February 16, 2004

PRP Executive Committee
C/O Lake Pontchartrain Basin Foundation
3838 North Causeway Blvd., Suite 2070
Metairie, Louisiana 70002

RE: Pontchartrain Restoration Program FY 2002 Annual Report

Dear PRP Executive Committee Members:

Enclosed is the Review Briefing Package for the Pontchartrain Restoration Program Year 1, Fiscal Year 2002. The package contains the approved workplan, budget and executive summary.

All work has been completed, as outlined in the approved workplan. Funds awarded have been encumbered.

Thank you for providing the opportunity to contribute to the knowledge base needed to restore Lake Pontchartrain. We look forward to a continued research partnership with the Lake Pontchartrain Restoration Program.

Sincerely,

Dr. Michael A. Poirrier
Professor
Estuarine Research Laboratory

Encl: 1

PONTCHARTRAIN RESTORATION PROGRAM (PRP)
FY 2002 ANNUAL REPORT

APPROVED WORK PLAN, BUDGET & EXECUTIVE SUMMARY

From

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To

PRP Executive Committee
C/O Lake Pontchartrain Basin Foundation
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Title

Basin Monitoring and Environmental Report Card: Distribution and abundance of submersed aquatic vegetation (SAV or grassbeds) and benthic invertebrates (*Rangia* clams) as indicators of Lake Pontchartrain environmental quality.

Funding Agency: NOAA

Start Date: September 1, 2002
End Date: August 31,2004
Report Date: February 16, 2004

Total Funding: $77,520.00

PONTCHARTRAIN RESTORATION PROGRAM (PRP)
FY 2002 ANNUAL REPORT

APPROVED WORK PLAN

Title: Basin Monitoring and Environmental Report Card: Distribution and abundance of submersed aquatic vegetation (SAV or grassbeds) and benthic invertebrates (*Rangia* clams) as indicators of Lake Pontchartrain environmental quality.

General Introduction/Summary. Benthic invertebrates and submersed aquatic vegetation (SAV) are important to food chain and water quality dynamics. These organisms are generally accepted as meaningful indicators of the environmental health of estuaries. UNO studies have demonstrated that large clams are absent from a 100 square mile area influenced by episodes of low dissolved oxygen due to salinity stratification from more saline water entering through the Inner Harbor Navigation Canal. Clams filter a water volume equivalent to Lake Pontchartrain every four days, and add over one million tons of shell to the bottom each year. Restoration of this keystone clam species will improve water quality by reducing turbidity, algal blooms and water borne pathogens. This in turn will increase submersed aquatic vegetation and convert the unstable mud bottom to hard shell. Lake Pontchartrain SAV has declined by 50 to 75% since first studied in 1953. With SAV abundance rapidly decreasing, further disturbance, whether it is natural or anthropogenic, could possibly decimate remaining populations and decrease essential fish habitat. Continued monitoring is needed to determine the causes of this decline and to develop appropriate restoration methods. Proposed benthic invertebrate and SAV scope of services are presented below.

Proposed Benthic Invertebrate Study (scope of services) Including Clam Dynamics.

Introduction. Past studies of Lake Pontchartrain benthic invertebrates indicated a stressed benthic invertebrate community. Causes of stress were believed to be shell dredging and the accumulation of toxic compounds in the sediment from urban runoff (Sikora, Sikora and Prior 1981; Sikora and Sikora 1982). Recent studies of benthic invertebrates conducted at the University of New Orleans indicate that recovery from shell dredging has occurred, but that saltwater intrusion and episodic hypoxia (periodic occurrence of harmful low dissolved oxygen) are serious environmental problems in Lake Pontchartrain. Studies by the Louisiana Department of Environmental Quality and the United States Geological Survey indicated that sediment contamination is not a major problem (Schurtz and St. Pe 1984; Manheim, Hayes, Waters and Flocks 2001). Thus, the principal cause of benthic community degradation appears to be episodes of anoxia and hypoxia related to saltwater intrusion through the Inner Harbor Navigation Canal (IHNC).

Unnaturally, high salinity bottom water has entered Lake Pontchartrain through the IHNC since it was completed in 1963. This saline water produces stratification and bottom hypoxia (Poirrier 1979). The absence of large (> 20 mm) *Rangia cuneata* clams from a 100 square mile area north of the IHNC indicates a significant impact on aquatic resources (Abadie and Poirrier 2000, 2001a). Hypoxic episodes are known to extend beyond this zone of obvious impact, and the area affected may be much larger. Benthic invertebrates provide food for shrimp, crabs, fish and ducks and the clam, *Rangia cuneata*, is a keystone species. Clams filter a volume of water equivalent to the volume of Lake Pontchartrain every four days, and through this feeding activity reduce turbidity, fecal contamination and algal blooms. Clams add about a million ton of shells each year to the sediment. Dramatic improvements in the environmental quality of Lake Pontchartrain should occur if the benthic community is restored. Documenting impact, determining causes and developing techniques for restoration are major components of this proposed study.

