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* School of Economics, The University of Queensland, Brisbane, QLD 4072, Australia
Email: s4065731@student.uq.edu.au

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For more information write to Professor Clem Tisdell, School of Economics, University of Queensland, Brisbane 4072, Australia.

What are the Economic Prospects of Developing Aquaculture in Queensland to Supply the Low Price White Fillet Market? Lessons from the US Channel Catfish Industry

Abstract

The farming of channel catfish (*Ictalurus punctatus*) is the largest (by volume and value) and most successful (in terms of market impact) aquaculture industry in the United States of America. Farmed channel catfish is the most consumed (in terms of volume per capita) fish fillet in the U.S. market. Within Australia, it has long been suggested by researchers and industry that silver perch (*Bidyanus bidyanus*) and possibly other endemic teraponid species possess similar biological attributes for aquaculture as channel catfish and may have the potential to generate a similar industry. The current teraponid industry in Australia, however, shows very little resemblance to the catfish industry, either in production style or market philosophy.

A well established budget framework from the literature on U.S. channel catfish farming has been adapted for cost and climate conditions of the Burdekin region, Queensland, Australia. Breakeven prices for the hypothetical teraponid farms were found to be up to 50% higher than those published for catfish farms however were much lower than those reported for silver perch production in Australia using current, endemic styles of production. The breakeven prices for the hypothetical teraponid farms were most sensitive (in order of significance) to feed prices, production rates, interest rates, fingerling prices and electricity prices. At equivalent feed costs the costs of production between the hypothetical catfish farms in the Mississippi, U.S. and the hypothetical teraponid farms in the Burdekin, Australia were remarkably similar. The cost of feeds suitable for teraponid production in Australia are currently around double that of catfish feeds in the U.S. Issues currently hindering the development of a large scale teraponid industry in Australia are discussed.

What are the Economic Prospects of Developing Aquaculture in Queensland to Supply the Low Price White Fillet Market? Lessons from the US Channel Catfish Industry

1. Introduction

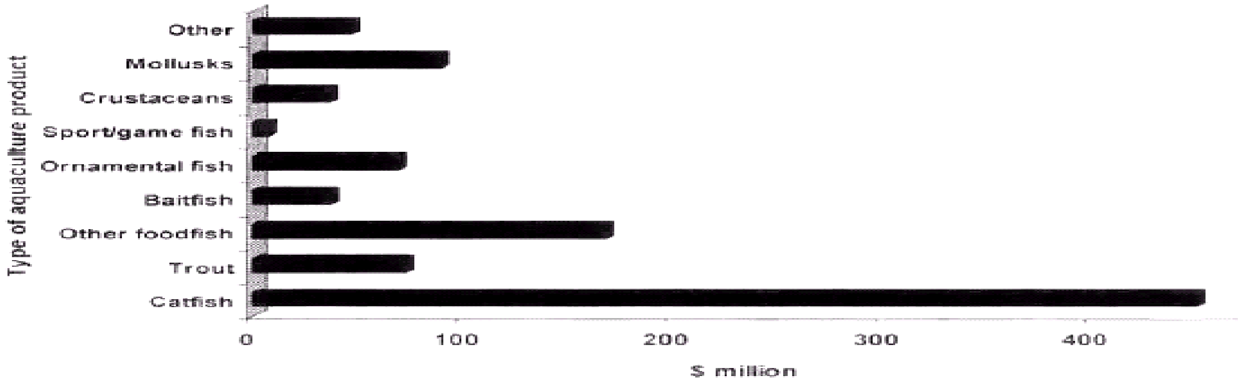
"*If questions have to be asked – how about this one? In Australian aquaculture's strategic grand plan, where is our basa? Where is our $5.00 - $10.00 kg fish fillet – the focal point of Australian consumer demand that currently requires us to comb the hake, hoki, Nile perch and basa fisheries of the world in an endless effort to satisfy a 100,000 tonnes per year (and growing) shortfall in local supply?*"

Norman Grant (Editor)
Editorial in *Seafood Australia* magazine (Summer 2003/2004)

The farming of channel catfish (*Ictalurus punctatus*) is the largest and most successful (in terms of market impact) aquaculture industry in the United States of America (Engle, 2003). It dominates both by volume (273 000 tonnes - about 75% in 2001 (Engle, 2003)) and value (approximately US$450 million - about 55% in 2001(Engle, 2003) see Figure 1.). The industry is characterised by relatively large farms (average about 150 ha in 2001 (Engle, 2003) see Figure 4.). Most catfish farming is conducted in a semi-intensive fashion in relatively large (4-10ha) freshwater, static, earthen ponds (Tucker and Robinson, 1991). Markets are well developed with catfish being a relatively low value, high volume product.

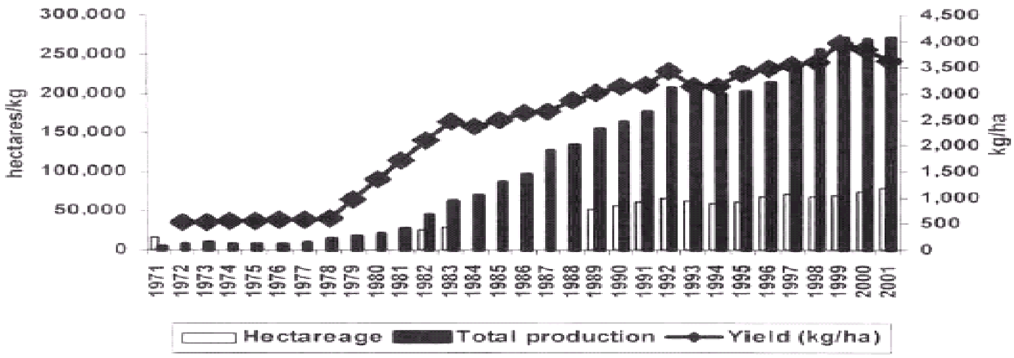
Pond side prices (live weight) have been in the range of around US$1.20/kg-1.80/kg (Au$[†] 1.60/kg-2.40/kg) over the past 10 years (see Figure 28). Catfish are mostly processed into fillets (60% in 2000) and 'whole dressed' (19 % in 2000) (Silva and Dean, 2001). The success of channel catfish farming has relied on the relatively low production cost of channel catfish production enabling catfish fillets to be cost competitive with other fish products and with chicken (Masser, 1998). The low production costs are a function of relatively simple production technology, cheap feed costs, regionally centralised production and economies of scale in pond size, farm size, processor size and industry size. Relatively strong marketing effort has also been a feature of the industry.

[†] US dollar values have been converted to Australian dollars using a nominal exchange rate of US$0.75= Au$1.00. This conversion rate is based on a rough average of actual exchange rates over the first 6 months of 2004 and is not intended to reflect equivalent purchasing power parity. It should be kept in mind that the validity of this exchange rate is important to many of the assumptions and conclusions in this paper.



Source: Engle (2003)

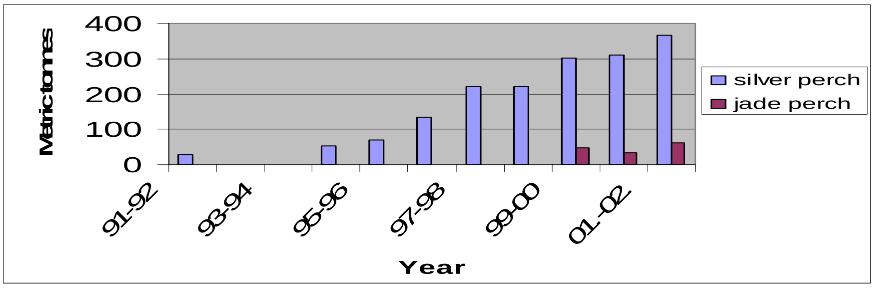
Figure 1: Value of catfish production in US$ relative to other aquaculture sectors in the United States of America in 2002 (originally USDA data)



Source: Engle (2003)

Figure 2: Growth in total farm production, yield rates and hectareage of the channel catfish farming industry in the United States of America

Australia does not currently have an equivalent low cost, high volume industry to supply the white fillet market. It has been suggested however that the Australian freshwater grunters, or teraponids, have the potential to be farmed in a similar fashion to the channel catfish of the US. Production of the Australian teraponid (freshwater 'grunter') species is currently dominated by two species, silver perch (*Bidyanus bidyanus*) (about 348 tonnes in 2001/2002, ABARE) and jade perch (*Scortum barcoo*) (about 61 tonnes in 2001/2002, O'Sullivan, 2003). In 2001-2002 there were 70 silver perch farmers with a combined pond area of 119.2ha (ABARE). Teraponids are generally cultured semi-intensively in 0.1ha – 0.5ha, static, freshwater, earthen ponds. In the late 1990's the industry consisted of a large number of non or insignificantly producing farms, 'average' farms of 4-8 ponds, and about 10 farms of a much larger size (Ruello, 1999). Average prices were $8.76/kg for silver perch in 2001/2002 (Love and Langenkamp, 2003) and $7.00 for jade perch in 2001/2002 (O'Sullivan, 2003). 70% of the silver perch produced in NSW in 1999/2000 (278 tonnes in 2001/2002) were sold live (Love and Langenkamp, 2003); similar percentages most likely apply to jade perch.



Sources: O'Sullivan (1994), O'Sullivan and Kiley (1996), O'Sullivan and Kiley (1997), O'Sullivan (1998), O'Sullivan and Dobson (2000), O'Sullivan and Dobson (2001), O'Sullivan and Savage (2003) and Love and Langenkamp (2003).

Figure 3: Growth in production of silver perch and jade perch in Australia.

Since the industries infancy when silver perch was first being assessed for aquaculture potential in the early 1990s, it has been suggested that these species have the potential to form the basis for a large, relatively low cost industry in Australia in a similar fashion to the channel catfish industry in the United States (eg. Rowland and Bryant, 1996).

Other teraponid species (other than jade perch, which is now biologically proven eg. Wingfield, 2002) may demonstrate equally attractive attributes for production however have been the subject of very little, if any, reliable research.

The current teraponid industry in Australia, while much younger than the US catfish industry, shows very little resemblance to the catfish industry, either in production style or market philosophy. Australian teraponid products will almost certainly never fill a similar market niche in Australia to that which channel catfish products occupy in the US, unless the costs of production are greatly reduced. In this paper the economics of US catfish industry style production techniques as applied to the hypothetical production of Australian teraponids (generically) in the Burdekin region of Queensland will be explored.

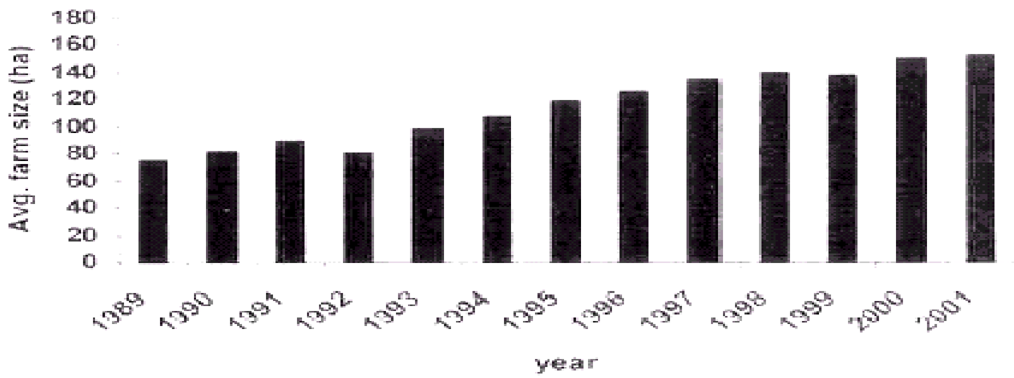
2. Brief History and Background on US Channel Catfish Industry

The development of commercial farming of channel catfish was preceded by work prior to 1960 into the breeding and raising of catfish fingerlings for restocking programmes and the small scale aquaculture of catfish by state and federal fish hatcheries in the South-eastern and Midwestern United States and the Auburn University in Alabama (Tucker and Robinson, 1991).

Commercial farming initially developed mostly in the state of Arkansas. Beginning in 1955 catfish production in Arkansas grew to about 6,800 tonnes per year in 1970 (Tucker and Robinson, 1991). However the industry in Arkansas then abruptly collapsed. The reason for this is described in Tucker and Robinson (1991):

"It appears that channel catfish farming in Arkansas failed to achieve the 'critical mass' necessary to expand from a small enterprise with decentralised production and local marketing to a larger, integrated industry with regional or national markets."

As the industry in Arkansas collapsed however, interest in catfish farming in the neighbouring state of Mississippi began to take off. Innovative and risk-taking row crop (eg. cotton) farmers in the Mississippi delta began to grow catfish as a diversification option (Engle, 2003). Initially ponds were constructed using borrowed farm machinery and catfish were cared for with 'borrowed' labour. Stocking, management and production rates were all initially low. When profits from traditional row crops declined in the late 1970s and early 1980s growers increasingly devoted their resources to catfish production and the industry boomed (Figure 2).



Source: Engle (2003)

Figure 4: Growth in the average catfish farm size in the United States of America.

The majority of catfish (59% of value in 2002, Catfish Journal, 2003) is produced in the state of Mississippi, the most developed farms being in the delta region of the Mississippi (Possadas, 2000). In general, farms in the Delta region differ from farms in other areas in being solely catfish farms (or if catfish are a part of a diversified farm, the catfish farm is run as a stand alone operation) and having a larger average size (179 ha). Catfish farming infrastructure is also the most developed in the Delta area (Possadas, 2000). Catfish farmers have shown a willingness to work together and have developed large, cooperative feed and processing plants. This, along with the large size of individual farms, has allowed the industry to exploit economies of scale (Tucker and Robinson, 1991).

Catfish has always been accepted as a food item in the Southeast of the US but other areas of the country have traditionally considered catfish to be a 'scavenger' and 'of little value as a food item' (Tucker and Robinson, 1991). National advertising campaigns have, however, improved the image and demand for catfish over recent times, despite relatively modest budgets (about $US 4 million in 2001; Kinnucan et al, 2003).

Excluding shrimp, catfish was the fourth most consumed seafood item in the US in 2000 (Silvia and Dean, 2001).

The catfish production business can be broken into 4 main stages. These are:

- Broodstock management, egg and fry production;
- Fingerling or stocker production;
- Food fish production (growout); and
- Processing and marketing

Most enterprises specialise in only one or two of the stages of catfish production (Engle, 2003).

Channel catfish are almost exclusively produced semi-intensively in static, earthen ponds. In aquaculture terminology 'semi-intensive' means that the fish receive the bulk of their nutritional requirements from prepared feed sources (pelleted feed) with only supplementary nutrition derived from natural sources within the pond. 'Static' ponds are ponds which do not receive any water exchange during the production period. Water is only added to make up for losses to seepage and evaporation and water is only taken out when the pond must be drained for harvesting or maintenance purposes. Catfish ponds are managed at a level where natural processes within the pond are able to assimilate all the waste produced by the fish (Hargreaves and Tucker, 2003).

The growout stage in channel catfish production is unusual in aquaculture in that a multiple batch, continuous cropping system is the most commonly used strategy. In this system several different batches of different sized fish are mixed within the one pond. When it is estimated that a commercial quantity of fish in the pond are above market size (about 0.57kg) the larger fish are cropped off using a large mesh sized net and more fingerlings are 'understocked' to replace those fish taken out. Ponds are only fully fished out and drained for periodic maintenance, generally every 7-8 years or so (Tucker and Robinson, 1991).

Some US catfish farmers do use the single batch (all in – all out) system which has been shown to be more profitable, due to better Food Conversion Ratios (FCR's) and production rates, in the absence of 'off-flavour' and cash-flow problems (Engle and Pounds, 1994).

Off-flavour is the occurrence of predominately 'earthy' or 'muddy' flavours in catfish which make the fish unsaleable. It is estimated to cost the industry some $US50 million per year (Oxford, 2003) mostly through the cost of holding fish for longer periods than would be most profitable. The off-flavour compounds that affect catfish are most commonly produced by certain varieties of blue-green algae (van der Ploeg, 1991) that naturally fluctuate in numbers in freshwater ponds. Multiple batch systems are risk-reducing for all but the largest farms in that if a pond becomes off-flavour, many of the other ponds on the farm will have harvest sized fish available.

The processing and marketing sector in catfish production is estimated to account for about 60% of the value of the industry (Masser, 1998). The processors take delivery of live catfish from the farmers and kill, process, pack and distribute the products. Catfish is mostly processed into fillets (60%) and 'whole dressed' (19%) with a large variety of value-added products constituted the remaining 21%. It has been considered that the processing companies have considerable monopsonistic power but market concentration seems to be decreasing over time and competition increasing (Hudson and Hanson, 1999).

3. Brief History and Background on the Australian Teraponid Industry

Silver perch hatchery techniques were developed at the NSW's Government Fisheries Research Station at Narrandera, in the late 1970s (Rowland and Bryant, 1996). Commercial breeding of silver perch for restocking markets began in private hatcheries in 1982 (Rowland and Bryant, 1996).

