NMSP WP – Food Security – Aquaculture

a. Abstract

Aquaculture is the fastest growing food production sector globally, with an annual growth rate of 8%, and currently supplies 50% of total seafood for human consumption. Demand and price for aquatic products are projected to continue rise. Australian aquaculture industry is relatively small by global standards (~$1 billion 2012-13) – but this need not be. Investment in R&D addressing the technological bottlenecks to production - including new species - husbandry and reducing the sector's environmental footprint and simultaneously improving its economic viability is needed. This would increase production and improve Australia's reputation and services for aquaculture technology and respond to the increasing global demand for high quality seafood. Additionally, aquaculture economic development opportunities for Indigenous Australians as well as addressing nutritional and food security for remote communities.

b. Background

Efficiency of aquaculture

- Aquaculture is one of the most efficient systems for converting feed into high quality food (e.g. 4 times more efficient than beef).
- Aquaculture can have a smaller environmental footprint than other livestock systems (e.g. lower carbon, nitrogen and phosphorus emissions per kg production; low freshwater requirement)
- Aquaculture in Australia is focused in regions which are both local enough to be managed and large enough to have a critical mass of stakeholders and investment (e.g. Tasmania and SA). They provide opportunity to lead world's best practice for whole of system approaches
- Australia has unique opportunities around R&D: Tasmania is a global climate change hot spot and is leading science including selective breeding; disease free status of several industries and potential to stock global hatcheries; world leading research depth across institutions in key fields.

***Australian aquaculture R&D capabilities**:* New technology and species production (State Governments, Universities), Environmental assessment and mitigation (State Governments, Universities), Applied breeding and quantitative genetics (CSIRO, Universities, State Governments), molecular genetics (CSIRO, Universities, State Governments), bioinformatics and genomics (CSIRO, Universities), virology and immunology (CSIRO, Universities, State Governments), physiology and general biology (CSIRO, Universities), nutrition and feed technologies (CSIRO, Universities, State Governments), microbiology (CSIRO, Universities, State Governments), bioactive (CSIRO, Universities), sensor based technology and decision support systems (CSIRO, Universities), integrated ecosystem and multiple-use management across sectors including aquaculture (CSIRO, Universities, State Governments) {see Capability audit - http://frdc.com.au/research/RDEPlanningandPriorities/Pages/RDE-Planning-2015-2020.aspx }

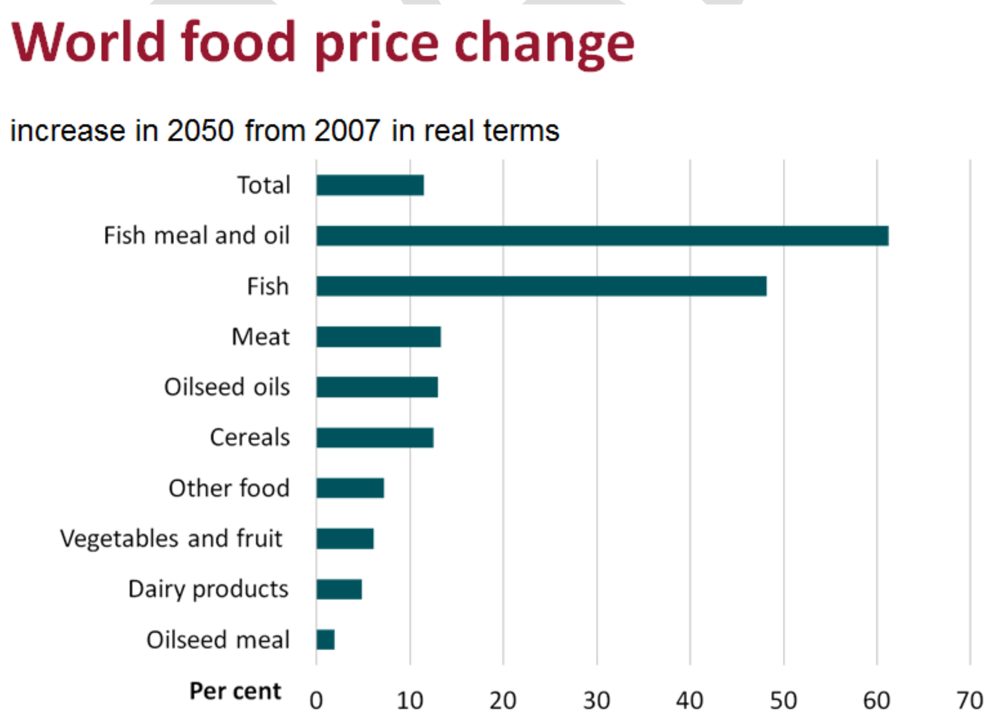
Depth and maturity: Australia's state government aquatic science institutes have a long history of supporting aquaculture expansion, from the development of the Sydney Rock Oyster sector to the last 40 years of R&D to develop the Tasmanian Atlantic Salmon farming sector. Twenty seven universities in Australia have capacity and capability in aquaculture with many playing leading roles both domestically and internationally. Universities play a role in both basic and applied science; fish health being an example of the latter. CSIRO has the largest single capacity and capability – it leads many aquaculture science disciplines including: genetics, feed development and fish health, biosecurity and ecosystem based management (where aquaculture is one of many competing uses of coastal ecosystems).

