Effects of Metals and Pesticides on Health and Physiology of Oysters (*Crassostrea virginica)* in Estero Bay Estuary: Implications for Management of Water Quality

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Abstract

Although historical records indicate that oyster reefs were once a significant feature of Gulf of Mexico estuaries, alterations in freshwater inflow resulting from watershed development and water management practices have impacted salinity and water quality, and led to declines in oyster populations within southwest Florida. This project examined the relationship between contaminants and water quality on the responses of American oyster, *Crassostrea virginica* within Estero Bay Estuary. Levels of metals, pesticides, and PCBs in the water column and in the oyster tissues, and water quality parameters in oysters were correlated with condition index, disease prevalence of *Perkinsus marinus*, reproductive state of adult oysters, growth and survival of caged juvenile oysters, and oyster spat settlement.

Results indicate that oyster condition index, spat recruitment, prevalence and infection intensity of *Perkinsus marinus* showed a seasonal trend and increased downstream. Heavy metals and pesticides concentrations varied between sampling locations and months. Average metal concentrations were below national averages. Oyster responses varied more with seasonality (salinity), rather than due to contaminant levels. These results will help establish water quality targets for restoration and to better understand the cumulative impacts of land use management practices.

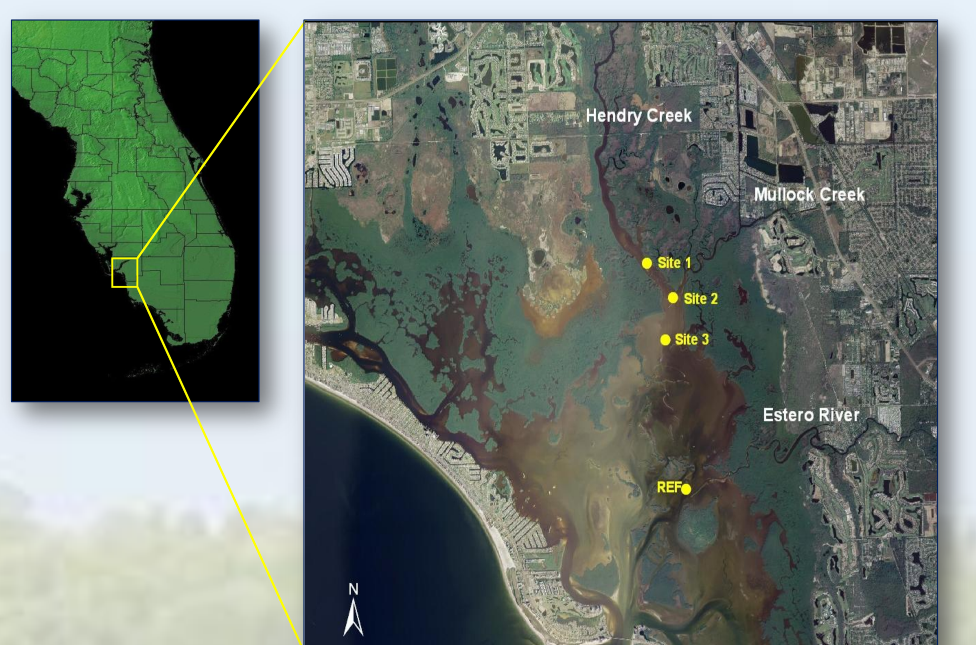

Fig. 1 Map of the study area in the Hendry Creek and Estero Bay Estuary with sampling locations.

Fig. 2 Staff collecting samples in Hendry Creek.

Objective

- •Investigate various heavy metals, pesticides, and PCBs in the water column and in the oyster tissues, and evaluate water quality parameters at three potentially impacted and one reference site (Fig. 1)
- •Examine seasonally the condition index, disease prevalence of *Perkinsus marinus*, and reproductive potential using adult oysters.
- •Study oyster spat settlement on oyster shells deployed at various sites.
- •Contrast and correlate the measured health and ecological parameters with contaminant concentrations.

