Chesapeake Bay Water Quality Criteria and their Assessment: The Monitoring and Assessment Framework Supporting the Chesapeake Bay TMDL

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Harding et al. 2012
The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.
To understand the importance of criteria we need to ask:

What are Water Quality Standards?

Standards are the foundation of the water quality-based control program mandated by the Clean Water Act.

Water quality standards (WQS)
• legally binding
• describe the desired ambient condition (i.e., level of protection) for a waterbody and
• consist of the following three principle elements:
  • designated uses
  • criteria
  • antidegradation requirements
Criteria

Criteria: specify the amounts of various pollutants, in either numeric or narrative form, that may be present in those waters without impairing the designated uses.
Monitoring and Assessment Framework
Supporting the Chesapeake Bay TMDL

Management Segmentation

Designated Uses

Water Quality Criteria Development

Criteria Development: Multiple lines of evidence

Good, low and dissolved oxygen

Chla

0 1 10 20 100 1000

Plankton IBI thresholds

Human health

Safety thresholds

Water Quality Criteria Assessment
Outline
Monitoring and Assessment Framework Supporting the Chesapeake Bay TMDL

- Chesapeake Bay Management Segmentation
- Designated Use Development
- Water Quality Criteria Development
- Water Quality Criteria Assessment
Chesapeake Bay Segmentation Scheme: Bay Segments
Chesapeake Bay Segmentation Scheme

Historical data sets 1949-1980s + Contemporary data 1984-present

Boundary Characterization

Biological
- plankton, fish

Chemical
- Salinity
- Turbidity max
- D.O.
- Nutrients

Hydrodynamics

Bathymetric

Geographical

<table>
<thead>
<tr>
<th>Year</th>
<th>Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>78</td>
</tr>
<tr>
<td>1997</td>
<td>89</td>
</tr>
<tr>
<td>2003</td>
<td>104</td>
</tr>
<tr>
<td>2008</td>
<td>92 (TMDL)</td>
</tr>
</tbody>
</table>

USEPA CBPO 2008
Outline
Monitoring Applications supporting the Chesapeake Bay TMDL

- Chesapeake Bay Management Segmentation
- Designated Use Development
Designated Uses under the Clean Water Act

- Protection and propagation of fish, shellfish, and wildlife
- Recreation
- Public water supplies
- Agriculture
- Industry
- Navigation
- Coral reef preservation
- Marinas
- Groundwater recharge
- Aquifer protection
- Hydroelectric power
Designated Uses under the Clean Water Act

- Protection and propagation of fish, shellfish, and wildlife
- Recreation
Designated Uses under the Clean Water Act

- Protection and propagation of fish, shellfish, and wildlife

- Recreation

- coldwater fish, warmwater fish, and shellfish
  - The use may also include protection of aquatic flora

- primary contact

- secondary contact
Chesapeake Bay
Designated Uses

Open Water: 
Rockfish, Bluefish 
Migratory Nursery and Spawning Habitat: 
Shad, Herring, Perch and Rockfish Spawning Habitat

Chesapeake Bay

Shallow Water: 
Bay Grasses Habitat

Benthic Community: 
Oyster, Crab, Croaker and Spot Habitat

Open Water: 
Rockfish, Bluefish 
Menhaden Habitat

Deep Water: 
Summertime Crab Food Habitat

Deep Channel: 
Seasonal Refuge

Source: EPA
Translate Local Habitats Information for Designated Use Delineation

Mining our historical and recent aerial photographs

Bay Grasses Habitat

Field survey support

GIS coverage mapping of SAV beds

Photo courtesy of W. Boynton.

Photo courtesy of MD DNR/VIMS
Translate the Best Scientific Information available for Designated Use Delineation

*Funderburk et al. 1991*

**Migratory Nursery and Spawning Habitat:**
- Shad
- Herring
- Perch
- Rockfish

Spawning Habitat

Chesapeake Bay
Designated Uses

Shallow Water: Bay Grasses Habitat

Open Water: Rockfish, Bluefish, Menhaden Habitat

Benthic Community: Oyster, Crab, Croaker and Spot Habitat

Deep Water: Summertime Crab Food Habitat

Deep Channel: Seasonal Refuge

Migratory Nursery and Spawning Habitat: Shad, Herring, Perch and Rockfish Spawning Habitat

