The Quandary of Gracilaria

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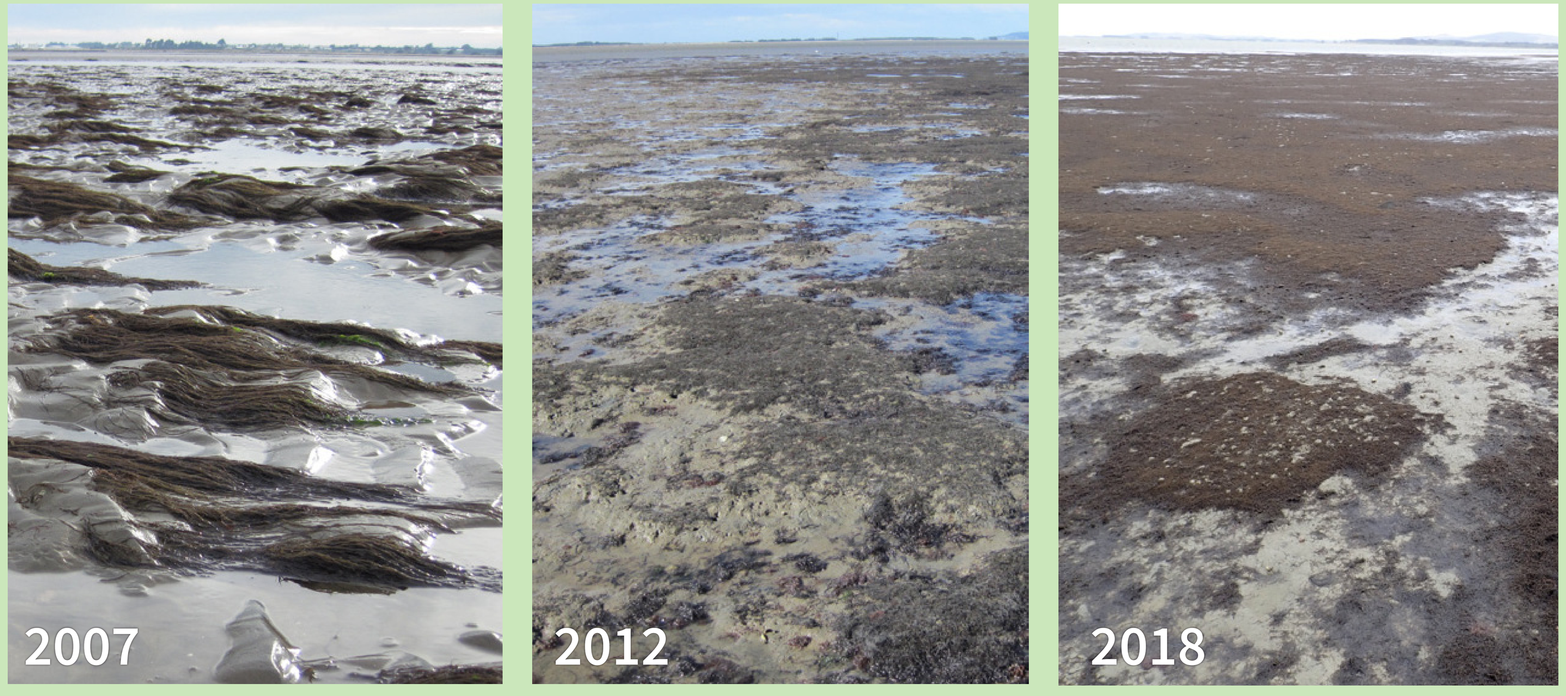
A wide range of habitats are found within healthy estuaries; from sub-tidal reefs, inter-tidal mud flats and sea grass beds to landward margin vegetation, including herb fields, saltmarsh, rush-land and sedge-land. These habitats support a diverse range of life; birds, shellfish, fish, and invertebrates, with many species using estuaries for part, or all of their life cycle. For example, sea grass beds play a critical role as nursery environments for various fish species, providing shelter and food.

Much like kidneys, estuaries perform an important function by filtering and assimilating contaminants from the land and so protect the nearby coastal environment. However estuaries can only cope with so much. The consequences of excess nutrients (eutrophication) and muddiness in particular can appreciably degrade ecosystem health and/or the sustainable provision of goods and services (Ferriera et al. 2011).

Opportunistic macroalgae, like Gracilaria are highly effective at utilising excess nitrogen and are a primary symptom of estuary eutrophication. At nuisance levels they can form mats on the estuary surface, which adversely impact underlying sediments and fauna, other algae, fish, birds, seagrass, and saltmarsh. Decaying macroalgae can also accumulate subtidally and on shorelines causing oxygen depletion, sediment sulphide toxicity, and nuisance odours and conditions. The greater the macroalgal cover, biomass, persistence, and extent of entrainment within sediments, the greater the subsequent impacts.