Benthic invertebrates were also affected by a eutrophic episode after the 1997 Bonnet Carre Spillway opening (Jeandron 1999), and relatively high salinity from a drought that extended from the winter of 1998 to the spring of 2001. An analysis of available data and additional studies would provide knowledge needed to properly manage these resources.

General Goals. Contribute to the knowledge base needed to restore Lake Pontchartrain by determining the status and historic trends in the distribution and abundance of benthic invertebrates. This study will focus on determining causes of changes, documenting restoration benefits and establishing corrective measures needed for restoration.

Materials and Methods. Materials and methods employed in past UNO studies of Lake Pontchartrain benthic invertebrates (Abadie and Poirrier 2000, 2001a &b) and the data bank generated will be used in the proposed work. This will include samples that were collected in 2000 and 2001 that were not sorted and identified because of lack of funding and samples that will be collected in 2002. Sites on established transects will be sampled (three replicates) with a petite Ponar grab, sieved through a 0.6 mm screen bucket, preserved in formalin with rose Bengal stain in the field, and sorted and identified in the laboratory. The statistical analyses of data will include ANOVA and analyses in PRIMER (Plymouth Routines in Multivariate Ecological Research).

Specific Objectives. (1) Determine the status of the bottom biota of Lake Pontchartrain by conducting a lake-wide survey of the distribution and abundance of benthic invertebrates. (2) Determine historic trends by comparing current and historic data. This analysis will focus on the effects of hypoxia from salinity stratification and a recent two-year drought, but will also include possible changes due to shell dredging, toxic chemicals, eutrophication and shifts in overall ecosystem structure. (3) Determine changes in the population dynamics of *Rangia* clams and hooked mussels, *Ischadium recurvum*, due to drought driven salinity changes. (4) Based on benthic-invertebrate indicator species, evaluate the current area affected by hypoxia from salinity stratification (100 mi^2 in 1999). (5) Obtain data related to the benefits of restoring the 100 mi^2 of shellfish habitat damaged by salinity stratification driven hypoxia. And (6) explore the possibility of placing a sill in Lake Pontchartrain near the mouth of the IHNC to reduce saltwater intrusion and related hypoxia.

Significance. Reduction of hypoxia would restore 100 mi^2 of bottom habitat including *Rangia* shellfish beds. Increased benthic invertebrate production would provide more food for fish, shrimp, and crabs. The shells of living and dead clams would provide natural reefs for seafood production. Increased water filtration from high densities of large clams would improve swimming by removing pathogens and improving water clarity. Increased water clarity would increase the abundance of grassbeds that provide essential fish habitat. Additional studies are needed to document impacts from hypoxia and the benefits of restoration to support the construction of a sill near the mouth of the IHNC. The hard substratum of the sill would also serve as a reef for fish and oyster production. This study will also provide information about the population dynamics of the hooked mussel, a nuisance species that interferes with commercial oyster production in Louisiana and Mississippi. The status and trends report would clarify information on the impact of toxic chemicals, salinity, effects of eutrophication and Bonnet Carre Spillway openings on benthic diversity and productivity.

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Proposed Study (Scope of Services) of Submersed Aquatic Vegetation (Grassbeds).

Introduction. Submersed aquatic vegetation plays several important ecological roles. Grassbeds serve as a major food source for waterfowl, fish, and aquatic invertebrates (Cottam 1939) and they serve as critical nursery areas for larval and juveniles of estuarine organisms (Orth and Moore 1984). Their roots and rhizomes help to stabilize sediments (Ginsburg and Lowenstam 1958) and reduce shoreline erosion by buffering wave energy with aboveground vegetative shoots (Orth 1977, Ward *et al*. 1984). In addition, oxygen is produced as a byproduct of SAV photosynthesis (Hartman and Brown 1966, Moeslund *et al*. 1981). Moreover, they assimilate excess plant nutrients (Mickle and Wetzel 1978, 1979) and remove some pollutants from the water column (Ray and White 1976, Fayed *et al*. 1985, Mortimer 1985). Thus, SAV is an important component of aquatic ecosystems and SAV distribution, abundance and composition are excellent indicators of water quality.

