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C A Coughanowr

THE GREEN ALGAE PROBLEM

Many concerns have been raised about the extensive green algal blooms that proliferate in areas with large numbers of salmon pens - particularly where pens are located in sheltered, poorly flushed coastal waters. These blooms are generally are absent or of minor temporal/spatial extent elsewhere. Recent examples on the Tasman Peninsula include on-going blooms at Long Bay/Port Arthur since 2018, in the vicinity of Tassal's Long Bay lease (14-16 pens). In addition, there have been periodic blooms at White Beach (e.g. Nov 2018, Nov 2019, Sept 2020), which is just around the corner from the Creeses Mistake lease (20 pens) and Badgers Cove lease (8-10 pens). These types of algal blooms have also been observed at a number of areas around the Channel, where fish pens occur in large numbers, and are a major concern to the community there.

Species of concern include filamentous drift algae – particularly green tangleweed (*Chaetomorpha billiardii)*, attached filamentous green algae (e.g. *Enteromorpha spp*) and attached intertidal algae such as sea lettuce (*Ulva spp*). Collectively, I refer to these here as nuisance green macroalgae, to differentiate them from microscopic algal blooms.

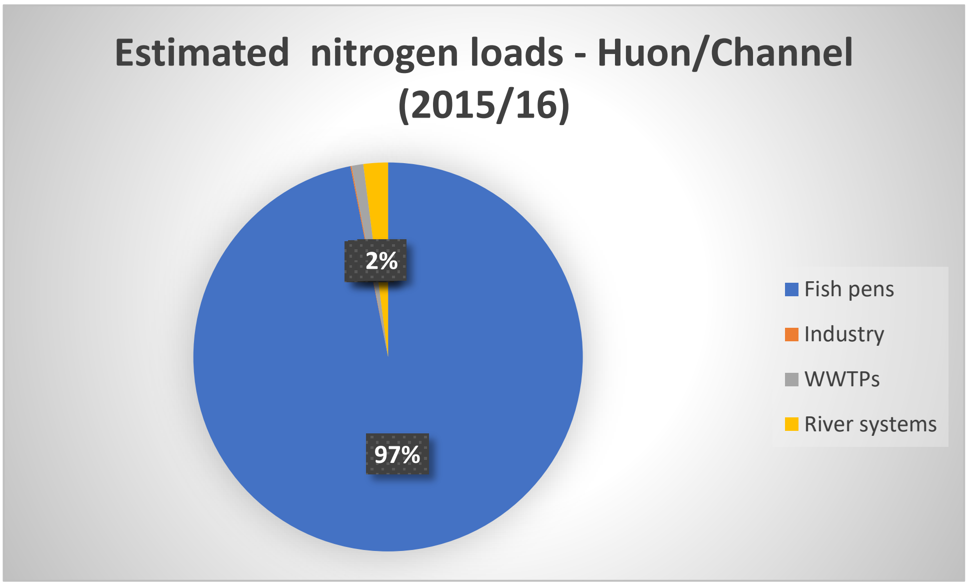
These blooms should come as no surprise. After all, nutrients stimulate plant growth, and green algae has evolved to take advantage of excess nutrients. In fact, filamentous green algae such as *Chaetomorpha* are often used to filter out nutrients from saltwater aquariums[1] because they are so efficient at absorbing bioavailable nitrogen and phosphorus.

Nutrients discharged from aquaculture pens in open waters are likely to be taken up by microscopic algae (phytoplankton), which are more easily dispersed, and are readily monitored and modelled. However, nutrients discharged into sheltered nearshore waters are often taken up by various forms of attached and drifting green macroalgae, as well as by epiphytes (small clinging plants) that grow on seaweeds and on seagrasses. If this mass of algae becomes too prolific, it can smother and shade out other plant life, and when it dies off, this decomposing mass of vegetation can sink to the bottom and draw down oxygen levels leading to the death of crayfish, abalone and other bottom-dwelling organisms. The endangered spotted and red handfish are also at risk, as their preferred habitat and spawning substrates may become fouled by drift algae[2], potentially leading to poor reproductive outcomes. Furthermore, seagrass beds, which are vital nursery habitats for flathead and other fish, may eventually die out, and rocky reef communities can also be damaged. Finally, once there is a critical mass of green nuisance macroalgae, it can become self-sustaining as the nutrients continue to recycle into recurring and persistent blooms.

