# Coral Reef Biological Criteria: Using the Clean Water Act to Protect a National Treasure
# Reconciliation: External Peer Review

version 23 June 2010

Reviewer 1

| Comment | Page # | How Reconciled |
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| **Classification**<br>The heterogeneity of reefs makes habitat classification a critical step in biocriteria development. The value of separation by habitat type and ecoregions in Chapter 7 to reduce variability is extremely relevant and was addressed clearly. Geographic classification groups similar characteristics that are not dominated by human disturbance. This helps separate natural from anthropogenic impacts. However, in coral reef environments many marine organisms are stratified by wave energy and depth. The significance of depth in explaining coral cover is analogous to stratification of vegetation by elevation, the most apparent environmental gradient in terrestrial ecology. The phenomenon of coral cover increasing with increasing depth is partially a function of decreasing wave energy. This study supports Peter Glynn's research (1976) conducted in the eastern Pacific suggesting that physical factors like depth and wave regimes control shallow environments, while biological factors are the forcing function in deeper waters. Corals have been reported to stratify by depth and waves in Hawai'i, with wave energy reported as the most dominant forcing function structuring coral communities (Grigg 1983). Thus, further classification may be appropriate. | Page 7-2, replaced paragraph 5 that begins with "Micro..." with: | 'Micro' does not refer to the importance of the differences—the differences can be quite dramatic—but to the spatial scale. For coral reefs, microhabitat differences might be associated with depth or wave energy (Glynn 1976; Grigg 1983). The challenge for biocriteria development is to select measurements and thresholds that are relevant at a regional scale despite microhabitat variability. The best solution is to identify indicators that are immune to microhabitat differences, but this is not always possible. |
| IBID | Page 7-2, replaced the last paragraph with: | Similar strategies could be used to identify the most important natural features that influence coral reefs. The driver could be habitat type (e.g., fore reef, back reef, patch reef) or underlying physical processes (currents, depth, wave energy). Fisher et al. (2008) identified indicators of stony coral that showed a consistent response to human disturbance despite differences in reef habitat type. However, if greater detection power were needed, data collection might be limited within a region to a single habitat type. Alternatively different expectations of condition could be established for different physical environments. Despite potential strategies and promising indicators, the natural spatial variability of coral reefs is an area where research is still needed (Jameson et al. 2003; Rodgers et al. 2010). |
| The development of biocriteria in this report relies heavily on reference conditions for comparison. However, the use of reference sites to provide thresholds can be flawed (Rodgers 2005). This document clearly addresses spatial and temporal variability in Chapter 7. In many areas there is high spatial and temporal variability that cannot be encompassed by a single reference site or a small number of reference sites. The reference concept can be defective in some regions largely because it can not embrace the diversity of unimpacted reef communities. Because of this high variability there is limited power in detecting disturbance. It prevents discrimination on a fine scale. | Page 7-3, replaced 3rd full paragraph (begins with "Scarcity..." with: | Historic data for coral reef ecosystems is scarce because they could not be widely studied until the late 20th century when diving equipment became available. Relevant data on conditions prior to human influences are rare, although a few studies provide valuable insights to previous, if not historic, condition (Dustan 1977; Dustan and Halas 1987; and Porter and Meier 1992). |

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| Another major underlying problem is that selection of a reference site is highly subjective, even by experts as stated in Table 7.1. There is seldom agreement by any two investigators. Also, since no two reefs are exactly alike reference site selection can be subjective, biased and inaccurate. When reference conditions are derived through modeling and estimations this can also be subjective.<br><br>It is difficult to distinguish the degree of impairment. Comparisons can appear to be a reasonable approach if only a single parameter such as coral cover is being compared. For example, a reef with high coral cover is usually taken as a reference for comparison to an impacted reef with low coral cover but the comparison begins to break down as more measured parameters are added to the analysis. We begin to see that the two reefs are quite different in other fundamental respects.<br><br>Although useful in other environments such as freshwater streams and wetlands, the reference site paradigm does not appear to be highly applicable in some coral reef environments. Knowing the value and limitations of reference sites, classification, and potential metrics is important to developing reef indicators. | Page 7-3, replaced 4th full paragraph (begins with "Consequently..." with: | Consequently, coral reef biocriteria may have to rely on reference conditions derived from present day reef assessments, which are unlikely to represent the biological integrity typical of historic conditions. Loss of integrity over time can result in a shifting baseline, that is, a lowering of our expectations for what good conditions should look like (Pauly 1995; Sheppard 1995; Knowlton and Jackson 2008; and Sandin et al. 2008). |
| The use of historical data in developing reference sites creates the issue of shifting baselines. This is addressed in the section on temporal variability. However, if different baselines from different time periods are used as reference conditions this creates an inaccurate representation of overall conditions. | Page 7-3, replaced 5th full paragraph (begins with "Use..." with: | Use of the BCG addresses the complexity of temporal variability and changing reference conditions by placing contemporary measurements within a context of regional potential. Historic data, empirical models and expert consensus have been used to develop BCGs for highly disturbed resource types, e.g., streams in the agricultural plains. For this type of situation, the BCG provides a framework to compare current biological conditions to natural (historic) conditions and develop reasonable expectations for restoration and protection (Herlihy et al. 2008). |
| | Added to Bibliography (1. Works cited), after Frey: | Glynn PW. 1976. Some physical and biological determinants of coral community structure in the eastern Pacific. Ecological Monographs 46:431-456. |
| | Added to Bibliography (1. Works cited, after Global Environment Facility: | Grigg RW. 1983. Community structure, succession and development of coral reefs in Hawai'i. Marine Ecology Progress Series 11: 1-14. |
| | Added to Bibliography (1. Works cited) after Richmond: | Rodgers KS, Jokiel PL, Bird CE and Brown EK. 2010. Quantifying the Condition of Hawaiian Coral Reefs. Aquatic Conservation: Marine Freshwater Ecosystems 20:93-105. |
| | Added to Bibliography (1. Works cited), after Healthy Reefs Initiative: | Herlihy AT, Paulsen SG, Van Sickle J, Stoddard JL, Hawkins CP and Yuan LL. 2008. Striving for consistency in a national assessment: the challenges of applying a reference condition approach at the continental scale. Journal of The North American Benthological Society 27(4):860-877. |

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| The climate change variability section is critical and the inclusion of the consequences of ignoring this global impact is a vital addition. In Table 8.1 the response to the stressor global climate change is coral bleaching, loss of *Acropora* spp. Although the major coral in many regions they are not dominant in other areas such as in the Hawaiian Islands where *Pocillopora* spp. show the strongest response to temperature increases. This table also includes ocean acidification as a stressor. A missing response that will be critical to the survival of corals reefs is the impact to calcareous coralline algae (Kuffner et. al 2008). The list in Table 8.1 is only a partial list of responses. Global stressors will affect all coral life stages and those of many other marine organisms. Managing the entire watershed as included in the report will indeed be important at many locations. | Page 8-1 Paragraph 3 Beginning with "A particular challenge…" Replaced with: | A particular challenge is to distinguish local stresses from global and regional stresses. Biological impairment resulting from global and regional stressors should be reported, but local management actions can do little to reduce these threats. Nonetheless, resource managers need to identify sources and causes of degradation that can be eliminated through local management practices. |
| IBID | Page 8-2 last paragraph, beginning with "Although unique…"; replaced with: | Although unique biological indicators have not been identified for all the stressors that affect coral reefs, some relationships are emerging (Table 8-1 for examples). Coral bleaching has increased dramatically in recent years in response to elevated sea temperatures, particularly for *Acropora* and *Pocillopora* species; however, bleaching is also a sign of excessive sediment as well as other stressors. Nonetheless, the pattern and timing of bleaching, as well as the species that bleach, could be used to characterize the influence of different stressors. |
| IBID | Page 8-3, legend of Table 8-1; Replaced legend with: | Table 8-1. Examples of commonly observed biological responses characteristic for particular coral reef stressors. |

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| Appendix 6 Ocean Acidification is an important inclusion if water quality standards are amplified to include no observable change in pH for marine coastal waters. However, Appendix 6 states the following: *"Generally the oceans are well buffered, meaning that they resist changes in pH. This occurs because hydrogen ions, the concentration of which determines pH, react with carbonate to form bicarbonate. This removes hydrogen ions from the water and diminishes any change in pH. Unfortunately, it also removes carbonate ions that are needed by corals and marine organisms to construct calcium carbonate skeletons and shells. By 2100, it is expected that there will be 30-50% less carbonate available for calcification. This will likely affect growth and survival of corals, mussels, oysters, snails, sea urchins, and microscopic plants and animals that use calcium carbonate to build shells and tests."*<br>Bicarbonate not carbonate is the most abundant form of dissolved inorganic carbon in the oceans and is the principal form taken up by corals and utilized by zooxanthellae for photosynthesis (Al-Moghrabi et al. 1996; Gorian et al. 1996; Moya et al. 2008). Bicarbonate will be even more abundant in future acidic waters and will not be the limiting factor in decreases in coral growth. Although coral growth will decline in the future (Jokiel et al. 2008, and many others) decreases in carbonate ions is not the explanation. | Page # F-1, paragraphs 1 & 2: replaced with: | Since the Industrial Age began, burning of fossil fuels has added significant amounts of carbon dioxide ($CO_2$) into the atmosphere. Concentrations have risen from 280 ppm in the atmosphere to today's level of 387 ppm (Feely et al. 2004). About a third of atmospheric $CO_2$, approximately 22 million tons per day, is absorbed into oceans. The estimated time lag for absorption is at least 10 years, meaning that today's level of atmospheric $CO_2$ will still influence ocean chemistry a decade from now (Veron et al. 2009). Once dissolved, $CO_2$ reacts with the seawater to form carbonic acid, which dissociates into hydrogen and bicarbonate and decreases ocean pH. During the last 250 years, oceans have become more acidic by 0.1 pH units (Feely et al. 2004). This may at first seem small but the pH scale is logarithmic so this represents a 30% increase in acidity. Models forecast continued acidification—another 0.3 to 0.4 pH units—by the end of this century.<br><br>Oceanic absorption of atmospheric $CO_2$ mitigates some climate change impacts, but may generate others. Increased absorption has led to a decline in ocean saturation state for aragonite and calcite, forms of calcium carbonate incorporated into shells and skeletons of many marine organisms (Kleypas et al., 1999). Reduced saturation states reduce the ability to form shells and tests, and consequently reduce the growth of organisms such as corals, mussels, oysters, snails, sea urchins, and a wide variety of microscopic plants and animals. Many other physiological effects on marine life may result from changes in ocean chemistry from $CO_2$ absorption. Overall, little is known about the effects on particular species or on population and community interactions. |
| | Added to bibliography (1. works cited) | Kleypas JA, Buddemeier RW, Archer D, Gattuso JP, Langdon C, and Opdyke BN. 1999. Geochemical consequences of increased carbon dioxide on coral reefs. Science 284:118-120. |
| | Added to bibliography (2. Additional Resources that May be of Interest) | Al-Moghrabi S, Goiran C, Allemand D, Speziale N and Jaubert J. 1996. Inorganic carbon uptake for photosynthesis by the symbiotic coral-dinoflagellate association. 2. Mechanisms for bicarbonate uptake. Journal of Experimental Marine Biology and Ecology 199:227–248. |
| | Added to bibliography (2. Additional Resources that May be of Interest) | Goiran C, Almoghrabi S, Allemand D and Jaubert J. 1996. Inorganic carbon uptake for photosynthesis by the symbiotic coral/dinoflagellate association. 1. Photosynthetic performances of symbionts and dependence on sea water bicarbonate. Journal of Experimental Marine Biology and Ecology 199:207–225. |

