International
Specialised
Skills
Institute Inc

PRATT FOUNDATION

Grouper Culture Techniques from Selected Countries in the Asia–Pacific Region

Mark Oliver
The Pratt Foundation/ISS Institute Overseas Fellowship

Fellowship supported by The Pratt Foundation

ISS Institute Inc.
MARCH 2010

ISS Institute
Suite 101
685 Burke Road
Camberwell Vic
AUSTRALIA 3124

Telephone
03 9882 0055

Facsimile
03 9882 9866

Email
issi.ceo@pacific.net.au

Web
www.issinstitute.org.au

Published by International Specialised Skills Institute, Melbourne.

ISS Institute
101/685 Burke Road
Camberwell 3124
AUSTRALIA

March 2010

Also extract published on www.issinstitute.org.au

Executive Summary

Asia is the dominant aquaculture region in the world today. Between November 2008 and April 2009 the Fellow visited government operated and privately owned commercial aquaculture facilities in Indonesia, Thailand and Palau to study the recent advances in grouper culture techniques with specific focus on the coral trout *Plectropomus leopardus*. As result of the international experience the Fellow found that:

- Many grouper species are now commercially produced in South East Asia (Indonesia & Thailand) and Micronesia (Palau)
- The coral trout *Plectropomus leopardus* is a favoured species because of its high commercial value and relatively fast growth rate
- The coral trout *Plectropomus leopardus* was grown in net pens in estuarine situations with tidal salinity fluctuations
- Coral trout larvae were stocked at relatively low densities in hatcheries visited by the Fellow
- Traditional techniques of diet enhancement are still utilised such as the addition of garlic and turmeric
- Artemia are heavily used as nauplii through to adults, some of which are frozen and fed to many post larval grouper species after day 45
- Some microalgae cultures run at three parts per million of chlorine in order to minimise ciliate infestation
- Most growers that the Fellow liaised with consider the barramundi cod *Cromileptes altivelis* to be marginal at best as a commercial species due to its very slow growth rate
- Extension and training of grouper culture techniques are provided by government institutions tasked with aquaculture development and are free to commercial growers
- The government institutions visited by the Fellow all cultured grouper 'fingerlings' and sold them to private commercial growers.

Since returning from the Pratt Foundation/ISS Institute Overseas Fellowship trip, Oliver acquired an international travel bursary with the Fisheries Research Development Corporation. In November 2009 he will travel to Malaysia, Indonesia, Thailand and Vietnam. The Fellow will present a paper and chair a conference and visit aquaculture training facilities within the region. He will further explore at a deeper level the training aspects of the grouper species and will investigate how to transfer these frameworks within the Australian context.

Table of Contents

Abbreviations and Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
AquaED	Aqua Educators, an online aquaculture educators' community of practice
CRC	Cooperative Research Centres
DPI&F	Department of Primary Industry and Fisheries
ISS Institute	International Specialised Skills Institute
KFRDC	Krabi Coastal Fisheries Research and Development Centre, Thailand
MDC	The Mariculture Development Centre, Batam, Indonesia
NACA	Network of Aquaculture Centres in Asia–Pacific
PMDC	The Palau Mariculture Development Centre
SCIT	Sunshine Coast institute of TAFE
TAFE	Technical and Further Education – colleges and institutes

Definitions

Artemia	Also known as the brine shrimp. The shrimps lay cysts, which are packed dry and have a long shelf life. Contact with water activates the cyst and the development and hatching process begins. The artemia are used to feed marine fish larvae and some freshwater species.
Broodstock	A fish being kept with the intention of using it for reproduction.
Cannulated	Inserting a tube into the urogenital pore and collecting a small egg sample.
Copepods	Crustaceans found in marine and freshwater environments used as a live prey item for larval fish.
Design	Design is problem setting and problem solving. Design is a fundamental economic and business tool. It is embedded in every aspect of commerce and industry and adds high value to any service or product – in business, government, education and training, and the community in general. *Reference: 'Sustainable Policies for a Dynamic Future', Carolynne Bourne AM, ISS Institute 2007.*
Innovation	Creating and meeting new needs with new technical and design styles (new realities of lifestyle). *Reference: 'Sustainable Policies for a Dynamic Future', Carolynne Bourne AM, ISS Institute 2007.*
Microalgae	Single-celled aquatic plants used in fish hatcheries to culture zooplankton.
Photophilic	An organism that thrives in light.
Rotifer	Microscopic animals commonly used in the culture of marine species where live diets are essential during early stages.
Skills deficiency	A skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. There may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass away. Firms likewise come and go. *Reference: 'Directory of Opportunities. Specialised Courses with Italy. Part 1: Veneto Region', ISS Institute, 1991.*

Definitions

Sustainability	The ISS Institute follows the United Nations NGO on Sustainability, *"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* *Reference: http://www.unngosustainability.org/CSD_Definitions%20SD.*htm

Acknowledgments

Mark Oliver would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body - International Specialised Skills Institute (ISS Institute)

We know that Australia's economic future is reliant upon high level skills and knowledge, underpinned by design and innovation.

The International Specialised Skills Institute Inc (ISS Institute) is an independent, national organisation, which has a record of nearly twenty years of working with Australian industry and commerce to gain best-in-the-world skills and experience in traditional and leading-edge technology, design, innovation and management. The Institute has worked extensively with Government and non-Government organisations, firms, industry bodies, professional associations and education and training institutions.

The Patron in Chief is Sir James Gobbo AC, CVO. The ISS Institute Board of Management is Chaired by Noel Waite AO. The Board comprises Franco Fiorentini, John Iacovangelo, Lady Primrose Potter AC and David Wittner.

Through its CEO, Carolynne Bourne AM, the ISS Institute identifies and researches skill deficiencies and then meets the deficiency needs through its *Overseas Skill Acquisition Plan (Fellowship Program),* its education and training activities, professional development events and consultancy services.

Under the Overseas Skill Acquisition Plan (Fellowship Program) Australians travel overseas or international experts travel to Australia. Participants then pass on what they have learnt through reports, education and training activities such as workshops, conferences, lectures, forums, seminars and events, therein ensuring that for each Fellowship undertaken many benefit.

As an outcome of its work, ISS Institute has gained a deep understanding of the nature and scope of a number of issues. Four clearly defined economic forces have emerged out of our nearly twenty years of research. The drivers have arisen out of research that has been induced rather than deduced and innovative, practical solutions created - it is about thinking and working differently.

A Global Perspective. 'Skills Deficiencies' + 'Skills Shortages'

Skill deficiencies address future needs. Skill shortages replicate the past and are focused on immediate needs.

Skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. This is the focus of the work of ISS Institute.

There may be individuals or firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass away. Firms likewise come and go. If Australia is to create, build and sustain Industries, knowledge/skills/understandings must be accessible trans-generationally through nationally accredited courses and not be reliant on individuals.

Our international competitors have these capabilities as well as the education and training infrastructure to underpin them.

