An Overview of Nekton Resources in the Pontchartrain Estuary: Research, Baseline Data, and Recent Disturbances






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Outline

– importance of nekton in the Pontchartrain Estuary

– historical overview of baseline data and areas of research

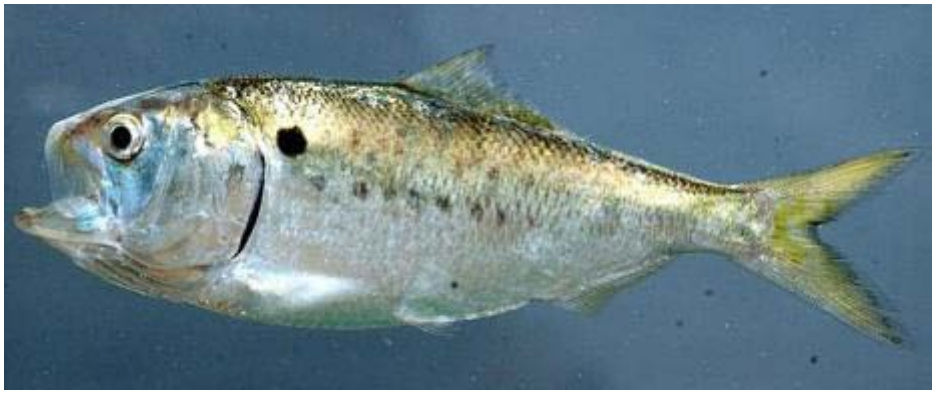
– significant disturbances that have affected the area and nekton

– damage, recovery, and the current conditions

– best future practices to define “at risk” areas and resources

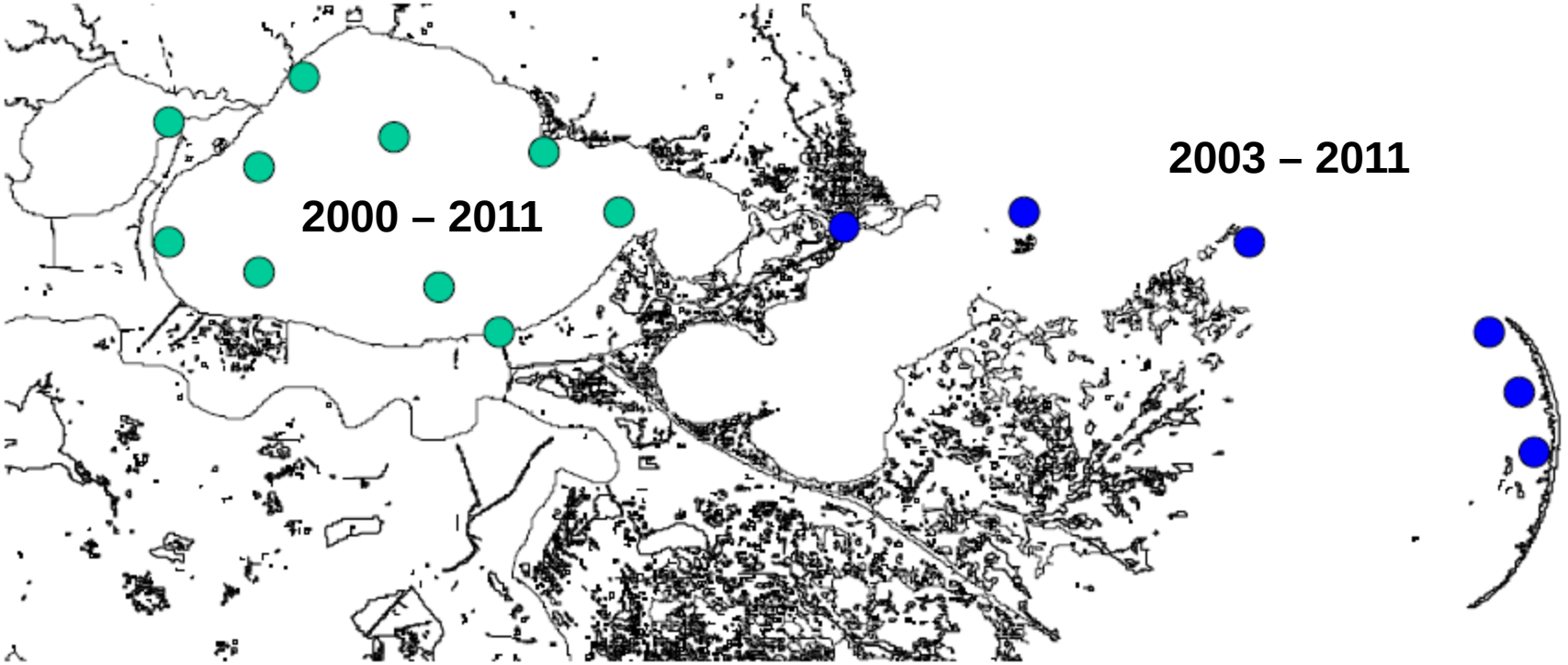
– possible approaches to monitor nekton health

Important Nekton Species



All are ‘estuarine dependent’

NRL Baseline Nekton Data and Areas of Research



– estuarine dependent species
– different gear types (e.g., seines, trawls, gillnets, larval nets, throw traps, etc.)
– also tagging and tracking (e.g., lemon sharks)

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Fish Assemblage Stability Over Fifty Years in the Lake Pontchartrain Estuary; Comparisons Among Habitats Using Canonical Correspondence Analysis

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ABSTRACT: We assessed fish assemblage stability over the last half century in Lake Pontchartrain, an environmentally degraded oligohaline estuary in southeastern Louisiana. Because assemblage instability over time has been consistently associated with severe habitat degradation, we attempted to determine whether fish assemblages in demersal, nearshore, and pelagic habitats exhibited change that was unrelated to natural fluctuations in environmental variables (e.g., assemblage changes between wet and dry periods). Collection data from three gear types (trawl, beach seine, and gill nets) and monthly environmental data (salinity, temperature, and Secchi depth) were compared for four collecting periods: 1954 (dry period), 1978 (wet period), 1996–1998 (wet period), and 1998–2000 (dry period). Canonical correspondence analysis (CCA) revealed that although the three environmental variables were significantly associated with the distribution and abundance patterns of fish assemblages in all habitats (with the exception of Secchi depth for pelagic samples), most fish assemblage change occurred among sampling periods (i.e., along a temporal gradient unrelated to changing environmental variables). Assemblage instability was the most pronounced for fishes collected by trawls from demersal habitats. A marked lack of cyclicity in the trawl data CCA diagram indicated a shift away from a baseline demersal assemblage of 50 yr ago. Centroid positions for the five most collected species indicated that three benthic fishes, Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), and hardhead catfish (*Arius felis*), were more dominant in past demersal assemblages (1954 and 1978). A different situation was shown for planktivorous species collected by trawls with bay anchovy (*Anchoa mitchilli*) becoming more dominant in recent assemblages and Gulf menhaden (*Brevoortia patronus*) remaining equally represented in assemblages over time. Changes in fish assemblages from nearshore (beach seine) and pelagic (gill net) habitats were more closely related to environmental fluctuations, though the CCA for beach seine data also indicated a decrease in the dominance of *M. undulatus* and an increase in the proportion of *A. mitchilli* over time. The reduced assemblage role of benthic fishes and the marked assemblage change indicated by trawl data suggest that over the last half century demersal habitats in Lake Pontchartrain have been impacted more by multiple anthropogenic stressors than nearshore or pelagic habitats.

