Status of non-CITES listed anguillid eels

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Executive summary

There are 16 species within the family Anguillidae, all of the genus *Anguilla*. Anguillid eels are globally distributed, and inhabit the fresh, brackish and coastal waters of more than 150 different countries. They feed and grow in continental waters, spawn in the marine environment and have multiple life stages. Their complex life history means that anguillids are susceptible to a range of threats. These include unsustainable exploitation and trade, changes in oceanic currents and/or climatic conditions, barriers to migration (including hydro-power stations which damage and/or kill eels), loss of freshwater habitat, disease and pollution. It is generally agreed that stocks of many of the anguillid eels, most notably in temperate Northern Hemisphere regions, have exhibited declines in recent decades due to a combination of these threats.

In 2007, *Anguilla anguilla* was listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Since that time, it has been observed that this listing and/or Parties' responses to the listing have had impacts on other species of anguillids. At the 17th meeting of the Conference of the Parties to CITES, four Decisions (17.186-17.189), relating to anguillid eels were adopted. Decision 17.186, states that the Secretariat shall contract independent consultants to undertake a study on non-CITES listed *Anguilla* species:

the Secretariat shall, subject to external funding:

> *b) contract independent consultants to undertake a study on non-CITES listed Anguilla species:*
> *i) documenting trade levels and possible changes in trade patterns following the entry into force of the listing of the European Eel in CITES Appendix II in 2009;*
> *ii) compiling available data and information on the biology, population status, use and trade in each species, as well as identifying gaps in such data and information, based on the latest available data and taking account* inter alia *of the Red List assessments by the IUCN Anguillid Eel Specialist Group;*

The CITES Secretariat contracted the Zoological Society of London (ZSL) to prepare the aforementioned report and ZSL in turn contracted TRAFFIC and consultants with expertise in eel trade issues and freshwater species assessments to deliver elements of the report. A questionnaire was developed to facilitate the gathering of relevant information from Parties. The CITES Secretariat made the questionnaire available to Parties as an Annex to Notification to the Parties No. 2018/018. Twenty responses to this Notification were received from Parties and a number of individuals were contacted directly when appropriate for further clarification. In parallel to this a review of relevant scientific and grey literature was conducted, and trade data were analysed. In addition to this, authors attended workshops in the Dominican Republic 4th-6th April and London 18th-20th April 2018 to collate further information and engage Parties.

Species Accounts

Available data were compiled for each species to provide an account of their present status. These accounts are briefly summarised below:

Anguilla australis is a temperate eel primarily found in New Zealand and Australia, and appears to have the healthiest stock status of all the anguillids, with range States indicating that populations were stable. There are some concerns relating to the impacts of barriers to migration and while exploitation for export does occur, there are fisheries management mechanisms in place.

Anguilla bengalensis is a poorly understood species with a range that spans the Indian Ocean, having been identified in East Africa, and Central and South East Asia. Little information was available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla bicolor is widely distributed between the Indian and Pacific Oceans. There have been a number of studies on the biology of the species, but the stock status is less well understood. The primary concern relating to this species has been an increase in exploitation and trade to East Asia, since the EU banned export of *A. anguilla* in 2010. Both Indonesia and the Philippines, key export nations of the species, have implemented policies that relate to the export of the species, but exploitation continues and there are little data to determine whether this off-take is sustainable in the long-term.

Anguilla borneensis is restricted to Indonesia, Malaysia and the Philippines, and is very poorly understood. Little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla celebesensis has been reported to occur in Indonesia, Papua New Guinea and the Philippines, however, the geographic range of this species has still to be fully understood due to misidentification of other species. Little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla dieffenbachii is endemic to New Zealand and its offshore islands, and is the largest of the anguillid eels. There are concerns relating to the impacts of fisheries and barriers to migration – particularly hydropower. The status of the species appears to vary significantly with location and while some areas have seen increasing abundances in recent years, prior to this, a number of studies indicated there have been significant historic population declines across its range.

Anguilla interioris has a known range restricted to Indonesia, Papua New Guinea and the Philippines, however, the distribution of this species has still to be fully understood due to misidentification of other species. Little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla japonica is native to Japan, China, Hong Kong, Taiwan and South Korea and is relatively well studied. Barriers to migration, climate change, habitat loss/modification and unsustainable/illegal harvest and/or trade have been identified as threats across its range. It is the most sought after species for consumption in East Asia, but catches have been declining for decades and it is generally accepted that the stock is under threat. National fisheries management mechanisms are in place and China, Japan, South Korea and Taiwan have signed a voluntary agreement to co-operate on the management of the species.

Anguilla luzonensis has an extremely limited known range within certain catchments in the Philippines. However, the distribution of this species has still to be fully understood due to misidentification of other species. As the species was only discovered in 2009, very little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla marmorata has the widest geographical distribution of any anguillid species with a range that spans the Indian and Pacific Oceans. Due to its extensive range it is exposed to a wide range of threats and barriers to migration and unsustainable harvest are of particular concern. However, Parties considered the status of this stock to be of lower concern.

Anguilla megastoma is found across the islands of the Pacific Ocean. Present understanding of its biology is limited, but it appears to have a preference for the headwaters of rivers. Little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla mossambica is present in many of the east flowing river drainages of coastal Africa. Understanding of its biology is poor, but recent research has indicated that within regions of South Africa, its range has diminished significantly. Over the past 10-15 years, there has been an increase in exports of *A. mossambica* to East Asia, but beyond this, little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla obscura has a range that encompasses Australia and the islands of the Pacific Ocean. Present understanding of its biology is limited, but it appears to have a preference for the lower reaches of rivers. Little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla reinhardtii is found in Australia, New Zealand, New Guinea, New Caledonia and Vanuatu. Present understanding of its biology is poor, but it is believed to be extremely fast growing and may outcompete sympatric species. Little information is available relating to threats, trade and use or species-specific management, and baseline data collection for this species is urgently needed.

Anguilla rostrata has a distribution that ranges from Greenland to the northern portion of the Atlantic coast of South America. Its biology is relatively well understood across the northern part of its range, but much less so in the regions south of the USA. Barriers to migration (including hydropower), habitat loss and unsustainable fisheries were identified as significant threats. This species has been increasingly sourced to meet demand from East Asia resulting in a number of new management mechanisms being implemented in recent years. The stock status declined significantly from the 1970s to the 1990s at which point it has been relatively stable, though the depleted abundance remains of concern.

Trade of non-CITES listed anguillid eels

Eel farming is reliant on growing out wild-caught juvenile eels (glass eels, elvers, eel fry), so eel farms need to obtain juvenile eels as "seed". Although the main species traditionally used for farming in East Asia was *A. japonica*, which is native to the region, demand for eel seeds and declines in recruitment has led to the use of other *Anguilla* spp. from the 1990s onwards, in particular *A. anguilla* and *A. rostrata*. Following the CITES listing, the European Union banned all trade in *A. anguilla* from and to the EU in December 2010. This, and the declining annual harvest of *A. japonica*, has meant other regions have become increasingly important sources of juvenile *Anguilla* spp. for East Asian farms. Trade in anguillid eels was examined regionally due to the challenges in identifying individual species from data currently available.

Imports of live juvenile eels from the Americas - assumed to be *A. rostrata* - into East Asia seem to have increased considerably in recent years. Much of the eels from Caribbean and Central American countries seem to be traded via the USA or Canada. The demand for juvenile eel from South East/South Asia and East/Southern Africa – likely *A. bicolor* and *A. mossambica* respectively - seemed to have reached a peak in 2013-2014. However, as the *A. japonica* glass eel harvest in the 2017-2018 fishing season has been extremely low, demand for live juvenile eels from other regions may increase again in the future.

Illegal harvest and trade in *Anguilla* spp. is a serious issue in many countries/territories especially in range States of *A. japonica* and *A. bicolor*. Among *Anguilla* spp., *A. japonica* is considered to be the most commercially important species and illegal harvest and trade is prevalent in all the range States/territories. Although many South East Asian countries do not allow the export of glass/juvenile eels, a significant volume of imports of live eel fry was reported by East Asia over the last five years.

Conclusions

This study, the responses to CITES Notification 018/2018 and the workshops have highlighted that the knowledge relating to the 15 species of non-CITES listed anguillid eels is highly variable. Temperate species are generally better understood than tropical species, many of which have practically no readily available information relating to their biology and status. Yet, even for the temperate species there are often large variations in understanding across their ranges. Robust, long-term abundance data sets to allow monitoring of the species status were generally lacking and should be a priority for future research. Further, the understanding of how the various possible threats impact each species is generally poor.

Trade data analyses of *Anguilla* spp. over the last 10 years shows that there were substantial shifts in trade patterns relating to live eels, especially juveniles. In some cases, this trade has shifted to species/populations that are poorly understood and where there is little fisheries management to ensure off-take is both legal and sustainable. Considering that several populations of *Anguilla* spp. are reported to have declined over recent decades, and *A. japonica* and *A. rostrata* are both currently listed as Endangered on the IUCN Red List of Threatened Species, it is of urgent necessity to adapt management and conservation measures in a regionally and/or globally co-ordinated manner to ensure sustainable use of *Anguilla* species into the future.

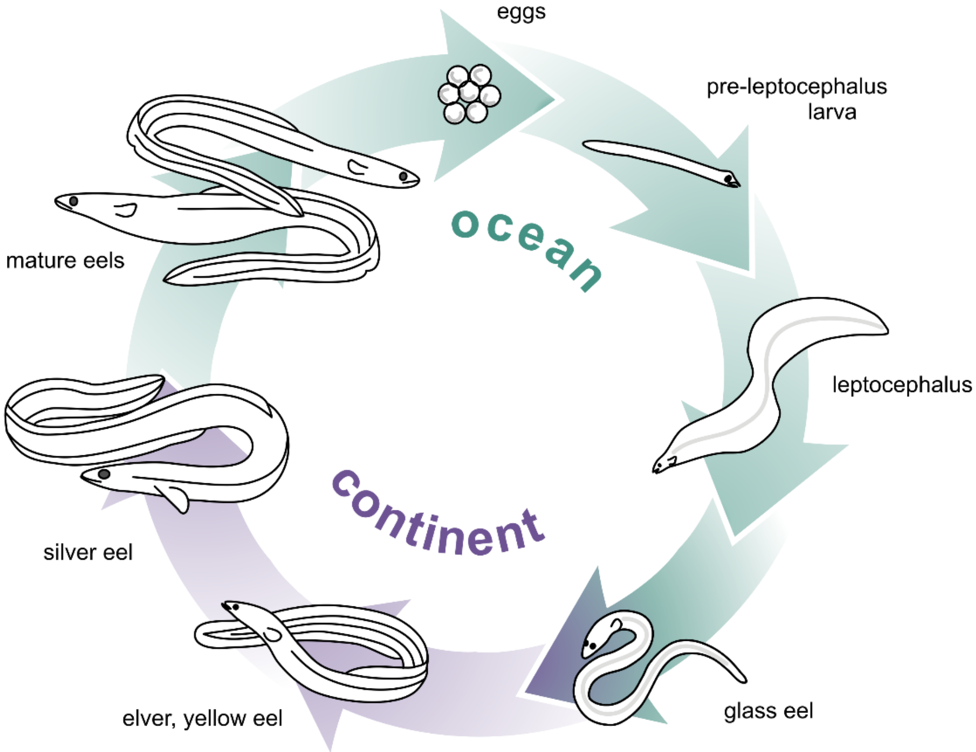
1. General Introduction

There are 16 species within the family Anguillidae. They are globally distributed, and inhabit the fresh, brackish and coastal waters of more than 150 different countries (Jacoby *et al*., 2015). As such, despite its common usage in relation to these species, the term 'freshwater eel is misleading as anguillid eels are generally facultatively catadromous, with the possibility that a proportion of any population, rarely, if ever, enters fresh water (Arai *et al*., 2004; Daverat *et al*., 2006; Edeline, 2007; Tsukamoto *et al*., 1998). True catadromy could be described as feeding and growing in freshwater, and breeding in the marine environment, however, the growth phase of anguillid eels is best described as 'continental' with 'freshwater' not believed to be essential to the continuation of the species – hence facultative catadromy. Breeding and spawning of anguillid eel occurs in the marine environment and this element is believed to be essential for the completion of the life cycle (Tesch, 2003). While there is some understanding of the eel's continental life history, relatively little is known about its marine phase. Anguillid eels also have multiple life stages (Figure 1), are semelparous, i.e. have a single breeding event; and are believed to be panmictic (Aida *et al*., 2003; Als *et al*., 2011; Côté *et al*., 2013; van Ginneken and Maes, 2005).

As stated above, there are a number of phases in an eel's life that have specific terminology that will be used throughout this document. After hatching, the marine larval leptocephalus stage is leaf-shaped and very different from the elongate shape most associated with the anguillids (Aoyama, 2009; Tesch, 2003). During the migration the leptocephali grow and elongate to become transparent glass eels upon arrival at the continental shelf – it is the glass eel stage that is the primary focus of global exploitation (Crook and Nakamura, 2013b; Shiraishi and Crook, 2015). As the glass eels grow and pigment – be it in freshwater or saline waters - they become elvers and then yellow eels; these are morphologically similar, distinguished primarily on size, with a counter-shade of yellow / brown / green dorsum and lighter ventrum (Aoyama, 2009; Tesch, 2003). Anguillid eels are generally separated in to 'bi-coloured' or 'mottled' species, which applies to the dorsal colouration (Silfvergrip, 2009). The final stage is the marine-migratory silver eel, which will ultimately mature to breed, is characterised by a darkened dorsum, silvery counter-shading and large eyes (Aoyama, 2009; Tesch, 2003).

This idiosyncratic and complex life history means that anguillids are susceptible to a range of threats, both in the marine and freshwater environments, and present unique challenges in relation to conservation, management and policy development. They are exploited from juvenile to adult life stages, however, fisheries and trade are one of a number of proposed threats that also include changes in oceanic currents and/or climatic conditions; barriers to migration (including hydro-power stations which damage and/or kill eels); loss of freshwater habitat; disease; and pollution (Jacoby *et al*., 2015). These issues, and how they relate to individual species will be discussed in the species-specific sections, however, stocks of many anguillid eel species, most notably those in temperate Northern Hemisphere regions, have exhibited declines in recent decades due to these impacts (Casselman, 2003; Dekker and Casselman, 2014; Haro *et al*., 2000; Jacoby *et al*., 2015; Tsukamoto *et al*., 2003).

Figure 1. A schematic diagram of the life cycle of anguillid eels. Source: Henkel *et al.* 2012.



At the 14th CITES Conference of the Parties in 2007, the European eel (*Anguilla anguilla*) was listed in Appendix II of the convention. This listing came in to force in March 2009, and soon after, in December 2010, the European Union (EU) banned the import and export of European eel, as the Scientific Review Group (SRG) '*agreed that it was not possible to perform a "non-detriment finding" for the export of European eels, i.e. that it was not possible for the SRG to consider that the capture or collection of European eel specimens in the wild or their export will not have a harmful effect on the conservation status of the species or on the extent of the territory occupied by the relevant population of the species.*' This situation remains unchanged at present, however, since the EU's decision there has been increased export of European eel outside of the EU and other anguillid species, particularly the American eel (*Anguilla rostrata*) and the shortfin eel (*Anguilla bicolor*). There have also been concerns relating to illegal trade of a number of anguillid eel species.

At the 17th meeting of the Conference of the Parties to CITES, held in Johannesburg, South Africa, 24 September to 5 October 2016, four decisions, 17.186 - 17.189, relating to anguillid eels were adopted[1]. Decision 17.186, directed to the CITES secretariat, stated the following:

The Secretariat shall, subject to external funding:

*a) contract independent consultants to undertake a study compiling information on challenges and lessons learnt with regards to implementation of the Appendix II listing of European Eel (*Anguilla anguilla*) and its effectiveness. This includes in particular the making of non-detriment findings,*

[1] https://cites.org/eng/dec/valid17/81868

enforcement and identification challenges, as well as illegal trade. This study should notably take account of the data compiled and advice issued by the ICES/GFCM/EIFAAC Working Group Eel;

b) contract independent consultants to undertake a study on non-CITES listed Anguilla species:

> *i) documenting trade levels and possible changes in trade patterns following the entry into force of the listing of the European Eel in CITES Appendix II in 2009;*
>
> *ii) compiling available data and information on the biology, population status, use and trade in each species, as well as identifying gaps in such data and information, based on the latest available data and taking account inter alia of the Red List assessments by the IUCN Anguillid Eel Specialist Group; and*
>
> *iii) providing recommendations for priority topics for technical workshops based on gaps and challenges identified under i)-ii);*

c) make the reports from the studies above available to the 29th meeting of the Animals Committee (AC29) for their consideration; and

d) organize, where appropriate, international technical workshops, inviting cooperation with and participation by the relevant range States, trading countries, the Food and Agriculture Organization of the United Nations (FAO), the IUCN Anguillid Eel Specialist Group, the ICES/GFCM/EIFAAC Working Group Eel, industry and other experts appointed by Parties as appropriate. Such workshops should in particular cover the topics identified by the reports described in subparagraphs a) and b) of this Decision and could focus on challenges specific to the various eel species, such as

> *i) in relation to European eel, the realization of and guidance available for non-detriment findings, as well as enforcement of the Appendix II listing including identification challenges; and*
>
> *ii) in relation to the other eel species, to enable a better understanding of the effects of international trade, including trade in their various life stages, and possible measures to ensure sustainable trade in such species ;*

e) make any workshop report available to the 30th meeting of the Animals Committee (AC30) for their consideration; and

f) make available to the Standing Committee relevant information on illegal trade in European eels gathered from the study and the workshop report mentioned in paragraphs a) and e).

Due to issues with securing funding, the Decision has not been implemented in time to submit the reports outlined in paragraphs a) and b) to AC29 or technical workshops, as per paragraph c) and b)iii, respectively. However, it was agreed that the reports should be submitted to AC30. As such, this report fulfils the requirements of paragraph b) i and ii, in addressing the status of all non-CITES-listed species.

2. Methods

2.1 Review of existing published studies, reports and data

A search of published scientific papers was carried out using Web of Knowledge. In addition to this, IUCN Red List assessments were used as a source of information if available – 12 out of the 15 species. Grey literature was identified using web searches and through engagement with relevant stakeholders.

Production and trade data for *Anguilla* spp. were collated from several sources to provide an overview of production and trade dynamics and examine possible changes in trade patterns following the entry into force of the listing of the European Eel in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2009.

Globally, there are several six-digit Harmonised Systems (HS) Customs codes designated for eel, however these codes do not differentiate between the various life stages or species:

- live eels (*Anguilla* spp.) (HS 030192);
- fresh or chilled eels (*Anguilla* spp.) (HS 030274);
- frozen eels (*Anguilla* spp.) (HS 030326); and
- prepared/preserved eels (HS 160417)[2].

Some countries/territories have more detailed Customs codes for live eels, which enable users to differentiate between live eel fry (used for farming) and larger live eels (for consumption) and conduct a more detailed analysis.

The issues of over- and under-reporting must be considered when interpreting Customs data and information. Double counting may occur as *Anguilla* spp. are traded internationally before and after being converted into different types of commodities. In addition, eel-like species (non-*Anguilla* spp.) seem to be traded under HS codes for *Anguilla* eels in some countries/territories. For example, live eel exports from South East Asia are known to include *Monopterus albus* (Swamp Eels) (SEAFDEC, 2018, unpublished data; the Philippines' response to CITES Notification 2018/018) and trade to and from some countries in the Americas reported as *Anguilla* spp. is known to include Hagfish *Myxine* spp., Conger *Conger* spp., Moray Muraenidae and Snake Eel *Ophichthus remiger* (United States' response to CITES Notification 2018/018; Bustamante and Segovia 2006; UN Comtrade 2018).

For the purposes of analysis, it was assumed that countries/territories named in trade data as the origin of exports were the sources of the eels in trade, with the species assigned based on their range State distribution. The range States of each species were identified based on the most recent IUCN Red List assessment except for *A. australis*, *A. dieffenbachii* and *A. reinhardtii*, which have not been assessed. As several *Anguilla* spp. can be caught in several countries/territories, species trade was analysed by assuming the data referred to the *Anguilla* species mostly traded from a particular region i.e. East Asia - *A. japonica*, Americas - *A. rostrata*, South East Asia – *A. bicolor*+ (*A. bicolor* and other

[2] HS Nomenclature 2017 edition: http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2017-edition/hs-nomenclature-2017-edition.aspx

tropical species), Oceania - *A. australis+* (*A. australis*, *A. dieffenbachii and A. reinhardtii)* and East/Southern Africa - *A. mossambica+ (A. mossambica* and other tropical species). Scientific publications, government reports, press releases, online news article, company websites and other anecdotal information were used to provide an indication as to the species involved.

Food and Agriculture Organization (FAO) of the United Nations

Global and country/territory specific *Anguilla* "capture" and "aquaculture" data for 1950–2016 were downloaded from "Global Statistical Collections" http://www.fao.org/fishery/statistics/en in March 2018. FAO capture and aquaculture production data for China[3] from 1997 to 2006 were estimated, based on a downwards adjustment of 13% made by FAO in response to the China Second National Agriculture Census (S. Vannuccini, FAO, *in litt*. to TRAFFIC, September 2014). All other estimated quantities (marked with "F" in the FAO data) were also included in the analysis.
Anguilla spp. trade data for 1976–2015 were also downloaded from the "Global Statistical Collections" in March 2018. These FAO trade data were used to supplement UN Comtrade data (see below) on prepared/preserved eels traded from 2012 to 2016 inclusive.

UN Comtrade

Global *Anguilla* export and import data of live, fresh, frozen and prepared/preserved eel for 2007–2016 were downloaded in February 2018 from the UN Comtrade Database (http://comtrade.un.org/). UN Comtrade data were more detailed (including data from individual trading partners) and up to date than FAO Fisheries Commodities and Trade data and were therefore selected for analysis especially for the period 2012–2016. UN Comtrade data do not differentiate the various life stages of eels. Taiwan Province of China (hereafter, Taiwan) data are reported under "Other Asia *nes*" in UN Comtrade[4].

East Asia and other Customs data

Customs import and export data for live, fresh, frozen and prepared/preserved *Anguilla* eel for East Asian countries/territories for 2008–2017 were obtained through the following sources:

- China Customs Information Centre (data requested via China Cuslink Co. Ltd.);
- Hong Kong Trade Development Council (http://bso.hktdc.com/bso/jsp/bso_home.jsp);
- Ministry of Finance, Trade Statistics of Japan (http://www.customs.go.jp/toukei/info/);
- South Korea International Trade Association (http://www.kita.org/); and
- Taiwan Bureau of Foreign Trade (http://cus93.trade.gov.tw/ENGLISH/FSCE/).

All East Asian countries/territories have adopted more detailed eel Customs codes in comparison to the global HS codes, differentiating between "live eel fry" for farming and "other live eel" for consumption purposes (except for Japan's live eel export Customs code); however, the definition of "live eel fry" varies between them. For example, in Japan, "live eel fry" refers to glass eels and elvers

[3] 'China' refers to 'mainland China'
[4] https://unstats.un.org/unsd/tradekb/Knowledgebase/50104/Taiwan-Province-of-China-Trade-data?Keywords=Taiwan Accessed 6th March 2018.

13 g or less per specimen, however in the Republic of Korea (hereafter, South Korea), the term includes young eels up to 50 g per specimen (Table 1). Furthermore, South Korea differentiates between two different sizes of eel fry (by weight) and Taiwan differentiates between three sizes (by pieces per kg).

For this report, unless otherwise specified, the following terms apply:

- "live eel fry" refers to juvenile/young eels (irrespective of the size, including glass eels and elvers) used for farming; and
- "other live eel" refers to larger sized eels used for consumption (including large elvers, yellow and silver eels).

Table 1: Customs codes and descriptions of live Anguilla eels in East Asia

	Customs Code	Commodity
China[5]	0301.92.10.10	Live eel fry of Marbled Eel *Anguilla marmorata*
	0301.92.10.20	Live eel fry of European Eel *Anguilla anguilla*
	0301.92.10.90	Live eel fry, other *Anguilla* spp.
	0301.92.90.10	Live eels, other than fry of *Anguilla marmorata*
	0301.92.90.20	Live eels, other than fry of *Anguilla anguilla*
	0301.92.90.90	Live eels, other than fry of other *Anguilla* spp.
Japan	0301.92.10.0	Live eel fry "*Anguilla* spp." (only used for imports)
	0301.92.20.0	Live eels, other than fry of *Anguilla* spp. (only used for imports)
	0301.92.00.0	Live eel of *Anguilla* spp. (only used for exports)
South Korea	0301.92.10.00	Glass eel (≤0.3 g per unit, for aquaculture)
	0301.92.20.00	Young eel (>0.3 g and ≤50 g per unit, for aquaculture)
	0301.92.90.00	Live eels, other than fry of *Anguilla* spp.
Hong Kong	0301.92.10	Live eel fry "*Anguilla* spp."
	0301.92.90	Live eels, other than fry of *Anguilla* spp.
Taiwan	0301.92.10.10-1	Eels, *Anguilla japonica*, live
	0301.92.10.20-9	Eels, *Anguilla marmorata*, live
	0301.92.10.90-4	Other eels (*Anguilla* spp.), live
	0301.92.20.10-9	Glass eel (=>5000 pcs per kg)
	0301.92.20.20-7	Eel fry (=>500 and <5000 pcs per kg)
	0301.92.20.30-5	Young eel (elver) (>10 and <500 pcs per kg)

Source: Editorial Department of the Customs Import and Export Tariff of China (2016); Hong Kong Census and Statistics Department; Ministry of Finance, Trade Statistics of Japan; Korea International Trade Association; Taiwan Bureau of Foreign Trade. Note: mainland China uses 10-digit codes for Tariff purposes, but only 8-digit data (non-species-specific) are available for analysis.

Hong Kong Special Administrative Region of the People's Republic of China (hereafter Hong Kong) plays a crucial role as an eel trade hub, in particular for live eel fry. Hong Kong is sometimes described as the source of live eel fry in East Asian Customs data, which obscures their actual source as there are no glass eel fisheries or eel farms in Hong Kong (Agriculture, Fisheries and Conservation Department of the Hong Kong Special Administrative Region (AFCD), pers. comm. to TRAFFIC,

[5] Only 8-digit Customs code data are made available to the public (China Customs Information Center and China Cuslink Company, Ltd., *in litt.* to TRAFFIC, March 2018)

November 2017) and these are re-exports. Live eel fry data describing Hong Kong as the source have been excluded from analysis in this report in order to minimise double-counting, unless otherwise specified. Of two types of import data (by origin and by supplier) available in Hong Kong, origin data were used for this report, unless otherwise specified.
Other national sources were also analysed if *Anguilla* production/trade data were available (e.g. New Zealand).

2014 "Joint Statement" and 2017 "Joint Press release"

Live eel fry input into farms for 2004–2017 was provided by mainland China, Japan, South Korea and Taiwan as per the "Joint Statement on International Cooperation for Conservation and Management of *A. japonica* and other relevant *Anguilla* spp." (http://www.jfa.maff.go.jp/j/saibai/pdf/140917unagi_data.pdf) in September 2014 and the "Joint Press Release on the occasion of the Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species" (https://cites.org/sites/default/files/eng/com/ac/29/inf/E-AC29-Inf-13.pdf) in July 2017. Live eel fry input data for 2007–2017 are presented in the Annex. Input is used to describe the supply of live eel fry into grow-out eel farms. Mainland China, Japan, South Korea and Taiwan are trying to manage eel resources by setting input limits rather than catch limits (see Joint Statement).

Business-to-Business Trade Platforms

English language versions of Global Business to Business (B2B) trade platforms Alibaba[6], EC21[7], Food & Beverage (F&B) Online[8] and Weiku[9] were searched for "glass eel" advertisements and individual *Anguilla* species in March and April 2018. The search results were filtered according to product types (to exclude non-*Anguilla* products) and the location of suppliers, product origin, species offered, and availability (by quantity and month). The aim was to obtain qualitative information as it was difficult to determine if all the advertisements were recent without publication dates.
Where price information is given below, average annual exchange rates for Chinese Yuan (CNY), Japanese Yen (JPY), Korean Won (KRW) and Canadian Dollars (CAD) to US Dollars (USD) were taken from the World Bank[10] up to 2017 and from OANDA[11] for 2018.

2.2 Questionnaire

To gather information from the CITES Parties, and other stakeholders, a questionnaire was developed by the authors (Annex A). The questionnaire was made available through Notification to the Parties 2018/018, published by the Secretariat on 01/02/2018; some range States were also contacted directly. This was also sent to the chair of the CITES Animal Committee Inter-Sessional Working Group on anguillid eels established at AC29 to encourage input.

[6] http://www.alibaba.com/
[7] http://www.ec21.com/
[8] http://www.21food.com/
[9] http://www.weiku.com/
[10] https://data.worldbank.org/indicator/PA.NUS.FCRF
[11] https://www.oanda.com/currency/converter/

Responses were submitted by the following Parties: Australia, Canada, China, Cuba, Denmark, France, Germany, Greece, Indonesia, Japan, Malaysia, Netherlands, New Zealand, Philippines, Slovakia, Tunisia, Turkey, United Kingdom, the United States of America, and the Virgin Islands. We were also to able to obtain modified questionnaires used to inform a workshop for American eel range states held in the Dominican Republic (4th-6th April 2018) from the Bahamas, Belize, Canada, Costa Rica, Cuba, the Dominican Republic, Honduras, Jamaica, Mexico, Nicaragua and the United States of America[12].

2.3 Workshops

Two workshops were held during the period that this study was being carried out:

- American eel Range State workshop – 4th-6th April 2018, Santo Domingo, Dominican Republic[13]
- CITES international technical workshop on Eels *(Anguilla* spp.*)* – 18th to 20th April 2018, London, UK

There was representation at both by study authors and while reports from both workshops will be submitted to Animals Committee, we will include information collected during discussions, where relevant.

[12] These can be accessed here - http://www.sargassoseacommission.org/about-our-work/workshops/american-eel-range-states-workshop

3. Species Accounts

Below are 15 short species accounts that collate summary information collected from the sources listed in the methodology – more detailed species accounts, including range maps, can be found in Annex 1. Information provided by the Parties in the response to CITES Notification 018/2018 is outlined first and is then followed by additional information from literature and other sources. All sources are referenced and the full list of citations for both summary and full accounts can be found in the reference list. Vagrant occurrences have not been included in accounts, and instances where Parties have reported occurrences of species far outside of the known range have been highlighted. Trade of these species has been addressed more fully within Section 4.

3.1 *Anguilla australis*

Summary species account

Distribution: *Anguilla australis* is a temperate eel found in New Zealand, eastern Australia, Tasmania, Norfolk Island, Lord Howe Island, New Caledonia and the Chatham islands (Watanabe *et al*., 2010). *Anguilla australis* shows morphological differences between populations in Australia and New Zealand and two sub-species have been proposed*; Anguilla australis australis* and *Anguilla australis schmidtii* (Leander *et al*., 2012; Shen and Tzeng, 2007a; Watanabe *et al*., 2010). This contrasts with genetic studies (Dijkstra and Jellyman, 1999; Jellyman, 1987) suggesting that *A. australis* found in both New Zealand and Australia form a single biological stock, as they are homogenous at the glass eels stage (Jellyman, 2007).

Biology: *Anguilla australis* are believed to spawn in the tropical oceans and a few leptocephali have been found in an area northwest of Fiji, thus Castle (1963) suggested a spawning site between Fiji and Tahiti (170°W by 18°S). Other suggested spawning sites include near New Caledonia (Schmidt, 1928), and east of Tonga (August and Hicks, 2008; Jellyman, 1987). Spawning is proposed to occur between September and February (Arai *et al*., 2001b; Jellyman, 1987).

A study of *A. australis* glass eel recruitment into the Waikato River, New Zealand (Jellyman *et al*., 2009) found a positive correlation of migrations with spring tides. Tagging studies, as well as otolith micro-chemistry, suggest that *A. australis* exhibits behavioural plasticity regarding whether or not to enter freshwater, remain in marine environments or shift between the two habitats multiple times (Arai *et al*., 2003a; Arai and Chino, 2012; Crook *et al*., 2014). Downstream migration of *A. australis* in southeastern Australia was associated with high river flows while estuarine departure was influenced by lunar phase and water temperature (Jellyman *et al*., 2009). In a study of 97 tagged eels in southeastern Australia (Crook *et al*., 2014), twenty-three migrated into an estuarine environment, primarily at night, while the rest remained in freshwater. Time in the estuary ranged from one to 305 days. The extended residence of migrating eels in the estuary render them considerably more vulnerable to exploitation than had they migrated quickly to the sea where commercial eel-harvest does not occur (Crook *et al*., 2014).

Anguilla australis principally occurs in lowland waters such as estuaries, swamps, the lower reaches of rivers and warmer slower-flowing areas of streams (Glova *et al*., 2001; McCleave and Jellyman, 2002) or still waters such as coastal lakes and lagoons (Arai *et al*., 2003a). *Anguilla australis* reaches a maximum size of about 1.1 m and 3 kg (Jellyman, 2007) and females usually live to around 30 years

(Jellyman, 2009). *Anguilla australis* shows typical sexual dimorphism in size as per other temperate anguillid species. *Anguilla australis* is predominantly a nocturnal feeder of aquatic macroinvertebrates and fish (Broad *et al*., 2002) with differing preferences among different size classes (Sagar *et al*., 2005) – eels greater than 500 mm feed extensively on fish (Ryan, 1986).

Threats: In their responses to CITES Notification 018/2018 Australia and New Zealand identified threats across the range as barriers to migration, climate change, habitat loss/modification and pollution. Their unique migratory behaviour renders eels especially vulnerable to blockage of migration routes by dams, and mortality associated with passage through hydroelectric turbines (Bruijs and Durif, 2009; Calles *et al*., 2010; Crook *et al*., 2014).

Warmer temperatures associated with climate change may have a detrimental effect on glass eel recruitment in their current range. The upstream migration of *A. australis* glass eels was optimum at 16.5°C but was almost completely inhibited at temperatures outside the range of 12 and 20°C (August and Hicks, 2008). *Anguilla australis* in the north of New Zealand, are close to their northern geographic limits when compared to their latitudinal range in other countries and may retreat southwards as a result of increasing temperatures (Ling, 2010).

The *A. australis* fishery in New Zealand is based on the exploitation of immature females, as most males migrate before reaching the minimum catch size of 220 g (implemented throughout New Zealand). This may result in a skewed sex ratio in escaping silver eels.

Stock status: As of 2014, *A. australis* was classified as 'Not threatened - increasing' in New Zealand (Goodman *et al*., 2014). To date, there have been few concerns about the status of *A. australis* stocks as standard fishery measures have been maintained at levels consistent with an exploited fishery (Jellyman *et al*., 2009). In southern New Zealand, *A. australis* has been less affected by fishing pressure than *A. dieffenbachii,* possibly allowing *A. australis* to expand its range further inland (Beentjes *et al*., 2006). However, local level declines have been identified in New Zealand. Jellyman *et al.* (2009) showed a reduced catch per unit effort and duration of runs compared with the 1970s which indicate that a reduction in recruitment may also have occurred during this period (Jellyman *et al*., 2009; Kuroki *et al*., 2008).

This species has not yet been assessed using the IUCN Red List Categories and Criteria.

Use: *A. australis* support important commercial fisheries across its range, as well as Maori fisheries (Jellyman, 1993; McDowall, 1990) and in some areas are still a frequent part of the diet for Maori (Green, 2004). Eels are also valued for their spiritual, mythological, economic, and nutritional significance (Lyver *et al*., 2005). Freshwater eels have long been consumed by Aboriginal people in eastern Australia and have strong cultural significance (Gomon and Bray, 2017).

Management: Australia manages all anguillid eels via legislation specific to each state[14] implementing controls on fishing gears used, life-history stages harvested and spatio-temporal access to fishing grounds (Australia's response to CITES Notification 018/2018). The New Zealand Fisheries Act 1996 requires that Total Allowable Catches and Total Allowable Commercial Catches are set to provide for utilisation while ensuring sustainability; fishers may not keep eels smaller than 220 grams, nor eels larger than 4 kg. Recreational use is also regulated with a bag limit of 6 eels per day. Maori customary use is regulated by Maori guardians and is only for local consumption (New Zealand's response to CITES Notification 018/2018).

[14] Queensland: https://www.daf.qld.gov.au/business-priorities/fisheries/aquaculture/aquaculture-species/eels
New South Wales: https://www.dpi.nsw.gov.au/fishing/aquaculture/publications/species-freshwater/eels-aquaculture-prospects
Victoria: https://vfa.vic.gov.au/commercial-fishing/eels
Tasmania: https://www.ifs.tas.gov.au/about-us/publications/fish-fact-sheets/short-finned-eel

Knowledge Gaps

Despite the fact that range States indicate that the status of this species is of lower concern than other sympatric anguillids, it would still be valuable to establish long-term data sets to understand the dynamics of the continental life stages. As most other anguillds are under threat, this species could act as a baseline for certain comparative metrics. Furthermore understanding the impact of potential threats such as barrier to migration and hydropower, and what mitigation may be needed, would be of value.

3.2 *Anguilla bengalensis*

Summary species account

Distribution: Range States of this species are Bangladesh, India, Indonesia, Kenya, Madagascar, Malawi, Malaysia, Mozambique, Myanmar, Nepal, Pakistan, South Africa, Sri Lanka, Swaziland and Tanzania, There are also occasional records of vagrant individuals in the Arabian Peninsula (Attaala and Rubaia 2005). There are proposed to be two sub-species/sub-populations of this species – *A. bengalensis bengalensis* (Asia) and *A. bengalensis labiata* (Africa).
Biology: There remains uncertainty around where *A. bengalensis* might spawn in the Indian Ocean. Very few *A. bengalensis* leptocephali have been gathered and it is still not known whether this species has a single or multiple spawning locations and/or whether the spawning location(s) overlap with other anguillids (see Robinet *et al.* 2008, Watanabe *et al.* 2013 for discussion). A study of 47 *A. bengalensis* from Penang Island in Malaysia indicated that seaward migration took place for at least six months of the year (April to September), in contrast to the more seasonally focussed migration of temperate species (Arai and Kadir, 2017). This species inhabits various niches in river systems depending on local conditions and other anguillid species present (Bell-Cross and Minshull, 1988; Arai and Kadir, 2017).
Threats: The CAMP report on the freshwater fishes of India (Molur and Walker, 1998) declared *A. bengalensis* as 'Endangered' due to damming, fishing, loss of habitat, overexploitation and domestic trade as the main drivers of decline. Islam (2014) noted similar threats in Bangladesh. Both in Nepal and Zimbabwe, dams were recognised to be a significant threat to eels and other migratory species (Matiza and Crafter 1994; Shrestha 2003). In the Ganges River, West Bengal, *A. bengalensis* specimens that were caught contained methyl mercury concentrations that were higher than the limits set by the PFA (Prevention of Food Adulteration Act) for human consumption (Pal *et al.* 2012).
Use: Despite its wide distribution there is very little species-specific information available on the use and trade of *A. bengalensis*. In India (Maharashtra), this species was much prized as a food fish, and is supposed to have special nutritional value (Talwar and Jhingran, 1991) and medicinal uses (arthritis). In addition, A. bengalensis is considered a 'pristine rare ornamental species of the Himalayan drainage' often being preserved in temple ponds for religious purposes (Shrestha, 2003).
Stock status: There is very little information available on the status of *A. bengalensis*. A recent monitoring programme in KwaZulu Natal in South Africa (2015-2017), indicated that the species had a very patchy presence that had decreased over the past 10 years (Hanzen, personal communication). If this pattern is reflected across the species range, this would be of significant concern. This species

was classified as 'Endangered' in India (Molur and Walker 1998), and a more recent national assessment in Bangladesh using the IUCN Red List Categories and Criteria, suggested the species to be 'Vulnerable' (Islam, 2014). It is presently listed as globally 'Near Threatened' on the IUCN Red List of Threatened Species.

Management: There is little information on the management of this species and/or policy related to this species, both regionally and nationally. Islam (2014) stated that in Bangladesh, '*the species is included in any schedule of the Wildlife (Conservation and Security) Act, 2012*'. No species-specific management actions or policies were identified but Indonesia has enacted the Ministry of Marine Affairs and Fisheries Regulation No. PER.19/MEN/2012[15] which prohibits the export of anguillid eels ≤ 150 grams (Indonesia's response to CITES Notification 018/2018).

Knowledge Gaps

Little is known about the status of *A. bengalensis*; there are no long-term metrics for the abundance of any life stages across the range and establishing these would be hugely beneficial. Collection of baseline data on the status of this species is required including establishing abundance metrics for all life-stages, threat analysis - including determining both targeted harvest and by-catch levels, identifying spawning areas and understanding migration patterns. Further, improving the understanding of the impact of the identified threats to this species across its range would greatly strengthen management.

3.3 *Anguilla bicolor*

Summary species account

Distribution: *Anguilla bicolor* has the widest geographic distribution of any anguillid species apart from *Anguilla marmorata* (Arai *et al*., 2015). *Anguilla bicolor* has diverged between the Indian and Pacific Oceans which has led to the hypothesis that there are two sub-populations (Ege 1939); *A. bicolor bicolor* in the Indian Ocean and *A. bicolor pacifica* in the Pacific Ocean (Minegishi *et al*., 2012). The species has been found in Australia, Bangladesh, Guam, India, Indonesia, Kenya, Madagascar, Malaysia, Maldives, Mauritius, Federated States of Micronesia, Mozambique, Myanmar, Northern Mariana Islands, Oman, Papua New Guinea, Philippines, Réunion Island, Somalia, South Africa, Sri Lanka, Taiwan, Tanzania, Thailand, Viet Nam, and Yemen.

Biology: *Anguilla bicolor* inhabits a wide-range of aquatic systems (Pethiyagoda, 1991; Skelton, 1993; EPAA 2002; Seegers *et al.* 2003; Chino and Arai, 2010; Hamzah *et al.*, 2015; (Arai and Kadir, 2017) and spawning has been suggested to occur in several locations in both the Pacific and Indian Oceans (Jespersen 1942; Robinet and Feunteun 2002; Kuroki *et al.* 2006; Aoyama *et al.* 2007; Kuroki *et al.* 2007; Aoyama *et al.*, 2014). The spawning migration is believed, as with many of the tropical species, to be significantly shorter than that of temperate species and that spawning occurs year-round (Arai *et al.* 1999; Kuroki *et al.* 2006; Kuroki *et al.* 2007; Arai *et al.*, 2017; Kadir *et al.*, 2017).

Threats: To date, few studies or surveys have considered the threats facing this species. From the six responses to CITES Notification 018/2018 - Australia, France (Réunion Island), Indonesia, Malaysia, the Philippines and the USA (Guam and the Northern Mariana Islands) – threats across the range were identified as climate change, habitat loss/modification, pollution and unsustainable/illegal harvest

[15] http://jdih.kkp.go.id/peraturan/per-19-men-2012.pdf

and/or trade. The major concern for *A. bicolor*, is believed to be the growing legal and illegal exploitation of this species across much of its range (Shiraishi and Crook, 2015). In years when availability of *A. japonica* is low, marked import shifts occur to *A. bicolor* and other tropical eels fulfilling the demand for 'plain' coloured eels (Jacoby *et al*., 2015).

Stock status: *Anguilla bicolor* is classified as Near Threatened by the IUCN Red List of Threatened Species primarily due to the increase in trade in this species over the past decade. In their responses to CITES Notification 018/2018 only Indonesia (stable) and the Philippines (declining) were able to provide information on the status of the populations.

Use: Given that this species has such a broad distribution it is likely to be caught alongside multiple other anguillid species. According to FAO data there are *Anguilla* spp. caught in Indonesia and the Philippines and a significant proportion of this likely consists of *A. bicolor*. Internet searches reveal that *A. bicolor* (live and frozen) can be easily purchased in bulk online. *Anguilla bicolor* glass eels have been increasingly used to stock farms in East Asia after *A. anguilla* was listed in CITES Appendix II in 2009 and the EU banned all trade in *A. anguilla* from and to the EU in 2010. This appears to increase in years where *A. japonica* has poor recruitment. East Asian Customs data suggest that the demand for *A. bicolor* and other tropical eels seems to have declined after 2014. There appears to have been an increase in *A. bicolor* farming in Indonesia and the Philippines in recent years (SEAFDEC, 2018, unpub. data).

Management: There are no known species-specific policies for *A. bicolor*. Réunion (France) has developed a conservation plan for the anguillid species in its waters[16]. Indonesia has legislation that applies to trade of all anguillid species (see *A. bengalensis*). The Philippines has enacted two pieces of legislation that apply to anguillid eels generally; Fisheries Administrative Order (FAO) No. 233 – "Aquatic Wildlife Conservation" - which regulates the catching, use and trade of aquatic wildlife, and FAO No. 242 – "Reinstating the ban on the export of elvers" – which 'prohibits the export of elvers, of a size greater than five centimetres but not exceeding 15 centimetres in length'[17]. Australia manages anguillid eels via legislation specific to each state (see *A. australis*). In Viet Nam *Anguilla* eel export is banned except for farmed eels (SEAFDEC, unpublished data, 2018).