Lake Pontchartrain has experienced a continual decrease of SAV areal coverage since first reported by Suttkus *et al*. (1954). It decreased by 25-35 % between 1954 and 1973 (Turner *et al*. 1980), 50 % between 1973 and 1984 (Mayer 1986) and 17 % between 1985 and 1992 (Burns *et al*. 1993). The vegetated area of Lake Pontchartrain was estimated as approximately 810 ha in 1973 (Montz 1978). SAV foliar coverage on the north shore was estimated to be 76 ha, and 12 ha on south shore during 1991-1992 (Burns *et al*. 1993). *Ruppia maritima* increased in abundance during the 1999-2000 drought, but other species declined and some were eliminated from the lake. *Ruppia* declined in 2001 and *Vallisneria* distribution and abundance were the lowest ever recorded.

The maximum depth of SAV in 1954 was 1.8 m (6 ft) (Suttkus *et al*. 1954) in Lake Pontchartrain. In surveys of 1996 and 1997, SAV has rarely been found deeper than 0.9m (3ft) (Cho 1998; Poirrier *et al.* 1998). The decrease in the depth distribution of SAV since the 1950's may be the result of increased turbidity. Changes in shoreline slope, water clarity, epiphytic overgrowth, macroalgal competition, desiccation during low water periods, tropical storms and hurricanes and the prevailing salinity regime affect the distribution and abundance of SAV in Lake Pontchartrain and have contributed to this decline (Cho and Poirrier 2000).

General Goals. The long-term goal is to provide the knowledge base needed to restore historic grassbeds in Lake Pontchartrain. We estimate that 30 km^2 (3,000 ha) could be restored on the north shore by improving water clarity. South shore restoration would require shoreline alteration and nutrient reduction along with improving water clarity. The proposed work includes an analysis of the status of SAV distribution and abundance, a comparison of recent and historic data to determine trends, the elucidation of the causes of observed trends, and the determination of most appropriate restoration methods.

Specific Objectives. (1) Determine the status of SAV populations based on 2002 quantitative surveys. (2) Determine prevailing water quality by monthly measurements at survey sites. (3) Analyze current and historic SAV and water quality data to determine causes of any observed changes based on a statistical analysis of quantitative data. (4) Obtain data on the location of critical restorations sites. And, (5) Based on an analysis of all historic data develop a model that will quantify restoration goals by predicting unit area (hectares) of SAV that will be restored with unit increases in water clarity.

Materials and Methods. Species foliar cover was measured by the line-intercept method (Gertz 1984) with continuous observations along transects. Survey sites will be the same as those used in the past (2000 & 2001). Pointe aux Herbes, Bayou Lacombe, Goose Point and three sites near Fontainebleau State Park were surveyed from 1996 to 1999. In 2000 Bayou Chinchuba, Cane Bayou, Point Platte, Pt. du Chien, and Lincoln Beach were added and two similar sites at Fontainebleau State Park were omitted. At each site, five randomly placed line transects were extended out at least 200 m perpendicular from the shore. Water depths at which SAV occur were recorded on each transect. Surveys will be conducted in late summer 2002.

Monthly measurements of temperature, salinity, dissolved oxygen, pH, turbidity and photosynthetically active radiation (PAR) will be continued at Fontainebleau State Park, Bayou Lacombe, Pointe aux Herbes, Lincoln Beach and Bayou St. John (sites accessible by automobile). The following instruments were used: Li-Cor quantum sensors and photometer; an Oakton WD-35615 pH meter and; a model 85 YSI salinity, conductivity, temperature and dissolved oxygen meter. Sampling followed general recommendations in Standard Methods (APHA 1995) and the operation manuals for each instrument. All measurements have been made at a depth of 1 m except for PAR that was measured at variable depths (surface, 0.3, 0.6 and 0.9m).

Data will be analyzed by three-way analysis of variance (ANOVA) and after-ANOVA unplanned contrasts with fixed variables of time period, study site and water depth contour. The data will be compared with data from previous years (1996-2001). Residuals will be analyzed to test for normality and homogeneous variances.

Significance. Submersed aquatic vegetation (SAV) provides a number of important ecological functions in Lake Pontchartrain. Unfortunately, it has been in a state of decline since first studied in 1953. A resurgence of *Ruppia* occurred during the 1999-2000 drought, but *Vallisneria* continued to decline and *Potomogeton* was absent. Reestablishing historic SAV beds is an important restoration goal and provides an indicator of changing habitat quality. This study will evaluate the status of SAV, determine causes of population changes, and provide restoration goals and methods. Without proper conservation and management, this important resource will be lost.

