Clean Water Act (CWA)

(33 U.S.C. 1251 et seq.)

Objective: "To restore and maintain the chemical, physical and **biological integrity** of the Nation's waters"

QUANTITATIVE MEASURES

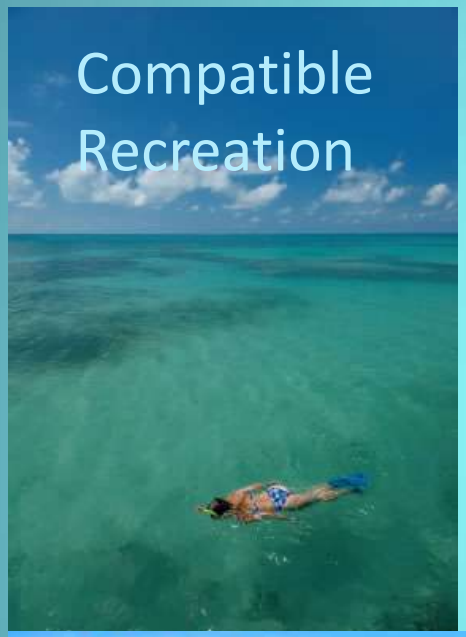
Biological Integrity: The capacity of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the **natural habitats within a region.**

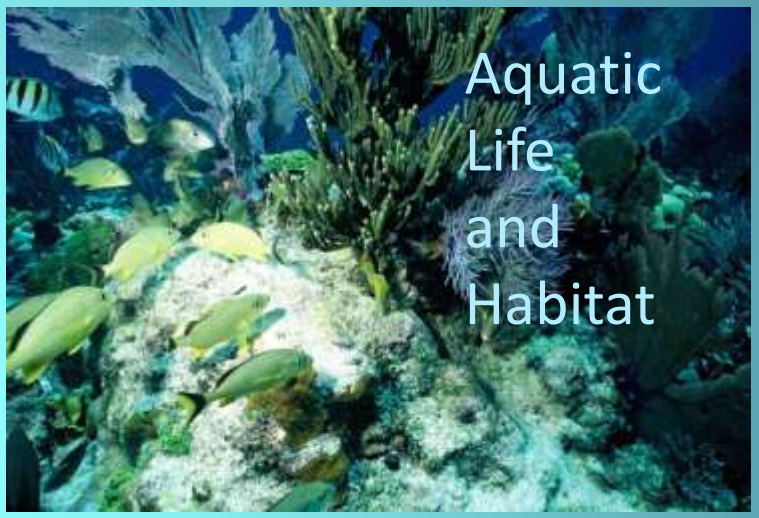
(As modified from Karr and Dudley, 1981)

CLASSIFICATION

REFERENCE

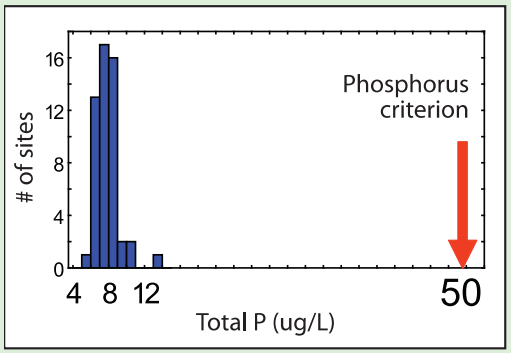
Designated Uses

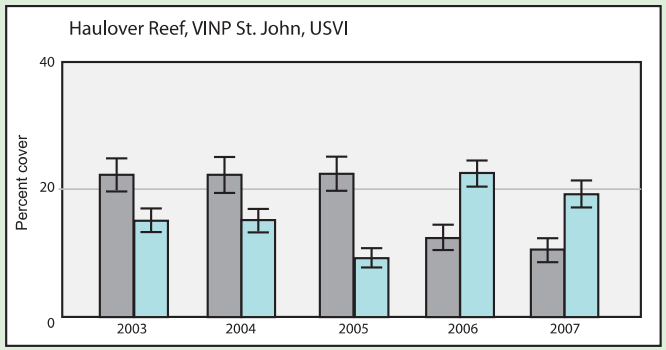




Why Not Simply Use Chemical Criteria?