In 1990, significant research into the aquaculture of silver perch began at the Eastern Freshwater Fish Research Hatchery at Grafton. After 3 years of research it was demonstrated that silver perch had appealing biological characteristics for aquaculture.

> *"The results… demonstrated that silver perch is an excellent species for intensive culture in static, aerated ponds, with a production capacity similar to, or better than channel catfish, carp and tilapia; species which form the basis of some of the world's largest and most successful aquaculture industries."*
>
> Carole Bryant, Stuart Rowland – Preface
> *Silver Perch Culture* (1996)

According to Rowland and Barlow (1991) silver perch is the species of fish with the most biological potential for aquaculture in Australia due to:

- established hatchery techniques;
- a hardy fish that can be held in captivity at high densities;
- rapid and uniform growth;
- omnivorous;
- amenable to artificial feeding;
- non-cannibalistic;
- diseases under hatchery conditions are known;
- high meat recovery of 40%;
- marketing attributes, including an Australian native fish;
- attractive appearance and colour;
- excellent cooking and edible qualities; and
- white flesh, few bones.

Other Australian teraponid species have, or are likely to have, similarly favourable attributes for aquaculture.

The similarities between silver perch farming and the culture of channel catfish in the US have been recognised for as long as the silver perch aquaculture industry has existed in Australia.

"Silver perch is the one aquaculture species on the horizon in Australia that could replace much of the lost wild fisheries and imports of white-fleshed finfish; it could parallel the highly successful and rapidly growing channel catfish industry…"

Carole Bryant, Stuart Rowland – Preface
Silver Perch Culture (1996)

Teraponid aquaculture in Australia has shown a high but steadying rate of increase in annual production, albeit from a very low base, since 1990 (see Figure 3). It has however so far failed to meet the expectations of those who had expected it to develop along the same lines as the US channel catfish industry.

Table 1:
Possible aquaculture candidates - Australian freshwater Teraponid species with a maximum adult size >300mm.

Species	Distribution	Notes	Current aquaculture status
Silver perch (*Bidyanus bidyanus*)	Northern section of the Murray-Darling river system, south to about northern VIC	Proven aquaculture species, excepted marketability	About 343 tonnes produced in 2001/2002 (O'Sullivan, 2003) mostly in NSW and Queensland
Welch's grunter (*Bidyanus welchii*)	Inland Australian streams including the Lake Eyre drainage and the Bulloo river	Very simular to *Bidyanus bidyanus*, some hybrids (*bidyanus* x *welchii*) in production but not identified in the markets	Some hybrid *bidyanus* x *welchii* included in silver perch production figures, possibly also some pure *welchii*
Long-nose sooty grunter (*Hephaestus epirrhinos*)	Drysdale and Carson River systems of the far north Kimberley	Little known	No known production
Sooty grunter (*Hephaestus fuliginosus*)	Northern Australia from the Daly River, NT to about Mackay, QLD	Some fingerling production for restocking, little known about aquaculture potential	No known production
Jenkin's grunter (*Hephaestus jenkinsi*)	Kimberley district of northern WA and the NT	Little known, some expression of interest of aquaculture in the Kimberley district	No known production
Spangled perch (*Leiopotherapon unicolour*)	Widely distributed through coastal and inland NSW, QLD and NT and parts of SA and WA	Some interest, becomes precocious at very small sizes	Not known to be produced in marketable quantities
Jade perch (*Scortum barcoo*)	Inland Australia (Lake Eyre drainage, Cooper ck and Bullo River) and some north-western Gulf of Carpentaria drainages	Proven aquaculture performer, faster growth and better fillet yield than *Bidyanus bidyanus* (Ramage and McLennan, 2002, Wingfield, 2002) marketability not as proven as silver perch	About 61 tonnes produced in 2001/2002 (O'Sullivan, 2003) mostly in Queensland
Leathery grunter (*Scortum hillii*)	Fitzroy river system, central QLD	Little known, wild fish not considered good eating fish	No known production
Small headed grunter (*Scortum parviceps*)	Upper Burdekin river system, north-eastern QLD	Little known	No known production

Source: Allen (1989)

Most silver perch production in Australia takes place in NSW (76% or 278.1 tonnes in 2001/2002 (O'Sullivan, 2003)) and Queensland (12% or 43.6 tonnes in 2001/2002 (O'Sullivan, 2003)). Jade perch production is currently confined to Queensland (74% or 45.5 tonnes in 2001/2002 (O'Sullivan, 2003)) and Victoria (26% or 15.6 tonnes in 2001/2002 (O'Sullivan, 2003)). Other Australian teraponid species are not cultured at significant levels or are not reported.

Judging from various articles in the Australian aquaculture popular press, most enterprises in the silver perch and jade perch industries seem to have followed more or less the recommendations given in Rowland and Bryant (1996) for the culture of silver perch. Interest has been shown in producing silver and jade perch in cages and tanks (Rowland, RIRDC, no date) but silver perch does not seem to perform well in these environments (Rowland and Bryant, 1996) although jade perch may (Wingfield, 2002).

Rowland and Bryant (1996) recommend the use of 0.1 – 1.0 ha static, aerated, earthen ponds with production stages that are superficially simular to those used in the channel catfish industry. The recommended phases in the culture and marketing of silver perch are:

- Hatchery phase;
- Fingerling phase;
- Growout phase;
- Purging phase; and
- Marketing phase.

No mention of the use of multi-batch production systems in Australian teraponid aquaculture has been found in any sources. Australian teraponids are affected by off-flavour just as are catfish; however the recommended approach has been to purge the fish for 7-21 days in clean water tanks prior to marketing. This removes the risk of being unable to harvest ponds when the crop is sufficiently grown. However it adds further cost and carries the risk of mortalities in the purging process itself.

About 70% of the silver perch produced in NSW in 1999/2000 (278 tonnes in 2001/2002) was sold live (Love and Langenkamp, 2003) and similar percentages most likely apply to jade perch (Ruello, 1999). Silver and jade perch are popular with the live fish market for Asian restaurants and the biggest market is in Sydney (Ruello, 1999). The remaining fish are mostly sold whole-chilled, being directly marketed and delivered to 'white tablecloth' restaurants by the grower (Ruello, 1999). Currently silver perch (and jade perch) have not yet had a significant impact on the mainstream fish market in Australia.

"The current price levels coupled with the low consumer awareness of the fish are principally responsible for the absence of silver perch from most fishmonger is (sic) *window, and the supermarkets, despite the fish's many fine characteristics"*

Nick Ruello (Ruello and Associates)

According to a report (Rowland, RIRDC, No date) by Stuart Rowland (NSW's Fisheries Principal Researcher into silver perch aquaculture) for the Rural Industries Research and Development Corporation (RIRDC) the major challenges for the silver perch industry are:

- to reduce feeding and production costs;
- to develop efficient farms using good aquaculture practices;
- to develop and implement a quality control programme; and
- to establish a processing component leading to the supply of silver perch in a consumer-friendly form with an effective marketing campaign.

4. Differences between the Australian Teraponid and US Channel Catfish Farming Industries

Table 2:

Characteristics of the Australian teraponid farming industry compared with the US channel catfish farming industry

	Australian Teraponid Industry	US Channel Catfish Industry
Industry Characteristics Annual production	428 tonnes in 2001/2002 (O'Sullivan, 2003)	Expected to be about 295,000-305,000 tonnes in 2003 (Howie, 2003)
Value of production	$Au 3.65 million in 2001/2002 (O'Sullivan, 2003, Love and Langenkamp, 2003)	Processor revenues (about 90% of the industries production is marketed through the processors) expected to be between $US 655 -665 million in 2003 (Howie, 2003).
Farm gate whole fish price	Silver perch $Au 8.76/kg (O'Sullivan, 2003), Jade perch $7.00/kg (Love and Langenkamp, 2003)	US$1.20/kg-1.80/kg (Au$*1.60/kg-2.40/kg)
Retail price	In August 1999 (Ruello, 1999) - $13.50-$15.50/kg for live fish - $11.50-$12.50/kg for chilled fish	(Fillets Au$* 9.00 - $15.00/kg)
Major production costs	According to Weston, Hardcastle and Davies, 2001 - Feed (35-39% of annual operating costs) - Packaging and marketing (2nd largest annual operating cost) - Labour (3rd largest annual operating cost)	(from Engle, 2003) Annual operating costs (81-82% of total costs) of which - Feed (52-54%) - Labour (9-11%) - Interest on operating expense (7.6%) Annual fixed costs (18-19% of total costs) of which 1. Depreciation (55%) 2. Interest on investment (43%)
Feed composition	For 28-35% protein diets 3. Meatmeal (15-37%) 4. Bloodmeal (2-4%) 5. Fishmeal (5%) 6. Soybean meal (0-25%) 7. Canola (5%) 8. Peanut meal (5%) 9. Lupins (0-11%) 10. Field peas (0-10%) 11. Millrun (17-38%) 12. Poultry meal (0-8%) 13. Corn gluten (0-5%) 14. Fish oil (3.3%) 15. Dicalcium phosphate (0-2%) 16. Also Vitamin and mineral premix	For 28% protein growout diet (Robinson, Menge and Manning, No date) 17. Soybean meal (24-30%) 18. Cottonseed meal (10%) 19. Fishmeal (0-4%) 20. Meat/blood/bone meal (4%) 21. Corn grain (34-36%) 22. Wheat middlings (20%) 23. Fat/oil (1.5%) 24. Also dicalcium phosphate and catfish vitamin/mineral mix

Farm Characteristics Farm size	Average about 2 ha, producing farms mostly about 2-4ha with largest farms about 20 – 30 ha	Average about 150 ha
Pond size	0.5ha 'standard' 0.1-1ha	7 ha 'standard', 4 – 20 ha
Aeration rates	Recommended about 10/hp/ha	Around 5 hp/ha of electric aeration as well as emergency, tractor powered aeration as needed (Engle, 2003)
Breeding Characteristics Fecundity (eggs/kg)	Average around 125,000 eggs per kg of female broodfish	5,500 – 8,800 eggs per kilogram female broodstock
Hatchery technology	Simple, although slightly more complex than for channel catfish	Simple
Production Characteristics Annual Production rates	Hard to quantify for industry due to many non-producing and part-time farms Silver perch proven production rates in static research ponds of 10 tonnes/ha/annum (Rowland and Bryant, 1996) Claims from farmers up to 11- 13 tonnes/ha/annum (Mosig, 2001)	Variable from 2800kg/ha/yr – 8000kg/ha/yr, average about 4000kg/ha/yr (Heikes, Engle and Kouka, 1996)
Growing season	From about 4-5 months in southern areas of silver perch production, 7 months at Grafton, Northern NSW (Rowland and Bryant, 1996), up to about 10 months in tropical Queensland areas of silver and jade perch production.	5 – 6 months (Tucker and Robinson, 1991), see also Figure 11
Growth rates	From 50g in size: 3g to 5g per day when temperatures exceed 20^{o}c for silver perch (i.e. 50g -500g in 5 months or less) (Rowland and Bryant, 1996). Higher for jade perch; reports up to 6g to 10g per day (Mosig, 2001)	Generally egg to ≈ 450g in 18 months or less, 30g+ to 450g -675 in 12 months (l growing season, ≈ 5-6 months) (Tucker and Robinson, 1991)
Food Conversion Ratio's (FCR's)	Experiment results from 0.7-2.3:1(Rowland and Bryant,1996)	Experimental results often as low as 1.3:1 but commercial results often over 2.0:1 (Tucker and Robinson, 1991)
Stocking rates	8,000 to 30,000 per hectare	12,000 – 25,000 per hectare (Engle, 2003)
Feed	Currently around $700-$900 per tonne Most common diets about 32% protein	$US 230 - 270 per tonne (Au$* 307 – 360 per tonne) 26-34% protein for growout diets
Feeding rates	Experimentally up to 168 kg/ha/day (Rowland and Bryant, 1996) but usually lower (eg. up to 120kg/ha/day)	Mostly not above 120-130 kg/ha/day averaged over several days
Processing Characteristics Fillet recovery rate	Various claims from about 31% to about 55%, most consistently reported around 40-45%. (Rowland and Bryant, 1996, Mosig, 1999, Mosig, 2002)	42% - 44% (Silva and Dean, 2001, Masser, 1998)
Product forms	Live (70%+), whole chilled (<30%), fillets (neglible, Ruello, 1999)	Fillets – 60% Whole dressed – 19% Other – 21%

5. Statement of Intended Scope of Study

This study intends to explore the similarities and differences between the economic conditions relevant to the United States channel catfish aquaculture industry and the teraponid aquaculture industry in Australia (and particularly Queensland). In an attempt to highlight the most significant differences, published catfish farming budget frameworks will be reworked for hypothetical teraponid farming in the Burdekin region of Queensland.

It is beyond the scope of this study to collect primary data to substantiate the figures used in these analyses. Most figures have been taken from published literature and some have been assumed or adapted from the figures used in the original, US published frameworks.

The results from this study are not intended to reflect the commercial worth or otherwise of teraponid farming in Queensland. The static farm budgets used do not best reflect the viability of establishing new enterprises. More complex discounted cash flow analysis is needed to better highlight the consequences of the time value of money and cash flow and profit requirements. The hypothetical farm budgets that have been run bear little relationship to existing teraponid aquaculture ventures. US style catfish farming techniques may not necessarily be adaptable to the farming of teraponids in Queensland (although the balance of probabilities suggests they would). Risk is also a significant factor in a production business such as this.

Furthermore the success of an aquaculture industry depends on far more than simply the production economics. Some of the upstream and downstream activities will be briefly examined in this paper. It is however beyond the scope of the study to explore these in depth.

6. Processing and Markets

Farmed catfish is a relatively low priced product that is almost exclusively processed and value added before being marketed. Catfish products are distributed across the entire USA and are regular supermarket items. The processing, marketing and distribution activities in the catfish industry are well developed and researched and reflect the scale of the industry.

Silver perch and jade perch are mostly (70%) sold live to Asian restaurants in Sydney and also to a lesser extent in Melbourne and Brisbane (Ruello, 1999). The remaining fish are grower marketed to ‘white table cloth’ restaurants and passed off at auction at the Sydney fish markets. Only very small amounts of product is processed (Ruello, 1999). Data on the processing, marketing and distribution activities of the Australian teraponid industry is scarce as is data on the seafood industry in Australia in general.

Catfish Demand and Market composition factors

Consumption of catfish products in the US has increased significantly over the last decade from 186 grams per capita per year in 1985 to 486 grams per capita per year in 1999 (Silva and Dean, 2001). Since 1998 catfish has been the fifth most consumed seafood item in the US in terms of per capita consumption (see Figure 5). The seafood items currently consumed most in the US are shrimp, tuna (largely canned), salmon (also largely canned) and pollock (used almost exclusively to produce surimi - fake crab meat products). Therefore, since 1998 farmed channel catfish has been the most consumed fish fillet in the US. For many years before 1998 it was surpassed only by cod.

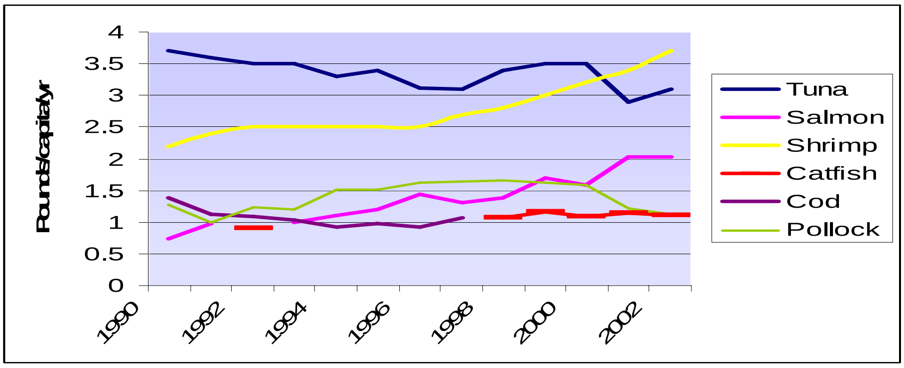


Figure 5: Top five seafood items (by per capita consumption) in the US from 1990-2002. Consumption in pounds/capita/year. Catfish consumption was decreased for 2002 by not including imported basa, tra etc as catfish. (Data from National Fisheries Institute, 2004). Both a decrease in the catch from the cod fishery and an increase in the production of catfish led to catfish becoming the most consumed white fillet in about 1998

Table 3

Top ten seafood items in the US in 2002

(pounds per capita consumption)

2002	
Shrimp	3.7
Canned Tuna	3.1
Salmon	2.021
Pollock	1.13
Catfish	1.103
Cod	.658
Crabs	.568
Clams	.545
Tilapia	.401
Flatfish	.317

Data from National Fisheries Institute, 2004

The catfish farming industry has been coherently promoting its product since 1987 (Kinnucan et al, 2003) through the establishment of the Catfish Institute. The Catfish Institute is funded by a $US 5 per ton levy on all catfish feed sold. In 2001 this levy generated about $US 4 million in promotion revenue (Kinnucan et al, 2003).

