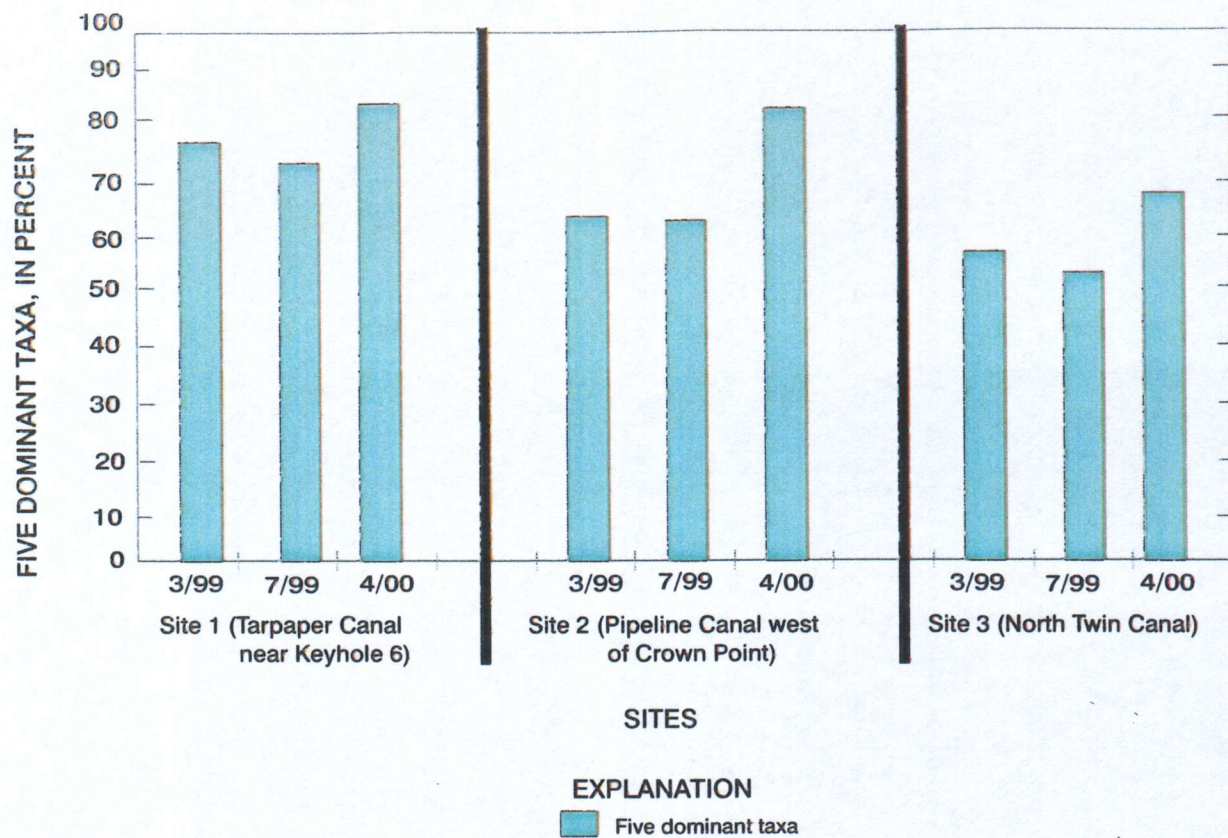


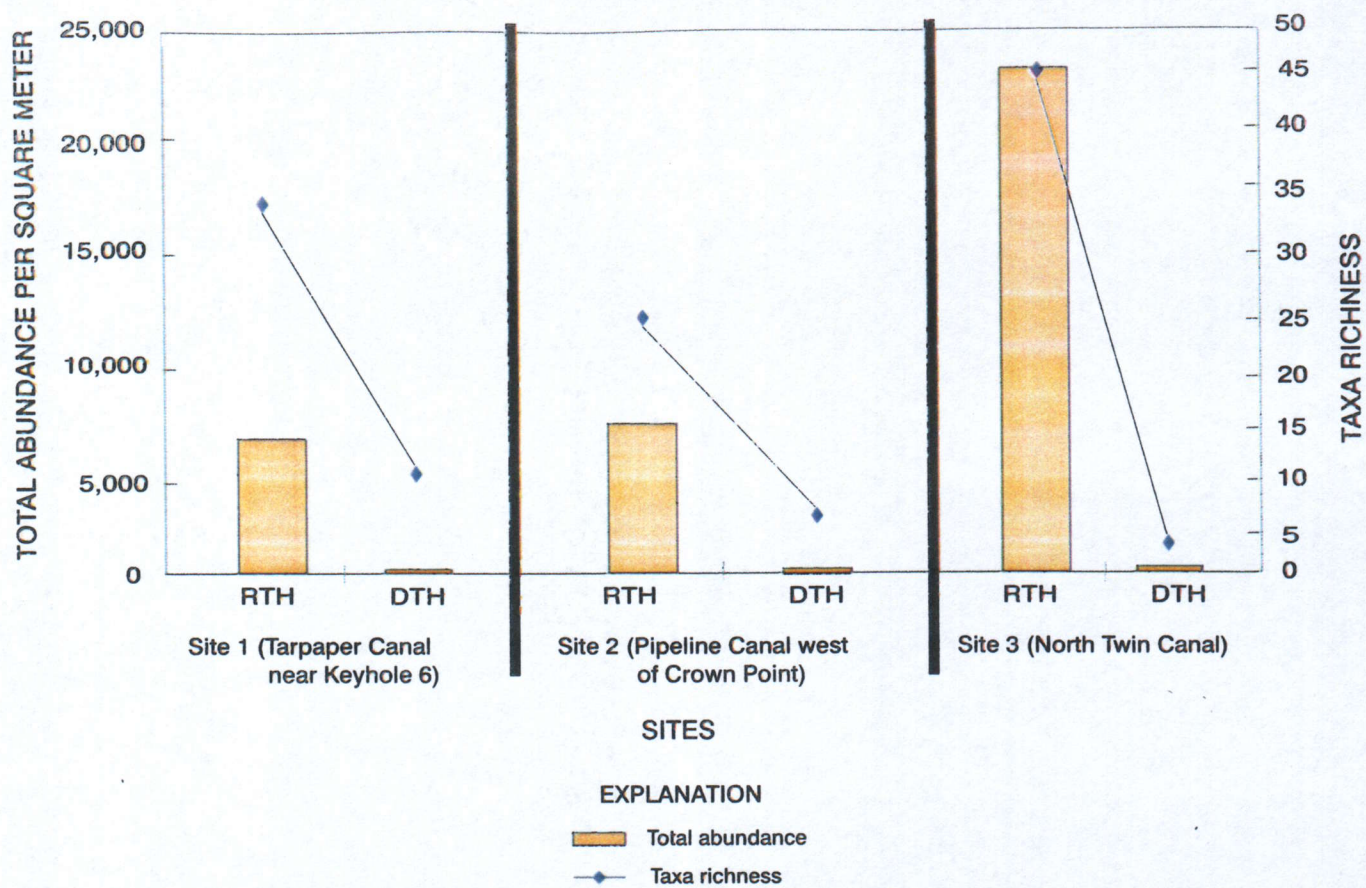
Figure 5. Relative abundances of predominant groups of aquatic invertebrates for richest-targeted habitat in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000.



Bold
 Figure 6. Total abundance and taxa richness of aquatic invertebrates for richest-targeted habitat in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000.



Bold
 Figure 7. Percentages of five dominant taxa of aquatic invertebrates for richest-targeted habitat in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, 1999-2000.



Bold

Figure 8. Total abundance and taxa richness of aquatic invertebrates for richest-targeted habitat (RTH) and depositional-targeted habitat (DTH) in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, April 2000.

