Assessing aquatic community composition, habitat, and environmental conditions in the northern Gulf of Mexico over a three decadal period: 1986-2015

Martin T. O'Connell
University of New Orleans

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Overview

- acknowledgments
- spatial and temporal scales
- research goals
- methods and data analyses
- results and summary

Acknowledgments

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

MARTIN T. O'CONNELL[1], ROBERT C. CASHNER, and CHRISTOPHER S. SCHIEBLE

Nekton Research Laboratory, Pontchartrain Institute for Environmental Sciences, Department of Biological Sciences, University of New Orleans, New Orleans, Louisiana 70148

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-

[1] Corresponding author; tele: 504/280-4032; fax: 504/280-4022; e-mail: moconnel@uno.edu

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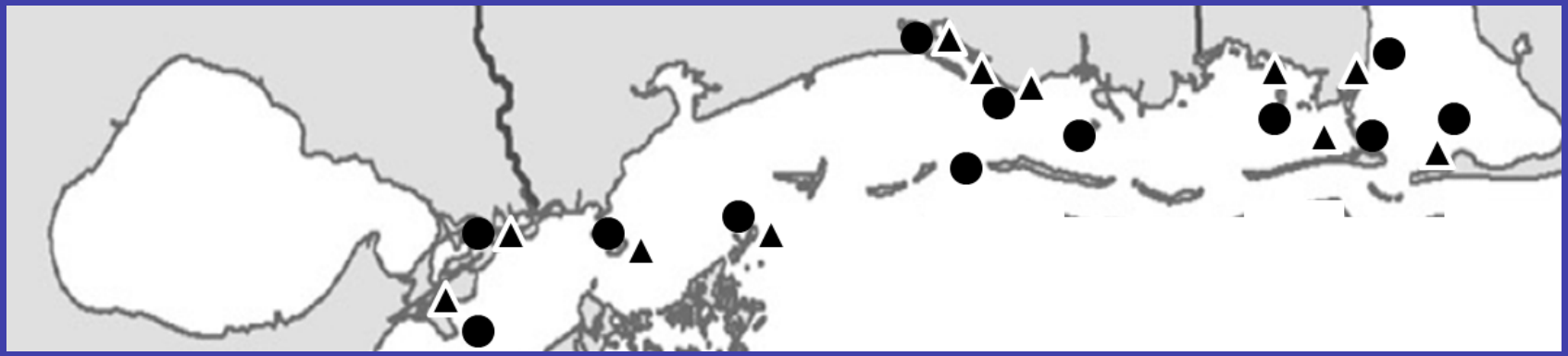
Research Goals

- use data on large spatial and temporal scales to assess long term trends in important commercial species

- generate useful baseline data that could be used in the future to understand which species are in which habitats

Methods



trawl

beach seine

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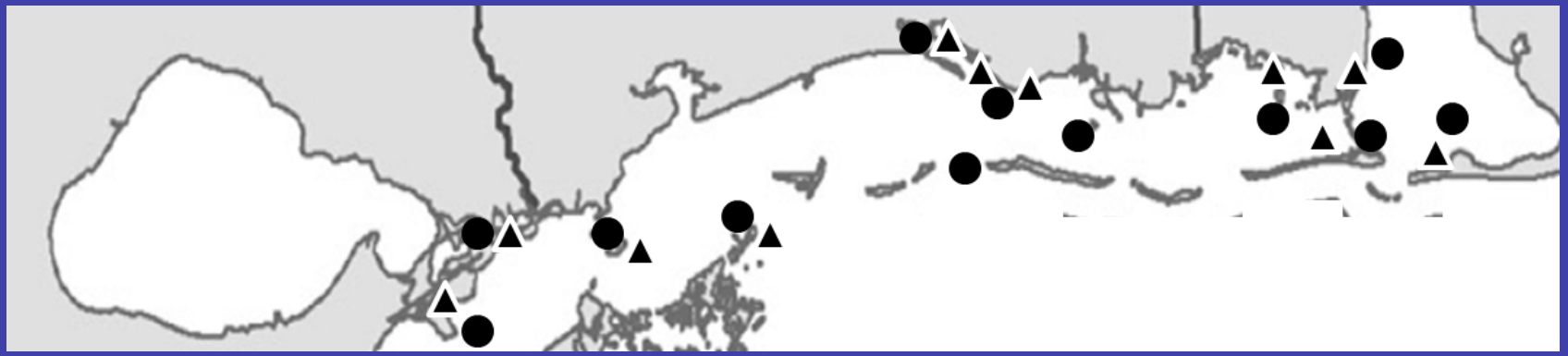
Methods



- 4 trawl sites, 4 seine sites (LA, AL)
- 4 trawl sites, 3 seine sites (MS)
- spring (Apr. – Jun.) and fall (Sep. – Nov.)