According to Kinnucan et al (2003) this level of promotion is still at least 54% below the optimum economic level (ignoring opportunity cost). They found that their results were insensitive to product differentiation and by this questioned the industry's recent moves away from generic advertising to brand advertising. The situation in the catfish industry was opposite to that in the Norwegian salmon industry where the optimal economic advertising level was predicted to be below the current industry expenditure and the product differentiation effects were found to be large. In the US the domestic catfish industry has about a 93% share of the domestic catfish market so, unlike Norwegian salmon in its market, generic advertising is not very subject to free-rider effects (Kinnucen et al, 2003).

Table 4:
Baseline data and parameter values for US catfish and Norwegian salmon industries 1999-2001 average

Item	Definition	Value	
		Catfish	Salmon
p	Farm Price, US$/lb	0.71[a]	1.53[b]
q	Farm quantity, mil lbs	596[a]	913[b]
r	Farm revenue (=*pq*). mil US$	423	1.397
a	Advertising expenditure. mil US$	4.0[c]	21.0[b]
v	Advertising intensity (=*alr*)	0.0095	0.0150
η	Overall demand elasticity	0.63[d]	1.50[c]
α	Advertising elasticity	0.015[d]	0.040[f]
ε	Supply elasticity	0.73[g]	0.39[e]
S	Share of world market	0.93[e]	0.45[e]

Source: Kinnucan et al (2003)

Catfish demand has been found to be highly elastic. Using supermarket scanner data from Houston, Texas, Engle, 1998 estimated own price elasticities for catfish to be between -3.15 and -4.937. For convenience catfish products own price elasticities were even more elastic (-3.285 to -11.550). These compare with own price elasticities in Australia of -0.4 for beef, -1.3 for lamb, -0.9 for pork and -0.5 for chicken (Piggot et al, 1996). Clearly the success of catfish in the US must owe a great part to the ability of the industry to produce a relatively cheap product. Engle (1998) suggested that due to the high elasticity of demand for catfish, lowering prices would increase total revenue.

Both Engle (1998) and Houston and Ermita (1992) found significant habit formation effects in the demand for catfish, strengthening the suggestion by Kinnucan et al (2003) that increased advertising expenditure would have positive economic effects. Indeed Engle (1998) estimated producers returns from advertising to be between $US 0.48 and $US 7.46 for each dollar spent. Kinnucan and Miao (1999) estimated similar rates of return. Because farm supply elasticity for catfish is highly inelastic in the short term (at 0.15 reflecting the long term and exclusive nature of catfish farm investments (also Kouka and Engle, 1998)) gains from advertising are mostly returned as higher prices (Engle, 1998).

Table 5:

Impact of generic advertising by the US catfish industry, 1987-89, at the wholesale and farm levels

Market Level	Variable	Simulated long-run equilibrium values			Absolute difference	Percent difference
		unit	without advertising	with advertising		
Wholesale						
	price	$/lb	1.64	1.75	0.11	6.7
	quantity	mil. lb/mo	12.88	13.04	0.16	1.30
	revenue	mil. $/mo	21.12	22.82	1.70	8.00
Farm						
	price	$/lb	0.73	0.79	0.06	8.20
	quantity	mil. lb/mo	24.76	25.00	0.33	1.30
	revenue	mil. $/mo	18.08	19.82	1.74	9.50

Source: Kinnucan and Miao (1999).

Interestingly the demand for catfish appears to be changing over time and this may reflect the success of promotional activities by the industry. Kinnucan and Miao (1999) suggested that the own price elasticity for catfish is becoming less elastic over time and that catfish has overcome its status as an inferior good and may now be considered as a normal (but not superior) good.

It has also been suggested that catfish is a ready substitute for chicken (Masser, 1998). Kinnucan and Miao (1999) estimated the cross price elasticity with chicken to be 0.229, however this was not significant. They also found no evidence of cross price elasticity effects with salmon.

Catfish processing and distribution

Table 6:

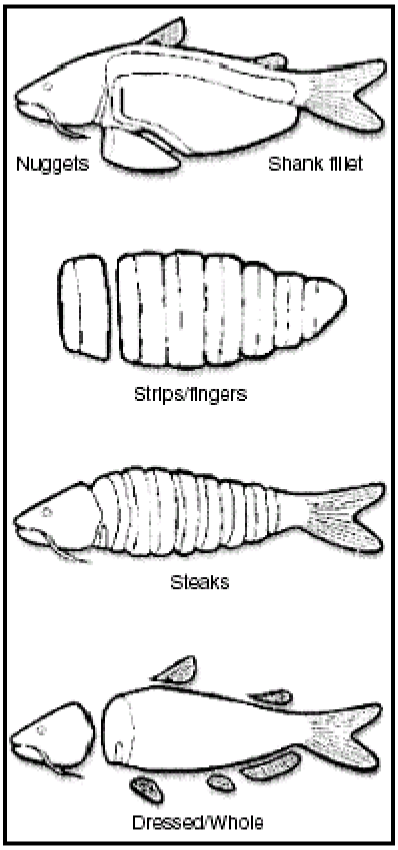
Product forms sold by US farmed catfish processors in 2000. (2001)

	Ice pack[1]	Frozen[1]	Total sales[1]	% of total	Ice pack % of total	Frozen % of total
Whole dressed[2]	41,392	13,798	55,190	19	75	25
Fillet[3]	58,529	119,649	178,178	60	33	67
Other[4]	16,813	46,975	63,788	21	26	74
Total	116,734	180,422	297,156	100	39	61

Source: Silva and Dean

Figures are based on data from the USDA, Agricultural Statistics Board "Catfish" 2000 publications. *Http://usda.mannlib.cornell.edu/*

[1] Thousand pounds
[2] Head, viscera and skin removed
[3] Includes fillets, shank and strip fillets; excludes any breaded product
[4] Includes all products not already reported, including weight of breading and added ingredients



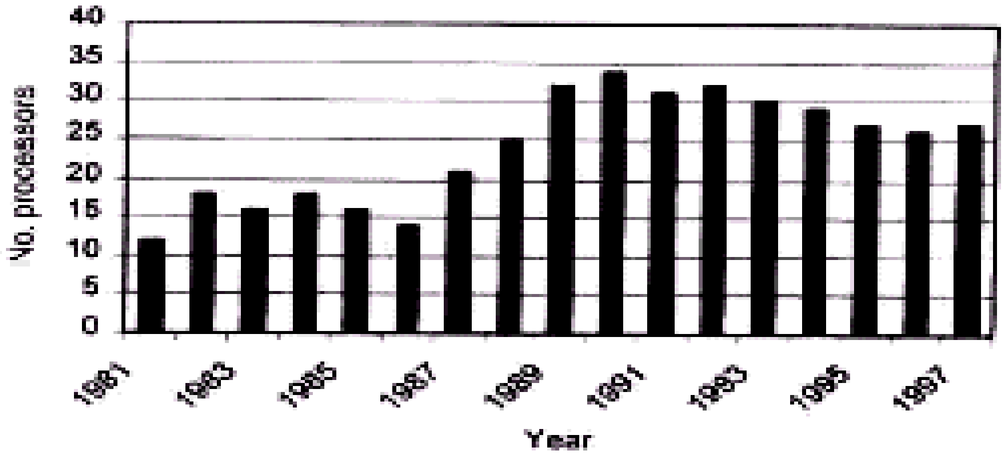
Source: Silva and Dean, 2001

Figure 6: Catfish product forms

The processing sector of the US catfish aquaculture industry is crucial to its success. In 1998 over 90% of channel catfish production in the US was marketed through commercial processors (Silva and Dean, 2001). Channel catfish has little appeal in its raw, whole fish state.

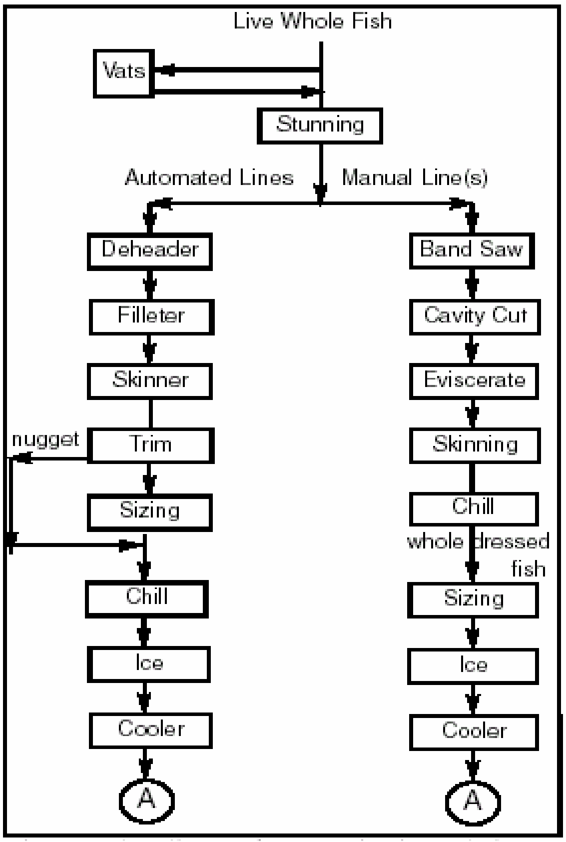
The major products produced in 2001 were fillets (60% of sales) and whole dressed (19% of sales) (see Table 6). The remaining 21% consists of a variety of breaded, marinated, flavoured and value added products. Whole dressed was originally the major product produced but fillets have steadily increased their share (Silva and Dean, 2001). The offal from catfish processing is also significant in that it is on sold for use in animal feeds.

Catfish production is traditionally concentrated in the Mississippi delta region and the processors are also concentrated there (Hudson and Hanson, 1999). Studies in the 1980s have found the processing industry to have monopsonistic power (Hudson and Hanson, 1999). However the number of processors has been increasing and the market power of individual processors decreasing. In the late 1970s the four firm concentration ratio in the catfish processing industry was 98% but had decreased to between 60% and 70% by 1995 (Hudson and Hanson, 1999).



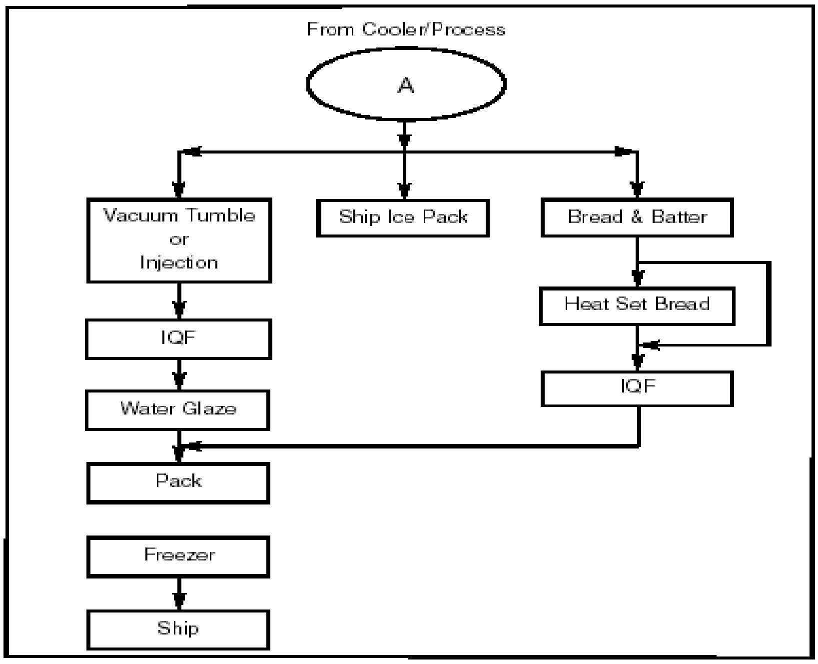
Source: Hudson and Hanson (1999)

Figure 7: **Number of catfish processors operating at the beginning of each year**.



Source: Silva, Ammerman and Dean (2001)

Figure 8: **Flow diagram for processing ice-packed channel catfish fillets**



Source: Silva, Ammerman and Dean (2001)

Figure 9: Flow diagram for processing frozen channel catfish fillets.

Hudson and Hanson (1999) found no evidence that processors were exhibiting monopsonistic power. Wholesale prices had become less rigid over time, which was suggested as being a result of increased competition. Long term price transmission elasticities were 0.707 for whole fish and 0.497 for fillets (the two results were not statistically different). While catfish supply is very inelastic in the short term (Engle, 1998) as it is a farming business, it is very elastic in the long term. Hence cost savings are likely to be passed on the consumers in the longer term.

Technological savings in the processing of whole fish and fillets appear to have been passed on to consumers (Hudson and Hanson, 1998). Processors margins were sensitive to minimum wage rates with long term elasticities of wage rates being 0.453 for whole fish and 0.652 for fillets.

Because channel catfish is farmed and the supply can be timed to meet demand, catfish products have a huge advantage of freshness on the US market. In theory, a live fish brought to the processing plant may be ready for distribution in 2 to 4 hours (Silva, Ammerman and Dean, 2001).

Teraponid Demand and Market Composition Factors

Australian teraponids have not yet had any significant impact on the mainstream fish market in Australia (Ruello, 1999). Total Australian production of silver and jade perch in 2001/2002 was 404 tonnes (O'Sullivan, 2003). Production is from relatively small producers who seek niche live fish and 'white table cloth' novelty markets in order to obtain high prices.

This study is focussed on evaluating the economics of US channel catfish style production techniques with reference to a hypothetical teraponid industry in Australia. It is has been suggested that if production costs for silver perch could be brought to a low enough level, that the demand for the product would be greatly expanded-

"*If the production costs decrease and farm gate prices fall to $6.00 per kilogram for whole fish in the medium to long term, as is widely anticipated, the demand will expand enormously because the fish can then be retailed by fishmongers and the supermarkets at a $9.99 per kilo price point and sold as a boneless skin on fillet for just under $20 per kilo. At these price levels, or slightly higher, silver perch has a tremendous future domestically and in overseas markets*"

Nick Ruello (Ruello and Associates)
Silver Perch Market Assessment (1999)

In the above assessment (Ruello, 1999) it was suggested that silver perch probably had the best future in the Australian market as a medium priced fillet.

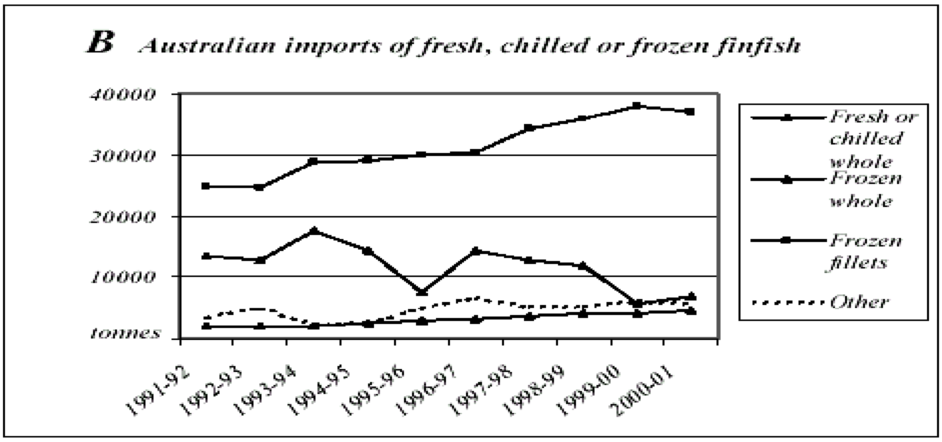
Jade perch is also claimed to be suited to the fillet market;

"*It is now clear that jade perch is a hardy, omnivorous species, capable of achieving rapid growth rates on relatively inexpensive diets. It is, therefore reasonable to assume that this species can be grown at a relatively low cost of production. Furthermore, while jade perch do accumulate significant stores of body fat, they are well suited to filleting and provide a high recovery rate of flaky, white flesh*."

Max Wingfield (DPI extension officer)
Preliminary results of jade perch feed trial (2002)

The above, and other, authors and commentators on silver and jade perch market potential have all assumed high price elasticity for these species. Price elasticity for channel catfish in the US is very high, although it is decreasing (Kinnucan and Miao, 1999). From 1980-1988 real catfish prices declined from $US 4.42 to $US 4.13 per kilo, while consumption increased from 54.5 grams/capita/year to 277 grams/capita/year (Houston and Ermita, 1999). In Australia, a similar product to channel catfish (Narong, 2001), Vietnamese catfish ('basa' or 'tra'), has within several years of introduction become what is possibly Australia's most consumed seafood (Seafood Australia, 2003/04) despite essentially no promotion. It seems a reasonable assumption that consumers in Australia are primarily interested in prices in making their fish fillet purchasing decisions. Mosig (1998-1999) observed that at the lower end of the retail market for fish fillets in Australia, species is not as important as price as a purchase determinant.

