COASTAL WATER EUTROPHICATION

Nutrient loads and nuisance phytoplankton blooms in estuaries

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High nutrient concentrations cause phytoplankton blooms in many shallow coastal waters. Recent studies in Manukau Harbour have shown how reduction of a point source of nutrients should help control blooms.

IN EARLY 1993, shellfishing areas in many parts of the New Zealand coast were closed because of contamination with toxins produced by microscopic plant cells called "dinoflagellates". Although this was the first many people had heard of the problem, nuisance "algal blooms" have, in fact, been around for a long time. Indeed, some authorities believe the biblical description of the waters of the Nile "turning to blood" (Exodus 7) was actually the earliest-recorded instance of the type of phytoplankton bloom we call a "red tide" – the aggregation of millions of cells of highly pigmented phytoplankton near the water surface. However, we don't know whether such blooms are occurring more frequently in the modern world than was previously the case.

Some experts have suggested that we are now experiencing a "global epidemic" of blooms of previously unimportant species of phytoplankton, regarding this as yet another symptom of the environmental degradation associated with modern societies. There is certainly evidence that the loads of the important plant nutrients nitrogen (N) and phosphorus (P) to many shallow coastal ecosystems are increasing, and that such nutrient enrichment stimulates the growth of phytoplankton. Should we be concerned about this? Should we be setting limits on nutrient inputs to coastal waters?

The urbanised northeast region of Manukau Harbour where phytoplankton blooms occur each summer in the nutrient-enriched waters. (Photo: Bill Vant)

Blooms and nutrients

In many water bodies, high nutrient concentrations result in rapid phytoplankton growth, producing high densities of plant cells ("biomass"). Marked increases in phytoplankton biomass are called phytoplankton blooms. The photosynthetic plant pigment chlorophyll *a* is widely used as an index of phytoplankton biomass. In "oligotrophic" or nutrient-poor ocean waters, chlorophyll *a* concentrations are generally less than 1 mg/m^3. Concentrations are often considerably higher than this in more "eutrophic" or nutrient-rich coastal waters, with levels in excess of about 10 mg/m^3 being widely regarded as blooms.

Phytoplankton blooms can cause a range of problems for water supplies, aquaculture, ecosystem protection and recreational and aesthetic enjoyment. In estuarine and other coastal waters the most common bloom-related problems include: fish kills; contamination of shellfish with plant products which are toxic to people; oxygen depletion caused by the eventual decay of the high biomass; and the production of surface scums and poor water clarity, which as well as being aesthetically displeasing, can mean there is not enough light for the growth of desirable aquatic plants such as seagrasses.

While the upwelling of nutrient-rich oceanic bottom waters can be important in certain coastal waters, activities on the adjacent land are often the major cause of elevated concentrations of N and P in estuaries and other embayments. Important nutrient sources include large rivers draining intensively farmed catchments, and discharges from municipal sewage wastewater treatment plants.

Many such land-based activities are governed by the Resource Management Act (RMA) 1991. Several of the water quality classes of this Act require that: "There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water". However, apart from the possible use of coastal waters for industrial cooling, there are no national guidelines for the interpretation or application of this standard to blooms of coastal phytoplankton. Local communities are expected to make their own decisions as to what constitutes "undesirable" in their particular water body. Having done so, they can then determine what degree of nutrient enrichment is acceptable, and whether catchment nutrient loads should be reduced.

Unfortunately the ecological understanding on which such assessments should be based is thus far restricted to a small number of coastal water bodies, and there are few robust management models of coastal eutrophication. In most instances managers are obliged to "deal with each case on its merits".

Other controlling factors

In deep, still environments – as found in many lakes, for example – nutrients are often the main factor controlling phytoplankton abundance, and nutrient concentrations provide a sound basis for predicting the size of phytoplankton blooms. However, in many coastal waters a variety of physical and biological factors often moderate the effects of nutrients. Shallow, turbulent estuarine waters are often turbid because of resuspension of bottom sediments, and this can mean that underwater light levels are not high enough to support rapid phytoplankton growth. A further physical limitation can apply if the estuarine waters are rapidly flushed, for example by tidal exchange. In this situation phytoplankton may be washed out of the water body before blooms have time to develop. Grazing can also prevent phytoplankton biomass from accumulating. Zooplankton – tiny animals of various sizes which live suspended in the water – feed on phytoplankton, as do certain shellfish living on the sea-floor; indeed, calculations show