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Methods

- collected all finfishes and blue crabs, brown shrimp, and white shrimp
- collected from 2012-2017 (2012-2015 data)
- abiotic data: temperature, salinity, and dissolved oxygen
- habitat data: substrate composition

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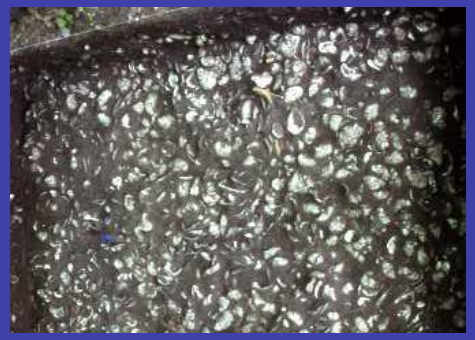
Data Analyses

- combined current data with historical data from 1986 – 2011 (large temporal scale)

- biotic spatial analyses: species composition, ANOSIM

- environmental and habitat spatial analyses: BIOENV, PCA, LINKTREE



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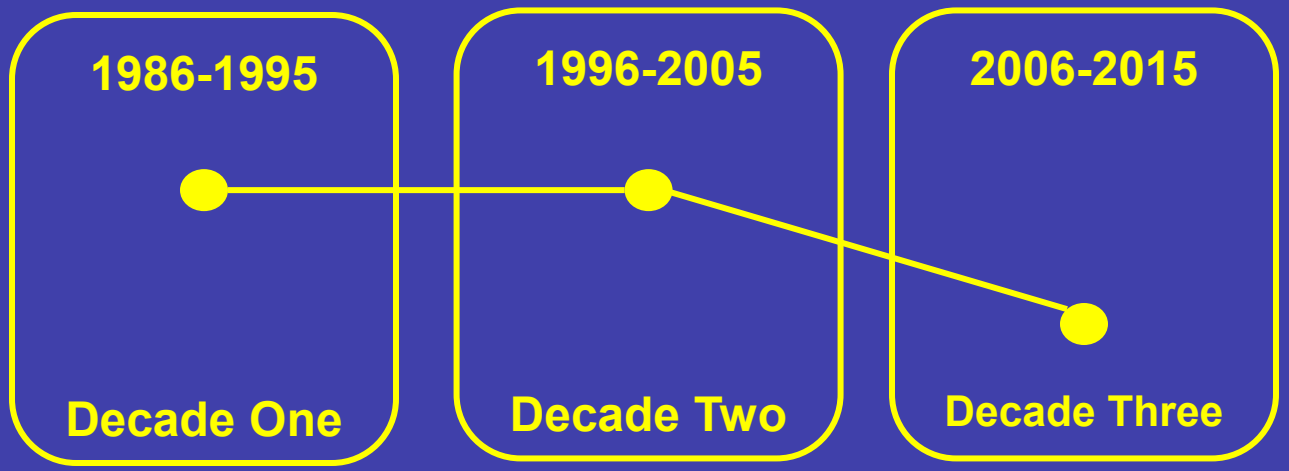
Data Analyses

- biotic temporal analyses: INDVAL

- index combining species abundance and frequency of occurrence in different time periods (Dufresne and Legendre, 1997; Sirot et al. 2015)



Data Analyses

- abiotic temporal analyses: ANOVA, environmental variables only (habitat mostly static)

- temperature, salinity, and dissolved oxygen

- detecting possible significant changes among the three decades

Results: biotic spatial analyses

- species composition in trawl samples differed among all three states

  spring: ANOSIM, R = 0.543, p = 0.001

  fall: ANOSIM, R = 0.722, p = 0.001

- not apples and apples…its apples, oranges, and kumquats; implications for analyses

