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THE HANDLING AND VALUE ADDING OF FARMED BARRAMUNDI

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Report prepared for the

National Seafood Centre

and the

Australian Barramundi Farmers Association

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FISHERIES RESEARCH & DEVELOPMENT CORPORATION

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FOREWORD AND DISCLAIMER

This report has been prepared for the National Seafood Centre and the Australian Barramundi Farmers Association.

It is based on information gathered by the writer from published reports, primary research and by means of interviews with persons believed to be reputable and reliable.

I believe the report to be accurate but readers should make their own enquiries to satisfy themselves about particular matters.

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Principal Consultant

ACRONYMS and TERMINOLOGY

ABFA : Australian Barramundi Farmers Association

ABARE : Australian Bureau of Agriculture and Resource Economics

JCU : James Cook University

NSC: National Seafood Centre

QDPI : Queensland Department of Primary Industries

g & g Gilled and gutted (ie eviscerated)

vis a vis: in comparison with

rigor mortis: stiffening of the body after death

>.... Greater than ....

<.... Less than ....

Size classifications used in this report:

plate size: fish up to 500 grams each

medium size/intermediate size: fish from 501 grams to 2.0 kilograms

Large fish : fish from 2.001-3.000 kg

Extra large/very large: fish larger than 3 kg

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EXECUTIVE SUMMARY

The commercial handling, packing and distribution of farmed barramundi from producers to interstate markets and consumers were examined to assess the effectiveness of current practices.

The industry has relied almost entirely on a single product, ungutted whole fish, sold chilled or alive, therefore an examination of the impact of gall bladder bile stain in the belly cavity and a comparison of the distribution and marketing of gutted and ungutted fish were primary objectives.

The potential of new products from large fish and value adding opportunities were also examined so that industry could reduce its reliance on plate size fish and reduce its exposure to falling prices (of this single product) in the peak supply period of February - April.

Observations on farms and in fish marketing businesses indicated that almost one in four fish develop a noticeable gall stain in the belly during the harvesting and on-farm handling operations. However this visual defect in the ungutted fish product is essentially masked by current marketing and cooking practices and goes unnoticed by consumers.

Nevertheless farmers need to minimise the impact of belly stain because as the tonnage of gutted fish in the marketplace increases with industry expansion so too do the chances of consumers noticing the defect (when they examine the belly of the cleaned fish).

Fish arriving in Sydney after overnight air transport had an average temperature of 6.8°C, mainly because of relatively high fish temperatures when packed. Storage trials and field observations indicate that the commercial shelf life of whole barramundi is approximately 15 days at an average temperature of 1°C and 7-8 days at a temperature of 7°C, temperatures which were considered representative of best practice and common practice respectively in seafood handling and storage.

The shelf life of gilled and gutted fish was not noticeably different to that of the ungutted ones at storage temperatures of up to 7°C. However this finding should not be seen by producers as a recommendation that fish not be gutted.

Consumers are mostly purchasing fish (whole or eviscerated) which has adequate shelf life to produce a tasty and satisfying meal. However fish on offer in the original styrene case or other fish cases without ample ice, at wholesale or retail premises, frequently had a temperature higher than 5°C.

Freshness and shelf life are rapidly lost at these high temperatures hence the quality of fish in businesses receiving fish only once per week from the producer was only marginal at the end of the week. Such marginal quality fish, while still fit for consumption, has insufficient quality and shelf life to satisfy a consumer several days later.

Freshness and quality loss is cumulative, therefore if the industry wishes to gain new farmed barramundi consumers and continue growing at a strong pace fish should be packed at sufficiently low temperature so that it does not exceed 5°C (the commonly recommended limit for fish) in the marketing chain. The adoption of quality assurance programs to manage temperature control is recommended to producers and fish merchants.

The expanding production of large fish (2+ kgs) and the availability of intermediate or medium sizes has led to a diverse range of sizes entering the marketplace and an overall economic gain for producers.

The demand for large fish has outstripped supply during the course of this study and will continue to do so for a few more years as the popularity of large farmed barramundi (whole and fillets) grows.

Cutlets from large fish are also liked by consumers and the seafood industry, according to market tests, but they are not yet offered for sale because of a shortage of very large fish (3+ kgs) and their high cost.

The relatively high costs of fillets and cutlets, and deboned plate size fish, compared to other species, accounts for their absence from retail displays; but fish merchants do process and produce these products to order.

The heads and wings, livers and air sacs in barramundi are edible, and the skins can be utilised for manufacturing leather goods. A barramundi liver pate was developed and taste tested with encouraging results. These valuable underutilised resources are likely to be utilised commercially in the near future as the volume of large fish processed increases.

Tourism also offers a number of opportunities for the barramundi industry to increase its income, directly or indirectly via leasing or other mutually profitable arrangements.

In short, the industry can continue to develop strongly by increasing the range of products and by-products on offer, adopting a Code of Practice and formal Quality Assurance and investing in the promotion of its new products and services.

1. INTRODUCTION

The barramundi farming industry has grown from its start in North Queensland in the mid 1980's to a total production of 510 tonnes in 1996/7 from 37 licensed farms around all mainland states except Victoria.

Barramundi (*Lates calcarifer)* are grown in marine cages ("pens"), freshwater ponds (mainly cages but also free range) and indoor freshwater tanks around the mainland but production is dominated by five farms in north Queensland and one in South Australia.

The produce is predominantly whole (ungutted) plate size fish packed in styrene cases destined for interstate sale with Sydney and Melbourne wholesalers being the major primary market for the fish. Export sales are currently negligible.

There are two producers of salt water fish, in North Queensland, one marketing ungutted large fish (mostly) and the other marketing whole or gutted fish of a range of sizes. Both of these marine farms have packing/processing premises some distance from their grow out cages, unlike the other producers who have chilling and packing facilities on the farm site.

In addition to these substantial commercial ventures there is a fast growing number of small operations in Queensland growing fish in one or two above ground tanks with recirculating water systems (R Lobegeiger personal communication).

Although there is a large body of research on the biology, feed and nutrition and commercial production of barramundi (reported regularly in the proceedings of the Australian Barramundi Farmers annual workshops) the present project represents the first study on the commercial handling and spoilage of farmed fish in Australia.

Food studies on Australian barramundi are essentially limited to chemical analyses of fish in regard to species substitution problems (Williams et al 1993) and more recent work on the chemical composition in relation to fish nutrition (Williams et al 1995).

A Singaporean study on the iced storage of farmed barramundi is also relevant with its description of chemical changes and the shelf life on ice (Low et al 1988).

A laboratory study on the effect of feeds and harvesting practices, and associated stress responses, on the flesh characteristics of barramundi started at the Zoology Department, James Cook University (JCU) at about the same time as the present project .

1.1 Background To This Research

At an Australian Barramundi Farmers Association (ABFA) handling and marketing workshop in Innisfail in November 1995 farmers noted that the industry's current reliance on the sale of plate size ungutted fish was unsustainable because:

- At that time there was only one farm dedicated to the production of large fish. Therefore it was believed that continued substantial increases in the production and sale of plate size fish alone would affect market prices adversely.

- There were indications that some fish were being marketed with a "gall bladder burn" mark inside the belly cavity (a stain due to bile escaping from the bladder) which could reduce their consumer appeal and final value.

Also, there was a need to investigate opportunities for increasing industry returns through value adding current products and developing new products.

1.2 Need For Research

While the annual production volume of farmed barramundi has grown from 35 tonnes to more than 500 tonnes in the last seven years the industry development and profitability has been constrained by a strong reliance on ungutted plate size fish.

A reliance on this one product has meant that prices for the fish fall at peak times of the year (February-April) when supply commonly exceeds demand. This seasonal problem has something of a "ratchet effect" on prices in that they are slow to return to earlier levels and consequently depresses overall industry returns.

Almost all of the production had been sold ungutted (some live, but mostly chilled) because of market pressures to keep the per kg price of fish as low as possible so that it can appeal to a larger market. Several farmers sell fish gutted or deboned at times but the benefits of such processing had not been examined and hence were uncertain.

Some of the ungutted fish sold have a gall bladder stain inside the belly wall which detracts from their appearance when gutted and this defect can adversely affect the image of this new aquaculture industry. The benefits of marketing of fish in the ungutted form (*vis a vis* eviscerated) were also questioned by some producers and marketers.

Economic and biological research on barramundi farming suggested that large fish (2+ kg) could be produced without much added difficulty and the costs- benefits of producing such large fish appeared very attractive (Hinton 1994 and C Barlow personal communication) because :

- of the rapid growth from 500 gm to 2 kg (in approximately one additional year) and the much higher dollar return from each fingerling (versus that from a plate size fish of about 400 gm)

- market research by Ruello & Associates in 1995 indicated that "new" aquaculture products such as large barramundi and their fillets and cutlets would be welcomed by the seafood trade and restaurateurs.

Any increase in the percentage of farm production sold as large fish (whole, fillet or cutlet), small gutted fish or deboned product rather than the traditional ungutted plate size fish would improve market penetration, avoid damaging price drops at peak times and substantially improve overall industry profitability.

The handling, packaging and distribution of barramundi from commercial farmers to customers interstate warranted examination so that existing practices and financial performance could be improved.

The barramundi farming industry was therefore pleased to be able to financially support an application for funding this research project to the National Seafood Centre.

1.3 Research Objectives

The objectives of the project were to :

Examine current handling, processing packaging and distribution of farmed barramundi to identify any weaknesses and propose improved procedures to maximise quality, shelf life and the economic returns on the fish. Of particular interest was a comparison of the spoilage and shelf life of gutted and the ungutted fish.

Gather information on the strengths weaknesses, costs and benefits for fish merchants and fish farmers of selling plate size fish in the gutted, ungutted and in a deboned form.

Examine the costs and benefits of utilising 2+ kg fish for the production of fillets and cutlets rather than selling at the smaller size whole (as commonly practiced).

Examine the costs and benefits of utilising processing by-products of large fish and any other opportunities for total utilisation and maximising returns from barramundi farming.

2. METHODOLOGY

The methodology employed in this project is outlined here but further details are provided in the subsequent sections dealing with each particular research area.

The focus of the field research was on North Queensland farms and in the Sydney marketplace, the dominant producing area and major market respectively, but fish samples for experimental studies were obtained from fish produced in Queensland and South Australia. Fish on offer on the Sydney Fish Market auction floor were regularly examined, particularly for temperature measurements and sensory assessment of quality.

The study commenced with field work in North Queensland in August 1996 and finished with market observations in Sydney in November 1997.

Current Handling Practices On Farm

The handling practices on 15 farms were ascertained during farm visits (7 farms) or by discussions with the operators personally or by telephone (Appendix 1).

Handling and Shelf Life Off Farm

The handling, storage, and shelf life off farm was examined *in situ* in retail and wholesale fish outlets in Sydney and Melbourne, the Sydney Fish Market auction floor and the Providores (wholesale) section of the Melbourne Fish Market at Footscray.

Storage, spoilage and shelf life trials of fish harvested and transported in the typical manner were undertaken in Sydney under various controlled temperature conditions. These data were supplemented with field observation in the marketplace to produce a simple guide to the shelf life and sensory quality assessment of farmed barramundi for fish merchants and processors.

Temperature Measurements and Recordings

Fish core temperatures were measured by inserting a PDP brand probe thermometer into the anus and dorsally towards the backbone.

Temperatures inside styrene cases of fish were taken by inserting a probe thermometer inside one end of the case (one third of the way up from the bottom, to avoid insertion into the ice/gel pack) and also inside one of the long faces of the case. The average of the two temperatures were then recorded; preliminary trials indicated that these temperatures, designated as "case

temperatures", were within one centigrade degree of the fishes' average core temperature.

In-transit temperatures were monitored with Deltatrak five-day paper recorders placed inside styrene packs of fish by the fish farmers.

Evaluation of Processing Costs and Recovery Rates

The recovery rates (yields) and processing costs of filleting, deboning or gilling and gutting were monitored at two of the Queensland producers operations and in two Sydney fish businesses and supplemented with data gathered from fish samples provided by farmers.

Costs of Producing Large Fish, Fillets and Cutlets

Estimates of production costs of different sized fish were obtained from farmers. These costs and the recovery rates (yield) of fillet or cutlets obtained from the Sydney processing operations were then utilised to estimate product costs.

Evaluation of New Products and By Products

Large fish, fillets, deboned whole fish and cutlets were evaluated by selected groups and individuals and by follow up interviews with consumers and commercial users in the marketplace.

A barramundi liver pate was developed by the researcher and evaluated by a group of prospective commercial users and consumers.

Information on other by products such as fish skins was obtained from specialists in the respective field.

Industry Feedback and Follow Up Service

Farmers actively participating in this study were given progress reports on the condition of their fish on arrival in Sydney, particularly when there were problems with packing or unusually high product temperatures. These packs with high temperatures were also bought to the attention of the consignees.

Progress results and interim recommendations were presented to farmers at a special meeting of the Australian Barramundi Farmers Association at South Johnstone Research Station in February 1997 and later at the Annual General meeting in August.

Invited fish merchants and restaurateurs in Sydney were appraised of the growing availability of large fish, many intermediate sizes and the processed products at a promotional function in March 1997 (Appendix 2).

3. ON-FARM HANDLING

The harvesting, chilling, packing and shipping of fish was examined on three north Queensland farms in both summer and winter and the fish from these farms were also regularly monitored in the Sydney marketing chain as they moved from the auction or wholesaler to retailers.

Single visits were made to three other Queensland operations and to a Northern Territory farm and the fish handling practices on another eight farms around Australia were ascertained from detailed discussions with the owner-operators at meetings of the Australian Barramundi Farmers or through telephone consultation.

The following discussion on the handling procedures is based on the information from 15 farms in four states : nine freshwater cage operations, four tank grow-out systems and two marine cages operations.

3.1 Harvesting and Killing

Fish are normally harvested by scooping fish out of tanks or cages. With the larger cages the bottom is raised or the fish herded into one corner or small area where they can more easily be scooped out with the hand scoop net, quickly selected (or rejected, according to size) and then killed by immersion in an ice slurry in a variety of chilling-killing boxes and tanks. Harvesting and killing is essentially a single operation on cage farms.

