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Aquaculture in Regional Australia: Responding to Trade Externalities. A Northern NSW Case Study.

Jeffrey A. Guy
Southern Cross University

Alistair McIlgorm
University of Wollongong

Peter Waterman
University of the Sunshine Coast

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Abstract

Australia's aquaculture industry is predominantly based in rural coastal regions where it makes a significant contribution to local economies as well as to national food security. Over the past decade changing global economic and trade conditions have resulted in Asia supplying an ever-increasing amount of seafood to Australian consumers. From 2003 to 2007 landings of cheaper imported Asian prawns increased dramatically, seriously impacting the eastern Australian prawn farming industry as graphically illustrated by the collapse of prawn farming in the Northern Rivers region of NSW. In response, the Southern Cross University's National Marine Science Centre researched the feasibility of farming the finfish mulloway or jewfish (*Argyrosomus japonicus*) as an opportunity for Australian prawn farmers to diversify their production base. In this context, the purpose of this case study was to assess the effect of imported products on the viability of the northern NSW prawn farming industry by reviewing the output and cost structures of a local prawn farm before (2002-2003) and after the influx of competing imports (2006-2007). Secondly, the findings of a two year trial of farming mulloway in ponds on a converted prawn farm are critically evaluated, and possible opportunities are identified. Finally, regional policy implications of the case study are examined and current constraints and limitations to the uptake of mulloway farming in northern NSW are identified.

Keywords

Aquaculture, imports, bio-economic models, cost-benefit analysis, diversification, jewfish

Cover Page Footnote

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Introduction

Aquaculture continues to be the fastest-growing, meat-producing sector in the world, growing from less than 1 million tonnes of annual production in 1950 to more than 50 million tonnes in 2008 (Food and Agriculture Organisation of the United Nations (FAO), 2010). Global per capita supply from aquaculture has increased from 0.7 kilogram in 1970 to 7.8 kilogram in 2008; an average annual growth rate of 6.6 percent (FAO, 2010).

Southeast Asian countries in particular have responded to this global demand with massive increases in low-cost aquaculture production. One important issue this raises is: *What does this mean for Australia's aquaculture potential, especially the production of identical or similar species for domestic and overseas markets*? This is a pivotal question because the global production of many commodities, including seafood, is shifting to Asian countries that have the lowest costs of production. Exports of their products to Australia in the past decade have and will continue to provide competition for local farmers competing in the same markets.

Although aquaculture growth in Australia has been slower than that in Asia, aquaculture is still Australia's fastest-growing primary industry, accounting for 30 percent of national fisheries production and increasing in value by 13 percent per year since 1990 (Department of Agriculture, Fisheries and Forestry (DAFF), 2004). The seafood industry is also Australia's fourth most valuable food-based primary industry, after beef, wheat and milk (Dundas-Smith and Huggan, 2006). Aquaculture production occurs throughout Australia, from the tropical north to the temperate south. The industry is largely based in rural Australia. It makes a significant and positive contribution to regional development and has the potential to become a $1 billion per year industry (Mazur and Curtis, 2006; DAFF, 2013).

Currently, the bulk of Australian aquaculture gross value is sourced from relatively few 'high value' species. In 2008-09, the gross value of production (GVP) of the five main farmed groups was salmonids (AU$330 million), southern bluefin tuna (AU$158 million), pearl oysters (AU$106 million), edible oysters (AU$89 million) and prawns (AU$57 million) (O'Sullivan and Savage, 2011).

The bulk of Australian prawn production comes from tropical north Queensland (QLD) with other significant farming areas being the Mackay, Bundaberg and the Sunshine Coast and Gold Coast regions. Prawn farms in New South Wales (NSW) are located in the warm temperate coastal zones of the Northern Rivers from Ballina south to Coffs Harbour. Virtually all Australian prawn farms are managed intensively: the industry average pond size is one hectare, with stocking densities of more than 40 post-larvae per square metre and a total ponded area of around 750 hectares (Wingfield and Willett, 2011; Trenaman, 2011). Pond production techniques are well developed and farms south of Mackay produce one summer crop a year while those in the tropical north have the potential to produce more (Queensland Department of Primary Industries and Fisheries (QDPIF), 2006). The black (giant) tiger prawn (*Penaeus monodon*) is the major farmed marine prawn species in Australia, although the banana (*Fenneropenaeus merguiensis*), brown tiger (*P. esculentus*) and the kuruma prawn (*P. japonicas*) have also been farmed (Love and Langenkamp, 2003).

However, the black tiger prawn is also one of two main species (including *P. vannamei*) produced in Asia. This raises interesting questions in relation to the likely impacts on the profitability and continued growth of prawn farming in Australia and the challenges producers face due to the globalisation of seafood markets. With forecasts of increasing prawn aquaculture production in Asia, greater quantities of prawns are likely to enter Australia, further eroding the market share of Australian producers. For example, in 2012 the Malaysian government approved a 1090ha site in Merchang, Merang for prawn farming. This joint venture between Malaysia's Ocean Aquatic Marine and the Chinese prawn company, Zhanjiang Guolian Aquatic Products is focused solely on the export market (Teng, 2013). Many Australian seafood wholesalers may find it cheaper in future to import rather than buy product that is processed locally. Despite the available evidence, there has been little publicity or documentation of this important rural issue, especially linking increased imports to the decline in production and earnings of primary industries; and there is even less commentary on strategies required to combat this.

There is a growing need for Australian aquaculture industries to develop appropriate response strategies to such drivers. Experience in other developed countries also indicates the need for rural industries to provide diversification opportunities to remain competitive and avoid excessive reliance on a single species or commodity (Basurco and Abellán, 1999; McMaster, Kloth, Coburn and Stolpe, 2007). Such an approach is essential irrespective of it being either in the agricultural or the aquaculture sectors. At present, the Tasmanian salmon industry is the only aquaculture industry actively investigating this option (although the driver is climate change.) The industry has identified the striped trumpeter (*Latris lineata*) as the best species for diversifying sea cage culture (Battaglene, Carter, Hobday, Lyne and Nowak, 2008).

The benefits of species diversification to aquaculture operations include market expansion, the spreading of risk and improved production efficiency (Basurco and

Abellán, 1999). Prawn farmers diversifying into fish culture would add a large (50,000 tonne) new national market to their existing business (Makrid and Associates, 2002) while having alternate species and markets also reduces the risk from serious disease and income fluctuation (supply-driven price decreases). Furthermore, sales and distribution channels are not restricted to the supermarket/grocery chains and higher returns are possible using independent fishmongers and restaurateurs who pay higher prices to source fresh seafood for their customers.

The option to move part of the production capacity to another species, which is not affected by disease or sells for more, has merit. This was the case in 1994-1995 when an outbreak of viral nervous necrosis (VNN) in European seabass (*Dicentrarchus labrax)* hatcheries in the Mediterranean was averted by shifting production to gilthead seabream (*Sparus aurata*) (Basurco and Abellán, 1999; Castric, Thiéry, Jeffroy, de Kinkelin and Raymond, 2001). Also, by working with other species that can be reared in different seasons and with similar technology and facilities, resources are used more efficiently. One option for prawn farmers is to adapt their existing on-site hatchery facilities to finfish production, as prawn and fish hatcheries have similar requirements. Having more than one species to breed reduces the risk of failure. Farmers can also rotate their crops, allowing the pond to recover from unfavourable changes resulting from the culture of a single species, making farming more sustainable (Liao, 2000).