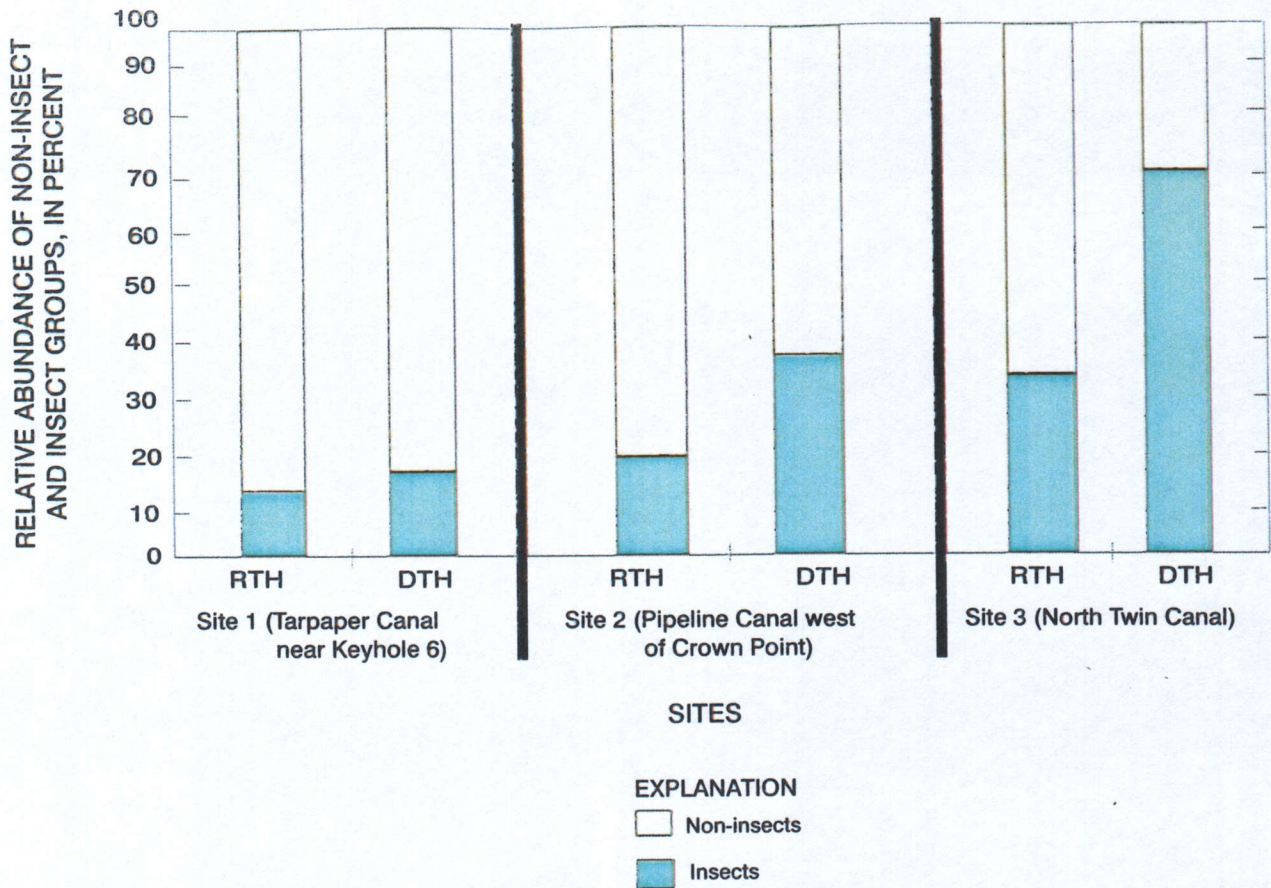
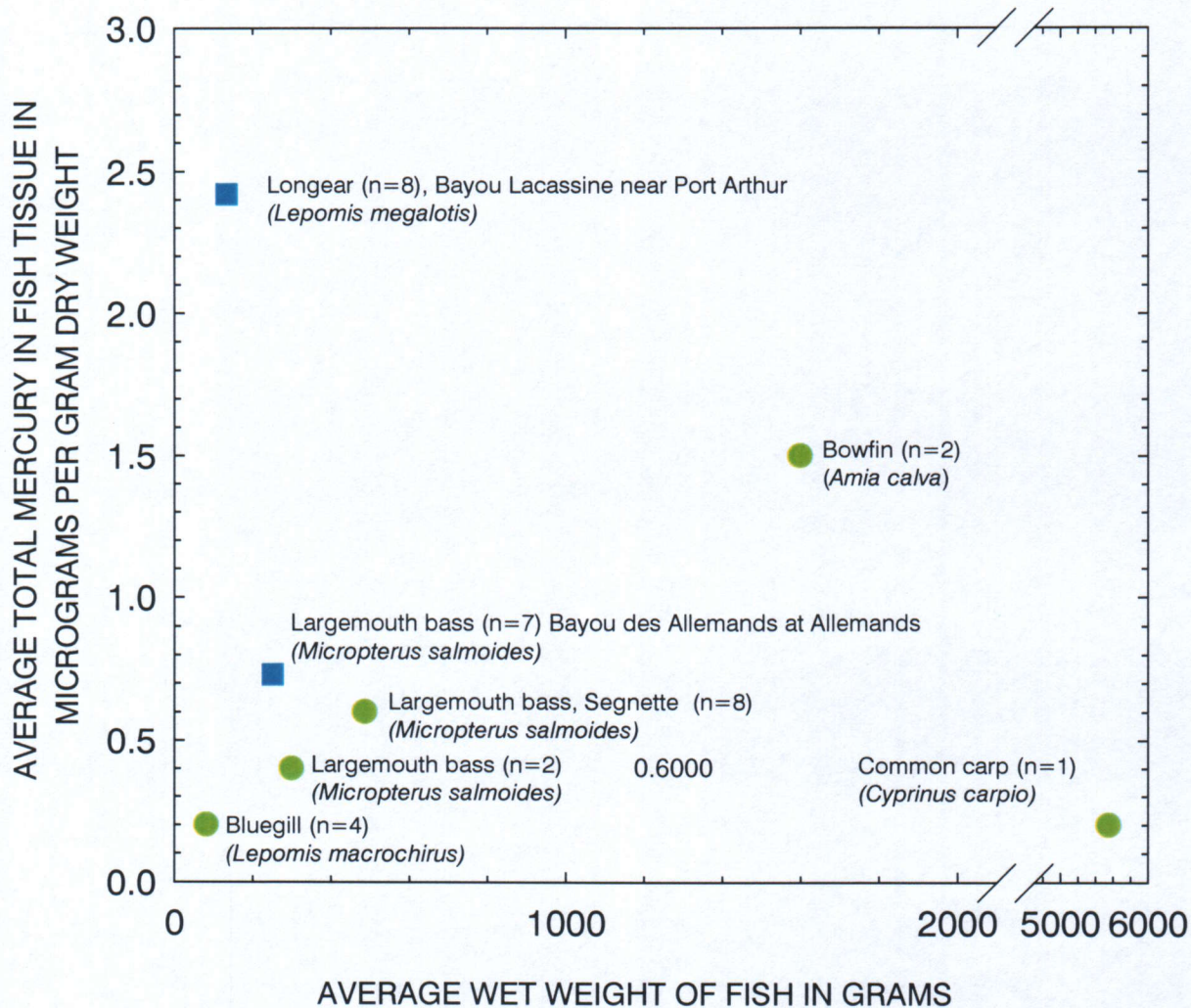


Figure 9. Relative abundance of noninsect and insect groups of aquatic invertebrates for richest-targeted habitat (RTH) and depositional-targeted habitat (DTH) areas for three sites in the Barataria Preserve, Jean Lafitte National Historical Park and Preserve, Louisiana, April 2000.



EXPLANATION

Except where noted, fish were caught in the Barataria Preserve.
Fish at all sites were caught between May 1998 and November 1999

n = sample number

- Fish from other coastal Louisiana waterways
- Fish composite from three sites in Jean Lafitte National Park

Figure 10. Relation between total mercury concentrations in composited fish fillet tissue and average wet weight of fish in selected surface-water sites in southern Louisiana.