Fish were not fed on the day prior to harvesting on outdoor farms in order to have fish with empty stomachs at harvest. On indoor operations fish are held without food and purged for about three to five days prior to harvesting.

The harvesting operation usually took about 5-15 minutes per cage but on one occasion it was observed that a large cage was not completely emptied until an hour from the start.

Thus the actual harvesting was mostly efficiently executed when all the necessary equipment and personnel were available. However on occasions when harvesting was slow (>20 minutes) the fish are under considerable stress while they were crowded in a small part of the growing cage at ambient water temperatures around 29°C.

Most fish had succumbed to the cold and were dead within 15 minutes of immersion in the slurry but a small number of fish were still moving their tail up to an hour later. The chilling tanks at sea cages farms were moved by boat and truck to onshore bases for chilling and packing (see below).

3.2 Chilling

The usual chilling technique immediately following harvest (prior to packing) is to drop the fish into a container of ice and water. The equipment and procedures used to cool the harvested fish on the various farms varied considerably, from excellent to unsatisfactory, but was mostly good.

On the larger or better equipped farms a number of sufficiently large plastic/fibreglass boxes (Xactics, Nylex etc) or home made tanks of cold ice-water slurry were normally ready alongside the cage to accommodate and quickly chill the volume of fish for the day's order .

In almost all cases slurry was at a temperature of about -1 to + 3°C at the start of the chilling and the fish were chilled down to about 5° C or less within a few hours preparatory to packing. Salt was usually added to the freshwater and ice slurry.

However the ice slurry volume/temperature or the immersion time was highly variable as was the temperature in non air conditioned packing room and hence fish were sometimes packed at higher temperatures than indicated above. The highest slurry temperature observed was 6.2°C and the highest fish core temperature observed in a packing operation was 9.0°C.

Table 1 below shows the temperatures observed in one operation after large fish had been in slurry for three hours and immediately prior to packing.

Table 1. Large fish core temperatures and slurry temperatures prior to packing, after three hours in slurry.

	Temperature range °C	Average temp. °C
Fish temp. (6 fish)	4.7- 6.4	5.6
Slurry temp. (6)	1.3- 2.8	2.2

A notable feature of the industry was the variety of cooling tanks (varying size and shape) which meant that the cooling and temperature of fish prior to packing was not uniform and varied as much as 5°C (eg 1.3-6.4). on any one consignment. This lack of uniform procedures was reflected in the wide range of temperatures of fish on arrival in Sydney (Section 5.1).

The onset of rigor mortis was normally evident within about one hour for plate size fish in slurry temperature of 1-3°C and about 3 hours for fish 2-3 kg. Thus almost all plate fish were in rigor when packed while only about 50-60% of large fish were completely stiff when packed.

Scheduled chilling time was usually nominated as about 2-3 hours but chilling operations observed appeared to be planned around airline shipping times rather than a specified fish temperature. In other words, chilling was more often terminated to pack and transport the fish to meet a plane rather than after the fish had attained a particular core temperature.

Although farmers had thermometers on the farms to measure fish or water temperatures they were not in the habit of monitoring slurry temperatures or the progressive chilling of fish in the slurry.

3.3 Packing

Packing is undertaken in workrooms near the ponds but several farms have packing facilities remote from the growout facility. These workrooms or sheds range from modern air conditioned premises (several) to the more common ordinary room at ambient temperature.

Fish are removed from the chilling tanks to a sorting table where they are size graded by eye and hand packed according to sizes; some fish are check weighed on scales when their size is difficult to gauge visually.

Almost all small fish were in early stages of rigor mortis or completely stiff when they were neatly packed by hand (belly down, head against the end of the box and tail in the centre) into plastic lined styrene cases. Rigor stiffness did not present any problems with the smaller fish but fish about 2.5 kg or larger were sometimes difficult to pack when bent stiff. The cases of fish were then weighed and the weight marked on the outside of the styrene case.

About 1 kg of ice or a proprietary gel pack, at a temperature of about zero to -20°C was normally placed on top or amongst the fish in each case before closing off the plastic liner bag with a plastic tie or tape. A small minority of farmers (10%) packed without any ice or gel pack and very occasionally fish were just casually packed into the cases without any particular alignment.

Ice was most often home made by freezing water in a plastic bottle or bag and appeared to be clean except for one farm which consigned fish with bags of ice clearly contaminated with grass and soil on at least three occasions.

The styrene cases were sealed with tape and then held at ambient indoor temperature until the morning's harvest was ready to take to the airport, or the cases stored in a cool room until delivery to the airport.

These cases were marked with the consignees details but date marking (packing date) or lot labelling was not a normal practice.

3.4 Transport to Airport

Fish were placed onto a truck and driven to the nearest airport in time to be loaded onto a scheduled departure within an hour or so. Occasionally packed fish would be held at the Cairns airport cool room if the loading of the next aircraft was more than an hour distant.

The vehicles used to transport fish to the airport ranged from refrigerated trucks to open utilities without any covering over the styrene cases whatever. The transport vehicle varied from farm to farm but also changed, sometimes to the family station wagon, according to the volume to be shipped out on the day.

On one occasion on an open truck situation the temperature of the fish inside some styrene cartons had risen two degrees in the two hour period from sealing the styrene case and consignment at the airport. Most of this temperature rise was brought about by direct exposure of the cases to the sun while on the back of the truck for just half an hour.

By contrast temperatures in cases transported in an air conditioned station wagon had only risen about 1°C in three hours after packing.

These styrene cases were picked up by the consignees in Sydney the next morning approximately 18-20 hours after packing. Flights and transport to Melbourne are less reliable and farmers reported that cases landing in Melbourne are sometimes not picked up until 36 hours after packing.

Styrene Case Breakage

One particular model of styrene case was noted as far more prone to breakage (in transit) than other types on arrival at the Sydney Fish Market. This matter was brought to the attention of the farmers and the manufacturer concerned.

3.5 Discussion

The major barramundi producers have made significant progress in the packaging and distribution of fish to distant markets over the last few years but all enterprises, large and small, have insufficient consistency in their procedures and this is reflected in the variability of the temperature and appearance of the fish reaching the marketplace.

The rapid onset of *rigor mortis,* within just one hour in slurry, *vis a vis* several hours for most other fish species (Huss 1988) suggests that many are exhausted in the harvesting operation and that harvesting should be better planned and executed to minimise stress to the fish if producers are seeking to turn out premium quality fish.

Sufficient personnel, containers and a suitable ice slurry (high ice concentration-low temperature) should be available in sufficient volume to lower fish temperature to a suitable level, ideally 0 to -1°C, before they are packed for transport. Adequate personnel are also needed to ensure that fish are quickly packed before they warm up on the work table and during the packing process.

A factor inhibiting adequate chilling on some farms was the common belief that too long an immersion in a slurry led to the loss of body slime and excessive clouding of the eyes which would make the fish unattractive to Asian buyers (in Sydney or Melbourne).

This belief was investigated through interviews with five Asian buyers and shown to be unfounded; buyers were happy to take clean fish even with somewhat cloudy eyes. After the cause of the loss of slime and eye clarity was explained and the benefits of the longer shelf life resulting from lower temperature were explained to these buyers in Sydney some actively sought clean fish with cloudy eyes.

Fish are chilled quickly enough after harvest but in many cases are not sufficiently chilled to arrive at their destination at a temperature less than the 5°C limit prescribed by food or health authorities. A short immersion (2 hr) in ample very cold slurry (-1 to 0°C) can produce a product to please everyone.

Current practices are often inadequate --principally because little account is taken of fish and slurry temperatures -- for normal distribution of barramundi let alone delayed flights, which are not infrequent on the air routes involved.

Transport to airport is another area warranting attention; ideally it should be undertaken in insulated or refrigerated transport but at the very least the styrene fish cases need to be covered with a tarpaulin and protected against warming by sun, wind and rain.

Date marking or batch coding and detailed packing records were almost non existent although several farms started to date mark cases during this study. There is a strong need for industry wide marking of packs with the packing date to facilitate stock rotation and efficient sale by those parties receiving fish.

Universal date marking also allows all parties to quickly see how many days have elapsed since the fish was packed and this helps to reduce the incidence of "old" fish (or fish that has been frozen in the styrene case) being sold as fresh. Furthermore date marking or batch coding and reliable records are essential for efficient product recall in case of any public health problem.

In short many farmers need to improve their handling practices to ensure that fish is packed and transported to the airport at appropriate temperatures to maintain premium quality in transit to customers.

The proposed development of a Code of Practice by Queensland barramundi farmers and the QDPI is commendable but the adoption of a formal Quality Assurance approach to quality management is strongly recommended to Australian barramundi producers as well to provide customers and consumers with some assurance of a designated quality.

4. Gall Belly Stain

The incidence and severity of gall bladder (bile) stain or gall burn on the inside wall of the abdomen was examined on farm fish, fish being commercially processed on farm or in Sydney, Melbourne and north Queensland businesses and on sample lots forwarded by farmers for research work. Observations on the condition of wild fish on sale in Sydney were also recorded on an opportunistic basis.

The area of belly wall stained was invariably on the right hand side of the fish and did not vary significantly in size from one fish to another, usually covering an area the size of a 10 or 20c coin in plate size fish. The severity of burn however was noticeably different and judged according to the colour or stain of the burn on the abdominal wall as light (negligible) moderate (noticeable) or severe (dark prominent stain) as shown in Figure 1.

4.1 Frequency and Severity of Stain

The incidence of belly stain ranged from complete absence to 100% and the severity also varied considerably, from farm to farm and from batch to batch (Table 2). Belly stain was observed at all times of the year and in fish from all farms but there were no indications of seasonal change in incidence or severity.

Sixty per cent of fish examined were unaffected by gall stain and only 12% were severely stained. Fish with severe belly burn however were only recorded in batches of fish deprived of food, ie purged (in tanks) for three days or more; fish harvested from ponds or marine cages had only light or medium stains.

The type of staining within a sample was remarkably uniform ie they were predominantly unaffected, mostly lightly stained, or most fish in a batch had medium staining. As noted earlier the area of the belly wall affected was typically small but for one fish examined in Sydney in which the gall bladder had apparently ruptured and stained the entire belly cavity.

Experimental killing by *iki jime* (brain spiking) of small fish produced fish with no belly stain at all, and delayed the onset of rigor mortis to 5-6 hours. Fish which were processed commercially on farm or gutted for research showed signs of light or medium belly burn as soon as an hour after harvest and killing.

Figure 1A. Small fish with moderate stain (left) and one with severe staining (right) on the belly wall. Photo B. Gilled and gutted fish with no gall stain.

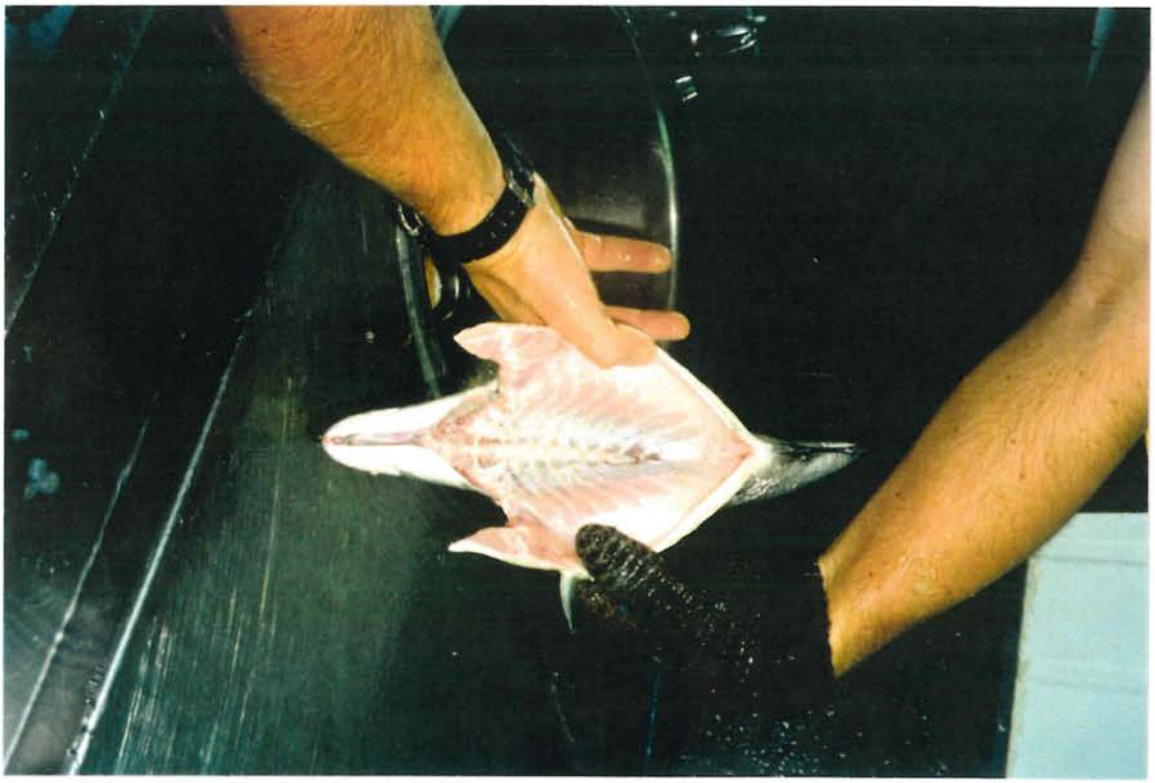


Table 2. Gall belly stain, incidence and severity.