Addressing skill shortages, however, is merely delivering more of what we already know and can do to meet current market demands. Australia needs to address the ***dual*** challenge – skill deficiencies and skill shortages.

Acknowledgments

Identifying and closing skills deficiencies is vital to long-term economic prospects in order to sustain sectors that are at risk of disappearing, not being developed or leaving our shores to be taken up by our competitors. The only prudent option is to achieve a high skill, high value-added economy in order to build a significant future in the local and international marketplace.

The Trades

The ISS Institute views the trades as the backbone of our economy. Yet, they are often unseen and, in the main, have no direct voice as to issues which are in their domain of expertise. The trades are equal, but different to professions.

The ISS Institute has the way forward through its 'Master Artisan Framework for Excellence. A New Model for Skilling the Trades', December 2004. The Federal Government, DEEWR commissioned ISS Institute to write an Australian Master Artisan School, Feasibility Plan.

In 2006, the ISS Institute established an advisory body, the **Trades Advisory Council.** The members are Ivan Deveson AO; Martin Ferguson AM, MP, Federal Labor Member for Batman; Geoff Masters, CEO, Australian Council of Educational Research; Simon McKeon, Executive Chairman, Macquarie Bank, Melbourne Office, and Julius Roe, National President Australian Manufacturing Workers' Union. ISS Institute also puts on record its gratitude to the former Chairman of Visy Industries, the late Richard Pratt, for his contribution as a member of the Trades Advisory Council.

Think and Work in an Holistic Approach along the Supply Chain - Collaboration and Communication

Our experience has shown that most perceive that lack of skills is the principal factor related to quality and productivity. We believe that attitudes are often the constraint to turning ideas into product and a successful business; the ability to think laterally, to work and communicate across disciplines and industry sectors, to be able to take risks and think outside the familiar, to share – to turn competitors into partners.

Australia needs to change to thinking and working holistically along the entire Supply Chain; to collaborate and communicate across industries and occupations - designers with master artisans, trades men and women, Government agencies, manufacturers, engineers, farmers, retailers, suppliers to name a few in the Chain.

'Design' has to be seen as more than 'Art' discipline – it is a fundamental economic and business tool for the 21st Century

Design is crucial to the economic future of our nation. Australia needs to understand and learn the value of design, the benefits of good design and for it to become part of everyday language, decision making and choice.

Design is as important to the child exploring the possibilities of the world, as it is to the architect developing new concepts, and as it is to the electrician placing power points or the furniture designer working with a cabinet-maker and manufacturer. As such, design is vested in every member of our community and touches every aspect of our lives.

Our holistic approach takes us to working across occupations and industry sectors and building bridges along the way. The result has been highly effective in the creation of new business, the development of existing business and the return of lost skills and knowledge to our workforce, thus creating jobs - whereby individuals gain; industry and business gain; the Australian community gains economically, educationally and culturally.

ISS Institute, Suite 101, 685 Burke Rd, Camberwell 3124, Australia
P 61 3 9882 0055 **F** 61 3 9882 9866 **E** issi.ceo@pacific.net.au **W** www.issinstitute.org.au

Acknowledgments

Fellowship Supporter

The Pratt Foundation was established in 1978 by Richard and Jeanne Pratt with the shared vision of supporting charitable enterprises and adding value to philanthropy. The Foundation is now one of the largest private sources of philanthropy in Australia. In the words of its mission statement, it aims *"to enrich the lives of our community"* and, in the words of Jeremiah, it works to fulfil this aim in a spirit of *"kindness, justice and equity"*.

Supporters

The Fellow would like to formally acknowledge the following individuals and organisations:

- Carolynne Bourne AM – ISS Institute, for her management and mentoring of the Fellow.
- Paul Sumner – ISS Institute, for his management and mentoring of the Fellow.
- Peter Clack – AgriFood Skills Australia, for his letter of support.
- Graham Dalton – Queensland Aquaculture Industry Federation, for his letter of support.
- Phil Evans – Head of the School of Applied Sciences, Sunshine Coast Institute of TAFE, for his encouragement and support.
- Chris Robertson – The Department of Primary Industries and Fisheries, Queensland, for his letter of support.

Individuals/Organisations Involved in the Development of the Fellowship

- Syamsul Akbar – Director of the Mariculture Development Centre, Indonesia.
- Paiboon Bunliptanond – Director of the Krabi Fishereis Research and Development Centre.
- Professor Abigail Elizur – University of the Sunshine Coast, for her mentoring in the report writing process.
- Theo Isamu – Director of the Division of Marine Resources, Republic of Palau.
- Rod Missen – EcoFish, for his industry mentoring.
- Miguel Delos Santos – Palau Community College.
- Simon Wilkinson – The Network of Aquaculture Centres in the Asia–Pacific, for his excellent list of Indonesian contacts.

Australian Organisations Impacted by Marine Finfish Aquaculture in Australia*

Government Agencies

- Federal Department of Agriculture, Fisheries and Forestry
- The Department of Primary Industries and Fisheries, Queensland
- Department of Primary Industries, New South Wales
- Department of Primary Industries, Victoria
- Department of Primary Industry and Fisheries, Tasmania
- Department of Primary Industries and Resources, South Australia
- Department of Fisheries, Western Australia
- Department of Regional Development, Primary Industry, Fisheries and Resources, Northern Territory

Acknowledgments

National and International Industry Bodies and Associations

- The Australian Prawn Farmers Association
- The Australian Barramundi Farmers Association
- The National Aquaculture Council
- The Network of Aquaculture Centres in the Asia–Pacific

Education and Training

- Sunshine Coast Institute of TAFE, Queensland
- Tropical North Institute of TAFE, Queensland
- The National Fishing Industry Education Centre, New South Wales
- Northern Melbourne Institute of TAFE, Victoria
- Seafood Training Tasmania
- TAFE South Australia
- Challenger TAFE, Western Australia
- Batavia Coast Maritime Institute, Western Australia
- Kimberley College of TAFE Western Australia
- Charles Darwin University, Northern Territory
- James Cook University, Queensland
- University of Tasmania
- Flinders University, South Australia
- The Curtin University of Technology, Western Australia

* *This is not a definitive list*

About the Fellow

For the past nine years, Oliver has been an aquaculture trainer for the Sunshine Coast Institute of TAFE (SCIT). This is the largest provider of vocational education in what is now one of Australia's fastest growing regions. SCIT currently enrols almost 15,000 students every year in a wide diversity of programs to meet the needs of local, national and international industry and professions.

The aquaculture training division is a part of the SCIT School of Applied Sciences and is a small but thriving division that delivers aquaculture training ranging from entry level through to management, in both on-campus and off-campus modes. A common thread that binds all aspects of the SCIT aquaculture training is the emphasis placed on the need for all training and engagement to be of commercial relevance.