Knowledge gaps

Current research and understanding of the biology of *A. bicolor* is relatively advanced in comparison to most other tropical eel species. However, there are no long-term metrics for the abundance of any life stages across the range and establishing these would be hugely beneficial. Considering the relatively short generation length of this species – a mean of eight years according to IUCN - it would take less than a decade to gather a meaningful data set.

This data collection is especially important considering the increase in demand for this species, particularly in East Asia, as a replacement for temperate species. In relation to this, improving the understanding of the impacts of the identified threats to this species across its range would greatly strengthen management.

Two range States have implemented policies that relate to the export of the species, but from present understanding, exploitation remains and there is little data to determine whether this off-take is sustainable in the long-term. Improved fisheries monitoring would help to move towards sustainable off-take and also understand the impact on non-target species in systems where multiple anguillid

[16] http://www.reunion.developpement-durable.gouv.fr/IMG/pdf/pdc_anguilles_reunion_v4_2018_04_23web.pdf
[17] https://www.bfar.da.gov.ph/LAW?fi=405#post

species are present. Improving traceability at the national and international level, would also be beneficial to better understand trade and also combat the illegal exploitation and trade that has been identified (see Section 4).

3.4 *Anguilla borneensis*

Summary species account

Distribution: *Anguilla borneensis* has a range restricted almost exclusively to Borneo and parts of Sulawesi, Indonesia and the surrounding Celebes Sea, Sulu Sea, Maluku Sea and the southern end of Makassar Strait region (Shirotori *et al*., 2016). Indonesia, Malaysia and the Philippines have been identified as range States of *A. borneenis.*

Biology: Little is known about the ecology of *A. borneensis*. It is the only bi-coloured long-finned eel in Indonesian waters making it relatively easy to identify. *Anguilla borneensis* is suspected to spawn 100km to 650km away from its growth habitats (Aoyama *et al*., 2003; Shirotori *et al*., 2016). Like *A. celebesensis*, it is thus thought that *A. borneensis* undertake much smaller-scale, local migrations to spawn in deep waters compared to other species (Aoyama *et al*., 2003; Kuroki *et al*., 2006a, 2014; Wouthuyzen *et al*., 2009). There is no data on the spawning season, glass eels lengths or age at recruitment (Kuroki *et al*., 2014).

Threats: Little information exists about the threats facing *A. borneensis*. From their responses to CITES Notification 018/2018 the Philippines and Indonesia listed barriers to migration, habitat loss/modification and unsustainable/illegal harvest and/or trade as threats, but neither party indicated that *A. borneensis* has a targeted fishery, suggesting by-catch is an issue.

In the Poso river watershed, Indonesia, damming for hydropower and unsustainable harvest of both glass eels and parent eels are two reported threats (Watupongoh and Krismono, 2015). In Mentawai, yellow-stage anguillid eels are intensively harvested (Fahmi *et al*., 2012). There has been an increase in fisheries and export of anguillid eel from the Philippines in the past decade (Crook, 2014) but the impact on this species is unquantified. As a bi-coloured eel, it may prove a possible target for future exploitation due to restrictions on the trade of other species and (Nijman, 2015) reported that *A. borneensis* is commercially exploited and exported from Indonesia – in contrast with the Notification response (see above).

Use: Even though fishing and trade of *Anguilla* species is known to occur in all parts of the distribution of *A. borneensis*, in particular in Indonesia, very little is known of this species' use or trade. *Anguilla borneensis* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.

Stock status: There is very little information on the status of *A. borneensis*. Inger and Kong (1962), however, reported that in a river on Borneo Island (Karabakan River), 50% of eels caught in suitable freshwater eel habitat were *A. borneensis*, while the other 50% comprised *A. marmorata*. During an expedition in 1998 to the same localities, researchers found only *A. marmorata* (Aoyama, pers. comm). Due to this shrinking range, *A. borneensis* is listed as Vulnerable on the IUCN list of Threatened Species.

Management: No species-specific management actions or policies were identified by the Parties for *A. borneensis* but both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* accounts respectively).

Knowledge gaps

Little is known about the status of *A. borneensis*. This may be in part due to the difficulty of visually determining this species from other tropical species. Collection of baseline data on the status of this species is required including establishing abundance metrics for all life-stages, threat analysis - including determining both targeted harvest and by-catch levels, identifying spawning areas and understanding migration patterns.

3.5 *Anguilla celebesensis*

Summary species account

Distribution: *Anguilla celebesensis* are a mottled eel that are found to inhabit tropical freshwater, brackish and marine ecosystems. *Anguilla celebesensis* is found in the Western Pacific from Indonesia to the southern Philippines, mainly within the Celebes Sea and the Gulf of Tomini, and Indonesia, Papua New Guinea and the Philippines are known range States (Tabeta *et al.,* 1976; Arai *et al.,* 1999; Arai *et al.,* 2003; Sugeha *et al.*, 2001; Aoyama *et al.,* 2015; Shirotori *et al.*, 2016). However, the geographic range of this species has still to be fully understood. Indeed, it has been suggested that eels from this area – particularly the Philippines - identified as *A. celebesensis* in previous studies may actually be *A. luzonensis* (Kuroki *et al.,* 2012).
Biology: It is believed they have a relatively short migration to their spawning grounds compared to temperate species (Aoyama *et al.,* 2003; Arai, 2014). It has since been confirmed by Wouthuyzen *et al.* (2009) that *A. celebesensis* has multiple local spawning locations which contrasts with the single, spawning areas used by temperate species. Similar to other tropical species, and unlike temperate anguillid eels, recruitment to freshwater is thought to occur all year round (Arai *et al.,* 2001).
Threats: Little is known about the threats facing this species, however, considering its range, it is likely to be exposed to similar threats as species such as *A. bicolor*, *A. borneensis* and *A. marmorata*. Indonesia identified climate change and habitat loss as threats to the species (Indonesia's response to CITES Notification 018/2018).
Use: Even though fishing and trade of *Anguilla* species is known to occur in all parts of the distribution of *A. celebesensis* very little is known of this species' use or trade. *Anguilla celebesensis* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.
Stock status: Little is known about the stock status of *A. celebesensis*. Ultimately, taxonomic uncertainty and misidentification make assessing the status to this species challenging. It is listed as Near Threatened on the IUCN Red List of Threatened Species due to its limited range.
Management: There are no species-specific management actions or policies for *A. celebesensis* but both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* respectively).

Knowledge gaps

Little is known about the status of *A. celebesensis*. This may be in part due to the difficulty of visually determining this species from other tropical species. Collection of baseline data on the status of this species is required including establishing abundance metrics for all life-stages, threat analysis - including determining both targeted harvest and by-catch levels, identifying spawning areas and understanding migration patterns.

3.6 *Anguilla dieffenbachii*

Summary species account

Distribution: *Anguilla dieffenbachii* is a temperate eel endemic to New Zealand and its offshore islands (Jellyman and Unwin, 2017). Genetic structure of *A. dieffenbachii* throughout North and South island indicate that the species is derived from a single spawning population (Smith *et al*., 2001).
Biology: Jellyman and Tsukamoto (2005), provided the first evidence of *A. dieffenbachii* moving to the tropics during spawning migrations when one of three tagged individuals commenced transmissions at a location 700 km east of New Caledonia. A more recent study of three tagged individuals revealed ascent locations and swimming speeds that were consistent with spawning in the tropics, possibly in the South Fiji basin (Jellyman and Tsukamoto, 2010). Studies of otolith micro-chemistry suggest that *A. dieffenbachii* exhibits behavioural plasticity regarding whether or not to enter freshwater or remain in estuarine or marine environments (Arai *et al*., 2003a; Arai and Chino, 2012). Rainfall and flow increases were found to be key factors triggering migration events. Emigration of female *A. dieffenbachii* from Lake Manapouri generally took place during large outflows and activity was markedly diurnal (Jellyman and Unwin, 2017). Migrations generally began once water temperatures began declining and ended when temperatures dropped below ~11°C (Boubée *et al*., 2001).
At a macro- habitat scale, probability of eel occurrence declined with increasing elevation and, for a given elevation, was higher in tussock and pasture catchments and lower in pine and native forest settings (Broad *et al*., 2001a). *Anguilla dieffenbachii* is a nocturnal feeder with diet comprising a large proportion of ostracods (Sagar and Glova, 1994) and other aquatic invertebrates (Sagar *et al*., 2005). *Anguilla dieffenbachii* reaches much larger sizes than other temperate eels (Arai *et al*., 2004) and is possibly the world's largest freshwater eel, with a maximum reported length of two metres and mass of up to 50 kg. These dimensions are, however, more common historically, while more recently few individuals encountered exceed 120 cm and 25 kg (Chisnall, 2000).
Growth rates of *A. dieffenbachii* are typically slow, around 27 mm for low-land waters (Chisnall, 2000), but vary between individuals, waters and reaches (Graynoth and Taylor, 2004).
Threats: In their responses to CITES Notification 018/2018 New Zealand identified threats across the range as barriers to migration, habitat loss/modification and pollution. The Waiau catchment in New Zealand's South island contains the country's largest hydroelectric station (700MW) and also the largest stock of unexploited *A. dieffenbachii* in the country (Graynoth and Bonnett, 2008). The high hydraulic head results in 100% mortality of *A. dieffenbachii* that enter the intake (Beentjes *et al*., 2005). River diversion into the lake causes changes to inflows and outflows that are likely to be detrimental to silver *A. dieffenbachii* emigration (Jellyman and Unwin, 2017).
It is argued that the mean total body length and body condition of *A. dieffenbachii* were lower in accessible sites, consistent with considerable fishing pressure at such sites (Broad *et al*., 2002). Further, *A. dieffenbachii* yellow eels are susceptible to capture by baited nets (Jellyman and Graynoth, 2005) thus one of the goals of the fishery managers is to maximize escapement of silver *A. dieffenbachii* (Ministry for Primary Industries, 2016).

Warmer temperatures associated with climate change may have a detrimental effect on glass eel recruitment in its current range. The upstream migration of *A. dieffenbachii* glass eels was optimum at 16.5*°C* but was almost completely inhibited at temperatures outside the range of 12 and 20*°C* (August and Hicks, 2008). The glass eel migration periods appear to occur several weeks earlier at the present day than previously, based on comparison of catch data 30 years apart from the Waikato River (Jellyman *et al*., 2009) indicating that temperatures are increasing.
There have been some concerns over threats to the eel fishery in New Zealand from 1080[18] contamination.
Use: *Anguilla dieffenbacchii* support important commercial fisheries across its range, as well as Maori fisheries (McDowall, 1990; Jellyman, 1993) and in some areas are still a frequent part of their diet (Green, 2004). Eels are also valued for their spiritual, mythological, economic, and nutritional significance (Lyver *et al*., 2005).
Stock status: The status of the species appears to vary significantly with location (New Zealand's response to CITES Notification 018/2018). Historically, *A. dieffenbachii* was classified as a species 'in gradual decline' (Hitchmough *et al*., 2007) and there have been concerns about the scarcity of large specimens, an indication that recruitment is declining (Boubee *et al*., 2008) and concern over viability of stocks overall (Jellyman *et al*., 2009; Kuroki *et al*., 2008). These results, together with other life-history features like extensive longevity (Jellyman, 1995), susceptibility to capture (Jellyman and Graynoth, 2005), and reduced habitat and access (Graynoth *et al*., 2008) have raised concerns over population status (Jellyman *et al*., 2009).
In contrast to the above declines, more recently New Zealand reported that eel numbers have increased between 2015 and 2017 (New Zealand's response to CITES Notification 018/2018).
This species has not yet been assessed using the IUCN Red List Categories and Criteria.
Management: There are no known species-specific management actions or policies for *A. dieffenbachii. S*ee *A. australis* for New Zealand's Fisheries Act which covers all native anguillid species. There are also examples of where mitigation measures have been implemented in power stations such as compensation flows, construction of fish passes and trap and trans schemes (Boubee *et al.* 2008).

Knowledge Gaps

This species is relatively well understood, but from the data presented above there is some uncertainty regarding the status of the species – recent information provided in response to CITES Notification 018/2018 encouragingly suggests that the status is improving and understanding the drivers behind this and whether it is occurring across the species range would be beneficial. Furthermore, understanding the impact of potential threats such as barrier to migration and hydropower, and what mitigation may be needed, would be of value.

[18] 1080 (sodium fluoroacetate) is a poison used to create a toxic bait.

3.7 *Anguilla interioris*

Summary species account

Distribution: There is very limited information available on the distribution of *Anguilla interioris* but the Philippines, Indonesia and Papua New Guinea are known to be range States (Wouthuyzen *et al*., 2009; Fahmi *et al.*, 2012; Shirotori *et al.*, 2015).
Biology: Analysis of growth rates and age at metamorphosis of leptocephali, suggest that this species is typical for tropical eels with a small migration loop similar to *A. borneensis* and *A. celebesensis* (Kuroki *et al.*, 2006, Kuroki *et al.* unpubl.). The western part of Sumatra and northern part of Sulawesi are likely spawning areas of *A. interioris* (Fahmi *et al*., 2012).
Threats: Little information exists about the threats facing *A. interioris*. From their responses to CITES Notification 018/2018 the Philippines and Indonesia listed barriers to migration, habitat loss/modification and unsustainable/illegal harvest and/or trade as threats. Considering its range, it is likely to be exposed to similar threats as species such as *A. bicolor*, *A. borneensis, A. celebesensis* and *A. marmorata*.
Use: Even though fishing and trade of *Anguilla* species is known to occur in parts of the distribution of *A. interioris* very little is known of this species' use or trade. *Anguilla interioris* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.
Stock status: Little is known about the status of *A. interioris* and the species is listed as Data Deficient on the IUCN Red List of Threatened Species. This is in part due to the difficulty of visually determining this species from other tropical species.
Management: There are no species-specific management actions or policies for *A. interioris* but both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* respectively).

Knowledge gaps

Little is known about the status of *A. interioris* and the species is listed as Data Deficient on the IUCN Red List of Threatened Species. This may be in part due to the difficulty of visually determining this species from other tropical species. Collection of baseline data on the status of this species is required including establishing abundance metrics for all life-stages, threat analysis - including determining both targeted harvest and by-catch levels, identifying spawning areas and understanding migration patterns.

3.8 *Anguilla japonica*

Summary species account

Distribution: It is known that *A. japonica* primarily occurs as a native species in Japan, China, Hong Kong, Taiwan and South Korea. There are records of recruitment in northern Luzon and Mindanao Islands of the Philippines (Aoyama *et al*., 2015; Shirotori *et al*., 2016). However, the true range of *A. japonica* within countries such as Japan can be difficult to determine because of widespread restocking by fisheries cooperatives. The eggs, pre-leptocephali and post-spawning adults of this species have been collected in the North Equatorial Current (NEC) along the western side of the West Mariana Ridge (13–17° N, 142–143° E) to the west of the Mariana Islands (Tsukamoto 2006, 2009; Kurogi *et al.,* 2011; Tsukamoto *et al.* 2011). This implicates this area, west of the Mariana Islands, as the spawning area for this species.

Biology: Some *A. japonica* may never enter freshwater, but remain in estuaries or nearby marine habitats (Tsukamoto *et al.*, 1998). Analysis of the strontium:calcium ratios within the otoliths of maturing eels reveals a signature of the transition between these environments and eels in some areas might be estuarine/marine residents (Kotake *et al.* 2005). This suggests that there is some flexibility in the continental migration of some *A. japonica*, which shows an ability to adapt to various habitats and salinities and implies that movement into freshwater is clearly not obligatory. In a study across 12 river systems in Japan, Yokouchi *et al.,* (2014) found significant demographic heterogeneity - sex ratios, body lengths, growth rates and age structures. Growth rate was higher for both sexes in brackish/seawater while male growth was higher than that of females in river systems (Yokouchi *et al.,* 2014). Thus to maintain the demographic variability that may confer resilience it is necessary to preserve the variety of habitats in and across river systems.

As with many eel species, the generation times for *A. japonica* are highly variable depending on sex, individual variation and locality/latitude. For example, Kotake *et al.,* (2007) studied *A. japonica* from three different latitudes and found that the age of males at maturity ranged from 4 to 10 years and females from 3 to 17 years. During their growth phase, *A. japonica* feed mostly on invertebrates such as benthic crustaceans and insect larvae, and also on small fishes (Kaifu *et al.,* 2013).

Little is known about the marine component of anguillid life histories in general, but *A. japonica* stands alone in having a well-studied spawning ecology (Kimura and Tsukamoto, 2006; Tsukamoto, 2009; Tsukamoto *et al.,* 2011). Pop-up tag studies for *A. japonica* showed that they mostly migrate to the region along the western side of the seamount chain of the Mariana Ridge (Tsukamoto, 1992, 2006, 2009; Tsukamoto *et al.,* 2003). The depths where adults and newly hatched larvae were captured indicate that spawning occurs in shallower layers of 150–200 m and not at great depths (Tsukamoto *et al.,* 2011). Over the course of five to six months *A. japonica* leptocephali drift towards their estuarine recruitment areas (Kuroki *et al.,* 2009, Shinoda *et al.,* 2011) on oceanic currents and then metamorphose into transparent glass eels before becoming pigmented elvers in estuaries. The subsequent timing of upstream migration of glass eels depends on the water temperature, tidal current and moon phase (Tzeng 1985). The beginning of spawning migration of eels is affected by various factors such as sufficient body size, age and lipid content, as well as environmental variables (Chino *et al*., 2017; Sudo *et al*., 2017).

Threats: In their response to CITES Notification 018/2018 Japan, China and the Philippines identified threats across the range as barriers to migration, climate change, habitat loss/modification and unsustainable/illegal harvest and/or trade. Moreover, it is probable that a combination of these factors is responsible. The uncertainty of factors responsible for the *A. japonica* decline highlights the urgent need for a comprehensive understanding of their demography and ecology (Yokouchi *et al.*, 2014).

On average, 76.8% of the effective habitat area was lost in 16 rivers in Japan, Korea, Taiwan, and China from the 1970s - 2010s (Chen *et al*., 2014). Indeed, the Ministry of the Environment of Japan concluded that the main factor affecting individual density of *A. japonica* inhabiting rivers in Japan is upstream migration barriers such as weirs and dams reducing the availability of effective habitat based on a dataset obtained from 135 sampling stations in five rivers in Japan in 2014-2015 (Ministry of the Environment, 2016). Another identified threat is the loss of river habitat due to agricultural, urban and industrial development, which in Japan has resulted in the extensive revetment of the shorelines of rivers and lakes for flood control purposes (Yoshimura *et al.,* 2005, Itakura *et al.,* 2015a). Itakura *et al.* (2015b) investigated the possible effects of riverbank modifications on yellow-phase *A. japonica* in the Tone River, Japan, and reported that their abundances and condition factors were higher in the natural shore areas than those of revetment areas and the number of feeding eels, their food consumption, and the diversity of consumed prey were also generally greater.

Anguilla japonica has one of the longest histories of fishing, stocking and farming for consumption purposes of all the *Anguilla* species. It is argued that fishing of *A. japonica* glass eels to stock farming facilities on a national/international scale likely constitutes a major threat to the population. Data submitted by Japan in response to CITES Notification 018/2018 indicated that glass eel catches, had been steadily declining since the early 1960s, reaching a historically low plateau in the early 1990s. The catch in the 2017-2018 fishing season was 'historically' low. This decline was mirrored by 'total harvest' data submitted by Japan, which relates to yellow and silver eel catches. It should be recognised that no effort data was provided with these catch metrics. Further a decline in catch cannot solely be attributed to fisheries considering the range of threats.

Anguilla japonica is host to the nematode (*Anguillicola crassus*) that parasitises the swim bladder which has been proposed to affect survivorship and migration behaviour. This species, however, appear to show more evidence of acquired immunity and significantly reduced pathological effects than the *A. anguilla* (Knopf, 2006) possibly because of longer historical exposure to this parasite (Münderle *et al.,*2006). Studies are required on another nematode, *Heliconema anguillae,* to evaluate the impact of its infection on *A. japonica*, though the authors found no detectable damage in the heavily infected eels (Kan *et al*., 2016). Urban and agricultural development has increased the amounts of pollution caused by industrial effluent/agricultural runoff/herbicides/pesticides, all of which are known to negatively impact eel numbers through displacement, reduced reproductive success and direct mortality (e.g. Tzeng *et al.,* 2006). Arai (2014b) examined the concentrations of toxicants in *A. japonica*. Concentrations in the silver stage (maturing) eel were significantly higher than those in the yellow stage (immature) eel, in accordance with the higher lipid contents in the former versus the latter.

Use: *Anguilla japonica* was historically caught in waters throughout its range, predominantly in Japan, mainland China, Taiwan and South Korea, with large eels caught destined directly for consumption or small eels destined for farming, from the early 1900s onwards (Ringuet *et al*., 2002). Globally, these are also the main eel farming, trading and consuming countries/territories, with Japan in particular having a long tradition of consumption of *A. japonica* eels. Declines in the availability of *A. japonica* in the 1990s, however, resulted in many farms in the region stocking *A. anguilla* and more recently some other Anguilla species (Crook, 2010; Crook and Nakamura, 2013). *Anguilla japonica* however, is still the preferred species for farming in East Asia and for consumption in Japan, and high demand for this declining resource has resulted in dramatic increases in price for this species in particular.

Stock status: In 2013, *A. japonica* was classified as Endangered both at the national level by the Japanese Ministry of the Environment[19] and globally on the IUCN Red List of Threatened Species. It was recently classified as Critically Endangered in Taiwan[20].

In their response to CITES Notification 018/2018 Japan reported the stock status as declining.

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[19] https://www.japantimes.co.jp/life/2013/02/02/environment/ministry-officially-classifies-japanese-eel-as-species-at-risk-of-extinction/#.WvLsxZch3b0

[20] http://conservation.forest.gov.tw/latest/0061063

As stated above, catches of wild glass, yellow and silver eels have been steadily declining since the 1960s in Japan, with the most recent year being of particular concern for glass eel catches. There is much heterogeneity across river systems, however temporal trends of the *A. japonica* stock in Japan have generally been reported as gross catch of the species in Japan, not as catches respective to river systems (Yokouchi *et al*., 2014). Yokouchi *et al.* (2014) found that between 1999 and 2004 declines occurred in all 12 river systems across 9 prefectures that were studied. The magnitude of decline, reasons for decline as well as demographic parameters of the eels in each river system differed. A stock assessment by Tanaka (2014) at the East Asian scale reports that the fishing effort in most lakes has reduced (based on fishery census data) with the units targeting exploitable stocks of eels decreasing from 551 units in 1968 to 91 in 2008. Tanaka (2014) suggests that the estimated stock size has recovered since 1990 to 24% (18.7 thousand tons) of carrying capacity in 2010. The author reports the biggest difficulty in stock assessment of the Japanese eel is the lack of systematic data on both catch records and the index of stock abundance meaning multiple inferences, interpolations and assumptions were required in models. These models did not take into account the effect of stocking in the rivers by fisheries cooperatives and recent studies indicated that stocked eels are predominant in Japanese inland waters where this practice has occurred (Itakura *et al.*, 2018; Kaifu *et al.*, 2018). Overall, it appears that recruitment, population and escapement of the Japanese eel is declining (Jacoby and Gollock, 2014).

Management: China, in its response to CITES Notification 018/2018indicated that there were species-specific licenses are issued by the provincial governments are required to catch glass eels and fishing is allowed from December to March. China has also introduced a licensing system for eel farming. In Japan, the catch of glass eels is subject to licenses to be issued by prefectural governments, and the duration of fishing season is generally limited to the period between December and April next year under relevant regulations under Fishery Act (1949) (Japan's response to CITES Notification 018/2018). The catch of eels using certain fishing gears is subject to licenses to be issued by prefectural governments, and is prohibited between October and March of the next year, when mature eels migrate from rivers to the sea for spawning, in major prefectures under relevant regulations under Fishery Act (1949). In June 2015, a licensing system was introduced for eel farming, under the Inland Water Fishery Promotion Act. The amount of initial input of eel seeds is restricted per eel species and allocated for each individual farmer under this Act. The Fisheries Act in Japan mandates inland water fishery cooperatives that catch eels in rivers and lakes to increase eel populations, and they typically stock eels to fulfil this obligation (Kaifu *et al.,* 2014). The primary method of eel stocking in Japan is to release small yellow eels from eel farms into rivers and lakes (Kaifu *et al.,* 2014) and recent studies indicate that stocked eels are predominant in Japanese inland waters where this practice is conducted. In addition to this China, Japan, Korea and Taiwan have voluntarily agreed to co-operate on the management of *A. japonica* and other anguillids in their Joint Statement (see Section 2.1). In Taiwan, exports of all sizes of juvenile eel between November and March have been banned since October 2007. In South Korea, eel fisheries are banned from 1 October to 31 March and catch of eels between 15-45cm is banned. The Philippines have legislation that applies to trade of all anguillid species (see *A. bicolor*).

<u>Knowledge Gaps</u>

Anguilla japonica is by far one of the better understood species of anguillids. There is a significant amount of research that has been conducted on the spawning grounds of *A. japonica* but more work is required on the continental phases and stock management in coastal and inland waters. This particularly applies to countries in the species' range other than Japan. Gaining a better understanding of how threats, particularly those other than fishing, impact the species and how they can be mitigated, across the species' range, would be hugely valuable.

3.9 *Anguilla luzonensis*

Summary species account

Distribution: Only described as a species in 2009, *A. luzonensis* appears to have a limited range with specimens found on the Philippine island of Luzon and rarely in Mindanao (Watanabe *et al.*, 2009, Han *et al.*, 2012; Aoyama *et al.*, 2015; Shirotori *et al.*, 2016).
Biology: A recent study indicated that recruitment occurred in the summer months, peaking between June and August (Aoyama *et al.* 2015). They are arguably the most localised species, suggesting some degree of niche specialisation in this species.
Threats: In their response to CITES Notification 018/2018, the Philippines listed unsustainable/illegal harvest and/or trade as a threat to the species and indicated that harvest of the species occurred in their waters for domestic consumption, domestic grow-out and domestic stocking. There are currently few major barriers to migration in the Cagayan River system[21] - the largest freshwater system in the Philippines, and one of the few locations this species has been identified.
Use: Even though fishing and trade of *Anguilla* species is known to occur in the distribution of *A. luzonensis* very little is known of this species' use or trade. *Anguilla luzonensis* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.
Stock status: As *A. luzonensis* was only relatively recently discovered, there is very little information relating to the population dynamics of the species. It is listed as Near Threatened on the IUCN Red List of Threatened Species due to its limited range.
Management: No species-specific management actions or policies were identified for *A. luzonensis* but the Philippines has legislation that applies to trade of all anguillid species (see *A. bicolor*).

Knowledge gaps

Little is known about the stock status of *A. luzonensis*. This may be in part due to the difficulty of visually determining this species from other tropical species. It is listed as Near Threatened on the IUCN Red List of Threatened Species due to its extremely limited range. Collection of baseline data on the status of this species is required including establishing abundance metrics for all life-stages, threat analysis - including determining both targeted harvest and by-catch levels, identifying spawning areas and understanding migration patterns. As this species has such a limited range, it could be significantly more achievable to gather meaningful data on threats and stock status than other anguillids.

[21] http://rbco.denr.gov.ph/MPDISPLAY/masterplans/CAGAYANMP/#page/63

3.10 *Anguilla marmorata*

Summary species account

Distribution: *Anguilla marmorata* spans temperate regions and the tropics and has the widest geographical distribution of any anguillid species (Arai, 2014a). Known range States are American Samoa, Cambodia, China, Comoros, Cook Islands, Fiji, French Polynesia (Society Is.), Guam, Hong Kong, India, Indonesia, Japan, Kenya, Korea, Republic of, Lao People's Democratic Republic, Madagascar, Malaysia, Mauritius, Mayotte, Micronesia, Federated States of, Mozambique, Myanmar, New Caledonia, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Réunion Island, Samoa, Solomon Islands, South Africa, Sri Lanka, Swaziland, Taiwan, Province of China, Tanzania, United Republic of, Thailand, Tonga, Vanuatu, Viet Nam, Wallis and Futuna, and Zimbabwe. Dependent on location *A. marmorata* has been found from river mouths and estuaries to the upper reaches of continental waters (Shiao *et al.* 2003; Briones *et al.* 2007; Chino and Arai 2010; Leander *et al.*, 2012; Lin *et al.*, 2012; Arai *et al.*, 2013).

Biology: There is considerable debate over the number of sub-populations of *A. marmorata,* with four to six being proposed (Ishikawa *et al.*, 2004). The locations of their respective, potential spawning areas are equally uncertain (Réveillac *et al.*, 2008; Robinet *et al.*, 2008; Pous *et al.*, 2010; Kuroki *et al.*, 2008; E. Feunteun pers. comm. 2012). *Anguilla marmorata* has intermediate-scale migrations compared to other species (Hagihara *et al*., 2012) ranging from 1000 km to 3000 km, similar to that of *A. japonica* (Arai, 2014a). The spawning season of *A. marmorata* has been found to extend throughout the year through a back calculation of otolith daily increments in North Sulawesi of Indonesia (Arai *et al*., 2017). The recruitment season of *A. marmorata* is mainly from early summer to autumn (mainly Spring in Taiwan) but can occur almost year round (Leander *et al*., 2012).

Threats: In In their responses to CITES Notification 018/2018 China, France, Indonesia, Japan, Malaysia, the Philippines and the USA reported threats across the range were listed as climate change, pollution, barriers to migration, habitat loss/modification, unsustainable/illegal harvest and/or trade and disease/parasites. Within all range States, major impoundments and weirs are barriers to upstream eel movement (Wasserman *et al.* 2011) and mortalities can occur on downstream passage of silver eels through turbines and pumps. In developing countries, hydroelectric capacity is being rapidly developed and fish passage requirements are scarcely taken into account (e.g., Roberts, 2004). According to Indonesian media reports, *A. marmorata* may be the most exported eel species in Indonesia along with *A. bicolor* (Nijman, 2015), especially from outer islands such as Sulawesi.

Use: *Anguilla marmorata* is found in subsistence and commercial fisheries and is farmed in some regions (e.g., southern Africa, Madagascar and Reunion Island). It is popular and highly sought after in China, where there is high demand for mottled eels. *Anguilla marmorata* are currently relatively easy to purchase in bulk via online traders sold as glass eels, live adult eels and frozen eels.

Anguilla marmorata glass eels are increasingly being used to stock farms in East Asia. Eel farmers in Taiwan began farming of *A. marmorata* targeting a large commercial market domestically and in mainland China (FBCA, 2009; Huang *et al*., 2016). DNA analysis on prepared eels found *A. marmorata* in Japan in 2015 (Yoshinaga, 2015) and in the UK in 2014–2015 (Vandamme *et al*., 2016).

Stock status: In their responses to CITES Notification 018/2018, three range States provided information on the status of the species: France (increasing), Indonesia (stable) and the Philippines (stable). A recent study shows that when estimated using molecular techniques, the effective population size of *A. marmorata* is much smaller than in all other eel species (Delgado, 2013). This

suggests a higher vulnerability of *A. marmorata* to bottlenecks and population decline than in any other species. *A. marmorata* is classified as Least Concern on the IUCN Red List of Threatened Species, however, in Taiwan was on the endangered species list according to the Wildlife Conservation Act of Taiwan until 2009 (Leander *et al*., 2012) thus fishing for and farming of *A. marmorata* were illegal on the island before April 2009 (Leander *et al*., 2012). *Anguilla marmorata* are one of only two species that have specific customs codes – in both China and Taiwan. *Anguilla marmorata* is in the list of endangered and protected species as a Class II species in mainland China[22].
Management: No species-specific management actions were identified by Parties but, Réunion (France) has developed a conservation plan for the anguillid species in its waters[23]. There are no species-specific policies for *A. marmorata* but both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* respectively). See *A. bicolor* for how the U. S. Endangered Species Act relates to *Anguilla* species. In Viet Nam *Anguilla* eel export is banned except for farmed eels (SEAFDEC, unpublished data, 2018).

Knowledge Gaps

Present understanding of the biology of *A. marmorata* is relatively good in comparison to most tropical species, however, there are no long-term metrics for the abundance of any life stages across the range and establishing these would be hugely beneficial. There appears to be international demand for *A. marmorata*, particularly in East and South East Asia, which is unusual for a mottled species. However, this demand is not to the same scale as that of bi-coloured eels. In relation to this, improving the understanding of the impact of the identified threats to this species across its range would greatly strengthen management.
Two countries have implemented policies that relate to the export of the species, but from present understanding, exploitation remains and there is little data to determine whether this off-take is sustainable in the long-term. Improved fisheries monitoring would help to move towards sustainable off-take and also understand the impact on non-target species in systems where multiple anguillids are present. Improving traceability at the national and international level, would also be beneficial to better understand trade and also combat the illegal exploitation and trade that has been identified.

3.11 *Anguilla megastoma*

Summary species account

Distribution: *Anguilla megastoma* is found in the Pacific Ocean from Pitcairn to Papua New Guinea in the South Pacific (Ege, 1939; Marquet and Lamarque, 1986; Marquet and Galzin, 1991; Marquet, 1996; Marquet *et al.,* 2003; Sugeha and Suharti, 2008; Keith *et al.*, 2010; Watanabe *et al.*, 2011; Keith *et al.,* 2013; Schabetsberger *et al.*, 2013; Sichrowsky *et al.,* 2015). Known range States are the Cook Islands, Fiji, French Polynesia, New Caledonia, Papua New Guinea, Pitcairn, Samoa, Solomon Islands, Tonga, Wallis and Futuna, Tahiti and Morea.
Biology: *Anguilla megastoma* is proposed to be found only in the headwaters of freshwater rivers (Sichrowsky *et al*., 2015; Schabetsberger *et al*., 2017) but there is little information available on the ecology of this species. The few leptocephali collected so far support the hypothesis that the spawning

[22] http://zdx.forestry.gov.cn/portal/bhxh/s/645/content-334732.html
[23] http://www.reunion.developpement-durable.gouv.fr/IMG/pdf/pdc_anguilles_reunion_v4_2018_04_23web.pdf

area for the species is thought to be somewhere in the Southern Equatorial Current (SEC) (Miller, 2003; Kuroki *et al.* 2008; Schabetsburger *et al.* 2013). One of the few other studies into the ecology of this species showed that following maturation, migrating silver eels tagged with satellite transmitters off Vanuatu were shown to exhibit diel vertical migrations in the water column, ranging from 200 m at night down to 750 m during the day (Schabetsberger *et al.* 2013).
Threats: According to Smith (1999), *A. megastoma* is caught locally throughout its range, however, there are no data to determine the level of threat this is posing to the population. It is believed that damming (French Polynesia) and nickel mining (New Caledonia) will likely be impacting freshwater populations (P. Sasal 2013 pers. comm.). Dams in particularly are likely to be a main threat across the species range due to its preference for mountainous headwaters.
Use: Despite *A. megastoma*'s wide range, very little is known of its use or trade. Pacific fisheries authorities reported an increasing level of enquiries about *Anguilla* spp. from East Asian investors and traders particularly from China in 2016[24][25].There was one company from French Polynesia offering both large *A. megastoma* and juveniles on several online sites, however this company has not been active for a number at the time of writing.
Stock status: Currently there are little to no quantitative data available on the status of this species. It has been reported that there have been declines in *A. megastoma* numbers residing in the lakes of French Polynesia since the 1980s (Marquet G. and Galzin R. 1991), however, again there are little data to support this claim. The species is listed as Data Deficient on the IUCN Red List of Threatened Species.
Management: To date there are no known policy and management initiatives for *A. megastoma.*

<u>Knowledge gaps</u>

Collection of baseline data on the status of this species is required including establishing abundance metrics for all life-stages, threat analysis - including determining both targeted harvest and by-catch levels, identifying spawning areas and understanding migration patterns. Monitoring of this species is of particular importance given the habitat restriction in headwaters of small oceanic islands across a large proportion of its range.

<u>3.12 *Anguilla mossambica*</u>

<u>Summary species account</u>

Distribution: *Anguilla mossambica* is present in many of the east flowing river drainages of coastal Africa. Range States are presently listed as Comoros, Kenya, Madagascar, Mauritius, Mayotte, Mozambique, Réunion, Seychelles, South Africa, Swaziland, Tanzania and Zimbabwe.
Biology: This bi-coloured species is hypothesised to breed northeast of Madagascar, west of the Mascarene Ridge in the Indian Ocean (Réveillac *et al.* 2009). Elvers in the Eastern Cape, South Africa, arrive in higher numbers in the summer months (Wasserman *et al.* 2012) – the fact that they recruit all year-round indicates that they have a life cycle similar to other tropical species (Arai *et al.* 2001). Otolith microchemistry from yellow eels in South Africa, suggests that some individuals are inter-habitat migrants that move between freshwater and saltwater (Lin *et al.* 2012). A later study using otolith micro-chemistry carried out in Madagascar, indicated that 70% of the eels sampled had

[24] http://www.criobe.pf/wp-content/uploads/2017/03/EEL-WORKSHOP-RECORD-DER-1.pdf
[25]https://bit.ly/2rJMMMD

an atypical life history and associated Sr:Ca, characterised by slow growth and increased parasite load (Lin *et al.* 2015).

Threats: In their responses to CITES Notification 018/2018, threats specific to *A. mossambica* on Réunion (France) were habitat fragmentation (high), habitat loss and degradation (high), diminishing water quality (medium) and poaching (high). Over the past 10-15 years, there has been an increased export of *A. mossambica* to East Asia, particularly from Madagascar (Crook and Nakamura 2013), and as stated in the Notification Response from the United States of America, this species is being proposed for grow-out. A study carried out in the Eastern Cape of South Africa indicated that this species is particularly vulnerable to an invasive parasitic gill worm (*Pseudodactylogyrus anguillae*) (Parker *et al.* 2011). In high numbers, for example, under farm conditions, this parasite can cause gill damage and anaemia (Kennedy, 2007).

Use: There are indications that demand for this species has increased over recent years (Crook and Nakamura, 2013b). No range State has reported catch or farming production to FAO while according to UN Comtrade, Madagascar and South Africa exported live *Anguilla* eels from 2007 to 2016. The first known records of imports of live juvenile eel into Asia from Madagascar are from 2005 which reached a peak in 2013; no imports have been recorded in 2016–2017. The majority has been imported into Hong Kong and South Korea, but farming of this species is presently being proposed at a facility in the USA[26].

Stock status: With virtually no abundance monitoring and little fisheries data across the species range, there are currently huge knowledge gaps in the understanding of the population dynamics of this species. However, a recent monitoring programme in KwaZulu Natal in South Africa (2015-2017), indicated that the species had a very patchy presence which had decreased over the past 10 years (Hanzen, personal communication). The species is presently listed as Least Concern on the IUCN Red List of Threatened Species, however, it is clear that there is increasing concern for the status of this species.

Management: No species-specific management actions were identified but Réunion (France) has developed a conservation plan for the anguillid species in its waters[27]. In South Africa there are plans to try and increase upstream and downstream river connectivity by linking adjoining sub-catchments in an attempt to aid migration (Rivers-Moore *et al.* 2011).

Knowledge Gaps

Little is known about the status of *A. mossambica*; there are no long-term metrics for the abundance of any life stages across the range and establishing these would be hugely beneficial. This data collection is especially important considering the increase in demand for this species – including for farming in the United States of America – and the proposed range shrinkage. Improved fisheries monitoring would help to ensure sustainable off-take and also understand the impact on non-target species in systems where multiple anguillids are present. Improving traceability at the national and international level, would also be beneficial to better understand trade and exploitation. Further, improving the understanding of the impact of the identified threats to this species across its range would greatly strengthen management.

[26] https://www.fws.gov/fisheries/ans/erss/uncertainrisk/Anguilla_mossambica_ERSS.pdf
[27] http://www.reunion.developpement-durable.gouv.fr/IMG/pdf/pdc_anguilles_reunion_v4_2018_04_23web.pdf

3.13 *Anguilla obscura*

Summary species account

Distribution: *Anguilla obscura* is a bi-coloured eel which has a distribution throughout the Pacific Ocean from western New Guinea, the Solomons and Fiji to French Polynesia. (Lecomte-Finiger *et al*., 2000); (Moravec and Justine, 2007); (Schabetsberger *et al*., 2009); (Sichrowsky *et al*., 2015). Known range States for the species are Cook Islands, Australia, Fiji, French Polynesia, Indonesia, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Tahiti, Tonga, Vanuatu and Wallis Island.
Biology: *Anguilla obscura* is hypothesised to be primarily found in the lower reaches of rivers (Resh *et al*., 1999). Glass eels have been found to recruit to atolls, such as the Rangiroa atoll in French Polynesia, where only one third of the atoll rim is above sea level (Lecomte-Finiger *et al*., 2000). Maturing eels are hypothesised to migrate into marine waters to spawn east of Tahiti (Jellyman, 1991). However, only three *A. obscura* larvae have been found, two southwest of Vanuatu and one south of Fiji, thus further information is required (Schabetsberger *et al*., 2013).
Threats: In their responses to CITES Notification 018/2018, Australia, Indonesia and France (French Polynesia and New Caledonia) identified threats to the species as climate change, barriers to migration and habitat loss/modification. Indonesia indicated that harvest of the species occurred in their waters. Unlike other anguillid eels, *A. obscura* occurs mainly in the lower parts of river systems or in lagoons and thus is less likely to be impacted by barriers to migration such as dams, although estuarine habitat is likely to be more vulnerable to anthropogenic impacts such as pollution and development. Pollution from mining is an ongoing threat in some localities (P. Sasal 2013, pers. comm.). As a bi-coloured eel, it may prove a possible target for future exploitation due to restrictions on the trade of other species.
Use: *Anguilla obscura* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms. There was one company from French Polynesia offering both large *A. megastoma* and juveniles on several online sites, however this company has not been active for a number at the time of writing. Anecdotal evidence suggest that in the market places of the Solomon Islands, juveniles of *A. obscura* are sold (R. Schabetsberger 2014, pers. comm.).
Stock status: Little is known about the status of *A. obscura* and the species is listed as Data Deficient on the IUCN Red List of Threatened Species.
Management: No species-specific management actions were identified for *A. obscura* but Australia manages anguillid eels via legislation specific to each state (see *A. australis*) and Indonesia has legislation that applies to trade of all anguillid species (see *A. bengalensis*).

Knowledge gaps

Collection of baseline data on the status of this species is required including establishing abundance metrics for all life-stages, threat analysis - including determining both targeted harvest and by-catch levels, identifying spawning areas and understanding migration patterns. Monitoring of this species is of particular importance given the habitat restriction in and around river mouths of small oceanic islands across a large proportion of its range.

3.14 *Anguilla reinhardtii*

Summary species account

Distribution: *Anguilla reinhardtii,* the Australian longfinned eel, is found in Australia, New Zealand, New Guinea (Gomon and Bray, 2017) and New Caledonia (Marquet, 1996), and has also been caught on the islands of Vanua Lava and Maewo in Vanuatu (Schabetsberger *et al*., 2013). Its distribution is restricted in New Zealand (Jellyman *et al*., 2009) being a more 'tropical' species (Arai *et al*., 2004; McDowall *et al*., 1998).

Biology: Although the exact spawning area or timing of spawning is still to be verified, this species is reported to spawn in the Coral Sea in depths of 400 m or greater and more generally, the South Equatorial Current region (Kuroki *et al.*, 2008; Watanabe *et al.*, 2011; Gomon and Bray, 2017). The oceanic dispersal of larvae from tropical spawning grounds results in a north to south recruitment along the eastern seaboard of Australia and Tasmania (Beumer and Sloane, 1990; Chisnall, 2000). Glass eel recruitment in Australia is greatest in summer-autumn (Beumer and Sloane, 1990; Sloane, 1984) thus suggesting an autumn-winter arrival in New Zealand (Jellyman *et al*., 1999). *Anguilla reinhardtii* may remain in freshwater environments for more than 50 years before migrating to the sea to breed (Gomon and Bray, 2017). Shen and Tzeng (2007) suggest that *A. reinhardtii* displays year-round spawning similar to other tropical species, as evidenced by hatching dates (Shiao *et al*., 2002) and year-round collection of glass eels.

Anguilla reinhardtii is known to occur in a variety of habitats including rivers, streams, lakes, swamps and floodplains, however is more common in faster flowing riverine waters than in still waters (Gomon and Bray, 2017). It exhibits growth rates 2-3 times faster by length and 4 times faster by weight than the sympatric *A. dieffenbachii* and is an opportunistic feeder, becoming an increasingly aggressive carnivore with increasing size (Chisnall, 2000). It is proposed that it may outcompete sympatric species of anguillids (Chisnall, 2000).