Introduction

The environmental degradation of essential estuarine habitats in the United States threatens fishes of commercial, recreational, and ecological importance (Thayer et al. 1996; Waste 1996; Peterson et al. 2000; Baltz and Jones 2003). The highly variable physiochemical and biotic nature of estuaries precludes simple diagnoses of significant environmental problems (Peterson and Ross 1991; Nordstrom and Roman 1996; Matern et al. 2002). Determining the effects of natural and anthropogenic disturbances on fishes is particularly difficult because of their mobility relative to other estuarine organisms (Poff and Allan 1995; Able and Fahay 1998; Wagner 1999). In estuaries, interhabitat movement, especially by migrating estuarine-dependent fishes, creates temporally dynamic fish faunas (Thompson and Fitzhugh 1985; Peterson and Ross 1991). Accurate assessment of fish assemblage changes relative to possible habitat degradation effects requires the comparison of data along large temporal and spatial scales (Poff and Allan 1995).

Lake Pontchartrain, an oligohaline estuary in southeastern Louisiana, has been subject to numerous anthropogenic impacts over the last half century including urban and agricultural runoff, shell dredging, overfishing, artificial saltwater and freshwater inputs, shoreline alteration, and industrial discharges (Francis and Poirrier 1999; Penland et al. 2002). Although some of these environmental stressors (urban and agricultural runoff, artificial saltwater and freshwater inputs) exist presently within the estuary while others (shell dredging) have been discontinued, the environmental degradation of Lake Pontchartrain has increased over time (Penland et al. 2002). Between 1900 and 1980, fisheries production in Lake Pont-

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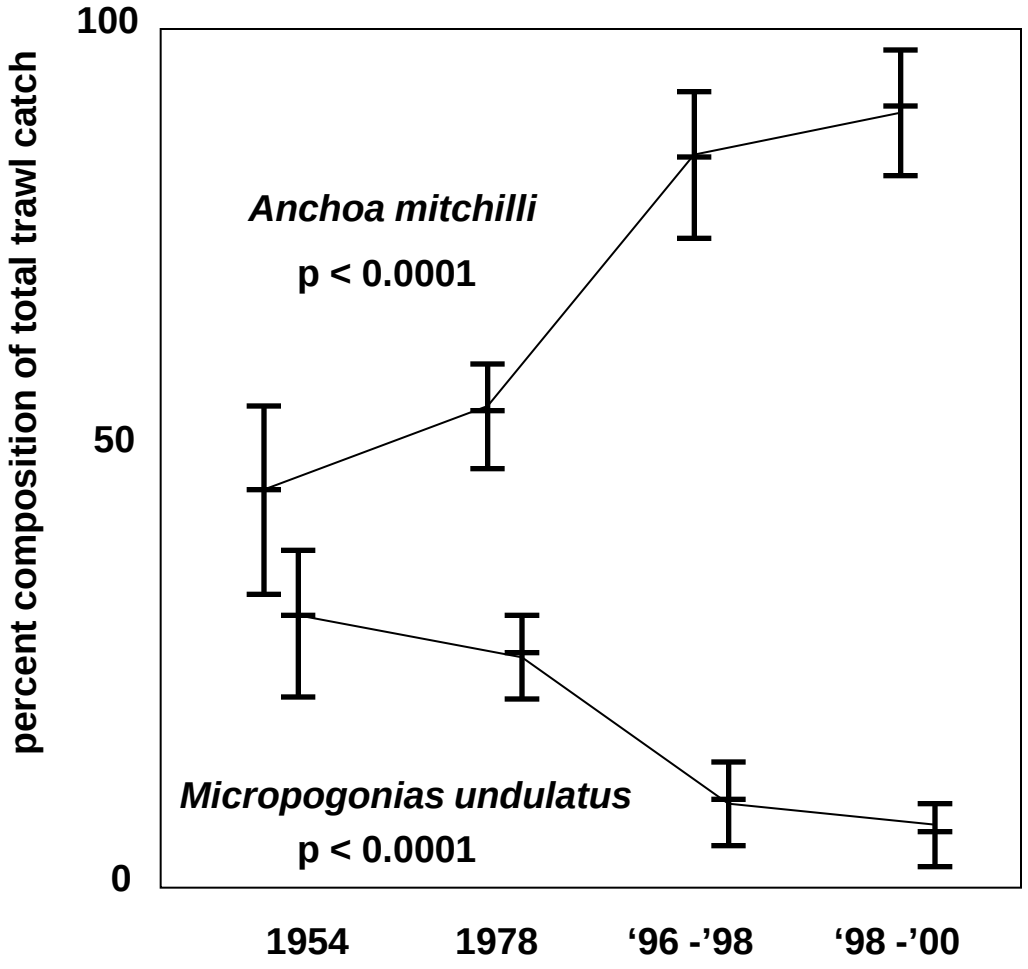
Significant Disturbances That Have Affected the Area and Nekton



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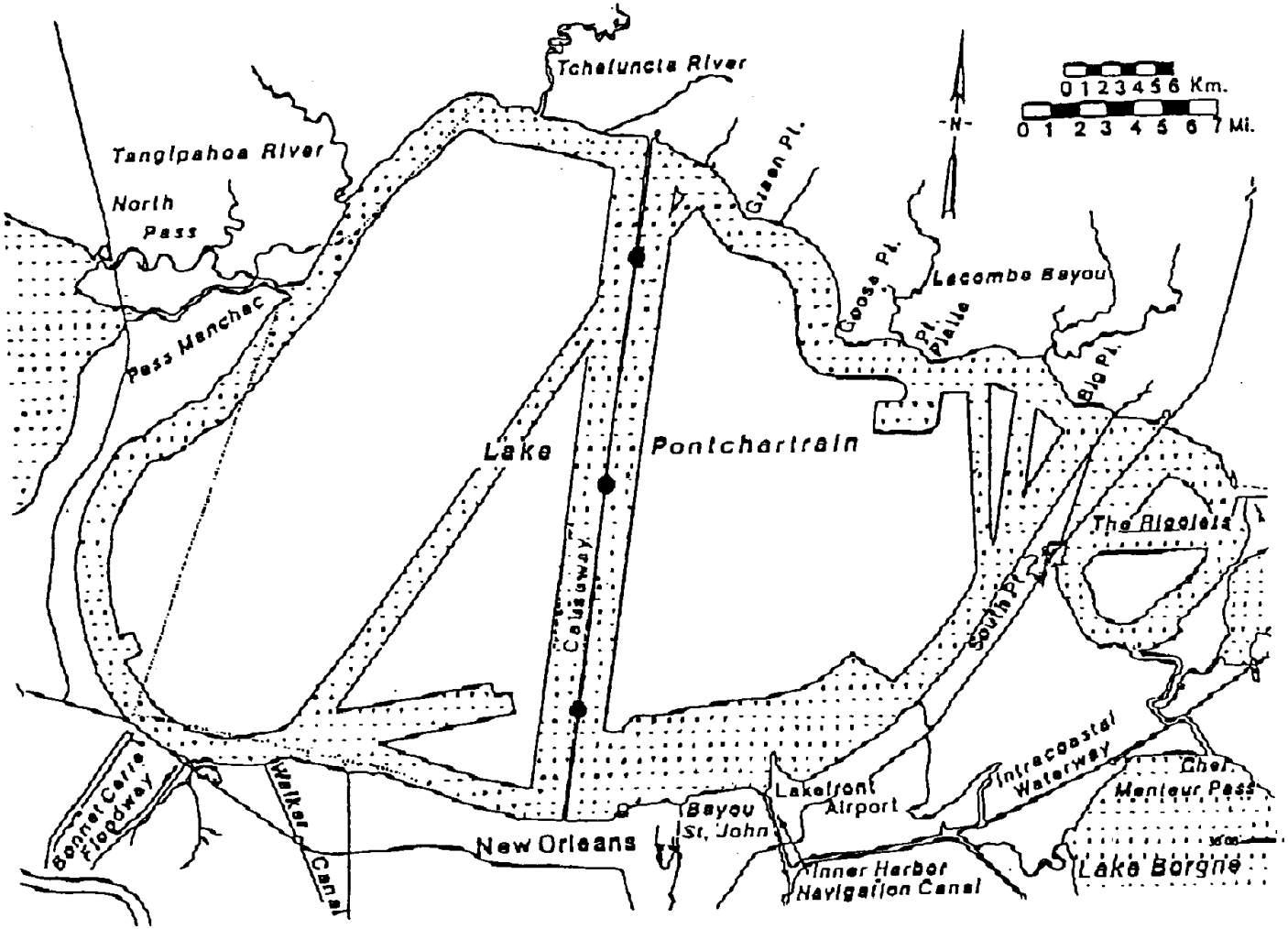

