South Carolina's Integrated Indices Approach for Assessing Water Quality, Sediment Quality and Biotic Condition and Its Uses by Resource Managers

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The South Carolina Estuarine and Coastal Assessment Program

Partners:

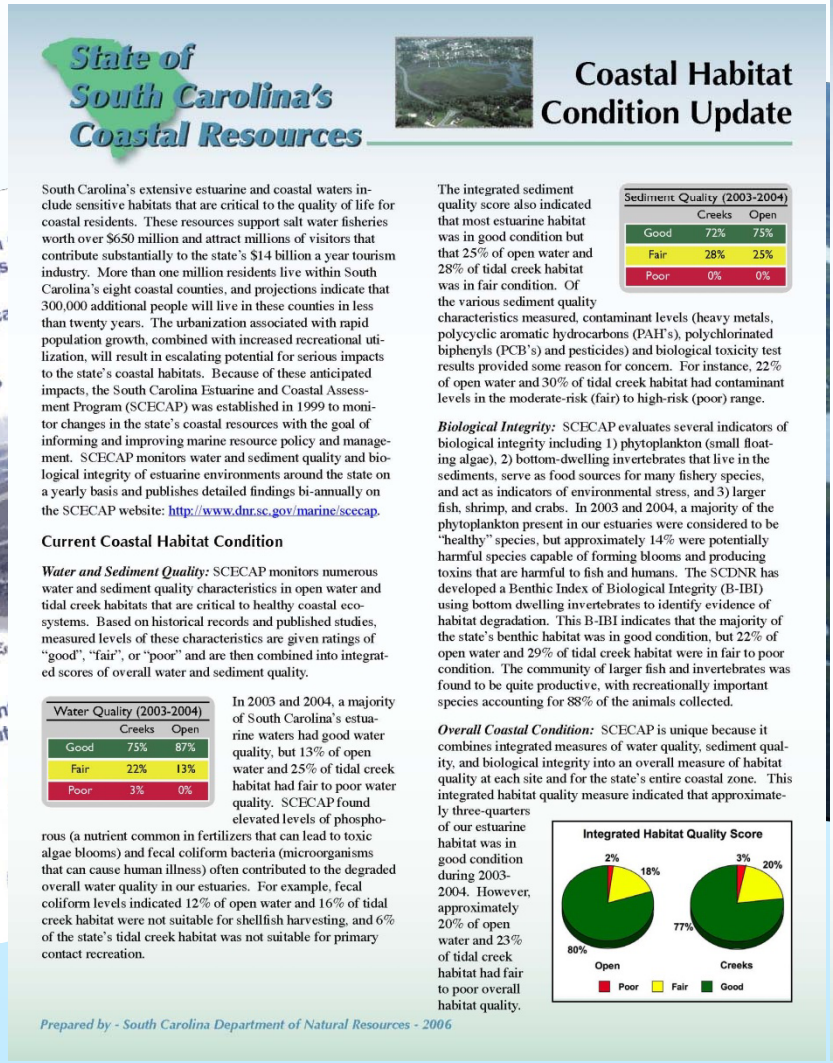
Time Frame:

- *Established in 1999 and surveys are conducted annually*

Objectives:

- *Monitor the overall quality of all South Carolina estuaries using integrated measures of condition*
- *Report findings to coastal managers and the public in understandable formats*

SCECAP Biennial Status Reports



State of South Carolina's Coastal Resources

Coastal Habitat Condition Update

South Carolina's extensive estuarine and coastal waters include sensitive habitats that are critical to the quality of life for coastal residents. These resources support salt water fisheries worth over $650 million and attract millions of visitors that contribute substantially to the state's $14 billion a year tourism industry. More than one million residents live within South Carolina's eight coastal counties, and projections indicate that 300,000 additional people will live in these counties in less than twenty years. The urbanization associated with rapid population growth, combined with increased recreational utilization, will result in escalating potential for serious impacts to the state's coastal habitats. Because of these anticipated impacts, the South Carolina Estuarine and Coastal Assessment Program (SCECAP) was established in 1999 to monitor changes in the state's coastal resources with the goal of informing and improving marine resource policy and management. SCECAP monitors water and sediment quality and biological integrity of estuarine environments around the state on a yearly basis and publishes detailed findings bi-annually on the SCECAP website: http://www.dnr.sc.gov/marine/scecap.

Current Coastal Habitat Condition

Water and Sediment Quality: SCECAP monitors numerous water and sediment quality characteristics in open water and tidal creek habitats that are critical to healthy coastal ecosystems. Based on historical records and published studies, measured levels of these characteristics are given ratings of "good", "fair", or "poor" and are then combined into integrated scores of overall water and sediment quality.

Water Quality (2003-2004)	Creeks	Open
Good	75%	87%
Fair	22%	13%
Poor	3%	0%

In 2003 and 2004, a majority of South Carolina's estuarine waters had good water quality, but 13% of open water and 25% of tidal creek habitat had fair to poor water quality. SCECAP found elevated levels of phosphorous (a nutrient common in fertilizers that can lead to toxic algae blooms) and fecal coliform bacteria (microorganisms that can cause human illness) often contributed to the degraded overall water quality in our estuaries. For example, fecal coliform levels indicated 12% of open water and 16% of tidal creek habitat were not suitable for shellfish harvesting, and 6% of the state's tidal creek habitat was not suitable for primary contact recreation.

The integrated sediment quality score also indicated that most estuarine habitat was in good condition but that 25% of open water and 28% of tidal creek habitat was in fair condition. Of the various sediment quality characteristics measured, contaminant levels (heavy metals, polycyclic aromatic hydrocarbons (PAH's), polychlorinated biphenyls (PCB's) and pesticides) and biological toxicity test results provided some reason for concern. For instance, 22% of open water and 30% of tidal creek habitat had contaminant levels in the moderate-risk (fair) to high-risk (poor) range.

Sediment Quality (2003-2004)	Creeks	Open
Good	72%	75%
Fair	28%	25%
Poor	0%	0%

Biological Integrity: SCECAP evaluates several indicators of biological integrity including 1) phytoplankton (small floating algae), 2) bottom-dwelling invertebrates that live in the sediments, serve as food sources for many fishery species, and act as indicators of environmental stress, and 3) larger fish, shrimp, and crabs. In 2003 and 2004, a majority of the phytoplankton present in our estuaries were considered to be "healthy" species, but approximately 14% were potentially harmful species capable of forming blooms and producing toxins that are harmful to fish and humans. The SCDNR has developed a Benthic Index of Biological Integrity (B-IBI) using bottom dwelling invertebrates to identify evidence of habitat degradation. This B-IBI indicates that the majority of the state's benthic habitat was in good condition, but 22% of open water and 29% of tidal creek habitat were in fair to poor condition. The community of larger fish and invertebrates was found to be quite productive, with recreationally important species accounting for 88% of the animals collected.

Overall Coastal Condition: SCECAP is unique because it combines integrated measures of water quality, sediment quality, and biological integrity into an overall measure of habitat quality at each site and for the state's entire coastal zone. This integrated habitat quality measure indicated that approximately three-quarters of our estuarine habitat was in good condition during 2003-2004. However, approximately 20% of open water and 23% of tidal creek habitat had fair to poor overall habitat quality.

