

A PILOT SURVEY ON THE IDENTITY OF FISH SPECIES AS SOLD THROUGH FOOD OUTLETS IN AUSTRALIA

Participating Jurisdictions: Food Standards Australia New Zealand, New South Wales, Northern Territory, South Australia, Queensland and Western Australia

Introduction

Barramundi (*Lates calcarifer*) inhabits the South-East Asian region, including northern Australia where they are a basis for a lucrative commercial fishery [Aquaculture WA, 1996]. It's reputation as one of Australia's finest table fish has been the catalyst for the occasional scandal due to substitution of other cheaper fish in the restaurant trade [Native Fish Australia]. In Western Australia, mislabelling of Barramundi has been suspected for many years [Hoare M, 1995a & 1995b] which is an offence under the Health Act [Health Act WA, 1985]. Other surveys in Australia have also revealed widespread mislabelling for example, a survey by the Australian Consumers' Association found that 22% of fish in 30 restaurants and 30% in 12 high turnover retail shops were incorrectly labelled [Choice, 1988]. A subsequent survey in Victoria found that up to 75% of premises selling fish claimed to be Barramundi had falsely labelled the fish [Tam J, 1994].

Traditional methods of identifying fish species from flesh samples in the laboratory include capillary zone electrophoresis of muscle proteins [Gallardo JM, 1995] and enzyme-linked immunosorbent assay (ELISA) [Hsieh YHP et al, 1995]. However, susceptibility of proteins to intracellular degradation prevents the species identification of processed (eg. filleted, cooked, marinated or preserved) fish prompting the search for other molecular identifiers. Unlike proteins, DNA: is more stable at high temperatures; is present in all tissue types within the same organism; offers greater discriminatory power for detecting genetic variability. The development of polymerase chain reaction (PCR) raised the notoriety of DNA and since then has established DNA as the molecular marker for species identification.

The Random Amplified Polymorphic DNA (RAPD) PCR technique is the most simple form of DNA fingerprinting and has been used successfully in fish [Bardkci F & Skibinski DOF, 1994] but relies on DNA that is uncontaminated and of high quality [Partis L, 1996]. Difficulties in the handling and storage of fish and fish products as evidential material (eg. whole, filleted or cooked) has meant that the quality of DNA cannot always be guaranteed when samples are eventually presented to the food analyst. A more reliable method (other than RAPD PCR) that can analyse degraded DNA is required.

The mitochondrial cytochrome *b* gene has been shown to be highly conserved in vertebrates, including fish [Kocher TD, et al, 1989 & Eposti MD et al, 1993]. Using specific primers, the polymerase chain reaction (PCR) can amplify a 360 base pair motif with sufficient genetic variation to enable the determination of species of origin in meat [Meyer R et al, 1993, 1995] and cooked meat products [Food Watch, 1999]. Recently, this method was shown to be suitable for differentiating fish species [Tagliavini J, 1995], and four restriction fragment length polymorphisms (RFLP) were identified that differentiated *Lates calcarifer* (Australian Barramundi) from *Lates niloticus* (Nile Perch) [K Ho, 1998, 2000].

The objectives of this collaborative pilot survey were; [1] to undertake a limited sampling across the whole supply chain to assess the incidence of failure to correctly identify the species of fish and therefore a measure of fraudulent activity occurring in the industry; [2] to use the survey as a model for addressing several key issues, including: optimising systems and procedures for consistency across jurisdictions on sampling, testing, interpretation and reporting: establishing guidelines so that cost-efficiency can be vetted against expected outcomes and; capturing the regulatory needs and wants of individual jurisdictions and; [3] to use the survey as a precursor to the launch of a fully-intergrated Australia-wide investigation.

The scope of the survey was intended to collect samples from food businesses in Queensland, New South Wales, Northern Territory, Australian Capital Territory, South Australia and Western Australia. The agreed sampling strategy for the study was to limit the scope of samples collected to those claiming to be Australian Barramundi (*Lates calcarifer*) and Red Emperor (*Lutjanus sebae*). These were considered likely to be nationally available, have a high market value and least likely to have any ambiguity concerning the recognised marketing name of the fish. Additionally, Western Australia also submitted samples of local Dhufish (*Glaucosoma hebraicum*).