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FISH ASSEMBLAGE INSTABILITY AND HYDROLOGIC INFLUENCES IN LAKE PONTCHARTRAIN, LOUISIANA (USA), A DEGRADED OLIGOHALINE ESTUARY

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ABSTRACT

Lake Pontchartrain, an oligohaline estuary in southeastern Louisiana, has been subject to numerous anthropogenic impacts over the last half century including urban and agricultural runoff, shell dredging, over-fishing, artificial saltwater and freshwater inputs, shoreline alteration, and industrial discharges. Previous analysis of long-term fish data showed that significant changes in fish assemblages have occurred between 1954 and 2000. To assess the current condition of fish assemblages in Lake Pontchartrain relative to multiple ongoing and past environmental stressors, we conducted a three-year (2000-2003) monthly survey of fishes using trawls (7 sites), gillnets (5 sites), and beach seines (5 sites). Because increased fish assemblage variability has been used as an identifiable symptom of perturbed situations, we compared relative multivariate dispersion indices for assemblages representing different sites to determine which region appeared most affected by anthropogenic impacts. We also examined possible correlations between fish assemblage stability and five hydrologic

over the three years for trawl, gillnet, and beach seine samples were 465, 119, and 184 samples, respectively. Details of sampling methods are discussed in O'Connell et al. (2004). All analyses were conducted using PRIMER v5 software (Clarke and Warwick, 2001).

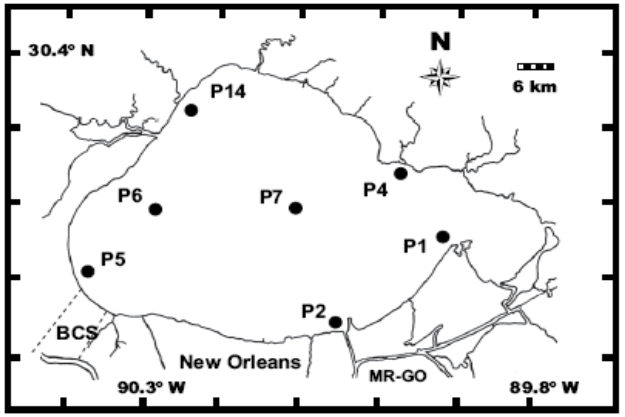

Fig. 1. Location map of Lake Pontchartrain, Louisiana showing the seven fish assemblage sites that were sampled monthly between July 2000 and June 2003. Note that only trawl samples were collected at mid-lake sites P6 and P7. Sources of anthropogenic disturbances shown are the Bonnet Carre Spillway (BCS), the City of New Orleans, and the Mississippi River Gulf Outlet (MR-GO).

Our secondary goal was to determine which hydrologic conditions could be influencing changes in fish assemblages over time. Previous research with estuarine fish assemblages has shown that assemblages from impacted habitats are not only more variable over time but also respond less to natural changes in hydrologic factors (Araujo et al., 2000; Peterson et al., 2000; Clarke and Warwick, 2001; O'Connell et al., 2004). For example, in less-

fish assemblages accurately reflected the relative habitat quality

Lake Pontchartrain fishery-independent data and the 2008 Bonnet Carré Spillway opening: a comparison of historic and post-opening surveys

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Analytical Approach

- basic idea: see if post-opening assemblages are different than historical fishery-independent data
- long-term data since 2000
- used six sites from around Lake Pontchartrain
- looked only at trawl data

Summary

– Natural Resource Management textbook: long-term monitoring, NGOs, teamwork, and adaptive management; encouraging

– river diversions can bring in good fishes (natives) and bad fishes (non-native)

– significant post-opening changes in fish assemblages occurred, with the most in June (i.e., lag period)

– assemblages at south shore sites (P5 and P2) most influenced; same as the past, need better habitat

Significant Disturbances That Have Affected the Area and Nekton: Hurricane Katrina

Title: Response of Lake Pontchartrain Fish Assemblages to Hurricanes Katrina and Rita

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Significant Disturbances That Have Affected the Area and Nekton: Hurricane Katrina

Abstract: To assess possible long-term impacts on fishes from the 2005 hurricanes and the pumping of New Orleans floodwaters into Lake Pontchartrain, we compared monthly collections taken prior to the hurricanes (2000-2003, 2005) with collections taken after (2006-2009). These analyses indicated which species contributed to any significant changes in assemblages. Those species contributing significantly to assemblage changes and the top 15 species of each gear type (trawl, seine, and gillnet) were further examined to see if numbers of individual species differed between the two time periods. Environmental parameters were examined to see which explained assemblage patterns, and plots of these parameters and species were made to determine if any parameters explained changes in assemblage or species numbers with the storms. Benthic fish assemblages exhibited the most post-hurricane changes with significant (ANOSIM, two-way crossed, $p < 0.05$) pre/post assemblage changes occurring in five of twelve months examined: March, April, June, July, and August. Global R values for these differences, though, were all markedly low ($R < 0.221$) suggesting that pre/post assemblage changes were not especially drastic. Assemblage analyses showed that in all five months, bay anchovies (*Anchoa mitchilli*) and Atlantic croaker (*Micropogonias undulatus*) were more numerous after the hurricanes, while fewer Gulf menhaden (*Brevoortia patronus*) were collected in post-hurricane trawls. Analyses of individual species yielded similar trends as assemblage analyses for Atlantic croaker and Gulf menhaden and found that sea catfish (*Ariopsis felis*) and hogchocker (*Trinecte. s maculatus*) increased significantly after the hurricanes as well. Pre/post beach seine and gillnet collections only yielded one month each of significant differences, again with relatively low global R values: November beach seines (ANOSIM, two-way crossed, $R = 0.319$, $p < 0.01$), April gillnets (ANOSIM, two-way crossed, $R = 0.275$, $p < 0.01$). No environmental parameters explained any assemblage changes due to the storms. These results suggest that four years after the hurricanes, Lake Pontchartrain fish assemblages have mostly recovered and there have been no long term environmental effects on fishes. While the two most common species (*A. mitchilli* and *M. undulatus*) actually increased, concerns exist about possible declines in *B. patronus* populations.

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A Meta-analytical Comparison of Fish Assemblages from Multiple Estuarine Regions of Southeastern Louisiana Using a Taxonomic-Based Method

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ABSTRACT

O'CONNELL, M.T.; O'CONNELL, A.M.U., and HASTINGS, R.W., 2009. A meta-analytical comparison of fish assemblages from multiple estuarine regions of southeastern Louisiana using a taxonomic-based method. *Journal of Coastal Research*, SI(54), 101–112. West Palm Beach (Florida), ISSN 0749-0208.

