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Editorial

Heeding a call to action for US coral reefs: The untapped potential of the Clean Water Act

Dramatic declines in both taxonomic diversity and abundances of reef taxa from bacteria to stony corals to sharks provide ample evidence that coral reef ecosystems are at risk globally (Knowlton and Jackson, 2008; Mora, 2008; Sandin et al., 2008). Climate-related factors such as rising temperatures and ocean acidification are frequently cited as primary drivers of those declines (Hoegh-Guldberg et al., 2007; Richardson and Poloczanska, 2008). Although global effects of climate change are potentially catastrophic for reefs, local impacts due to overfishing, physical damage and land-based pollutants (e.g., sediment, sewage) also contribute to reef degradation (Lough, 2008; Peterson et al., 2008; Wooldridge, 2009).

Marine protected areas (MPAs) have been the dominant approach to coral reef protection in recent years. Although biological measures such as density, diversity, and size of organisms indicate better biological condition inside some MPAs (Halpern, 2003), their effectiveness as management tools has come into question due to the small differences observed outside the protective boundary, difficulties associated with enforcement, and the relatively small percentage of reef area that is protected (Kareiva, 2006; Mora, 2008; Sale, 2008).

Creation of MPAs is one of nine actions recommended by Dodge et al. (2008) to reverse the decline of coral reefs, but the other eight cannot be addressed within an MPA framework. Dodge et al.'s call to action echoes an emerging recognition that areas outside of MPAs must also be monitored, protected and restored (Borja et al., 2008).

For US waters, the Clean Water Act (CWA; PL 92-500, 33 U.S.C. 1251 et seq.) is designed specifically for this purpose (Adler, 1995). The CWA provides a mandate to "restore and maintain the physical, chemical, and biological integrity of the Nation's waters", which includes all territorial seas within three miles of land (Secs. 101 and 502). Although often perceived and historically interpreted as a regulatory tool to address end-of-pipe contaminants (Richmond et al., 2007), the actual scope of the CWA provides a regulatory framework that can potentially support most of the actions listed by Dodge et al. (2008). Furthermore, the CWA provides an opportunity to incorporate scientific knowledge into the management of coral reefs and other coastal resources (Keller and Cavallaro, 2008).

1. How does the CWA work?

The Clean Water Act requires states and territories to define goals for each water body by defining or "designating" uses for the water body; examples include protection and propagation of aquatic life, recreation, drinking water, and navigation. After designating uses, states or territories must then define narrative or numeric criteria (thresholds) that protect those uses. These two actions are the essential components of legally adopted water quality standards. Physical, chemical, and biological criteria are used to determine whether a water body supports its designated uses.

A water body that violates narrative or numeric criteria for its designated use(s) is listed as impaired (Sec. 303(d)). States and territories are required to report on the condition of their waters every two years, but simply listing a site as impaired does not solve the problem; they are also mandated to use the best available science to determine the sources of impairment and to use their regulatory authorities to restore impaired waters (Houck, 1999; Karr and Yoder, 2004). Should they fail to do so, the CWA sanctions legal challenges by citizen groups (Keller and Cavallaro, 2008).

Since the 1980s, a growing recognition that chemical criteria alone cannot protect biological resources has prompted national, regional, and local efforts to supplement end-of-pipe chemical assessments with integrative biological assessment (Davis and Simon, 1995; Karr, 1991; Karr and Dudley, 1981). Most states and territories now use local and regional biological assessments of fish, invertebrates, and algae to assess the condition of streams, lakes, and estuaries. These assessments fulfill regulatory and reporting requirements under the CWA (US EPA, 2002).

2. Nine actions to protect coral reefs

We endorse the "bold and urgent steps" outlined by Dodge et al. (2008) and propose that the CWA can be used to advance all nine actions (Fore et al., 2008).

(1) Cut CO_2 emissions.

