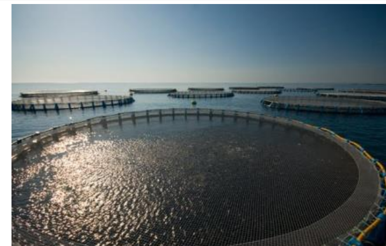
THE UNIVERSITY OF MELBOURNE

Marine Biology
MSc Projects 2021

Sustainable Aquaculture Laboratory – Temperate and Tropical (SALTT)



Aquaculture is booming globally - so too are the problems it creates. Our focus is finding solutions to environmental and animal welfare problems by working both inside and outside aquaculture systems. We invent and innovate new techniques and technologies and we have a history of seeing out work rapidly create change in the wider world. Our projects are both in Australia and abroad, which provide opportunities for students to work in unique settings, often with industry, at the cutting-edge of research. All travel and accommodation for projects in Norway (no. 1-5 in the list below; typically 2 x 2 month field trips per project) will be covered and a stipend is provided for living costs.

Multiple MSc projects are available for 2021.

1. Prevention of a major parasite of farmed salmon **(with Tim Dempster and Frode Oppedal)**

Salmon lice are a wicked problem for salmon farming. These ‘ticks of the sea’ cost ~ $1 billion per year to control. This project will test some of the most important methods to prevent and control salmon lice to work out how effective they are under different conditions. The project will involve lab and/or field experiments at the Institute of Marine Research station in Norway.

2. Biological control of parasites with cleaner fish **(with Tim Dempster, Luke Barrett and Frode Oppedal)**

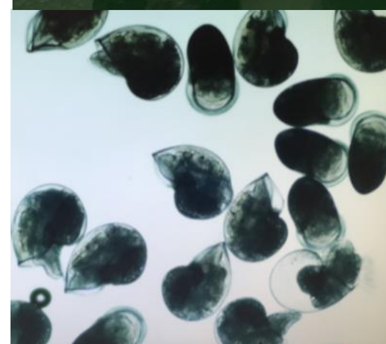
Salmon aquaculture uses 60 million cleaner fish each year to eat parasites directly off the salmon. Our recent work has shown that this is often ineffective in certain conditions and leads to high mortality for the cleaner fish. We think we can do better by inventing new technologies that help the cleaner fish approach and clean the salmon in conditions that keep cleaner fish healthy. This project will mix animal behaviour and technological innovation in lab and field experiments at the Institute of Marine Research at their research station in Norway.

3. Behaviour and biology of an ectoparasite (with Tim Dempster, Frode Oppedal and Samantha Bui)

Sea lice are a major parasite of salmon aquaculture, with a new problematic species *Caligus elongatus* emerging recently. This species is mainly found on salmon in its adult stage having parasitised other fish species for much of its juvenile life. Little is known about their ability to move between hosts as adults. This so project will focus on the dispersal dynamics of this ectoparasite and its host preferences. The experiments will be conducted in the lab and possibly field at a research station in Norway hosted by the Institute of Marine Research.

4. Hot water to control ectoparasites (with Samantha Bui, Ole Folkedal and Tim Dempster)

A common parasite treatment method in salmon aquaculture is to treat fish with hot water of over 30 °C. This approach has recently been under scrutiny for its effectiveness, and likely negative impact on fish welfare. Although used widely in the industry, few studies have investigated this robustly. This project will look in detail at the relationship between water temperature and parasite mortality, then put this into practice by testing procedures for safe application without impacting fish welfare. This project will focus on parasitology, welfare, and applied aquaculture science by conducting experiments at the Institute of Marine Research, at their research station in Norway.

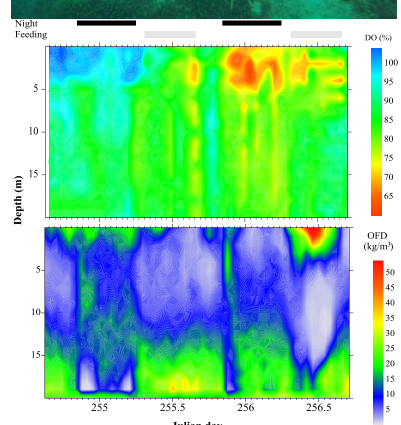


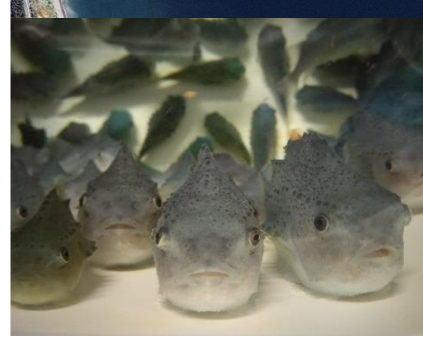
5. Solving a planktonic mystery – where are parasites in the sea? (with Samantha Bui, Frode Oppedal and Tim Dempster)