The estuarine ecosystems of southeastern Louisiana are threatened by numerous environmental impacts such as wetland loss, coastal development, and overharvesting of natural resources. If the relative health of different estuaries can be determined, then management efforts might be focused on those regions needing the most protection. Unfortunately, estuaries are by definition dynamic, precluding easy comparisons of relative environmental health. Meta-analyses can be used to overcome problems associated with this natural variability. Analyzing sizable ecological data sets that cover large spatial and temporal scales is helpful in assessing relative ecosystem health among different regions. To compare the health of four estuarine regions of southeastern Louisiana (the Barataria Basin, Lake Maurepas, Lake Pontchartrain, and the Biloxi Marsh and Chandeleur Islands region), we calculated taxonomic distinctness and variation in taxonomic distinctness for fishery-independent data collected from three habitats: demersal, nearshore, and pelagic habitats. Taxonomic distinctness is a biodiversity index that measures taxonomic distance between species collected in a single sample. This taxonomic-based method is robust to differences in sample size and generally more useful for large-scale meta-analyses than other diversity measures. We analyzed data collected by trawls (demersal habitats), beach seines (nearshore habitats), and gill nets (pelagic habitats) over various periods in the last half century. Demersal fish assemblages from Lake Pontchartrain and pelagic fish assemblages from the Barataria Basin were more affected than fishes collected in similar habitats in the other regions. Nearshore fish assemblages, though, were equally healthy across all regions studied.

ADDITIONAL INDEX WORDS: *Environmental health, coastal systems, Lake Pontchartrain, Lake Maurepas, Barataria Basin, Biloxi Marshes, Chandeleur Islands.*

INTRODUCTION

Over the last half-century the estuarine ecosystems of southeastern Louisiana have been affected by numerous environmental stressors such as wetland loss, coastal development, pollution, channelization of natural waterways, barrier island erosion, and overharvesting of natural resources (Chesney, Baltz, and Thomas, 2000; Day *et al.*, 2007; O'Connell *et al.*, 2005). In this region both the Pontchartrain and Barataria–Terrebonne basins contain productive estuaries that are adjacent to areas of high human density, namely the Greater New Orleans Metropolitan Area (GNOMA), which is the most populous area of the state (Penland *et al.*, 2002). This proximity to human development means that these estuaries are particularly vulnerable to multiple anthropogenic impacts as was seen in the aftermath of Hurricanes Katrina and Rita. However, different estuarine ecosystems may have different sources of environmental stress with different levels of impact. For example, the artificial corridor created by the Mississippi River Gulf Outlet (MRGO) into Lake Pontchartrain may have more of a significant impact on that estuary than does recreational harvesting of game fishes in lower Barataria Bay (O'Connell *et al.*, 2005). As we attempt to protect and properly manage these estuaries, it will be valuable to not only determine which regions need the most help but also ascertain which stressors most influence the health of these ecosystems.

Unfortunately, evaluating the relative health of multiple estuarine regions is often a case of comparing "apples and oranges." Even without anthropogenic influences, the estuarine portion of the Pontchartrain Basin, which extends west to east from Lake Maurepas to the Chandeleur Islands, differs from the more north–south oriented Barataria Bay, which is the estuarine portion of the Barataria Basin. Although these two estuarine regions share typical estuarine fish species, a comparison of their fish assemblages using traditional biodiversity indices (*e.g.*, species richness, evenness, *etc.*) may not be appropriate. In the past, these indices

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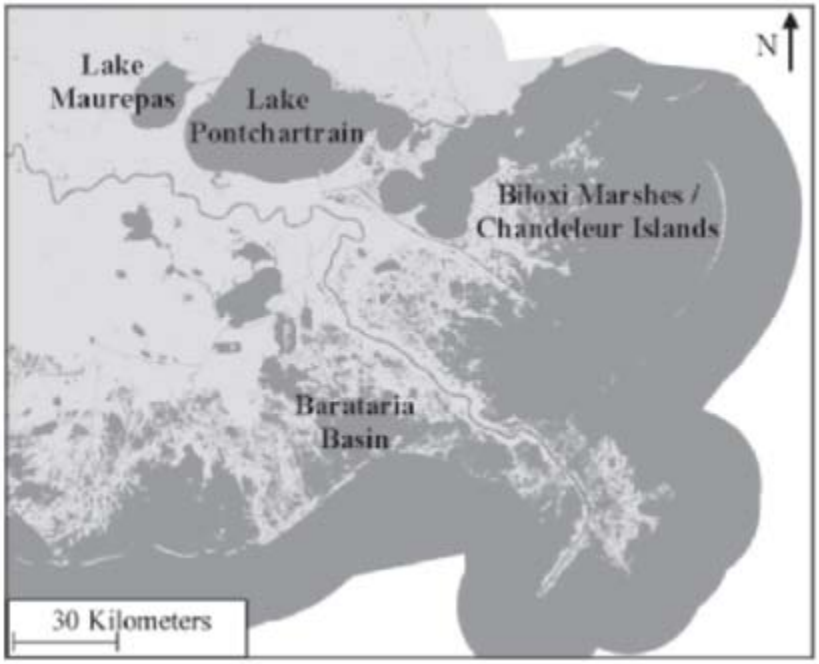
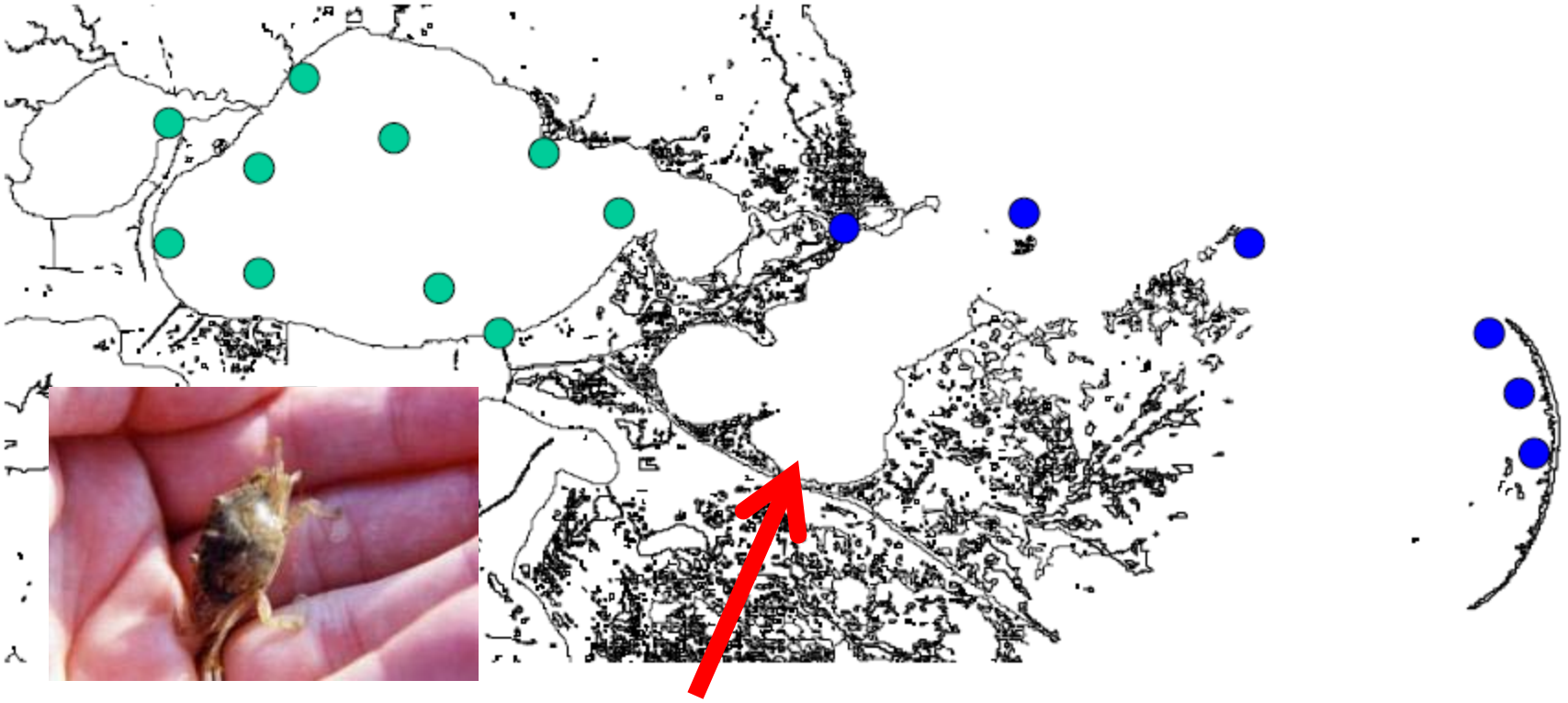