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| | Added to bibliography (2. Additional Resources that May be of Interest) | Jokiel PL., Rodgers KS, Kuffner IB, Andersson AJ, Cox EF and Mackenzie FT. 2008. Ocean acidification and calcifying reef organisms: a mesocosm investigation. Coral Reefs. 27:473-483. |
| | Added to bibliography (2. Additional Resources that May be of Interest) | Kuffner IB, Andersson AJ, Jokiel PL, Rodgers KS and Mackenzie FT. 2008. Decreased abundance of crustose coralline algae due to ocean acidification. Nature Geoscience 1: 114-117. |
| | Added to bibliography (2. Additional Resources that May be of Interest) | Moya A, Tambutte S, Bertucci A, Tambutte E, Lotto S, Vullo D, Supuran CT, Allemand D and Zoccola D. 2008. Carbonic anhydrase in the scleractinian coral *Stylophora pistillata*: characterization, location and role in biomineralization. The Journal of Biological Chemistry 283(37):2547 – 2548. |
| | Added to bibliography (2. Additional Resources that May be of Interest) | Rodgers KS. 2005. Evaluation of Nearshore Coral Reef Condition and Identification of Indicators in the Main Hawaiian Islands. PhD Dissertation. University of Hawai'i, Department. of Geography. Honolulu, Hawai'i. Pp.203. |

Reviewer 2

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| :xv– Why you should read this section | **Does the report provide a useful framework for coral reef managers to develop biocriteria? Please identify any deficiencies.**<br>It does provide a framework to guide biocriteria development, and it does it in a way that should be easily understood by diverse audiences. That said, it does not provide enough detail so that the average reef manager could embark on such an effort with comprehensive understanding of the opportunities and pitfalls that lie ahead. To quote the report (page xv), it "describes the basis for biocriteria development under the CWA. . . . the manual is intended as informational, rather than a 'how-to' document . . ." Leadership and action to fill the need for a how to manual will have to be shown by state and federal agencies responsible for water resource protection and coral reef conservation if the power of the CWA is to be effectively tapped. But their actions should be guided and informed by the insight of the scientists and managers with day-to-day knowledge of coral reef ecosystems.<br><br>Most important, the framework advocated in this important document can be best implemented by pooling the knowledge, energy, and resources of the many institutions, managers, and groups charged with protection of coral reef environments. It cannot, indeed should not, be done narrowly for each reef location or environment. | added after the final sentence (now on page viii):<br><br>The responsibility for implementing coral reef biocriteria lies with the state and federal coral reef managers. However, to be successful, their actions must be guided and informed by the knowledge, energy and resources of scientists and other stakeholders. |
| Page xv | **Are the steps necessary for biocriteria development clearly explained and logical? Please recommend improvements.** | Page ix, replaced with:<br>Many states have incorporated biocriteria for freshwater and estuarine waterbodies. Examples of |

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| | As hinted above, the steps outlined in Table P-2 provide an excellent introduction and framing of the challenges ahead. The individual chapters, cast to answer a sequence of simple questions, provide important and accessible guidance to audiences interested in advancing coral reef protection and restoration. I suspect that more people could be successfully enlisted to take the actions proposed here if a few simple examples from earlier work, conveyed through simple graphics, were developed to show how successful application of biocriteria concepts have improved CWA implementation in other situations. I am not speaking of the details of studies but brief synthesis of examples from earlier work and their key conclusions as well as explicit reference to how they have advanced the goals of the CWA. | their development and application can be found at EPA's biocriteria web site (http://www.epa.gov/waterscience/biocriteria). Much of the information in this report draws from this combined experience. Information on planning, assessment and management needs for development of coral reef biocriteria are outlined. Table P-2 briefly summarizes some of the important steps, which are sometimes simultaneous and iterative, and where in this report these steps are discussed.<br><br>Page x, Table P-2 legend. Replaced with:<br>Table P-2. Top ten steps for establishing a coral reef biocriteria program, who is usually responsible for completing those steps, and where in this report the steps are discussed.<br><br>Page 1-15, end of last paragraph: deleted the last sentence: "Relevant concepts and information related to development and application of coral reef biocriteria are presented in the following chapters".<br><br>Page 1-15, after last paragraph added three new paragraphs:<br>"There are many applications for bioassessment approaches and biocriteria. Some of these are iterated at the EPA Biocriteria web site (http://www.epa.gov/waterscience/biocriteria) and include support for enforcement and restorative assessments, setting protection priorities and restoration goals, assessment of water quality to identify impaired waters, contributing to stressor identification, supporting permit decisions, protecting watersheds and tracking restoration progress.<br><br>Many aspects of biocriteria development were pioneered in Ohio. Prior to 1978, Ohio's water quality standards reflected a single aquatic life designated use for all of the State's waters. In 1978, the standards were revised to account for the natural variability of aquatic ecosystems using a tiered classification scheme based on ecological components. It was recognized that environmental conditions for biological integrity varied for different populations and habitats. However, the water quality criteria linked to these classifications remained physical and chemical (Figure 1-4). In 1980, narrative biological criteria were developed for each ecological classification. These narrative biocriteria were the forerunners of the current numeric biocriteria adopted in state water quality standards in 1987 (Yoder and Rankin 1995).<br><br>A typical example of the utility of bioassessments in a biocriteria program might be a fish kill experienced in Rock Creek Maryland in 2000 (Gerritsen et al., 2001). Investigation revealed a point-source pesticide spill as the likely cause. Biological assessments played a role in several aspects of the case. Routine biological monitoring provided historical data and a 'before' picture of the integrity of the fish and |

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| | | macroinvertebrate communities. Standard methods recommended by EPA were used for all bioassessments. Sampling immediately after the event and then several months later provided legally defensible data for impact of the event and the degree of recovery. In 2001 the owner of a pesticide company pleaded guilty to federal CWA violations. The routine biological monitoring of this biocriteria program provided a powerful tool for documenting degradation from previous and historical condition and recovery. Data assisted enforcement agencies in assessing damage, levying fair and reasonable fines, and determining the rate of stream recovery."<br><br>Added to bibliography (1. Works cited):<br>Yoder CO and Rankin ET. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144 (Chapter 9). In W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.<br><br>Added to bibliography (1. Works cited):<br>Gerritsen J, Cresswell C, Pavlik K. 2001. *Assessment of the Biological Effects of a Pesticide Spill in Rock Creek (Maryland and District of Columbia)*. Prepared for USEPA by Tetra Tech, Inc. under contract #68-C-99-249, Work Assignment #1-46. EPA Office of Water, Washington, D.C. |
| | **Is the presentation, including tables and graphs, clear, relevant and concise? Please recommend improvements.**<br>I do suggest that a careful examination of the glossary might be in order. I comment on a number of glossary entries in my more detailed review comments. Unfortunately, I did not keep a list of the words that I looked for in the glossary but did not find; there were a number but that is not a very helpful comment. | Document was reviewed and additional terms added to the glossary. |
| | **Has the appropriate literature been cited? Are there publicly available, peer-reviewed papers that have not been included, but that should be? Please provide copies of any papers or reports for consideration.**<br>I attempted to provide a summary of issues related to biological monitoring and assessment in a recent paper that the authors might find useful. That paper focuses on seven foundations that relate to development and use of biocriteria through biological monitoring and assessment. The full citation of that paper is as follows: Karr, J. R. 2006. Seven foundations of biological monitoring and assessment. *Biologia Ambientale* 20(2): 7-18. A PDF of that paper is sent with this review. In addition to the framework of seven foundations, it provides an appendix of key papers on the subject published over the past several decades. | Page 1-13, changed citation for last sentence in paragraph 1 to this: (Karr 2006 [see Appendix for other key biocriteria papers]; Figure 1-3). |

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| vii, Executive Summary, Paragraph 2, line 5 | "Biological criteria can be. . ." Why not should be? Why just can be? Without biological criteria one cannot be sure that living systems are being protected and, thus, if the goal of the CWA is being attained. | No change. OW and OGC changed wording throughout the document from "should" to "can". EPA does not require states to use biocriteria. |
| vii, paragraph 3, line 3: | "condition of reef organisms" Many will I fear interpret this to be a focus on individual organisms or species, leading to the selection of indicator species. Better choice of phrase might be "condition of reef living systems" in an effort to suggest a broader biological framework than species. | Now on page xv - Replaced "condition of reef organisms" with "condition of reef living systems" |
| xi, last bullet of intended audience. | Need to add close parenthesis at end | Now on page v - Closed parenthesis at end |
| xii, bulleted list of stakeholders. | I suggest that the document here misses the opportunity to clearly state that all U.S. citizens are key stakeholders. The bulleted list captures some of the specific groups, but the overarching group of stakeholders is all US citizens. I think that should be explicit with the bulleted list added to indicate especially active groups. | Now on page vii - Revised the paragraph prior to the bullets to read:<br><br>Reef managers and government scientists aren't the only people interested in protecting coral reefs. All U.S. citizens are stakeholders. The Clean Water Act includes many opportunities for citizens and other stakeholders to comment, understand and influence regulatory decisions either during mandated public comment periods or through citizen lawsuits (USC33, §1365 and §505). Stakeholders include: |
| xvi. item 9 in table, first column. | I see biological integrity as the endpoint of a condition gradient. Not all water bodies will be restored to that integrity level. That is simply a practical reality that is captured in the designated use component of water quality standards. Using integrity in this text here is not clear about that reality. | Replaced "Implement management activities that restore biological integrity to…" with:<br><br>Implement management activities that restore the biological condition of impaired waterbodies |
| 1-1, paragraph 1, lines 5-7. | Lack of parallelism in these phrases is a bit jarring. | Replaced "They" with "Coral reefs" |
| 1-2, first sentence. | I suggest deleting this sentence. It adds nothing of value. | Deleted the sentence "Presented below is a brief overview of the CWA and emergence of biocriteria." |
| 1-3 | Replaced "…evolutionary and biogeographic context." with: | evolutionary and biogeographic context (Karr 2006). |
| 1-3, box definition of biological integrity | Replaced "(EPA 1990)" with: | (Karr and Dudley 1981) |
| 1-5, first sentence | Same comment for sentence at top of page 1-5. | Deleted the sentence: "Provided below is a ...." |
| 1-7, California example box. | I have never understood the logic of saying that fishing is a factor of concern and habitat is a factor of concern but there is no simple statement that the biota is not only a factor of concern but the primary goal in the crafting of this list. As I see it, habitat is a new euphemism for that biota just like water quality, the old euphemism, we now know is a flawed euphemism for that goal. Why not state the goal in the form of the primary endpoint of interest: the biota! The same comment applies for the ALU box below. | No Change. This is an example drawn from California WQS – we cannot change their language. |