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Results: biotic spatial analyses

- species composition in beach seine samples similar among all three states

  spring: ANOSIM, $R < 0.06$, $p = 0.61$

  fall: ANOSIM, $R < 0.167$, $p = 0.14$

- Huh? estuarine resident species, juvenile estuarine-dependent species 'sprayed' into habitats

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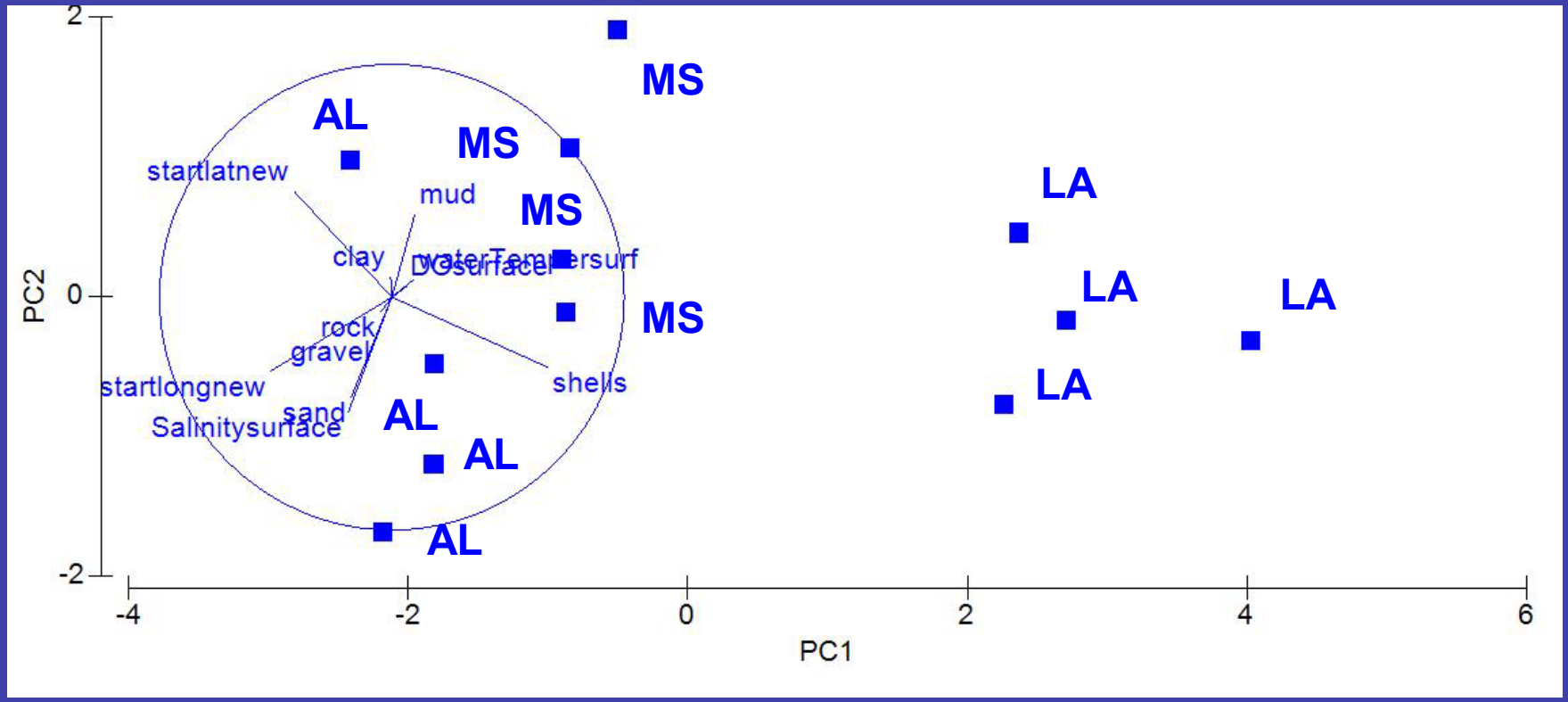
Results: abiotic spatial analyses



"…greatest significant ($p < 0.05$) separation of groups involved LA differing from MS and AL (B% = 86) based on…substrates that were >11% shell ."