		TYPE OF STAIN				
		Nil	Light	Moderate	Severe	Total No. in sample
Month	Farm	Number of Fish				
Aug 96	A	7	1	0	0	8
	B	5	3	0	0	8
	C	18	2	0	0	20
	D	0	5	0	0	5
	E	1	1	0	4	6
Sep 96	C	8	2	0	0	10
	F	0	0	6	0	6
	G	0	0	0	6	6
	H	0	0	6	0	6
JAN 97	A	10	0	0	0	10
	B	0	8	0	0	8
	C	4	6	0	0	10
	D	0	0	5	0	5
	I	10	0	0	0	10
FEB 97	A	4	0	0	0	4
	B	0	1	3	0	4
	E	9	1	0	0	10
	F	0	0	0	6	6
	G	0	0	1	7	8
	H	0	0	0	6	6
	I	11	0	0	0	11
APR 97	A	8	1	1	0	10
	B	4	4	2	0	10
	D	8	1	1	0	10
JUL 97	A	6	2	0	0	8
	B	8	0	0	0	8
	C	9	1	0	0	10
	I	11	0	0	0	11
	J	4	0	0	0	4
Total No.		145	39	25	29	238
Percentage		60.9	16.4	10.5	12.2	100

Belly stain evidently develops very quickly, during commercial harvesting and killing-chilling in ice slurry; it does not arise later in transit to market although in some cases it may darken or increase in area marginally in transit or after some days storage.

Storage trials in Sydney indicated that the severity of staining did not increase substantially with storage time although there may be some breakdown of the inner belly after prolonged storage (Section 5).

The severity of staining was found to be related to the harvesting-killing procedures and the size of the gall bladder. In most fish examined on farm and at market the gall bladder was small and inconspicuous and often hidden by fat deposits whereas on fish with severe burn marks the bladder was enlarged, obvious and in close contact with the belly wall.

Fish grown in indoor tanks and starved during the usual purging practice commonly had a high frequency of severe or medium belly burn, while fish from farm dams or sea cages where fish were not starved more than a day prior to harvesting were less affected as far as frequency and severity.

Severe stains were recorded in seven of eight lots of purged fish examined in Sydney : five lots had 100% with severe staining, one had 77.5% another 67% while the best of these seven lots had nil severely stained. In the eighth lot of purged barramundi one fish (of 10) was stained, with a light stain.

The gall bladder in fish deprived of food for more than five days was grossly enlarged and the belly of such fish severely stained. The worst example of stained fish was a batch which had been without food for ten days.

Chris Barlow the biologist in charge of QDPI's Aquaculture Program in North Queensland advises that deprivation of food leads to an enlargement of the gall bladder in barramundi.

This increase in the volume of bile stored in the bladder with the starvation prior to harvesting and the subsequent leakage or bursting of the bile fluid during harvesting and killing in slurry appears to be the primary cause of severe stain.

Observations on wild caught barramundi support the conclusion that food deprivation and enlargement of the bladder is the primary cause of the severe staining. Of 63 wild fish examined, from 6 consignments from a variety of sources around Queensland and the Northern Territory, none had the severe type of belly burn seen in farmed fish; belly burn in the wild fish was unusual (3%) and only light; wild fish at sea are not known to go without food for lengthy periods.

4.2 Discussion

The incidence of belly stain due to bile leakage from the gall bladder has had no noticeable economic impact on farmers or fish merchants to date principally because moderate or severe cases only occur in a minority of fish. Furthermore severe case were only observed in the fish grown in indoor tanks and these are mostly sold whole, alive or chilled, and the staining is not evident to the consumer.

Moreover most live or whole fish are eviscerated at a restaurant or at a retail store; consumers rarely take fish home to clean and gut themselves, they just cook them without any internal examination and the stain has gone unnoticed.

Retail or restaurant staff have evidently not been bothered by the belly stain and the consumer presumably has not noticed it in the raw or cooked fish, or perhaps not been sufficiently bothered to comment on it.

It is also significant that the live fish are invariably prepared for Asian cuisine served with a colourful dressing of shallots, coriander and black bean, chilli or ginger sauce and these tend to colour the cooked fish and mask any discolouration of the inner belly wall.

As the barramundi market develops and a greater tonnage of fish is sold in the gutted form in more retail outlets the opportunity to attract unfavourable consumer attention will increase. This is because the inside of the belly cavity is often examined by customers as part of their quality assessment before purchase.

Although belly stain has not been a barrier to the sale of farmed barramundi to date, farmers and others in the marketing chain should remain vigilant to reduce this defect in some of their product and handle live or ungutted fish with care so as to minimise damage to the fish.

Farmers should harvest and kill fish with care so that they are not unduly stressed or physically injured, and feed any unsold fish (after purging), to minimise the incidence of severe belly burn.

Fish merchants should be cognisant of the nature and cause of the belly burn and trim away any severely stained flesh when producing fillets or gutting fish if the industry is to keep attracting new consumers to farmed barramundi.

5. HANDLING IN THE MARKETPLACE

The general handling, storage and display of fish at fish markets and by fish merchants was examined repeatedly in Sydney and on two chance visits to Melbourne.

In Sydney, handling and storage and consequent shelf life was noted to be highly variable, mainly satisfactory but sometimes substandard in regard to temperature control of fish.

The temperature control problems related mainly to retail display and to fish still in the original unopened styrene packs on display for sale (auction, wholesale or retail market) or held in cool rooms; this problem is not unique to barramundi, it impacts on all seafoods.

5.1 Styrene Packs

The common weakness in handling practices is the failure to open packs, examine fish on arrival and take corrective action when fish temperatures are high.

Case temperatures on arrival at the Sydney Fish Market. at the auction floor or wholesale outlets ranged from 2 to 12°C at 7-8 AM in the mornings (Table 3) with a 6.8 average over the year. Within any one particular consignment there was also considerable variability with temperatures eg 4.0 to 10.4°C.

Winter temperatures were not consistently lower than summer ones for any particular farm, but it may be significant that the lowest average temperatures over the year were from a farm (C) with an air conditioned packing room (Table 3).

Fish handling and storage conditions, and hence temperatures, varied considerably from one business to another and from day to day according to trading conditions. Styrene cases on display for auction or wholesale trade were exposed to ambient temperatures of up to 27°C for a number of hours in the summer mornings and later returned to a cool room by the buyer.

The temperature of the fish inside the closed styrene case only falls slowly if the cases are not open and fish iced or exposed to the cold air flow from the blowers.

One temperature tracking trial in March 1997 showed that the temperature inside a styrene case of fish rose from 4 to 13°C in the 18 hours from packing to pick up in Sydney, then fell to 5° C over the next 12 hours inside the fish merchants cool room before it was opened. A rise of about 3 °C in six hours of Sydney's summer mornings was the common history of fish after arrival at Mascot airport shortly after midnight.

Table 3. Styrene case temperatures noted at Sydney Fish Market

Date	Producer	Case 1	Case 2	Case 3	Case 4	Average °C
August 96	A	6.6	2.4	4.6		4.5
	B	4.8	2.8	3.9		3.8
	C	1.8	3.0	2.7		2.5
Sep 96	C	3.0	4.4	4.4	2.9	3.7
	B	8.9	8.3	5.9	11.8	8.7
	D	10.0	10.0	12.0	8.2	10.0
	E	9.2	8.5	9.5	8.5	8.9
Jan 97	E	8.6	8.8	12.7	11.6	10.4
	F	9.1	10.1	10.7	11.7	10.4
	C	6.2	4.8	5.6	4.6	5.3
	A	8.1	5.4	5.3	7.8	6.7
	G	5.8	8.0	5.2	7.0	6.5
	B	6.3	7.6	7.3	9.0	7.5
Feb 97	H	8.7	9.3	10.7	9.0	9.4
	C	5.3	2.5	6.5	5.8	5.0
	B	8.0	9.1	11.1	9.9	9.5
Jul 97	E	9.1	6.2	4.7	6.4	6.6
	J	7.0	5.7	4.3		5.6
	K	7.5	7.0	7.4	6.0	7.0
	B	8.2	6.5	6.4	8.5	7.4
	C	5.9	5.9	6.3	6.6	6.2
Nov 97	B	6.0	5.7	4.4	4.7	5.2
	C	2.3	6.5	3.0	3.2	3.8
						Average 6.8

5.2 Retail Sale

Fish in retail premises were also subjected to a wide range of temperature conditions. The time-temperature history of fish in retail outlets fluctuates from day to day in any one business and it varies from one fish to another, because of many factors including:

> *type of refrigeration, amount of contact with refrigeration or ice, and earlier storage condition.*

The remaining shelf life for consumers is consequently highly variable too.

The common retail practice is to store fish in ice in a cool room at night and then have fish on display for sale during the day. This means that fish commonly has a low temperature, typically 0-4°C, after a night in a cool room. Fish temperatures rise during the day depending on the exact placement and the level of mechanical refrigeration and frequency of icing throughout the day.

In the common semi-enclosed cold plate display counters with periodic icing of fish by staff, temperatures of five to nine degrees were typical, with extremes of 1 and 19 °C recorded in barramundi (Table 4).

Fish in close contact with the cold plate had these minimum temperatures while fish presumably not in contact with ice for some time recorded the extreme high temperatures.

Table 4 Retail temperature observations

Retail outlet type	Cold Plate Display (5 stores)	Open box/stall (2 outlets)
Summer temps. (Jan 97)	1.2-19.4 average 9.2°C	3.3-24.1 average 13.7°C
Winter temps. (Aug 96)	1.1-12.6 average 4.9°C	3.0-16.5 average 6.3°C

Fish in completely open non-refrigerated displays with little ice, as seen in day markets stalls, were commonly exposed to unsatisfactory (high) temperatures. Fish temperatures in these market stalls typically were from 6 to 14°C but a high of 24°C was observed in January 1997 (Table 4); the coldest temperature

recorded here was 3°C immediately after fish had been placed on display after removal from ice storage.

Seven and 1°C were therefore selected as representative of the average temperature history from on-farm packing to retail sale for "common practice" and "best practice" respectively for the experimental evaluation of spoilage and commercial shelf life described in Section 6.

The freshness quality of fish observed on sale in Sydney throughout this study was mostly quite satisfactory with but two notable exceptions, despite some remarkably high temperatures as noted earlier.

One problem area exists throughout the summer months and that is in retail outlets without adequate ice or refrigeration to maintain the prescribed temperature limit of 5°C. Retail outlets without adequate facilities clearly represent a problem area for the seafood industry in that they sell seafood, including barramundi, with little shelf life remaining for customers.

The other problem identified in this research program, fortuitously also noted by fish farmers on a visit to Sydney, was February- March 1997 when there was an oversupply of small farmed fish in the marketplace. Fish shipped by one of the visitors more than a week earlier was still being offered to retailers as "fresh" by one distributor when the quality of the old stock was only marginal.

It is noteworthy that for most of the study period except February-April 1997 fish supply and demand had been more or less in balance and almost all the stock forwarded to Sydney fish merchants has been sold by the consignees within a few days or before new stocks of farmed barramundi arrived into wholesale or retail stores.

This turnover of stock had ensured that fish had sufficient freshness and remaining shelf life (Section 6) to satisfy customers and very few examples of obviously unacceptable fish were therefore seen outside of the day market stalls.

However it is evident that there is a need for greater attention to stock turnover and temperature control in both the wholesale and retail marketplace in the warmer months.

5.3 Processed Fish

Many fish merchants (wholesalers and retailers) in Sydney regularly stock the small whole farmed barramundi but only about half a dozen regularly cut fillets off large farmed fish and only after they had received an order for such fillets.

Fish are normally offered for sale ungutted but retailers will clean ie gill and gut the fish for customers at no cost; pre-cleaned fish are not offered for sale because the higher cost of the cleaned fish is seen as a deterrent to sales (as discussed below, Section 5.4).

Another reason for the demand for ungutted fish is that many Asians and some Europeans like to buy fish in the round (not cleaned) as they like to be able to examine the gills and intact belly in order to assess the fish quality.

Cutlets off farmed fish and deboned small fish also have not been offered for retail or wholesale but have only been cut to order. This situation prevails mainly because of price as discussed in Section 7.

Observations on fish gutting in several wholesale and retail premises clearly indicated that fish unpacked from the shipping cases on the morning of arrival and immediately iced had excellent keeping qualities.

Such fish, stored in cool rooms operating at low temperatures, of about 0-5° C, for a week, was still in good condition and able to be gutted, deboned or filleted to produce an attractive product with a shelf life sufficient for normal commercial trade ie at least several days.

In other words ungutted fish, handled and stored with sufficient care were capable of producing satisfactory eviscerated or deboned fish or fillets at a later date.

The notable weakness observed in most processing operations in Sydney or Queensland was the warming up of fish after immersion or rinsing in ambient tap water in the summer months. Fish temperatures were observed to rise from 2°C to 12 °C in just a matter of ten minutes immersion in water during processing in January.

5.4 Processing Costs

Two producers were processing small fish to market gilled and gutted fish both locally and to interstate customers, during the study period. The average loss in this processing was quoted as 13 and 15% respectively.

With a mean weight loss of 14% the cost of the cleaned fish rises by 11.6%, but the sale price of these gilled and gutted small barramundi was only 11.5% greater than that of the whole fish.

The labour and other costs associated with this processing mean that the sale of gutted fish was not as profitable (per kilogram) as that for whole fish. The few farmers who process fish do so to increase aggregate returns by maximising sales with a wider product range and larger customer base.

This processing loss plus a labour cost of about 40 cent per kilogram in Sydney raises the cost price of gutted fish for the fish merchants from a nominal base of $10.00 per kg to about $12.00 per kg which is about double the cost of gilled and gutted farmed rainbow trout and approximately the same as g &g Atlantic salmon (T Adams, personal communication).

This high price is widely seen as an impediment to sales and market development and accounts for the common practice of offering whole fish only. As noted earlier fish are cleaned on demand for customers after they have been billed for the intact fish weight.

The fish's scales are normally removed for the customers too so that the fish are ready to eat and this would represents a further loss of some 4% of the fishes initial weight. (Scale removal is normally postponed to the last moment in a fish business because the skin damage in scaling reduces the appearance and shelf life of the fish).

Deboned fish

Several fish merchants have offered deboned fish for sale to their restaurant customers, with some success and additionally several other restaurants debone fish in house and offer their patrons boneless barramundi.