In the Mediterranean, species diversification has been used as a tool to combat market saturation due to the oversupply of the European seabass and the gilthead seabream (Basurco and Abellán, 1999). Numerous suitable new species from several families (Sparidae, Polyprionidae, Serranidae, Sciaenidae, Soleidae, Carangidae, Scombridae) have now entered the Mediterranean mariculture industry (Rigos and Katharios, 2010; Monfort, 2010). In the USA, the Florida pompano (*Trachinotus carolinus*), a carangid, has been investigated as an alternative to prawn farming (McMaster et al., 2007) while the prawn aquaculture industry in Ecuador evaluated numerous marine fish species for diversification including the Mazatlan yellowtail (*Seriola mazatlana*), flounder (*Paralichthys woolmani*), snook (*Centropomus nigrescens*), red drum (*Sciaenops ocellatus*) and Pacific pompano (*Trachinotus paitensis*) (Benetti, Acosta and Ayala, 1995).

In Taiwan, following the collapse of the black tiger prawn industry from Monodon Baculovirus (MBV) in 1988, the government recommended that prawn farmers diversify pond culture by including finfish, clams and other shellfish (Lin, 1989). Taiwan now has about 100 species of finfish that are cultured commercially. More than 65 species of these can be artificially propagated (Liao, Su and Chang, 2001). There is also increased interest in the use of abandoned shrimp ponds for fish culture, in developing countries such as India, Bangladesh, Sri Lanka, Vietnam, Cambodia, Philippines and Indonesia (Stevenson, 1997).

In 2008 the National Marine Science Centre (NMSC) commenced research into mulloway, as a potential species for NSW prawn farmers to diversify their production base. Mulloway or jewfish (*Argyrosomus japonicus*) is a carnivorous, temperate, euryhaline finfish of the family Sciaenidae, which is ideally suited to the warm temperate coastal zones of northern NSW. Mulloway has been identified as having the most potential for land-based farming in this area (Gibson, Allan, File, Mullen and Scott-Orr, 2005). A move to replace black tiger prawn aquaculture with, an alternative finfish culture opportunity, mulloway, is a productive way of offsetting the impact of imported prawns on prawn farm businesses, thus strengthening the rural economy. Furthermore, grow-out data to date (Guy and Cowden, 2012) shows that mulloway perform extremely well in prawn ponds and that they have desirable market attributes (Guy and Nottingham, 2013). Nonetheless, the overall economic viability of commercial scale, intensive grow-out aquaculture is still to be determined.

This paper presents a case study of the impact of Asian prawn imports on black tiger prawn (*Penaeus monodon*) production in northern NSW, Australia. The paper describes how lower-priced Asian prawn imports grew rapidly post 2002-2003, leading to changes in the pattern of trade and farming of prawns in NSW. Over a five year period, the industry rapidly declined, severely impacting the prawn farming community and its associated service industries. To illustrate this we use historical data on fresh, chilled or frozen prawn imports, aquaculture production reports over the past decade and production output and cost structures of a representative local prawn farm before (2002-2003) and after the influx of competing imports (2006-2007).

The paper also includes a preliminary evaluation of an alternative finfish culture opportunity for these impacted prawn farm businesses. The aquaculture viability and economic potential of pond-grown mulloway is examined through investment and sensitivity analysis based on a two year pilot program (2008 to 2010) conducted under commercial conditions on a converted prawn farm. Finally, the regional policy implications of the case study are discussed, including current limitations and some key barriers to industry development.

Data and Methods

Trade and production data

Historical data on landings and unit gross value of fresh, chilled and frozen prawn imports were obtained from the Australian Bureau of Agricultural and Resource Economics (ABARE) Australian Fisheries Statistics, which provide a comprehensive account of historical trends in, and the outlook for, Australian fisheries. NSW production data was sourced from the NSW Department of Primary Industries aquaculture production reports.

Economic analysis

A two year commercial pilot for a 96 tonne converted prawn farm facility was used to assess the economic viability of mulloway farming in northern NSW. Investment and sensitivity analyses were applied to provide estimates of economic and financial feasibility and whole farm profitability for conversion to mulloway. These approaches have been widely used in aquaculture economic studies worldwide (Cacho, 1997; Liu and Sumaila, 2007) including in Australia (Keys, Crocos and Cacho, 2004; Melville-Smith, Johnston, Johnston and Thomson, 2008; Guy, Johnston and Cacho, 2009). The analysis uses a combination of experimental and best practice industry data. A standard investment appraisal net cash flow model was used which presents data in a format showing annual profit, cash flows and discounted cash flow analysis. The investment in the farm was analysed over a 20-year time frame to produce a set of results that are specific to finfish production and the Australian aquaculture industry. Sensitivity analysis enables key variables that promote viable mulloway farming to be identified. Indicators included: net present value (NPV), which is a measure of annual returns generated over the life of the project expressed in dollars at time zero; the internal rate of return (IRR), which describes the discount rate at which the project has an NPV of zero; and the return on capital employed (ROCE).

An appropriate discount rate for an aquaculture venture assessment is not universally agreed upon. Aquaculture is acknowledged to be a high-risk investment and consequently investors would expect rates to be well above 5 percent, which can currently be obtained in a risk-free bank investment in Australia (Love, 2003). In this context, an 8 percent discount rate was chosen. A risk-adjusted discount rate of 15 percent was also considered but not used because at least one other Australian aquaculture study (Melville-Smith et al., 2008) found this to be too high to generate a positive return.

Study site and infrastructure

The 18 hectare owner-run mulloway farm began operation in 2008 and is located on Palmers Island about 7 km west of the coastal town of Yamba in northern New South Wales. The Clarence River is the source of brackish-saline water at the farm and mulloway are grown in 12 earthen ponds which receive regular inputs of river-derived water from a central intake canal. Stock is fed a formulated, extruded, generic type marine fish diet, once or twice daily and oxygenation of pond water is maintained by paddle-wheel aeration. The remaining farm area has an office complex, hatchery building, processing shed, house and a larger effluent-settlement discharge pond. This represents the current level of land-based investment and activity in mulloway aquaculture in NSW.

Farm production cycle

The climate in Palmers Island is sub-tropical with typical ambient summer (November to April) temperatures of 25–40°C. Guy and Cowden (2012) describe the locality as having a distinct seasonal climate and water temperatures reflect this ranging from 13-14°C (July) to 31-32°C in January/February. Under these conditions mulloway reach market size (2.0 kg) in two years. To initiate the production cycle, fingerlings weighing about one gram are stocked in four ponds that are netted to exclude predators at a density of approximately 14,000-15,000 fish per pond. They grow to 'plate size', that is about 500 to 600 grams, in one year. Individual ponds are then drain-harvested, graded and split evenly (approximately 6,000 to 6,500 fish) into two ponds (large and small grade) for grow-out to market size, which is some two kilograms, in two years. Based on the work of Fielder and Heasman (2010), it was assumed that purchased fingerlings would be available through out-of-season spawning and could be stocked in late September/early October each year to utilise all of the summer growing season.