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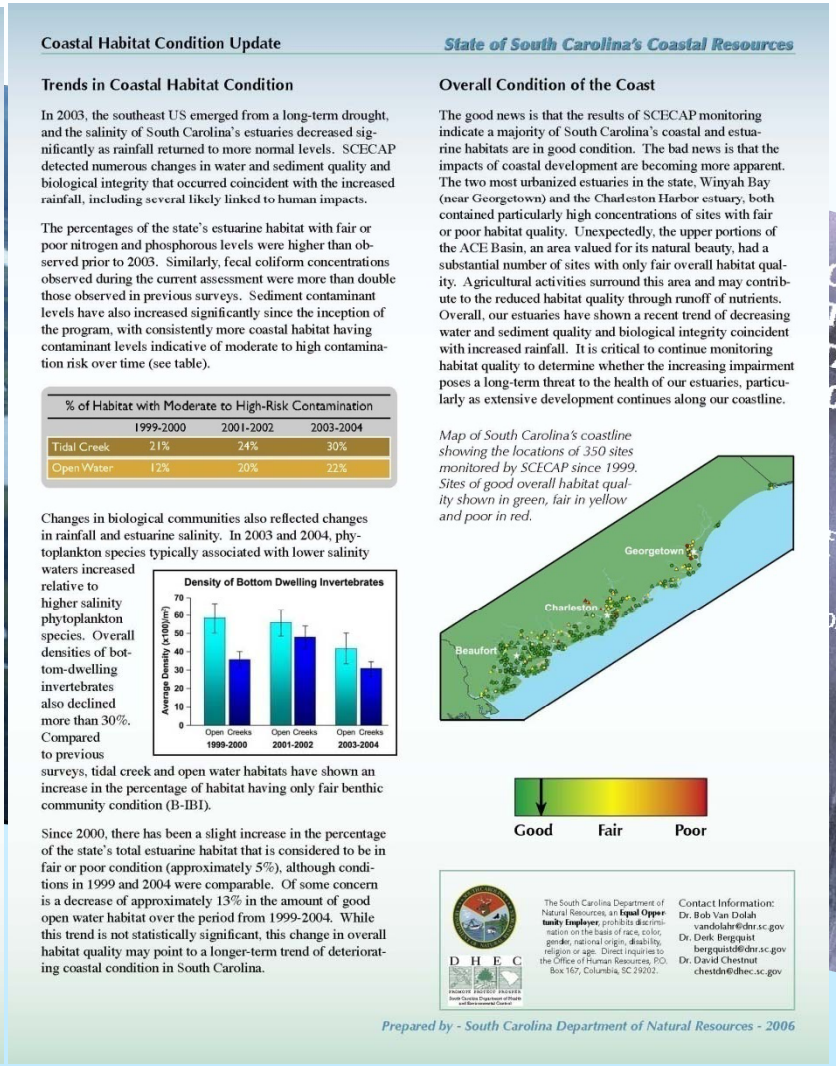

Coastal Habitat Condition Update — State of South Carolina's Coastal Resources

Trends in Coastal Habitat Condition

In 2003, the southeast US emerged from a long-term drought, and the salinity of South Carolina's estuaries decreased significantly as rainfall returned to more normal levels. SCECAP detected numerous changes in water and sediment quality and biological integrity that occurred coincident with the increased rainfall, including several likely linked to human impacts.

The percentages of the state's estuarine habitat with fair or poor nitrogen and phosphorous levels were higher than observed prior to 2003. Similarly, fecal coliform concentrations observed during the current assessment were more than double those observed in previous surveys. Sediment contaminant levels have also increased significantly since the inception of the program, with consistently more coastal habitat having contaminant levels indicative of moderate to high contamination risk over time (see table).

% of Habitat with Moderate to High-Risk Contamination	1999-2000	2001-2002	2003-2004
Tidal Creek	21%	24%	30%
Open Water	12%	20%	22%

Changes in biological communities also reflected changes in rainfall and estuarine salinity. In 2003 and 2004, phytoplankton species typically associated with lower salinity waters increased relative to higher salinity phytoplankton species. Overall densities of bottom-dwelling invertebrates also declined more than 30%. Compared to previous surveys, tidal creek and open water habitats have shown an increase in the percentage of habitat having only fair benthic community condition (B-IBI).

Since 2000, there has been a slight increase in the percentage of the state's total estuarine habitat that is considered to be in fair or poor condition (approximately 5%), although conditions in 1999 and 2004 were comparable. Of some concern is a decrease of approximately 13% in the amount of good open water habitat over the period from 1999-2004. While this trend is not statistically significant, this change in overall habitat quality may point to a longer-term trend of deteriorating coastal condition in South Carolina.

Overall Condition of the Coast

The good news is that the results of SCECAP monitoring indicate a majority of South Carolina's coastal and estuarine habitats are in good condition. The bad news is that the impacts of coastal development are becoming more apparent. The two most urbanized estuaries in the state, Winyah Bay (near Georgetown) and the Charleston Harbor estuary, both contained particularly high concentrations of sites with fair or poor habitat quality. Unexpectedly, the upper portions of the ACE Basin, an area valued for its natural beauty, had a substantial number of sites with only fair overall habitat quality. Agricultural activities surround this area and may contribute to the reduced habitat quality through runoff of nutrients. Overall, our estuaries have shown a recent trend of decreasing water and sediment quality and biological integrity coincident with increased rainfall. It is critical to continue monitoring habitat quality to determine whether the increasing impairment poses a long-term threat to the health of our estuaries, particularly as extensive development continues along our coastline.

Map of South Carolina's coastline showing the locations of 350 sites monitored by SCECAP since 1999. Sites of good overall habitat quality shown in green, fair in yellow and poor in red.

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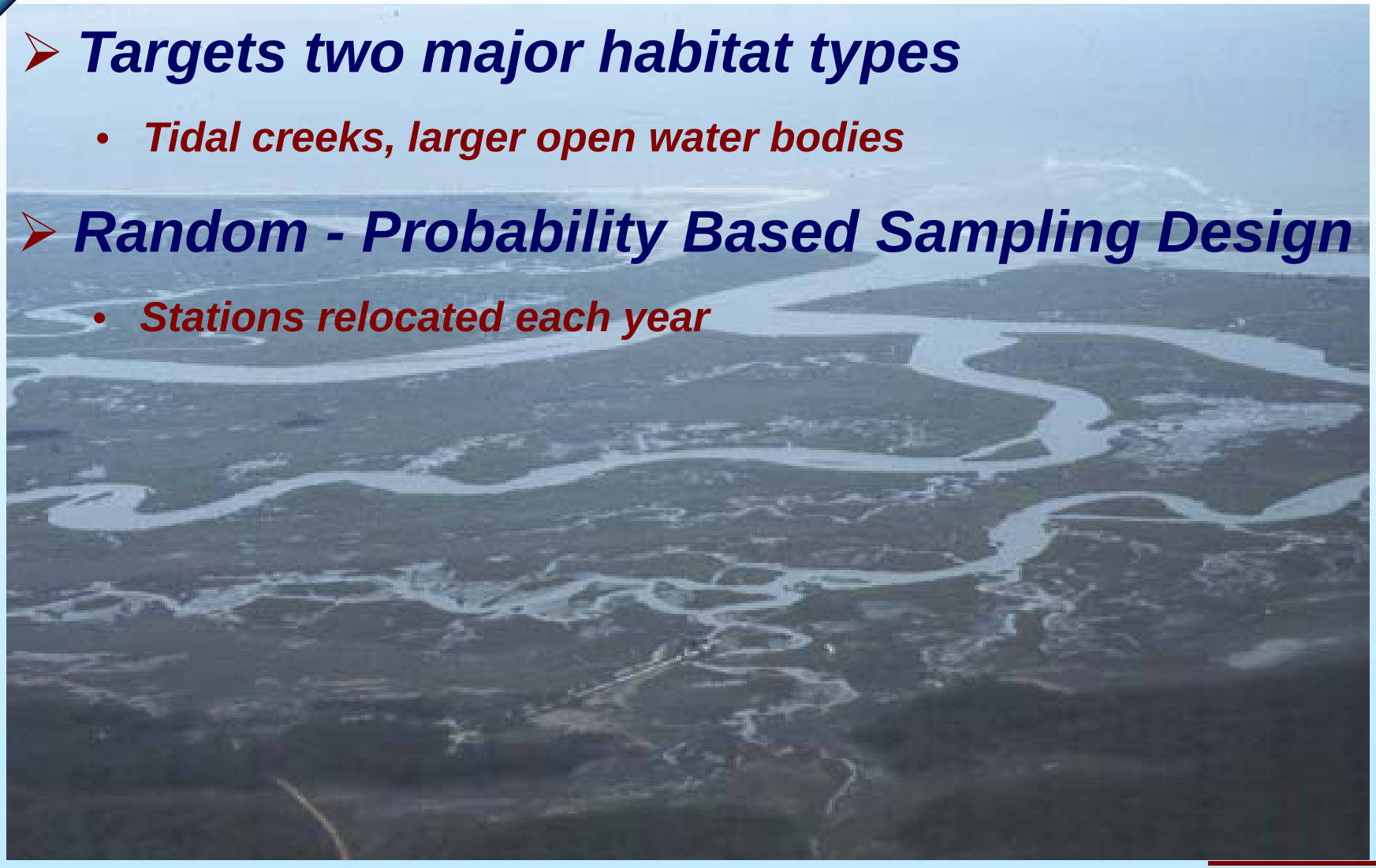
Monitoring Approach