Materials

All biochemicals used were of DNA grade. Australian Barramundi (*Lates calcarifer*), Red Emperor (*Lutjanus sebae*), WA Dhufish (*Glaucosoma hebraicum*) and other fish were authenticated by Dr Barry Hutchins from the Museum of Western Australia [Hutchins, 1999]. Nile Perch (*Lates niloticus*) was from Lake Victoria (Uganda), and was authenticated by the WA Museum [Hutchins, 1999] and by the Office of the Ministry of Agriculture, Animal, Industry and Fisheries, Uganda [Atyang J, 1998].

The primary reference used for naming conventions for this survey is the CSIRO Australian Seafood Handbook [Yearsley, 2001]. However, should the identified species not be listed in this reference then the naming recommended in Fishbase has been used [Froese, 2003].

Methods

Sample Collection

Sampling was coordinated by the Environmental Health Service, Health Department of Western Australia and was carried out by Environmental Health jurisdictions of New South Wales, Northern Territory, South Australia, Queensland and Western Australia. In addition, samples were collected in the Australian Capital Territory and submitted by Food Standards Australia New Zealand.

DNA Fingerprinting

Biopsies were taken from which DNA was isolated and subjected to PCR-RFLP analysis [In-house method SOP 84]. PCR amplification was performed at an annealing temperatures 50°C, unless otherwise specified. Subsamples of PCR amplified DNA were digested with a panel of restriction enzymes for 4 hours at 37°C. Restriction fragment length polymorphic patterns were developed by horizontal gel electrophoresis. DNA fingerprints were matched according to the following provisions; [1] the presence or absence of restriction sites; [2] the number of restriction sites and; [3] the restriction fragment length polymorphic pattern.

Sample Traceability

Unless otherwise indicated, Lab Numbers refer to Chemistry Centre sample traceability identifiers and Sample Marks represent sample identifiers appearing on the sampling proforma of respective jurisdictions, as received.

Abbreviations

B = Barramundi (*Lates calcarifer*); BS = Barramundi species (*Lates spp.*); NP = Nile Perch (*Lates niloticus*); KT = King Threadfin (*Polydactylus macrochir*); RE = Red Emperor (*Lutjanus sebae*); SE = Spangled Emperor (*Lethrinus choerorhynchus*); RTE = Redthroat Emperor (*Lethrinus miniatus*); WD = WA Dhufish (*Glaucosoma hebraicum*); NPP = Northern Pearl Perch (*Glaucosoma buergeri*); PP = Pearl Perch (*Glaucosoma scapulare*). *Cfo 1*, *Hae III*, *Hinf 1*, *Rsa 1*, *Hpa II* and *Taq 1*, are restriction enzymes; M = matched; C = closely related but not DNA identical to Australian Barramundi (*Lates calcarifer*); U = unmatched.

Scoring Convention

The presence (+) or absence (-) of a cleavage site(s) for restriction enzymes is shown. Where more than one fingerprint is generated, that which is specific to the Reference Standard is assigned (+) followed by the number 1. Other fingerprinting patterns are identified in numerical order (ie. from 2 onwards). A sample is considered true to label where DNA fingerprints are identical to those of the Reference Standard on three different restriction enzymes. *Applicable to WA Dhufish samples only, is the term 'did not amplify', which refers to DNA of samples containing gene sequences that were sufficiently different from those of Reference Standard causing the lack of PCR amplification.* A Reference Standard is defined as the DNA fingerprint, from whole fish that has been nomenclatured and certified by experts from the WA Museum according to international taxonomic convention.

Results

Results on individual jurisdictions (Attachments 1 – 6) and a consolidation from these (Attachments 7 – 9), are attached.

Discussion/Conclusions

Overall the collaborative pilot survey found that 76.8% ($n = 138$) of samples correctly identified the species of fish as sold, with 86.8% of all samples sold as Barramundi correctly identifying as Barramundi or closely related to species of Barramundi. However, the level of correct species identification for Red Emperor was considerably lower with 58.8% of all samples sold as Red Emperor samples correctly identified. The survey found there was some variability across the wholesale, retail and food service sectors, with the food service sector showing the lowest level of compliance with correct species identification. Furthermore, additional samples taken in Western Australia of local Dhufish showed similar trends in correctly identifying the species as was seen with Red Emperor, with 53.8% of samples identified as Dhufish.