Guy and Cowden (2012) reported that grow-out results from the trials indicate 90 percent survival of juveniles in the first 12 months and 95 percent over the next 12 months. The authors also reported that feed conversion ratio (FCR) and growth performance data was obtained from the two-year, on-farm trials. These production cycle results should be applicable to coastal regional locations with similar biophysical conditions.

Production, income and capital investment assumptions

Key production parameters are summarised in **Table 1** and financial data in terms of cash inflow (market price and production yield) and outflow (capital and operating costs). A wholesale market price (outside of the Sydney Fish Market auction system) was set at $10 per kg (personal communication, Andrew Carroll, farm manager; PIM, 2012), yields at 12 tonne per pond with a total farm output

and revenue of 96 tonne and AU$960,000 per annum, respectively (Guy and Cowden, 2012). Full production was assumed to be achievable by year three, with year two calculated at 67 percent of the total farm output to allow for lost production and cost inefficiencies in the learning phase of farming a new species.
Total capital outlay was AU$1.1 million (**Table 2**) which included the cost of land. The land value (AU$668,000) was derived from the original farm purchase price ($1.2 million) less those assets that could not be converted to mulloway culture (prawn hatchery and processing equipment) and then adjusted to reflect proportional use of the site (80%). The capital value of the farm therefore represents the infrastructure directly attributable to mulloway production. The investment model also assumes that fingerlings are purchased and the farm can operate efficiently with a full-time manager, a skilled worker and one full time labourer with part time labourers at peak periods (**Table 3**). The total cost of feed is based on AU$2,000 per tonne. Feed consumption per year for the grow-out is 36 tonne to plate and 128 tonnes for market-size, respectively.

Table 3 also shows that the farm has been allocated a smaller first year annual budget (AU$15,000) for electricity rising to AU$88,068 at full production, and does not include any future rises in electricity costs nor consideration of the use of renewable energy. The investment appraisal model does not include any tax planning to assist with the cash shortages experienced during the initial two years during which the farm has limited income from production.

Conversion Costs

Conversion to mulloway farming requires some new capital investment, primarily exclusion netting over the ponds used for the year one fish. Exclusion can be either partial or total and the modelling assumes the later. Total exclusion is more expensive, costing AU$20,000 per pond, which includes posts and tensioning wires and UV-stabilised netting. Experience with the host farm site has shown there can also be issues with the power system inherited from prawn farms (dropping back to two-phase). Capital expenditure may be required for upgrade to three-phase power. Additional capital costs include harvest nets and lifting equipment (AU$20,000) for a combined total of AU$100,000.

Table 1: Key production parameters (AU$) for a 96 tonne model mulloway farm.

Description	**Parameters**
1. Physical property	
Number of ponds	12 (4 nursery and 8 grow-out)
Pond dimension[1]	104 m long x 81 m wide x 1.6 m deep
Pond surface area[1]	0.85 hectares
Pond capacity[1]	13.9 mega litres
No. aerators per pond	5
2. Nursery and fingerlings (Year 1)	
Month fingerlings stocked	October
Fingerlings required per crop	55,000 for 4 ponds
Fingerling cost[2]	$1.00 per 1 g fingerling
Mortality rate[3]	10% for 12 months
Weight of fish harvested	500-600 grams
Feed consumed[4]	9,000 kg per pond
Feed cost per crop	$72,000
Food conversion ratio[5] (Kg feed: kg body weight)	1.2 in 1 gram to 600 gram fish
3. Grow-out (Year 2)	
Month fish stocked	September
Stocking density	6,500 plate size per pond
Production per pond	12,000 kg
Pond dry-out period	1 month
Mortality rate[3]	5% for 12 months
Weight of fish harvested	2 kilogram (kg)
Feed consumed[4]	16,000 kg per pond
Feed cost per crop	$256,000
Food conversion ratio[5] (Kg feed: kg body weight)	1.8 in 0.5 kg to 2 kg fish
4. Market and freight costs	
Packing supplies and freight	5% of gross revenue in year3
Sales price (GST free)[6]	Chilled whole @ $10.00 per kg
5. Labour requirements[7]	
Casual	$15.00 per hour
Leave loading	17.5% of four weeks wages
Superannuation contribution	9% of wages
Workers compensation	5% of wages
Training	2% of wages
Annual wage bill[8]	$156,000

[1]Average from three ponds; [2]Government hatchery price (Allan, 2008); [3-5] Data from Guy and Cowden (2012); [6] Sales price range AU$9.75 to $10.25 per kg from 2010-2012 [7]Aquaculture industry award (AIRC, 2010), [8] From Year 3 when in full production.

Table 2: Capital Costs (AU$) for the model 96 tonne mulloway farm. No processing equipment is included in the budget.

Capital item	No. of items[1]	Cost of items ($)	Total cost ($)	Life (years)[2]	Salvage value (%)[3]
1. Site & Pond Infrastructure					
Site purchase cost			668 000 [4]	20	100
Construction (earthworks)	12	10 000	120 000	20	100
Plumbing and infrastructure	12	5 000	60 000	20	100
Pond electricity connection	12	1 000	12 000	20	100
Moorings and walkways	12	100	1 200	0	0
2. Other Infrastructure					
Bird netting	4	20 000	80 000	20	25
Generator	1	15 000	15 000	20	40
Workshop tools	1	10 000	10 000	20	20
Pumps	2	5 000	10 000	10	20
Aerators	60	700	42 000	5	0
Harvesting equipment	1	2 000	2 000	10	20
Feeding equipment	1	800	800	5	0
Water monitoring equipment	1	1 000	1 000	10	60
3. Buildings					
Workshop/storage shed	1	20 000	20 000	20	40
Coldroom	1	10 000	10 000	20	40
4. Vehicles and Machinery					
Trucks	1	20 000	20 000	10	40
Tractor/bobcat	1	25 000	25 000	10	50
Motorbikes/four wheelers	2	4 000	8 000	7	20
Mower/slasher	1	3 000	3 000	10	40
Trailer	1	2 000	2 000	5	20
Total capital outlay			**1 110 000**		

[1] All items purchased when project begins (year zero); [2] The expected life span of the capital item before it has to be completely replaced, rather than repaired; [3] If an item is to be completely replaced it may be sold for a certain value or used as part payment on a new item; [4] Derived from original purchase cost ($1,200,000) less farm assets associated with prawn production ($365,000) and adjusted to reflect proportional use of site (80%) for mulloway grow-out.

