Reef Digress: Quarantine or *Eggs in One Basket* Aquaculture: arguments for and against

Chris Aslett

From reading hobbyist's grey literature, influential authors appear to suggest that quarantine is a prerequisite for successful "reefing", while environmental "friendliness" demands we minimise the consumption of energy. Given that commercial mariculture would be economically inviable if every life support system had to be duplicated and operated simultaneously to satisfy "just in case", so quarantine is typically less robust with suboptimal conditions which diminishes the recouperation-likelihood of compromised animals, we are faced with unavoidable dichotomy.

Whether you are a hobbyist, retailer, mariculturist, or exporter, the information herein will prove invaluable. An opportunity to have a well-deserved break from the leading-edge science that typically pervades the author's editorials, extensive hands-on commercial and domestic experience best position him to present a straightforward unbiased review of the pros and cons with an aim of arming the reader with the wherewithal to make an informed decision.

Fish-Only versus Reef

Corals and reef-specialised fish are best conserved under markedly different conditions. Corals require ultrapure water with respective nitrate and phosphate of around 0.75 and 0.65 mg l^{-1} (ppm) so their in- and -organic nourishment must be strictly moderated, whereas marine fish effortlessly withstand 90 mg l^{-1} of nitrate and at least 1 ppm of phosphate, so they can eat to their hearts content. Hence reputable outlets construct and operate separate systems for fish and corals with the latter also accommodating significant, albeit nominal, populations of janitorial fish.

Filtration, Maturity, Feeding and Remedies

Science continues to discover that microscopic oxidisers of ammonia do not demand its constant presence (Spieck & Bock 2015; Hovanec, personal communication 2019); however, this does not seem the case for those that oxidise nitrite which appear to decline without its continuous biosynthesis (Aslett 2024). Therefore, quarantine must accommodate at least one ammonia-liberating (ammoniotelic) resident fish. Various species and colour morphs of *Chromis* are small, peaceful, and hardy with rapid metabolisms (header and footer image). A small well-fed shoal of three to five is exceedingly apt for a domestic 30-gallon fish-only quarantine. However, feeding at significant rates in coral systems creates hostile conditions, and backboneless invertebrates are intolerant of fish-curing remedies, especially those that contain copper and chelates, or derivatives like malachite (Lewis et al. 2016), so ideally, we would require both reef and fish-only facilities.

Coral life support must exploit zones in rockwork and substrate that are home to denitrifying microorganisms; however, commercial fish-only systems must withstand shock-loading, as acceptable water quality must prevail in the face of a doubling of inhabitants which are fed several times a day including three times a week to satiation. Exerting this kind of pressure diminishes dissolved oxygen (DO), pH, and oxidation-reduction potential (ORP) to such an extent that it turns microaerobic zones into anaerobic (Nielsen et al. 2010), which can cause their microorganisms to liberate lethal hydrogen sulphide gas (H_2S) which can in extreme circumstances, kill all residents via a life support system "crash". Hence fish-only facilities utilise merely nitrifying filters to the exclusion of denitrifyers and pathogen-nurturing substrate and rockwork (Wilson, personal communication). Fish anxiety is lessened by environmental enrichment in the form of weighted plastic plants, whereas nitrate is capped at 90 mg l^{-1} by a weekly 10 percent water change.

Systems accumulate mildly-reductive photoactive organic acids like carotenoids and phenols manufactured by aggressive "soft" Octocorallia and numerous nitrifying and organic-biomineralizing microbes. However, after accrual attains a toxic threshold in both fish-only and reef systems, they terminate nitrification, attack the central nervous systems (CNSs) of fish (Wilson, personal communication) and prevent the penetration of beneficial ultraviolet A (UVA) and some UVB (Riddle 2014). These pollutants colour the water yellowish brown which is appraised by marking a thick yellow line on white paper and holding it at the end of an aquarium whilst viewing down its length, where water laden with phenols precludes perception of the yellow line.