The appropriate authority for regulation of CO_2 emissions is the Clean Air Act (CAA). Recognition that CO_2 emissions degrade water bodies is more likely to derive from assessments triggered under the CWA. If states and territories identify ocean acidification or increased water temperatures as a source of water body impairment, this finding is reported as required under Sections 303(d) and 305(b) of the CWA. Identification of impairment is the first step toward regulatory action and restoration.

Although the regulation of air and water may be programmatically isolated, both the CAA and CWA were used to control acid rain from power generating plants in North America. Effects of acid rain on surface waters and their biota have been a primary driver be-

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hind legislation to reduce air emissions for several decades. The monitoring and assessment programs for streams and lakes that informed that legislation continue today (Menz and Seip, 2004). Reporting the effects of CO_2 emissions on coral reefs through the formal, legal process of the CWA frames the issue to legislators and citizens in a way that scientific publications cannot.

(2) Eliminate open-access fisheries in coral reef ecosystems and establish and enforce sustainable fisheries regulations; and (3) ban the harvest of coral reef herbivores, including parrotfish.

Although the CWA's broad mandate does not include specific language on regulation of fisheries, it does provide for the "protection and propagation of fish, shellfish, and wildlife" (Sec. 101). This mandate combined with the CWA's broad definition of pollution as "the man-induced alteration of the chemical, physical, biological, and radiological integrity of water" demonstrates its relevance to problems associated with overfishing (Sec. 502). To protect biological resources, criteria are defined from observations of biological condition at minimally disturbed or reference locations. The number or percentage of coral reef herbivores observed at reference sites, for example, could be used to define thresholds for biological criteria. If overfishing of herbivores impairs the coral reef, efforts to modify that source of impairment (e.g., controls on fishing) can be initiated in the same manner as for non-point source pollutants from agriculture or any other human activity.

Precedents for use of the CWA to alter fish quotas or restrict fishing are limited; however, designated uses have been used to protect fisheries. In Washington State, dam construction in the Dosewallips River was blocked by a US Supreme Court decision to support the state's designated use to protect migration, rearing, and spawning of salmonids (Ransel, 1995).

(4) Establish and enforce marine protected areas that include No-Take Areas.

The CWA does not have the authority to establish reserves, but agencies with that responsibility, e.g., the National Park Service, could use a state's biocriteria to define expected levels of biological condition for fish and invertebrates and to determine whether the reserves are protective.

(5) Effectively manage the waters between marine protected areas.

The CWA provides an umbrella of protection that extends beyond MPAs to include the biological resources of all coastal waters within three miles of shore. The CWA requires states to assign designated uses to all water bodies and ensure that water bodies support their designated uses. These regulations provide a potent management tool that can influence management decisions, regulatory actions, and incentive programs (e.g., best management practices, land use allocations, building permits, discharge permits). In this way, the CWA has the potential to integrate management efforts across municipalities, industries, and landscapes.

(6) Maintain connectivity between coral reefs and associated habitats such as mangroves, sea grass beds, and lagoons.

All nearshore environments and aquatic resources are protected by the CWA; but protection requires designated uses that are specific to these environments and their biological components. With these foundations, defensible biocriteria can be defined that will protect the diverse components of the nearshore environmental mosaic.

(7) Report regularly and publicly on the health of local coral reefs.

Reporting the condition for water resources is required under the CWA (Sec. 305(b)). The biennial National Water Quality Inventory report to Congress provides information about the status of water resources, type and location of impaired waters, and sources of impairment for rivers, streams, lakes, bays, and coastal resources (US EPA, 2009a). Although coral reefs were included as a coastal resource in the 2000 report to Congress, they were not mentioned in the most recent reports (2002 and 2004). National reporting on the condition of coral reefs would raise the attention of the public and increase the transparency of coastal and watershed decisions that affect reefs. Congress uses these reports to allocate funding for programs that support the restoration goals of the CWA. For example, Congress has allocated $200 million every year since 1999 to address nonpoint source pollution (US EPA, 2009b).

(8) Recognize the links between what we do on land and how it affects the ocean.