Sensitivity to changes

The model is sensitive to changes in a range of revenue and cost-impacting variables. A sensitivity analysis identified the risk implications for the commercial fish venture. For the base case, a series of 10 percent increases and 10 percent decreases were made to key revenue and cost variables to measure the change in the IRR. Revenue has both the risk of price reductions from AU$10 per kg induced by competing farmed fish products and shortfalls in production from loss of stock, below the envisaged 96,000 kg produced in year three. The costs of fish food (AU$328,800 pa) in year three and labour (AU$156,000) require management to limit the risk of cost increases**.**

Table 3: Annual operating costs (AU$) for the 96 tonne mulloway farm model when in full production (Year 3).

Item	Unit	Unit cost ($)	No. of units	Annual cost ($)
Variable Expenses				
Marketing (freight and packing)[1]	week	923	52	48 000
Fingerlings[2]	each	1	52 727	52 727
Feed[3]	ton	2 000	164.4	328 800
Electricity[4]	kwh	0.09	978 533	88 068
Labour[5]				
– owner/manager	week	1 269.2	52	66 000
– casual	hour	13	6 923	90 000
Fixed Expenses				
Aquaculture licenses, permits and rates[6]	each	3 125	4	12 500
Vehicle registration and insurances[7]	each	2 100	5	10 500
Fuel and oil[8]	litre	1.50	5 000	7 500
Hardware and plumbing[9]	each	100	5 9.1	5 909
Repairs and maintenance[10]	hour	50	372.7	18 636
Aquaculture supplies[11]	month	1 917	12	23 000
Miscellaneous[12]	month	1 667	12	20 000
Total				**771 640**

[1] Freight cost (chilled whole fish) to Sydney market including insulated boxes, ice, plastic liner, tape and label; [2] Juveniles that need to be bought, to achieve the target farm biomass; [3] Includes delivery and GST; [4] Related to the operation of the farm only; [5] Basic weekly or hourly wage for the period of stated employment; [6] Fees or permits paid to governing bodies to conduct aquaculture farming and rates payable by the owner of the property to the local council; [7] Cost of registering and insuring all farm vehicles and any other insurance such as income protection, buildings and stock; [8] Purchase of fuel (both diesel and unleaded) and oil for machinery on the farm; [9] Farm operation and pond inlet and outlet piping; [10] Of machinery and infrastructure. It does not include the full replacement of capital items; [11] Includes cleaning, medicinal and agricultural chemicals such as disinfectants, those used in the treatment of fish for health reasons and for pond preparation (lime) or control of water quality (molasses); [12] Administration (domestic and mobile phone, tax accountants, legal services, business advice), office operation (paper, staples, pens, computer disks), including lab equipment, pest control and travel incurred conducting business and/or gathering information (industry meetings, conferences, market visits).

Results

Changes in market trends: the growth in prawn imports to Australia

While imported whole prawns have long been contributors to the national prawn supply, this trend has grown alarmingly in the past decade. As shown in **Figure 1**, over the 10 years to 2006-07, the quantity of imported shrimp more than doubled, while at the same time real average unit import prices fell by 30-40 percent.

Specifically, in 2003-2004, the combined volume of imports from the three main traditional suppliers India, Thailand and Vietnam almost doubled from 6,942 to 12,703 tonnes. During this period China began its rapid rise to become the top source of imported prawns. Since 2003-04, landings of imported Chinese prawns increased dramatically from 544 to 3,894 tonnes in 2004-2005 to 8,469 tonnes by 2006-2007. **Figure 2** shows that growth in imports from Vietnam was equally dramatic, increasing from 1,256 tonnes in 2000-2001 to more than 7,000 tonnes by 2006-2007.

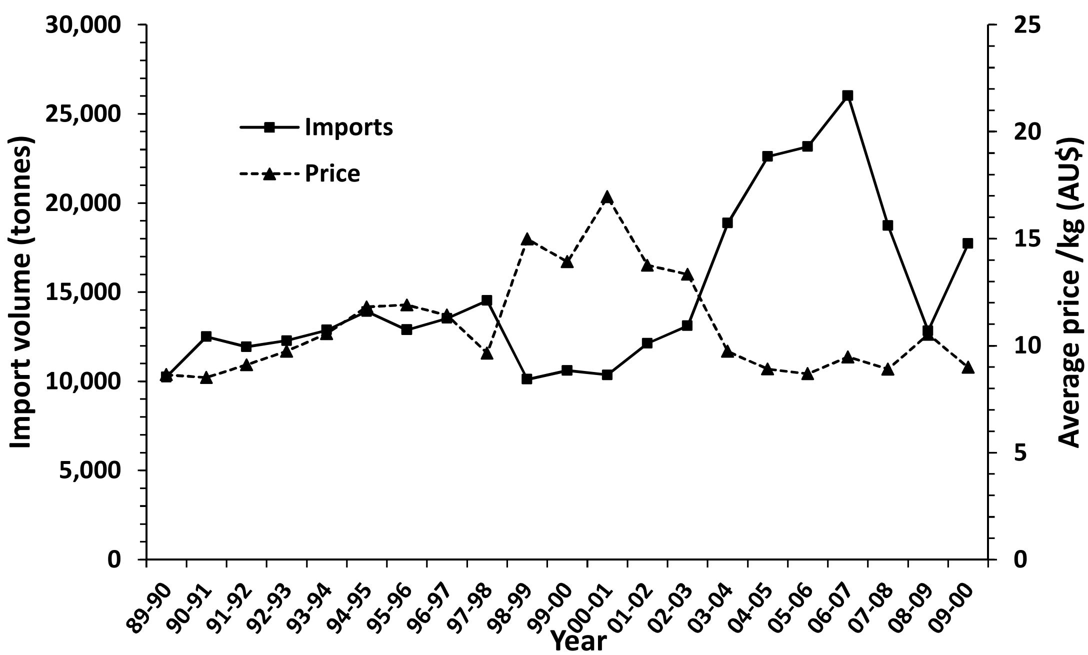

Figure 1: Australian imports and unit gross value of fresh, chilled or frozen prawns from 1989-2010. Data from ABARE (1989-2010). (Note: New quarantine restrictions introduced in September 2007 resulted in a marked drop in the landings of this category).