Table 2. *Summary of fishery-independent collections with reduced taxonomic distinctness (Δ+) and reduced variation in taxonomic distinctness (Λ+) from four estuarine regions of southeastern Louisiana (Barataria Basin, Lake Maurepas, Lake Pontchartrain, and the Biloxi Marsh and Chandeleur Islands region).*

Habitat and Gear Type	Estuarine Region	Total Collections Analyzed	Collections with reduced Δ+	Significance and Adjusted Residual (χ^2)	Collections with reduced Λ+	Significance and Adjusted Residual (χ^2)
Demersal/Trawl	Barataria Basin	2094	50	NS*	1	NS
	L. Maurepas	148	2	NS	1	NS
	L. Pontchartrain	719	**45**	**$p = 0.016/5.17$**	0	NS
	Biloxi/Chand.	174	5	NS	0	NS
Nearshore/Seine	Barataria Basin	835	8	NS	1	NS
	L. Pontchartrain	457	2	NS	0	NS
	Biloxi/Chand.	182	6	NS	0	NS
Pelagic/Gill net	**Barataria Basin**	977	**46**	**$p = 0.049/3.76$**	0	NS
	L. Maurepas	161	2	NS	0	NS
	L. Pontchartrain	167	0	NS†	0	NS
	Biloxi/Chand.	56	0	NS	**1**	**$p = 0.046/4.83$**

Significant Disturbances That Have Affected the Area and Nekton: An Open MRGO (2006 Blue Crab Sampling)



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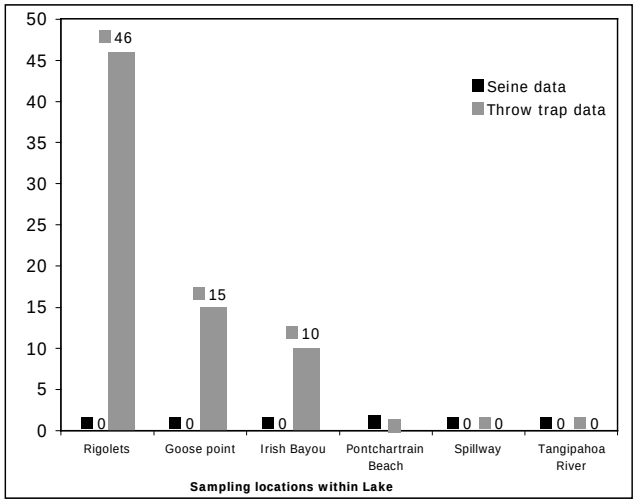
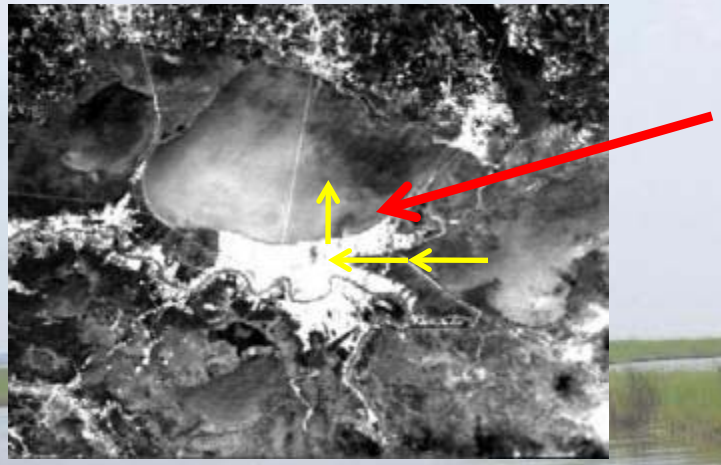


Circulation Differences During Recruitment Peaks



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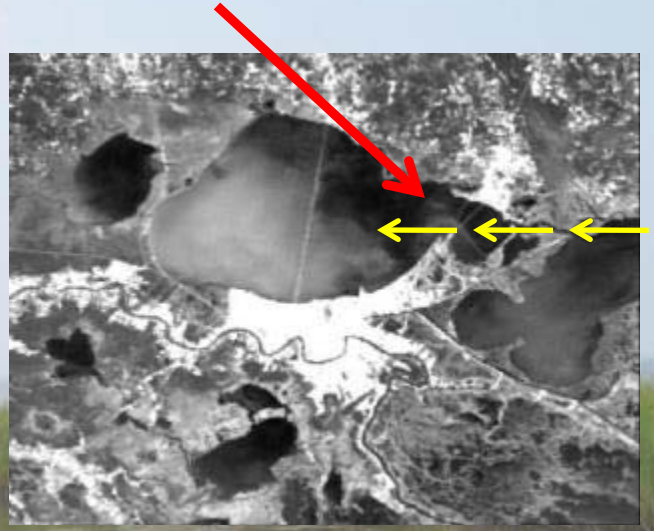