Most sediment and nutrients and a large share of toxic chemicals that affect coral reefs originate on land and are transported to near shore environments by rivers, streams and stormwater systems. Moreover, water withdrawal and other activities that alter the flow of freshwater to coastal environments originate with human land use. The CWA has authority over freshwater and estuarine environments and states and territories are required to monitor and regulate their condition. Biological criteria in nearshore environments can potentially be linked to physical, chemical, and biological criteria in rivers, wetlands and estuaries, providing a direct connection to land-based sources of pollution.

(9) Bring together industry, civil society, local government, and the scientific community to develop a vision of healthy reefs and a plan to get there.

Reporting and public participation are integral to the CWA and specifically required at many steps throughout the regulatory process. A primary goal of the Act is "public participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program" (Sec. 101).

Biological criteria provide the mechanism to translate scientific understanding into legal instruments to protect biota. Ideally, scientists work with managers to determine indicators of biological condition that can reliably measure reef condition, respond predictably to human disturbance, and be monitored for a reasonable cost (McElfish and Varnell, 2006). Examples of indicators that show a measurable response to human influence include the size of stony corals (Fisher et al., 2008), the percentage of algal cover (HRI, 2008), and taxa richness of benthic invertebrates (Nelson et al., 2007). Many other biological indicators show promise in theory (Jameson et al., 2001; Sandin et al., 2008) but need to be empirically validated as they have been for freshwater systems (Fore, 2003; Pont et al., 2009; Simon, 2002).

Criteria for water quality standards and particularly the levels selected to represent impairment are regularly debated as a consequence of legal challenges brought by regulated industries and citizen groups (Rizzardi, 2001). The criteria may be modified or upheld, but water quality standards cannot be ignored: they are required by law (Brill, 2003). The CWA authorizes any citizen to file suit against a governmental agency in violation of water quality standards (Sec. 505; Ohio Environmental Council, 2009). An independent audit by the Government Accountability Office combined with a spate of judicial decisions driven by citizen challenges has reinvigorated state and federal activities to use the CWA to protect water resources (GAO, 1989; Keller and Cavallaro, 2008; NRC, 2001). Recent petitions from the Center for Biological Diversity provide an example of a citizen group challenging government agencies for failure to list their waters for impairment of water quality standards for pH (CBD, 2007; US EPA, 2009c). Although compelling, many of these legal challenges continue to focus on chemical endpoints, rather than the plants and animals that are equally protected under the CWA (Karr and Yoder, 2004).

3. Protecting coral reefs

Protocols to measure biological condition have been vetted through scientific testing, public comment, and legal challenge and have been used to protect and restore streams, lakes, wetlands,

and estuaries in nearly every state and territory (US EPA, 2002). Although widely applied to freshwater and estuarine systems, the CWA has not yet been used to its full potential for protection of coral reefs and other marine environments.

The key to engaging the CWA to protect coastal resources is to formally document what we know about their condition and incorporate that knowledge into the regulatory and reporting process (Bradley et al., 2008). Congress, citizens, and stakeholders cannot act if they do not know. Water quality standards with a biological focus are essential for effective protection of coral reefs. If coastal resources are degraded, they must be reported as impaired and the causes of that impairment determined before they can be restored. The formal legal process defined by the CWA provides a broad foundation to protect and restore coral reefs.

References

Adler, R.W., 1995. Filling the gaps in water quality standards: legal perspectives on biocriteria. In: Davis, W.S., Simon, T.P. (Eds.), Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL, pp. 345–358.

Borja, A., Bricker, S.B., Dauer, D.M., Demetriades, N.T., Ferreira, J.G., Forbes, A.T., Hutchings, P., Jia, X., Kenchington, R., Marques, J.C., Zhu, C., 2008. Overview of integrative tools and methods in assessing ecological integrity in estuarine and coastal systems worldwide. Marine Pollution Bulletin 56, 1519–1537.