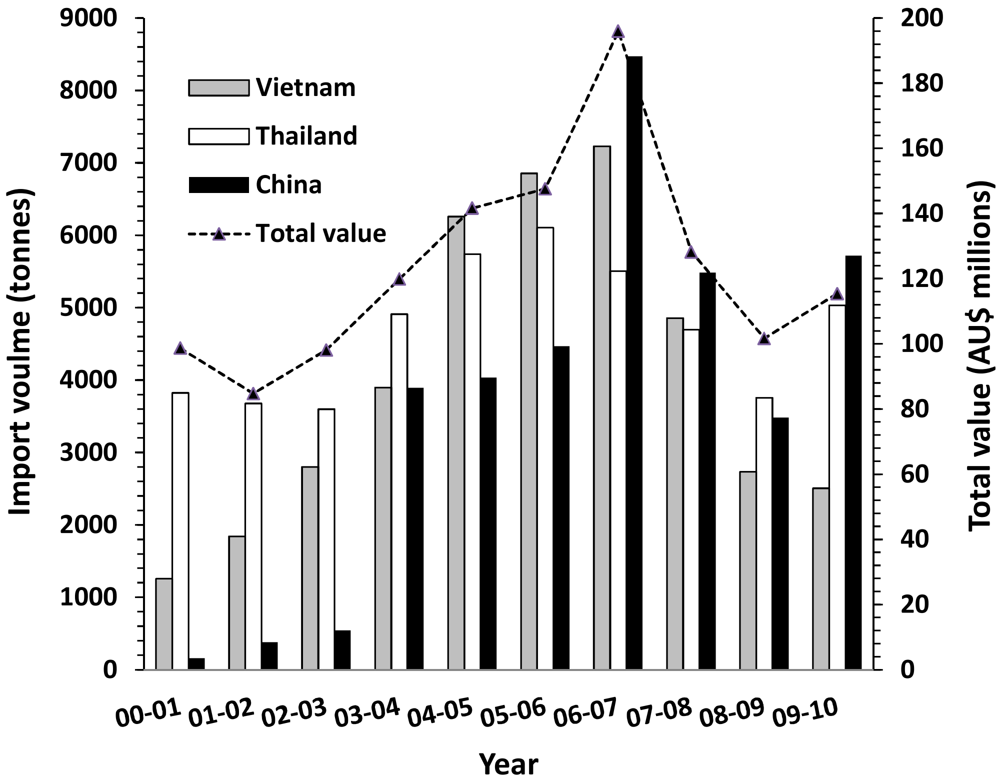

Figure 2: Australian imports and total value (all countries combined) of fresh, chilled or frozen prawns from China, Thailand and Vietnam from 2000-2010. Data from ABARE (2000-2010).

Four major drivers have been identified for this growth. The first is the strong appreciation of the Australian dollar which has made imports more attractive to Australian consumers (Love and Langenkamp, 2002). The second is the massive expansion of low cost *P. vannamei* culture in Asia (Gabaudan, 2008). Thirdly, there are no barriers (import taxes and tariffs) to entry of imported prawns into the Australian marketplace. The absence of small Australian east coast wild school prawns due to decade-long drought reported by Ruello (2011) is the fourth driver as this latter condition allowed imported cooked whole vannamei prawns to fill a market gap. Unfortunately, in addition, over this decade Australian prawn producers also faced rising wage, water and energy costs which affected their profitability. This in turn hampered market development and the product innovation necessary to stimulate local demand. Collectively, the aforementioned drivers and these additional factors seriously impacted this industry.

The impact on the NSW prawn farming industry

Production of black tiger prawns in NSW peaked at 408.82 tonnes in 2002-2003, which was prior to the import influx. At that time seven producers had some 134.3 hectares under cultivation with a production rate 3.04 tonnes per hectare per year. The gross value of production was in the order of AU$ 6.2 million. As indicated, the industry has declined significantly from this date and in 2010-2011 two producers marketed 148 tonnes from 87.63 hectares with a production rate 1.68 tonnes per hectare per year. This yield was worth AU$ 1.7 million, representing a direct gross value loss of AU$4.5 million (**Figure 3**). However the total impact on the Northern Rivers economy was much greater, at about AU$10 million, calculated using the NSW agricultural sector multiplier of 2.2 for primary output (NSW Trade and Investment, 2012).

In NSW, the response to cheaper and smaller imported farmed prawns, was to scale back production in 2003 and focus on a larger, high quality product (Kerr and O'Sullivan, 2005). Larger size grades (>25g), rarely face competition from imported product and gain a substantial price premium over smaller size grades (Ruello, 2002). Stocking densities were lowered from 45 to 10 post-larvae per square metre in order to achieve larger grade prawns. As shown in **Figure 3**, this resulted in a downturn in output and productivity.

The direct impact of imported products on local growers is well illustrated using the financial returns of a representative northern NSW black tiger prawn farm pre and post influx of imported product (**Table 4**). Established in the early seventies, from a 40 hectare (ha) sugar cane farm, the prawn farm has been in production since 1984 and at the peak of production in 2003 had 26 ponds with a total area of 21.6 hectares. Unfortunately for the producer, by 2006-07 the total business revenue had been reduced to one quarter of the 2003 level with the loss of income being attributed to the direct competition from imported black tiger prawns in the Individually Quick Frozen market component. As a result, the grower made no profit from his operations in 2006-2007.

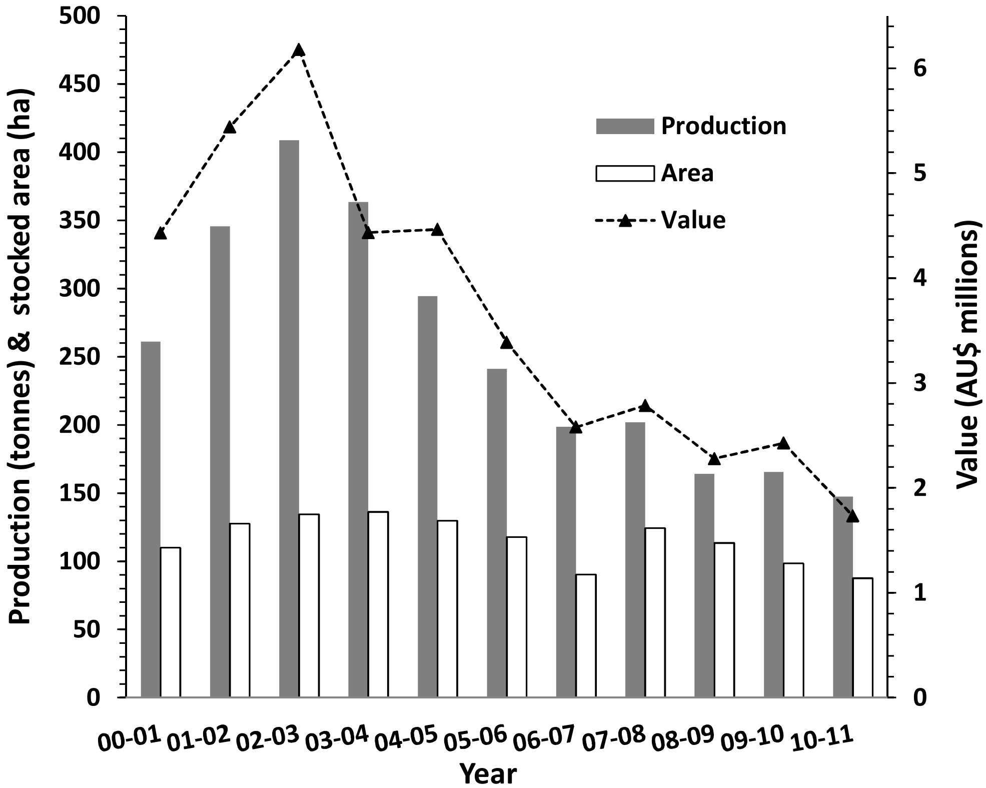

Figure 3: Production, area stocked and total value of farmed black tiger prawns in NSW 2000-2011. Data from NSW DPI Aquaculture Production Reports (2001-2011).