This project used the American oyster, *Crassostrea virginica*, as sentinel organisms in contaminant monitoring programs. The results from this study will help determine what the desired water quality conditions should be for the estuary, thereby giving resource managers a target for restoration. This correlation will be valuable to better understand the cumulative impacts of land use management practices and to identify areas that need further attention to restore ecological function. (Volety et al. 2003)

Introduction

- •Why use oysters?
  - ▪Sessile, benthic, filter feeders, huge filtering capacity and poor detoxification mechanisms (Fig. 2)
  - ▪Used in NOAA Status and Trends Program & International Mussel Watch Program.
  - ▪Easy to make cause and effect relationships
  - ▪Comparisons can be made with prior data
- •SW FL has experienced accelerated population growth in recent years
- •Watersheds are heavily managed to accommodate development
- •Runoff is directed into sensitive estuarine environments
- •Alterations have resulted in water quality degradation and loss of fish and wildlife habitat, including oysters
- •Connections between land use and impacts on the ecosystem is necessary, but this information is currently lacking

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Chemical Analyses: FDEP-Tallahassee Lab

Materials and Methods

- •Chemical analyses (Oyster & Surface H20)
  - •Metals: Aluminum, Antimony, Arsenic, Cadmium, Chromium, Copper, Iron, Lead Magnesium, Manganese, Selenium, Silver, Strontium, & Zinc (EPA 6020, EPA 6010B)
  - •Mercury (DEP SOP: HG-007-1)
  - •Pesticides, PCBs & Organochlorines (EPA8081/8082, EPA 8141)
  - •Water quality: Specific conductance, salinity (Fig. 3), pH, temperature, & dissolved oxygen
- •Bivalve analyses (Indication of oyster health)
  - •Disease: *Perkinsus marinus* infection prevalence and intensity (Ray 1954, Mackin 1962)
  - •Condition Index ratio of meat to shell (Lucas & Beninger 1985)
  - •Reproduction: spat recruitment (Haven & Fritz 1985) (Fig. 8); Gonadal Index (Heffernan et al. 1989) (Fig. 7)

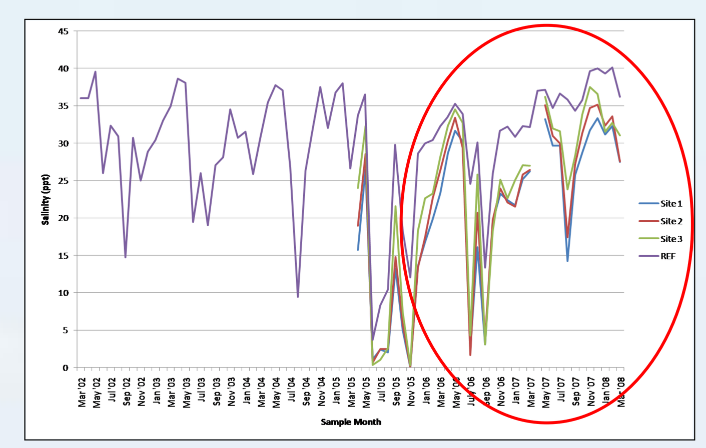

Fig. 3 Surface water salinity at the sampling locations in Hendry Creek during the sampling period. Salinities exhibited an expected seasonal trend with lower salinities during the warmer summer / fall months.

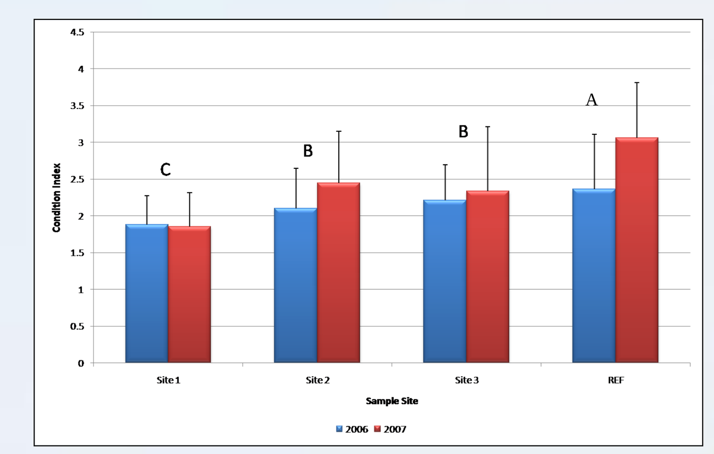

Fig. 4 Mean Condition Index of oysters at the sampling locations in Hendry Creek averaged for each location for the sampling period.

