Application to amend the current List of Specimens taken to be Suitable for Live Import (Live Import List), to include the Asian Arowana – *Scleropages formosus* and *Scleropages inscriptus*

Submitted to the Department of the Environment on 28th July 2014

TABLE OF CONTENTS

DEFINITIONS/ABREVIATIONS

Scleropages – Taken to include both *Scleropages formosus* and *Scleropages inscriptus*. Also inclusive of all colour variations or subspecies of *Scleropages formosus* (*S. legendrei, S. macrophalus and S. aureus,* by Pouyaud *et al.* 2003).

Scleropages formosus – Refer to definition for *Scleropages*.

S. formosus – Refer to definition for *Scleropages*.

Arowana – Refer to definition for *Scleropages*.

***Scleropages sp.* –** Species *Scleropages*, also refer to definition for *Scleropages*.

IUCN – International Union for Conservation of Nature, also refer www.iucn.org/.

CITES – An international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

1.0 INTRODUCTION

This document has been created for the purpose of assessing the potential impacts of the genus *Scleropages* on the Australian environment, based on terms of reference developed by the Department of Environment (Commonwealth). These terms of reference have been developed to assess the inclusion of a new ornamental fresh water aquarium fish species for import into Australia.

Environment as defined in the EPBC Act includes:
(a) Ecosystems and their constituent parts, including people and communities; and
(b) Natural and physical resources; and
(c) The qualities and characteristics of locations, places and areas; and
(d) The social, economic and cultural aspects of a thing mentioned in paragraph (a), (b) or (c).

2.0 SPECIES TAXONOMY

Table 1 - Species Taxonomy

	SPECIES 1	*SPECIES 2*	*SPECIES 3*	*SPECIES 4*	*SPECIES 5*
Family name:	OSTEOGLOSSIDAE				
Genus name:	*SCLEROPAGES*				
Species:	*FORMOSUS*	*INSCRIPTUS*	*AUREUS*	*LEGENDREI*	*MACROCEPHALUS*
Subspecies:	N/A				
Taxonomic Reference:	http://www.fishbase.org/summary/Scleropages-formosus.htmL Scleropages *formosus* (Müller & Schlegel, 1844) *Scleropages inscriptus* (Roberts, 2012) *Scleropages aureus* (Pouyaud *et al*. 2003) *Scleropages legendrei* (Pouyaud *et al*. 2003) *Scleropages macrocephalus* (Pouyaud *et al*. 2003)				
Common Names:	ASIAN AROWANA DRAGON FISH ASIAN BONYTONGUE KELESA MALAYAN BONYTONGUE	INDIA AROWANA/ DRAGONFISH	GOLD & RED-TAILED GOLDEN AROWANA/ DRAGON FISH	RED AROWANA/ DRAGON FISH	SILVER AROWANA/ DRAGON FISH
Genetically-Modified Organism (GMO)	The Species are not genetically-modified and are a naturally occurring species in Asia.				

The genus *Scleropages* is the basis of this report and has been reported having multiple colour variations depending on the location the species has been found. These colour variations have been recorded as the following species:

- *Scleropages inscriptus* (Roberts, 2012);
- *Scleropages formosus* (Müller & Schlegel, 1844)
- *Scleropages aureus* (Pouyaud *et al*. 2003);
- *Scleropages legendrei* (Pouyaud *et al.* 2003);
- *Scleropages macrocephalus* (Pouyaud *et al*. 2003); and
- *Scleropages jardini* (Saville-Kent, 1892); and
- *Scleropages leichardti* (Günther, 1864).

Currently, the species *S. formosus* and *S. inscriptus* are recognised as independent species (*CITES*) native to Asia. *S. leichardti* and *S. jardini* are also recognised as independent species, native to both Australia and Papua New Guinea (PNG).

S. formosus exhibits multiple colour variations and combinations consisting of reds, greens, blues and gold's. These variations have since been classified as the species *S. legendrei, S. macrophalus* and *S. aureus*, by Pouyaud *et al.* (2003, Figure 1 – 4). Although appearing to be of different colours, these varieties are considered one species by Kottelat and Widjanarti (2005) because they can crossbreed with one another (Goh and Chua *1999*) and produce viable hybrids with colouration traits from both parents (Chang Kuok Weai Alex 2010, Figures 5).

In order for more than one species to be recognised as proposed by Roberts (2012) and Pouyaud *et al.* (2003), a professional standard study would need to be presented (*IUCN 2011*[1]). However, so far, there are relatively few scientific papers being published about the species in peer-reviewed journals (*Yue et al. 2006*). More still needs to be done to resolve the confusion in species determination.

This submission assumes *S. formosus* and *S. inscriptus* are the primary species and the other colour variations are sub-species, however should those colour variations be recognised as independent species in the future, then this report is intended to be inclusive of those separate species. Any reference of *S. formosus* herein this report shall be inclusive of *S. inscriptus*.

The following images are representative of the identified colour strains as documented above.

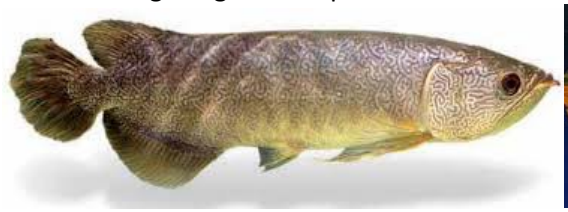
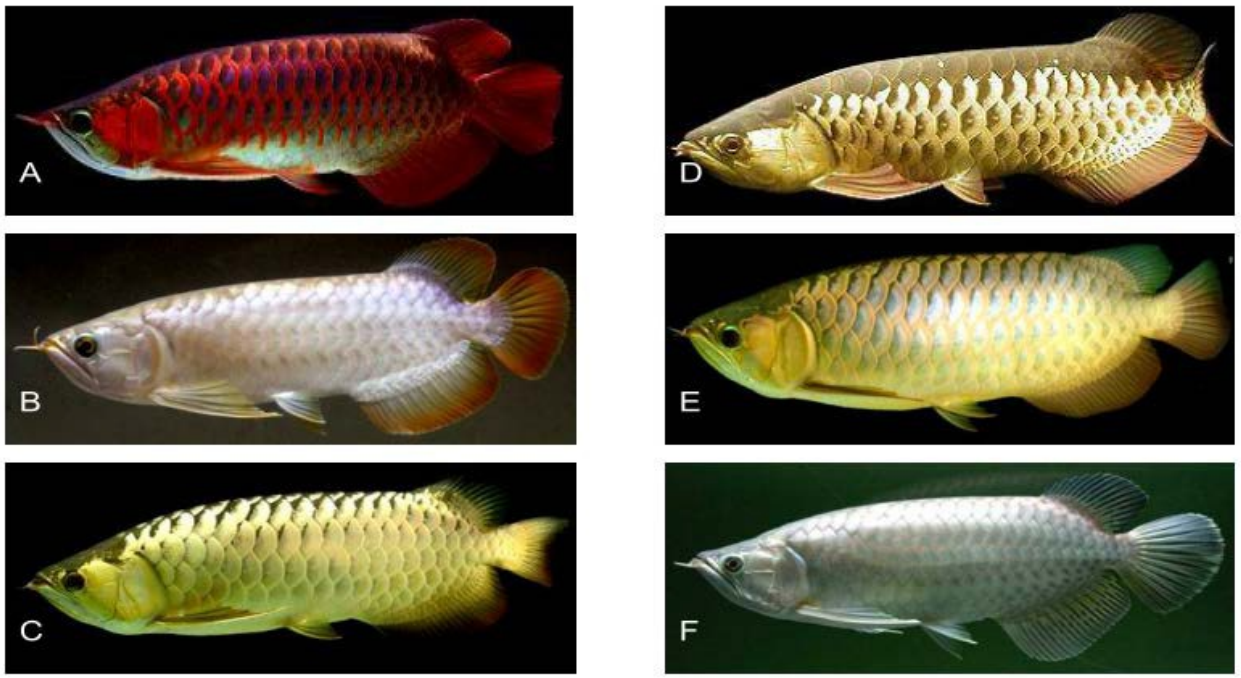


Figure 1 - *Scleropages inscriptus*

Figure 2 - *Scleropages aureus*

Figure 3 - *Scleropages legendrei*

Figure 4 - *Scleropages macrocephalus*



Figures 1 - Various colour polymorphs (from Chang Kuok Weai Alex 2010). A) Red Arowana: Scleropages legendrei (Pouyaud et al. 2003); B) Red tail Gold Arowana: Scleropages aureus (Pouyaud et al. 2003); C) Malaysian Gold Arowana: Scleropages formosus (Müller & Schlegel 1844); D) Indonesian Gold Arowana: Scleropages aureus (Pouyaud et al. 2003); E) Tong Yan Hybrid Arowana [Singapore captive hybridisation between A and C above]; F) Green Arowana: Scleropages formosus (Müller & Schlegel 1844)

[1] The IUCN Red List of Threatened Species, 2011

3.0 CITES STATUS

In the Asian culture the Arowana is a creature of beauty and splendour and it is believed to bring good fortune to its owners. It is for this very reason the Asian Arowana were excessively captured and traded. This has resulted in rapid depletion of Arowana in the wild, brought the species close to extinction and eventually led to its listing as an endangered species by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES[2]) in 1975. CITES species are listed under three categories with associated regulations (Appendix 1 – 3). Both *Scleropages formosus* (Asian Arowana) and *Scleropages inscriptus* are listed in Appendix I – "threatened with extinction".

Under CITES regulations the Asian Arowana can now only be traded and sold if they are bred in captivity and are of second generation (F2) and beyond.

Any import or export/re-export of Asian Arowana's require CITES permits and for commercial trade, the importer or exporter must be licensed under the licence to import or export ornamental fish. Only tagged captive-bred Asian Arowana from CITES-registered operations are allowed to be imported, exported or re-exported.

Additional requirements for the import and export of the CITES listed Asian Arowana include;

- every Asian Arowana must be implanted with one microchip at the dorsal muscle prior to export, and
- Asian Arowana must be pre-packed for inspection, with only one fish in each clear packing bag allowing easy viewing by inspectors, prior to export/import.

The restrictions and control measures placed on the Asian Arowana through CITES has both restricted the sales of these fish and created a complete tracking database to identify the global location and distribution of individual fish.

Table 2 - CITES Listing

		SCLEROPAGES				
		FORMOSUS	*INSCRIPTUS*	*AUREUS*	*LEGENDREI*	*MACROCEPHALUS*
CITES Listing	Appendix I	X	X	-	-	-

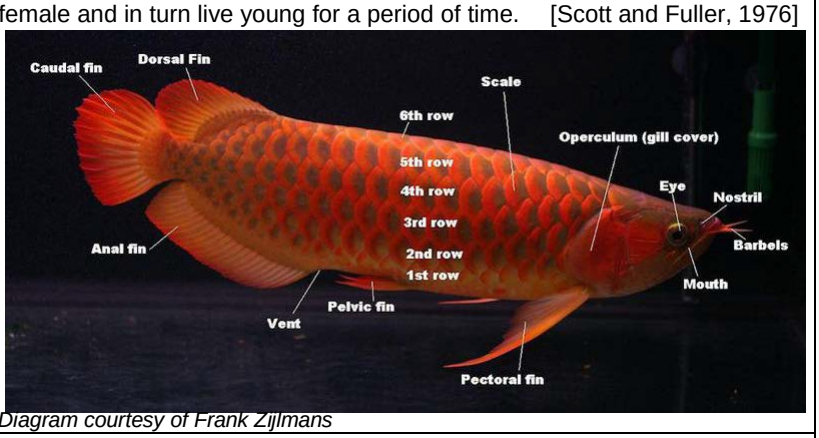
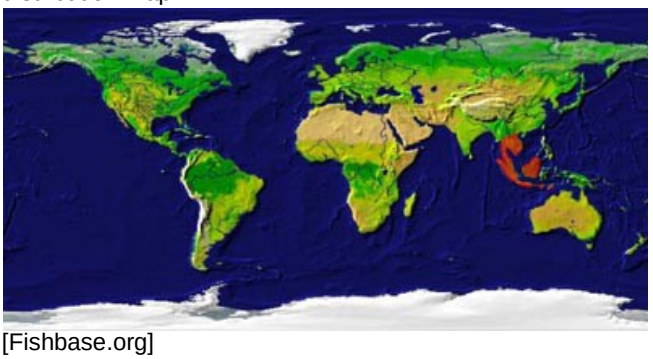
X – Denotes species inclusion in relevant documentation.

The species may already be extinct in Thailand (Kottelat 1996) and has become locally extinct in a number of drainages in Peninsular Malaysia and Sumatra (Tung 1986). *Scleropages formosus* is currently classified as endangered (Kottelat 1996), and is one of only a few freshwater fish whose international trade is restricted under CITES (Moreau and Coomes 2006).

[2] CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

4.0 ECOLOGY

Table 3 - Species Ecology (adapted from Fishbase.org 22nd July 2014 and other references as indicated)

Scleropages formosus	
Longevity (Lifespan)	10 – 20 years in ideal circumstances [multiple internet sources]
Size	≤ 90cm (max.); Typically 40 - 60cm max. for adults 6cm Juvenile at birth (i.e. when free swimming)
Weight	≤ 7kg [multiple internet sources]
Identification of species	The Asian Arowana is readily distinguishable from other species of fish, given its long slender and somewhat prehistoric appearance. The sexing of this species can only be done once the fish reaches maturity at approximately 3-4 years of age. At which point the mouth of the male is said to be slightly wider and deeper than that of the female and overall, finage of the male (tail & fins) are longer than that of the female. Sexing this species can be quite difficult and the gender could only be precisely determined by examination of gonads. The male carries the eggs of the female and in turn live young for a period of time. [Scott and Fuller, 1976]  *Diagram courtesy of Frank Zijlmans*
Natural Geographic range	Asia: Southern Myanmar to Malay Peninsula and Indonesia, eastern Thailand to Cardamom Range. Refer to Figure 6 for a more detailed distribution map.  [Fishbase.org] Due to the limited geographic range of this species and competition for these natural resources with humans the wild distribution of the Arowana is continually being restricted, hence it's listing as endangered in CITES.
Habitat & Migration	Freshwater (only) Benthopelagic Temperature range: 26°C - 30°C (Optimum) [Pouyaud *et al,* 2003] PH: 5 – 6 (Optimum) [Pouyaud *et al,* 2003] Low conductivity, max. 200us Occurs in tannin stained blackwater streams. Found in forest covered streams including peat adjacent areas. Slow-moving streams flowing through forested swamps and wetlands. The species is confined to small lagoons and slow flowing streams and once established in a territory generally does not migrate given the isolation of the lagoons they inhabit. Typically spend daylight hours confined in and around structure (logs, weed, water lilies and grass banks) and move out of the structure to feed at night.
Hibernation	This species is not known to be able to establish a breeding population, nor survive long, outside of their restrictive temperature range.
Breathe Atmospheric Air	Arowana are unable to breathe atmospheric air.[Discussions with breeders]

Scleropages formosus (continued)	
Diet	Young individuals feed on insects at the water surface while adults may also take fishes and smaller vertebrates.
Behaviour (social, groupings, territorial & aggressive)	Arowana can be found in solitude or in small unified breeding groups. Due to the size and aggressive nature of this species dense populations are unable to form in the small habitat streams and lagoons in which that inhabit. Adult fish are opportunistic feeders and will prey on juvenile conspecifics. Large breeding adults will pair for life and develop a territory which they will aggressively defend.
Natural predators	Birds of prey. Larger individuals of same species.
Characteristics that may cause harm to Humans	There are no known characteristics of this species that could cause harm to humans.
Characteristics that may cause harm to other species	The Arowana is a predatory fish and will prey on smaller fish, insects and invertebrates.
Resilience	Low, minimum population doubling time 4.5 - 14 years *[www.fishbase.org]* (tm = 3-4; Fec = 50 (in concrete tanks)) [Rowley *et al.* 2008*]*

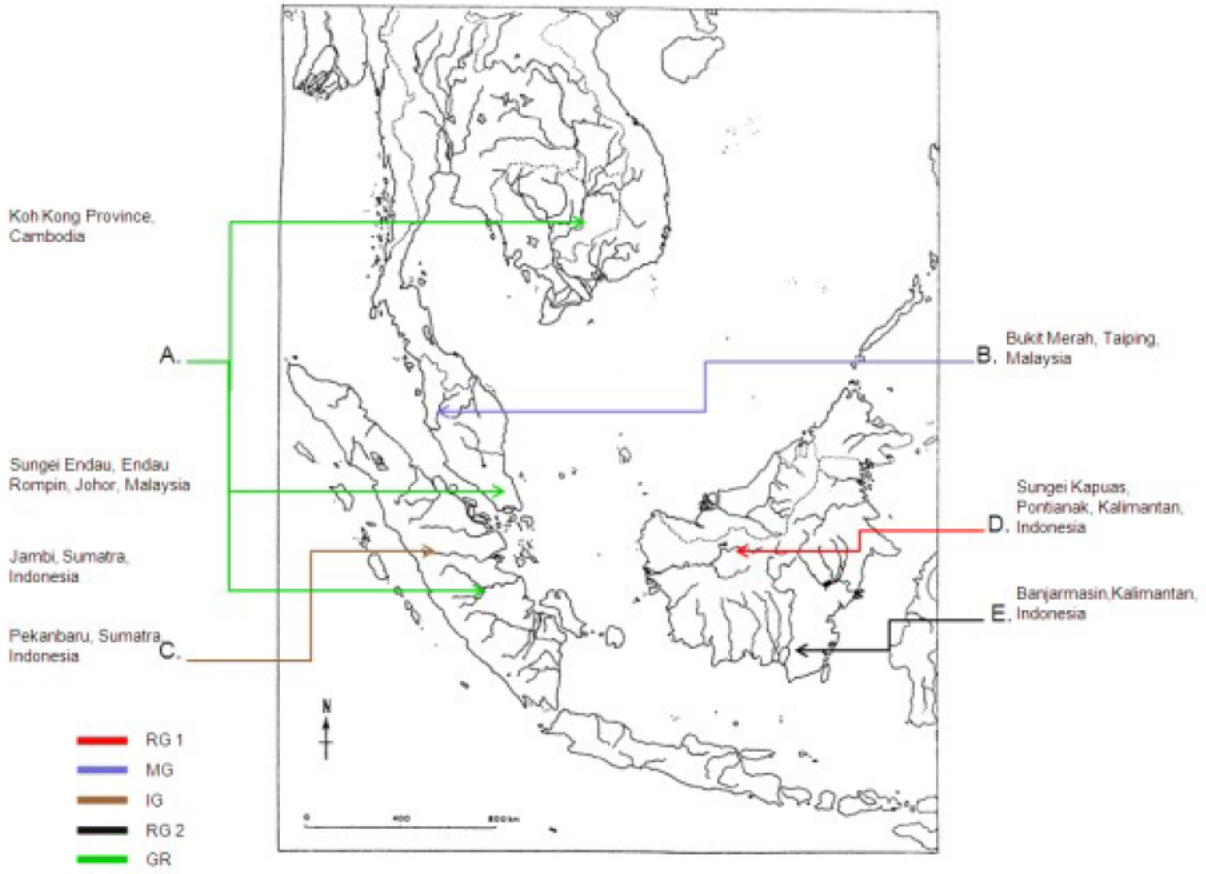


Figure 3 - Distribution map displaying the geographic locations of different colour variations. RG1 is red, MG is Malaysian golden, IG is Indonesian gold, RG2 is red grade 2 and GR is green (Chang Kuok Weai Alex, 2010)

Colour variations of the Asian Arowana naturally occur in different geographical locations through South East Asia. Colour variety is endemic to single geographical locations except green which is found in Cambodia, Peninsular Malaysia and Indonesia.