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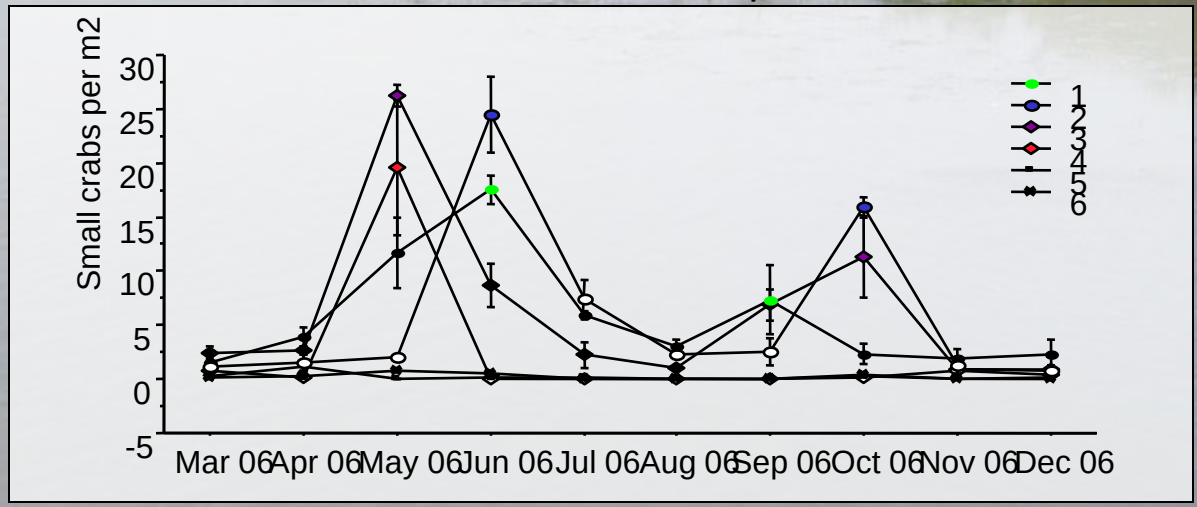
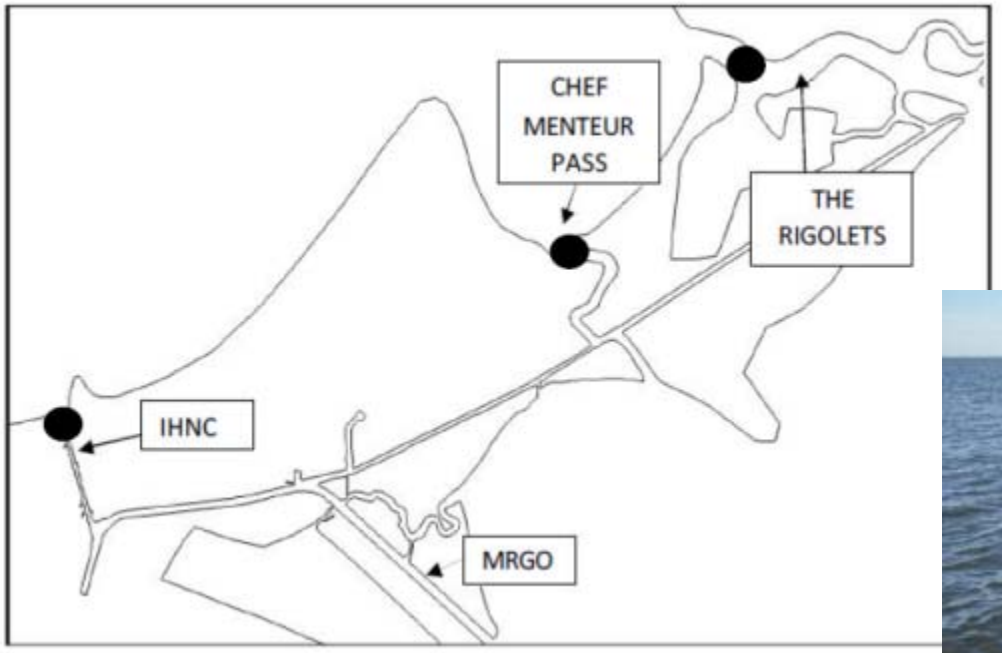
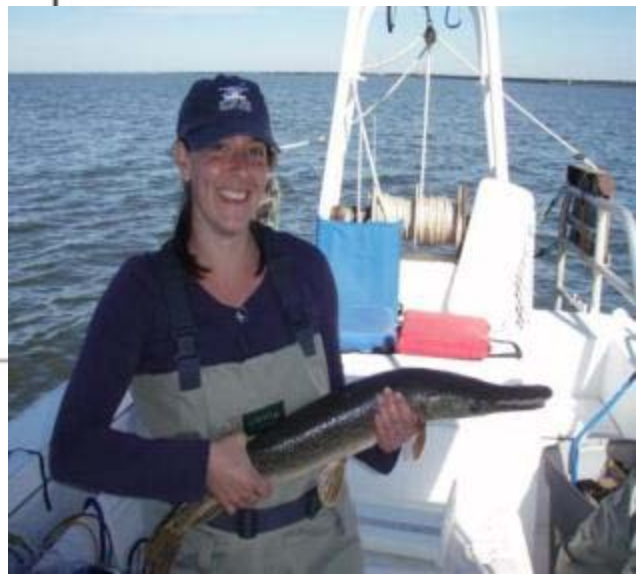


Lyncker et al. (*in prep.*)

Significant Disturbances That Have Affected the Area and Nekton: MRGO Closed (2009 – 2011)





MRGO study is now also an oil spill study

Significant Disturbances That Have Affected the Area and Nekton: 2010 *Deepwater Horizon* Oil Spill

- NRL received preliminary funding from NSF, Sea Grant, and NGI to examine immediate nekton response
- sampled areas in Lake Pontchartrain, Lake Borgne, and the Chandeleur Islands
- preliminary data suggest little immediate effects but will need to continue monitoring over long-term
- for adult nekton, it is not so much the trophic toxicity as the possible loss of the 2010 year class

… which leads nicely into

Damage, Recovery, and the Current Conditions

- estuaries and estuarine organisms are resilient things
- if a nuclear device were detonated in Lake Pontchartrain, most nekton species would return the next year
- as I've been telling reporters, when things are bad adult fishes 'Get out of Dodge'
- Hurricane Katrina example

Damage, Recovery, and the Current Conditions

"That toxic sludge will kill the lake for many years to come."

"Pumping that catastrophe into the lake will wreak havoc on the ecosystem."

"The lake route (for pumping floodwaters) would kill several thousand acres of nearby swamps and marshes which have already been rapidly diminishing because of alterations to the Mississippi River."

… well, not really

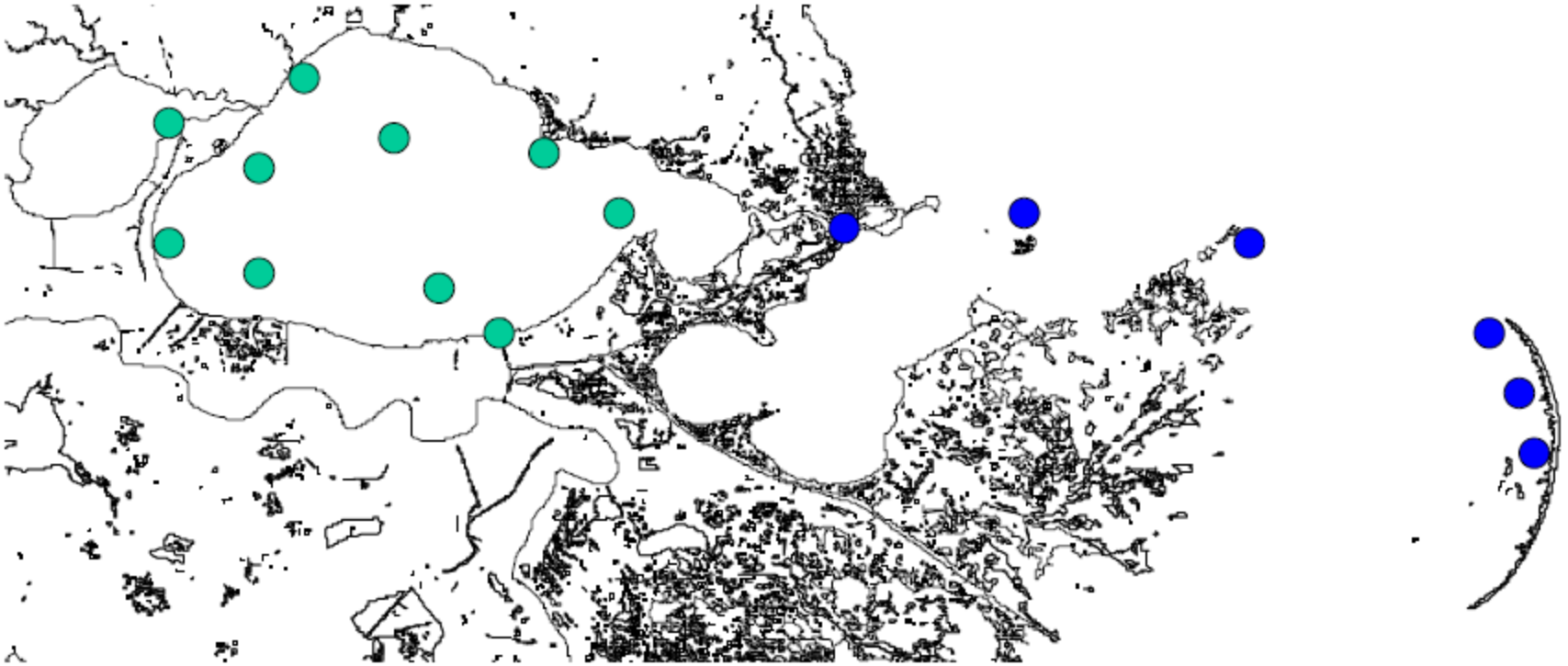
Damage, Recovery, and the Current Conditions

– “This is great! Marty says estuarine critters will survive dredging, hurricanes, spillway openings, and oil spills. We’re good-to-go!”