- ***Targets two major habitat types***
  - ***Tidal creeks, larger open water bodies***
- ***Random - Probability Based Sampling Design***
  - ***Stations relocated each year***



Sampling Frequency

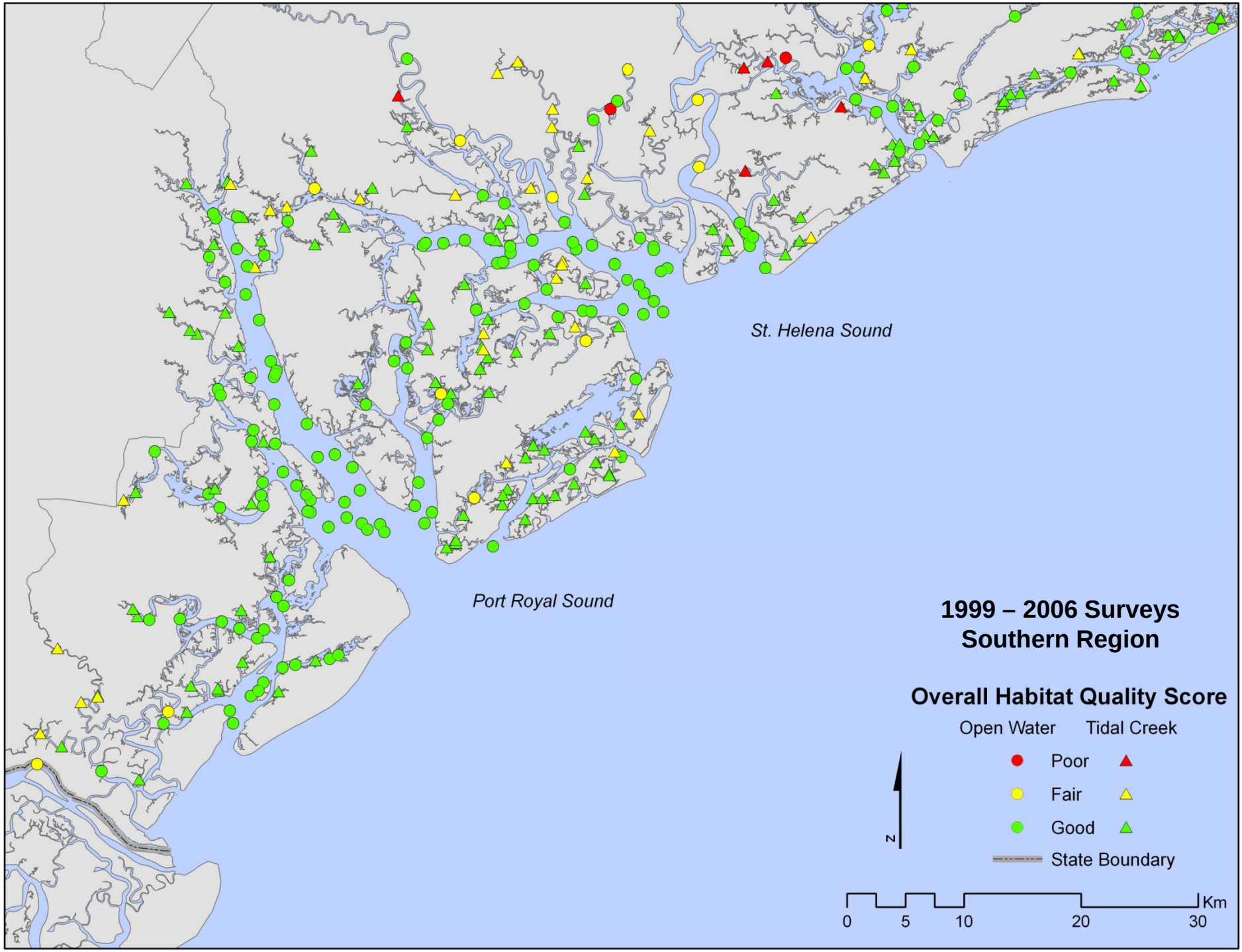
1999-2006

- ***Sampled 50-60 stations each year***
  - ***Summer sampling period***
  - ***Subset (30) sampled monthly (DHEC- Water quality only 2001-2006)***

2007-2009

- ***30 core stations***

- ***Total of <u>520</u> stations sampled to date***


St. Helena Sound
Port Royal Sound
1999 – 2006 Surveys
Southern Region
Overall Habitat Quality Score
Open Water
Tidal Creek
Poor
Fair
Good
State Boundary
N
0
5
10
20
30
Km

Measures of Condition

Water Quality

- **Continuous monitoring for salinity, DO, pH, temp (25 hr)**
- **Nutrients** (Dissolved and Totals)
- **Fecal coliform bacteria, BOD, TOC, metals**

Sediment Quality

- **Contaminants (85 + analytes, including some emerging)**
- **Toxicity (seed clam, microtox, amphipod** – only with EPA funding**)**

Biological Condition

- **Phytoplankton composition**
- **Benthic invertebrate communities** (B-IBI described by Van Dolah et al. (1999) for use in Southeast region)
- **Finfish and Crustacean communities**