The collaborative pilot survey focussed on the collection of Barramundi and Red Emperor fish fillets from wholesale, retail and food service sectors. In addition, the Western Australian Department of Health submitted samples that were claimed to be locally caught Western Australian Dhufish. These species were selected because there is no ambiguity in the accepted marketing names or identity and there is no historical alternative marketing name for Barramundi or Red Emperor or Western Australian Dhufish. Both cooked and raw samples of fish were collected from food service outlets while raw fish were collected from the wholesale and retail outlets.

Food service establishments showed the lowest level of compliance with 43 (64.2%, $n = 67$) samples correctly identifying the species of fish, while the retail sector showed 39 (88.6%, $n = 44$) samples were compliant and the wholesale sector showed 24 (88.9%, $n = 27$) samples were compliant with correct identification.

Of the two species surveyed at a collaborative level, species identification was higher for Barramundi (86.8%; $n = 91$) than for Red Emperor (58.8%, $n = 34$). It was found that the majority of Barramundi samples matched the reference for Australian Barramundi (69.2%, $n = 63$), a significant number showed slight genetic variation and were closely related species of barramundi (17.6%, $n = 16$).

In contrast, the lowest level of correct species identification was found at the food service level for Red Emperor with 5 (31.3%) of 16 samples matched to the reference sample. However, this is primarily based on samples submitted by Western Australia and Queensland as South Australia did not obtain any samples of Red Emperor while New South Wales, Australian Capital Territory and the Northern Territory only obtained one or two samples. The species identification of Barramundi at the food service level was better with 35 (81.4%, $n = 43$) samples matched or closely related to Barramundi.

The Western Australian samples of Dhufish showed the lowest overall level of compliance in comparison with the other two species of fish, with 7 (53.8%) of 13 samples compliant. However the level of compliance at the food service level was 3 (37.5%) of 8 samples and therefore slightly better than that found with Red Emperor.

Some regional variation was observed in the level of compliance and the industry sectors, however the number of samples per industry sector from each State for each fish did not allow for a statistically meaningful comparison. Total compliance with labelling was observed for barramundi samples from the Northern Territory (100%, n =10) and from Queensland (100%, n = 22). All other States showed varying degrees of non compliance but it is noted that Western Australia did not obtain sufficient barramundi samples to enable a statistical comparison with other regions.

Experience with some samples of barramundi underlined the potential that varietal differences can have in influencing the outcome of speciation. Such genetic variations could be accounted for by analytical laboratories adopting an expanded set of reference standards. Significantly, the identification of species variation as a key issue in this collaborative pilot survey has reinforced the need to ensure genetic uniformity in vouched standards. With endorsement from all collaborating jurisdictions, Western Australia and Queensland will be seeking support from an appropriate funding body to establish an interlaboratory trial involving an exchange of vouched reference samples towards gaining more knowledge on the genetic variability of sub-species of commercially significant fish. Interestingly, the high concordance in results on samples of Red Emperor from independent analyses undertaken by Western Australia and Queensland suggested that species variation may not be an issue with this fish.

Another major finding for this survey was that the “DNA fingerprinting” technique was able to discriminate between samples to a high degree for either cooked or raw fish samples. This enabled States to purchase samples of food from food service establishments as purchased by consumers and as such may enable enforcement agencies to undertake prosecution for the sale of food not demanded by the purchaser and misleading or deceptive conduct.

It is concluded that although there were relatively few samples, the pilot survey is indicative of problems in consistently and correctly identifying the species of fish at all levels of the food supply.

