OVERVIEW

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Eutrophication refers to the process by which bodies of water become over-enriched with nutrients such as nitrogen and phosphorus. This occurs when agricultural run-off carrying fertilizers and sewage end up in coastal marine ecosystems through rivers and streams.

Excess nutrients cause simple plant organisms (e.g. algae) to grow in abundance. Once the algae die, large populations of bacteria decompose the algae, depleting the water of oxygen needed to support other marine life.

TOP SOURCES OF NUTRIENT POLLUTION

Top Sources of Nutrient Pollution

Municipal Sewage

Human sewage is the most common source of nutrient pollution, particularly in South America, Asia, and Africa.

Agricultural Fertilizers

Often applied to crops in excess, chemical fertilizers containing nitrogen and phosphorus seep into groundwater or are washed away as runoff.

Livestock Waste

Manure from animal production, which is often used as fertilizer, contributes additional nitrogen and phosphorous.

Stormwater Drainage

Stormwater runoff washes nutrients from residential lawns and impervious surfaces into nearby rivers and streams.

Aquaculture

Direct discharge of excrement, uneaten food, and other organic waste generates concentrated amounts of nitrogen and phosphorous in the waters surrounding fish farms.

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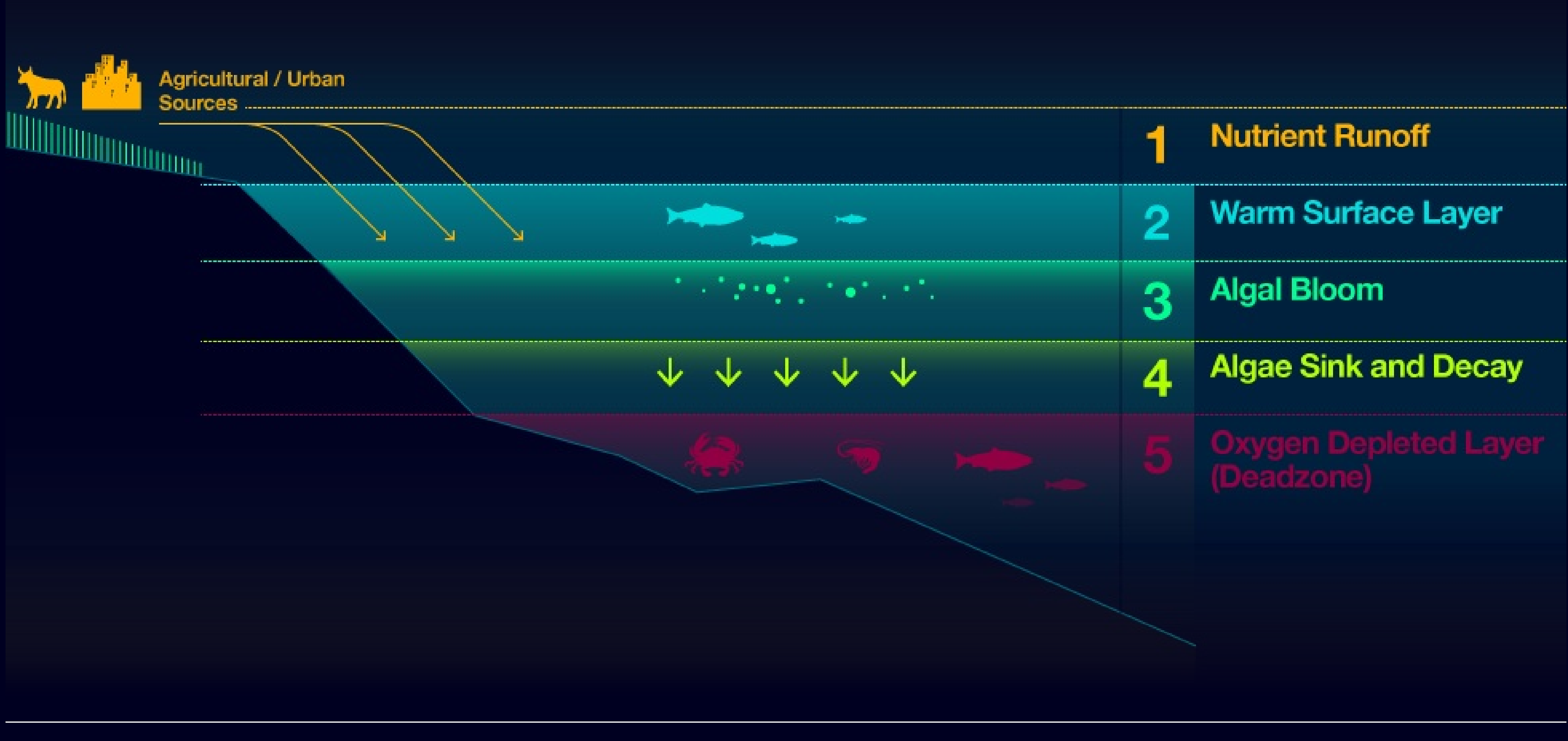
THE EUTROPHICATION PROCESS

The Eutrophication Process



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HOW WAS IT MEASURED?

