Washington State’s Marine Dissolved Oxygen (DO) Criteria: Application to Nutrients

Bryson Finch
Watershed Management Unit
Water Quality Program
Overview

- Water Quality Standards
  - Numeric DO Criteria
  - Aesthetic Narrative Criteria
  - Anthropogenic Allowance

- History and Rationale for Marine DO Criteria

- Nutrient Criteria Alternatives

- Application of Marine DO Criteria
  - Water Column
  - Site Specific Locations
  - Anthropogenic Allowance
Water Quality Standards
Water Quality Standards

- The water quality standards set limits on pollution in our lakes, rivers and marine waters in order to protect beneficial uses, such as aquatic life and swimming.
DO Criteria

- DO criteria in the water quality standards are intended to set levels that protect healthy, robust aquatic communities, including the most sensitive species.

- Assumption: if numeric criteria are met for the most sensitive organisms of each habitat, then the waterbody will protect all other species.

- Criteria: magnitude, duration, & frequency component.
## DO Numeric Criteria

<table>
<thead>
<tr>
<th>Aquatic Life Use</th>
<th>DO Criteria (1-day min.)</th>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraordinary quality</td>
<td>7.0 mg/L</td>
<td>Extraordinary quality salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.</td>
</tr>
<tr>
<td>Excellent quality</td>
<td>6.0 mg/L</td>
<td>Excellent quality salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.</td>
</tr>
<tr>
<td>Good quality</td>
<td>5.0 mg/L</td>
<td>Good quality salmonid migration and rearing; other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.</td>
</tr>
<tr>
<td>Fair quality</td>
<td>4.0 mg/L</td>
<td>Fair quality salmonid and other fish migration.</td>
</tr>
</tbody>
</table>

Criteria exceedances may occur once every ten years on average.
WQ Dissolved Oxygen Standards in Puget Sound

- **7.0 mg/L** - most of Puget Sound and the Straits
- **6.0 mg/L** – Bellingham Bay, Samish Bay, Skagit Bay, around Whidbey, other inlets/bays
- **5.0 mg/L** - Commencement Bay, Budd Inlet, and portions of some inlets
- **4.0 mg/L** – finger of Commencement Bay
Aesthetics Criteria

- Aesthetic values must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of light, smell, touch, or taste.
  - Used when numeric criteria are insufficient
Anthropogenic Allowance

- Allowance: 0.2 mg/L DO

- Based on concept of a measurable change
  - Measurable change: change in physical, chemical, or biological quality of the water to determine that a lowering of water quality occurred
  - Represents a detectable change in water quality based on precision of the instrument
  - Not a biologically derived value
Marine DO Criteria Rationale
1968 Dept. of Interior recommendations:
- DO levels between **5 and 8 mg/L** protect survival and growth of fish
- Coastal wasters shall not be <5.0 mg/L
- Estuaries & tidal tributaries shall not be <4.0 mg/L
Supporting Scientific Data

- **Vaquer-Sunyer & Duarte (2008):**
  - Reviewed 872 experiments spanning 206 species
    - **4.6 mg/L DO:** maintain most populations & biodiversity
    - **5.0 mg/L DO:** protective of sub-lethal effects for most species
      - 4.6 and 5.0 mg/L values represent 90th percentile of LC50s
      - Most sensitive species not protected at these levels

- **Conclusion:**
  - Full protection >>>5.0 mg/L DO
Nutrient Criteria Alternatives
DO : Nutrient Dynamics

Diagram courtesy of VIMS
Translating Numeric Criteria to Nutrients

Dissolved Oxygen

- Interrelationships between DO and nutrients
- Variations in DO can be associated with excessive nutrient inputs
- Marine models used to demonstrate relationships
  - Develop nutrient reduction volumes to achieve goals
  - Initiate actions to protect aquatic life
Translating Narrative Criteria to Nutrients

- Aesthetics narrative applies to effects of presence or offense to senses (light, smell, touch, taste)

- Various measures:
  - Percent oxygen saturation
  - Chlorophyll levels
  - Photographic evidence of algal mats/blooms
  - Others...

- Relationships between nutrient over-enrichment and aesthetics can be established
Application of DO Criteria
Application of DO Criteria: Water Column

- DO measurements should represent the dominant aquatic habitat of the monitoring site
  - Samples should not be collected from shallow stagnant backwater areas, within isolated thermal refuges, at the surface or at the water’s edge

- Deep waters:
  - Water samples should be assessed within:
    - Relatively homogenous conditions
      (e.g. euphotic zone; below or above the pycnocline; bottom waters)
    - Various dominant aquatic habitat of communities
      (e.g. benthic, fish, phytoplankton, zooplankton communities)
Application of DO Criteria: Site-Specific Locations

- Water boundaries are established in the water quality standards
- Surface waters are required to be in compliance year-round at all assessment sites
- Fresh/marine water boundaries are determined by salinity measurements
Application of DO Criteria: Anthropogenic Allowance

- Human actions considered cumulatively may not cause DO concentrations to decrease by >0.2 mg/L
  - Does not apply if water body is in compliance

- Based on 1-day minimum concentrations

- Applies year-round at all locations unless otherwise noted in WAC 173-201A
Nutrient Criteria

- EPA provides national strategies for developing nutrient criteria
  - Nationally recommended numeric criteria not available
  - Chesapeake Bay guidance document for various refugia
    - Serves as a good template when robust data is available

- WA has elected to use water quality responses for excessive nutrients to protect aquatic life
Questions?

- **Contact Information:**

  Bryson Finch  
  Water Quality Standards Scientist  
  WA Dept. of Ecology, WQ Program  
  bfin461@ecy.wa.gov  
  360.407.7158