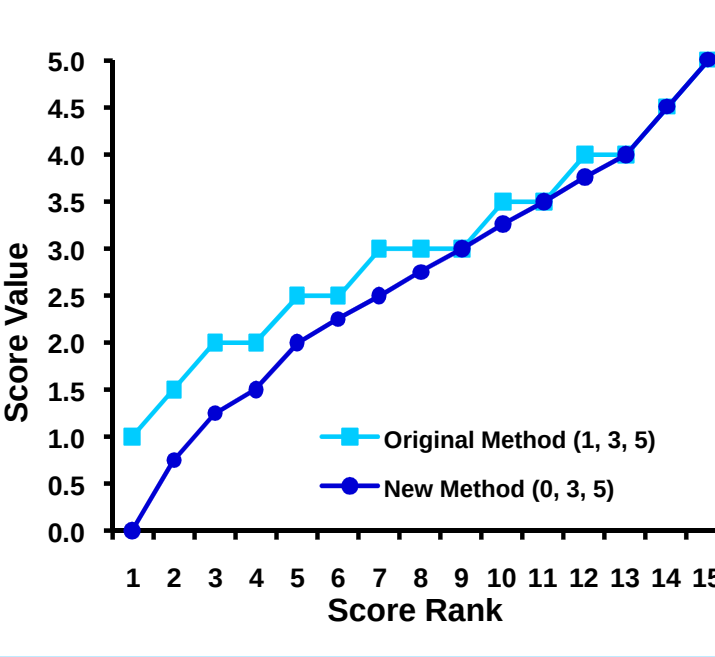
Integrated Measures

Water Quality

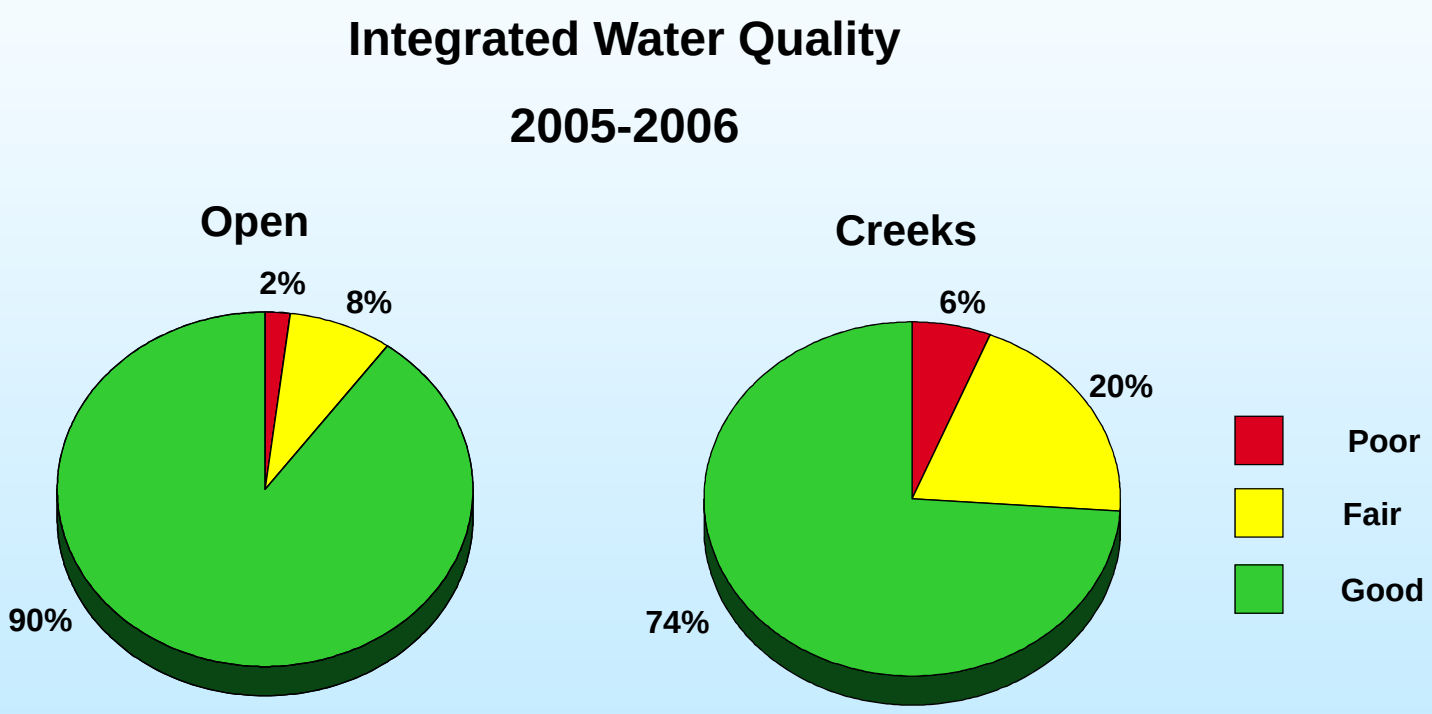
- **Primary measures: DO, pH, fecal coliform bacteria, (TN, TP, Chla)**
- **Each measure scored based on water quality criteria or historical data** (thresholds 75th and 90th percentiles)
- **Scores (0,3,5) averaged for integrated water quality measure**

Previous Scoring Method					
Parameter					
A	B	C	D	Average Score	
1	1	1	1	1.00	Poor (0)
3	1	1	1	1.50	Poor (0)
5	1	1	1	2.00	Poor (0)
3	3	1	1	2.00	Poor (0)
5	3	1	1	2.50	Poor (0)
5	5	1	1	3.00	Poor (0)
3	3	3	1	2.50	Poor (0)
5	3	3	1	3.00	Poor (0)
5	5	3	1	3.50	Fair (3)
5	5	5	1	4.00	Fair (3)
3	3	3	3	3.00	Poor (0)
5	3	3	3	3.50	Fair (3)
5	5	3	3	4.00	Fair (3)
5	5	5	3	4.50	Good (5)
5	5	5	5	5.00	Good (5)

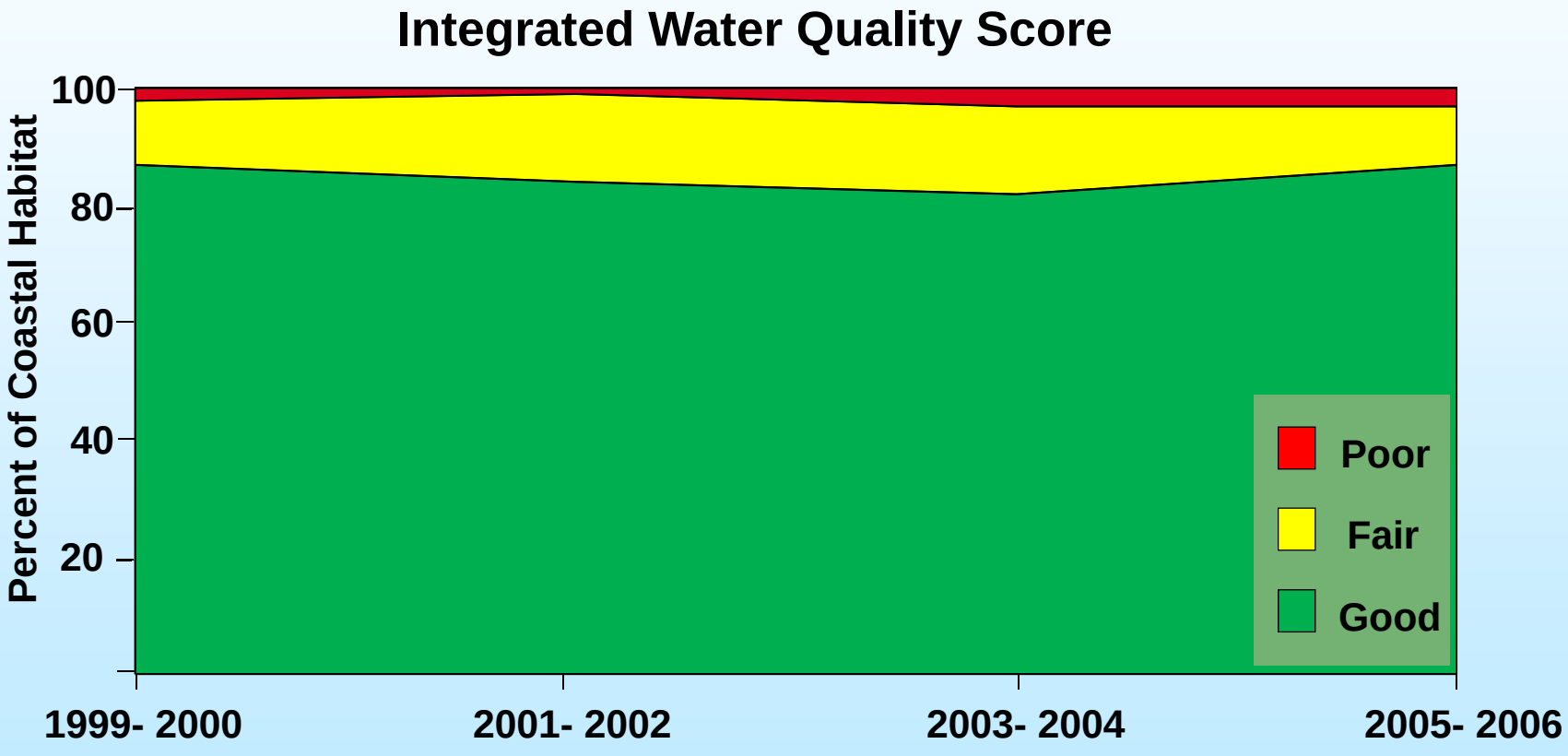
New Scoring Method					
Parameter					
A	B	C	D	Average Score	
0	0	0	0	0.00	Poor (0)
3	0	0	0	0.75	Poor (0)
5	0	0	0	1.25	Poor (0)
3	3	0	0	1.50	Poor (0)
5	3	0	0	2.00	Poor (0)
5	5	0	0	2.50	Poor (0)
3	3	3	0	2.25	Poor (0)
5	3	3	0	2.75	Poor (0)
5	5	3	0	3.25	Fair (3)
5	5	5	0	3.75	Fair (3)
3	3	3	3	3.00	Fair (3)
5	3	3	3	3.50	Fair (3)
5	5	3	3	4.00	Good (5)
5	5	5	3	4.50	Good (5)
5	5	5	5	5.00	Good (5)