Eutrophication was measured as country-level fertilizer use and then summed by watershed to estimate the likely amount of this pollution that reached river mouths. The raw data were derived from Halpern et al. (2008), which modeled plumes of land-based nitrogen pollution and produced intensity of pollution at $1km^2$ resolution.

The Clean Water goal is unusual because its four components--Nutrient Pollution, Chemical Pollution, Pathogen Pollution and Trash Pollution--indicate both Status and Pressure. Low levels of those factors produce a high goal score, but high levels produce a low score. For example, perfectly clean water has no nutrient pollution, so Status for this component is expressed as 1 - Nutrient Pollution. Status for the other components is similarly expressed. Input data for calculating Status and Pressure for each component is listed in Table S23 of Halpern et al. (2015). The overall goal score is the geometric mean of the scores for the four components, which are weighted equally.

Use of the geometric mean magnifies the importance of a very bad score for any one of the components, matching public perception that very high levels of a single pollutant would make waters seem ‘too dirty’ to enjoy for recreational or aesthetic purposes.

Nutrient Pollution is a pressure for nearly all of the Ocean Health Index goals. All pressures, including nutrient pollution, have different affects on different goals. For each goal, the affect of each pressure is weighted 'low' (1), 'medium' (2) or 'high' (3). The actual data-derived value of the pressure is then multiplied by the weight assigned to it for that goal. That process is repeated for each pressure-goal combination. The sum of those values divided by 3 (the (the maximum pressure-goal value) expresses the total affect of that pressure on the goal.

Nutrient pollution has high affect (weight = 3) on Tourism & Recreation, Food Provision (Mariculture), Carbon Storage (Seagrass), Coastal Protection (Seagrass), Coastal Livelihoods and Economies (Mariculture and Tourism), Biodiversity (Habitats-Seagrass, Species), and Clean Waters. It has medium effect (weight = 2) on Natural Products (Coral and Seaweed), Carbon Storage (Salt Marshes), Coastal Protection (Corals and Salt Marshes), Biodiversity (Habitats-Salt Marshes, Habitats-Soft Bottom and Habitats-Corals) and Sense of Place (Lasting Special Places). Its effects on other goals are low (weight = 1).

See Raw Data

WHAT ARE THE IMPACTS?

ECOLOGICAL IMPACT

Eutrophication often leads to the formation of dead zones, where the lack of oxygen limits the ability of many marine species to survive. Hypoxic zones in Mobile Bay, Alabama, for example, cause an annual “jubilee” in which bottom-dwelling fish, shrimp and crabs move towards the shore to avoid suffocation.

The incidence of dead zones worldwide has risen dramatically in the last 50 years, from 10 reported cases in 1960 to 405 cases in 2008 (Selman 2009)

While most marine species cannot survive in dead zones, some species thrive. Nomura’s jellyfish, for example, have plagued the Sea of Japan every summer since 2005. With few surviving predators and plenty of plankton for food, the jellyfish overpopulate the waters. They can grow up to 2 meters in width and become numerous enough to clog fishers' nets and compete with commercially valuable fish.

HUMAN HEALTH IMPACT

Between 1970 and 1990, more than 21,000 cases of serious waterborne infections were reported each year because of harmful algal blooms along the coast of the Black Sea (Merla 2008). Exposure through the consumption of contaminated seafood can cause diarrhea, paralysis, memory loss, and other symptoms that can be fatal, or last for years after initial contamination.

ECONOMIC IMPACT

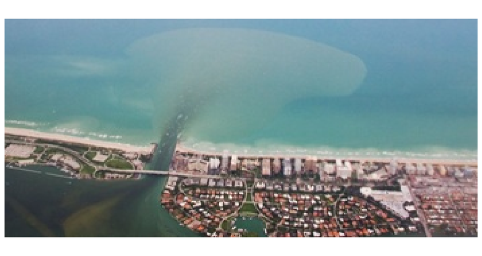
Harmful algal blooms caused by eutrophication can lead to fishery closures, loss of tourism revenue, and high cleanup costs.

In the United States alone, harmful algal blooms are estimated to cost the economy at least US $82 million per year (Hoagland and Scatasta, 2006).

Between 1970 and 1990, an estimated US $2 billion worth of fish catch in the Black Sea was lost because of eutrophication, as well as US $500 million in tourism revenue (Merla 2008).

WHAT HAS BEEN DONE?

In 1986, Denmark implemented a wastewater tax aimed at decreasing nutrient discharge into the Baltic Sea. Nitrogen and phosphorous from agricultural fertilizers were causing eutrophication, resulting in ecologically and economically detrimental dead zones. The goal of the tax was to reduce the amount of nitrogen by 50%, and the amount of phosphorous by 80%. Since 1990, phosphorous concentrations have declined by 22%.



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WORLD RESOURCES INSTITUTE (WRI): WORLDHYPOXIC AND EUTROPHIC COASTAL AREAS

This WRI map identifies 762 eutrophic and hypoxic coastal systems worldwide.

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Overview of Harmful Algal Blooms (HABs). How to prevent and respond to the impacts of harmful algal blooms.

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HYPOXIA: DEAD ZONE

Scientists Jack Barth and Francis Chan of Oregon Sate University conduct hypoxia research along Oregon's coast.

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