Climate Change Adaptation Research Grants Program
- Marine Biodiversity and Resources Projects

Project title:
Effects of climate change on reproduction, larval development, and population growth of coral trout (*Plectropomus* spp.)

Principal investigators: Dr Morgan Pratchett
Lead organisation: James Cook University

Objectives:

1. To assess sensitivities of coral trout to climate-related changes in temperature and seawater chemistry, during fertilisation and early larval development
2. To test the effects of increasing temperature and ocean acidification on growth, condition, behaviour and survivorship of early post-settlment coral trout
3. To test for spatial variation in sensitivities to increasing temperatures for coral trout in three distinct sectors along the Great Barrier Reef
4. To measure coral-dependence at different ontogenetic stages, to test whether coral trout will be adversely affected by climate-induced bleaching and coral loss

Methods:
Objective 1 – To assess consequences of climate change on reproduction by coral trout, select females within the brood stock currently maintained at the QDEEDI Northern Fisheries Centre, will be subject strip spawning during the reproductive season. On each occasion eggs from at least 2 different females will be mixed with sperm collected from 2 different males within 3 replicate containers for each treatment Initially fertilisation rate will be assessed under 4 different temperature treatments (low, normal, high and very high) at normal pH and 3 different levels of pH (low, medium, high) at normal temperature. Fish spermatozoids are immobile in the seminal fluid and are activated only after making contact with an aqueous medium, with physical-chemical factors (osmolarity, temperature, pH and ionic composition) having a key role in activating or modulating the flagella activity. These initial experiments focus on the effect of temperature and pH on sperm activation and fertilisation. Subsequent experiment will assess fertilisation rate using selected combinations of these different treatments (normal, low impact, high impact) as determined by pervious experimental results. Fertilisation rates will be assessed by fixing eggs within each replicate 1 hour post sperm activation once onset of cellular division is significant (typically at 4-6 cell stage) and a total count of fertilised/unfertilised eggs.

Developmental effect prior to hatching will be assessed against the same temperature, pH and combination of treatments as above. On each occasion eggs from at least 2 different females will then be mixed with sperm collected from 2 different males under each treatment variable. Then after 1 hour post activation only fertilised eggs (rafting) will be selected from each treatment, placed into three replicate container (120 eggs each) and monitored for development over the next 24 hour period. A sub-sample of 10 eggs will be fixed at 1 hour post activation, then every 2 hours thereafter. Environmental treatments to be used in these experiments are intended to resolve both optimal conditions (relevant to aquaculture production) as well as assessing effects of adverse conditions associated with changes in environmental conditions due to ongoing climate change on the Great Barrier Reef by 2050. This information is critical for assessing the severity and immediacy of climate impacts on both captive stock held in open systems and fisheries production in wild populations.

Objective 2 – Climate-related changes in temperature and seawater chemistry are likely to have the significant impact on larval stages for coral trout, both because this is when they are most vulnerable, but also because they are directly exposed to oceanic environmental conditions during the pelagic larval stage. The early larval stages of coral trout has both an endogenous (yolk reserves) and

exogenous (active feeding) nutrition phases. This critical transition occurs three days after hatching, coincidning with the mouth opening. Impediments on development or nutrition during this transition results in starvation as maternal nutrition is exhausted by six days post hatching. Cohorts of coral trout will be cultured across 4 different temperature regimes, to identify optimal temperatures and also assess consequences of further increases in temperature for growth, development, food consumption and survival during early larval stages.

These experiments will be conducted at the QDEEDI Northern Fisheries Centre, under direction of Reynolds and Knuckey, as well as dedicated staff from QDEEDI-NFC that are employed on this project.

Similarly, larvae will be reared at three levels of pH, reflective of current and expected future levels of ocean acidification, testing for effects on growth, development, behaviour and survival. Prior research with anemone fishes has shown that ocean acidification may reduce olfactory discrimination, which is critical in detection of reefs and appropriate habitats during settlement (Munday et al. 2009 - PNAS).

It is unknown, however, whether this finding applies to all fishes (especially, important fisheries species), and so we will repeat these experiments with larval coral trout. The team of researchers at JCU has pioneered techniques to test olfactory discrimination, and has already conducted a pilot study that confirmed that larval trout will be amenable to these behavioural tests.

Objective 3 - Thermal tolerances can be adapted to the local thermal environment across a species geographic range (Angilleta 2009). Even where gene flow between populations leads to genetic homogenization, individuals can acclimate to different temperatures among locations. In aquatic systems, keeping pace with increased oxygen demand is the key parameter affecting species' response to higher temperatures (Portner and Farrell 2008 - Science). Therefore, thermal reaction norms of respiratory performance can be used to test for local adaptation to different thermal environments (Portner and Knust 2007 - Science, Gardiner et al. 2010- PloS One). The potential for adaptation of coral trout to different thermal environments will be tested by sampling individuals from populations on the northern, central and southern Great Barrier Reef. Populations at these three locations experience average summer temperatures that differ by approximately 2°C. Individuals at each location will be acclimated in replicate aquariums to temperatures from 27-33°C. This encompasses the range of summer temperatures currently experienced among the locations, plus temperatures that could be experienced in the future under climate change scenarios (Lough 2008 - Geophysical Research Letters). Closed system respirometry will then be used to estimate resting and maximum rates of oxygen uptake across this temperature range at each location (Nilsson et al. 2009- Global Change Biology). Local adaptation among populations would be indicated by aerobic scope for activity (maximum oxygen uptake – resting oxygen uptake) varying in a manner consistent with variation in local thermal environments. The absence of local adaptation would be indicated by similar patterns of aerobic scope at each location. The sensitivity of each population to increasing ocean temperature will be assessed by comparing the rate of decline in aerobic performance with increasing temperature beyond current-day averages (Nilsson et al. 2009 - Global Change Biology, Gardiner et al. 2010 - PloS One). Furthermore, tissue samples will be taken from all sample individuals to test for variation in expression of Lactate Dehydrogenese (Ldh-B), which is a candidate gene for local thermal adaptation (Van Herwerden et al. unpublished data)

The relationship between scope for activity estimated by respirometry and changes in fundamental life-history traits, such as growth rate, will be determined by rearing fish from the central Great Barrier Reef at 4 different temperatures across the experimental temperature gradient (27, 29, 31, 33°C). Juveniles collected from the Orpheus Island region will be reared in environmentally controlled rearing facilities at James Cook University's Research Aquarium Complex for a period of 3 months. The functional relationship between respiratory performance and growth rate will then be used to predict relative changes in growth at all the locations given equivalent food supply.

Objective 4 - Critical resource requirements of coral trout will be assessed based on patterns of habitat use at various stages of habitat degradation and recovery following climate-induced coral bleaching. Key habitat requirements of newly settled and juvenile coral trout are currently unknown, though preliminary findings from initial field surveys have revealed that juvenile coral trout tend to be found in close association with individual coral colonies located over sand or rubble. Further tests are required to establish the relative importance of biological versus physical characteristics of these habitats. If however, juvenile coral trout are obligately dependent upon live corals at any stage in their life-history, this will make them vulnerable to climate change (Pratchett et al. 2008 - Oceanogr Mar Biology Ann Rev). Similarly, if coral trout depend on prey fishes that are themselves dependent on live corals (e.g., coral-dwelling damselfishes) then these trophic linkages may make coral trout vulnerable to ongoing climate change. Field sampling, and collections of fishes for tests of thermal tolerance, will be conducted by Dr Morgan Pratchett, and a current PhD student, Mr Colin Wen. Field-based studies will be organized and co-ordinated dedicated research officer (V. Messmer) employed on this project