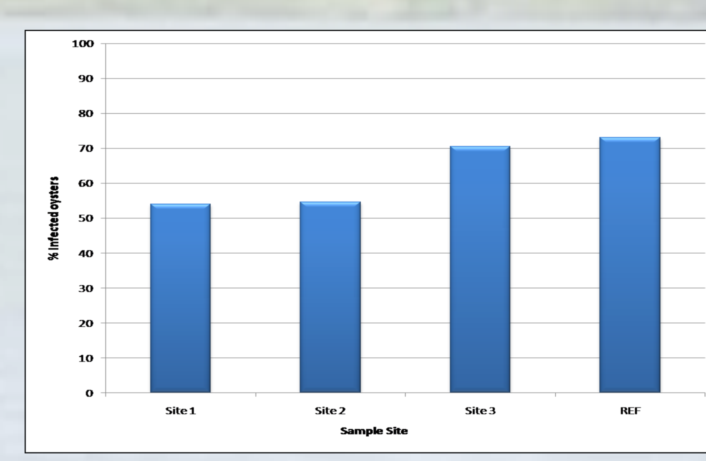

Fig. 5 Mean prevalence of *P. marinus* (% infected oysters) at the sampling locations in Hendry Creek averaged for each location for the sampling period.

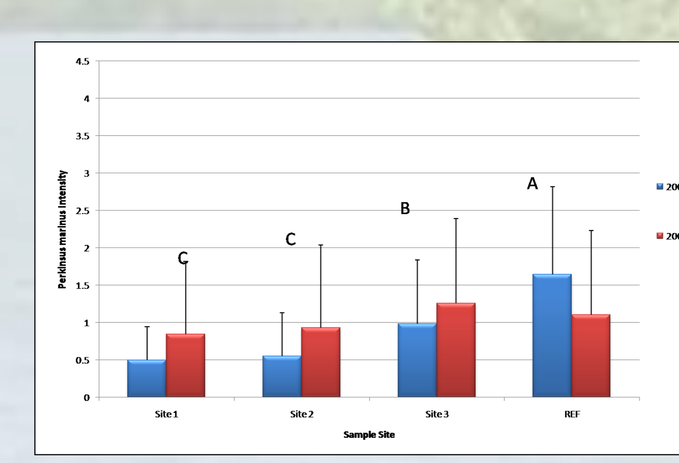

Fig. 6 Mean intensity of *P. marinus* infection in oysters at the sampling locations in Hendry Creek averaged for each location for the sampling period.

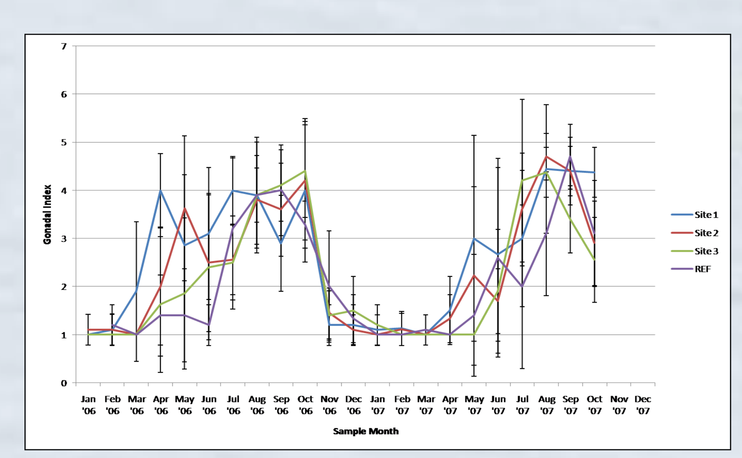

Fig. 7 Mean Gonadal Index at the sampling locations in Hendry Creek averaged for each location for the sampling period.