The major supermarket chains are the largest buyers of NSW farmed black tiger prawns as 10 kg green or large-cooked whole or smaller grade 'Individually Quick Frozen' (IQF) boxes that usually sell from AU$12.50 to 16.50 per kg depending on size (Ruello, 2002).

A significant portion of a farm's annual income is derived from the IQF product sold later in the year through these outlets. However, this category is identical to the imported frozen cooked BT prawns from Thailand and Vietnam, which are more than 10 percent cheaper, allowing imports to quickly gain market share in the supermarket sector (Ruello, 2011). Although vannamei prawns, mainly from China, fill a different low price supermarket segment they do provide some competition for domestic producers, especially at the point of sale where they are significantly cheaper than all other prawns.

Table 4: Observed annual operating costs, income and profit for a representative 150 tonne black tiger prawn farm in northern NSW pre (2002-2003) and post-influx (2006-2007) of imported product. Source: prawn farming industry personal communication.

Item	**2002-2003**	**2006-2007**
Operating costs	AU$	AU$
Feed	439 541	111 427
Post-larvae (stock)	282 764	45 936
Labour & superannuation	203 888	147 054
Capital	182 627	8 700
Repairs and maintenance	118 740	68 710
Packaging & IQF	101 724	12 975
Plant hire	94 560	2 780
Electricity	63 843	38 788
Freight	51 313	15 062
Fuel, oil and gas	35 022	16 740
Fertiliser & chemicals	25 839	4 670
Vehicle registration & insurances	25 170	15 001
Licenses, permits & rates	25 103	10 772
Travel (related to business)	12 235	0
Administration (phone & FAX)	7 635	6 381
Cleaning, postage & advertising	7 505	4 092
Accountancy & legal	6 819	3 000
R & D & shrimp return	6 125	8 341
Total Operating costs	**1 690 453**	**520 429**
Income		
- Fresh	1 077 794	471 125[2.]
- IQF	873 807[1.]	0[3.]
Total income	**1 951 601**	**471 125**
Profit	261 148	-49 304

[1.] 45% of total farm income is derived from IQF, highlighting its importance.
[2.] Income derived from fresh product has declined due to reduced stocking densities.
[3.] The loss of income from direct competition with imported black tiger prawns is seen in the IQF income component which is zero in 2006-2007.

Economics of an alternative finfish species - mulloway

The investment appraisal net cash flow model indicates that when fully operational in year three, the annual revenue of AU$960,000 exceeds the total annual cost of AU$771,640 giving a benefit-cost ratio of 1.24 (**Table 5**). The discounted cash flow analysis shows a 20-year NPV of AU$162,014 under the 8 percent discount rate and IRR of 9.5 percent. The IRR is the rate at which future net cash flows will equal the initial investment. By traditional profit-and-loss and return-on-investment criteria the project in year three shows a gross profit of AU$188,360 on the investment of AU$1,110,000. Thus, a return on capital employed (ROCE) of 17 percent. The assessment takes into account a staged increase in production of 56 tonne per annum in year two leading to maximum production of 96 tonnes in year three. Estimates of economic and financial feasibility and whole-farm profitability are summarized in **Table 5**. The four main input costs per kg of mulloway produced are feed ($3.42 per kg); labour ($1.62 per kg), electricity ($0.92 per kg) and fingerling purchase ($0.55 per kg).

Table 5: Mean results (AU$) for the model 96 tonne mulloway farm using a whole-farm quantitative cost-benefit analysis method.

Summary statistics	**Northern NSW climate (two year grow-out)**
Output summary	
Annual production (kg	96,000 kg
Annual gross revenue	$960,000
Annual production cost	$771,640
Production cost per kg	$8.04
Revenue per kg	$10.00
Profit-on-costs per kg	$1.96
Cost structure summary	
(Cost per kg)	
Feed	$3.42
Labour	$1.62
Electricity	$0.92
Fingerlings	$0.55
Process/Pack/Freight	$0.50
Fuel, oil, repairs & maintenance	$0.38
Supplies, hardware & plumbing	$0.30
Fees, licenses permits & rates	$0.13
Other	$0.22
Economic indicators	
Net present value @ 8%	$186,000
Internal rate of return	9.5%
Return on Capital Employed	17%
Benefit-cost ratio	1.24
Annual return	$188,360
Years to positive cash flow	2

Sensitivity analysis

The degree of sensitivity to key variables over the lifetime of the investment was generated by altering the traditional investment appraisal cash flow model (**Table 6**). The results of this analysis indicate that revenue is the most sensitive variable reflecting price and quantity changes. Managing the quantity of mulloway produced and the price received at market will have the largest potential impact on returns over the lifetime of the farm. A reduction of 10 percent in the price of fish feed and/or reducing the quantity of feed used would result in a 2.7 percent increase in the IRR over the lifetime of the project. The model assumes that fingerlings are bought and changes in price can impact the IRR by 0.4 percent. Controlling the cost of labour (including pay rates and hours worked by casuals) is also required, as a 10 percent change would impact the project IRR by 1.3 percent. Likewise, a 10 percent overrun on capital investment would reduce the IRR of the project by 0.9 percent over the 20-year life of the project. Discussion surrounding the carbon tax may lead to the electricity prices being increased. Fish producers were not aware of any compensation currently available from government.

Table 6: The change in Internal Rate of Return (IRR) for a percentage change in each of the key variables for the model 96 tonne mulloway farm.

	% Change in Variable			
Variable	**-10%**	**Base case**	**+10%**	**Change in IRR**
Revenue (P*Q)	2.3%	9.5%	15.9%	6.4%
Food ($)	12%	9.5%	6.8%	-2.7%
Fingerlings ($)	10%	9.5%	9.1%	-0.4%
Labour ($)	10.8%	9.5%	8.2%	-1.3%

Discussion of findings and implications of the case study

The 'Asian Century' and the future of regional industries

Asia's economic rise has been increasing at an unprecedented pace and scale. Japan, South Korea, Singapore (and more recently, China and India) have doubled their income per person within a decade. China and India have also tripled their share of the global economy and increased their absolute economic size almost six fold (Commonwealth of Australia, 2012a). Asia is the most populous region in the world and the world's largest producer of goods and services. This also extends to aquaculture production; in 2010, the world's six largest aquaculture producers were China, Indonesia, India, Vietnam, Philippines and Korea (Centre for International Economics (CIE), 2013).

Asia's extraordinary ascent has profound implications within regional Australia for people, businesses and institutions. Some regions and sectors have experienced strong growth in population, employment and income due to the strength of the mining sector. In contrast, some food producing regions, such as the Northern Rivers of NSW, are facing stiff global competition (Wahlquist, 2009; Wahlquist and Minus, 2010). Overall, those primary industries unable or too slow to adapt to increased competition have declined rapidly. Australia-wide, this downturn has affected farming communities and their associated service industries. As shown in the case study, this situation also applies to the aquaculture industry with a range of consequences and implications for development of the industry in regional Australia.