– the reality is somewhere between ‘doom-and-gloom’ and ‘everything is just rosy’

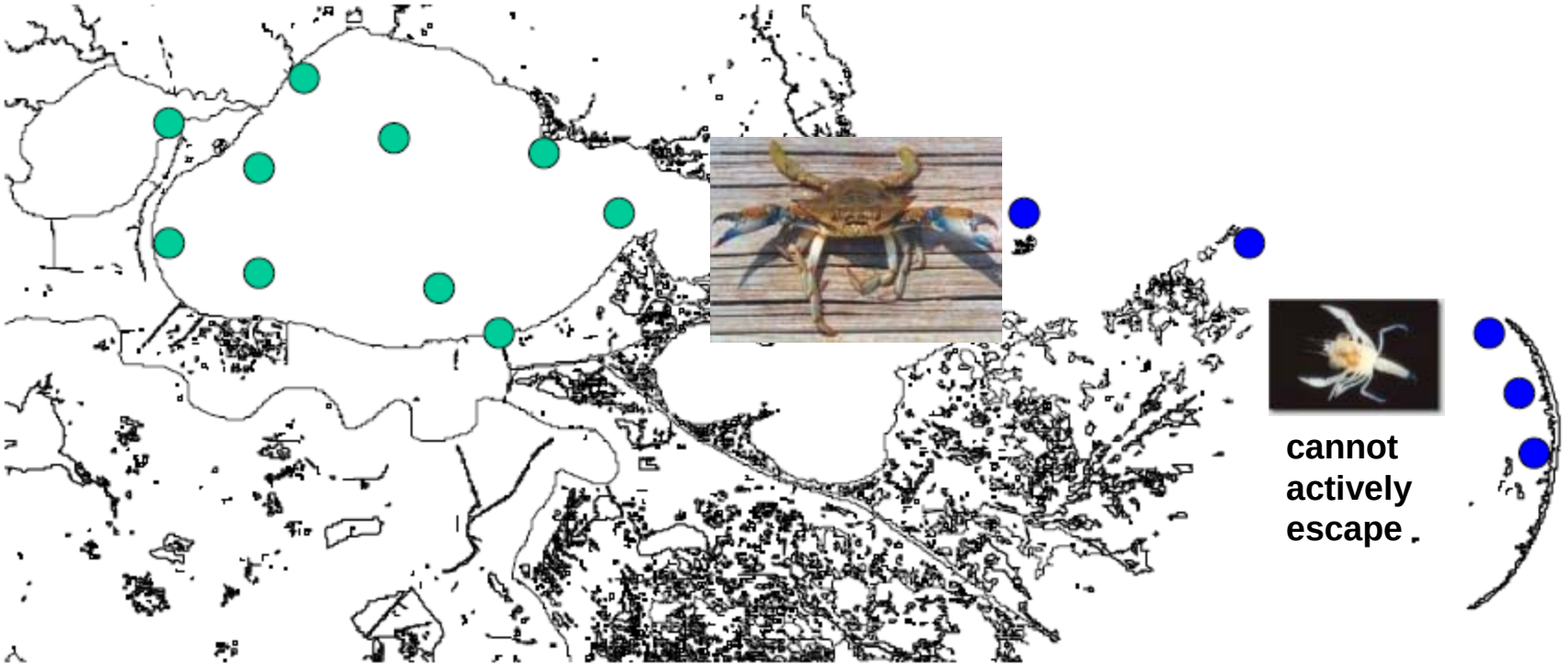
– key point: because estuarine nekton are resilient and estuaries themselves are highly variable on a year-to-year basis, we need long-term data to even detect possible changes to the system (e.g., dredging)

Damage, Recovery, and the Current Conditions



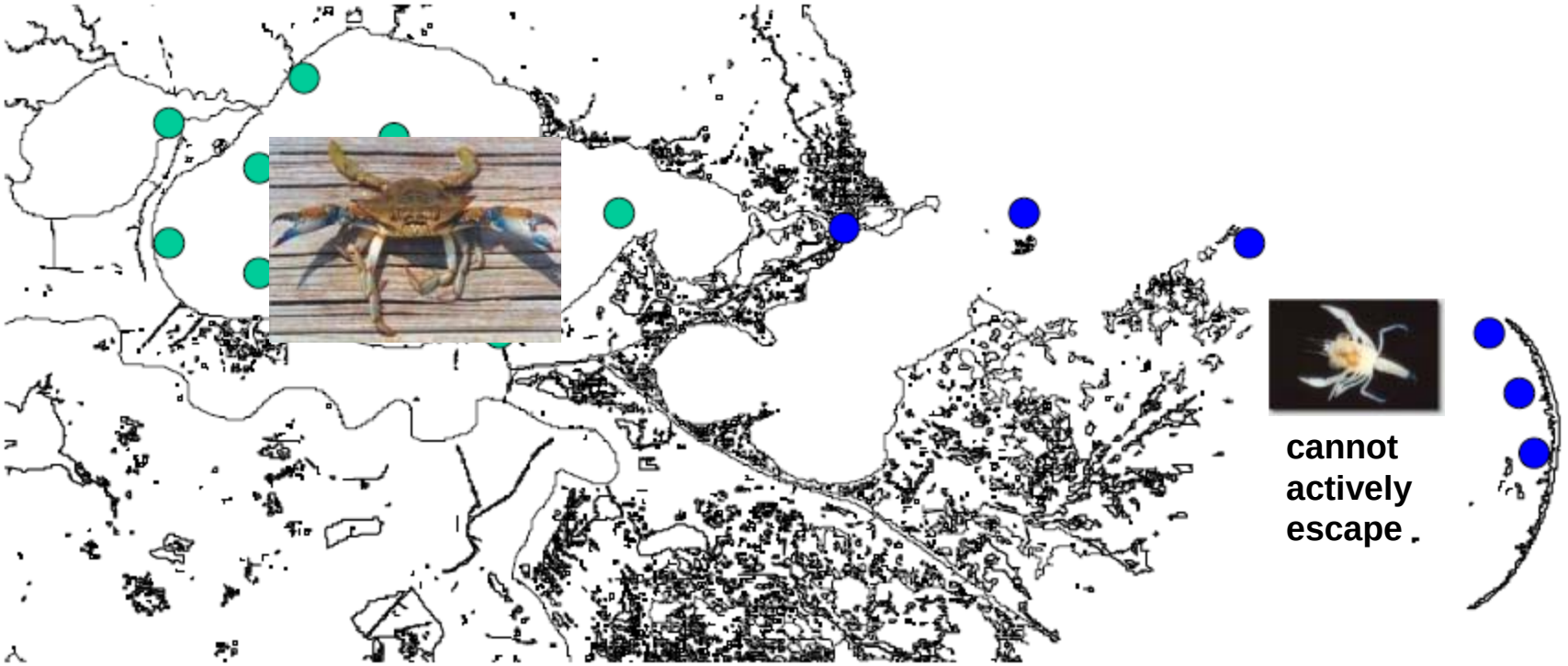
– in fact, we need data over large temporal scales and large spatial scales to really understand estuaries