Retailers have not offered deboned fish to the public, mainly because of the widespread belief that the high cost of this product limits its market potential.

The deboning of plate size barramundi to produce a deboned product requires about a minute per fish to cut and adequately prepare the product. At current remuneration levels this represents an additional cost of approximately 75 cents per kg above the cost of the traditional gutted fish. After taking account of the weight loss of about 9% from backbone and ribcage and the 4% from the scales the cost of the deboned fish has climbed to about $14.70 per kilogram from the $10.00 per kg base price of whole fish.

This makes a relatively dear fish an even dearer processed fish product and thereby reduces the potential market for the product. This costing accounts for the practice of cutting to order where the real cost of the product per kilogram is not evident.

Nonetheless several fish wholesalers specialising in the sale of premium fresh seafood *(vis a vis* frozen) do prepare deboned barramundi to order regularly with apparently sufficient reward for themselves and their customers.

A Sydney restaurant, which had deboned barramundi on the menu continuously for three months, was highly complimentary of the product and rated it as superior to deboned snapper or rainbow trout in both taste and presentation.

Price however is the principal constraint to the widespread use of deboned barramundi products, as it is for the usual barramundi with rib and pin bones in.

5.5 Melbourne Marketplace

Observations at the Melbourne wholesale market on two chance visits to Melbourne during this study coupled with discussions with fish merchants in Melbourne suggest that the handling and temperature control of barramundi in Melbourne is similar, but perhaps marginally better than Sydney.

Fish in the wholesale or retail trade in Melbourne are probably exposed to somewhat cooler temperatures because of the slightly lower ambient air temperatures prevailing most of the year compared to Sydney. Certainly in Melbourne as in Sydney there are retail outlets without adequate ice or refrigeration capacity to maintain fish temperatures at prescribed levels.

5.6 Discussion

5.61 Processed Products

Field observations in a variety of fish premises clearly indicate that ungutted fish can be distributed and marketed satisfactorily provided adequate temperature control is maintained along the marketing chain from the farmer through to the retailer or restaurateur.

However this finding should not be taken as a recommendation to farmers (or fish merchants) not to gut fish. There is clearly a demand for both whole and g & g fish and both markets can and should be served; many Asian and Europeans for example like to buy ungutted fish.

It is clear from the storage-shelf life trials (Section 6.3), field observations and discussion with fish merchants and restaurateurs that processed barramundi products such as gilled and gutted fish or deboned fish compare favourably with similar products from rainbow trout or snapper in their visual appeal, shelf life and taste but suffer because of their higher price per kilogram.

Nevertheless there is a growing demand for boneless fillets and deboned fish which can be met with barramundi if the producers provide recipes and promotional literature for the innovative fish merchants and restaurateurs who are prepared to stock "new" lines.

The concept of a value added deboned barramundi in the form of small stuffed deboned fish should be pursued by farmers. Several innovative retailers have been marketing small rainbow trout with a home made breadcrumb and seafood extender stuffing.

There are many minor and inexpensive ways of surpassing this basic stuffed product eg with the addition of chilli or other exotic flavours. The high price ticket barrier facing farmed barramundi can be avoided by selling a value added barramundi product such as a stuffed baby fish (say 330 grams) with a unit price (eg $6.00 each) rather than raw fish at a per kilogram price.

In short, the barramundi producers need to invest in product development and promotion if they seek to match the offerings of competitors in the food industry. Fish merchants and supermarkets all expect the producers or manufacturers to provide point of sale promotional material such as recipes and handling instructions; the Atlantic salmon farmers in Tasmania have recognised this situation with considerable success and provide a good model within the seafood industry for the barramundi producers to emulate.

5.62 Handling Practices

There is clearly need for improvement in temperature control to maintain low temperatures and maximise shelf life and flavour for consumers. Many of the fish sold in day markets without ice or refrigeration facilities were observed to be of marginal quality and some unacceptable. Fortunately even such old fish are not intrinsically dangerous to eat after cooking (despite widespread popular perceptions about the danger of eating "old" fish). Nonetheless the barramundi industry cannot develop rapidly if fish of marginal quality continues to be sold.

The spoilage trials described in Section 6.3 indicate that shelf life at storage temperatures around 7°C --a temperature level common in retail outlets--is 7-8 days post harvest. This suggests that anyone receiving fish only once a week from producers may be selling fish, towards the end of the week, with little shelf life remaining for consumers unless temperature control has been consistently maintained below this level.

The practice of some fish farmers of shipping fish to customers only once a week should be reassessed by farmers in the light of the limited shelf life of fish (detailed in Section 6.3) and the consumers quest for fresher and safer food.

Greater attention to temperature control by wholesale and retail fish merchants and the storage of fish at lower temperatures than those common in many situations would reduce the spoilage rate of fish and provide consumers with more flavoursome fish. This would not require any great increase in time or money just a change in procedures and attitudes which would benefit fish farmers, fish merchants and the consumers alike.

The seafood trade should recognise that the practice of selling fish of marginal quality is counterproductive, particularly for a new industry sector such as barramundi farming with ambitions for further growth. Such fish has insufficient fresh flavour to provide a tasty meal and hence prompt consumers to buy barramundi again or recommend it to a friend.

Current handling practices are being reviewed by many prominent fish merchants in Sydney and Melbourne, and the Sydney Fish Market, as part of the development of formal Quality Assurance programs or of the mandatory food safety plans proposed by the Australian and New Zealand Food Authority reforms.

Such reviews will no doubt highlight the need to change handling procedures to maintain product at appropriate temperatures to satisfy health authorities as well as the corporate customers who are driving the move to more formal quality management. There are already ample signs that seafood is being handled with more care by the companies developing QA programs.

Commercial pressures and competitive forces will see to it that other companies change their handling practices either formally or informally and this will ultimately lead to better temperature control of barramundi and other seafood.

At the same time the move to formal quality assurance and mandatory food safety programs will impact on farmers too as their customers seek assurances that fish are handled with care, adequately chilled and packed to agreed specifications.

Fish farmers should not merely wait for such evolutionary changes to come about, they should be more proactive and regularly visit their existing customers and ensure that prospective new customers have the necessary facilities and knowledge to adequately handle and market their fish.

6. SPOILAGE and SHELF LIFE

6.1 Controlled Temperature Trials

A series of controlled temperature storage trials on sample batches of fish were undertaken in Sydney, in parallel with field studies in the marketplace, to examine the influence of:

> *storage temperature on the spoilage, shelf life and marketability of whole fish (plate size and large), gilled and gutted plate size, and deboned plate size fish.*

Fish samples (5-10) consigned to Sydney in the usual commercial manner for sale or research purposes were held in stainless steel dishes inside a refrigerated cabinet with temperatures maintained within 2°C of the designated storage temperature.

Fish were examined daily and records maintained of :
colour/appearance, smell, eyes, gill colour and smell, flesh firmness and the slime on the fish. The condition of the belly cavity (appearance and smell) was examined for gilled and gutted and the deboned fish.

These sensory quality parameters were selected for the study because they are commonly used by fish merchants (and researchers) and it was intended to produce descriptive material that could assist the fish marketing sector in handling and marketing barramundi.

The reject/unacceptable standard for each of these parameters (in Table 5 & 6) was selected after preliminary trials and in consultation with fish merchants, and represents the standard currently used by "good operators" ie those selling fish that is safe, attractive and has the characteristic fresh taste of the species.

Fish were deemed as reject quality ie beyond their commercial shelf life once the majority in the batch had any one parameter classed as unacceptable or when all of these quality parameters were assessed as marginal for the batch.

Table 5. Sensory assessment of quality of whole farmed barramundi into five arbitrary grades.
Note: This is a general summary of the spoilage process, but all fish in a batch may not neatly fit into such categories

Quality	Very Good	Good	Satisfactory	Marginal	Reject
At 7°C	Day 1-2	Day 3-5	Day 5-6	Day 7	Day 8+
Eyes	Very convex (bulging); the centre (pupil) is dark with green crystalline look and contrasts with the outer rim (iris) which is shiny white-yellow	Bulging still but iris has lost its crystalline look. The cornea (membrane) over the eye is starting to cloud up.	Eyes flat or with slight bulging. Clouding of eye, little contrast now between pupil and iris which are icy grey in colour now.	Eyes sinking or flat and cloudy- white in appearance. No colour contrast between iris and pupil	Eyes sunken and with greasy corneal surface, colour is pink-yellow
Fish colour/ appearance	Varies from silver to charcoal grey but all have a strong sheen. Purple hue evident in the very fresh.	Purple hue lost but a gold or silver sheen is still evident partic. along the dorsal (upper) half	Sheen is dull but fish still has clean attractive looks; mostly grey in colour	Dull grey in appearance, darker along dorsal half	Drab dry grey coloration some yellow under dorsal and anal fins & base of tail
Body odour	Nil	Light earthy smell	Light fishy smell	Light off smell ,apple like or sour	Strong off smell: sour, ammonia or sulphurous
Body slime	Runny slime if present, clear or a little cloudy	Thin white or yellow slime	Slime is thick, discoloured earthy and tacky	Greasy bacterial slime is evident to touch	Thick slime at base of dorsal & anal fins and tail, drying elsewhere
Flesh firmness/ resilience	All very firm; most in rigor still and stiff	Very firm still but rigor has passed	Firm flesh and elastic to touch finger mark quickly bounces back	Still firm and resilient but slower to recover after touch	Resilient but not firm, slow recovery after touch. Belly wall softening up
Gill colour	Red to bright red in colour	Red colour	Red-Burgundy colour with some brown around the edges	Colour is mostly burgundy or brown but some may still be a weak red	Colour has faded to a dull earthy-brown and brown slime evident
Gill odour	Nil	light earthy smell in some	light earthy smell in most fish	Most have a light sour smell	Sour smell evident in all fish

Table 6 Sensory assessment of quality of g & g farmed barramundi into five arbitrary grades. This table only shows the changes in the belly cavity; other quality changes (in external quality attributes) have been presented in the previous table.

Note: This is a general summary of the spoilage process, but all fish in a batch may not neatly fit into such categories

Quality	Very Good	Good	Satisfactory	Marginal	Reject
At 7°C	Day 1-2	Day 3-5	Day 5-6	Day 7	Day 8+
Belly cavity	Cut flesh (belly wall) is translucent pink Peritoneum is clean and clear, flesh under is pink Kidney ("blood line") remnants bright red	Flesh light pink, lost translucency. Flesh under peritoneum is pink. Kidney remnants red	Dull pink colour to cut flesh. Flesh under peritoneum is pinky-white. Kidney remnants darkening, brown-red in colour	Cut flesh is yellowing-brown Flesh under peritoneum is white. Kidney remnants red-brown	Cut flesh is brown and greasy to touch (bacterial slime) Belly wall also has greasy bacterial film which hides the white flesh below. Kidney remnants ugly brown
Belly smell	Faint earthy smell	Light earthy smell	Earthy or light apple like smell	Apple smell	Strong apple smell or off smell

6.2 Spoilage and Quality Changes

Information from the controlled temperature trials and field observations were used to develop a general description of the quality changes and the spoilage process in whole barramundi (Table 5) and for the gilled and gutted fish (Table 6) and a five grade quality assessment system as shown in these tables.

The changes observed in barramundi were similar to those commonly found in other fish species, that is :

- The fish's colour, sheen and attractive appearance fades with time and finally the fish is unattractive.
- Body odour is nil in the fresh fish, then has a light earthy smell which changes to a fishy smell and then an unpleasant sour/ ammonia like smell.
- The eyes lose their clarity and bulge and become sunken and discoloured and finally a blood shot red colour
- The gills lose their bright red colour and go dark brown in colour which then fades to a lighter colour by which time the gills have an unpleasant smell.
- The flesh slowly loses its firmness and becomes less resilient to touch.

It should be noted however that:

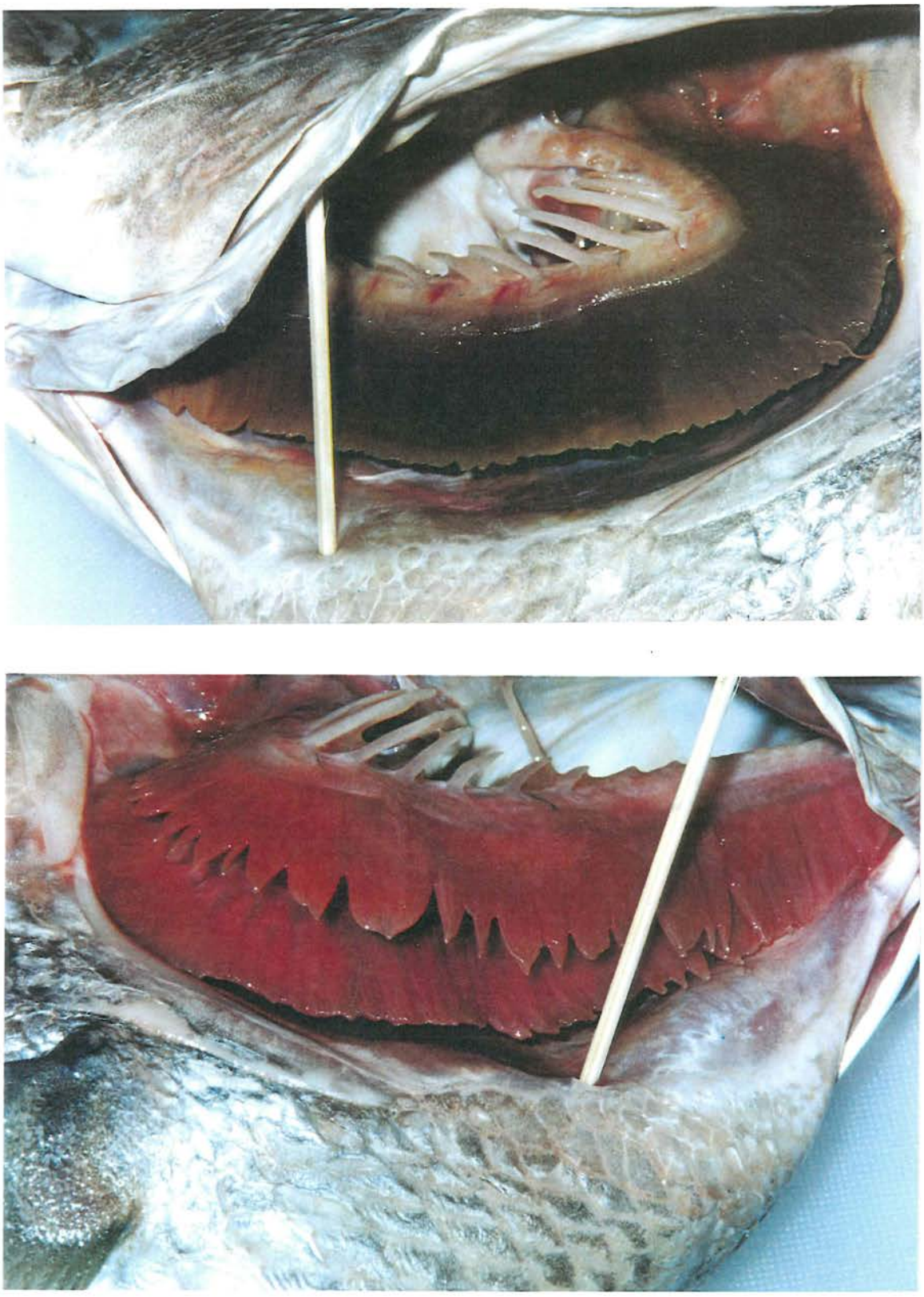
- These general descriptions of spoilage and the loss of quality in these tables are a composite picture from the many storage-shelf life trials (Table 7) and are offered as a guide only. Furthermore the changes documented in tables 5 and 6 relate to commercial quality of the raw fish and take no account of food safety issues ie it is assumed that the fish were not contaminated by chemicals or pathogenic microorganisms.
- Spoilage is a continuous process and does not proceed in a step like manner as implied by the five quality categories; furthermore fish in a particular batch do not of course all neatly fit into any one of these five arbitrary quality categories.
- The changes in the different parameters are not synchronous. That is, changes in one parameter eg gill colour, do not necessarily proceed at exactly the same pace as changes in other parameters eg gill odour.

