# Microalgae and fisheries production

## Why are microalgae important?

Marine plants, including mangroves, seagrass, samphires, saltcouch and saltmarsh plants, algae and other plants growing adjacent to the tidal zone, are specifically protected under the Queensland *Fisheries Act 1994*. The Department of Primary Industries and Fisheries (DPI&F) recognises that this broad definition includes a diverse group of microalgae found within sediments of fish habitats such as mudflats, sandflats, salt marshes, tidal marshes and estuaries.

Microalgae are extremely important for primary production within intertidal habitats and constitute a major food source for higher trophic levels. A number of activities such as dredging and extractive industries may impact on fish habitats and microalgae populations and the impacts could lead to reduced local and regional fisheries production.

Although algae are included in the definition of marine plants, there are practical difficulties in their identification and estimates of abundance. Where there is readily available evidence of algae, DPI&F will be a concurrence agency and exercise its ability to require an approval for disturbance of these (Couchman and Beumer 2007).

The results of a literature review (undertaken in 2002) on the available information on the importance of microalgae in primary production within intertidal fish habitats is summarised below.

**Fish habitat** is defined in the *Fisheries Act 1994*, "Includes land, waters and plants associated with the life cycle of fish, and includes land and waters not presently occupied by fisheries resources". This definition captures the habitats occupied by microalgae.

## What are microalgae?

"Microalgae are unicellular microscopic algae called phytoplankton ('phyto'= plant; 'planktos'= made to wander). These small plants range in size form 1/1000 of a mm to 2mm floating in the upper 200m of the ocean where sunlight is available for photosynthesis. Phytoplankton species range from primitive blue-green algae (cyanobacteria) to diatoms, dinoflagellates and green flagellates" Hallegraef (1991).

The table below (from Underwood and Chapman, 1995) explains the definition of microalgae:

| ***Phylum*** | ***Class*** | ***Common Name*** | ***Notes*** |
|---|---|---|---|
| **Chysophyte group including:** | | | |
| Chrysophyta | Chrysophyceae | Golden Algae | All microscopic |
| Bacillariophyta | Bacillariophyceae | Diatoms | All microscopic |
| Haptophyta | Haptophyceae | | All microscopic |
| **Other marine microalgae, including:** | | | |
| Dinophyta | Dinophyceae | Dinoflagellates | All microscopic |

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"Microphytobenthos refers to microscopic, photosynthetic eukaryotic algae and cyanobacteria that grow in habitats ranging from wave swept beaches to detritus-laden backwater lagoons." (Macintyre et al, 1996). Intertidal microphytobenthos include motile benthic diatoms (mainly pinnate) that migrate vertically upward to the sediment surface at the beginning of the day and downward at the end of the day (Guarini et al, 2002).

## Where is microalgae found?

Marine microalgae live in many different habitats within the sediment of intertidal areas. These habitats include estuaries, sand flats, muddy shores, saltmarshes and bare soft substrate. Microphytobenthos occupy habitats such as salt marshes, submerged aquatic vegetation beds, intertidal sand and mudflats and subtidal, illuminated sediments (Macintyre et al, 1996).

### Bare soft substrates

The Status of Fisheries Resources Report NSW (1997/1998) defines subtidal, soft substrates as "all areas of unvegetated fine-sediment bottom occurring within estuarine and marine waters below low tide level". Examples of soft substrates include mud, ooze, silt, sand, shell grit and finer gravels.

Common "bare" habitats that can be found within estuaries are mudflats, sand flats and deeper soft substrate areas. They are commonly considered to be unproductive compared to easily visible macro-vegetated habitats such as seagrass beds (NSW Fisheries, 1999). Generally, vegetated habitats support more fish and benthic invertebrates than "bare" substrates, but it is the mosaic of vegetated and "bare" substrates together that provides the complete habitat needs for organisms (Warburton and Blaber, 1992; Laegdsgaard and Johnson, 1995).

### Estuaries

In estuaries microalgae inhabit the few top millimeters of the sediment and live interstitially between the sediment grains so they are able to conduct photosynthesis. (Underwood and Chapman, 1995).

### Muddy shores

Large densities of photosynthetic protists (including diatoms, dinoflagellates and flagellates) cyanobacteria and filamentous green and brown algae live interstitially within the sediment particles. These organisms are very small [0.062mm]. (Underwood and Chapman, 1995).