5.0 REPRODUCTIVE BIOLOGY

Genetic studies confirmation shows the ancestor of the Asian Arowana diverging from the ancestor of the Australian Arowana, *Scleropages jardini* and *Scleropages leichardti*, about 140 million years ago, during the early Cretaceous period. This divergence took place in the eastern margin of Gondwanaland, with the ancestors of Asian Arowana being carried on the Indian subcontinent or smaller landmasses into Asia. Phylogenetic relationships among the Family Osteoglossidae (bony fish) was developed by Pouyaud *et al.* (2003) Figure 7.

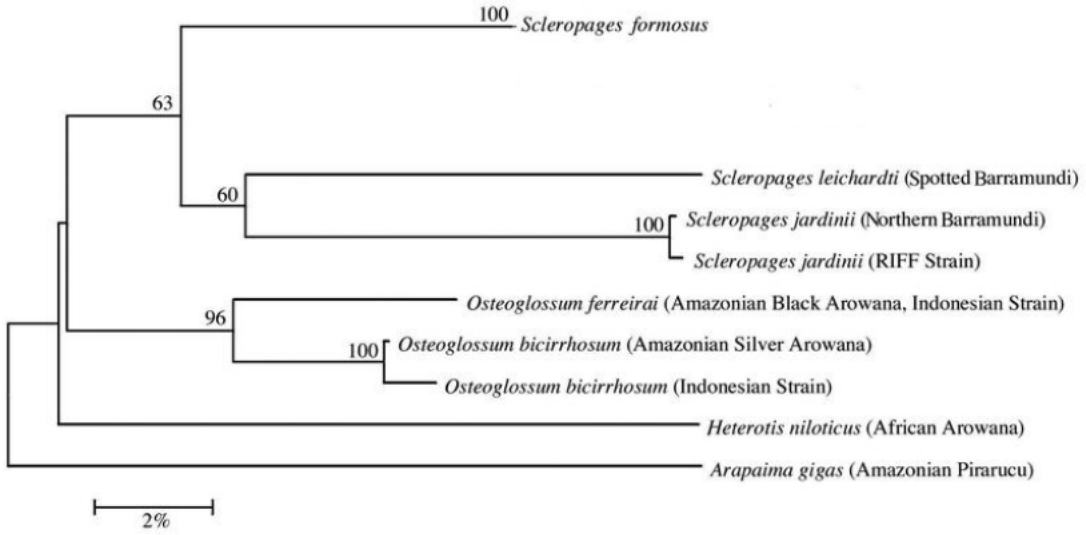


Figure 7 – Phylogenetic relationship among the Family Osteoglossidae (modified from Pouyaud *et al.* 2003)

Table 4 – Reproductive Biology of the Asian Arowana

Sexual Maturity	3 to 4 years of age. [Fishbase.org]
Ability to reproduce • **Triggers** • **Breeding site requirements** • **Frequency of breeding**	Arowana spawn during the rainy season beginning in August each year. Arowana are mouth brooders and young fish are incubated in the mouth of the **male** parent until free-swimming. Males mature in their 2+ year at 30 – 45 cm in length. In mature specimens the testis remain small, and little sperm is produced. Some females mature in their 2+ year, although at that time, most have only reached the stage of secondary oocyte production. The chorion and follicular granulosa of secondary oocytes are deeply invaginated into the cytoplasm. All fish spawn in their 3+ year, when 45–60 cm in length. The single ripe ovary contains 20–30 ova. [Müller & Schlegel, 2006] Arowana produce relatively few (20-80), extremely large eggs (12-15 mm in diameter) and they are mouth-brooded by one of the parents for 40-50 days. The free-swimming larvae can be first seen after 35-42 days with the large yolk sac fully absorbed. During this period of time they are typically highly alert and clustered together for protection and returned rapidly into the buccal cavity of the parent when sensing danger. After 45 - 48 days, the free-swimming larvae are released to fend for themselves. Larvae will seek shelter at shallow waters where aquatic and semi-aquatic vegetation provide plenty of protection and enough source of food such as worms, insects, insect larvae and small fish/fish larvae. [Chang Kuok Weai Alex, 2010]
Ability of species to hybridise	Successful hybridisation has only been documented to have been achieved between the various colour strains of *Scleropages formosus*. [Chang Kuok Weai Alex, 2010]
Hybridise with Australian Species	There is no recorded documentation of hybridisation between *Scleropages formosus* (Asian Arowana) and the Australian species *S. jardini* and *S.leichardti*. Farms have also shown that the colour strains interbreed readily whilst, there have not been successful breeding events between the three *Scleropages* species. In previous publications, *S. leichardti* and *S. jardinii* have both been described as **female** mouthbrooders and this might be one of the reasons why interspecific hybridisation has not yet occurred. [Chang Kuok Weai Alex, 2010]
Sexing change ability	Gonochoristic (single sex either male or female and do not have to ability to alter sex).

6.0 ESTABLISHMENT OF FERAL POPULATIONS

There is limited available information on the establishment of breeding populations of *Scleropages* outside of their natural range, however, Table 5 displays a register of all known introductions (total of 27) [Fishbase.org, 22nd July 2014There has been only one occasion out of 27 introductions where the species has been able to establish a population and this occurrence was within its natural range (Singapore) although it is not known if this population is currently still established. There has been no record of the Asian Arowana establishing as a pest on any other content. This may be attributed, in part, to the limited number of releases and the high monetary expense associated to releasing a quantifiable number of specimens to a suitable location.

Table 5 – Register of all known introductions [Fishbase.org, 22nd July 2014]

Year / Period	From	To	Established	Ecol. effects
Unknown	Unknown	United Kingdom	no data	
Unknown	Unknown	Korea	no data	
Unknown	Unknown	Malaysia	no data	
Unknown	Unknown	Mauritius	no data	
Unknown	Unknown	New Zealand	no data	
Unknown	Unknown	Norway	no data	
Unknown	Unknown	Philippines	no data	
Unknown	Unknown	Russia	no data	
Unknown	Unknown	Saudi Arabia	no data	
Unknown	Unknown	VietNam	no data	
Unknown	Unknown	Switzerland	no data	
Unknown	Unknown	Thailand	no data	
Unknown	Unknown	Japan	no data	
Unknown	Unknown	Israel	no data	
Unknown	Unknown	Indonesia	no data	
Unknown	Unknown	Australia	no data	
Unknown	Unknown	Bangladesh	no data	
Unknown	Unknown	Brazil	no data	
Unknown	Unknown	Brunei	no data	
Unknown	Unknown	Canada	no data	
Unknown	Unknown	Sri Lanka	no data	
Unknown	Unknown	Taiwan	no data	
Unknown	Unknown	France	no data	
Unknown	Unknown	Germany	no data	
Unknown	Unknown	India	no data	
1980 - 1989	Unknown	Singapore*	established	probably none
1990	Thailand	China	unknown	unknown

*Arowana is naturally occurring in this location.

7.0 ENVIRONMENTAL RISK ASSESSMENT

The Applicant found no documented environmental risk assessment on Genus *Scleropages* undertaken for Australia, or any other country.

Within Australia the species *Scleropages formosus* was grey listed by the National Ornamental Fish working group as a species which required further assessment for its potential risk to the Australian Environment due to importing into the country. In May 2014 a report by Marty Deveney and Kathleen Beyer, "Assessing the risks associated with the Australian trade in live ornamental fish species: development of a risk assessment tool" was published on the Department of Environments website in which assessed *Scleropages formosus*.

The report was published by the South Australia research and Development Institute (SARDI) and supported by the former Ornamental Fish Management and Implementation Group (OFMIG: now Freshwater Fish Working Group) and the OFMIG Technical Working Group (TWG). Funding for the report was through OFMIG by the Australian State and Territory Governments and the Commonwealth Department for Sustainability, Environment, Water, Population and Communities (SEWPaC), and the Department for Agriculture, Fisheries and Forestry (DAFF) through the Natural Resource Management Ministerial Council (Deveney, and Beyer (2014)).

The objective of this report was to develop a robust tool for assessing grey listed ornamental aquarium fish within the Australian aquarium trade. The report assessed *Scleropages formosus* finding it to be a low risk species that could be traded freely with little risk of an invasion occurring within Australia. The complete risk assessment and scoring calculated by Deveney and Beyer (2014) is attached (Appendix 5). Deveney and Beyer (2014) calculated a score of 13, with a scale of 1 representative of no risk and 1000 representative of a high risk.

An independent risk assessment has also been completed by the applicant and is discussed further in this report (Section 9.0).

8.0 ASSESS LIKELIHOOD OF ESTABLISHING BREEDING POPULATION IN AUSTRALIA

To assess the likelihood of establishing a breeding population within Australia, the applicant adopted the Five Rank Risk Outcome System by Bomford (2006). Bomford had modified the *Four Rank Risk Outcome* System developed by Bomford and Glover (2004).

Bomford (2006) proposes five key factors associated with the establishment success of exotic fish in Australia. Adding the scores for each of these factors provides a rank that can be used as the likelihood portion of the risk calculation. The factors include:

(i) Climate match;
(ii) Overseas geographic range size;
(iii) History of establishing exotic populations elsewhere;
(iv) Number of release events; and
(v) Taxonomic group.

Table 6 – Establishment Risk Score ranges based on Bomford and Glover (2004), modified by Bomford (2006).

Establishment Risk Rank	Establishment Risk Score Ranges*
Very low	0 – 6
Low	7 – 8
Moderate	9 – 11
High	12 – 17
Very High	18 – 20
Extreme	21 - 24

*The threshold scores for these Establishment Risk Score ranges were selected to maximise discrimination.

Based on Bomford's (2006) modified *Five Rank Risk Outcome*, the Asian Arowana (*S. formosus*) was calculated a Low risk of establishment within Australia (Establishment Risk Score = 8, based on the calculations in Appendix 4).

Another risk assessment tool established by Deveney and Beyer (2014) investigated the potential establishment of feral populations by *S. formosus* and also resulted in a low risk result (see Section 7.0).

Based on the calculations here (and Appendix 4), and the results from Deveney and Beyer (2014) (see Section 7), it is the applicant's opinion that *Scleropages* sp. are a low risk species that could be traded freely with little risk of an invasion occurring within Australia (Table 7).

Table 7 – Summary of Establishment Risk Scores *Scleropages formosus*

Application of *Bomford and Glover (2004), modified by Bomford (2006)*	*Deveney, M. and Beyer, K. (2014)*
Low Risk	Low Risk

In addition to the information provided above, it should be noted that;

- *S. formosus* is a top order predator with small natural population size (Fernando *et al*., 1997), and
- adults are territorial and therefore quite spatially dispersed (Ng and Tan, 1997).

These factors alone would prove to make the establishment of feral populations quite difficult. Further, wild-caught animals are typically more successful at establishing exotic populations than captive-reared animals (Griffith *et al*. 1989, Wiley *et al.* 1992, Snyder et al 1994, Wolf et al 1996) and all traded Arowana are required to be a *minimum* second generation captive bred specimen. These factors would suggest the establishment of ferrel populations in Australia highly unlikely.

9.0 IMPACT OF SPECIES IF ESTABLISHED IN AUSTRALIA

Deveney and Beyer (2014) reviewed the potential impact on the environment for importing *Scleropages formosus* using a very detailed in depth assessment. Those authors suggest the Low Risk assessment of this species justifies free trade of this species with low risk of invasion occurring (Deveney and Beyer (2014)).

Although assessed to have a low risk of invasion if introduced it can never be assumed that the fish would not be released. So in addition to the assessment undertaken by Deveney and Beyer (2014), the applicant has developed an independent risk assessment (Appendix 6). Based on this risk assessment undertaken the following events were initially considered key risk factors (refer Appendix 6 for all risk events identified and assessed).

Table 8 – Events risk register

No. #	Event	Likelihood	Risk Score*
1	Disease outbreaks into native waterways affecting native flora & fauna as a direct result of importing *S. formosus.*	Possible	H6
2	Native species (*S. jardini* and *S.leichardti*) wiped out or numbers reduced due to competition.	Possible	M9
3	Species (*S.* formosus) establishment in Australian waterways with a breeding population	Unlikely	M10
4	Endanger existing native species (*S. jardini* and *S.leichardti*)	Unlikely	M10
5	Eradication of native aquatic flora & fauna	Unlikely	M10
6	Develops feral populations	Unlikely	M14
7	Reduced gene pool for native species *S. jardini* & *S. leichardti*	Unlikely	M14

*L – Low, M – Medium and H – High; Numerals: 1 – Catastrophic & almost certain to 25 – Rare & insignificant

Following the initial medium to high risk ranking of these events the applicant continued to re-assess following additional research information and mitigation/control methods for each event (Table 9).

Table 9 – Proposed mitigation and controls and the resulting recalculated risk score.

Event #	Additional information	Proposed controls (in order of precedence)	Residual Risk Score
1	*S. formosus* is described as a host of some pathogens and parasites of low significance. (Fishbase 2012, Rainboth 1996). Due to the high quality of these ornamental fish and low quantities of potential import (due to low numbers available), disease shall be controlled and contained through the current Australian Quarantine process. The Department of Agriculture - Biosecurity (DAFF Biosecurity) has established a range of quarantine procedures under the *Quarantine Act 1908*.	1. Grant the applicant sole permission to import/ export Scleropages in Australia for a period of five years to allow a controlled introduction of the species. Use the species as a test case and collaboration effort with the applicant to obtain real time data (transactional information, number of species imported, distribution etc.) to assist in future assessments and amendments to the live importation list. 2. Limit importing to a select number of CITES approved farms/ breeders, to reduce the numbers of fish being imported and also assists in quality and disease management. 3. Limit importing to businesses with single species import (i.e. limit to businesses who purely import Arowana only and no other species). Given the nature of the species being a high end quality fish, limiting imports to those businesses who will deal in Arowana alone will increase the quality of fish imported, assist in disease management and reduce the potential for mass importation. 4. Track location of species through a national database using the CITES microchips as ID's. 5. Similar to upper market reptiles within Australia a license could be introduced to track where each individual specimen is at any one time. 6. Sale of species would be limited through the high cost to purchase and difficulty to the keep species. 7. S. formosus is a CITES listed species which is considered to be critically endangered. This factor along with its highly prize value as an ornamental aquarium fish maintains the cost of individuals as one of the most expensive fresh water aquarium fish globally. As such, one approach to control/ eradicate any potential population could simply consist of advertising the location of the outbreak and allowing individuals caught to be retained by those who capture them (once tagged and recorded in the records database), or these fish could be sold back to international breeders and hobbyist. Alternatively fish could be caught through electrofishing, spot lighting on water's surface at night or netting the small lagoons and streams that they would inhabit. As this species typically inhabits very small water bodies, it may be possible in extreme circumstances to use a biodegradable fish poison such as rotenone to eradicate the population.	L19
2	Multiple Arowana are required to be released into the same location. Arowana do not pair up with every male/female combination, they are a more selective when choosing appropriate breeding partners. They will also pair for life. As such a large number would need to be released to have even a low chance of a breeding pair establishing. In addition the financial expense of these fish makes it unl kely that anyone would intentionally release such large numbers for a low chance of a return.		L19
3	• *S. formosus* would have a restricted range where it could be established in Australia, isolated to small streams & lagoons in Far north QLD and Far northern NT. • Natural predators such as crocodiles, barramundi, birds of prey etc. would also impact on species ability to establish. • Native established populations of *S. jardini* would also make it difficult for species to establish as the *S. jardini* is also a highly territorial species.		L19
4	Due to the limited range of this species habitat and highly restricted rate of reproduction, it would be unlikely to foresee the species being able to establish a population which could bring another species (*S. jardini*) to extinction. It should also be noted that *S. leichardti* exists outside the ideal climate conditions sort by *S. formosus* (refer to CLIMATCH results). Also refer to comment 2, above.		L19
5	There is no evidence in literature of cases found where S. formosus has had an impact on native flora or fauna (Deveney and Beyer, 2014) and it is not unl kely that this would eventuate in Australia, should the species be released. As per comment 4, above.		L19
6	As per comment 3, above.		L20
7	Currently there has been no known interbreeding between our native species & the Asian Arowana. A university thesis student in Singapore concluded in his studies that this may be due to the differing breeding processes between species. (Chang Kuok Weai Alex 2010).		L20

Based on the assessment (Appendix 6) summarised above, the residual risk of importing genus *Scleropages* into Australia has been assessed as a low risk (refer residual risk scores).

The applicant believes it would be of benefit to the Department of Environment, if any business potentially provided with a permit to import/ export *Scleropages* in Australia, was to maintain a complete database including number of import exports, distribution of fish within Australia, number of sales, mortality in captivity and any records of disease. This would allow complete control of the number of specimens in the country and provide a very descriptive and comprehensive database of all known individuals.

The Department of Environment (DoE) may also see benefit in granting the applicant sole permission to import/ export *Scleropages* in Australia for a period of five years to allow a controlled introduction of the species and to allow close and careful monitoring of the introduction of the genus as an ornamental species. This would allow a direct collaboration with the Freshwater Fish Working group and Deveney and Beyer (2014) to refine assessment tools. Should any unforeseeable concerns arise, with a single business operation, it would be possible for the DoE to respond in a timely and effective manner. Such a test case may provide an invaluable source of data to both the DoE and the Freshwater Fish Working group, data which is currently unavailable for any species of aquarium fish.