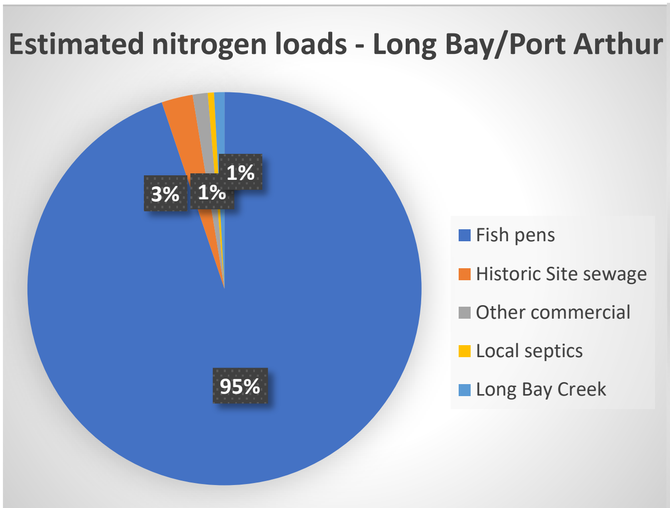
For reasons that are hard to fathom, this issue has not yet been taken seriously in Tasmania. Nuisance green macroalgal blooms are rarely[3] monitored or studied, are not included in nutrient response models, are not included as an environmental impact by regulators, and are not mitigated or otherwise managed. However, proliferation of nuisance algae is a much surer indication of persistent, raised dissolved nutrient level than the transient parameters that are monitored at present. Typical responses to complaints about nuisance include the following:

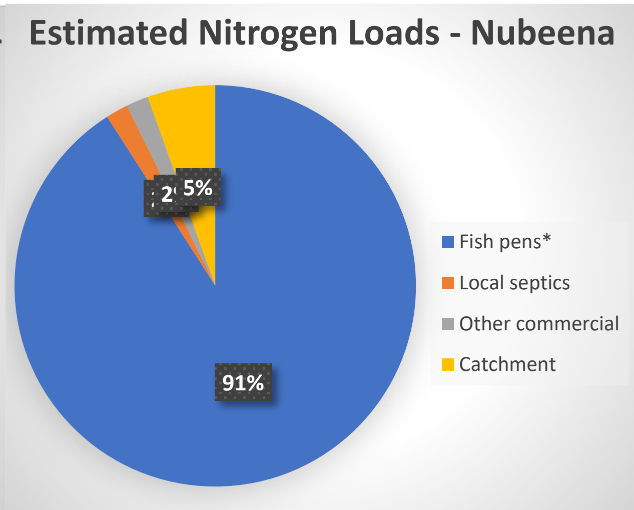
'This is a natural phenomenon'. Well, yes but no. Yes, the types of green macroalgae that proliferate in the vicinity of fish farms do occur naturally at certain times of the year, particularly in late winter/early spring when nutrient levels in southern Tasmanian waters are naturally high and there is increasing sunlight and warmer water temperatures as the days grow longer. But no, they do not grow so profusely nor persist for long periods of time in the absence of a sustained source of nutrients, particularly during summer months. If this response is to be considered valid, some clear documentation of these 'natural' macroalgae blooms should be provided, including the species, extent and duration.

'*There are other sources of nutrients too – you can't necessarily tie it to salmon farming*'. It's actually relatively easy to draw up a nutrient budget and do the maths. Areas with high levels of salmon farming tend to be in regional areas with low populations and relatively low levels of catchment activities that would produce nutrients. Where nutrient inputs have been documented (e.g. Channel/Huon region), bioavailable nutrient inputs from salmon farms clearly predominate, particularly during summer months when background oceanic levels are very low. For example, an IMAS report[3] estimated that over 95% of the bioavailable nitrogen load to the Channel/Huon region was derived from salmon farms, with only 2-3% attributed to rivers and less than 1% to sewage treatment plants. In other areas (e.g. Long/Bay Port Arthur and Nubeena/White Beach) preliminary calculations suggest salmon pens contribute well over 95% of the bioavailable nitrogen load. It is simply not credible to suggest that salmon farms are not a significant contributor to nutrient emissions and to the subsequent algal blooms that are occurring in Tasmania's sheltered coastal waterways



Data sourced from IMAS Report (Bell et al, 2017)





These estimated loads are based on biomass values previously provided by Tassal, effluent criteria in the Port Arthur sewage treatment plant license; typical loading rates associated with septic systems and nutrient generation rates from catchment land use. These are initial estimates and should be further refined.

It is important to note here that nuisance macroalgal blooms also occur as the result of excess nutrient inputs from other sources, and many have been tied to sewage, stormwater or agricultural discharges. In addition, other factors, such as a change in flushing characteristics (e.g. resulting from construction of pens, oyster racks, docks, etc) can also influence algal growth. The key to management is to identify the primary nutrient sources and/or other causes and address these accordingly.

