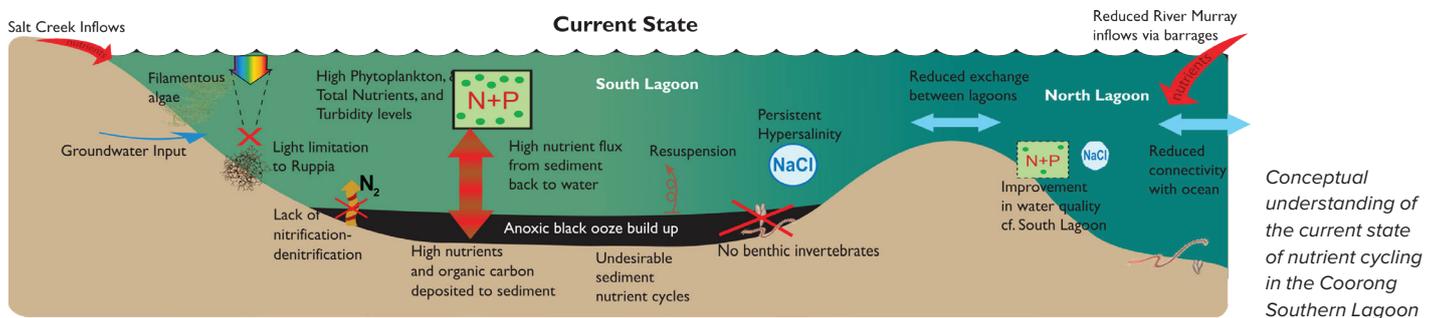


Nutrient cycling in the Southern Coorong



Plants and animals of the Coorong need nutrients to thrive. Some nutrients, principally nitrogen, phosphorus, and carbon, are essential to plant and animal growth. The presence of these nutrients also affect water and sediment quality, which influences the overall health of ecosystems. Nutrients enter the Coorong ecosystem through water that flows into the system from multiple sources. These nutrients are incorporated into the Coorong's ecological cycle through interactions between water, sediment, plants, animals and microbes. Healthy Coorong nutrient cycles should be supported by functional foodweb cycling, for example, where high levels of productivity enable recycling of organic matter and the capacity to sequester and store carbon.

It's important to understand how nutrients move between the water and sediments into living organisms and are then recycled back to the environment. This is the nutrient cycle, which is out of balance in the Southern Coorong due to long-term environmental change. We now know that nutrient levels and cycling processes in the Southern Coorong are in an unhealthy, hyper-eutrophic state (i.e. contain high nutrient and organic matter loads).

Nutrients remain trapped within the South Lagoon because there is insufficient 'flushing' of water and nutrients out to the North Lagoon and ocean via the Murray Mouth. Narrow constrictions and expansive shallow areas (particularly in spring-summer) reduce connectivity and water flow between the north and south lagoons. Excess nutrients accumulate and promote the growth of phytoplankton and filamentous algal blooms, which disrupt healthy nutrient cycling.

The sediment plays an important role in nutrient cycling. In the Southern Coorong, filamentous algae and phytoplankton break down on the sediment surface, increasing sediment nutrient and organic carbon loads. Organic matter is decomposed by bacteria that consume oxygen to fuel rapid growth and create anoxic (no oxygen) sediments. In anoxic sediments, only anaerobic (without oxygen) respiration occurs, which increases the release of

nitrogen and phosphorus into the water and promotes enhanced algal growth. These conditions further exacerbate the hyper-eutrophic state in the Southern Coorong.

Organic-rich sediments called 'monosulfidic black oozes' can also form when the sediment becomes anoxic. Oxygen-rich zones in the sediment prevent this from occurring and promote nutrient cycling into more beneficial nutrient forms.

Anoxic sediments and hypersaline (high salinity) conditions are also toxic to macroinvertebrates and aquatic plants. In healthy systems, sediments are oxygenated by macroinvertebrates (e.g. via burrowing by worms and bivalves) and aquatic plants (via roots). As these important parts of the natural ecosystem currently occur in low amounts or are in poor health in the Southern Coorong, sediments can't be oxygenated sufficiently, which further fuels negative impacts to the nutrient cycle.

The Southern Coorong can be restored to its desired state by understanding and addressing what has led to the hyper-eutrophic state including changes to the nutrient cycle.

Further reading:

Mosley, L., S. Priestley, J. Brookes, S. Dittmann, J. Farkas, M. Farrell, A. J. P. Ferguson, M. Gibbs, M. Hipsey, J. Huang, O. Lam-Gordillo, S. Simpson, P. Teasdale, J. Tyler, M. Waycott, and D. Welsh. 2020. Coorong water quality synthesis with a focus on the drivers of eutrophication. Goyder Institute for Water Research, Adelaide.

Acknowledgements

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The Goyder Institute for Water Research is the delivery partner for research components of Healthy Coorong, Healthy Basin, providing independent research to inform future management decisions for the region.

Glossary

Ammonium — A dissolved form of nitrogen readily taken up by algae and aquatic plants.

Anoxic — Lacking oxygen.

Aquatic plants — A phrase used to describe the mixed submerged aquatic plant community that includes *Ruppia tuberosa*, *Ruppia megacarpa* and *Althenia cylindrocarpa*. Where otherwise stated, the phrasing will be referring to either species independently or the genus.

Bacteria — A unicellular microorganism with simple internal structures.