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PONTCHARTRAIN RESTORATION PROGRAM (PRP)
FY 2002 ANNUAL REPORT

APPROVED BUDGET

Approved SAV and Benthic Invertebrate Project Budget

P.I. (two months summer)		16,000
Research Associate (half-time)		15,000
Employee Benefits (21% of $31,000)		6,510
Graduate Students (one, half-time Ph.D., 12 months)		19,000
Student Workers (Part- time, $600- 7.00/ hr)		5,586
Travel (local field trips, including boat time & meetings)		2,000
Supplies (reagents, preservatives, glassware, field items etc.)		2,150
Subtotal		
Overhead (14 % of $66,246)		9,274
	Subtotal	75,520
Equipment (water quality field meters)		2,000
	Total	**$77,520**

Budget Justification.

Principal Investigator (P.I.). Funds are requested for two months summer salary for Michael A. Poirrier. These funds are needed because his university appointment does not provide summer support during this period of intense research effort.

Research Associate. Funds to support a half-time research associate are requested. It is anticipated that James Sinclair will fill this position. He is currently a full-time employee who has experience with field and laboratory studies pertaining to submersed aquatic vegetation and benthic invertebrates. This position will be full-time with the other portion of his salary paid from other sources.

Fringe benefits. Standard university fringe benefits (health insurance/retirement) at 21% of full-time salaries are requested for Poirrier and Sinclair.

Graduate Student. Funds are requested to support J. Cho, a third-year Ph.D. candidate in the Conservation Biology Program. Ms. Cho has five years of experience working with Lake Pontchartrain submersed aquatic vegetation.

Student workers. Funds are requested to support undergraduate student workers. These students are needed to help process benthic invertebrate samples.

Travel. Funds are requested to support local field travel and participation at a national meeting. Local field travel will include vehicle mileage ($.28/mi) and boat gas and maintenance.

Supplies. Funds are requested to purchase preservatives, reagents, glassware, microscope slides, field survey tapes, waters sample bottles, computer software and other item needed to conduct the proposed research.

Overhead. 14% of costs excluding equipment.

Equipment. Funds are requested to replace older field equipment such as SCT/DO meters, light meters and turbidimeters which may cease to function properly during the study (cost $600 to $1,400).

Budget Status: All funds awarded have been encumbered.

PONTCHARTRAIN RESTORATION PROGRAM (PRP)
FY 2002 ANNUAL REPORT

EXECUTIVE SUMMARY

GOALS

This study was undertaken to obtain data needed to evaluate current environmental quality in the Lake Pontchartrain basin related to the effects of restoration efforts.

RELEVANCE TO THE COMPREHENSIVE MANAGEMENT PLAN

The project supports numerous objectives of the Lake Pontchartrain Basin Foundation Comprehensive Management Plan. Submersed aquatic vegetation (SAV) is an impaired, critical fisheries habitat that needs to be restored, and SAV improves environmental quality by stabilizing shoreline sediments, producing oxygen and treating contaminants. Because clams are abundant filter feeders, they reduce the impact of pollution from diverse sources. Invertebrates and SAV also serve as excellent indicators of the condition of estuaries and the success of restoration efforts. This project also educates university students at all levels, and results are presented to the public through diverse media.

SUBMERSED AQUATIC VEGETATION

Work Completed

The following are completed tasks in the work plan objectives. (1) Status of SAV populations was determined based on 2002 quantitative studies. SAV survey results were compared with those of previous year's (1996-2001) using a three-way analysis of variance (ANOVA) with fixed variables of year, site, and depth. (2) Prevailing water quality at survey sites was measured monthly. (3) Current and historical SAV and quantitative water quality data were statistically analyzed to determine causes of any observed changes. Principal component analyses (PCA's) were applied to water quality variables (water temperature, dissolved oxygen, pH, salinity, turbidity, and photosynthetic active radiation) to determine factors responsible for any annual and spatial variation in water quality. The annual response of SAV to changes in environmental factors was used to examine causes of long-term historic changes. (4) Locations of critical restoration sites were identified. (5) A potential SAV habitat model was developed to predict unit area of SAV that would be restored with unit increases in water clarity. Information obtained through the study was related with landscape characteristics of Lake Pontchartrain to suggest successful restoration strategies.

Results

In 2002, there was a significant increase ($P<0.001$, 3-way ANOVA) in SAV that was five times greater than 2001 (Fig. 1). There was a shift in species composition from *Vallisneria americana* to *Ruppia maritima* from 1997 through 2002 (Figs.1 and 2). Although freshwater SAV (*Vallisneria americana* and *Najas guadalupensis*) increased significantly between 2001 and 2002, *R. maritima* continued to dominate in 2002 due to its dramatic increase at Goose Point (8-fold increase) and Lacombe (5-fold). *Potamogeton perfoliatus*, an SAV species whose Louisiana distribution is limited to Lake Pontchartrain, was not present during the 1998-2002 surveys. The increase in the distribution and abundance of SAV in recent years rivaled the historic distribution of SAV.