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| 1-8, second paragraph of water quality criteria, line 4. | Add 's' to first word to make "supports" | Added 's' to first word to make "supports" |
| 1-11, paragraph 4, last line. | An interesting approach to getting around some complex subjects. Is anything being done, or should anything be done, to move important but presently ignored/neglected effects on water quality into the authority group? Why or why not? If not, is there any hope that we can accomplish the goals of the CWA? | No change. We cannot address potential policy changes in this document. It is guidance based upon current policy. |
| 1-12, paragraph 1, line 3. | Why the copyright symbol here? | Now on page 1-11 - Replaced with: (c) |
| 1-13, figure 1-3. Second frame. | Serious problems with the bottom frame of this figure. The y-axis is not labeled; is it taxa richness? Also there is much wasted space. The values present rarely exceed 20 but the range on the y-axis goes to 100. This leaves much wasted space and limited ability to see the differences among the years. | Labeled the Y-axis: "Percent cover".<br><br>Changed the height of the y-axis only showing up to 40%. Also began with 2003 on x-axis.<br><br>Changed caption to:<br>"Figure 1-3. Biological assessments can sometimes detect impairment when chemical criteria do not. Top panel shows phosphorus values for USVI well below the criterion. In contrast, bottom panel shows coral cover (gray bars) being replaced by macroalgae (blue bars) at a reef in St. John (Waddell and Clarke 2008)." |
| 1-15, paragraph 2, line 5. | Here and elsewhere I suggest an effort to avoid this kind of vague antecedent construction (it is, there is, there are, etc.). Make important issue the subject of active sentences, an approach that leads to more direct communication and saves space. See also third line of next paragraph. Here and elsewhere I suggest an effort to avoid this kind of vague antecedent construction (it is, there is, there are, etc.). Make important issue the subject of active sentences, an approach that leads to more direct communication and saves space. See also third line of next paragraph. | Revised last sentence to read:<br><br>"There is an opportunity to extend and set goals for coral reef protection through implementation of coral reef biocriteria." |
| 1-15, Figure 1-4 caption. | Odd and a bit annoying font here that provides a peculiar looking (narrow) l and cap i. | No change. Font is fine in print version. |
| 2-3, paragraph 1, line 2. | Here again I suggest noting that they provide diverse values to all citizens, not just local residents and tourists. Although not really ignored with the language here, I suggest an affirmative statement of importance to all citizens is warranted and wise. | No change. We already made this point on page vii in the Preface. However, we took out the reference to local residents and the sentence now reads: Coral reefs provide numerous benefits…. |

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| 2-3, definition box. | This dichotomy ignores the parts of the system. They should be explicitly acknowledged as crucial to our success. See below for similar problems, and for other approaches that do not narrow the conceptual framework to functions or processes (e.g., the US Virgin Islands language on these topics is broader and stronger). | Replaced the 3rd sentence in Para 2, with:<br><br>Coral reef ecosystems include items one can count (***ecosystem structure***) plus the processes (function) that generate and maintain them. The structure of the coral reef ecosystem includes:<br><br>• The composition of the biological community including species, numbers, biomass, life history and distribution in space.<br>• The quantity and distribution of abiotic factors (non-living physical and chemical characteristics of the environment), including solar energy (amount of sun light), oxygen, $CO_2$, water, temperature, humidity, ph, and availability of nitrogen.<br>• The conditions of existence such as temperature, light, etc.<br><br>Coral reef ***ecosystem function*** includes the following processes:<br>• The synthesis and storage of organic molecules during the growth and reproduction of photosynthetic organisms (primary productivity).<br>• The trophic interactions (the relationships between the feeding habits of organisms in the coral reef food chain)<br>• Flow (fluxes) of nutrients and energy throughout the ecosystem.<br><br>Both structure and function are integral components of ecological integrity.<br><br>Deleted the "s" on "function in the old 4th sentence and first definition<br><br>Added a new definition to definitions box on page 2-3:<br><br>Ecosystem structure: The physical and spatial aspects of an ecosystem that are contributed by the biotic and abiotic composition. |

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| 2-4, Table 2-1. | The three classes here capture things in the language and concepts of economics. I suggest that an alternative non-economic perspective is also appropriate and in many respects better. Perhaps more appropriate they are complementary and without both one does not communicate as well and as broadly as is useful. An alternate framing, also that comes from MEA, places services in four classes: supporting, provisioning, regulating, and cultural. I slightly modified that framing in a recent paper in Encyclopedia of Ecology (Figure 2 (inserted as next page in this review); also see attached PDF file).<br><br>One final point on this. The "Charge" letter sent to reviewers (first sentence) says the following "Coral reef ecosystems are valuable economic, ecological, and aesthetic resources . . ." Here is the place to do the best we can to show efforts to capture the values (inclusive of money based but not only money based) that derive from the presence and persistence of healthy coral reefs. | No change to the classification. This is more simple that the MEA classes.<br><br>The points in the "Charge" letter have been addressed in comment above. |

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| 2-5, Quantifying ecosystem services box. | This box provides justification for the economic view and approach. As far as it goes, it does that but equally important in my view is the need to ensure that readers understand more comprehensively what is left out of this approach. One weakness is the dependence on numeric values provided in dollar terms. In reality, many things cannot be valued in those terms at all (so they are often then left out of the discussion), and others can be valued in those terms but the foundation for those values is at best a slippery slope or distortion of their importance to human society and to life on earth writ large. I think it is essential that another box be added that captures these kinds of things, perhaps using the above-mentioned MEA classification as a complement to this box. The title of this box perhaps even implies that valuing (quantifying) can only be in dollar/economic terms. | Page 2-5; Revised the text box (Quantifying Ecosystem Services); first paragraph should read:<br>"The concept of ecosystem services is not new and services have been quantified by several authors (e.g., Spurgeon 1992, Pendleton 2009). Many studies place a monetary value on reef services—monetary valuation is widely applied, broadly accepted and can be highly influential in decisions and policies. But coral reefs provide more than direct (e.g., fishing, tourism) and indirect uses (e.g., habitat, shoreline protection), so a strictly monetary approach can overlook important benefits (see Bateman 1993). An approach used in environmental economics, called 'total economic value', includes monetary values but also provides a context for non-monetary social, cultural and historical values. Total economic value includes direct and indirect uses, option values and non-use values. Option values reflect the willingness to preserve an option for potential future use and non-use value (existence or bequest value) is placed on a resource that will never be used. Many ecosystem valuation studies provide a total economic value (e.g., Gren et al. 1994), but incorporating non-monetary into decision scenarios presents a significant challenge.<br><br>Revised the first sentence of the second paragraph to read:<br>"A few studies have extrapolated coral reef monetary values (direct and indirect uses) to a worldwide scale.<br><br>Replaced the third paragraph with the following:<br>Many authors incorporate "ecological integrity", resilience, or biodiversity as an ecosystem service (Turner et al. 2005). Without these characteristics, the ecosystem would ultimately fail and other services would decline. The Millennium Ecosystem Assessment (MEA 2005) identified these as supporting services. This ecosystem 'glue', which all other services depend upon, is often viewed as a biological service, directly benefiting components of the ecosystem and indirectly benefiting human society. |
| 3-1, paragraph 1, line 1. | We not only "care about" these things, we also and perhaps more important, depend upon them for our very existence. | Replaced paragraphs 1 and 2 with:<br><br>Tourism, recreation, and fisheries are examples of ecosystem services that we care about. Protecting these services and the economic values derived from them means protecting the plants and animals, the biota that provide them. The CWA protects these aquatic life uses as the "fishable/swimmable" goal, that is, the "protection and propagation of fish, shellfish, and wildlife and recreation in and on the water" (Section |
| 3-1, paragraph 1, last two lines. | ARGH! It also reflects the presence of the native species/biota characteristic of the region. It is about more than functions in support of human needs. This leaves off half of the core components/contexts of the integrity definition used earlier. The glossary, for example, notes that integrity is defined as the extent to which "all (1) parts or elements of a system . . . are present and (2) functioning. | |

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| 3-1, second paragraph, last line. | What does it mean to have an intact ecosystem function? How would one recognize an ecosystem function that is not intact? Is that like saying a place meets the integrity goal or does not, with the latter failing to recognize the rather broad gradient of biological condition that ranges from slight divergence from integrity to nothing alive. | 101(a)(2)). Making the connections between the ecosystem services provided by the biota and protection of the aquatic life use helps stakeholders understand how protection of the biological parts and processes of natural ecosystems also provides valuable economic benefits to society (Table 3-1). Sustainable fisheries, for example, depend on ecosystem functions to support the persistence of large, abundant fish and invertebrates. Only an intact, functioning ecosystem can support the production of large fish and invertebrates.<br><br>Although the aquatic life use goal is broadly protective, refined designated uses can make selection of indicators (Chapter 4) and establishing criteria (Chapter 5) more relevant to a particular waterbody and to stakeholders. Refined designated uses specifically describe the expected biological assemblage that the use depends on, for example "natural coral reef communities to support recreational diving," "undisturbed fish nursery areas to support fisheries," or "restricted spawning areas to support grouper propagation" specifically highlight the biological resources that are particularly important to stakeholders. The primary purpose of designated uses is to communicate the desired condition of water resources to water resource managers, the regulated community, and the stakeholders. The best designated uses translate easily into indicators that respond in predictable ways to degradation and can be assessed with data collected from the waterbody (EPA 2005). |
| Table 3-1 | | Replaced the caption and table with (2) below. |
| 3-2, table 3-2. | This set of ecosystem services does not seem coherent relative to the earlier comments re economic context. Internal consistency in the document on these and related subjects seems essential in my view. Note that the economic perspective is necessary but not sufficient. Also language not coherent among the segments of the table. | Tables 2-1, 2-2 and 3-2 have been harmonized somewhat. However, they serve different purposes and are drawn from different source material, so do not need to be exactly comparable. |
| 3-4, paragraph 3, biocriteria discussion, line 12. | Refers to metrics but I don't remember seeing much on metrics before this in the report. Seems it needs some foundation of definition and context if the language here is to help the naïve reader. Here is where a simple graphic from the coral reef work, or from freshwater systems that shows the concordance among good metrics, between metrics and dose-response curves in toxicology, and effective indicators of biological condition. | Page 4-2 changed text to read: Indicators that demonstrate a reliable and consistent association with human disturbance (typically referred to as "metrics") provide the best candidates for biocriteria development (Karr and Chu 1999). |