References

- Aquaculture WA (1996). "Barramundi. *Lates calcarifer*." A series on aquaculture species. Fisheries Department of Western Australia. ISSN 1323-8442
- Atyang J (1998). "Certificate of authentication of *Lates niloticus* and *Oreochromis niloticus*." Health Certificate No. U03/94. Ministry of Agriculture, Animal, Industry & Fisheries, Uganda.
- Bardkci F & Skibinski. Department of Fisheries (1994). "Application of the RAPD technique in tilapia fish: species and subspecies identification." *Heredity*. 73:117-123
- CCWA (2002). "Fish Speciation. Barramundi." Lab. No. 02D 274
- Choice (1988). "Fish out of Water." Australia Consumers Association. July: 3-8
- Esposti MD et al. (1993). " Mitochondrial cytochrome b: Evolution and Structure of the Protein." *Biochim. Biophys. Acta*. 1143:243-271
- Food Watch (1999). "What's the beef with sausages." A Western Australian Food Monitoring Program Newsletter, Health Department of Western Australia.
- Froese R and Pauly D. Editors. 2003. FishBase. World Wide Web electronic publication. <http://www.fishbase.org>, version 19 November 2003.
- Gallardo JM et. al. (1995). "Use of capillary zone electrophoresis for fish species identification. Differentiation of flatfish species." *J Science of Food and Agriculture*. 43:1238-1244
- Health Act of Western Australia [1985]. "It is an offence to sell food that is packed or labelled in a manner that is false or misleading." Section 246Q. Amendments to the State Health Act of 1911.
- Ho K (1998). "Fish PCR-RFLP trials: Barramundi and Nile Perch." Methods File, November.
- Ho K (2000). "Fish speciation: Barramundi labelling." CCWA File 00D 303.
- Hoare M (1995a). "Fish Species Substitution Identification: When Barra on Mundi may be Nile Perch on Tuesday."
- Hoare M, Doughty I & Tam J. (1995b). "Liquid Chromatographic Protein Profiling as a means of Fish species Identification." 7th Government Food analysts Conference." Werribee, victoria. 14th-17th November, 1995.
- Hsieh YHP et al. (1995). "Detection of species substitution in raw and cooked meats using immunoassays." *J Food Protection*. 58:555-559

Hutchins B (1999). "Certificate of authentication of fish species." Certificate dated 18 February 1999. Department of Aquatic Zoology, Fish Section, Western Australian Museum of Natural Science.

Yearsley, GK et al. (1999). "Australian Seafood Handbook. An Identification Guide to Domestic species."

Kocher TD et al. (1989). "Dynamics of mitochondrial DNA evolution in animals: Amplification and sequencing with conserved primers." Proc. Natl. Acad. Sci. USA. 86:6196-6200

Meyer R et al. (1993). "Detection of pork in heated meat products by the polymerase chain reaction." J. AOAC International. 77:617-622

Meyer R et al. (1995). "Polymerase chain reaction-restriction fragment length polymorphism analysis: A simple method for species identification in food." J. AOAC International. 78:1542-1551

Native Fish Australia. "Australian Barramundi: *Lates calcarifer*." <http://www.nativefish.asn.au/barramundi.html>

Partis L. (1996). "Fish speciation using random amplified polymorphic DNA (RAPD)." Australian Government Analytical Laboratories (AGAL), New South Wales.

Tagliavini J et al. (1995). "Discrimination between *Anguilla anguilla* and *A. Rostrata* by polymerase chain reaction-restriction fragment length polymorphism analysis." J. Fish Biol. 47:741-743

Tam J. (1994). "Identification of Meat and Fish Species using High Performance Liquid Chromatography." Research Project CSC3292 Practicum 2, Edith Cowan University.

Yearsley GK, Last PR and Ward RD (eds) (2001) "Australian Seafood Handbook" CSIRO Marine Research and Fisheries Research & Development Corporation.

Attachment 1: Australian Capital Territory Data

Collaborative Pilot Fish Identity Survey 2003. Lab. No. 03D 229.