The major parasite that plagues salmon aquaculture is dispersed in coastal waters during its larval stage. We have a good understanding of how these lice behave in response to stimuli in the lab, but not in the field. This project will use large-scale mesocosms to test behavioural responses of planktonic parasites to different natural conditions (e.g. temperature, salinity and light), and to the presence of hosts. The results from this will provide input to a predictive dispersal model that plays a significant role in government regulations.

***6. Genomics for breeding better fish and shellfish* (with Nick Robinson)**

Genetic improvement programs are supplying better performing seedstock to aquaculture producers around the world. Genomic technologies (e.g. genomic selection) are being used and have been shown to increase the accuracy of selection and the rate of genetic improvement possible, especially for traits like disease resistance which are difficult to measure on living breeding candidates. The projects in this area are in collaboration with Nofima (Norwegian Institute of Aquaculture Research) and there are possibilities for some travel (with airfares, and accommodation expenses covered).





7. Innovating a new aquaculture industry for sea urchins (with Fletcher Warren-Myers and Tim Dempster)

Sea urchins are an integral part of the marine ecosystem, but when populations boom they can turn kelp reefs into barren reefs, negatively impacting biodiversity. One approach to reducing urchins is to mass cull, but this is costly and unsustainable. An alternative approach is to harvest urchins for roe enhancement aquaculture, creating a sustainable cost neutral way to regulate urchins. This project will test innovative tank and cage designs for urchin culture to help innovate an urchin aquaculture industry. The project will be based in Victoria and involve the design, construction and testing of prototype culture systems, animal husbandry and field collections.

8. Sea urchins and lost predators in Port Phillip Bay (with Luke Barrett, Fletcher Warren-Myers, Tim Dempster and Steve Swearer).

Native sea urchins are overabundant in Port Phillip Bay, leading to the formation of large barren areas and a loss of biodiversity in recent decades. Globally, urchins benefited from over-exploitation of predators, but here the evidence is less clear. Large fish and lobsters, now rare in the Bay, may have controlled urchin populations historically, or it may be that predators never played an important role here and urchin abundance is instead governed by environmental factors. This project will use a combination of historical accounts, data on ecological niches, and/or field surveys to infer historical changes in abundance of potential urchin predators.

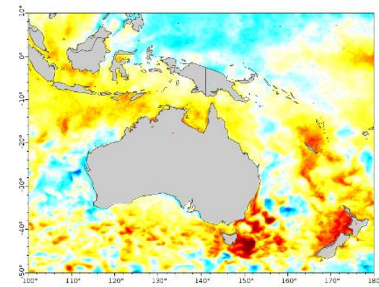
9. Global trends in aquaculture infrastructure (with Luke Barrett and Tim Dempster)

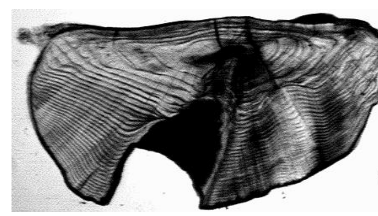
The design and placement of aquaculture infrastructure affects how well farms stand up to the elements, whether they can raise healthy animals economically, and how much they impact the environment. This project will use satellite imagery and large, publicly available datasets to track global patterns in aquaculture infrastructure (fish, shellfish and algae) and relate these to environmental impacts and/or disease risk.

Other projects in the lab are possible, just get in touch for a chat.

For more information contact Tim Dempster dempster@unimelb.edu.au or Assoc. Prof. Nick Robinson nick.robinson@nofima.no

Aquatic Ecology and Evolution Laboratory





We are a group of ecologists and evolutionary biologists working in marine and freshwater systems investigating how animals respond to environmental change on contemporary and evolutionary time scales. We are keenly interested in the impacts of, and adaptations to, fishery activity, natural and human-induced flow variability, and environmental change. We ask questions at different levels of biological organisation, ranging from individuals (e.g. growth and behaviour) to assemblages (e.g. diversity and fishery productivity), using field-based and experimental techniques.