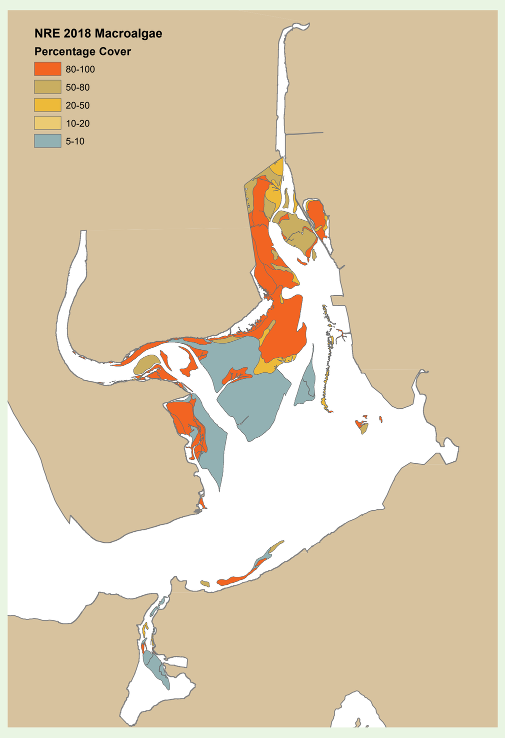
Changes in macroalgal cover at Bushy Point

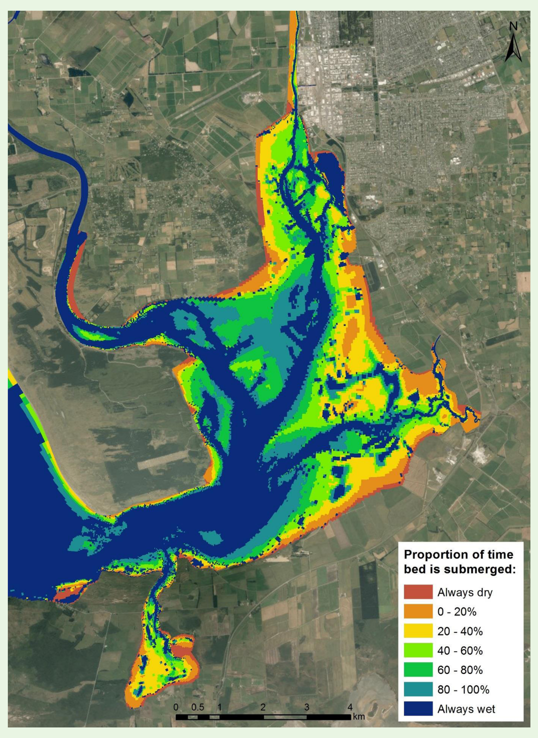


Mobile sands, 10% macroalgal cover, Redox Potential Discontinuity >5cm | Muddy sands, 20–50% macroalgal cover, Redox Potential Discontinuity 3–5cm | Soft muds, 80–100% macroalgal cover, Redox Potential Discontinuity 0–1cm

To grow or not to grow?

Nitrogen (N) inputs are widely recognised as the primary driver for eutrophication in estuaries (Howarth et al. 2000, Boesch 2002, Howarth and Marino 2006). New River Estuary in Southland has experienced very dramatic increases in macroalgae cover (>800%) and soft mud extent (>25%) since 2001. At the same time, high value seagrass has undergone a dramatic decline. Since 2007, Gracilaria has become particularly dominant in the muddy, sheltered, depositional areas of upper estuary tidal flats that are covered by water for only small period of the tidal cycle. Because nutrient water concentrations in the estuary were at saturating levels prior to the large increase in growth recorded in 2007, it is unclear what triggered the excessive nuisance growth. One possible explanation is the utilisation of sediment bound nutrients.





Measures (2016)

Gracilaria

Gracilaria spp. are characterised by a simple thallus with a high surface area to volume ratio, allowing for high rates of nutrient uptake and growth (Pedersen 1994, Pedersen and Borum 1997). This growth form also makes Gracilaria a highly effective sediment trap. It could be possible that eutrophication is exacerbated by excessive Gracilaria growth due to a reinforcing mechanism of sediment accumulation and nutrient supply with N-enriched muddy sediments acting as a slow-release fertilizer, sustaining supplies of N between high river inflow events (Kamer et al. 2004; Sutula et al. 2004) and tidal inundation. Their rapid growth may be further enhanced by their ability to preferentially utilise NH_4^+, which is more prevalent than in NO_3^- in anoxic sediments, although recent NIWA studies found little difference in uptake between NH_4^+ and NO_3^- (John Zeldis, pers. comm. June 2018).

In the New River Estuary, water column nutrient concentrations usually exceed thresholds above which the appearance of eutrophic symptoms are reported. During critical summer growing periods there is more than enough NO_3^- in the water column, and more than enough NH_4^+ in sediment to drive growth.

The quandary

- What's triggers rapidly increasing macroalgal growth under high nutrient conditions?
- Is growth preferentially driven by water column nutrients, sediment nutrients, or both?
- If water column nutrients are reduced, how much macroalgal growth can sediment bound nutrients drive?
- What other factors may control or sustain growth? e.g. light tolerance, resistance to dessication, sediment entrainment.

Next steps

Contextualise the growth conditions by researching saturation concentrations, growth rates, exposure times, the potential legacy effect from sediment nutrients, potential impacts on denitrification and toxicity from anoxic sediments.

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