Two remedial approaches are used to purge or oxidise phenols to less harmful products: *a*) *reef grade* granular activated carbon (GAC) is fluidised following prewashing in copious amounts of reverse osmosis (R/O) water, or water is forced through it for merely 48 hours after which it is discarded, or *b*) an hour of the lowest setting on the smallest ozoniser is applied to oxidise heavily reduced dull and grey water in fish-only systems where the frequency of fish respiration is elevated. Ozone and phenols are potentially lethal

Keywords: centralised recirculating life support system, granular activated carbon, harmful algal blooms, phenols, quarantine, volume and immunity, volume and stress.

so be sure to consult Aslett 2025(a) freely-available at: https://reefranch.co.uk/reef-research-and-aquarium-advice/

Volume and Centralised versus Separate Facilities and their Impact on Livestock Health

Water quality aside, fish are more difficult to care for than corals, insofar as their senses are inextricably linked to their central nervous and endocrine systems which makes them hypersensitive to their immediate surroundings. Stress saturates their blood with corticosteroids from their adrenal cortex which causes immunosuppression (Tomasso 1994) which conceivably leaks from the gill into their environment which may affect non-stressed fish sharing the same water. Apart from the inescapable certainty that animals must be physically accommodated and have room to swim in holding aquaria, numerous typically unconsidered factors are influenced by volume.

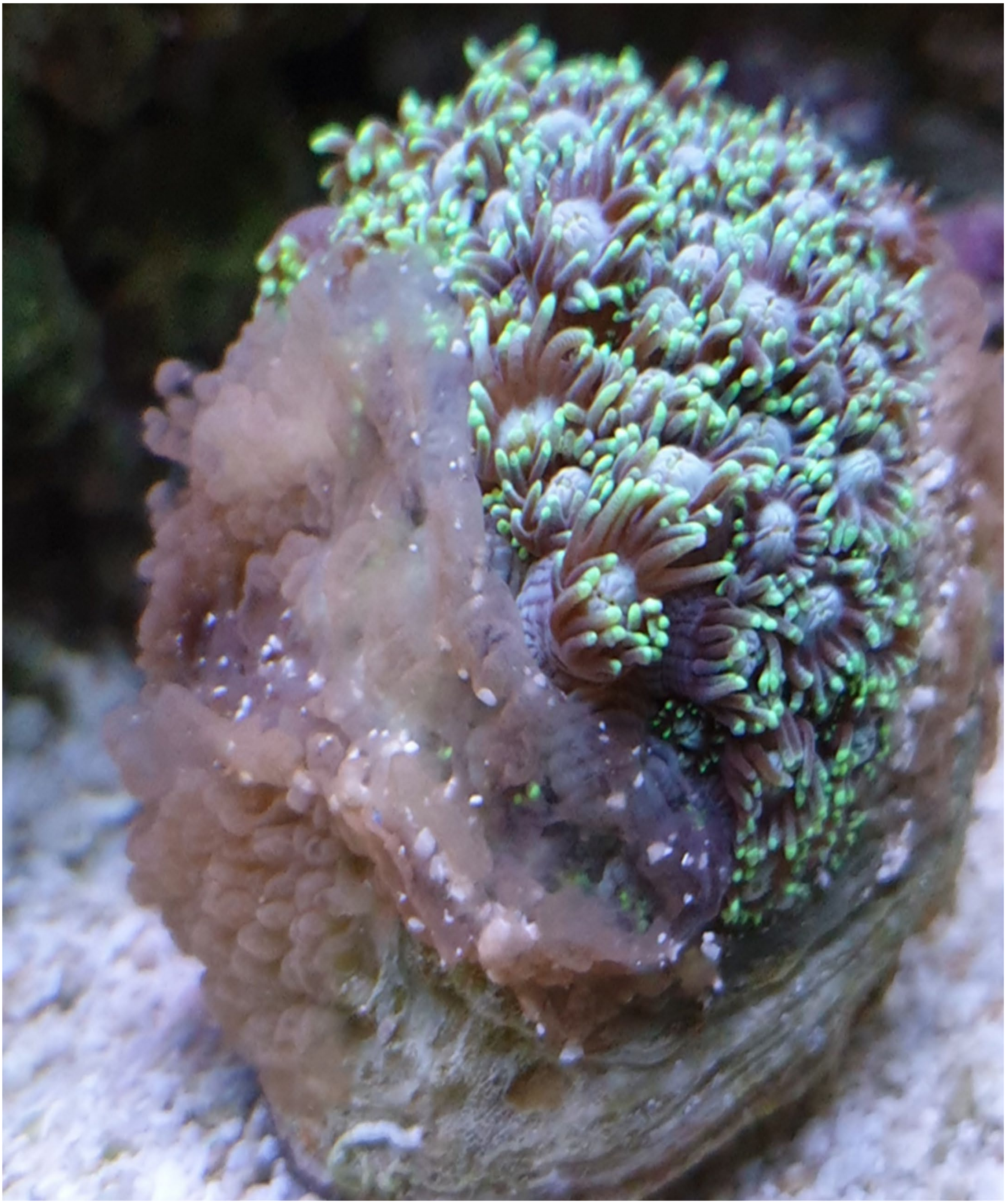


Fig. 1. A colony of *Goniopora stokesi* with brown jelly syndrome. Image courtesy of Liam Furlong ©, Staffordshire, UK.

