

Sediment Quality Assessment Survey of Lavaca and Matagorda Bays

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MATAGORDA BAY MITIGATION TRUST



Do Stressors Affect Ecosystem Health of Lavaca-Matagorda Bay System

- Suspected that anthropogenic pressures have impacted Lavaca-Colorado Estuary, Texas since the late 1960's
- Superfund site - ALCOA Plant (1940s-1990s)
- Clean Water Act violations - Formosa Plastics Plant (1983-2019)
- Reduced inflow (increasing salinity)
- Climate change (increasing temperature and decreasing dissolved oxygen)



Bioindicators of Ecosystem Health

What is Ecological Health?

- Ecological health is assessed by determining if indicators of ecological conditions are in an acceptable range



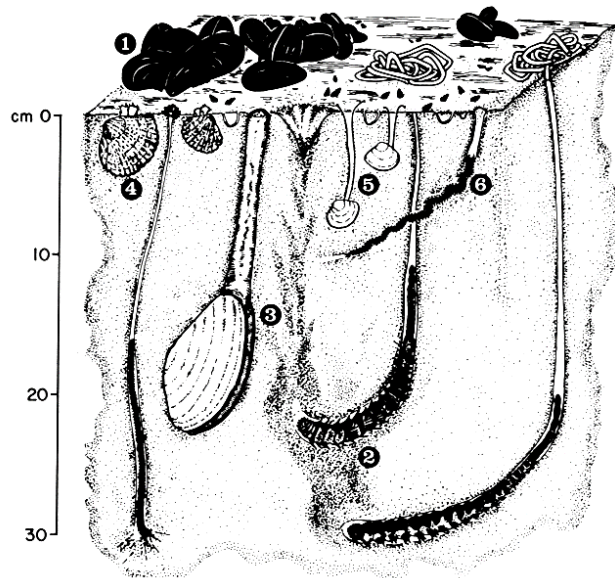
What are Bioindicators?

- Measure risk
- Point to need for action



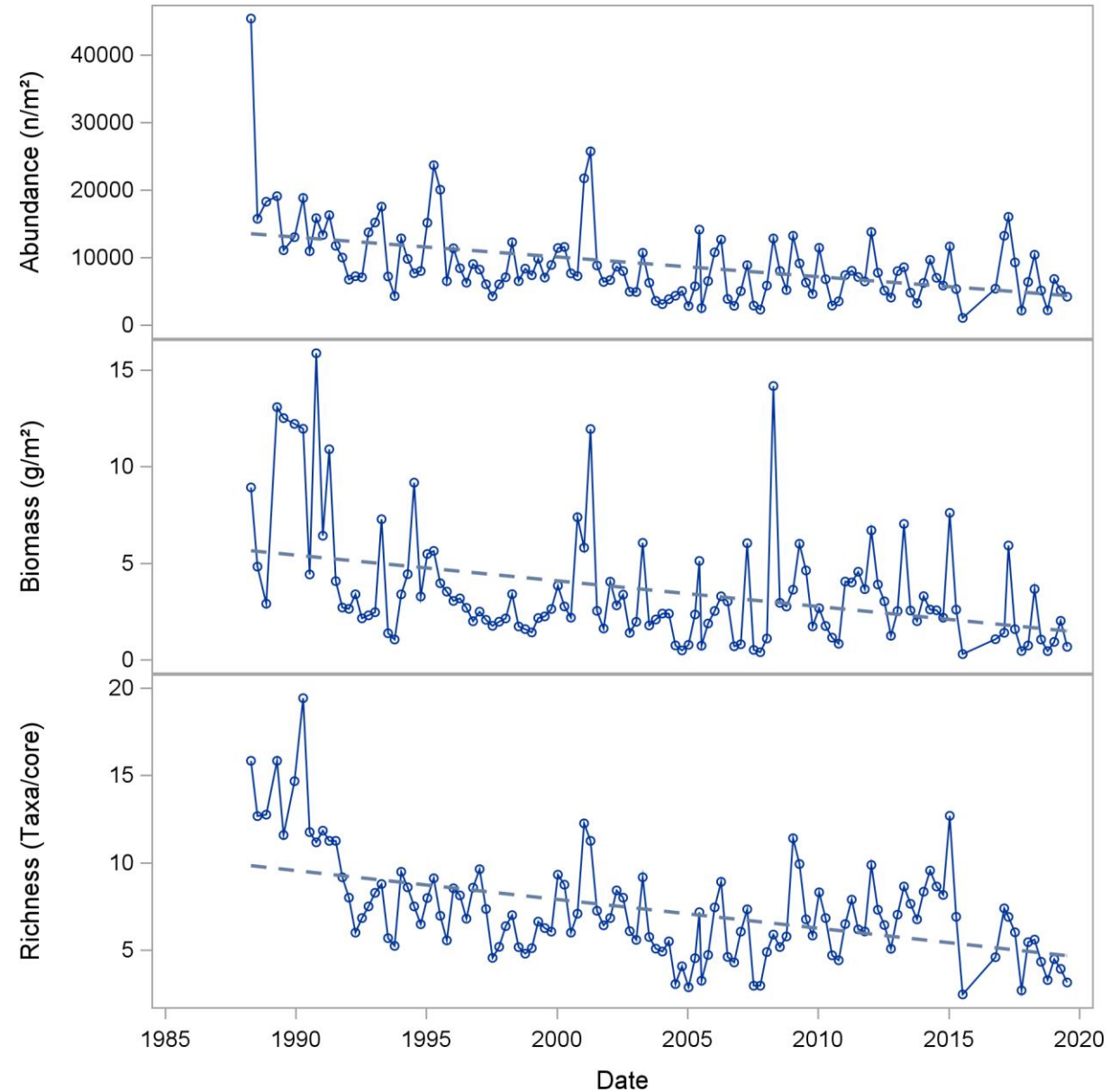
Bottom-Dwelling Critters (Benthos) are Excellent Bioindicators of Ecosystem Health