Although SCIT has a successful on-campus training facility that cultures both freshwater and marine species, the majority of the Fellow's workload is in the form of off-campus training and assessment. Both trainees and higher-level management students are managed by the Fellow and are geographically dispersed throughout Queensland. Student participation comes from a wide range of facilities encompassing many different species and culture techniques. The Fellow continues to have a high level of exposure to numerous commercial operations.

Prior to employment at SCIT, Oliver had 11 years commercial aquaculture experience. This work mainly centred around farming various finfish species with a particular emphasis on hatchery operations. During this time period the Fellow completed an undergraduate science degree from the University of the Sunshine Coast and also an honours degree from The University of Queensland. The Fellow's thesis was titled: 'Optimising larval rearing techniques for the Sea Mullet *Mugil cephalus* and the Rabbitfish *Siganus nebulosis'*. While at SCIT the Fellow has completed a Diploma of Aquaculture from Tropical North Queensland TAFE and a Graduate Diploma in Education from The University of the Sunshine Coast.

The Fellow has commenced a PhD through the University of the Sunshine Coast. The research, centred around developing sustainable aquaculture through effective policy decision making processes is partially funded by the Seafood CRC. The Fellow is now on the Board of directors for the World Aquaculture Society, Asia-Pacific Chapter and is part of a recently formed online aquaculture educators' community of practice known as AquaED.

Oliver is committed to the proliferation of sustainable aquaculture development throughout Queensland and indeed the rest of the Australia. He is intensely interested in two main areas.

First, from a strategic policy level: developing clear pathways and support for individuals and organisations wishing to commence sustainable aquaculture operations within a particular region. From then, capacity building can occur where quality trained staff and management are identified and accessible to the operations.

Second, developing frameworks that have the appropriate measures in place for quality technology/skills transfer between either willing commercial operators or national/ international research facilities to other aquaculture operators. A crucial facet of the second point is how the specific training will be conducted to ensure this technology or skills transfer is undertaken in a way that maximizes both the quality and effectiveness of it within the commercial environment.

Aims of the Fellowship Program

The aims of this Fellowship program centred around gaining hands-on experience and documenting industry best practice in hatchery and grow-out techniques of particular highly priced aquaculture species including coral trout *Plectropomus leopardus* and barramundi cod *Cromileptes altivelis*.

The Fellow also gained exposure to emerging technologies and skill sets utilised for culture of the above species. The Fellow visited a blend of commercial and research facilities in Indonesia, Thailand and the Republic of Palau.

A longer-term aim for the Fellow is to transfer these acquired skill sets and technologies to the Australian Aquaculture Industry through effective education and training strategies.

The Australian Context

The Australian Industry

Aquaculture is Australia's fastest growing primary industry, increasing in value by an average of 13 per cent per annum since 1990 (Commonwealth Statistics, 2004). The gross national value of production in 2006–07 was $793 million, which was a $35.7 million rise from the previous year's production. Many sectors contributed to this total as depicted in Figure 1.

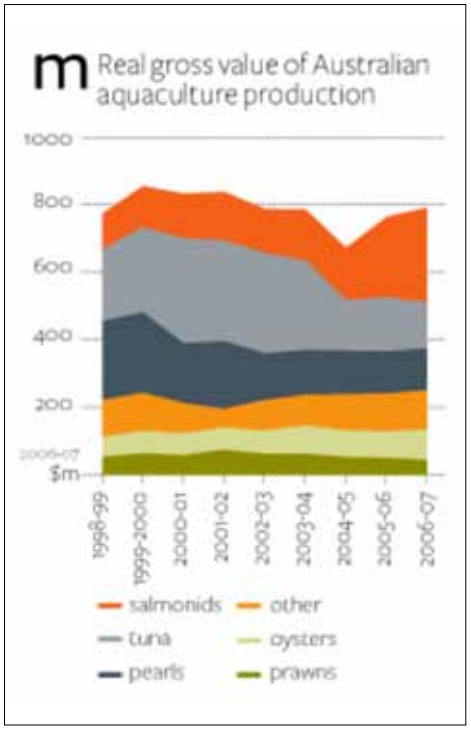

Figure 1. Gross value of Aquaculture within Australia from 1998–2007 (ABARE 2007)

Figure 2. Coral trout Plectropomus leopardus

Figure 3. Barramundi cod Cromileptes altivelis

Figure 4. Barramundi Lates calcarifer

Marine finfish, namely salmon and tuna, accounted for nearly half of Australia's gross value production in 2006–07. Both of these species are grown in temperate climates with salmon produced almost primarily in Tasmania and tuna in South Australia. They are both considered a highly priced commodity, with tuna marketed mainly into Japan as an eventual sashimi product and salmon sold within Australia and exported as a range of products including whole fish, fillets, smoked and caviar.

The groups of marine finfish to be researched by the Fellow are not temperate species. They are warm-water species with a collective common name of groupers including the coral trout *Plectropomus leopardus* (Figure 2) and barramundi cod *Cromileptes altivelis* (Figure 3).

To the best of the Fellow's knowledge there is no official data as to the gross value of production of these two species within Australia. The number of commercial operations specifically developed to attempt to commercialise these species and of the facilities that are culturing them are extremely limited. Rather, they are using these species as a farm diversification option or as a future species model.

The Australian Context

Barramundi production, although small compared to salmon and tuna, is one of the fastest growing aquaculture sectors within Australia. In Queensland, the gross value of barramundi production increased by 32 per cent from $14 million in 2005–06 to $18.5 million in 2006–07 (DPI&F 2008). During this same time period in Queensland, 4.5 million barramundi fingerlings were produced in hatcheries to be sold to grow-out facilities. Other states and territories grow barramundi using various methods.

South Australia's Barramundi production for 2006–07 of $3.7 million (ABARE 2007) were grown solely in indoor recirculation facilities due to the low outside temperatures not being conducive to the culture of barramundi. Barramundi are also cultured in Western Australia and the Northern Territory with similar production figures to South Australia.

The other sector that has expressed an interest in diversification into groupers is the marine prawn industry as their pond based grow-out facilities, and indeed their hatcheries, can be converted into marine fish farms with minimal cost and effort.

Drivers for Farm Diversification

There are many drivers for current and future commercial operators to diversify into highly priced marine fish species such as coral trout *Plectropomus leopardus* and barramundi cod *Cromileptes altivelis*. From a purely marketing perspective, although there has been growth in the Australian Barramundi Industry, an increased tonnage of the importation of this species from countries such as Myanmar and Taiwan is a commercial reality. These cheaper imports will have an eventual competitive effect on the domestic barramundi market as has already happened and continues to happen within the marine prawn market.

These higher priced species offer an export option to Australian aquaculture operators that barramundi and most aquacultured marine prawns do not. With prices of $A90 per kilogram for live coral trout, and even higher for barramundi cod in Hong Kong (Castle Peak Wholesales Fish Market as of 06/10/2008) this makes these species a very attractive alternative.

