July 2015

Costs and Benefits of Fixing Gulf Hypoxia

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Recommended Citation
Available at: http://lib.dr.iastate.edu/iowaagreview/vol14/iss4/4

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Each spring and summer in the Gulf of Mexico, nutrient-rich effluent from the Mississippi and Atchafalaya Rivers stimulates algae growth. The rates of growth are typically so high that when the algae die and decompose, they consume more dissolved oxygen than can be replenished by the ocean. The Gulf hypoxic zone or “dead zone” is created when dissolved oxygen levels become too low to support sea life. The extent of the 2008 hypoxic zone is shown in the chart below.

In a recent article in Science, Robert Diaz and Rutger Rosenberg report that the Gulf of Mexico is just one of 405 hypoxic zones identified around the world. In the 1980s, Diaz counted only 162 such zones. The hypoxic zone that has received the most attention in the United States is in the Chesapeake Bay, where hypoxia was first identified in the 1930s.

The increase in the number of hypoxic zones around the world is a result of increased nitrogen and phosphorus finding its way into rivers and, eventually, oceans. Excess nutrients come primarily from loss of applied nitrogen and phosphorus on farm fields, golf courses and lawns, and nutrient discharges from sewage treatment plants. A 1999 study by the National Oceanic and Atmospheric Administration concluded that only 10 percent of the nutrients that contribute to Gulf hypoxia can be traced to point sources such as sewage treatment plants and industry discharge sites. An updated analysis performed in 2006 and included in a scientific reassessment undertaken by the U.S. Environmental Protection Agency’s Science Advisory Board (Hypoxia in the Northern Gulf of Mexico: An Update, 2007) implicates point sources for about 14 percent of the nitrogen loads and 27 percent of the phosphorous. Even with these updated estimates, nonpoint sources contribute the lion’s share of nutrients, and agriculture is the largest contributor of non-point losses.

Nutrient losses from agriculture occur in a variety of ways. Heavy rainfall events leach soil nitrogen into tile lines that discharge into ditches and streams. Eroded soil that is rich in phosphorus finds its way into rivers and streams. Rainfall can wash surface-applied manure off farm fields. The evidence is overwhelming that extensive Gulf hypoxia would not occur if all farm-applied nutrients stayed on the farm and were used by crops or were stored in wetlands or other natural sinks.

Cost-Benefit Analysis for Environmental Challenges

Weighing the benefits against the costs of alternative decisions is a common-sense guide that helps us run our everyday lives in an efficient manner and provides us with goods and services at the lowest cost. Making decisions without this kind of analysis would waste time, money, effort, and natural resources. This logic has led governments to use cost-benefit analysis to determine whether actions to correct environmental problems should be taken. After all, it would be foolish to correct a difficult-to-fix environmental problem if the benefits of fixing it were small. Targeting scarce resources to those problems in

Notes: Map of bottom water oxygen levels in mg/l (or ppm). The dark blue area outlined in black shows where readings are less than 2, where hypoxia exists.

Bottom dissolved oxygen (mg/L), July 1-27, 2008
which benefits exceed costs by the greatest amount yields the greatest good per unit of effort expended. But a number of unique difficulties arise in using cost-benefit analysis to solve environmental problems.

The first difficulty arises because unlike private decisions in which costs and benefits are both borne by the private decision maker, environmental problems are typically caused by people who do not experience the outcome of their actions. Upstream polluters receive the benefits of low-cost waste disposal, but downstream users suffer the consequences. In the absence of legal obligations, the costs of getting upstream polluters to take actions to reduce their pollution should also be considered in addition to the benefits of water quality improvements to downstream users when comparing the costs and benefits. A political problem often arises after a decision is made to take corrective action, because the party asked to pay the costs of cleanup will naturally try to get some other party to pay.

Perhaps the greatest difficulty arises because of the complexity of accurately measuring benefits of actions to improve environmental quality. Unlike most privately purchased goods and services, environmental goods (such as clean air, clean water, and pleasing landscapes) typically do not have an observable market price associated with them that can be used to determine their value. If an environmental improvement results in an increase in the production of a traded good, then the increase in production is one measure of the benefits. For improvements in other goods, economists have learned how to estimate benefits of, say, clean water in lakes, by observing how much extra people are willing to pay to travel to lakes with clean water relative to similar lakes with degraded water. Similarly, differences in real estate values can often be used to reveal how much people value clean air or vistas. But these approaches can be limited because the benefits of environmental improvements are not limited to just those who actually use them for production or recreation.