Water clarity and salinity were positively correlated ($P<0.05$, correlation analysis and PCA). These variables significantly changed with year ($P<0.01$, ANOVA), but not with site ($P=0.23$, ANOVA).

Data from studies of SAV dynamics along fixed transects indicate that water clarity was the principal factor affecting SAV abundance and salinity was the principal factor affecting species composition (R^2 = 0.95, regression analysis). According to analyses of depth distribution and underwater photosynthetically active radiation (PAR), Lake Pontchartrain SAV colonized up to a depth where PAR availability was 10% of the surface irradiance. Therefore, SAV maximum depth (Z_{max}) was mainly determined by water clarity during the growing season (R^2 = 0.71, regression analysis), whereas the lower limit of SAV colonization depth (Z_{min}) was determined by water level and water level fluctuation. Both empirical (transect data) and calculated (daily lake level data) lower depth limit of SAV colonization were 0.3 m. When water clarity and water level were comparable, site differences in SAV areal coverage were explained by differences in shoreface slope (underwater profile). Shoreface slope determined the distance between the maximum and minimum colonization depth (R^2 = 0.87, regression analysis).

Based on four key factors of water clarity, water level, water level fluctuation, and shoreface slope, we developed a linear model to predict habitat increase with improvements in water quality, specifically water transparency (Fig. 3). Approximately 4.5 mi^2 of potential habitat would be gained for a unit decrease in the vertical absorption coefficient (K_d) on the north shore where most SAV occurs in the lake.

The continual decrease in SAV maximum colonization depth and areal coverage from 1953 to early 1990's has been attributed to decreased water clarity due to increased nutrient input from expanded urban areas and increased sediment resuspension from shell dredging, as well as toxins associated with urban runoff. Although the initial SAV increase in 1999 and its fluctuation through 2000 and 2001 indicate significant effects of a climate shift from the El Ninõ to La Ninã patterns, the continued increase in total SAV coverage in 2002 demonstrated that water clarity in Lake Pontchartrain is improving due to restoration efforts. The increase in SAV would not have occurred if shell dredging were not stopped and other improvements such as improved sewage treatment, construction of dairy retention ponds and preservation/restoration of swamps and marshes.

Restoration of historic grassbeds could be accomplished by improving water clarity. Continued efforts to reduce turbidity caused by suspended solids in runoff and restoration of clams would increase water clarity lake-wide. Maintaining and increasing SAV "friendly shorelines" and culture and transplanting *Vallisneria* would enhance restoration efforts.

BENTHIC INVERTEBRATES/ RANGIA CLAMS

Work Completed

The following are completed tasks in the work plan objectives. (1) A lake-wide survey of benthic invertebrates was conducted in August 2002. Samples from 2002 and samples collected in 2000 and 2001 were processed and data were entered into a spreadsheet. (2) Data from 2000, 2001 and 2002 was compared with annual data obtained since 1996 and an analyses of major trends conducted. (3) An analysis of salinity related changes in *Rangia* and *Ishadium* populations was completed. (4) An evaluation of the extent of the area affected by anoxia and hypoxia was conducted. (5) Data were obtained related to the benefits of restoring the 100 mi^2 of shellfish habitat damaged by salinity stratification driven hypoxia. (6) The possibility of placing a sill in Lake Pontchartrain near the mouth of the IHNC to reduce saltwater intrusion and related hypoxia was explored.

Results
Past UNO studies demonstrated that large *R. cuneata* clams are absent from a 100 square mile area due to saltwater intrusion through the Inner Harbor Navigational Canal (IHNC). A prolonged drought from 1999 to 2001 that was associated with a shift from the El Ninõ to La Ninã climate patterns resulted in a lake-wide salinity increase three times the historic mean of 4 ppt (Fig. 4). Much higher bottom salinity occurred throughout the lake, and episodic hypoxia was also widespread. These hypoxic events coupled with increased salinity resulted in a lake-wide decrease in species diversity and *Rangia* clams.

Species diversity was used to evaluate annual changes in benthic invertebrate community structure. Values from 1996 through 2002 fluctuated as a result of changes in salinity, hypoxia, and the interaction of the two. In coastal marine systems, diversity increases with salinity, and low salinity estuaries, such as Lake Pontchartrain, are characterized by relatively few species. Since salinity usually increases from west to east in Lake Pontchartrain, there is corresponding increase in species diversity. Exceptions to the west to east diversity increase occurred during the 1997 Bonnet Carre Spillway opening and during the spring of 2000, when east and west salinities were the same. In 1997, they were the same due to the massive influx of Mississippi River water and in 2000 due to the lack of stream flow from a severe drought.