Biological indicators integrate chemistry, habitat, pathogens and other stressors & can detect impairment when chemical criteria do not.





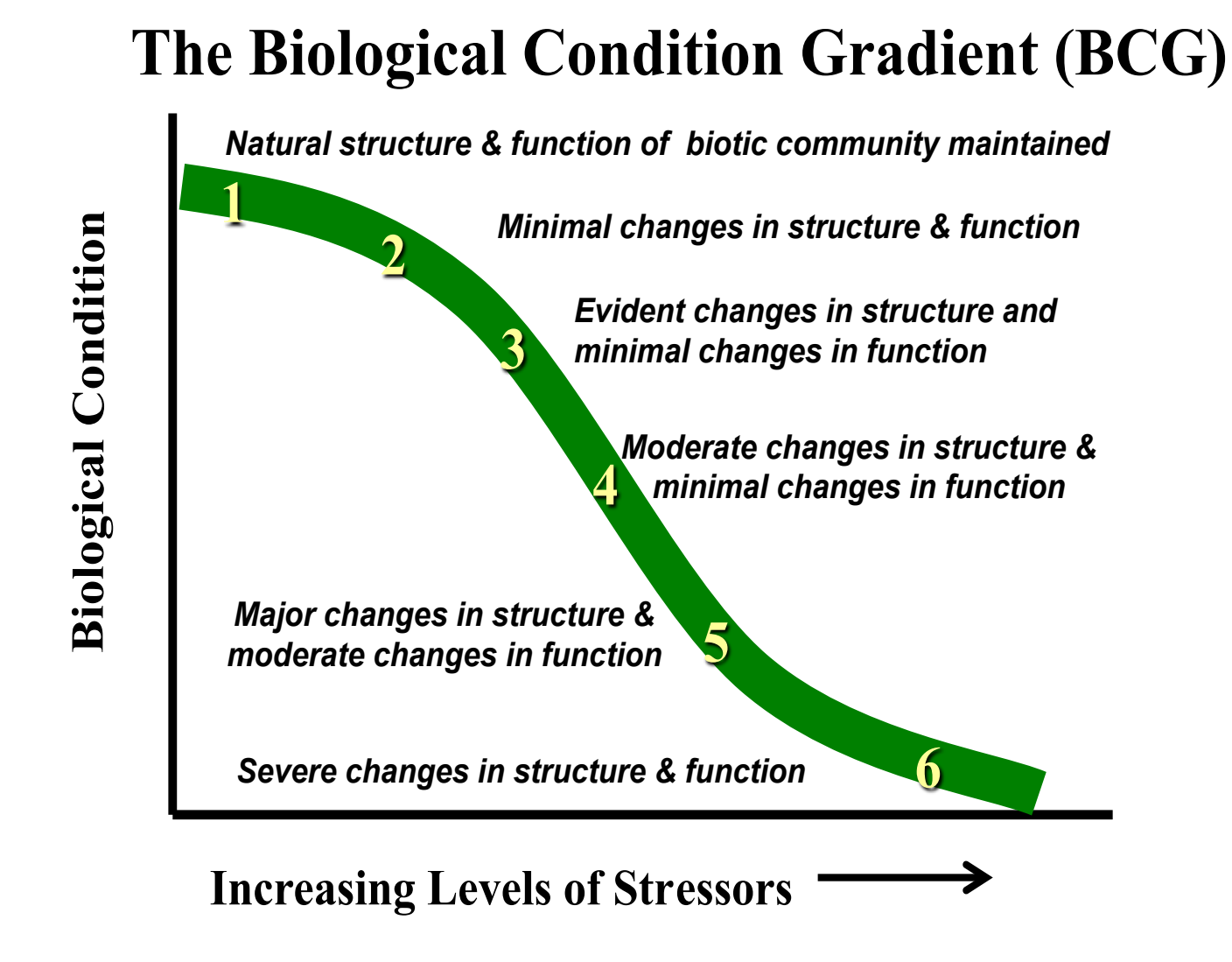
Top - phosphorus values for USVI well below the criterion.

Bottom - Coral cover (gray bars) replaced by macroalgae (blue bars) at a reef in St. John (Waddell and Clarke 2008).

Why Biological Criteria?