Bradley, P., Fisher, W.S., Bell, H., Davis, W.S., Chan, V., LoBue, C., Wiltse, W., 2008. Development and implementation of coral reef biocriteria in US jurisdictions. Environmental Monitoring and Assessment 150, 43–51.

Brill, L., 2003. A bugs life: perspective on biocriteria, its validity under the Clean Water Act, and the implementation of a uniform national program. Capital University Law Review 31, 627–657.

CBD (Center for Biological Diversity), 2007. Petition for Revised pH Water Quality Criteria Under Section 304 of the Clean Water Act, 33 U.S.C. 1314, to Address Ocean Acidification. Before the Environmental Protection Agency. (<www.biologicaldiversity.org/campaigns/ocean_acidification/index.html>).

Davis, W.S., Simon, T.P. (Eds.), 1995. Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. CRC Press, Boca Raton, FL.

Dodge, R.E., Birkeland, C., Hatziolos, M., Kleypas, J., Palumbi, S.R., et al, 2008. Science 322, 189–190.

Fisher, W.S., Fore, L.S., Hutchins, A., Quarles, R.L., Campbell, J.G., LoBue, C., Davis, W.S., 2008. Evaluation of stony coral indicators for coral reef management. Marine Pollution Bulletin 56, 1737–1745.

Fore, L.S., 2003. Developing Biological Indicators: Lessons Learned from Mid-Atlantic Streams. U.S. Environmental Protection Agency, Office of Environmental Information and Mid-Atlantic Integrated Assessment Program, Region 3, Ft. Meade, MD. EPA-903-R-003. (<www.epa.gov/bioindicators/>).

Fore, L.S., Karr, J.R., Fisher, W.S., Davis, W.S., 2008. Making waves with the Clean Water Act. Science 322, 1788.

GAO (Government Accountability Office), 1989. Water Pollution: More EPA Action Needed to Improve the Quality of Heavily Polluted Waters. Government Accountability Office, Washington, DC. GAO-RCED-89-38.

Halpern, B.S., 2003. The impact of marine reserves: do reserves work and does reserve size matter? Ecological Applications 13, S117–S137.

HRI (Healthy Reefs Initiative), 2008. Report Card for the Mesoamerican Reef: An Evaluation of Ecosystem Health. (<www.healthyreefs.org/Report_Card/Report_2008/Report_2008index.html>).

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N., Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., Hatziolos, M.E., 2007. Coral reefs under rapid climate change and ocean acidification. Science 318, 1737–1742.

Houck, O.A., 1999. The Clean Water Act TMDL Program: Law, Policy, and Implementation. Environmental Law Institute, Washington, DC.

Jameson, S.C., Erdmann, M.V., Karr, J.R., Potts, K.W., 2001. Charting a course toward diagnostic monitoring: a continuing review of coral reef attributes and a research strategy for creating coral reef indexes of biological integrity. Bulletin of Marine Science 69, 701–744.

Kareiva, P., 2006. Conservation biology: beyond marine protected areas. Current Biology 16, R533–R535.

Karr, J.R., 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1, 66–84.

Karr, J.R., Dudley, D.R., 1981. Ecological perspective on water quality goals. Environmental Management 5, 55–68.

Karr, J.R., Yoder, C.O., 2004. Biological assessment and criteria improve total maximum daily load decision making. Journal of Environmental Engineering 130, 594–604.

Keller, A.A., Cavallaro, L., 2008. Assessing the US Clean Water Act 303(d) listing process for determining impairment of a waterbody. Journal of Environmental Management 86, 699–711.

Knowlton, N., Jackson, J.B.C., 2008. Shifting baselines, local impacts, and global change on coral reefs. PLoS Biol. 6 (2), e54. doi:10.1371/journal.pbio.0060054.

Lough, J.M., 2008. 10th anniversary review: a changing climate for coral reefs. Journal of Environmental Monitoring 10, 21–29.

McElfish Jr., J.M., Varnell, L.M., 2006. Designing environmental indicator systems for public decisions. Columbia Journal of Environmental Law 31, 45–86.

