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

Project title:
Vulnerability of an iconic Australian finfish (Barramundi, *Lates calcarifer*) and related industries to altered climate across tropical Australia

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Lead organisation: James Cook University

Objectives:

1. Define current thermal tolerances and associated physiological/energetic consequences of thermal adaptation in genetically divergent barramundi stocks across tropical Australia.
2. Develop predictive models incorporating new physiological and genetic data with available population genetic, environmental and fisheries data to identify vulnerable wild stocks and associated stakeholders under realistic climate change predictions. Opportunities for expansion of fisheries and aquaculture will be determined.
3. Establish genetic basis of thermal tolerance differences through identification of candidate thermal tolerance related genes within functionally/genetically divergent stocks. These candidate genes can be used as biomarkers for the aquaculture industry in the identification of fish with genetic tolerance to thermal stress.
4. Quantify parasite impacts on sea-cage barramundi under different temperature, pH and salinity and develop adaptive management strategies to minimize impacts under altered climate change scenarios.

Methods:

General

Wild barramundi from five Qld and NT genetic strains will be collected using electrofishing by DEEDI. Here local consultation will be used to identify lagoons and riverine areas where fish between 15-30 cm can easily be targeted. We will endeavour to collect up to 50 fish per strain. Fish will be transported back to the Marine and Aquaculture Research Facility at James Cook University using JCU and DEEDI fish transporters. Activities 2 and 3 will use these wild fish in the experiments outlined below.

Activity 1 – Probabilistic climate change impact modelling

Climate change is occurring with little (but increasing) understanding of how such changes may influence natural and anthropogenic systems; here we are exploring the potential impacts of climate change on a) wild populations of barramundi and the corresponding fishery, and b) pond-based aquaculture industry. The project seeks to inform conservation and adaptation strategies to ensure the long-term persistence of viable populations of wild barramundi, while sustaining active commercial and recreational fisheries. Knowledge of where the species occurs, population levels, life-history attributes, genetic structure both neutral and adaptive, and physiological limits will be used to inform models recreating current spatial patterns of distribution and abundance of wild stocks. Such knowledge will come from a variety of sources (e.g., catch reports, published literature, expert opinion) including other activities defined here. The models will then be projected into the future based on IPCC scenarios to provide a probabilistic assessment of sustainability of the wild barramundi fishery. Further, this information will assist in assessing when & where pond-based aquaculture will be suitable for different genetic stocks, now and into the future. Modelling activities will focus around two components.

Activity 2: Functional genetic population structure and determination of strain upper thermal tolerance

Varying degrees of genetic structure have been reported between Australian barramundi populations but the biological/physiological and evolutionary consequences of such structure have been debated but not rigorously tested. New advances in the emerging field of landscape genetics facilitate the incorporation of population genetic data with environmental or landscape data and offer a valuable framework for testing the influence of site-specific environmental factors (such as temperature, rainfall, connectivity of habitat) on geographical patterns of adaptive variation in ways that were previously impossible (Sork and Waits, 2010). Landscape genetics also provides a powerful interdisciplinary new approach for assessing the potential of populations to respond to climate change (see for example Sork et al 2010).

Past genetic studies of barramundi in Australia have utilised only neutral genetic markers (i.e. those not under the effects of directional selection) and while these prior studies provide valuable insights into population processes such as gene flow and genetic drift, important signals of functional genetic divergence (potential local adaptation) have gone unexamined. Recent finfish studies (e.g. Andre et al 2010, Hemmer-Hansen et al 2007) have highlighted that substantially higher levels of stock structure, and evidence of localised adaptation, can be revealed even in high gene flow species, through examination of non-neutral markers (candidate genes). The incorporation of candidate gene markers into the landscape genetics framework enables a sophisticated examination of environmental associations with functional genotypic variation and can identify potentially selected gene markers (see for example Eckert et al 2010).

This approach simultaneously allows the identification of key climate variables underlying genetic gradients that may be subject to climate change impacts. We will apply high resolution genetic markers that are both neutral (i.e. microsatellites) and potentially selected, (i.e. candidate gene markers) to barramundi samples collected over a broad geographic area and will incorporate this data into a landscape genetics approach to redefine stock structure in this species and identify key environmental and landscape factors influencing barramundi genetic structure. This information will be incorporated into climate change models as outlined in Activity 1 to assess the vulnerability of defined genetic stocks. The data will be used to inform fisheries managers and associated stakeholders on genetic stock boundaries, environmental variables affecting those boundaries and climate-change vulnerable areas of the fishery so that the need for stakeholder adaptation (future relocation of fishing effort, possible need to change target species) or fishery conservation strategies (restocking, reduced fishing pressure) can be identified. The population genetic data collected and candidate gene SNP panel will be particularly valuable for identifying appropriate stocks for consideration in future restocking programs and aquaculture ventures in climate change sensitive locations. The development of new candidate gene markers also provides a valuable new genotyping resource for broader applications such as parentage assignment and future broodstock selection in this important tropical finfish species.

Activity 3: Physiological indicators and bioenergetic modeling under different climate change Scenarios

This experiment will provide key information on the thermal limitations of aerobic capacity in five reproductively isolated barramundi stocks. In particular, it will address the question of the potential severity of climate change on loss of aerobic performance and fitness through a narrowing of thermal tolerance. The earliest indication of thermal stress is a reduction in the capacity to perform aerobically (i.e. a reduction in aerobic scope). Knowing the potential magnitude of this reduction across these isolated stocks is critical as it will be the first process to bring about latitudinal range shifts and/or reductions in fitness. Results from Activity 3a will generate metabolic data that will feed into modelling (i.e. a reduction in aerobic scope). Knowing the potential magnitude of this reduction across these isolated stocks is critical as it will be the first process to bring about latitudinal range shifts and/or reductions in fitness. Results from Activity 3a will generate metabolic data that will feed into modelling components of Activity 1. Additionally, identification of populations of barramundi that have a lower thermal dependence on their metabolic rate, or that exhibit wider aerobic scope, under climate change scenarios, will provide possible adaptation options for aquaculture/restocking, as there is accumulating evidence that thermally tolerant fish cope better with thermal stresses and associated susceptibility to diseases.