BARRAMUNDI						RED EMPEROR					
Lab No.	Sample Marks	Cfo	Hinf	Rsa	M/C/U	Lab No.	Sample Marks	Cfo	Hae	Rsa	M/C/U
1	1	+	+ ₁	+ ₁	M	16	7	+	+ ₁	-	M
2	2	+	+ ₁	+ ₁	M						
3	3	+	+ ₁	+ ₁	M						
4	4	+	+ ₁	+ ₁	M						
5	5	+	+ ₁	+ ₁	M						
6	6	+	+ ₁	+ ₁	M						
7	8	+	+ ₁	+ ₁	M						
8	9	-	-	-	U						
9	10	+	+ ₁	+ ₁	M						
10	11	+	+ ₁	+ ₁	M						
11	12	-	-	+ ₁	C						
12	13	+	+ ₁	+ ₁	M						
13	14	-	-	-	U						
14	16	-	-	+ ₁	C						
15	19	+	+ ₁	+ ₁	M						
	KEY						KEY				
	B	+	+ ₁	+ ₁			RE	+	+ ₁	-	
	BS	-	-	+ ₁			SE	-	+ ₂	-	
	NP	-	-	-			RTE	-	+ ₃	+	
	KT	-	+ ₂	+ ₂							

M = matched; C = closely related but not DNA identical to Australian Barramundi; U = unmatched

Attachment 2: Northern Territory Data

Collaborative Pilot Fish Identity Survey 2003. Lab. No. 03D 135

BARRAMUNDI						RED EMPEROR					
Lab No.	Sample Marks	Cfo	Hinf	Rsa	M/C/U	Lab No.	Sample Marks	Cfo	Hae	Rsa	M/C/U
1	1	+	+ ₁	+ ₁	M	11	1	-	+ ₁	-	U
2	2	+	+ ₁	+ ₁	M						
3	3	+	+ ₁	+ ₁	M						
4	4	+	+ ₁	+ ₁	M						
5	5	+	+ ₁	+ ₁	M						
6	6	+	+ ₁	+ ₁	M						
7	7	+	+ ₁	+ ₁	M						
8	8	+	+ ₁	+ ₁	M						
9	9	+	+ ₁	+ ₁	M						
10	10	+	+ ₁	+ ₁	M						
	KEY						KEY				
	B	+	+ ₁	+ ₁			RE	+	+ ₁	-	
	BS	-	-	+ ₁			SE	-	+ ₂	-	
	NP	-	-	-			RTE	-	+ ₃	+	
	KT	-	+ ₂	+ ₂							

M = matched; C = closely related but not DNA identical to Australian Barramundi; U = unmatched

Attachment 3: New South Wales Data

Collaborative Pilot Fish Identity Survey 2003. Lab. No. 03D 131

BARRAMUNDI						RED EMPEROR					
Lab No.	Sample Marks	Cfo	Hinf	Rsa	M/C/U	Lab No.	Sample Marks	Cfo	Hae	Rsa	M/C/U
1	03034	-	+ ₂	-	U	2	1019	+	+ ₁	-	M
3	1020	+	+ ₁	+ ₁	M	5	1022	+	+ ₁	-	M
4	1021	+	+ ₁	+ ₁	M						
6	1023	+	+ ₁	+ ₁	M						
7	1024	-	+ ₂	-	U						
8	1025	-	+ ₁	+ ₁	U						
9	1026	+	+ ₁	+ ₁	M						
10	3574	+	+ ₁	+ ₁	M						
11	3575	+	+ ₁	+ ₁	M						
12	3576	-	-	-	U						
13	3577	+	+ ₁	+ ₁	M						
14	3578	+	+ ₁	+ ₁	M						
15	3579	+	+ ₁	+ ₁	M						
16	3580	-	-	+ ₁	C						
17	3581	-	-	+ ₁	C						
18	1670	-	-	-	U						
19	1671	+	+ ₁	+ ₁	M						
20	1672	+	+ ₁	+ ₁	M						
21	3301	+	+ ₃	+ ₃	U						
	KEY						KEY				
	B	+	+ ₁	+ ₁			RE	+	+ ₁	-	
	BS	-	-	+ ₁			SE	-	+ ₂	-	
	NP	-	-	-			RTE	-	+ ₃	+	
	KT	-	+ ₂	+ ₂							

M = matched; C = closely related but not DNA identical to Australian Barramundi; U = unmatched