Threats: In their responses to CITES Notification 018/2018 Australia and New Zealand identified threats across its range as barriers to migration, climate change, habitat loss/modification and pollution. However, there is very limited information on the impact of potential threats facing *A. reinhardtii* - it could be assumed that as there is overlap with sympatric species such as *A. australis* and *A. dieffenbachii* threats might be similar. In order to mitigate anthropogenic changes to river systems that can impede glass eel migration, a study by Langdon and Collins (2000) recommended that, based on sustained and burst swimming speeds for *A. reinhardtii* (and *A. australis*), mean and maximum fishway velocities should not exceed 30 and 75 cm per second respectively, and fishway cells should be specifically designed to permit glass eel passage (Langdon and Collins, 2000). In Australia, *Edwardsiella tarda* is regarded as an exotic disease in native fish, however, *E. tarda* was isolated from a diseased wild-caught *A. reinhardtii*. Eels infected with *E. tarda* have been shown to act as carriers of infection in culture ponds (Eaves *et al.* 1990 and references therein). *Photobacterium damsel* is a pathogen known from the marine environment that can cause fatal skin ulcerations in fish, mammals and reptiles. It was found in multiple *A. reinhardtii* which had died in holding tanks pre-export (Ketterer and Eaves, 1992).

Use: Freshwater eels have long been consumed by Aboriginal people in eastern Australia and have strong cultural significance (Gomon and Bray, 2017). *Anguilla reinhardtii* has been fished in Australia since the 1950's or 60's and is commercially important on the east coast of Australia, primarily for export to East Asia (De Silva *et al*., 2001)

Stock status: In their responses to CITES Notification 018/2018, Australia indicated that the *A. reinhardtii* population remains stable and New Zealand stated it was unknown. No further information is available on the population status of *A. reinhardtii*, however Chisnall (2000) suggests that *A. reinhardtii* may have a competitive advantage over *A. australis* and *A. dieffenbachii* in New Zealand due to its accelerated growth rate.
Management: No species-specific management actions were identified but Australia manages anguillid eels via legislation specific to each state and and New Zealand highlighted management measures for all species in its waters (see *A. australis*). No information was available in relation to management across the rest of the species' range.

Knowledge gaps

Of the three species that are found in Australia and/or New Zealand, this is most poorly understood; and there is no information on this species from the rest of its range. Initiating monitoring programmes to gather abundance data on continental life stages would therefore be very helpful. Additionally, understanding which and to what extent the various possible threats impact the species across its range would be useful to inform management interventions. There are several references to the fact that *A. reinhardtii* might outcompete sympatric anguillid species and assessing to what extent this is occurring would be beneficial for managing multi-species catchments.

3.15 *Anguilla rostrata*

Summary Species Account

Range: The continental distribution of *A. rostrata* ranges from West Greenland in the north to the northern portion of the Atlantic coast of South America (Ogden *et al.*, 1975; Wenner, 1978; Erdman, 1984; Van Den Avyle, 1984; Nielsen and Bertelsen 1992; Böhlke and Chaplin, 1993; Claro, 1994; Kenny, 1995; Bussing, 1998; Lim *et al.*, 2002; see Benchetrit and McLeave, 2015 for a comprehensive analysis of the range). Known range States are Belize, Bermuda, Canada, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Dominican Republic, Greenland, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Providencia, Puerto Rico, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Trinidad and Tobago, United States of America (USA), Venezuela and the US Virgin Islands. Despite this large range there is strong evidence that this species forms one panmictic population with all mature individuals migrating to the Sargasso Sea area (Bonhommeau *et al.,* 2008, Miller *et al.,* 2009, Gagnaire *et al.,* 2012; Côté *et al.,* 2013). This said, phenotypic variation observed during recent stocking experiments in Canada have indicated that indicated that the stock structure may be more complex than this (Côté *et al.*, 2015; Stacey *et al.*, 2015)
Biology: Little is known about the precise spawning habitat of the *A. rostrata*. A recent modelling study has suggested spawning primarily takes place from December to March (Westerberg *et al.*, 2018) and the spawning location is inferred from the smallest leptocephali captured over a relatively large 550 km arc in the southern Sargasso Sea within the frontal area of the Subtropical Convergence Zone (ASMFC, 2012; DFO, 2014). Leptocephali, drift and swim with prevailing currents (Antilles Current, Florida Current, and Gulf Stream), which take them to areas near continental coasts or continental-slope waters (Kleckner and McLeave, 1985). Environmental predictors of glass eel runs are variable, but increased temperature and reduced flow may trigger upstream movement (Greene *et al.*, 2009).

Yellow-phase *A. rostrata* spend 3 to 30 or more years inland or in coastal areas before becoming mature, entering the silver phase (Daverat *et al.*, 2006; MacGregor *et al.*, 2009).

Threats: Habitat loss resulting from barriers may contribute to reduced eel abundance in eastern Canada (Jessop, 2000). In the St Lawrence watershed alone, 13% (14,000 km²) of yellow eel rearing habitat is no longer accessible (DFO, 2014). However, in the late 1990s and early 2000s a number of eel ladders were constructed on barriers which attempted to reduce this loss. Throughout the USA, it is reported that as much as 84% of historic stream length is now inaccessible to eels (DFO, 2014). Passage through turbines at hydropower dams during downstream migration represents a major source of eel mortality (Ritter *et al.*, 1997). Turbine-induced mortality ranges from 5 to 97%, depending on turbine type, flow rate, and length of the fish (Hadderingh, 1990; Bussye *et al.*, 2014). A recent study indicated that turbine shutdown during darkness may reduce mortality of escaping silver eels (Eyler *et al.*, 2016).

The USA and Canada have historically been the primary fishing range States, but more recently there has been an increase in harvest in the Caribbean – particularly Haiti and the Dominican Republic (see Section 4). Overall catches across the species range have declined since the late 1970s, though this appears to have plateaued in the late 1990s (ASMFC, 2017; FAO, 2018). By weight, the American *A. rostrata* fishery primarily targets yellow eel throughout the Atlantic States (ASMFC, 2017). Glass eel fisheries are prohibited in all states except Maine and South Carolina, with only the former landing significant catches (ASMFC, 2017). There are both elver and yellow eel fisheries in Canada, the former being more limited in range (Canada's response to CITES Notification 2018/018).

Pollutants have been implicated as having an impact on the health and spawning success of *A. rostrata* (Caron *et al.*, 2016; Pannetier *et al.*, 2016). However, several studies indicate that, in some regions, levels of certain toxins are declining (Byer *et al.*, 2013, 2015), and in some specific cases negative effects are apparently absent (Hoobin *et al.*, 2018). *Anguillicola crassus* has been found in some catchments in the range of *A. rostrata*, (see ASMFC, 2017) but at present, and from a single study, seem to be absent from those that drain in to the Gulf of Mexico (Cox *et al.,* 2016).

At the larval stage, changes in marine primary production and thus food availability associated with climate change have been suggested as a cause of declines of *A. rostrata* (Bonhommeau *et al.*, 2008). A recent study indicated that abundance of larval *A. rostrata* in the Sargasso Sea had declined since the early 1980s (Hanel *et al.,* 2014). It also has recently been discovered that predation of adult eels may be a further impact in the oceanic environment (Béguer-Pon *et al.*, 2012; Wahlberg *et al.*, 2014).

Use: *Anguilla rostrata* has traditionally been consumed in small amounts domestically across its range. Harvested glass eels and elvers are exported primarily to Asia, to meet demand for farms and *A. rostrata* has increasingly met this demand since the export of *A. anguilla* was banned in 2010 (Crook and Nakamura, 2013). Yellow eels are used for bait in other fisheries in the USA. *Anguilla rostrata* eels were revered and widely used for sustenance and practical purposes by indigenous peoples in prehistoric and historic times (Casselman, 2003; MacGregor *et al.* 2009; Engler-Palma *et al.* 2013; Miller and Casselman, 2014). In their response to CITES Notification 018/2018, Costa Rica indicated that there was still a small subsistence fishery of larger eels by indigenous peoples.

Stock status: *Anguilla rostrata* is listed as globally Endangered on the IUCN Red List of Threatened species (Jacoby *et al.,* 2017). A recent assessment was carried out by the Atlantic States Marine Fisheries Commission on the status of the species, which built upon a similar analysis carried out in 2012 (ASMFC, 2012; 2017). While results varied, analyses indicated downward trends in the datasets until the early 1990s, after which this has stabilised. As a consequence, the stock has been designated as 'depleted' (ASMFC, 2012; 2017). In Canada, the Committee on the Status of Endangered Wildlife in

Canada (COSEWIC) assessed the species as 'Threatened' (COSEWIC, 2012). Department of Fisheries and Oceans carried out a 'recovery potential assessment', the outcome of which was to concur with the observed decline outlined on the COSEWIC report (DFO, 2014). There is little understanding of the stock status across the southern part of the species range.

Management: In the USA, management of the species is overseen by the Atlantic States Marine Fisheries Commission (ASMFC), which drafted and approved the American Eel Fishery Management Plan (FMP) in 1999 (ASMFC, 2017). Implementation is devolved to the state-level as is monitoring and commercial regulations. There is a coast-wide quota of 907,671 pounds of yellow eel and since 2015, there has been a 9,688 pound quota for Maine's glass eel fishery. More broadly, the U. S. Endangered Species Act covers all *Anguilla* species under the definition of wildlife except when the species are imported or exported as non-living products for human or non-human consumption. In 2010, the U.S. Fish and Wildlife Service (USFWS) received a petition seeking to extend federal protection to the *A. rostrata* – this followed a similar application in 2004. A review of the species status was competed in 2015 and did not consider the species warranted listing under the ESA as Threatened[28].

Management of American eel in Canada is multi-jurisdictional involving five administrative regions of Department of Fisheries and Oceans (DFO) (Central and Arctic, Gulf, Maritimes, Newfoundland and Labrador, and Quebec) and the Provinces of Ontario and Quebec (Canada's response to CITES Notification 2018/018). Each region/province has specific regulations for commercial yellow and/or silver eel fisheries. There is a licenced commercial elver fishery in the Maritimes and licences come with a number of restrictions associated with them. There is also an Integrated Fisheries Management Plan for this fishery.

Stocking has been proposed as a way to bolster the continental populations, however, studies in the upper St.Lawrence River system showed that stocked eels survived and grew quickly, emigrated faster than natural recruits, in a sex ratio skewed to males and at a similar to the size similar to their site of original capture in Nova Scotia (Pratt and Mathers, 2011; Pratt and Threader, 2011; Stacey *et al.*, 2015). A further study relating to the stocking programme estimated that emigrating stocked eels would not have the fat reserves to reach spawning grounds (Couillard *et al.*, 2014). As such it is essential that long-term monitoring of the effects of this practice on the species and broader freshwater ecosystem are carried out, ideally with baseline data being collected prior to stocking.

In the southern part of the species range there are limited known management measures in place. In Cuba, a resolution of the Ministry of Science, Technology and Environment (CITMA) has been prepared and is in the phase of consultation and approval, to add *A. rostrata* to the list of Species of Special Significance of the Biological Diversity of the country which will result in the species being treated similarly to those included in Appendix II of CITES. Cuba also has a Manual of Work Procedures for the management of *A. rostrata* and operates fishing licenses. In November 2013, the Dominican Republic declared a ban on fishing, processing and trade/sale of *A. rostrata* (all life stages) between 1st April and 14th September every year, via Resolution 80-2013[29]. The details of this resolution have been updated annually, with the most recent in 2017 (Resolution 003-2017) extending the closed season to 31st October. The resolutions also cover aspects such as licences, holding stations, quotas and permitted ports of export. More generic policies that relate to *A. rostrata* include the Government of Bermuda's Protected Species Act (2003).

[28] https://www.fws.gov/northeast/americaneel/pdf/20150820_AmEel_12M_NotWarranted_BatchFormat_v2_Signed.pdf
[29] http://elnacional.com.do/establecen-veda-pesca-y-comercio-de-la-anguila/

Knowledge gaps

Anguilla rostrata is one of the better understood species of anguillids. While much research has been carried out in the northern part of the species' range – primarily in Canada and the USA – there is a lack of knowledge relating to the southern portion, particularly within the Caribbean. There has been increasing demand for *A. rostrata* glass eels and elvers for export to East Asia since the export ban of *A. anguilla* was imposed in 2010 and it is essential that this harvest is monitored to inform sustainable management across the range. Further, there are increasing reports of illegal fishing and trade of American eel; co-operation between range States and import nations is essential to better understand the scale and how to address these issues.

4. Trade of non-CITES listed anguillid eels

Below is a summary of research and trade data analysis relating to non-CITES listed eels. A more detailed account of the trade in these species can be found in Annex 2**.**

4.1 Global *Anguilla* eel production and trade

4.1.1 Global *Anguilla* production/supply to farms

According to FAO data, global eel production has steadily increased over the decades and reached more than 290,000 t in 2016, due to the expansion of farming, which accounted for 98% of total production that year. Figure 2: Global Anguilla production, highlighting farming production in East Asian countries/territories, 1950–2016, t.2 shows the importance of eel farming production particularly in East Asia. According to FAO data, mainland China was responsible for nearly 86% of the global eel farming production in 2016. However, according to the farming production data in the "Joint Statement on International Cooperation for Conservation and Management of *A. japonica* and other relevant *Anguilla* spp.", released in September 2014 (hereafter referred to as the Joint Statement), mainland China's farming production was 35,480 t in 2012 and 56,000 t in 2013, substantially less that the total farmed production reported to FAO (212,464 t in 2012 and 206,026 t in 2013). If FAO farming production data were replaced with the data provided in the statement, global eel production would be only ~82,000 and ~97,000 t in 2012 and 2013 respectively (Shiraishi and Crook, 2015).

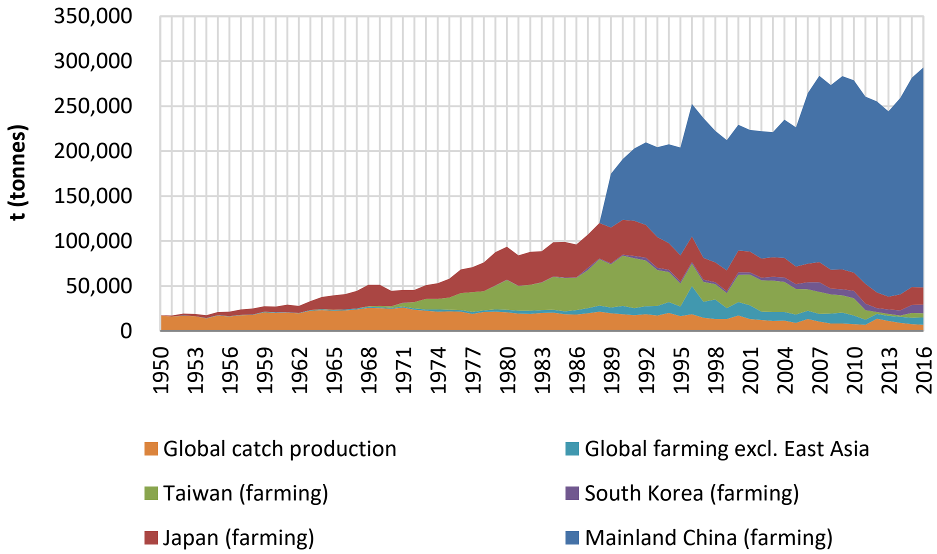

Figure 2: Global Anguilla *production, highlighting farming production in East Asian countries/territories, 1950–2016, t.*
Source: FAO Fisheries Production.

Eel farming is reliant on wild-caught juvenile eels (mainly glass eels or elvers, hereafter live eel fry). Although the main species used for farming in East Asia is *A. japonica*, which is native to the region, demand and population declines has led to the use of other *Anguilla* spp. including *A. anguilla* and *A. rostrata* from the 1990s onwards and *A. bicolor* in recent years (Crook and Nakamura, 2013b; Shiraishi and Crook, 2015).

According to Customs data from mainland China, Japan, South Korea, Hong Kong and Taiwan, imports of live eel fry into these countries/territories steadily decreased from 170 t in 2005 to 66 t in 2017 (with imports from Hong Kong excluded to avoid double counting – see below). Changes in "source" regions of live eel fry imported into East Asia during 2004–2017 are shown in Figure 2 in order to illustrate the trends after the CITES listing (2009) and EU trade ban in *A. anguilla* (2010). Annual imports from Europe and North Africa (likely to be *A. anguilla*) declined gradually. Imports from the Americas (likely to be *A. rostrata*) and South East/South Asia (likely to be *A. bicolor* and other tropical *Anguilla* species) increased in 2012 and 2013. While imports from the Americas remained high up to 2017, those from South East/South Asia decreased considerably from 26 t in 2016 to 10 t in 2017, which suggests there is still high demand for *A. rostrata* whereas demand for *A. bicolor* and other tropical eels declined.

Figure 3 suggests that the quantities of live eel fry imported into East Asia varied depending on the quantity of glass eel farming input of *A. japonica* in East Asia. When harvest of *A. japonica* was higher, imports of non-*japonica Anguilla* species were less (e.g. in 2009, 2014) whereas when harvest of *A. japonica* was poor, imports of non-*japonica Anguilla* species tended to be high (e.g. in 2008, 2010-2013).

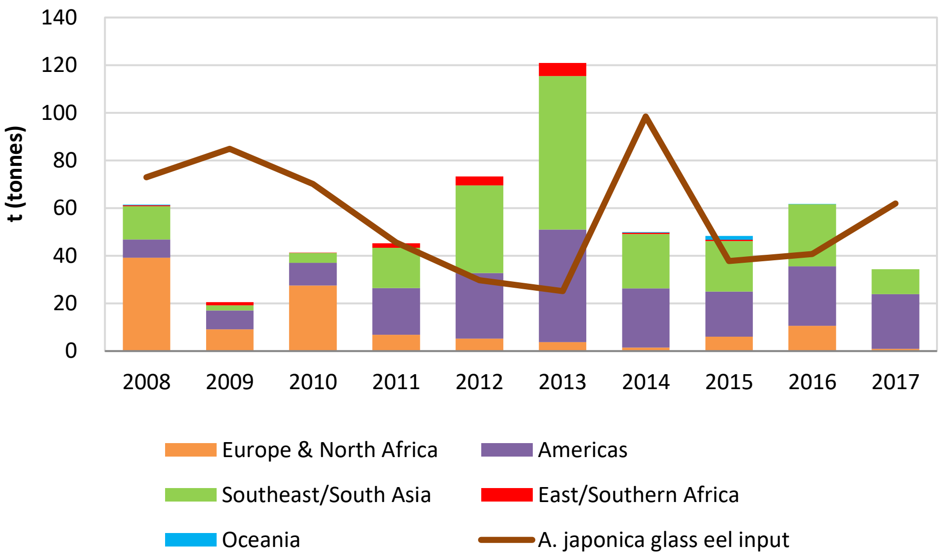

Figure 3: Imports of live eel fry for farming (all sizes) into East Asia and A. japonica glass eel input, 2004-2017, t.
Note: ***Europe and North Africa*** *(likely to be* A. anguilla*):* ***Americas*** *(likely to be* A. rostrata*);* ***South East Asia*** *(likely to be* A. bicolor *and other tropical* Anguilla *species):* ***East/Southern Africa*** *(likely to be* A. mossambica *and other tropical species);* ***Oceania*** *(likely to be* A. australis*). Source: East Asian Customs, Joint Press Release, Joint Statement and Nihon Yoshoku Shimbun.*

Mainland China, Japan, South Korea and Taiwan set an upper limit on glass eel input used for farming in each country/territory in 2014. Table 2 shows glass eel input in these countries/territories from 2008 to 2016. In the Joint Statement, they agreed that *A. japonica* glass eel input for 2014–2015 (and onwards) should be no more than 80% of that in 2013–2014 and for *Anguilla* species other than *A. japonica* "to take every possible measure not to increase the amount of initial input of eel seeds from the recent level (the last three years)." As Table 2 suggests, mainland China's glass eel input for other *Anguilla* species for 2014–2015 (35.5 t) and 2015–2016 (39.5 t) exceeded the upper limit (32 t) (highlighted in grey in Table 2). A criticism of the quota is that the upper limit for *A. japonica* was calculated based on the year the glass eel recruitment was particularly good (see Figure 3) (Matayoshi and Tano, 2014). Additionally, the input for 2014 was reported to be higher than the actual input in Japan (Tano, 2018) and in mainland China by 10 t (Anon, 2014).

Table 2: glass eel input in mainland China, Japan, South Korea and Taiwan from 2008 to 2016 and the upper limit of glass eel input agreed in the Joint Statement in 2014, t.

Species	Country/ territory	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	upper limit
A. japonica	China	9.0	26.5	10.5	8.0	7.0	45.0	9.3	8.2	36.0
	Japan	28.9	19.9	21.8	15.9	12.6	27.1	18.3	19.7	21.7
	South Korea	22.0	10.6	9.5	3.6	3.0	13.9	7.4	9.3	11.1
	Taiwan	25.0	13.1	3.8	2.2	1.5	12.5	2.8	3.6	10.0
***A. japonica* total**		**84.9**	**70.1**	**45.6**	**29.7**	**24.1**	**98.5**	**37.8**	**40.8**	**78.8**
Other *Anguilla* spp.	China	48.8	17.1	31	14.5	20	32	35.5	39.5	32.0
	Japan	0.1	0.03	0.01	0.4	1.3	3.5	0.0	0.2	3.5
	South Korea	1.5	1.5	1.6	6	13.1	2.9	5.1	3.7	13.1
	Taiwan				5.5	10.0	1.5	0.2	0.08	10.0
Other *Anguilla* spp. total		**50.4**	**18.63**	**32.61**	**26.4**	**44.4**	**39.9**	**40.8**	**43.48**	**58.6**

Source: Joint Statement, Joint Press Release and Fisheries Agency of Japan (2018).

Hong Kong has played an increasingly important role in trade of live eel fry over the decades (Table 3). As glass eel fishing or eel farming does not exist in Hong Kong (AFCD, pers. comm. to TRAFFIC, November 2017), it is considered as a transit point for trade in *Anguilla* spp. to East Asia for farming. Although the quantities of live eel fry imported into Hong Kong from various countries/territories exceeded imports from Hong Kong as reported by other East Asian countries/territories until 2015, reported imports from Hong Kong were higher in 2016 by 9.1 t and in 2017 by 3-9 t (Table 3).

Table 3: Imports of live eel fry into mainland China, Japan, South Korea and Taiwan from Hong Kong and imports into Hong Kong from various countries/territories, 2008–2017, t.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Imports of live eel fry into mainland China, Japan, South Korea and Taiwan from Hong Kong (a)	24.6	23.2	24.8	20.2	14.3	21.1	32.7	26.5	42.9	28.6
Imports of live eel fry into Hong Kong from various countries/territories (b)	63.5	55.0	54.5	32.1	57.2	59.3	41.5	30.7	33.8	25.6
(b) – (a)	38.9	31.9	29.7	11.9	42.9	38.2	8.8	4.2	-9.1	-3.1

Source: East Asian Customs.

4.1.2 Global *Anguilla* trade

Live, fresh, frozen and prepared *Anguilla* eels are traded globally. According to FAO and UN Comtrade, the volume of global live, fresh, frozen and prepared/preserved eel exports peaked at approximately 133,000 t in 2001, after which they declined to below 81,000 t in 2011 then increased slightly to approximately 90,000 t in 2013–2015. The export value of these commodities has steadily increased over the past 40 years, reaching USD ~1.6 billion in 2012.

While global reported exports of live, fresh, frozen and prepared eels for 2016 was approximately 93,000 t, the reported import quantity of those commodities for 2016 was 48,000 t. The discrepancy may be partially because some major exporters use the *Anguilla* spp. Customs codes for reporting trade in other eel-like species (i.e. "lookalikes", non-*Anguilla* spp. such as Swamp Eel *Monopterus albus*; see Annex 2 for more detail/examples of possible lookalike species for eels). The main eel exporter over the past decade has been mainland China, with Japan the being the main importer. Mainland China's number of trading partners increased steadily from 35 countries/territories in 2008 to 47 countries/territories in 2017, with the US and Russia becoming important destinations (Figure 4).

Figure 4: Prepared eel exports from mainland China in 2017, by weight. Source: China Customs

<u>4.2 Regional reports</u>

4.2.1 East Asia - *A. japonica* (Japanese Eel)

4.2.1.1 *Anguilla* farming production and supply for eel farms

Historically, *A. japonica* has been caught throughout its range, predominantly in Japan, mainland China, South Korea and Taiwan, with large eels caught destined directly for consumption or small eels destined for farming (Ringuet *et al*., 2002). According to FAO, global *A. japonica* catch production steadily declined over recent decades from more than 2000 t in 1986 to 136 t in 2016 (reported only by Japan and South Korea in 2016). Annual *A. japonica* glass eel input into farms in mainland China, Japan, South Korea and Taiwan has also decreased over the years (Figure 5).

4.2.1.2 Trade in *A. japonica* within East Asia

According to East Asian Customs, imports of live eel fry from mainland China, Japan, South Korea and Taiwan into these countries/territories reached a peak around at 105 t in 2009, after which they dropped to less than 7 t in 2013, increasing slightly again and ranging between 20 and 35 t in 2015–2017. Despite the reported volume of live eel fry traded within East Asia, the full scale of *A. japonica* trade is unknown as a large number of *A. japonica* glass eels are considered to be traded via Hong Kong together with other *Anguilla* species.

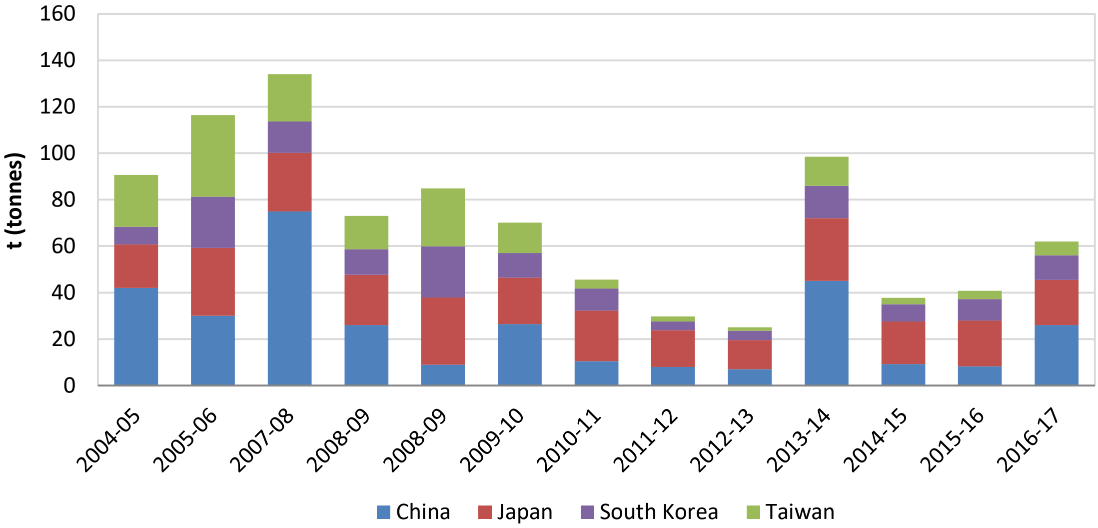

Figure 5: Annual A. japonica glass eel input in China, Japan, South Korea and Taiwan, 2004-2017, t.
Source: Joint Statement, Joint Press Release (Anon., 2017a)

The full scale of *A. japonica* trade is unknown as a large number of *A. japonica* glass eels are considered to be traded via Hong Kong together with other *Anguilla* species. Further, discrepancies exist in the data, for example, China reported exporting 9.5–19 t of *A. japonica* glass eels each year between 2009 and 2017 in the Joint Press Release, although this was not reflected in the Customs statistics. It would be important to establish the reasons for these discrepancies, which may include illegal and unreported fishing and trade. A close examination of monthly East Asian Customs import data and relevant data held by the Japanese government for approval of live eel fry exports should be carried out in order to detect possible illegal exports.

4.2.1.3 Illegal trade and use

Illegal fishing and trade, mainly in glass eels, remains a concern in East Asia. According to Japan Customs, an average of 7.4 t of glass eels was imported into Japan from Hong Kong during 2008–2017. Glass eel imports into Japan are considered to be mostly *A. japonica*, with a considerable proportion derived from re-exports from Hong Kong. Glass eels imports by Hong Kong from mainland China, South Korea and Taiwan, where *A. japonica* might conceivably be sourced, were not correspondingly reported as exports by these countries/territories. In addition, large discrepancies between domestic glass eel catch and glass eel input suggest that illegal or unreported glass eel catch potentially accounted for 43–63% of total glass eel catch in Japan (Figure 6). During 2014–2015 to 2016–2017, 57–69% of glass eels input into farms in Japan (11–12 t) were estimated to be sourced from illegal or unreported fishing and/or through illegal trade. Taiwan Customs seized 320,000 *A. japonica* glass eels in 128 bags from check-in baggage from eight people at Taiwan Taoyuan International Airport in November 2016, which were bound for Hong Kong (Anon, 2016). In April 2018, 32 suspects were arrested by police in Jingjiang City, Jiangsu Province for illegal harvest of glass eels. This group was involved in harvesting, collecting and selling glass eels; the collectors purchased glass eels from fishermen at CNY22–27 (USD3.5–4.3) per eel then sold them to wholesalers for 30% more than the purchase price (Ding, 2018). An estimated 7 t of elvers were smuggled to Japan and South Korea in 2011[30]. In South Korea, about 50 people were found to be engaged in illegal glass eel fishing in the Han river in 2013 (Seong and Hee, 2013). The president of a company was charged with purchasing 500,000 eels at KRW1 billion (USD913,000) that were illegally caught in rivers and selling them in 2017 (Anon, 2017).

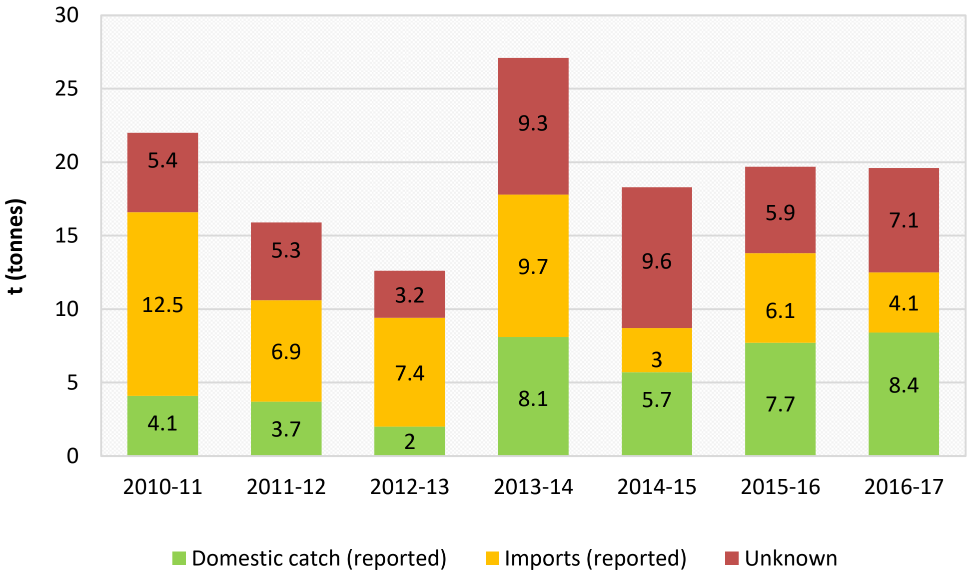

Figure 6: A. japonica *glass eel input for eel farms by source, 2010–2017, t.* Note: Red is from unknown potentially illegal sources (illegal harvest and import). Source: Fisheries Agency of Japan (2018).

4.2.2 Americas - *A. rostrata* (American Eel)

4.2.2.1 Anguilla rostrata production

According to FAO production data, the USA (since 1950), Canada (since 1956), Mexico (since 1975), Cuba (since 1989), and the Dominican Republic (since 1995) have reported catch production of *Anguilla* spp. (assumed to be *Anguilla rostrata*). The Dominican Republic is the only *A. rostrata* range State to report farming production, starting in 1988, reaching 49 t in 1994 and dropping to zero during 1996–2016. Canada and the USA accounted for 93% of reported *Anguilla* catch production from *A. rostrata* range States during 2007–2016 (Figure 7). FAO catch production data do not differentiate life stages.

[30] "The hometown of eels in China" faces many challenges, how to save it? ("中国鳗鱼之乡"潜伏危机重重 要拿什么拯救). http://www.daynew.cc/CN/news/Sub.htm/2807

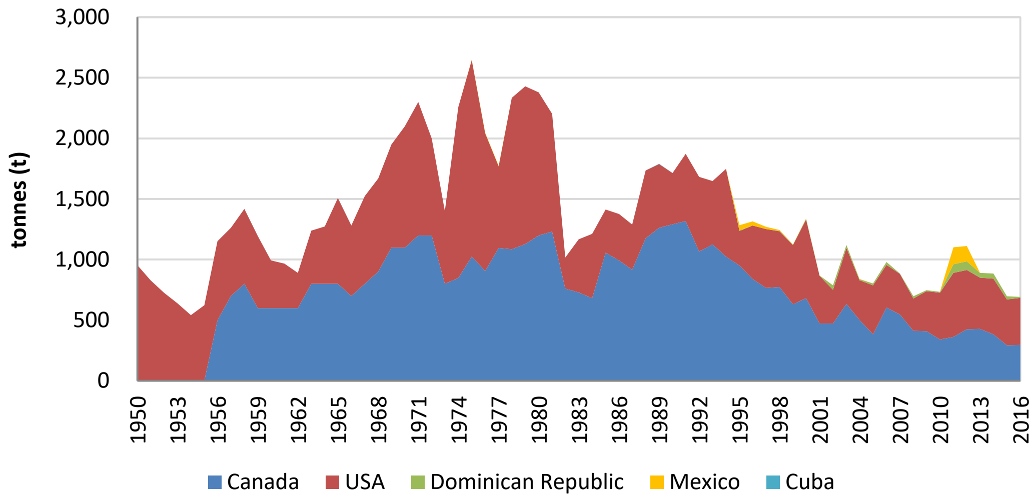

Figure 7: A. rostrata *catch production, by weight (t), 1950–2016. Source: FAO (2018).*

4.2.2.2 Global *Anguilla* trade from *A. rostrata* range States

According to data reported to UN Comtrade, exports of eel commodities (live, fresh, frozen and prepared eel) from *A. rostrata* range States have gradually decreased over the last decade; while live eel exports have increased. Canada and the USA accounted for 98% of all live eel exports from *A. rostrata* range States during 2007–2016 (Table 4). It is important to note that two *A. rostrata* range States that are known to be involved in eel trade have not reported any trade of any commodity to UN Comtrade since 1994 (Haiti) and since 2007 (Cuba).

Increases in price/kg suggest that recent exports from Canada, the Dominican Republic and Jamaica included a significant proportion of the higher value life stages (live eel fry or glass eels/elvers). Experts at the American Eel range State workshop held in Santo Domingo on 4–6th April 2018 confirmed this—all *Anguilla* exports from the Dominican Republic and Jamaica were glass eels and Canada is an important transit hub for glass eels being exported from *A. rostrata* range States to Asia.

Table 4: Exports of live Anguilla *spp. from* A. rostrata *range States, as reported by weight (t), 2007–2016.*

	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
USA	355.7	368.7	284.5	260.7	476.1	628.4	1,041.6	1,181.0	1,114.3	
Canada	334.8		272.1	214.9	176.6	228.6	273.3	174.1	158.5	171.1
Costa Rica	1.0	0.8	15.2	28.1	28.2	8.9		1.1		
Panama					53.8					
Dominican Republic	0.6				1.4	1.6	4.7	1.6	1.3	2.8
Jamaica								0.0	0.0	0.1
Nicaragua		0.0						0.0		
Total	**692.1**	**369.5**	**571.8**	**503.7**	**736.1**	**867.4**	**1,319.6**	**1,357.8**	**1,274.2**	**174.0**

Note: Values of 0.0 refer to unit value of less than 50 kg. At the time of writing, the USA has not reported any live eel exports for 2016 by weight (only by value).Source: UN Comtrade (2018).

In addition to exports, Canada, Jamaica and the USA reported re-exports of eel commodities in 2007–2016, with the USA being the principal re-exporter of live eels (Table 5).

Table 5: Re-exports of live Anguilla *spp. from* A. rostrata *range States, as reported by weight (t), 2007–2016.*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
USA	3.7	1.3		1.0	39.3	0.1	18.5	97.8	63.5	
Canada					1.7				2.6	1.1
Jamaica										0.1
Total	**3.7**	**1.3**	**0**	**1.0**	**41.0**	**0.1**	**18.5**	**97.8**	**66.1**	**1.2**

Note: At the time of writing, the USA has not reported any live eel re-exports for 2016 by weight (only by value). Source: UN Comtrade (2018).

Imports of live *Anguilla* spp. into Canada and the USA from *A. rostrata* range States during 2008–2016 are shown in Table 5. The majority of live eel trade occurred between Canada and the USA, however, both countries started to report imports of live eels from other *A. rostrata* range States (Cuba, Haiti, Dominican Republic, Dominica and Jamaica) from 2011 onwards. The average price of live eels imported from these countries ranged between USD250/kg and USD1400/kg during 2014–2016 (highlighted in grey in Table 6), suggesting that most imports from these emerging countries were likely to be live eel fry. According to UN Comtrade, in 2011–2016 live eel imports into Canada from Caribbean countries exceeded live eel re-exports from Canada. Therefore, it is likely that some re-exports from Canada to East Asia of live eels originating in the Caribbean/Central America were in fact reported as exports originating in Canada.

Table 6: Imports of live Anguilla *spp. from* A. rostrata *range States, as reported by Canada and the USA, by weight (t), 2007–2016.*

Importer	Source	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Canada	USA	124.9	250.3	98.9	117.8	114.6	57.9	23.7	8.7	14.0	13.5
	Cuba					3.2	13.2	4.8	1.5	2.0	0.1
	Haiti							2.2	8.6	6.9	2.8
	Dominican R.							0.7	1.0	2.9	1.9
	Dominica								0.0	0.2	0.0
	Jamaica										0.1
	Canada total	**124.9**	**250.3**	**98.9**	**117.8**	**117.9**	**71.1**	**31.4**	**19.8**	**26.0**	**18.4**
USA	Canada	225.8	141.9	166.2	69.7	4.3	15.8	10.9	20.8	35.0	
	Haiti							7.9			
	Dominican R.							3.3			
	Jamaica								0.0		
	USA total	**225.8**	**141.9**	**166.2**	**69.7**	**4.3**	**15.8**	**22.2**	**20.8**	**35.0**	**0.0**

Note: Values of 0.0 refer to unit value of less than 50 kg. Grey cells indicate the average price was over USD250/kg and may include trade in live eel fry. At the time of writing, the USA has not reported any live eel imports for 2016 by weight (only by value). Source: UN Comtrade (2018).

4.2.2.3 East Asian imports of *A. rostrata* from *A. rostrata* range States

i) Live eel fry supply and imports

According to East Asian Customs agencies, total East Asian imports of live eel fry from *A. rostrata* range States gradually increased from 2008 (Figure 8). South Korea's reported imports of live eel fry increased dramatically in 2013, mainly due to the import of approximately 17 t of larger sized young eels (not glass eels, see methods). Back and Park (2017) noted that although South Korean eel farmers have experimented with several *Anguilla* species as substitutes for *A. japonica*, including *A. anguilla*, *A. rostrata* and *A. bicolor,* only *A. bicolor* appears to be well suited to Korean eel farming methods.

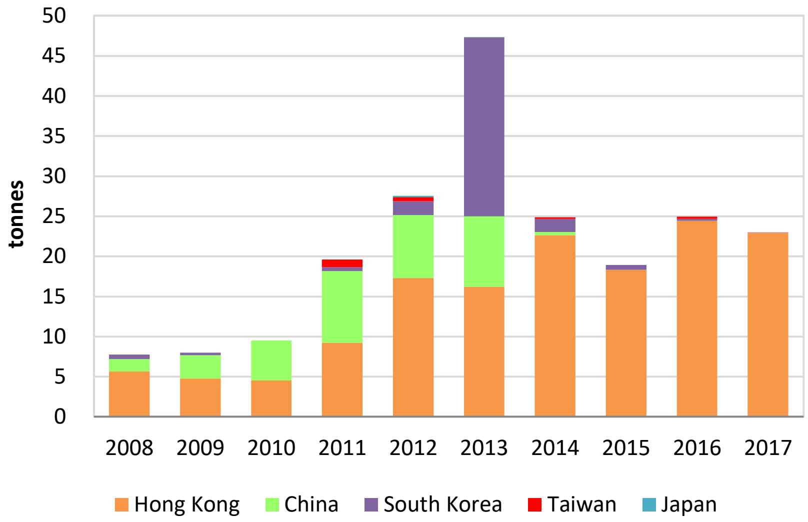

Figure 8: Annual imports of live eel fry into mainland China, Japan, South Korea, Hong Kong and Taiwan from A. rostrata *range States, by weight (t), 2008–2017. Source: East Asian Customs.*

East Asian countries/territories imported more than 210 t of live eel fry from at least five countries in the Americas over the last decade (Table 7). It should be noted that Haiti has not reported any *Anguilla* spp. catch production to FAO, nor has Cuba since 1995.

Table 7: Imports of live eel fry from A. rostrata *range States reported by East Asian Customs, kg, 2008–2017.*

Source	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Canada	5,420	6,536	8,146	13,836	14,751	18,609	10,904	7,403	8,221	9,134
USA	2,319	1,461	1,367	5,764	12,188	26,593	12,043	9,707	14,366	11,956
Haiti						626	1,476	1,704	2,340	1,908
Dominican R.					351	875	183	103	40	
Cuba					264	628	106			
C&S America						20	60			
Total	**7,739**	**7,997**	**9,513**	**19,600**	**27,554**	**47,351**	**24,772**	**18,917**	**24,967**	**22,998**

Note: C&S America indicates unknown Central/South American country. *Source: East Asian Customs.*

Hong Kong import data are available in two formats – by origin (used for the principal analysis above) and supplier (i.e. (re-)exporting country/territory, which may be different from the commodity's origin). When comparing these two data sources, it becomes apparent that live eel fry are traded via other countries e.g. Hong Kong imported 2,257 kg and 1,873 kg of live eel fry from Haiti in 2016 and 2017 respectively, 60% and 94% of which were reportedly traded via the USA and Canada (Table 8).

Table 8: Live eel imports from USA, Canada and Haiti reported by Hong Kong Customs by origin and by supplier, kg, 2017.

	USA	Canada	Haiti
Imports by origin (a)	11,956	9,134	1,873
Imports by supplier (b)	13,405	9,438	120
(b) – (a)	1,449	304	-1,753

Source: Hong Kong Trade Development Council

Furthermore, according to Hong Kong's monthly origin data for 2016 and 2017, imports from the USA and Canada between March and July (the principal glass eel/elver fishing season in these countries) accounted for less than 50% of total annual imports into Hong Kong from the USA and Canada in 2016 and 2017. The remaining imports occurred in months outside the US and Canadian glass eel/elver fishing season; imports between October and February (the principal glass eel fishing season in the Caribbean and Central America) exceeded 10 t both in 2016 and 2017. This suggests that even more live eel fry caught in the Caribbean region are being traded via the USA and Canada, but do not appear as such in origin/re-exporter data. Toronto is known to be a major hub for American Eel glass eel trade, including those originating in the Caribbean and the USA. Most shipments clear Customs and are transported to glass eel holding facilities near the airport. These eels are then exported at a later date to Hong Kong, often being declared as of Canadian origin[31].

ii) Glass eel catches in* A. rostrata *range States

Figure 8 and Figure 9 shows annual commercial elver landings for Canada (2012–2016) and the USA (2010–2017)[32] compared with live eel fry imports from these countries into East Asia. In both cases, and in all years but 2010, live eel imports exceed the quantity of elver landings. This suggests that significant quantities of eel fry may have been sourced from other range States and re-exported from the USA and Canada (see above) or those exports include unreported (and potentially illegal) landings. It is important to note that these data are not directly comparable, however, as imports may include a variety of sizes of live eel fry.

Maine and South Carolina are the only two States in the USA which currently allow elver fisheries, for which annual quotas are set. In 2017, Maine's quota was set at 9,688 lbs, and total reported catch was 9,282 lbs[33] (~4.2 t, compared to 12 t eel fry imported into East Asia from the USA). In Canada, the commercial elver fishery is conducted in the Maritimes Region, in the provinces of New Brunswick and Nova Scotia, in addition to there being a small farming and experimental elver Fishery in the Newfoundland and Labrador region. Elvers are defined as eels with a maximum length of 10 cm[34].

The average unit price for elvers landed in Canada appears to have declined over the last five years; while the annual average price for those landed in the US generally appears to have increased (Figures 8 and 9). Average prices during the first week of the current elver fishing season in Maine (end of March 2018) were over USD5,000/kg, after a very poor *A. japonica* catch season in East Asia and hence very high demand for *A. rostrata* (Chase, 2018).

[32] Datasets provided in Canada's and the US response to CITES Notification No. 2018/018.
[33] US response to CITES Notification No. 2018/018.
[34] Canada's response to CITES Notification No. 2018/018.