The Australian fishery catch is meagre considering the size of our fishing zone. About 186,000 tonnes were caught in 2000-01 (Love and Langenkamp, 2002). This low catch reflects the low productivity of our waters and not the underutilisation of our resources. Australia typically exports a large proportion of the national catch of high value species and imports cheaper products to meet domestic demand. About 60% of the seafood consumed in Australia is imported (Love and Langenkamp, 2002)



Source: Love and Langenkamp,

Figure 10: **Australian imports of finfish (2002)**

To a seemingly greater extent then the US (possibly due to market protection in the US), Australia is well supplied with imported fish fillets and fish products. The average price of imported fish fillets in 2000-01 was $5.01 per kilogram. There has been a slight upwards trend in imported fish fillet prices (from $4.47/kg (2000-01 prices) average in 1991-92 (Love and Langenkamp, 2002)).

The author found no source which gave detailed figures on the quantity of different species of fish marketed in Australia. Using a number of different (and often vague sources) the following figures were (very roughly) approximated for the major fish fillet species sold in Australia.

Table 7:

Major fish species (by volume) sold in Australia

	Major source	**Import price (fillets), wholesale price will include mark-up**	**Quantity (fillets)**
Major Species			
Hake	Chile and South Africa	≈ $4.50/kg	≈ 8,000 tonnes
Hoki	New Zealand	≈ $5.60/kg	≈ 8,000 tonnes
Nile Perch	Kenya, Uganda and Tanzania	≈ $4.00-5.50/kg	≈ 6,000 tonnes
Basa	Vietnam	≈ $5.00/kg	≈ 3,000 tonnes (02-03) – ≈ 10,000 tonnes
Atlantic salmon	Tasmania	≈ $7.80/kg*	≈ 9,000 tonnes*
Minor Species			
Orange roughy		≈ $18.00/kg	
Barramundi		≈ $11.30/kg	
Ling		≈ $9.50/kg	
Leather jacket		≈ $8.00/kg	
Red snapper		≈ $8.00/kg	
Smooth dory		≈ $7.50/kg	
Red cod		≈ $3.80/kg	

* Head on, Gilled and Gutted (HOGG)

Sources: Love and Langenkamp (2002), ABARE (2004), Ruello (1999), Weston, Hardcastle and Davies (2001), Seafood Australia (2004).

The Sydney fish market, although only handling a relatively small volume of seafood sold in Australia, plays an important role in setting prices for seafood products that are observed in other markets (Smith, Griffiths and Ruello, 1998). Table 8 provides an indication of whole weight prices for the more common Australian landed species that are used to produce fillets for the domestic market. As the figures are for whole weight, fillet yields and processing costs need to be considered in estimating the fillet prices. As an indication, blue grenadier is the same species as New Zealand hoki, above.

Table 8:

White fillet fish – average of monthly prices (whole weight), average annual throughput, and linear trend in prices, July 1998 to June 2001

	Average of monthly prices	Average annual throughput	Linear trend in monthly prices
	$/kg	t/yr	$/kg
Blue grenadier (all)	2.52	34.8	0.058
Ling (medium)	4.79	102.5	0.053
Gemfish (all)	3.99	16.5	-0.007
Silver trevally (medium)	2.65	113.5	0.002
Tiger flathead (medium)	2.25	289.7	0.013
Ocean perch (large)	4.17	73.2	0.023
Angel shark (large)	3.92	59.5	0.017
Redfish (medium)	1.82	382.6	0.011
Mirror dory (large)	3.97	101.7	0.034
John dory (large)	9.56	53.5	0.030
Orange roughy (large)	5.65	10.5	-0.002
Silver warehou (medium)	2.05	49.9	0.026
Blue warehou (large)	3.62	30.4	0.029

Source: Love and Langenkamp (2002)

It is clear from Table 8 that the current prices for silver and jade perch (of around $Au 7.00-8.00) would put them in the premium end of the filleting fish market. There are however many more factors than simply the price of the whole weight fish in determining the value of a fish to processors. Smith, Griffiths and Ruello (1998) found that volume (supply) only had limited influence of prices for fillet species on the Sydney fish market.

Fish size, on the other hand, had a large effect on prices and demand for filleting species on the Sydney fish market. For example redfish receives a consistently low price due to its small size.

Larger fish are preferred as they are cheaper to fillet per kilogram of fillets produced. Catfish processors are increasing their minimum size requirements for these reasons (Engle, 2003). Filleting yield (percentage of saleable fillet recoverable from the fish) also has a major influence on the value of filleting species.

How the Australian market would respond specifically to the attributes of teraponid fillets if they were available at a reasonable price is beyond the scope of this study. A study of retail sale and consumption in Sydney (Ruello and Associates Pty Ltd, 1999) identified the most important factors influencing the species that sold well were:

- Fresh
- Boneless
- Attractive price
- Australian Origin

Table 9:

Results of surveys in Sydney on the main types of finfish bought/sold and the reasons cited for their purchase

Main fish species	Reasons given for buying/selling
Nile perch	Boneless; price right; good taste; frozen (no waste for retailer); well known name
Blue grenadier/hoki	Boneless; cheap fillet; frozen (no waste for retailer); well known
Hake	A nice cheap reliable fillet; easy to cook; boneless
Flathead	An old favourite; well known and liked; sells well deboned; white flesh
Atlantic salmon	Fresh, popular although is expensive, seen as a good fish to serve when entertaining, available as fillet/cutlet
Smooth dory	Boneless; good well known name
Smoked cod	Attractive colour, popular with the elderly; frozen (no waste for retailer)
Morwong/Deep sea bream fillet	Medium price range, fresh fillet, popular with families
Red cod	Frozen (no waste for retailer)
Sole/Flounder	Cheap fish with good taste
Orange roughy/Sea Perch	Well selling fillet, but getting too expensive
Shark/boneless/Flake	Fresh fillet, popular with families; looks good, Australian; well known; is 100% boneless
Barramundi	Australian product with a very well know name; sells well as fillet or plate sized fish

Source: Ruello and Associates Pty Ltd (1999).

Interestingly, contrary to the attributes outlined as positive for the saleability of finfish in Ruello and Associates Pty Ltd (1999) many of the most popular fish sold were imported and frozen. This is probably best explained by high price elasticity for white fish fillet products in general, as has been determined for catfish fillets in the US. Although significant quantities of barramundi are imported into Australia it is perceived as an Australian product.

7. Production Economics

"*While pond aquaculture is often seen as a relatively simple, perhaps technologically unsophisticated production system, commercial catfish production is a very complex business*."

Engle (2003)

Like other forms of agriculture, aquaculture producers face considerable production and market risk. The most significant difference between aquaculture and other types of agriculture is the fact that large initial investments must be made with little capacity to change to alternative crops if conditions change (Hatch and Fei, 1997). Hence, economic analysis in aquaculture should evaluate alternative long-term models to be of the best use in investment and management decisions (Hatch and Fei, 1997). Single year models do not sufficiently consider inventory, cash-flow and investment impacts (Hatch and Fei, 1997).

While the limitations of single year (static state) models should be kept in mind the static state model of Kazmierczak and Soto (2001) has been chosen to best demonstrate the economic similarities/dissimilarities between US channel catfish and hypothetical teraponid production in Queensland. This model has been chosen because:

- Long term cash-flow analyses, particularly those from start-up, are scant or lacking in the literature;

- The basic budget framework has been adjusted and reworked in a number of academic papers including Keenum and Waldrop (1988), Engle and Pounds (1993), Engle and Kouka (1996) and Kazmierczak and Soto (2001);

- The model is simple and within the scope of this study but complete enough to generate useful sensitivity analyses. Kazmierczak and Soto (2001) used the model to analyse various risk factors (climate, catfish price, feed price, production rates) for catfish farming; and

- The scale of the hypothetical farms, the costs of the inputs and the bio-economic assumptions (eg. FCR's, productions rates, climate effects) are relevant, having been developed from figures derived from the commercial catfish industry.

Table 10:

Budget framework (operating costs) of Kazmierczak and Soto (2001) converted into Australian dollars (exchange rate of $Au 1.00 = $US 0.75) and Australian units of measurement.

Explanatory notes follow

Farm size (Water area)[a]	64 (56) ha	188 (113.6) ha	256 (227.6) ha
Income			
Catfish yield[b]	318,000.0	645,000.0	1,293,000.0
Catfish breakeven price[c]	2.15	2.12	2.03
Total income[d]	720,800.0	1,462,000.0	2,930,800.0
Total income per hectare[e]	12,871.4	12,869.7	12,877.0
OPERATING COSTS			
Fixed operating costs			
Repairs and Maintenance[f]	16,000.0	26,666.7	48,000.0
Pond Renovation[g]	9,600.0	17,333.3	30,666.7
All fuel (electricity, diesel, petrol and oil)[h]	24,930.7	50,660.0	101,3333
Chemicals[j]	646.7	1,313.3	2,666.7
Telephone[k]	2,666.7	3,333.3	4,133.3
Water Quality[l]	0.0	600.0	2,666.7
Fingerlings[m]	56,000.0	113,600.0	182,080.0
Labour[n]	48,800.0	113,333.3	243,950.7
Management[o]	28,000.0	46,666.7	80,000.0
Harvesting and Hauling[p]	37,333.3	75,733.3	113,800.0
Accounting/Legal[q]	2,400.0	3,200.0	4,666.7
Bird scaring ammunition[r]	1.333.3	2,666.7	5,333.3
Subtotal fixed operating costs	227,710.7	455,106.7	819,297.3
Interest on fixed operating costs	18,786.1	37,546.3	67,592.0
Total fixed operating costs	246,496.8	492,653.0	886,889.4
Variable operating costs			
Feed (tonne)[s]	700.0	1,420.0	2,845.0
Price of feed/tonne[t]	410.7	410.7	410.7
Subtotal var. operating costs	287,466.7	583,146.7	1,168,346.7
Interest on feed[u]	23,716.0	48,109.6	96,388.6
Total variable operating costs	311,182.7	631,256.3	1,264,735.3
Total operating costs	557,679.5	1,123,909.2	2,151,624.6
Operating costs per hectare	9,958.6	9,893.6	9,453.5
FIXED OWNERSHIP COSTS			
Depreciation			
Ponds[v]	18,144.5	34,727.6	69,539.6
Water Supply[w]	6,666.7	13,333.3	26,666.7
Office building[x]	1,200.0	1,933.3	3,000.0
Feed storage[y]	693.3	1,386.7	1,733.3
Equipment[z]	43,377.3	80,689.3	158,682.7
Interest on Investment			
Land[aa]			
Pond construction[ab]	23,906.7	47,373.3	94,306.7
Water supply[ac]	9,979.5	19,100.2	38,246.8
Equipment[ad]	3,666.7	7,333.3	14,666.7
Taxes and Insurance[ae]	16,766.2	30,324.1	58,778.1
Total Ownership costs	2,666.7	5,333.3	8,000.0
Ownership costs per hectare	127,067.6	241,534.5	473,620.5
Total costs per hectare	2,269.1	2,126.2	2,080.9
Residual returns per hectare[af]	12,227.6	12,019.8	11,534.5
Total Farm return[ag]	0.0	0.0	0.0
	0.0	0.0	0.0

Notes:

The nominal interest rate use in this budget framework is 11% pa. Interest on fixed operating costs and feed have been calculated as ¾ of 11% presumably to reflect that operating and feed costs are negligible during the depths of winter and hence do not accrue interest.

[a] **Farm size (water area)**. Water area refers to productive pond area only.

[b] **Catfish yield (kg)**. Production is assumed at about 5,800kg/water hectare/year of saleable catfish

[c] **Catfish price**. The breakeven price calculated for Kazmierczak and Soto's (2001) budget is shown. In the original budget framework, Kazmierczak and Soto (2001) use a price of Au$* 2.30/kg liveweight for the catfish.

[d] **Total income**. Yield times the breakeven price. Also equals total annual costs.

[e] **Total income per hectare**. Breakeven returns per water hectare. Also equals total annual costs per hectare

[f] **Repairs and maintenance**. Involves routine ongoing costs associated with the servicing of equipment ([z]) aside from depreciation. Taken as arbitrary figures.

[g] **Pond renovation**. Involves routine ongoing costs involved with the maintenance and upkeep of pond levees and structures, aside from depreciation. Taken as arbitrary figures.

[h] **All fuel (electricity, diesel, petrol and oil)**. Mostly electricity costs. Taken as arbitrary figures.

[j] **Chemicals**. Cost of chemicals (eg Formalin, Copper sulphate) used for the treatment of disease outbreaks in ponds. Taken as arbitrary figures.

[k] **Telephone**. Taken as arbitrary figures.

[l] **Water Quality**. Cost of testing done on water quality (aside from routine testing done with farm equipment). Taken as arbitrary figures.

[m] **Fingerlings**. Cost of stocker sized fingerlings for stocking production ponds. Taken as arbitrary figures.

[n] **Labour**. Taken as arbitrary figures.

[o] **Management.** Appears that on smaller farms management is paid partly as labour, partly as management, whereas on larger farms management is full time. Taken as arbitrary figures.

[p] **Harvesting and hauling**. In the US industry contract harvest teams are often used. Taken as arbitrary figures.

[q] **Accounting/legal**. Taken as arbitrary figures.

[r] **Bird scaring ammunition.** Taken as arbitrary figures

[s] **Feed (tonne)**. A commercial Food Conversion Ratio (FCR) of 2.2:1 (Tonnes of feed purchased: tonnes of catfish sold) has been used to calculate the feed requirement.

[t] **Price of feed/tonne**. Taken as arbitrary figures. Catfish feed fluctuates both above and below this figure depending on the costs of major ingredients.

[u] **Interest on feed**. Calculated at 11% on 9 out of 12 months (presumably to reflect the winter months where feed is not required).

[v] **Depreciation – Ponds**. Calculated as 10% of total pond construction costs below.

[w] **Depreciation – Water supply**. Calculated as 10% of water supply cost below.

[x] **Depreciation – Office building**. Calculated as 5% of relevant office building cost below.

[y] **Depreciation – Feed storage**. Calculated as 5% of relevant feed storage cost below.

[z] **Depreciation – Equipment**. Depends on mix of equipment (not given) but apparently about 14.2% for the 64ha farm, 14.6% for the 128ha farm and 14.8% for the 256ha farm.

[aa] **Interest – Land**. Calculated at 11% per annum.

[ab] **Interest – Pond construction**. Calculated at 11% per annum on half of investment.

[ac] **Interest – Water supply**. Calculated at 11% per annum on half of investment.

[ad] **Interest – Equipment**. Calculated at 11% per annum on half of investment.

[ae] **Taxes and Insurance**. Taken as arbitrary figures.

[af] **Residual returns per hectare**. Equals zero as catfish price has been adjusted to the breakeven point.

[ag] **Total Farm return**. Equals zero as catfish price has been adjusted to the breakeven point.

Table 11:

Budget framework (Capital costs) of Kazmierczak and Soto (2001) converted into Australian dollars (exchange rate of $Au 1.00 = $US 0.75) and Australian units of measurement.

Explanatory notes follow

Farm size (Water area)	64 (56) ha	128 (113.6) ha	256(227.6) ha
Land[a]	217,333.3	430,666.7	857,333.3
Pond construction			
Earth moving ($0.92/m2)[b]	156,586.7	297,720.0	596,270.7
Drainage structure[c]	13,580.0	27,158.7	54,318.7
Gravel ($10.46/m3)[d]	9,196.0	18,582.7	37,166.7
Vegetative cover[e]	2,082.7	3,814.7	7,640.0
Subtotal	181,445.3	347,276.0	695,396.0
Water supply (well, pump, motor, pipe)[f]	66,666.7	133,333.3	266,666.7
Feed storage[g]	13,866.7	27,733.3	34,666.7
Office building			
6.6m x 13.1m[h]	24,000.0		
9.8m x 16.4m[i]		38,666.7	
13.1m x 19.7m[j]			60,000.0
Equipment[k]	304,840.0	551,346.7	1,068,693.3
Total investment	808,152.0	1,529,022.7	2,982,756.0
Investment per water surface hectare	14,431.3	13,459.7	13,105.3
Investment per land hectare	12,627.4	11,945.5	11,651.4

Notes:

[a] **Land**. There is a small scale component to the land prices used: for the 64ha farm - $3396/ha, the 128ha farm - $3365/ha and the 256ha farm - $3349/ha.

[b] **Pond construction – Earth moving**. Cost of moving earth was given as $0.92/m^3$. This implies that the amount of earth moved for the 56 ha farm - 170,203 m^3, the 113.6ha farm - 323,609 m^3 and the 227.6ha farm - 931,884 m^3.

[c] **Pond construction – Drainage structure**. Assumed that the farms are built with the standard 7 ha ponds (Tucker and Robinson, 1991). Therefore the 56 ha farm has 8 ponds, the 113.6ha farm has 16 ponds and the 227.6ha farm has 32 ponds. This implies the cost of drainage structures to be $1697.5 per pond.