- Sessile (can't move away)
- Relatively long-lived
- Diverse
- Well known
- Diversity indicates integrity and is a sensitive indicator of change
 - During a disturbance:
 - Tolerant species stay the same or increase
 - Sensitive species decline or die



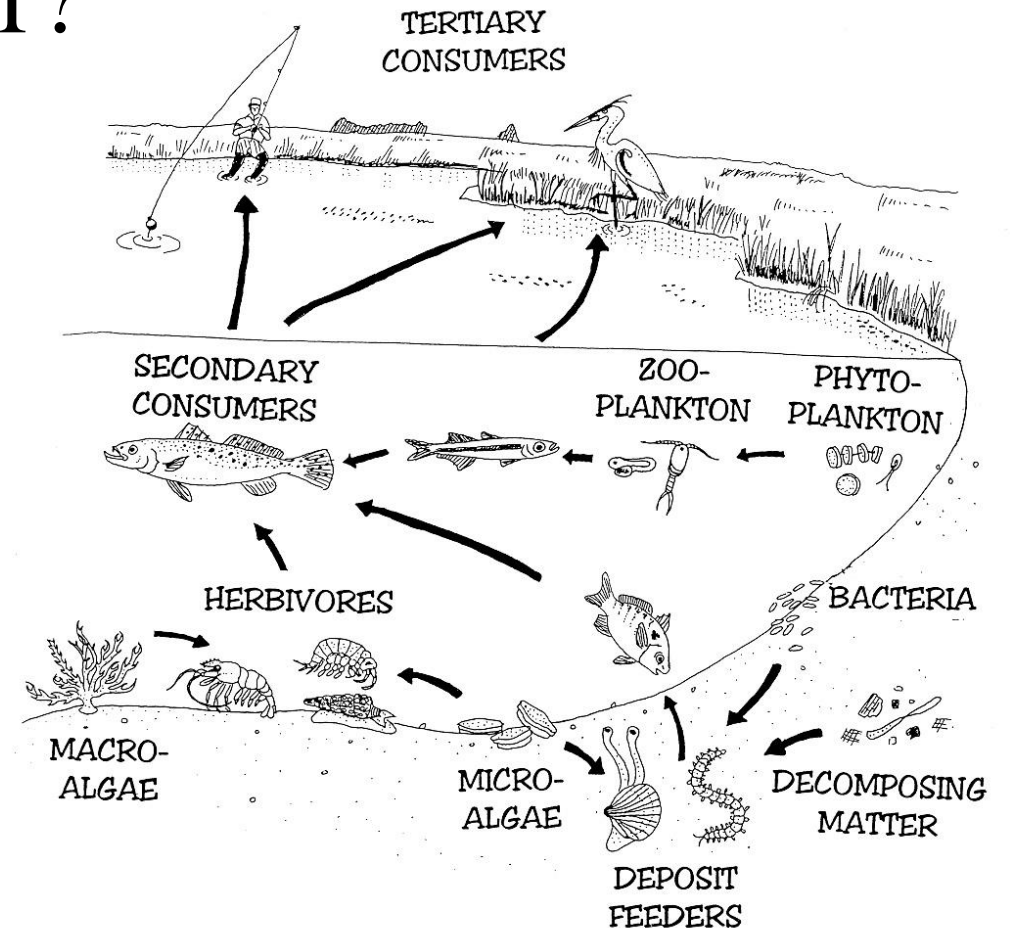
Benthic Declines in the Lavaca–Colorado Estuary

- There has been a long-term decline in benthic abundance, biomass, and diversity in the TX Lavaca–Matagorda Bay system since 1988
- Is pollution a possible cause of the decline?
- What does this indicate?
- Does it matter?



So, What if Benthos Disappear?

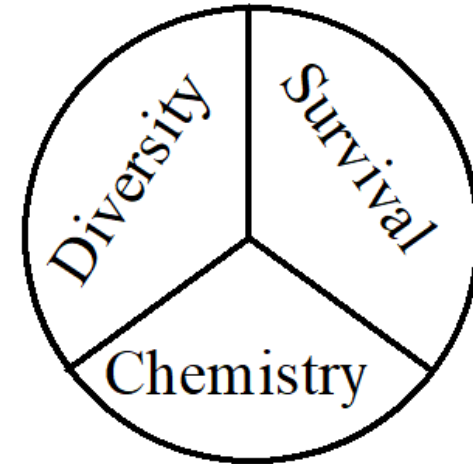
- Benthos are food for many bottom-feeding fish such as flounder, red drum, black drum, and other
- So, trophic links will be affected causing a bottom-up effect
 - Declining fish populations
- Which then affects human food sources, commercial and recreational fishing, and job security



Source: Montagna et al. 1996, CCBNEP #8
<http://cbbep.org/publications/virtuallibrary/ccbnep08.pdf>