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| 3-4, proposed WQS, class b waters. | Wisely, this language captures contexts beyond ecosystem functions that I have already commented upon. Surely if the USVI can cover this full range, this report can be revised to ensure that the dimensions of biological integrity (living systems; parts and processes) is captured beyond the constraining concept of functions. See earlier comments.<br><br>Checking the dictionary definition of function the key phrase seems to be "the normal or characteristic action." We can restore ecosystem function in water resources by adding wastewater treatment to break down organic material. Or by introducing non-indigenous fish in the Columbia River to make fish biomass (of carp instead of salmon). But the accomplishment of the action (function) is simply not enough in my view if the normal actors (diverse native assemblage of inverts, fungi, bacteria; salmon) responsible for that action are replaced by an artificial and narrow set of non-indigenous actors. Function is simply not enough, to paraphrase a paper from 15 years ago titled "Clean Water is Not Enough." | No action needed |
| 3-4. | The language from USVI materials (and elsewhere in the use of the biological condition gradient graphic) there is heavy dependence on recent work from EPA that seems to set up expectations grounded in fuzzy ecological theory. The thresholds of diversity change and maintenance of ecological functions are at best fuzzy, at worst grounded in ecological theory that has not been empirically demonstrated and tested. In my view, it shows confidence in vague ecological theory in much the same way that use of diversity indexes did nearly 40 years ago. As we know now, they became key parts of state agency rules (e.g., Florida and elsewhere), a problem that is still vexing societal movements toward better approaches. | No change. This is drawn from USVI legislation. It is the best available example for coral reefs. |
| 4-1, Indicator guidelines box. | Note that both structure and function (or alternately phrased, parts and processes) are mentioned here. This important duality should be emphasized throughout the document, not just in random places making considerable inconsistencies in this important conceptual foundation through the document. | No action needed. |
| 4,2, line 1. | More vague antecedents. | Replaced 1st sentence with:<br><br>Biological assessments serve a variety of different purposes, and the purpose influences the type of indicators that will be used. |
| 4-2, paragraph 2 | | Replaced: "... determining the biological integrity" with:<br><br>"determining the biological condition" |
| 4-2, paragraph 2, line 5 | | Replaced: "…characterize biological integrity" with:<br><br>"…characterize biological condition" |
| 4-3, first full paragraph, next to last line. | Delete "that" | Deleted "that" |

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| 4-3, Figure 4-1. | The nature of and interactions of the three levels (stations, replicates, habitats) is not clear to me from this figure. | Figure 4-1. *Leave current caption as is.* Added this text after "… different habitat type.": Data from the 10 primary stations would be used to test for a biological response to disturbance, replicates would be used to evaluate precision of the assessment protocol, and data from stations in a different habitat would test for consistency of the biological response across different habitat types. |
| 4-3, second paragraph, line 3. | Might be useful to add something here about the context of properly selected metrics. The connections between metrics, metric behavior, and these patterns should/could perhaps be clearer. | Replaced paragraph beginning with "At this stage…" with this text: At this stage of indicator development, a consistent response to human disturbance must be documented in more than one setting to demonstrate that the indicator is reliable. Detailed information about the source of human influence may not be necessary, for example, changes in coral condition across a gradient of industrial land use can suffice. If connections can be made between certain types of human disturbance and specific biological indicators, this link can potentially identify causes of impairment and guide restoration plans; however a causal link is not necessary for indicator selection. |
| 4-3, last paragraph, line 1: | "consider if" seems an odd phrase here. How about "ensure that"? | Eliminated sentence beginning with "Indicator selection should consider…" Add text to sentence ending: "…expected to be sampled year after year." with this text: …year after year given the available funds, equipment, expertise, and time. |
| 4-4, Para. 2 | | Replaced: "…important both for characterizing biological integrity and communicating" with:<br><br>"… important both for characterizing biological condition and communicating" |
| 4-6, first paragraph, line 2. | Why only functional? | Inserted prior to "function aspect":<br><br>"structural and " |
| 4-6, figure section 3. | Nothing provided here to suggest why and how the 52 threshold was selected and the effects of that judgment. This may not be the place but it should be present someplace in the document. I especially suggest that it must be grounded in biological context and terms, not some arbitrary statistical threshold. Perhaps something of this kind, taking experience from recent coral reef work in Caribbean and the more extensive freshwater work could be added as a short appendix. | Changed text in figure from "24% of coral reefs are impaired (coral index < 52)" to "24% of coral reefs are impaired (below biocriteria threshold)" |
| 5-1, paragraph 2, line 2: | Period after al. in citation. | Added a period after "al" in citation. |

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| 5-1, third paragraph: | One needs to be careful about only including rocky areas. To what extent have past human actions caused sedimentation or other alteration of substrates in areas that were historically occupied by corals. I suggest this point should at least be identified. An analog is sediment-laden streams with no rocky substrates although they did occur in abundance before altered land use provided the heavy silt loads to embed the stream substrate. This comment is also relevant to the next paragraph, if hard bottom is used in area based evaluations but some hard bottom has been lost due to a history of human actions in the region. A similar point could be made in coastal marine systems that only evaluated areas currently occupied by eelgrass. We know that many good eelgrass areas have been obliterated by human actions. | Page 5-1, third paragraph beginning with "To assess coral reefs…" added the following sentence to the end of the paragraph:<br><br>In some cases, sonar mapping can detect hardbottom areas covered with sediment; corals may have previously inhabited these areas. |
| 5-3, first full paragraph, line 2: | Are you sure about the statement that "they yield statistics for all water bodies." Doesn't one need to make sure that there is a stratified sampling array that ensures the all water body types are sampled at appropriate levels? How can you be sure that all water bodies (including all water body types) are represented? Would it be better to clarify that this is true only for all water body types designed into the sampling program? Or am I missing something here? To some extent the discussion in Figure 5-2 deals with this issue. | Replaced text "...because they yield summary statistical for all waterbodies,…" with this text:<br><br>…because they provide summary statistics for all areas included in the survey design, not just selected locations, segments or areas. |
| 5-6, last paragraph, lines 3-4. | I agree with comments here about individuals. But household unit is a very heterogeneous thing: single, married, two sexes, single sex couple, with or without children, and so on is more like the various kinds of reefs. | Changed sentence beginning with "For surveys of people…" to this text: For surveys of people, the sampling units are typically easier to define, for example, a registered voter. |
| 5-8, last paragraph, line 3. | Replace "for example" with "such as" | Replaced "for example" with "such as" |
| 6-1, paragraph 2, last line. | I suggest that it can also be instrumental in diagnosing the cause(s) of degradation if done properly. | After sentence ending: "…waterbody is meeting its expectations." Added this new sentence: Biological information may be useful in distinguishing between different types of impairment. |
| 6-1, paragraph 4, last line. | I suggest it is important here to note that this measures condition and in the end must be interpreted in the context of divergence (or not) from the reference condition or standard. The raw numbers just described in the last sentence have no meaning, are not useful without inclusion of that interpretative context. | No change. The interpretive context for reference condition is provided in the next section. |
| 6-1, last paragraph, first line. | Vague antecedent again. Rephrase to say: "Many challenges remain for insightful definition of impairment thresholds." | Rephrased to say: "Many challenges remain for insightful definition of impairment thresholds." |
| 6-2, first paragraph, line 4. | Not for "all other sites in the region" as stated here but for all other sites of the same ecological class. | Replaced this text: "…expected for all other sites in the region…" with this text: …expected for ecologically similar sites. |
| 6-2, last paragraph, next to last line. | Should it be "meet" instead of "mean" near the end of the line. | Replaced "mean" with "meet" |

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| 6-3, paragraph 2. | I am not enthusiastic about this 25% and 75% approach to thresholds. I suggest the thresholds should be based on explicit biological context rather than an arbitrary statistical percentage. I know, "this train has already left the platform." My prediction is it will be corrected in the future as we are now trying to correct use of diversity indexes. | No change. Point is well taken, but there is little alternative at this point. Use of an explicit biological context is sometimes seen as a problem with circularity, so the reference site approach is still the recommended approach from EPA. Selection of percentiles reflect the confidence in the reference sites representing desirable conditions. |
| 6-3, Figure 6-2. | I am not convinced that the presentation of a sigmoid shaped line is the best presentation. What is the evidence of that shape to the curve? And the words re changes in structure and function are in my view simple wishful thinking without any empirical foundation. Again, this train has already left the station for good or evil. | Added citation after parenthetic reference to Figure 6-2. Change text to: …six categories (Figure 6-2, EPA 2005a) |
| 6-3, box | Reference condition definition. | Replaced: " For biological integrity are areas undisturbed or minimally disturbed by human activity" with:<br><br>Areas that are undisturbed or minimally disturbed by human activity. |
| 6-4, paragraph 1, line 2. | What is the thinking behind the "increasing pollution and human disturbance" language. Is the intent that pollution is things added to water (equals pollutant from CWA)? Or is it meant to convey the larger context as the word pollution is defined in CWA? If the latter, then human disturbance is redundant in the sense that human disturbance is the generator of pollution. I suggest this should be clarified. | Revised to read: increasing human disturbance (e.g., pollution, sediment, loss of habitat and overfishing). |
| 6-4, paragraph 2, line 4. | These two papers were not the first to use the concept of a graphical display of human influence gradient vs. a biological condition gradient. See, for example, figure 3 in Karr and Chu, Restoring Life in Running Waters and Karr Freshwater Biology 1999, p.223 and any number of other papers from that period as well. | No change. These papers and many others have related human influence and biological condition. The BCG is more than this graphic relationship it is also a framework for categories of biological condition across resources types. |
| 6-6, paragraph below 1, 2, 3 list, next to last line. | Should it say "to set" rather than "for set"? | Replaced "for set" with "to set" |
| 6-6, paragraph before heading 6.3. | Are we back to the standard that all (physical, chemical, and biological) must exceed some threshold before we conclude that a water body is not impaired? I thought there was some movement toward a hierarchy here when multiple types of data are available. What about the study we did in WA (see attached) that showed biology impaired but chemical standard not giving an impaired signal? Would we use this to say that the water bodies are not impaired because both chemical and biological are not below established standard levels? This is a problem in my view, although my example is backwards from the text here. | Changed the following for clarification….<br>Add "independent applicability" after "A state following this"….and before "approach would identify"<br><br>The text states that all of the criteria need to be met to consider the waterbody to be attaining its use. This is the most protective approach and is what we refer to as independent applicability. |
| 6-7. | This discussion and the figure provide a solid intro to the importance of sampling design for regional (or other similar) condition assessment. In addition, it illustrates the important components of this with specific discussion of a model approach. | No action. |
| 7-3, paragraph 2 | | Replaced "…provide a reasonable characterization of biological integrity for the region." with:<br><br>"…provide a reasonable characterization of biological condition for the region." |

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| 7-3, third full paragraph, lines 3-4. | The sentence here seems to be missing words, a verb. | Changed to read:<br><br>"..to human influences are rare, although a few studies provide valuable insights to previous, if not historic, condition (Dustan 1977; Dustan and Halas 1987; and Porter and Meier 1992)." |
| 7-3, paragraph 4 | | Replaced: "…which will likely have lower integrity than historic condition" with:<br><br>…which are unlikely to represent the biological integrity typical of historic condition |
| 7-4, Table 7-1. | A bit simplistic and narrow in description of both strengths and weakness but a good first effort. | No real comment to address. Agreed, but this is meant to be a more simple summary. |
| 7-4, last two paragraphs. | These last paragraphs each have important points to make but the connections between them and lessons are not clear to me. I suggest deleting the last short paragraph and move on to the paragraph on the next page. | Page 7-4, last paragraph: deleted in its entirety:<br>The intent of the CWA is to protect and maintain the biological integrity of water resources. If present-day data are used to define reference conditions, a BCG approach should be used to document that they represent conditions already degraded from a natural state. |
| 7-5, paragraph 1, line 5. | Delete "are attaining the goals to" | Deleted "are attaining the goals to" |
| 7-5, paragraph 2, line 1. | Is the intent here to be pollution in the broad CWA sense or the narrow pollutant CWA sense?<br><br>The rest of paragraph 2 is very good with illustration to make a very important point! | No change. |