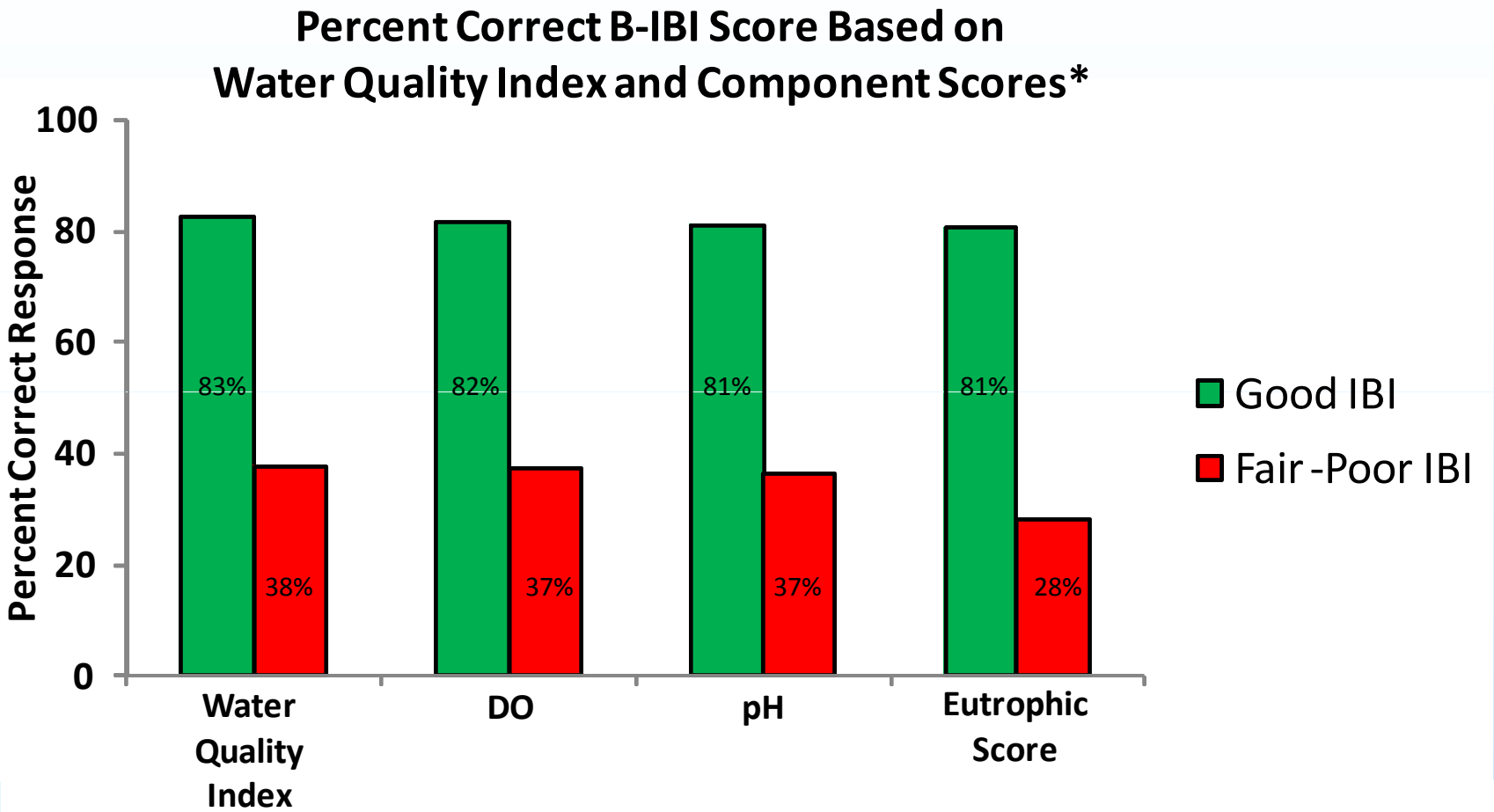


Integrated Measures



Trend in Water Quality Condition



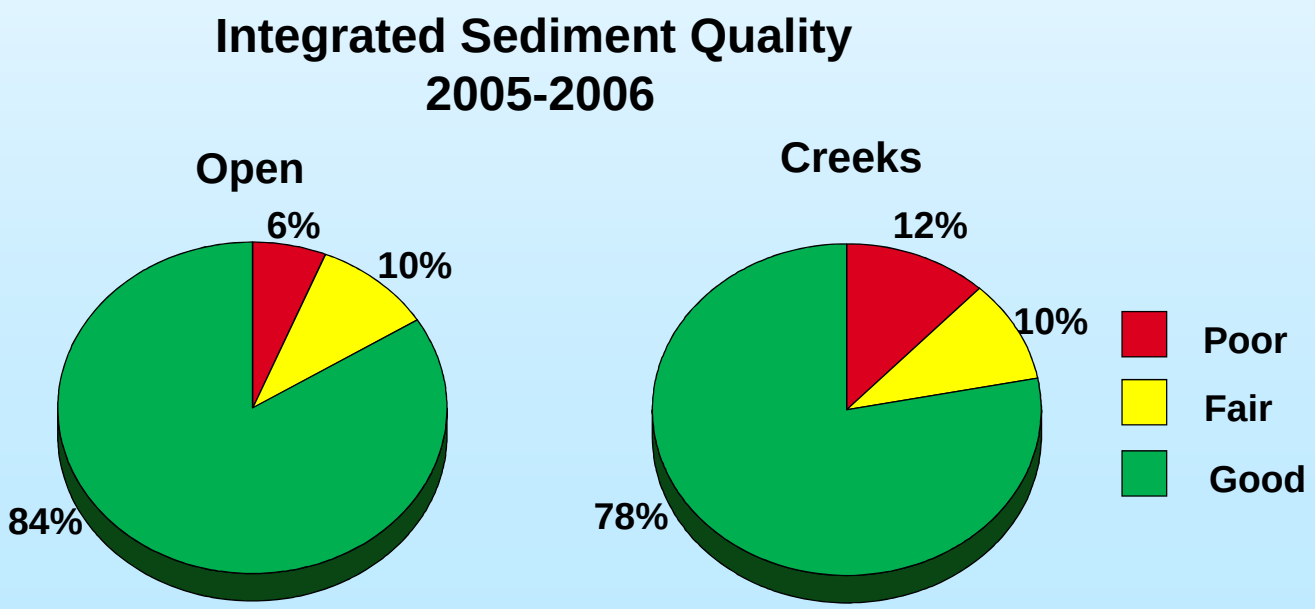


* Fecal Coliform measure not considered

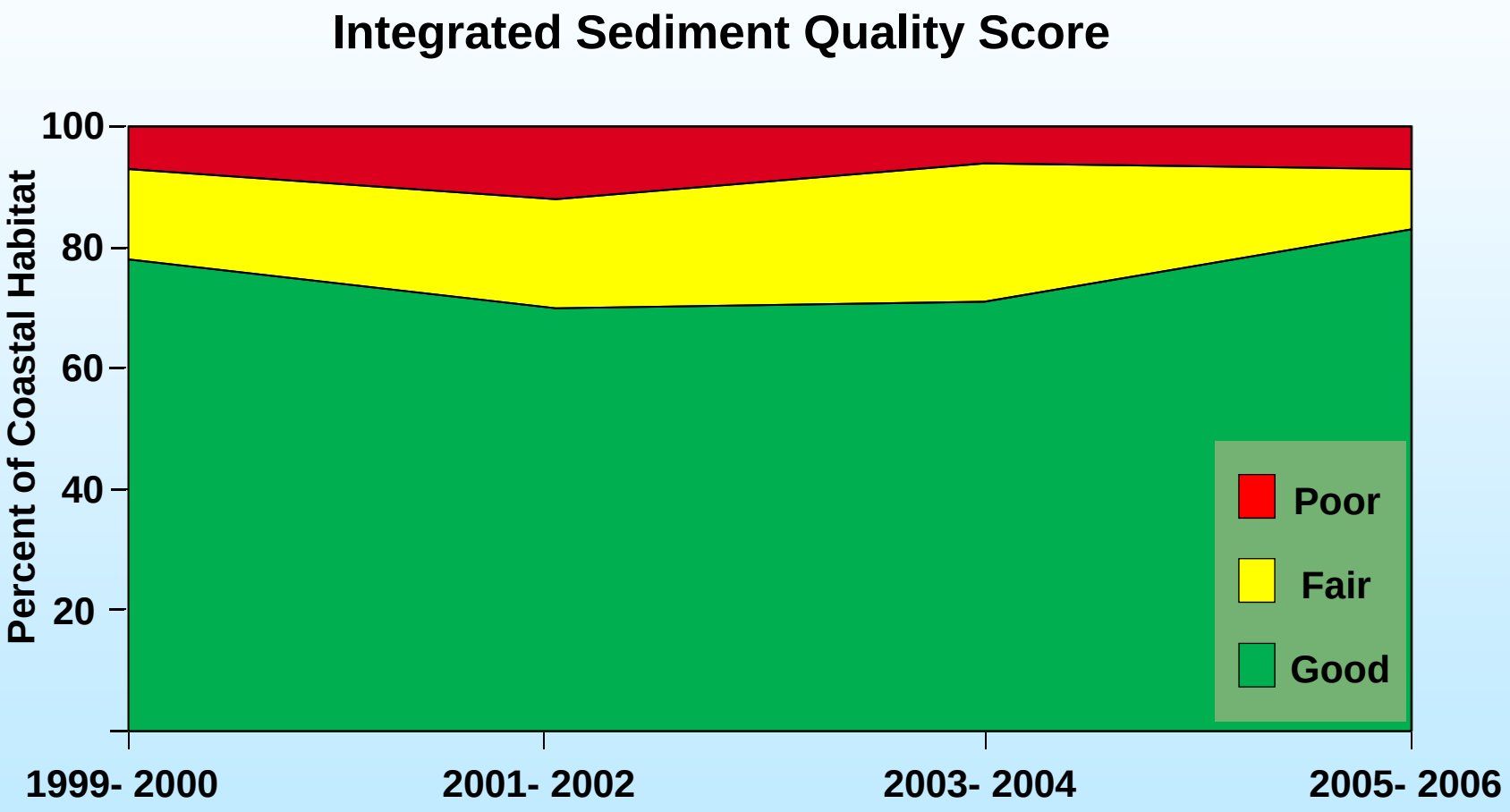
Integrated Measures

Sediment Quality