System capacity has a marked effect on fish behaviour which is not simply limited to saltwater fish. For instance, red bellied piranha (*Pygocentrus nattereri*) of the family Serrasalmidae can be reared in sibling groups in small aquaria until one day they begin to voraciously eat one another until merely one satiated fish remains. However, well-fed adults will shoal passively with community fish in volumes of 500 gallons or more (Schleser 1997). The author has setup expansive systems in which the simultaneous release of numerous kinds of fish elicits the formation of protective snake-like shoals until they can hide and / or appraise the dangers that lurk in their new surroundings.

The fish at the Reef Ranch^{TM} appeared to perceive the entire volume of the centralised system as the holding aquaria were comparatively small which lessens capture anxiety, while their water was filtered 10 times per hour. Fish were confident and pugnacious possibly because the holding aquaria were merely a quarter of the entire volume of the system where the fish-free sump was home to several hundred gallons.

Ideal husbandry mimics the vitality-sustaining natural conditions in which animals have evolved and to which they are thus suited. Oceanic volumes tend to “iron out” change and dilute pollutants. Given that fish appear to sense volume, most oceanic environs are exceedingly stable, their immunity is responsible for keeping them “fighting fit”, wavering conditions cause immunosuppression long after the stressor has ceased (Odio et al. 1986; Barton 2002), and commercial fish systems will never be analogous to aquaria, larger volumes remain key for innate fish defence and vigour.

Fig. 2. *Acropora* with rapid tissue necrosis (RTN).

Therefore, saltwater fish housed in comparatively small commercial systems of around 100 gallons may be predisposed to illnesses that they might otherwise withstand, yet banks of such systems are utilised by numerous profitable enterprises presumably to prevent one disease-causing agent from overwhelming livestock. These standalone units were probably designed for pond-reared tropical freshwater fish, where turnovers and volumes are less critical and H_2S poisonings are rare. Next time you visit such an outlet ask to look at the sump to appraise its size and purifying / stabilising competency.

Trying to catch a fish in a three-foot-long aquarium is significantly stressful for all the inhabitants, remarkably so, for the fish that is eventually caught which is intensified by a stressful journey and acclimation into a new system. As anyone who has taken their cat to the vet knows, there is a lot to be said for reenforcing positive experiences, where nets are probably perceived as a potential threat to their mere survival. Mammalian and piscine stress responses and their long-term consequences are very different (Barton 2002).

Imported fish are most probably shipped from a single enormous and centralised export hub (Townsend 2011) where they share the same water. Some of these facilities may be partial flowthrough so the residents are exposed to all endemic disease-causing agents (pathogens). Diseases become rampant and rapidly overwhelm recirculating fish-only systems because they gain access to an elevated density of potential hosts which cannot swim away or be sold, especially so, if they are presenting with a conspicuous disease. Exporters in the tropics do not have the luxury of temporarily closing their facility because they strive each day to feed their families. Some proprietors may have assumed that providing small systems will prevent the spread of disease thus negating a requirement for quarantine. However, if all fish originate from one export hub, they have equal opportunity to carry disease, so conceivably, all fish in numerous small systems may be infected simultaneously. Controlling disease and water quality in commercial systems is laborious and expensive, yet it is eminently possible in one body of water, but totally impractical and economically inviable in multiple. Be that as it may, generally, a single carrier is implicated in systemwide infestations.

Upon occasion, commercial aquarists excel at keeping fish in such facilities which is pleasurable yet bewildering to behold. However, it is likely that livestock turnover is sufficient for them to operate as a temporary holding facility, acquisitions are regular and no systems are shock-loaded, and feeding is kept to a minimum. All the same, this does not explain the apparent absence of infectious disease whilst the author's enquiries have failed to identify the use of chemotherapies or ozone despite ultra-clear somewhat sparkly water. Most commercial aquarists are reluctant to share their closely-guarded husbandry for fear of slander from the inexperienced and ill-advised. *Alas*, such is human nature.