Multiple MSC projects are available for 2021.

1. ***Impacts of marine heatwaves on fisheries productivity (with Dr Emily Fobert)***

Marine heatwaves affect fish species distributions, and evidence suggests these heatwaves also affect fish growth. Anthropogenic climate change is expected to increase the frequency, magnitude and duration of these extreme warming events. This project will investigate the impact of heatwaves on the reef fish assemblages of Pacific Islands which support important subsistence and commercial fisheries. You will identify which fish species are vulnerable to extreme warming events and which species are robust to change. The project will work with collaborators in the Pacific Community and will use reconstructed growth histories from individual fish otoliths ("ear bones"), from fish that have experienced different magnitude, frequency and duration heatwave events. Otoliths are calcium carbonate structures that record annual growth increments, similar and analogous to tree rings, and life-history data extracted from otoliths can be used to explore the impacts of extreme warming events on fish growth and fisheries productivity.

2. Fishing and climate change impacts on fish growth (with Dr Emily Fobert)

Fishing and anthropogenic climate change induce similar trait responses in fishes, despite being underpinned by very different mechanisms. Fishing can affect the phenotypic diversity of harvested stocks through the selective removal of, for example, the biggest or oldest individuals. Likewise, warming has been implicated in 'shrinking fish' and shifts in phenology. Disentangling the relative importance of fishing and warming can be difficult in marine systems where long-term observational or experimental data are often sparse. This project will address this data gap by reconstructing growth histories of individual fish from the growth increments in their otoliths ("ear bones"), in which annual deposits are laid down, similar and analogous to tree rings. This data can then be used to explore the impacts of fishing and environmental change on fish growth. This project will utilise existing otolith collections from either the east coast of Australia and/ or across Pacific Islands.

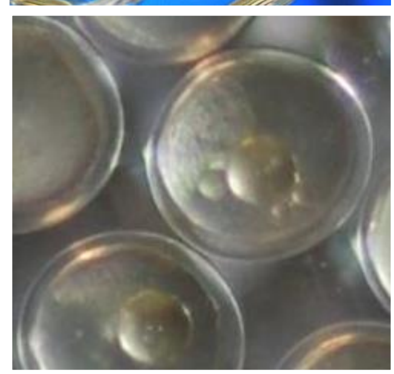
Aquatic Ecology and Evolution Laboratory

3. Connectivity, demography and stock size of Victorian pipis

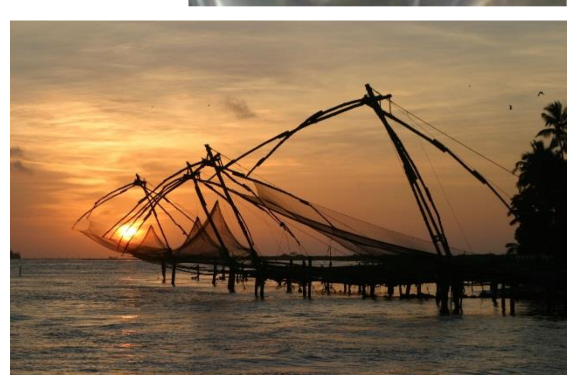
Sustainable fisheries management requires an understanding of how harvested populations are structured (population connectivity), and the spatio-temporal dynamics in their abundance and demography (assessed by monitoring). Previous work indicates that Australian pipi stocks consist of two large, reproductively isolated, groupings occurring on Australia's east and south coasts, however, we lack information on more relevant finer-scale stock structure. The project will determine the spatial and temporal patterns in harvestable pipi biomass on Victorian beaches, the recruitment potential of individual stocks, and potentially the connectivity among populations. Ultimately, the project will help identify pipi populations that can sustain ongoing commercial harvest, and those that are vulnerable to over-exploitation.

4. Exploring how river flow affects the diet and growth of native fish (with Dr Zeb Tonkin and Dr Wayne Koster, Arthur Rylah Institute)

The regulation of river flow is a widespread phenomenon across many of the major rivers in Southern Australia. Large dams capture winter rains and spring snow melt. This water is then released during summer, at a time when rivers are naturally meant to running low, for agricultural and domestic use. Regulation-induced alterations to the natural flow regime can pose challenges for native species that have evolved to high winter and spring flows and low summer flows. This project will explore the impacts of river regulation on river food webs and how this in turn affects the growth of larval and juvenile native fish. You will work closely with government scientists from the Arthur Rylah Institute to deliver fundamental research with clear applied outcomes.