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| 8-1, paragraph 3, lines 1-2. | The dichotomy here between global climate change and local human disturbance is a bit simplistic and I suggest inadequate. What is the meaning of local? Changes in coastal environments from say damming a river such as the Elwha may alter the pattern of sediment transport to coastal areas that have influences far down the coast as point bars (e.g. Dungeness Spit) affect things for some distance down the coast. Same could be said about over harvest of fish across a region rather than just local. I am sure that many other examples could be cited that are not just local and are not global climate change. What about changes in land use in the Columbia basin far from the sea? It is not local it seems to me for its influence on coastal areas and salmon; it is not global climate change. What does local mean here? Does it mislead the reader as implied in these illustrations and examples?<br><br>The next sentence begins with coastal development. The Columbia River example just mentioned does not include coastal development but with major consequences on the coastal environment. What about the effects of agricultural land management across the Mississippi Basin (e.g., Iowa, Illinois, etc.) and its effect on the lower reaches of the Mississippi delta in Louisiana and in the developing dead zone in the Gulf of Mexico. Although these examples do not directly relate to coral reef situations the principles still apply.<br><br>I suggest broadening the sentence to note that development wherever it is often connects through a chain of effects from areas remote from the location of a coral reef to degrade that coral reef in ways that are not just tied to global climate change. | Page 8-1, paragraph 3 beginning with "A particular challenge…" Replaced first sentence with:<br>A particular challenge is to distinguish local stresses from global and regional stresses.<br><br>Page 8-1, paragraph 4, beginning with "Even…". Replaced paragraph with:<br>Even a single human activity can have multiple effects on a coral reef, and that activity may be anywhere in the watershed. Human activities can affect coral reefs through changes in water quality (increased sediment), habitat structure (construction of docks), flow regime (freshwater releases from upstream dams), food sources (loss of prey from shoreline armoring) and biotic interactions (fishing). The relative risk to coral reef ecosystems associated with different stressors (e.g., toxic chemicals vs. sediment) is not known, but synergistic effects of multiple stressors from across the watershed is likely. |
| 8-1, Figure 8-1 | Add period after "al" in citation in the caption to Figure 8-1. | Deleted citation. Reference is not publically available. (Note: this is now on page 8-2). |
| 8-3, Table. | Might be useful to add changes in flow of freshwater to coastal environments due to land use change. | No change. There has not been sufficient research to document the biological response associated with additional freshwater |
| 9-1, paragraph 1, lines 1-3. | Don't near coastal coral reefs also fall under the jurisdiction of relevant state agencies tasked to implement the CWA at the state level? This text seems to disempower or neglect the role of states. Many of the items noted in Figure 9-1 (page 9-2) involve state action. | Revised the first sentence to read:<br><br>"Coral reef ecosystems not only fall under the states' jurisdictions, but also under the jurisdiction of .... |
| 9-2 and 9-3, Table 9-1. | Isn't this table and some of the associated discussion more or less a direct outtake of a published paper (Fore et al. 2009, Marine Pollution Bulletin). Isn't proper citation of that source appropriate? Wasn't this table drafted but excluded from a manuscript submitted by the same group of authors to Science? The provision of foundation papers and sources in publications give credit where due and guide readers to a broader literature on a subject. | Added to the legend (Fore et al. 2009) |
| 9-4, paragraph 1 | | Replaced: "…identify waters with outstanding biotic integrity" with:<br><br>"…identify waters with outstanding biological condition" |

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| 9-4, paragraph 2, Managing Tourism | | Replaced: "…identify waters of outstanding biological integrity" with:<br><br>…identify waters with outstanding biological condition. |
| 9-8, Para. 1, CWA Section 312 | | Replaced: "…identify locations with outstanding biological integrity" with:<br><br>…identify locations with outstanding biological condition |
| 10-2, second full paragraph. | Also, one doesn't know if factor(s) other than nutrients and pathogens were the culprit causing coral reef decline. Must keep in mind that many times these standard pollutants are much less important than non-pollutant activities of humans. | Page 10-2, paragraph 2 beginning with "The most challenging…" Replaced last sentence in paragraph with :<br>That means that we are not controlling other important stressors unrelated to nutrient and contaminant pollution. |
| 10-2, third paragraph. | Good question and topic sentence to convey this important concept (reporting that empowers people to understand what is happening in terms that they can understand). | No change. |
| 10-4, fourth paragraph. | Here and elsewhere it seems appropriate to give specific examples from freshwater systems how these things have been done. I think of Ohio EPA's effort to evaluate the causes of degradation across landscapes and watersheds. Perhaps there is some EPA prohibition against citing this kind of work too much. | No change. No EPA prohibition, just was trying to be more coral specific at this point in the document. |
| 10-3, first partial paragraph. | I would reiterate the point made earlier that the MEA and others have also noted that appeal to noneconomic thinking and frameworks is also useful because it is also relevant and important to many people. The next paragraph illustrates why this larger context is important and should be made explicit here and elsewhere in this report. | No change. We have made this point throughout the document. |
| | Definitions of attribute. metric, multimetric, and so on are nearly identical to what was originally proposed by Karr and Chu 1999, Table 3, page 47. Many other definitions in this section are nearly identical to those used in other publications by non-EPA people, yet all are cited as if new in EPA, 2009b. Note also that biomass definition cites non-EPA document. The biological integrity definition here was popularized by its use in Karr and Dudley 1981 (Environmental Management), having been developed in a paper by David Frey in The Integrity of Water 1977. | Changed citations for definitions as follows:<br><br>Attribute. (Karr and Chu 1999)<br>Metric (Karr and Chu 1999)<br>Multimetric (Karr and Chu 1999)<br>Biological Integrity (Karr and Dudley 1981) |
| | Ecological integrity definition too comes directly from Karr and Dudley 1981. | Changed citations for definitions as follows:<br><br>Ecological integrity (Karr and Dudley 1999) |

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| | Nonpoint source (NPS) pollution. This definition constrains the word pollution to the CWA definition of pollutant. As such it glosses over, even ignores, the non-pollutant contexts of NPS such as those effects that come from changes in flow regime. The last sentence says that the cumulative impact of nonpoint source pollution is significant. Sadly, this definition and explanation misses the mark in leaving out many of the most important contributors to biological degradation that derive from nonpoint source pollution. It narrows the scope of the concept to nonpoint source pollutants. How can we expect the states and the citizens to frame these issues comprehensively if this kind of federal document doesn't do it? Sorry but this text pushes one of my soapbox buttons. Similar effort should be made in my view to clean up the use of point pollution definitions as well. | Replaced current definition with:<br><br>Any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act. NPS pollution is widespread because it can occur any time activities disturb the land or water. Agriculture, forestry, grazing, septic systems, recreational boating, urban runoff, construction, physical changes to stream channels, and habitat degradation are potential sources of NPS pollution. NPS pollution includes adverse changes to the vegetation, shape, and flow of streams and other aquatic systems.<br>NPS pollution also results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification that can pick up pollutants, and deposit them into rivers, lakes and coastal waters or introduces them into ground water. NPS sources are automobile emissions, road dirt and grit, and runoff from parking lots; runoff and leachate from agricultural fields, barnyards, feedlots, lawns, home gardens and failing on-site wastewater treatment systems; and runoff and leachate from construction, mining and logging operations. Most NPS pollutants fall into six major categories: sediment, nutrients, acid and salts, heavy metals, toxic chemicals and pathogens. The cumulative impact of nonpoint source pollution is significant. |
| | Nutrient management. I suggest that nutrient management is not a BMP but an action employed to alter the delivery of nutrients to a water body. Many different BMPs can be used to accomplish that goal. | Eliminated this definition. Not a concept that is prevalent in the document and it doesn't have a specific technical definition. |
| | Nutrients. Might be useful to mention the importance of both macronutrients and micronutrients to plant growth and reproduction. | No change. |
| | Pollutant. I think the quotation of language from CWA as done here is a good idea. Perhaps it might also be useful to simplify that with language such as "pollutant, then, the addition of anything to water as a result of human actions." Should that be stated here to make the connection clearer and simple as a brief simple English summary to the long quote from CWA. Also, I find it interesting how the CWA explicitly leaves some things out of the pollutant definition such as oil field waste. | No change. This is a pretty straight up definition from the CWA, the section is cited. |
| | Resilience. I am amused by the standard approach to this word with the implication that we want things to be resilient. Isn't a tubificid (sewage sludge worm) assemblage downstream of a poorly operated WWTP a very resilient community? But I don't think we can make a case for wanting that kind of biota because of its resilience. | No change – this is a large focus of the Natural Conservancy's Reef Resilience Program, as well as efforts by the Great Barrier Reef. |
| | Responses. This word seems to come in two contexts in the report. First the responses of humans as defined in this glossary and second the responses of organisms to the presence of a stressor from the actions of humans. But only one is defined here. | Started definition with: The term "response" is used in two contexts in this report: 1) Human actions….. 2) Ecosystem processes …..<br><br>Added a 2nd definition:<br><br>Ecosystem processes occurring due to the effect of some stressor or combination of stressors. |

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| | Risk. I suggest looking at the President's Commission on Risk and other document to find a cleaner definition of risk. I found this a bit convoluted and came away not having a clear view of the perspective this report wants to convey. | Removed this term from the glossary. We never use risk in this sense in the document. We use it in a very general way. This is a more technical definition for risk assessment. |
| | Runoff. But some water that is absorbed into the soil and moves to subsurface levels also will runoff through subsurface flows. This definition needs some clarification. | Removed this term from the glossary. It is not an important concept in the document. |
| | Scale. Recall my comments earlier about inadequacy of the dichotomy of global vs. local. This definition leaves open considerations of regional and other scales, including microscales. | No change to this definition. This is a general definition of different aspects of scale, not meant to capture all magnitudes. |
| | Stakeholder. Going back to an earlier comment above, all citizens of the nation are stakeholders with respect to the protection of their interests in the quality of water resources. | Revised 2nd sentence to read: "All citizens of the nation are stakeholders, including residents of local communities adjacent to coral reefs ....." |
| | State of the environment. Why is biology or "living systems" not included in the initial parenthetical list of environmental compartments? | Removed this term from the glossary. |
| | Stormwater. I like the expanded discussion of stormwater from the 2008 NRC report on the subject better than the one here. It is clearly too long but contains some key concepts and context that are at best ambiguous by the glossary definition here.<br>URBAN STORMWATER MANAGEMENT IN THE UNITED STATES. Committee on Reducing Stormwater Discharge Contributions to Water Pollution, Water Science and Technology Board, Division on Earth and Life Studies, NATIONAL RESEARCH COUNCIL *OF THE NATIONAL ACADEMIES*, THE NATIONAL ACADEMIES PRESS, Washington, D.C. www.nap.edu<br>From that report:<br>BOX 1-1<br>What Is "Stormwater"?<br>"Stormwater" is a term that is used widely in both scientific literature and regulatory documents. It is also used frequently throughout this report. Although all of these usages share much in common, there are important differences that benefit from an explicit discussion.<br>Most broadly, stormwater runoff is the water associated with a rain or snow storm that can be measured in a downstream river, stream, ditch, gutter, or pipe shortly after the precipitation has reached the ground. What constitutes "shortly" depends on the size of the watershed and the efficiency of the drainage system, and a number of techniques exist to precisely separate stormwater runoff from its more languid counterpart, "baseflow." For small and highly urban watersheds, the interval between rainfall and measured stormwater discharges may be only a few minutes. For watersheds of many tens or hundreds of square miles, the lag between these two components of storm response may be hours or even a day.<br>From a regulatory perspective, stormwater must pass through some sort of engineered conveyance, be it a gutter, a pipe, or a concrete canal. If it simply runs over the ground surface, or soaks into the soil and soon reemerges as seeps into a nearby stream, it may be | Replaced definition with:<br><br>Water from rain that flows over the ground surface and is subsequently collected by natural channels or artificial conveyance systems, and also includes water that has infiltrated into the ground but nonetheless reaches a stream channel relatively rapidly and that contributes to the increased stream discharge that commonly accompanies almost any rainfall event in a human-disturbed watershed. |