Damage, Recovery, and the Current Conditions



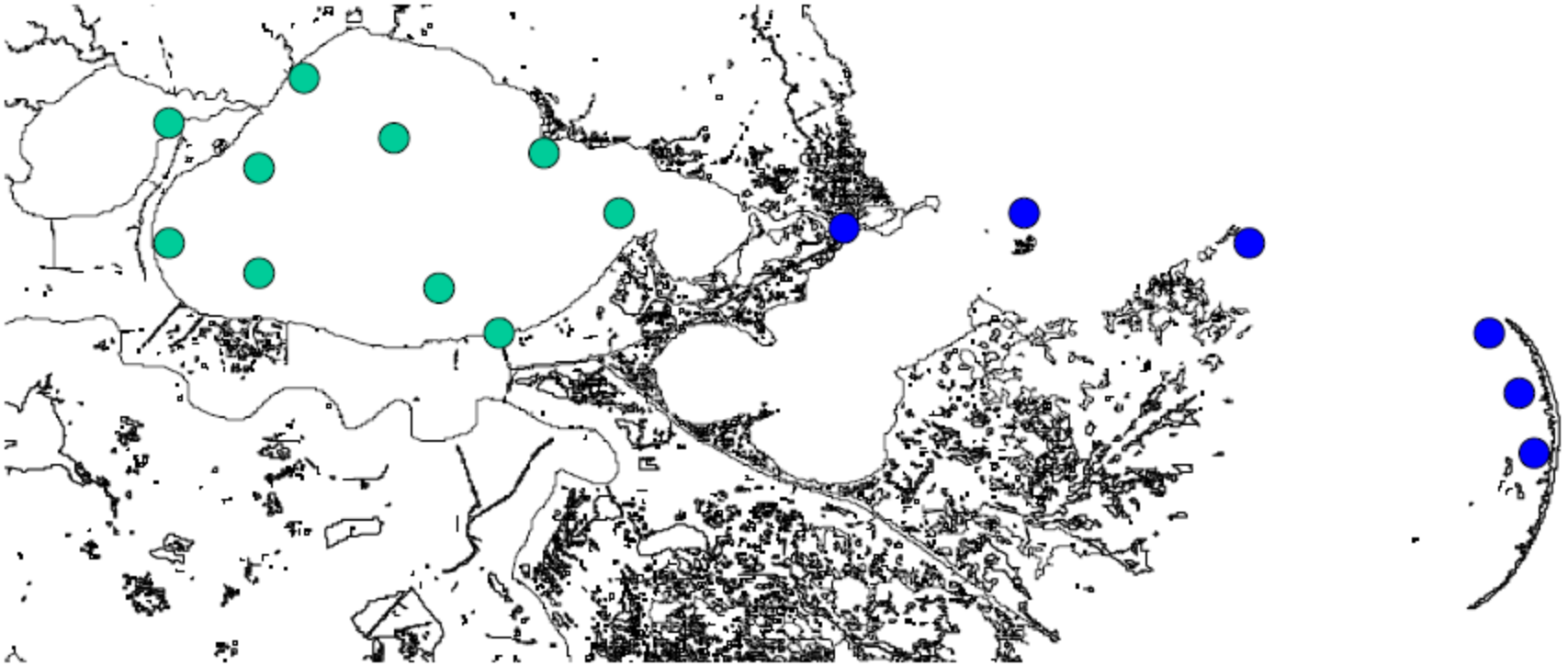
– let's go back to this statement: for adult nekton, it is not so much the trophic toxicity as the possible loss of the 2010 year class; nekton versus plankton

Damage, Recovery, and the Current Conditions



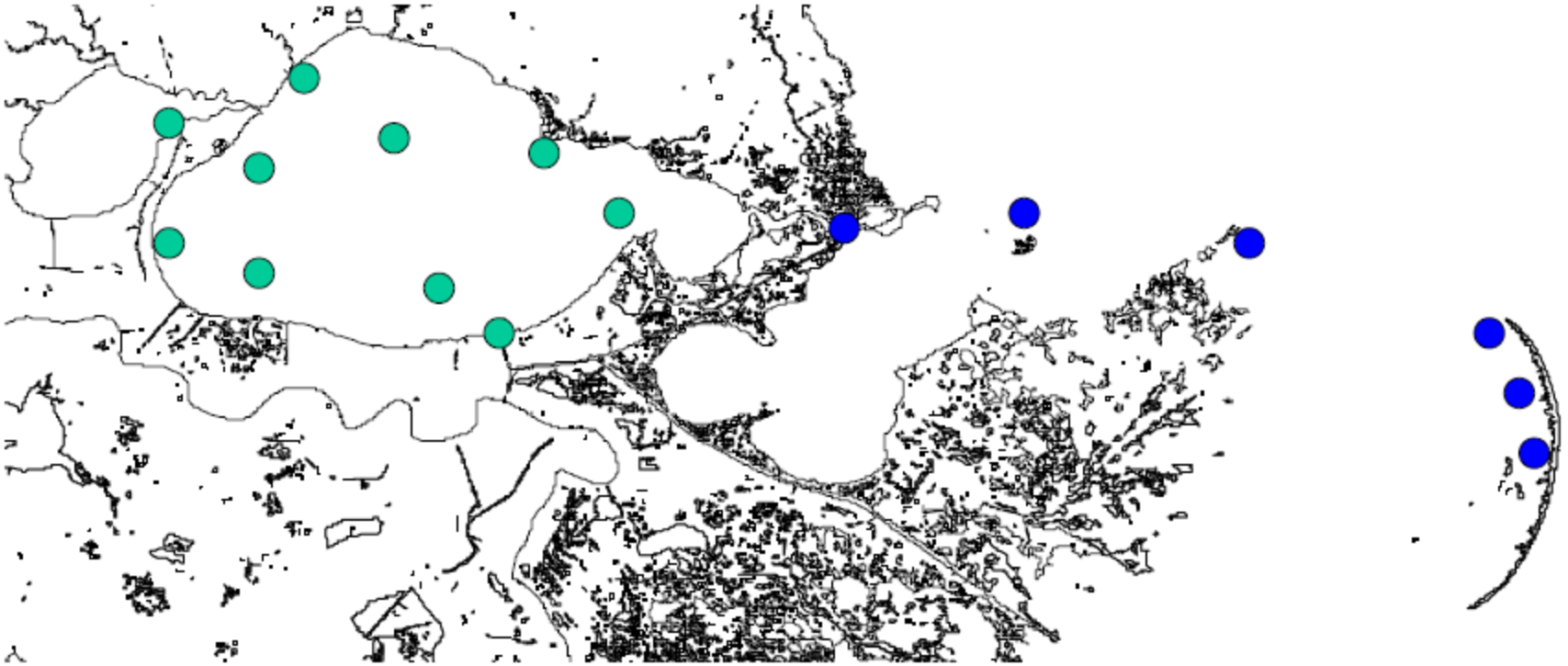
– to find out which species may have been impacted by oil or dispersants, we need to assess the community years later when these larvae should be adults

Best Future Practices to Define "at risk" Areas and Resources



– find spawning localities for key species
– right now we can guess general areas, but more specific information needed

Possible Approaches to Monitor Nekton Health



– monitor at historical baseline localities with multiple gear types: compare to baseline data
– when something goes wrong, we know what species <u>should</u> be present

Chandeleur Island Lemon Shark Nursery Habitat

Pre-Oil Spill

Post-Oil Spill

Reference

Lyncker, L. 2008. Abundance and distribution of early life stage blue crabs (*Callinectes sapidus*) in Lake Pontchartrain, Louisiana. Master's thesis, University of New Orleans, New Orleans, LA. 78 pp.