For Further information, contact Dr John Morrongiello (john.morrongiello@unimelb.edu.au)



Our research focuses on four broad themes:
I. Habitat Restoration and Ecological Engineering: We develop solutions to pressing environmental challenges associated with habitat loss and modification in marine and freshwater ecosystems.
II. Fish and Fisheries Ecology: We study the early life-history stages of marine, estuarine, and freshwater fishes to understand how their populations are replenished and to identify the causes of variation in recruitment.
III. Eco-Evolutionary Dynamics: We explore the feedbacks between individual life-history trait evolution and the population dynamics of fish.
IV. Environmental Pollution: We investigate the impacts of chemical and light pollution on the biology and ecology of aquatic animals.

Multiple MSC projects are available for 2021.

1. ***Maximizing the benefits of aquatic habitat restoration for animals (with Dr Robin Hale, Arthur Rylah Institute)***

Biodiversity is declining globally, with habitat loss identified as one of the primary causes, so there is an urgent need to restore habitats. Despite significant investment, restoration often fails because target animals do not respond as expected and desired. Understanding why habitat restoration fails and how we might increase success rates are vital knowledge gaps. The goal of this project is to improve current understanding of why restoration efforts succeed or fail, and the underpinning mechanisms. It will focus on stream restoration for fishes with possible aims being to:
(1) Conduct empirical work to explore how a greater knowledge of habitat selection behaviour and fitness can improve restoration outcomes
(2) Experimentally test if increased fish population sizes are due to increased production or a simple redistribution of individuals.
Collectively, the results of the project will help us understand why restoration often fails to produce intended outcomes, and how future efforts could be better targeted. It will also help elucidate the drivers of successful restoration responses.

2. Impacts of culverts on fish movement in streams (with Dr Robin Hale and Dr Matthew Jones, Arthur Rylah Institute)

Connectivity is important for freshwater fishes, allowing them to complete all aspects of their life history linked with movement. However, habitat loss and fragmentation in streams and rivers is occurring globally. While the focus is often on the impacts of large structures (e.g. dams), smaller structures like culverts are more widespread and can also disrupt fish movement. While culverts can be physical barriers (e.g. being too steep or long for fish to traverse), they also change the light environment and thus can be behavioural barriers (e.g. fish avoid them if they are too dark). Understanding and managing the effects of the culverts is critical to ensure their impacts on fish movement are minimised.

The goal of this project is to better understand how changes to the light environment around culverts might disrupt fish movement, and how these impacts could be mitigated. Possible aims include:
- Determining the optimal light environment for movement of different fish species via field experiments; and
- Exploring how different fish species might respond to altered light environments.

3. Impacts of Artificial Light at Night (ALAN) on temperate reef fishes (with Drs Emily Fobert and John Morrongiello)

Artificial light at night (or ALAN) is a global driver of significant environmental change and loss of biodiversity, affecting the behaviour, physiology, reproduction, and survival of many terrestrial, freshwater and marine organisms. Currently, an estimated 22% of the world's coastal regions are exposed to artificial light at night and the impacts this has on the biological rhythms that have evolved under stable day/night, light/dark cycles are not well understood. This project will undertake a field research project to:
1. Quantify the degree of nocturnal light pollution in the coastal waters of Port Phillip Bay;
2. Evaluate whether there are differences in the composition of diurnally and nocturnally active fish assemblages among coastal habitats that vary in their level of exposure to ALAN; and
3. Assess whether species of fishes 'attracted' to ALAN exposed habitats suffer reduced or enhanced survival.

Contact: Prof Stephen Swearer (s.swearer@unimelb.edu.au) for more information.

The National Centre for Coasts and Climate

There is an emerging crisis in Australia, arising from the increasing concentration of economic and population centres in coastal areas. With climate change, sea levels are rising and coastal places are increasingly subject to flooding and inundation. Coastal flooding damages ecosystems and infrastructure, with flow-on effects to the economy, and impacts on the health, wellbeing and livelihoods of coastal residents. Our focus is on solutions-driven science that co-produces knowledge in conjunction with relevant stakeholders. Our students have the opportunity to produce research that has a direct relevance for coastal management in Australia.