| Page # | Comment | How Reconciled |
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| | water generated by the storm but it is not regulated stormwater.<br>This report emphasizes the first, more hydrologically oriented definition. However, attention is focused mainly on that component of stormwater that emanates from those parts of a landscape that have been affected in some fashion by human activities ("urban stormwater"). Mostly this includes water that flows over the ground surface and is subsequently collected by natural channels or artificial conveyance systems, but it can also include water that has infiltrated into the ground but nonetheless reaches a stream channel relatively rapidly and that contributes to the increased stream discharge that commonly accompanies almost any rainfall event in a human-disturbed watershed. | |
| | Threshold. Shouldn't it be at either higher or lower levels. Line 3 | No change to this definition. The example for species diversity is most commonly for values below the threshold. |
| | Water pollution. Better to use the definition as provided in the CWA. The one here emphasizes water the fluid or discharge of pollutant rather than the broader context of water resource in the CWA section 502(19). | Replaced this definition with:<br><br>the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water. |
| | Water is used in several of the definitions here that could be construed to be the fluid water rather than the larger context of water bodies or the multiple dimensions of water resources. | No change. |
| A4-1, first question right column. | I suggest replacing "biological expectations" in the last line with something that ties more directly to CWA language. E.g., "biological condition as defined by defined designated uses" | Replaced "biological expectations" in the last line with "biological condition as defined by defined designated uses" |
| A4-1, last question right column. | I have resisted making this point a number of times, but will add it here. Line 3 from bottom states "the biological integrity of resident biota." This is an awkward phrasing that could be cleaned up with the following goal in mind. Distinguish the measurement of biological condition, the goal of biological monitoring, from assessment of whether that condition approximates the endpoint of the biological condition gradient, biological integrity.<br>This sentence might then say something like: "Because biosurveys provide both integrative evaluations of current biological condition and the information needed to determine if that condition diverges from the biological integrity goal, permit writers can make informed decisions on whether to maintain or modify permits." | Replaced last sentence with:<br><br>"Because biosurveys provide both integrative evaluations of current biological condition and the information needed to determine if that condition diverges from the biological integrity goal, permit writers can make informed decisions on whether to maintain or modify permits." |
| A4-2, first question left column | This answer represents a substantial advance in thinking in the last couple decades. I can remember when the party line from EPA was to make biomonitoring/biocriteria a volunteer/citizen program, largely in my experience to marginalize it as a scientific endeavor. I am glad to see that we have come so far since the 1970s. | No action required. |

| Page # | Comment | How Reconciled |
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| A4-2, answer in top right column, line 7. | I suggest inserting a comment before "Alternative forms . . " to convey the following important point. In fact, this larger biological context and diagnostic analysis may even spread the responsibility more broadly than the current focus on point source dischargers. In that way it would be more able to address the most important causes of degradation, rather than all the regulatory attention being given to point dischargers. This is not the correct final language but the point is perhaps worth making to provide a more balanced framework of thinking. It would also serve to help permit holders to understand that they might even be relieved of some regulatory pressure if/when the broader framework of analysis does a better job of identifying causes of degradation. | No change. Q&As were vetted through OW and any major change would require additional OW review. |
| A5-1, paragraph 2, line 3. | ES is not defined. I assume it is ecosystem services, but better to define upon first use here than assume the reader will figure it out. If it is not in fact used again, then get rid of it entirely. | Replaced "ES" with: "ecosystem services" |
| A5-2, paragraph 1, line 9. | Delete "single". Better yet get rid of the vague antecedent with the following: " . . . suggests that no current programs are capable of delivering overall support . . ." | Replaced the last sentence with:<br><br>This situation is not unique to coral reefs. Curran (2009) suggests that there are no programs capable of delivering overall support (including social and economic perspectives) to environmental decision-making. Curran also emphasizes the need for further research on viable decision-support frameworks. |
| A6-1, first paragraph, line 6. | Shift CO2 to the same notation as other appearances in this paragraph. That is, with the subscript 2. | Replaced CO2 with $CO_2$ |
| A7-1, top of right column, box 2. | Here is a place where I think it would be more appropriate to say "outstanding biological condition" rather than "outstanding biological integrity." See note above (A4-1) re this same point. See other places in this same column for this point. | Replaced "outstanding biotic integrity" with:<br><br>"outstanding biological condition" |
| A7-1, right column (mooring buoys) | | Replaced "outstanding biotic integrity" with:<br><br>"outstanding biological condition" |
| A3 - Bibliography | Add after "Karr JR. 1996. | Karr JR. 2006. Seven Foundations of Biological Monitoring and Assessment. Biologia Ambientale 20(2):7-18. |
| A3. Bibliography – Additional references that may be of interest | Add after: "Adler RW. 2003." | Allan JD, Erickson DL, and Fay J. 1997. The influence of catchment land use on stream integrity across multiple spatial scales. Freshwater Biology 37: 149-161.<br>Angermeier PL and Karr JR. 1986. Applying an index of biotic integrity based on stream-fish communities: considerations in sampling and interpretation. North American Journal of Fisheries Management 6:418-427. |
| A3. Bibliography – Additional references that may be of interest | Add after "Andrews JC and Pickard GL." | Australian and New Zealand Environment and Conservation Council (Anzecc). 1992. Australian Water Quality Guidelines for Fresh and Marine Waters: National Water Quality Management Strategy. |

| Page # | Comment | How Reconciled |
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| A3. Bibliography – Additional references that may be of interest | Add after Aronson RB .... | Bailey RC, Kennedy MG, Dervish MZ and Taylor RM. 1998. Biological assessment of freshwater ecosystems using a reference condition approach: comparing predicted and actual benthic invertebrate communities in Yukon streams. Freshwater Biology 39:765-774. |
| A3. Bibliography – Additional references that may be of interest | Add after Barber RT ... | Barbour MT and Yoder CO. 2000. The multimetric approach to bioassessment, as used in the United States of America. Pages 281-292 in J.F. Wright et al. (Editors). Assessing the Biological Quality of Fresh Waters: RIVPACS and Similar Techniques. Freshwater Biological Association, Ambleside, UK. |
| A3. Bibliography – Additional references that may be of interest | Add after Frontani H and Hopkins A | Goldfarb W. 1988. Water Law, second edition. Lewis, Chelsea, Michigan. |
| A3. Bibliography – Additional references that may be of interest | Add after "Government Accountability Office (GAO) | Harig AL and Bain MB. 1998. Defining and restoring biological integrity in wilderness lakes. Ecological Applications 8:71-87.<br>Hawkins CP, Norris RH, Hogue JN and Feminella JW. 2000. Development and evaluation of predictive models for measuring the biological integrity of streams. Ecological Applications 10:1456-1477. |
| A3. Bibliography – Additional references that may be of interest | Add after Hubbard DK | Hughes RM, Larsen DP and Omernik. 1986. Regional reference sites: a method for assessing stream pollution. Environmental Management 10:629-635. |
| A3. Bibliography – Additional references that may be of interest | Add after Karr JR. 1995. | Karr JR and Chu EW. 1997. Biological monitoring: Essential foundation for ecological risk assessment. Human and Ecological Risk Assessment 3: 993-1004.<br>Karr JR and Dudley DN. 1981. Ecological perspective on water quality goals. Environmental Management 5: 55-68. |
| A3. Bibliography – Additional references that may be of interest | Add after Ohio Environmental Council. 2009. | Ohio EPA. 1989. Addendum to biological criteria for the protection of aquatic life: Volume 1. The role of biological data in water quality assessment. Ohio Environmental Protection Agency, Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio. |
| A3. Bibliography – Additional references that may be of interest | Add after Rizzardi KW. 2001. | Rogers WE Jr. 1994. Environmental Law, second edition. West Publishing, St. Paul, Minnesota. |
| A3. Bibliography – Additional references that may be of interest | Add after Shick JM, Lesser MP and Jokiel PL. 1996. | Simon TP (Ed.). 1999. Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Boca Raton, Florida. |

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| A3. Bibliography – Additional references that may be of interest | Add after Wells JW. 1957. | Westra LP, Miller P, Karr JR, Rees WE and Ulanowicz RE. 2000. Ecological integrity and the aims of the global integrity project. Pages 19-41 in D. Pimentel, L. Westra, and R. F. Noss (Editors). Ecological Integrity: Integrating Environment, Conservation, and Health. Island Press, Washington, DC. |
| A3. Bibliography – Additional references that may be of interest | Add after Woolridge SA. 2009. | Yoder CO and Rankin ET. 1998. The role of biological indicators in a state water quality management process. Environmental Monitoring and Assessment 51:61-88. |

(2)
Table 3-1 Relationship of designated use, ecosystem function, biological components and ecosystem services.

| Designated Use | Ecosystem Function | Biological Components | Ecosystem Services |
|---|---|---|---|
| Coral reef communities | Nutrient cycling; herbivory | Rare and colorful fish and invertebrates; abundant herbivores such as urchins and parrotfish | Tourism and Recreation |
| Coral reef communities | Calcification and skeletal growth; photosynthesis and water clarity | Large, abundance scleractinian (stony) corals and crustose coralline algae to bind them | Shoreline Protection |
| Coral reef, seagrass, and mangrove communities | Competition and predation | Taxonomic diversity | Pharmaceuticals |
| Fish spawning, aggregation and nursery areas | Complex trophic structure and food web dynamics | Habitat and food provided by corals, seagrasses, and mangroves | Fisheries |

Updated information in Table 2-1 with:

**Direct use (goods)**

Renewable: Fisheries and pharmaceuticals

Non-renewable: Construction materials (coral blocks and sand), energy (oil and gas), and decorative items (curios and jewelry)

**Indirect use**

Physical: Shoreline protection, land accretion, lagoon formation, beach sand

Biological: Ecosystem Integrity (biodiversity, genetic repository, ecosystem regulation, ecosystem resilience)

Biogeochemical: Nitrogen fixation, $CO_2$ regulation, primary production

**Non-use**

Information: Research, education, pollution record, climate record

Social: Tourism and recreation, aesthetics, artistic inspiration, folklore, tradition, religion

Updated table 7-1 with and bulleted

Table 7-1. Comparison of approaches for defining reference condition (Stoddard et al. 2006).

| | Historical Data | Present-Day Biology | Predictive Methods | Best Professional Judgment |
|---|---|---|---|---|
| Strengths | Uses available data<br>Provides a permanent benchmark<br>Only generate once<br>Compelling vision for stakeholders | Realistic description of current best condition<br>Based on current sampling methods<br>Any assemblages or communities can be | Uses existing data, avoids expensive sampling<br>Results can be extended to areas without data | Perspective and experience of professionals with specific ecological knowledge of the specific region is valuable<br>Could apply expert consensus rules for reference conditions |

| | | | | |
|---|---|---|---|---|
| | Rare or extirpated species can be included | used | | |
| Weaknesses | Data may be limited | Even best available sites have experienced human influence | Inference beyond existing data is risky | May be qualitative description of "ideal" communities |
| | Studies likely were designed for different purposes | Potential for shifting baselines | Can be subjective when data are unavailable | Experts might be biased |
| | Human impacts in historic times were sometimes severe | | | |