There is currently an industry within Australia that sells live grouper species to Asia, in particular coral trout to mainland China and Hong Kong. The live Reef-Fish Line Fishing Industry in Queensland was worth $35 million in 2003 with over 1000 tonnes of live coral trout being exported to Asia (Reef CRC 2005). The industry, like many other commercial fishing industries has decreased in size mainly due to a combination of changes in policy and management regimes, zone closures and increased operational costs.

There is, however, an already established supply chain for export of highly priced live marine fish into Asia stemming from this industry and also technologies and infrastructure are already available for live transport of the product. The only real difference is that the product will be aquacultured and not wild caught.

Another factor that needs to be taken into account is that grouper culture, especially within Asia, is a relatively common aquaculture venture. According to Rimmer (Production update, 2008) Global grouper production, of which the vast majority is within Asia, was 60,074 tonnes in 2005–06. This was a five per cent increase from the previous year. Although this figure is nowhere near the staggering amounts of production of some freshwater species within the powerhouse of aquaculture, that is Asia and in particular China, the grouper production figures are still significant.

There is a suite of technical skills needed to successfully culture these species, discussed later within this report, but they are attainable. There are many people within the existing aquaculture industry who posses a suite of skills that gives them a solid platform for learning these new grouper culture techniques. This will empower the facility to manage change at a much higher level of confidence, as these trained staff will have the capability to succeed if the need or desire to diversify arises or is forced upon the business.

With all of this experience and expertise in production of groupers just to the north of our nation, Australia runs a real risk of being left behind when it comes to the commercial production of these highly priced marine species unless this education process is commenced as soon as possible.

SWOT Analysis

Below is a SWOT analysis for the Fellowship. It covers pre-, during, and post-international experience.

The Overseas Experience and Skills Acquisition

Strengths

- Travelling to world renowned grouper culture facilities.
- Staff and management at overseas facilities are eager to engage.
- The Fellow has had previous international business travel experience.
- Travel itinerary is manageable.
- The destinations are relatively close to Australia and air travel within the countries is reliable.

Weaknesses

- There may be a language barrier between staff and the Fellow at some of the facilities.
- If travel schedule is slightly modified due to unforeseen circumstances, communications within the country to forewarn facilities may be difficult.
- The Fellow has not travelled to the facilities before or met any of the staff or management.

Opportunities

- Develop a working relationship with staff and management of the overseas facilities.
- Raise the profile of the ISS Institute within the Asia–Pacific region.
- Transfer a meaningful suite of skills to the Australian aquaculture industry.

Threats

- A strong weather event may disrupt travel itinerary.
- The Fellow becoming ill during the overseas experience.
- Security within the international destinations

Figure 5. SWOT – The Overseas Experience and Skills Acquisition

Recommendations and Skills Transfer to Industry

Strengths

- Minimal costs to industry because of existing commercial infrastructure.
- Industry has confidence in existing established markets and product chain.
- Some industry sectors are eager to have staff trained in a diverse range of species.
- Can insulate operations against market shifts in single-species farms.
- Species are commercially viable in other countries.
- Techniques for spawning and grow-out are established.

Weaknesses

- Some individual commercial operators are not amenable to new species or culture techniques.
- Industry is very geographically dispersed and mass on-farm training may be a challenge.
- Dealing with multiple associations and peak bodies across states and territories.
- Product market has, in the past, been susceptible to high price fluctuations mainly due to very rare health events (avian flu example in Hong Kong).

Opportunities

- Up-skilling and diversifying both staff and managers in different species culture techniques.
- Potential to increase profitability of enterprise.
- Increase meaningful dialogue between commercial facilities.
- Raise the profile of the ISS Institute within the Australian aquaculture industry.

Threats

- Environmental regulatory agencies suppressing diversification.
- Existing frameworks within agencies may not support new species diversification.
- Market failure.
- No uptake of new skills.

Figure 6. SWOT – Recommendations and Skills Transfer to Industry

Identifying the Skills Deficiencies

Skills Deficiencies: Definition

As already established, a skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas.

There may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass away. Firms likewise come and go.

Identifying and Defining the Deficiencies

The suite of aquaculture skills required and their subsequent skills deficiencies can essentially be broken up into five separate phases of grouper culture. These are:

- Broodstock management
- Spawning
- Live feed culture
- Larval rearing and weaning
- Product grow-out.

The concise manner in which the specific skills deficiencies are defined for the above five separate phases is illustrated below:

Broodstock Management

- Broodstock feeding and conditioning: choosing correct feed types, sizes, frequency
- Feed preparation: manual feed enhancement (vitamins) applications.
- Gauging broodstock condition: anesthetising the fish, cannulation of fish with catheter, judging egg quality under microscope, recovering the fish
- Disease management: bathing techniques for parasitic infections, disease identification and treatment.

Spawning

- Spawning tank design: colour, depth, aeration types, water exchange rate and lighting
- Spawning tank maintenance schedule: cleaning, vacuuming, water quality testing and documentation
- Broodstock and or egg removal: handling techniques of recently spawned/vulnerable broodstock, Manual egg removal/netting/siphoning
- Egg handling disinfection: chemical disinfection procedure or the use of ozone, time, strength and safety
- Egg movement techniques: netting/siphoning or passive pumping
- Egg acclimatisation techniques: amount of new water introduced and its quality.

Identifying the Skills Deficiencies

Live Feed Culture

- Microalgae culture: parent stock storage, up-scaling, nutrient development, transferring algae in a way that minimizes contamination
- Culturing the zooplankton— *Brachionus rotundiformis* SS rotifer): feeding, gauging density, manual harvesting, contamination avoidance techniques
- Culturing copepods: feeding techniques, harvesting techniques and contamination avoidance techniques.

Larval Rearing and Weaning

- First-feeding larval techniques: ensuring the larval rearing tank has enough live prey items for the newly hatched larval fish
- Documenting what diet enhancements are being used
- Documenting larvae culture environment including lighting and aeration
- Live prey selection and tank introduction phases for live prey organisms through to weaning.

Weaning Skills Documented

- Product grow-out
- Feeding techniques, in particular the usage of trash fish
- Feed supplement design and utilisation
- Disease management: parasite bathing and disease identification
- Harvesting techniques used to minimise damage to product
- Live transport techniques

The International Experience

The Fellow visited three separate international destinations in the Asia–Pacific region. The general information about the facilities that were visited as well as outlining the skills, underpinning knowledge and insights gained are structured under the following sub headings:

- Broodstock management
- Spawning
- Microalgae and live feed culture
- Larval rearing and weaning
- Product grow-out
- Institutional capacity

The Mariculture Development Centre (MDC), Batam, Indonesia

The MDC in Batam is the central technical implementation unit in mariculture under the Director General for Aquaculture at the Department for Marine Affairs and Fisheries, Indonesia.