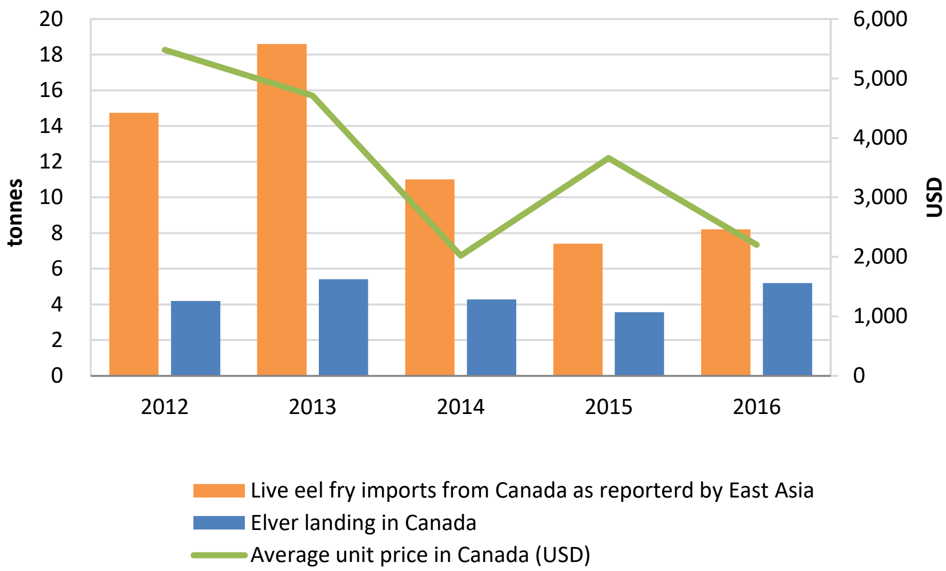

Figure 8: Live eel fry imports from Canada as reported by East Asia Customs and annual elver landings in Canada, 2012–2016, by weight (t). Sources: Canada's response to CITES Notification 2018/018; East Asian Customs.

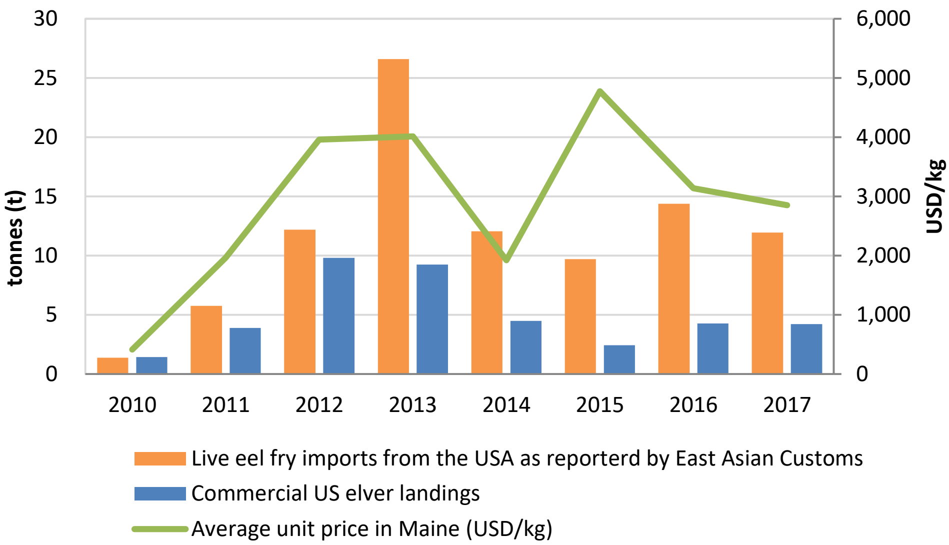

Figure 9: Annual US elver landings and live eel fry imports from the USA as reported by East Asia Customs, by weight (t), 2010–2017. Note: Elver landings in South Carolina for 2010–2012 and 2016–2017 are not included.
Sources: US response to CITES Notification 2018/018; East Asian Customs.

There are known glass eel fisheries in the Dominican Republic, Haiti and Cuba. In recent years there are reports of a developing glass eel fishery in Jamaica, and in 2013 a research licence was granted to assess the distribution and harvest levels around the island[35]. A total of only 362 kg was harvested under this programme in 2013–2018, and of this only 85 kg was exported (to Hong Kong via Canada).

2013 appeared to be a peak year for interest and investment in glass eel fishing in the Dominican Republic, and in January 2013, there were reportedly 80 foreign companies (from Spain, South Korea, mainland China, Japan, the UK and Argentina) requesting permission to harvest and export *Anguilla* in the Dominican Republic. A press release from the time suggested that CODOPESCA (the Dominican Republic's Fisheries authority) was not authorising more permits (only two companies had acquired

[35] http://www.moa.gov.jm/Ministry%20Papers/2015/Capture%20_Fishery_Development_Ministry_Paper.pdf

them at the time) and as a result the glass eels were being harvested by local fisherman without any controls and being exported illegally, across the border to Haiti, and to Europe and Asia via cargo, from Las Américas airport and Multimodal Caucedo port in Santo Domingo[36]. In 2013, fishermen in the Dominican Republic were being paid USD140–300/kg and intermediaries reported selling the eels on/exporting them for USD1,000/kg[37] [38].

In November 2013, CODOPESCA declared a ban on fishing, processing and trade/sale of the species (all life stages) between 1st April and 14th September every year, via Resolution 80-2013[39]. The details of this resolution have been updated annually in relation to quotas, points of departure and licences, with the most recent in 2017 (Resolution 003-2017) extending the closed season to 31st October.
Based on Customs data and press releases, Haiti appears to have become the principal glass eel fishing nation and exporter in the Caribbean region in recent years. An article from November 2016 reports that every year, 8 t of glass eels are exported from Haiti, without counting the quantity that goes undetected across the border to the Dominican Republic; eel is reportedly in the top seven national products being exported[40]. There is no legislation currently governing eel harvesting or trade in Haiti, however in 2017 an eel exporters' association was set up to try and control harvesting levels. The number of exporters has consequently reduced from 30 to nine, each having a quota of 700 kg per fishing season[41].

Experimental glass eel fishing and farming occurred in Cuba in 1974–1977, after which there was no fishing again until the late 1990s. Legislation covering use and management of eels came into force in 1996. Since 2000, on average 3 t of glass eels have been caught and exported (a mix of live and frozen) every year, however catches have been particularly low in Cuba during the last two fishing seasons (~0.2 t both in 2016–2017 and 2017–2018) due to the impacts of Hurricane Irma. Only one company is currently permitted to export fisheries products from Cuba.

iii) Live eel fry farming
The Japanese, Chinese, South Korean and Taiwanese Fisheries authorities released trade and input data for eel farming in a joint statement on the occasion of the "Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species" in June 2017[42]. According to the statement, China and South Korea reported imports and input of *A. rostrata* for farming (Table 9). Japan and Taiwan only provided species-specific farming data for *A. japonica*, all remaining input was grouped together as "other eel". Data suggest that mainland China is the main East Asian farmer of *A. rostrata*. In the same statement, China also reported exports of broiled (prepared) *A. rostrata* eels from 2014 onwards, which increased from 16,296 t in 2014 to 22,110 t in 2016, which was more than double the exports of broiled *A. japonica* in 2016 (10,140 t), highlighting the importance of *A. rostrata*.

[36] http://elnacional.com.do/empresas-ofertan-explotacion-rd-del-pez-anguila/
[37] https://www.youtube.com/watch?v=Em4eesYKzK0
[38] http://hoy.com.do/las-anguilas-se-convierten-en-buen-negocio-en-la-isabela/
[39] http://elnacional.com.do/establecen-veda-pesca-y-comercio-de-la-anguila/
[40] https://challengesnews.com/le-juteux-commerce-des-anguilles/
[41] Presentations by range States at the American eel range State workshop held in Santo Domingo, 4-6 April 2018.
[42] Joint Press Release on the occasion of the Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species (https://cites.org/sites/default/files/eng/com/ac/29/inf/E-AC29-Inf-13.pdf)

Table 9: Live eel fry input into eel farms in mainland China and South Korea, reported as A. rostrata*, by weight (t), 2008–2017.*

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
China	3.5	5.5	8.5	9.0	13.0	18.5	32.0	27	input not complete
South Korea			0.5	1.7	5.6	0.5	0.1	0.7	0.035

Note: The period of the data relates to the glass eel fishing season, from 1st November to 31st October the following year.
Source: Joint Press Release

China began to import small quantities of *A. rostrata* from North America for farming trials in 1994 (Fan and Qin, 2016). *A. rostrata* input into farms stayed consistantly low for many years until 2010 when farming of Caribbean and Central American glass eels became more successful; and in 2016 the input volume of *A. rostrata* live eel fry reportedly exceeded those of *A. anguilla* and *A. japonica*.

iv) Other live eels

East Asian countries/territories reported importing "other live eels" (live eels other than fry) from five *A. rostrata* range States (Figure 10). According to experts, there is minimal fishing and consumption of larger life stages in Caribbean and Central American range States, and no exports[43].

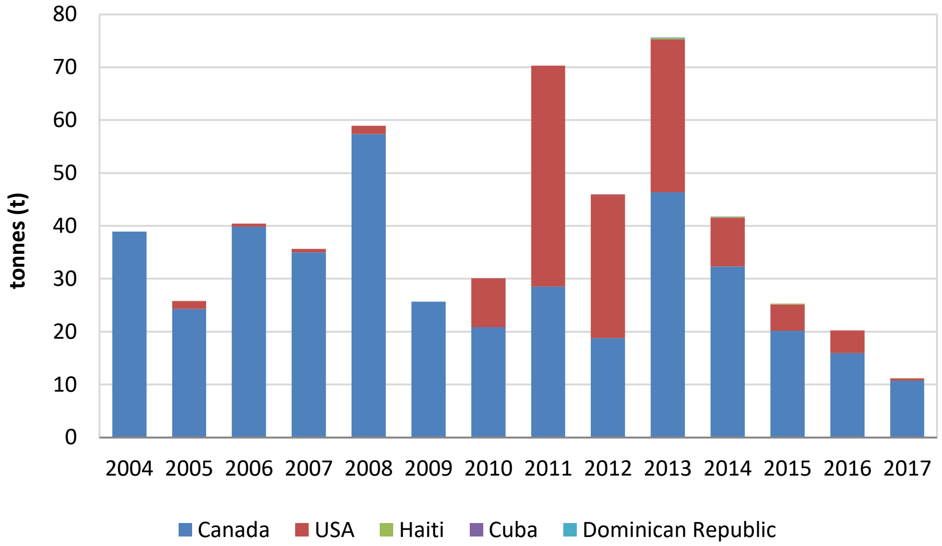

Figure 10: Annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from A. rostrata *range States, by weight (t), 2004–2017. Source: East Asian Customs data*

4.2.2.4 Illegal fishing and trade

Considerable levels of poaching and illegal trade, driven by the increasing prices offered for *A. rostrata* glass eels, have been reported in the USA. "Operation Broken Glass," a multi-jurisdiction U.S. Fish and Wildlife Service investigation to combat the trafficking of *A. rostrata* resulted in 19 people having pleaded guilty in Maine, Virginia and South Carolina as of January 2018, with more than USD4.5 million worth of elvers illegally traded (Department of Justice of the United States [DJUS], 2018).

[43] Presentations by range States at the American eel range State workshop held in Santo Domingo, 4–6th April 2018.

4.2.3 South East/South Asia – *A. bicolor* and other species (*bicolor+)*

4.2.3.1 *Anguilla bicolor+* production

As there are several *Anguilla* species distributed in South East/South Asia including *A. bicolor, A. marmorata* and *A. bengalensis*, catch and exports/imports from these countries may contain several *Anguilla* species. According to FAO, in South East Asia, Indonesia has reported catch and farming production of *Anguilla* spp. and the Philippines has reported catch production. Although eels are caught in Myanmar, Thailand and Viet Nam as well as being farmed in Cambodia, Myanmar, Thailand and Viet Nam, there are no catch statistics in these countries (SEAFDEC, unpublished data, 2018).

The combined eel catch production for Indonesia and the Philippines increased gradually from less than 1,400 t in 2007 to over 5,400 t in 2013, after which it dropped to ~2,400 t in 2016. Indonesia's eel farming production declined from ~5,800 t in 2008 to ~30 t in 2012, increasing again to ~16,700 t in 2016. However, other information sources suggest Indonesia's *Anguilla* farming production was 200 t in 2014 and 355 t in 2015 (SEAFDEC, unpublished data, 2018), lower than the quantities reported to FAO. Many South East Asian countries do not have official statistics of *Anguilla* catch and farming production (SEAFDEC, unpublished data, 2018), which is yet to be collected and reported to FAO.

4.2.3.2 Global *Anguilla* trade from South East/South Asia

According to UN Comtrade, exports of eel commodities (live, fresh, frozen and prepared eel) from South East and South Asian countries[44] increased from ~8,420 t (excluding prepared eels whose global HS code was introduced in 2012) in 2008 to 32,640 t in 2016.

Live eel exports from South East and South Asia increased from 1,625 t in 2007 to 22,124 t in 2013, after which they slightly declined during 2014–2016 (Figure 11). However, non-*Anguilla* species are known to be traded under HS codes for *Anguilla* eels. Live eel exports from South East Asian countries include *Monopterus albus* (Swamp Eels) and *Pisodonopsis* sp. (snake eels) (SEAFDEC, 2018, unpublished data; the Philippines' response to CITES Notification 2018/018). In Myanmar, catch production of *Monopterus albus* (approximately 50%) and *Pisodonopsis* sp. (40%) are much larger than *Anguilla* spp. (10%) (SEAFDEC, unpublished data, 2018). Also see Annex 2.

[44] South East and South Asian countries include Bangladesh, Brunei Darussalam, Cambodia, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Viet Nam.

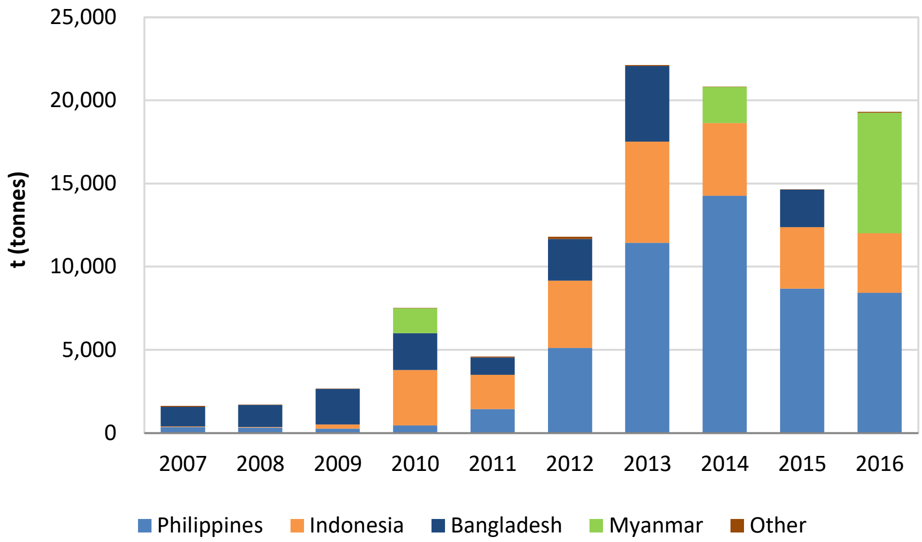

Figure 11: Exports of live Anguilla *spp. from South East and South Asia, as reported by weight (t), 2007–2016. Source: UN Comtrade (2018).*

4.2.3.3 East Asian imports and farming of *A. bicolor*+ from South East Asia/South Asia

i) Live eel fry supply and imports

According to East Asian Customs data, East Asian countries/territories imported ~220 t of live eel fry from eight countries in South East/South Asia over the decade 2008–2017, 73% of which came from the Philippines. (Table 10). Hong Kong, followed by South Korea was the main importer of live eel fry from South East Asia during 2008–2017. South Korea's imports of live eel fry reached ~26 t in 2013 due to ~18 t of imports of larger sized eels (young eels).

Table 10: Imports of live eel fry from South East/South Asian countries reported in East Asian Customs data, kg.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Philippines	13,774	1,993	3,347	16,379	34,831	32,388	10,086	16,782	21,081	8,265
Malaysia					402	9,354	3,813	2,796	2,301	1,782
Viet Nam						13,739	48		85	
Thailand					498	3,569	1,398	1,579	2,360	444
Bangladesh							7,594			
Indonesia	182	87	868	636	1,045	2,008	10	95	194	
Singapore						3,304	7	36		
Timor Leste						10				
Total	**13,956**	**2,080**	**4,215**	**17,015**	**36,776**	**64,372**	**22,956**	**21,288**	**26,021**	**10,491**

Note: *Green cells indicate import records from the country where neither glass eel fishing or farming exist. Grey cells indicates import records from the country where glass eel exports are regulated (Indonesia: Philippines: Viet Nam: export ban for eels taken from wild). Source: East Asian Customs authorities.*

It should be noted that exports of glass eels from a number of South East Asian countries, including the Philippines and Indonesia since 2012, are not permitted[45]. Singapore and Timor Leste are not presently listed as range States of *Anguilla* spp. (Jacoby and Gollock, 2014a). Additionally, glass eel fishing or farming does not exist in Malaysia and Thailand, and in Viet Nam *Anguilla* eel export is banned except for farmed eels (SEAFDEC, unpublished data, 2018).

[45] Information provided by range States at the CITES International technical workshop on eels (*Anguilla* spp.) held in the UK, 18-20th April 2018.

A. bicolor live eel fry input into eel farms in China and South Korea during 2008–2017 as reported in the Joint Press Release is shown in Table 11 and imports of live eel fry for 2013–2017 from the Philippines and Indonesia to South Korea and Taiwan are shown in Table 12. South Korea and Taiwan's Customs codes differentiate life stages of live eel fry, which shows that South Korea and Taiwan imported glass eels whose size was smaller than permitted trade (highlighted in grey). The Philippines limits exports of live eel by length, which makes it difficult to compare the datasets to determine whether imports of live eels into South Korea were the permitted size under Philippine law. All young eel imports from Indonesia were less than 91 g per piece, less than is permitted by Indonesia for export.

Table 11: A. bicolor *live eel fry input into eel farms in East Asia, 2008–2017, t.*

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
China	0.3	1.1	3.5	5.5	7.0	13.5	3.5	8	not finished
South Korea			0.8	3.7	6.7	2.4	5	3	0.58

Note: The period of the data relates to the glass eel fishing season, from 1st November to 31st October the following near.
Source: Joint Press Release.

Table 12: Imports of live eel fry from the Philippines and Indonesia to South Korea and Taiwan, 2013-2017, kg.

Importer	Source	Commodity	2013	2014	2015	2016	2017
South Korea	Philippines	Glass eel	6,409	1,582	5,367	2,072	584
		Young eel	4,217	385	6,634	14,481	4,751
	Indonesia	Glass eel	807		33	194	
		Young eel	320				
Taiwan	Philippines	Glass eel	44				
		Elver	220				168
		Young eel	865	3,565		1,077	2,003
	Indonesia	Glass eel	2				
		Elver	92				

Note: Glass eel indicates live eel fry ≤0.3 g per unit while young eel indicates live eel fry >0.3 g and ≤51 g per unit for South Korea and glass eel, elver, young eel indicates live eel fry over 5,000 eels per kg, not less than 501 eels, less than 5000 eels per kg and not less than 11 eels, less than 500 eels per kg respectively for Taiwan.
Source: Korea International Trade Association and Taiwan Bureau of Foreign Trade.

ii) Other live eels

East Asian countries/territories reported importing ~9,100 t of other live eels (live eels other than fry) from South East/South Asian countries between 2008 and 2017. Hong Kong imported approximately 83% of other live eels during the period. The main sources were Indonesia, followed by the Philippines and Bangladesh (Figure 12).

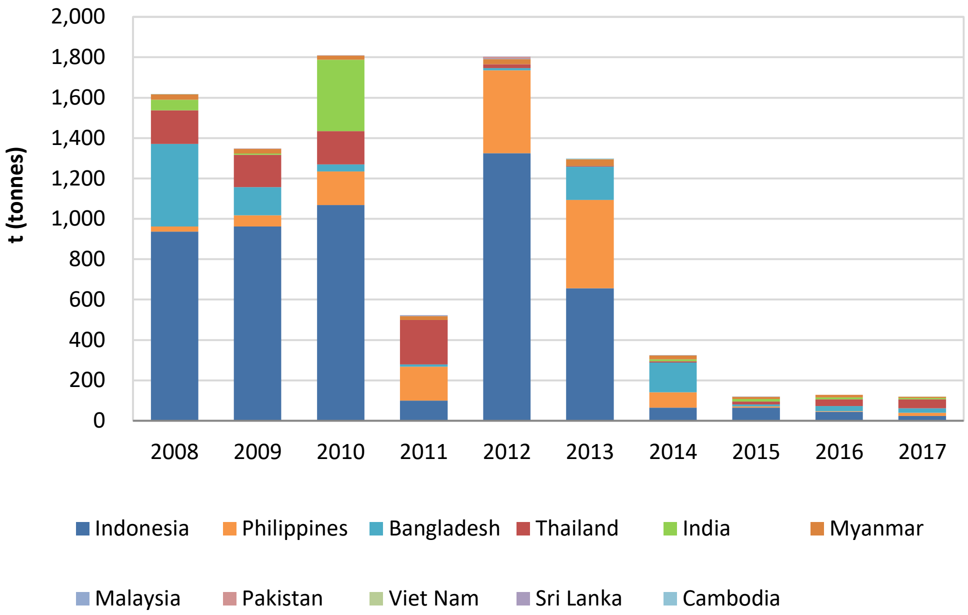

Figure 12: Total annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from South East Asia, 2004–2017, t Source: East Asian Customs agencies.

According to Hong Kong Customs data which are available by origins and by supplier, Hong Kong reportedly imported 3.3 t of other live eels originating in Indonesia and 4.9 t of other live eels originating in Pakistan via the Philippines in 2012. South East/South Asian countries seemed to be used as transit points from other regions as well; 10 t of other live eels originating in Bulgaria via Bangladesh in 2012 and 93 t of other live eels originating from Madagascar were traded via Thailand in 2013.

4.2.3.4 Trade in *A. marmorata*

A. marmorata is a widely distributed species with approximately 40 countries/territories with Pacific and Indian Ocean coastlines specified as range States of the species (Jacoby and Gollock, 2014b). *A. marmorata* farming is relatively new in East Asia, and most of the *A. marmorata* live eel fry seem to be imported from South East Asia, especially the Philippines (Huang *et al*., 2016). Eel farmers in Taiwan began farming of *A. marmorata* targeting a large commercial market in mainland China and Taiwan after the Council of Agriculture lifted the conservation status of the species in April 2009 due to recovery of the resources (FBCA 2009; Huang *et al.* 2016). According to the Joint Press Release, South Korea also input 500 kg and 300 kg of *A. marmorata* live eel fry for farming in 2011–2012 and 2012–2013. Some Chinese eel farmers use *A. marmorata* as a certain percentage of *A. bicolor* is included in imported live eel fry, which cannot be distinguished at early life stages.

4.2.4 Oceania – *A. australis* and other species

There are several *Anguilla* species distributed in Oceania including *A. australis*, *A. reinhardtii* and *A. dieffenbachii*. According to FAO production data, Australia and New Zealand have reported catch production of *Anguilla* spp. and Australia has reported farming production of *Anguilla* spp. since 1950. Catch production in these countries reached ~2,800 t in 2014, after which it declined gradually to 535 t in 2016. *A. australis* accounted for approximately 70–80% of the commercial catch and is often exported live for direct consumption, while *A. dieffenbachii* accounted for the remaining 20–30% in recent years. According to Australia's response to the CITES Notification 2018/018 only *A. australis* and *A. reinhardtii* are harvested and the farming production for these species has not been reported since 2012.

According to data reported to UN Comtrade, exports of eel commodities (live, fresh, frozen and prepared eel) from Oceania were reported by New Zealand, Australia and Samoa during 2007–2016. New Zealand was the dominant exporter, accounting for 74% of exports and Australia exported 2,635 t of eel commodities during 2007–2016, 91% of which were live eel exports. According to New Zealand Customs data, New Zealand exported 3,636 t of frozen eels and 2,818 t of live eels during 2008–2017. Based on East Asian Customs data, East Asia recorded imports of live eel fry only from Australia in Oceania during 2008–2017, 2.2 t in total. Imports ranged zero to 270 kg except for 2015 when imports exceeded 1.5 t (Table 13). There was no information suggesting these species are currently used in eel farms in East Asia.

Table 13: Imports of live eel fry from Australia reported in East Asian Customs data, kg.

Importer	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Hong Kong							217	1,544		
China	263									
South Korea								3	177	
Total	**263**	**0**	**0**	**0**	**0**	**0**	**217**	**1,547**	**177**	**0**

Source: East Asian Customs data

East Asian countries/territories reported importing approximately 2,300 t of other live eels (live eels other than fry; all *Anguilla* spp.) in total from Australia and New Zealand between 2008 and 2017 (Figure 13). While Hong Kong was the main importer of other live eels from Oceania during 2008–2013, China took the top position during 2014–2017.

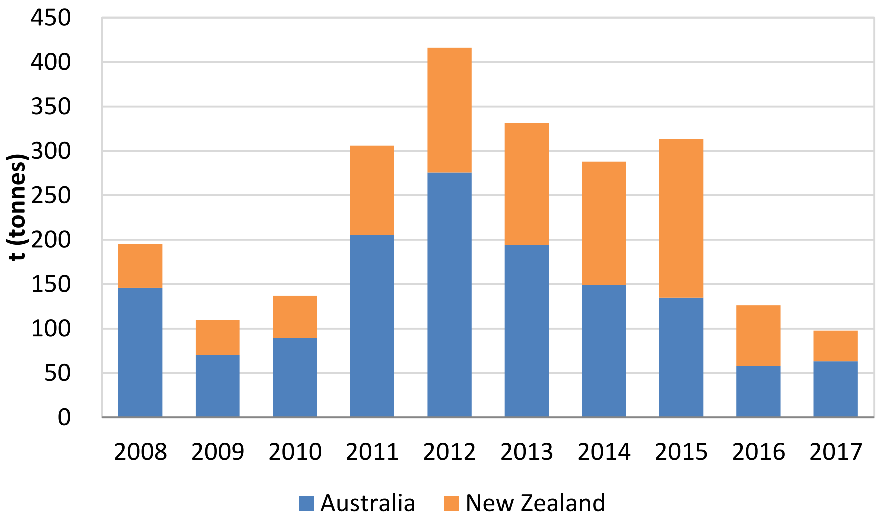

Figure 13: Total annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from Oceania, 2004–2017, t. Source: East Asian Customs data

4.2.5 East/Southern Africa – *A. mossambica* and other tropical species

There are several *Anguilla* species distributed in East/Southern Africa including *A. mossambica*, *A. marmorata*, *A. bicolor* and *A. bengalensis.* As such, catch and exports/imports from these countries may contain several *Anguilla* species. No country in the region has reported *Anguilla* catch/farming production to FAO while according to UN Comtrade, Madagascar and South Africa exported live *Anguilla* eels from 2007 to 2016, with 98% reported by Madagascar (Table 14).

Table 14: Live eel exports from Madagascar to other countries/territories by destinations, as reported by weight (t), 2007–16.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hong Kong	2	5	42	133	175	333	344	87	52	11
France	90	117	125	95	32	60	24	62	67	24
China						18	117	117	147	40
Netherlands				236	16					
Other	3	2			32	15	29	3		
Total	**95**	**123**	**167**	**464**	**257**	**426**	**515**	**269**	**266**	**74**

Source: UN Comtrade

According to East Asian Customs data, East Asia imported live eel fry from Madagascar, Mauritius and South Africa between 2008 and 2017 (Table 15). Hong Kong was the leading importer, accounting for 67% of imports from these countries.

Table 15: Imports of live eel fry from East/Southern African countries reported in East Asian Customs data, t.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Madagascar	0.4	1.4	0.0	1.8	3.8	5.6	0.5	0.5		
Mauritius				0.0						
South Africa						0.0				

Note: Values of 0.0 refer to unit value of less than 50 kg. *Source: East Asian Customs data*

South Korea tried farming of *A. mossambica* and *A. bicolor* when the price of *A. japonica* glass eels increased dramatically due to their shortage during 2011–2013, most of which was unsuccessful (Back and Park, 2017; Kim, 2015). There was a case in which *A. mossambica* was sold as a different *Anguilla* species. In mainland China, Fujian Inspection and Quarantine Bureau found glass eels sold as *A. rostrata* were actually *A. mossambica* from Mozambique using DNA identification (Li, 2017). A small portion of *A. mossambica* was found by DNA analysis in prepared eels sold in Japan in 2015 (Yoshinaga, 2015).

East Asian countries/territories reported importing 106 t of other live eels (live eels other than fry) in total from East/Southern African countries (Madagascar, Mauritius, Mozambique and Comoros) during 2008–2017 (Table 16). Mainland China and Hong Kong were the main importers, accounting for 99% of other live eel imports from the region during the period.

Table 16: Total annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from East/Southern African, 2008–2017, t

	2008	2010	2011	2012	2013	2014	2015	2016	2017
Madagascar	0.0	0.8	9.3	5.8	26.1	14.5	20.5	9.3	4.5
Mauritius		7.5	5.3	0.2					
Mozambique								1.2	0.2
Comoros							0.5		
Total	**0.0**	**8.3**	**14.6**	**6.0**	**26.1**	**14.5**	**21.0**	**10.5**	**4.7**

Source: East Asian Customs data

5. Conclusions

The study, responses to CITES Notification 018/2018 and workshops have highlighted that the knowledge relating to the 15 species of non-CITES listed anguillid eels is hugely variable. Temperate species are generally better understood than tropical species, and for many of the tropical species there is practically no readily available information relating to their biology and status. Even for the temperate species there are often large variations in understanding across their ranges. Despite these data limitations and gaps, there is significant concern for a number of anguillid eels. Both *A. japonica* and *A. rostrata* were identified by range states to have had significant declines in some, or all life stages over the past 40-50 years. Both species face impacts from habitat loss, barriers to migration and legal and illegal exploitation. While these two species are arguably the most studied and well known, they are also possibly the most at risk.

Anguilla bengalensis, *A. bicolor, A. borneensis*, *A. celebesensis*, *A. interioris*, *A. luzonensis, A. marmorata, A. megatsoma, A. mossambica* and *A. obscura* have varying degrees of sympatry with one or more other *Anguilla* species across their ranges. This can make species-specific management challenging and where species are exploited this can result in by-catch of non-target eels. In recent years, it is generally believed that of the tropical species, *A. bicolor, A. marmorata* and *A. mossambica* have seen the greatest increases exploitation, particularly for glass eels. The former two species have the broadest distributions of the anguillids, which potentially puts many other more restricted range species at risk through by-catch. Furthermore, a number of tropical species are morphologically similar, which has confounded efforts to accurately describe their ranges and study them.

The three species of eels that are primarily found in Australia and New Zealand have variable stock statuses. *Anguilla australis* appears to have stable populations across its range, and while it is exposed to threats such as exploitation and barriers to migration, these do not appear to be impacting the species significantly. *Anguilla dieffenbachii* has historically been of concern due to declining continental populations, primarily as a result of exploitation and hydropower schemes. While the situation remains uncertain for the species, there are areas where it appears to be recovering to some extent. *Anguilla reinhardtii* is the least well understood of the southern temperate species and there is a relatively poor understanding of its biology and status.

Robust, long-term abundance data sets which allow monitoring of the status of these species are generally lacking and their development should be a priority for future research and/or management efforts. Further, understanding of how the various possible threats impact each species is generally poor. It is generally accepted that the threats encountered by these species across their complex life history will impact them synergistically and/or cumulatively and understanding these interactions will be challenging (Jacoby *et al*., 2015). However, in terms of managing these threats, interventions relating to those that affect the species during their continental phase are likely to have the greatest measurable effects on species status.

The trade data analysis of *Anguilla* spp. over the last 10 years shows that there were substantial shifts in trade patterns related to live eels, especially live eel fry. According to East Asian Customs data, annual imports of live eel fry from Europe and North Africa (likely to be *A. anguilla*), which accounted for 64% of live eel fry imports of imports from outside East Asia in 2008 (39 t). Imports from those sources declined to 7 t in 2011 while imports from other regions increased from 14 t in 2010 to 38 t in 2011, and reached a peak of 117 t in 2013. The Americas and South East Asia became increasingly important live eel fry source regions for East Asian farms during this time. These fluctuations coincided with the CITES listing of *A. anguilla* coming into force in 2009, the banning of all trade in *A. anguilla* from and to the EU in 2010, and low harvest of *A. japonica* for four consecutive years in 2010–2013. This shift in demand also seems to be closely related to East Asian farms developing new farming

techniques for different *Anguilla* species/populations. Once techniques for farming glass eels coming from previously un-exploited regions are successfully developed, the demand for eel fry of other *Anguilla* species could also increase in the future.
The trade analysis also highlights possible illegal trade in live eel fry from/to East Asia, South East Asia and the Americas. While exports of live eel fry were rarely recorded in East Asia, many countries/territories seem to have imported live eel fry from other East Asia countries/territories. Although many South East Asian countries do not allow the export of glass/juvenile eels, a significant volume of imports of live eel fry was reported by East Asia. Imports of live eel fry from Canada and the USA reported by East Asia exceeded elver landings recorded in Canada and the USA.

During the London Workshop, a working group was created to specifically discuss non-CITES listed species. It was agreed that reporting of trade data needed to be improved through applying consistent codes and metrics, harmonising legislation and strengthening traceability. As discussed in the report, it was acknowledged that a serious impediment to conservation and management are the knowledge and data gaps relating to these species. Understanding the status of the stocks is essential if sustainable off-take is to occur and at present there are many species where this information is not available. It was also recognised that since the listing of European eel in CITES Appendix II, and the associated cessation in export from the EU in 2010, exploitation and trade in other species had undoubtedly increased. It was also noted that much of this exploitation is occurring in locations with no historic fisheries or experience. Finally, the importance of international co-operation and capacity building of developing countries was discussed. A number of existing initiatives were identified e.g. SEAFDEC, as were notable gaps. Several recommendations were proposed by the working group; these and a full account of the workshop can be found in the report submitted to Animals Committee.

Considering that many populations of *Anguilla* spp. are believed to have declined over the last few decades and *A. japonica* and *A. rostrata* are both currently listed as Endangered on the IUCN Red List of Threatened Species, coordinated regional and/or global adaptive management and conservation measures are essential in order to ensure sustainable use of all *Anguilla* species into the future. To this purpose, the following points in relation to population status, trade, traceability and international and inter-agency co-operation are highlighted for further discussion and consideration:

- Increasing the understanding of the basic biology of these species, across their full range would hugely improve our ability to manage them.
- Similarly, the establishment of abundance monitoring programmes for the different life stages of these species would inform both management and the assessment of their status. For some of the tropical species with generation lengths of less than 10 years, this could be achieved relatively easily and at low cost.
- Understanding the dynamics of multi-species aquatic systems is essential for management in some range States. Both Indonesia and the Philippines are believed to have seven species of anguillid in their continental waters, some of which particularly *A. bicolor*, have increased in trade over the past 10 years. This increase in exploitation has the potential to impact other species.
- Encouraging cooperation among range States to understand the biology of these species across their ranges, conduct joint programmes of work and share knowledge, and manage *Anguilla* resources based on scientific evidence is essential to conserve these shared resources.
- Using standardised or comparable definitions/codes for reporting trade in the different *Anguilla* eel life stages, and coordinating any future changes to Customs codes to ensure this

is applicable across all *Anguilla* range States, would facilitate trade data analyses. This is also relevant to fisheries/other management measures, such as limits on export set by length or weight.

- It is important that that Customs codes for *Anguilla* spp. are only used to report trade in *Anguilla* species and not other eel-like species (non-*Anguilla,* i.e. look-alikes). A guide to these other eel-like species in trade, with common names and photos, may help to raise awareness, and ensure accurate reporting.
- Further research on consumption especially in emerging and/or lesser-known markets such as China, South Korea and Russia, would help to identify changes in the potential drivers of the global *Anguilla* trade. Strengthening multi-lateral and bilateral cooperation between exporting and importing countries is vital, in particular between enforcement agencies to control imports of glass eels from countries/territories which have fishing/export restrictions are in place.
- Improved traceability of all anguillid eels in trade is essential in evaluating the true impact of exploitation on these species and preventing illegal fishing and trade.

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Annex 1 – Species Accounts

These accounts have been developed in light of the text of Decision 17.186 and the information has been summarised in the main text of the report. Due to time and resource constraints, they are not exhaustive, but collate information from Parties responses to CITES Notification (2018/018), a search of published peer-reviewed literature and relevant reports, and resources such as the IUCN Red List of Threatened Species.

Common names are not provided, however, there would be enormous value in collating these across species.

Where possible, existing maps have been provided; if they are not available, they have been created. In these instances, where information is available they show distribution at the sub-national level. They do not include vagrant populations.

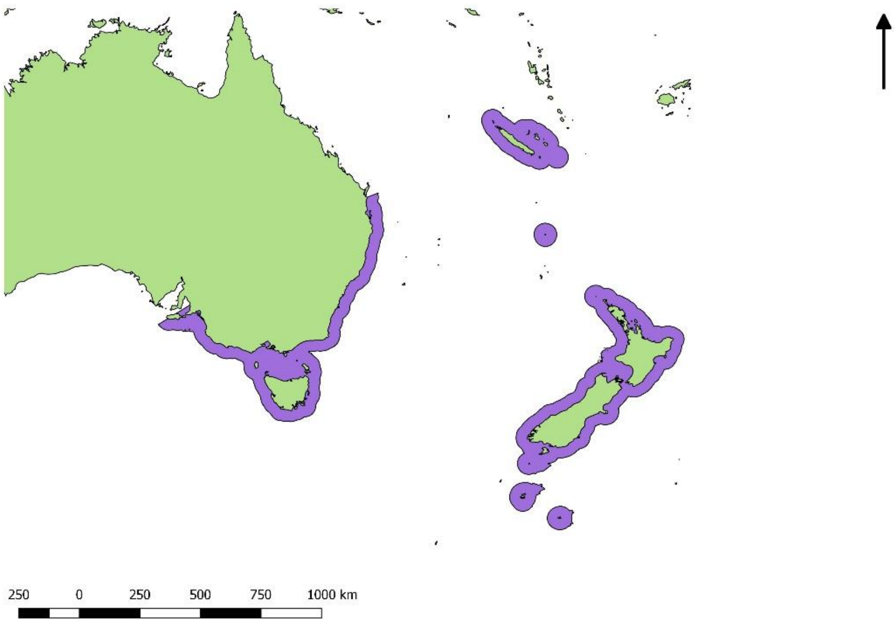
Anguilla australis

Life history

- **Range**

Anguilla australis, is a temperate eel (Arai *et al*., 2004) found in New Zealand, eastern Australia, Tasmania, Norfolk Island, Lord Howe Island, New Caledonia (Ege, 1939) and the Chatham islands (Watanabe *et al*., 2010). It is the most abundant species of eel in New Zealand along with the endemic *Anguilla dieffenbachii* (Beumer, 1996; Ege, 1939; Jellyman *et al*., 1996). In Australia, the duration of the marine larval period (longer for *A. australis* than *A. reinhardtii*) and growth rate (slower for *A. australis* than *A. reinhardtii*) are thought to be key factors in determining the geographical distribution of A. australis, which tends to occur in temperate waters (c.f. *A. reinhardtii*, which predominate in more tropical-subtropical waters) (Shiao *et al*., 2002).
Anguilla australis shows morphological differences between populations in Australia and New Zealand two sub-species are proposed*; Anguilla australis australis* and *Anguilla australis schmidtii* (Leander *et al*., 2012; Shen and Tzeng, 2007a; Watanabe *et al*., 2010). This contrasts genetic studies (Dijkstra and Jellyman, 1999; Jellyman, 1987) suggesting that *A. australis* found in both New Zealand and Australia form a single biological stock as they are homogenous at the glass eels stage (Jellyman, 2007). Jellyman (2007) suggests that the species should be managed cooperatively by Australia and New Zealand as if it were a single fish stock.

Range states: Australia, New Zealand, New Caledonia, Chatham Islands.



Range map of *Anguilla australis*

- **Biology**

Anguilla australis are believed to spawn in the tropical oceans and larval eels drift in the South Equatorial Current and/or the East Australian Current to eastern Australia (Shiao *et al*., 2002). Based on early life history traits, Shiao *et al*. (2001) suggest it is unlikely that New Zealand glass eels arrive having been transported on the East Australian Current from southern Australia but an alternative route is as yet unknown. Leptocephali also travel to New Caledonia, Norfolk Island, and the Chatham Islands by various currents that branch off the East Australian Current (Ridgway and Dunn, 2003; Watanabe *et al*., 2010). A few leptocephali have been found in an area northwest of Fiji, thus Castle (1963) suggested a spawning site between Fiji and Tahiti (170°W by 18°S). Other suggested spawning sites include near New Caledonia (Schmidt, 1928), and east of Tonga (August and Hicks, 2008; Jellyman, 1987). In Australia, the older ages at estuarine arrival of *A. australis* suggest that the spawning grounds of this species lie further from Australia than those of *A. reinhardtii* (Shiao *et al*., 2002). Spawning is proposed to occur between September to February in *A. australis* (Arai *et al*., 2001b; Jellyman, 1987).

In a study of *A. australis* glass eel recruitment into the Waikato River, New Zealand (Jellyman *et al*., 2009), there was a positive correlation of migrations with spring tides, with peak migration periods typically occurring within a few hours of the peak of high tide, and between two and four days after the day of spring tide. Tagging studies, as well as otolith micro-chemistry, suggest that *A. australis* exhibits behavioural plasticity regarding whether or not to enter freshwater, remain in marine environments or shift between the two multiple times (Arai *et al*., 2003a; Arai and Chino, 2012; Crook *et al*., 2014). Freshwater, estuarine and marine-resident Anguilla spp. are hypothesised to begin their spawning migration towards the open ocean at about the same time (Chino and Arai, 2009). This type of synchronization has important implications for conservation as individuals from each habitat type can potentially contribute to the spawning stock (Arai and Chino, 2012). Such plasticity has been documented in *A. dieffenbachii* and several northern temperate anguillid species, A. anguilla and A. japonica (Arai *et al*., 2004).

Age at seaward migration varies considerably between areas depending on growth rates; the range in age and length at migration for *A. australis* males is 5–22 years and 40–48 cm, and for females 9–41 years and 64–80 cm (Ministry for Primary Industries, 2017). Estuarine departure of *A. australis* in southeastern Australia was also influenced by lunar phase and water temperature, while downstream migration was associated with high river flows (Jellyman *et al*., 2009).

Crook *et al*. (2014) report that *A. australis* began seaward migration (entry to the estuary from Darlots Creek/Fitzroy River system in southeastern Australia) occurs throughout the year, with an increase in frequency over summer. Movement into the sea occurred from late summer to early autumn (Crook *et al*., 2014). In a study of 97 tagged eels in southeastern Australia (Crook *et al*., 2014), twenty-three migrated into an estuarine environment, primarily at night, while the rest remained in freshwater. Time in the estuary ranged from 1 to 305 days. The extended residence of migrating eels in the estuary render them considerably more vulnerable to exploitation than had they migrated quickly to the sea where commercial eel-harvest does not occur (Crook *et al*., 2014).

Anguilla australis principally occurs in lowland waters such as estuaries, swamps, the lower reaches of rivers and warmer slower-flowing areas of streams (Glova *et al*., 2001; McCleave and Jellyman, 2002) or still waters such as coastal lakes and lagoons (Arai *et al*., 2003a). In a study of habitat preference of different size classes of *A. australis* in Lake Ellesmere, New Zealand, juvenile eels were mainly caught on a gravel and/or mud substrate in the 0.6 to 1.2 m depth range, and within 1 km of the shore (Jellyman and Chisnall, 1999). In contrast, eels greater than 300 mm preferred sandy substrates, but no preference for depth or distance off shore was detected. Both size groups showed a preference for mixed gravel/mud substrate; the smaller eels avoided sand probably as it does not afford cover (Jellyman and Chisnall, 1999). Within an estuarine environment, *A. australis* prefers areas with macrophytes and rocks/cobbles (Silberschneider *et al*., 2004).

A. australis reaches a maximum size of about 1.1 m and 3 kg (Jellyman, 2007) and females usually live to around 30 years (Jellyman, 2009). The mean size of glass eels of *A. australis* when they recruit to the New Zealand coast is 59.3 mm (Arai *et al*., 2004). The length of silver eels of *A. australis* ranged from 358 to 1035 mm in a study of 20 male and female individuals between 13 and 33 years old from Lake Ellesmere; the same general size as other silver eels reported from elsewhere in New Zealand

(Arai *et al*., 2004). *Anguilla australis* shows typical sexual dimorphism in size as per other temperate anguillid species. Somatic growth rates of silver eels ranged from 14.4 to 56.6 mm/per year (Arai *et al*., 2004). *Anguilla australis* often grows considerably faster than *A. dieffenbachii* from the same location, although on the North Island of New Zealand *A. australis* grows slower than *A. dieffenbachii* in some areas (e.g. parts of the Waikato catchment). *Anguilla australis*, on the South Island of New Zealand, take an average of 12.8 years (range 8.1 to 24.4 years) to reach 220 g (minimum legal size), while on the North Island the average is 5.8 years (3 to 14.1 years) (Ministry for Primary Industries, 2017).

