



## *Teach a Person to Fish... SPS Academy Part VII*

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Last time we commenced to explore the significance and upkeep of the rarer trace elements of seawater in recirculating systems because ionic speciation is different from the wild. Herein we continue opting for the safest and most natural replenishment strategies, while we strive to keep the terminology within the realm of the hobbyist without impinging on the author's style.



Fig 1. Sky blue *Acropora* cf. *verweyi* featuring a wave action-resilient, light harvesting-ineffectual, branching configuration. Photograph courtesy of the Reef Ranch™ ©. The colony was perhaps acquired from the crest of an eastward reef front. Branching corals with diminished surface area to volume ratios were indigenous inshore and offshore yet were lacking mid-shelf (Doszpot et al. 2019).

**Keywords:** aquarium; bleaching; coral; iodate, iodide; iodine; Lugol's; microbiome; mucosal; reef; ROS; shrimp; SPS; supplement; thyroxine; toadstool; worm; *Xenia*.

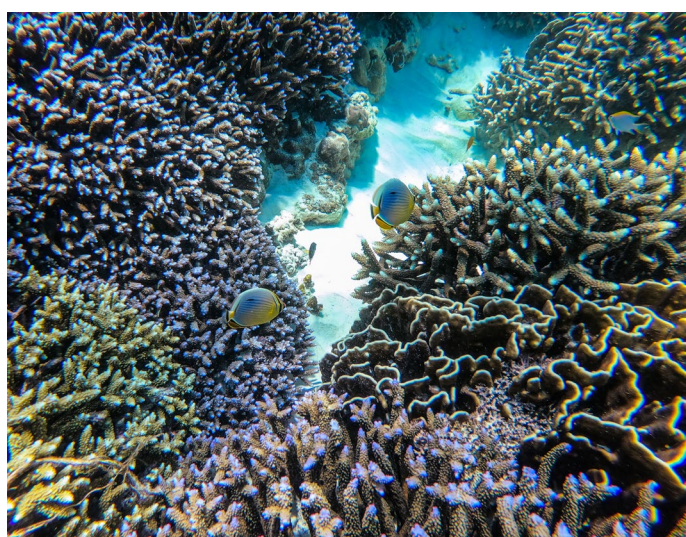


Fig 2. Three striped butterflyfish (*Chaetodon trifasciatus*) nibbling at corals flanking a substrate channel in a pristine Red Sea environment.

The halogens appear in group 17 of the periodic table which only need one electron to fill their orbitals and attain the configuration of a highly unreactive and grounded noble gas. They thus oxidise other atoms by capturing one of their electrons, however, the autoionization catalyst water reduces these elements to noble gas-like solubilised negatively charged anions while it oxidises group 1 and 2 sodium, potassium, calcium, and magnesium to the noble gas-like cations  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$ .



The foremost and pertinent halogens of seawater are chlorine (Cl), bromine (Br), and iodine (I) which tend to manifest as chloride (Cl<sup>-</sup>), bromide (Br<sup>-</sup>), iodide (I<sup>-</sup>), and iodate (IO<sub>3</sub><sup>-</sup>). Nevertheless, their unstable nature is somewhat retained in their ionic form, inasmuch as they are the first to react when ozone is applied to unreduced seawater. Such total residual oxidants (TROs) can also arise when iodine is supplemented or up to 36 hours after a water change in ozone-utilising systems (Wilson, personal communication; Latson et al. 2018).



Fig 3. A tunicate or sea squirt (Chordata: Ascidiacea).

Chloride (Cl<sup>-</sup>) is the most abundant and rapidly moving anion and potent oxidising-agent that disrupts ionic bonds and readily captures electrons from iodide (I<sup>-</sup>) and bromide (Br<sup>-</sup>; Balling et al. 2008).

Iodine is the least abundant and the most readily expended of the three primary halogens in recirculating systems while its gaseous form occurs in air (Dembitsky 2006). "Algae" including zooxanthellae may store iodine as iodate (IO<sub>3</sub><sup>-</sup>) and reduce it to iodide (I<sup>-</sup>) when required, while it may provide photosynthetic overload protection and thus its dearth may expedite bleaching (Balling et al. 2008), whereas bromine performs a similar role in the kelp *Laminaria digitata* (Kupper et al. 2013).

Nori seaweed used to wrap sushi comprises several macro- and pico-minerals in comparable ratios to those of seawater, while iodine is significantly enriched. It is a useful supplement for angelfish, tangs, surgeonfish, and hermit crabs; however, exercise caution because it comprises much phosphorus. See: Part IV.

Numerous marine organisms amass iodine to deter predation like sea squirts of the phylum Chordata and subphylum Tunicata, while it remains a prominent constituent of shrimp and worm integuments that may be necessary for the coloration of blue species of *Acropora* (Fig 1.; Fig 3.; Holmes-Farley 2003).