Microalgae standing stocks can vary from temperate to tropical areas, for example Alongi (1990) reports that mud on temperate shores contain greater standing stocks of microalgae and smaller densities of bacteria. This is caused by cooler temperatures and less turbid waters. Alongi (1998) states that bacteria and microalgae are the most productive groups within tropical and temperate intertidal sediments.

Mud habitats on temperate shores contain greater standing stocks of microalgae and smaller densities of bacteria when compared to those of tropical muddy areas, as a result of the cooler temperatures and less turbid waters (Alongi, 1990). Bacteria are able to multiply and metabolise nutrients faster in warmer climates and tropical mud, therefore have smaller nett rates of primary production (Underwood and Chapman, 1995).

### Sandy Beaches

There are two types of microflora; benthic microalgae (tiny single-celled plants living in or on the bottom) and phytoplankton (small drifting forms), but diatoms dominate both groups.

## Why is microalgae important to primary production?

Algae play an important part in primary production and are a major food source for many organisms. When dividing production and respiration among benthic size groups, bacteria and microalgae are the most productive within tropical and temperate intertidal sediments. On tidal flats benthic macroorganisms receive their nutritional needs by feeding on benthic microalgae and labile organic matter settling out of the overlying water. When the high tide covers the mud flat, filter feeding benthos such as bivalves and polychaetes may consume up to 25% of the phytoplankton production of 82g Cm-2 yr-1. Some remaining phytoplankton carbon is exported by the tide and deposited on the sediment surface (Alongi, 1998).

Macroalgae, benthic microalgae, phytoplankton, epiphytes and neuston may in total contribute more than half of total nett production in some systems. The contribution of different autotrophs to annual net primary production (gCm-2 yr-1) in some saltmarshes and Australian mangrove forest are: marsh/mangrove-2969, microalgae-104, phytoplankton-150, epiphytes & neuston-260 (Alongi, 1998).

A study conducted in Mexico by Coultas and Hsieh (1997), on the ecology and management of tidal marshes, found that one of the main primary producers in this system was microalgae. Consumers included zooplankton, postlarval fish and invertebrates, microbes, meiofauna and larger animals such as shrimps, crabs, fish and birds. Soil microalgae contributed approximately 10% of the total marsh primary production and were a major food source for secondary producers. Benthic and planktonic microalgae form the basis of the food chain for the fish and invertebrate fauna of the Spartina marsh habitats.

Microphytobenthos [benthic] microalgae provide a major energy source to the higher trophic levels in marine littoral ecosystems, especially food webs connected to intertidal mudflats. There is a net increase of microphytobenthos biomass in the top layers of the sediment during daytime exposures due to increased microalgal photosynthesis. Microphytobenthic communities contribute to the intertidal biological and physical processes (Blanchard et al, 2001).

Guarini et al (2002) conducted a study in San Francisco Bay and found that the two key communities that contributed to primary production in tidal estuaries were phytoplankton and microphytobenthos. Motile benthic diatoms (mainly pinnate forms) migrated upward during the day and downward at night. Microphytobenthic primary production occurs during the day on the surface of the intertidal mudflats although primary production is limited by the high turbidity in shallow areas. At the beginning of the day time emersion period the surface of the mud reaches a saturation value, with microphytobenthos production dynamics mostly governed by the biomass specific productivity of benthic microalgae and changes in light exposure.

The study conducted by Brouwer and Stal (2001), on short-term dynamics in microphytobenthos distribution and associated extracellular carbohydrates in surface sediments of an intertidal mudflat, showed that benthic epipelic diatoms were the most important group of primary producers in intertidal mudflats. These diatoms have the ability to produce copious amounts of extracellular polymeric substances (EPS), mainly consisting of carbohydrates. The presence of diatom biofilms increases the stability of the sediment surface, which can have a major affect on the morphodynamics of mudflats. Through the excretion of EPS, diatoms are responsible for the input of high-quality organic carbon into the sediment and this maybe used as a food source for heterotrophic consumers.

## What organisms feed on microalgae?

Nozais et al (2001) states that primary producers such as phytoplankton and the sediment associated microalgal microphytobenthos have crucial ecological functions in providing links between inorganic compounds and organic matter to make these available to higher trophic levels and top predators.