The main role of the centre is to apply breeding and husbandry techniques for marine species as well as to conserve marine broodstock/seed resources and the marine environment, in particular:

- To evaluate, access and supervise the application of standards connected with the breeding and culture of marine organisms
- To evaluate the standards for and the implementation of certification for quality control systems and the certification of personnel in connection with the breeding and culture of marine organisms
- To evaluate the systems and management for the production and husbandry of broodstock of marine organisms
- To undertake applied research in the fields of marine organism breeding and culture
- To evaluate the standards for seed quality control, farming practices and the control of pests and diseases of marine organisms
- To evaluate standards for environmental impact control and for marine broodstock/seed resources
- To implement a laboratory network system for testing/specimen examination, seed quality surveillance and the culture of marine organisms
- To manage and provide access to an information and publication system for marine hatchery and mariculture related subjects
- The centre has succeeded in breeding Asian seabass *Lates calcarifer*, sandbass, mangrove snapper *Lutjanus argentimaculatus*, tiger grouper *Epinephelus fuscoguttatus*, humpback grouper *Cromileptes altivelis*, pompano and golden trevally *Gnathodon speciosus*. Other species such as estuary grouper *E. Coioides*, duskytail grouper *E. Bleekeri*, and giant grouper *E. Lanceolatus* are new species in development.

The MDC is a multi-species hatchery utilising a range of traditional techniques coupled with host of new notable technologies. This blend of old and new made the MDC an enlightening place to visit.

Broodstock Management

The majority of broodstock are held in floating net pens (Figure 7). These pens are situated in an adequate position from water quality perspective; however, the pens need to be constantly cleaned of flotsam and jetsam that are floating through the general area. The broodstock are held in species-specific pens and are fed trash fish only. Broodstock in pens are only handled when moved to spawning tanks or when they need to be treated for external parasites. The only broodstock species not held in pens is the giant grouper (Figure 8). This is mainly due to their size (over 50 and up to 80 kilos).

Figure 7. Broodstock pens at the MDC

Figure 8. Giant grouper broodstock tanks at the MDC

Spawning

All fish are spawned in large 50m³ circular or rectangular tanks and eggs are collected in passive egg collectors. Prior to spawning selected female broodstock are cannulated to check for egg quality. Eggs are checked under a dissecting microscope.

Micro Algae and Live Feed Production

The major species of microalgae produced at the MDC is nano *Nannochloropsis oculata*. The purpose built microalgae lab has a standard layout (Figure 9). The intermediate flasks have a screw-top lid that, according to the microalgae technician, makes them easier to work with and clean. After culturing the algae in the laboratory it is then moved to 60 litre aquarium tanks and from there to 40m³ rectangular tanks. Apart from using the glass aquariums for an intermediate growth phase, the culture methods were standard industry practice. The most notable technique used for the MDCs microalgae culture was the use of garlic. The garlic is used in the flask cultures to prevent high levels of bacterial infestation. It was difficult to ascertain the exact amount added, as the garlic was in a liquid prior to adding. The MDC also makes its own microalgae paste which can be used as a back up to fresh algae. The living microalgae are centrifuged and garlic is also added, which according to the microalgae technician, helps with the long-term preservation of the algae paste.

The two major species of live feed produced at the MDC is the rotifer *Brachionus plicatilis* and brine shrimp artemia. They utilise standard green-water culture practices for the rotifer and normal hatching and enriching procedures for the artemia.

Figure 9. Microalgae culture facility at the MDC

Figure 10. Feeding stations in rearing tanks at the MDC

Larval Rearing and Weaning

During the Fellow's visit to the MDC two marine fish species were in the larval rearing facility. These were the tiger grouper *E. Fuscoguttatus* and the estuary grouper *E. Coioides*. Both species were being weaned from live feeds to a microencapsulated artificial diet. It was noted that these live feeds were fed within the larval rearing tank only within a feeding station. (Figure 10).

Product Grow-Out

The Fellow visited an adjacent net-pen grow-out facility. It's not the MDC's role to produce grow-out product for sale; however, it is their role to produce fingerling size (5–10 cm) fish for sale to adjacent grow-out facilities. This new net-pen facility was situated in an area quite conducive to net-pen grow-out. With clear water and adequate current it was an ideal grow-out site. On the day of the Fellow's visit they were receiving fingerlings from the MDC.

The fish on site are fed only trash fish of varying sizes. For the smaller fish, trash fish is manually cut up using either scissors or a knife by the many staff and fed directly to the product. The owner was very mindful of the nutritional requirements of the fish and was adamant that the additives he introduced into the feed increased the strength of the species and decreased the incidence of external parasites. The two additives he used were turmeric and garlic. Both these products were fed for one week when new stock arrived and for one week after that every month. When product was ready for market, it was sold to specialised live fish vessels that collected selected grouper species from commercial facilities off Indonesia and Southern Malaysia and then these vessels ferried the product to Hong Kong where they were sold to the live fish trade.

Institutional Capacity

The MDC is part of a network of aquaculture research and extension agencies spread throughout the Indonesian Archipelago. Other centres are situated in East Java, Southern Sumatra, Sulawesi, Bali and Lombok. The Fellow spent a considerable amount of time with the director of the facility, Syamsul Akbar, and asked many question relating to the role and capacity of the MDC. The primary goal for the facility was to generate sustainable growth in commercial aquaculture in the region. The way this was to be achieved was by the MDC undertaking the following core operations:

- Provide free advice on-site and species selection to potential investors (either local or international)
- Help with the approvals process needed for commercial aquaculture

- Provide free ongoing on-site advice to commercial facilities
- Provide free training either on-site or at the MDC in a range of aquatic husbandry techniques
- Provide good quality fingerlings, for a price, to commercial facilities for grow-out
- Undertake research into the culture of various marine species
- Provide a facility for undergraduate and postgraduate research and work experience
- Undertake a school-based work experience program

This focus upon free services was foreign to the Fellow who is accustomed to the 'user pays' system within the framework of most levels of the Australian Government. It was refreshing to see the enthusiasm with which the staff interacted with commercial operators, and also the enthusiasm shown by the director himself.

The other major observation was that decisions regarding the approvals process for the commercial facilities were not handled by the MDC in any way. This, once again, was different to Australia where most aquaculture related departments have to adhere to both the 'promoter' and 'policeman' bodies.

The Krabi Coastal Fisheries Research and Development Centre, Thailand (KFRDC)

The KFRDC is a world-renowned aquaculture research and extension facility that is part of a Thai Fisheries network of centres throughout Thailand that encompass both freshwater and marine-based aquaculture. The KFRDC works closely with the nearby Phuket Fisheries Centre.

Like the MDC, the KFRDC's primary goal is sustainable aquaculture development throughout the region. Professional staff within the facility carry out meaningful research into the developing techniques for the breeding and rearing of new potential aquaculture species. These skills are then disseminated throughout the aquaculture community through publications, workshops, seminars and site visits.