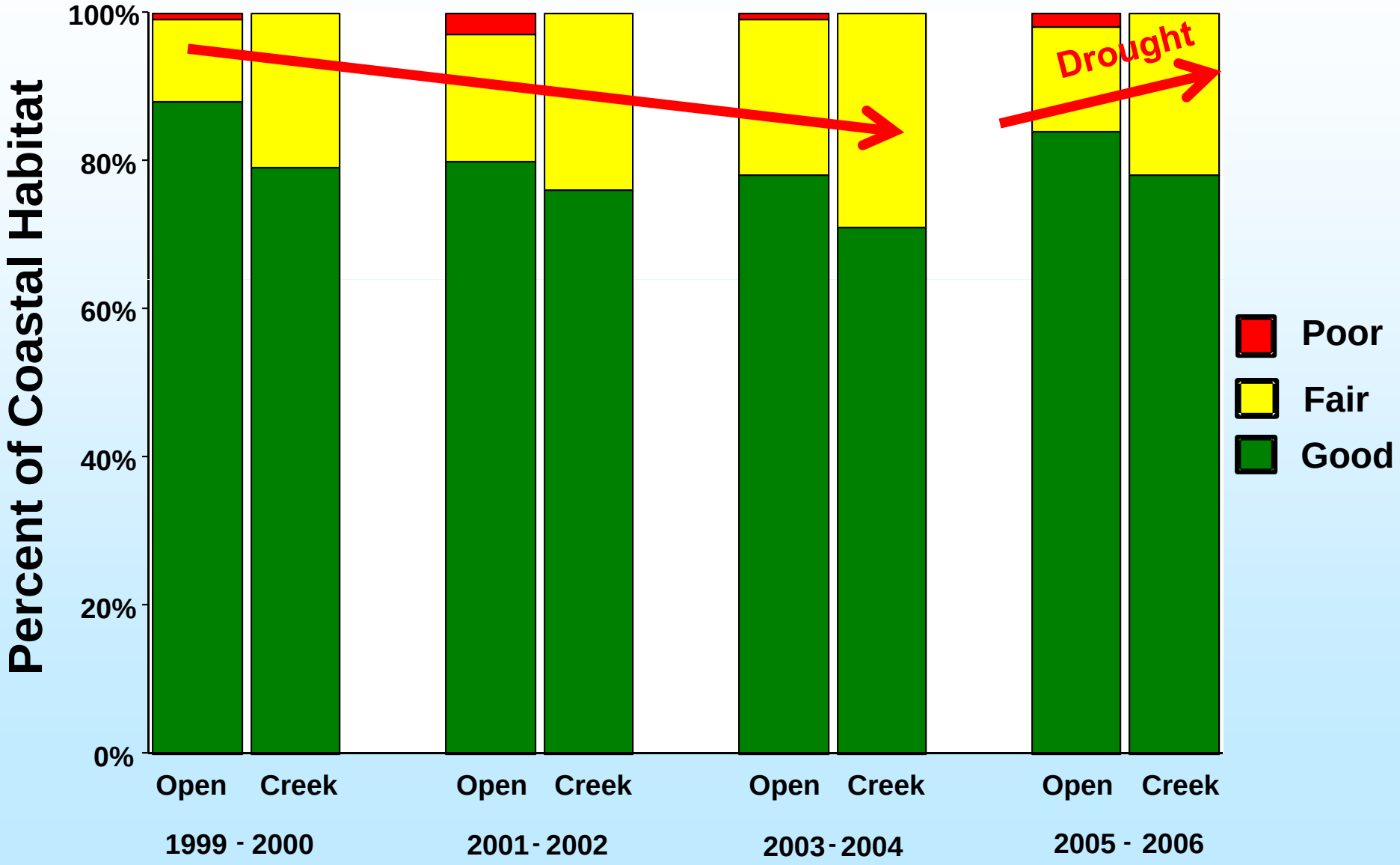
- **Contaminant Concentrations**
  - 24 priority pollutants– related to ERM-Q (Long et al. 1998)
  - Thresholds related to probability of observing degraded benthos (Hyland et al., 1999)
- **Toxicity Assays and TOC**
- **New scoring process (0,3,5)**