The gills in fish are commonly used to assess quality in fish but they cannot always be used on their own as a single quality criteria in barramundi because they were found to be variable in colour and odour in fresh or stale fish. Furthermore there was even an occasional example of unilateral changes in colour ie red and clean on one side and brown-fading and smelly on the other side of the head (Figure 2).

Table 7 Shelf life, in days, for different types of barramundi products at various storage temperatures. The origin of the fish is shown in parentheses.

Date	Storage temp.	Small whole fish	Large whole fish	Small g & g fish	Deboned small fish
Jan 97	7°C	7 (A) 8 (B)	8 (D)	7 (B)	6.5 (B)
Feb 97	7°C	8 (A) 8 (B)	8 (D)		
Jul 97	7°C	8 (A) 8 (C) 7(A)	7 (D)	8 (A)	
		7.7 average	*7.7 average*	*7.5 average*	
Jan 97	1°C	15 (B)			
Feb 97	1°C	15 (F) 15.5 (G) 14.5 (H)	14 (E)	14 (F) 15 (G) 14 (H)	
Mar 97	1°C	16 (A)		15 (A)	
		15.2 average		*14.5 average*	
Feb 97	4°C	11 (A) 11 (B)		11 (B)	10 (A)

Figure 2. Photos of gills from a large fish held at 7°C for 9 days. The top photo is of the left side and the lower photo is the right hand side of the same fish.



In a sample of eight fish two had bright red coloured gills and six had gills with a burgundy colour, all with no smell, one day after harvest. Six days later four had brown gills and four burgundy colour and three of the latter had a sour smell while the remainder had only a light smell. There were even examples where the gills on one side of the head were red while the other side was brown and smelly (Figure 2).

Another notable feature of farmed barramundi is the heavy scale covering, robust body and firm flesh. The flesh remains resilient and "bounces back", after touching with a finger, for a remarkably long period, even after the fish has spoiled and smells noticeably.

The slime on the fish is also of importance. Fish held in an ice slurry for more than about four hours emerge with only a thin layer of clear slime while those with only a couple of hours in slurry have a heavier covering of clear slime which is still clearly evident on arrival at market in Sydney or Melbourne.

It should be noted that the barramundi designated as unacceptable quality as whole fish are not intrinsically unsafe --but certainly lacking in fresh flavour--and may be washed and filleted by some operators and sold as fresh.

Despite the qualification outlined above such descriptions and gradings as shown in Table 5 and 6 are useful training tools for fish merchants. Furthermore numerical values can be assigned to each of these categories (eg 5 for very good and 1 for unacceptable) and a quality scoring system can be devised to suit the particular needs of processors and fish merchants. Branch and Vail (1985) even developed a simple hand held computer programming system for processing such sensory assessment scoring data in the field.

6.3 Spoilage and Shelf Life Trials

The controlled temperature trials summarised in Table 7 clearly demonstrate the direct relationship between storage temperature and spoilage rate and the shelf life of barramundi. They also confirmed that on-farm gilling and gutting is not necessary for successful marketing if adequate temperature control was maintained from the farm through to the retail outlet.

In general terms, the shelf life of whole barramundi, as commonly distributed commercially to Sydney (or Melbourne), was estimated at approximately one to two weeks after killing: about one week(7-8 days) at an average temperature of 7°C and approximately 15 days at temperatures around 1°C.

The shelf life of large fish was not found to be significantly different to that of small fish. Also, there were no noticeable differences in shelf life from summer to winter in fish stored under controlled conditions (Table 7).

The farm origin had little impact on the shelf life: the differences in shelf life observed from farm to farm (about one day at 7°C) were of the same order of magnitude as the variability observed for any particular farm at different times of the year.

6.31 Whole *vis a vis* Gilled and Gutted

Table 7 shows that the differences in shelf life between whole fish and gilled and gutted fish were not substantial and contrary to popular perception the whole fish sometimes fared better.

The gilled and gutted fish are vulnerable to more rapid quality loss and spoilage because the belly cavity is opened and accessible to contamination by drip water, slime and other fluids (coming from fish and ice) which can thereby accelerate bacterial spoilage.

Whole fish held at 7°C for seven days did not commonly exhibit any obvious harmful effects from not having been eviscerated although some of the fish were softening up in the belly area.

Only 20% of the fish which were gutted after at least seven days refrigerated storage showed any signs of digestion of the belly wall (peritoneum) due to leakage of fluids from the digestive system. The peritoneum was intact and in good order in the vast majority of fish.

The extensive fat deposits in the belly, around the innards, probably act as a protective shield and limit the potential damage to the belly wall from the stomach, gall bladder and liver.

The most obvious and most common damage was a red rash or staining from the liver and contrary to widespread expectations gall bladder burn was not exacerbated during refrigerated storage. Any damage to the belly wall from the innards was usually superficial and could be removed while trimming the fillet in the normal way; severe erosion of the belly was rare.

In other words most of the damage from gall bladder burn is generated in the first day after harvest, and as noted earlier, gilling and gutting is not needed immediately.

As indicated earlier, farmed barramundi remains edible (after cooking) for a longer period than the shelf life indicated above.

Fish that was classified as reject grade as a whole fish in the storage trials was in fact found to be edible after cooking the fillets in a microwave without any condiments as much as four days later at 7°C storage (representing almost another 50% of time). These fillets however had only a bland flavour; this bland flavour is typical of "old" fish (Huss 1988)

6.32 Deboned Fish

The shelf life of deboned fish was found to be marginally shorter than that of whole fish (Table 7). Nevertheless there is ample shelf life with the deboned product for commercial sale and consumer satisfaction.

The reduction in shelf life arises because so much of the fish has been cut open and been exposed to air and to contamination from slime, drip and water which can accelerate chemical and bacterial spoilage respectively.

The handling and cutting process of deboning or filleting a fish plus the need to wash off remnants of gut and other tissue from the processed product noticeably softens and discolours the flesh and also raises the temperature of the fish.

The washed cut flesh in the deboned fish quickly loses its attractive natural pink colour, over a period of a few days at a temperature of 7°C.

Fish merchants have recognised this reduced shelf life of such cut fish and the need for extra care in handling and therefore debone fish to order only and do not have stock pre-prepared.

6.4 Discussion

The spoilage process and shelf life observed in Australian farmed barramundi during the controlled temperature trials were remarkably similar to those reported by Low et al (1998) for fish farmed in Singapore.

Their observations that the development of undesirable smells in the gills precedes any evidence of spoilage or smell in the flesh is relevant. Equally interesting was their finding that the raw flesh develops an ammoniacal smell after 19 days on ice (Low et al 1988) and Ng et al's report (1988) that the steamed fillet of farmed barramundi (from Singapore) changes from "borderline" to "reject" quality after 19 days on ice.

Many laboratory oriented studies focus on ice storage trials ie at 0°C but a consistent steady temperature history of 0°C is never encountered in commercial cool rooms or retail display. This is because day time ambient temperatures are invariably always higher than night time ; furthermore fish temperatures fluctuate greatly within a day and from day to day according to the flow of fish and personnel in and out of the commercial cool room.

As noted in Section 5, 7°C and 1°C were selected for storage trial and shelf life studies on farmed barramundi as they were considered to be representative of common practice and best practice respectively in the Australian seafood industry today.

We can nevertheless compare the shelf life of Australian barramundi in this study with the Singaporean ones, and with other species by utilising the relative spoilage rates table produced by Olley and Thrower (1978) from the literature on fish spoilage studies around the world.

The 15 day average shelf life of barramundi in the 1°C storage trials in Section 6.3 actually represents 14 days at 1°C plus one day in transit at a temperature averaging about 5°C. This translates to a 19 days shelf life on ice according to the *Equivalent Days on Ice / Relative Spoilage Rate* tables of Olley and Thrower et al (table 8, next page).

This table indicates that the spoilage rate at 1°C is 1.2 times faster than at ice temperature, and 14 days at 7°C is equivalent to 16.8 days on ice while one day at 5°C is equivalent to 2.2 days, thus giving a total of 19 days.

Table 8 Equivalent days on ice (ice time) corresponding to actual number of days of storage at a particular temperature (only 0-10°, and 20°C shown here)

Temp °C	Time of storage at given temperature 1 day	5 days	10 days	15 days	Relative Spoilage Rate
0	1.0	5.0	10	15	1.00
1	1.2	6.0	12	18	1.20
2	1.4	7.0	14	21	1.40
3	1.7	8.3	17	24.8	1.65
4	1.9	9.5	19	28.5	1.90.
5	2.2	11.0	22	33	2.20
6	2.5	12.5	25	37.5	2.50
7	2.8	14.0	28	42	2.80
8	3.2	16.0	32	48	3.20
9	3.6	18.0	36	54	3.60
10	4.0	20.0	40	60	4.00
20	8.1	40.5	81	121.5	8.10

This 19 day figure corresponds remarkably well with Low et al(1988) and Ng et al (1988) observations on Singaporean fish and Whittle's (1996) observations on farmed salmon. Whittle reported that Atlantic salmon stored "properly and undisturbed" in melting ice at 0°C remains in "top condition" for 10-12 days and "medium or acceptable" quality for up to about 20 days.

The controlled temperature trials indicated that there was no significant difference in shelf life of whole and gutted farmed barramundi maintained at 7°c or at 1°C. Whittle also reported that there was no significant difference in the shelf life of gutted and ungutted salmon starved for 7 day prior to slaughter.

It would appear from the storage trials and the tasting of the cooked flesh of reject quality barramundi that bacterial spoilage on the outer and inner surface of the fish (eyes, skin, gills and open belly cavity) limits commercial shelf life rather than biochemical breakdown of the belly wall, the flesh (muscle) or the development of any off flavours in the flesh.

The Relative Spoilage Rate information in the preceding table highlights the importance of rapid chilling and temperature control on farm in maximising shelf life.

It also should serve as a reminder for all parties in the fish marketing chain of the need to keep (chilled) fish temperatures as close as possible to zero degrees if the freshness and sweet flavour of the fresh fish is to be maximised for the benefit of the consumer at the end of the chain.

Even though farmed barramundi may not develop unpleasant flavours until the fish has spoiled the industry should strive to sell the freshest fish possible if it wishes to continue to find new consumers and increase its markets.

The 19 day shelf life of Australian barramundi is comparable with most other tropical or temperate water fish. Huss 1988 reported the shelf life of a number of temperate water fish as ranging from 11-21 days on ice and 7-31 days for tropical fish.

No differences were found in the commercial shelf life of large and small farmed barramundi. This finding is contrary to a widely held belief that large fish keep longer than small fish (Huss 1988) but it is in agreement with a more recent Northern Territory study. Poole et al (1990) found no differences in the shelf life of large and small red emperor *Lutjanus sebae* and rock cod *Epinephalus* spp.

7. LARGE FISH PRODUCTION AND MARKETING

7.1 Large Fish Economics

The production of large fish by farmers does not present any great technical problems. Provided the business has sufficient funds to allow for the larger cages, greater feed costs and delayed cash flow entailed in waiting at least two years for the harvest (rather than one) large fish can be produced by most farmers blessed with a little luck.

The actual cash cost of producing large fish (2+ years) is a little less per kilogram than that for producing plate size fish in a year or less. This arises because the fingerling cost is the same for small or large fish, there is more rapid and massive increase in weight in the second and because of the lower per kilogram labour costs in handling and packing large fish.

The cost of growing plate size fish (1 year old or less) varies from farm to farm but in Queensland it is approximately $7-8 per kg at farm gate (exclusive of bank finance costs) according to farmers participating in this study.

Farmers with experience in growing large fish estimate that the cost of producing large fish 2+ years old is the same as for small fish or up to a dollar per kilogram less (as much as 13 % less than for plate fish).