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Results: biotic temporal analyses

- split into state-season-gear scenarios
- of the 56 most common species we analyzed, 31 exhibited a significant decline in at least one state-season-gear scenario over the study period
- focused on those 13 species that exhibited significant declines in more than one state-season-gear scenario

Results: biotic temporal analyses

Table XX. List of 13 coastal species that exhibited significant declines in more than one state-season-gear scenario over a three-decade period (1986-2015) in the northern Gulf of Mexico states of Louisiana (LA), Mississippi (MS), and Alabama (AL). Samples were taken over two seasons (spring and fall) each year and two gear types (trawl and beach seine) were used. Species are listed from most to least total scenario declines. For each species, it is noted whether the decline occurred in the second (1996-2005) or third (2006-2015) decade. Note that for beach seine samples, there were no significant differences in species composition found among the three states so all states were combined for the analyses. *One of three ecologically and commercially important crustacean species included in the analyzed community. **Member of the Order Pleuronectiformes (flatfishes).

Species\Scenario	LA spring trawl	LA fall trawl	MS spring trawl	MS fall trawl	AL spring trawl	AL fall trawl	LA/MS/AL spring seine	LA/MS/AL fall seine
*Callinectes sapidus**	no decline	**declined in third decade**	**declined in third decade**	**declined in third decade**	**declined in third decade**	no decline	no decline	no decline
Sphoeroides parvus	no decline	no decline	**declined in third decade**	**declined in second decade**	not present in samples	**declined in third decade**	**declined in second decade**	not present in samples
*Citharichthys spilopterus***	not present in samples	not present in samples	**declined in third decade**	not present in samples	**declined in third decade**	**declined in third decade**	not present in samples	not present in samples
*Etropus crossotus***	not present in samples	not present in samples	not present in samples	**declined in second decade**	**declined in second decade**	**declined in third decade**	not present in samples	not present in samples
*Symphurus plagiusa***	not present in samples	not present in samples	**declined in third decade**	**declined in second decade**	no decline	**declined in third decade**	not present in samples	not present in samples

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Results: biotic temporal analyses

Species\Scenario	LA spring trawl	LA fall trawl	MS spring trawl	MS fall trawl	AL spring trawl	AL fall trawl	LA/MS/AL spring seine	LA/MS/AL fall seine
Ariopsis felis	no decline	no decline	**declined in second decade**	**declined in second decade**	no decline	no decline	**declined in second decade**	no decline
*Farfantepenaeus aztecus**	no decline	no decline	**declined in third decade**	**declined in third decade**	no decline	no decline	no decline	no decline
*Paralichthys lethostigma***	**declined in third decade**	not present in samples	**declined in third decade**	not present in samples	not present in samples	not present in samples	not present in samples	not present in samples
Menidia peninsulae	not present in samples	not present in samples	not present in samples	not present in samples	not present in samples	not present in samples	**declined in second decade**	**declined in second decade**
Fundulus similis	not present in samples	not present in samples	not present in samples	not present in samples	not present in samples	not present in samples	**declined in third decade**	**declined in third decade**
Ictalurus furcatus	**declined in second decade**	not present in samples	**declined in third decade**	not present in samples	not present in samples	not present in samples	not present in samples	not present in samples
Cynoscion arenarius	no decline	no decline	**declined in third decade**	**declined in third decade**	no decline	no decline	no decline	no decline
Polydactylus octonemus	no decline	not present in samples	**declined in second decade**	not present in samples	**declined in second decade**	not present in samples	not present in samples	not present in samples

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- somewhat concerned about benthic species

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Results: abiotic temporal analyses

- LA trawl sites became saltier in both spring (ANOVA, $p < 0.01$) and fall (ANOVA, $p < 0.01$)

- MS spring trawl sites (ANOVA, $p < 0.02$) and AL trawl sites for both spring (ANOVA, $p < 0.01$) and fall (ANOVA, $p < 0.01$) became warmer

- LA: losing wetland buffer, but perhaps the River will keep temperatures cool in future

Summary

- biotic differences among state trawl samples

- likely driven in part by differences in environmental conditions and habitat

- no differences in species composition among states for beach seine samples

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Summary

- declines over time for blue crabs, brown shrimp, some flatfishes, and other benthic-oriented species

- LA sites have become saltier while most MS and AL sites have become warmer

- concern: east-west running coast…no escape