Oceanic iodine ranges from 0.04 to 0.06 mg I<sup>-1</sup> (ppm) of iodate (IO<sub>3</sub><sup>-</sup>) and 0.01 to 0.02 mg I<sup>-1</sup> iodide (I<sup>-</sup>) where its full speciation remains enigmatic, albeit anaerobic bacteria and phytoplankton take up iodate (IO<sub>3</sub><sup>-</sup>) and liberate iodide (I<sup>-</sup>) which algae preferentially absorb and utilise (Holmes-Farley 2003).

Methyl iodide (CH<sub>3</sub>I; iodomethane) is the simplest form of organiodine, whereas the meta- and ana-bolism of several marine organisms manufacture complex kinds. Ultraviolet (UV) sterilisers and ozone oxidise iodide (I<sup>-</sup>) to iodate (IO<sub>3</sub><sup>-</sup>; Holmes-Farley 2003) which is one of the few reasons to exploit UV sterilisation.

Macroalgal reactive oxygen species (ROS) may provoke organiodine synthesis, while their peroxidases may form the by-

products diiodomethane (CH<sub>2</sub>I<sub>2</sub>), methyl iodide (CH<sub>3</sub>I), and iodobutane (C<sub>4</sub>H<sub>9</sub>I; Collén et al. 1994; Laturnus 2008) where mono-carbon tri-halogenated hydrocarbons like bromodichloromethane (CHBrCl<sub>2</sub>) and dibromochloromethane (CHBr<sub>2</sub>Cl) remain rare oddments (Laturnus 2008).

### Toxicity

Lugol's iodine and tinctures contain molecular iodine (I<sub>2</sub>) which is sterilising and potentially harmful yet ionic forms are non-biocidal (Holmes-Farley 2003). Coral dips of diluted Lugol's iodine may partially sterilise the mucosal microbiome which is the colony's first line of defence (Pantos et al. 2003; Garber 2011; Ho 2013; Soffer et al. 2013; Rivera-Ortega & Thomé 2018; Santoro et al. 2021) which may render corals susceptible to microbial attack (Oakey & Owens 2000; Oakey et al. 2002; Lesser et al. 2007; Hall et al. 2018; Morrow et al. 2018).



Fig 4. Black coral, *Antipathes* cf. *grandis* (Hexacorallia: Antipatharia).

Molecular iodine (I<sub>2</sub>) commences to poison teleosts at <1 mg I<sup>-1</sup> (ppm) while I<sub>2</sub> and I<sup>-</sup> prove toxic to some invertebrates at nominal concentrations, but only when the latter approaches twenty times that of natural seawater. Culturists of macroalgae will observe enhanced growth during I<sup>-</sup> and IO<sub>3</sub><sup>-</sup> enrichment which appears the most benign, whereas the former inhibits growth of *Caulerpa* species at ~13 mg I<sup>-1</sup> (Holmes-Farley 2003).

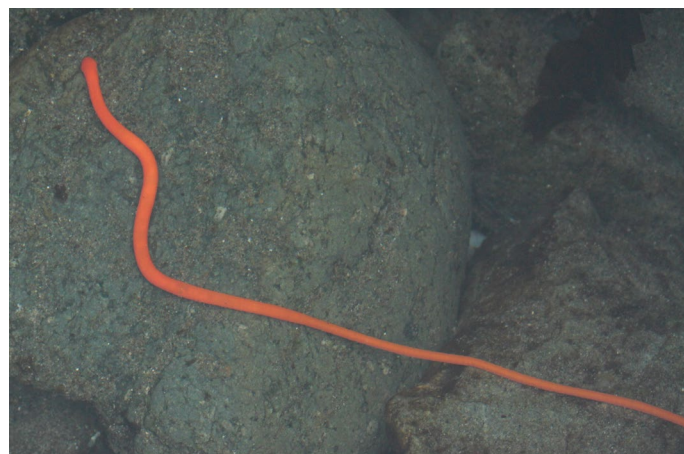


Fig 5. A relative of the rare and elusive ribbon worm, *Lineus ruber* which reach merely 6 to 7 cm (2.4 to 2.8").

Mammalian biphenyl thyroxine (C<sub>15</sub>H<sub>11</sub>I<sub>4</sub>NO<sub>4</sub>) is manufactured in the thyroid gland yet it remains a constituent of the supportive spicules of sea fans/sea whips (Octocorallia: Alcyonacea) while its synthesis demands UV radiation (Kingsley et al. 2001). Tunicates manufacture thyroxine and the cytotoxin lukianol B (C<sub>25</sub>H<sub>16</sub>INO<sub>5</sub>) from dissolved inorganic iodine (DI<sub>2</sub>; Fig 3.; Fig 4.; Goldberg 1978; Yoshida et al. 1992; Goldberg et al.