'It's mostly an amenity issue'. Clearly amenity is a major aspect of community concern, and certainly a valid one – visuals, odours and the ability to swim, fish, set pots and nets, and anchor boats are all impacted. However as discussed above, of possibly greater concern is the potential longer-term impacts of critical nearshore habitats and the marine life that depend on these.

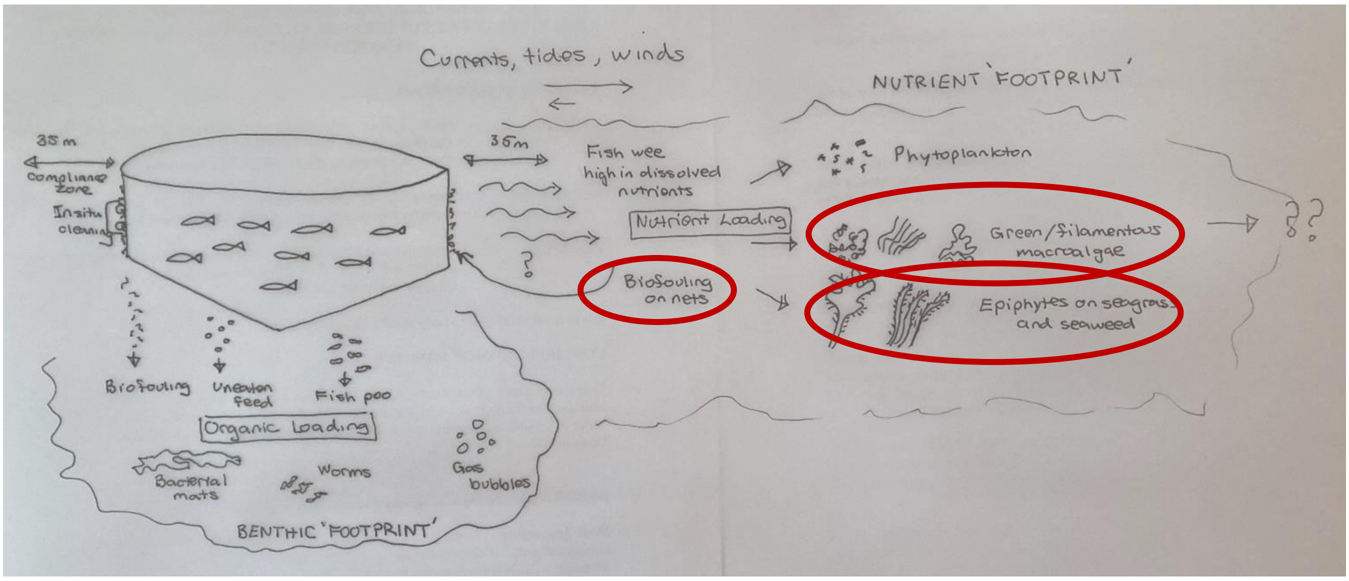
In summary, it's time to take the issue of nuisance algal blooms more seriously. We should start with the assumption that high levels of bioavailable nutrients discharged to sheltered waterways are likely to have a biological response, including nuisance macroalgal blooms. These have been documented all around the world. Why would Tasmania waters respond any differently?

Nuisance macroalgal blooms should be documented and monitored – including the species involved, the extent and duration. Likewise, impacts of sustained blooms on sensitive habitats such as seagrass beds and rocky reefs should be monitored in a rigorous way.

Similarly, the nutrient response models that are used to support the expansion of fish farming should be extended to include growth of nuisance macroalgae. This may require some experimental work to derive the correct algorithms, which is also very much needed.

License conditions set by the EPA should include nuisance algal blooms as one of the biological impacts that should be monitored and managed beyond the 35m compliance zone around leases. At present, only benthic impacts, microscopic algae, nutrient concentrations and dissolved oxygen levels are monitored and regulated. Broadscale water quality monitoring conducted by the industry on a fortnightly or monthly schedule only collects water samples at an instant in time at a small number of locations and depths without reference to tides or currents.

Finally, a mitigation strategy is needed where nuisance algal blooms are already occurring and to prevent future outbreaks. This could include a reduction in the biomass kept in fish pens, removal of drift algae from beaches and/or others approaches.