Reviewer 3

| Page # | Comment | How Reconciled |
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| | *Does the report accurately convey the potential of the Clean Water Act (CWA) to protect coral reefs?* However, when discussing biological integrity at the beginning of the document, the Biological Condition Gradient (BCG) should have been initially introduced to better describe the concept. In Chapter 6, the report should have provided guidance on how to quantify a minimum level on the BCG that relates to the biological integrity goals described in the CWA (*i.e.*, Category 2 and higher for the ultimate goal, and Category 4 as a minimum for the interim goal). On page 1-15, there is a statement that should be revised as it misinterprets the CWA, which does not actually say that underlying premise of biological integrity is "natural conditions." Rather, the CWA mandates that the designated use (typically viewed as a healthy, well balanced community) be achieved. The consensus opinion of over 42 experts participating in two separate BCG calibration exercises in Florida was that a departure from the natural condition was acceptable as long as ecosystem functions and some reproducing populations of sensitive taxa were maintained (which is a BCG of 4 or higher). | No changes made:<br>1. It is difficult to introduce the BCG earlier in the text and would restructure elements best kept in the current context.<br>2. EPA is not quantifying a minimum level on the BCG to reflect the "protection and propagation goal". It is not appropriate to use the BCG in this manner as many waters would be seriously under protected. EPA supports the reference site approach for determining aquatic life use targets.<br>3. EPA has not made a determination that there is a significant difference between the "biological integrity objective" and the "protection and propagation goal" because of the widespread landscape degradation affecting the nation's waters. What may have been viewed as a biological integrity objective in 1972 could represent the "protection and propagation goal" today.<br>4. EPA has determined that biological integrity is a natural condition and the congressional testimony on the Clean Water Act, as well as the mid-course correction in 1975, support this.<br>5. EPA does not necessarily agree with the interpretation of the reviewer on the use of expert elicitation to establish water quality targets, nor with the ability to define or measure ecosystem function, nor with the view that it is acceptable to have waters with only "some reproducing populations of sensitive taxa". These issues are being reviewed separately by EPA and new guidelines are intended to be published in the next year to clarify EPA's position. What may be suitable or desired by one State may not be appropriate for other states. EPA seeks a reasonable approach to accommodate needs for state flexibility with the requirement to ensure that the nation's waters are protected and restored. |

| Page # | Comment | How Reconciled |
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| | *Are the steps necessary for biocriteria development clearly explained and logical?*<br>Yes, this was accomplished quite eloquently, and I completely agree with the overall steps, approach, and framework presented. However, I think the document should acknowledge an important component of coral Biocriteria, which has not yet been successful in Florida and may be a general constraint for other states as well. This involved our present inability to establish a Human Disturbance Gradient (HDG) for coral communities related to land-based sources of pollution. Although discussion of overarching stressors that may interfere with HDG development, such as the effects of global climate change (more high temperature events), subsequent bleaching events and coral disease susceptibility (from *Vibrio*s, etc.) was provided in Chapter 8, there was no resolution concerning establishment of a practical HDG. Without an acceptable, objective HDG, coral metric selection may be viewed as arbitrary and not scientifically defensible. In my opinion, proper HDG development and metric selection, as well as BCG validation of the final index are the critical components for moving forward with coral Biocriteria in Florida. | Paragraph on Page 4-5 beginning with "Initial.." rewritten as three paragraphs, as follows:<br><br>"Field data have addressed a few of the important questions for biocriteria development in the U.S. Virgin Islands. Recent testing of candidate stony coral indicators found several measurements responded in a consistent and predictable manner to local human activity (Table 4-1). One gradient was selected along the south shore of St. Croix using an industrial ship channel as the center of a zone of human influence (Fisher et al. 2008). Another gradient was selected across the entrance to Charlotte Amalie, the major city of St. Thomas and a hub of cruise ship activity (unpublished). In both studies, a similar set of stony coral indicators showed a significant association with distance from the center of the zone of activity. However, disturbance gradient surveys may not always be as fruitful. For example, in the Florida Keys there is a small watershed and reefs occur relatively far offshore—what watershed influences there may be are likely diluted and more broadly distributed across the reefs. This does not mean that human activity doesn't affect the reefs, only that the disturbance gradient is hard to detect.<br><br>Field surveys in U.S. Virgin Islands also demonstrated the feasibility of the bioassessment protocol and demonstrated that measurement error (differences among divers making measurements) was low enough that differences among stations were statistically significant (Fore et al. 2006c). Although stony corals were examined in these studies, other assemblages could also be tested. Field testing could examine the potential of several assemblages simultaneously.<br><br>It may seem that the process for developing biological indicators is agonizing when answers for declining reef condition are needed quickly. However, biocriteria are legal thresholds and if precision, accuracy, measurement error, statistical design and protocol are not appropriate, carefully measured or documented, the stakeholders will (and should) actively oppose them. It is an iterative process that requires a rigorous approach and high quality, defensible procedures (Jackson et al. 2000; Fore et al. 2006b; Fore et al. 2006c). This should include development of Standard Operating Procedures with appropriate database management and documentation. It might also include intra- and extra-mural method validation/ variability studies and proficiency evaluations.<br><br>Also the first sentence of the next paragraph revised to read: Ultimately, indicators could be combined into a 'multimetric index'. |

| Page # | Comment | How Reconciled |
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| | Another small shortcoming of the document was insufficient attention to Quality Assurance when developing Biocriteria. If a procedure is perceived to be too variable or unreliable due to lack of quantifying the precision and accuracy of the method, stakeholders will actively oppose it. The document should describe the importance of Standard Operating Procedure development, intra- and extra-mural method variability studies, sampler auditing and proficiency evaluation, and proper data base management when developing Biocriteria. | This is covered in the changes above made to Page 4-5. |
| | *Has the appropriate literature been cited?*<br>In general yes, but there were some broad statements, such as the following, that were not well supported by citations: "First and foremost, coral reef ecosystems are declining, threatened by a variety of human activities including polluted runoff from agriculture and land-use practices, over-fishing, ship groundings, coastal development and climate change, as well as with natural stressors such as tropical storms, bleaching and disease that may also be increasing due to human actions". There were a few expansive statements similar to the one quoted that do not appear to be fully supported by results presented in the document or by citations of other scientific literature. For example, no information to definitively demonstrate that "polluted runoff from agriculture and land use practices" was described in the Chapter 4 discussion of quantifying a human disturbance gradient. The examples shown only referred to ship channels and harbors as sources of human disturbance, not the many factors broadly stated in the above quote. | No change. |
| | *Are there publicly available, peer-reviewed papers that have not been included, but that should be?*<br>I did not notice and obvious omissions, but my recommendation would be for the authors to visit the DEP Southeast Florida Coral Reef Initiative website: http://www.dep.state.fl.us/coastal/programs/coral/reports/ and scan the resources for potential additional citations. | Added this reference to p. C-12, Additional Resources.<br>Florida Department of Environmental Protection. Southeast Florida Coral Reef Initiative: Project Reports and Products. http://www.dep.state.fl.us/coastal/programs/coral/reports/ |

Reviewer 4

| Page # | Comment | How Reconciled |
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| Chapter 9 | Should be more open-ended to incorporate new management strategies such as managing for resilience and active propagation and selection<br>Bill says – the problem with this comment is that the section/ chapter is intended to show how biocriteria can aid existing management programs. In a way this is asking us to introduce new management programs. I think the only way to address it without diluting the objective is to add a phrase/ sentence within one of the existing subheadings. I've chosen restoration as the topic for active propagation and selection and marine protected areas for the resilience. | Page 9-4 under the 'Marine Protected Area' heading, last paragraph. In the last sentence, replaced 'connectivity' with 'connectivity and resilience'<br><br>Page 9-6 under the 'Damage Assessment and Restoration' heading. Inserted the following sentence before the words "Development of a BCG…":<br>Some restoration activities now underway include active propagation and selection of stress-resistant colonies (e.g., staghorn coral restoration by The Nature Conservancy www.nature.org). |

Reviewer 5

| Page # | Comment | How Reconciled |
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| Ch 1, Introduction | This is somewhat superficial, lacking in facts and references related to the description of coral reefs, their significance and value. | No change.<br><br>Chapter 1 describes the CWA foundation for coral reef biocriteria and is not intended to characterize coral reefs. The intended audience for this report is aware of what a coral reef is, its significance and value. An extended bibliography is included in Appendix 2. |
| Table 1-1 | Why are the FL Keys and Caribbean omitted? This is where the most significant number of reefs are located vs. the Gulf of Mexico. Similarly Hawaii is probably the least representative of the Pacific reefs as they have low diversity. | This table is illustrative. Information was already published for these two locations. Added an additional clarifying sentence:<br><br>Even greater diversity may be found at other locations. |
| Table 1-1 | The entry for Cnidaria: there is a duplication of anemones in the first column. | Deleted second 'anemone' (leaving only corals, anemones, jellies |
| Table P-2 | As each one of the steps outlined in Table P2 is addressed and its application to coral reef ecosystems identified, the authors should provide linkage back to the step in this table their points address. This will provide some measure of continuity and reference back to the larger picture and actual goal the authors are trying to achieve. | No change.<br><br>Table P-2 is intended to show a general framework, not guide the discussion. |
| Chapter 1 | Overall I think this chapter could be improved by setting out a clear premise that is tightly tied to coral reefs. The chapter comes across more as a jargon that reiterates generalities about water quality standards and associated components and then tries to make a case for a biocriteria program. Because the information is so generalized the case the authors build is weak. I agree that biocriteria for reefs are important but as a scientist I would like to see more substance to the material presented. | No change.<br><br>The CWA was not enacted specifically for coral reefs, so the introductory section on the CWA must be broader in scope. It is repeatedly stated that the purpose of the document is to establish the link with coral reefs, but it is not appropriate in this section. The subject here is CWA. |
| Chapter 2 | The treatment of this topic is very superficial and overly simplified. The authors need to strengthen their argument for why reefs are important and substantiate their points with adequate peer-reviewed references. | No change.<br><br>Seminal and influential citations for coral reef ecosystem services are included. The purpose of this section is to provide a moderate stimulus beyond saving reefs just for the sake of saving them. If there is too much emphasis placed on valuation, many argue that you ignore intrinsic right to exist. |