1994; Holmes-Farley 2003). Marine worms use several toxic compounds to discourage predation (Göransson et al. 2019), while the marine ribbon worm (*Lineus ruber*) produces pharyngeal thyroid-like hormones and thus was a likely participant in thyroid gland development (Fig 5.; Balfour & Willmer 1967).

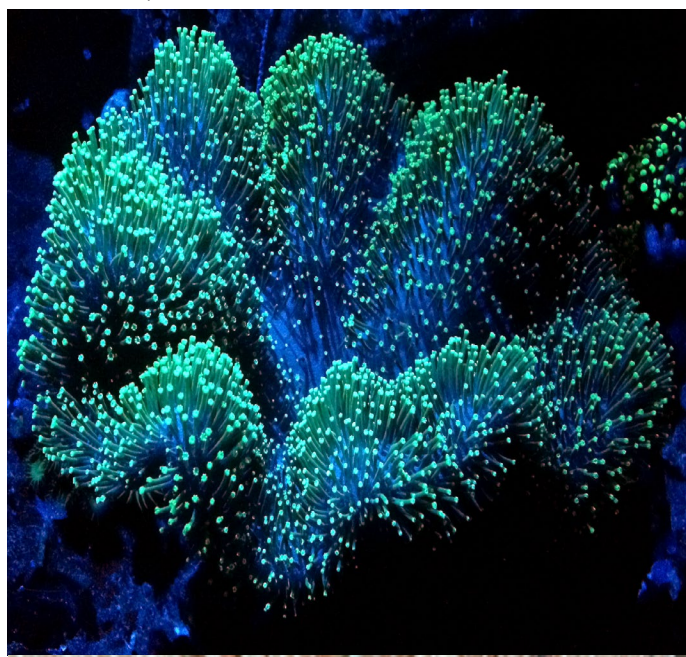


Fig 6. Top - toadstool coral (*Sarcophyton* species). Bottom - a colony of pulse xenia, *Xenia umbellata*.

The bases of antipatharian black corals amass up to 23 percent iodine, while organoiodine may render macroalgal flesh unpalatable (Fig 4.; Holmes-Farley 2003).

Toxigenesis in *Geodia* species of leathery barrel sponge yields geodiamolide A and B which consist of a tripeptide, iodine,

and bromine (Chan et al. 1987). Iodine represents ~1 percent of dry sponge weight which predators may find foul-tasting (Solimabi et al. 1981), whereas sponges either absorb Dli or acquire dietary organoiodine (Holmes-Farley 2003).

Shrimp anabolism is stimulated by organoiodine-rich diets (Fa-yi et al. 1995) because iodine is assimilated systemically including their shell (Holmes-Farley 2003; Bottaro et al. 2007) while the tissues of *Xenia* and *Sarcophyton* species contain ~100 mg kg<sup>-1</sup> (ppm; Fig 6.; Shimek 2002).

Reef salts may be a significant source so *test everything*, while much may be sustained by the ingestion and biomineralization of feeds. Iodine has proven toxic at ionic strengths that barely exceed those of seawater, and several manifestations are unlikely to appear in the results of aquarium assays. It is normally ill-advised to supplement an ion without first ascertaining its dilution and the author advises **extreme moderation**.

Supplements are usually formulated from dilute solutions of potassium iodide (KI) which may be cycled in our reefs to iodate (IO<sub>3</sub><sup>-</sup>) using UV sterilisation but ozone must cease for up to 24 hours post-administration. The author has described a DIY iodine supplement for completeness however...

**As with any potentially dangerous procedure, the reader prepares and uses these DIY supplements at their own risk, because the author, Reef Ranch Publishing Ltd, websites hosting this article, and their owners cannot be held responsible for any harm to pets, people, possessions, or properties. Personal protective equipment (PPE) is advised, and immediately cleanse the compound from skin.** See: Part VI for stock solution and PPE guidance.

Thoroughly dissolve 50 g of pharmaceutical or food grade anhydrous potassium iodide (KI) in 100 ml (100 g) of R/O water to create a stock concentrate from which 1-ml is added to 199 ml of R/O water to make up the 1.93 g l<sup>-1</sup> **iodide supplement**. Botulinum cook as described in Part VI, clearly label, and **store in a dark refrigerator out of reach of children and pets**.

Administering four drops (0.39 mg iodide) **of the supplement** for every 30 litres of system volume creates a systemic fortification of 1.3 x 10<sup>-2</sup> mg l<sup>-1</sup> wk<sup>-1</sup> of iodide, which is appropriate for merely fully stocked aquaria exploiting a UV steriliser with ample coralline and macroalgae. Remarkably KI increases the efficacy of UV sterilisation which appears otherwise non-bactericidal (Huang et al. 2017; Vieira et al. 2018).

Join us next time when we shine a spotlight on strontium, boron, and aluminium which are more than adequately maintained by nominal husbandry.

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