Bioturbation — The reworking of sediments by animal activities including burrowing, ingestion, and defecation of sediment grains. It has a profound effect on sediment condition and the environment.

Connectivity — A mechanism that allows for the movement of water, materials and animals between areas, including between the north and south lagoons of the Coorong, between the sea and the Coorong through the Murray Mouth, and from the River Murray or south east flows to the Coorong (but not typically vice versa). It is an important element of hydrodynamics, has a strong influence on water quality (through exchange of salt and nutrients) and is essential for some ecological processes, such as migration of fish at different times of year and for the transport of zooplankton from freshwater inflows to support food webs of the Coorong.

Detritivore — An animal that feeds on dead material, especially plant parts.

Denitrification — The process by which nitrate is converted to nitrogen gas bubbles, which are released to the atmosphere. If the sediment is anoxic, then nitrification-denitrification cannot occur and the nitrogen remains in the nutrient cycle.

Eutrophication — The process of nutrient enrichment and the increase in the supply of organic matter. Eutrophic systems typically have excessive plant and algal growth, which become internally produced organic matter loads as they decay. They grow excessively in response to nutrient enrichment such as nitrogen and phosphorus inputs. Eutrophication has cascading effects for the entire ecosystem. The hyper-eutrophic state in the Southern Coorong is characterised by high concentrations of chlorophyll-a (>50 mg/L), total nitrogen (>4 mg/L) and total phosphorus (>0.2 mg/L) in the water.

Evapo-concentration — The concentration of solutes such as salt and contaminants as water evaporates. The effects of evapo-concentration increase with increasing water residence time, and at higher temperatures in summer.

Filamentous algae — The green filamentous algal community which occurs in the Coorong, consisting of *Ulva paradoxa*, *Rhizoclonium sp.* and *Cladophora sp.*

Herbivore — An animal that eats plants.

Hyper-eutrophic — An extremely high-nutrient state due to eutrophication.

Hyper-saline — Salinities that are greater than that of normal seawater.

Macroinvertebrate — Invertebrate fauna that are greater than 0.5 mm.

Mesotrophic — Intermediate levels of nutrients, common in healthy estuaries. A mesotrophic Coorong would be fairly productive (with plant and animal life), but could be at risk of having water quality problems.

Millennium Drought — An Australian drought which impacted the Murray-Darling Basin over the period 1996–2010, and substantially impacted the Coorong over the period 2001–2010. The period from 2007–2010 was particularly extreme with extended periods of no flow through the barrages to the Coorong.

Monosulfidic black oozes — Monosulfidic black oozes (MBOs) form when there is an excess of organic matter, and sediments become anoxic as the bacteria consume all the oxygen to decompose the organic matter. Iron (III) and sulfate are converted by bacteria to iron (II) and hydrogen sulfide, because there is no oxygen. The iron typically comes from iron oxide minerals in the sediment that are reduced, whereas sulfate comes from water (it is plentiful in seawater and saline groundwaters)

Nitrogen — A nutrient that is essential to plants and animals and forms compounds such as amino acids and proteins. Nitrogen can be found in aquatic environments in dissolved, particulate, inorganic, organic and gaseous forms. Too much nitrogen can be associated with eutrophication.

Nitrate — A dissolved form of nitrogen.

Glossary

Nitrification — Nitrification is the process by which ammonium is converted to nitrite and then nitrate. It can also take place in the sediment and requires oxygen. Denitrification is the process by which nitrate is converted to nitrogen gas bubbles, which are released to the atmosphere. If the sediment is anoxic, then nitrification-denitrification cannot occur and the nitrogen remains in the nutrient cycle.

Nutrient cycle — The movement or exchange of nutrients, such as nitrogen, from inorganic and organic forms into organic matter, including plants and animals, and back again.

Oxygenate — Supply or enrich with oxygen. Sediments in aquatic systems need to be oxygenated in order for healthy nutrient cycling and nutrient exchange from sediment to water and to the atmosphere to occur. Oxygenation of sediments can occur through biological processes (e.g. animal movement, pumping through plant roots), or physical processes such as water turbulence and currents moving sediments around.

Phosphorus — A nutrient essential to life and strongly influencing water and sediment quality in the Coorong. Phosphate is the dissolved form of phosphorus, which is uptaken by plants and algae.

Photosynthesis(e) — The conversion of light energy to organic compounds, can be referred to as carbon fixation.

Phytoplankton — Small plankton algae that is essential to aquatic food webs.

Respiration — Respiration is a chemical reaction which takes place in all living cells and releases energy from glucose. Anaerobic respiration occurs without oxygen and releases less energy but more quickly than aerobic respiration.

Ruppia — A genus of aquatic plant, referring to the species *Ruppia tuberosa* in the Southern Coorong.

Salinity — Salinity can be defined as the concentration of dissolved mineral salts present in waters and soils on a unit volume or weight basis.

Southern Coorong - The Southern Coorong is defined here as the area ranging from Parnka Point in the north and south to 42 Mile Crossing, approximately 65 to 105 km from the Murray Mouth that connects the estuary to the sea.

Turion — Reproductive structure of *Ruppia tuberosa* (Type I and Type II) and *R. polycarpa* (Type I) produced underground that is capable of forming into a new plant

Water quality — The condition of water or some water-related resource as measured by biological surveys, habitat-quality assessments, chemical-specific analyses of pollutants in water bodies, and toxicity tests.

Zooplankton — Animals (often microscopic) that either move by water currents or are weak swimmers in the water column.

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