In assessing the potential impacts and risks, the applicant has also answered the following queries;

1. **Does the species have similar niche/living requirements to a native species?**
   In Australia there are currently two species with a similar niche, *S.jardini* and S. *leichardti*. CLIMACH Score (Bureau of Rural Science) indicates *S*. *formosus* has a similar distribution range to *S*. *jardini* only, with the *S. leichardti* preferring cooler water temperatures intolerable to *S. formosus*. Also see (Fishbase.org).

   If ferrel populations of *S. formosus* established in Australia they would likely use similar resources (food, waterholes & streams, breeding sites etc.) to the native *S*. *jardini*, however, as calculated in previous sections the likelihood of this event occurring is very low. (Deveney and Beyer (2014))

2. **Is the species susceptible to, or capable of transmitting any pests or disease?**
   S. formosus is described as a host of some pathogens and parasites of low significance by Fishbase (2012) and Rainboth (1996).

3. **Probable prey/food sources?**
   S. formosus is not known to prey on domestic or commercial animals or plants. Due to the size and nature of its diet *S. formosus* could only prey on small fish, invertebrates and potentially small marsupials such as mice if the opportunity presented itself.

   S. formosus feeds on zoobenthos and nekton. Young individuals feed on insects at the water surface; adults take fishes and smaller vertebrates (Vidthayanon (2002), Fishbase (2012).

4. **Impact on habitat and local environments?**
   - **Could the species reduce the ground vegetation cover to an extent where it could cause or increase soil erosion?**
     - There is no documented evidence of *S. formosus* reducing ground vegetation cover.
   - **Does the species construct burrows or dig near or around waterways?**
     - There is no documented evidence of *S. formosus* constructing or digging burrows.
   - **Has the species ever been recorded causing damage to: native animals' habitats; natural communities; native plants; forestry; agriculture?**
     - There is no documented evidence of this occurring as a result of *S. formosus*.

5. **Discuss any control/eradication programs that could be applied if the species escaped or was released within Australia?**
   S. formosus is a CITES listed species which is considered to be critically endangered. This factor along with its highly prize value as an ornamental aquarium fish maintains the cost of individuals as one of the most expensive fresh water aquarium fish globally. As such, one approach to control/ eradicate any potential population could simply consist of advertising the location of the outbreak and allowing individuals caught to be retained by those who capture them (once tagged and recorded in the records database), or these fish could be sold back to international breeders and hobbyist. Alternatively fish could be caught through electrofishing, spot lighting on water's surface at night or netting the small lagoons and streams that they would inhabit. As this species typically inhabits very small water bodies, it may be possible in extreme circumstances to use a biodegradable fish poison such as rotenone to eradicate the population.

6. **Behaviours that cause environmental degradation?**
   - **Behavioural characteristics. Describe any behaviours of the species which cause physical disturbance to the environment e.g. hooves, digging etc.**
     - There is no literature documenting behavioural characteristics by *S. formosus* which would cause disturbance to the environment.
   - **Does the species eat or disturb wetlands/wetland vegetation?**
     - *S. formosus* consumes live food in the wild or pellets within an aquarium. The species is not known for eating or disturbing wetlands or wetlands vegetation and there are no documented cases of this.
   - **Could the species cause pollution of water bodies?**
     - There is no literature documenting evidence of *S. formosus* polluting waterways in any way.

7. **Impact on primary industries?**
   There is no documented evidence of *Scleropages* having any impact on primary industries of any sort and it is expected that if the species were to establish a wild population within Australia it would have no impact on any of our current primary industries.

8. **Is the species a nuisance or danger?**
   S. formosus has not been documented as having any characteristics considered to be a social nuisance or danger.

9. **Describe any potentially harmful characteristics of the species?**
   There is no documented evidence in the literature to suggest that *S. formosus* have any harmful characteristic towards humans (Deveney and Beyer (2014)) *S. formosus* is described as a host of some pathogens and parasites of low significance (Fishbase (2012), Rainboth (1996)).

10.0 WHAT CONDITIONS OR RESTRICTIONS COULD BE APPLIED TO THE IMPORT OF THE SPECIES TO REDUCE ANY POTENTIAL NEGATIVE ENVIRONMENTAL IMPACTS

It is recommended that *S. formosus* is placed on Part 2 of the Live Import list and regulated initially through the release of a single license restricted for five years and granted to the applicant for a controlled introduction into Australia. This is an opportunity for the industry and regulators within Australia to use the information gathered from the applicant in a controlled manner to further refine future risk assessment tools, evaluate future amendments to the live import list and provide for timely and effective response to any unforseen concerns and incidents that may arise from the introduction.

The following restrictions to the Part 2 license could also be considered;

a) Limit to Australian Businesses only.
b) Limit to Australian Businesses who solely import Scleropages *formosus* (i.e. do not import other species) for quality control and reduce the opportunity for mass importation.
c) Limit each License to import from a maximum of three farms/breeders only.

Additional controls in order of precedence could be as follows:

1. Limit the number of CITES certified farms/breeders available for import into Australia to a maximum of ten farms and ensure that there is always a minimum of five farms approved for import into Australia. This will have two effects, ensure that the selected farms are ethical farms and also limit the number of fish imported into Australia to reduce any residual risk of import.

   By acting in an unethical manner some breeders have been documented deceiving customers through altering fish colour with particular food & hormones, changing the storing tanks lighting and even blinding the fish with needles to artificial pronounce darker more marketable colours. Fish are also sold when juvenile and not displaying adult colours as higher quality fish. By limiting the import list to a maximum of ten farms would both promote ethical behaviour within the industry and also reduce the risk on import to Australia.
2. Track the location of individual specimens through a national database using the CITES microchips as ID's, as all imported fish are required to be micro chipped under the existing CITES regulations.
3. Similar to the existing upper market reptile trade within Australia a license could be introduced to track where each individual specimen is at any one time (i.e. individual owners to hold a license for each individual fish).
4. Limit the distribution to below Latitude 16' 20" within Australia. Location is below the lower extent to which the *S. Jardini* is known to inhabit. It should be noted that *S. leichardti* inhabits further southern extents which *S. formosus* could not inhabit and thrive.

11.0 SUMMARY OF PROPOSED ACTIVITY

The following is a list describing the intended purpose of import.

1. Primary intended purpose for the import of *Scleropages formosus* is exclusively to be traded live in the ornamental aquarium fish industry as pets.
2. A secondary intended purpose of import would include captive breeding for commercial ornamental aquarium trade.
3. It is noted this species is **currently traded within Australia** as juveniles. The applicant considers that the currently traded juvenile fish are illegally imported and intends to reduce the risk of this illegal activity by providing an avenue for enthusiasts to access the species legally in a controlled and low risk manner.

The primary reason for choosing *Scleropages formosus* as the topic of this report is to assist in promoting further awareness and conservation of a CITES listed critically endangered fresh water fish. By allowing the import into Australia would enable the applicant to assist in establishing an ethical trade of these fish and also enable the applicant to assist in the international conservation efforts as well. It is the intention of the applicant to research avenues to establish or sponsor existing farms to breed juveniles to restocking programs within the bounds of their natural waterways.

The applicant initially intends to import approximately 50-100 juvenile fish per month, with the numbers of imports following the initial order varying dependent upon demand and supply.

As discussed in the Section above (refer Section 3.0), this species is endangered and on CITES Appendix list I (refer Appendix 1) and as such all animals are regulated through CITES and must only be imported and obtained from CITES permitted farms.

12.0 GUIDELINES ON HOW THE SPECIES SHOULD BE KEPT

Transportation of the fish for import and export purposes have been set out by both CITES regulations and the regulations of the country of export and import. A good example of effective controls for export/import is demonstrated through Singapore Agri-Food and Veterinary Authority. (www.ava.gov.sg) The Singapore Agri-Food and Veterinary Authority (AVA) have specific requirements in place for import/export of the Asian Arowana and these have been based on the requirements as set-out by CITES. These requirements would also be valid for the import into Australia as they are standard requirements requested by CITES. The requirements are as follows.

1. Licensee is permitted to only import and export/re-export Asian Arowana from CITES-registered captive-breeding operations.
2. For export, every Asian Arowana must be implanted with one microchip at the dorsal muscle before CITES permit application and according to the conditions of the AVA's Arowana Fish Farm Registration Scheme.
3. For export in which the Asian Arowana has been pre-packed for inspection, there must be only one Asian Arowana in each packing bag. The packing bags must be clear or allow easy viewing by AVA inspectors. Consignments that do not meet the conditions will not be inspected and not allowed for export.
4. For import, there shall only be one Asian Arowana in each packing bag. The packing bags must be clear or allow easy viewing by AVA inspectors.
5. Styrofoam boxes used to contain Asian Arowana for export must be placed in paper carton boxes for sealing by the AVA. Consignments that do not meet AVA's requirements will not be allowed to be exported/re-exported.
6. For import and export of Asian Arowana, the fish must arrive or depart through Changi Airfreight Centre with inspection at CAPQ, unless approval has been sought for entry/exit through other port of entry/exit.
7. All consignments of Asian Arowana to be exported must be inspected and sealed by the AVA prior to departure from Singapore

Currently there are no official documented standards in place for the housing of Arowana. Arowana are known to grow to lengths of 90cm and as such best practice would suggest they should be kept in an aquarium of a minimum length of at least 1.5m and be sufficiently wide for the fish to turn around easily i.e. >60cm wide. Juveniles could be kept in smaller aquariums in the short term.

Containment of male and females specimens would not be possible to control due to the level of experience required to sex these fish. It would also not be possible until the fish reached maturity at approximately 3 – 4 years of age.

As these are typically a temperamental fish sensitive to changes, for benefit of the fishes welfare, the applicant recommends each is kept in a "For Life" aquarium (i.e. an aquarium that can comfortably house the fish at its mature size and comfortably allow for freedom to swim and turn around).

13.0 STATE AND TERRITORY CONTROLS

There are currently no restrictions to keeping the species *S. formosus* within any of the states or territories within Australia. Refer to the attached Appendix 7 for a comprehensive list of all freshwater fish species which are prohibited within Australian states and territories.

14.0 CONCLUSION

The applicant has reported that two independent risk assessments have identified *S. formosus* poses a low risk of import to the Australian environment. While there is a low risk to the Australian environment, the applicant is requesting that the control of the import of *S. formosus* into Australia is to be considered as explained below.

To minimise the current occurrence of unethical and inhumane procedures to alter the nature of colour of fish, such as blinding fish (Section 10.0) by certain farms and persons, it is highly recommended that the import of this species into Australia is initially restricted to a maximum of ten farms/ breeders. The applicant has established working relationships with a small number of farms in Asia and can assist in choosing farms which could provide high quality and healthy fish that represent a low disease and escape risk within Australia.

The applicant also proposes a unique opportunity through the release of a single license restricted for five years and granted to the applicant alone for a controlled introduction into Australia. This could be used exclusively on this fish as a test case to refine the Risk Assessment Tool recently developed by Deveney and Beyer (2014) in a controlled and transparent manner. Significantly, the mitigation measures identified by the applicant (Section 9.0) to minimise the identified risks could be slowly assessed and reviewed regularly for effectiveness. A slow introduction such as this would also provide the opportunity for the Department of Environment to respond in a timely and effective manner should any unforseen concerns be raised.

The applicant could make information such as number of sales, location of sales, location of individual fish (tracking database) and import farm details available to both the Department of Environment and the Ornamental Fish Working group in Australia to use to assist future evaluations.

It is considered based on the assessments undertaken within this report that *Scleropages formosus* and *Scleropages inscriptus* should be included on the current list of species allowed to be imported into Australia. Furthermore it should be considered to place this species on Part 2 of the Live Import list and that the applicant is granted a five year exclusive license to control, regulate and document this new introduction into the Australian market.

REFERENCES

1. http://www.dfat.gov.au/
2. http://www.cites.org/eng/disc/what.php
3. http://www.speciesplus.net/
4. http://www.ava.gov.sg/AnimalsPetSector/ImportExportTransOfAnimalRelatedPrd/OrnamentalFish/ImportandexportDragonFish.htm
5. http://www.fishbase.org/summary/*Scleropages*-formosus.html
6. http://library.enaca.org/AquacultureAsia/Articles/July-Sept-2003/July-Sept-2003.pdf#page=6
7. http://taxo4254.wikispaces.com/*Scleropages*+formosus+(M%C3%BCller+and+Schlegel,+1844)
8. Müller, S. and H. Schlegel, 1840 - Verhandelingen over de natuurlijke geschiedenis der Nederlandsche overzeesche bezittingen, Leiden: 1-7
   Beschrijving van een' nieuwen Zoetwater-visch van Borneo, Osteoglossum formosum.
9. Kottelat, M., 2013 - The Raffles Bulletin of Zoology Supplement 27: 1-663
   The fishes of the inland waters of Southeast Asia: a catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries.
10. Kottelat, M. and E. Widjanarti , 2005 - The Raffles Bulletin of Zoology Supplement 13: 139-173
    The fishes of Danau Sentarum National Park and the Kapuas Lakes area, Kalimantan Barat, Indonesia.
11. Pouyaud, L., Sudarto and G. G. Teugels , 2003 - Cybium 27(4): 287-305
    The different colour varieties of the Asian Arowana *Scleropages* formosus (Osteoglossidae) are distinct species: morphologic and genetic evidences.
12. Roberts, T. R., 2012 - Aqua 18(2): 113-118
    Scleropages inscriptus, a new fish species from the Tananthayi or Tenasserim River basin, Malay Peninsula of Myanmar (Osteoglossidae: Osteoglossiformes).
13. Van Oijen, M. J. P. and S. E. T. van der Meij, 2013 - Zootaxa 3722(3): 361-371
    The types of Osteoglossum formosum Müller & Schlegel, 1840 (Teleostei, Osteoglossidae).
14. The *IUCN* Red List of Threatened Species*, 2011* - www.iucn.org/
15. The reproductive biology of *Scleropages formosus* (Müller & Schlegel) (Osteoglossomorpha, Osteoglossidae) in Malaya, and the morphology of its pituitary gland, D. B. C. Scott and J. D. Fuller, *24 JAN 2006*
16. Molecular Analysis of the Breeding Biology of the Asian Arowana (*Scleropages formosus*), (*Chang Kuok Weai Alex),* Thesis National University of Singapore, *2010*
17. Bomford, M. (2003) Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia. Bureau of Rural Sciences, Canberra.
18. Mary Bomford and Julie Glover June (2004) Risk assessment model for the import and keeping of exotic freshwater and estuarine finfish, A report produced by the Bureau of Rural Sciences for The Department of Environment and Heritage
19. Mary Bomford (2006), Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models, Bureau of Rural Science
20. Rowley, Emmett and Voen (2007), Harvest trade and conservation of the Asian arowana Scleropages formosus in Cambodia
21. Andy Moore, Nicholas Marton and Alex McNee (March 2010), A strategic approach to the management of ornamental fish in Australia communication strategy and grey list review - A REPORT TO OFMIG, Department of Agriculture Fisheries and Forestries
22. Bomford, M. (2008). Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand. Invasive Animals Cooperative Research Centre, Canberra.

23. Deveney, M. and Beyer, K. (2014). Assessing the risks associated with the Australian trade in live ornamental fish species: development of a risk assessment tool. Report to Freshwater Fish Working Group of National Biosecurity Committee. South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

APPENDIX 1 – CITES Appendix I

For the purpose of this report the applicant has referenced CITES Appendix I and provides the following link for a complete list of species included in this list - http://www.cites.org/eng/app/appendices.php

APPENDIX 2 – CITES Appendix II

For the purpose of this report the applicant has referenced CITES Appendix II and provides the following link for a complete list of species included in this list - http://www.cites.org/eng/app/appendices.php

APPENDIX 3 – CITES Appendix III

For the purpose of this report the applicant has referenced CITES Appendix III and provides the following link for a complete list of species included in this list - http://www.cites.org/eng/app/appendices.php

APPENDIX 4 – ESTABLISHMENT LIKELIHOOD ASSESSMENT

Four Rank Risk Outcome system developed by Bomford and Glover (2004) and modified by Bomford (2006) to a *Five Rank Risk Outcome* system.

RISK OF ESTABLISHMENT WITHIN AUSTRALIA:

Method 1: Five Rank Risk Outcome – [Bomford and Glover (2004), modified by Bomford (2006)]

This assessment identifies five key factors associated with the establishment success of exotic fish within the Australia environment. These include:

(i) Number of release events
(ii) Climate match
(iii) History of establishing exotic populations elsewhere
(iv) Overseas geographic range size
(v) Taxonomic group

Establishment Risk Score = ***Score A*** + ***Score B*** + ***Score C*** + ***Score D*** + ***Score E***.