Sediment Quality Triad Approach

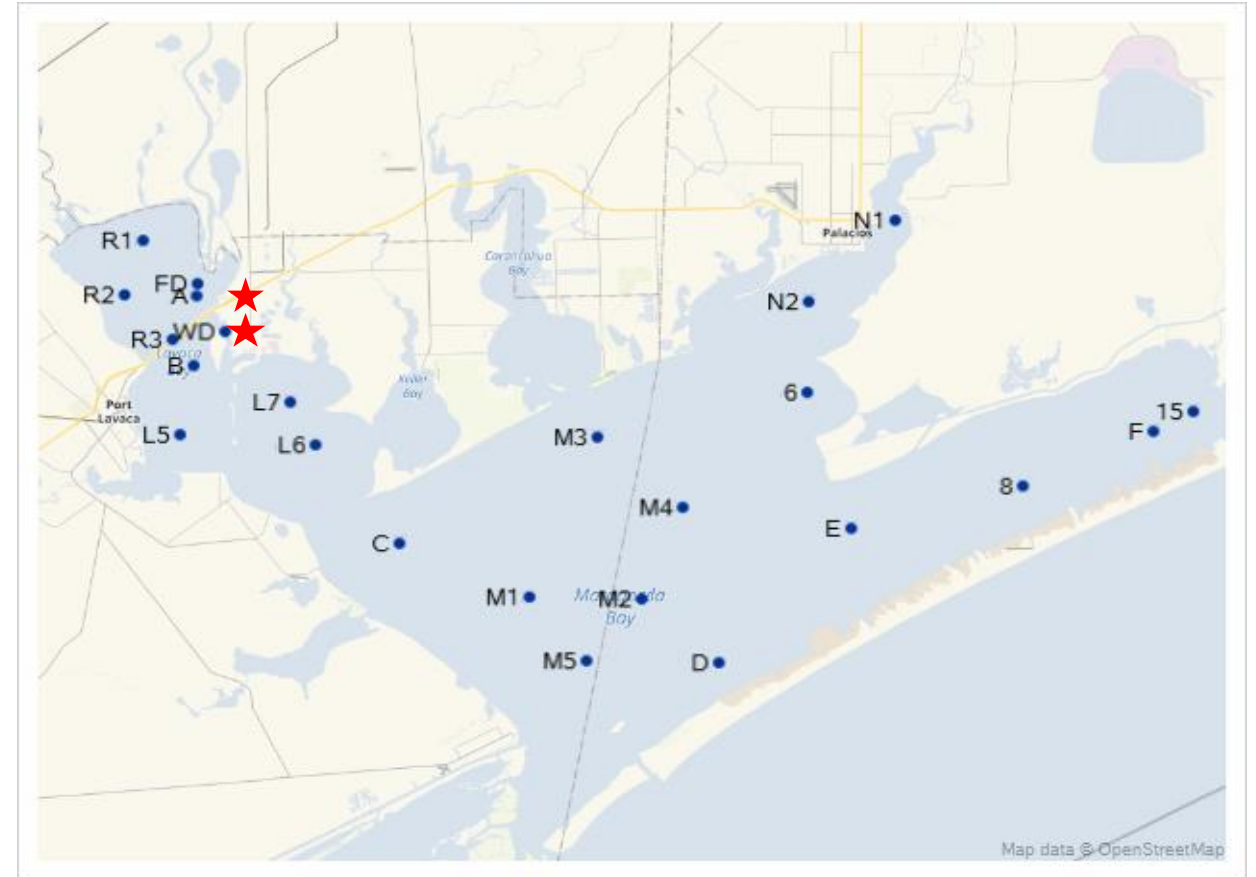
- Three measures because no one measurement provides comprehensive information
- Integrates environmental chemistry, biological, and ecological experimentation to determine pollution induced degradation (Chapman et al., 1987)



- Classify responses in two ways:
 - Based on known thresholds for sediment quality
 - Compared within the study

Study Locations

- Station selection based on:
 - Long-term studies by Harte Research Institute (HRI for the Lavaca-Colorado Estuary (LC)
 - Matagorda Bay Health Evaluation study by HRI
 - National Fish & Wildlife Foundation study for focused flows (N)
 - Formosa Plastics Corporation monitoring study (R)
 - Space between stations sampled in the past in Lavaca Bay (L) or Matagorda Bay (M).



Map of the stations in the Lavaca-Colorado Estuary
Stars are locations of Alcoa and Formosa.

Methods

- Three measurement analyses
 - Sediment chemistry: Measure of dose
 - Chlorinated Pesticides and PCBs
 - Polycyclic Aromatic Hydrocarbon (PAHs)
 - Total Petroleum Hydrocarbons (TPH)
 - Total Organic Carbon (TOC)
 - Trace Elements
 - Toxicology testing: Measure biological effects
 - Grass shrimp *Paleomonetes pugio*
 - Amphipod *Leptochirus plumulosus*
 - Polychaete *Neanthes arenaceodentata*
 - Macrofauna: Measure ecological effects
 - Abundance, Biomass, Diversity
 - Sediment grain size



Why Measure Sediment Chemistry?

- Sediments accumulate contaminants and serve as sources of pollution to the ecosystems
 - Pathogens, nutrients, metals, and organic chemicals are absorbed onto inorganic and organic materials that eventually settle to the bottom
- If the contaminant loading is large enough, sediments may accumulate excessive quantities of contaminants



Uses of Contaminants Measured

Oil:

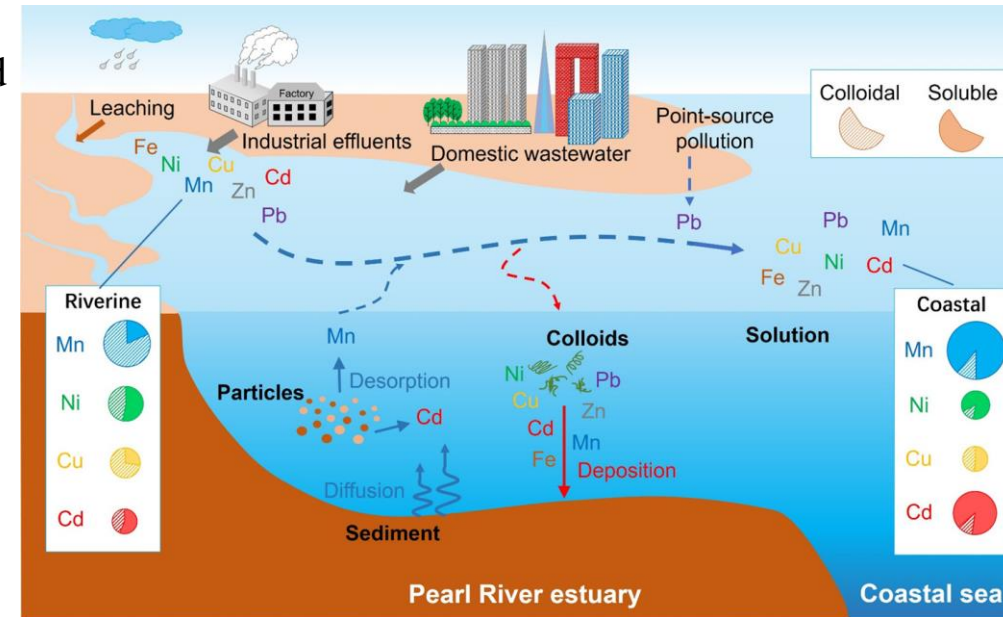
- **Total Petroleum Hydrocarbon (TPH):** crude oil and industrial products
- **Polycyclic Aromatic Hydrocarbon (PAH):** toxic components of coal, crude oil, and gasoline

Pesticides, Organochlorines:

- **Polychlorinated Biphenyls (PCB):** chemicals manufactured for insulators and electric appliances. Banned in 1979
- **DDT:** Insecticide since the 1940s and banned in 1972. Control insect-borne diseases and crop and livestock production.

Trace Metals:

- **Mercury (Hg):** Used to produce chlorine gas, and found in batteries and electrical switches
- **Cadmium (Cd):** Used in batteries, metal coating, and plastic
- **Arsenic (As):** Used in pesticides, mining, and wood preservatives
- **Lead (Pb):** Used in batteries, paint, gasoline, pipes, and ammunition
- **Nickel (Ni):** Used in batteries, tools, coins, boat propellers, and industrial appliances
- **Silver (Ag):** Used in jewelry, tableware, electronics, and water purifiers
- **Copper (Cu):** Used in wiring of electronics, household items, cars, and industrial machinery



Choosing Test Organisms?

1. Sensitivity to variety of substances
2. Availability
3. Representativeness of a variety of ecosystems
4. Ease of maintenance and culture under laboratory conditions