Andrew Hinton from the Queensland Department of Primary Industry Mareeba Station investigated the costs of growing plate fish versus large fish on a hypothetical model farm based on using census data obtained from growers in Queensland.

He reported (Hinton 1994), that the cost of producing large fish (3 kg) was approximately 19% less than that for one year old plate size barramundi.

The selling price of the larger fish has mostly been the same or as much as 5% higher than that for plate size fish, according to the major growers, because of the ample supply of the latter and a chronic undersupply of the large fish.

In short, the economics and profitability of growing large fish *vis a vis* small fish are very attractive for farmers with sufficient personnel and the necessary physical and financial resources to do so in the prevailing market conditions.

This is particularly so with the fish over three kilogram which can be used for cutlets as well as for fillets or whole fish and are even more attractive as a source of by products such as heads-wings, liver, air sacs and skins (Section 8).

7.2 Market Acceptance of Large Fish

The response of consumers, restaurateurs, food writers and fish merchants to the large farmed fish at various functions and in the marketplace has been uniformly very positive and highlights the widespread strength of the demand for the large fish. Supply of large fish has not been able to match demand and the shortfall is expected to continue for several years according to producers.

A reference group of two restaurateurs, two consumers and two fish merchants supplied with large farmed fish on two occasions has unanimously heaped praise on the fillets and cutlets in their own right and in preference to the plate size fish.

Martin Palmer, principal of Sydney wholesale company Martins Seafood has been selling more large fish than plate size fish over the last year, because he and his customers are "...so impressed with it". Martin has also had very positive response to the deboned fish from some of his restaurant clients.

The Queensland Centre for Food Technology at Hamilton gave the public the opportunity to try BarBQ'd fillets off large fish in October 1996 and found that 73.5% of 300 people polled liked it very much (only 0.8% disliked it).

Food writers invited to a trade function at Fish Face Restaurant (Sydney) in March 1997 to promote the diversity of fish sizes from aquaculture and particularly the availability of large fish for fillets and cutlets also unanimously praised the large fish.

Barbara Lowery the well known food commentator on ABC radio who was given plate size fish as well as fillets off a 2.5 kilogram fish reported that "... all were a great success, certainly very good, the large fillets were exceptionally good, flavour superb, white flesh, excellent texture."

John Newton a food writer formerly with the Sydney Morning Herald and now with the Financial Review, and a critic of farmed barramundi was given cutlets from a seven kilogram fish grown in a fresh water pond as well as several plate size fish. His comments were "... didn't like the plate size fish, soft and mushy, don't like the weak flavour, but I would love to have more of the big fish for a BarBQ this weekend".

Cherry Ripe an influential food writer with the Australian newspaper, and not known as a fan of farmed barramundi, was unable to attend the promotional function but responded to the invitation with some noteworthy comment including the following.

"I'm pleased to see they've got them up to 3 kg; the plate size is like committing infanticide. In the Top End I've seen 64 kg barra. "

7.3 Opportunities for Cutlets and Large Fillets

Many fish merchants (wholesalers and retailers) in Sydney regularly stock the small whole farmed barramundi but only about half a dozen regularly stock large farmed fish, and cut fillets or cutlets, and only after they have received an order for these processed products. The high price is the principal reason fish merchants do not routinely cut farmed barramundi and offer fillets or cutlets for sale.

The high cost of the whole fish (say $11 per kg) and a skinless fillet yield of about 46 % average puts the cost price up to $23.91. If labour and a profit margin were then added the fillets would be amongst the highest priced variety on sale on most days (T Adams, DeCosti Bros Seafoods, personal communication).

John dory fillets are probably the only fillets frequently in this $26+ price range. Farmed barramundi fillets would thus be dearer than salmon or john dory, the established market leaders in premium fillets in Sydney.

A positive feature of the large fish is that they exhibit little seasonal fluctuation in recovery rates and in fat deposits although there is some individual variation amongst a batch of fish (Appendix 3). The small fish have relatively larger fat deposits in the belly and show significant difference in fat content from summer to winter (Appendix 3).

Farmed barramundi fillets (from large or small fish) are sometimes displayed for sale, often at cost price or less, but these have been cut because of slow stock turnover and the need to clear all of the fish, including some as fillets, quickly before it deteriorates.

A small number of restaurants and home consumers still order fillets regularly despite the high "hidden" but real price and the availability of cheaper fillets from wild fish when the fishing season is open, and the more widespread availability of other premium fillets such as john dory, Atlantic salmon and blue eye.

Farmed barramundi fillets have appeal to a small but growing number of users and the demand for the large fish for fillets will continue to grow particularly if their price falls in real terms or relative to other species.

Cutlets

Cutlets from farmed fish have not proven commercially successful to date even though they also been very well regarded by consumers, restaurateurs, fish merchants and food media personnel who have had the opportunity to try them.

The strong demand and low availability of sufficiently large fish (> 3 kg) to produce an acceptable sized cutlet has however been the major constraint on market development of barramundi cutlets from farmed fish. The cost of cutlets has also been a major impediment.

Demand for large fish has almost always exceeded supply throughout this study period and fish merchants able to source large fish, anything larger than 2 kg, have them sold them whole or used them to prepare fillet.

The strong demand for any fish over two kg and the financial (cash flow) pressures facing farmers has meant that most large fish have been in the 2-3 kg size range and fish larger than 3 kg have been extremely rare.

The relatively high cost of fish coupled with the low recovery rate of only 60% as cutlets (Table 9) brings the cost of barramundi cutlets to about $17.00 from a fish cost of about $10.00. This cutlet is marginally more expensive than the Atlantic salmon and almost double the price of blue eye cutlets, the two market leaders in Sydney (T Adams personal communication).

Table 9. Cutlet yields from large farmed fish, expressed as a percentage of the whole weight.*

Processed product	Winter Aug 1996	Summer Jan 1997	Average Yield
Cutlet	60.1	60.8	60.5

*Appendix 3 has data on individual fish

The appearance, flavour and shelf life compare favourably with salmon and blue eye but price remains a considerable barrier to market development. Nevertheless there is a sizeable latent demand for cutlets from the extra large farmed barramundi that can be served once sufficiently large fish are available. More than one farm will be capable of producing such fish in 1998.

In short, the market prospects for large fish for sale as fillets or cutlets is very attractive notwithstanding their relatively high price.

8. BY PRODUCTS AND TOURISM

The large fish have more uses than just the flesh from fish, fillets or cutlets. The heads and wings (pectoral and ventral fin area), liver and air sac on almost all fish species are edible and are in barramundi too.

Furthermore the skins have value in manufacture of leather for clothing and other objects. The barramundi air sacs are considered as amongst the best fining agents for brewing purposes (personal communication Craig Davies, Food technology Centre Qld) and they may be eaten in "bush tucker" (following page).

The heads off large fish can also be used to produce a barramundi trophy shield (See following pages).

All of the fish parts identified above as by products of filleting or cutleting large fish total about a quarter of the original weight of whole fish (Table 10, below) and represent a valuable underutilised resource at present.

Current and potential uses of these various by products are discussed on the following pages.

Table 10. Yield of barramundi processing by products

Five fish (Aug 1996)	Total Weight (kg)*	Percentage
Whole fish	17.816	100
Head & wings	3.192	17.9
Fat deposits	0.482	2.7
Livers	0.374	2.1
Air sacs	0.214	1.2
Total By Products	4.262	23.9

*Appendix 3 shows data on individual fish

8.1 Air Sacs

Cherikoff's Air Sac Sausage or Fish Fries

Vic Cherikoff principal of Bush Tucker Supply Australia* a major supplier of Australian native gourmet foods to many restaurant and food service groups has researched native foods including barramundi and offered the accompanying recipe (included verbatim and unedited) for barramundi innards.

(The recipe has not been tried by Ruello & Associates and we make no comment on it).

Fish Fries

1 whole barra, unscaled and ungutted
mountain pepper(or cracked black pepper) and salt for seasoning

Cut open the gut cavity by making a shallow incision down the fish's belly from the gills to the vent. Carefully remove the entrails including the swim bladder. This is the long white sack at the top of the gut cavity. Discard the gut itself and any tissues with a bile green colour. Season the remaining tissues with salt and mountain pepper. Open the wider end of the swim bladder and stuff in the heart, liver, kidneys, any fat and associated connective tissues. Skewer the open end with a toothpick to seal the sausage and then fry the whole parcel in a dry skillet over the medium heat. The fat inside will adequately grease the pan. Turn the barra sausage often until crisp on the outside.

Use the fish fries simply chopped as a garnish for the cooked barra flesh or make the fish fries into a delicious sauce by blending the fish fries to smoothness in a food processor. Dilute the puree with twice the volume of fish stock and bring to a gentle simmer. Thicken the sauce with a splash of heavy cream and serve as is or pass through a sieve for a finer finished texture.

*PO Box B103 Boronia Park, NSW 2111. Fax (02) 98173587.

8.2 Heads and Wings

Barramundi heads and wings are currently being given *gratis* to valued customers in several wholesale and retail outlets in Sydney or occasionally sold. There is no established market for barramundi heads yet but retail prices have been of the order of $3.50 per kg in the past year.

It is relevant to note that several years ago blue eye heads had no value either and now are regularly imported from New Zealand chilled (fresh) and fetching $2-4 per kg at the Sydney Fish Market auction.

There is also a developing trade in the eastern states with Atlantic salmon heads and wings, wholesaling for about $2.50 per kg chilled or $2.00 frozen, and the prospects for trade in barramundi heads are also attractive for anyone wishing to develop this further.

Barramundi Head Trophy

The heads off large fish can be preserved chemically and /or by freeze drying, painted with clear satin finish and mounted on a shield for sale as a souvenir trophy. A prototype was prepared by the researcher with little difficulty.

These unique items may not appeal to all, but stuffed cane toads are apparently a profitable sales item in north Queensland despite their questionable looks. They would have considerable appeal to Australian recreational fishers and some tourists.

8.3 Livers and Pate

The livers of barramundi were found to be an attractive and substantial organ representing about 2% of the fish's weight. The livers can be fried as is commonly done with lambs fry or used to manufacture pate.

The livers of large fish filleted in Sydney were gathered on three occasions to develop a simple pate adapted from a classical ducks livers recipe.

The third batch of pate was offered for tasting to a representative group of prospective domestic and commercial users : five domestic consumers, five restaurateurs and six fish merchants.

All of the consumers and all of the restaurateurs liked the pate moderately or very much and would be interested in a purchase (subject to satisfactory pricing).

The response from fish merchants was mixed. Three did not like it but revealed that they were not really fond of pate of any type; the other three liked it moderately and thought they could be interested in selling a fish liver pate.

One of these three subsequently reported that he had a restaurateur very interested in the idea of serving a fish liver pate and was keen to obtain the recipe.

In short, the recipe development and taste testing with a diverse group indicates that barramundi livers can be used to make a delicious pate with commercial appeal.

The ingredients and recipe follow on the next page. This home made pate had a shelf life of at least seven days, in a ceramic pot covered with plastic wrap, held in a domestic refrigerator.

This domestic recipe can be scaled up and tested for further commercial development.

Barramundi liver pate

Ingredients

1/2 small onion finely chopped (approx 60 gm)
330 gm livers
150 g butter
30 ml marsala (or sherry)
40 ml brandy
1 bay leaf
1 clove
pinch of nutmeg
salt and pepper to taste

Method

Wash livers thoroughly and chop to 1 cm cube or smaller, put aside.
Melt butter, add chopped onion, bay leaf, nutmeg, clove and chopped liver.
Fry a few minutes and add salt and pepper to taste.
Add marsala and cook gently for 25 minutes
Mince in electric blender, add brandy and stir.
Melt rest of butter and add to the blend and then pour into ramekins or pots dress with parsley leaf, sliced olive or other garnish.

8.4 Skins and Leather

There are several companies in Australia that purchase fish skins for the manufacture of leather for clothing, clothing accessories and gift items such as purses and wallets.

Barramundi skins have proven successful for both manufacturing and marketing purposes and there are two companies which have made products from barramundi skins and which are interested in buying barramundi skins from farmers or processors with frozen or salted material for sale.

Details are provided below:

Western Australia
Mermaid Leather
PO Box 1619
Esperance WA 6450

Andrew Mc Dermott
Phone 0890 715240
Fax 0890 715240

Tasmania
Blue Horizons Outdoors Clothing Company
195 Auld Kirk Rd
Deviot
Tasmania.

Mrs Rae Turley
Telephone 0363 947240
Fax 0363 947240

8.5 Tourism

North Queensland has a very strong tourism industry but the farmed barramundi industry has not participated in this in recent years. One barramundi farm was actively engaged in the tourism sector with an attractive facility including fish out, souvenirs and meals some five years ago but discontinued for a number of reasons.

This tourist facility was probably "ahead of its time". The tourism trade is far more developed today because the baby boom generation is nearing retirement and because of the growing interest in ecotourism by domestic and overseas tourists.

Tourism offers potential for increased income to the fish producer today as an owner operator or via a sub leased business arrangement.

The other aspect of a tourist facility to be considered by the aquaculture industry is how it can be used to can increase community and public support for the aquaculture industry and its fish products.

Tourists and the local community alike are more and more interested in Info-tainment and environmental issues these days and the fish farmers can use a tourist facility to promote the aquaculturists point of view in the public debate over resource use.

Income can be generated from tourism via:

- entry fees
- souvenirs such as the ubiquitous T shirts and more novel products such as a Barramundi head trophy.
- fish and fillet sales
- meals, drinks and snacks
- books, postcard and magazines; indigenous barramundi art and curios
- guided farm tours
- fish out
- fishing guides

Barramundi fishing is one of the key attractions of north Queensland and given the short time many people, particularly Japanese visitors, have for holidays a "guaranteed" fish catch at a farm could be a great attraction.

Several trout farms in Victoria and NSW run in a very professional manner have already profited handsomely from tourist income and the aquaculture related tourism market is bound to grow with the influx of visitors for the World Aquaculture Society annual conference in Sydney in 1999 and the Olympics in 2000.

The range of products that could be marketed is limited only by creative ability and the financial resources available for such a venture.