The facility breeds many species of marine fish species including several foodfish grouper species such as the tiger grouper *Epinephelus fuscoguttatus*, barramundi cod or humpback grouper *Cromileptes altivelis*, estuary grouper *E. Coioides*, duskytail grouper *E. Bleekeri*, giant grouper *E. Lanceolatus* and the coral trout *Plectropomus leopardus*. They also successfully culture many marine ornamental species including seahorses and 10 different species of anemone fish (clown fish) as well as other popular marine ornamental species.

Broodstock Management

Unlike the MDC, the KFRDC is a fully land-based facility that is adjacent to the ocean and consequently there is no sea-based net pens for broodstock. All broodstock are housed in circular floating cages within a large purpose-built pond (Figure11). These cages are species specific and can be accessed by a timber walkway that skirts the cages.

The only species that are free to swim around the pond and not in cages are the giant grouper (Figure 12). Because the broodstock are held in a pond with virtually no current, external parasites are a problem and are treated with either a freshwater or formalin bath.

The other problem with the system is low dissolved oxygen at night. To circumvent the dissolved oxygen problem, paddlewheels are used at night to increase the turnover of the pond and they are also useful for providing the pond with a low flow current as well.

Broodstock are fed whole fish and a commercial broodstock enhancer is added to the diet at least one month prior to their spawning season. Grouper spawning condition is gauged by the fish being removed from the cages and then moved, by a tank on wheels, to an area where the fish are anesthetised and cannulated. During this exercise most fish are either dipped in a bath of freshwater, or placed in a formalin bath for 30 minutes to remove any external parasites present.

Figure 11. Broodstock cages at the KFRDC

Figure 12. Giant grouper broodstock at the KFRDC

Spawning

All grouper species are spawned in large 50m³ rectangular tanks. Hormonal manipulation is not commonly used as established broodstock spawn naturally within season.

Microalgae and Live Feed Culture

A number of marine microalgae species are cultured at the KFRDC. They are highly successful in mass culturing chlorella, *Nannochloropsis oculata* and *Isochrysis*. There is not a purpose-built microalgae laboratory because so many fish species are cultured with the mass production of algae occurring 365 days per year. If parent algae needs to be sourced it can be acquired from the fisheries centre at nearby Phuket. The KFRDC utilizes an innovative technique for minimising algae culture contamination by ciliates. They run all cultures in 3 parts per million of chlorine, which is enough to kill ciliates but not the algae.

Many live prey species are produced at the KFRDC. Two strains of rotifer, the standard size and the super small strain, are produced. Both are produced by the standard methods used in Australia. The KFRDC have used copepods in the past for humphead Maori wrasse larvae. The copepod species are smaller than small strain rotifers and conducive to the mouth gape of the larvae. The copepods are not mass cultured within the facility, but are filtered out of raw seawater and fed directed to the larvae.

Artemia are used for many species at the KFRDC. The artemia are mass cultured in large conical tanks and napulii are enriched overnight and then fed to larvae. The KFRDC also on grows artemia to adults, freezes them and feeds them to post-larval grouper species prior to weaning to an artificial diet. The adult artemia are harvested and then poured into blocks and frozen into plastic bags.

Larval Rearing and Weaning

The KFRDC have had great success in the larval rearing of coral trout and other grouper species. The technicians have developed a range of techniques that ensure optimal survival and growth of these species.

The stocking density of coral trout larvae are much lighter than any other species the Fellow has encountered. The coral trout larvae are stocked between six and 10 individuals per litre. Small strain rotifers are added to the culture vessel at two per ml and increases to ten per ml by day four, post-first feed. Standard rotifers are added at ten per ml from day four and artemia nauplii are added from day 15 to 45 at two per ml. All zooplankton are enriched with a commercial enriching product. Chlorella algae is added to the culture vessel as well. Once the larvae are to a point where they are actively chasing live prey, the artemia are introduced into the tank via a drip-feed system (Figure 13).

Figure 13. Coral trout being fed artemia via a drip-feed system

Figure 14. One of the commercial grouper facilities near Krabi

Adult artemia are mass-produced at the KFRDC and after day 45 frozen adult artemia are still fed to the coral trout post-larvae. Frozen adult artemia are fed as blocks and allowed to thaw in the tank. According to the technicians, this increases survival at this growth phase of the animal's life.

Product Grow-Out

Like the MDC, the KFRDC does not grow-out fish for sale but provides fingerlings to commercial farms within the region. The Fellow visited some commercial net-pen facilities in the estuary near the town of Krabi. There were over 20 net-pen facilities in the one area (Figure 14). All of the facilities had multiple grouper species and most products were sold live to seafood wholesalers or directly to hotels and their associated restaurants in Phuket.

All live products were shipped by the farmers directly to Phuket using a modified live transport vehicle (Figure 15). In conversation with numerous commercial operators, the Fellow determined that the estuary grouper is the preferred culture species and, as a live product, sell for around $US18 per kilogram. The other preferred species is the coral trout. This is a relatively new species available for grow-out and can sell for over $US35 per kilogram. The grow-out time for this species from fingerling to a sellable product, being fed trash fish, is between nine and twelve months. All commercial operators were confident in this fish as a culture species and are very keen to farm these in great numbers. They are, however, limited by the amount of fingerlings produced at the KFRDC and by their relatively high cost compared to other grouper species.

Figure 15. Grouper live transport vehicle

Figure 16. A tour group at KRFDC led by the centre's communications officer

Figure 17. Releasing post-larval prawns on a community based environmental awareness day

All commercial operators were also adamant that the barramundi cod, or humpback grouper, were not as commercially viable as the coral trout because their growth period is at least twice as long as the coral trout. Although attaining a higher price than any other product, over two years of grow-out prohibitively adds to the feed and maintenance costs.

Institutional Capacity

The Fellow found the institutional capacity of the facility to be of the highest quality. The facility's central role is to produce quality fingerlings for local farmers and they carry this out in a very professional manner.

Their extension to these farmers comes in the form of free workshops. An example of this would be if a new grouper species was produced and there needed to be some training with regard to introducing the fingerlings into their commercial facility, disease management and feeding techniques. These workshops are all free of charge, which once again is not the common practice in Australia. The KFRDC also allows both international and local tourists to visit the facility free of charge. They have a communications officer to take people around the facility and explain its operations (Figure 16).

The KFRDC are very active within the local community and undertake numerous restocking programs (Figure 17) to local reefs and estuaries and even incorporate these into environmental awareness days. The major species restocked are local marine prawn species, seahorses and clownfish. The restocking of clownfish is especially interesting because prior to restocking, wild anemones are sought on the reefs and if they have no clownfish within them, cultured ones are placed into the anemone on the day of restocking.

The Palau Mariculture Development Centre (PMDC)

The Fellow visited the PMDC from the 26th of March to the 2nd of Aril 2009. The PMDC is the largest aquaculture facility in the Republic of Palau and cultures the most diverse array of marine species in all of Micronesia. The facility has been operational for over 25 years and is world renowned for its success in culturing many species of marine clam. Other species cultured at the facility include tiger grouper *Epinephelus fuscoguttatus*, coral trout *Plectropomus leopardus*, rabbitfish *Siganus sp*, and milkfish *Chanos chanos*.