Grass shrimp *Paleomonetes pugio*



Amphipod *Leptocheirus plumulosus*



Polychaete *Nereis arenaceodentata*

Whole Sediment Test and Elutriate Test Set-up

Whole-Sediment Toxicity Test – Expose to sediment



Elutriate Toxicity Test – Expose to water



Chemical Contamination

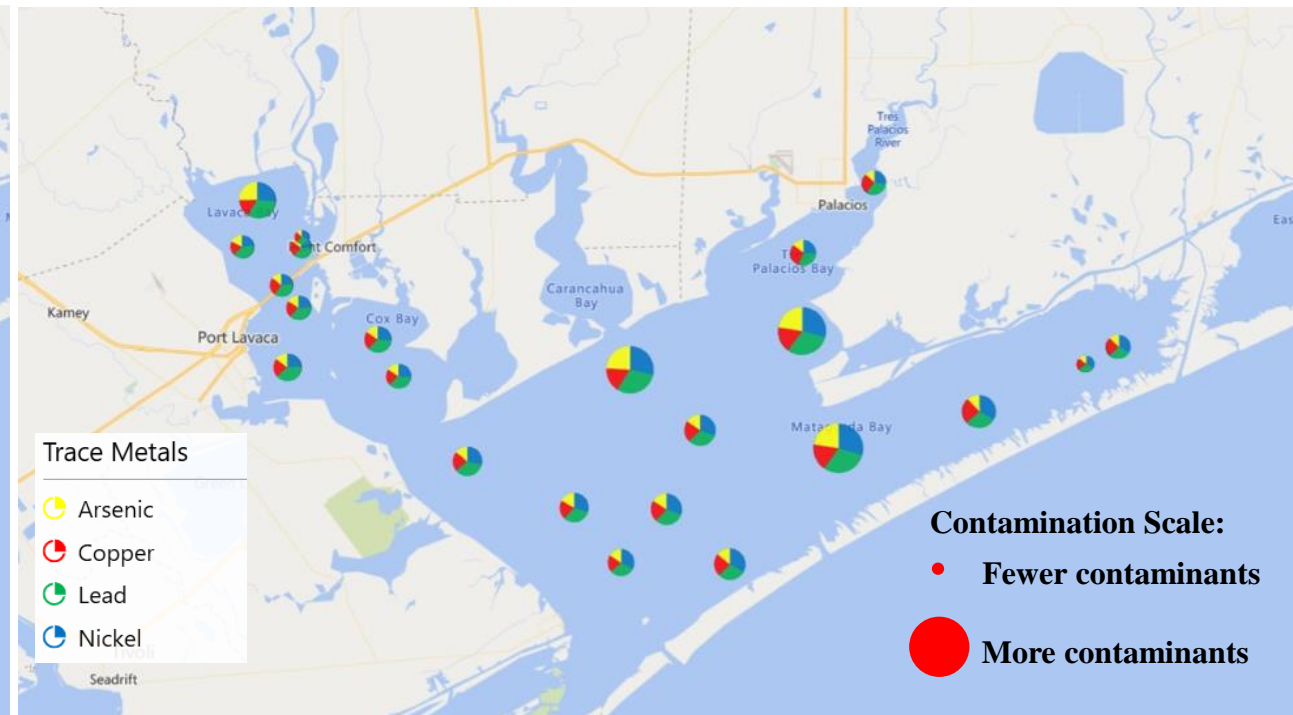
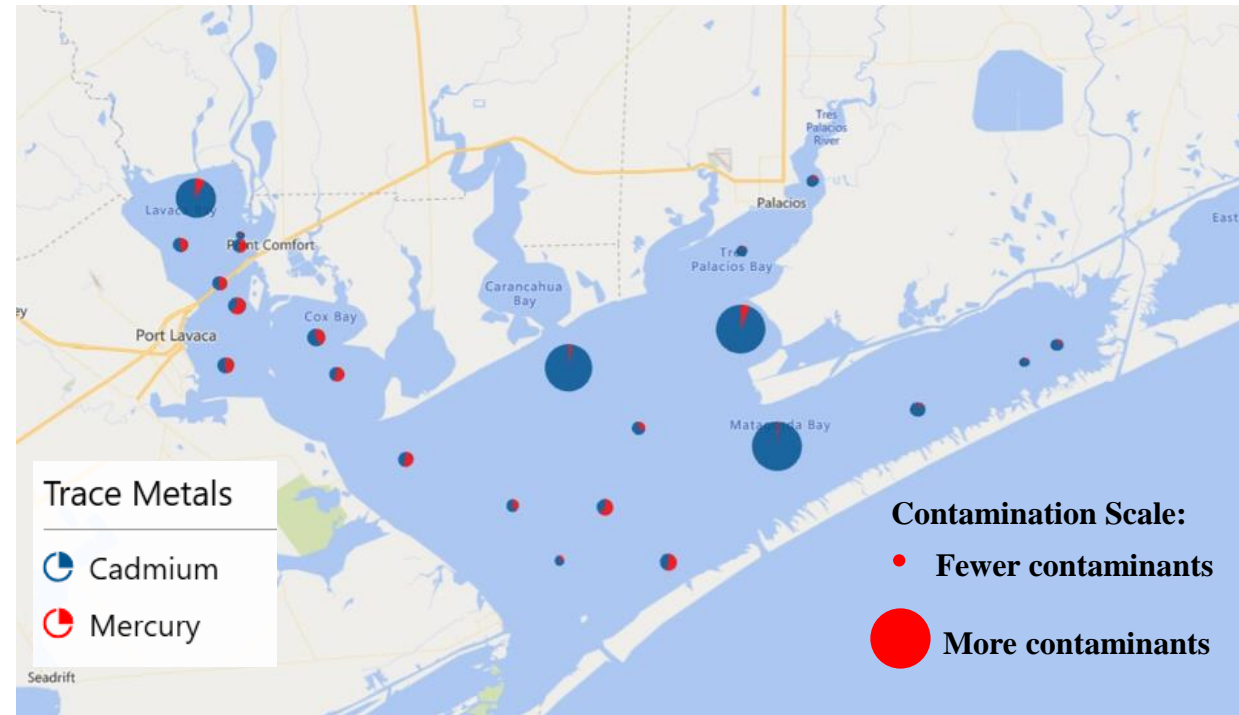
- About 46% of stations had chemical detections above threshold limits for trace metals at stations closer to Tres Palacios Bay and few in lower Lavaca Bay
- Dibenzo(a,h)anthracene only PAH above threshold at station WD
 - Exposure occurs from handling contaminated soil, breathing air, smoking tobacco products, and eating grilled and smoked meat or contaminated fish
- The highest contamination was found near rivers and creeks

Contaminant	Thresholds			# of Stations Exceeding Thresholds		
	TEL	ERL	PEL	TEL	ERL	PEL
Dibenzo(a,h)anthracene	6.22	63.4	135	1	1	
Arsenic	7.24	8.2	41.6	7	4	
Cadmium	0.68	1.2	4.21	4	4	
Copper	18.7	34	108	3		
Lead	30.2	46.7	112	3		
Mercury	0.13	0.15	0.7	6	4	
Nickel	15.9	20.9	42.8	6	3	
Silver			1.77			3

Chemical thresholds: TEL=threshold effects level, ERL= effects range low (ERL) PEL=probable effects level