Reputation and Performance Australian aquaculture R&D: Overall there is a significant lack of data to quantify Australia's research intensity for aquaculture and measures of performance. Both JCU, and University of Tasmania rank 4 in the ERA for fisheries science, and Deakin University, Flinders University and Murdoch University rank 3 in the ERA 2012 for fisheries science – However, there is no specific ranking within ERA for aquaculture. Australia's qualitative reputation is high in specialist areas. For example in aquatic fish health and nutrition. Further, most states and the northern territory have excellent modern aquaculture research facilities. There is a gap in research facilities for large fish science (production and health) and offshore systems.

Funding agencies for aquaculture research include: FRDC, RIRDC, ACIAR, AusAid, World Bank, Australian seafood CRC, Department of Industry, ARC

c. Relevance

The Australian Department of Agriculture estimates that only 2-5% of the Australian population is currently affected by food insecurity, and that Australia in fact produces sufficient food to sustain a population of 60 million (http://www.daff.gov.au/nationalfoodplan). This would suggest that food security will not be an acute issue in this country for some time to come, but external influences such as climate change, regional conflict and an uncertain economic future can bring forward what would otherwise have been considered only a long-term issue.



(Source ABARES)

Australia's location adjacent to world's largest market for seafood, and the southeast Asian region's predicted growth provides significant opportunity to produce seafood to support this demand and services for aquaculture growing in this region. It is significant of the major food sources, aquatic products are predicted to have the largest real price increase (see Figure above).

In summary the end-users will be the industry producers, regulators and our Asian and Pacific neighbours.

d. Science needs

key science gaps/needs/challenges:

Many of the easy advances in aquaculture production have been made. The next 20 years will require investment in multi-disciplinary science to solve technologically difficult and scientifically challenging problems that offer significant jump changes in aquaculture and advances in integrated management to ensure sustainable aquaculture in an increasingly competitively used marine environment.

Farming Systems:

- Environmental engineering and production system science for low footprint (enclosed), offshore and
- Overcoming constraints on the expansion of sustainable intensive aquaculture: sites; freshwater; markets; regulation; investment;
- Application of digital science to production and environmental monitoring – sensor etc
- Automation of farming systems
- Feasibility of semi-intensive aquaculture: e.g. low trophic level species; polyculture; algae for food and feed ingredients; freshwater fishes; integrated multi-trophic aquaculture (IMTA).
- Evaluation of enhancement strategies: restocking; translocation; management of environment e.g. artificial reefs

Societal Values:

- Quantitative indicators for assessing farming impact and multiple use interactions and cumulative impacts
- Development and retention of human capital across all parts of the sector including R&D, succession and fluid nature of career pathways (e.g. science to management).
- Biosecurity: e.g. monitoring; escapees; control of invasive pests and infectious disease management;
- Managing Climate Change impacts
- Seafood quality and value of Australian seafood versus imported seafood
- Animal Welfare in relation to domestic and international markets

Certification schemes Production Technologies:

- Optimising the use of all potential feed ingredients based on sustainability and societal values: e.g. alternatives to marine sources, the use of GMO products, product quality and human health.
- Advanced technologies in controlled breeding
- Integration of innovative advances in production technology with biology and commercialisation: e.g. recirculation aquaculture systems; off-shore farming; harvesting and product quality; hatchery systems; biotechnological solutions to vaccines, reproduction and genetic breeding.