Anguilla australis is predominantly a nocturnal feeder of aquatic macroinvertebrates and fish (Broad *et al*., 2002) with differing preferences among different size classes (Sagar *et al*., 2005). The amphipod *Paracalliope fluviatilis* comprised a major proportion of the diet of all three size classes of *A. australis* (Sagar *et al*., 2005).Gastropods such as *Potamopyrgus* antipodarum and *Physa variabilis* have been reported as major components of the diet of eels greater than 350 mm length (Cadwallader, 1975; Jellyman, 1989; Ryan, 1986; Sagar and Glova, 1998). In addition, black fly larvae, *Austrosimulium*, was a major component of the diet of small-sized eels (Sagar *et al*., 2005). Cased caddisflies, *Pycnocentrodes* spp., were consumed preferentially in one study (Sagar *et al*., 2005) but almost completely avoided by all size classes in another study (Sagar and Glova, 1998). *Anguilla australis* greater than 500 mm feed extensively on fish (Ryan, 1986).

<u>Threats</u>

The main threats to these species are cited as barriers to migration, habitat loss/modification and pollution (Ministry for Primary Industries, 2017). Their unique migratory behaviour renders eels especially vulnerable to blockage of migration routes by dams, and mortality associated with passage through hydroelectric turbines (Bruijs and Durif, 2009; Calles *et al*., 2010; Crook *et al*., 2014). A study by Langdon and Collins (2000) recommended that, based on sustained and burst swimming speeds for *A. australis*, mean and maximum fishway velocities should not exceed 75 cm per second, and fishway cells should be specifically designed to permit glass eel passage (Langdon and Collins, 2000).

Warmer temperatures associated with climate change may have a detrimental effect on glass eel recruitment in their current range. The upstream migration of *A. australis* glass eels was optimum at 16.5°C but was almost completely inhibited at temperatures outside the range of 12 and 20°C (August and Hicks, 2008). *A. australis* in the north of New Zealand, are close to their northern geographic limits when compared to their latitudinal range in other countries and may retreat southwards as a result of increasing temperatures (Ling, 2010).

The *A. australis* fishery in New Zealand is based on the exploitation of immature females, as most males migrate before reaching the minimum catch size of 220 g (implemented throughout New Zealand). The exception to this is Te Waihora where migratory males are also harvested (Ministry for Primary Industries, 2017). This may result in a skewed sex ratio in escaping silver eels.

<u>Use</u>

Anguilla australis support important commercial fisheries across its range, as well as Maori fisheries (Jellyman, 1993; McDowall, 1990) and in some areas are still a frequent part of the diet for Maori (Green, 2004). Eels are also valued for their spiritual, mythological, economic, and nutritional significance (Lyver *et al*., 2005). Freshwater eels have long been consumed by Aboriginal people in eastern Australia and have strong cultural significance (Gomon and Bray, 2017).

There have been some concerns over threats to the eel fishery in New Zealand from 1080[46] contamination. Although there is no evidence of significant or prolonged 1080 contamination in New Zealand streams and rivers, and the risk of acute poisoning to humans from eating contaminated eel

[46] 1080 (sodium fluoroacetate) is a poison used to create a toxic bait.

flesh is considered extremely low, public perceptions and food safety standards have the potential to limit eel exports and/or close an eel fishery if residue was discovered in tissue (Lyver *et al*., 2005).

Stock status

From both fishery-dependent and independent surveys, there was no evidence of national-level declines in *A. australis* stocks as of 2007 in New Zealand (Jellyman, 2007). As of 2014, *A. australis* was classified as 'Not threatened - increasing' in New Zealand (Goodman *et al*., 2014). In southern New Zealand, *A. australis* has been less affected by fishing pressure than *A. dieffenbachii,* possibly allowing *A. australis* to expand their range further inland (Beentjes *et al*., 2006).To date, there have been few concerns about the status of *A. australis* stocks as standard fishery measures have been maintained at levels consistent with an exploited fishery (Jellyman *et al*., 2009). However, local level declines have been identified in New Zealand. Jellyman *et al.* (2009) showed a reduced catch per unit effort and duration of runs compared with the 1970s which indicate that a reduction in recruitment may also have occurred during this period, something recorded in other temperate Anguilla species (Jellyman *et al*., 2009; Kuroki *et al*., 2008). As such, the status of *A. australis* within individual catchments may differ as movement of non-migratory eels is limited until their seaward migration; tagged eels have often been recaptured near or at the tagging site (Burnet, 1969; Chisnall and Kalish, 1993; Jellyman *et al*., 1996) and most movements of *A. australis* in Australia were limited to around 400 m (Beentjes and Jellyman, 2003; Beumer, 1979). Thus once glass eels have entered a catchment, each catchment effectively contains a separate population. The quota management areas in New Zealand mostly reflect a combination of these catchment areas (Ministry for Primary Industries, 2017).
This species has not presently been assessed using the IUCN Red List Categories and Criteria.

Management

No species-specific management actions were identified but Australia manages anguillid eels via legislation specific to each state[47] to implement controls on fishing gears used, life-history stages harvested and control spatio-temporal access to fishing grounds. In their response to CITES Notification 018/2018, New Zealand stated - "New Zealand Fisheries Act 1996: requires that Total Allowable Catches and Total Allowable Commercial Catches are set to provide for utilisation while ensuring sustainability; may not keep eels smaller than 220 grams, nor eels larger than 4 kg. Recreational use is also regulated with a bag limit of 6 eels per day. Maori customary use is regulated by Maori guardians and is only for local consumption." Further, in New Zealand a Quota Management System (QMS) exists for all anguillds that are fished. The fishing year for all stocks extends from 1 October to 30 September except for Te Waihora/Lake Ellesmere which has a fishing year from 1 February to 31 January. Currently, there exist minimum and maximum commercial size limits for all anguillids (220 g and 4 kg, respectively) throughout New Zealand.

[47] Queensland: https://www.daf.qld.gov.au/business-priorities/fisheries/aquaculture/aquaculture-species/eels
New South Wales: https://www.dpi.nsw.gov.au/fishing/aquaculture/publications/species-freshwater/eels-aquaculture-prospects
Victoria: https://vfa.vic.gov.au/commercial-fishing/eels
Tasmania: https://www.ifs.tas.gov.au/about-us/publications/fish-fact-sheets/short-finned-eel

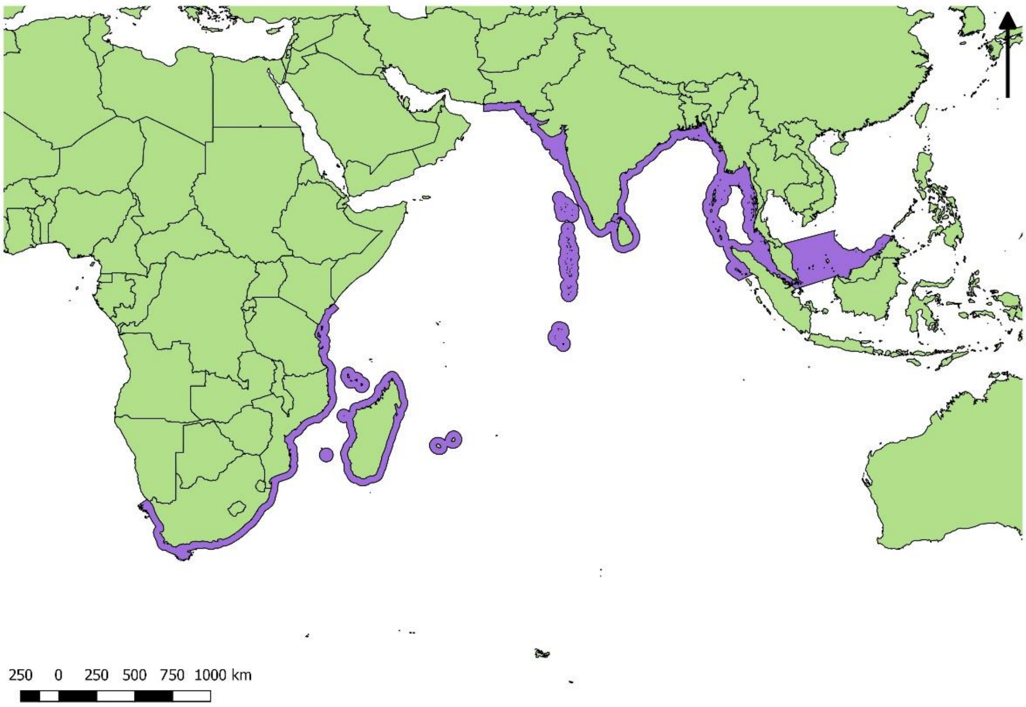
Anguilla bengalensis

Life history

- Range

Until recently, the species has been found in Bangladesh, India, Kenya, Madagascar, Malawi, Mozambique, Myanmar, Nepal, Pakistan; South Africa, Sri Lanka, Swaziland and Tanzania (Jacoby *et al*., 2014). In the past three years, published studies have expanded this range to include Aceh in Indonesia and Malaysian islands (Arai and Kadir, 2017; Arai and Wong, 2016; Muchlisin *et al*., 2017). There are also occasional records of vagrant individuals in the Arabian Peninsula (Wadi Haj in Yemen; (Attaala and Salem Rubaia, 2005)). There remains uncertainty around where *A. bengalensis* might spawn in the Indian Ocean. Very few *A. bengalensis* leptocephali have been gathered and it is still not known whether this species has a single or multiple spawning locations and/or whether the spawning location(s) overlap with other anguillids (see Robinet *et al.* 2008, Watanabe *et al.* 2013 for discussion).

Range States: Bangladesh; India; Indonesia; Kenya; Madagascar; Malawi; Malaysia; Mozambique; Myanmar; Nepal; Pakistan; South Africa; Sri Lanka; Swaziland; United Republic of Tanzania.



Range map of *Anguilla bengalensis*

- Biology

A study of 47 *A. bengalensis* from Penang Island in Malaysia indicated that seaward migration took place for at least six months of the year (April to September), in contrast to the more seasonally focussed migration of temperate species (Arai and Kadir, 2017). This species inhabits various niches in river systems depending on local conditions and other anguillid species present (Arai and Kadir, 2017; Bell-Cross and Minshull, 1988). Juveniles feed on insects and other aquatic invertebrates and larger eels feed on fishes (including trout in the streams of the eastern highlands of Zimbabwe) and crabs (Okeyo, 1998). Length estimates for escaping silver eels of this species range between 35 and 200 cm (Arai *et al*., 2017; Shrestha, 2003) and Pantulu (1957) found there to be strong positive length/weight

relationships. Further, a close linear relationship was found between length and fecundity of maturing silver eels studied in Malaysia (Kadir *et al*., 2017b).
There are proposed to be two sub-species/sub-populations of this species – *A. bengalensis bengalensis* (Asia) and *A. bengalensis labiata* (Africa).

Threats

The CAMP report on the freshwater fishes of India (Molur and Walker, 1998) declared *A. bengalensis* as 'Endangered' according to IUCN criteria, reporting damming, fishing, loss of habitat, overexploitation and domestic trade as the main drivers of decline. Similarly, (Islam, 2014) stated that in Bangladesh, '*loss and degradation to habitats caused due to siltation, construction of dams and reduction in freshwater inputs are considered threats to the species*' and '*the species has a good export market and is highly priced as food fish because of its nutritional value*.' As a mottled species, *A. bengalensis* is perhaps less desirable to the East Asian market, where bi-coloured eels are generally preferred; however, there is a growing market for mottled eels but to date this is *A. marmorata* (Shiraishi and Crook, 2015). In Nepal, it was highlighted that most dams in this region do not have fish and/or eel ladders and loss of freshwater habitat is a significant problem (Shrestha, 2003). Barriers to migration also appear to be problematic in Zimbabwe with dams such as the Cabora Bassa and Kariba dams preventing migration (Matiza and Crafter, 1994). Indeed the status of freshwater systems globally is of great concern and the range of this species, in Africa and Asia, has been highlighted as particularly vulnerable to anthropogenic impacts (UNEP, 2008).

In 2012 a new species of parasitic nematode was discovered in the intestines of *A. bengalensis* collected from the freshwater bodies of Kerala State in southern Indian (Moravec *et al*., 2012). In some parts of India, this species has also been found to contain levels of pollutants that could be toxic to humans. In the Ganges River, West Bengal for example, *A. bengalensis* specimens that were caught contained methyl mercury concentrations that were higher than the limits set by the PFA (Prevention of Food Adulteration Act) for human consumption (Pal *et al*., 2012). Conversely, levels of arsenic and mercury in the same river were found to be safe (Pal and Ghosh, 2013). Additionally, climate change has been proposed to play a role in fluctuations of abundance in anguillid species – particularly larval transport and glass eel recruitment – however, our understanding of these processes, and the scale of their influence, if any, is very limited (Jacoby *et al*., 2015).

Use

Despite its wide distribution there is very little species-specific information available on the use and trade of *A. bengalensis*. In India (Maharashtra), this species was much prized as a food fish, and is supposed to have special nutritional value (Talwar and Jhingran, 1991) and medicinal uses (arthritis). In addition, *A. bengalensis* is considered a 'pristine rare ornamental species of the Himalayan drainage' often being preserved in temple ponds for religious purposes (Shrestha, 2003).
According to East Asian Customs data, annual imports of *Anguilla* live eel from Bangladesh, India, Myanmar, Pakistan and Sri Lanka were around 430-490 t during 2008-2017 except for 2010 when it reached 790 t. Imports from Bangladesh accounted for 85% of all live eel imports from these countries. Hong Kong was the main importer, accounting for 83% of imports from the region during 2008-2017. More than 7.5 t of live eel fry were imported into Hong Kong from Bangladesh in 2014, which was the only reported import of live eel fry in East Asia from the region during the period.

Stock status

There is very little information available on the status of *A. bengalensis*. A recent monitoring programme in KwaZulu Natal in South Africa (2015-2017), indicated that the species had a very patchy presence which had decreased over the past 10 years (Hanzen, personal communication). If this pattern is reflected across the species range, this would be of significant concern. This species was classified as 'Endangered' in India due to decline in range and the extent and/or quality of habitat, however this assessment was carried out 20 years ago (Molur and Walker, 1998). A more recent national assessment in Bangladesh using the IUCN Red List Categories and Criteria, suggested the species to be 'Vulnerable' due as '*the population has probably declined by 30% throughout its habitat ranges…due to overexploitation and habitat degradation over the last ten years…*' (Islam, 2014). For other localities, there is limited information. In eastern and southern Africa, although the species is thought to be relatively widespread, there is also little information available on the population status which may be declining in range and size according to J. Freyhof (2014, pers. comm.). There is some anecdotal evidence for localised extirpation in Africa, for example in Lake Kariba, Zimbabwe where fisherman, in 1998, reported no freshwater eel had been found since the construction of a large hydroelectric dam in 1959 (S. Watanabe, 2014, pers. comm.).

<u>Management</u>

There is little information on the management of this species and/or policy related to this species, both regionally and nationally. Islam (2014) stated that in Bangladesh, '*the species is included in any schedule of the Wildlife (Conservation and Security) Act, 2012*'.

From the limited information included in this status report, it is clear that more research is needed into the population trends, threats and harvest levels of this species, and that management and policy related to these threats should be developed as appropriate.

<u>Anguilla bicolor</u>

<u>Life history</u>

- **Range**

Anguilla bicolor has the widest geographic distribution of any anguillid species apart from *Anguilla marmorata* (Arai *et al*., 2015). *A. bicolor* has diverged between the Indian and Pacific Oceans which has led to the hypothesis that there are two sub-populations; *A. bicolor bicolor* in the Indian Ocean and *A. bicolor pacifica* in the Pacific Ocean (Minegishi *et al*., 2012).

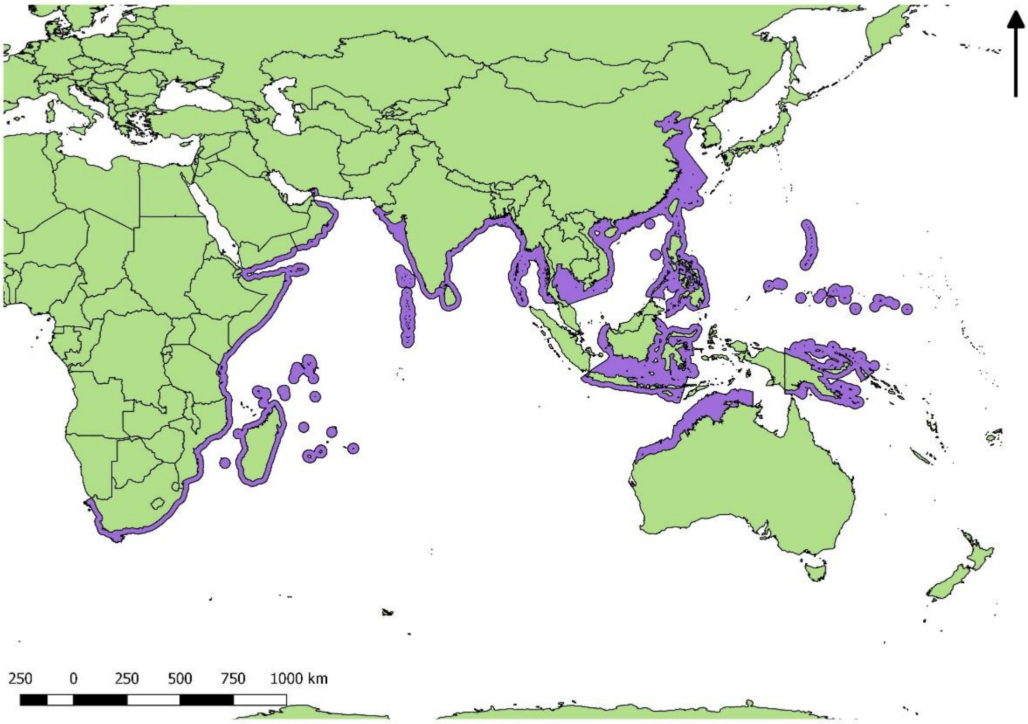
Anguilla bicolor pacifica is native to Borneo, Indonesia, the Marianas, New Guinea, the Philippines, Sulawesi Island, Taiwan and Vietnam.

Anguilla bicolor bicolor is found in the Arabian Peninsula (Oman and Yemen, including Socotra, in coastal drainages of the Gulf of Oman, Arabian Sea, and Gulf of Aden (Environment and Protected Areas Authority (EPAA), 2002)), it is widespread in the tropical Indian Ocean (Seychelles, Madagascar and Mascarenes), east to India, Sri Lanka, Bangladesh and Myanmar. It is also found across to northwestern Australia (Allen *et al*., 2002). Recent studies suggest that it is even more widespread also occupying the western and northern parts of the Malaysian Peninsula (Arai *et al*., 2015). In Africa, it is widespread but relatively uncommon along the east and South East coast from South Africa to Tanzania and Madagascar, including the Lower Shire River System of the Lower Zambezi in Malawi[48] and Tana River (Copley, 1958). In southern Africa it occurs in the eastern part of the region, only present in lower coastal plain sections. In Zimbabwe it is only known from the Save-Runde confluence. It may be present in eastward flowing rivers of east Africa, although it has not been recorded from Kenyan rivers (Seegers *et al*., 2003). There is a known locality in Somalia, which also suggests the subspecies is present the entire length of the African east coast. *Anguilla bicolor bicolor* is also present for five months of the year on Réunion Island of the Mascarene Islands (Arai *et al*., 2017).

Malaysian and Indonesian waters comprise overlapping parts of the ranges of the two subspecies (Arai *et al*., 2015). In a study conducted around the Indonesian Archipelago, *A. bicolor pacifica* was found from western Sulawesi to western Papua whilst *A. bicolor bicolor* was found from western Sumatra to southern Java (Sugeha and Suharti, 2008).

Range states: Australia ; Bangladesh; China; India; Indonesia (Java, Lesser Sunda Is., Sulawesi); Kenya; Madagascar; Malaysia; Maldives; Mauritius; Federated States of Micronesia; Mozambique; Myanmar; Northern Mariana Islands; Oman; Papua New Guinea; Philippines; Réunion Island; Somalia; South Africa; Sri Lanka; Tanzania, United Republic of; Thailand; Viet Nam; Yemen (Socotra).

[48] http://www.fishbase.se/References/FBRefSummary.php?ID=39192&database=FB



Range map of *Anguilla bicolor*

- **Biology**

Anguilla bicolor spends most of its life in estuaries, brackish waters, freshwater lakes, streams, pools and small rivers, preferring marshy habitats but can also be found over rock bottoms and in deeper pools (Pethiyagoda, 1991). Predominantly living in freshwater areas, as maturity approaches, the adult silver eels then migrate seaward (Seegers *et al*., 2003). Chino and Arai (2010a) found that 75% of adults resided in freshwater, such as those found in the upper reaches of the Kurau River in Bukit Merah (Malaysia), 20% in coastal seawater, and 5% in brackish water prior to their spawning migrations. Indeed, in Africa the species is noted as being restricted to lowland coastal reaches of river systems (Skelton, 1993) and in the Arabian Peninsula to wadis, estuaries and the coastal habitat (Environment and Protected Areas Authority (EPAA), 2002). *Anguilla bicolor bicolor* was widely distributed in both upstream to downstream areas of rivers in both tidal and non-tidal zones (Arai and Kadir, 2017). In a lagoon in Indonesia individuals tended to switch between freshwater and sea water residence with no constant freshwater residence (Arai *et al*., 2017). However in the northwest of peninsular Malaysia, most of the sampled *A. bicolor bicolor* were in the mature stage possibly indicating that they might remain entirely in freshwater before migration to the ocean for spawning (Hamzah *et al*., 2015). Overall *A. bicolor bicolor* appears to be flexible in its habitat use and migration strategy, possibly in response to local conditions.

Anguilla bicolor bicolor can grow to 1.2 m which is almost the same as those of temperate eels, and while this species can live for up to 20 years, the average age of maturation is younger than those of temperate eels, suggesting that growth in tropical eels is faster than temperate eels (Arai *et al*., 2011). Based on 408 specimens, the overall total length and body weight in *A. bicolor bicolor* ranged from 203 mm to 810 mm and from 9.8 g to 1,270 g (Arai and Kadir, 2017). The average total length and mean body weight of the migrating silver eels of *A. bicolor bicolor* was 651 mm and 593 g (Kadir *et al*., 2017b).

Eleven *A. bicolor pacifica* collected in the western South Pacific ranged in size from 29.3 mm to 54.1 mm. The early growth rate, before leptocephali reach maximum size of about 50 mm, was estimated at 0.48 mm per day (Kuroki *et al*., 2006a). The average total length of *A. bicolor pacifica* glass eels (n=16) recruiting to Mindanao, Philippines was 48.8 mm and ranged from 45 mm to 52.3 mm (Shirotori *et al*., 2016).

The growth rate of *A. bicolor bicolor* in the eastern Indian Ocean west of Sumatra was slower than other tropical eels such as *A. celebesensis* or *A. borneensis*, suggesting that this subpopulation has a longer leptocephalus stage during oceanic migration (Kuroki *et al*., 2007).

Subpopulations of *A. bicolor* in Java and Sumatra are thought to spawn off the southwest coast of Sumatra (Mentawai Trench) during a broad, protracted spawning season, with these areas a relatively short distance to where they recruit to their growth habitats (Aoyama *et al*., 2007; Jespersen, 1942; Kuroki *et al*., 2007; Robinet and Feunteun, 2002).

The eastern Indian Ocean off western Sumatra, Indonesia, has long been thought to be a spawning area of *A. bicolor bicolor*, however the distributions of leptocephali collected from the area and the patterns of ocean currents in the region suggest that the main spawning area may be located farther offshore (Aoyama *et al*., 2007). A further spawning area of *A. bicolor bicolor* may be in the eastern waters of Madagascar (Robinet *et al*., 2003b).

The spawning area and larval migration of *A. bicolor pacifica* in the North Pacific are virtually unknown, as only large leptocephali of this subspecies have been collected (Aoyama *et al*., 2015). Kuroki *et al*. (2006) speculate that, in the western North Pacific *A. bicolor pacifica* recruits mostly to Indonesia and the spawning area is located off the coast of New Guinea or that there may be multiple spawning areas in the western North Pacific.

In the central regions of Vietnam, migrations occur during the storm season, from October to December every year. A study of *A. bicolor bicolor* collected in Malaysia and *A. bicolor pacifica* collected in North Sulawesi in Indonesia, suggest that spawning occurs year-round (Arai *et al*., 2017; Kadir *et al*., 2017b). *Anguilla bicolor pacifica* exhibits year-round recruitment in North Sulawesi, Indonesia (Arai *et al*., 2017).

From research conducted on *A. bicolor pacifica* in the Dumoga River, North Sulawesi Island, Indonesia, the ages of glass eels at recruitment to the coast ranged from 124 to 202 days, with hatching being estimated as having occurred between November and March (Arai *et al*., 1999c). The duration of metamorphosis was estimated as 20 to 40 days (Arai *et al*., 1999c). Two specimens of metamorphosing leptocephali - 42.6 and 46.3 mm - were reported off the Indonesian Archipelago and their ages were estimated as 106 and 112 days, respectively (Kuroki *et al*., 2006b). During a sampling survey from Sumatra in 2003, leptocephali were collected west of Sumatra in the Mentawai Trench. Otolith microstructure of these larvae revealed size and age ranges of 44.1-55.5 mm and 114-158 days respectively (Kuroki *et al*., 2007). The transport of larvae of this species is likely to be heavily influenced by the South Equatorial Current (SEC), the South Equatorial Counter Current (SECC) and the South Java Current (SJC).

The fecundity range (millions of eggs) for *A. bicolor bicolor* was found to be 0.6 to 5 and relative fecundity (millions of eggs per kilogram of body weight) was 3.1 (Kadir *et al*., 2017b). This is within the fecundity range of temperate eels. Due to the year-round spawning ecology and similar fecundity to temperate eels, Kadir *et al.* (2017) suggest that the biomass of tropical eels may be higher than temperate eels which exhibit seasonal spawning ecology.

Threats

To date, few studies or surveys have considered the threats facing this species. With such an expansive range, however, *A. bicolor* is likely to be impacted by threats proposed to be common to many anguillid species (e.g. changing ocean currents, barriers to migration, mortality at hydropower turbines, pollution, exploitation and habitat reduction).
The major concern for *A. bicolor*, is believed to be the growing exploitation of this species across much of its range (Shiraishi and Crook, 2015). In years when availability of *A. japonica* is low, marked import shifts occur to *A. bicolor* and other tropical eels (Nijman, 2015) fulfilling the demand for 'plain' coloured eels (Jacoby *et al.*, 2015; Shiraishi and Crook, 2015). In Indonesia, *A. bicolor* is more commonly traded from Java and Sumatra (Nijman, 2015).

Use

Given that this species has such a broad distribution it is likely to be caught alongside multiple other anguillid species. According to FAO data there are *Anguilla* spp. caught in Indonesia and the Philippines and a significant proportion of this likely consists of *A. bicolor*. Internet searches reveal that *A. bicolor* (live and frozen) can be easily purchased in bulk online. *Anguilla bicolor* glass eels have been increasingly used to stock farms in East Asia after *A. anguilla* was listed in CITES Appendix II in 2009 and the EU banned all trade in *A. anguilla* from and to the EU in 2010. This appears to increase in years where *A. japonica* has poor recruitment. According to available data, *A. bicolor* live juvenile input to farms increased gradually from 0.3 t in 2008-2009 to 3.5 t in 2010-2011, reaching a peak of 13.5 t in 2013-2014 in mainland China. South Korea also began to use *A. bicolor* in 2010-2011 which reached a peak at 6.7 t in 2012-2013. East Asian Customs data suggest that the demand for *A. bicolor* and other tropical eels seems to have declined after 2014. There appears to have been an increase in *A. bicolor* farming in Indonesia and the Philippines in recent years (SEAFDEC, 2018, unpub. data).

Stock status

Anguilla bicolor is classified as Near Threatened by the IUCN Red List of Threatened Species. There is little quantitative information available on the population status of *Anguilla bicolor*. In studies conducted in southern Sri Lanka, the population was stated to be fairly stable as reflected in the catch per unit effort (Wickström, 2006; Wickström and Enderlein, 1988). Population densities of this species are very low in the Arabian Peninsula (Environment and Protected Areas Authority (EPAA), 2002) and considerably more research is required to determine population estimates. In the Philippines, multiple species of glass eels recruit to the coast and their relative abundances appear to fluctuate annually and regionally (Aoyama *et al*., 2015; Shirotori *et al*., 2016).

Management

There are no known species-specific policies for *A. bicolor*. Réunion (France) has developed a conservation plan for the anguillid species in its waters[49]. Indonesia has legislation that applies to trade of all anguillid species (see *A. bengalensis*). The Philippines has enacted two pieces of legislation that apply to anguillid eels generally; Fisheries Administrative Order (FAO) No. 233 – "Aquatic Wildlife Conservation" - which regulates the catching, use and trade of aquatic wildlife, and FAO No. 242 – "Reinstating the ban on the export of elvers" – which 'prohibits the export of elvers, of a size greater than five centimetres but not exceeding 15 centimetres in length'[50]. Australia manages anguillid eels via legislation specific to each state (see *A. australis*). In Viet Nam *Anguilla* eel export is banned except for farmed eels (SEAFDEC, unpublished data, 2018).

[49] http://www.reunion.developpement-durable.gouv.fr/IMG/pdf/pdc_anguilles_reunion_v4_2018_04_23web.pdf
[50] https://www.bfar.da.gov.ph/LAW?fi=405#post

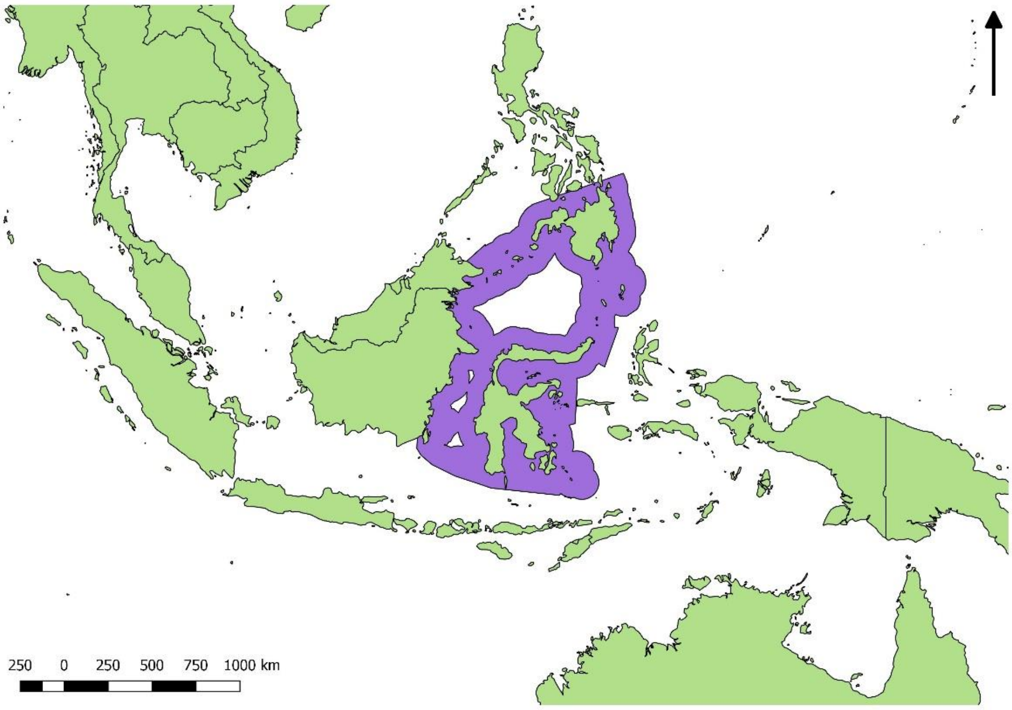
Anguilla borneensis

Life history

- **Range**

Anguilla borneensis has a range restricted almost exclusively to Borneo and parts of Sulawesi, Indonesia and the surrounding Celebes Sea, Sulu Sea, Maluku Sea and the southern end of Makassar Strait region (Kadir *et al*., 2017a; Kottelat, 1993; Kuroki *et al*., 2006a; Shirotori *et al*., 2016). During two surveys around Sulawesi island leptocephali of *A. borneensis* were caught in 2001 and 2002 (Wouthuyzen *et al*., 2009). *Anguilla borneensis* was one of the least abundant species found in General Santos, Mindanao, Philippines with one individual identified based on morphological and genetic analysis (Shirotori *et al*., 2016).

Range states: Indonesia; Malaysia; Philippines



Range map of *Anguilla borneensis*

- **Biology**

Little is known about the ecology of *A. borneensis*. It is the only bi-coloured long-finned eel in Indonesian waters making it relatively easy to identify. *Anguilla borneensis* is suspected to spawn 100 km (Arai *et al*., 2017; Kuroki *et al*., 2006a) to 650 km away from its growth habitats (Aoyama *et al*., 2003; Shirotori *et al*., 2016). Like *A. celebesensis*, it is thus thought that *A. borneensis* undertake much smaller-scale, local migrations to spawn in deep waters (Aoyama *et al*., 2003; Kuroki *et al*., 2006a, 2014; Wouthuyzen *et al*., 2009) compared to other species. Age at metamorphposis is 117 days (Kuroki *et al*., 2014). The smallest leptocephlus caught was reported in the Celebes Sea (8.5 mm, 20 days) and metamorphosing leptocephali – the stage just before continental recruitment as elongate glass eels - were caught in the western part of the Sulu Sea (49.1 mm, 133 days)(Kuroki *et al*., 2006a). Growth rate of the leptocephali, determined using otoliths, is faster than other species except *A. celebesensis* and is estimated at a mean rate of 0.52 mm/day. They reached maximum larval size of about 50 mm at around 80 days (Kuroki *et al*., 2006a, 2014). Hatching dates are estimated as February to September (Kuroki *et al*., 2006b). There are no data on the spawning season, glass eel lengths or age at recruitment (Kuroki *et al*., 2014).

It has been suggested that this species and *A. mossambica* could be basal species of the genus (Arai *et al*., 2001a; Minegishi *et al*., 2005).

Threats

Little information exists about the threats facing *A. borneensis*. Considering its range, it is likely to be exposed to similar threats as species such as *A. bicolor* and *A. marmorata*. In the Poso river watershed, Indonesia, damming for hydropower and unsustainable harvest of both glass eels and larger eels are two reported threats (Watupongoh and Krismono, 2015). In Mentawai, larger eels are intensively harvested (Fahmi *et al*., 2012). There has been an increase in fisheries and export of anguillid eel from the Philippines in the past decade (Crook, 2014) but the impact on this species is unquantified.
The decline in the population of this species in the Karabakan River, Borneo is thought to have been in response to extensive exploitation of the forest alongside the river and subsequent degradation of the freshwater habitat (Jacoby *et al*., 2015). As a bi-coloured eel it may prove a possible target for future exploitation due to restrictions on the trade of other species.

Use

Even though fishing and trade of *Anguilla* species is known to occur in all parts of the distribution of *A. borneensis*, in particular in Indonesia, very little is known of this species' use or trade. *Anguilla borneensis* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.

Population status

There is very little information on the population status of *A. borneensis*, with most of the current literature referring to the description of the species only. Inger and Kong (1962), however, reported that in a river on Borneo Island (Karabakan River), 50% of eels caught in suitable freshwater eel habitat were *A. borneensis*, while the other 50% comprised *A. marmorata*. During an expedition in 1998 to the same localities, researchers found only *A. marmorata* (Aoyama, pers. comm, 2014). The species thus appears to have been severely depleted, if not extirpated in the Malaysian territory of Borneo, where in the 1960s it was once abundant across multiple sites (Inger and Kong, 1962; Tsukamoto and Aoyama, 2014, pers. comm. in Jacoby *et al.*, 2015). Due to this shrinking range, *A. borneensis* is listed as Vulnerable on the IUCN list of Threatened Species, however, further research and monitoring of this species is required to determine the full extent of these declines and to gauge whether *A. borneensis* has a restricted and contracting distributional range.

Management

No species-specific management actions or policies were identified by the Parties for *A. borneensis* but both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* accounts respectively).

<u>Anguilla celebesensis</u>

<u>Life history</u>

- Biology

Anguilla celebesensis is a mottled species that inhabits tropical freshwater, brackish and marine ecosystems. It is believed they have a relatively short migration to their spawning grounds compared to temperate species (Aoyama *et al*., 2003; Arai, 2014a). According to the number of silver eels caught in weirs downstream of Poso Lake, in the Poso River (Sulawesi), the months of January through to July (peaking in April) appear significant for the downstream migration of silver eels out into Tomini Bay (Wouthuyzen *et al*., 2009). A later study in Indonesia found females of this species were at, or nearing, spawning condition while still in continental waters (Arai, 2014a).

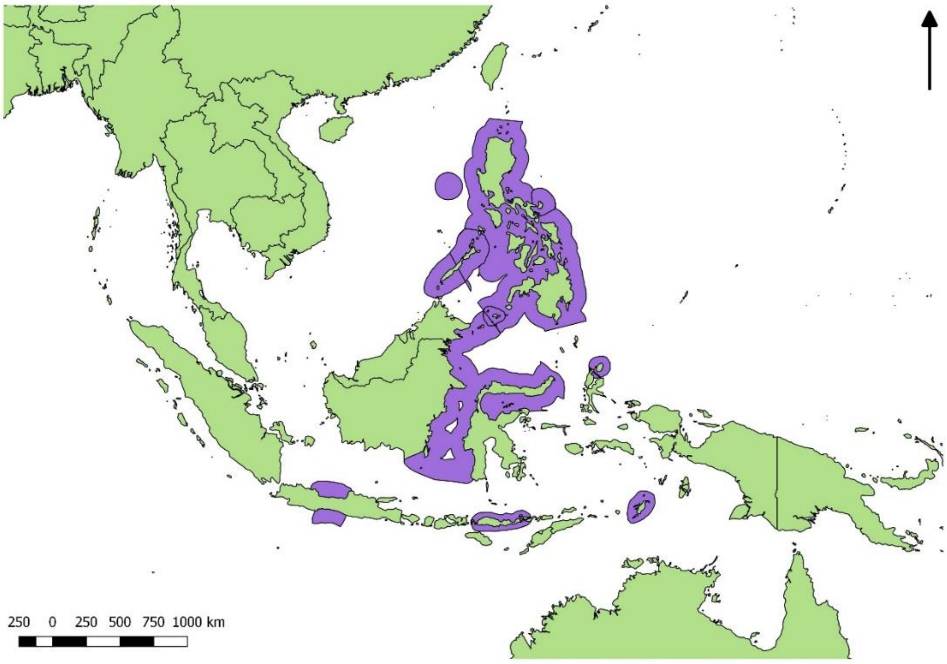
The small leptocephali have been found in both the Celebes Sea and Tomini Bay (Aoyama *et al*., 2003; Kuroki *et al*., 2006a). It has since been confirmed by Wouthuyzen *et al.* (2009) that *A. celebesensis* has multiple local spawning locations which contrasts with the single, spawning areas used by temperate species.

Hatching dates of the leptocephali collected in waters surrounding Indonesia were estimated to range from January to early May with a mean growth rate of 0.56 mm/day, reaching a maximum size at approximately 80 days (Kuroki *et al*., 2006a; Wouthuyzen *et al*., 2009). The otolith microstructure of *A. celebesensis* collected from the Indonesian coast revealed that the age of glass eels at recruitment ranged between 90 and 122 days for specimens in the Poso and Poigar Rivers in Indonesia (Arai *et al*., 2003b). Similar to other tropical species, and unlike temperate anguillid eels, recruitment to freshwater is thought to occur all year round (Arai *et al*., 2001b).

- Range

Anguilla celebesensis is found in countries in the Western Pacific from Indonesia to the southern Philippines, mainly within the Celebes Sea and the Gulf of Tomini. In some areas of Indonesia, *A. celebesensis* is the most abundant eel species (Arai *et al*., 1999a; Sugeha *et al*., 2001). However, the geographic range of this species has still to be fully understood. For example, *A. celebesensis* has until recently been thought common in the northern Philippines (Arai *et al*., 2003b; Tabeta *et al*., 1976) but recent work suggests that this species rarely inhabits this area (Aoyama *et al*., 2015). Indeed, it has been suggested that eels from this area identified as *A. celebesensis* in previous studies may actually be *A. luzonensis* (Kuroki *et al*., 2012). Another study carried out in the southern part of the Philippines indicated this species was similarly rare (Shirotori *et al*., 2016).

Range States: Indonesia; Papua New Guinea; Philippines.



Range map of *Anguilla celebesensis*

Threats

Little is known about the threats facing this species, however *A. celebesensis* is thought to support silver eel fisheries on watercourses leaving Lake Poso in Indonesia (K. Tsukamoto 2014, pers. comm.). Also in the Poso River, a large dam, as yet without a fish pass, has recently been constructed which will likely reduce the amount of eels in this system in the near future (J. Aoyama 2014, pers. comm.). There has been an increase in fisheries and export of anguillid eel from the Philippines in the past decade (Crook, 2014), but the impact on this species is unquantified. Ultimately, taxonomic uncertainty and misidentification make assessing the impact of threats to this species challenging.

Use

Even though fishing and trade of *Anguilla* species is known to occur in all parts of the distribution of *A. celebesensis* very little is known of this species' use or trade. *Anguilla celebesensis* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.

Stock status

There is currently very little information available on the population dynamics of this species. As stated above, it does appear that this species has suffered from misidentification and may not be as widespread a previously believed. Although little can be drawn from the observation in relation to the species status, recruitment of glass eels to a river in Indonesia showed large inter-annual variation over a three-year period (Sugeha *et al*., 2001).

Management

No species-specific management actions or policies were identified by the Parties for *A. celebesensis* but both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* accounts respectively).

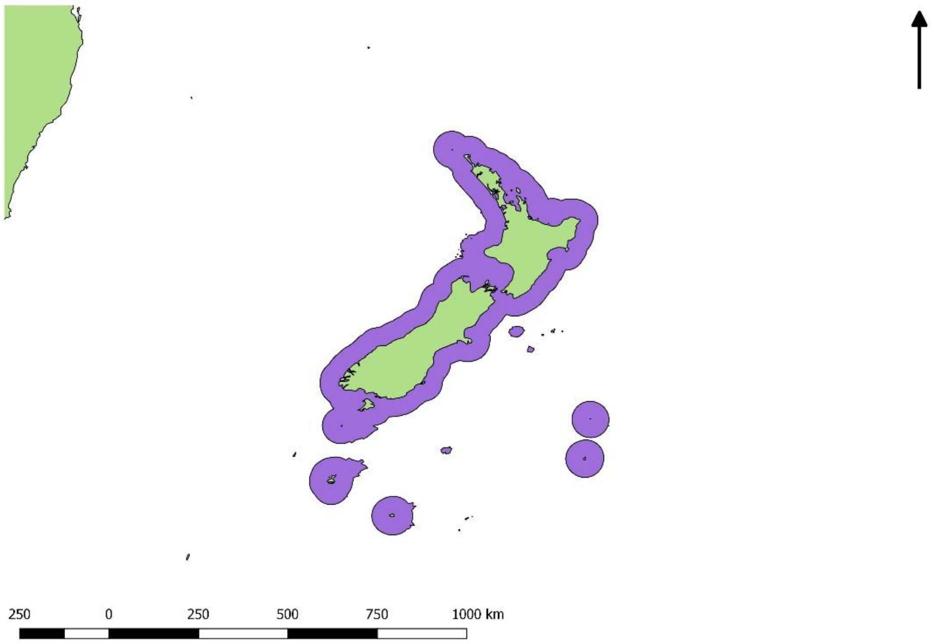
Anguilla dieffenbachii

Life history

- **Range**

Anguilla dieffenbachii, the New Zealand longfinned eel, is a temperate eel endemic to New Zealand and its offshore islands (Jellyman and Unwin, 2017). It is relatively common and widespread in rivers and lakes, including Hydro-electric lakes (Chisnall and Hicks, 1993), throughout New Zealand (Jowett and Richardson, 1995). Genetic structure of *A. dieffenbachii* throughout North and South island indicate that the species is derived from a single spawning population (Smith *et al*., 2001).

Range states: New Zealand



Range map of *Anguilla dieffenbachii*

- **Biology**

The marine spawning area of *A. dieffenbachii* is at present unconfirmed. In a study of four tagged females (Jellyman and Tsukamoto, 2002), estimated migration pathways showed that the eels moved substantial distances along inshore areas before moving offshore and eastward. There was no evidence of the expected north east movement to tropical waters (Jellyman and Tsukamoto, 2002). However, in a study by Jellyman and Tsukamoto (2005), the first evidence of *A. dieffenbachii* moving to the tropics during spawning migrations was found when one of three tagged individuals commenced transmissions at a location 700 km east of New Caledonia. A more recent study of three tagged individuals revealed ascent locations and swimming speeds that were consistent with spawning in the tropics, possibly in the South Fiji basin (Jellyman and Tsukamoto, 2010). *A. dieffenbachii* exhibits diel vertical movements with a study of three individuals revealing frequent dives to greater than 600 m and a maximum depth of 980 m. Ascents were to 150 to 200 m with one fish always returning to 1 to 10 m. Diel movements were assumed to be in response to predator avoidance and thermoregulation as eels often spent time in 5 to 6°C water (Jellyman and Tsukamoto, 2005).