Federal and state government positions and 'free' versus 'fair' trade

Recent government statements of policy ('white/green papers') clearly acknowledge that Australia is entering a major transformative period in terms of international trade policy and domestic responses (Commonwealth of Australia, 2012a,b and 2013). This is demonstrated in the National Food Plan (Commonwealth of Australia, 2013) with respect to short, medium and long term planning to meet changing global and national demands for food. The 2012 National Food Plan Green Paper (Commonwealth of Australia 2012b) also recognises that regional Australia plays a central role for the food industry and is responsible for producing the majority of food on the tables of Australian families. However, a major policy thrust of these documents is that competition from imported food is good for domestic consumers because it makes Australian producers more efficient and hence more productive. There is also a focus on future export potential to meet the demands of the emerging Asian middle-class.

This 'free-trade' (non-intervention) market position does not take into account that many Australian producers are required to operate in an environment that has limited use of chemicals and antibiotics, and they must abide by much stricter controls on environmental impacts. This is not always the case in Southeast Asia. Rather, a "fair trade" position would involve the imported product meeting the same regulations Australian producers adhere to. One avenue is through stricter food testing, especially for chemical residues such as antibiotics in imported seafood. Despite this unlevel playing field, and a recent senate inquiry indicating that seafood imported largely from Southeast Asia was failing antibiotic tests, there has been an inadequate response from successive federal governments; at present only 5 percent of the imported catch is currently screened by the

Australian Quarantine and Inspection Service, (AQIS) a government controlled entity (ABC, 2013).

In direct contrast, NSW producers must comply with relevant federal, state and local government laws and codes of practice. Together, the NSW Land Based Sustainable Aquaculture Strategy (NSW LBSAS) and the Aquaculture Industry Development Plan (AIDP) are aimed at ensuring best practice and the long-term sustainability of the industry (NSW Aquaculture Strategy Steering Group, 2009). Section one of the NSW LBSAS establishes details for an Aquaculture Industry Development Plan (AIDP) under s.143 of the Fisheries Management Act 1994". Specifically, this "identifies best management for business planning, species selection, site selection and design, planning and operation of the facility and includes the performance requirements for relevant environmental regulations. Importantly, section two of the strategy provides for "revised planning provisions for the NSW land based aquaculture industry to be gazetted under State Environmental Planning Policy 62 – Sustainable Aquaculture". As such, this framework provides a sound land use and sustainability policy and practice footing for assessing and rolling out aquaculture enterprises. However, compliance with numerous government agencies serves as a cost on business, which is often passed onto the consumer as higher prices.

Industry and peak body responses to the issue of imports

The larger Queensland prawn producers responded to their own cost-price squeeze in a number of ways. For example, O'Sullivan (2009) noted that some have exited the industry and converted their farms to finfish (barramundi (*Lates calcarifer*)). O'Sullivan (2010) reported that other producers are trialling cobia or black kingfish (*Rachycentron canadum*) along with several grouper species (*Epinephelus* spp.) as supplementary crops. Lobegeiger (2007) and Wingfield and Willett (2011) explain that those remaining growers have intensified production. This has led to average yields in Queensland increasing from four tonnes per hectare in 2007-2008) to six tonnes per hectare in 2009-2010 and from 1.1 to 1.24 crops per pond per year from 2008 to 2010.

Industry peak bodies such as the Australian Prawn Farmers Association (APFA) and the National Aquaculture Council (NAC) have been proactive in demanding that all sides of politics support a clear system of country-of-origin labelling (COOL), so shoppers can make informed decisions about their seafood purchases (such as between a cheaper imported product or a more expensive quality assured Australian product). The 2011 Australian Consumer Law (ACL) now clarifies the legal position of corporations that make representations regarding the country of origin of goods they supply (ACCC, 2012). Unfortunately Australians have a poor record when it comes to buying on price. Ruello (1999) reported that marketing studies demonstrate that Australian consumers are particularly sensitive to price when making their seafood purchasing decisions. This is illustrated in the rise of imported frozen Vietnamese freshwater catfish fillets or ‘basa’ at a landed cost of three dollars a kilogram. Basa went from no market share a few years ago, to possibly the most consumed fish in Australia and this was achieved with minimal promotional effort (Seafood Australia, 2003/2004; Asche, Roll and Trollvik, 2009).

More recently APFA has looked to stimulate Australian demand through marketing campaigns such as celebrating Queensland Day (by eating Queensland prawns) and a national branding strategy (“Love Australian Prawns”) that concentrates on a fresh premium quality whole product. This is based on the premise that there is a percentage of the population that does care about where their food comes from and how it is produced and would choose the local product over an imported one. The ban on imported frozen uncooked (raw) farmed and wild whole prawns in September 2007 also closed off this market segment for imports. In this context, the outlook for fresh whole prawns is still attractive, especially in August-September and/or December when traditionally there are supply shortfalls and prices are very strong (Ruello, 2002). Phillips (2010) recommends concentrating on premium fresh products and larger sizes that target new distribution channels and outlets for Australian aquaculture products facing increased competition from cheaper imported products. Ruello (2011) warns that competing directly with identical frozen imports on price alone is a poor strategy.

There has also been a strong movement to have imported product subjected to the same food safety regulations as the domestic industry. For example any beef, pork, chicken or seafood imported into the USA is administered by the United States Drug Administration (USDA) and has to meet the same food safety requirements as the internal industry. But while this may help in the short term (as the imported product may struggle to meet these stricter food safety regulations) this is a sensitive topic, and could have negative consequences across the entire seafood sector by reducing overall demand.

Is diversification the answer to an improved and more resilient future for NSW prawn farmers?

Northern NSW is too cold in winter for BT prawn production (and tropical finfish species like barramundi) as at 20°C water temperature, growth and feeding ceases, or is negligible and death can occur at 14-15°C (Jackson and Wang, 1998). As a consequence, NSW farms produce only one summer crop and all prawns need to be harvested before winter, making them less productive and adaptable than tropical farms (between Ayr and Port Douglas, Queensland). These constraints were recognised in a national aquaculture viability study 20 years ago (ABARE, 1991). This indicated prawn farming in southern Queensland and northern New South Wales was more marginal than in the tropics, very sensitive to price, had limited potential for expansion and would not be viable in the long term with further price falls relative to costs. This blunt economic assessment is still relevant in the light of the impacts of imported product on the northern NSW aquaculture prawn industry, as outlined previously.

This prompted investigation into other native prawn species that were more cold tolerant or could over-winter, such as the brown tiger prawn (*Penaeus esculentus*), banana prawn (*Fenneropenaeus merguiensis*) and the kuruma prawn (*Penaeus japonicas*) which was cultured in NSW exclusively for live export to Japan. The depressed Japanese economy was the primary factor in reduced production of this species after 1997/1998 and all species met with limited commercial success because of their inferior grow-out performance (ABARE, 1997; Hoang, Lee, Keenan and Marsden, 2002). It is unlikely that a temperate prawn species could be found that would give better economic returns than the BT prawn, and in this context, southern Queensland and northern NSW prawn farmers need to look for potential in other non-prawn species. To this end, Love (2003) makes the point that the large scale, intensive culture of high value marine finfish is potentially Australia's most lucrative aquaculture industry.