The primary role for the PMDC is to promote sustainable aquaculture development in the Republic of Palau. The PMDC is also part of the Ministry of Natural Resources, Environment and Tourism. This ministry is tasked with ensuring the preservation of the pristine waters within the Republic of Palau. Palau is a world-renowned diving destination and is known for its water quality and aquatic species diversity.

The PMDC is situated in a very conducive area for mariculture (Figure 18). The PMDC is all tank based and has no pens or cages. All of the facility is on a total flow-through system where the crystal clear water is simply pumped from the adjacent reef and discharged there as well. The PMDC has cultured giant clams on the adjacent reef that are over 1.2 metres across and at least 20 years old (Figure 19).

Figure 18. The Palau Mariculture Demonstration Centre (PMDC)

Figure 19. Giant clam at the PMDC (approx 1.2 metres across)

Figure 20. Large broodstock tank for grouper at the PMDC

Figure 21. Feed additives

Broodstock Management

The broodstock grouper are held in extremely large (100 m^3) tanks that were at least 3 metres deep (Figure 20). These tanks are on a flow-through system. The technicians remarked that some of the grouper have been in the tanks for over 10 years, which is a testament to their quality husbandry skills. They have a total hands-off approach to the broodstock and broodstock are only handled a minimum of times over this duration, mainly for the manual extraction of sea lice.

Grouper broodstock are fed whole or cut milkfish or skipjack tuna. Three different types of additives and enhancers are blended with regard to the diet for broodstock. These are a vitamin E and C mix (sea mix brand), Astaxanthin and a multivitamin (Aqua ACE brand) (Figure 21).

Spawning

The grouper spawn seasonally with no hormonal manipulation and all eggs are collected in external egg collectors.

Microalgae and Live Feed Culture

All microalgae and live feeds are native species of Palau and have not been imported from South East Asia. The microalgae species is thought to be Chlorella although it has never been officially identified. It has an extremely fast turnover rate and crashes can occur within seven days. They monitor algae cell counts daily, with 50 million cells per ml being optimal. A relatively simple nutrient media of phosphate, iron and urea is used. If contamination becomes an issue in the cultures, they boil the sea water at 90 degrees celsius for 20 minutes, as well as using a standard chlorination/de-chlorination technique.

The PMDC only cultures one unidentified species of rotifer, but it is around the size of *Brachionus plicatilis* . To feed newly hatched grouper larvae they strain their rotifer culture for the smallest size possible and then feed these directly to the larvae. The culture methods for rotifers and artemia are standard with the one exception being that in the rotifer culture tanks, they place large brush shaped implements that seems to attract a large amount of the organic waste accumulated in the culture vessels, therefore decreasing the need to undertake time consuming water changes.

The PMDC has developed an innovative method of acquiring copepods for larval feeding. The PMDC is directly adjacent to a reef and at high tide the water depth at the vertical rock wall that separates the PMDC from the reef would be around 3 metres deep. Every night they set out a boom with a very strong floodlight over the reef and this attracts the photophilic copepods. At the area of copepod congregation, a submersible pump is placed in the water and simply pumps the seawater, rich with copepods, up and into the PMDC where it is strained through a large sieve and all copepods are captured and the seawater is returned. The copepods are then further filtered the next day and either fed directly to the larvae or frozen for later use.

Larval Rearing and Weaning

Larvae are cultured using standard green-water culture techniques. The larvae are not weaned onto artificial feed because they are fed minced fish and moved onto larger pieces of trash fish in the nearby commercial net pens.

Product Grow-Out

The PMDC does not have grouper grow-out facilities; however, there is a small net-pen facility operated by the Palauan Government on the adjacent island of Babeldaob (Figure 22).

The other commercial net-pen facilities are owned by private companies. There are far fewer net-pen facilities within Palau than Indonesia and Thailand.

The Fellow visited two net-pen facilities and they were both stocked with marble grouper and some coral trout (Figure 23). The most notable thing about the grow-out situation in Palau was the environment itself. The net pens were placed in an idyllic setting in a water depth of around six metres and the visibility easily reached the pure white sand of the bottom. The environment was perfect for marine fish grow-out.

Figure 22. Grouper grow-out facility on the Island of Babeldaob, Palau

Figure 23. Commercial grow-out facility, Palau

Institutional Capacity

The PMDC does not have the quality of the systems of extension and community engagement that the MDC and KFRDC has; however, they are in the process of trying to emulate these models. The Palau community college has a very active aquaculture program that also utilizes the PMDC, and they have a very devoted individual heading up that program and they are tasked with aquaculture extension.

Noteworthy Points

MDC

- Garlic is used in microalgae culture in both flasks and on-site as a manufactured paste
- Feeding stations were used in all tanks during weaning
- Training and extension is free
- Heavily promote aquaculture development and do not police it

Grow-Out Facilities Near MDC

- Turmeric and garlic are added to the diet

KFRDC

- All broodstock are held in floating cages within a large pond
- All broodstock either have a freshwater or formalin bath regularly to eliminate parasites

- All microalgae cultures are run at 3 parts per million of chlorine to eliminate ciliate problems
- Artemia are constantly being grown out and frozen for later us
- Coral trout larvae are stocked very lightly in rearing tanks
- Adult frozen artemia are fed to coral trout larvae after day 45 post-hatch
- Extension and training are free
- Restocking programs are linked with community environment days

Grow-Out Facilities Near KFRDC

- Coral trout and estuary grouper are the preferred grow-out species
- Coral trout can grow-out to a sellable product from nine to 12 months
- The barramundi cod or humpback grouper are not considered commercially viable because of their extremely slow growth rate

PMDC

- Technicians have adopted a hands-of approach to broodstock
- Copepods are filtered from the adjacent reef with the use of strong lighting and a submersible pump
- The Palau Community College has an active aquaculture extension program

Knowledge Transfer: Applying the Outcomes

The transfer of knowledge gained from the Fellowship trip will be directed towards two distinct subgroups.

First, the practical knowledge of carrying out the culture of grouper species will be directed towards commercial growers, training institutions and research agencies.

The second subgroup is institutional capacity. This knowledge must be transferred to executives in peak aquaculture organisations of Australia and managers of governmental agencies at all levels of government tasked with aquaculture policy and development.

A knowledge transfer approach for the two subgroups is detailed below.

Grouper Culture

The knowledge transfer instrument would be in the form of a series of intensive workshops. Such workshops would run for at least 30 days, but not necessarily be concurrent, and must ensure that all practical exposure to critical life stages of the culturing process are met.

The workshop would commence in an off-campus mode at first, where the participants would be sent relevant information that can be learnt externally and not as a practical application. This would include, the current status of global grouper aquaculture, grouper biology, spawning theory and nutrition.