Degas / Regas and Gas Supersaturation

Satisfying fish respiration becomes challenging in commercial systems that are home to a significant biomass. The notion that protein skimmers can drive beneficial gases into solution irrespective of those that prevail, is erroneous. Saltwater can become saturated with undesirable gases such as carbon dioxide which prevents the dissolution of oxygen, so animals can expire. Particularly so, during the hours of darkness. Hence gaseous exchange is vital for *all* systems, where water must discharge unbeneficial gases (degas) before it can absorb useful (regas). Hence, trickle towers updrafted with air, are indispensable components of commercial life support whilst they have the capacity to revolutionise domestic. Uncover displays and sumps, and maintain systemwide rapid sump throughputs and reef "in-tank" turnovers of 10x and 20 to 70x per hour.

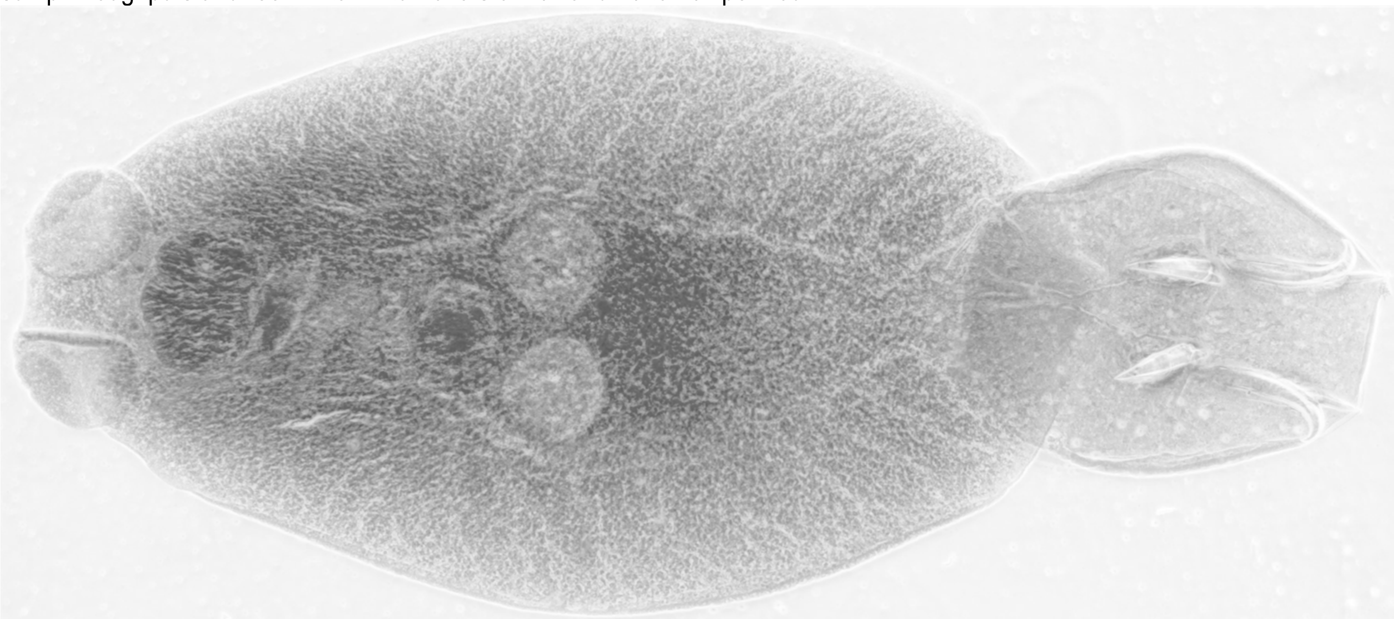


Fig. 3. A micrograph of *Benedenia seriolae* which is a common parasite of Australian cage-cultured kingfish (*Seriola lalandi*). This flatworm is essentially indiscernible from the eye parasite, *Neobenedenia melleni* that plagues tropical marine ornamental teleosts. Note the posterior attachment organ to the right called the haptor that bears hooks.

Attempting to force oxygen into water using the continuous reprocessing of air bubble suspensions within non-single pass protein skimmers can in some instances cause gas supersaturation and elicit gas bubble disease (GBD) which is the fish equivalent of "the bends". GBD is implicated in major mortalities in commercial, and to a lesser but significant extent, in domestic systems to which invertebrates are also susceptible. One tiny air bubble drawn and compressed into solution by a high-pressure sump return pump every minute, is sufficient to put a system on the verge of gas supersaturation. Symptoms typically emerge one to three days after elevated barometric pressure is the consequence of dry air descending on clear sunny days.