| Page # | Comment | How Reconciled |
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| Chapter 2 | The lack of references is problematic. Ex. Why use the Federal Register as a reference to describe ecosystem services? | No change.<br><br>Because so many different people have different 'lists' of ecosystems services and opinions on what should be included, we chose to provide the valid description that would most likely support regulatory decisions. The Federal Register announcement is significant because it is the first time that agencies must respond by measuring and valuing ecosystem services. This makes science and research policy relevant. |
| Chapter 2 | There seems to be a general lack of scholarship throughout this document. | No change.<br><br>Scholarship' in the sense of scientific journal articles has not successfully engaged resource managers in the development of coral reef biocriteria. |
| Chapter 3 | This chapter seems to lack a real thesis, and does not really fully answer the question the authors pose. There is no real rationale for their selection of 'what should be protected' and again seems to be more conjecture than substance relevant to their declared audience of 'managers'. | No change.<br><br>Knowing what to protect is critical to establishing designated uses as is clearly stated in this chapter. There is no 'answer' since each jurisdiction must decide independently what is important to protect. |
| Chapter 4 | The authors' treatment of this subject matter is so general and somewhat superficial, that I question the real value of this information to a coral reef resource manager. | No change.<br><br>This is an overview to set the direction for biocriteria. These issues are not well-known or understood to resource managers and the tone and approach are intended to introduce the subject matter and place it in a relatively simple framework. |
| 4-2, Para 2, line 6 | zooplankton is misspelled | Changed spelling in Para 2 line 6 to 'zooplankton' |
| pg 4-3; Para 1 | I disagree that an indicator needs no specific information about the source or type or degree of indicating. I believe going blindly to develop indicators is not a scientifically sound approach. | No change.<br><br>The principal purpose for biocriteria is reporting impairment, not determining cause of impairment. Diagnostic indicators are a separate process, and most definitely should not be developed blindly. |
| Chapter 4 | I would suggest the authors consider another criterion for developing an indicator is the time-scale needed or expected by a manager to be able to detect change, either for detecting impacts or restoration | There are perhaps several other criteria that are considered in different documents that are not elaborated here.<br><br>Added a sentence at end of last paragraph in Sec 4.1 (page 4-4): "Sometimes measurements may not respond within the time scale that is needed or expected by a manager; live coral cover, for example may change too quickly to assess long term trends in reef condition." |
| pg 4-5 – Table 4-1 | the legend is incomplete | No change.<br><br>Table legend is complete. |
| pg 4-5 Table 4-1 | the authors do not address the time scale within which these metrics are able to report. These metrics seem rather gross in nature. Though the authors may have found correlations along a gradient, there is no evidence that these are related to causation. | No change.<br><br>These are not results generated by this report, but rather cited from peer-reviewed literature. There is no evidence that impairment is related to a specific cause, but there is evidence that it is related to human activity. This type of result is critical to establishing human-generated stress, even if the type or intensity of stress is not known. |

| Page # | Comment | How Reconciled |
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| Table 4-2 | I would suggest avoiding the generality of stress genes and proteins. Though not clear in the legend, it seems that these are supposed to represent metrics of injury or damage. The use of stress genes and proteins should be avoided in this context as it is too general and imprecise. Often stress proteins or transcripts are only indicative of a response and do not alone indicate injury or damage. Measure of physiological parameters that indicate a pathology would be more appropriate consideration in the context of damage. | No change.<br><br>These are not results generated by this report but rather cited from peer-reviewed literature. Each of the example indicators identified in the cited reports have advantages and disadvantages, but all are considered by some as indicators for coral reef communities. |
| Chapter 5 | Again the subject matter is treated so superficially for this chapter the real message could be condensed into a page or less. There is a lot of superfluous rhetoric that dilutes the point. | No change.<br><br>There are many examples of coral reef studies where interpretations of data were not appropriate for the sampling design. While perhaps superficial, this section attempts to lay some ground rules. Without specific examples, there is little to change. |
| Figure 5-1 | is incorrect there are two maps of St Croix instead of the upper one being St John as described in the legend. | No change.<br><br>There is reference to St. Johns in the text, but not the legend. |
| Chapter 5 | The information presented seems to be developed around Caribbean reefs, particularly the USVI. Pacific reefs in structure, diversity and density is quite different than the Caribbean. It is well know that survey methods appropriate for the Caribbean are inappropriate for the Pacific, yet the authors do not seem to address these differences. | No changes.<br><br>Many methods used in the Caribbean, particularly those related to colony characteristics, are equally useful in the Pacific and vice-versa. Information presented here is focused on the Caribbean because that is where the data were collected. Detailing differences between Caribbean and Pacific coral reefs is not the topic of this section or report. |
| Chapter 5 | I am not sure how valuable this discussion will be for managers. | No response, no change. |
| Pg 6-2 last sentence of last paragraph: | UAA should be defined and 're' is unclear to its meaning. | Started last sentence, last paragraph on page 6-2 with: "If not, a Use Attainability Analysis (UAA) needs to be conducted…." |
| Pg 6-3, first sentence: | : "In heavily disturbed landscapes," a ',' needs to be placed in the sentence after landscapes. | Inserted "a".<br><br>Also changed 'chose' in first line of page 6-3 to 'choose' |
| Chapter 6 | The entire discussion of biological condition gradient is supposition from the freshwater work and though it may be appropriate for coral reefs, the authors have not provide a reasonable technical argument that it is indeed appropriate. Again this document is frustrating because there seems to be a lack of substance, a lot of generality that I cannot see the value, especially to support the publication of a document this long. It seems as though the authors had some data from the USVI that was not publishable in a peer-reviewed journal and so is being used as an example embedded in an attempt to make an argument that biological criteria are needed for coral reefs. This would be fine if there were sustentative arguments, theory and logic provided in the document along with some concrete guidance for developing the biological criteria, discussion of how to select criteria appropriate for the questions being asked etc. | No change.<br><br>Biological criteria have proved highly successful for protection of freshwater ecosystems. The concepts and regulatory authority are transferable to coral reefs, but not without an understanding of the CWA and some insight on how challenges were met in developing freshwater standards. Biocriteria are one of the few regulatory options available to protect coral reefs (particularly for land-based sources of pollution) and should not be ignored. Previous authors have suggested this approach (Jameson et al. 2001) and others have attempted to develop biocriteria monitoring approaches. The data referred to in this section (presumably) is in the peer-reviewed literature. Substantive arguments, theory and logic to support the need for coral reef biocriteria have been provided in preceding sections. |
| Pg 7-2; line 5. | 'Indicators' should be 'Indicator' | Changed 'indicators' to 'indicator' on line 5, page 7-2 |

| Page # | Comment | How Reconciled |
|---|---|---|
| Chapter 8 | Though again a superficial treatment of the subject, this is one of the better chapters. There are no references or real discussion of the numerous papers by Dr. Glen Suter and his colleagues. Consulting this group could greatly improve this chapter and likely the entire document, particularly Dr. Cormier who has past experience in marine and reef environments. | No response, no change. |
| Table 8-1 | not mentioned in the text. | Added, after first sentence in last Para of page 8-2: "Table 8-1 for examples" |
| Table 8-1 | needs to be qualified as only examples. The responses should be referenced back to their original papers and also given critical evaluation by the authors. As written it gives a very inappropriate message with many major responses overlooked, e.g., there are many more genetic expression alterations than just to heavy metals, in that regard there are specific protein expression profiles indicative of damage related to pollution, for boating and shipping – antifoulants were omitted; for invasive species – algae, one of the major problems in Hawaii was overlooked; tourism – sunscreens; nutrients. | No change.<br><br>This level of detail is not necessary since it is not the purpose of the document to review and analyze existing literature on coral reef stressors. Such an analysis would not help resource managers develop coral reef biocriteria. |
| Page 9-10 | has no page number or footer. | Added footer and page number to page 9-10 |
| Chapter 10 | Style in page numbering has changed from the rest of the document in the footer | Made style of page numbering in Chapter 10 consistent with the rest of the document |
| Chapter 10 | Add a period at the end of paragraph 2. | Added a period at the end of paragraph 2. |
| Appendix A1 | Add: TNC, UAA | Added "TNC" followed by " The Nature Conservancy" and added "UAA" followed by "Use Attainability Analysis" in alphabetical order in Appendix A1. |
| Appendix A2 Glossary | many of these have no reference as to the source of the definition. The addition of references would add more credibility to the entries in the glossary and correct some that are either incomplete or incorrect. | No change. |
| A2, | Acropora cervicornis and Acropora palmata - these are listed as THREATENED status on the ESA. The definition suggests they are ENDANGERED status. | Acropora cervicornis and Acropora palmata. Change definition to: "On May 4, 2006, Staghorn coral was recognized as a threatened species and placed on the Endangered Species List (71 Federal Register 89 2006)." |
| | Contaminant – format of colored font has changed | Contaminant. Changed font format. |
| | Disease – This definition is incomplete and inaccurate. I suggest the authors get an authoritative definition for this word. Disease is not caused by just infectious agents. Disease can occur from nutritional problems, genetic, toxicants etc. | Disease. Changed definition to: "An abnormal condition of an organism that impairs physiological function. Disease may be caused by external factors, such as infectious disease or exposure to toxicants, or by internal dysfunctions that may come from nutritional or genetic abnormalities. Coral bleaching, though not usually caused by an infectious agent, can be considered a disease." |
| | The authors included fauna but not flora. Flora should be added. | Added: "flora. Plant life, especially the plants characteristic of a region, period or special environment." |
| | Health – this definition needs to be better defined. The authors may consider reading David J. Schaeffer's papers on ecosystem health and measuring it. | Health: Replaced existing definition with: "Health is the general condition of a person in all aspects, including physical and mental. The term health is also sometimes used to represent condition of other organisms and even ecosystems, ecosystem health being synonymous with ecosystem integrity. Organism and ecosystem health usually implies a functioning system absent of disease," |

| Page # | Comment | How Reconciled |
|---|---|---|
| | pathogens – The authors should use a medical reference for appropriate definitions. They would discover that pathogens in the strict sense can also be noninfectious agents. | Replaced definition with:<br><br>An agent of disease. A disease producer. The term pathogen most commonly is used to refer to infectious organisms. These include bacteria (such as staph), viruses (such as HIV), and fungi (such as yeast). Less commonly, pathogen refers to a noninfectious agent of disease such as a chemical (MedicineNet.com 2010). |
| | | Added to Bibliography A1:<br><br>MedicineNet.com. 2010. MedTerms. URL: http://www.medterms.com/script/main/art.asp?articlekey=6383 |
| | PLEASE check a chemistry book for the distinction between pH and alkalinity! This is a gross error. | pH: Replaced second sentence of definition with: "It is a measure of the acidity or basicity of a solution." |
| | soft corals – this definition is poor and should at least show some scholarship when selecting these definitions. | Soft corals: Changed definition of soft corals to: "A term often used to describe a group of coral species (octocorals, Alconyonaria) that actually include soft coral, blue coral, sea pens and gorgonians (sea fans and sea whips). Octocorals are generally thick and fleshy and resemble stony corals in polyp size. Because they lack a calcium carbonate skeleton, octocorals move with ocean currents." |
| | stressors – the authors should include 'chemical' in addition to physical and biological factors | Stressors: Replaced stressors definition with: "Physical, chemical and biological factors that adversely affect aquatic organisms (EPA 2009b)." |
| Appendix A3 | did not review | No response, no change |
| Appendix A4 | this was a helpful section and really is the message of this lengthy document. | No response, no change |
| Appendix A5 | not sure this adds much to what was already said earlier in the document | No response, no change |
| Appendix A6 | this reads more like an EPA solicitation. It is not clear what value this adds. | Changed first sentence of last paragraph on page A6-1 to: "Specifically, EPA solicited information on …"<br><br>Changed second sentence of last paragraph to : "EPA also asked for information and views…"<br><br>Changed third sentence of last paragraph to: "Finally, EPA solicited information that could…" |
| Appendix A7 | no comments | No response, no change. |