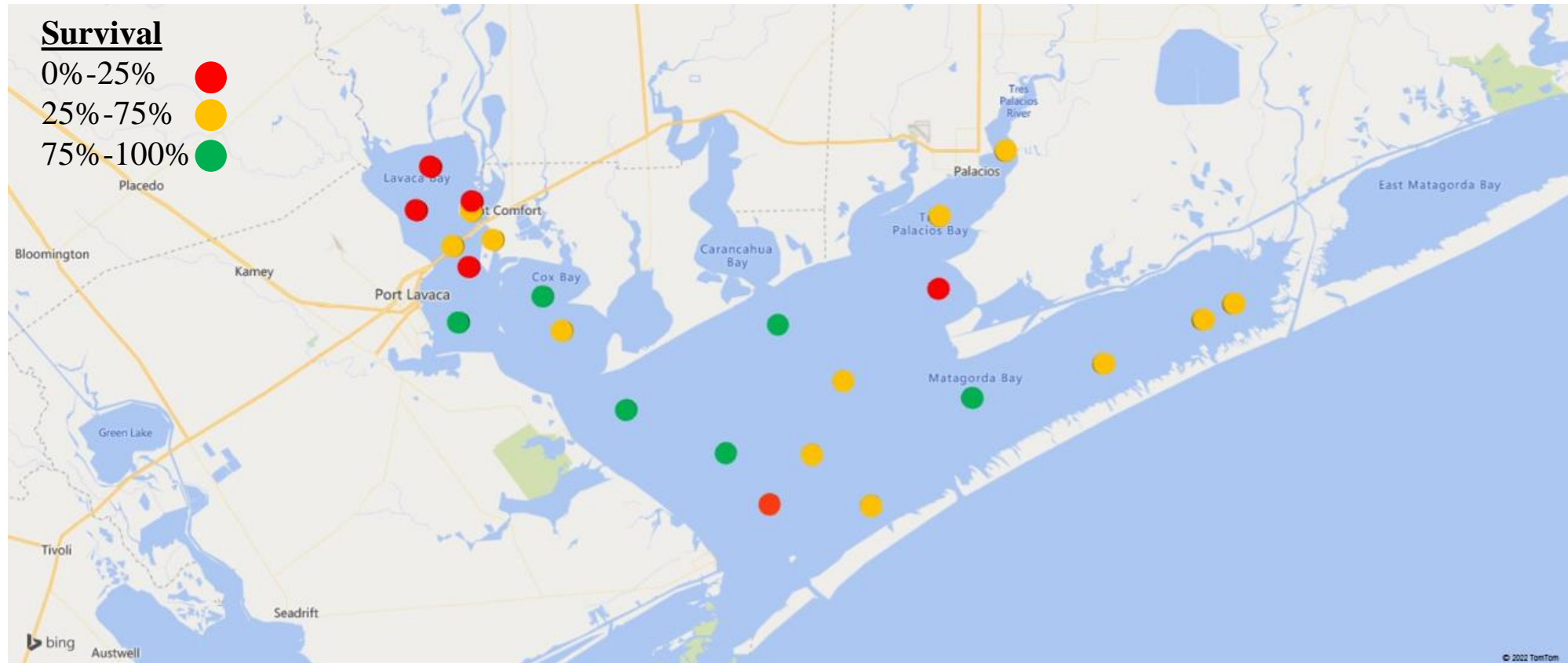
Trace Metal Contamination

- More cadmium in Matagorda Bay and more mercury in Lavaca
- Almost all equal proportions of arsenic, copper, lead, and nickel



Percent Survival in Each Bay

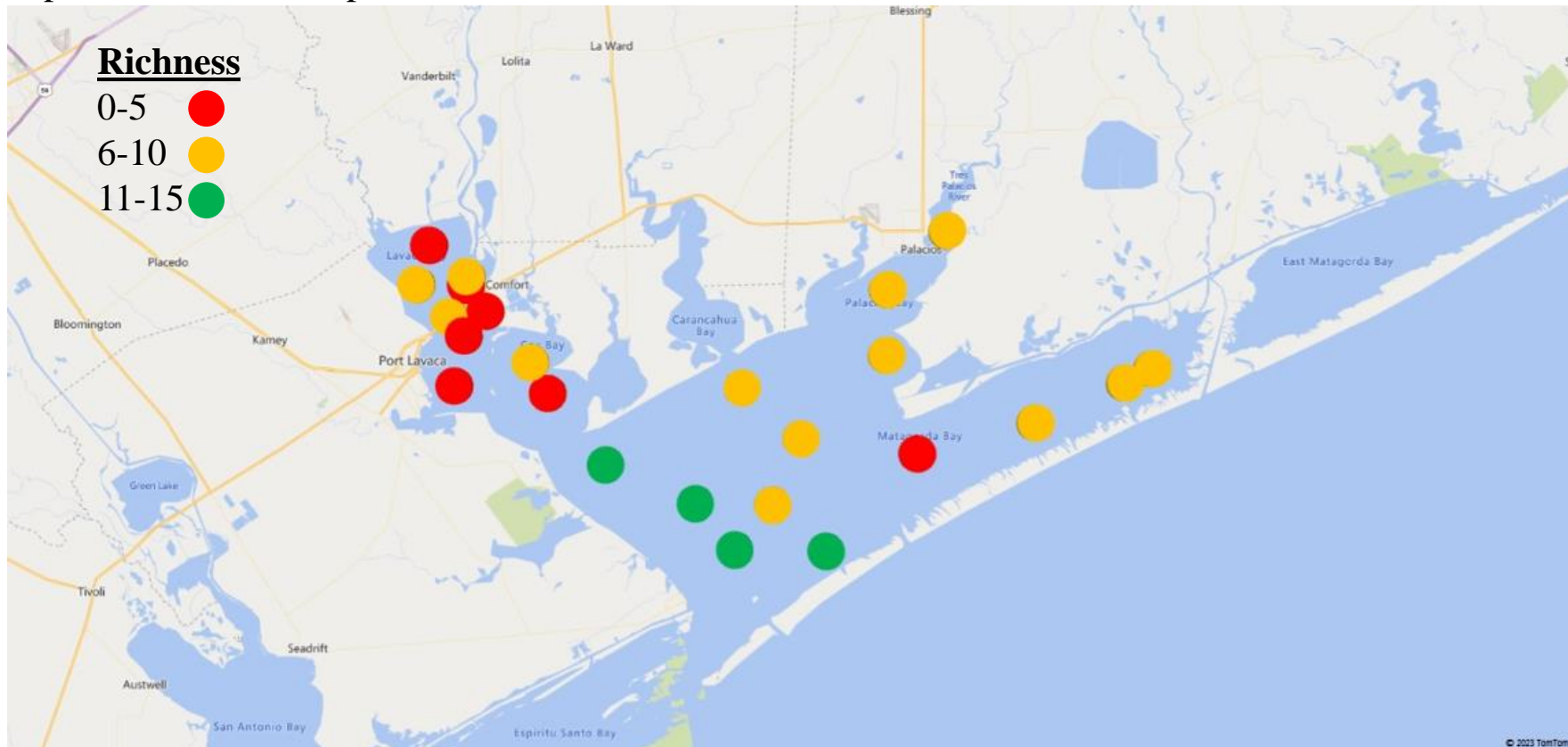
- Survival highest in Matagorda and lowest in the Upper Lavaca.
- Whole sediment test was the most sensitive and the elutriate test had the least deaths.
- Highest Survival: C
Lowest Survival: R2