Stress also causes a reduction in species diversity. In Lake Pontchartrain, the area affected by saltwater intrusion has low species diversity due to stress from low dissolved oxygen even though the salinity is higher. A trend of increasing species diversity with distance from the source of stress, the IHNC, was apparent from 1996 through 1999. However, a dramatic lake-wide decrease in species diversity occurred in fall 2000 and spring 2001 in spite of relatively high salinity from the drought. The benthic community was also dominated by stress-tolerant annelids during this period, typical of samples near the IHNC. This decrease in diversity indicated that a lake-wide episode of low bottom dissolved oxygen occurred. This was supported by loss of almost all *Rangia* clams.

After the cessation of shell dredging in 1990, the density of large *Rangia cuneata* clams (> 21 mm) increased lake-wide with the exception of a 100-mi^2 area affected by salinity stratification and episodic hypoxia. From 1996 to 1999, clam density appeared to be relatively stable. However, in 2000 through 2002, salinity levels increased, the density of *Rangia* clams dramatically decreased, the density of *Ischadium recurvum* mussels increased (Figure 4), and the area affected by episodic hypoxia increased. Although the decrease in *Rangia* clams coincided with an increase in salinity, it is unlikely that increased salinity alone was responsible for the decline. *Rangia* clams reproduce and are abundant at salinities up to 15 ppt and can survive salinities as high as 25 ppt. The underlying factor causing the decline was likely the interaction of stress from episodic hypoxia and abrupt salinity changes. The low species diversity in 2000 and 2001 discussed above supports a lake-wide hypoxic event.

Confounding the explanation of the disappearance of *Rangia* clams was the rapid increase of *Ischadium* mussels observed lake-wide. Prior to 1999, small numbers of *Ischadium* were confined to the easternmost area of the lake. As the density of *Rangia* decreased, the density of *Ischadium* mussels increased lake-wide, including the historically IHNC-affected area. The increase in *Ischadium* was most likely due to increased salinity levels and decreased competition from *Rangia*. *Ischadium* is abundant in higher salinities estuaries such as Lake Borgne. It generally occurs with oysters, and because of its numbers can become a nuisance.

A thin bottom layer of low oxygen water may not have as severely affected *Ischadium* because it occurs on substratum above the bottom and not in the sediment. This resulted in the rapid increase of not only small *Ischadium* (< 5 mm) but also the establishment and growth of larger mussels (>35 mm).

The lake-wide hypoxic event was probably caused by saltwater intrusion. Currently the USACOE is considering closure of the Mississippi River Gulf Outlet (MRGO) which would reduce intrusion from the IHNC and restore clam habitat, which in turn would result in increased water clarity, expansion of grassbeds, reduction of algal bloom and fecal coliforms, and conversion of the bottom from mud to shell.

MAJOR FINDINGS

<u>Submersed Aquatic Vegetation (SAV)</u>

- There was a rapid increase in SAV *(Ruppia maritima)* in 1999, but freshwater species, including *Vallisneria americana* declined.
- *Potomogeton perfoliatus,*a SAV species whose Louisiana distribution is limited to Lake Pontchartrain, has not been found since 1998.
- Changes in SAV species composition were due to increased salinity and changes in abundance were due to increased water clarity caused by a drought driven by an El Ninõ to La Ninã climate shift.
- Since water clarity controls abundance and SAV restoration depends on improving water clarity, our model predicts a 4.5 square mile increase in north shore SAV with a unit increase in water clarity.
- The SAV increase documented in this study rivaled the historic distribution and would not have occurred without habitat improvements such as the cessation of shell dredging.

<u>Benthos</u>

- Overall benthos diversity declined in 2000 and the density of *Rangia* clams in 2000 through 2002 dramatically declined.
- The decrease in overall diversity and clams occurred after a period of high salinity caused by a drought driven by an El Ninõ to La Ninã climate shift, but the underlying factor may have been widespread low dissolved oxygen near the bottom.
- Our studies indicated that saltwater intrusion and associated hypoxia are serious environmental problems in Lake Pontchartrain and bottom habitat could be greatly improved by modification of the Mississippi River Gulf Outlet to reduce saltwater intrusion.
- Reduction of saltwater intrusion would restore clam habitat and resulting in major habitat improvements such as: increased water clarity, expansion of grassbeds, reduction of algal blooms and fecal coliforms, and conversion of the bottom from mud to shell.