This off-campus commencement serves two purposes, first when the participant arrives for their practical, they have the required background knowledge, and second, it also decreases the costs of the workshop.

The venue for the workshop must have access to quality salt water and have a designated live feed and algae culture area, as well as tanks of adequate size to house both broodstock and young fish. There are numerous commercial facilities that could be venues for the workshops as well as some government run facilities listed below:

- Northern Fisheries Centre, Cairns
- The Darwin Aquaculture Centre
- Kimberly TAFE
- Sunshine Coast Institute of TAFE
- Batavia Coast Maritime Institute.

These suggested venues are by no means definitive and have been chosen mainly for their existing aquaculture practices and facilities. Other specialised aquaculture training facilities could also undertake this form of training, provided adequate heating was supplied.

The workshop would be segmented into the following specific workshops:

- Broodstock management
- Spawning
- Microalgae and live feed culture
- Larval rearing
- Post-larval care and weaning
- Product grow-out.

Knowledge Transfer: Applying the Outcomes

The workshops would be an 80/20 split of practical and theory. Common themes throughout all of the workshops would include water quality, health management, data recording and sustainability. The practical application would entail the participants actively undertaking the culture of grouper, from preparing the broodstock, all the way through to growing the product out for market.

The first four facets of the workshop dealing with broodstock, spawning, algae and live feed culture and larval rearing could be undertaken in a three-week, five days per week intensive workshop scenario.

The participants would then come back 30 days after this period for one more week for the weaning period. During this time the fish may be transferred to grow-out ponds/tanks or a different facility. It would be impractical for course participants to wait for such time as the product being ready to be sold as a table fish; however, a trip to a facility with products closer to that phase would also be added within the workshop scenario.

Institutional Capacity

The knowledge transfer of lessons learned about the institutional capacity of the agencies and their subsequent facilities visited would be targeted toward relevant National, State or Local Governmental personnel tasked with aquaculture development.

An invitation would also be extended to executives of the peak industry lead aquaculture bodies. The knowledge transfer could be a two-day workshop where on the first day detailed information would be given about the agencies visited by the Fellow and an in depth analysis would be undertaken to identify similarities and differences of participating agencies and the ones the Fellow visited.

The next day would then move to developing strategies that would allow for the sustainable development of a grouper culture industry within the state or region in question.

Recommendations

The following points are succinct recommendations developed by the Fellow with the aid of industry representatives:

Government

Recommendation: Australia should follow most South East Asian nations and recognise commercial grouper culture as a viable aquaculture prospective.

Recommendation: A series of institutional capacity workshops should be undertaken toward relevant National, State or Local Governmental personnel tasked with aquaculture development.

Recommendation: Australian agencies tasked with aquaculture development should access existing inter-country groups such as the Network of Aquaculture Centres in Asia–Pacific (NACA) to gain up to date information on grouper aquaculture.

Recommendation: The Fellow is available to AgriFood Skills Australia to develop industry standards and content as appropriate to needs.

Recommendation: A better suite of regulatory frameworks need to be implemented in order to have a more conducive marine aquaculture licensing and permit process.

Industry and Professional Associations

Recommendation: The findings of this Fellowship are to be presented at a number of Australian aquaculture conferences such as the Australasian Aquaculture 2010 International Conference and Trade Show.

Recommendation: The Fellow directly liaises either formally or informally with industry about the findings of the Fellowship.

Recommendation: A power point presentation of the Fellow's international experience is to be sent to all relevant industry bodies interested in grouper aquaculture.

Recommendation: An Australian grouper farming association should be created. This association may commence as an off-shoot of other associations such as the Australian Barramundi Farmers Association and existing members may opt to join an Australian Grouper Farming Association.

Education and Training

Recommendation: A series of grouper culture workshops be undertaken by the Fellow and other experienced technicians in the states of Queensland, Northern Territory and Western Australia.

Recommendation: South East Asian training in grouper culture should also be a viable option for people wishing to undertake commercial grouper aquaculture. An example would be through the Network of Aquaculture Centres in the Asia–Pacific (NACA) that run formal grouper training workshops on an annual basis. Training venues have included Southern Sumatra, Thailand and Bali.

Recommendation: Education and training institutions should collaboratively design the grouper culture workshops.

Recommendations

Recommendation: The training should be mapped to the Seafood Industry Training Package where workshops can be aligned to specific competencies, which would contribute towards a formal qualification. This mapping may allow for a greater level of state or federal-based funding.

ISS Institute

The ISS institute could contribute to the knowledge transfer by effectively advertising the Fellowship's outcomes through dissemination of this report and having accessible information related to the Fellowship on their website and in newsletters.

Recommendation: The Australian Government and/or industry associations such as AgriFood Skills Australia to sponsor more Fellowships to build on the findings in this report, targeted to specific breeds and locations, and to investigate 'Further Skills Deficiencies' below.

Further Skills Deficiencies

Following on from this Fellowship an area that needs to be examined in detail is institutional capacity. Although probably not fitting within the standard skills deficiency framework, it has shown time and again the vital role institutions play within the development and proliferation of grouper aquaculture.

There is a suite of management level skill deficiencies that could enhance the likelihood of a grouper industry in Australia.

Recommendation: Empowering commercial facility managers and owners in both risk and change management would maximise the decision making processes needed for farm development and diversification.

The final skill deficiency would be product marketing. Although existing markets are mainly concentrated in the Asian region, it sometimes has a very complex supply chain and can be a difficult market to break into. Australian producers or their marketers need to have an intimate knowledge of both the grouper supply chain and how to sell their product within Asia.

Recommendation: Product marketing programs to be developed, aimed at those in the industry to widen their approach so that they can compete successfully with overseas suppliers.

Conclusion

Australia is known for growing high value species in an environmentally sustainable manner. Marine grouper logically fits into the Australian aquaculture species profile. It is evident that the commercial aquaculture of grouper species in Asia and Micronesia are a viable option. All facilities the Fellow visited had specific techniques to spawn, raise and grow grouper species through to an existing market; however, there was enough commonality between facilities to highlight a suite of standard techniques that would work in most situations.

All of these skills are transferable within an Australian context and there are devoted individuals within the country that would like to see this happen. Ultimately it is up to the Australian Aquaculture Industry and their subsequent government institutions to formulate a strategy to progress the grouper sector.

References

Commonwealth of Australia, in Association with the National Aquaculture Council, 2004. Aquaculture Australia Industry Report . Invest Australia, Victoria.

ABARE 2007, Australian Fisheries Statistics 2006, Canberra, June.

Department of Primary Industries and Fisheries, Queensland, 2008.

Report to farmers – Aquaculture production survey Queensland 2006–07. The State of Queensland.

CRC Reef Resarch Centre, 2005. The Current State of Knowledge; Queensland East Coast Reef Line Fishery. Townsville, Queensland.

Rimmer, Michael. Production update – marine finfish aquaculture in the Asia–Pacific region. Marine Finfish Aquaculture Network, Indonesia.