Step 1 - **Score A** (Climate match score to Australia 0–8):
{Is an index of factor (ii): climate match}

Score A = Obtained from a correlation of **Value X**

Value X = Sum the values for the six highest match classes (ie the scores for match levels 10, 9, 8, 7, 6 and 5)

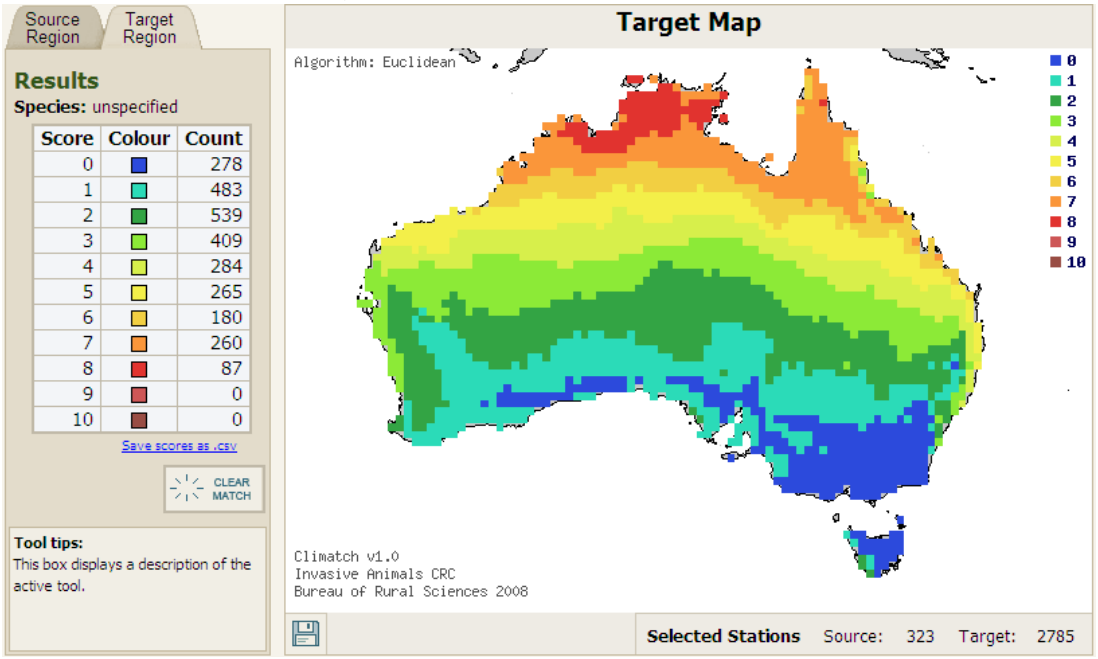


Figure 1: Results from Climatch v1.0 – Bureau of Rural Science
http://www.brs.gov.au/climatch

Scleropages Formosus: **Value X** = 265 + 180 + 260 + 87 + 0 + 0 = 792

Table 1: Convert Value X to a Climate Match Score (1–8) using the following cut-off thresholds:

CLIMATE Euclidian Sum Level 5 (Value X)	*Climate Match Score*
0	*1*
1–40	*2*
41–150	*3*
151–400	*4*
401–1000	*5 (Scleropages formosus)*
1001–1500	*6*

1501–2500	*7*
> 2500	*8*

Step 2 - **Score B** (Overseas range score 0–4):
{Score B uses the number of occurrence records in Fishbase as an index of factor (iv): overseas geographic range size}

Score B = Overseas Range Scores are calculated using the table below. Count the number of grid squares (1° latitude x 1° longitude) in which an occurrence of the species is recorded in Fishbase, excluding Australia.

Fishbase records 12 occurences.

Score B:
0: ≤4
1: 5–10
2: 11–20
3: 21–30
4: ≥31

Step 3 - **Score C** (Establishment score 0–3):
{Scores C and D are indices of factor (iii): history of establishing exotic populations elsewhere}

Score C = Locations where successful introductions of the species have occurred excluding Australia – from Fishbase (2004). Where there are no recorded introductions, a moderate risk ranking is given, although a precautionary approach could warrant a higher risk score being given.

Score C:
0: Introduced but never established
1: Never introduced
2: Only established exotic population(s) on island(s) or on one continent (from choice of five continents not including Australia: Africa; Europe; Asia; North and Central America; or South America)
3: Established exotic populations on more than one continent (excluding Australia).

(Scleropages Formosus) – Score = 0 *[Introduced and Established in Singapore in 1989, within natural occurrence range]*

Step 4 - **Score D** (Introduction success score 0–4):
{Scores C and D are indices of factor (iii): history of establishing exotic populations elsewhere}

The number of known successful introductions of the species worldwide expressed as a proportion of the total number of introductions – from Fishbase (2004) excluding Australia. Where there are no recorded introductions, a moderate risk ranking is given, although a precautionary approach could warrant a higher risk score being given.

Score D:
0: Introduced but success rate = 0 [Only known successful release of the species from Fishbase (2004) was a release in Singapore within the natural distribution, i.e. re-stocking process rather that an introduction]

1: Success rate of >0 ≤ 0.25
2: Success rate of >0.25 ≤ 0.5

OR
Never introduced
3: Success rate of >0.5≤ 0.75
4: Success rate of >0.75≤ 1.0

Step 5 - **Score E** (Taxa risk score 0–5):

{Score E is an index of factor (v): taxonomic group.}

Success rates for worldwide introductions of the family or genus of the species being assessed.

Genus risk score: The genus risk score is used as the taxa risk score when number introduction events of all species within the same genus as the species being assessed
" 4.

Genus success rate % = 100(Number of successful introductions to all countries of species in the genus/Total number of introductions to all countries of species in the genus)

Fish Base:
Scleropages Jardini – 3 introductions, no measured success
Scleropages leichardti – 2 introductions, no measured success
Scleropages formosus – 27 introductions, 1 measured success

Genus success rate % = 100(1/32) = 3.125%

Score E:
0 = Very low: Success rate = 0%
1 = Low: Success rate >0%<10
2 = Moderate: Success rate 10%–25%
3 = High: Success rate >25%<40%
4 = Very high: Success rate 40%–60%
5 = Extreme: Success rate >60%

Calculating risk rating:

Establishment Risk Score = ***Score A*** + ***Score B*** + ***Score C*** + ***Score D*** + ***Score E***.
(Establishment Risk Score values = 0–24)

Establishment Risk Score (Scleropages formosus) = 5 + 2 + 0 + 0 + 1 = 8

Table 2: Establishment risk score Rankings
[Bomford and Glover (2004), modified by Bomford (2006)]

Establishment Risk Rank	Establishment Risk Score Ranges*
Very low	0 – 6
Low	7 – 8
Moderate	9 – 11
High	12 – 17
Very High	18 – 20
Extreme	21 - 24

*The threshold scores for these Establishment Risk Score ranges were selected to Maximise discrimination.

Using Five Rank Risk Outcome [Bomford and Glover (2004), modified by Bomford (2006)], Scleropages formosus is ranked as a low risk of establishment if introduced in Australia.

Method 2: Checklist

Assessment method one (1), Checklist method (further expanded upon with the RISK assessment Appendices):

1. Have the species had adverse impacts elsewhere – No recorded impacts documented from previous species releases.
2. Have close relatives with similar behavioural and ecological strategies caused adverse impacts elsewhere– No recorded impacts documented from the Genus Scleropages.
3. Is the species a generalist feeders – Yes, wild Arowana are generalist feeders which feed predominantly on live foods. Captive bred species are more specialist and tend to eat a more manufactured diet consistent of factory manufactured pellets and feeds.
4. Is the species considered a predatory fish – Yes, the Arowana is considered to be a fish of prey within its natural environment.
5. Is there any documented destruction, vegetation modification or major habitat changes as a direct cause from this species – There is no documented habitat destruction which has been attributed to the Arowana on any continent.
6. Does the species have the potential to cause physical injury to humans – No.
7. Will the species harbour or transmit harmful diseases or parasites – No documented cases.
8. Does the species have potential to hybridise with close relatives among native species – No documented cases. University thesis in Singapore concluded that the Hybridisation between Scleropages *formosus* and the Australian Scleropages *jardini* & *leichardti* had not occurred to date potentially due to the differing breeding behaviours between species.
9. Is the species known to spread rapidly following their release into new environments? – No. Due to the relatively low breeding cycle these mouth brooders do not spread rapidly in the wild. It is also documented that the species does not automatically pair male/female and is more particular in choosing breeding partners.

Based on the Checklist method of analysis two (2) out of nine (9) checklist questions for the Scleropages formosus would require a further Risk assessment and investigation. These have been documented within the Risk Assessment for this report (Refer to Appendix).

APPENDIX 5 – ASSESSING THE RISKS ASSOCIATED WITH THE AUSTRALIAN TRADE IN LIVE ORNAMENTAL FISH SPECIES: DEVELOPMENT OF A RISK ASSESSMENT TOOL

Deveney, M. and Beyer, K. (2014)

Deveney, M. and Beyer, K. (2014)
Assessing the risks associated with the Australian trade in live ornamental fish species

Risk Assessment
Latin name: ***Scleropages formosus* (Müller & Schlegel)**
Common name: **Asian arowana**

ID	Risk query	Type of question	Significance (*Why this is important for the analysis?*)	Guidance (*Explanation of how the risk query should be answered.*)	Response notes (*Include the answer for the species in question.*)	Response	Score (*Numerical response to risk query* .)	Risk to: A aquaculture; E Environment; H Human Health; T Trade; C combined.	Scoring method (*How to score the response to the risk query?*)	Max Score	References
1	Is the species a high, medium or low volume trade species?	Likelihood of release.	It is expected that a species traded at high volumes is more likely to be released into a new environment. This is related to the concept of propagule pressure, which postulates that the greater the propagule pressure the more likely a species' the invasion success.	Assess at which volume the species is traded at. The answer should be based on the response from stakeholder surveys and/or other suitable data sources.	No trade.	N	0	T	Score as follows: Volume of c	3	e.g. Rowley et al. (2008)
2	Is the species a high, medium or low value trade species?	Likelihood of release.	It is expected that a species traded at high value is less likely to be released. This question assumes that with increasing value of individuals of the species the likelihood of release decreases.	Assess at which value an individual of the species is traded at. The answer should be based on the response from stakeholder surveys and/or other suitable data sources.	*S. formosus* is a high value species.	L	3	T	Score as follows: No trade 0;	3	Rowley et al. (2008)
3	Does the species have a history of deliberate release?	Likelihood of release.	If a species has a history of deliberate release then this will increase likelihood of release.	Assess if the species has been deliberately translocated and/or introduced. This typically occurs in species with value as food or angling fish, bait or a perceived environmental benefit, such as mosquito larvae control.	*S. formosus* has a history of deliberate release; large numbers but only established in Singapore.	Y	1	C	Score as follows: If there is do	1	Rainboth (1996)
4	Does the species have a history of accidental release?	Likelihood of release.	If a species has a history of accidental release then this will increase likelihood of release.	Evidence of accidental translocation and introduction should be well documented, and includes accidental translocation and or introduction into new environments. Assess whether the species has been subject to accidental translocation and/or introduction.	No evidence in the literature.	N	0	C	Score as follows: If there is do	1	
5	Does the species have characteristics that make it more likely to be accidentally released?	Likelihood of release.	If a species has characteristics that make it more likely to be accidentally released then this will increase the likelihood of release.	Assess whether the species possess characteristics that makes it more likely to be accidentally released including: difficult to identify, commonly kept in systems that could allow them to escape, and attachment on equipment.	No evidence in the literature.	N	0	C	Score as follows: If there is do	1	
6	Does the species have characteristics that make it more likely to be deliberately released?	Likelihood of release.	If a species has characteristics that make it more likely to be deliberately released then this will increase the likelihood of release.	Assess whether the species possesses characteristics that makes a species more likely to be deliberately released including: rapid growth to a large size, very high fecundity, and known aggression in aquaria and/or ponds.	No evidence in the literature.	N	0	C	Score as follows: If there is do	1	
7	Is the species domesticated or reared in a way that makes it more or less likely to survive if released?	Likelihood of invasion.	Domestication has the potential to enhance fitness (in terms of growth rate, mating success and/or fecundity) in domesticated strains (including transgenic strains) over wild strains (e.g. Muir and Howard, 1999). Domestication or rearing in a way that makes it more likely to survive if released increases the likelihood of invasion.	Assess if the taxon has been selectively bred for traits of benefit to humans (domesticated) or subjected to other selection or genetic modification.	No evidence in the literature.	N	0	C	Score as follows: If a species d	1	
8	Are the individuals in question of an invasive race/variety/sub-species?	Likelihood of invasion.	If a species has an invasive strain/race/subspecies then this will increase the likelihood of invasion.	Assess whether the species is of an invasive race/variety/sub-species; i.e. assess whether the species is of a taxonomic rank below that of species, and as such can be allocated a three-part infraspecific name.	No evidence in the literature.	N	0	C	Score as follows: If a species b	1	
9	Has the species established populations outside their native range?	Likelihood of invasion.	If a species has successfully established self-sustaining populations outside their native range then this will increase the likelihood of invasion.	Assess whether there are records of established populations of the species in question outside their native range.	Has established in Singapore.	Y	1	C	Score as follows: No 0; Speci	5	Rainboth (1996)
10	Is species reproductive tolerance suited to climates in the risk assessment area?	Likelihood of invasion.	The likelihood of invasion increases as the number of climate zones in the species' native range matching with Australian climate zones increases.	Using an approved climate matching approach such as Climex, GARP or Climatch (which use the Koppen-Geiger climatic zones), assess how the climate in the species' native range matches the climate zone in Australia. The number of climate zones that occur in the species native range are to be compared with the number of climate zones present in Australia. A climate zone match is confirmed when a climate zone is found in both, the native range and Australia.	Native to Cambodia, Indonesia, Malaysia, Vietnam, Taiwan and in regions with some comparable Australian climate.	M	2	C	Score as follows: 0-No; 1-Low	3	Rainboth (1996)

11	What is the quality of the climate match?	Likelihood of invasion.	The likelihood of invasions rises as the quality of climate match data improves.	Assess this as an estimate of the quality of the data used to generate the climate match, and whether specific environmental requirements are present in the species' native environment that are not present in Australia.	Aw, Am, Af, Cfa, Cfb, Cfc, Bsh Koppen-Geiger climate types in native range vs Aw, Dfb, Bsh, Cfa, Cfb, BWh, BWk, Bsk, Csa, Csb climate types in Australia.	M	2	C	Score as follows: 0-No; 1-Low	3	Rainboth (1996)
12	Is the species environmentally versatile?	Likelihood of invasion.	Environmental versatility is directly proportional to the species' likelihood of invasion.	Assess whether for the species of the following traits at least three apply: euryhaline, desiccation tolerant, takes wide range of food items, tolerates a wide range of water quality conditions, habitat variability, oxygen depletion tolerance and high temperature tolerance.	Tropical; 24°C - 30°C. Occurs in tannin stained blackwater streams. Found in forest covered streams including peat adjacent areas.	Y	2	C	Score as follows: If more than	2	Rainboth (1996)
13	Is the species' native range well defined?	Likelihood of invasion.	If a species' native range is well defined then this will increase the likelihood of invasion.	Assess whether uncertainty regarding the species' native range exists. Uncertainty can be confirmed if the native range expansion is not well documented and/or unclear.	The native range is well defined.	Y	1	C	Score as follows: The score re	1	Rainboth (1996)
14	Does the species have invasive congeners?	Likelihood of invasion.	The status as a member of an invasive genus adds to the likelihood of invasion. Invasive history of a species and its congeners is deemed to be a good predictor of invasiveness potential (Ruesink et al., 1995; Reichard 2001).	Assess whether the species in question belongs to a genus that contains invasive species.	No evidence in the literature.	N	0	C	Score as follows: The status as	1	
15	Is the species unpalatable to predators?	Likelihood of invasion.	If the species is unpalatable to predators where it is likely to be present then the likelihood of invasion (reduced potential for biological resistance in the system) is increased.	Assess whether the species in question is unpalatable to predators in Australia.	Valued as a food fish.	N	0	A	Score as follows: If the species	1	Rainboth (1996)
16	Are predators absent from waters where the species is likely to become invasive?	Likelihood of invasion.	If predators are absent then the likelihood of invasion is increased.	Assess if the species is suited to and likely to be introduced to environments with no natural predators.	Predators present; most predation may take place during early life due to *S. formosus* large ultimate body size.	N	0	A	Score as follows: If predators	1	
17	Does the species exhibit parental care, is it a livebearer or mouthbrooder?	Likelihood of invasion.	If a species expresses parental care, mouth-brooding and/or live-bearing behaviour, this will increase its likelihood of successful establishment.	Assess whether the species possesses parental care, mouth-brooding and/or live-bearing behaviour. Parental care in fish includes the protection of the clutch after spawning. Mouth-brooding fish hold eggs or newly hatched young in their mouths. Live-bearing fish bears live young rather than depositing eggs.	Mouth brooder.	Y	1	C	Score as follows: If a species d	1	Rowley et al. (2008); Vidthayanon (2002)
18	Is the species known to reduce age-at-maturity in response to environment?	Likelihood of invasion.	If the species in question is known to reduce age-at-maturity in response to environment then this will increase the likelihood of invasion.	Assess whether the species has the ability to adapt their life-history traits such as their age-at-maturity to a new environment.	No evidence in the literature.	N	0	C	Score as follows: If the species	2	
19	Is the species hermaphroditic?	Likelihood of invasion.	Hermaphroditism is expected to facilitate successful establishment, thus the likelihood of invasion increases. Some fish that exhibit this characteristic are simultaneous hermaphrodites, which means that they can be both genders at the same time and are able to mate with any individual in their species if present. Other fish species are sequential hermaphrodites, which means that they can change sex once or even multiple times in their lifetime.	Assess whether the species hermaphroditic. Hermaphroditism is a condition in which both male and female reproductive organs are present in the same individual.	No evidence in the literature.	N	0	C	Score as follows: If the species	3	
20	Is the species dependent on the presence of another species to complete its life cycle?	Likelihood of invasion.	If a species is dependent on the presence of another species to complete its life cycle then the likelihood of invasion is reduced.	Assess whether the species requires the presence of another species to complete its life cycle. Some species require specialist incubators (e.g. unionid mussels used by bitterling) in order to reproduce successfully.	No evidence in the literature.	N	0	C	Score as follows: If the species	0	
21	Is the species dependent on the presence of a specific habitat features to complete its life cycle, and is this particular habitat feature present in the areas susceptible to invasions?	Likelihood of invasion.	The presence of a habitat feature required by a the species to complete its life cycle is expected to increase the species' likelihood of invasion.	Assess whether the species requires a specific habitat feature to complete its life cycle. Some species require specific habitat features (e.g. fast-flowing water, particular species of plant or types of substrata) in order to reproduce successfully.	No evidence in the literature.	N	0	C	Score as follows: If the species	1	
22	Does the species have reproductive characteristics other than parental care that increase its likelihood of being invasive?	Likelihood of invasion.	If a species possesses such reproductive traits then this will increase its likelihood of invasion.	Assess whether the species possesses reproductive characteristics that increase the species' likelihood of being invasive include for example high fecundity (>10,000 eggs/kg), batch spawning, serial (multiple) spawning, extended spawning season or other facilitative reproductive traits.	No evidence in the literature. Low fecundity.	N	-1	A	Score as follows: If the species	1	Rowley et al. (2008)