Clinical signs include sudden death in quiescent gobies and dragonettes, while deepwater anthias develop gas embolisms in the rays of fins, behind their eyes ("pop eye"; exophthalmia) or at the gill, whereas laboriously-respiring butterflyfish lie on their sides. The former and latter are unlikely to survive in the absence of an immediate increase in pressure. Just like a decompressing scuba diver, fish overcome GBD by swimming deeper which cannot occur in aquaria. Contributing factors include water supplied to holding tanks from the bottom of overly deep multiple-pass protein skimmers or sumps. Yet lowering fish in cages in these sumps and their gradual retrieval, saves lives.

Expansive shallow long sumps provide suspended microbubbles with the opportunity to discharge at the surface before water is drawn into the pump that supplies the holding aquaria. De-bubbling is further enhanced by partition baffles or by discharging aquarium drains and the effluent from trickle towers and protein skimmers into *unfolded evenly-concertinaed* polyester needlefelt filter socks (Appendix). Animals in trickle towerless small systems where protein skimmer effluent encumbered with microbubbles is drawn into return pumps, remain particularly vulnerable. An imbalance of dissolved solute gases deprives water of its lustre, whilst unlike phenolic contamination, ORPs remain buoyant, yet the respiration of numerous deepwater fish will be elevated.

Coral Ailments: rescue or discard

Coral quarantine must provide ultrapure conditions so its primary use is for new specimens including fresh imports, as the recent overabundance of coral pests in nature, demands we use mucosal microbiome-disturbing stressful prophylactics or place corals in quarantine until observations identify infestations or colonies are declared pest-free. Dipping fresh imports will kill most hard corals, so monthlong recovery followed by prophylactic treatments before transference to a retail system is a recommended approach. Therefore, the reefs of customers will not be infected and colonies will not have to withstand another stressful and defence-compromising clearance.

Vis-à-vis coral disease: with few exceptions, most coral illnesses manifest at temperatures above 25ºC whereas other disorders are the likely embodiment of poor water quality, improper design, and / or unsuitable husbandry. Maintain year-round stable temperatures of 23.5ºC. Brown band disease and brown jelly syndrome are caused by the chromists, *Philaster digitiformis* strain FJ64835 (Sweet et al. 2013) which are uninfluenced by temperature and disease any zooxanthellate, yet the former and latter predominantly affect respective SPS branching hermatypes and fleshy LPS corals (Fig. 1.). Rapid tissue necrosis (RTN) which mostly affects *Acropora* and *Pocillopora* may be elicited by the presence of H_2S and / or diminished DO (Haas et al. 2014). Tissue loss is so immediate, the aquarist can see flesh peeling from the skeleton (Fig. 2.).

Thanks to the liberation of polluting- and system-destabilising quantities of dissolved inorganic nutrients from dying corals and the futility of trying to rescue those that are clearly degrading and unlikely to survive, they are best removed and discarded. Hence coral quarantine's primary role is to screen for pest / parasites on new specimens and allow for their post-import recuperation.

Cross-Contamination Avoidance and Fish Disease Acquisition

As ammonium is the preferred source of nitrogen for "algal" symbionts (Ezzat et al. 2015), a recirculating reef benefits from resident ammonioteles like bony fish (teleosts). Nevertheless, some parasites that affect fish can be transmitted to systems in water or on substrate and corals. One scourger of domestic reefs is the eye parasite that kills janitorial surgeonfish, tangs, and angels by instigating catastrophic and eruptive eye infections (Figs 3. & 4.).

Fig. 4. A capsalid of *Neobenedenia melleni* on the eye of a yellow tang (*Zebrasoma flavescens*) which is a discovery that necessitates immediate flatworm clearance to avert horrific pathology.

As the author does not consider efficacious remedies like praziquantel and flubendazole reef safe, insofar as they kill vast cross-sections of macro- and micro-biota which can lead to a loss of diversity and reef malfunction, commercial enterprises benefit from a single bank of three-foot aquaria of the kind adopted by some retail outlets in which fish can be treated. Otherwise, transferring infected fish to your parasite-free fish-only system is not for the fainthearted. Until starvation leads to parasite demise, ammonium is maintained in teleost-free reefs by ample ahermatype feeds.