Studies of otolith micro-chemistry suggest that *A. dieffenbachii* exhibits behavioural plasticity regarding whether or not to enter freshwater or remain in estuarine or marine environments (Arai *et al*., 2003a; Arai and Chino, 2012). Freshwater, estuarine and marine-resident *Anguilla* spp. are hypothesised to begin their spawning migration towards the open ocean at about the same time (Chino and Arai, 2009). This type of synchronization has important implications for conservation as individuals from each habitat type can contribute to the spawning stock (Arai and Chino, 2012). Such plasticity has been documented in *A. australis* and several northern temperate anguillid species*; A. anguilla* and *A. japonica* (Arai *et al*., 2004).

Rainfall and flow increases were found to be key factors triggering migration events. Emigration of female *A. dieffenbachii* from Lake Manapouri generally took place during large outflows and activity was highly diel (Jellyman and Unwin, 2017). Rainfall exceeding a cumulative total of 40 mm over three days accounted for 60% of migrant eels arriving at Lake Aniwhenua (Boubée *et al*., 2001). Migrations generally began once water temperatures declined and ended when temperatures dropped below approximately 11°C (Boubée *et al*., 2001). Such rainfall and flow triggers could be used as predictors to commence mitigation activities that would allow mature eels to proceed uninjured past barriers such as hydro-electric dams (Boubée *et al*., 2001). Anguilla dieffenbachii females were recorded arriving over four months (February to May) at two hydro dams (Boubée *et al*., 2001; Boubée and Williams, 2006), while in a spring-fed coastal stream silver *A. dieffenbachii* males were recorded every month of the year and silver females over seven months (October to April) (Burnet 1969 in Jellyman and Unwin 2017). Males preceded females in their entry to the sea (March to April and April to June respectively) (Todd 1981 in Jellyman and Unwin 2017).

Highest mean and maximum biomass of *A. dieffenbachii* occurred in wooded pools (Baillie *et al*., 2013) and in deep water habitats (>0.75 m) (Chadderton and Allibone, 2000). Yellow eels became less abundant in the cleared reaches, but elvers became more abundant (Jowett *et al*., 2009). A general preference for coarse gravel and cobbled substrates, a broad range of velocities and 0.4 m optimum depth was found by Jowett and Richardson (1995). A preference for upstream areas may be related to the greater availability of cover afforded by water depth, tree roots, and associated debris (Jellyman *et al*., 1997). Winter *A. dieffenbachii* locations were characterized by deeper and finer sediments and lower catches (Jellyman *et al*., 1997) compared to summer and spring locations (Broad *et al*., 2001b). At a macro-scale probability of eel occurrence declined with increasing elevation and, for a given elevation, was higher in tussock and pasture catchments and lower in pine and native forest settings (Broad *et al*., 2001a). *A. dieffenbachii* is a nocturnal feeder with diet comprising a large proportion of ostracods (Sagar and Glova, 1994) and other aquatic invertebrates (Sagar *et al*., 2005). Low and variable survival rates of juvenile eels were found in three rivers, declining in large juveniles possibly due to competition with larger eels for limited areas of suitable cover or food (Graynoth *et al*., 2008; Sagar *et al*., 2005).

A. dieffenbachii reaches much larger sizes than other temperate eels (Arai *et al*., 2004) and is possibly the world's largest freshwater eel, with a maximum reported length of two metres and mass of up to 50 kg. These dimensions are, however, more common historically, while more recently few individuals exceed 120 cm and 25 kg (Chisnall, 2000). The mean size of glass eels of *A. dieffenbachii* when they recruit to the New Zealand coast is 66.8 mm (Arai *et al*., 2004). The length of silver eels of *A. dieffenbachii* ranged from 574 to 1395 mm in a study of 20 male and female individuals between 15 and 59 years old (Arai *et al*., 2004). Jellyman *et al*. (1997) reported that length ranged from 170 to 1,200 mm for individuals in the diadromous life-history stage. While, length ranged from 170 to 1,095 mm in a study of 252 individuals between 4 and 60 years old (Chisnall and Hicks, 1993).

Growth rates of *A. dieffenbachii* are typically slow, around 27 mm for low-land waters (Chisnall, 2000), but vary between individuals, waters and reaches (Graynoth and Taylor, 2004). Annual growth was found to range from 20 to 30 mm per year in a South island glacial lake resulting in female silver *A. dieffenbachii* with a mean age of 93 years at the time of their spawning migration, while individual *A.*

dieffenbachii yellow eels were over 100 years old (Jellyman and Unwin, 2017). The fastest growth for *A. dieffenbachii* tends to be in hydroelectric lakes (Chisnall and Hicks, 1993) with the greatest annual growth increment (160 mm) recorded in the Waikato River hydro reservoirs (Chisnall *et al*., 1998). Growth is also faster (16.0 mm per year) in warm reaches (mean annual water temperatures >12.4°C) with low eel densities (<14 gm^2) (Graynoth and Taylor, 2004) and in pastoral streams (Chisnall and Hicks, 1993). Growth is slowest in streams in indigenous forest and in high country lakes (12 and 11 mm respectively) (Chisnall, 2000; Chisnall and Hicks, 1993; Jellyman, 1995).

Threats

Warmer temperatures associated with climate change may have a detrimental effect on glass eel recruitment in their current range. The upstream migration of *A. dieffenbachii* glass eels was optimum at 16.5*°C* but was almost completely inhibited at temperatures outside the range of 12 and 20*°C* (August and Hicks, 2008). The glass eel migration periods appear to occur several weeks earlier at the present day than previously, based on comparison of catch data 30 years apart from the Waikato River (Jellyman *et al*., 2009) indicating that temperatures are increasing.
Hydropower development has had a detrimental effect on *A. dieffenbachii*. The Waiau catchment in New Zealand's South island contains the country's largest hydroelectric station (700MW) and also the largest stock of unexploited *A. dieffenbachii* in the country (Graynoth and Bonnett, 2008). The high hydraulic head results in 100% mortality of *A. dieffenbachii* that enter the intake (Beentjes *et al*., 2005). River diversion into the lake causes changes to inflows and outflows that are likely to be detrimental to silver *A. dieffenbachii* emigration (Jellyman and Unwin, 2017).
Although there are no commercial fisheries in New Zealand that target silver *A. dieffenbachii*, fishing pressure manifests itself in a number of ways. First, the mean total body length and body condition of *A. dieffenbachii* were lower in accessible sites, consistent with considerable fishing pressure at such sites (Broad *et al*., 2002). Second, yellow *A. dieffenbachii* are susceptible to capture by baited nets (Jellyman and Graynoth, 2005) thus, to ensure adequate rates of female escapement, exploitation must be conservative (Hoyle and Jellyman, 2002). Consequently, one of the goals of the fishery managers is to maximize escapement of silver *A. dieffenbachii* (Ministry for Primary Industries, 2016).
Levels of Polychlorinated biphenyls (PCB) in *A. dieffenbachii* are the lowest found in anguillid eels worldwide. Eels, which have high lipid content, longevity and are omnivorous, are suitable indicators of persistent organic pollutants (POP) contamination in freshwater ecosystems (Holmqvist *et al*., 2006).

Use

Anguilla dieffenbachii support important commercial fisheries across its range, as well as Maori fisheries (McDowall, 1990; Jellyman, 1993) and in some areas are still a frequent part of the diet for Maori (Green 2004). Eels are also valued for their spiritual, mythological, economic, and nutritional significance (Lyver *et al*., 2005). Freshwater eels have long been consumed by Aboriginal people in eastern Australia and have strong cultural significance (Gomon and Bray, 2017).
There have been some concerns over threats to the eel fishery in New Zealand from 1080[51] contamination. Although there is no evidence of significant or prolonged 1080 contamination in New Zealand streams and rivers, and the risk of acute poisoning to humans from eating contaminated eel flesh is considered extremely low, public perceptions and food safety standards have the potential to limit eel exports and/or close an eel fishery if residue was discovered in tissue (Lyver *et al*., 2005).

Stock status

[51] 1080 (sodium fluoroacetate) is a poison used to create a toxic bait.

The status of the species appears to vary significantly with location (New Zealand's response to CITES Notification 018/2018). Historically, *A. dieffenbachii* was classified as a species 'in gradual decline' (Hitchmough *et al*., 2007). Although *A. dieffenbachii* is still amongst the most common freshwater fish species in New Zealand (for example, *A. dieffenbachii* was the third most abundant fish caught in a study of 16 species (Jowett and Richardson, 1995), there have been concerns about the scarcity of large specimens, indications that recruitment is declining (Boubee *et al*., 2008) and concern over viability of stocks overall (Jellyman *et al*., 2009; Kuroki *et al*., 2008). Studies on catch per unit effort and duration of runs (Jellyman *et al*., 2009; Kuroki *et al*., 2008) and hindcasting (Graynoth *et al*., 2008) show that annual recruitment of *A. dieffenbachii* has decreased by 75 per cent since significant levels of commercial fishing began in the early 1970s (Doole, 2005). These results, together with other life-history features like extensive longevity (Jellyman, 1995), susceptibility to capture (Jellyman and Graynoth, 2005), and reduced habitat and access (Graynoth *et al*., 2008) have raised concerns over population status (Jellyman *et al*., 2009).
In southern New Zealand, there has been a reduction in size and a skewing of the sex ratio toward male *A. dieffenbachii* over the last 60 years due to commercial fishing. Fishing may have favoured differentiation into males as well as the removal of the longer-lived females (Beentjes *et al*., 2006). Currently, the Waiau catchment in New Zealand's South island contains the largest stock of unexploited *A. dieffenbachii* in the country (Graynoth and Bonnett, 2008), protection of which is considered of high regional and national significance (Jellyman and Unwin, 2017).
In contrast to the above declines, and more recently, it was stated in the New Zealand's response to CITES Notification 018/2018 that abundances have increased between 2015 and 2017.
This species has not presently been assessed using the IUCN Red List Categories and Criteria.

<u>Management</u>

There are no species-specific management actions or policies for *A. dieffenbachii* but in their response to CITES Notification 018/2018, New Zealand highlighted management measures for all species in its waters (see *A. australis*). There are also examples of where mitigation measures have been implemented power stations e.g. compensation flows, construction a fish passes and trap and trans schemes (e.g. Boubee *et al.* 2008).

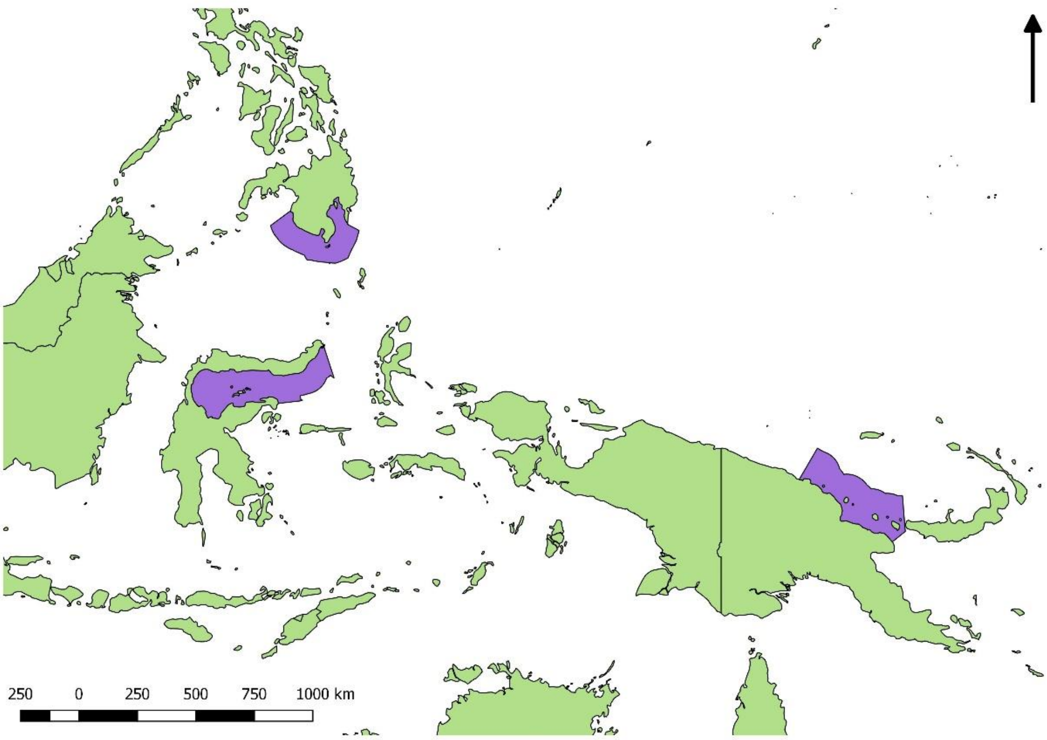
Anguilla interioris

Life history

- **Range**

There is very limited information available on the distribution of *Anguilla interioris*. The species is currently known from the northern half of New Guinea and Indonesia (Wouthuyzen *et al*., 2009). However, Fahmi *et al..* (2012) report *A. interioris* to be endemic to Indonesian waters, being found in Mentawai, Lombok, Poso, and Papua. In Indonesia, the glass eel stage was commonly found in Poso and Papua while larger eels was found in greater relative abundance in Mentawai (Fahmi *et al*., 2012). Shirotori *et al..* (2016) found *A. interioris*, in very low numbers in the Mindanao region of the Philippines.
Leptocephali of *A. interioris* have been collected in the waters of western Sumatra (Aoyama *et al*., 2007) and Sulawesi (Aoyama *et al*., 2003; Wouthuyzen *et al*., 2009).
Note that, in Indonesia, *A. interioris* was not found in the mouth of Cimandiri River, nor at the mouth of the Poigar River, in any season (Fahmi *et al.*, 2012 and references therein).

Range states: Indonesia; Papua New Guinea; Philippines.



Range map of *Anguilla interioris*.

- **Biology**

This little studied, catadromous species inhabits tropical freshwater, brackish and marine ecosystems.

Analysis of growth rates and age at metamorphosis of leptocephali, estimated at 0.49 mm/day and 91 days, respectively, suggest that this species is typical for tropical eels with a small migration loop similar to *A. borneensis* and *A. celebesensis* (Kuroki *et al.*., 2006, Kuroki *et al.*. unpubl.).

The western part of Sumatra and northern part of Sulawesi are likely spawning areas of *A. interioris* (Fahmi *et al*., 2012) given the capture of small leptocephali (44.1 to 55.5 mm TL) in the western part of Sumatra waters (Aoyama *et al*., 2007) and small leptocephali (33.1-49.5 mm TL) in northern Sulawesi waters (Aoyama *et al*., 2003; Wouthuyzen *et al*., 2009).

In Tomini Bay, Central Sulawesi, the hatching of leptocephali was estimated at between late February and early June (Wouthuyzen *et al*., 2009).

<u>Threats</u>

Beyond exploitation, little information exists about the threats facing *A. interioris*. Considering its range, it is likely to be exposed to similar threats as species such as *A. bicolor* and *A. marmorata*. In the Poso river watershed, Indonesia, damming for hydropower and unsustainable harvest of both glass eels and larger eels are two reported threats (Watupongoh and Krismono, 2015). In Mentawai, larger eels are intensively harvested (Fahmi *et al*., 2012). There has been an increase in fisheries and export of anguillid eel from the Philippines in the past decade (Crook, 2014) but the impact on this species is unquantified.

<u>Use</u>

Even though fishing and trade of *Anguilla* species is known to occur in parts of the distribution of *A. interioris* very little is known of this species' use or trade. *Anguilla interioris* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.

<u>Stock status</u>

Little is known about the population status of *A. interioris* and the species is listed as Data Deficient on the IUCN Red List of Threatened Species. This is in part due to the difficulty of visually determining this species from other tropical species.

<u>Management</u>

No species-specific management actions or policies were identified by the Parties for *A. interioris* but both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* accounts respectively).

Anguilla japonica

Life history

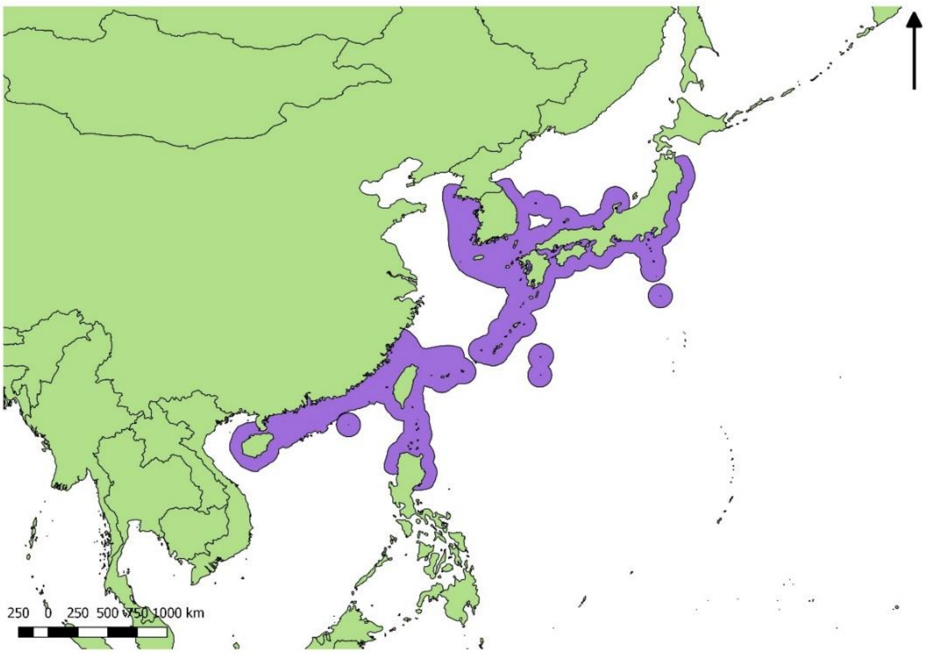
- **Range**

It is known that *A. japonica* primarily occurs as a native species in Japan, China, Hong Kong, Taiwan and Korea. The range of this species extends from the southern Pacific coast of Japan and further south to Hainan Island covering large areas of mainland China, Taiwan (more common on the west, north and south coasts of Taiwan) (Leander *et al*., 2012) and the Republic of Korea. There are records of recruitment in northern Luzon and Mindanao Islands of the Philippines (Aoyama *et al*., 2015; Shirotori *et al*., 2016).

The eggs, pre-leptocephali and spent adults of this species have been collected in the North Equatorial Current (NEC) along the western side of the West Mariana Ridge (13–17° N, 142–143° E) to the west of the Mariana Islands (Kurogi *et al*., 2011; Tsukamoto, 2006, 2009; Tsukamoto *et al*., 2011) . This implicates this area, west of the Mariana Islands, as the spawning area for this species. The latitude of spawning events, however, changes among years depending upon oceanic conditions (Kimura and Tsukamoto, 2006; Miller *et al*., 2009b; Tsukamoto *et al*., 2011) although the NEC and Kuroshio currents are the predominant transport mechanisms for this species (Tzeng *et al*., 2012). Spawning is thought to occur between April and August (Shinoda *et al*., 2011).

The true range of *A. japonica* within countries such as Japan can be difficult to determine because of widespread restocking by fisheries cooperatives. Research is currently under way to determine the relative abundance of wild and stocked eels in a few specific localities. For example, Kaifu *et al*. (2014) found no evidence of natural recruitment of *A. japonica* to the Japan Sea coast in the Hayase River system, Fukui Prefecture. The lack of such evidence for several decades suggests that the natural range of *A. japonica* has decreased and that only stocked eels are now found along the Japan Sea Coast (Kaifu *et al*., 2014). See 'Management and Policy' section below.

Range states: China; Hong Kong; Japan; Korea, Republic of; Philippines; Taiwan, Province of China



Range map of *Anguilla japonica*

- **Biology**

Some *A. japonica* may never enter freshwater, but remain in estuaries or nearby marine habitats and have been referred to as marine residents or 'sea eels' (Tsukamoto *et al*., 1998). Analysis of the strontium:calcium ratios within the otoliths of maturing eels reveals a signature of the transition between these environments and it has been estimated that between 40 to 50% of the eels in some areas might be estuarine/marine residents (Kotake *et al*., 2005). This suggests that there is some flexibility in the continental migration of some *A. japonica*, which shows an ability to adapt to various habitats and salinities and implies that movement into freshwater is clearly not obligatory as evidenced by these different ecophenotypes. Kotake *et al.* (2005) found that 40% of the eels in Mikawa Bay may have never migrated into freshwater throughout their life, and 43% of eels stayed in the estuary or frequently moved between freshwater and marine habitats (Sudo *et al*., 2017).

(Wakiya *et al*., 2016) provided evidence that growth differences can affect habitat selection in *A. japonica* via residence-emigration tactics. As such, migration barriers could bias the phenotypic tactics by interrupting emigration. In addition, stocking eels from downstream to upstream may also bias the phenotypic tactics (Wakiya *et al*., 2016). The importance of preserving different habitats at the catchment level has been shown for *A. japonica* (as well as other species *A. anguilla, A. rostrata* and *A. dieffenbachii*) as the density of individuals is the main factor affecting sex differentiation (Davey and Jellyman 2005 in Geffroy and Bardonnet 2016). That is, males develop in high density areas (generally lower reaches of rivers and estuaries), whilst in upper reaches of rivers where densities are lowest females tend to dominate (Geffroy and Bardonnet, 2016). In a study across 12 river systems in Japan, Yokouchi *et al.* (2014) found significant demographic heterogeneity - sex ratios, body lengths, growth rates and age structures. Growth rate was higher for both sexes in brackish/seawater while male growth was higher than that of females in river systems (Yokouchi *et al*., 2014). Thus to maintain the demographic variability that may confer resilience it is necessary to preserve the variety of habitats in and across river systems.

The maximum size this species attains is approximately 100 cm in length and 1.5 kg in weight (Kotake *et al*., 2007). For yellow phase *A. japonica* across Japan mean total lengths ± SD (mm) of females (n=3776) and males (n=962) were 495.6 ± 104.3 and 412.9 ± 80.7, respectively, and overall sex ratio (% female) was 79.6%. Mean age (years) and growth rate (mm year-1) were 5.0 ± 1.9 and 96.7 ± 38.6 for females (n=3,643) and 3.6 ± 1.7 and 120.5 ± 65.4 for males (n=907), respectively (Yokouchi *et al*., 2014). The range and mean total length ± SD (mm) of *A. japonica* glass eels in Taiwan was 45.45 to 57.79 (53.01 ± 4.54) mm (Leander *et al*., 2012). The total length of *A. japonica* increased with increasing length of river system and with distance from the river mouth as well as with reduced density. The upper reaches of rivers thus have the capacity to produce larger and older eels, a high proportion of which are female and thus upper reaches are important to conserve for contributing to the next generation (Yokouchi *et al*., 2014).

As with many eel species, the generation times for *A. japonica* are highly variable depending on sex, individual variation and locality/latitude. For example, Kotake *et al.* (2007) studied *A. japonica* from three different latitudes and found that the age of males at maturity ranged from 4 to 10 years and females from 3 to 17 years, but younger, small males were not adequately sampled. Other studies on the average age of silver-phase *A. japonica*, provide estimates of 6.9 and 7.8 years (Kotake *et al*., 2005) and 8.3 and 9.9 years (Yokouchi *et al*., 2009) for male and female eels, respectively, suggesting that the average generation length of *A. japonica* lies somewhere between 7 and 10 years.

A. japonica mainly forage at night and do so opportunistically but also utilize the food resources by targeting a single type of prey species during a single feeding session (Kaifu *et al*., 2013). During their growth phase, *A. japonica* feed mostly on invertebrates such as benthic crustaceans and insect larvae, and also on small fishes (Kaifu *et al*., 2013).

Little is known about the marine component of anguillid life histories in general, but *A. japonica* stands alone in having a well-studied spawning ecology (Kimura and Tsukamoto, 2006; Tsukamoto, 2009; Tsukamoto *et al*., 2011). Pop-up tag studies for *A. japonica* showed that they mostly migrate between depths of about 100 to 400 m at night (much deeper during the day) to the region along the western side of the seamount chain of the Mariana Ridge (Tsukamoto, 1992, 2006, 2009; Tsukamoto *et al*., 2003). The depths where adults and newly hatched larvae were captured indicate that spawning occurs in shallower layers of 150–200 m and not at great depths (Tsukamoto *et al*., 2011).

All types of data suggest the spawning region is from about 12–16°N (Aoyama *et al*., 2014). When salinity fronts form within the latitudes of the spawning area, spawning will occur just before new moon at or south of the front (Aoyama *et al*., 2014). The salinity front is typically present in the region as a result of tropical rainfall (Arai, 2014b; Kimura and Tsukamoto, 2006). The salinity front was hypothesised to act as a cue for the eels to help them find the spawning area (Arai, 2014b). However, in some years no distinct salinity front is present within the latitudes of the spawning area, spawning can occur at various latitudes within the lower salinity surface water and eggs may appear in many places along the west side of the ridge as the seamount chain acts as a landmark of the eastern edge of the spawning area (Aoyama *et al*., 2014).

The drifting *A. japonica* leptocephali are transported by the North Equatorial Current (NEC) and then enter the westward branch of the Kuroshio Current that takes them to continental waters of East Asia (Leander *et al*., 2012).

Lin *et al.* (2017) proposed that the decreased eel catches experienced by East Asian countries in 1983, 1992, 1998 could be explained by the periodicity of the combination mode of climate variability. The associated changes in precipitation, associated with the area of maximal Sea Surface Temperate (SST) in the tropics, causes a shift in the salinity front and corresponding shift in the spawning grounds such that the eels spawn beyond the range of the North Equatorial Current (NEC) and the eel larvae failed to join the NEC nursery thus effecting recruitment to East Asian countries (Lin *et al*., 2017). The modelling studies showed that a slight difference in latitudes of spawning can theoretically have a significant effect on the proportions of larvae entering the Kuroshio (chance for successful recruitment) or the southward branch entering the Mindanao Current (recruitment failure) (Aoyama *et al*., 2014). Factors that may influence inter-annual recruitment fluctuations of Japanese eels include climate variability, current fluctuations, ocean eddies, the NEC bifurcation, available spawner numbers each year, and productivity changes affecting larval survival rate (Lin *et al*., 2017). The detection of unusual temporal patterns of glass eel recruitment has also raised the question about the possibility of there being a shift in the spawning season recently. Which of these factors may be more important in influencing the decline or interannual recruitment fluctuations of the Japanese eel is not known (Aoyama *et al*., 2014).

Over the course of five to six months *A. japonica* leptocephali drift towards their estuarine recruitment areas (Kuroki *et al*., 2009; Shinoda *et al*., 2011) on oceanic currents and then metamorphose into transparent glass eels before becoming pigmented elvers in estuaries. Age upon arrival to estuaries is estimated between 154 and 182 days while age at metamorphosis is between 115 to 137 days. Therefore, time from metamorphosis to estuarine arrival is thought to be between 32 and 45 days (Cheng and Tzeng, 1996). The subsequent timing of upstream migration of glass eels depends on the water temperature, tidal current and moon phase (Tzeng, 1985). In Korea, glass eels are caught in the Geum River when temperatures are between 5 and 15°C and the annual catch in this river is highly representative of catch throughout the rest of Korean freshwater habitat (Hwang *et al*., 2014). Factors that influence the daily variation in catch level of *A. japonica* glass eels were tidal range, water temperature, and salinity. Additionally, strong winds may affect *A. japonica* glass eel immigration into the estuary (Hwang *et al*., 2014).

The beginning of spawning migration of eels is affected by various intrinsic and extrinsic factors. Intrinsic factors such as sufficient body size, age and lipid content are believed to be prerequisites for starting the migration (Sudo *et al*., 2017). Age varies considerably possibly due to habitat variability (Sudo *et al*., 2017). Chino *et al.* (2017) looked at maturity levels at the beginning of spawning migration. Yellow and silver eels were collected during their spawning migration season in the Nagata River and the Oji tidal flat, Shimonoseki, Yamaguchi Prefecture. It appears that the maturation level for the silver eel migration to the open ocean varies depending on the life history. Gonads of river eels were more developed compared to eels with other migratory histories, such as sea eels and estuarine eels (Chino *et al*., 2017; Chino and Arai, 2009).

Threats

A variety of anthropogenic factors such as overfishing, habitat loss, changes in oceanic conditions, parasites, pollution, and diseases are thought to be causing the declines of anguillid eels. Moreover, it is probable that a combination of these factors is responsible. The uncertainty of factors responsible for the *A. japonica* decline highlights the urgent need for a comprehensive understanding of their demography and ecology (Yokouchi *et al*., 2014).

On average, 76.8% of the effective habitat area was lost in 16 rivers in Japan, Korea, Taiwan and China from the 1970s - 2010s. Taiwan and China had the highest percentages of loss, with declines of 49.3% and 81.5%, respectively. Along with overfishing and regional climate phenomena, extensive habitat loss may play an important role in the decline of *A. japonica* (Chen *et al*., 2014). Indeed, the Ministry of the Environment of Japan concluded that the main factor affecting individual density of *A. japonica* inhabiting rivers in Japan is upstream migration barriers such as weirs and dams reducing the availability of effective habitat based on a dataset obtained from 135 sampling stations in five rivers in Japan in 2014-2015 (Ministry of the Environment of Japan, 2016). In Japan, construction of dams has reduced eel catches in some areas (Tatsukawa, 2003). Annual eel (yellow and silver) catch data during 1953 to 2009 were obtained from the database of the Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan and Yoshimura *et al.* (2005) report that in Japan alone there are 2,675 dams that are higher than 15 m and thus are considered impassable to eels.

Other threats include the loss of river habitat due to agricultural, urban and industrial development, which in Japan has resulted in the extensive revetment of the shorelines of rivers and lakes for flood control purposes (Itakura *et al*., 2014; Yoshimura *et al*., 2005). Habitat quality can also affect Japanese eel density and their survival and growth. (Itakura *et al*., 2014) showed that eel catch reduced more in rivers and lakes of which shorelines had higher rate of revetment based on investigation on 27 rivers and lakes in Japan. Another study (Itakura *et al*., 2015) that investigated the possible effects of riverbank modifications on yellow-phase *A. japonica* in the Tone River, Japan reported that their abundances and condition factors were higher in the natural shore areas than those of revetment areas and the number of feeding eels, their food consumption, and the diversity of consumed prey were also generally greater.

It is argued that fishing of *A. japonica* glass eels to stock farming facilities on a national/international scale likely constitutes a major threat to the population. Farms meet 90% of demand for eel products and all seeds for farms come from wild stock (Shiraishi and Crook, 2015). There are a number of confounding issues relating to reporting of farm production but it was globally estimated to be at least ~100,000 tonnes in 2013. Not all of this is *A. japonica,* but this is the preferred species in East Asia where the majority of the demand is from (CITES Notification 018/2018 responses from China and Japan[52]). Data submitted by Japan in response to CITES Notification 018/2018 indicated that glass eel catches, had been steadily declining since the early 1960s, reaching a historically low plateau in the early 1990s. The catch in the 2017-2018 fishing season was 'historically' low. The Japanese Fisheries Agency reported that eel fry input to aquaculture ponds (including both domestic catch and imported glass eels) in Japan between November 2017 and March 2018 was less than 60% of the same season of the previous year. This decline was mirrored by 'total harvest' data submitted by Japan, which relates to yellow and silver eel catches, though there appears to be no plateau in the 1990s. It should be recognised that no effort data was provided with these catch metrics. Further a decline in catch cannot solely be attributed to fisheries considering the range of threats; however, it is arguably the easiest potential threat to manage.

There have been efforts to successfully produce *A. japonica* in captivity and the life cycle was fully closed in 2010 (Masuda *et al*., 2012). However, better feed and simplification and shortening of the rearing process is required for mass production of eels in Japan to become biologically and economically viable.

Environmental phenomena, such as El Niṅo and sunspots, have been proposed to influence larval transport and survival, and as a consequence impact upon recruitment of glass eels to coastal and freshwater habitats (Bonhommeau *et al*., 2008a; Kimura *et al*., 2001; Miller *et al*., 2009b; Tzeng *et al*., 2012). Such environmental factors are proposed to have fluctuating effects on recruitment of glass eels, while exploitation and river habitat modification and degradation have a more consistent effect. However, the role that changing ocean currents play in driving population level changes such as recruitment remains unclear.

Additionally, like other eel species, *A. japonica* is host to the nematode (*Anguillicola crassus*) that parasitizes the swim bladder which has been proposed to affect survivorship and migration behaviour. This species, however, appears to show more evidence of acquired immunity and significantly reduced pathological effects than *A. anguilla* (Knopf, 2006) possibly because of longer historical exposure to this parasite (Münderle *et al*., 2006). Studies are required on another nematode, *Heliconema anguillae,* to evaluate the impact of its infection on *A. japonica* as no information is available on the pathogenicity of *H. anguillae*, though the authors found no detectable damage in the heavily infected eels (Kan *et al*., 2016).

Urban and agricultural development has increased the amounts of pollution caused by industrial effluent/agricultural runoff/herbicides/pesticides, all of which are known to negatively impact eel numbers through displacement, reduced reproductive success and direct mortality (e.g. Tzeng *et al.* 1995). Arai (2014b) examined the concentrations of organochlorine compounds (OCs) HCB, PHCHs, PCHLs and PDDTs in *A. japonica* and found that varying migratory histories and lipid contents of individuals affected the OC accumulations. Concentrations in the silver stage eel were significantly higher than those in the yellow stage eel, due to the higher lipid contents in the former. The ecological risk of OCs increased as the freshwater residence period in *A. japonica* lengthened (Arai, 2014c). The accumulation of OCs in *A. japonica* did not depend on total length, body weight or age. The authors primarily detected metabolites for each OC and suggest that therefore, the OCs might be eliminated or attain less accumulate if the eels are not continuously exposed lowering the correlation between the OCs accumulation and the size and age (Arai, 2014c).

[52] China appear to have begun consuming *A. japonica* much more recently than Japan.

Use

Anguilla japonica was historically caught in waters throughout its range, predominantly in Japan, mainland China, Taiwan and South Korea, with large eels caught destined directly for consumption or small eels destined for farming, from the early 1900s onwards (Ringuet *et al*., 2002). Globally, these are also the main eel farming, trading and consuming countries/territories, with Japan in particular having a long tradition of consumption of *A. japonica* eels. Declines in the availability of *A. japonica* in the 1990s, however, resulted in many farms in the region stocking *A. anguilla* and more recently some other Anguilla species (Crook, 2010; Crook and Nakamura, 2013). *Anguilla japonica* however, is still the preferred species for farming in East Asia and for consumption in Japan, and high demand for this declining resource has resulted in dramatic increases in price for this species in particular.

Stock status

In 2013, *A. japonica* was classified as Endangered both at the national level by the Japanese Ministry of the Environment[53] and globally on the IUCN Red List of Threatened Species. It was recently classified as Critically Endangered in Taiwan[54].
As stated above, catches of wild Japanese glass, yellow and silver eels have been steadily declining since the 1960s in Japan, with the most recent year being of particular concern for glass eel catches. Catch effort can be variable in fishing data and under-reporting and, in some cases, an absence of reporting of landings is a potential problem across the range but trends are often indicative of the species status. Further, these catches are in only one range state and it is accepted that a proportion of the population may be resident in saline waters which fisheries may not capture (Kotake *et al*., 2005; Mochioka *et al*., 2012; Tsukamoto *et al*., 2009).

There is much heterogeneity across river systems yet temporal trends of the *A. japonica* stock in Japan have been reported as the gross catch of this species in Japan, not as catches respective to river systems (Yokouchi *et al*., 2014). There is more understanding required about their (inland) ecology to inform effective management strategies. Yokouchi *et al.* (2014) found that between 1999 and 2004 declines occurred in all 12 study river systems across 9 prefectures. The magnitude of decline, reasons for decline as well as demographic parameters of the eels in each river system differed. Large rivers tended to decline about 50% until the 2000s and small rivers and brackish lakes were somewhat stable in recent years. Thus management must involve conserving a variety of habitats across multiple river systems as well as within a single river system. This was based on the only available fisheries data which is catch only (not standardised by effort) but the authors state that trends were so marked that declines are likely (Yokouchi *et al*., 2014).

A stock assessment by Tanaka (2014) at the East Asian scale reports that the fishing effort in most lakes has reduced (based on fishery census data) with the units targeting exploitable stocks of eels decreasing from 551 units in 1968 to 91 in 2008. Tanaka (2014) suggests that the estimated stock size has recovered since 1990 to 24% (18.7 thousand tons) of carrying capacity in 2010. The author reports the biggest difficulty in stock assessment of the Japanese eel is the lack of systematic data on both catch records and the index of stock abundance meaning multiple inferences, interpolations and assumptions were required in models. These models did not take into account the effect of stocking in the rivers by fisheries cooperatives and recent studies indicated that stocked eels are predominant in Japanese inland waters where this practice has occurred (Kaifu *et al*., 2018).

[53] https://www.japantimes.co.jp/life/2013/02/02/environment/ministry-officially-classifies-japanese-eel-as-species-at-risk-of-extinction/#.WvLsxZch3b0
[54] http://conservation.forest.gov.tw/latest/0061063

Overall, it appears that recruitment, population and escapement of the Japanese eel is declining (Jacoby and Gollock, 2014a). These declines are thought to be caused by multiple factors (see Threats) and this was discussed for all northern temperate species, which includes *A. japonica*, by Miller *et al.* (2016) who indicate that this was very likely to be the case.

Management

China, in its response to CITES Notification 018/2018indicated that there were species-specific licenses are issued by the provincial governments are required to catch glass eels and fishing is allowed from December to March. China has also introduced a licensing system for eel farming. In Taiwan, exports of all sizes of eel fry between November and March have been banned since October 2007. In a number of other range states, there are genus-wide measures in place. In Japan – from their response to CITES Notification 018/2018 - the catch of glass eels is subject to licenses to be issued by prefectural governments, and the duration of fishing season is generally limited to the period between December and April of the next year under relevant regulations of Fishery Act (1949). The catch of larger eels using certain fishing gears is subject to licenses issued by major prefectural governments, and is prohibited between October and March of the next year, when mature eels migrate from rivers to the sea for spawning, under relevant regulations of Fishery Act (1949). In June 2015, a licensing system was introduced to eel aquaculture, under the Inland Water Fishery Promotion Act. The amount of initial input of eel seeds is restricted per eel species and allocated for each individual farmer under this Act. According to "Joint Press Release"[55], in South Korea, eel fisheries are banned from 1 October to 31 March and catch of eels between 15 and 45cm is banned.

The Fisheries Act in Japan mandates an increase in eel populations for inland water fishery cooperatives that catch eels in rivers and lakes, and these cooperatives typically stock eels to fulfil this obligation (Kaifu *et al*., 2014). The primary method of eel stocking in Japan is to release small yellow eels from eel farms into rivers and lakes (Kaifu *et al*., 2014). It is suggested that most eels in Lake Mikata may be stocked eels (Kaifu *et al*., 2014). A recent study showed that 98.1% of the 161 eels captured in freshwater areas of the three rivers in Okayama Prefecture, Japan, were discriminated as stocked (Kaifu *et al*., 2018), based on recently developed discrimination method between wild and stocked individuals (Kaifu *et al*., 2017). According to the similar method, Itakura *et al.* (2018) reported that 73.0% of the 122 eels captured in six rivers and three lakes in Japan, where eel stocking has been conducted by fisheries cooperatives, were identified as stocked. These studies indicate that stocked eels are predominant in Japanese inland waters where eel stocking is conducted.

The Philippines have legislation that applies to trade of all anguillid species (see *A. bicolor* account), though *A. japonica* is a very low proportion of catches in this range State.

The 'Joint Statement of China, Japan, Korea and Chinese Taipei on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species' put an agreed ceiling on the amount of Japanese eel that can be used for aquaculture[56]. Although the limit is 78.8 t, actual amount used for aquaculture was 37.8, 40.8 and 50.5 t in 2015, 2016 and 2017 seasons respectively (amount in 2017 season is tentative)[57].

[55] https://cites.org/sites/default/files/eng/com/ac/29/inf/E-AC29-Inf-13.pdf
[56] http://www.jfa.maff.go.jp/j/saibai/pdf/140917jointstatement.pdf
[57] http://www.jfa.maff.go.jp/j/press/sigen/attach/pdf/170711-2.pdf

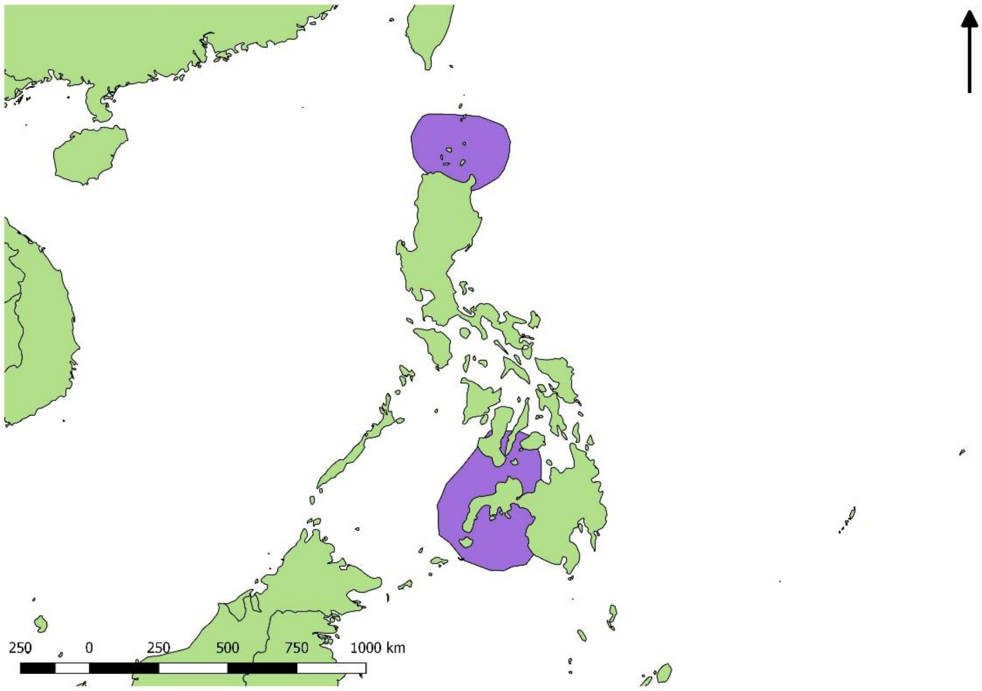
Anguilla luzonensis

Life history

- **Range**

Only described as a species in 2009, *A. luzonensis* appears to have a limited range with specimens found on the Philippine island of Luzon and rarely in Mindanao (Aoyama *et al*., 2015; Han *et al*., 2012; Shirotori *et al*., 2016; Watanabe *et al*., 2009a). Some studies suggest that this species could potentially have a broader range than currently thought, extending into adjacent areas such as Taiwan, but these appear to be vagrant individuals and due to morphological similarities with *A. celebesensis* and *A. interioris* molecular techniques would be required to determine the regular occurrence of this species in other areas (Kuroki *et al*., 2012; Leander *et al*., 2012; Minegishi *et al*., 2009). Conversely, it is possible that the range of these other species may have been over-estimated prior to the discovery of *A. luzonensis*.

Range States: Philippines.



Rang map of *Anguilla luzonensis*

- **Biology**

Leptocephali of this species have been collected in the western North Pacific between the months of April and July (Kuroki *et al*., 2012). As such, spawning is proposed to occur in an area of the North Pacific where leptocephali are transported on the North Equatorial Current (NEC) (Kuroki *et al*., 2012). As juveniles, *A. luzonensis* glass eels migrate upstream inhabiting freshwater where they grow and mature prior to their final spawning migration to the open ocean. They are arguably the most localised species, rarely having been found outside of the Cagayan River Basin on the island of Luzon (Aoyama *et al*., 2015; Leander *et al*., 2012; Shirotori *et al*., 2016) suggesting some degree of niche specialisation in this species.

Threats

There are currently few major barriers to migration in the Cagayan River system[58], and as such the species presently has good access to freshwater habitat. Beyond the more generic impacts of habitat loss, water quality and climate change, which we know to be impacting all species of anguillids, the major identifiable threat is the growing exploitation of glass eels caught to stock farm programs in East Asia. This species is not one that is being directly exploited, however, *A. bicolor*, and to a lesser extent, *A. marmorata*, are both caught and exported from the Philippines (Crook, 2014). However, as highlighted in Aoyama *et al*. 2015, there is little selectivity in fisheries and by-catch will be high unless it is recognised that recruitment of these three species varies intra-annually. As such, it is highly likely that this species has been impacted by fisheries for other species, although the scale of this has yet to be quantified.