DELIVERABLES

All tasks have been completed and allocated funds have been encumbered. Results of this work were included in papers presented at a national shellfish restoration conference at Charleston, S.C. in November 2002; at a seagrass restoration workshop at Sarasota, Fl in March 2003; and at the Estuarine Research Federation Meeting at Seattle, WA in October 2003. Complete results of the submersed aquatic vegetation studies are available in the University of New Orleans Ph.D. dissertation prepared by Hyun-jung Cho entitled <u>Ecology of Submersed Aquatic Vegetation in Lake Pontchartrain Louisiana, May 2003</u>. Manuscripts are being prepared for submission for publication in peer-reviewed scientific journals.

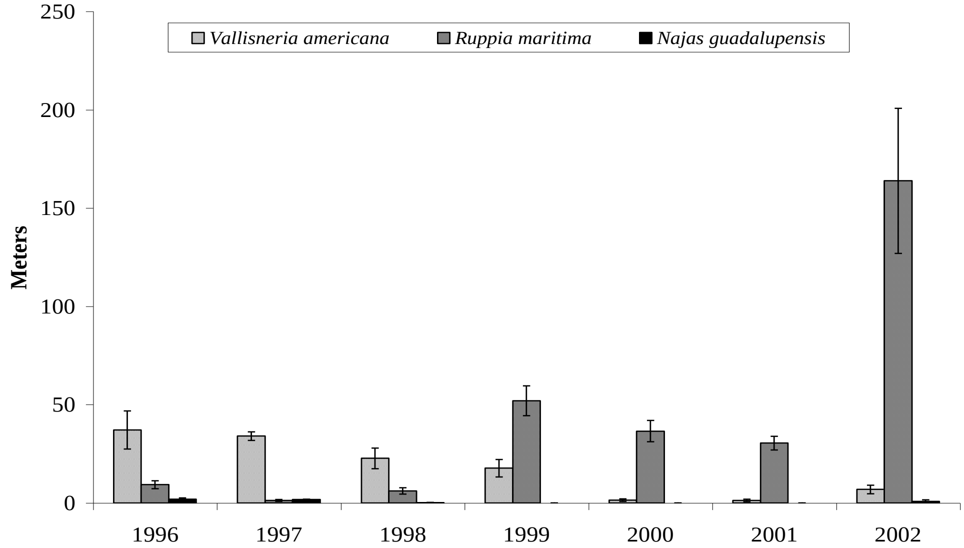

Figure 1. Annual mean submersed aquatic vegetation (SAV) foliar coverage (linear portion of the line-intercept survey transect that is covered by shoots of each SAV species in meters) averaged across four sites – Fontainebleau State Park, Goose Point, Lacombe, and Pointe aux Herbes. Error bars indicate standard deviation.

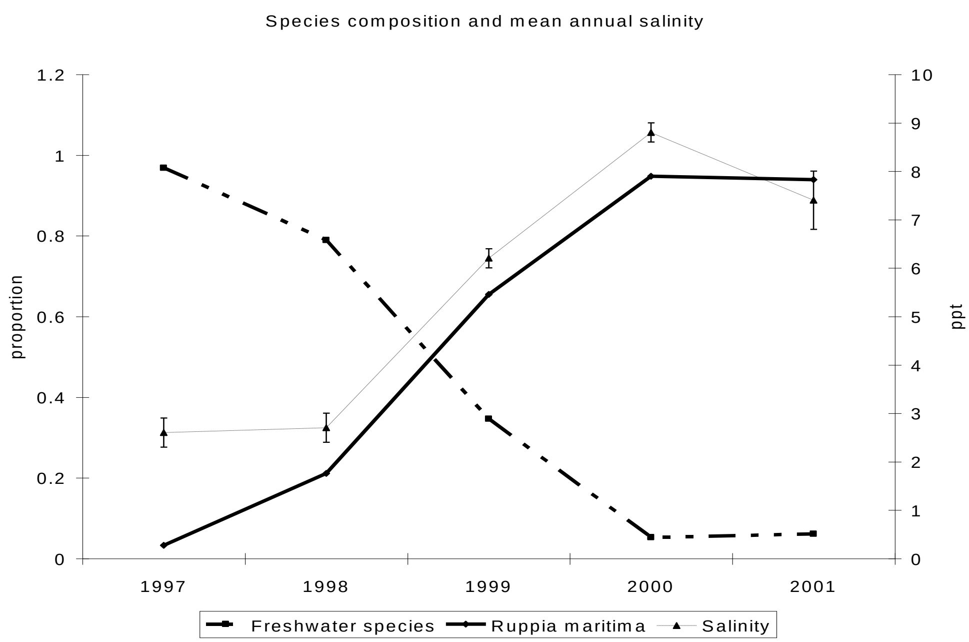

Figure 2. Annual mean salinity measured at Lacombe and Pointe aux Herbes plotted against proportions of freshwater species (*Vallisneria americana*, *Najas guadalupensis* and *Myriophyllum spicatum*) and the euryhaline species (*Ruppia maritima*) observed on transects at Goose Point, Lacombe, and Pointe aux Herbes. Error bars indicate standard error of annual mean salinity.