Source: EPA
Designated Uses

Time: Seasonal

Space:

Summer
Open Water

Fall, Winter
Spring

Source: EPA
Outline
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- Chesapeake Bay Management Segmentation
- Designated Use Development
- Water Quality Criteria Development
- Water Quality Criteria Assessment
Water Quality Criteria

DISSOLVED OXYGEN

WATER CLARITY/SAV

CHLOROPHYLL CRITERIA

Historical and Contemporary data
Water Quality Criteria (e.g. CHLA)

CHLOROPHYLL CRITERIA DEVELOPMENT

Historical and Contemporary data
Concentrations of chlorophyll $a$ in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in ecologically undesirable consequences — such as reduced water clarity, low dissolved oxygen, food supply imbalances, proliferation of species deemed potentially harmful to aquatic life or humans or aesthetically objectionable conditions — or otherwise render tidal waters unsuitable for designated uses (USEPA 2003).
NARRATIVE CHLOROPHYLL CRITERIA

Concentrations of chlorophyll \(a\) in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in ecologically undesirable consequences — such as reduced water clarity, low dissolved oxygen, food supply imbalances, proliferation of species deemed potentially harmful to aquatic life or humans or aesthetically objectionable conditions — or otherwise render tidal waters unsuitable for designated uses (USEPA 2003).

QUANTITATIVE CHLOROPHYLL CRITERIA

USEPA 2007

Criteria Development: Multiple lines of evidence

USEPA 2007
NARRATIVE CHLOROPHYLL CRITERIA

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QUANTITATIVE CHLOROPHYLL CRITERIA

Applicable Criteria Seasons

Spring: March 1 - May 31
Summer: June 1 – September 30
Outline
Monitoring and Assessment Framework Supporting the Chesapeake Bay TMDL

- Chesapeake Bay Management Segmentation
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- Water Quality Criteria Development
- Water Quality Criteria Assessment
Monitoring and Assessment - as easy as baking a cake!

Collect the ingredients

Follow the Recipe as the rules for Creating a cake

Create a layer, and then another, ...

Voila! Assemble into the finished product!
Water Quality Criteria Assessment

Water Quality Data Collection
Water Quality Criteria Assessment

Water Quality Data Collection

Interpolation of Water Quality Monitoring Results

Dissolved Oxygen

Picture courtesy of A. Muller, USNA
Water Quality Criteria Assessment

Water Quality Data Collection

Interpolation of Water Quality Monitoring Results

Dissolved Oxygen

D.O. (mg/l)

Season x 3-year Criteria assessment

Single month Criteria assessment

SPACE...

Exceedance Layer

[Image: Dissolved Oxygen graph showing concentrations and exceedance layers.]

...and TIME

Exceedance Layers

[Image: Time series of dissolved oxygen concentrations and exceedance layers.]

Picture courtesy of A. Muller, USNA
Water Quality Criteria Assessment

Monitoring Data
1 segment
Over time

Percent of Time

Percent of Space

CFD Curve
Reference Curve
Area of Criteria Exceedence
Area of Allowable Criteria Exceedence

USEPA 2003

Pass or Fail Assessment
1 segment
Water Quality Criteria Assessment

Monitoring Data
1 segment
Over time

USEPA 2003

Pass or Fail Assessment
1 segment

Water Quality Standards
Attainment
“Either you’re in or your out!”

Percent of Space

Percent of Time

CFD Curve
Reference Curve
Area of Criteria
Exceedence
Area of Allowable Criteria
Exceedence
Water Quality Criteria Assessment

Monitoring Data
1 segment
Over time

Pass or Fail Assessment
1 segment

USEPA 2003

Water Quality Standards Attainment

92 segment Baywide Assessment Summary

Percent of Time

Percent of Space

CFD Curve
Reference Curve
Area of Criteria
Exceedence
Area of Allowable
Criteria
Exceedence
5 Components of Chesapeake Bay Criteria Assessment

- Space
- Time
- Magnitude
- Duration
- Frequency
Law: Clean Water Act (1972)

- Objective: “restore and maintain the chemical, physical and biological integrity of the Nation’s waters” (Clean Water Act 101(a))

- Interim goal: “water quality which provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation in and on the water” wherever attainable by 1983 (Clean Water Act 101(a)(2))

- Implementation by States, Territories, and authorized Tribes