23	Is the species' generation time facilitative of invasions?	Likelihood of invasion.	Generation time is directly proportional to the species' likelihood of invasion.	Generation time is defined as the time from hatching to full maturity (i.e. active reproduction, not just presence of gonads). Assess what the species' average time from hatching to maturity in years is and allocate score according to the scoring method.	Low, minimum population doubling time 4.5 - 14 years (tm 3-4; Fec 50 (in concrete tanks))	>4.5	-1	C	Score as follows: With increas	1 Rowley et al. (2008); Fishbase (2012)
24	What is the likelihood of compliance activity preventing deliberate release?	Likelihood of invasion.	Compliance effort preventing deliberate release is inversely proportional to the risk of release.	Assess if there are legal frameworks that proscribe release of exotic fish, education programs or information about deliberate release that are widely disseminated, and/or active compliance programs that attempt to detect deliberate releases when they occur or as soon as possible after they occur. Compliance activities preventing deliberate release include quarantine procedures, rules and regulation regarding the movement of fish.	There is a sound legal framework, widely dispersed education/information, active compliance program to prevent deliberate release of *S. formosus.*	L	1	C	Score as follows: This likelihood of invasion will increase the less compliance there is. No legislative, educational, or active compliance to address deliberate release (High): Score 3. Legal framework, some education/information, no or very limited active compliance to address deliberate release (Medium): Score 2. Substantial legal framework, widely dispersed education/information, active compliance program to address deliberate release (Low): Score 1.	3
25	What is the likelihood of compliance activity preventing accidental release?	Likelihood of invasion.	Compliance effort preventing accidental release is inversely proportional to the risk of release.	Assess if there are: legal frameworks that proscribe activities that can inadvertently release exotic fish (controls on the location of fish farms and ponds, licensing or registration processes), education programs or information to aid in preventing accidental release that are widely disseminated, and/or active compliance programs that attempt to detect inadvertent releases when they occur or as soon as possible after they occur. Compliance activities preventing accidental release include improvement of identification expertise	There is a limited legal framework, and some education/information, material. Active compliance is limited	M	2	C	Score as follows: The likelihood of invasion will increase the less compliance there is. No legislative, educational, or active compliance to address accidental release (High): Score 3. Legal framework, some education/information, no or very limited active compliance to address accidental release (Medium): Score 2. Substantial legal framework, widely dispersed education/information, active compliance program to address accidental release (Low): 1.	3
26	Where the species occurs outside its native range are there impacts on wild aquatic species?	Consequence.	History of impacts on wild aquatic species outside its native range is expected to increase the probable consequence (further impact).	Assess whether there is documented evidence of impacts on wild aquatic species such as the decline, endangerment or extinction of native species.	No evidence in the literature.	N	0	H	Score as follows: No impacts o	5
27	Where the species occurs outside its native range are there impacts on farmed aquatic species?	Consequence.	History of impacts on farmed aquatic species outside its native range is expected to increase the probable consequence (further impact).	Assess whether there is documented evidence of impacts on farmed species such as costs from control of the species or productivity losses.	No evidence in the literature.	N	0	A	Score as follows: No impacts	5
28	In the species' non-native range is there documented evidence that the species has altered the structure or function of a natural ecosystem?	Consequence.	If the species in question has altered the structure or function of a natural ecosystem then this increases the probable consequence.	Assess whether in the species' non-native range there is documented evidence that the species has altered the structure or function of a natural ecosystem.	No evidence in the literature.	N	0	E	Score as follows: No 0; Speci	5
29	Does the species pose a risk to human health?	Consequence.	If a species is known to cause harm to humans, e.g. poison, venom this will increase the probable consequence.	Assess whether the species is known to cause harm to humans for example through, e.g. poison, venom, or whether it is otherwise traumatogenic.	Harmless.	N	0	C	Score as follows: If the species	2 Rainboth (1996)
30	Where established outside its native range does the species out compete native species?	Consequence.	If a species has a record of outcompeting native species where it has established outside its native range then this will increase the probable consequence.	Assess whether the species has a record of outcompeting native species where it has established outside its native range. Outcompeting of native species takes place through, e.g. the suppression of growth, or by displacing native species from their microhabitat.	No record in the literature. Though possible through indirect environmental effects.	N	0	C	Score as follows: If the species	1
31	Is the species parasitic?	Consequence.	If the species is parasitic then this increases the probable consequence.	Assess whether the species is a parasite which is obligately or facultatively dependant on a non-mutual relationship with another species, or whether the species is a micropredator, consuming parts of other species without killing them.	No record in the literature.	N	0	C	Score as follows: If the species	1
32	Does the species prey on a native species, particularly those previously subjected to low (or no) predation?	Consequence.	The feeding on a native species is expected to result in an increase of the probable consequence.	Assess whether the species is likely to establish in hydrosystems normally devoid of predatory fish or in river catchments in which predatory fish have never been present.	No record in the literature.	N	0	C	Score as follows: If the species	1

33	Does the species host, and/or is it a vector, for recognised pests and pathogens, especially non-native?	Consequence.	If a species is the host, and/or a vector, for recognised pests and pathogens, especially non-native ones, this will increase the risk for consequence.	Assess whether the species is associated with non-native pathogens and parasites, with the host either being the original introduction vector of the disease or as a host of the disease brought in by another species. It is acknowledged that disease Import Risk Analysis is a separate, required system of risk analysis.	*S. formosus* is described as a host of some pathogens and parasites of low significance.	L	1	C	Score as follows: Species is no	3	Fishbase (2012); Rainboth (1996)
34	Does feeding or other behaviours of the species reduce habitat quality for native species?	Consequence.	Feeding or other behaviours that reduce habitat quality for native species will increase the probable consequence.	Assess whether the species exhibits feeding or other behaviours that reduce habitat quality (e.g. increase turbidity) for native species.	No record in the literature.	N	0	E	Score as follows: Species is no	1	
35	Does the species feed on a broad range of diet items?	Consequence.	If a species feeds on a broad range of diet items, the probable consequence is increased.	Assess whether the species feeds on a wide range of both plant and animal material as their primary food sources including insects, crustaceans, macroalgae, plankton, molluscs, brine shrimp, etc. Assess whether the species is an opportunistic, general feeder that is not specifically adapted to eating and digesting either meat or plant material in particular.	Feeds on zoobenthos and nekton. Young individuals feed on insects at the water surface, adults take fishes and smaller vertebrates.	Y	2	E	Score as follows: Species is kn	2	Vidthayanon (2002); Fishbase (2012)
36	Can the species hybridize naturally with native species?	Consequence.	Interspecific hybridization with native species under natural conditions increases the probable consequence.	Asses whether interspecific hybridization with native species under natural conditions has been recorded for this species.	No record in the literature.	N	0	A	Score as follows: Species is kn	2	
37	Is the receiving environment facilitative of species dispersal?	Consequence.	If the receiving environment is facilitative of the species dispersal then the probable consequence is increased.	Assess whether the new environment is a catchment (open flowing water) where natural dispersal of that eggs or larvae happens either intentionally or accidentally, or whether the environment is a lake (closed water) where natural dispersal is unlikely.	*S. formosus* is unlikely to be introduced into environments that are facilitative of species dispersal. *S. formosus* populations are found mainly in lentic water bodies.	N	0	C	Score as follows: If the receivin	1	Chong et al (2010)
38	Is the species migratory?	Consequence.	If there is evidence of migratory behaviour this will increase the probable consequence.	Assess whether the species exhibits migratory behaviour. Fish migrate on a regular basis, on daily to annually or longer time scales, and over distances from a few metres to thousands of kilometres. They migrate because of diet or reproductive as part of the fulfilment of their life cycle.	Some dispersion and movement is expected to be related to reproduction/spawning activities.	Y	1	E	Score as follows: If the species	1	Fishbase (2012); Rainboth (1996)
39	Is the species susceptible to control measures?	Consequence.	Susceptible to control measures is inversely proportional to the species' probable consequence.	Assess whether there the species is documented to be resistant to control agents including piscicides or whether no control options available.	There is no evidence that *S. formosus* is resistant to piscicides or other control measures.	Y	0	A	Score as follows: If the species	3	
40	Does the species tolerate or benefit from environmental disturbance?	Consequence.	If the species tolerates or benefits from environmental disturbance then the probable consequence is increased.	Assess whether there is documented evidence of the species' growth and spread being enhanced by disruptions or unusual events especially human impacts. Disturbance is a temporary change in the average environmental conditions and includes flooding, drought, as well as anthropogenic disturbances, etc.	No record in the literature.	N	-1	A	Score as follows: If the species	1	
41	Is there a history of economic loss caused by the fish species within its naturalised range?	Consequence.	History of economic loss increases the probable consequence.	Assess whether the species has caused economic impacts loss of earnings due to reduced productivity, costs of mitigation, remediation and eradication, research costs, reduced earnings, impacts to export markets, banning of sale of commercially popular species, displacement of more valuable native species that were commercially exploited, interruption of commercial aquatic activities, increased requirements for biosecurity/management in aquaculture or irrigation, decreased quality of commercially valuable water, or other relevant	No record in the literature.	N	0	A	Score as follows: Consequence is proportional to the history of economic loss. No history of economic loss (No): Score 0. Some economic loss with limited geographic spread. Score 1. Substantial economic loss on one continent: Score 2 Substantial economic loss on more than one continent: Score 4 Some direct or indirect economic loss recorded (Medium): Score 2. Substantial economic loss or industry collapse (High): Score 4.	4	http://www.fao.org/fishery/introsp/8940/en

42	Are there any icon species, high value environmental assets, or other environmentally significant values in Australia placed at risk by the establishment of this species?	Consequence.	If the species places any icon species, high value environmental assets, or other environmentally significant values in Australia at risk will increase the probable consequence.	Assess whether the species has a history of impacts that could affect native species which have public appeal, promotional and publicity value, or which have been used to harness conservation for that species and other taxa. Assess whether there are species that may be exposed to significantly increased levels of predation or competition (for food or habitat), or whether there are any closely related taxa or species with a similar ecology/morphology that may be particularly susceptible. Impacts include predation, competition, reduced	If *S. formosus* did become established, they might displace native saratoga species.	M	2	E	Score as follows: Consequence is increased the greater the threat to icon species, high value environmental assets, or other environmentally significant values in Australia at risk. Impacts on icon species, high value environmental assets, or other environmentally significant values in Australia unlikely (Low): Score 0. Direct or indirect impacts on icon species, high value environmental assets, or other environmentally significant values in Australia likely (Medium): Score 2. Substantial impacts on icon species, high value environmental assets, or other environmentally significant values in Australia likely	4	http://www.fao.org/fishery/introsp/8940/en
43	Are there any socially significant assets or amenities (not related to human health) threatened by the establishment of this species?	Consequence.	If the species threatens any socially significant assets or amenities (not related to human health) in Australia this will increase the probable consequence.	Assess whether the species has a history of impacts that affects the way humans use the invaded environment, with special relevance to noted vistas, famous natural landmarks and other notable features that have social value.	No record in the literature.	N	0	C	Score as follows: Consequence is proportional to the threat to socially significant assets or amenities (not related to human health) in Australia. Impacts on socially significant assets or amenities (not related to human health) in Australia unlikely (Low): Score 0. Direct or indirect impacts on socially significant assets or amenities (not related to human health) in Australia likely (Medium): Score 2. Substantial impacts on socially significant assets or amenities (not related to human health) in Australia likely (High): Score 4.	4	http://www.fao.org/fishery/introsp/8940/en

Total	**19**

Likelihood of:	*Score*	*Max*	*Calculation*	*Score*	*Max*
Release	4	10	4	4	10
Invasion	10	34	2.941176471	3	10
Consequence	5	46	1.086956522	1	10
Total	200	15640	12.78772379	13	1000

APPENDIX 6 – RISK ASSESSMENT

Risk Assessment undertaken by the applicant.

Formal Risk Assessment Scope

(Scleropages formosus)

Title:	*Environmental Risk Assessment - Scleropages formosus (Asian*
Business:	*Arowana) ####*
Purpose:	*Proposed Import into Australia for Ornamental Aquarium Fish purposes*
Subject:	The objective of this risk assessment is to review risks related to the import of the Asian Arowana into Australia for Ornamental aquarium fish and propose measure to mitigate of reduce the level of risk identified.

Risks have been systematically examined, scoring each risk according to the risk ranking.

Risk Rank scores greater than	*M10*	Are considered as high risk and require further review and controls (refer to attached Risk Matrix)

	Name	Business:
Developed by:	####	####
Reviewed and Amended by:	Name	Position
1		
2		
3		

17 Other comments: *This risk assessment has been prepared for the purpose of reviewing the potential risks imposed by allowing the live import of S. formosus for ornamental aquarium fish trade within Australia.*

LEVEL	RATING	ENVIRONMENTAL (E)
1	Insignificant	No or very low environmental impact.
2	Minor	Low environmental impact. Environmental Impact is able to be completely reversed.
3	Moderate	Moderate environmental impact. Impact confined to controllable locations and small areas.
4	Major	Major environmental impact. Severe environmental damage only recoverable in the long term. Considerable effort required to manage and rectify.
5	Catastrophic	Severe regional environmental impact. Local species destruction and likely long recovery period. Widespread, chronic damage with doubtful recovery. Extensive efforts required to rectify.

CONSEQUENCE TABLE

		PROBABILITY FACTOR (CHANCE OF CONSEQUENCE OCCURING AS A RESULT OF THE UNWANTED EVENT)				
		VERY DIFFICULT TO IMAGINE HOW IT COULD OCCUR (1)	CONCEIVABLE, BUT ONLY IN EXTREME CIRCUMSTANCES (2)	HAS BEEN KNOWN TO HAVE HAPPENED (3)	COULD EASILY HAPPEN (4)	EXPECTED TO HAPPEN EVERY TIME (5)
EXPOSURE FACTOR (FREQUENCY OF EXPOSURE TO THE UNWANTED EVENT)	CONTINUOUS (all the time) (1)	UNLIKELY (D)	POSSIBLE (C)	LIKELY (B)	LIKELY (B)	ALMOST CERTAIN (A)
	FREQUENT (once a month or so) (2)	UNLIKELY (D)	POSSIBLE (C)	POSSIBLE (C)	LIKELY (B)	LIKELY (B)
	OCCASIONAL (once or twice a year) (3)	RARE (E)	UNLIKELY (D)	UNLIKELY (D)	POSSIBLE (C)	POSSIBLE (C)
	UNUSUAL (once or twice every 10 years) (4)	RARE (E)	RARE (E)	UNLIKELY (D)	UNLIKELY (D)	UNLIKELY (D)
	REMOTE (once or twice in 100 years) (5)	RARE (E)	RARE (E)	RARE (E)	RARE (E)	RARE (E)

LIKELIHOOD CALCULATOR

LIKELIHOOD			CONSEQUENCE				
			1	2	3	4	5
			INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC
	A	ALMOST CERTAIN	M11	H7	H4	H2	H1
	B	LIKELY	M15	M12	H8	H5	H3
	C	POSSIBLE	M18	M16	M13	M9	H6
	D	UNLIKELY	L23	L22	M17	M14	M10
	E	RARE	L25	L24	L21	L20	L19

RISK MATRIX

Environmental Risk Assessment - Scleropages formos (Asian Arowana)

Activity: Importing Scleropages formosus into Australia for Ornamental Aquarium trade.