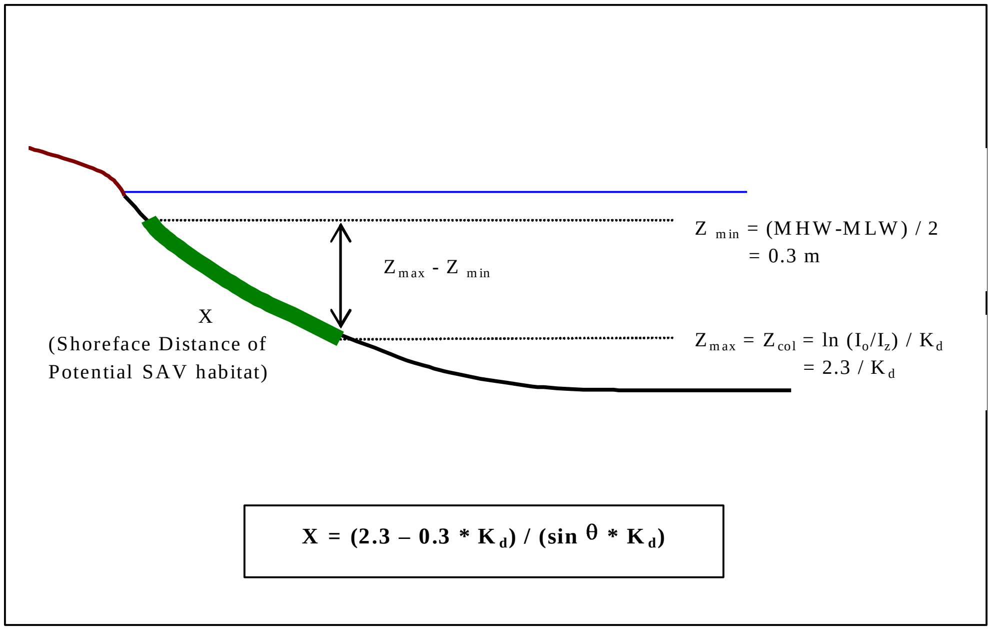

Figure 3. Linear model of potential submersed aquatic vegetation habitat in Lake Pontchartrain where θ is the shoreline slope angle in radians and when I_z is 10% of I_0.

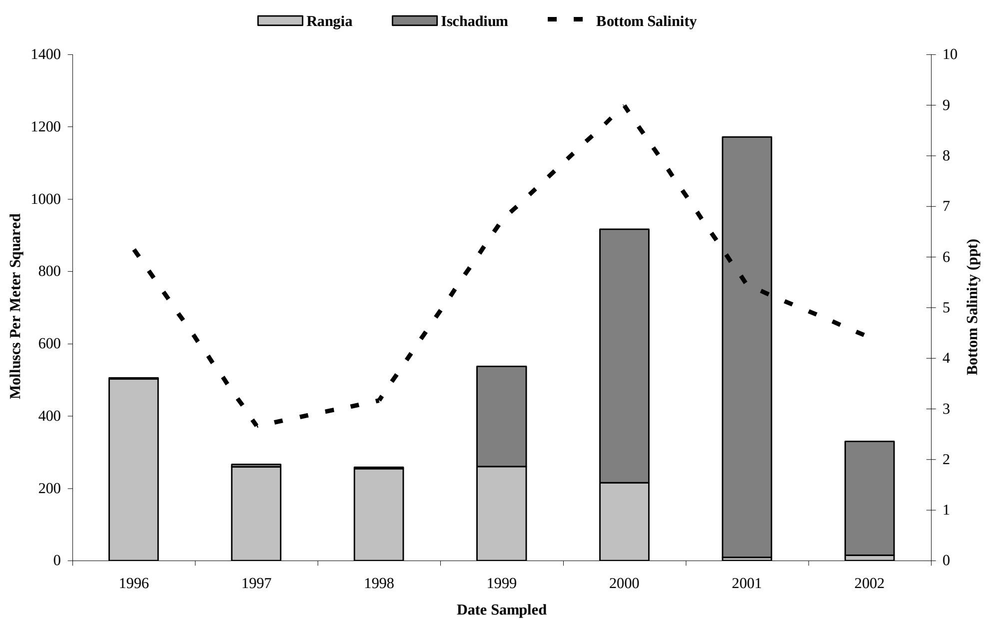

Figure 4. Density of *Rangia cuneata* and *Ischadium recurvum* and average bottom salinity level in Lake Pontchartrain.