# Engagement and Impact 2018

## James Cook University

## JCU06 (HLS) - Impact

## Overview

**Title**

*(Title of the impact study)*

Building a globally important aquaculture industry through understanding the complex genetics of barramundi

**Unit of Assessment**

06 - Biological Sciences

**Additional FoR codes**

*(Identify up to two additional two-digit FoRs that relate to the overall content of the impact study.)*

**Socio-Economic Objective (SEO) Codes**

*(Choose from the list of two-digit SEO codes that are relevant to the impact study.)*

83 - Animal Production and Animal Primary Products

**Australian and New Zealand Standard Industrial Classification (ANZSIC) Codes**

*(Choose from the list of two-digit ANZSIC codes that are relevant to the impact study.)*

02 - Aquaculture

**Keywords**

*(List up to 10 keywords related to the impact described in Part A.)*

Aquaculture

Barramundi

Genetics

Selective breeding

Genetic diversity

**Sensitivities**

Commercially sensitive

No

Culturally sensitive

No

**Sensitivities description**

*(Please describe any sensitivities in relation to the impact study that need to be considered, including any particular instructions for ARC staff or assessors, or for the impact study to be made publicly available after EI 2018.)*

**Aboriginal and Torres Strait Islander research flag**

*(Is this impact study associated with Aboriginal and Torres Strait Islander content?*
*NOTE - institutions may identify impact studies where the impact, associated research and/or approach to impact relates to Aboriginal and Torres Strait Islander peoples, nations, communities, language, place, culture and knowledges and/or is undertaken with Aboriginal and Torres Strait Islander peoples, nations, and/or communities.)*

No

**Science and Research Priorities**

*(Does this impact study fall within one or more of the Science and Research Priorities?)*

Yes

| Science and Research Priority | Practical Research Challenge |
|---|---|
| Food | Enhanced food production |

# Impact

**Summary of the impact**

*(Briefly describe the specific impact in simple, clear English. This will enable the general community to understand the impact of the research.)*

An Australian company has become a world leader in the farmed barramundi market as a direct result of JCU research to understand barramundi's unique reproductive characteristics in aquaculture breeding programs. Mainstream Aquaculture Pty Ltd has gone from a small company with a co-located barramundi hatchery and R&D facility based on wild founder broodstock to the world's largest supplier of high-quality, genetically improved barramundi fingerlings. The company's business model is based on having complete control and provenance of broodstock pedigrees and exploiting genetic diversity. Its ability to do this was made possible by JCU applied biology research that elucidated the complex genetics of barramundi, thereby unleashing the fish's genetic potential.

**Beneficiaries**

*(List up to 10 beneficiaries related to the impact study)*

Mainstream Aquaculture Pty Ltd

Most of Australia's largest Barramundi aquaculture companies, such as Pejo Industries, Humpty Doo Barramundi, King Reef Barramundi and Marine Produce

barramundi aquaculture firms in 24 countries e.g. Canada, China, India, Indonesia, Israel, Japan, Malaysia, Singapore, Thailand, UAE, UK, USA, Vietnam

Melbourne restaurants who purchase Mainstream Aquaculture's live product.

**Countries in which the impact occurred**

*(Search the list of countries and add as many as relate to the location of the impact)*

**Details of the impact**

*(Provide a narrative that clearly outlines the research impact. The narrative should explain the relationship between the associated research and the impact. It should also identify the contribution the research has made beyond academia, including:*
*- who or what has benefitted from the results of the research (this should identify relevant research end-users, or beneficiaries from industry, the community, government, wider public etc.)*
*- the nature or type of impact and how the research made a social, economic, cultural, and/or environmental impact*
*- the extent of the impact (with specific references to appropriate evidence, such as cost-benefit-analysis, quantity of those affected, reported benefits etc.)*
*- the dates and time period in which the impact occurred.*

*NOTE - the narrative must describe only impact that has occurred within the reference period, and must not make aspirational claims.)*

Barramundi is a mass spawning species and as a consequence maintaining pedigree information throughout the

breeding and subsequent production process is difficult. Without the potential to track pedigree and link it to an individual's performance, identifying superior broodstock and selecting them for genetic improvement is not possible, and this places limits on the commercial development of barramundi aquaculture.