Many people who have never traveled to the Everglades still would not want to see this natural area destroyed. Maintaining the Everglades has value to some people either because they want to have the option of visiting there in the future or just because the knowledge that this natural area exists generates value. Estimation of these types of values is quite difficult and prone to large uncertainties, but this does not mean that those values are necessarily small and should not be considered in a cost-benefit comparison.

A review of the benefits and costs of eliminating the hypoxic zone in the Gulf of Mexico shows why, in the absence of strong regulatory requirements, we should expect little action to be taken quickly.

Benefits of Eliminating Gulf Hypoxia

While there is abundant evidence that the size and duration of the Gulf of Mexico hypoxic zone is large and caused by human actions, research to clearly identify the impacts on the ecosystem of the Gulf, including the effects on the size and diversity of fish stocks and the ability of the system to rebound after a long hypoxic event, is still incomplete. Furthermore, understanding thoroughly the benefits of reducing the dead zone to the goal articulated by the EPA requires knowledge about:

- the resulting changes in recreational opportunities and commercial fishing that come about from these changes in fish stocks; and
- how important the preservation of this ecosystem is to current and future residents of the region and the rest of the country.

What evidence is available? A number of recent studies have established links between hypoxic conditions and declines in habitat quality that likely affect the diversity and quantity of life. From a commercial fishing perspective, declines in Brown shrimp populations and catches appear to be directly linked to hypoxic events, with estimates in one study of a loss of up to 25 percent of shrimp habitat on the Louisiana shelf. The commercial fishing industry in the Gulf is one of the most valuable fisheries in the country, with an annual value of over $650 million, and Brown Shrimp is one of the most valuable of those fish stocks. Further, changes in catch rates or population levels of a single species can mask effects on the entire food chain that may not be as easily measured as those directly related to commercially caught fish.

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mean that even larger and longer-term reductions in nutrients would need to be made in order to restore the Gulf to its original functioning.

Concerns about the effects of the dead zone on the living resources of the Gulf are all well and good, but might there be any benefits closer to home from undertaking actions that would improve the conditions in the Gulf? Interestingly, here the evidence is perhaps more compelling that changes would be beneficial. Lakes and streams in Iowa are among the most impaired in the country, and there is significant pressure from the EPA and environmental groups to improve this situation. A number of the agricultural practices that could help address Gulf hypoxia would contribute directly to improvements in local water quality. Other local benefits would also accrue from changes in agricultural landscapes. For example, a major investment in strategically placed wetlands and buffers would likely reduce the risk of flood damage and provide habitat to a number of species that hunters and recreationists enjoy.

Costs of Eliminating Gulf Hypoxia

Because agriculture is the primary source of nutrients that cause Gulf hypoxia, those involved in agriculture would need to take action in any clean-up program. The main sources of lost nutrients are nitrogen losses from leaching and run-off, phosphorus in eroded soil, and animal manure runoff. Focus on control of nutrients in the Upper Midwest are needed for high yields, but nitrogen-laden soils are also susceptible to large losses from unexpected rainfall events. One key to controlling losses is to reduce the time between nitrogen fertilizer applications and rapid plant uptake. Rapid uptake of nitrogen by corn does not occur in most of the Corn Belt until the last two weeks of June. Nitrogen that is applied at or just before corn planting in the first part of May will be subject to losses for four of five weeks. Nitrogen that is applied in the early spring or in the fall is subject to losses for at least an additional six weeks. Applying nitrogen in a side-dressed fashion in the middle of June would reduce losses substantially. However, application costs would increase, as would the risk of yield losses from poor timing of applications. An alternative to controlling soil losses in tiled fields is to route drainage water into constructed wetlands that have the ability to capture and utilize excess nitrogen, thereby cleaning the water before it travels into streams.

What Should We Do?

Definitive research that demonstrates either that the benefits of reducing Gulf hypoxia exceed the costs or that the costs exceed the benefits simply does not exist. And while economists have made great strides in their ability to estimate benefits and costs, such definitive research for a problem as complex as Gulf hypoxia may not be forthcoming. Furthermore, recent high prices for agricultural commodities signal farmers that more fertilizer needs to be applied to crop land, not less. Both the uncertainty about costs and benefits and the current need to maintain high production levels gives advocates of the status quo the upper hand in the Gulf hypoxia debate.

But the evidence seems quite strong that our inability to keep fertilizer nutrients on the farm is doing significant damage to many coastal waters. Over time, as food shortages recede, we may decide to move to a common-sense approach to managing farmland and livestock production. By locating livestock in nutrient-deficient crop locations, by controlling soil erosion to maintain long-term soil health, and by reducing soil nitrogen losses or by treating nitrogen-rich runoff before it enters streams and rivers, we should be able to achieve both healthy coastal waters and profitable farms.

For More Information

To learn more, go to http://www.epa.gov/msbasin.

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