Coastal eutrophication research: a new awareness

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Abstract An analysis of the contents and conclusions of the papers contained in this issue (Hydrobiologia Volume xxx) suggests that a new vision is taking shape that may correspond to an emerging new paradigm in the way we understand and manage coastal eutrophication. This new paradigm emphasizes its global dimension and the connections with other global environmental pressures, and re-evaluates the targets of remedial actions and policies. Eutrophication research must evolve toward a more integrative, ecosystem perspective which requires that it be extended to include impacts beyond primary producers and to examine possible cascading effects and feedbacks involving other components of the ecosystem. A quantitative framework that incorporates the interacting top-down and bottom-up effects in eutrophication models must be urgently developed to guide diagnostics and establish targets to mitigate coastal eutrophication. The required macroscopic view must also be extended to the managerial and policy frameworks addressing eutrophication, through the development of policies that examine activities in the environment in an integrative, rather than sectorial, manner. Recent evidence of complex responses of coastal ecosystems to nutrient reduction requires that management targets, and the policies that support them, be reconsidered to recognize the complexities of the responses of coastal ecosystems to reduced nutrient inputs, including non-linear responses and associated thresholds. While a predictive framework for the complex trajectories of coastal ecosystems subject to changes in nutrient inputs is being developed, the assessment of managerial actions should be reconsidered to focus on the consideration of the status achieved as the outcome of nutrient reduction plans against that possibly derived from a ‘do nothing’ scenario. A proper assessment of eutrophication and the efforts to mitigate it also requires that eutrophication be considered as a component of global change, in addressing both its causes and its consequences, and that the feedbacks between other components of global change (e.g., climate change, overfishing, altered biogeochemical cycles, etc.) be explicitly considered in designing eutrophication research and in managing the problem.

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Eutrophication in Coastal Ecosystems: Selected papers from the Second International Symposium on Research and Management of Eutrophication in Coastal Ecosystems, 20–23 June 2006, Nyborg, Denmark

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Introduction

About 15 years have elapsed between the first conference on coastal eutrophication convened in Denmark, in 1993, and the Second International Symposium on Research and Management of Eutrophication in Coastal Ecosystems (Nyborg, Denmark, 20–23 June, 2006), the results of which are collected in this special issue. The symposium addressed a range of topics (Andersen & Conley, 2009) and promoted active discussion among the 200 participants. Whereas the first conference included the definition of ‘eutrophication’ as a noun (Nixon, 1995), the definition now coined by Scott Nixon is that for ‘oligotrophication,’ the antonym of eutrophication (Nixon, 2009). This is symptomatic of the evolution of eutrophication science and the management of eutrophied coastal ecosystems.

In 1993, we were creating an awareness of the spread of eutrophication as a threat to coastal ecosystems, lagging about two decades behind the recognized impacts of eutrophication in lakes. We now have a better appreciation of the scale of problem (e.g., Nixon, 2009), a better understanding of its processes and dynamics (e.g., Cloern, 2001; Boesch, 2002; Howarth & Marino, 2006; Conley et al., 2009; Duarte et al., 2009; Soetaert & Middelburg, 2009), improved diagnostic tools and indicators (e.g., Eyre & Ferguson, 2009; Jaanus et al., 2009), and have taken action to mitigate it (e.g., Nørring & Jørgensen, 2009, Petersen et al., 2009; Savchuk & Wulff, 2009), as clearly exemplified by the papers compiled in this issue. Collectively, these papers portray a major development of the field over the past decade. Although less explicitly, a critical analysis of the contents and conclusions of these papers, along with recent papers published elsewhere, suggests that a new vision is taking shape that may correspond to an emerging new paradigm in the way we understand and manage coastal eutrophication.

In this summary, I will not attempt to list the insights derived from each individual contribution to this special issue, which can best be obtained through an examination of the papers themselves. I will, instead, focus on what these papers collectively inform as the challenge for coastal eutrophication research in the future. I argue that these challenges accrete to conform a new vision of coastal eutrophication that emphasizes its global dimension and connection with other global environmental pressures, and reconsiders the targets for remedial actions and policies.

Challenges for coastal eutrophication research

Eutrophication research has focused mainly on phytoplankton, but clearly eutrophication impacts on all components of coastal ecosystems. The diagnostics of these impacts require that robust indicators be developed that help assess the responses of coastal ecosystems to eutrophication (e.g., Jaanus et al., 2009). The search for reliable ecosystem-level indicators of eutrophication impacts is not driven by an academic interest in better understanding eutrophication, but by the requirements of legislation and policy to identify and abate coastal eutrophication, as exemplified by the EU Water Framework Directive and the OSPAR Convention (e.g., Claussen et al., 2009; Duarte et al., 2009; Henriksen, 2009). Long-lived components of coastal ecosystems sensitive to degraded water quality, such as seagrass, can be particularly useful because their response integrates variability in nutrient concentrations and water quality, offering a robust diagnostic of change (Duarte, 1995, 2002; Olivé et al., 2009). Such an ecosystem approach to understanding and managing eutrophication requires that research be extended to include impacts beyond primary producers and to examine possible cascading effects and feedbacks involving other components of the ecosystem.

The role of changes in the upper levels of the food web in facilitating eutrophication has received limited attention, but research on eutrophied coral reef ecosystems has clearly shown that the integrity of the fish community can greatly affect the resilience and resistance of coral reefs to eutrophication (Dulvy et al., 2004; Mumby et al., 2006). Indeed, a recent meta-analysis of the role of fish removal in the loss of ecosystem resistance to eutrophication has provided compelling evidence that the depletion of top predators from coastal waters may have increased the vulnerability of coastal ecosystems to eutrophication (Heck & Valentine, 2007). Heck & Valentine (2007) showed that the widespread overharvesting of large consumers, which once played pivotal roles in regulating ecosystem structure and function (Jackson et al., 2001), may trigger indirect effects that may enhance those of eutrophication. Indeed, overfishing and eutrophication