Fish farmers have not shown much interest in tourism in recent years but as suggested earlier a tourist facility and the educational tours, can be subcontracted out.

The financial returns from activities such as those listed above as well as the intangible benefits arising from the development of stronger community and public relations should not be lightly dismissed.

8.6 Discussion

There is a remarkable range of by products that can result from the filleting or cutleting of large farmed barramundi. Currently filleting is essentially confined to the premises of fish merchants and all of the by products identified earlier are mostly being wasted.

This wastage represents a loss of food, chemical, trophy and leather material and provides opportunities for additional income for anyone preparing to fillet substantial volumes of large barramundi.

As the output of large barramundi increases, and more fish is processed, over the next few years these by products will amount to substantial volumes and will undoubtedly be harnessed by entrepreneurs interested in increased income and maximum utilisation of the fish.

9. CODE OF PRACTICE

A number of factors which influence the handling, shelf life, quality and market success of farmed barramundi were identified in this research project and should be considered by farmers in the development of the proposed code of practice for their industry.

The high variability seen in harvesting practices, fish pack temperatures, use/non use of refrigerant in packs are all evidence of a lack of formal quality assurance procedures and highlight the need for adoption of formal quality assurance by the barramundi farming industry in order to turn out a higher quality product more consistently. The code can serve as a guide for both new operators and established businesses.

The factors recommended for consideration in a Code of Practice are:

- Fish colour
- Harvesting practices
- Fish temperature at packing and during transport
- Use of potable (clean) ice and refrigerants in packs
- Packaging materials and standards
- Earthiness, taints or off-flavours
- Permitted levels of antibiotics and pesticide residues
- Scale loss or skin damage
- Spinal deformities
- Fin deformities, damage or fin absence
- Uniform names on size grades
- Recall procedures
- Date marking

Fish Colour

Fish colour has varied from a dull silver through to bright silver, golden, light grey and charcoal grey. Agreement on uniform names to describe the spectrum of colours can reduce the confusion amongst buyers of fish.

Purging and Harvesting Practices

There is an obvious need to control the period of deprivation of food and to harvest fish with the minimum stress in order to maximise eating quality.

Fish Temperature and Refrigerant

Industry should establish a specified target temperature for packing of fish and provide sufficient clean refrigerant to ensure that fish temperature does not exceed the prescribed limit of 5°C whilst in transit to the consignee.

Producers should take account of the longest time the fish remains inside the original pack before it is picked up, unpacked and reiced by the consignee and not just the scheduled time between aircraft take-off and landing

Packaging Materials and Standards

The key issues here are the use of second hand styrene cases by farmers and the safe carrying capacity of the case.

Although there are probably no health risks incurred in using a clean second hand styrene case lined with a new plastic liner bag for distant transport, such a practice does not promote an image of a premium product from caring producers. In short it is at odds with modern marketing practices and consumer concerns about food safety.

The other factor warranting consideration is the actual packing arrangement for different sized fish and associated maximum weight that can safely be carried without cracking the case and exposing the fish to premature warming by the outside environment.

Earthiness, taints or off-flavours

Farmed fresh water fish are known to sometimes have an earthy flavour or taint. Most farmers recognise this and purge fish in clean fresh water for several days to a week when they feel the fish require such treatment.

The duration and effectiveness of this purging practice needs to be objectively evaluated by each business and quality controls based on results of objective testing of fish and not just a vain assumption of successful removal of off flavours. This purging period needs to be assessed in the light of its impact on gall belly stain

Antibiotics and Residues

Farmers must comply with regulations on prescribed levels of permitted antibiotics and residues in order to satisfy consumer concerns about food safety

Fin and Tail deformities

Producers should establish some criteria about the type and number of deformities to be acceptable for prime grade fish.

Spinal Deformities

Producers should also establish some criteria about the type and severity of spinal deformities to be acceptable for prime grade fish.

Skin and scale damage

Producers should establish some criteria about the type and severity of skin and scale damage which is deemed acceptable for prime grade fish.

Uniform Names on Size Grades

Farmers are grading fish using various size categories and with no uniform names on each size range. Consequently fish graded as 300 -400, 400-500, and another consignment of 400-700 are all being marketed as "Small" at the Sydney Fish Market auction while fish from 1 kg or larger are called large.

This large range of sizes under the one name is confusing to consumers and retailers and needs to be reviewed by farmers and some agreement reached on more useful names and grades. Similar confusion reigns with "large" fish; agreement should be reached on what size range is large and what is "extra large".

Recall Procedures

Producers should develop and document procedures for quick and efficient recall of faulty or unsafe product.

Recall procedures are almost certain to become mandatory under the proposed food safety plans proposed by the Australian and New Zealand Food Authority. Food safety recall procedures for food businesses are mandatory in the Food Safety Bill currently before the Victorian Parliament.

Date Marking

Product and batch identification by date marking is indispensable for stock management and stock rotation by all parties. It is an essential component of a food safety plan; without date marking or batch coding any product recall would entail the removal of all barramundi from sale and not just a particular batch in question.

Sydney recorded three seafood product recalls in 1997 because of public health problems experienced by a large number of consumers. Each one of these recalls was impeded by the absence of a reliable product labelling system.

10. CONCLUSIONS

Australian barramundi producers recorded a 19% increase in aggregate sales volume in 1996/7 (over the previous year) without any decline in average value per kilogram) (ABARE fisheries statistics). This was achieved mainly because of the diversification in products and markets and a three-four fold increase in sales of fish larger than plate size, according to industry sources.

While this is a commendable achievement the industry should not be indifferent to the fact that a significant volume of fish has lost much of its shelf life by the time it is bought by consumers.

Producers should aim for a lower and more consistent fish temperature and fish merchants should also maintain effective temperature control so that consumers get really fresh and tasty fish, and want more, and recommend farmed barramundi to their friends too.

There is ample evidence that many Australians have still to try farmed barramundi. The Centre for Food Technology found that more than 60% of people sampling fish at the Queensland Seafood Festival in Brisbane in October 1996 had never eaten farmed barramundi before and that another 29 % were not sure if they had.

The market for Australian farmed barramundi products cannot continue to grow strongly in the face of some formidable competition from a vast offering of seafood and other foods unless the industry addresses its weaknesses in quality management and promotion.

The Australian barramundi industry should continue to promote the benefits of the various products it currently produces and should encourage and assist in the market development of new value added products and the by products identified in this report.

The market prospects for large fish are very attractive as indicated by the continued shortfall in supply of large fish. Wild barramundi catches are limited by various fisheries management measures and are indeed under further threat because of resource sharing conflicts with recreational fishers and the issue of dugong habitat and protection. Therefore the long term prospects for extra large fish over 3 kg are particularly very exciting.

The growing demand for large fish and the shift in production emphasis away from small fish coupled with the prospects of additional income from non traditional products including the tourism related ones auger well for the barramundi industry.

However as indicated above, the industry must be prepared to continue to improve its handling practices and invest in recipe and product development and other forms of market promotion if it is to fully realise the potential rewards. It cannot expect the marketing sector to do so, although it should enlist its participation and support.

This research project should be just the beginning not the end of attempts at improving quality and value adding the farmed barramundi industry.

10. 1 Benefits Of The Research

This research program has:

- Identified a need for more effective temperature control along the marketing chain from the producer to retailer to ensure that consumers get fish with sufficient freshness and flavour to meet their expectations.

- Demonstrated that severe gall belly burn is infrequent and usually hidden by contemporary gutting and cooking practices and consequently has not generated any significant adverse economic impact.

- Demonstrated that ungutted fish can be handled and marketed satisfactorily by careful producers and fish merchants.

- Assisted the industry in promoting public awareness of the availability of a diverse range of fish sizes (and colours) and in generating a more positive image for farmed barramundi amongst the food media.

Barramundi producers are now far more quality conscious, market oriented and are promoting the development of an industry Code of Practice to bring about more consistent and higher quality products.

The overall result has been a three-four fold increase in the output of fish larger than plate size in 1996/7 (over the previous year) and that demand for large fish now substantially outstrips supply and is likely to do so for the next couple of years at least, according to industry sources.

The increasing supply of a wide range of fish sizes has reduced the likelihood of a glut, price crash and inferior quality in the plate size fish in the marketplace in the traditional peak supply period of February-April. This represents a benefit to all sectors of the seafood industry and for consumers too.

This widening of the product size range and the maintenance of strong prices all year round represents a benefit of about 50 cents per kg for farmers. On a production of about 600 tonnes in 1997-98 this will mean $300,000 added income to producers; a payback of more than ten times the investment in this research, in just one year. Additional benefits will undoubtedly be generated from by products too once large fish output increases in the future.

In the words of Cris Phillips, presiding President of the ABFA, the reduced reliance on plate size that came about from the development and promotion of markets for all sizes of barramundi "... has taken the panic out of selling."

10.2 Further Research & Development

The large fat deposits in the belly cavity of small fish and at the base of the dorsal and ventral fins currently represents a commercial loss to fish farmers or processors. Research could be undertaken to examine the chemical nature of this fat and any nutritional or pharmaceutical value it may possess, in order to offset the current waste when fish is gutted.

Fish nutrition researchers also need to be cognisant of this seemingly useless high fat content (to humans) and formulate pellet diets which maximise fish flesh production without unnecessarily building up fats, which may also harbour unwanted off flavours (K. Williams personal communication) which are evident in some fish.

The stiffness which is evident in some farmed barramundi in less than an hour of killing and immersion in ice slurry, *vis a vis* several hours in most fish species (Huss 1988) is probably not due to rigor mortis alone.

The condition commonly recognised as "cold shortening" in the red meat industry (a muscle fibre contraction that can occur during chilling; AMT, 1996) may be a contributory factor. Johansen at al (1996) reported that ***cold shock*** " ... is a phenomenon that is found to occur in some tropical fish species during icing, similar to cold shortening in mammalians".

The harvesting, killing and chilling of large fish therefore warrants further attention by researchers and farmers in view of an emerging interest in exporting farmed barramundi of prime sashimi quality for consumption raw. The use of anaesthetics such as AQUI-S for harvesting fish for this purpose may be useful.

We therefore endorse any extension of research on the effect of harvesting practices on flesh characteristics to encompass field and laboratory studies on large fish destined for consumption raw. The quality parameters and buyers requirements for farmed barramundi intended to be eaten raw represent a totally new challenge for researchers and producers alike.

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APPENDIX 1

Farms actively or passively involved in this research

Farm	Case temp/ outside of fish examined	Fish examined internally	On-site visit	Personal/ telephone Contact off farm
QLD				
Austar	+			+
Barbieri	+			
Barra. Waters	+	+	+	
Belvedere	+			
Barramundi Gardens	+			
Blue Waters	+	+	+	
M & L Edwards	+			+
Harts	+	+	+	
Harvest Home	+			
Haut de Rue	+			
Kuranda	+	+		
Mountain Shadow	+			+
NQ Barra	+	+	+	
Plath	+			
Rockhampton			+	
Sugarland	+	+	+	
Tropical Aqua	+			
Warrabullen	+	+		
South Aust.				
Barramundi Supplies	+	+		+
Inish	+	+		+
Robarra	+	+		+
Three Rivers	+	+		+
NSW				
Barraclear				+
NT				
Richards			+	

Australian
Barramundi
Farmers
Association

A B F A

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Appendix 2

BARRA MONDAY : FISH FARMERS CELEBRATE

The Australian Barramundi Farmers Association has declared March 17 as **Barra Monday** to launch the inaugural Farmed Barramundi Week to celebrate the record production of 500 tonnes last year and to raise awareness of the variety of farmed barramundi grown in Australia today.

Many farmers also want to celebrate the departure of cyclone Justin from north Queensland too, after its damaging winds and flood tides.

After a decade of painful and costly research and developmental work by farmers and scientists the Australian farmed fish is now the most common barramundi in most restaurants, outnumbering imports or sea caught fish.

Thanks to recent developments in breeding technology the farmers can delay the usual sex change in barramundi from a male to female (at about three years of age) and now breed fish at any time of the year. This has resulted in fish of all sizes from 300 g to at least 3 kg being available in a variety of colours from a silvery white through to a charcoal grey, all year.

Barramundi are grown commercially in :

- warm artesian spring waters in South Australia and NSW,
- in large indoor tanks in Queensland and South Australia
- in freshwater or saltwater ponds in Queensland and the Northern Territory
- and in sea cages in northern Queensland

by more than 60 fish farming enterprises.

Approximately half of the 1996 production was grown by half a dozen Queensland farms in the area between Townsville and Cairns. These have ponds of 0.1 to 1.0 hectares each (tennis court and football field size respectively) or circular sea cages of 10 to 20 metres diameter.

The industry now appears set for further strong growth in output over the next few years. However life on a barra farm is still not without heartache, danger and setbacks. Cyclones and crocodiles are part of life in north Queensland and they inflicted great damage on some sea cage barra farms again this summer.

Cyclone Justin resulted in a loss of more than $5000 of fish last week at one Townsville farm and crocodiles and sharks were responsible for even greater financial damage in the Hinchinbrook Channel sea cages this summer.

Farmed Barramundi Week aims to draw consumer and trade attention to the diversity of delicious fresh fish produced by a range of enterprising fish farmers around the country and to facilitate growth of this ecologically sound industry. The barramundi industry has more to offer than baby barramundi and consumers can now look forward to even bigger and better fish .

Tastings and price specials are being held at retail outlets at the Sydney Fish Markets at Pyrmont and a new information-recipe leaflet is available for free distribution.

Why has barra become so popular in Australia and a living legend in Queensland ?

The barramundi has only eight pairs of rib bones which have usually been removed in fillets on sale , and no pin bones in the fillets. Farmed fish larger than 500 gm produce excellent fillets and fish of about 3 kilos or larger can also be cut up into cutlets.

Barramundi fish - from farms or the wild - are robust because of their firm covering of large scales but once scaled the fish, fillets or cutlets are more delicate.

The attractive translucent pink colour, mild flavour, absence of bones and easy cooking appeal to all ages and ethnic groups.