[d] **Pond construction – Gravel**. Cost of gravel given as $10.46/ m^3. Thus amount of gravel used for the 56ha farm – 879 m^3, the 113.6 ha farm – 1,777 m^3 and the 227.6ha farm – 3,553 m^3

[e] **Pond construction – Vegetative cover**. Newly formed pond levees are seeding with grass in order to reduce erosion during rain periods. Based on pond levee area – treated as an arbitrary figure.

[f] **Water supply (well, pumps, motor, pipe)**. Standard practice in the US is to sink one bore for each 4 ponds (Tucker and Robinson, 1991). Calculated at the cost of $8,333.3 per pond

[g] **Feed storage**. Scale effects are apparent; the 128ha farm requires double the investment of the 64ha farm however the 256ha farm only requires a slightly bigger investment.

[h] **Office building – 6.6m x 13.1m**. Taken as an arbitrary figure.

[i] **Office building – 9.8m x 16.4m**. Taken as an arbitrary figure.

[j] **Office building – 13.1m x 19.7m**. Taken as an arbitrary figure.

[k] **Equipment**. Consists of aerators (eg. paddlewheels), vehicles, boats, trailers, testing equipment and a variety of other sundries. Equipment costs have significant scale effects, particularly between the 64ha farm and the 128ha farm. Aeration is at the rate of 5hp/ha. US catfish farmers use 10hp paddlewheels that cost about $US 3,500 or $Au 4,667* each. Hence the cost of paddlewheel component of the equipment costs for the farms are about: 8 ponds – 28 paddlewheels ($130,676), 16 ponds – 56 paddlewheels ($261,352), 32 ponds – 112 paddlewheels ($522,704)

8. Hypothetical Teraponid Production in the Burdekin Region of Queensland, Australia

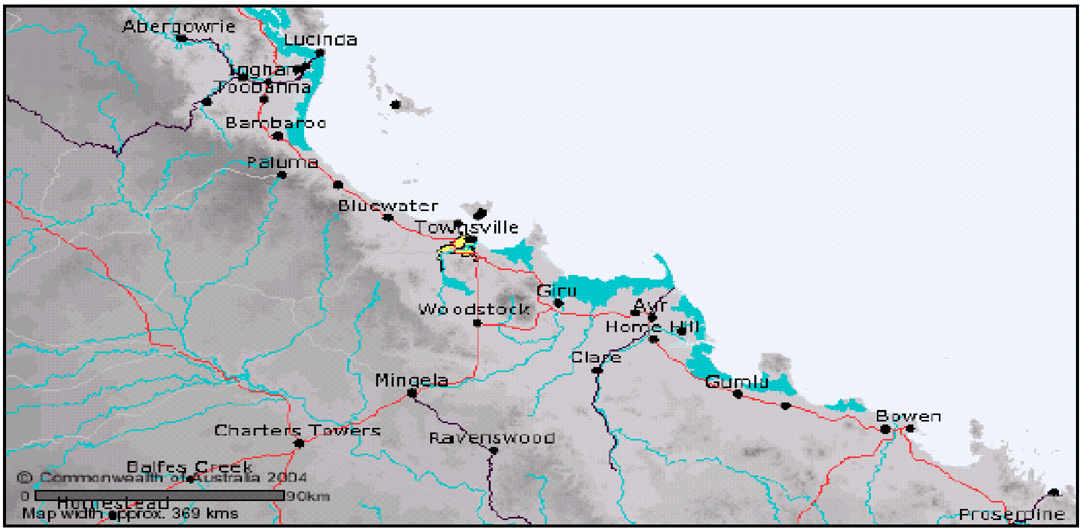
Some economic analysis has been completed for silver perch production in Australia (eg. Kable, 1994, Weston, Hardcastle and Davies, 2001). These analyses have looked at the economics of small scale production (50-100 tonnes/annum) using small ponds (0.5ha). The production philosophies examined in these studies have little in common with US style catfish production. Profitability for the analysis conducted by Kable (1994) and Weston, Hardcastle and Davies (2001) suggest only marginal economic viability for silver perch culture at prices of $6.00 to $8.50 per kilo.

The Burdekin region in North Queensland has been used to develop the costs (where site specific costs were required) for the hypothetical budget. The Burdekin region has been selected for the study for the following reasons

- The area has large volumes of freshwater available through a well developed irrigation scheme (including large volumes of unallocated water) and has been assessed as suitable for freshwater aquaculture (Pacific Aquaculture and Environment, 1998);
- The area has a suitable climate for most, if not all, teraponids;

- The area is well developed for agriculture, so difficulties with infrastructure should be minimal; and

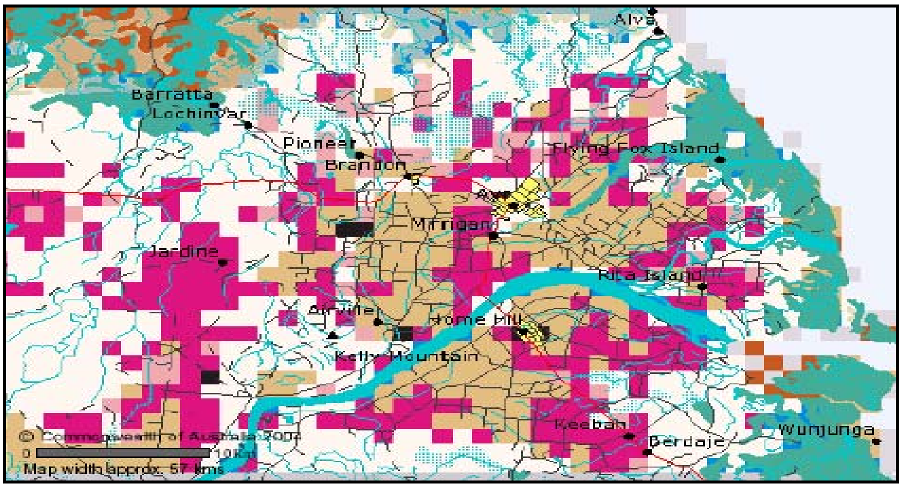
- ABARE (Beare et al, 2003) has published figures that can be used to develop most of the site specific costings



Source: www.audit.gov.au (2004)

Figure 11: **Location of the Burdekin irrigation area. Centred around the towns of Ayr and Home Hill, the Burdekin irrigation area roughly extends to Giru in the north, past Clare in the west, and about half way to Gumlu in the south.**

Climate is a major determinate of the production rates that can be achieved in pond aquaculture (Boyd, 1994). Indeed Kazmierczak and Soto (2001) used long term climate data from Jackson, Mississippi to model seasonal climatic risk to catfish farm production. For the catfish industry production is limited by the length of the growing season where water temperatures remain above about 20°c. Rowland and Bryant (1996) also suggested that the length of the silver perch growing season is determined by the length of time that water temperatures remain above about 20°c.



Source: www.audit.gov.au (2004)

Figure 12: **The Burdekin river delta region. Pink represents areas currently under irrigated crops.**

Boyd (1994) suggested that a reasonable estimate of average pond water temperatures can be made by determining the midpoint of the average monthly maximum and minimum air temperatures at any particular site.

Using the technique suggested by Boyd (1994) water temperatures have been estimated for climate data from Ayr (Burdekin region, Queensland) and Belzoni (Mississippi: centre of the main catfish producing region in the Mississippi).

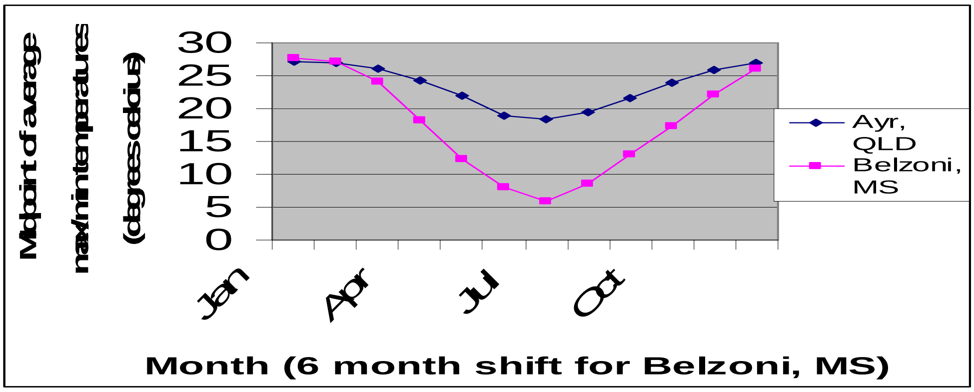


Figure 13: Estimated water temperatures for Ayr (Queensland) and Belzoni (Mississippi) based on climate date from the Australian Bureau of Meteorology and the National Climatic Data Center

According to the above graph Ayr has a growing season of about 9 months per year whereas Belzoni has a growing season of about 5-6 months per year. This has significant implications for the differences in the economics of pond production in these two climates.

Table 12:

Budget framework (Operating costs) of Kazmierczak and Soto (2001) adapted for the hypothetical production of teraponids in the Burdekin region, Queensland, Australia. Explanatory notes follow

Farm size (Water area)[a]	64 (56) ha	128 (113.6) ha	256 (227.6) ha
Income			
Perch yield (kg)[b]	438,480.0	889,488.0	1,782,108.0
Perch breakeven price[c]	3.17	3.03	2.96
Total income[d]	1,388,663.6	2,694,885.4	5,277,350.5
Total income per hectare[e]	24,797.6	23,722.6	23,187.0
OPERATING COSTS			
Fixed operating costs			
Repairs and Maintenance[f]	20,000.0	30,000.0	60,000.0
Pond Renovation[g]	9,600.0	17,333.3	30,666.7
All fuel (electricity, diesel, petrol and oil)[h]	104,761.2	212,515.7	425,779.6
Chemicals and water charges[j]	9,717.9	19,722.0	39,552.9
Telephone[k]	2,666.7	3,333.3	4,133.3
Water Quality[l]	1,500.0	2,100.0	4,166.7
Fingerlings[m]	120,582.0	244,609.2	490,079.7
Labour[n]	70,000.0	130,000.0	260,000.0
Management[o]	60,000.0	70,000.0	80,000.0
Harvesting and Hauling[p]	37,333.3	75,733.3	113,800.0
Accounting/Legal[q]	2,400.0	3,200.0	4,666.7
Bird scaring ammunition[r]	1,333.3	2,666.7	5,333.3
Subtotal fixed operating costs	439,894.4	811,213.5	1,518,178.9
Interest on fixed operating costs	35,191.6	64,897.1	121,454.3
Total fixed operating costs	475,086.0	876,110.6	1,639,633.2
VARIABLE OPERATING COSTS			
Feed (tonne)[s]	877.0	1,779.0	3,564.2
Price of feed/tonne[t]	800.0	800.0	800.0
Subtotal var. operating costs	701,568.0	1,423,180.8	2,851,372.8
Interest on feed[u]	56,125.4	113,854.5	228,109.8
Total variable operating costs	757,693.4	1,537,035.3	3,079,482.6
Total operating costs	1,232,779.4	2,413,145.8	4,719,115.8
Operating costs per hectare	22,013.9	21,242.5	20,734.3
FIXED OWNERSHIP COSTS			
Depreciation			
Ponds[v]	18,203.0	34,727.6	69,539.6
Water supply[w]	9,750.0	13,333.3	26,666.7
Office building[x]	1,200.0	1,933.3	3,000.0
Feed storage[y]	693.3	1,386.7	1,733.3
Equipment[z]	58,646.0	101,228.6	200,272.6
INTEREST ON INVESTMENT			
Land[aa]	34,826.2	69,652.5	139,305.0
Pond construction[ab]	7,281.2	13,955.1	27,942.5
Water supply[ac]	3,900.0	8,060.0	16,190.0
Equipment[ad]	16,520.0	27,733.9	54,127.7
Taxes and Insurance[ae]	4,864.3	9,728.6	19,457.3
Total ownership costs	155,884.1	281,739.6	558,234.7
Ownership costs per hectare	2,783.6	2,480.1	2,452.7
Total costs per hectare	24,797.6	23,722.6	23,187.0
Residual returns per hectare[af]	0.0	0.0	0.0
Total Farm return[ag]	0.0	0.0	0.0

Notes:

The nominal interest rate used in this budget is 8% pa (based on current commercial interest rate in Australia)

[a] **Farm size (water area)**. Water area refers to productive pond area only.

[b] **Perch yield**. Based on climate and loading factors discussed earlier, production is assumed at about 10,440kg/water hectare/year of saleable fish. However 1 in 4 ponds assumed to be required for fingerling production (as stocker sized fingerlings not available in Australia for teraponids). Therefore production assumed to average 7,830kg/water hectare/year. This is more conservative than in the budget developed by Weston, Hardcastle and Davies (2001) for ABARE which assumed a production rate of 10,000kg/water hectare/year for a farm in the cooler climate of NSW.

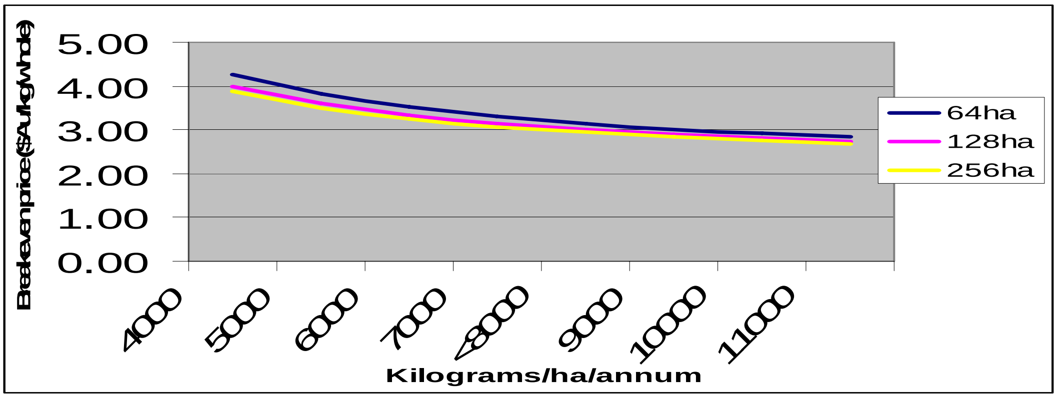


Figure 14: Sensitivity of the hypothetical teraponid farms to production rates.

< signifies the base rate used in the above analysis. Elasticity of breakeven price to increase in production rate (calculated at just above the base production rate) is

- 64ha farm: -0.316
- 128ha farm: -0.291
- 256ha farm: -0.272

[c] **Perch price**. Calculated breakeven price (returns equal zero).

[d] **Total income**. Yield times the breakeven price. Also equals total annual costs.

[e] **Total income per hectare**. Breakeven returns per water hectare. Also equals total annual costs per hectare

[f] **Repairs and Maintenance**. Scaled up from Kazmierczak and Soto (2001) in roughly the same proportion as the equipment costs

[g] **Pond Renovation**. Left the same as for Kazmierczak and Soto (2001).

[h] **All fuel (electricity, diesel, petrol and oil)**. Teraponid ponds in Australia are aerated for set periods each night. Assumed aerators run for 10 hours per night in summer (9 months) and 5 hours per night in winter (3 months). Off-peak power rate of $0.08 per KW/hr has been assumed. Extra 30% added to electricity requirements for power to run pumps and other equipment plus an arbitrary figure added for fuel costs.

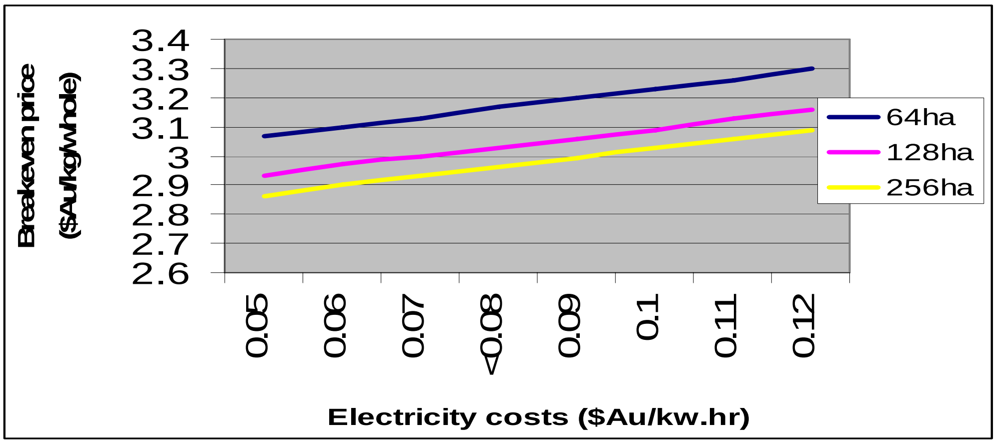


Figure 15: Sensitivity of the hypothetical teraponid farms to electricity costs.

< signifies the base rate used in the above analysis. Elasticity of breakeven price to increase in electricity price (calculated at just above the base electricity price) is

- 64ha farm: 0.076
- 128ha farm: 0.079
- 256ha farm: 0.081

[j] **Chemicals and water charges**. Chemical costs assumed to not be significantly different from Kazmierczak and Soto (2001). Costs of using water (water charges from Sunwater) have been included in this section for convenience. Average cost of using water is $9.86 per megalitre for cane farmers in the Burdekin region (Beare et al, 2003).