- Need for small scale, low maintenance production systems for Indigenous communities utilising key traditional target species
- Strategic approach to the Identification and route to commercialisation for new species
- Greater use of information technology in aquaculture production to access real time data for production, health and environmental management, production chain management and lifecycle analysis
- Shift research paradigm to large scale whole of chain research and integration across R&D disciplines such as technology, biology, and food science and marketing.

Key outcomes/ national benefit:

5 Year Horizon

- Commercialisation of at least one new aquaculture species production (eg Yellowtail Kingfish, Cobia)
- Strengthen biosecurity, and foster new links with energy technology, product development, packaging and cold-chain opportunities.
- Development of information technology that incorporates bio-sensors and farm management decision tools.
- Expand activities in applied breeding programs, including the move into the ‘omics’ domain (managing and applying metadata) and integration with other domains (physiology and health).
- Expand activities in nutrition and feed technologies; in particular, fishmeal and fish oil alternatives; and closer linking of health and nutrition.
- Improved public support for the sustainability of aquaculture and improved understanding of aquaculture associated trade-offs in strategic marine planning and spatial management.
- Development of a small scale, low maintenance production systems for Indigenous communities utilising key traditional target species

10 Year Horizon

- Increased activities in the application of sensor technologies for animal welfare and monitoring and controlling production environments
- Further establishment of new aquaculture systems being developed overseas, including offshore aquaculture, multi-trophic integrated aquaculture (MTIA), and on-land recirculating aquaculture systems (RAS).
- Increased automation of farming and harvesting systems
- Establishment of novel preventive health management technologies –including vaccines and integrated breeding.
- Improved biosecurity technologies for detection and control.

- Improved integration of aquaculture into the management of all sectors active in the marine and coastal zones.
- Climate change impacts being managed effectively through the development of new species; selective breeding of current species and changes in technology used to growth them.
- Australia dominates world supply of disease free stocks of several key species e.g. salmonids; prawns and lobsters.
- Integrated sector leadership underpins integrated approach to R&D and adoption, research mainly done by large multi-discipline teams located across world leading organisations.
- Strong societal support for industry achieved through whole of system approaches to sensitive issues including animal welfare and multiple use of environment. Research underpins decision making and informs debate on values.

20 Year Horizon

- Close lifecycle of high value difficult to produce endemic species
- Increased aquaculture production to meet more of domestic market and increased export in niche areas where Australia has a competitive advantage. Aquaculture based on a 'whole of system' approach using shared values.
- Develop a 'whole of system' approach by integrating current capabilities with enhanced capabilities in aquaculture systems (open ocean, closed containment, recirculation), production environment monitoring and management (nutrient dynamics, ecosystem health and integrated adaptive multiple use and ecosystem based management).

e. Perspective

Key drivers and opportunities:

- Aquaculture is playing an increasingly important role in global food production and food security. It is the fastest growing food production sector in the world, with an annual growth rate of 7%, and now supplies 50% of total fish and shellfish for human consumption.
- Globally, the industry will need to produce and additional 40 million tonnes of aquatic food per year by 2030 just to maintain the current per capita consumption. The demand will be higher still if the current flat trajectory of wild capture fish production is persistent into the long term.
- The Australian aquaculture industry has an annual growth rate of 6% (albeit from a small base). Atlantic salmon is now Australia's most valuable seafood industry (>$500 M), with an aggressive growth trajectory to double by 2030 (if suitable climate resilient locations can be found). Farmed oysters, abalone, mussels, prawns and barramundi sectors are all increasing production. The Australian aquafeed sector is keeping pace with the growth of the industry by increasing domestic production. It is also taking advantage of CSIRO's new aquafeed technology to penetrate the global aquafeed market, the largest aquafeed market in world.