Conceptual diagram of impacts associated with benthic and dissolved nutrient 'footprints'. Nutrient impacts circled in red are not currently included in monitoring, modelling or regulation

References and relevant research

(1) https://www.aquariumdomain.com/SpeciesProfiles/MarinePlants/ChaetomorphaAlgae.shtml
(2) Wong LSC, Lynch TP, Barrett NS, Wright JT, Green MA, Flynn DJH (2018). Local densities and habitat preference of the critically endangered spotted handfish (*Brachionichthys hirsutus*): Large scale field trial of GPS parameterised underwater visual census and diver attached camera. PLoS ONE 13(8): e0201518. https://doi.org/10.1371/ journal.pone.0201518
(3) Oh ES, Edgar JS, Kirkpatrick JB, Stuart-Smith RD and Barrett, 2015. Broad-scale impacts of salmon farms on temperate macroalgal assemblages on rocky reefs. Marine Pollution Bulletin 98 (1-2)
(4) Bell J, Ross J, Mardones J, Wild-Allen K and C MacLeod, 2017. Huon Estuary/D'Entrecasteaux Channel nutrient enrichment assessment Establishing the potential effects of Huon Aquaculture Company P/L nitrogen inputs. IMAS Report

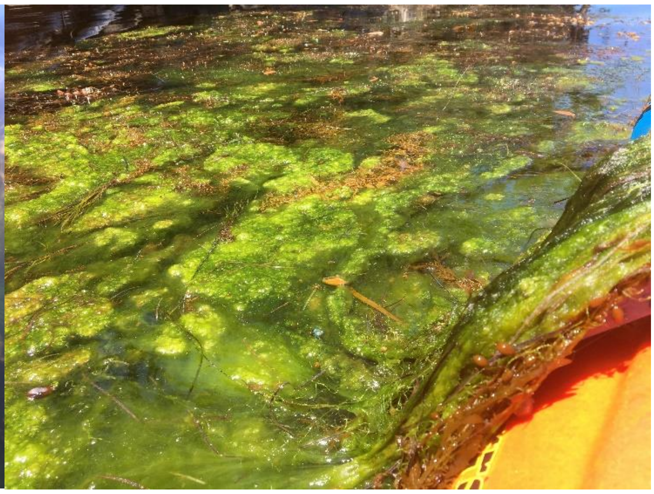
Oh et al (2015)[3] assessed enrichment effects of salmonid farms on Tasmanian reef communities by comparing macroalgal cover at four fixed distances from active fish farm leases across 44 sites. Macroalgal assemblages differed significantly between sites immediately adjacent (100 m) to fish farms and reference sites at 5 km distance, while sites at 400 m and 1 km exhibited intermediate characteristics. Epiphyte cover varied consistently with fish farm impacts in both sheltered and exposed locations. The green algae *Chaetomorpha spp.* predominated near fish farms at swell-exposed sites, whereas filamentous green algae showed elevated densities near sheltered farms.

Several other Tasmania studies have also investigated the impacts of fish farm proximity on temperate reef systems. These include studies by Valentine et al, 2016[5] and Mcleod et al, 2016[6]. In addition, several other investigations are still in progress or being finalised (e.g. FRDC 2015-024), but were not available at this time. Impacts of aquaculture derived nutrients on Tasmanian seagrass beds have not been investigated at all.

For the most part, these studies have not shown a clear relationship between fish farm proximity and fundamental shifts in reef community structure. However, they were not designed to target nutrient accumulation hotspots, where nuisance green algae bloom are likely to occur – or indeed areas where macroalgal blooms have already been documented. Furthermore, some did not include baseline or reference sites[6], and most of the sites investigated by Valentine et al, 2016 were not located in close proximity to salmon leases, taking a more regional approach. The timing of the observations also differed between the various studies, with surveys in Oh et al, 2015 conducted in spring/summer, when nuisance algal blooms tend to occur, while those of Valentine et al, 2016 were done in winter/autumn, when nuisance algae are typically at low levels. Finally, the timing, location and magnitude of nutrient inputs from individual leases is not documented in these studies, nor is the prevailing transport direction. Clearly this is a topic of considerable complexity, and further work is needed to better understand, predict and manage macroalgal blooms associated with aquaculture production in Tasmania.

(5) Valentine J, M Jensen, D Ross, S Riley and S Ibbott (2016). Understanding broad scale impacts of salmonid farming on rocky reef communities. FRDC 2014-042
(6) Macleod C, D Ross, S Hadley, L Henriquez and N Barrett (2016). Clarifying the relationship between salmon farm nutrient loads and changes in macroalgal community structure/distribution. FRDC Project 2011-042

PHOTOS OF ALGAL BLOOMS AT PORT ARTHUR

Long Bay/Port Arthur Dec 2018


Long Bay/Port Arthur Oct 2019


Long Bay/Port Arthur May 2020

PHOTOS OF ALGAL BLOOMS AT WHITE BEACH

White Beach, Nov 2018

White Beach, Nov 2019

White Beach Sept 2020