- Biology integrates cumulative impacts of multiple stressors
- Biocriteria benchmark the desired biological condition (to support the designated uses)
- Biocriteria can be specifically tied to coral reef attributes
- Bioassessments can then be directly linked to regulatory action
- Regulatory responses are far-reaching and comprehensive (links waterbody and watershed)

BCG Framework



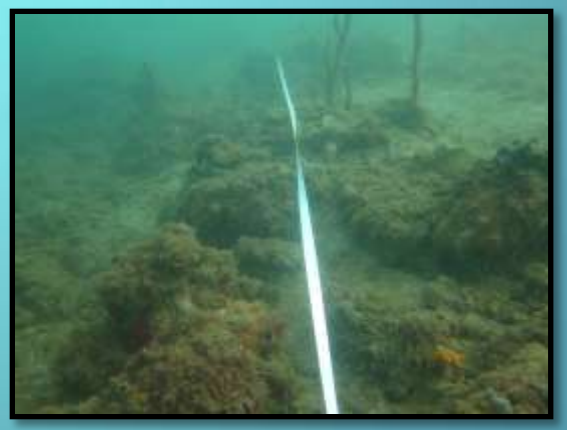
Attributes: Examples from Freshwater Streams

1. Historically documented, sensitive , long-lived regionally endemic taxa
2. Sensitive, rare or specialist taxa
3. Sensitive, ubiquitous taxa
4. Taxa of intermediate tolerance
5. Tolerant taxa
6. Non-native taxa
7. Organism condition
8. Ecosystem function
9. Influence of spatial and temporal scale of disturbance on biological response and recovery potential
10. Ecosystem connectivity

Process to Develop Coral Reef BCG

1. Establish expert panel of coral reef scientists.
2. Workshops elicit information from expert panel. Use visual and electronic data to identify reference condition and determine which coral reef ecosystem attributes define classes of biological condition along a stressor gradient.
3. The condition classes will reflect the continuum of environmental quality from pristine (left photo) with intermediate quality (middle photo), to severely degraded (right photo).
4. The BCG serves to apply metrics for different coral reefs into a common framework to provide a consistent definition for each class by developing well-defined narratives and specific metric scores into discrete classes.





Workshop on Biological Integrity of Coral Reefs

August 21-22, 2012

- Participants were experts on Puerto Rican coral reefs.
- Identify key reef attributes that determine condition of shallow linear coral reefs.
- Use key reef attributes to recommend categorical condition rankings for establishing a BCG.
- Identify reference condition (a natural, fully-functioning system of reef organisms and communities) for coral reefs through expert consensus.
- Develop conceptual, narrative BCG model that describes how biological attributes of reefs change along a gradient of increasing anthropogenic stress.

Attributes of good sites

Improved condition	Attribute	Sub-attribute /measurements
increase	3D structure	rugosity, cover
increase	Coral abundance	*M. annularis* complex, *A. palmata*, *A. cervicornis*, *D.strigosa*, lg stony corals
increase	Coral condition	% live tissue, absence of disease
increase	Coral diversity	large stony
increase	coral population structure	large colonies
increase	coral recruitment	
decrease	dominance of tolerant species	*C. natans*, *S. siderea*, *P. asteroides*
increase	coralline algae	
decrease	zooanthids	*Palythoa* species
absent	exotic species	exotic fish, corals
decrease	filter feeders	heterotrophic sponges
increase	fish abundance	
balanced sizes	fish population structures	
increase	fish biomass	
balanced trophic	fish trophic structure	
increase	fish diversity	
decrease	fleshy algae	
increase	gorgonian abundance	
increase	gorgonian condition	% live tissue, absence of disease & predators (*Cyphoma gibbosum*)
increase	gorgonian diversity	
increase	other invertebrates	anemones, *Diadema antillarum*, conch, lobsters, crabs
increase	sponge abundance	autotrophic sponges
decrease	sponge abundance	heterotrophic sponges
increase	sponge diversity	
increase	substrate condition	clean, no fuzzy algae, open space recruitment
increase	water clarity	
decrease	corallivores/bioeroders	bioeroders, *Coralliophila*, clionids