Use

Even though fishing and trade of *Anguilla* species is known to occur in the distribution of *A. luzonensis* very little is known of this species' use or trade. *Anguilla luzonensis* is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms.

Stock status

As *A. luzonensis* was only relatively recently discovered, there is very little information relating to the population dynamics of the species. A recent study indicated that recruitment occurred in the summer months, peaking between June and August (Aoyama *et al*., 2015), however, this only collected data over short time periods and a quantitative assessment of abundance was not carried out. Kuroki *et al.* (2012), suggest that the migration loop for *A. luzonensis* is unique among anguillid species in this region which may account for the localised distribution.

Management

No species-specific management actions or policies were identified by the Parties for *A. luzonensis* but the Philippines have legislation that applies to trade of all anguillid species (see *A. bicolor* account).

58 http://rbco.denr.gov.ph/MPDISPLAY/masterplans/CAGAYANMP/#page/63

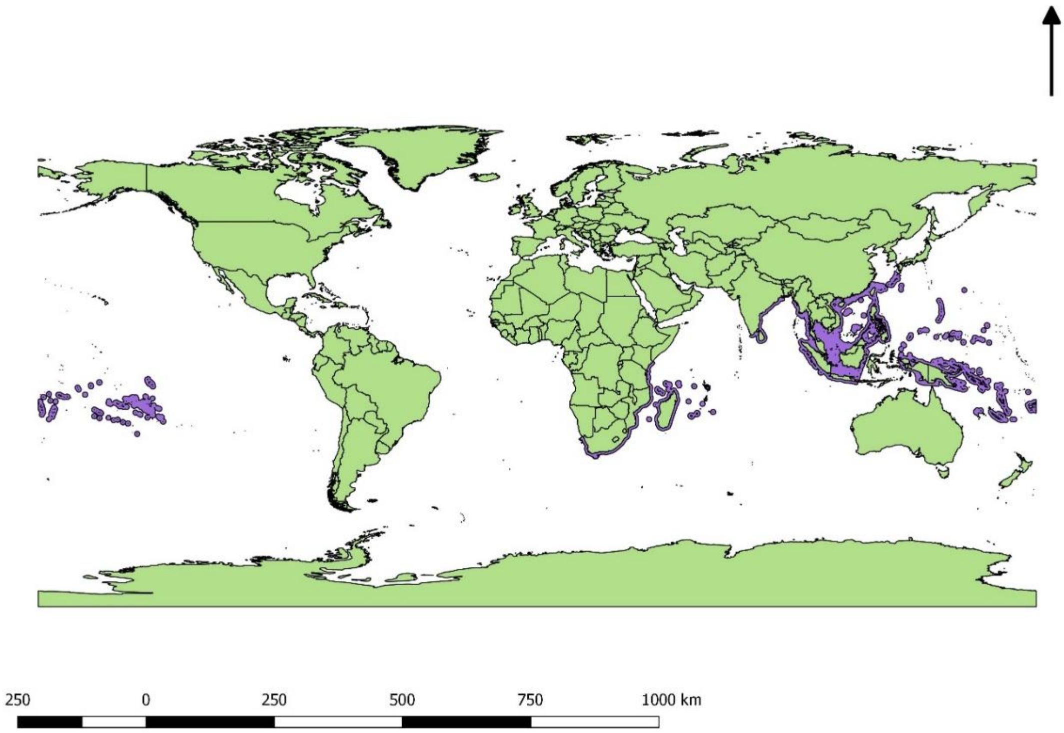
Anguilla marmorata

Life history

- **Range**

Anguilla marmorata spans temperate regions and the tropics and has the widest geographical distribution of any anguillid species (Arai, 2014a). It occurs across two different ocean basins; the tropical and subtropical western Central Pacific and Indian Oceans. Its range covers the East Coast of Africa, east across the Indian Ocean (Ege, 1939), including Madagascar and Réunion Islands, to India and Sri Lanka, the Indo-Pacific region (including Sumatra, Sulawesi and Ambon islands in Indonesia, the Philippines and Papua New Guinea) and as far east as Fiji, New Caledonia and the island chains in the Central South Pacific (e.g. the Marquesas Islands in French Polynesia). Latitudinally, this species ranges from Guam, southwestern Japan, Taiwan and South Eastern China (e.g., Upper Mekong, Yangtze, Xijiang and Zhujiang rivers (Kuang, 1991; Wang *et al*., 1998)), south through Viet Nam and Malaysia, with its most southern distribution being the southern Cape in South Africa (Watanabe *et al*., 2009b). In Africa it is restricted to southern Africa, and is more common south of the Limpopo River (Skelton, 2001). Individuals have recently been found in the Pacific in the Palmyra Atoll in the Central Pacific ocean and as far east as the Galapagos Islands (McCosker *et al*., 2003), although it is not known if these are the result of natural migration, vagrant individuals, or introduction as the species is at the edge of its range here and inland distribution is limited (Tesch, 2003).

Range states: American Samoa; Cambodia; China; Comoros; Cook Islands; Fiji; French Polynesia (Society Is.); Hong Kong; India; Indonesia; Japan; Kenya; Korea, Republic of; Lao People's Democratic Republic; Madagascar; Malaysia; Mauritius; Mayotte; Federated States of Micronesia; Mozambique; Myanmar; New Caledonia; Northern Mariana Islands; Palau; Papua New Guinea; Philippines; Réunion; Samoa; Solomon Islands; South Africa; Sri Lanka; Swaziland; Taiwan, Province of China; Tanzania, United Republic of; Thailand; Tonga; United States; Vanuatu; Viet Nam; Wallis and Futuna; Zimbabwe.



Range map of *Anguilla marmorata*

- **Biology**

Anguilla marmorata is the second largest anguillid eel behind Anguilla dieffenbachii. Historically it was reported to reach almost 2 m in length and 21 kg (Castle, 1984). More recent studies report the total length of *A. marmorata* across yellow and silver stages in Vietnam ranged from 566 to 1,385 mm, and the body weight ranged from 365 to 9,200 g (Arai *et al*., 2013). The total length of *A. marmorata* glass eels collected in Taiwan (n=30) ranged from 46.47 to 58.04 mm with a mean ± SD of 49.43 ± 2.32 mm (Leander *et al*., 2012) and in the Philippines (n=16) ranged from 47.9 to 51.4 mm with a mean ± SD of 49.2 ± 1.1 mm (Shirotori *et al*., 2016).

The early growth rate *of A. marmorata* collected in the Indo-Pacific region, before leptocephali reach maximum size of about 50mm, was estimated at 0.44 mm per day, that is approximately 100 days in the leptocephalus stage (Kuroki *et al*., 2006a). Further details show *the ages of A. marmorata* were 22 to 137 days in the leptocephalus stage (n=121), 147 days in the metamorphosing leptocephalus (n=1) and 159 and 160 days in oceanic glass eels (n=2) (Kuroki *et al*., 2006a).

Onset of metamorphosis from leptocephalus to glass eel in the Philippines occurred at about 120 ± 13.0 days (Arai *et al*., 1999b) or approximately 125 days across the western North Pacific (Arai *et al*., 2002). The mean age at recruitment was 154 ± 13.5 days in the Philippines (Arai *et al*., 1999b). The mean duration of metamorphosis was approximately 18 days (Arai *et al*., 1999b). The yellow eel growth stage may be as short as two to three years in warm productive habitats, but about six to 20 years or more in more northerly latitudes, e.g. in the Pearl River, China (Williamson and Boëtius, 1994). Arai *et al.* (2013) found that *A. marmorata* tended to reside in the lower, saline reaches of rivers in Vietnam. When found in sympatry with other anguillid species, *A. marmorata* seem to be preferentially located in the middle to upper reaches (Leander *et al*., 2012). The species tended to avoid seawater and reside in freshwater during the yellow eel stage in Taiwan and the Philippines (Briones *et al*., 2007; Shiao *et al*., 2003). While a high percentage of the population were estuarine residents in the Bonin Islands of Japan (Chino and Arai, 2010a) and in a river system in Vietnam (Arai *et al*., 2013). Thus brackish estuaries, river mouths or coastal regions may be important habitat for *A. marmorata* during periods when river flows are unfavourable for upstream migration (Lin *et al*., 2012). The migratory behaviours of *A. marmorata* may differ among habitats in response to inter- and intra-specific competition. Most *A. marmorata* in the silver stage, studied by Arai *et al.* (2013), were estuarine residents. The remaining eels switched between high and low saline water environments or resided consistently in freshwater exhibiting behavioural plasticity as per other species of eel (Arai *et al*., 2013). Arai and Chino (2018) recently confirmed the occurrence of marine resident *A. marmorata*, in Indonesia and Vietnam, which have never migrated into freshwater.

There is considerable debate over the number of populations of *A. marmorata,* with four to six different populations proposed (Ishikawa *et al*., 2004). The locations of their respective spawning areas are equally uncertain (Kuroki *et al*., 2008; Pous *et al*., 2010; Réveillac *et al*., 2008; Robinet *et al*., 2008). The North Pacific population (Sulawesi, northern Indonesia, the Philippines, Taiwan, China, Korea and Japan) (Hamzah *et al*., 2015) is currently the better known population. The North Equatorial Current region of the western North Pacific Ocean is the spawning area of the North Pacific population (Kuroki *et al*., 2009; Miller *et al*., 2002; Tsukamoto *et al*., 2011) in an overlapping area with *A. japonica* (Kuroki *et al*., 2006a; Miller *et al*., 2002; Tsukamoto, 1992). Adult spawners and early-stage larvae (pre-leptocephali) were found west of the Mariana Islands (Chow *et al*., 2009; Kuroki *et al*., 2009). Their larvae are transported by the Kuroshio Current and NEC to their destinations (Kuroki *et al*., 2009; Miller *et al*., 2009a). Spawning in this area by *A. marmorata* would result in its leptocephali being first transported westward by the NEC, which bifurcates east of the Philippine Islands at about 127° E (Toole *et al*., 1990), into either the southward flow of the Mindanao Current or the northward flow of the Kuroshio Current (Fine *et al*., 1994; Lukas *et al*., 1991). The leptocephali that enter the Kuroshio recruit to the northern Philippines or southern areas of East Asia, and those that enter the Mindanao Current recruit to the southern Philippines or northern Indonesia (Leander *et al*., 2012).

Anguilla marmorata has intermediate-scale migrations compared to other species (Hagihara *et al*., 2012) ranging from 1,000 km to 3,000 km, similar to that of *A. japonica* (Arai, 2014a). The spawning season of *A. marmorata* has been found to extend throughout the year through a back calculation of otolith daily increments in North Sulawesi of Indonesia (Arai *et al*., 2017). The hatching dates were from November to February and from late May to early August for *A. marmorata* (Kuroki *et al*., 2006a). The recruitment season of *A. marmorata* is mainly from early summer to autumn (mainly Spring in Taiwan) but can occur almost year round (Leander *et al*., 2012). In the Indian Ocean, upstream migration of elvers into freshwater habitats does occur year round but is most pronounced between January and April. In this region particularly, upstream invasion patterns of *A. marmorata* elvers appear to be synchronized with regular cyclonic floods (Robinet *et al*., 2003a).

Threats

Within all range states, major impoundments and weirs are barriers to upstream eel movement (Wasserman *et al*., 2011) and mortalities can occur on downstream passage of silver eels through turbines and pumps. In developing countries, hydroelectric capacity is being rapidly developed and fish passage requirements are scarcely taken into account (e.g., (Roberts, 2004)). Loss and/or deterioration of habitats due to land drainage and reclamation and pollution may become problems in parts of the species range. Development of farming initiatives could locally threaten this species as this will require the collection of glass eels and elvers in estuaries as seed stock. In central Vietnam, this species has been shown to accumulate, in their muscle tissue, high levels of trace metals (Cr, Mn, Co, Cu, Zn, Sr, Cd and Pb) suggesting pollution poses a threat to some subpopulations and consumers (Le *et al*., 2009). According to Indonesian media reports, *A. marmorata* may be the most exported eel species in Indonesia along with *A. bicolor* (Nijman, 2015).

Use

Anguilla marmorata is found in subsistence and commercial fisheries and is farmed in some regions (e.g., southern Africa, Madagascar and Reunion Island). It is popular and highly sought after in China, where there is high demand for mottled eels. Given that this species has such a broad distribution it is likely to be caught alongside multiple other anguillid species. *Anguilla marmorata* are currently relatively easy to purchase in bulk via online traders sold as glass eels, live adult eels and frozen eels. *Anguilla marmorata* glass eels are increasingly being used to stock farms in East Asia. Eel farmers in Taiwan began farming of *A. marmorata* targeting a large commercial market domestically and in mainland China (FBCA, 2009; Huang *et al*., 2016). DNA analysis on prepared eels found *A. marmorata* in Japan in 2015 (Yoshinaga, 2015) and in the UK in 2014–2015 (Vandamme *et al*., 2016).

Stock status

A recent study shows that when estimated using molecular techniques, the effective population size of *A. marmorata* is much smaller than in all other eel species (Delgado, 2013). This suggests a higher vulnerability of *A. marmorata* to bottlenecks and population decline compared to other species. Sub-populations are impacted by local threats, and local declines have been hypothesised in some areas such as Réunion Island due to over fishing and Madagascar due to river management (e.g. rice culture in Madagascar has led to the disappearance of silver eel stocks in the Highlands of Tananarive) (E. Feunteun pers. comm. 2012). Population declines have also been reported from China (E. Feunteun pers. comm. 2013) and Japan (K. Tsukamoto pers. comm. 2014). While some studies have looked at species composition in certain locations such as Malaysia (Arai and Kadir, 2017) and Indonesia (Sugeha

et al., 2001), these focus on relative abundance among species and none have conducted longitudinal studies on the population status of *A. marmorata*.
A. marmorata is classified as Least Concern on the IUCN Red List of Threatened Species, however, in Taiwan *A. marmorata* was on the endangered species list according to the Wildlife Conservation Act of Taiwan until 2009 (Leander *et al*., 2012) thus fishing for and aquaculture of *A. marmorata* were illegal on the island before April 2009 (Leander *et al*., 2012).

<u>Management</u>

Anguilla marmorata are one of only two species that have specific customs codes – in both China and Taiwan. In Indonesia, farming of tropical species, which may include *A. marmorata* is underway in large and small-sized eel farms, targeting the international and domestic markets, respectively (Shiraishi and Crook, 2015). There are already concerns with respect to over-fishing of tropical eel species in Indonesia, however, there are no national regulations in place concerning glass eel catch and farming (Nomura, 2015). Both Indonesia and the Philippines have legislation that applies to trade of all anguillid species (see *A. bengalensis* and *A. bicolor* accounts respectively).

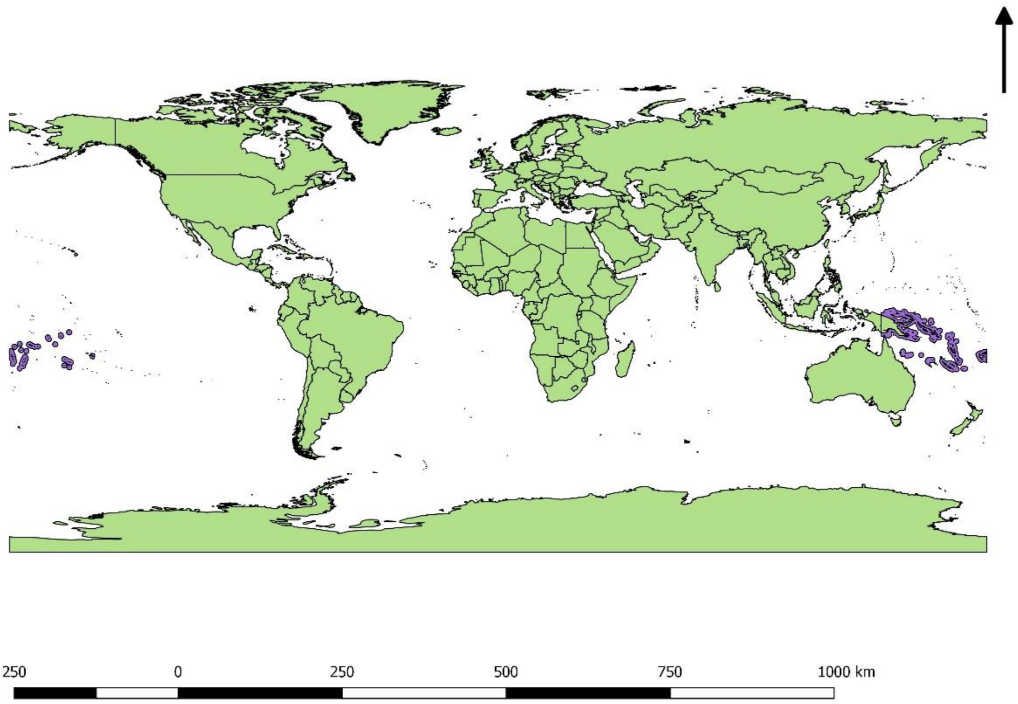
Anguilla megastoma

Life history

- **Range**

Anguilla megastoma is found in the Pacific Ocean from Pitcairn to Papua New Guinea in the South Pacific (Ege, 1939; Marquet, 1996; Marquet and Galzin, 1991; Marquet and Lamarque, 1986; Sugeha and Suharti, 2008; Watanabe *et al*., 2011). More specifically, this species is distributed in Pitcairn, French Polynesia, Cook Islands, Samoa, Wallis and Futuna (Keith *et al*., 2013), Fiji, Salomon, Vanuatu (Keith *et al*., 2010; Schabetsberger *et al*., 2013), New Caledonia (Marquet *et al*., 2003), and Papua New Guinea. In Gaua Island, Vanuatu, *A. megastoma* is found in Lake Letas and Mbe Solomul River (Sichrowsky *et al*., 2015).

Range states: Cook Islands; Fiji; French Polynesia; New Caledonia; Papua New Guinea; Pitcairn; Samoa; Solomon Islands; Tonga; Wallis and Futuna; Tahiti; Morea.



Range map of *Anguilla megastoma*

- **Biology**

Anguilla megastoma is proposed to be found only in the headwaters of freshwater rivers (Sichrowsky *et al*., 2015; Schabetsberger *et al*., 2017) but there is little information available on the ecology of this species. The indigenous name in Tahiti is puhi-mauá (eel of the mountains) - and Schmidt (1927) reported that this species can surmount obstacles by leaving the water and crawling over the moist forest. Past studies into the feeding ecology of these eels have found the remains of crustaceans, gastropods and various insects including, heteroptera, odonata and decapoda (Cook, 2004; Schabetsberger *et al*., 2013). The few leptocephali collected so far support the hypothesis that the spawning area for the species is thought to be somewhere in the Southern Equatorial Current (SEC) (Kuroki *et al*., 2008; Miller, 2003; Schabetsberger *et al*., 2013). In Vanuatu, *A. megastoma* may share a sympatric spawning area with *Anguilla mamorata* (Schabetsberger *et al*., 2015). It was first postulated by (Ege, 1939), and recently discussed by Watanabe *et al.* (2011), that *A. megastoma* might be separated into eastern and western subpopulations in the western Pacific Ocean. The statistical analysis of vertebral counts for *A. megastoma* found a highly significant difference between the eels from Tahiti and those from Samoa, suggesting that there could be eastern and western populations of this species (Watanabe *et al*., 2011). There is a lack of further empirical data to confirm this assumption.

One of the few other studies into the ecology of this species showed that following maturation, migrating silver eels tagged with satellite transmitters off Vanuatu were shown to exhibit diel vertical migrations in the water column, ranging from 200 m at night down to 750 m during the day (Schabetsberger *et al*., 2013).

<u>Threats</u>

According to Smith (1999), *A. megastoma* is caught locally throughout its range, however, there are no data to determine the level of threat this is posing to the population. On Gaua, in northern Vanuatu, there is anecdotal evidence that the number of silver eels coming down from Lake Letas in the river Mbe Solomul are declining and that the fishing pressure along the river is increasing; although as yet there are no data available to support this (P. Sasal 2013 pers. comm.).
It is believed that damming (French Polynesia) and nickel mining (New Caledonia) will likely be impacting freshwater populations (P. Sasal 2013 pers. comm.). Dams in particularly are likely to be a main threat across the species range due to its preference for mountainous headwaters.

<u>Use</u>

Despite *A. megastoma*'s wide range, very little is known of its use or trade. Pacific fisheries authorities reported an increasing level of enquiries about *Anguilla* spp. from East Asian investors and traders particularly from China in 2016[59][60].There was one company from French Polynesia offering both large *A. megastoma* and juveniles on several online sites, however this company has not been active for a number at the time of writing.

<u>Stock status</u>

Currently there are no quantitative data available on the population status of this species. It has been reported that there have been declines in *A. megastoma* numbers residing in the lakes of French Polynesia since the 1980s (Marquet and Galzin, 1991), however, again there are little data to support this claim. Due to the size of the small oceanic islands where this species is often found, recruitment to these areas is likely to experience considerable fluctuations between years. Recent research for example, suggests that there are no eels left in Lake Vaihiria, an area that showed a relatively high abundance of eels before the 1980s (P. Sasal, 2013 unpub. data). Due to development around the lake and water abstraction for hydropower plants the silver eels that once used the lake during migration are now blocked from using this route. Lately just one *A. megastoma* specimen was caught in the rivers upstream of the lake during extensive electrofishing survey sampling of the area (P. Sasal, 2013 unpub. data).

<u>Management</u>

To date there are no known policy and management initiatives specific to *A. megastoma*.

[59] http://www.criobe.pf/wp-content/uploads/2017/03/EEL-WORKSHOP-RECORD-DER-1.pdf

[60] https://spccfpstore1.blob.core.windows.net/digitallibrary-docs/files/1c/1c1b8ae06e0d88caaa7c48b594745232.pdf?sv=2015-12-11&sr=b&sig=2w6P11uGgbzufXSHc1i7nzE6MFdVGCJ8Tym6D6AOl%2B8%3D&se=2018-07-08T12%3A37%3A19Z&sp=r&rscc=public%2C%20max-age%3D864000%2C%20max-stale%3D86400&rsct=application%2Fpdf&rscd=inline%3B%20filename%3D%22Anon_17_PolicyBrief29_EelUtilisation.pdf%22

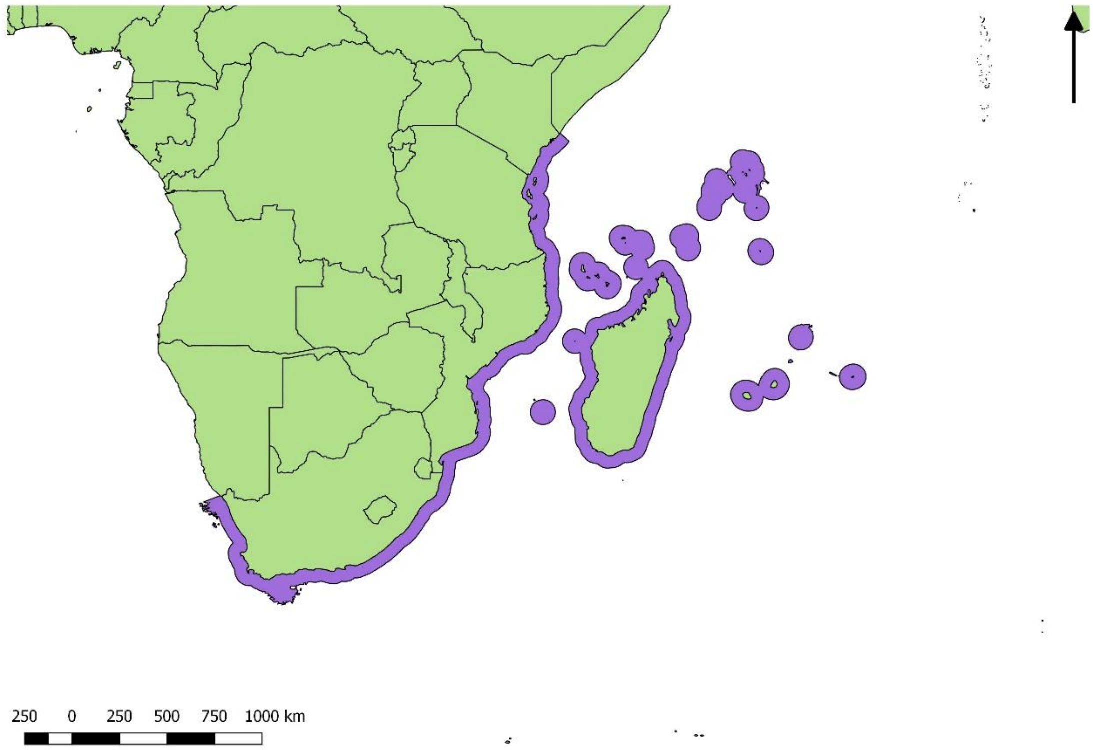
Anguilla mossambica

Life history

- **Range**

It has previously been stated that across its range, *Anguilla mossambica* is present in most of the east flowing river drainages, however a recent monitoring programme in KwaZulu Natal in South Africa (2015-2017), indicated that the species had a very patchy presence which had decreased over the past 10 years (Hanzen, personal communication). If this pattern is reflected across the species range, this would be of significant concern.

Range States: Comoros; Kenya; Madagascar; Mauritius; Mayotte; Mozambique; Réunion; Seychelles; South Africa; Swaziland; Tanzania; Zimbabwe.



Range map of *Anguilla mossambica.*

- **Biology**

This bi-coloured species is hypothesised to breed northeast of Madagascar, west of the Mascarene Ridge in the Indian Ocean (Réveillac *et al*., 2009). The leptocephali larvae are believed to be transported southwards by the South Equatorial Current (SEC) and the present continental range would suggest a migration of 1,000 - 2,000 km (Réveillac *et al*., 2009).

Elvers in the Eastern Cape, South Africa, arrive in higher numbers in the summer months (Wasserman *et al*., 2012). The fact that they recruit all year-round indicates that they have a life cycle similar to other tropical species (Arai *et al*., 2001b). Otolith microchemistry from yellow eels in South Africa, suggests that some individuals are inter-habitat migrants that move between freshwater and saltwater (Lin *et al*., 2012). A later study using otolith micro-chemistry carried out in Madagascar, indicated that 70% of the eels sampled had an atypical life history and associated Sr:Ca, characterised by slow growth and increased parasite load (Lin *et al*., 2015).

Threats

The fragmentation of rivers caused by various barriers (weirs, dams, causeways etc) could potentially prevent the migration of glass eels upstream, and silver eels downstream, threatening the year on year recruitment of *A. mossambica* to freshwater habitat. However, two studies carried out in South Africa, indicate that this species was found furthest upstream compared to other marine spawning species (Muller *et al*., 2015; Wasserman *et al*., 2011).

Over the past 10-15 years, there has been an increased exploitation of *A. mossambica* to East Asia, particularly from Madagascar (Crook and Nakamura, 2013b). A study carried out in the Eastern Cape of South Africa indicated that this species is particularly vulnerable to an invasive parasitic gill worm (*Pseudodactylogyrus anguillae*) (Parker *et al*., 2011; McHugh *et al*., 2017) In high numbers, for example, under aquaculture conditions, this parasite can cause gill damage and anaemia (Kennedy, 2007).

Use

There are indications that demand for this species has increased over recent years (Crook and Nakamura, 2013b). No range State has reported catch or farming production to FAO while according to UN Comtrade, Madagascar and South Africa exported live *Anguilla* eels from 2007 to 2016, with 98% of exports reported by Madagascar. The first known records of imports of live juvenile eel into Asia from Madagascar are from 2005 which reached a peak in 2013; no imports have been recorded in 2016–2017. The majority has been imported into Hong Kong and South Korea, but farming of this species is presently being proposed at a facility in the USA[61].

Stock status

With virtually no monitoring and little fisheries data across the species range, there are currently huge knowledge gaps in our understanding of the population dynamics of this species. However, given the data relating to range shrinkage cited above (C. Hanzen, 2018, pers. comm.), the status of the species has declined over the last decade, at least.

Management

There is little information available regarding the conservation efforts throughout the range of the African Longfin Eel. In South Africa, however, there are plans to try and increase upstream and downstream river connectivity by linking adjoining sub-catchments in an attempt to aid migration (Rivers-Moore *et al*., 2011).

[61] https://www.fws.gov/fisheries/ans/erss/uncertainrisk/Anguilla_mossambica_ERSS.pdf

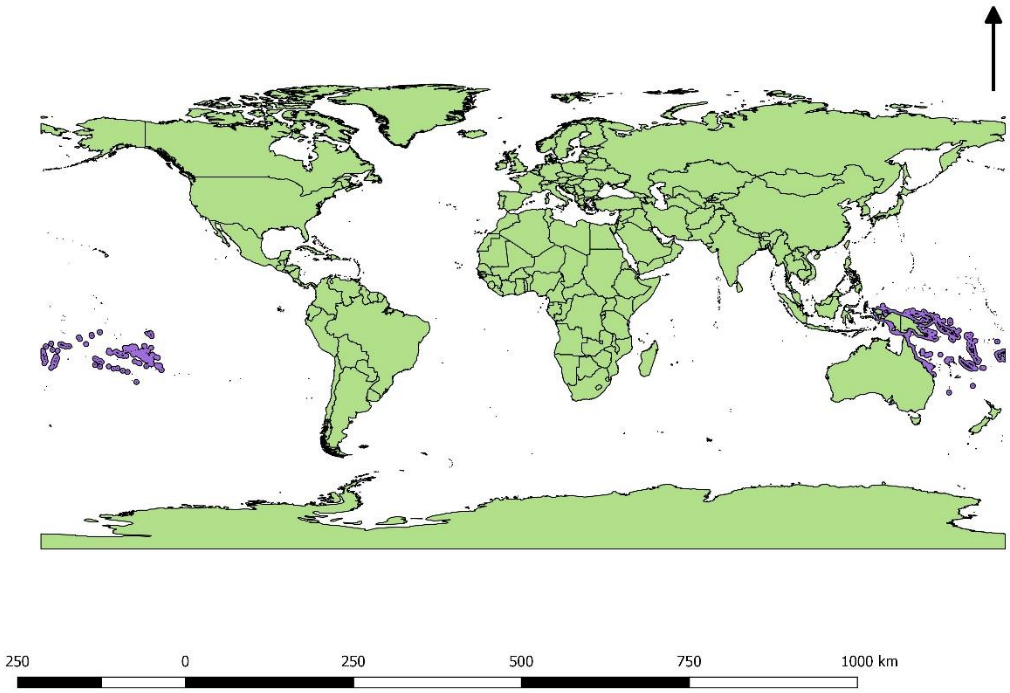
<u>Anguilla obscura</u>

<u>Life history</u>

- **Range**

Anguilla obscura has a similar distribution to *Anguilla megastoma,* throughout the Pacific Ocean from western New Guinea, the Solomons and Fiji to French Polynesia. Specific locations include Lalolalo Lake on Wallis Island (Bareille *et al*., 2015), Rangiroa atoll in French Polynesia (Lecomte-Finiger *et al*., 2000), Pouembout and La Foa Rivers in New Caledonia, (Moravec and Justine, 2007), Lake Rotonui in the Cook Islands (Schabetsberger *et al*., 2009) and Lake Letas and Mbe Solomul River in Vanuatu (Sichrowsky *et al*., 2015).

Range states: Cook Islands; eastern Australia; Fiji; French Polynesia; Indonesia; New Caledonia; Papua New Guinea; Samoa; Solomon Islands; Tahiti; Tonga; Vanuatu, Wallis Island.



Range map of *Anguilla obscura*

- **Biology**

Anguilla obscura is a catadromous, freshwater eel that inhabits freshwater, lakes, marshes, swamps and coastal lagoons but is primarily found in the lower reaches of rivers (Resh *et al*., 1999). Glass eels have been found to recruit to atolls, such as the Rangiroa atoll in French Polynesia, where only one third of the atoll rim is above sea level (Lecomte-Finiger *et al*., 2000). This perhaps suggests these tropical glass eels are able to survive in warm, shallow, saline environments.

A. obscura feeds mainly on fishes, crustaceans, molluscs and insect larvae (Resh *et al*., 1999).

Specimens caught in the Cook Islands were found to be heavier than specimens of equivalent length captured in French Polynesia (Jellyman, 1991). Similar length-weight relationships across different localities have also been found in other anguillids (Jellyman, 1991).

Satellite tagging of migrating eels in the marine environment revealed that, like other anguillid species, *A. obscura* exhibit diel vertical migration, descending to at least 320 m in the water column (Schabetsberger *et al*., 2013). Mature eels are hypothesised to migrate into marine waters to spawn east of Tahiti (Jellyman, 1991) with the larvae being transported south and west by the South Equatorial Current (SEC). Nearby offshore spawning to the Vanuatu archipelago cannot be ruled out (Schabetsberger *et al*., 2013). However, only three *A. obscura* larvae have been found, two southwest of Vanuatu and one south of Fiji, thus further information is required (Schabetsberger *et al*., 2013). The East Australian Current carries larval *A. obscura* southwards from the as yet undefined spawning ground in the Coral Sea (Beumer and Sloane, 1990). Glass eel recruitment of *A. obscura* within the Vanuatu archipelago has been observed between April and July (Schabetsberger *et al*., 2013).

Threats

Unlike other anguillid eels, *A. obscura* occurs mainly in the lower parts of river systems or in lagoons (Resh *et al*., 1999) and thus is less likely to be impacted by barriers to migration such as dams, although estuarine habitat is likely to be more vulnerable to anthropogenic impacts such as pollution and development. Pollution from mining is believed to be an ongoing threat in some localities (P. Sasal 2013, pers. comm.).

Use

Anguilla obscura is not currently being offered for sale on online trade platforms, and there is no available information on potential demand for glass eels of this species for supplying East Asian eel farms. There was one company from French Polynesia offering both large *A. megastoma* and juveniles on several online sites, however this company has not been active for a number at the time of writing. Anecdotal evidence suggest that in the market places of the Solomon Islands, juveniles of *A. obscura* are sold (R. Schabetsberger 2014, pers. comm.).

Stock status

Information on the population status of *A. obscura* is currently limited. A survey of lakes, by Schabetsberger *et al.* (2009), found the eel populations within Lake Letas to be among the largest in the South Pacific (Schabetsberger *et al*., 2013). Monitoring is required to determine the abundance of this species at many of the island chains where it is found. This is of particular importance given the restriction of this species to specific growth habitat in and around river mouths of small oceanic islands.

Management

No species-specific management actions or policies were identified by the Parties for *A. obscura* but Indonesia has legislation that applies to trade of all anguillid species (see *A. bengalensis*).

Anguilla reinhardtii

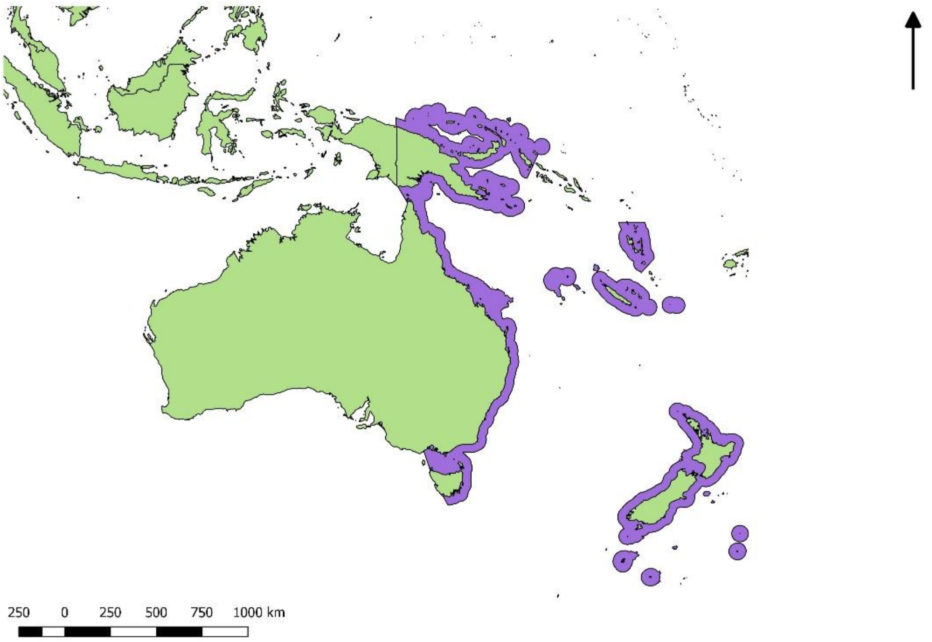
Life history

- **Range**

Anguilla reinhardtii, the Australian longfinned eel, is found in Australia, New Zealand, New Guinea (Gomon and Bray, 2017), New Caledonia (Marquet, 1996) and has also been caught on the islands of Vanua Lava and Maewo in Vanuatu (Schabetsberger *et al*., 2013). Its distribution is restricted in New Zealand (Jellyman *et al*., 2009) being a more 'tropical' species than *A. dieffenbachii* and *A. australis*, and is the most recently discovered of the three eel species in New Zealand, appearing to occasionally recruit there (Arai *et al*., 2004; McDowall *et al*., 1998). *Anguilla reinhardtii* is highly successful and its distribution in New Zealand seems limited only by oceanic dispersal of its larval stage (Chisnall, 2000). The species also occurs along the east coast of Australia from northern Queensland to Tasmania (Gomon and Bray, 2017). *Anguilla reinhardtii* ranges from 10–43°S in continental waters but is most abundant between latitudes 20–34°S (Beumer and Sloane, 1990; Shiao *et al*., 2002). In Australia, the duration of the marine larval period (shorter for *A. reinhardtii* than *A. australis*) and growth rate (faster for *A. reinhardtii* than *A. australis*) are thought to be key factors in determining the geographical distribution of *A. reinhardtii*, which tends to occur in tropical-subtropical waters (c.f. *A. australis*, which predominate in more temperate waters) (Shiao *et al*., 2002).

No clear evidence of population structure was found in studies of *A. reinhardtii* across its range in the western South Pacific Ocean based on total number of vertebrae (TV) data (Watanabe *et al*., 2011) or molecular genetics (Shen and Tzeng, 2007b) suggesting a randomly mating panmictic population (Shen and Tzeng, 2007b). Although Watanabe *et al.*, (2011) note that neither study was geographically comprehensive enough to reach a conclusive result, current evidence supports *A. reinhardtii* being managed as a single population.

Range states: Australia, New Zealand, New Caledonia, New Guinea, Vanuatu.



Range map of *Anguilla reinhardtii*

- **Biology**

Although the exact spawning area or timing of spawning is still to be verified, this species is reported to spawn in the Coral Sea in depths of 400 m or greater (Gomon and Bray, 2017) and more generally, the South Equatorial Current region based on the collection of some 20.0–34.0 mm leptocephali at one location (Kuroki *et al.*, 2008; Watanabe *et al.*, 2011). Distribution to New Zealand from Australia occurs at the larval stage (McDowall *et al*., 1998) with the East Australian Current (EAC) likely to be the predominant transport agent for larval dispersal from spawning grounds in the tropics (Chisnall, 2000).

The oceanic dispersal of larvae from tropical spawning grounds results in a north to south recruitment along the eastern seaboard of Australian and Tasmania (Beumer and Sloane, 1990; Chisnall, 2000). In Australia, the younger ages at estuarine arrival of *A. reinhardtii* suggest that the spawning grounds of this species lie closer to Australia than those of *A. australis* (Shiao *et al*., 2002). Glass eel recruitment in Australia is greatest in summer-autumn (Beumer and Sloane, 1990; Sloane, 1984) thus suggesting an autumn-winter arrival in New Zealand (Jellyman *et al*., 1999).

Anguilla reinhardtii may remain in freshwater environments for more than 50 years before migrating to the sea to breed (Gomon and Bray, 2017). *Anguilla reinhardtii* has been found to migrate throughout the year, including at times when water temperatures reach 25°C (Pease *et al.* 2003 in August and Hicks 2008). Similarly, Shen and Tzeng (2007) suggest that *A. reinhardtii* displays year-round spawning as evidenced by hatching dates (Shiao *et al*., 2002) and year-round collection of glass eels in six estuaries of New South Wales, Australia (Silberschneider 2005 in Shen and Tzeng 2007).

Anguilla reinhardtii is known to occur in a variety of habitats including rivers, streams, lakes, swamps and floodplains, however is more common in faster flowing riverine waters than in still waters (Gomon and Bray, 2017). *Anguilla reinhardtii* has shown a preference for rocks/cobbles over sand, mud or seagrass habitat (Silberschneider *et al*., 2004). The species is also known to inhabit deeper waters of freshwater reservoirs (Gomon and Bray, 2017). In New Zealand, A. reinhardtii is likely to occupy all known habitats of eels within its range of dispersal (Chisnall, 2000).

Anguilla reinhardtii is a long-lived species and attains a large size comparable to that of *A. dieffenbachii* (Merrick and Schmida, 1984)*;* up to 1,650 mm and 22 kg, (McDowall 1990 cf. Tesch 1977 in Chisnall 2000). However, *A. reinhardtii* exhibits growth rates 2-3 times faster for length and 4 times faster for weight than for the sympatric *A. dieffenbachii* (Chisnall, 2000). *Anguilla reinhardtii* is an opportunistic feeder, principally nocturnal, becoming an increasingly aggressive carnivore with increasing size (Chisnall, 2000) and may be the top predator in many habitats (Gomon and Bray, 2017). In Australia, fish (including galaxiids) were found to be the major dietary component of *A. reinhardtii* over a wide size range (Beumer, 1979) and the species is also reported to eat catfish (*Tandanus tandanus*) (Merrick and Schmida, 1984) crustaceans, molluscs, insects and occasionally juvenile waterfowl (Gomon and Bray, 2017). In New Zealand, the diet of *A. reinhardtii* is likely to consist of introduced fish such as trout, carp, rudd and mosquitofish, native fish such as galaxiids, bullies and other eels, as well as the crayfish genus *Paranephrops* (Chisnall, 2000).

Overall, the fast rate of growth of *A. reinhardtii*, similar choice of habitats, overlapping diet, and territorial behaviour of large individuals suggests that *A. reinhardtii* is likely to be highly competitive with both other eel species in New Zealand (*A. australis* and *A. dieffenbachii*) and may displace *A. dieffenbachii* as the top predator. This is most likely to become apparent if *A. reinhardtii* penetrate upper catchment waterways where habitat becomes confined (Chisnall, 2000).

<u>Threats</u>

In their responses to CITES Notification 018/2018 Australia and New Zealand identified threats across the range as barriers to migration, climate change, habitat loss/modification and pollution. However, there is very limited information on the impact of potential threats facing *A. reinhardtii* - it could be assumed that as there is overlap with sympatric species such as *A. australis* and *A. dieffenbachii* threats might be similar.

In order to mitigate anthropogenic changes to river systems that can impede glass eel migration, a study by Langdon and Collins (2000) recommended that, based on sustained and burst swimming speeds for *A. reinhardtii* (and *A. australis*), mean and maximum fishway velocities should not exceed 30 and 75 cm per second respectively, and fishway cells should be specifically designed to permit glass eel passage (Langdon and Collins, 2000).

Edwardsiella tarda is the cause of an economically important disease, edwardsiellosis, in a range of food fish species including pond cultured eels in Japan and Taiwan (Eaves *et al.* 1990 and references therein). In Australia, edwardsiellosis was regarded as an exotic disease in Australian native fish, however, *E. tarda* was isolated from a diseased wild-caught *A. reinhardtii*. Eels infected with *E. tarda* have been shown to act as carriers of infection in culture ponds (Eaves *et al.* 1990 and references therein). *Photobacterium damsel* is a pathogen known from the marine environment that can cause fatal skin ulcerations in fish, mammals and reptiles. It was found in multiple *A. reinhardtii* which had died in holding tanks pre-export (Ketterer and Eaves, 1992).

<u>Use</u>

Freshwater eels have long been consumed by Aboriginal people in eastern Australia and have strong cultural significance (Gomon and Bray, 2017). *Anguilla reinhardtii* has been fished in Australia since the 1950's or 60's and is commercially important on the east coast of Australia, primarily for export to East Asia (De Silva *et al*., 2001)

<u>Stock status</u>

In their responses to CITES Notification 018/2018 Australia indicated that the *A. reinhardtii* population remains stable and New Zealand stated it was unknown. No further information is as yet available on the population status of *A. reinhardtii*, however Chisnall (2000) suggests that *A. reinhardtii* may have a competitive advantage over *A. australis* and *A. dieffenbachii* in New Zealand due to its accelerated growth rate.

This species has not presently been assessed using the IUCN Red List Categories and Criteria.

<u>Management</u>

No species-specific management actions were identified but Australia manages anguillid eels via legislation specific to each state and and New Zealand highlighted management measures for all species in its waters (see *A. australis*). No information was available in relation to management across the rest of the species’ range.