NCCC
National Centre for Coasts and Climate

1. Shellfish reef restoration – informing future restoration efforts and assessing ecosystem services (with Dr Simon Reeves and Mr Simon Branigan, The Nature Conservancy)

Shellfish reefs, dominated by the native flat oyster *Ostrea angasi* and/or blue mussel *Mytilus galloprovincialis*, were once a key ecological feature of the Australian coastline. These shellfish reefs were also a dominant feature of Port Phillip covering up to 50% of the seafloor, however historical overfishing, compounded by poor water quality and increased sedimentation has decimated these reefs. Their loss removed a thriving ecosystem which provided many social and economic benefits to Melbournians. The restoration of shellfish reefs 'at scale' will provide new reef areas for many marine species (including recreationally important fish species), enhanced denitrification, natural water filtration and improved stabilisation of sediments.

Over the past four years, The Nature Conservancy (TNC) has led the Port Phillip Bay Shellfish Reef Restoration Project through developing the science from feasibility studies and in-water trials to deployment of 2.5 hectares of reef at Wilson Spit, Geelong Arm and Margaret's Reef, Hobsons Bay. This project continues later this year expanding the reef restoration to another two sites, providing an opportunity for continued research in collaboration with the University of Melbourne.

TNC have identified a number of areas of research that will contribute significantly to shellfish restoration efforts. Possible MSc research projects include:

A. Successful recruitment of shellfish to reefs is critical to sustain local shellfish populations. This project will investigate oyster and blue mussel larval behaviour to improve our understanding of drivers of settlement and recruitment, and inform better reef design and siting of restoration projects.

B. Restored shellfish reefs provide habitat for many marine organisms. Does the community supported by restored shellfish reefs differ from other existing habitats in PPB? This project will use stable isotopes to investigate how food web structure develops on restored shellfish reefs in comparison to other key habitats in PPB.

C. From monitoring surveys, large numbers of snapper have been observed utilising the restored reefs in Port Phillip. Are these fish resident on these reefs, or are they transitory? This project will use a combination of mark-recapture methods, otoliths and comparative analysis of gut contents to examine if these reefs are beneficial for fish production or attraction.

D. Shellfish reefs are renowned for their ability to positively influence biogeochemical cycling. Shellfish filter feeding enhances denitrification efficiency through greater connection between the water column and benthic sediments. However, the sediments in Port Phillip are also well known for their denitrification capacity and they play an important role in maintaining water quality. This project will compare biogeochemical cycling, between sediments and different ages of shellfish reefs to understand the role of shellfish reefs in Port Phillip Bay's denitrification ecosystem service.

Contact: Prof Stephen Swearer (s.swearer@unimelb.edu.au), Dr Rebecca Morris (rebecca.morris@unimelb.edu.au), Dr Emily Fobert (emily.fobert@unimelb.edu.au) or Dr Luke Barrett (luke.barrett@unimelb.edu.au) for more information.

2. ***Multifunctional aquaculture – wave attenuation of shellfish farms (a joint NCCC and SALTT project)***
Floating leases are used to grow mussels and oysters offshore in coastal areas. These offshore structures have the potential of providing a number of other services as well as aquaculture, one being coastal defence through wave attenuation. This project will use global data to determine the extent and distribution of shellfish aquaculture, combined with a field study that investigates the wave attenuation of mussel and oyster leases in Victoria and New South Wales.

Contact: Dr Rebecca Morris (rebecca.morris@unimelb.edu.au), Prof Stephen Swearer (s.swearer@unimelb.edu.au) or Prof Tim Dempster (dempster@unimelb.edu.au)