Date: 24/07/2014	INHERENT RISK (NO CONTROLS)						Risk Rank scores greater than M10 Are to considered as high risk and require further review and controls (refer to attached Risk Matrix)	PROPOSED CONTROLS & RESULTING RISK SCORE						ACTIONS	
HAZARD/RISK	UNWANTED EVENT	CONSEQUENCE	PROBABILITY	EXPOSURE	LIKELIHOOD	RISK SCORE	Comments:	PROPOSED CONTROLS	CONSEQUENCE	PROBABILITY	EXPOSURE	LIKELIHOOD	RISK SCORE	RECOMMENDED ACTIONS	Responsibility of:
1.0 Release into Australian waterways															
1.1 Outbreak of Arowana in Australian waterways	Species (*S. formosus*) establishment in Australian waterways with a breeding population	5 CATASTROPHIC	2	1	Unlikely	M10	- *S. formosus* would have a restricted range where it could be established in Australia, located in small streams & lagoons in Far north QLD and Far north them NT. - Natural predators such as crocodiles, barramundi, birds of prey etc. would also impact on species ability to establish. - Native eastern established population of *S. jardini* would also make it difficult for species to establish as the *S. jardini* is also a highly territorial species.	1. Grant the applicant sole permission to import/ export Scleropages in Australia for a period of five years to allow a controlled introduction of the species. Use the species as a test case and collaboration effort with the applicant to obtain real time data (transactional information, number of species imported, distribution etc.) to assist in future assessments and amendments to the live import list. 2. Limit importing to a select number of CITES approved farms/ breeders, to reduce the numbers of fish being imported and also assist in quality and disease management.	5 CATASTROPHIC	2		Rare	L19	Both the 'Comment' and 'Proposed controls' should be reviewed in conjunction with each other. It is understood that not all proposed controls may be able to be implemented by the Australian Government and hence the comments need to be taken on board. * Limit distribution to below latitude 16° 20' (Aust. Government) * Track cost on of species through importer data base. (Importers)	Australian Government / Importers & Owners
1.2 Interspecies breeding between Scleropages (i.e. *formosus interbreeding with jardini & leichardti (Australian natives)*)	Reduced gene pool or native species *S. jardini* and *S. leichardti*	MAJOR	2	1	Unlikely	M14	Currently there has been no known interbreeding between our native species & the Asian Arowana. A university thesis student in Singapore concluded in his studies that this may be due to the differing breeding processes between species. (Cheng Kuok Weal Alex 2010).	3. Limit importing to businesses with single species import i.e. limit to businesses who purely import Arowana only and no other species. Given the nature of the species being a high end quality fish, limiting imports to those businesses who will deal in Arowana alone will increase the quality of fish imported, assist in disease management and reduce the potential for mass importation. - Track cost on of species through a national database using the CITES microchips as IDs. 5. Similar to upper market reptiles within Australia a license could be introduced to track where each individual specimen is at any one time. 6. Sale of species would be limited through the high cost to purchase and difficulty to breed species. 7. *S. formosus* is a CITES listed species which is considered to be critically endangered. This factor along with its highly prized value as an ornamental aquarium fish main aline the cost of individuals as one of the most expensive fresh water aquarium fish globally. As such, one approach to control/ eradicate any potential population could simply consist of advertising the cost on of the outbreak and allowing individuals caught to be retained by those who capture them (once tagged and recorded in the records database), or these fish could be sold back to international breeders and hobbyists. Alternatively fish could be caught through electrofishing, spotlighting on waters surface at night or netting the small lagoons and streams that they would inhabit. As this species typically inhabits very small water bodies, it may be possible in extreme circumstances to use a biodegradable fish poison such as rotenone to eradicate the population. 8. Limit the distribution to below Latitude 16° 20' within Australia. Location is below the Lower extent of which the Scleropages *Jardini* inhabits. It is not odd that Scleropages *leichardti* inhabits further southern extents but the Scleropages *formosus* could not inhabit the same location due to low temperatures.	MAJOR	2		Rare	L20	As per item 1 above.	Australian Government / Importers & Owners
1.3 Asian Arowana competing with native species or food & breeding sites	Native species (*S. jardini* and *S. leichardti*) wiped out or numbers reduced due to competition.	5 CATASTROPHIC	2	1	Possible	M9	Multiple Arowana are required to be released into the same location. Arowana do not pair up with even two male/female combination, they are a more selective when choosing appropriate breeding partners. They will also pair or life. As such a large number would need to be released to have even a low chance of a breeding pair establishing. In addition the financial expense of these fish makes it unlikely that anyone would in an illegally release such large numbers or a low chance of a return.		5 CATASTROPHIC	2		Rare	L19	As per item 1 above.	Australian Government / Importers & Owners
1.4 Ability to survive and adapt to Australian climatic conditions	Spread throughout Australian waterways	MAJOR	1	1	Unlikely	M14	Species will only have a natural survival range similar to that of the Scleropages *Jardini* in north QLD and Far northern them in NT. They are very susceptible to temperature changes.		*Risk has been assessed as lower than M10, therefore no further re-assessment has been undertaken.*					As per item 1 above.	Australian Government / Importers & Owners
1.5 Ability to live in human modified habitats (i.e. dams, channels, drains,)	Species establishment in Australian modified waterways	3 MODERATE	2	1	Possible	M13	Will populate modified waterways only in those regions within their temperature range (i.e. Far North QLD & NT).		*Risk has been assessed as lower than M10, therefore no further re-assessment has been undertaken.*					As per item 1 above.	Australian Government / Importers & Owners
1.6 Species longevity, birth rates and number of offspring increasing likelihood of species establishment.	Species establishment in Australian waterways due to longgevity & birth rates	MAJOR	1	1	Unlikely	M14	Species is currently rare and endangered, one factor is due to their low birthrates and poor breeding capabilities.		*Risk has been assessed as lower than M10, therefore no further re-assessment has been undertaken.*					As per item 1 above.	Australian Government / Importers & Owners
1.7 Predation on native species (freshwater invertibrates, fish, insects, etc..)	Endanger existing native species (*S. jardini* and *S. leichardti*)	5 CATASTROPHIC	1	1	Unlikely	M10	Due to the limited range of this species has as well as highly restricted rate of reproduction, it would be unlikely to foresee the species being able to establish a population which could bring another species *S. jardini* to extinction. It should also be noted that *S. leichardti* exists outside the ideal climate conditions sort by *S. formosus* (refer to CLIMATCH results). Also refer to comment or item 1.3, above.		5 CATASTROPHIC	1		Rare	L19	As per item 1 above.	Australian Government / Importers & Owners
1.8 Species susceptible to, or capable of transmitting disease	Disease outbreaks into native waterways effecting native flora & fauna as a direct result of importing *S. formosus*.	5 CATASTROPHIC	2	1	Possible	H6	*S. formosus* is described as a host of some pathogens and parasites of low significance. (Fishbase 2012, Reinboth 1966). Due to the high quality of these ornamental fish and low quantities of potential import (due to low numbers available), disease shall be controlled and contained through the current Australian Quarantine process. The Department of Agriculture - Biosecurity (DAFF Biosecurity) has established a range of quarantine procedures under the Quarantine Act 1908.		5 CATASTROPHIC	2	5	Rare	L19	Ensure all imports are undertaken as per the current Australian import guidelines and as per the Quarantine Act 1908.	Importers
1.9 Reduction in ground vegetation cover from species release and causing increased soil erosion and natural habitat devistation.	Increased bank erosion and loss of critical riparian vegetation.	MAJOR	1		Rare	L20	The arowana is an upper water column inhabitant which is not known to burrow into and/or construct their beds or banks.		*Risk has been assessed as lower than M10, therefore no further re-assessment has been undertaken.*					No further action required.	-
1.10 Destruction of native aquatic vegetation	Eradication of native aquatic flora & fauna.	5 CATASTROPHIC	1	1	Unlikely	M10	There is no evidence in literature of cases found where *S. formosus* has had an impact on native flora or fauna (Devaney and Beyer, 2011) and it is not unlikely that this would eventuate in Australia, should the species be released. As per comment or item 1.7, above.		5 CATASTROPHIC	1		Rare	L19	As per item 1 above.	Australian Government / Importers & Owners
1.11 Impossible to eradicate and remove from native waterways	Developed farmed populations	MAJOR	2	1	Unlikely	M14	Refer to comment for item 1.1, above.		MAJOR	2		Rare	L20	As per item 1 above.	Australian Government / Importers & Owners
2.0 Species impacts to a life style cost	Death or illness to humans	5 CATASTROPHIC	1	5	Rare	L19	There is no known documented illness related injury from an Asian Arowana on humans. Furthermore the ornamental fish generally contained within an enclosure (aquarium) which limits human contact. (Reinboth, 1966)		*Risk has been assessed as lower than M10, therefore no further re-assessment has been undertaken.*					No further action required.	-

OPPORTUNITIES ARISING FROM IMPORT APPROVAL	
1 0 Reduce pressure of w ld caught *Scleropages jard ni* in Australia	The na ve Australian Saratoga (Scleropages *jardini* & *leichardti*) are sold qu te frequen ly in the aquarium trade. Major ty of the *jardini* are wild caught w th very few being farmed in what could be described as hobby farms. The *leichardti* is mainly a farmed ish w th most fa ms producing 50 - 500 juven e ish for sale each yea . A lowing the Arowana to be imported in o Australia would ake the pressure off wi d caught specimens of the Austra ian Saratoga.
2 0 Reduced i legal trading of the endangered CITES l sted spec es Sc eropages formosus	Currently like most ornamental aquarium spec es in Austra ia the Sc eropages *formos* is il egal o import but egal to keep in a l s ates of Austral a. As recently as ast week (June 201) juven le Sc eropages *formosus* could be found or sale ranging from $1,750 (Au) o $9,000 (Au) all of a juvenile size and including CITES microchip and paperwork. There are currently no approved CITES l s ed arms within Austral a, therefore the specimens which have been noticed for sale w th CITES microchip and paperwork could only be assumed to be imported llega ly into the country. A lowing the import of these fish in a controlled manner in o the country would elimina e the current llegal dealing in these fish and allow for a more control ed platfo m or the Austral an ornamental f sh trade.
3 0 Increased trade opportuni ies between Austral a and As a	Currently these f sh can only be bred, so d and imported from CITES reg stered breeders in Indonesia, Ma asia, Singapore and Tha land. A lowing the import of th s species in o Australia would therefo e increase trade rela ions w th these Countries. This aligns with Australia's Free Trade agreement w th Singapore (SAFTA), Indonesia-Austra ia Comprehensive Economic partnership agreement (IA-CEPA), Tha land Austral a free trade agreement and a so the Trans-Pacific Partnership Agreement (TPP) which s cur ently under nego ia ion during the preparat on of th s report.
0 Increased awareness of an endange ed species	Draw awareness o the spec es.
5 0 Increase ornamental aquarium trade within the Austra ian industry.	Currently the Australian market has lim ted to few upper market fresh wa er ornamental aquarium f sh avai ab e o legally trade. The Scleropages *fo mosus* is highly recognised and h ghly prized to those within the international aquarium industry. It wou d offer a new element to the Austra ian industry
6 0 Prov de a est case for the Australian Ornamental aquarium f sh trade	Scleropages *formosus* would provide a good test case for introducing an upper market ish into Austral a or trade. Due to the imited number of these ish avai ab e in As a to both purchase and import the pr ce wou d remain s gn ficantly h gh. The Prices would expect to range from $600 - $8,000 (Au) or juven le ish of varying colour and quality. For this reason t would be a great test case to view the real e fects of al owing the import.
7 0 Increased gene pool for the CITES l s ed endangered species	Scleropages *formosus* s cu ren ly an endangered CITES l sted spec es and by a lowing the import into Austral a would increase the funds to breeding programs in Asia and also increase the gene pool of the species in o another country. An increased gene pool s crucial or the survival of a spec es which is on the verge of natural extinct on.

APPENDIX 7 – CURRENT STATE & TERRITORY CONTROLS

Current lists of prohibited fish, listed by State's and Territory's.

Current declared noxious fish species per state

Information current as at (24/07/2014)

QUEENSLAND	
Common name	*Scientific name*
aba aba	Gymnarchus niloticus
Adriatic sturgeon	Acipenser naccarii
African butter catfish	Schilbe mystus
African lungfish	Protopterus annectens
African pike	Hepsetus odoe
African pike-characin, tubenose poacher, fin eater	fish of the subfamily Ichthyborinae
American gar, alligator gar, armoured gar	Lepisosteus spp. and Atractosteus spp.
Alfaro huberi	Alfaro huberi
Amur sturgeon	Acipenser schrenckii
angler catfish	Chaca bankanensis
angler, catfish, frogmouth catfish, squarehead catfish	Chaca chaca
Atlantic sturgeon	Acipenser oxyrinchus oxyrinchus
Baikal sturgeon	Acipenser baerii baicalensis
banded jewelfish	Hemichromis fasciatus
banded sunfish, spotted sunfish	family Centrachidae
barred tail pearlfish	Leptolebias minimus
beluga	Huso huso
bighead carp	Aristichthys nobilis
bigmouth sleeper	Gobiomorus dormitor
blackchin tilapia	Sarotherodon melanotheron melanotheran
bluegill	Lepomis spp.
bottlenose, cornish jack	Mormyrops anguilloides
bowfin	Amia calva
brook stickleback	Culaea inconstans
burmensis frogmouth catfish	Chaca burmensis
candiru catfish, parasitic catfish, pencil catfish	family Trichomycteridae
carp	Cyprinus carpio
catla	Catla catla
chameleon goby, striped goby	Tridentiger trigonocephalus
channel catfish	Ictalurus punctatus
Chinese sturgeon	Acipenser sinensis
Chinese swordfish	Psephurus gladius
Chinese weatherfish, weatherloach	Misgurnus anguillicaudatus
climbing perch	Anabas testudineus
copper mahseer	Neolissochilus hexagonolepis
discus ray	Paratrygon aiereba
electric catfish	Malapterurus spp.
electric eel	Electrophorus electricus
European catfish, wels catfish	Silurus spp.
European sturgeon	Acipenser sturio
fat sleeper	Dormitator maculatus
flatnose catfish, dwarf giraffe catfish	Anaspidoglanis macrostomus
forktail lates	Lates microlepis
fourspine stickleback	Apeltes quadracus
freshwater minnow	Zacco platypus
fringebarbel sturgeon	Acipenser nudiventris
gambusia, mosquito fish	Gambusia spp.
giant barb	Catlocarpio siamensis
giant bully	Gobiomorphus gobioides
giant cichlid	Boulengerochromis microlepis
gilled lungfish	Protopterus amphibius
grass carp	Ctenopharyngodon idella
green sturgeon	Acipenser medirostris
Gulf sturgeon	Acipenser oxyrinchus destotoi
Hypseleotris tohizonae	Hypseleotris tohizonae
Japanese sturgeon	Acipenser multiscutatus
knife-edged livebearer	Alfaro cultratus
lake sturgeon	Acipenser fulvescens
largemouth bass	Micropterus salmoides
Leptolebias aureoguttatus	Leptolebias aureoguttatus
marbled lungfish	Protopterus aethiopicus
marbled pearlfish	Leptolebias marmoratus
marble goby	Oxyeleotris marmorata
Mekong giant catfish	Pangasianodon gigas
Mississippi paddlefish	Polyodon spathula
mrigal	Cirrhinus cirrhosus
Nile perch	Lates niloticus
ninespine stickleback	Pungitius pungitius
opal pearlfish	Leptolebias opalescens
orange-fin labeo	Labeo calbasu
Oxyeleotris siamensis	Oxyeleotris siamensis
Oxyeleotris urophthalmoides	Oxyeleotris urophthalmoides
Oxyeleotris urophthalmus	Oxyeleotris urophthalmus

Pacific sleeper	Gobiomorus maculatus
Pacific fat sleeper	Dormitator latifrons
Pangasius conchophilus	Pangasius conchophilus
Pangasius elongatus	Pangasius elongatus
Pangasius krempfi	Pangasius krempfi
Pangasius kunyit	Pangasius kunyit
Pangasius macronema	Pangasius macronema
Pangasius nasutus	Pangasius nasutus
Pangasius nieuwenhuisii	Pangasius nieuwenhuisii
Persian sturgeon	Acipenser persicus
pike characin	Acestrorhynchus microlepis
pike cichlid	Crenicichla spp.
pike minnow, pike killifish	Belonesox belizanus
pikes	Esox spp.
pink, slender, greenwoods, mortimers, cunean and green happy	Sargochromis spp.
piranhas, pacus	fish of the subfamily Serrasalminae, other than Metynnis spp. and Myleus rubripinnis
purpleface largemouth	Serranochromis spp.
pygmy sunfish	Elassoma spp.
redfin bully	Gobiomorphus huttoni
red swamp crayfish	Procambarus clarkii
reedfish	Erpetoichthys calabaricus
ripsaw catfish, black doras, black shielded catfish	Oxydoras spp.
river carp, deccan, high backed, jungha, putitor, Thai mahseer	Tor spp.
rohu	Labeo rohita
Russian sturgeon	Acipenser gueldenstaedtii
Sakhalin sturgeon	Acipenser mikadoi
Sentani gudgeon	Oxyeleotris heterodon
shiners	Notropis spp.
shortnosed gar	Lepisosteus platostomus
shortnose sturgeon	Acipenser brevirostrum
shoulderspot catfish	Schilbe marmoratus
Siberian sturgeon	Acipenser baerii baerii
silver carp	Hypophthalmichthys molitrix
silver catfish	Schilbe intermedius
slender lungfish	Protopterus dolloi
snakehead	Channa spp.
snooks	Centropomus spp.
South American lungfish	Lepidosiren paradoxa
Southern redbelly dace	Phoxinus erythrogaster
spot pangasius	Pangasius larnaudii
starry sturgeon	Acipenser stellatus
sterlet	Acipenser ruthenus
stinging catfish	Heteropneustes fossilis
tiger catfish	Pseudoplatystoma fasciatum
tigerfish (African), pike characin	Hydrocynus spp., subfamilies Hydrocyninae and Alestinae
tigerfish (South American) or trahira	Erythrinus, Hoplerythrinus and Hoplias spp.
tilapia	Tilapia spp, Oreochromis spp and Sarotherodon spp.
Tomeurus gracilis	Tomeurus gracilis
tropical carp-gudgeon	Hypseleotris cyprinoides
twospot lebiasina	Lebiasina bimaculata
twospot livebearer	Heterandria bimaculata
Ubangi shovelnose catfish	Bagrus ubangensis
Valencia toothcarp	Valencia hispanica
walking catfish, airbreathing catfish	family Clariidae
white sturgeon	Acipenser transmontanus
Yangtze sturgeon	Acipenser dabryanus
yellowbelly gudgeon	Allomogurnda nesolepis
yellowfin goby	Acanthogobius flavimanus
yellowtailed catfish	Pangasius pangasius

NSW	
Class 1 noxious fish	
Common name	Scientific name
Yellow fin goby	*Acanthogobius flavimanus* (Gobiidae family)
	Acestrorhynchus microlepis (Acestrorhynchidae family)
Siberian sturgeon	*Acipenser baerii baerii* (Acipenseridae family)
Baikal sturgeon	*Acipenser baerii baicalensis* (Acipenseridae family)
Shortnose sturgeon	*Acipenser brevirostrum* (Acipenseridae family)
Yangtze sturgeon	*Acipenser dabryanus* (Acipenseridae family)
Lake sturgeon	*Acipenser fulvescens* (Acipenseridae family)
Russian sturgeon	*Acipenser gueldenstaedtii* (Acipenseridae family)
Green sturgeon	*Acipenser medirostris* (Acipenseridae family)
Sakhalin sturgeon	*Acipenser mikadoi* (Acipenseridae family)
Japanese sturgeon	*Acipenser multiscutatus* (Acipenseridae family)
Adriatic sturgeon	*Acipenser naccarii* (Acipenseridae family)
Fringebarbel sturgeon	*Acipenser nudiventris* (Acipenseridae family)
Gulf sturgeon	*Acipenser oxyrinchus desotoi* (Acipenseridae family)
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus* (Acipenseridae family)
Persian sturgeon	*Acipenser persicus* (Acipenseridae family)
Sterlet	*Acipenser ruthenus* (Acipenseridae family)
Amur sturgeon	*Acipenser schrenckii* (Acipenseridae family)
Chinese sturgeon	*Acipenser sinensis* (Acipenseridae family)
Starry sturgeon	*Acipenser stellatus* (Acipenseridae family)
European sturgeon	*Acipenser sturio* (Acipenseridae family)
White sturgeon	*Acipenser transmontanus (* Acipenseridae family)
Knife-edged livebearer	*Alfaro cultratus* (Poeciliidae family)
	Alfaro huberi (Poeciliidae family)
Yellowbelly gudgeon	*Allomogurnda nesolepis (* Eleotridae family)
Bowfin	*Amia calva* (Amiidae family)
Climbing perch	*Anabas testudineus* (Anabantidae family)
Flatnose catfish	*Anaspidoglanis macrostoma* (Bagridae family)
Four spined stickleback	*Apeltes quadracus* (Gasterosteidae family)
Bighead carp	*Aristichthys nobilis* (Cyprinidae family)
American gar, armoured gar	*Atractosteus* spp. (excluding *Atractosteus spatula*) (Lepisosteidae family)
Ubangi shovelnose catfish	*Bagrus ubangensis* (Bagridae family)
Copper mahseer	*Barbodes hexagonolepis* (Cyprinidae family)
Pike minnow, pike killifish	*Belonesox belizanus* (Poeciliidae family)
Giant cichlid, yellow belly cichlid	*Boulengerochromis microlepis* (Cichlidae family)
European green crab, green shore crab	*Carcinus maenas* (Portunidae family)
Catla	*Catla catla* (Cyprinidae family)
Giant barb	*Catlocarpio siamensis* (Cyprinidae family)
	Centrarchidae family
Snook	*Centropomus* spp. (Centropomidae family)
Angler catfish	*Chaca bankanensis* (Chacidae family)
Burmensis frogmouth catfish	*Chaca burmensis* (Chacidae family)
Squarehead catfish	*Chaca chaca* (Chacidae family)
Snake head	*Channa* spp. (Channidae family)
Mrigal	*Cirrhinus cirrhosus* (Cyprinidae family)
Walking catfish	*Clarias* spp. (Clariidae family)
	Colossoma spp. (Characidae family)
Grass carp	*Ctenopharyngodon idella* (Cyprinidae family)
	Culaea inconstans (Gasterosteidae family)
Pacific fat sleeper	*Dormitator latifrons* (Eleotridae family)
Pacific sleeper	*Dormitator maculatus* (Eleotridae family)
Pygmy sunfish	*Elassoma* spp. (Elassomatidae family)
Electric eel	*Electrophorus electricus* (Gymnotidae family)
Reedfish	*Erpetoichthys calabaricus* (Polypteridae family)
	Erythrinus spp. (Erythinidae family)
Pike	*Esox* spp. (Esocidae family)
Eastern gambusia	*Gambusia holbrooki* (all waters except greater Sydney region) (Poeciliidae family)
Mosquitofish	*Gambusia* spp. (*excluding *Gambusia holbrooki*) (Poeciliidae family)
Giant bully	*Gobiomorphus gobioides* (Eleotridae family)
Redfin bully	*Gobiomorphus huttoni* (Eleotridae family)
Bigmouth sleeper	*Gobiomorus dormitor* (Eleotridae family)
	Gobiomorus maculatus (Eleotridae family)
Aba aba	*Gymnarchus niloticus* (Gymnarchidae family)
Banded jewelfish	*Hemichromis fasciatus* (Cichlidae family)
African pike	*Hepsetus odoe* (Hepsetidae family)
Twospot livebearer	*Heterandria bimaculata* (Poeciliidae family)
Stinging catfish	*Heteropneustes fossilis* (Heteropneustidae family)
Aimira	*Hoplerythrinus* spp. (Erythinidae family)
Trahira	*Hoplias* spp. (Erythinidae family)

