Cleaners of the deep

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Manufactured filtration systems are to thank (or to blame!) for the water clarity in our community and backyard swimming pools. But when the filter's broken, many of us would rather head for the beach.

In coastal shallows we expect to see through the water to the sand surrounding our toes. But what processes are we relying on to keep these waters so clear? Unlike inland swimming pools, oceans aren't serviced by central filtration systems. Much of the task is performed instead by a large range of sea creatures known as filter feeders.

Filter feeders come in all shapes, colours and sizes (microscopic to 0.5 metres long). Mussels, scallops, sea squirts, sponges and barnacles are some of the better-known ones, but they also masquerade under less-familiar names such as bivalves, echinoderms, tunicates, polycheates, bryozoans and hydroids. Some live on the ocean floor (epibenthic), while others attach themselves to plants (epiphytic), to other animals (epifaunal), or simply float in the water.

Filter feeders are vital to the ocean food web as the first step in collecting suspended particles such as phytoplankton, zooplankton, bacteria and detritus (for example, kelp fragments). They do this by pumping water through a biological filter in which all food particles are trapped. Only clean water is pumped out of the animal. This process effectively dilutes the concentration of particles in the water column.

In shallow areas filter feeders can process the equivalent of the water mass above them in a few days, thus they have a significant impact on the nutrient cycling, and consequently the environmental health of coastal waters.

In depths of less than three metres, filter feeders can counteract the effects of eutrophication on coastal seagrass beds. This is because seagrass distribution is largely determined by light availability. When light penetration is blocked by high phytoplankton concentrations (a result of increased nutrient levels), seagrasses are contracted to shallower areas, with those in deeper waters dying due to lack of light. Filter feeders can delay this process by stripping the water column of phytoplankton, thereby improving light penetration.

Eutrophication (or nutrient enrichment) of the coastal environment originates from sources such as fertiliser use in river catchments, nutrient enrichment of groundwater, sewage outfalls, industrial effluents and bilge water release.

Delving deeper

Learning more about the activities of filter feeders for the benefit of coastal managers is the focus of a three-year study led by CSIRO's Dr Sjaak Lemmens. He is based at the Division of Fisheries at Marmion, north of Perth in Western Australia.

Lemmens and his research team (CSIRO staff in collaboration with the WA Department of Environment Protection and students from Edith Cowan, Murdoch and Curtin universities) are studying the filter feeder communities of two marine environments off the Perth coastline. The first is Cockburn Sound, an embayment south of Fremantle that in the past 30 years has lost 80-90% of its seagrass beds, a result of receiving waste from various heavy industries. The second site is the relatively undisturbed Marmion Lagoon.

Surveys carried out during the project's first year (1994) revealed significant differences in the species composition and abundance of filter feeder communities at these locations. Lemmens says this may be partly due to higher phytoplankton densities in Cockburn Sound, but since this relatively sheltered area is quite different from the more exposed Marmion Lagoon, physical processes such as currents, wave action and mixing are likely to have contributed to the differences between the two sites.

At both study sites, however, filter feeder distribution patterns correlated to those of phytoplankton biomass. In Marmion Lagoon the density of filter feeders is significantly higher inshore, a region characterised by consistently higher phytoplankton levels. In seagrass meadows of Cockburn Sound, on the other hand, filter feeder communities are substantially denser at the south-eastern corner, where phytoplankton generally accumulates. These observations – given that phytoplankton levels are an established indicator of eutrophication – raises an interesting question. Could filter feeders be used as bio-indicators of nutrient stress in coastal waters?

Lemmens says that different species of filter feeders are adapted to specific densities of suspended organic matter. This means that the amount of energy they use to filter the water is balanced by the amount of food they gather in the process.

Filter feeders adapted to low food densities have a highly efficient filtering mechanism designed to process large quantities of water. At the other end of the scale, the species adapted to higher food densities have a less-efficient filtering mechanism. They need more food to fuel the extra effort!

When food densities increase due to

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eutrophication, the species best adapted to these conditions will have an advantage. A shift in species composition, as well as an overall rise in filter feeder biomass, is the likely result. Thus filter feeders may well be a valuable indicator of eutrophication.

The potential use of filter feeders as bio-indicators is important because other indicators such as nutrient levels and phytoplankton concentrations often fluctuate considerably in the short-term, requiring lengthy sampling periods to detect changes. Using filter feeders as indicators would take the monitoring procedure deeper down the food chain, one step removed from these fluctuations.

Much remains to be learned about Australia's filter feeders. Lemmens says that although studies in Europe, America and Canada have shown that these communities perform a vital role in coastal processes, their importance in Australia's waters has been largely ignored. 'We have 60-odd species of sponges in WA waters and no-one has a clue about their identity,' he says.

As well as facilitating research on the taxonomy of Australia's lesser-known filter feeders, Lemmens is studying the physiology of species resident in Marmion Lagoon and Cockburn Sound. This will bring him closer to quantifying the rate at which individual species 'turn over' the water (their filtering capacity). One way of testing this capacity is to add algae to an aquarium of filter feeders and monitor its decline over time. When estimating filtering capacity in open waters, external factors – such as temperature and season, habitat type, other filter feeders, the level of mixing in the water column and the behaviour of the water mass – must also be considered.

Quantifying the activities of filter feeders is necessary so they can be accounted for in computer models that simulate the cycling of nutrients in coastal waters. The models are to help understand and manage the ecological effects of increased nutrient and pollutant inputs resulting from human activities (just as air flows and particulates are modelled to simulate pollution in the atmosphere).

An example of this process is the discharge of sewage off the coast of Perth. The Water Authority of WA, at the request of the WA Department of Environment Protection, has conducted a three-year study to determine acceptable levels of nutrient loading to the marine environment. A computer model (COASEC) was developed to simulate the impact of nitrogen enrichment (increased sewage output) on Perth's coastal ecosystems.

The COASEC model has three major components: hydrodynamics, transport and dispersion, and ecological responses. Due to the lack of local data, however, the role of filter feeders initially was excluded as an ecological parameter. When evaluating the model, it became clear that the role of filter feeders was indeed significant and should be included.

Private consultants working on the COASEC model have since gathered data on Perth's filter feeders. One of the consultants, Kinhill Engineers aquatic ecologist Dr Karen Hillman, says because much of Perth's coastline experiences high rates of water movement, the role of filter feeders is probably less significant than in less-dynamic environments such as Melbourne's Port Phillip Bay. A recently-completed study of Port Phillip Bay by the CSIRO Institute of Natural Resources and Environment concluded that filter feeders made up half of the bay's biomass in benthic (bottom-dwelling) animals. These animals are capable of processing the volume of the entire bay approximately twice a month.

More about filter feeders

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