Coastal and Estuarine Adaptation Lab

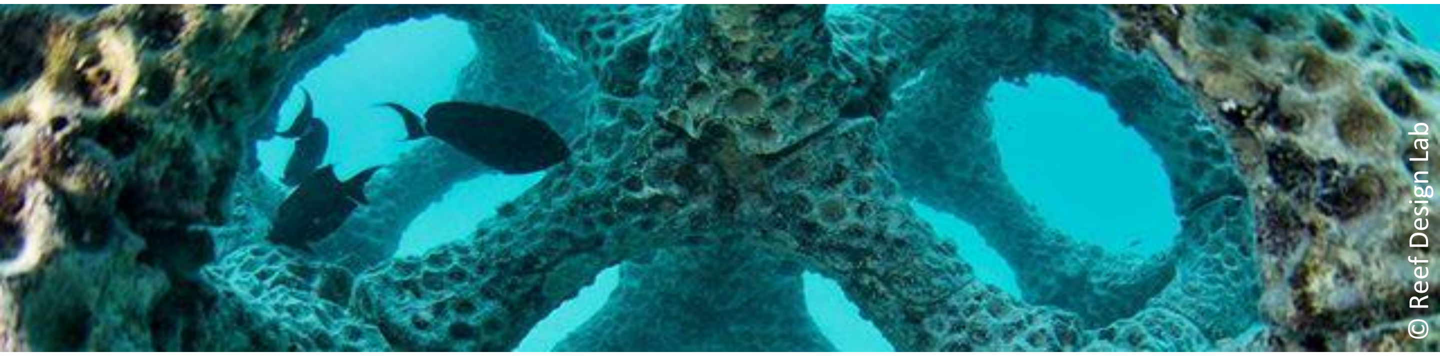
Climate change is increasing the risk of erosion and flooding to growing coastal communities and infrastructure. Nature-based coastal defences present an adaptive solution to protecting the coast into the future, as an alternative to traditional hard structures. Our research investigates when and where nature-based coastal defences can be successfully used, and how to design them for positive ecological and engineering outcomes. We work in interdisciplinary teams of ecologists, engineers and social scientists in close collaboration with end users to produce stakeholder-focussed science for coastal management.

1. Living revetments for enhancing urban biodiversity

Revetments are common structures for erosion control along our shorelines. These structures decrease shoreline complexity, which impacts biodiversity and ecological functioning. Introducing microhabitats into these structures can enhance their ecological value. This project will test methods for increasing the biodiversity of revetments using ecological engineering techniques.

2. *Multi-functional artificial reefs (with City of Greater Geelong Council and Reef Design Lab)*

Novel 3D printing technologies are allowing endless possibilities for the design of artificial reefs that can provide habitat, coastal defence and recreational amenity. This project can include a variety of different research pathways investigating the value of the reef structure for benthic assemblages or fish, wave attenuation and sediment dynamics, or recreation.



© Reef Design Lab

3. Where do shellfish like to live?

Shellfish reef living shorelines are being increasingly constructed globally as a sustainable method of shoreline protection. A critical piece of information needed to effectively create shellfish reefs is the optimum aerial exposure (amount of time a reef is out of the water during the tidal cycle) of a shellfish species. This information is unknown for the Australian native flat oyster and blue mussel. Further, the optimum aerial exposure is likely to change with change in climate. This project will involve field experiments manipulating aerial exposure and temperature to produce information that will be directly useful for shellfish living shoreline and restoration projects.

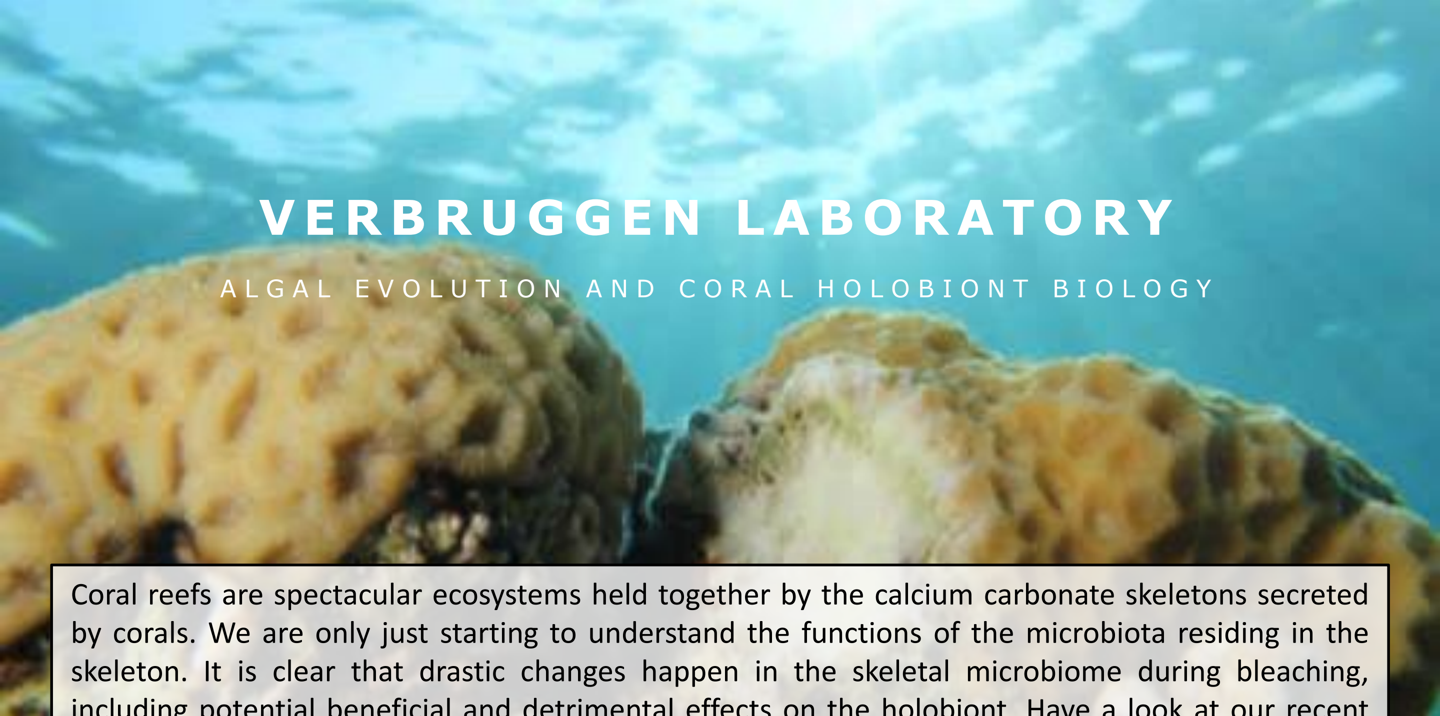
4. Spatial prioritisation of nature-based coastal defence under climate change (with Dr Rebecca Runting, School of Geography)