[k] **Telephone**. Assumed to not be significantly different from Kazmierczak and Soto (2001).

[l] **Water Quality**. Added $1,500 per year to the figures of Kazmierczak and Soto (2001) to reflect higher monitoring costs due to lack of measurements from other farms.

[m] **Fingerlings**. Fingerling requirement calculated as (harvested weight divided by 600g average harvest size) plus 10% to allow for mortalities. For the 64ha farm -803,880, the 128ha farm -1,630,726 , and the 256ha farm – 3,267,200.

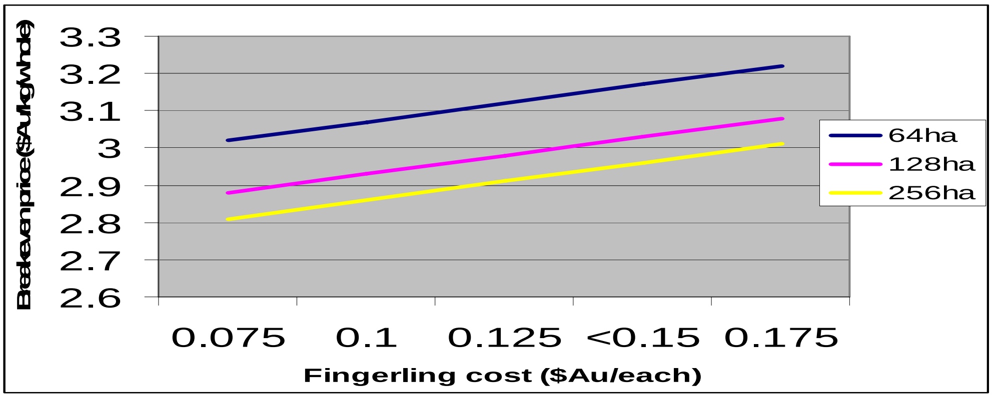


Figure 16: Sensitivity of the hypothetical teraponid farms to fingerling costs

< signifies the base rate used in the above analysis. Elasticity of breakeven price to increase in fingerling cost (calculated at just above the base fingerling cost) is

- 64ha farm: 0.095
- 128ha farm: 0.099
- 256ha farm: 0.101

[n] **Labour**. Assumed costs – Technician $40,000 pa and Farm hand $30,000 pa. 64 ha farm assumed to require 1 Technician and 1 Farm hand, 128 ha farm assumed to require 1 Technician and 3 Farm hands and 256 ha farm assumed to require 2 Technicians and 6 Farm hands.

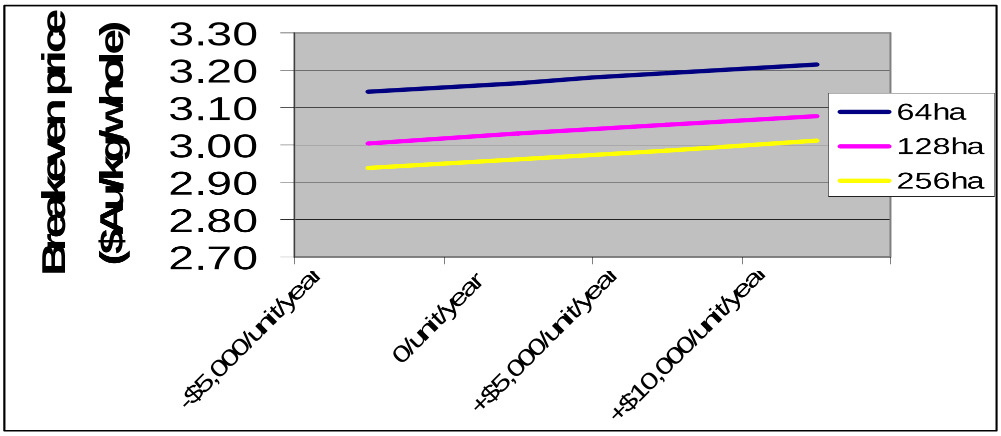


Figure 17: Sensitivity of the hypothetical teraponid farms to labour costs.

0/unit/year is the base rate used in the above analysis. Elasticity of breakeven price to increase in labour cost (calculated at just above a base average labour cost of $32,500 per unit per annum) is

- 64ha farm: 0.051
- 128ha farm: 0.052
- 256ha farm: 0.053

[o] **Management**. Management assumed to cost $60,000 for 64 ha farm, $70,000 for 128 ha farm and $80,000 for 256 ha farm.

[p] **Harvesting and Hauling**. Difficult to determine for this study without a specific farm model (beyond scope of this article). Same figures have been used as for Kazmierczak and Soto (2001) however may be considerably inaccurate. Purging (to be discussed later) is standard in the production of teraponids in Australia and would add significantly to costs.

[q] **Accounting/legal**. Assumed to not be significantly different from Kazmierczak and Soto (2001).

[r] **Bird scaring ammunition**. Assumed to not be significantly different from Kazmierczak and Soto (2001).

[s] **Feed (tonne)**. Single batch system is the only system proven for teraponid culture and hence used for this study. Therefore assumed slightly better commercial Food Conversion Ratio (FCR) than Kazmierczak and Soto (2001) of 2.0:1 (Tonnes of feed purchased: tonnes of perch sold) has been used.

[t] **Price of feed/tonne**. Base figure of $800 per tonne has been used assuming relatively large purchase at roughly current prices (Weston, Hardcastle and Davies (2001) assumed a price of $900-$600 per tonne for much smaller volumes). Sensitivity analysis uses figures from $400 per tonne to $1200 per tonne. There may be scope to import suitable, much cheaper feeds designed for tilapia, carp or catfish from Asia or even the US. Jade perch at least has shown the ability to efficiently utilise a variety of feeds (Wingfield, 2002). Otherwise based on similarity of ingredients and the cost of catfish feed in the US it could be expected that Australian produced feed prices could fall very significantly if large volumes were required.

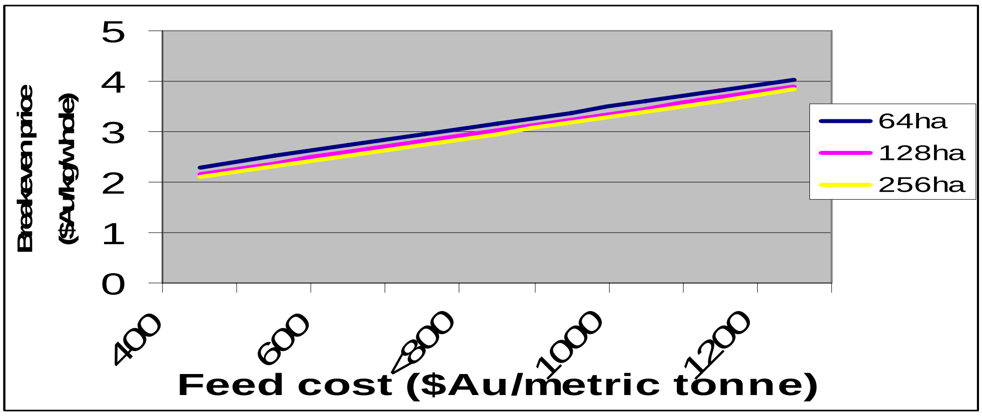


Figure 18: **Sensitivity of the hypothetical teraponid farms to feed costs.**

< signifies the base rate used in the above analysis. Elasticity of breakeven price to increase in feed cost (calculated at just above the base feed cost) is

- 64ha farm: 0.530
- 128ha farm: 0.581
- 256ha farm: 0.595

[u] **Interest on feed**. Interest on feed has been calculated for the full year to reflect the much longer growing season in the Burdekin as apposed to the Mississippi.

[v] **Depreciation – Ponds**. Calculated as 10% of total pond construction costs below

[w] **Depreciation – Water supply**. calculated as 10% of water supply cost below.

[x] **Depreciation – Office building**. calculated as 5% of relevant office building cost below.

[y] **Depreciation – Feed storage**. calculated as 5% of relevant feed storage cost below.

[z] **Depreciation – Equipment**. Difficult to determine exact figures (due to individual equipment makeup) used in Kazmierczak and Soto (2001) hence used same total ratios as a proxy, i.e. 14.2% for the 64ha farm, 14.6% for the 128ha farm and 14.8% for the 256ha farm

[aa] **Interest – Land**. Base rate calculated at 8% per annum.

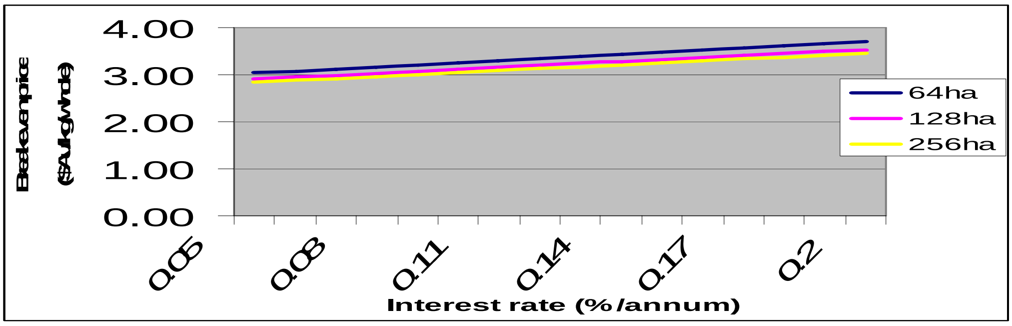


Figure 19: Sensitivity of the hypothetical teraponid farms to interest rates.

< signifies the base interest rate used in the above analysis. Elasticity of breakeven price to increase in interest rates (calculated at just above the base interest rate) is

- 64ha farm: 0.111
- 128ha farm: 0.111
- 256ha farm: 0.111

[ab] **Interest – Pond construction**. Calculated on base rate of 8% per annum on half of investment.

[ac] **Interest – Water supply**. Base Calculated on base rate of 8% per annum on half of investment.

[ad] **Interest – Equipment**. Calculated on base rate of 8% per annum on half of investment.

[ae] **Taxes and Insurance**. Based on figures from Kazmierczak and Soto (2001) however adapted for land taxes (rates) from the Burdekin region of about $60.38 per hectare per year (Beare et al, 2003).

[af] **Residual returns per hectare**. Equals zero as perch price has been adjusted to the breakeven point.

[ag] **Total Farm return**. Equals zero as perch price has been adjusted to the breakeven point.

Table 13:

Budget framework (Capital costs) of Kazmierczak and Soto (2001) adapted for the hypothetical production of teraponids in the Burdekin region, Queensland, Australia Explanatory notes follow

Farm size (Water area)	64 (56) ha	128 (113.6) ha	256 (227.6)ha
Land[a]	435,328.0	870,656.0	1,741,312.0
Pond construction			
Earth moving[b]	153,182.7	291,248.1	583,308.0
Drainage structure[c]	13,580.0	27,158.7	54,318.7
Gravel[d]	13,185.0	26,655.0	53,295.0
Vegetative cover[e]	2,082.7	3,814.7	7,640.0
Subtotal	182,030.4	348,876.4	698,561.7
Water supply (water rights)[f]	97,500.0	201,500.0	404,750.0
Feed storage[g]	13,866.7	27,733.3	34,666.7
Office building			
6.6m x 13.1m[h]	24,000.0		
9.8m x 16.4m[i]		38,666.7	
13.1m x 19.7m[j]			60,000.0
Equipment[k]	413,000.0	693,346.7	1,353,193.3
Total investment	1,165,725.0	2,180,779.1	4,292,483.7
Investment per water surface hectare	20,816.5	19,197.0	18,859.8
Investment per land hectare	18,214.5	17,037.3	16,767.5

Notes:

[a] **Land**. Average cost of cane land in the Burdekin region in 2001-02 was $6802 per hectare (Beare et al, 2003). Cost of land calculated for total farm area i.e. 64ha, 128ha and 256ha. Land assumed to come with 8.29 meg/ha water rights from average figures (Beare et al, 2003). Extra water rights assumed to cost $250/megalitre (Sunwater). As cane land is overdeveloped for conversion into fish ponds cheaper land may be suitable.

[b] **Pond construction – Earth moving**. Cost of moving earth in Australia from various sources;

- $0.70 per m^3 for constructing salt basin levees in Southern Australian (Singh and Christen, 2000)
- $1.00 - $2.40 per m^3 for constructing prawn ponds in Australia in Hardman, Treadwell and Maguire (1992). It was noted that for cleared, flat land $1.00 per m^3 was reasonable and this is the rate used for this study.

Earth to be moved for the 64 ha farm - 170,203 m^3, the 128ha farm - 323,609 m^3 and the 256ha farm - 931,884 m^3

[c] **Pond construction – Drainage structure**. Cost of drainage structures assumed not to be significantly different from Kazmierczak and Soto (2001).

More complicated intake and drainage structures for prawn ponds in Australia assumed to cost $4,000 per pond in Hardman, Treadwell and Maguire (1992).

[d] **Pond construction – Gravel**. Cost of gravel assumed as $15/ m^3.

[e] **Pond construction – Vegetative cover**. Cost of vegetative cover assumed not to be significantly different from Kazmierczak and Soto (2001).

[f] **Water supply (Water rights)**. Water budgets calculated with the following assumptions

- Ponds average 1.5m deep
- Seepage is 0.25cm/day (Boyd, 1994). If seepage is not this high (rice pondage studies in the Burdekin suggest that seepage may be lower (Gardner and Coughlan, 1979)) than the difference will be used for irrigation to prevent build-up of concentration of salts.
- Pan evaporation averages 5.7mm/day (BOM). Pond evaporation = Pan evaporation x 0.81 (Boyd, 1994)
- Rainfall averages 954mm/year (Bureau of Meteorology)
- All water not lost to evaporation or seepage (or irrigation) is recycled. Catfish farmers typically recycle their water for around 7-8 years (Tucker and Robinson, 1991).

Based on these assumptions the annual water requirements are – 64ha, 920 ml/yr, - 128ha, 1,867 ml/yr, - 256ha, 3,741 ml/yr.

Water rights assumed to be already present with land – 64ha, 530 megalitres - 128ha, 1,061 megalitres - 256ha, 2,122 megalitres.

Therefore extra rights required are 64ha, 390 megalitres – 128ha, 806 megalitres– 256ha, 1619 megalitres.

The sensitivity analysis looks at the cost of water usage from 100% to 0% (+15ml/ha/year) recycle rates.

[g] **Feed storage**. Assumed not to be significantly different from Kazmierczak and Soto, (2001). Although feed usage is higher than Kazmierczak and Soto (2001) for equivalent sized farms, peak feed usage per week or month is not higher. The higher feed usage is purely due to a longer season of peak feeding rates.

[h] **Office building – 6.6m x 13.1m**. Assumed not to be significantly different from Kazmierczak and Soto (2001).

[i] **Office building – 9.8m x 16.4m**. Assumed not to be significantly different from Kazmierczak and Soto (2001).

[j] **Office building – 13.1m x 19.7m**. Assumed not to be significantly different from Kazmierczak and Soto (2001).

[k] **Equipment**. Aeration in Kazmierczak and Soto (2001) at 5hp/ha. US catfish farmers use 10hp paddlewheels that cost about $Au 4,667 each. Standard aeration rates for Australian teraponid farms are about 10hp/ha (Rowland and Bryant, 1996) however use smaller paddlewheels (2hp currently costing about $550 from China) that are about 33% or less efficient (in terms of O_2 transferred per hp/hr) than the US paddlewheels. Hence for this study it is assumed that US style paddlewheels are used costing $5,000 each at the rate of 7.5hp/ha (giving the same effective aeration rate of the 10hp/ha with the smaller paddlewheels).

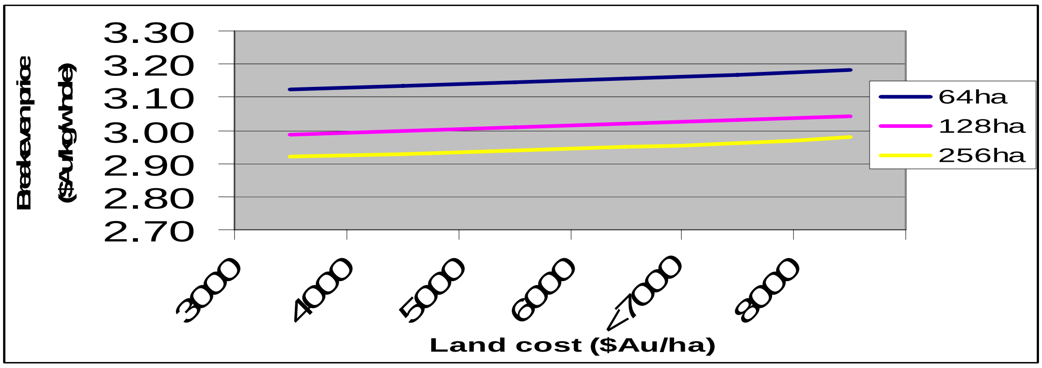


Figure 20: Sensitivity of the hypothetical teraponid farms to land costs.