Beluga	*Huso huso* (Acipenseridae family)
Pike characin, giant tigerfish	*Hydrocynus* spp. (Alestiidae family)
Silver carp	*Hypophthalmichthys molitrix* (Cyprinidae family)
Tropical carp-gudgeon	*Hypseleotris cyprinoides* (Eleotridae family)
	Hypseleotris tohizonae (Eleotridae family)
African pike-characin, tubenose poacher, fin eater	*Ichthyborinae* subfamily (Citharinidae family)
Channel catfish	*Ictalurus punctatus* (Ictaluridae family)
Orange fin labeo	*Labeo calabasu* (Cyprinidae family)
Rohu	*Labeo rohita* (Cyprinidae family)
Forktail lates	*Lates microlepis* (Centropomidae family)
Nile perch	*Lates niloticus* (Centropomidae family)
Twospot lebiasina	*Lebiasina bimaculata* (Lebiasinidae family)
South American lungfish	*Lepidosiren paradoxa* (Lepidosirenidae family)
	Leptolebias aureoguttatus (Rivulidae family)
Marbled pearlfish	*Leptolebias marmoratus* (Rivulidae family)
Barred tail pearlfish	*Leptolebias minimus* (Rivulidae family)
Opal pearlfish	*Leptolebias opalescens* (Rivulidae family)
Electric catfish	*Malapterurus* spp. (Malapteruridae family)
Wea herloach, oriental weatherloach	*Misgurnus anguillicaudatus* (Cobitidae family)
Cornish jack	*Mormyrops anguilloides* (Mormyridae family)
Black striped mussel	*Mytilopsis* spp. (Dreissenidae family)
Shiner	*Notropis* spp. (Cyprinidae family)
Tilapia	*Oreochromis* spp. (Cichlidae family)
Ripsaw catfish, black doras, black shielded catfish	*Oxydoras* spp. (Doradidae family)
Sentani gudgeon	*Oxyeleotris heterodon* (Eleotridae family)
Marble goby	*Oxyeleotris marmorata* (Eleotridae family)
	Oxyeleotris siamensis (Eleotridae family)
	Oxyeleotris urophthalmoides (Eleotridae family)
	Oxyeleotris urophthalmus (Eleotridae family)
	Pangasius conchophilus (Pangasiidae family)
	Pangasius elongatus (Pangasiidae family)
Mekong giant catfish	*Pangasianodon gigas* (Pangasiidae family)
	Pangasius krempfi (Pangasiidae family)
	Pangasius kunyit (Pangasiidae family)
Spot pangasius	*Pangasius larnaudii* (Pangasiidae family)
	Pangasius macronema (Pangasiidae family)
	Pangasius nasutus (Pangasiidae family)
	Pangasius nieuwenhuisii (Pangasiidae family)
Yellowtailed catfish	*Pangasius pangasius* (Pangasiidae family)
Discus ray	*Paratrygon aiereba* (Potamotrygonidae family)
Pantanal parasitic catfish	*Paravandelia oxyptera* (Trichomycteridae family)
Redfin perch	*Perca fluviatilis* (Percidae family)
Southern redbelly dace	*Phoxinus erythrogaster* (Cyprinidae family)
Mississippi paddlefish	*Polyodon spathula* (Polyodontidae family)
Red swamp crayfish	*Procambarus clarkii* (Cambaridae family)
Marbled lungfish	*Protopterus aethiopicus* (Protopteridae family)
Gilled lungfish	*Protopterus amphibius* (Protopteridae family)
African lungfish	*Protopterus annectens* (Protopteridae family)
Slender lungfish	*Protopterus dolloi* (Protopteridae family)
Chinese swordfish	*Psephurus gladius* (Polyodontidae family)
Ninespine stickleback	*Pungitius pungitius* (Gasterosteidae family)
Red piranha	*Pygocentrus* spp. (Characidae family)
Pink happy, slender happy, cunene happy, green happy	*Sargochromis* spp. (Cichlidae family)
Blackchin tilapia	*Sarotherodon* spp. (Cichlidae family)
Silver butter catfish	*Schilbe intermedius* (Schilbeidae family)
Shoulderspot catfish	*Schilbe marmoratus* (Schilbeidae family)
African butter catfish	*Schilbe mystus* (Schilbeidae family)
	Serranochromis spp. (Cichlidae family)
Redeye piranha	*Serrasalmus* spp. (Characidae family)
European catfish, wels catfish	*Silurus* spp. (Siluridae family)
Redbelly tilapia	*Tilapia* spp. (excluding *T. buttikoferi*) (Cichlidae family)
	Tomeurus gracilis (Poeciliidae family)
River carp, deccan mahseer, high backed mahseer, jungha mahseer, Thai mahseer	*Tor* spp. (Cyprinidae family)
Chameleon goby, striped goby, Japanese goby	*Tridentiger trigonocephalus* (Gobiidae family)
Valencia toothcarp	*Valencia hispanica* (Valenciidae family)
Freshwater minnow	*Zacco platypus* (Cyprinidae family)
Class 2 noxious fish	
Common name	**Scientific name**
Banded grunter	*Amniataba percoides* (Terapontidae family)
Pacific oyster	*Crassostrea gigas* (Ostreidae family) in estuarine and ocean waters (other than Port Stephens)
Speckled mosquitofish, dusky millions fish	*Phalloceros caudimaculatus* (Poeciliidae family)

VIC	
Scientific name	**Common name**
Acanthogobius flavimanus	Yellowfin goby
Acestrorhynchus microlepis	Pike characin
Acipenser baerii baerii	Siberian sturgeon
Acipenser baerii baicalensis	Baikal sturgeon
Acipenser brevirostrum	Shortnose sturgeon
Acipenser dabryanus	Yangtze sturgeon
Acipenser fulvescens	Lake sturgeon
Acipenser gueldenstaedtii	Russian sturgeon
Acipenser medirostris	Green sturgeon
Acipenser mikadoi	Sakhalin sturgeon
Acipenser multiscutatus	Japanese sturgeon
Acipenser naccarii	Adriatic sturgeon
Acipenser nudiventris	Fringebarbel sturgeon
Acipenser oxyrinchus destotoi	Gulf sturgeon
Acipenser oxyrinchus oxyrinchus	Atlantic sturgeon
Acipenser persicus	Persian sturgeon
Acipenser ruthenus	Sterlet
Acipenser schrenckii	Amur sturgeon
Acipenser sinensis	Chinese sturgeon
Acipenser stellatus	Starry sturgeon
Acipenser sturio	European sturgeon
Acipenser transmontanus	White sturgeon
Alfaro cultratus	Knife-edged livebearer
Alfaro huberi	
Allomogurnda nesolepis	Yellowbelly gudgeon
Amia calva	Bowfin
Anabas testudineus	Climbing perch
Anaspidoglanis macrostoma	Flatnose catfish
Apeltes quadracus	Fourspine stickleback
Asterias amurensis	Northern Pacific seastar
Atractosteus spp	Alligator gar
Bagrus ubangensis	Ubangi shovelnose catfish
Belonesox belizanus	Pike minnow, pike killifish
Boulengerella maculata	Spotted pike-characin
Boulengerochromis microlepis	Giant cichlid
Bryconops affinis	Orangefin tetra
Bryconops melanurus	
Catlocarpio siamensis	Giant barb
Caulerpa taxifolia	Aquarium caulerpa
Centrarchidae family	Bass, sunfish
Centropomus spp	Snooks
Chaca chaca	Squarehead catfish
Chaca bankanensis	Angler catfish
Chaca burmensis	Burmensis frogmouth catfish
Channa spp	Snakehead
Cherax cainii	Smooth marron
Cherax quadricarinatus	Red claw crayfish
Cherax tenuimanus	Hairy marron
Cichlasoma urophthalmus	Mexican mojarra
Cirrhinus cirrhosus	Mrigal
Citharinidae, Ichthyborinae subfamily	African pike-characin, tubenose poacher, fin eater
Clarias spp	Walking catfish
Colossoma spp	Tambaqui
Crenicichla lacustrus	
Crenicichla lepidota	Pike cichlid
Crenicichla notophthalmus	
Crenicichla saxatilis	Ringtail pike cichlid
Ctenopharyngodon idella	Grass carp
Ctenopoma kingsleyae	Silverbelly centopoma
Ctenopoma ocellatum	Eyespot ctenopoma
Ctenopoma weeksii	Mottled ctenopoma
Culaea inconstans	Brook stickleback
Cyprinus carpio	Common carp
Dianema longibarbis	Porthole catfish
Dormitator latifrons	Pacific fat sleeper
Dormitator lebretonis	Sleeper
Dormitator maculatus	Fat sleeper
Elassoma spp	Sunfish
Electrophorus electricus	Electric eel
Erpetoichthys calabaricus	Reedfish
Erythrinus spp	Trahira
Esox spp	Pikes
Fundulus chrysotus	Golden topminnow
Gibelion catla	Catla

Gambusia spp	Mosquitofish
Gasterosteus aculeatus	Three-spined stickleback
Gobiomorphus gobioides	Giant bully
Gogiomorphus huttoni	Redfin bully
Gobiomorus dormitor	Bigmouth sleeper
Gobiomorus maculatus	Pacific sleeper
Gymnarchus niloticus	Aba aba
Hemichromis fasciatus	Banded jewelfish
Hepsetus odoe	African pike
Herichthys cyanoguttatus	Rio Grande cichlid
Heterandria bimaculata	Twospot livebearer
Heteropneustes fossilis	Stinging catfish
Hollandichthys multifasciatus	
Hoplerythrinus spp	
Hoplias spp	Trahira
Huso huso	Beluga
Hydrocynus spp	Pike characin, Giant tigerfish
Hypophthalmichthys molitrix	Silver carp
Hypophthalmichthys nobilis	Bighead carp
Hypseleotris cyprinoides	Tropical carp-gudgeon
Hypseleotris tohizonae	
Ictalurus punctatus	Channel catfish
Irvineia voltae	Butterfish
Knodus savannensis	
Labeo calbasu	Orange-fin labeo
Labeo rohita	Rohu
Lates microlepis	Forktail lates
Lates niloticus	Nile perch
Lebiasina bimaculata	Twospot lebiasina
Lepidosiren paradoxa	South American lungfish
Lepisosteus spp	Gar
Leptolebias aureoguttatus	
Leptolebias marmoratus	Marbled pearlfish
Leptolebias minimus	Barredtail pearlfish
Leptolebias opalescens	Opal pearlfish
Leptolebias splendens	Splendid pearlfish
Malapterurus spp	
Microctenopoma ansorgii	Ornate ctenopoma
Microctenopoma congicum	Congo ctenopoma
Microctenopoma fasciolatum	Banded ctenopoma
Microctenopoma nanum	Dwarf ctenopoma
Misgurnus anguillicaudatus	Oriental weatherloach
Mormyrops anguilloides	Bottlenose, Cornish jack
Mytilopsis sallei	Black-striped mussel
Nandopsis tetracanthus	Cuban cichlid
Neolissochilus hexagonolepis	Copper mahseer
Notropis spp	Shiners
Ompok bimaculatus	Butter catfish
Oreochromis spp	Tilapia
Osteoglossum bicirrhosum	Arawana
Oxydoras spp	Ripsaw catfish, black doras, black shielded catfish
Oxyeleotris heterodon	Sentani gudgeon
Oxyeleotris marmorata	Marble goby
Oxyeleotris siamensis	
Oxyeleotris uropthalmoides	
Oxyeleotris uropthalmus	
Pangasianodon gigas	Mekong giant catfish
Pangasianodon hypophthalmus	Sutchi catfish
Pangasius conchophilus	
Pangasius elongatus	
Pangasius gigas	Mekong giant catfish
Pangasius krempfi	
Pangasius kunyit	
Pangasius larnaudii	Spot pangasius
Pangasius macronema	
Pangasius nasutus	
Pangasius nieuwenhuisii	
Pangasius pangasius	Yellowtailed catfish
Parachanna obscura	Snake-head
Paratrygon aiereba	Discus ray
Phago loricatus	African pike characin
Phoxinus erythrogaster	Southern redbelly dace
Polyodon spathula	Mississippi paddlefish
Polypterus endlicherii	Saddled bichir
Polypterus retropinnis	West African bichir
Pomoxis spp	Crappie
Procambarus clarkii	Red swamp crayfish

Protopterus aethiopicus	Marbled lungfish
Protopterus amphibius	Gilled lungfish
Protopterus annectens	West African lungfish
Protopterus dolloi	Slender lungfish
Psephurus gladius	Chinese swordfish
Pseudocrenilabrus philander	Dwarf Victorian mouthbrooder
Pungitius pungitius	Ninespine stickleback
Pygocentrus spp	Piranha
Sabella spallanzanii	European fan worm
Sargochromis spp	Happy
Sarotherodon spp	Tilapia
Schilbe intermedius	Silver catfish
Schilbe marmoratus	Shoulderspot catfish
Schilbe mystus	African butter catfish
Serranochromis spp	
Serrasalmus spp	Piranha
Silurus spp	European catfish, wels catfish
Sorubim lima	Duckbill catfish
Spartina anglica	Rice grass/Common cord-grass
Tilapia spp except T. buttikoferi	Tilapia
Tomeurus gracilis	Guppy
Tor spp	Mahseer
Trichomycteridae family	Parasitic catfishes
Tridentiger trigonocephalus	Chameleon goby, striped goby
Undaria pinnatifida	Wakame seaweed
Valencia hispanica	Valencia toothcarp
Xiphophorus pygmaeus	Pygmy swordtail
Zacco platypus	Freshwater minnow

SA	
Species	**Common name**
Acestrorhynchus microlepis	
Hydrocynus spp	Pike characin, Giant tigerfish
Amia calva	Bowfin
Anabas testudineus	Climbing perch
Anaspidoglanis macrostoma	Flatnose catfish
Bagrus ubangensis	Ubangi shovelnose catfish
Centrarchidae — entire family	Banded or spotted sunfish, largemouth bass, bluegill
Centropomus spp	Snooks
Lates microlepis	Forktail lates
Lates niloticus	Nile perch
Channa spp	Snake head
Chaca chaca	Angler, frogmouth and squarehead catfishes
Colossoma spp	
Serrasalmus spp	Redeye piranha
Pygocentrus spp	Red piranha
Boulengerochromis microlepis	Giant cichlid, yellow belly cichlid
Oreochromis spp	Tilapia
Hemichromis fasciatus	Banded jewelfish
Sargochromis spp	Pink, slender, greenwoods, mortimers,cunean and green happy
Sarotherodon spp	
Sarotherodon melanotheron	Blackchin tilapia
Serranochromis spp	
Tilapia spp (All except T. buttikoferi)	Redbelly tilapia
Family Citharinidae, entire subfamily *Ichthyborinae*	African pike-characin, tubenose poacher, fin eater
Clarias spp	Walking catfish
Misgurnus anguillicaudatus	Weatherloach
Hypophthalmichthys nobilis	Bighead carp
Neolissochilus hexagonolepis	Copper mahseer
Gibelion catla	Catla
Catlocarpio siamensis	Giant barb
Cirrhinus cirrhosus	Mrigal
Ctenopharyngodon idella	Grass carp
Labeo calbasu and *L. rohita*	Orange fin labeo, rohu
Zacco platypus	Freshwater minnow
Hypophthalmichthys molitrix	Silver carp
Tor spp	River carp, Deccan, high backed, jungha, putitor, Thai mahseer
Notropis spp	Shiners
Phoxinus erythrogaster	Southern redbelly dace
Oxydoras spp	Ripsaw catfish, black doras, black shielded catfish
Elassoma spp	Pygmy sunfish
Oxyeleotris marmorata	Marble goby
Erythrinus spp	Trahiras
Hoplerythrinus spp	
Hoplias spp	
Esox spp	Pikes
Pungitius pungitius	Ninespine stickleback
Apeltes quadracus	Four spined stickleback
Culaea inconstans	
Acanthogobius flavimanus	Yellow fin goby
Tridentiger trigonocephalus	Chameleon goby, striped goby
Gymnarchus niloticus	Aba aba
Electrophorus electricus	Electric eel
Hepsetus odoe	African pike
Heteropneustes fossilis	Stinging catfish
Atractosteus spp	American, armoured or alligator gars
Lepisosteus spp	American, armoured or alligator gars
Malapterurus spp	Electric catfish
Mormyrops anguilloides	Bottlenose, Cornish jack
Belonesox belizanus	Pike minnow, pike killifish
Polyodon spathula	Mississippi paddlefish
Psephurus gladius	Chinese swordfish
Protopterus annectens	African lungfish
Schilbe mystus	African butter catfish
Silurus spp	European catfish, wels catfish
Paravandellia oxyptera	Parasitic catfish
Valencia hispanica	Valencia toothcarp
Procambarus clarkii	Red swamp crayfish
Cyprinus carpio	'European' carp, Koi carp
Acipenser fulvescens	Lake sturgeon
Acipenser brevirostrum	Shortnose sturgeon
Acipenser persicus	Persian sturgeon
Acipenser sinensis	Chinese sturgeon
Acipenser sturio	European sturgeon