Nature-based coastal defence is a promising climate adaptation solution for shoreline protection. One barrier to it's wider implementation in Australia is information on where it would be appropriate to apply these solutions. This project will involve the use of spatial prioritization models to provide information on where it is appropriate to use nature-based coastal defence based on a number of ecological and environmental parameters, and how this may change under different climate change scenarios.

5. Barriers and opportunities for nature-based methods: policy and socialisation *(with A/Prof Anthony Boxshall)*

To more broadly implement nature-based methods for hazard risk reduction in Australia, we need to understand the ecological, engineering, and socio-political context in which they work. This project will use data from interviews with local, state and federal governments combined with questionnaires and interviews aimed at on-ground coastal managers and landowners to map the opportunities and barriers for nature-based coastal defence in Australia. This research will inform coastal adaptation planning into the future.

Projects can be tailored to a student's interest or there may be others available.
Contact: Dr Rebecca Morris (rebecca.morris@unimelb.edu.au) for more information.



VERBRUGGEN LABORATORY

ALGAL EVOLUTION AND CORAL HOLOBIONT BIOLOGY

Coral reefs are spectacular ecosystems held together by the calcium carbonate skeletons secreted by corals. We are only just starting to understand the functions of the microbiota residing in the skeleton. It is clear that drastic changes happen in the skeletal microbiome during bleaching, including potential beneficial and detrimental effects on the holobiont. Have a look at our recent review paper on the topic to learn more: https://doi.org/10.1186/s40168-019-0762-y

Our research aims to deliver better insight into this understudied skeletal side the coral holobiont. Several micro-environmental factors affect the distribution and activity of the endolithic microbial community, including light, pH and O_2. Almost all light is absorbed by Symbiodiniaceae in the coral tissue, and the remaining light penetrating the skeleton is almost devoid of the wavelengths typically used for eukaryotic photosynthesis, but the skeletal algae and bacteria have evolved far red-shifted absorption spectra. Most of the O_2 in the skeleton is produced through the photosynthetic activity of *Ostreobium*, a green alga. At night, the entire skeleton becomes anoxic.

Our work characterises the physico-chemical and microbial landscapes in the skeletons of healthy and bleached corals using a combination of chemical imaging to visualise O_2 and pH, hyperspectral imaging to map pigment distributions and metabarcoding to understand the spatial distribution of microbial species across the skeleton. An example of oxygen production imaged in the skeleton is shown on the right.

A project is available for Honours or MSc, aiming to map oxygen and pH dynamics during coral bleaching with chemical imaging. During bleaching, skeletal algae bloom in response to the higher light levels. Following coral mortality, reefs often get overtaken by turf algae (photo below) and for that habitat too, we wish to gain insight in oxygen and pH dynamics. Check the lab website (http://phycoweb.net) for more information and contact Francesco or Heroen if you are interested.