Unfortunately, unless the supply chain is parasite-free, sporadic infections of this kind will continue, whereas aquarists are alerted by mandatory bidaily eye inspections of both eyes on *all fish*. Eradicate diseases and parasites in commercial and domestic fish-only systems after watching open-access Reef Ranch™ videos at: https://www.reefranch.co.uk/

Reefs can be infected by toxigenic photosynthetic harmful algal blooms (HABs) otherwise known as red tides (Hallegraeff 1993; Burkholder et al. 1995; Burkholder 1998; Springer et al. 2002; Fdez-Riverola & Corchado 2004; Imai et al. 2006; Martnez et al. 2010; Shi et al. 2012; Wang et al. 2018; Hargreaves et al. 2019; Tibiriçá et al. 2019; Aslett 2024) which are generally kept in check with rigorous nutrient management (Figs 5. & 6.). However, cross-contaminating your polluted fish-only system can lead to catastrophic losses (O'Halloran et al. 2006; Rensel et al. 2010; Mohamed & Al-Shehri 2012; Branco et al. 2014; Kim et al. 2015; Aslett 2024), whilst aerosols can spread harmful microorganisms to systems that share airspace (Roberts-Thompson et al. 2006). Fortuitously, therapeutic copper will kill many, whereas others can survive *safe* concentrations*:* 0.05 to 0.1 mg l^{-1} Cu^{2+}. GAC will remove algal blooms within hours, whereafter Kent Marine phosphate sponge safely attains growth limiting concentrations of phosphate (PO_4^{3-}) which leads to algal demise. Illumination can be withdrawn from fish-only systems as long as ambient is sufficient to wake animals before feeds. Therapeutic copper will kill fish if applied in the wrong way, as animals must be gradually exposed to increasing concentrations over several days. Consult: open-access Aslett 2025 available at: https://reefranch.co.uk/reef-research-and-aquarium-advice/

HABs are diagnosed by examining a glass scrape under moderate magnification using a light microscope (Appendix). See: open-access Aslett 2024a. Do not be tempted to use lanthanum chloride to lessen algal blooms in fish-only systems as their sudden demise is associated with fish- and wildlife-decimating ecological hypoxia (Lee & Hirayama 1992; Fukuda & Endoh 2006; D'Silva et al. 2012; Turkoglu 2013), where DO is depleted by the overzealous respiration of exploding populations of housekeeping microorganisms. *And besides*, La^{3+} are likely toxic to gill-respiring animals (Aslett 2024).

When not in use, nets and other paraphernalia should be submerged in daily-formulated 3 percent hydrogen peroxide (H_2O_2).

Employees should cleanse their hands with unfragranced hand sanitiser made from only *Aloe vera* gel and methanol / ethanol followed by rinsing and thorough drying. Nevertheless, incessant usage can lead to occupational dermatitis.

Fig. 5. A micrograph of a toxigenic dinoflagellate of the genus *Prorocentrum* (Dinophyceae: Prorocentraceae) isolated from an established reef, which featured in a thread on the Reef2Reef.com forum in 2020. The skin-like sheath suggests *Prorocentrum malayense* as described by Verma and colleagues that synthesise dinophysistoxin (DTX) and okadaic acid (OA) which cause diarrhetic shellfish poisoning in humans (Lim et al. 2019; Verma et al. 2019). Aslett ©.