< signifies the base rate used in the above analysis. Elasticity of breakeven price to increase in land cost (calculated at just above the base land cost) is

- 64ha farm: 0.026
- 128ha farm: 0.027
- 256ha farm: 0.047

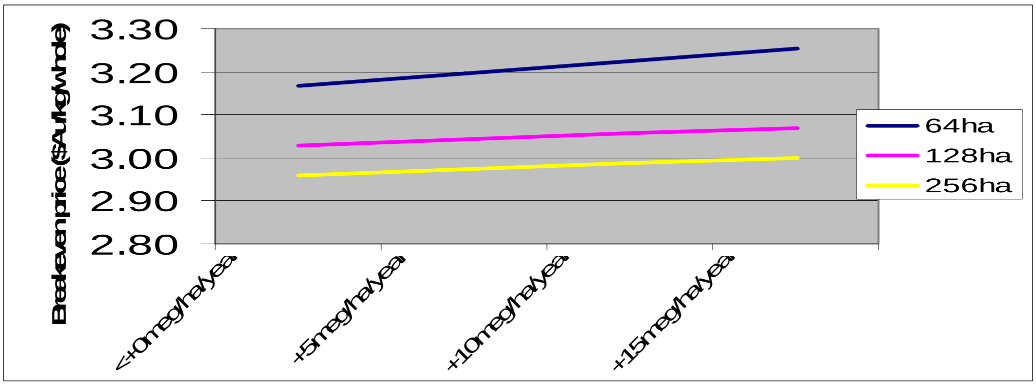


Figure 21: **Sensitivity of the hypothetical teraponid farms to water usage.**

< signifies the base rate used in the above analysis. Elasticity of breakeven price to increase in feed cost (calculated at just above the base feed cost) is

- 64ha farm: 0.030
- 128ha farm: 0.014
- 256ha farm: 0.016

9. Results

The breakeven prices for the hypothetical teraponid farms are significantly (up to 50%) higher than for the US channel catfish farms. The breakeven prices are, however, significantly lower than for other studies looking at the economics of silver perch farming in Australia. Weston, Hardcastle and Davies (2001) suggested a most likely Benefit: Cost ratio of less than one (0.97) for a farm producing 100 tonnes per annum at a price of $6.00/kg. Kable (1996) calculated a breakeven price of $6.80/kg for a farm producing 80 tonnes per annum. The scale of the farm models used in this study would be expected to return lower production costs than smaller farm models used by the Weston, Hardcastle and Davies (2001) and Kable (1996).

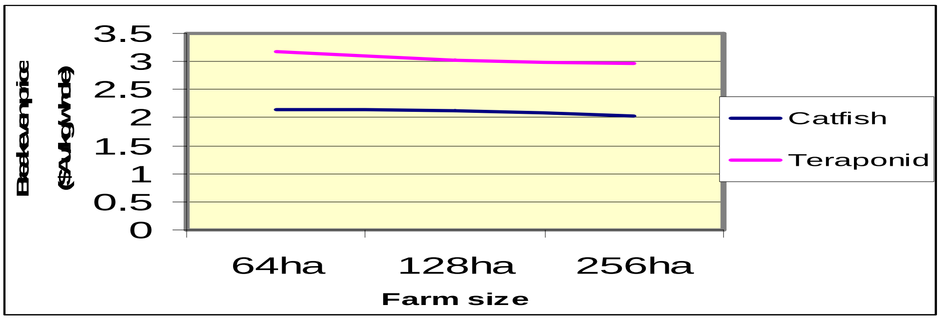


Figure 22: **Breakeven pondside prices ($Au*/kg/wholeweight) for three farm sizes for channel catfish production in the US (developed from Kazmierczak and Soto, 2001) and hypothetical teraponid production (base figures) in the Burdekin region, QLD, Australia**

The results of the sensitivity analysis conducted showed that feed price had the most significant effect on breakeven price. A 10% decrease in feed price would result in a 5.3%-6.0% decrease in breakeven price. Engle (2003) highlighted similarly high sensitivities of catfish production to feed prices.

Improvements in Feed Conversion Ration (FCR) also have strong effects on breakeven prices; by lowering the feed cost component of production they are somewhat analogous to reductions in feed prices. The next most significant factors (in order of importance) were – production rate, interest rate, fingerling price and electricity price.

Table 14:

Elasticity response results (in order of importance) of sensitivity analysis of breakeven price to changes in major inputs in the hypothetical teraponid farm budgets

	64 ha	128 ha	256 ha
Feed price	0.530	0.581	0.595
Production rate (kg/ha/year)	-0.316	-0.291	-0.272
Interest rate	0.111	0.111	0.108
Fingerling price	0.095	0.099	0.101
Electricity price	0.076	0.079	0.081
Labour cost	0.051	0.052	0.053
Water usage	0.030	0.014	0.016
Land cost	0.026	0.027	0.047

Interestingly water usage and land cost do not seem to have a great effect on breakeven price. For example a doubling of water usage would only lead to a 1.4%-3.0% increase in breakeven price. However the land cost and water usage would be more significant if interest rates were higher, as both have significant upfront capital costs. Also the static nature of the budget probably did not properly account for the investment costs of these factors.

Given that feed price had such a significant effect on the breakeven price of the hypothetical teraponid farms it was felt that it would be useful to compare the channel catfish budgets of Kazmierczak and Soto (2001) with the hypothetical teraponid budgets developed in this study at equivalent feed costs.

Given that the ingredients for catfish and teraponid feeds are reasonably similar it is likely that if a large teraponid industry was ever to develop in Australia that local feed costs would become much more comparable to those of the channel catfish industry.

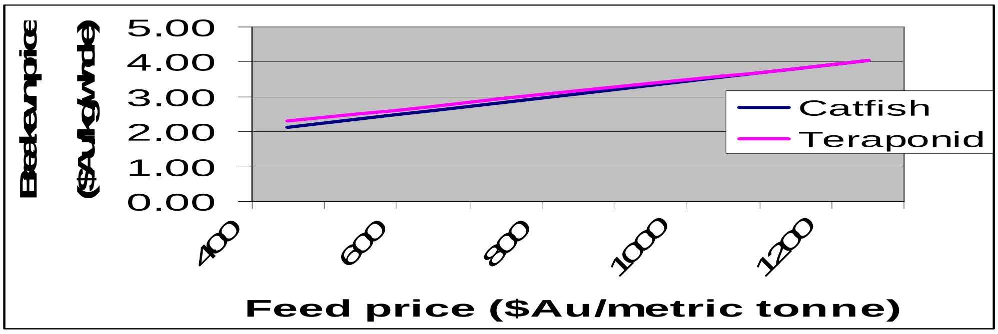


Figure 23: **Sensitivity of breakeven price of the 64ha channel catfish farm (developed from Kazmierczak and Soto (2001)) and the hypothetical 64ha teraponid farm (base figures) to feed costs**

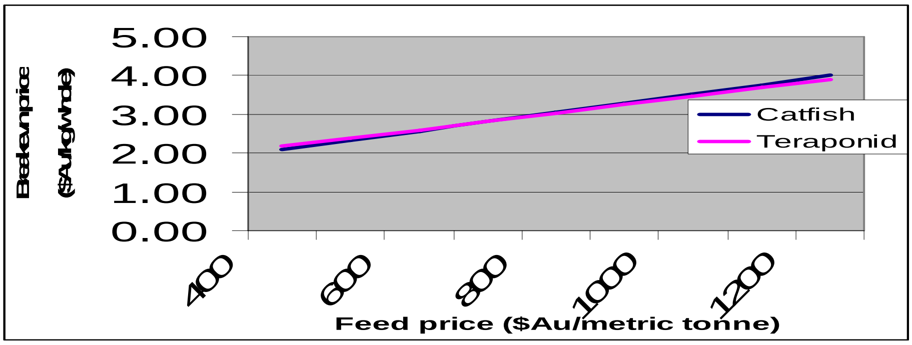


Figure 24: **Sensitivity of breakeven price of the 128ha channel catfish farm (developed from Kazmierczak and Soto (2001)) and the hypothetical 128ha teraponid farm (base figures) to feed costs**

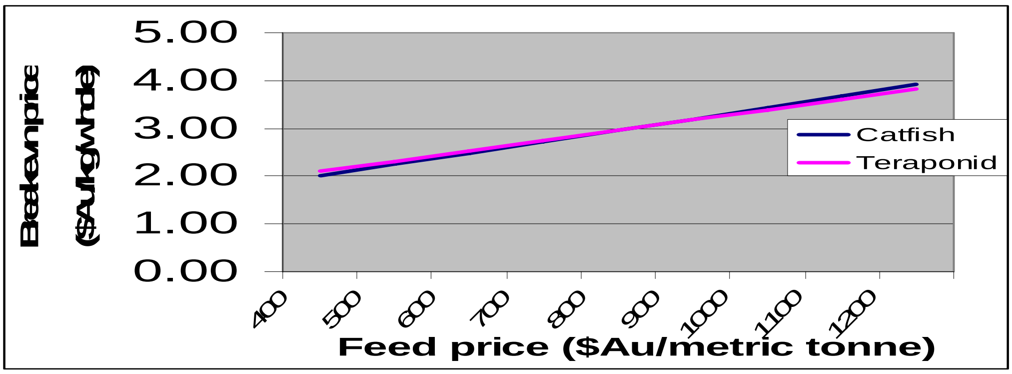


Figure 25: **Sensitivity of breakeven price of the 256ha channel catfish farm (developed from Kazmierczak and Soto (2001)) and the hypothetical 256ha teraponid farm (base figures) to feed costs**

The results of the comparison of feed price effects on the catfish and teraponid breakeven prices are illuminating. These results are highly dependent on the validity of the assumed exchange rate ($US0.75=$Au1.00) representing relevant purchasing power parity and the assumptions used in the teraponid budgets. Also the static state nature of the budgets used and the breakeven price measure does not best demonstrate the true costs and cash flow requirements of the industries studied. Furthermore there are a number of further costs downstream of the farming process (purging, processing, distribution, marketing) that are not considered in the above budgets.

Within these limitations however, the results suggest that at equivalent feed costs the farm-gate cost of producing channel catfish in the Mississippi and teraponids in the Burdekin are remarkably similar.

The overall economies of scale effects were shown to be greater for the teraponid farms than for the catfish farms. A great part of the competitive advantage of the channel catfish industry is the 'critical mass' of the industry that allows smaller farmers to access economy of scale advantages for many of their inputs. For example the cost component of stocker sized (30g+) fingerlings for channel catfish is about $Au* 0.14-0.18 per kilogram of catfish produced whereas the cost component of perch fingerlings of 0.5g (that still have to be grown to stocker size) is $Au 0.275 per kilogram of perch produced (according to the figures used in this study). The major competitive advantage which allows the hypothetical teraponid farms to be competitive with the channel catfish farms at similar feed price levels is the longer growing season available in Queensland. This has the effect of increasing production rates while maintaining the same stocking and loading parameters as the catfish farms.

10. Discussion

Further costs and barriers to industry establishment

While channel catfish and teraponid farming are similar activities, and given comparable economies of scale, appear to be viable at similar price levels (assuming similar feed costs), there remain a great many barriers to the establishment of a large scale, relatively low cost aquaculture industry based on teraponid production in Australia. Currently the Australian teraponid industry shows very little resemblance to the channel catfish industry in almost every parameter examined.

Differences between the Australian industry and the US industry that present barriers to the development of a high volume, low cost teraponid industry in Australia include:

- Australian feed manufacturers do not have the economies of scale in perch feed to produce a diet at comparable costs to the US catfish feeds;
- Practical production expertise in operating high volume, low cost pond aquaculture businesses in Australia is lacking;
- The industry is not large or powerful enough to negotiate lowest costs of inputs. For example the US catfish industry has been able to negotiate very low electricity costs for catfish producers through their Catfish Bargaining Association (Masser, 1998);
- Government and University extension is limited and inexperienced in large scale, low cost aquaculture;

- Genetic improvement of teraponid species is in a very early stage of development;
- Breeding, fingerling production and stocker production lack economies of scale;
- Purging will probably remain a requirement of the industry for the foreseeable future (in order to ensure continuity of supply free from off-flavour episodes) adding to complexity, cost and risk;
- There is not the option to contract out activities such as harvesting while the industry is so small;
- Much of the capital equipment required is not produced domestically and would need to be imported or produced in low volumes domestically (presumably at higher cost);
- Distribution and hauling processes and channels are not established;
- Processing facilities and methodologies are not established;
- Wholesaler, retailer and consumer awareness of teraponids is very low and knowledge of the product as a relatively low cost fillet is non-existent;
- Australia is open to strong competition from a number of imported sources of fish;
- Production risk is high due to new, relatively untested nature of the industry. However investments needed to develop a farm of the size needed to capture the economies of scale that would give the possibility of entering the mainstream market are high; and
- Because of the high risk nature of the investment rational investors would require high rates of return that would only add to prices and impede the ability of the product to enter the mainstream market.

The results of both this study and those preceding it suggest that feed costs are the major cost component of teraponid production. Cheaper Australian produced diets require further research into ingredient suitability (Allen and Rowland, 1996) and economies of scale in production. Jade perch has shown the ability to make efficient use of a variety of aquaculture diets, none of which have been specifically designed for the species (Wingfield, 2002). Silver perch and other teraponids may also prove to be amendable to alternative feed sources. There may be scope to import suitable, much cheaper feeds designed for tilapia, carp or catfish from Asia or even the US. Almost all prawn feed used in Australia is currently imported from various Asian countries.

The lack of practical production expertise in high volume, low cost pond aquaculture in both the private and public sectors would add a ‘learning curve’ to any development towards large scale teraponid farming in Australia. In theory this learning curve should be able to be reduced with the wealth of information available to the Australian industry on the development and progress of the US industry.

Government support for new aquaculture research in Australia has been relatively high. The amount of research that has been generated to date for silver perch is impressive given the small size of the industry.
None the less, the differences required in skill levels from simply being able to produce a crop well to being able to generate a viable business from the production of a crop are great. Catfish farming is a complicated business (Engle, 2003) and large scale teraponid farming would also be complicated.

While the industry is small it will never be likely to have the power to negotiate major discounts in the way the US industry can. However the aquaculture industry in Australia as a whole is reasonably well organised and has the support of various government departments. For example, the Australian aquaculture industry has recently been able to negotiate a tax rebate for diesel fuel used in the construction of aquaculture facilities.

Some work into the genetic potential of silver perch has been conducted with NSW's Fisheries but unsurprisingly it lags behind advancements made with channel catfish in the US. There are a significant number of Australian teraponid species that have yet to be investigated for their aquaculture potential and the considerable regional variation within most of the species (Allen, 1989) may be useful for genetic exploitation. Genetic improvement is currently an underutilised vehicle through which an Australian industry could develop significant competitive advantages.

Economies in scale in breeding, fingerling and stocker production and other associated downstream and upstream activities (such as contract harvesting, equipment manufacture and supply, fish distribution, fish hauling), can only develop through organic growth in the industry. There does not appear to be any impediments other than economies of scale to the supply of these products and services at similar costs to the US industry. Very significant cost benefits would accrue to Australian teraponid production if stocker sized fingerlings were available at comparable prices to those within the US industry.

The cost of fingerlings per kilo of production would be reduced by up to 50% while the productivity of the farm would be increased to around 10t/ha/year without any increase in loading rates. This would lead to breakeven price reductions of around \$0.30-0.45 per kilo according to the models outlined above as well as simplifying operations and reducing risk (through faster turnover times from fingerling to sales).

Purging live fish in clean water tanks for a week or two for the removal of off-flavours is standard practice in the Australian teraponid industry. The cost of this is significant and has not been investigated in this study. The US catfish industry is large enough to maintain continuity of supply by simply withholding fish from harvest from ponds until off-flavour episodes naturally pass (Oxford, 2003). Nevertheless the cost of this practice is also significant; it is estimated to cost the industry some $US50 million per year (Oxford, 2003) or about $Au* 0.22 per kilo of catfish on average. No figures were found in the literature attempting to quantify the costs of purging to Australian producers.

Processing is an essential component to the success of the US industry. Catfish has little appeal in its raw, whole form. Australian teraponids probably have more appeal than catfish as a whole product. Accessing the mainstream market would however almost certainly involve the production of fillets (Ruello, 1999).

The two options for further processing are:

- To send whole, chilled fish to established seafood processors for filleting; and
- To develop farm specific or local/regional processing plants

For smaller farms, the first option is likely to be the most viable. Existing seafood plants, particularly those that conduct filleting by hand, would likely have little trouble contract filleting quantities of perch. Weston, Hardcastle and Davies (2001) assumed a freight cost of $0.30 for the live transport of silver perch to market.