Attachment 4: South Australian Data

Collaborative Pilot Fish Identity Survey 2003. Lab. No. 03D 133

BARRAMUNDI						RED EMPEROR					
Lab No.	Sample Marks	Cfo	Hinf	Rsa	M/C/U	Lab No.	Sample Marks	Cfo	Hae	Rsa	P/F
1	1	+	+ ₁	+ ₁	M						
2	2	+	+ ₁	+ ₁	M						
3	3	+	+ ₁	+ ₁	M						
4	4	+	+ ₁	+ ₁	M						
5	5	+	+ ₁	+ ₁	M						
6	6	+	+ ₁	+ ₁	M						
7	7	-	-	+ ₁	C						
8	8	-	-	+ ₁	C						
9	9	+	+ ₁	+ ₁	M						
10	10	+	+ ₁	+ ₁	M						
11	11	+	+ ₁	+ ₁	M						
12	12	+	+ ₁	+ ₁	M						
13	13	+	+ ₃		U						
14	14	-	-	+ ₁	C						
15	15	+	+ ₁	+ ₁	M						
16	16	-	-	-	U						
17	17	+	+ ₁	+ ₁	M						
18	18	+	+ ₁	+ ₁	M						
19	19	-	-	+ ₁	C						
20	20	-	-	+ ₁	C						
	KEY										
	B	+	+ ₁	+ ₁							
	BS	-	-	+ ₁							
	NP	-	-	-							
	KT	-	+ ₂	+ ₂							

M = matched; C = closely related but not DNA identical to Australian Barramundi; U = unmatched

Attachment 5: Queensland Data

Collaborative Pilot Fish Identity Survey 2003. Lab. No. 03D 132

BARRAMUNDI						RED EMPEROR					
Lab No.	Sample Marks	Cfo	Hinf	Rsa	M/C/U	Lab No.	Sample Marks	Cfo	Hae	Rsa	M/U
2	2	+	+ ₁	+ ₁	M	1	1	+	+ ₁	-	M
3	3	+	+ ₁	+ ₁	M	5	5	+	+ ₁	-	M
4	4	+	+ ₁	+ ₁	M	6	6	+	+ ₁	-	M
7	7	+	+ ₁	+ ₁	M	9	9	-	+ ₂	-	U
8	8	-	-	+ ₁	C	10	10	+	-	+ ₁	U
12	12	+	+ ₁	+ ₁	M	11	11	+	+ ₁	-	M
14	14	-	-	+ ₁	C	13	13	-	+ ₃	-	U*
15	15	+	+ ₁	+ ₁	M	17	17	+	+ ₁	-	M
16	16	-	-	+ ₁	C	23	21	-	+ ₃	-	M*
18	18	+	+ ₁	+ ₁	M	25	23	+	+ ₁	-	M
19	19	+	+ ₁	+ ₁	M	26	24	+	+ ₁	-	M
20	19a	+	+ ₁	+ ₁	M	27	25	+	+ ₁	-	M
21	20	-	-	+ ₁	C	30	28	+	+ ₁	-	M
22	20a	-	-	+ ₁	C	31	29	+	+ ₁	-	M
24	22	+	+ ₁	+ ₁	M	32	30	+	+ ₃	+ ₂	U
28	26	+	+ ₁	+ ₁	M	34	32	+	+ ₁	-	M
29	27	+	+ ₁	+ ₁	M	37	35	-	+ ₂	-	U
33	31	+	+ ₁	+ ₁	M	40	39	-	+ ₃	-	U*
35	33	+	+ ₁	+ ₁	M	41	40	-	-	+ ₁	U
36	34	+	+ ₁	+ ₁	M						
38	37	+	+ ₁	+ ₁	M						
39	38	+	+ ₁	+ ₁	M						
	KEY						KEY				
	B	+	+ ₁	+ ₁			RE	+	+ ₁	-	
	BS	-	-	+ ₁			SE	-	+ ₂	-	
	NP	-	-	-			RTE	-	+ ₃	+	
	KT	-	+ ₂	+ ₂							

M = matched; C = closely related but not DNA identical to Australian Barramundi; U = unmatched

* Although lab number 23 (QH sample 21) was observed not to match the DNA profile of the WA certified Red Emperor, follow-up analysis by QHSS reported an identical match with the QLD Red Emperor reference sample by two independent methods, namely iso-electric focussing (IEF) and DNA sequencing. It was therefore concluded that the sample was likely to be a Red Emperor.