Species Richness Map

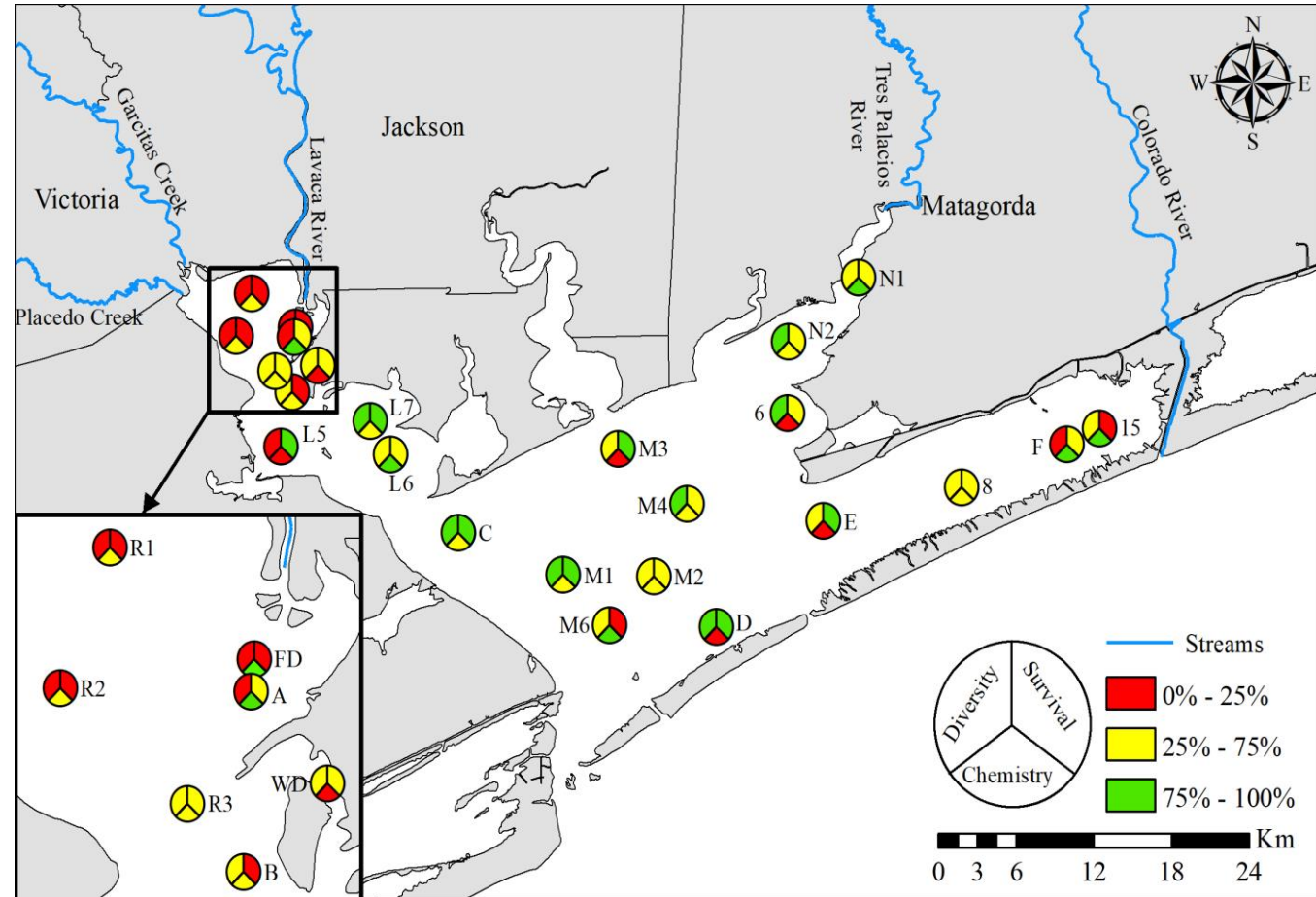
- Upper Lavaca was the least diverse and Matagorda was the most diverse bay
- Medium diversity nearer river mouths