Good Coral Reef Condition

Preliminary Attributes of Very Good Sites

Condition Level	Attributes
VERY GOOD – EXCELLENT **(Approximate BCG level 1)** 	**Physical structure:** High rugosity or 3D structure, substantial reef built above bedrock, many irregular surfaces provide habitat for fish, very clear water, no sediment, flocs or films **Corals**: High species diversity including rare species; large old colonies (*Montastraea*) with high tissue coverage; balanced population structure (old & middle-aged colonies, recruits); *Acropora* thickets present **Sponges**: Large autotrophic & highly sensitive sponge species abundant **Gorgonians**: Gorgonians present but subdominant to corals **Condition**: Low prevalence disease, tumors, mostly live tissue on colonies **Fish:** Populations have balanced species abundance, sizes & trophic interactions **Vertebrates**: Large, long-lived species present & diverse (turtles, eels, sharks) **Other invertebrates**: *Diadema*, lobster, small crustaceans & polychaetes abundant, some large sensitive anemone species **Algae/plants**: Crustose coralline algae abundant, turf algae present but cropped & grazed by *Diadema* or other herbivores, low abundance fleshy algae

Preliminary Attributes of Fair Sites

Condition Level	Attributes
FAIR **(Approximate BCG level 4)** 	**Physical structure:** Low rugosity, limited reef built above bedrock, erosion of reef structure obvious, water turbid, more sediment accumulation, flocs & films; *Acropora* usually gone, present as rubble for recruitment substrate **Corals**: Reduced coral diversity; emergence of tolerant species, few or no large old colonies (*Montastraea*) mostly dead; *Acropora* thickets gone, large remnants mostly dead with long uncropped turf algae **Sponges**: Mostly heterotrophic sponges with tolerant species, clionids **Gorgonians**: Gorgonians more abundant than in levels 1 & 3; replace sensitive corals and sponges species **Condition**: High prevalence of diseased coral, sponges, gorgonians, evidence high mortality, usually less tissue than dead portions on colonies **Fish:** absence of large reef fish with mostly damselfish present **Vertebrates**: large, long-lived species locally extirpated (turtles, eels) **Other invertebrates**: *Diadema* absent, *Palythoa* overgrowing corals, crustaceans, polychaetes, & sensitive anemones conspicuously absent **Algae/plants**: Some coralline algae present but no crustose, turf is uncropped covered in sediment, lots of fleshy algae with high diversity (e.g. *Dictyota)*

Preliminary Attributes of Poor Sites

Condition Level	Attributes
POOR **(Approximate BCG level 6)** 	**Physical structure:** Very low rugosity, no or low reef built above bedrock; no or low relief for fish habitat, very turbid water; thick sediment film and high flocs covering bottom, no substrate for recruits **Corals**: Absence of colonies, those present are small, only highly tolerant species, little or no tissue **Sponges**: Heterotrophic sponges buried deep in sediment, highly tolerant sponge species **Gorgonians**: Small & sparse colonies, mostly small sea fans, often diseased **Condition**: High prevalence of disease on small colonies of corals, sponges, & gorgonians, if present, low or no tissue coverage **Fish:** No large fish, few tolerant species, lack of multiple trophic levels **Vertebrates:** Usually devoid of other vertebrates **Other invertebrates**: Few or no reef invertebrates, high abundance of sediment dwelling organisms as polychaetes, holothurians **Algae/plants**: high cover of fleshy algae (*Dictyota)*; possibly smothering sessile invertebrates; no turf or crustose coralline algae

Next Steps

- Continue engage panelists through webinars
- Hold several more workshops in next 3 years
  - Reference Conditions
  - Develop Data Portal
  - Sensitivities of coral reef assemblages (taxa)
  - Develop Quantitative BCG
  - Calibrating BCG

Summary
Biological Condition Gradient

- **A conceptually simple framework**
  - Scale up or down to match sampling and assessment unit
- **Organizes and prioritizes research needs**
  - Uncovers gaps in knowledge
  - Uncovers discrepancies in assessment conclusions
  - Enables hypothesis testing
- **Enhances communication**
  - Independent of methods
  - Conceptually complete scale
- **Biological integrity or condition is in discrete levels**
  - framework for assessment, management, and regulatory decisions

Thanks to:

Workshop Participants

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