Pangasius elongatus	
Pangasius nieuwenhuisii	
Erpetoichthys calabaricus	Reedfish
Acipenser ruthenus	Sterlet
Acipenser dabryanus	Yangtze sturgeon
Acipenser medirostris	Green sturgeon
Acipenser mikadoi	Sakhalin sturgeon
Acipenser naccarii	Adriatic sturgeon
Acipenser oxyrinchus oxyrinchus	Atlantic sturgeon
Acipenser baerii baicalensis	Baikal sturgeon
Acipenser nudiventris	Fringebarbel sturgeon
Acipenser schrenckii	Amur sturgeon
Acipenser multiscutatus	Japanese sturgeon
Acipenser oxyrinchus destotoi	Gulf sturgeon
Oxyeleotris heterodon	Sentani gudgeon
Pangasius gigas	Mekong giant catfish
Pangasius conchophilus	
Pangasius krempfi	
Pangasius kunyit	
Tomeurus gracilis	
Huso huso	Beluga
Oxyeleotris urophthalmoides	
Oxyeleotris siamensis	
Acipenser stellatus	Starry sturgeon
Alfaro cultratus	Knife-edged livebearer
Protopterus dolloi	Slender lungfish
Leptolebias opalescens	Opal pearlfish
Gobiomorphus gobioides	Giant bully
Heterandria bimaculata	Twospot livebearer
Chaca bankanensis	Angler catfish
Allomogurnda nesolepis	Yellowbelly gudgeon
Dormitator maculatus	Fat sleeper
Acipenser baerii baerii	Siberian sturgeon
Chaca chaca	Squarehead catfish
Paratrygon aiereba	Discus ray
Lebiasina bimaculata	Twospot lebiasina
Pangasius pangasius	Yellowtailed catfish
Pangasius nasutus	
Leptolebias aureoguttatus	
Leptolebias marmoratus	Marbled pearlfish
Leptolebias minimus	Barred tail pearlfish
Gobiomorus dormitor	Bigmouth sleeper
Oxyeleotris urophthalmus	
Acipenser gueldenstaedtii	Russian sturgeon
Acipenser transmontanus	White sturgeon
Lepidosiren paradoxa	South American lungfish
Pangasius larnaudii	Spot pangasius
Gobiomorphus huttoni	Redfin bully
Alfaro huberi	
Chaca burmensis	Burmensis frogmouth catfish
Pangasianodon hypophthalmus	Sutchi catfish
Pangasius macronema	
Protopterus aethiopicus	Marbled lungfish
Schilbe marmoratus	Shoulderspot catfish
Gobiomorus maculatus	Pacific sleeper
Hypseleotris cyprinoides	Tropical carp-gudgeon
Protopterus amphibius	Gilled lungfish
Hypseleotris tohizonae	
Dormitator latifrons	Pacific fat sleeper
Ictalurus punctatus	Channel catfish
Schilbe intermedius	Silver catfish
Oxyeleotris marmorata	Marble goby

NT		
Family	**Scientific name**	**Common name**
Acestrorhynchidae	*Acestrorhynchus microlepis*	
Alestiidae	*Hydrocynus* spp	Pike characin, giant tigerfish
Amiidae	*Amia calva*	Bowfin
Anaban idae	*Anabas testudineus*	Climbing perch
Bagridae	*Anaspidoglanis macrostoma*	Flatnose catfish
	Bagrus ubangensis	Ubangi shovelnose catfish
Cambaridae	*Procambarus clarkii*	Red swamp crayfish
Centrarchidae	entire family	Banded sunfish, spotted sunfish, largemouth bass, bluegill
Centropomidae	*Centropomus*	Snooks
	Lates microlepis	Forktail lates
	Lates niloticus	Nile perch
Chacidae	*Chaca chaca*	Angler catfish, frogmouth catfish, squarehead catfish
Channidae	*Channa* spp	Snake head
Characidae	*Colossoma* spp	
	Serrasalmus spp	Redeye piranha
	Pygocentrus spp	Red piranha
	Pygopristis spp	Piranha
Cichlidae	*Boulengerochromis microlepis*	Giant cichlid, yellow belly cichlid
	Oreochromis spp	Tilapia
	Hemichromis fasciatus	Banded jewelfish
	Hypselecara spp	Chocolate cichlid
	Sargochromis spp	Pink, slender, greenwoods, mortimers, cunean, green happy
	Sarotherodon spp	Tilapia
	Melanotheron melanotheron	Blackchin tilapia
	Serranochromis spp	
	Tilapia spp	Tilapia, spotted tilapia, mouthbreeder
Citharinidae	*Ichthyborinae* (syn. *Distichodontinae*) entire subfamily	African pike-characin, tubenose poacher, fin eater
Clariidae	Entire family	Snake catfish, walking catfish
Cobitidae	*Misgurnus anguillicaudatus*	Weatherloach
Cyprinidae	*Aristichthys nobilis*	Bighead carp
	Barbodes hexagonolepis	Copper mahseer
	Barbonymus schwanenfeldii	Tinfoil barb
	Catla catla	Catla
	Catlocarpio siamensis	Giant barb
	Cirrhinus cirrhosus	Mrigal
	Ctenopharyngodon idella	Grass carp
	Cyprinus carpio	European carp
	Labeo calbasu	Orange fin labeo
	Labeo rohita	Rohu
	Zacco platypus	Freshwater minnow
	Hypophthalmichthys molitrix	Silver carp
	Tor spp	River carp, Deccan, high backed, jungha, putitor, Thai mahseer
	Notropis spp	Shiners
	Phoxinus erythrogaster	Southern redbelly dace
Doradidae	*Oxydoras* spp	Ripsaw catfish, black doras, black shielded catfish
Elassomatidae	*Elassoma* spp	Pygmy sunfish
Eleotridae	*Oxyeleotris marmorata*	Marble goby
Erythrinidae	*Erythrinus* spp	Trahiras
	Hoplerythrinus spp	
	Hoplias spp	
Esocidae	*Esox* spp	Pikes
Gasterosteidae	*Pungitius pungitius*	Ninespine stickleback
	Apeltes quadracus	Four spined stickleback
	Culaea inconstans	
Gobiidae	*Acanthogobius flavimanus*	Yellow fin goby
	Tridentiger trigonocephalus	Trident goby
Gymnarchidae	*Gymnarchus niloticus*	Aba aba
Gymnotidae	*Electrophorus electricus*	Electric eel
Hepsetidae	*Hepsetus odoe*	African pike
Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish

Lepisosteidae	*Atractosteus* spp	American gar, armoured gar, alligator gar
	Lepisosteus spp	American gar, armoured gar, alligator gar
Malapteruridae	*Malapterurus* spp	Electric catfish
Mormyridae	*Mormyrops anguilloides*	Bottlenose, Cornish jack
Poeciliidae	*Belonesox belizanus*	Pike minnow, pike killifish
	Gambusia spp	Gambusia, mosquito fish
Polyodontidae	*Polyodon spathula*	Mississippi paddlefish
	Psephurus gladius	Chinese swordfish
Protopteridae	*Protopterus annectens*	African lungfish
Schilbeidae	*Schilbe mystus*	African butter catfish
Siluridae	*Silurus* spp	European catfish, wels catfish
Trichomycteridae	*Paravandellia oxyptera*	Parasitic catfish
Valenciidae	*Valencia hispanica*	Valencia toothcarp

WA	
Scientific name	**Examples of common names used**
Acanthogobius flavimanus	Yellow Fin Goby
Acestrorhynchus microlepis	Pike Characin
Acipenser baerii baerii	Siberian Sturgeon
Acipenser baerii baicalensis	Baikal Sturgeon
Acipenser brevirostrum	Shortnose Sturgeon
Acipenser dabryanus	Yangtze Sturgeon
Acipenser fulvescens	Lake Sturgeon
Acipenser gueldenstaedtii	Russian Sturgeon
Acipenser medirostris	Green Sturgeon
Acipenser mikadoi	Sakhalin Sturgeon
Acipenser multiscutatus	Japanese Sturgeon
Acipenser naccarii	Adriatic Sturgeon
Acipenser nudiventris	Fringebarbel Sturgeon
Acipenser oxyrinchus destotoi	Gulf Sturgeon
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon
Acipenser persicus	Persian Sturgeon
Acipenser ruthenus	Sterlet
Acipenser schrenckii	Amur Sturgeon
Acipenser sinensis	Chinese Sturgeon
Acipenser stellatus	Starry Sturgeon
Acipenser sturio	European Sturgeon
Acipenser transmontanus	White Sturgeon
Alfaro cultratus	Knife-edged Livebearer
Alfaro huberi	
Allomogurnda nesolepis	Yellowbelly Gudgeon
Ameiurus brunneus	Snail Bullhead
Ameiurus catus	White Catfish
Ameiurus melas	Black Bullhead
Ameiurus natalis	Yellow Bullhead
Ameiurus nebulosus	Brown Bullhead
Ameiurus platycephalus	Flat Bullhead
Ameiurus serracanthus	Spotted Bullhead
Amia calva	Bowfin
Anabas cobojius	Gangetic Climbing Perch
Anabas testudineus	Climbing Perch
Anaspidoglanis macrostoma	Flatnose Catfish
Apeltes quadracus	Four-Spined Stickleback
Aristichthys noblis	Bighead Carp
Astyanax aeneus	Banded Tetra
Astyanax fasciatus	Banded Astyanax
Bagrus ubangensis	Ubangi Shovelnose Catfish
Barbodes hexagonolepis	Copper Mahseer
Belonesox belizanus	Pike Minnow, Pike Killifish
Boulengerochromis microlepis	Giant Cichlid, Yellow-belly Cichlid
Catla catla	Catla
Catlocarpio siamensis	Giant Barb
Centrarchidae (entire family)	Banded Sunfish, Spotted Sunfish, Largemouth Bass, Bluegill
Centropomus (entire genus)	Snooks (American)
Chaca bankanensis	Angler Catfish
Chaca burmensis	Burmensis Frogmouth Catfish
Chaca chaca	Angler, Frogmouth and Squarehead Catfish
Channa spp. (entire genus)	Snakehead
Cirrhinus cirrhosus	Mrigal
Clarias spp. (entire genus)	Walking Catfish
Colossoma spp. (entire genus)	Tambaqui Pacu, Pirapitinga
Crenicichla lepidota	Pike Cichlid

Ctenopharyngodon idella	Grass Carp
Ctenopoma argentoventer	Silverbelly Ctenopoma
Ctenopoma kingsleyae	Tailspot Ctenopoma
Ctenopoma multispine	Manyspined Ctenopoma
Ctenopoma muriei	Ocellated Labyrinth Fish
Ctenopoma nigropannosum	Twospot Climbing Perch
Ctenopoma ocellatum	Eyespot Ctenopoma
Ctenopoma weeksii	Mottled Ctenopoma
Culaea inconstans	Brook Stickleback
Dormitator latifrons	Pacific Fat Sleeper
Dormitator lebretonis	
Dormitator maculatus	Fat Sleeper
Elassoma spp. (entire genus)	Pygmy Sunfish
Electrophorus electricus	Electric Eel
Eleotris amblyopsis	Large Scaled Spiny Cheek Sleeper
Eleotris sandwicensis	Sandwich Island Sleeper
Erpetoichthys calabaricus	Reedfish
Erythrinus spp. (entire genus)	Trahiras (Various)
Esox spp. (entire genus)	Pikes (Freshwater)
Gambusia spp. (entire genus)	Mosquito Fish
Gobiomorphus gobioides	Giant Bully
Gobiomorphus huttoni	Redfin Bully
Gobiomorus dormitor	Bigmouth Sleeper
Gobiomorus maculatus	Pacific Sleeper
Gymnarchus niloticus	Aba Aba
Helicophagus leptorhynchus	
Helicophagus waandersii	
Hemichromis fasciatus	Banded Jewelfish
Hepsetus odoe	African Pike
Heterandria bimaculata	Twospot Livebearer
Heteropneustes fossilis	Stinging Catfish
Himantura kittipongi	
Himantura krempfi	Marbled Freshwater Whip Ray
Himantura oxyrhyncha	Marbled Whipray
Hoplery hrinus spp. (entire genus)	Trahiras (Various)
Hoplias spp. (entire genus)	Trahiras (Various)
Huso huso	Beluga
Hydrocynus spp. (entire genus)	Tigerfish
Hypoph halmichthys molitrix	Silver Carp
Hypseleotris cyprinoides	Tropical Carp-gudgeon
Hypseleotris tohizonae	
Ichthyborinae (entire subfamily)	African Pike-characin, Tubenose Poacher, Fin Eater
Ictalurus balsanus	Balsas Catfish
Ictalurus dugesii	Lerma Catfish
Ictalurus furcatus	Blue Catfish
Ictalurus lupus	Headwater Catfish
Ictalurus mexicanus	Rio Verde Catfish
Ictalurus ochoterenai	Chapala Catfish
Ictalurus pricei	Yaqui Catfish
Ictalurus punctatus	Channel Catfish
Labeo calbasu	Orange Fin Labeo
Labeo rohita	Rohu
Lates microlepis	Forktail Lates
Lates niloticus	Nile Perch
Lebiasina bimaculata	Twospot Lebiasina
Lepidosiren paradoxa	South American Lungfish
Leptolebias aureoguttatus	
Leptolebias marmoratus	Marbled Pearlfish
Leptolebias minimus	Barred Tail Pearlfish
Leptolebias opalescens	Opal Pearlfish
Malapterurus spp. (entire genus)	Electric Catfish
Melanotheron melanotheron	Blackchin Tilapia
Misgurnus anguillicaudatus	Weatherloach
Mormyrops anguilloides	Cornish Jack, Bottlenose
Mytilopsis spp. (entire genus) and *Congeria spp* . (entire genus)	Black Striped Mussel
Notropis spp. (entire genus)	Shiners
Noturus albater	Ozark Madtom
Noturus baileyi	Smoky Madtom
Noturus crypticus	Chucky Madtom
Noturus elegans	Elegant Madtom
Noturus eleutherus	Mountain Madtom
Noturus exilis	Slender Madtom
Noturus fasciatus	Saddled Madtom
Noturus flavater	Checkered Madtom
Noturus flavipinnis	Yellowfin Madtom
Noturus flavus	Stonecat

Noturus funebris	Black Madtom
Noturus furiosus	Carolina Madtom
Noturus gilberti	Orangefin Madtom
Noturus gladiator	
Noturus gyrinus	Tadpole Madtom
Noturus hildebrandi hildebrandi	Least Madtom
Noturus hildebrandi lautus	
Noturus insignis	Margined Madtom
Noturus lachneri	Ouachita Madtom
Noturus leptacanthus	Speckled Madtom
Noturus maydeni	Black River Madtom
Noturus miurus	Brindled Madtom
Noturus munitus	Frecklebelly Madtom
Noturus nocturnus	Freckled Madtom
Noturus phaeus	Brown Madtom
Noturus placidus	Neosho Madtom
Noturus stanauli	Pygmy Madtom
Noturus stigmosus	Northern Madtom
Noturus taylori	Caddo Madtom
Noturus trautmani	Scioto Madtom
Oreochromis spp. (entire genus)	Tilapia (Various)
Oxydoras spp. (entire genus)	Ripsaw Catfish, Black Doras, Black Shielded Catfish
Oxyeleotris heterodon	Sentani Gudgeon
Oxyeleotris marmorata	Marble Goby
Oxyeleotris siamensis	
Oxyeleotris urophthalmoides	
Oxyeleotris urophthalmus	
Pangasianodon gigas	Mekong Giant Catfish
Pangasius conchophilus	
Pangasius elongatus	
Pangasius krempfi	
Pangasius kunyit	
Pangasius larnaudii	Spot Pangasius
Pangasius macronema	
Pangasius nasutus	
Pangasius nieuwenhuisii	
Pangasius pangasius	Yellowtailed Catfish
Paratrygon aiereba	Discus Ray
Paravandelia oxyptera	Parasitic Catfish
Phoxinus erythrogaster	Southern Redbelly Dace
Polyodon spathula	Mississippi Paddlefish
Procambarus clarkii	Red Swamp Crayfish
Protopterus aethiopicus	Marbled Lungfish
Protopterus amphibius	Gilled Lungfish
Protopterus annectens	African Lungfish
Protopterus dolloi	Slender Lungfish
Psephurus gladius	Chinese Swordfish
Pseudoplatystoma fasciatum	Tiger Catfish
Pungi ius pungitius	Ninespine Stickleback
Pygocentrus spp. (entire genus)	Piranha (Various)
Pylodictis olivaris	Flathead Catfish
Rutilus rutilus	Roach
Sargochromis spp. (entire genus)	Pink, Slender, Greenwood's, Mortimer's, Cunene and Green Happy
Sarotherodon spp. (entire genus)	Tilapia (Various)
Schilbe intermedius	Silver Catfish
Schilbe marmoratus	Shoulderspot Catfish
Schilbe mystus	African Butter Catfish
Serranochromis spp. (entire genus)	Cichlids
Serrasalmus spp. (entire genus)	Piranha (Various)
Silurus spp. (entire genus)	European Catfish, Wels Catfish
Tilapia spp. (all except *T buttikoferi*)	Tilapia (Various)
Tinca tinca	Tench
Tomeurus gracilis	
Tor (entire genus)	River Carp, Deccan, High Backed, Jungha, Putitor, Thai Mahseer
Tridentiger trigonocephalus	Chameleon Goby, Striped Goby
Valencia hispanica	Valencia Toothcarp
Zacco platypus	Freshwater Minnow