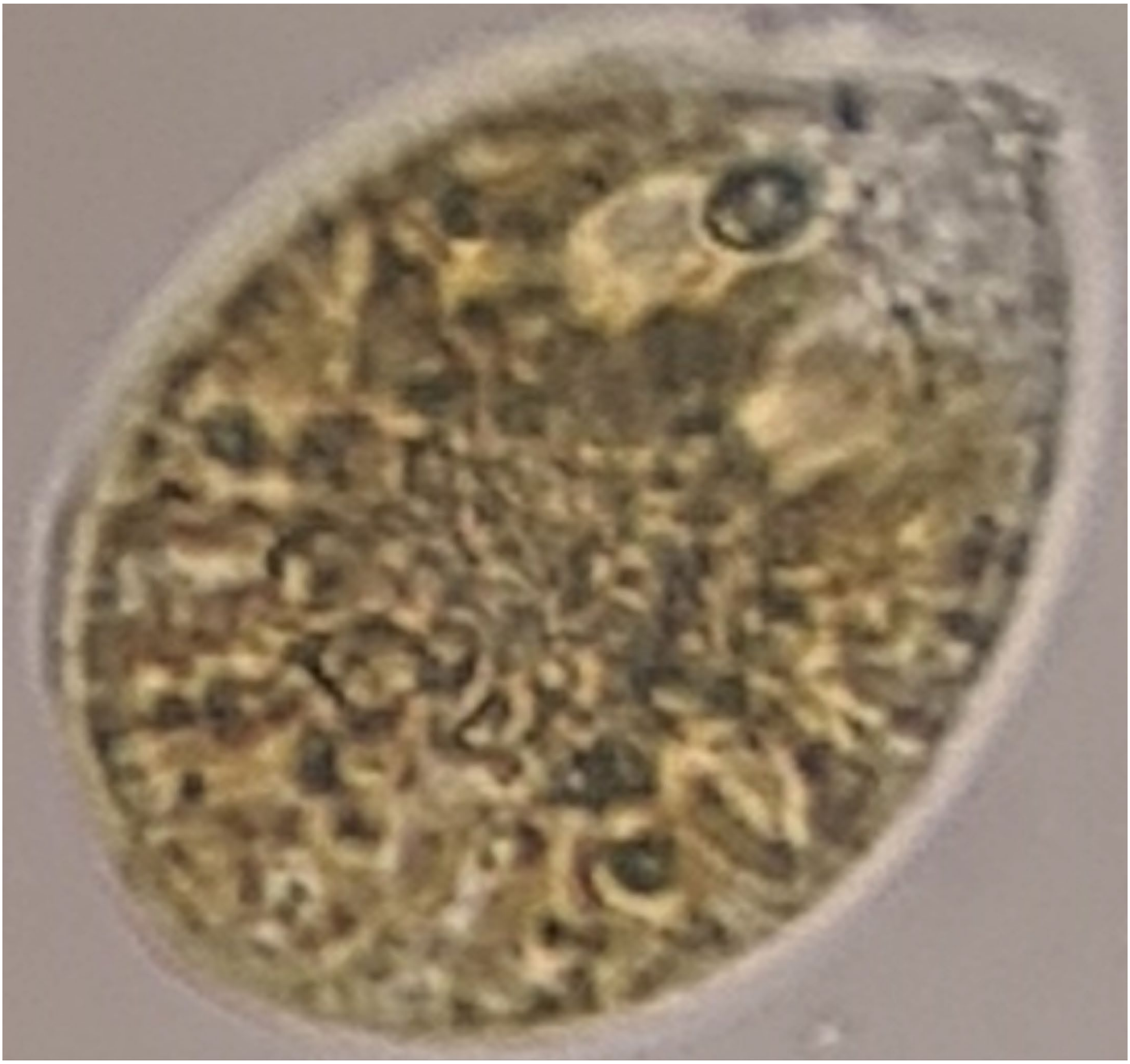


Fig. 6. A micrograph of a toxigenic motile cell of the genus *Ostreopsis* (Dinophyceae: Ostreopsidaceae), possibly *Ostreopsis* cf. *ovata* (Accoroni & Totti 2016). Featured in a posting on the Reef2Reef.com forum in 2020. Aslett ©.