Species Richness Map



Summary Map of SQT Responses

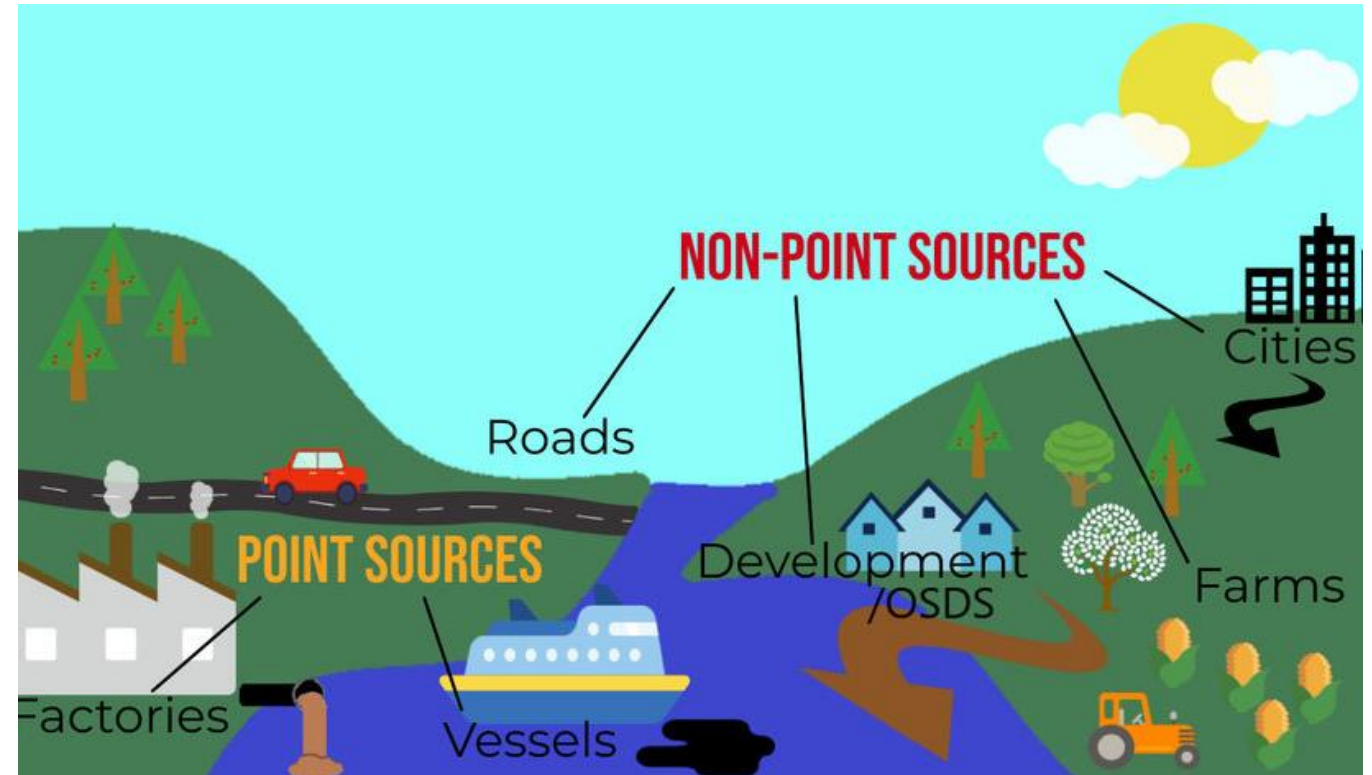
- Lavaca Bay is more degraded relative to Matagorda Bay
- But four stations in Matagorda Bay contain the most metals above threshold limits
- Most degraded sites occur near rivers and creeks
- There is no strong connection between chemistry and toxicity or diversity.



Sediment quality triad data summarized internally based on quartile ranges.

Non-Point Source (NPS) Pollution Explains Degradation

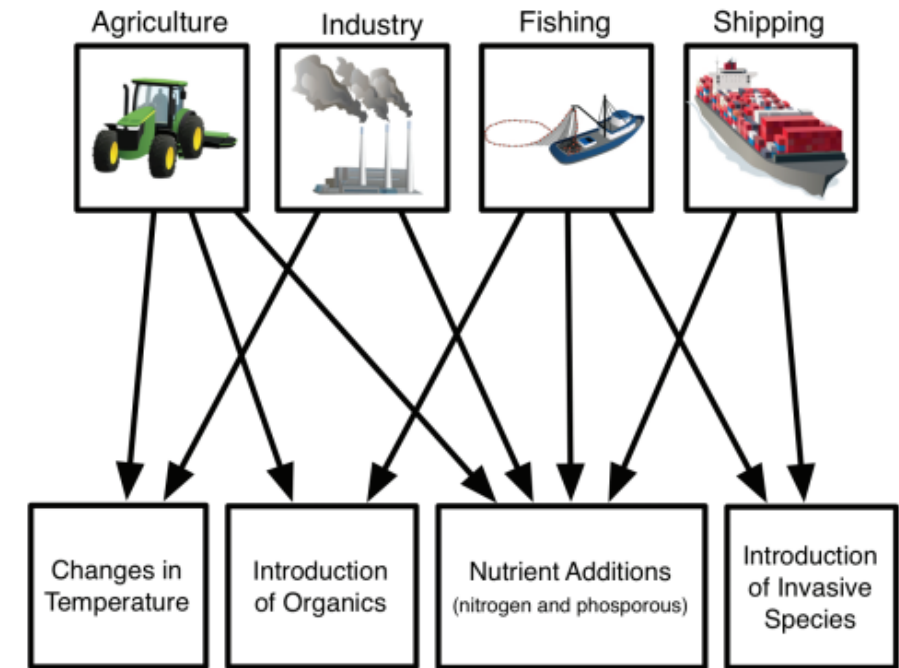
- Rivers play a role in degradation and benthic decline from NPS pollution
- NPS pollution originates from urban runoff, agricultural lands, oil, pet waste
- The estuary has three freshwater inflow sources that regulate salinity levels, nutrient and sediment transport, and nursery grounds
- Rivers are a source of contaminants from NPS
- NPS Could explain poor diversity and high toxicity of sediments



Mezzacapo et al. 2020

There are Multiple Stressors in the Lavaca and Matagorda Bays

- Multiple Stressors: Studies tend to focus on a single stressor – comparing locations with or without the stressor- or before and after stressed ecosystems but fail to measure the magnitude of multiple stressors over time and space
- Relatively poor sediment quality near creek and river mouths is not just due to pollutants, the combined effects increased temperatures, suspended sediments, increased salinity levels, reduced dissolved oxygen, etc. which is affecting survival and benthic diversity



Mach et al., 2015

Pollution is not system wide, rather contamination is localized

- Benthic decline and survival are correlated but contamination and benthic diversity only co-occur near river inlets and creeks
- Because more contamination is coming from rivers and creeks than from industrial sources, NPS should be a regulatory focus for the future
- **Recommendation:**
- Establish a Watershed Management Plan