Menz, F.C., Seip, H.M., 2004. Acid rain in Europe and the United States: an update. Environmental Science and Policy 7, 253–265.

Mora, C., 2008. A clear human footprint in the coral reefs of the Caribbean. Proceedings of the Royal Society B 275, 767–773.

National Research Council (NRC), 2001. Assessing the TMDL approach to water quality management. National Academy Press, Washington, DC.

Nelson, W.G., Brock, R., Lee, II, H., Lamberson, J.O., Cole, F.A., 2007. Condition of Estuaries and Bays of Hawaii for 2002: A Statistical Summary. U.S. Environmental Protection Agency, Washington, DC. EPA-620-R-07-001.

Ohio Environmental Council, 2009. Guide to Clean Water Act Citizen Suits. (<www.theoec.org/WaterWaterQualityLaws.htm>).

Peterson, E.L., Beger, M., Richards, Z.T., 2008. Thinking outside the reef. Science 319, 1759.

Pont, D., Hughes, R.M., Whittier, T.R., Schmutz, S., 2009. A predictive index of biotic integrity model for aquatic-vertebrate assemblages of western US streams. Transactions of the American Fisheries Society 138, 292–305.

Ransel, K.P., 1995. The sleeping giant awakens: PUD No. 1 of Jefferwson County v. Washington Department of Ecology. Environmental Law 25, 255–283.

Richardson, A.J., Poloczanska, E.S., 2008. Under-resourced and under threat. Science 320, 1294–1295.

Richmond, R.H., Rongo, T., Golbuu, Y., Victor, S., Idechong, N., Davis, G., Kostka, W., Neth, L., Hamnett, M., Wolanski, E., 2007. Watersheds and coral reefs: conservation science, policy and implementation. BioScience 57, 598–607.

Rizzardi, K.W., 2001. Alligators and litigators: a recent history of Everglades regulation and litigation. The Florida Bar Journal 75, 18–27.

Sale, P.F., 2008. Management of coral reefs: where we have gone wrong and what we can do about it. Marine Pollution Bulletin 56, 805–809.

Sandin, S.A., Smith, J.E., DeMartini, E.E., Dinsdale, E.A., Donner, S.D., Friedlander, A.M., Konotchick, T., Malay, M., Maragos, J.E., Obura, D., Pantos, O., Paulay, G., Richie, M., Rohwer, R., Schroeder, R.E., Walsh, S., Jackson, J.B.C., Knowlton, N., Sala, E., 2008. Baselines and degradation of coral reefs in the Northern Line Islands. PLoS ONE 3 (2), e1548. doi:10.1371/journal.pone.0001548.

Simon, T.P. (Ed.), 2002. Biological Response Signatures: Indicator Patterns Using Aquatic Communities. CRC Press, Boca Raton, FL.

US EPA (U.S. Environmental Protection Agency), 2002. Summary of Biological Assessment Programs and Biocriteria Development for States, Tribes, Territories, and Interstate Commissions: Streams and Wadeable Rivers. U.S. Environmental Protection Agency, Washington, DC. EPA-822-R-02-048.

US EPA (US Environmental Protection Agency), 2009a. National Water Quality Inventory Report to Congress. Office of Water, Washington, DC. EPA-841-R-08-001. (<www.epa.gov/305b/>).

US EPA (US Environmental Protection Agency), 2009b. Clean Water Act Section 319(h) Grant Funds History. Office of Water, Washington, DC. (<www.epa.gov/owow/nps/319hhistory.html>).

US EPA (U.S. Environmental Protection Agency), 2009c. Ocean acidification and marine pH water quality criteria: notice of data availability. Federal Register 74(71), 17484–17487.

Wooldridge, S.A., 2009. Water quality and coral bleaching thresholds: formalizing the linkage for the inshore reefs of the Great Barrier Reef, Australia. Marine Pollution Bulletin 58, 745–751.

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