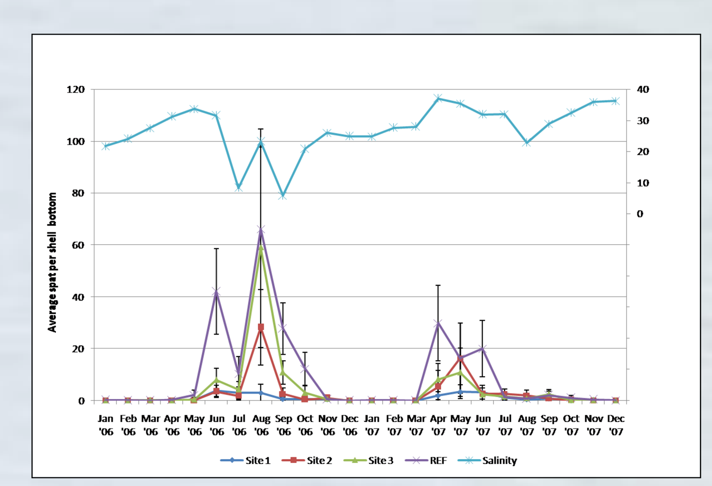

Fig. 8 Spat recruitment (spat/shell) at the sampling locations in Hendry Creek during the sampling period. Spat recruitment was highest during the summer / fall months when oysters are spawning.

Summary

- •Oyster responses varied more with seasonal patterns (salinity) than due to contaminant levels
- •Pesticide and PCB concentration in water & oyster tissue samples collected bi-monthly were below detection limits; PAHs were not examined
- •Metal concentrations varied between sampling locations and sampling months
- •Average metal concentrations were below National average (Table 1)
- •Condition index, spat recruitment, and Gonadal Index showed a seasonal trend varying with spawning activity and increased downstream (Fig. 4)
- •*Perkinsus marinus* infection in oysters increased with increasing distance downstream (Fig. 5 & 6)
- •Data supports oyster reef creation and restoration within the Bay (Fig. 9)
- •Adaptive Science Management is a tool resource managers can use to design WQ plans/goals that account for the various forms of uncertainty found within complex systems

Fig. 9 One year growth

SITE	Ag	As	Cd	Cu	Hg	Zn
Estero Bay	1.3	5.5	1.4	126	0.08	2164
Caloosahatchee [a]	1.4	10.1	0.9	220	0.15	3315
Gulf of Mexico [b]	3.4	9.2	4.4	178	0.13	2901
Chesapeake Bay [c]	5.0	6.6	6.9	266	0.04	4900
National "High" [d]	2.4	17	2.8	490	0.24	6500

Table 1 Average oyster tissue Units are in mg/kg (ppm) dry weight.
[a]Volety et al. 2001, [b] Presley et al. 2004, [c] NOAA NS& T webs site, [d] O'Connor & Beliaeff 1995

References

Haven, D.S., and L. W. Fritz. 1985. Marine Biology. 86: 271-282.

Heffernan, P. B., R. L. Walker and J. L. Carr. 1989. Gametogenic cycles of three marine bivalves in Wassaw Sound, Georgia II *Crassostrea virginica* (Gmelin, 1791). Journal of Shellfish Research 8:61-70.

Lucas, A. and P. G. Beninger. 1985. The use of physiological condition index in marine bivalve aquaculture. Aquaculture 44:187-200.

Mackin, J. G. 1962. Mortalities of oysters. Proceedings of the National Shellfisheries Association. 50: 21-40.

O'Connor, T. P. and B. Beliaeff. 1995. Recent trends in coastal environmental quality: results from the Mussel Watch Project 1986-1993. NOAA Silver Springs, MD.25 pp.

Presley, B.J., G. A. Wolfe, R. J. Taylor and P. N. Boothe. 2004. Trace elements in Gulf of Mexico oysters, 1986-1999. Geochemical Investigations in Earth and Space Science: A Tribute to Isaac R. Kaplan 267-285.

Ray, S. M. 1954. Biological studies of *Dermocystidium marinum*. The Rice Institute Pamphlet. Special Issue. November 1954, pp. 65-76.

Volety A. K., S. G. Tolley and J. T. Winstead. 2003. Effects of seasonal and water quality parameters on oysters (*Crassostrea virginica)* and associated fish populations in the Caloosahatchee River. Interpretive final report to South Florida Water Management District.

Volety, A.K., G. Romeis and B. Boler. 2001. Effects of heavy metals and pesticides on health and physiology of oysters in the Caloosahatchee Estuary: implications for management of water quality and restoration of oyster reefs. Interpretive final report to Charlotte Harbor National Estuary Program.