Attachment 6: Western Australian Data

Collaborative Pilot Fish Identity Survey 2003. Lab. No. 03D 134

BARRAMUNDI						RED EMPEROR						WA DHUFISH					
Lat No	Sample Marks	Cfr	Hin1	Rsa	M/I /U	Lat No	Sample Marks	Cfo	Hae	Rsa	M/I	Lab No	Sample Marks	Cfo	Hpa	Taq	M/I
3	3	-	+ ₁	+ ₁	U	1	1	-	+ ₂	+	U	11	D11	+ ₁	+ ₁	+ ₁	M
7	7	-	-	+ ₁	C	2	2	+ ₁	+ ₁	-	M	12	D12	+ ₁	+ ₁	+ ₁	M
8	8	-	-	+ ₁	C	4	4	-	+ ₁	+	U	13	D13	+ ₁	+ ₁	+ ₁	M
21	31	+	+ ₂	-	U	5	5	-	+ ₂	+	U	14	D14	Did not amplify			U
22	32	+	+ ₁	+ ₁	M	6	6	+ ₁	-	+	U	15	D15	Did not amplify			U
						9	9	+ ₂	+ ₃		U	16	D6	+ ₁	+ ₁	+ ₁	M
						10	10	-	-	-	U	17	D7	+ ₁	+ ₁	+ ₁	M
						26	27	+ ₁	+ ₁	-	M	18	D8	Did not amplify			U
						27	28	+ ₁	+ ₁	-	M	19	D9	+ ₁	+ ₁	+ ₁	M
						28	29	+ ₁	+ ₁	-	M	20	D10	Did not amplify			U
						29	30	+ ₁	+ ₁	-	M	23	D33	+ ₁	+ ₁	+ ₁	M
												24	D34	Did not amplify			U
												25	D35	Did not amplify			U
	KEY						KEY						KEY				
	B	+	+ ₁	+ ₁			RE	+ ₁	+ ₁	-			WD	+ ₁	+ ₁	+ ₁	
	BS	-	-	+ ₁			SE	-	+ ₂	-			NPP	+ ₂	+ ₂	+ ₂	
	NP	-	-	-			RTE	-	+ ₃	+			PP	+ ₂	+ ₂	+ ₂	
	KT	-	+ ₂	+ ₂													

M = matched; C = closely related but not DNA identical to Australian Barramundi; U = unmatched

Attachment 7. Collaborative Fish Survey 2003

Labelling Compliance across Jurisdictions, Fish Species and Industry Sectors

	BARRAMUNDI				RED EMPEROR				WA DHUFISH			
ACT	Category	TA	TTL	%C	Category	TA	TTL	%C	Category	TA	TTL	%C
	S	15	13	86.6	S	1	1	100	S	-	-	-
	W	1	1	100	W	0	0	-	W	-	-	-
	R	7	7	100	R	0	0	-	R	-	-	-
	F	7	5	72	F	1	1	100	F	-	-	-
NT	Category	TA	TTL	%C	Category	TA	TTL	%C	Category	TA	TTL	%C
	S	10	10	100	S	1	0	0	S	-	-	-
	W	2	2	100	W	1	0	0	W	-	-	-
	R	3	3	100	R	0	0	-	R	-	-	-
	F	5	5	100	F	0	0	-	F	-	-	-
NSW	Category	TA	TTL	%C	Category	TA	TTL	%C	Category	TA	TTL	%C
	S	19	13	68.4	S	2	2	100	S	-	-	-
	W	6	6	100	W	0	0	-	W	-	-	-
	R	6	3	50	R	2	2	100	R	-	-	-
	F	7	4	57	F	0	0	-	F	-	-	-
SA	Category	TA	TTL	%C	Category	TA	TTL	%C	Category	TA	TTL	%C
	S	20	18	90	S	0	0	-	S	-	-	-
	W	5	5	100	W	0	0	-	W	-	-	-
	R	5	5	100	R	0	0	-	R	-	-	-
	F	10	8	80	F	0	0	-	F	-	-	-
QLD	Category	TA	TTL	%C	Category	TA	TTL	%C	Category	TA	TTL	%C
	S	22	22	100	S	19	12	63.2	S	-	-	-
	W	5	5	100	W	4	4	100	W	-	-	-
	R	7	7	100	R	5	5	100	R	-	-	-
	F	10	10	100	F	10	3	30	F	-	-	-
WA	Category	TA	TTL	%C	Category	TA	TTL	%C	Category	TA	TTL	%C
	S	5	3	60	S	11	5	46	S	13	7	54
	W	1	0	0	W	1	0	0	W	1	1	100
	R	0	0	-	R	5	4	80	R	4	3	75
	F	4	3	75	F	5	1	20	F	8	3	38
COMBINED	Category	TA	TTL	%C	Category	TA	TTL	%C	Category	TA	TTL	%C
	S	91	79	86.8	S	34	20	58.8	S	13	7	53.8
	W	20	19	95	W	6	4	66.7	W	1	1	100
	R	28	25	89.3	R	12	11	91.7	R	4	3	75
	F	43	35	81.4	F	16	5	31.3	F	8	3	37.5