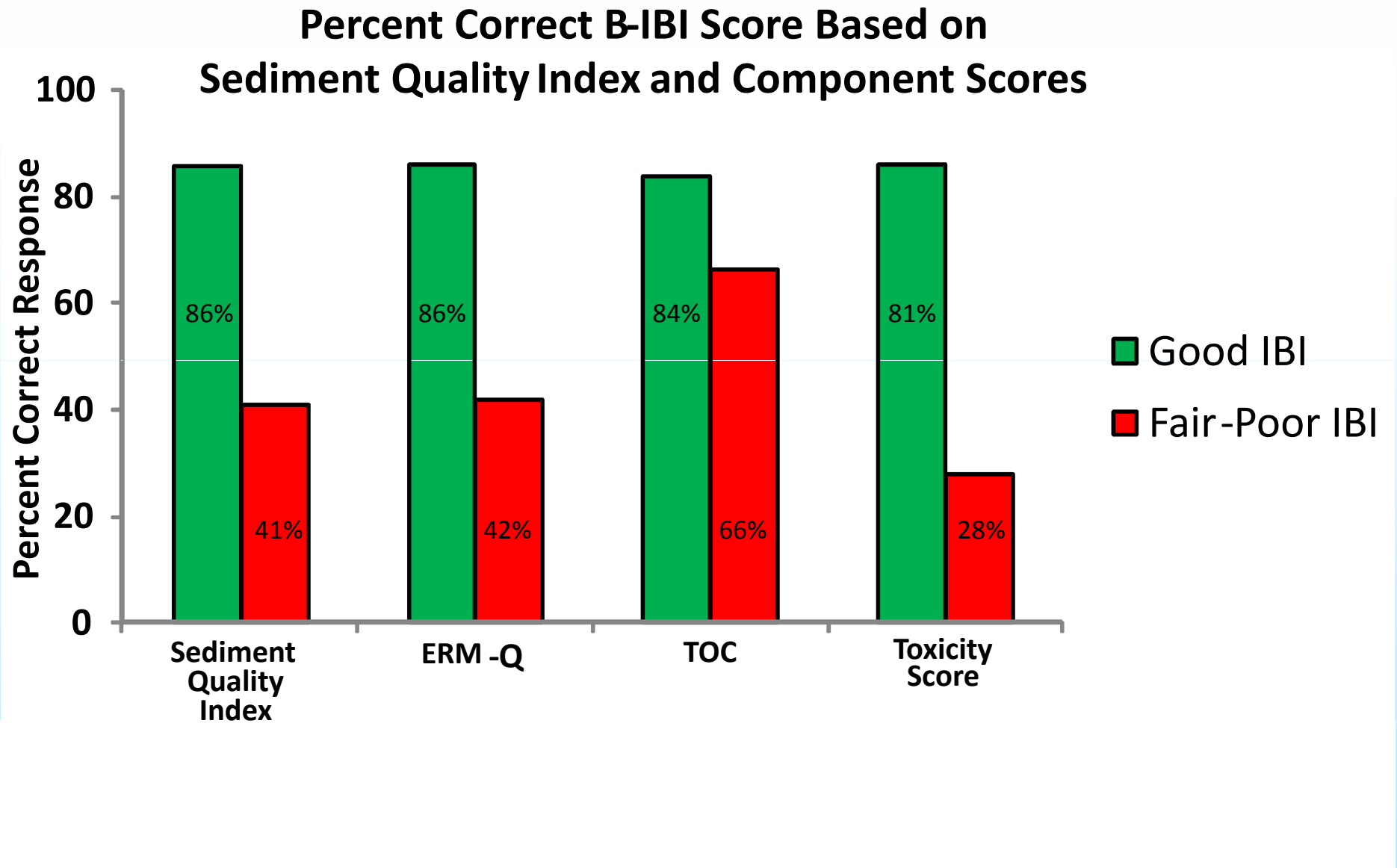


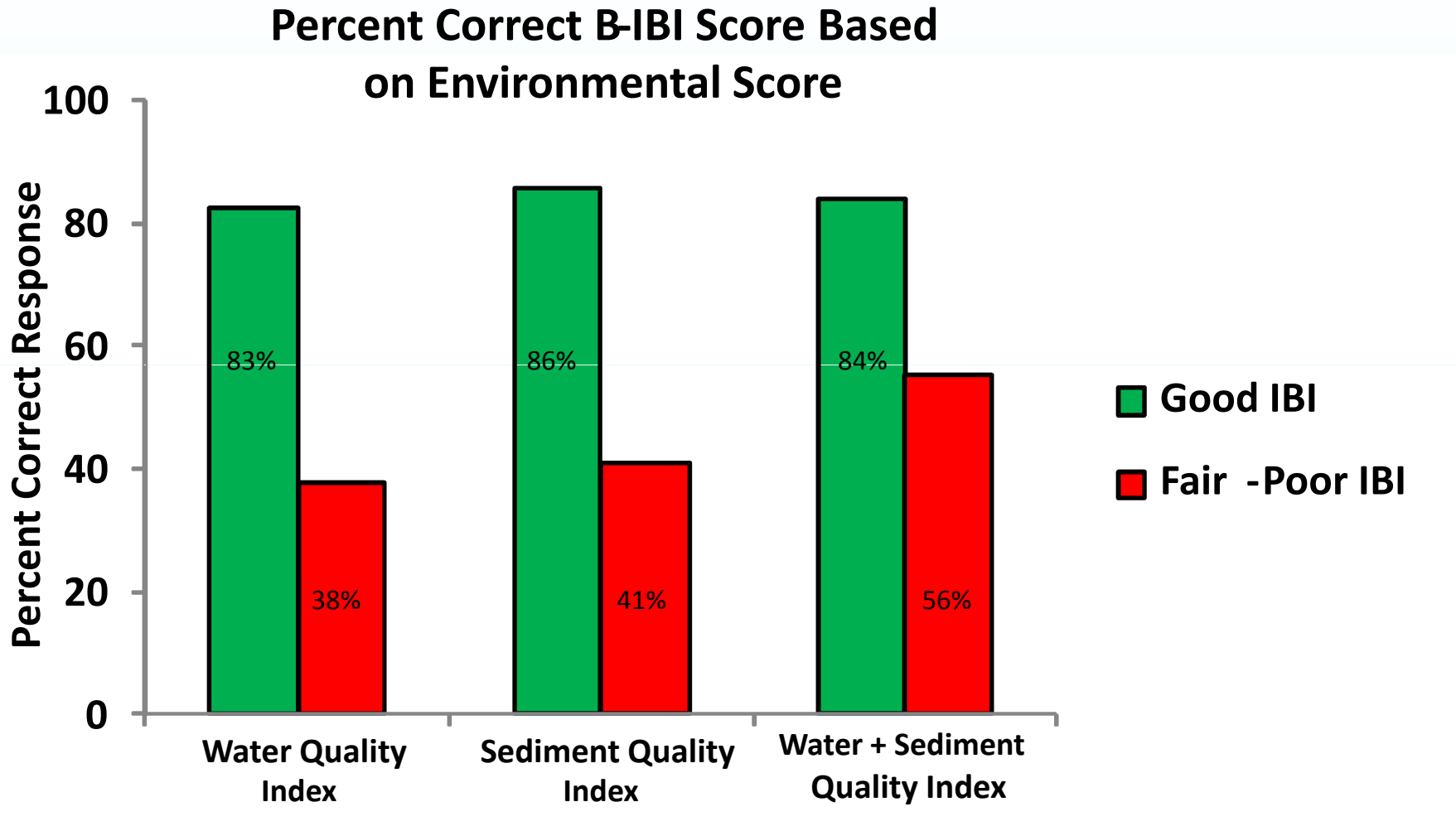
Trend in Sediment Quality Condition



Sediment Contaminant Concentrations



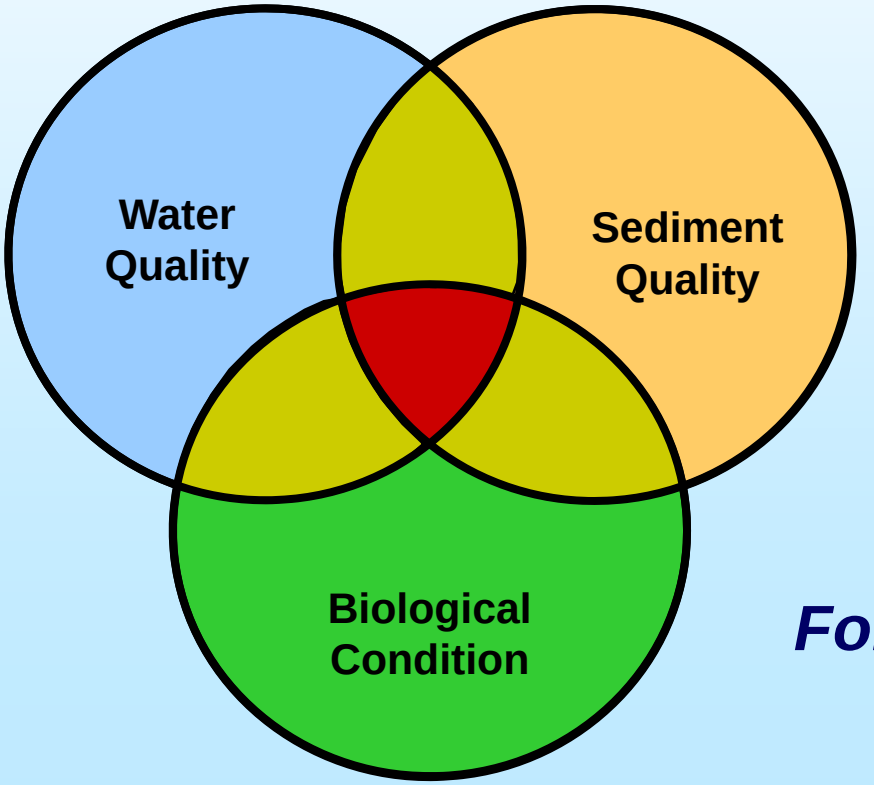

Percent Correct B-IBI Score Based on
Sediment Quality Index and Component Scores
Percent Correct Response
100
80
60
40
20
0
86%
41%
86%
42%
84%
66%
81%
28%
Sediment Quality Index
ERM -Q
TOC
Toxicity Score
Good IBI
Fair-Poor IBI


Percent Correct B-IBI Score Based on Environmental Score
Percent Correct Response
100
80
60
40
20
0
83%
38%
86%
41%
84%
56%
Water Quality Index
Sediment Quality Index
Water + Sediment Quality Index
Good IBI
Fair -Poor IBI

Integrated Measures

Overall habitat quality

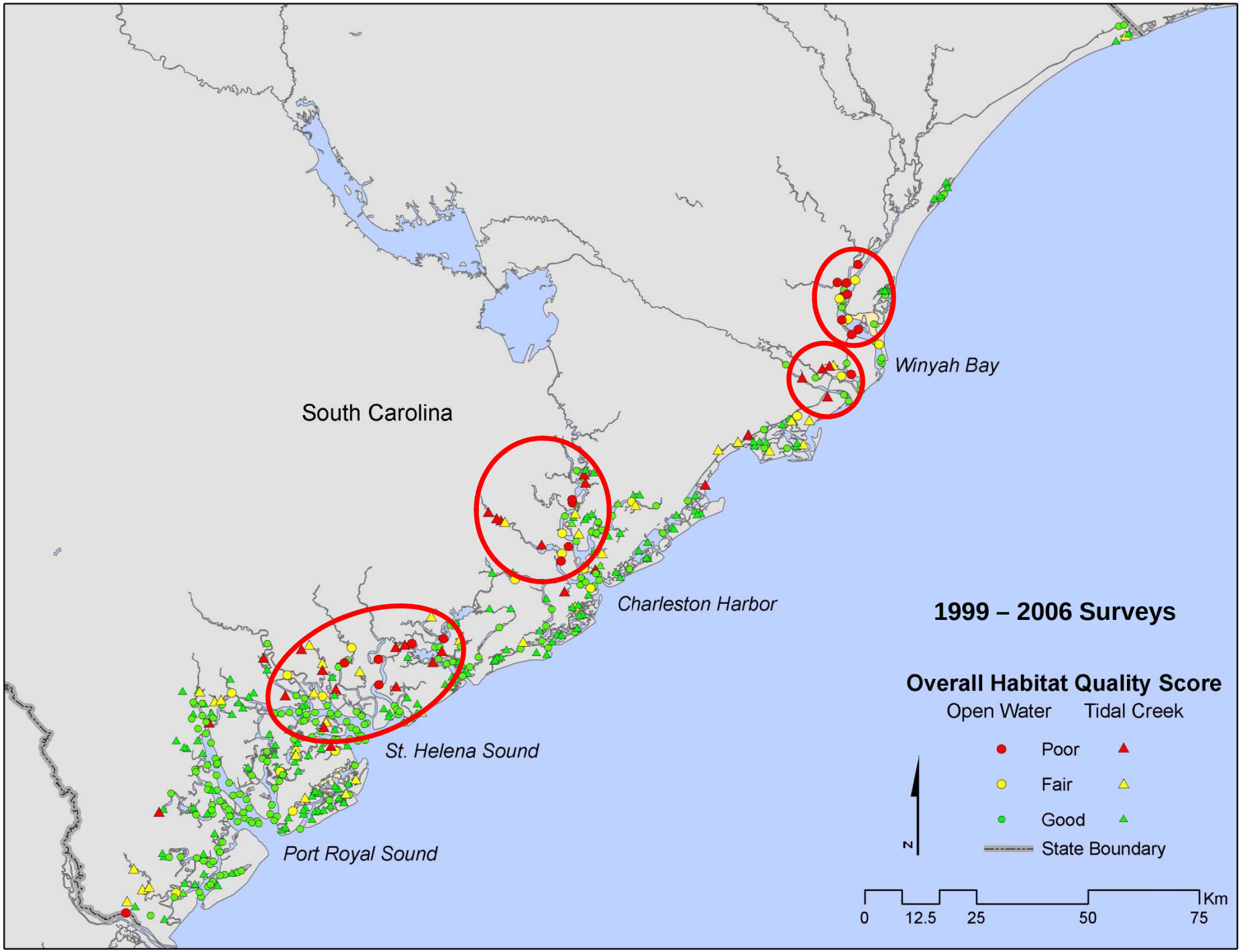
- **Averaged scores of each subcomponent into an integrated score for overall habitat quality**
- **Each component weighted equally**



For more information: Google South Carolina SCECAP

Approach Useful at Several Levels

- **State Wide Assessment**
  - Approach used for 305(b), 303(d) reporting
  - Better than index sites
  - Unbiased random sample
  - Represents entire resource
  - Known confidence of estimates
- **Specific watersheds**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Charleston Harbor
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Overall Habitat Quality Score
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Good
State Boundary
N
0
12.5
25
50
75
Km

Other Agency Uses

- ***DNR***
  - *Fishery monitoring data (spot, croaker, weakfish)*
  - *Watershed condition assessments – (e.g. May River)*
- ***DHEC - OCRM***
  - *Assessment of effects of docks in tidal creeks*
- ***NOAA - EPA***
  - *Oceans and Human Health Initiative*
  - *Dolphin Health Assessment*
  - *Nutrient Studies (EPA Narragansett Laboratory)*
  - *EPA National Coastal Assessment*
- ***Academic Scientists***
- ***County and Local Governments, Organizations***

Summary

- ***SCECAP approach is useful to SCDNR and SCDHEC***
  - *Provides unbiased assessment of state's estuarine environmental quality and biotic condition*
  - *Incorporates improved integrated measures of ecosystem condition*
    - *Using indices relevant to the state agencies and resource managers*
  - *Benthic IBI critical component*
    - *Does not necessarily reflect only effects of water and sediment quality*
  - *Useful for evaluating change over time – state wide*
  - *Allows for watershed or county assessments once enough stations*
  - *Robust database useful for basic research in understanding relationships between environmental and biotic condition*