Aquaculture researchers at James Cook University (JCU) have been working with Mainstream Aquaculture Pty Ltd, based at Werribee in Victoria, since 2006. The researchers have contributed to helping the company maintain the genetic diversity of its fish, while at the same time developing new genetic technologies that will improve its ability to select high performing bloodlines and begin an industrial scale selective breeding program. All genetic tool development and research data analyses were performed at JCU.

Mainstream Aquaculture is an Australian-based premium producer of barramundi for both domestic and international markets. It has a production capacity of 70+ million fingerlings (juvenile fish) and also produces 600 tonnes p.a of plate-sized barramundi for the Melbourne restaurant market. Research to bring the company to this point has required unravelling the environmental causations and genetic mechanisms that make this highly desirable species so difficult to farm. JCU's project with Mainstream has attracted two ARC Linkage Program grants, in 2009 and 2013, along with a Cooperative Research Centre Project (CRC-P) grant in 2017.

Investments in broodstock and hatchery management have diversified the company's business to include the sale of fingerlings to over 20 countries. However, a poor understanding of infertility problems in the broodstock results in highly unpredictable spawning rates that lead to a sudden inability to supply industry demand for seed stock. Fixing this problem greatly assists growth in this side of the business.

The scientific challenges of this work are significant. Barramundi breeding programs to boost the productivity and international competitiveness of aquaculture businesses are hindered by a lack of reproductive control. Barramundi change sex from male to female at 3-5 years of age, requiring hatcheries to maintain male broodstock for several years before they can be bred as females. This increases required infrastructure and decreases the rate of genetic improvement that can be achieved.

JCU research on barramundi genetics has been able to elucidate the genetic mechanisms regulating barramundi sex change and develop approaches allowing hatcheries to efficiently control broodstock sex. At JCU, the barramundi genome was sequenced and markers indicative of sex genes and their expression identified, along with use of hormonal regulation. Targeting these genes through environmental manipulations has resulted in the production of precocious (early) sex maturing females. This ability to obtain reproductive control in barramundi is having a dramatic impact on the aquaculture industry, and particularly Mainstream Aquaculture, by removing the major impediment to establishing efficient breeding programs.

Mainstream has had an R&D relationship since 2006 with JCU on barramundi genetics. However, inconsistent reproductive performance of broodstock is a major constraint to the business and is driving a change in direction for its R&D investment. As part of that shift, Mainstream is establishing a new partnership at JCU to take advantage of reproductive expertise held by JCU researcher Dr Damien Paris from the Discipline of Biomedicine in the College of Public Health, Medicine and Veterinary Science (CPHMVS). The company has contributed $40,000 cash and $90,000 in-kind to the most recent project in 2017. This new agreement broadens the scope of current collaborations by CPHMVS into new and emerging food production industries, tipped to be the core driver of development in Northern Australia, and further entrenches JCU's ongoing and highly fruitful relationship with Mainstream.

The managing director of the company, Mr Boris Musa, said: "Mainstream Aquaculture has enjoyed a successful collaboration with James Cook University for over a decade. Since 2007 we have completed multiple projects primarily focused on accelerating our world leading selective breeding program, many of which have involved experimental work at a co-located research and development facility located at the university campus using human resources, infrastructure and intellectual property from both partners. The research and development conducted with James Cook University remains central to sustaining Mainstream Aquaculture's competitive advantage and underpinning our growth. During the period in which we have worked with James Cook University, we have become one of the largest suppliers of Barramundi table fish in Australia using our revolutionary land based aquaculture technology and the largest supplier of improved Barramundi fingerlings to the world, with exports into 24 countries across 5 continents."