ABBREVIATIONS

F = food service
R = retail

S = samples analysed
TA = total analysed

TTL = total true to label
W = wholesale

%C = percent compliance

Figures on this table were calculated from results of individual States (see Attachments 1 – 6) and information contained in field records of officers who performed the sampling. Percent compliance was calculated by dividing TTL by TA, then multiplying by 100.

Attachment 8. Collaborative Fish Survey 2003

Labelling Compliance Consolidated across Jurisdictions and Industry Sectors

Health Authority	Fish Labelling			
AUSTRALIAN CAPITAL TERRITORY	Category	TA	TTL	%C
	Fish Samples	16	14	87.5%
	Wholesale	1	1	100.0%
	Retail	7	7	100.0%
	Food Service	8	6	75.0%
NORTHERN TERRITORY	Category	TA	TTL	%C
	Fish Samples	11	10	90.9%
	Wholesale	3	2	66.7%
	Retail	3	3	100.0%
	Food Service	5	5	100.0%
NEW SOUTH WALES	Category	TA	TTL	%C
	Fish Samples	21	15	71.4%
	Wholesale	6	6	100.0%
	Retail	8	5	62.5%
	Food Service	7	4	57.1%
SOUTH AUSTRALIA	Category	TA	TTL	%C
	Fish Samples	20	18	90.0%
	Wholesale	5	5	100.0%
	Retail	5	5	100.0%
	Food Service	10	8	80.0%
QUEENSLAND	Category	TA	TTL	%C
	Fish Samples	41	34	82.9%
	Wholesale	9	9	100.0%
	Retail	12	12	100.0%
	Food Service	20	13	65.0%
WESTERN AUSTRALIA	Category	TA	TTL	%C
	Fish Samples	29	15	51.7%
	Wholesale	3	1	33.3%
	Retail	9	7	77.8%
	Food Service	17	7	41.2%
COMBINED	Category	TA	TTL	%C
	Fish Samples	138	106	76.8%
	Wholesale	27	24	88.9%
	Retail	44	39	88.6%
	Food Service	67	43	64.2%

ABBREVIATIONS

TA = total analysed; TTL = total true to label

Calculations on this table were based on figures brought forward from Attachment 7.

Attachment 9. Collaborative Fish Survey 2003

Labelling compliance across jurisdictions and between raw and cooked fish

	RAW			COOKED		
	Total	Comply	Not comply	Total	Comply	Not comply
ACT	9	7	2	7	5	2
		77.8%	22.2%		71.4%	28.6%
NT	6	5	1	5	5	0
		83.3%	16.7%		100%	0%
NSW	11	8	3	10	5	5
		72.7%	27.3%		50.0%	50.0%
SA	10	8	2	10	5	5
		80.0%	20.0%		50.0%	50.0%
QLD	21	18	3	20	11	9
		85.7%	14.3%		55.0%	45.0%
WA	12	8	4	17	5	12
		66.7%	33.3%		29.4%	70.6%
National	69	54	15	69	36	33
		78.3%	21.7%		52.2%	47.8%

Percent compliance/non compliance was calculated by dividing the number of samples that passed/failed by the total number of samples in that category, and multiplying by 100.