The many culinary features and strong fighting capability of this beautiful toothless fish have made barramundi a living legend among Queenslanders.

* barramundi : aboriginal word for river fish with large scales

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Compliments of the
Australian
Barramundi
Farmers
Association

Appendix 2b

Barramundi is a popular table and angling fish that is found naturally in the fresh and salt waters of northern Australia. It is a beautiful silvery coloured fish that can grow to a length of 1.5 metres and more than 30 kg.

Today it is also farmed and the farmed fish is the most common product seen nowadays. They are commercially grown in :

- warm artesian spring waters in South Australia and NSW,
- in large indoor tanks in Queensland and South Australia
- in freshwater or saltwater ponds in Queensland and the Northern Territory
- and in sea cages in northern Queensland

Thanks to recent developments in breeding technology the farmers can now breed fish at any time of the year. This has resulted in fish of all sizes from 300 g to at least 3 kg being available in a variety of colours from a silvery white through to a charcoal grey.

The larger fish produce excellent fillets, and fish of about 3 kilos or larger can also be cut up into cutlets. The barramundi has only eight pairs of rib bones which are easily cut out (these have usually been removed in fillets on sale).

Barramundi fish - from farms or the wild - are robust because of their firm covering of large scales but once scaled the fish, fillets or cutlets are more delicate. The flesh has an attractive translucent pink colour and mild flavour that seems to appeal to all ages and ethnic groups. Barramundi has an unusually good shelf life and can be held in a home refrigerator for several days after purchase.

Cooking barramundi is easy as it is quite versatile and tastes delicious steamed, grilled, deep fried or on the Bar B Q plate and served with lemon or a herb butter.

Steamed Barramundi with ginger garlic and coriander

Recipe from Paul at Fish Face Cafe, Darlinghurst Sydney. Serves 2

Two plate size barramundi
2 cloves sliced garlic
season salt and pepper
2 tablespoon sliced ginger
Picked and chopped coriander
Sauce : juice 4 limes, 2 tablespoon unsalted butter and 200 ml fish stock

Scale and gut fish. Slice ginger, garlic and coriander and place inside the fish. Steam the fish until it has a soft texture when touched with a knife (approx 6 minutes). For the sauce place lime juice butter and stock in a pan, simmer and reduce to half then place fish onto plate and pour the sauce over the top.

Barramundi filled with blue swimmer crab, shitake mushroom & greens.

Recipe from Luke Mangan, Restaurant CBD, Sydney; as seen on BBC Television and on ABC television later this year. Serves 4

4 whole baby barramundi, scaled and gut in
4 large shitake mushroom sliced
100 ml soy sauce
1 bunch baby Bok Choy, washed and picked
olive oil
200 g blue swimmer crab meat
50 ml Mirin
100 ml fish stock
1 bunch choy sum, washed & picked
1 bunch baby Moon Bok, washed & picked
salt and pepper to taste

Trim and remove all fins from fish. Make an incision along the top of the fish from head to tail. With a firm hand, cut with short strokes down one side of the fish lifting flesh away from the rib bones. Take care not to pierce skin. Turn and repeat on the other side. Using sharp kitchen scissors snip through the backbone, just behind the head and before tailfin. Remove backbone, any other bones and stomach contents.(This can be done by your fishmonger).

In a heavy based fry pan place the barramundi in hot olive oil and gently fry each side for 3-4 minutes. Once cooked remove from pan and set aside. In the same pan add shitake, Mirin, soy, fish stock and Bok choys stirring for a further minute.

Once cooked place the barramundi in the centre of a large dinner plate and fill the cavity with shitake, Bok Choys and crab mixture. Pour juices over the fish, filling the base of the plate.

Blackened Barra Cutlet

Recipe from Jean-Paul Bruneteau Riberries Restaurant Sydney; from his book Tukka Real Australian Food (Angus & Robertson). Serves 4

1 teaspoon ground black pepper
1 teaspoon white pepper
1/2 teaspoon oregano
1/2 teaspoon onion and chilli powder
4 barramundi cutlets
1 teaspoon cayenne pepper
1/2 teaspoon thyme
1/2 teaspoon garlic powder
1/2 teaspoon chilli powder
300 g butter melted

This recipe requires a very hot plate to seal the spices. It is best cooked outside as it produces a fair amount of smoke.

Mix all the herbs and spices together. Pat dry the fish cutlets. Coat one side of the fish with melted butter. Shake the herbs and spices over the coated side of the fish. Wait until the butter has set the herbs and spices to the flesh.

Cook the seasoned side for 1 1/2 to 2 minutes. Turn the fish over to cook the other side. Do not return to the blackened side. The longer this side is cooked the stronger the flavour will be.

You can buy Bruneteau's blend of herbs and spices premixed : use one jar of Gundabluey "Blackened Fish Blend" in the recipe above.

Food By Sheridan Rogers

A fish for all seasons

Light and flaky, barramundi is delicious barbecued, steamed or lightly fried

IF YOU haven't been to the Fish Markets recently, go today. Barramundi is at the peak of its season and retailers are offering tastings and special prices.

It will be worth the trip because this glorious tropical, silvery-grey fish has often been difficult to buy fresh in southern markets, but recent developments in breeding technology, have made it more readily available.

Plate-size barramundi from 300g, through to larger specimens weighing 3kg (excellent for cutlets and fillets), are being farmed throughout Australia in indoor tanks, ponds, sea cages and warm artesian spring waters.

It took some time, however, for the farmers to figure out just how to breed this fish, as barramundi start life as males but turn into females at the age of three.

"This posed a problem at the farms," says Nick Ruello, consultant to the Australian Barramundi Farmers' Association.

"They'd bring in a three-year-old male, but by the time he'd settled down, he'd turned into a female.

"Now, with more experience, they are able to breed them at any time of the year."

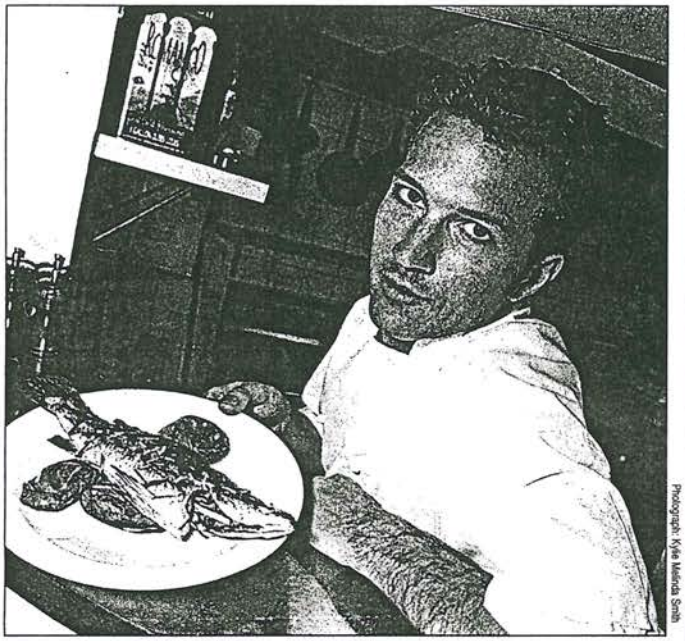
Fresh, wild barramundi are also available in the markets, though Ruello predicts we'll see less of these in the future.

"There is concern about dugongs (a protected species) being caught in the barramundi nets," he says.

The word "barramundi" is Aboriginal and refers to certain river fish with large scales. To catch the fish, Aborigines would wade into the water at night holding a spear in one hand and a bundle of lighted sticks in the other. The fish were attracted to the light – and then speared.

Wild barramundi can grow to a weight of 54kg or more. There is even a record of one which weighed 267kg being caught in the Bay of Bengal – not quite plate size!

Barramundi makes excellent eating because of its moist flesh, firm texture and good flavour. It also lends itself to most forms of cooking: steaming, char-grilling, pan-frying and barbecuing.



Photograph: Kylie Melinda Smith

SIMPLE AND SATISFYING: Paul Wrightson with barramundi done the Fishface Cafe way.

While at the markets, check out some of the other fish available. Smaller fish like barbounia, garfish, red spot whiting and whitebait are good value. West Australian sardines (butterflied or filleted), mullet and blue mackerel – all oily fish high in Omega 3 – are also available.

■ The Sydney Fish Market is gearing up for one of its busiest times of the year: Easter. When the doors open at 5am on Thursday the markets will begin 36 hours' continuous trading which ends at 5pm on Good Friday. Retailers will trade from 7am to 5pm for the rest of the Easter weekend.

Tips for buying fresh fish

■ Cutlets and fillets should be firm to the touch, not spongy; flesh should be clear in colour, not grey or yellow.

■ Fish should have a pleasant fresh – not fishy – smell.

■ If fish is whole, look for firm, springy flesh, bright eyes and bright shiny scales and skin. Score the fish while raw to ensure even cooking.

■ Ask the fishmonger to scale, gill and gut whole fish for you because this is a messy procedure to do at home.

Quick-cook ideas

■ Toss sardine fillets in flour seasoned with cracked pepper. Shallow fry in hot olive oil, about one minute each side. Drain on paper towels and serve with a wedge of lemon. Make sure the oil is hot before you start frying, otherwise the fish will be greasy.

■ Scale and gut whole barbounia. Rinse and dry on paper towels. Marinate in olive oil and lemon juice: for 1kg fish allow 125ml oil, the juice of 2 lemons and a handful of freshly chopped parsley. Leave to stand 10–15 minutes. Shallow fry in hot olive oil. Drain on paper towels. Sweet and delicious.

■ Scale and gut whole red spot whiting. Rinse and dry. Toss in flour and shallow fry in hot oil with one finely chopped garlic clove. Serve with a wedge of lemon and some cracked pepper.

■ Toss whole, cleaned sea garfish in flour. Shallow fry in hot olive oil, about 2 minutes each side. Treat whitebait in the same manner, cooking until golden.

■ Stuff plate-size barramundi with this mixture: fry ½ finely chopped Spanish onion and 1 clove finely chopped garlic in a little oil. When golden add a little coconut cream and some freshly chopped basil. Toss in some peanuts. Use this mixture to fill the cavity and close with a skewer. Brush outside of fish with a little "Song Gai" Panaeng curry paste. Place fish on a plate and steam (see method below) 10–12 minutes or until fish flakes when pierced with a knife. Remove fish to a warm serving platter, reserving juices. Add a teaspoon or two of the paste to juices, mix well, and pour over fish. Top with a dollop of coconut cream and garnish with freshly chopped basil and peanuts.

■ Brush oily fish such as mackerel and mullet fillets with a Cajun spice mix and cook on a hot plate until blackened. Or try a tandoori curry paste mixed with a little oil and garlic. Delicious if skin is left on and cooked until crispy.

Recipes

STEAMED WHOLE BARRAMUNDI

Serves 3–4

1 x 1kg barramundi (or 2 x plate-size), scaled and gutted
½ tsp salt
1 tsp toasted sesame oil
3–4 slices fresh ginger, peeled and shredded
2 tbsp light soy sauce
2 tbsp dry sherry or rice wine
2 large shallots, sliced on the diagonal
2 tbsp vegetable oil

Rinse and dry fish. Make three diagonal slashes on each side. Rub inside and out with the salt and sesame oil. Place fish on a heat-proof plate and scatter the ginger over the top. Put a rack in the centre of a wok (or baking dish) and fill with boiling water to within 2.5cm of the rack. Place the plate on the rack. Cover with a large, tight-fitting lid and steam vigorously 15–18 minutes or until a knife inserted in thickest part of the flesh comes out clean. Allow 10–12 minutes for smaller fish. Remove plate from steamer. Slide fish onto a warm serving platter and pour soy sauce and wine over the top. Top with shallots. Heat oil in a small pan and pour over the surface of the fish. Delicious with steamed rice and bok choy.

CHAR-GRILLED BARRAMUNDI

Serves 4

4 plate-size barramundi (about 400g each), scaled and gutted
Vegetable oil
Sea salt and cracked pepper
Butter
Basil, freshly chopped

Rinse and dry fish. Brush with oil and season with salt and pepper. Heat char-grill or barbecue and cook fish 3–4 minutes each side, until brown. Check to see if flesh is cooked – it should be firm and flake away from thickest part when pierced with a knife. Serve with a knob of butter topped with freshly chopped basil.

Note: fillets or cutlets can be cooked in the same way.

BARBECUED BARRAMUNDI

This recipe is from Paul Wrightson of Fishface Cafe, 132 Darlinghurst Road, Darlinghurst. Phone (02) 9332 4803.

2 plate-size barramundi, scaled and gutted
2 cloves garlic, sliced
2 tbsp sliced fresh ginger
Handful freshly chopped coriander leaves
Salt and pepper
Sauce:
200ml fish stock
Juice 2 limes
2 tbsp unsalted butter

Rinse and dry fish. Put the ginger, garlic and coriander inside the fish. Barbecue on a lightly oiled hot plate or char-grill until flesh is soft and flakes away from bone.

To make the sauce, put fish stock, lime juice and butter into a saucepan, bring to the boil and reduce by half.

Place the fish on a plate and pour the sauce over the top.

Appendix 3 Processing yields and fat deposits in fish

Cutlet yield of large barramundi sample August 1996

August 1996	Whole	Cutlets	Air sac	Head+ wings	Fat deposits	Liver
Fish 1	2.768 Kg	1.680 Kg	36 Kg	504 gm	76 gm	60 gm
Fish 2	3.318	2.082	38	560	92	70
Fish 3	3.178	1.872	36	546	118	84
Fish 4	3.062	1.800	34	550	80	50
Fish 5	2.584	1.516	30	496	58	60
Fish 6	2.906	1.762	40	536	58	50
Average Yield (%)	100%	60.1%	1.2%	17.9%	2.7%	2.1%

Summer and winter fat condition of plate size fish samples.

	Whole fish (5)	Fat deposits in belly
Summer Jan. 97	1.990 kilograms	32 grams (1.6%)
Winter July 97	1.900 kilograms	90 grams (4.7%)
Average		3.1%