**Associated research**

*(Briefly describe the research that led to the impact presented for the UoA. The research must meet the definition of research in Section 1.9 of the EI 2018 Submission Guidelines. The description should include details of:*

*- what was researched*
*- when the research occurred*
*- who conducted the research and what is the association with the institution)*

JCU's R&D relationship with Mainstream Aquaculture resulted from initial investment in 2003-4 by the University in aquaculture-related research, in particular work on developing molecular based tools to assay genetic diversity and determine parentage. This investment came in the form of several career-development grants of around $40,000 and a large investment by the University of $667,500 in the form of a Research Advancement Program (RAP) grant.

These grants enabled the development of the first DNA based parentage suites for barramundi, and also funded the first studies into how the mass-spawning behaviour of barramundi in hatcheries captured and retained genetic diversity relevant to the future of selective breeding programs. The molecular platforms and understanding of mating behaviour and its effects on genetic diversity generated by these early research studies later were the core knowledge base that Mainstream Aquaculture relied on in future R&D projects.

JCU aquaculture has also used barramundi as its primary teaching and research model since 1995, during which numerous experiments have been conducted on nutrition, survival and water quality impacts on the species culture. This internally funded research has positioned JCU as the world-leader in barramundi related R&D.

**FoR of associated research**

*(Up to three two-digit FoRs that best describe the associated research)*

06 - Biological Sciences

**References (up to 10 references, 350 characters per reference)**

*(This section should include a list of up to 10 of the most relevant research outputs associated with the impact)*


Domingos, J., Zenger, K.R. and Jerry, D.R. (2015). Whole-genome shotgun sequence assembly enables rapid gene characterization in the tropical fish barramundi, Lates calcarifer. Animal Genetics 46(4), 468-469

Loughnan, S.R., Smith-Keune, Jerry, D.R., Beheregaray, L.B., Robinson, L.A. (2015). Genetic diversity and relatedness estimates for captive barramundi (Lates calcarifer, Bloch) broodstock informs efforts to form a base population for selective breeding. Aquaculture Research DOI: 10.1111/are.12807

Thepot, V. and Jerry, D.R. (2015) The effect of temperature on the embryonic development of barramundi, the Australian strain of Lates calcarifer (Bloch) using current hatchery practices. Aquaculture Reports, 2, 132-138.

Domingos, J.A., Smith-Keune, C. and Jerry, D.R. (2014). Early prediction of long-term family growth performance based on cellular processes - a tool to expedite the establishment of superior foundation broodstock in breeding programs. Aquaculture 428-429, 88-96.

Newton, J.R., Zenger, K.R. and Jerry, D.R. (2013). Next-generation transcriptome profiling reveals insights into genetic factors contributing to growth differences and temperature adaptation in Australian populations of barramundi (Lates calcarifer). Marine Genomics 11C, 45-52

Domingos, J.A., Smith-Keune, C.S.K., Robinson, N., Loughnan, S., Harrison, P.J. and Jerry, D.R. (2013)

Heritability of harvest growth traits and genotype-environment interactions in barramundi Lates calcarifer (Bloch). Aquaculture 402, 66-75.

De Santis, C., Gomes, G., and Jerry, D.R. (2012). Abundance of myostatin gene transcripts and their correlation with muscle hypertrophy during the development of barramundi, Lates calcarifer. Comparative Biochemistry and Physiology part B, 163, 101-107.

Newton, J.R., De Santis, C., and Jerry, D.R. (2012). The gene expression response of the catadromous perciform barramundi (Lates calcarifer) to an acute heat stress. Journal of Fish Biology 81, 81-93.

Domingos, J.A., Fromm, P. Smith-Keune, C and Jerry, D.R. (2012). A robust flow cytometric protocol for assessing growth rate of hatchery reared barramundi Lates calcarifer larvae. Journal of Fish Biology 80, 2253–2266.

# Additional impact indicator information

**Additional impact indicator information**

*(Provide information about any indicators not captured above that are relevant to the impact study, for example return on investment, jobs created, improvements in quality of life years (QALYs). Additional indicators should be quantitative in nature and include:*
*- name of indicator (100 characters)*
*- data for indicator (200 characters)*
*- brief description of indicator and how it is calculated (300 characters).)*