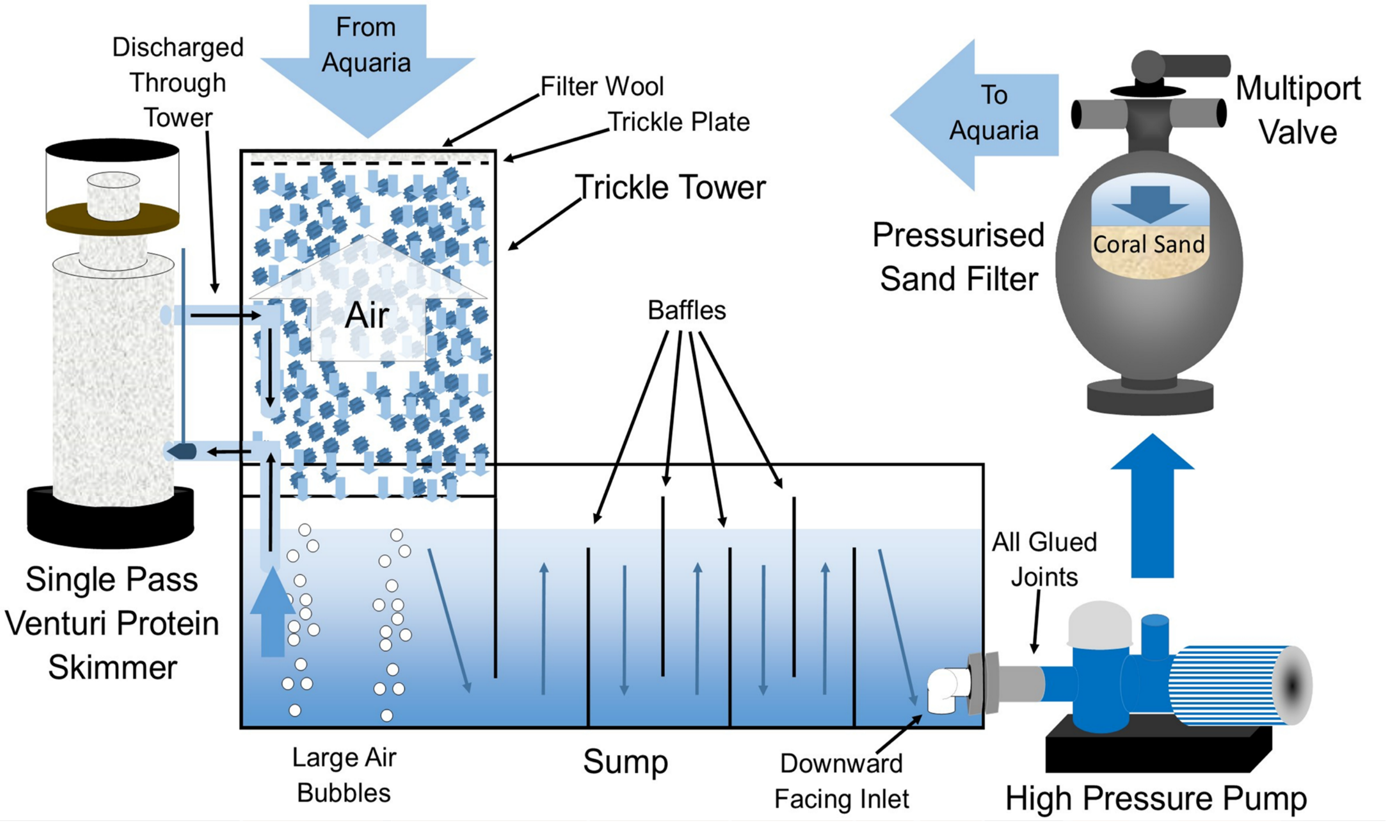
The most successful wholesalers of ornamental tropical marine livestock, construct and operate sizeable centralised systems where an expansive sump recirculates water through countless aquaria (Appendix). Keep your eggs in one basket, but take great care of the basket (Wilson, personal communication). All things considered, wise hobbyists have a three-foot aquarium with a resident fish lit with a single fluorescent tube alongside sizeable reservoirs of continuously warm and ***aerated*** salt- and fresh-water.

Chris Aslett

As the principal director of Reef Ranch Publishing Ltd (https://reefranch.co.uk/) and author of The Complete Reef Aquarist—A Conservation Manual (https://reefranch.co.uk/reef-aquarium-guide/), Chris has over 55 years of experience keeping aquatic animals with 47 of them nurturing marine species. His innate passion for system dynamics drove him from the laboratory to university where he gained a greater appreciation of biochemistry, biotechnology, epidemiology, genetics, histology, inorganic and organic chemistry, mariculture, molecular and microbiology, saltwater zoology, and the diagnosis and treatment of aquatic diseases. His dedicated marine livestock supplier, The Reef Ranch™, demanded he devise, streamline, and establish protocols for combined acclimation and prophylactic pest/parasite clearance, and innovate system design, optimisation, maintenance, and husbandry in the face of incessant influxes of hundreds of delicate marine animals. With exceptional, uncompromising, and likely the UK's most disease-free reef and fish-only facilities, losses were less than one resident every six months. 20 years hence, he has refined his expertise for digesting, authoring, editing, and publishing reef conservation-driven scientific literature (https://reefranch.co.uk/reef-research-and-aquarium-advice/), to an end of diminishing the impact the tropical marine ornamental industry exerts in the wild.

Appendix

Commercial Fish-Only System Sump and Filtration Components



Upscaled for sizeable centralised systems or downscaled for domestic aquaria, an illustration of the essential filtration components of a marine fish-only system.

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Tentatively black axle chromis, *Chromis* cf. *atripectoralis.*