All fauna derive their nutritional requirements (energy and nutrients) from plants. In “bare” substrates microalgae are an important food source for fishes such as juvenile mullet, bream and whiting. Microalgae also support diverse communities of small benthic invertebrates, for example polychaetes, nematode worms, cumaceans, copepods and soldier crabs (Hollaway and Tibbets, 1995). Bacteria and diatoms are common within muddy shores and provide a primary food source for associated larger fauna (Underwood and Chapman, 1995).

In muddy intertidal shores large deposit-feeding gastropods, such as the eastern Australian gastropods, Pyrazus ebeninus and Velacumantus australis, are found in large numbers. These invertebrates consume sediments as they move over the surface of the mud and digest the nutritive material (Underwood and Chapman, 1995).

Previous studies involving grazing experiments have shown that a variety of benthic infauna and epifauna are able to consume large quantities of algal matter, with localized "bare" patches being the result of grazing on the sediment surface. The effects of grazing by large densities of bivalves can inhibit the development of microalgal communities in some marshes (Alongi, 1998).

Microalgae are a major carbon source for higher trophic levels such as benthic macrofaunal communities. They are known to respond to increases in food resources with population increases. When food is limited these macrofaunal communities would also be affected (Stocks and Grassle, 2001).

A study using multiple isotopes has clarified the importance of microalgae, phytoplankton and mangrove material in the diet of penaeid prawns. Juvenile Penaeus merguiensis feed on a mixed diet of benthic microalgae and mangrove detritus in mangrove creeks, while adults offshore feed on phytoplankton and benthic microalgal material with a lower intake of mangrove detritus. The majority of isotope studies have indicated that algae and detritus are equally important food sources for macroconsumers (Alongi, 1998).

A study using stable isotope analysis in Port Curtis Queensland, to investigate the contribution of plants from different estuarine habitats to supporting fisheries species caught over "bare" mudflats, found the plant species most important to fish and crustaceans were seagrass and its associated microalgae, saltmarsh grass and microalgae on the mudflats.

## What links are there between microalgae and fisheries production?

Microalgae provides an important link within the food chain as one of the major primary producers. In some systems macroalgae, benthic microalgae, phytoplankton, epiphytes and neuston may, in total, contribute more than 50% of total nett production (Alongi, 1998). Microalgae support diverse communities of small benthic invertebrates such as polychaetes, nematode worms, cumaceans, copepods and soldier crabs (Hollaway and Tibbets, 1995). Microalgae lives interstitially within the sediment and form part of the local and regional fish production cycle.

## What type of activities could impact on microalgae?

Extractive dredging in the marine environment, impacts on marine plants and local tidal fluctuations influence the movement and distribution of sediments and turbidity plumes throughout the water column. Increased turbidity, caused by dredging will vary the marine environment impacts depending on the prevailing tidal and current regimes.

Potential impacts of dredging activities in coastal areas include; direct smothering of marine habitats such as seagrass, coral and other benthic organisms, reduction of light from increased turbidity resulting in stress and/or mortality of photosynthetic organisms and remobilization of heavy metals and pesticides/herbicides. The removal of shallow intertidal and subtidal fish habitats from dredging cause a disruption to the local food chain, resulting in changes to fish catches.

Other impacts that could affect microalgae are;

- The direct and indirect effects of agricultural and industry practices
- Pollution from point and non point sources (e.g. urban runoff and town sewage)
- Channelisation (to regulate flows and reduce flooding)
- Construction works (e.g. jetties)

DPI&F recognises that impacts from dredging and other extractive industries may cause temporary or long-term changes to microalgae production. DPI&F would have an interest if these long-term impacts caused adverse affects on fisheries production.

## What environmental conditions promote microalgae growth?

Macintyre et al (1996) conducted a study about microphytobenthos and the ecological roles of bare, shallow water marine habitats. As light only penetrates the sediment to a depth of 2-3mm, microphytobenthos could only photosynthesis to this depth. Microphytobenthos live, grow and are consumed in the top few mm of these shallow, bare ecosystems. Phytoplankton and microphytobenthos use light energy to fix CO2 into organic matter. The depth distribution of microphytobenthos depends on the extent of the currents, sediment mixing by waves and the abundance of benthic macrofauna. Microphytobenthos can be limited to the upper few mm of oxygenated sediments, due to the low energy organic rich environment. Microalgae can be found to a depth of 10cm in well-mixed sandy sediments within high-energy environments.

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