- Although the aquaculture industry is growing, Australia currently imports 60% of its seafood. There is an opportunity for a step-change in the sustainable growth of Australian aquaculture. This would increase Australia's self-sufficiency in seafood and enable the industry to respond to the increasing demand for high quality seafood from Asia.
- There is a now critical need and opportunity to further integrate Australia's aquaculture research capabilities in; genetics, health, nutrition, biotechnology and feed technology, welfare, biosecurity, energy efficiency, production systems, supply chain and environmental management into a whole of system approach to aquaculture production. This integration should draw on broader capabilities in marine ecosystem nutrient dynamics and modelling expertise in whole of system approaches for agriculture and marine and coastal management.
- At the same time, there is an opportunity to strengthen Australia's global aquaculture industry partnerships to continue to develop and commercialise elite aquaculture genotypes and novel feed technologies (e.g. China, Vietnam and Indonesia). This will require enhancing our Business Development expertise so that we can respond to increasing international private and public sector/aid agency demands for Australian knowledge and technology.

Horizon	Science Priorities
5 year	Disease reduction and prevention through research including on management, vaccines and selective breeding. Research into improving the sustainability of aquaculture production, such as alternatives to marine products in feeds , reducing nutrient outputs and increasing growth performance Improving the efficiency of energy and resources use on farms including the feasibility of new aquaculture systems and technology(offshore aquaculture, multi-trophic integrated aquaculture (MTIA), and on-land recirculating aquaculture systems (RAS). Pre-commercialisation research as next step from experimental proof-of-concept research.
10 year	Investigation of native species of fish, crustaceans, molluscs and seaweeds suited to large-scale low-cost production; research and development of new mariculture methods compatible with Australian conditions and long-term food security and sustainability strategies, such as offshore cages, MTIA, and RAS; research into disease control and management, development of vaccines and disease resistance markers; and development of low-cost feeds suited to species identified as suited to bulk low-cost production.
20 year	Commercial-scale trials of offshore aquaculture, MTIA, and RAS systems, using native species and all advancements in sustainability identified above (including genetic improvement of species in culture, particularly in disease resistance)

f. Realisation

Capabilities

In close consultation with national and global aquaculture industries and research communities, there is an opportunity to develop and expand Australia's aquaculture capabilities. The key capability requirements include:

- Establish a collaborative network for aquaculture under the Fishing and Aquaculture RD&E Strategy
- Developing a 'whole of system' approach by integrating current capabilities with enhanced capabilities in aquaculture systems (open ocean, closed containment, recirculation), production environment monitoring and management (nutrient dynamics and ecosystem health and integrated adaptive multiple use and ecosystem based management).
- Strengthen links biosecurity, and fostering new links with energy technology, product development, packaging and cold-chain opportunities.
- Expand activities in applied breeding programs, including the move into the 'omics' domain (managing and applying metadata) and integration with other domains (physiology and health).
- Expand activities in nutrition and feed technologies; in particular, fishmeal and fish oil alternatives; and closer linking of health and nutrition.
- Increased activities in the application of sensor technologies for animal welfare and monitoring and controlling production environments.
- Inclusion of Indigenous participants in the establishment of collaborative networks for aquaculture.

Infrastructure:

- CSIRO, in partnership with the Queensland Department of Agriculture, Food and Fisheries (QDAFF), has a developed a world class, controlled environment aquaculture facility on Bribie Island. The facility was critical to the success in developing and commercialising Novacq™. It will be equally critical to our ability to develop the next generation of novel aquaculture technology, including the cost-effective replacement of fishmeal in fish diets (fish equivalent of Novacq™). The opportunity exists to transform this facility into a Centre of Excellence for Aquaculture research in Australasia.
- All state government fisheries and aquaculture research institutes have extensive aquaculture facilities. For example NSW DPI at Port Stephens, SARDI at West Beach, NT Fisheries in Darwin.
- Many universities also have extensive capabilities – the key universities are: Southern Cross University, JCU, UTas, Flinders Uni, Deakin Uni, Curtin Uni, Charles Darwin Uni, Uni of Sunshine Coast, Wollongong Uni
- For the past decade, there has been a very compelling case to develop a controlled environment aquaculture research facility in Tasmania. There is a critical need to strengthen the current efforts to develop a shared facility of international standard to support the industry strategic plan.
- Improved fish health facilities –including large fish systems for developing feeds and vaccines

g. *Optional*: Additional comments (1 page max).

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World Fish Centre?