Freight costs for whole chilled product would be much cheaper on a per kilo basis as live transport involves the hauling of large quantities of heavy water which has no value. Based on the following (lenient) assumptions:

- a farm gate breakeven price of $3.00 per kilo;
- purging costs of $0.30 per kilo;
- a profit margin of $0.50 per kilo (the catfish model of Kazmierczak and Soto (2001) has profit margins of about $Au*0.15-0.30 per kilo on their assumptions - it can be assumed that an Australian teraponid producer would require a higher return – possibly higher than $0.50 per kilo); and
- freight cost of $0.20 for whole chilled product to market (eg. an established processor).

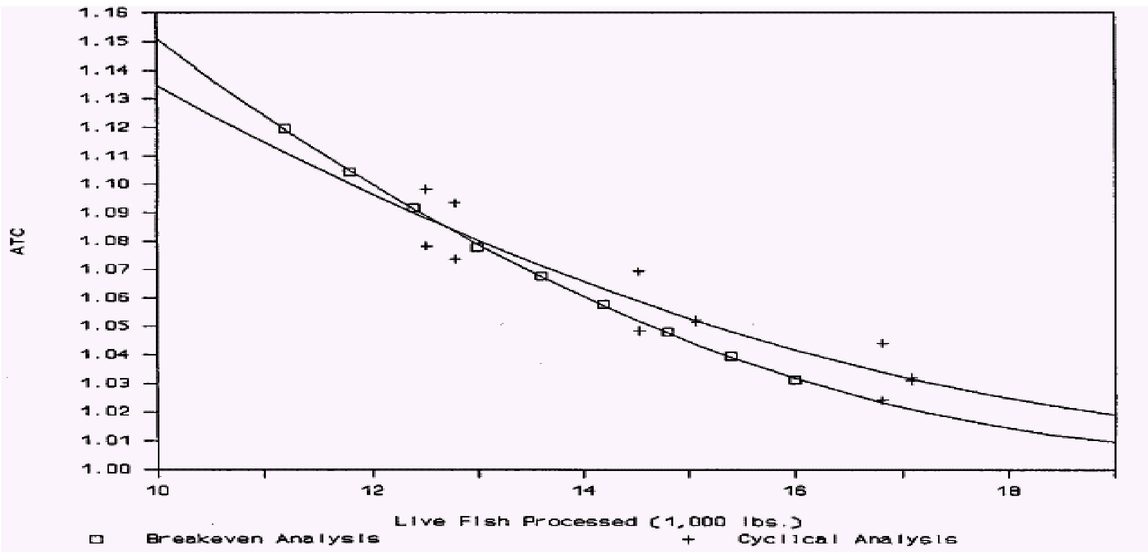
The cost of the perch (wholeweight) at the processors of market would be $4.00 per kilo. According to Table 8 (which gives the wholeweight cost of various filleting species at the Sydney fish markets from July 1998 to June 2001) this would place the perch at a similar price to gemfish, mirror dory, ocean perch, angel shark and blue warehou. These are significant, although not the major, fillet species in Australia.

Fillet recovery rates are very important in deciding how these wholeweight prices translate into fillet prices. The fillet recovery rates of the individual species presented in Table 8 are not given, but it has

been suggested that the fillet recovery rate of around 40% for teraponids is quite competitive (Rowland and Bryant, 1996).
The major cost component of the production of teraponids according to this study is feed. If, through imported sources or growth in Australian production, feed costs could be reduced to close to US catfish feed costs ($400-500 per tonne) then the price of perch at market on the above assumptions would be around $3.00-$3.50 per kilo. This is still not as cheap as the price for blue grenadier (hoki) at $2.50 per kilo, which is a major fillet species in Australia, but it would place perch well within the price range of commoner Australian fillet species.

On the most lenient assumption that a major teraponid farming industry could develop in Australia to the point that it was able to exploit similar economies of scale to the US catfish industry, a cost at market of $2.50 per kilo would be conceivable, based on the models and assumptions used in this study.

Larger farming developments may be able to find cost advantages in processing locally. The success of catfish farming in the US has seen the development of farms in areas such as California and Texas which are well outside of the traditional catfish producing regions. Branch and Tilley (1992) examined the costs of small scale (7.3 tonnes per day capacity) catfish processing plant that primarily produced frozen catfish fillets.



Source: Branch and Tilley (1992)

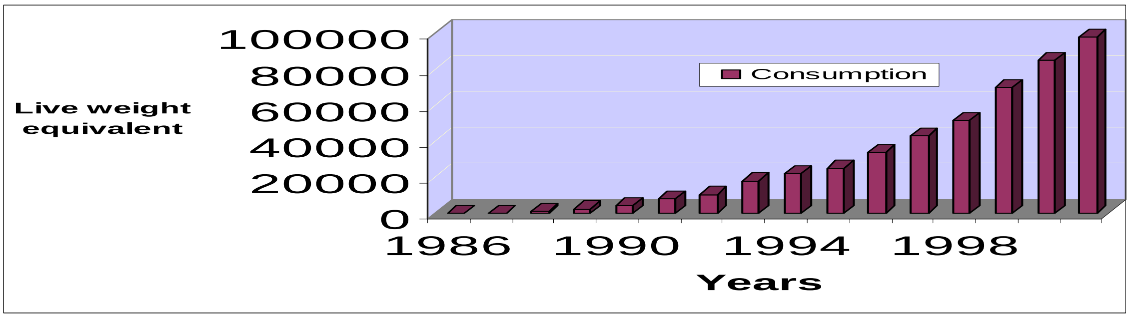
Figure 26: Average total cost per pound of live fish processed for a small scale (7.3 tonnes per day capacity) catfish processing plant.

To generate the average total $Au* cost per kilo of live fish multiply the total cost per pound in $US by 2.93.

Whether these costs would be applicable to an Australian processing plant is beyond the scope of this study. However Branch and Tilley (1992) did find that the plant could be profitable under a number of (but not all) price and risk combinations relevant to what (is assumed) is a competitive US market.

The extent to which the current low market awareness of teraponid products would affect the development of a significant industry are probably highly dependant on the prices at which producers are able to put their product to market through the various stages of development. It has been suggested that at the lower end of the fish fillet market in Australia, individual species is not particularly important (Mosig, 1998-99). The rise of Vietnamese catfish fillets (basa) in several years on the Australian market from non-existent to possibly the most consumed fish in Australia (Seafood Australia, 2003/04) with what appears to have been minimal promotional effort is testament to this view. However this apparent high substitutability of species at the lower end of the white fillet market in Australia is also a constant threat to any products in the market.

Australia imports large volumes of cheap, high quality white fillets from a variety of sources. Most of these products are from wild fisheries which are static or in decline in terms of volume and prices are slowly trending upwards (Love and Langenkamp, 2002). Provided a teraponid fillet could find a niche in this market it would be unlikely to face significantly increased competition from wild caught products in the foreseeable future. However imported or domestic farmed alternatives have the potential to be strong competitors as they share the same advantages of being able to gear up production to meet demand. The one major farmed white fillet on the Australian market is basa, which has shown phenomenal success and has the potential for increased supply (Gallagher, 2002). Another farmed white fillet that is rarely imported into Australia but has become a major success in the US and the UK is tilapia. In 2002 tilapia was third to catfish and cod for the most consumed white fillet in the US (see Table 3).



Source: (Fitzsimmons, 2001)

Figure 27: Growth in US tilapia consumption (live weight equivalent)

In the longer term, in order to be competitive against imported, farmed white fillets such as basa and tilapia, teraponid fillets would have competitive advantages in at least some of the following areas:

- Price;
- Quality;
- Freshness;
- Environmental credentials;
- Australian produced; and
- Availability.

It is beyond the scope of this paper to investigate how Australian teraponid fillets would compare to other products in these areas.

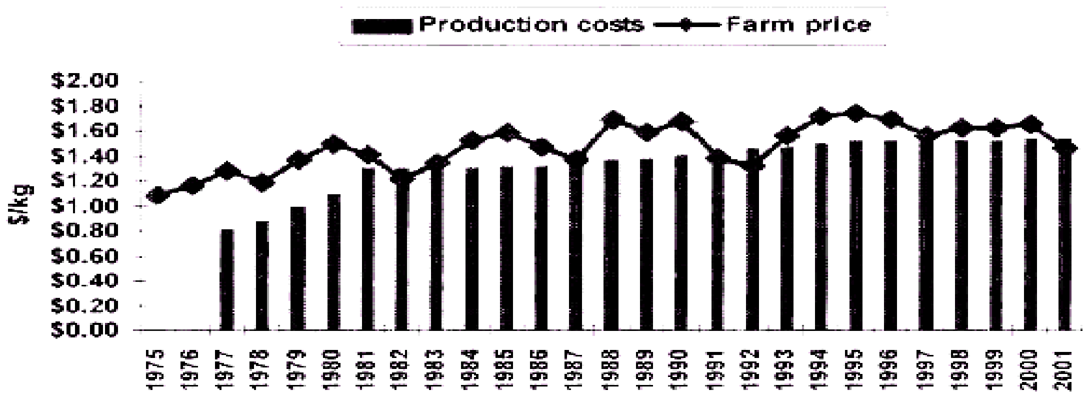
The major impediment to the development of an Australian teraponid industry along the lines of the US catfish industry appears to relate to scale. There is a certain ‘critical mass’ of production required for an industry to become self sufficient in terms of continuity of supply, support of upstream and downstream industries, economies of scale and stability and predictability for investment purposes. Interestingly the first attempts at developing channel catfish farming in the US collapsed at about 6,800 tonnes per year due to the inability of the industry to reach a critical mass (Tucker and Robinson, 1991). A spokesman for Nutreco-Skretting (the world’s largest aquaculture company), in discussing the development of a marine cod farming industry in Norway, suggested that individual farms would have to produce around 2000-4000 tonnes per annum and regional clusters around 20,000-30,000 tonnes per annum to reach critical mass in activities such as processing and marketing (Hole, 2002).

It appears from this study that if a large industry existed in Australia along the lines of the US industry (including finding a market niche similar to the US) it would be viable. However as such an industry does not exist at this stage any developments would be faced with higher input costs than the US industry. An important finding of this study is that, due to the longer growing season, these higher costs can mostly be absorbed due to higher production rates. The major input cost is feed and as its use rises with production level it is not negated by higher production rates. If a cheap feed suitable for teraponid production could be sourced into Australia it may be possible for a teraponid farm to produce fish at a similar cost to the US catfish industry, at least in terms of the pond side price.

A rational investor can be assumed to expect a much higher rate of return from a teraponid farm in Australia, given the current state of the industry and the risk involved with the investment, than his/her counterpart in the US catfish industry. This requirement would add significantly to the market cost of the product and reduce its competitiveness. A discounted cash flow analysis is needed to best model the rates of return that could be generated from an investment in teraponid farming.

However within the limitations of the model used in this study, interest rates (rates of return) had a significant effect on breakeven costs.

In common with almost all farming enterprises, catfish farming is not a highly profitable business. However it does tend to be a more profitable farming activity than traditional row crops in the south of the US (Engle, 2003). Also in common with most other farming, good returns in aquaculture are more likely to be returns to extraordinary management than other factors. Prices for catfish have declined in real terms as is common for agricultural products. Only a very small number of catfish farmers have made very high profits from catfish farming (Engle, 2003).



Source: Engle (2003)

Figure 28: Average costs and prices for the US catfish industry from 1975 to 2001.

The US catfish industry developed because poor returns from traditional row crops in the Mississippi during the 1960s, 1970s and early 1980s caused farmers to take significant risks in order to develop new sources of income. A similar situation in cane or cotton production in Australia may create conditions where a large scale teraponid industry could develop. Farmers trying to stay on the land are more likely to accept lower returns, even during the initial risky phases of an industry.

Currently there is interest from cotton and rice growers in Queensland and New South Wales in diversifying into silver perch farming (Gooley and Gavine, 2003). However these developments have not, to date, replicated the philosophies of the US catfish industry.

An industry could be encouraged to develop with sustained government support such as subsidies or special credit arrangements. While this has been practice in the past it is not a popular approach with governments in Australia today. In theory support is only needed until the industry reaches critical mass and can become self-sufficient. However in practice it is often difficult to reduce the accustomed levels of government support.

Otherwise a large investment from a deep pocketed source would be required to develop a farm of an initially large enough size to capture the economies of scale necessary to be viable. The development of such an enterprise would probably make other smaller operations more viable by greatly increasing the economies of scale of feed manufacturers, reducing perceived investment risk by demonstrating successful production and by promoting awareness of the product in the market. Returns for the risk of a large initial project are probably not likely to be found so much in the early years of production but in the potential to develop power within the industry and the market on the possibility that an industry comparable to the US industry could develop.

Areas for further study

This current study has focussed mostly on one part of a possible large scale teraponid farming industry. Even within this study there are a great many assumptions that could be investigated in more detail. Farming is a polymathic business and there is scope for research contributions from a wide range of disciplines into this type of industry. There is also scope for much more study into the economics of teraponid production and marketing in Australia. The US catfish industry provides a convenient and well documented source on which much of these investigations could be based. Major areas in economics for further study include:

- Economics of breeding, fingerling and stocker production;
- Economics of genetic improvement studies;
- Economics of feed production and alternative imported feed sources;
- Economics of growout using discounted cash flow analysis;
- Economics of processing and distribution;
- Economics of risk for all stages of production and processing;
- Marketability and competition studies;
- Economics of advertising ;
- Local economy and social impacts (for example the catfish industry is estimated to produce four off-farm jobs for each on farm job (Masser, 1998));
- Critical mass estimation; and
- Export possibilities

However given the very small nature of the present industry much of this suggested study may be of little more than academic value.

11. Conclusions

The channel catfish farming industry of the US and the teraponid farming industry in Australia are presently very different industries. The US industry produces some 300,000 tonnes of catfish per year at a pond side price of around $Au* 2.00 per kilo while the Australian industry produces around 430 tonnes of perch per year at a pond side price of around $Au 8.00 per kilo. Farmed US catfish is the most consumed white fillet in the US while silver and jade perch are essentially unheard of in Australia outside of the specialised Asian restaurant live fish market. However despite these differences channel catfish and teraponids are biologically quite similar in their attributes for aquaculture. This has resulted in speculation from the earliest days of teraponid production on the potential for a high volume, low cost industry in Australia similar to the channel catfish industry of the US.

The large differences in success between teraponid farming in Australia and catfish farming in the US (despite the biological similarities of the species for aquaculture) begs the question as to whether US style farming could achieve similar outcomes for Australian teraponid production.

In this study, a well established budget framework (most recently from Kazmierczak and Soto (2001)) for three sizes of catfish farms (64ha, 128ha and 256ha) have been adapted for cost and climate conditions of the Burdekin region, Queensland, Australia. Breakeven prices for the hypothetical teraponid farms were found to be up to 50% higher than those for the catfish farms published by Kazmierczak and Soto (2001). The breakeven costs were however much lower than those reported by Kable (1996) and Weston, Hardcastle and Davies (2001) for silver perch production in Australia using the production system recommendations of Rowland and Bryant (1996). The breakeven prices for the hypothetical teraponid farms were most sensitive (in order of significance) to feed prices, production rates, interest rates, fingerling prices and electricity prices.

When the hypothetical teraponid farms were compared to the equivalent sized catfish farms of Kazmierczak and Soto (2001) at equivalent feed costs, the breakeven prices were remarkably similar. Currently teraponid feed prices in Australia are about double that of catfish feed prices in the US. While the hypothetical teraponid farms had higher input prices for most variables, the much longer growing season of the Burdekin compared to the Mississippi meant that the increased production rates absorbed most of the costs. If cheap, effective feeds for teraponids could be sourced into Australia, teraponids could be produced at similar breakeven pondside prices to catfish in the US (subject to the validity of the assumptions used in the study).

Using further lenient assumptions, and based on current Australian feed prices, it is suggested that whole chilled teraponid perch could be marketed to processors at a price of about $4.00 per kilo. This is a similar price to some reasonably common Australian fillet species including gemfish, mirror dory, ocean perch, angel shark and blue warehou. If effective feed could be sourced at similar prices to catfish feed in the US, this price would be reduced to about $3.00-3.50 per kilo. On a somewhat optimistic assumption that a teraponid industry developed similar cost efficiencies to the US catfish industry in stocker fingerling production, a cost at market of around $2.50 per kilo wholeweight would be conceivable. This is similar to the average price of wholeweight blue grenadier (hoki) at the Sydney fish market from 1998 to 2001 (of $2.52 per kilo). Hoki is a major white fillet in the Australian market (Table 7).

Despite some promising figures, there remain many barriers to the establishment of significant teraponid industry in Australia and there are many other areas that would benefit from further research. The major challenge for the development of such an industry is getting around the ‘chicken and egg’ situation where a relatively large industry is needed to develop the economies of scale to be competitive in the mainstream market, however a successful market is needed to develop a large industry. In the US the catfish industry developed almost out of lack of alternative options for row crop growers in the south to profitably use their land.

Whether an industry ultimately develops in Australia (through the efforts of innovative cane or cotton growers or through the investment of a deep pocketed 'true believer') or whether it simply fails to develop (due to barriers of establishment to critical mass being too large) remains to be seen.

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