However, our economic analysis indicates that mulloway farming at present is a reasonably profitable venture. Achieving full production is a significant issue for emerging industries as cash flow and returns are often impacted by production delays or stock losses as farmers learn their trade. However, this assessment does not take into account improved production efficiencies that are now being achieved (Andrew Carroll, farm manager, Palmers Island Mulloway Pty. Ltd., personal communication). Increases in production levels are likely as the upper culture limit for mulloway in ponds is currently unknown and farmers are now experimenting with stocking rates equivalent to 20 tonnes per hectare per crop. Higher returns are therefore possible, especially as emerging industries often start from an inconsistent supply/high production cost position.

Reduction in production costs has been achieved with a closely related fish, the meagre or shade fish (*A. regius*), which is a new species for the diversification of aquaculture in the Mediterranean region. Monfort (2010) found that in the past few years, its production and processing costs fell significantly with the FCR down from 2.5 to 0.9 - 1.2:1 and fingerlings to 40 cents. This resulted in its rapid development from an emerging 296 tonnes of product in 2002 to mature industry, with 4,784 tonnes harvested in 2008.

Cost impediments and enhancing profitability

A range of issues have been identified with regard to reducing costs and enhancing the profitability of the emerging mulloway aquaculture industry. Many of these impediments are common to other aquaculture enterprises and costs saving measures are well known and implemented.

Feed and labour costs: **Table 6** shows that feed at $3.42 per kilogram per fish produced by year three is the largest single cost in mulloway aquaculture. De Silva and Anderson (1995) found that this cost can be reduced by up to 20 percent if feed management (feed choice and how to ration that feed) is optimised. Specifically, reducing waste and improving FCRs through husbandry and improvements in delivery could lead to a saving of around AU$60,000 per annum. Currently, farm labour costs $1.60 per kilogram of fish produced in year three. This expense can be addressed through the scale, design and mechanisation of feeding. Work reported in Mosig (2007) shows that mulloway feeding is particularly suited to electronically operated timer-controlled systems.

Reliable low cost supply of juveniles: At present, high fingerling costs (AU$1.05 per 35 mm fingerling) are acting as a disincentive for prawn farmers to invest in mulloway farming (Allan, 2008). Accessing or producing fingerlings at less cost than from the government hatchery is a high priority for industry and researchers are currently exploring the potential of modifying existing on-site prawn hatchery infrastructure for mulloway fry production, with the aim of halving seed stock costs.

Market dominance and marketing: The domestic aquaculture finfish market is dominated by better known competing farmed fish products such as Atlantic salmon (*Salmo salar*), barramundi, rainbow trout (*Oncorhynchus mykiss*), and yellowtail kingfish (*Seriola lalandii*). Adequate investment in marketing is crucial to profitability. Industry experience to date indicates that if the producer can achieve an increase of just AU$0.25 per kilogram for mulloway from effective marketing, this should translate into additional AU$24,000 per annum in gross revenue for the farm. Ruello (2004) argued that promotional funds are essential to gain preferred product status and a price premium with distributors, retailers and consumers. The current mulloway farm business has built relationships with several wholesale fish agents in the Sydney market and in turn, this has reduced price volatility. Tisdell (2001) has examined such linkages and notes that agents can build a customer base among restaurateurs and other consumers providing much greater stability and quality assurance for all parties.

Economies of scale: Production costs can also be reduced through economies of scale. The case study model examined in this paper is for only one size of farm. Economic analysis for land-based teraponid farming in Australia, as documented by ABARE (2002) and Lyster (2004), demonstrates the positive effects of larger farms. Both studies showed that returns were highly sensitive to scale factors such as farm size, market price and feed costs.

Current status of adoption of mulloway aquaculture

To date only one Palmers Island prawn farm (Pearler Pty. Ltd.) has been converted to finfish production. In 2010-2011 this operation had an output of 72 tonnes which sold at an average price of AU$9.51 per kilogram (Trenaman, 2011). There have been no attempts by the other three larger farms in the region to culture another commercial species with ponds either lying fallow or only used occasionally. This is quickly becoming a defining feature of rural areas within Australia, with many smaller industries lying idle, unable to compete with cheaper imported Asian products, whilst also facing increasing input and compliance costs and a federal government that has no desire to intervene.

On the other hand, this also represents an unmet regional development opportunity as the land needed has already been alienated, key infrastructure is in place and the scientific evidence that underpins the innovation has been demonstrated. As such, this could be looked at as a renewed source of regional earnings and jobs.

Adoption of mulloway aquaculture in the region appears to be inhibited by 3 key factors: market price (income per kilogram), length of production cycle and the impact of imports. The latter may be having a major effect on adoption because farmers are not willing to risk another venture. Considerable effort could be required to convince growers of the need to diversify and the identified benefits of making this move. In itself this is a regional development challenge that may need to be addressed using a consortium of growers, government and academia groups and innovative marketing initiatives sponsored through the NAC.

Bird (2010) found that the key features of innovations that affect the likelihood of adoption are: expected profitability (highly profitable innovations are more quickly adopted); degree of certainty about the outcomes; and the scale and complexity of investment required for change. Despite the converted prawn farm providing an effective demonstration of innovation, the absence of above normal profits from mulloway farming is making finfish entry less appealing. One way to catalyse adoption is through appropriate incentives. And this may be the best strategy considering the history of prawn farming business in the region and the impact of global markets on local producers.

Martin and Verbeek (2006) argue that incentive schemes, such as a tax credits or subsidies, promote and reward desired behaviour and can be designed to influence the input, process or the output of an endeavour. A range of incentive schemes are regularly used by NSW government departments to help build business or stimulate community motivation. As mulloway aquaculture promises to stimulate regional employment and economic growth, some early government support may be needed for this emerging industry.

Concluding remarks

The growth in Asian imports of a range of food products has raised concerns regarding whether local farmers can compete with cheaper products. Production from Southeast Asian countries enjoys a lower level of input costs and regulation and there are no barriers to entry into the Australian marketplace. Marginal rural industries unable to adapt to these market forces, like the northern NSW prawn aquaculture industry, have been seriously impacted and production has declined. There has been little desire from governments to intervene and the Australian industry and peak bodies have responded by encouraging Australian consumers to choose the local product over an imported one through initiatives such as country-of-origin labelling, advertising campaigns and product branding.

Product diversification is also an acknowledged response for primary production including aquaculture where biophysical and socio-economic conditions are suitable. While diversification from prawns to finfish, such as mulloway has merit, profitability is currently restricting uptake and this is due in part to the high input costs associated with the early lifecycle stage of a new industry.

Further applied research is needed, particularly on the major cost areas of diets, feeding and local fingerling production to make mulloway more competitive and encourage farmers to enter and grow the industry. However, transition from prawn to mulloway culture also appears to be a slow process and governments need to play a role by providing incentives for farmers to diversify, particularly if there is a desire to maintain the economic benefits of aquaculture to economically-challenged rural regions.

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