<u>Anguilla rostrata</u>

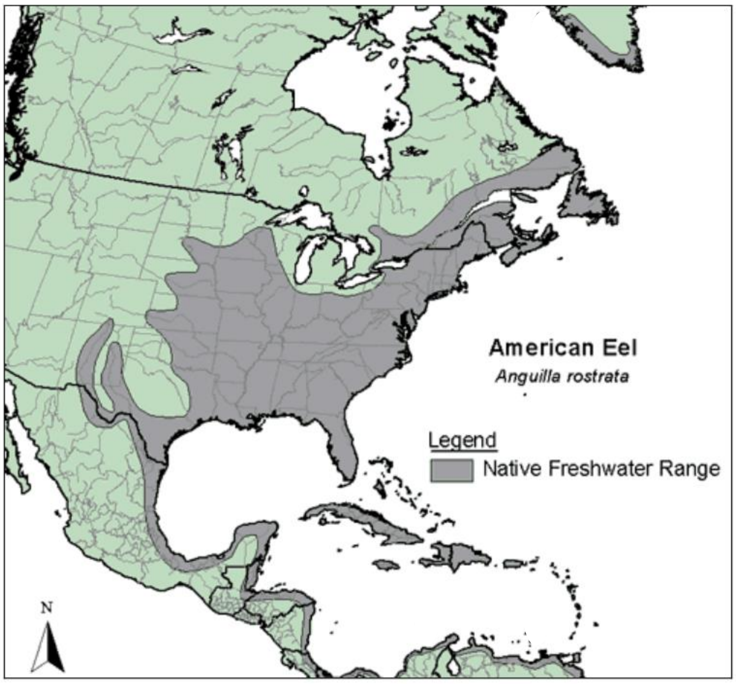
<u>Life history</u>

- **Range**

The continental distribution of *A. rostrata* ranges from West Greenland in the north (Nielsen and Bertelsen, 1992) southward along the Atlantic coast of Canada and the USA, curving around southern Florida and along the coast of the Gulf of Mexico to the northern tip of the Yucatan Peninsula. The southern part of its range continues along the eastern coast of Central America, encompassing many of the islands in the Caribbean Sea and extending to the northern portion of the Atlantic coast of South America (Ogden *et al.* 1975; Wenner 1978; Erdman 1984; Van Den Avyle 1984; Böhlke and Chaplin 1993; Claro 1994; Kenny 1995; Bussing 1998; Lim *et al.* 2002; see Benchetrit and McCleave 2015 for a comprehensive analysis of the range). Despite this large range there is evidence that this species forms one panmictic population with all mature individuals migrating to the Sargasso Sea (Bonhommeau *et al*., 2008a; Côté *et al*., 2013; Gagnaire *et al*., 2012; Miller *et al*., 2009a). This said, phenotypic variation observed during recent stocking experiments in Canada have indicated that the stock structure may be more complex (Côté *et al*., 2015; Stacey *et al*., 2015).

Historically, *A. rostrata* was widely distributed in the inland watersheds associated with this extensive range, including the Mississippi River basin and Great Lakes-St. Lawrence River basin below Niagara Falls. After construction of the Welland Canal to bypass Niagara Falls, eels, which were abundant in Lake Ontario, were frequently reported in the waters of Lake Erie (Trautman, 1957). Bensley (1915) reported that eels were occasionally seen at the mouth of the Severn River in South Eastern Georgian Bay, Lake Huron, possibly gaining access through the Trent-Severn Waterway. *Anguilla rostrata* found on the Canadian side of Lake Superior likely were ballast-water introductions (Mandrak and Crossman, 1992). Construction of many large and small dams throughout the eastern half of the North American Continent has greatly restricted the range of *A. rostrata* (USFWS, 2007).

Range states: Belize; Bermuda; Canada; Colombia; Costa Rica; Cuba; Curaçao; Dominica; Dominican Republic; Greenland; Guadeloupe; Guatemala; Haiti; Honduras; Jamaica; Martinique; Mexico; Nicaragua; Panama; Providencia; Puerto Rico; Saint Pierre and Miquelon; Saint Vincent and the Grenadines; Trinidad and Tobago; United States of America; Venezuela; Virgin Islands, U.S.



Range map of *Anguilla rostrata* (DFO, 2014).

- **Biology**

As a catadromous species, *A. rostrata* use marine habitats for migration to their spawning area, spawning, and egg and larval phases. Little is known about the precise spawning habitat of the *A. rostrata*. Breeding in the wild has never been observed, however, some evidence suggests that *A. rostrata* may spawn in the upper 150–200 metres of the water column (Kleckner *et al*., 1983; Kleckner and McCleave, 1985a). A recent modelling study has suggested spawning primarily takes place from December to March (Westerberg *et al*., 2018) though field studies have indicated larvae are present in low abundance outside of this period (Kuroki *et al*., 2017). A single individual has been tracked to the northern limit of the Sargasso Sea from continental waters (Béguer-Pon *et al*., 2015) but spawning location is inferred based on size of the leptocephali - the larval stage of anguillid eels - with the smallest leptocephali captured over a relatively large 550 km arc in the southern Sargasso Sea within the frontal area of the Subtropical Convergence Zone (ASMFC, 2012; DFO, 2014). The northern limit of spawning appears to be defined by temperature fronts separating surface water masses with high temperature and higher-saline water to the south and seasonally cooled, lower-saline water to the north (Kleckner and McCleave, 1988; McCleave and Kleckner, 1987; Munk *et al*., 2010). These highly dynamic fronts vary in shape and locations within months and between years.

Leptocephali, drift and swim with prevailing currents (Antilles Current, Florida Current, and Gulf Stream), which take them to areas near continental coasts or continental-slope waters (Kleckner and McCleave, 1985b). It is believed that metamorphosis from leptocephali to glass eels occurs in the first year primarily at the edge of the continental shelf; active transport is thought to be necessary for leptocephali and glass eels to exit the Gulf Stream (Kleckner and McCleave, 1985b). In the Gulf of St. Lawrence, migration of glass eels is 10–15 km/day primarily at night (Dutil *et al*., 2009). Research has indicated that coastal and estuarine waters could be appropriate growth habitat for eels within the species' range (Macgregor *et al.* 2008; Greene *et al.* 2009; Chaput *et al.* 2014; Boivin *et al.* 2015; Benchetrit *et al.* 2017). Jessop *et al.,* (2009) reviewed studies which used otolith microchemistry to investigate lifetime use of salinity zones by *A. rostrata*; eels can be divided into residents of freshwater, residents of brackish or salt water, and shifters between these habitats. Despite knowledge of these modes, there is still little known about the use of the saline waters by *A. rostrata* across its range.

Environmental predictors of glass eel runs are variable, but increased temperature and reduced flow may trigger upstream movement (Greene *et al*., 2009). This immigration begins when water temperatures reach 10°C and continue until temperatures exceed 20°C, though lower temperatures can decrease migratory activity (Martin, 1995). Glass eels appear to be attracted to flowing water with a current velocity <25-40 cm/sec (Greene *et al*., 2009). Yellow-phase *A. rostrata* spend 3 to 30 or more years inland or in coastal areas before becoming mature, entering the silver phase (Daverat *et al*., 2006; MacGregor *et al*., 2009). From an acoustic telemetry study in Eastern Canada, emigration appears to be a variable process between individuals but primarily nocturnal (Béguer-Pon *et al*., 2014).

Sex determination in anguillids is, at least to some extent, environmentally determined and appears to be a function of density and growth rate, with males occurring at higher local population densities (Davey and Jellyman, 2005; Krueger and Oliveira, 1999). Consequently and like other species of freshwater eels, regional sex bias is common in *A. rostrata*, potentially exacerbating the impact of localised threats. The once large and abundant eel stock of the upper St. Lawrence River–Lake Ontario system was exclusively females that were large, old, and potentially highly fecund (Casselman, 2003). As such, it has been argued that the northern portion of the geographic range of the *A. rostrata* may contribute a great proportion of the reproductive potential to this panmictic species because of apparent increases in average female size and female bias with latitude (Barbin and McCleave, 1997). Counter to these arguments, however, is the contention that individuals at lower latitudes grow more quickly, reaching maturity at a younger age, are more abundant and have a shorter generation time than those at more northern latitudes (ASMFC, 2012). Even though the individuals are smaller, this may result in a greater overall reproductive capacity.

Threats

In an extensive review of status of the *A. rostrata* in Canada - but that will likely apply across the species' range to varying degrees - COSEWIC (2012) identified the major threats to the species as: 1) barriers in freshwater resulting in the accumulative loss of formerly productive habitats; 2) turbine mortality from hydroelectric dams; 3) vulnerability of life stages to fisheries; 4) bioaccumulation of contaminants; 5) exotic swimbladder nematode parasite (*Anguillicola crassus*) potentially introduced from stocking; 6) climate change and shifting oceanic conditions.

Habitat loss resulting from barriers may contribute to reduced eel abundance in eastern Canada (Jessop, 2000). In the St Lawrence watershed alone, 13% (14,000 km^2) of yellow eel rearing habitat is no longer accessible (DFO, 2014). However, in the late 1990s and early 2000s a number of eel ladders were constructed on barriers which attempted to reduce this loss. Throughout the United States (USA), it is reported that as much as 84% of historic stream length is now inaccessible to eels (DFO, 2014). The Susquehanna River, the largest river system on the East Coast of the USA, once supported large numbers of eels; however the construction of Conowingo Dam, a large hydroelectric dam located near the mouth of the river as well as additional upstream dams has severely limited the access to this habitat (SRAFRC, 2010). Major habitat perturbations in the St. Lawrence River took place in the 1950s (e.g., construction of the St. Lawrence Seaway and hydroelectric dams), about 30 years before recruitment started declining; this long delay argues against these perturbations being primary causes of the decline (Castonguay *et al*., 1998). However, an unpublished, long-term CPUE series (1930–1965) provides evidence that the decline occurred simultaneously with the habitat alterations (see Castonguay *et al.* 1998).

Passage through turbines at hydropower dams during downstream migration represents a major source of eel mortality (Ritter *et al*., 1997). Turbine-induced mortality ranges from 5 to 97%, depending on turbine type, flow rate, and length of the fish (Buysse *et al*., 2014; Hadderingh, 1990). Cumulative direct turbine mortality from the two large hydroelectric dams on the St. Lawrence River system (Moses-Saunders and Beauharnois) accounts for a mortality of 40% of the emigrating eels (MacGregor *et al*., 2009). A recent study indicated that turbine shutdown during darkness may reduce mortality of escaping silver eels (Eyler *et al*., 2016).

Unsustainable exploitation is a threat that impacts many species of anguillid eels. Total catch across the species range have declined since the late 1970s, though this appears to have plateaued in the late 1990s (ASMFC, 2017). The USA and Canada have historically been the primary fishing range States, but more recently there has been an increase in harvest in the Caribbean – particularly Haiti and the Dominican Republic. By weight, the American *A. rostrata* fishery primarily targets yellow eel for bait, throughout the Atlantic States (ASMFC, 2017). Glass eel fisheries are prohibited in all states except Maine and South Carolina, with only the former landing significant catches, within a set quota (ASMFC, 2017). There are both glass eel/elver and yellow eel fisheries in Canada, the former being more limited in range (Canada's response to CITES Notification 2018/018). Glass eels/elvers are exported to Asia to meet demand for farms and *A. rostrata* has increasingly met this demand since the export of European eels was banned in 2010 (Crook and Nakamura, 2013a). Increased worldwide demand for glass eels and elvers also led to a rise in poaching[62] of *A. rostrata*. Recent regulations and increased enforcement appears to have curtailed much of this illegal activity in the USA and Canada.

Pollutants have been implicated as having an impact on the health and spawning success of *A. rostrata* (e.g organic and inorganic contaminants in Caron *et al.,* 2016; metals in Pannetier *et al.,* 2016). *Anguilla rostrata* from the St. Lawrence River have historically been identified as being heavily contaminated with chemicals such as Polychlorinated Biphenols (PCBs), Mirex (an insecticide), and various pesticides (Castonguay *et al*., 1998; Couillard *et al*., 1997; Hodson *et al*., 1994). Lethal toxicity from chemical contamination has been known to occur in St. Lawrence eels for more than 30 years (Castonguay *et al*., 1998). The highest concentrations of chemicals in migrating silver eels in the St. Lawrence River are in the gonads; chemical levels in eggs could exceed the thresholds of toxicity for larvae (Hodson *et al*., 1994). More recent studies indicate that levels of toxins are declining (Byer *et al*., 2013b, 2013a, 2015), and in some specific cases negative effects are apparently absent (e.g. dioxins;
Hoobin *et al.* 2018), but there is still regional concern in relation to other xenobiotics.

Anguillicola crassus has been found in some catchments in the range of *A. rostrata*, (see ASMFC 2017) but at present, and from a single study, seem to be absent from those that drain in to the Gulf of Mexico (Cox *et al*., 2016).

Oceanic effects on long-term patterns of *A. rostrata* recruitment are poorly understood, but they may play a role in the changing abundance of eels along the Atlantic coast of North America (Castonguay *et al*., 1994). A recent study indicated that abundance of larval *A. rostrata* in the Sargasso Sea had declined since the early 1980s (Hanel *et al*., 2014). At the larval stage, changes in marine primary production and thus food availability associated with climate change have been suggested as a cause of declines of *A. rostrata* (Bonhommeau *et al*., 2008b). Changes in frontal locations or oceanic currents may also play a role in determining recruitment to the coast (Miller *et al*., 2009a; Westerberg *et al*., 2018). It has recently been discovered that predation of adult eels may be a further impact in the oceanic environment (Béguer-Pon *et al*., 2012; Wahlberg *et al*., 2014).

[62] e.g. https://www.justice.gov/opa/pr/two-men-indicted-illegally-trafficking-american-eels

Stock status

It is generally accepted that the stock status of *A. rostrata* has declined over the past decades. It is listed as globally Endangered on the IUCN Red List of Threatened species (Jacoby *et al*., 2017). A recent assessment was carried out by the Atlantic States Marine Fisheries Commission on the status of the species, which built upon a similar analysis carried out in 2012 (ASMFC, 2012, 2017). A range of data sets for 'young of the year' and yellow eels, both fisheries dependent and independent, were used in both assessments. While results varied, all three analyses indicated downward trends in the datasets until the early 1990s, after which they have stabilised. As a consequence, the stock has been designated as 'depleted' (ASMFC, 2012, 2017).

In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) stated in 2012 '*This species is widespread in eastern Canada, but has experienced dramatic declines over a significant portion of its distribution (e.g., Lake Ontario and the upper St. Lawrence River). Although trends in abundance in other areas are highly variable, strong declines are apparent in several indices. Continuing habitat degradation, especially owing to dams and pollution, and existing fisheries in Canada and elsewhere may constrain recovery.*' As such, the status of *A. rostrata* in Canada was assessed as 'Threatened' (COSEWIC, 2012). In 2014, the Department of Fisheries and Oceans carried out a 'recover potential assessment', the outcome of which was to concur with the observed decline outlined on the COSEWIC report (DFO, 2014).
There is little understanding of the stock status across the southern part of the species range.

Use

Although *A. rostrata* has traditionally been consumed in small amounts domestically across its range, in particular in the USA and Canada, harvesting is predominantly carried out with the purpose of export. Unlike in Europe or Asia, there is no long-term tradition of farming eels in the Americas and most glass eels are exported to East Asia. Yellow eels are used for bait in other fisheries in the USA. It is well documented that *A. rostrata* were very important and widely used for sustenance, reverence, and practical purposes by indigenous people in prehistoric and historic times (Casselman, 2003; Engler-Palma *et al*., 2013; MacGregor *et al*., 2009; Miller and Casselman, 2014). In their response to CITES Notification 018/2018, Costa Rica indicated that there was a small subsistence fishery of larger eels by indigenous peoples.

Management

There are management measures in place for *Anguilla* spp. in a number of the *A. rostrata* range States. In the USA, the species is managed by the ASMFC and the American Eel Fishery Management Plan (FMP) was approved in 1999 (ASMFC, 2017). Implementation is devolved to the state-level as is monitoring and commercial regulations (ASMFC, 2017). There is a coast-wide quota of 907,671 pounds of yellow eel; but no state-specific allocation unless one of two management triggers are met[63] (ASMFC, 2017). Since 2015, there has been a 9,688 pound quota for Maine's glass eel fishery (ASMFC, 2017). More broadly, the U. S. Endangered Species Act covers all *Anguilla* species under the definition of wildlife except when the species are imported or exported as non-living products for human or non-human consumption. In 2010, the U.S. Fish and Wildlife Service (USFWS) received a petition seeking to extend federal protection to *A. rostrata* – this followed a similar application in 2004. A review of the species status was completed in 2015 and it did not consider the species warranted listing under the ESA as Threatened[64].

[63] (1) if the cap is exceeded by more than 10% in a given year, or (2) the coast-wide quota is exceeded for two consecutive years regardless of the percent overage.
[64] https://www.fws.gov/northeast/americaneel/pdf/20150820_AmEel_12M_NotWarranted_BatchFormat_v2_Signed.pdf

Installation of eel ladders along the U.S. portion of the species range is now a common restoration strategy, however, strategies to protect downstream migration though hydroelectric facilities are rare. Fish passage on other large hydro dams is addressed during the U.S. Federal Energy Regulatory Commission's licensing or relicensing process.

Management of American eel in Canada is multi-jurisdictional involving five administrative regions of DFO (Central and Arctic, Gulf, Maritimes, Newfoundland and Labrador, and Quebec) and the Provinces of Ontario and Quebec (Canada's response to CITES Notification 2018/018). Each region/province has specific regulations for commercial yellow and/or silver eel fisheries. There have been no commercial fisheries for *A. rostrata* in Ontario, since 2004. There is a licenced commercial elver fishery in the Maritimes and licences come with a number of restrictions associated with them. There is also an Integrated Fisheries Management Plan for this fishery.

Stocking has been proposed as a way to bolster the continental populations. The impacts of restocking programmes are still not fully understood, and while having been shown to increase escapement in some instances, must be carefully planned and executed in river systems that will benefit from an increase in freshwater population. A study that examined the macroinvertebrate densities in stream both with and without *A. rostrata* indicated the presence of this species can influence their abundance (Stranko *et al*., 2014). Studies of the stocking programme in the upper St. Lawrence River system showed strong evidence that stocked eels survived and grew quickly, emigrated faster than natural recruits, in a sex ratio skewed to males and at a size similar to their site of original capture in Nova Scotia (Pratt and Mathers, 2011; Pratt and Threader, 2011; Stacey *et al*., 2015). A further study relating to the stocking programme estimated that emigrating stocked eels would not have the fat reserves to reach spawning grounds (Couillard *et al*., 2014). This suggests seed stock for these programmes should be collected from areas as close as possible to rivers being stocked to ensure they are phenotypically appropriate for the habitat.

In the southern part of the species range there are limited known management measures in place. In Cuba, a resolution of the Ministry of Science, Technology and Environment (CITMA) has been prepared and is in the phase of consultation and approval, to add *A. rostrata* to the list of Species of Special Significance of the Biological Diversity of the country which will result in the species being treated similarly to those included in Appendix II of CITES. Cuba also has a Manual of Work Procedures for the management of *A. rostrata* and operates fishing licenses. In November 2013, the Dominican Republic declared a ban on fishing, processing and trade/sale of *A. rostrata* (all life stages) between 1st April and 14th September every year, via Resolution 80-2013[65]. The details of this resolution have been updated annually, with the most recent in 2017 (Resolution 003-2017) extending the closed season to 31st October. The resolutions also cover aspects such as licences, holding stations, quotas and permitted ports of export. More generic policies that relate to *A. rostrata* include the Government of Bermuda's Protected Species Act (2003).

[65] http://elnacional.com.do/establecen-veda-pesca-y-comercio-de-la-anguila/

Annex 2 – Full Trade Report

Analysis of trade in non-CITES listed *Anguilla* spp.

May 2018

Hiromi Shiraishi and Vicki Crook

1. Methods

Production and Trade data for *Anguilla* spp. were collated from several sources to provide an overview of production and trade dynamics and examine possible changes in trade patterns following the entry into force of the listing of the European Eel in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2009.

Globally, there are several six-digit Harmonised Systems (HS) Customs codes designated for eel, however these codes do not differentiate between the various life stages or species:

- live eels (*Anguilla* spp.) (HS 030192);
- fresh or chilled eels (*Anguilla* spp.) (HS 030274);
- frozen eels (*Anguilla* spp.) (HS 030326); and
- prepared/preserved eels (HS 160417)[66].

Some countries/territories have more detailed Customs codes for live eels, which enable users to differentiate between live eel fry (used for farming) and larger live eels (for consumption) and conduct a more detailed analysis.

The issues of over- and under-reporting must be considered when interpreting Customs data and information. Double counting may occur as *Anguilla* spp. are traded internationally before and after being converted into different types of commodities. In addition, eel-like species (non-*Anguilla* spp.) seem to be traded under HS codes for *Anguilla* eels in some countries/territories. For example, live eel exports from South East Asia are known to include *Monopterus albus* (Swamp Eels) (SEAFDEC, 2018, unpublished data; the Philippines' response to CITES Notification 2018/018) and trade to and from some countries in the Americas reported as *Anguilla* spp. is known to include Hagfish *Myxine* spp., Conger *Conger* spp., Moray Muraenidae and Snake Eel *Ophichthus remiger* (United States' response to CITES Notification 2018/018; Bustamante and Segovia, 2006; UN Comtrade, 2018).

For the purposes of analysis, it was assumed that countries/territories named in trade data as the origin of exports were the sources of the eels in trade, with the species assigned based on their range State distribution. The range States of each species were identified based on the most recent IUCN Red List assessment except for *A. australis*, *A. dieffenbachii* and *A. reinhardtii*, which have not been assessed. As several *Anguilla* spp. can be caught in several countries/territories, species trade was analysed by assuming the data referred to the *Anguilla* species mostly traded from a particular region i.e. East Asia - *A. japonica*, Americas - *A. rostrata*, South East Asia – *A. bicolor*+ (*A. bicolor* and other tropical species), Oceania - *A. australis+* (*A. australis*, *A. dieffenbachii and A. reinhardtii* and East/Southern Africa - *A. mossambica+ (A. mossambica* and other tropical species). Scientific publications, government reports, press releases, online news article, company websites and other anecdotal information were used to provide an indication as to the species involved.

Food and Agriculture Organization (FAO) of the United Nations

Global and country/territory specific *Anguilla* "capture" and "aquaculture" data for 1950–2016 were downloaded from "Global Statistical Collections" http://www.fao.org/fishery/statistics/en in March 2018. FAO capture and aquaculture production data for mainland China from 1997 to 2006 were

[66] HS Nomenclature 2017 edition: http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2017-edition/hs-nomenclature-2017-edition.aspx

estimated, based on a downwards adjustment of 13% made by FAO in response to the China Second National Agriculture Census (S. Vannuccini, FAO, *in litt*. to TRAFFIC, September 2014). All other estimated quantities (marked with "F" in the FAO data) were also included in the analysis.
Anguilla spp. trade data for 1976–2015 were also downloaded from the "Global Statistical Collections" in March 2018. These FAO trade data were used to supplement UN Comtrade data (see below) on prepared/preserved eels traded from 2012 to 2016 inclusive.

UN Comtrade

Global *Anguilla* export and import data of live, fresh, frozen and prepared/preserved eel for 2007–2016 were downloaded in February 2018 from the UN Comtrade Database (http://comtrade.un.org/). UN Comtrade data were more detailed (including data from individual trading partners) and up to date than FAO Fisheries Commodities and Trade data and were therefore selected for analysis especially for the period 2012–2016. UN Comtrade data do not differentiate the various life stages of eels. Taiwan data are reported under "Other Asia *nes*" in UN Comtrade[67].

East Asia and other Customs data

Customs import and export data for live, fresh, frozen and prepared/preserved *Anguilla* eel for East Asian countries/territories for 2008–2017 were obtained through the following sources:

- China Customs Information Centre (data requested via China Cuslink Co. Ltd.);
- Hong Kong Trade Development Council (http://bso.hktdc.com/bso/jsp/bso_home.jsp);
- Ministry of Finance, Trade Statistics of Japan (http://www.customs.go.jp/toukei/info/);
- South Korea International Trade Association (http://www.kita.org/); and
- Taiwan Bureau of Foreign Trade (http://cus93.trade.gov.tw/ENGLISH/FSCE/).

All East Asian countries/territories have adopted more detailed eel Customs codes in comparison to the global HS codes, differentiating between "live eel fry" for farming and "other live eel" for consumption purposes (except for Japan's live eel export Customs code); however, the definition of "live eel fry" varies between them. For example, in Japan, "live eel fry" refers to glass eels and elvers 13 g or less per specimen, however in South Korea, the term includes young eels up to 50 g per specimen (Table 2). Furthermore, South Korea differentiates between two different sizes of eel fry (by weight) and Taiwan differentiates between three sizes (by pieces per kg).
For this report, unless otherwise specified, the following terms apply:

- "live eel fry" refers to juvenile/young eels (irrespective of the size, including glass eels and elvers) used for farming; and
- "other live eel" refers to larger sized eels used for consumption (including large elvers, yellow and silver eels).

[67] https://unstats.un.org/unsd/tradekb/Knowledgebase/50104/Taiwan-Province-of-China-Trade-data?Keywords=Taiwan Accessed 6th March 2018.

Table 2: Customs codes and descriptions of live Anguilla eels in East Asia

	Customs Code	Commodity
China[68]	0301.92.10.10	Live eel fry of Marbled Eel *Anguilla marmorata*
	0301.92.10.20	Live eel fry of European Eel *Anguilla anguilla*
	0301.92.10.90	Live eel fry, other *Anguilla* spp.
	0301.92.90.10	Live eels, other than fry of *Anguilla marmorata*
	0301.92.90.20	Live eels, other than fry of *Anguilla anguilla*
	0301.92.90.90	Live eels, other than fry of other *Anguilla* spp.
Japan	0301.92.10.0	Live eel fry "*Anguilla* spp." (only used for imports)
	0301.92.20.0	Live eels, other than fry of *Anguilla* spp. (only used for imports)
	0301.92.00.0	Live eel of *Anguilla* spp. (only used for exports)
South Korea	0301.92.10.00	Glass eel (≤0.3 g per unit, for aquaculture)
	0301.92.20.00	Young eel (>0.3 g and ≤50 g per unit, for aquaculture)
	0301.92.90.00	Live eels, other than fry of *Anguilla* spp.
Hong Kong	0301.92.10	Live eel fry "*Anguilla* spp."
	0301.92.90	Live eels, other than fry of *Anguilla* spp.
Taiwan	0301.92.10.10-1	Eels, *Anguilla japonica*, live
	0301.92.10.20-9	Eels, *Anguilla marmorata*, live
	0301.92.10.90-4	Other eels (*Anguilla* spp.), live
	0301.92.20.10-9	Glass eel (=>5000 pcs per kg)
	0301.92.20.20-7	Eel fry (=>500 and <5000 pcs per kg)
	0301.92.20.30-5	Young eel (elver) (>10 and <500 pcs per kg)

Source: Editorial Department of the Customs Import and Export Tariff of China (2016); Hong Kong Census and Statistics Department; Ministry of Finance, Trade Statistics of Japan; Korea International Trade Association; Taiwan Bureau of Foreign Trade. Note: mainland China uses 10-digit codes for Tariff purposes, but only 8-digit data (non-species-specific) are available for analysis.

Hong Kong Special Administrative Region of the People's Republic of China (hereafter Hong Kong) plays a crucial role as an eel trade hub, in particular for live eel fry. Hong Kong is sometimes described as the source of live eel fry in East Asian Customs data, which obscures their actual source as there are no glass eel fisheries or eel farms in Hong Kong (Agriculture, Fisheries and Conservation Department of the Hong Kong Special Administrative Region (AFCD), pers. comm. to TRAFFIC, November 2017) and these are re-exports. Live eel fry data describing Hong Kong as the source have been excluded from analysis in this report in order to minimise double-counting, unless otherwise specified. Of two types of import data (by origin and by supplier) available in Hong Kong, origin data were used for this report, unless otherwise specified.
Other national sources were also analysed if *Anguilla* production/trade data were available (e.g. New Zealand).

2014 “Joint Statement” and 2017 “Joint Press release”

Live eel fry input into farms for 2004–2017 was provided by mainland China, Japan, South Korea and Taiwan as per the “Joint Statement on International Cooperation for Conservation and Management

[68] Only 8-digit Customs code data are made available to the public (China Customs Information Center and China Cuslink Company, Ltd., *in litt.* to TRAFFIC, March 2018)

of *A. japonica* and other relevant *Anguilla* spp." (http://www.jfa.maff.go.jp/j/saibai/pdf/140917unagi_data.pdf) in September 2014 and the "Joint Press Release on the occasion of the Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species (https://cites.org/sites/default/files/eng/com/ac/29/inf/E-AC29-Inf-13.pdf)" in July 2017. Live eel fry input data for 2007–2017 are presented in the Annex. Input is used to describe the supply of live eel fry into grow-out eel farms. Mainland China, Japan, South Korea and Taiwan are trying to manage eel resources by setting input limits rather than catch limits (see Joint Statement).

Business-to-Business Trade Platforms

English language versions of Global Business to Business (B2B) trade platforms Alibaba[69], EC21[70], Food & Beverage (F&B) Online[71] and Weiku[72] were searched for "glass eel" advertisements and individual *Anguilla* species in March and April 2018. The search results were filtered according to product types (to exclude non-*Anguilla* products) and the location of suppliers, product origin, species offered, and availability (by quantity and month). The aim was to obtain qualitative information as it was difficult to determine if all the advertisements were recent without publication dates.

Where price information is given below, average annual exchange rates for Chinese Yuan (CNY), Japanese Yen (JPY), Korean Won (KRW) and Canadian Dollars (CAD) to US Dollars (USD) were taken from the World Bank[73] up to 2017 and from OANDA[74] for 2018.

[69] http://www.alibaba.com/
[70] http://www.ec21.com/
[71] http://www.21food.com/
[72] http://www.weiku.com/
[73] https://data.worldbank.org/indicator/PA.NUS.FCRF
[74] https://www.oanda.com/currency/converter/

2. Global *Anguilla* eel production and trade

2.1 Global *Anguilla* production/supply to farms

According to FAO data, global eel production steadily increased over the decades and reached over 290,000 t in 2016, due to the expansion of farming, which accounted for 98% of total production that year. Figure 2: Global Anguilla production, highlighting farming production in East Asian countries/territories, 1950–2016, t. shows the importance of eel farming production particularly in East Asia. Mainland China has played an increasingly important role in eel farming since the 1990s, with production rising steadily and reaching over 240,000 t in 2016 (FAO, 2018). According to FAO data, mainland China was responsible for nearly 86% of the global eel farming production in 2016.

However, according to the farming production data in the "Joint Statement on International Cooperation for Conservation and Management of *A. japonica* and other relevant *Anguilla* spp.", released in September 2014 (hereafter referred to as the Joint Statement), mainland China's farming production was 35,480 t in 2012 and 56,000 t in 2013, substantially less that the total farmed production reported to FAO (212,464 t in 2012 and 206,026 t in 2013). If FAO farming production data were replaced with the data provided in the statement, global eel production would be only ~82,000 and ~97,000 t in 2012 and 2013 respectively (Shiraishi and Crook, 2015).

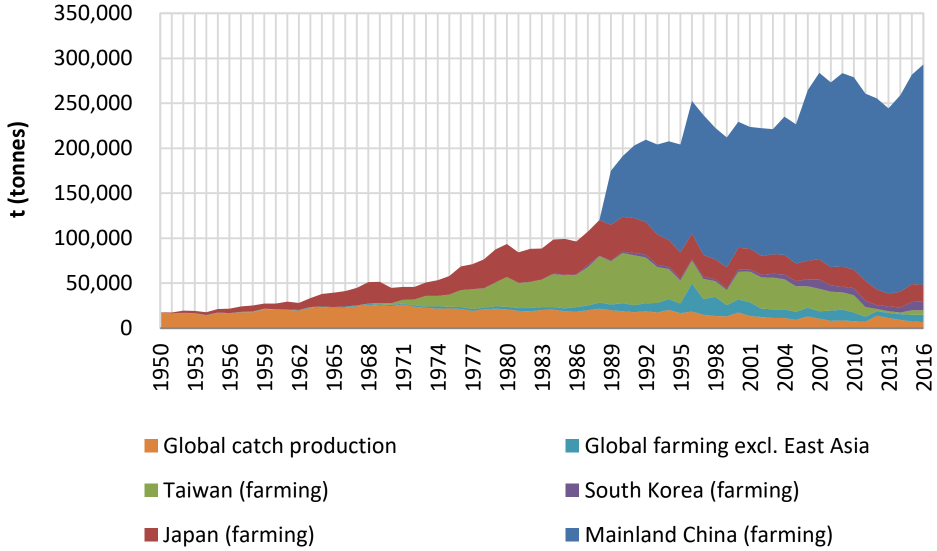


Figure 1: Global Anguilla *production, highlighting farming production in East Asian countries/territories, 1950–2016, t.*

Source: FAO Fisheries Production.

Eel farming is reliant on wild-caught juvenile eels (mainly glass eels or elvers, hereafter live eel fry), as breeding in captivity is not yet commercially viable. Eel farms therefore need to obtain juvenile eels as "seed". Although the main species used for farming in East Asia is Japanese Eel *A. japonica*, which is native to the region, demand for eel seeds and population declines has led to the use of other *Anguilla* spp. including European Eel *A. anguilla*, American Eel *A. rostrata* from 1990s onwards and *A. bicolor* in recent years (Crook and Namamura, 2013; Shiraishi and Crook, 2015).

According to Customs data from mainland China, Japan, South Korea, Hong Kong and Taiwan, imports of live eel fry into these countries/territories steadily decreased from 170 t in 2005 to 66 t in 2017 (with imports from Hong Kong excluded to avoid double counting – see below).

Changes in "source" regions of live eel fry imported into East Asia during 2004–2017 are shown in Figure 2 in order to illustrate the trends after the CITES listing came into force in March 2009 and trade in *A. anguilla* to and from the EU was banned in December 2010. Annual imports from Europe and

North Africa (likely to be *A. anguilla*), which accounted for 44% of all live eel fry imports (53 t) as reported by East Asia in 2004, declined gradually with some fluctuations; imports declined to 9 t in 2009 and increased in 2010 (~28 t), dropping again to less than 10 t during 2011–2015. Recorded imports into East Asia from *A. anguilla* range States were less than 1 t in 2017 after exceeding 10 t in 2016.

Imports from the Americas (likely to be *A. rostrata*) and South East/South Asia (likely to be *A. bicolor* and other tropical *Anguilla* species) increased in 2012 and 2013, accounting for more than 80% of annual non-*japonica* imports from 2011 onwards. Korean Customs data for 2013 suggest that South Korea is one of the most important East Asia destinations for live eel fry of tropical *Anguilla* species (Crook, 2014). While farming techniques were successfully developed for *A. rostrata* in mainland China (Moriyama, 2017), farming techniques for *A. bicolor* and other species are still being tested (Fan and Qin, 2016). While imports from Americas remained high up to 2017, those from South East/South Asia decreased considerably from 26 t in 2016 to 10 t in 2017, which suggests there is still high demand for *A. rostrata* whereas demand for *A. bicolor* and other tropical eels declined.

Figure 2 suggests that the quantities of live eel fry imported into East Asia varied depending on the quantity of glass eel farming input of *A. japonica* in East Asia. When harvest of *A. japonica* was good, imports of non-*japonica Anguilla* species were less (e.g. in 2009, 2014) whereas when harvest of *A. japonica* was poor, imports of non-*japonica Anguilla* species tended to be high (e.g. in 2008, 2010-2013). The working group of the CITES International technical workshop on eels (*Anguilla* spp.) held in the UK on 18-20th April 2018 noted that while demand for *A. rostrata* seems to have increased due to the CITES listing of *A. anguilla* coming into force in 2009, increase in demand for *A. bicolor* in 2012 and 2013 is likely to have to do with low harvest of *A. japonica*.

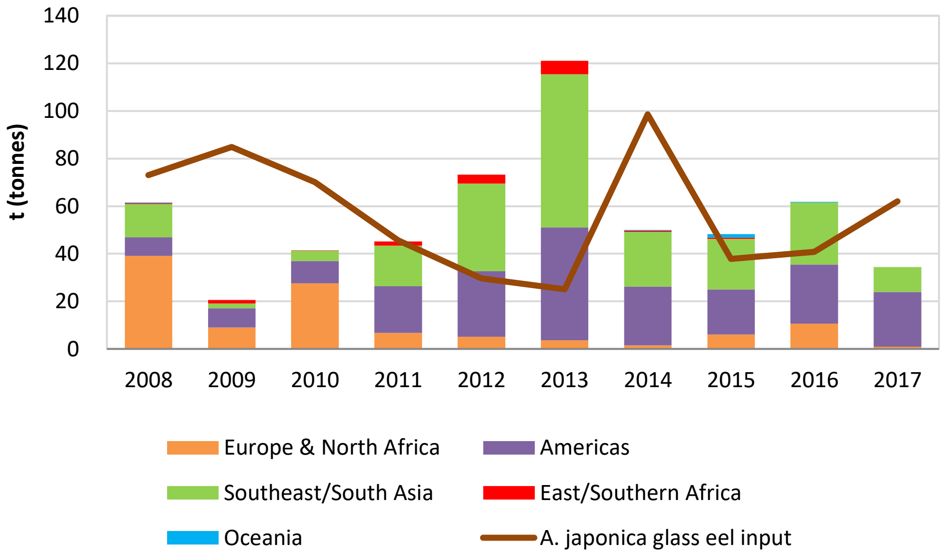


Figure 2: Imports of live eel fry for farming (all sizes) into East Asia and A. japonica glass eel input, 2004-2017, t.

*Note: **Europe and North Africa** (likely to be* A. anguilla*): France, Spain, the United Kingdom, Denmark, Belgium, Italy, Ireland, Romania, Greece, Morocco, Tunisia, Egypt and Algeria; **Americas** (likely to be* A. rostrata*): Canada, the USA, Haiti, Dominican Republic and Cuba; **South East Asia** (likely to be* A. bicolor *and other tropical* Anguilla *species): Indonesia, Philippines, Malaysia, Viet Nam, Thailand, Bangladesh, Timor Leste and Singapore; **East/Southern Africa** (likely to be* A. mossambica *and other tropical species): Madagascar, Mauritius and South Africa; **Oceania** (likely to be* A. australis*): Australia.*
Source: East Asian Customs, Joint Press Release, Joint Statement and Nihon Yoshoku Shimbun.

Mainland China, Japan, South Korea and Taiwan agreed to set an upper limit on glass eel input used for farming in each country/territory in 2014. Table 3 shows glass eel input in these countries/territories from 2008 to 2016. In the Joint Statement, they agreed that *A. japonica* glass eel input for 2014–2015 (and onwards) should be no more than 80% of that in 2013–2014 and for *Anguilla* species other than *A. japonica* "to take every possible measure not to increase the amount of initial input of eel seeds from the recent level (the last three years).” As Table 3 suggests, mainland China’s glass eel input for other *Anguilla* species for 2014–2015 (35.5 t) and 2015–2016 (39.5 t) exceeded the upper limit (32 t) (highlighted in grey in Table 3). A criticism of the quota is that the upper limit for *A. japonica* was calculated based on the year the glass eel recruitment was particularly good (see Figure 2) (Matayoshi and Tano, 2014). Additionally, the input for 2014 was reported to be higher than the actual input in Japan (Tano, 2018) and in mainland China by 10 t (Anon, 2014).

Table 3: glass eel input in mainland China, Japan, South Korea and Taiwan from 2008 to 2016 and the upper limit of glass eel input agreed in the Joint Statement in 2014, t.

Species	Country / territory	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	upper limit
A. japonica	China	9.0	26.5	10.5	8.0	7.0	45.0	9.3	8.2	36.0
	Japan	28.9	19.9	21.8	15.9	12.6	27.1	18.3	19.7	21.7
	South Korea	22.0	10.6	9.5	3.6	3.0	13.9	7.4	9.3	11.1
	Taiwan	25.0	13.1	3.8	2.2	1.5	12.5	2.8	3.6	10.0
***A. japonica* total**		**84.9**	**70.1**	**45.6**	**29.7**	**24.1**	**98.5**	**37.8**	**40.8**	**78.8**
Other *Anguilla* spp.	China	48.8	17.1	31	14.5	20	32	35.5	39.5	32.0
	Japan	0.1	0.03	0.01	0.4	1.3	3.5	0.0	0.2	3.5
	South Korea	1.5	1.5	1.6	6	13.1	2.9	5.1	3.7	13.1
	Taiwan				5.5	10.0	1.5	0.2	0.08	10.0
Other *Anguilla* spp. total		**50.4**	**18.63**	**32.61**	**26.4**	**44.4**	**39.9**	**40.8**	**43.48**	**58.6**

Source: Joint Statement, Joint Press Release and Fisheries Agency of Japan (2018).

Hong Kong has played an increasingly important role in trade of live eel fry over the decades. Imports into other East Asian countries/territories from Hong Kong increased from 4.5 t in 2004 to 24.6 t in 2008, reaching a peak of 43 t in 2016 (Table 4). As glass eel fishing or eel farming does not exist in Hong Kong (AFCD, pers. comm. to TRAFFIC, November 2017), Hong Kong is considered to be used as a transit point for trade in *Anguilla* spp. to East Asia for farming. Although the quantities of live eel fry imported into Hong Kong from various countries/territories exceeded imports from Hong Kong as reported by other East Asian countries/territories until 2015, reported imports from Hong Kong were higher in 2016 by 9.1 t and in 2017 by 3-9 t (Table 4).

Table 4: Imports of live eel fry into mainland China, Japan, South Korea and Taiwan from Hong Kong and imports into Hong Kong from various countries/territories, 2008–2017, t.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Imports of live eel fry into mainland China, Japan, South Korea and Taiwan from Hong Kong (a)	24.6	23.2	24.8	20.2	14.3	21.1	32.7	26.5	42.9	28.6
Imports of live eel fry into Hong Kong from various countries/territories (b)	63.5	55.0	54.5	32.1	57.2	59.3	41.5	30.7	33.8	25.6
(b) – (a)	38.9	31.9	29.7	11.9	42.9	38.2	8.8	4.2	-9.1	-3.1

Source: East Asian Customs.

A number of offers for sale of *Anguilla* glass eels were found on Business to Business (B2B) trade platforms (Alibaba, EC21, F&B Online and Weiku) in April 2018 although many advertisements did not provide publication dates so it was difficult to determine if they were recent. However, approximately

80% of supplier locations on these B2B platforms were South East/South Asia and the Americas. Whereas advertisements from the Americas only mentioned *A. rostrata* glass eels, those from South East Asia offered several species including *A. bicolor*, *A. japonica* and *A. marmorata*. Recent research suggests that *A. japonica* is a scarce native species in the northern Philippines (SEAFDEC, unpublished data, 2018; Shirotori *et al*., 2016; Yoshinaga *et al*., 2014).

According to the ''Joint Press Release on the occasion of the Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species" (hereafter referred to as the Joint Press Release), released in July 2017, the number of eel farming operators in mainland China declined from 810 in 2009 to 405 in 2011, then increased to 797 in 2017 (Table 5). In South Korea, there was a slight increase in farming operators during 2009–2016, reaching a peak of 564 in 2015. These data suggest that the number of eel operators in East Asia has not declined despite *A. japonica* glass eel resource depletion during the period.

Table 5: Number of eel farming operators in mainland China, Japan and South Korea, 2009–2017.

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
China	810	766	405	465	558	687	696	772	797
Japan	-	-	-	-	384	-	-	-	*520
South Korea	508	521	523	524	532	536	564	542	

Note: The number of eel farming operators in Taiwan is not available.
*Source: Joint Press Release and * Fisheries Agency of Japan (2018).*

2.1 Global *Anguilla* trade

Live, fresh, frozen and prepared *Anguilla* eels are traded globally. According to FAO and UN Comtrade, the volume of global live, fresh, frozen and prepared/preserved eel exports peaked at approximately 133,000 t in 2001, after which they declined to below 81,000 t in 2011 then increased slightly to approximately 90,000 t in 2013–2015. The export value of these commodities has steadily increased over the past 40 years, reaching USD ~1.6 billion in 2012. Of the four commodity types, live and prepared/preserved eel accounted for 80% of total exports by weight between 1988 and 2015.

The main eel exporter over the past decade has been mainland China, which accounted for 52% by weight and 71% by value of all eel exports during 2006–2015, with Japan the main importer, responsible for 54% and 72% of global eel imports by weight and value respectively during 2006–2015. While global reported exports of live, fresh, frozen and prepared eels for 2016 was approximately 93,000 t, the reported import quantity of those commodities for 2016 was 48,000 t. The discrepancy may be partially because some major exporters use the same Customs codes for *Anguilla* spp. as look-alikes (non-*Anguilla* spp. such as Swamp Eel *Monopterus albus*).

According to China Customs, exports of eel commodities (live, fresh, frozen and prepared eels) decreased to 37,100 t in 2013 after reached a peak of 81,800 t in 2001, increasing again to approximately 50,000 t in 2017. Prepared eels were the main export commodity, accounting for 71% of eel exports from mainland China in 2017.

Based on China Customs data, Japan has been the dominant importer of prepared/preserved eel from mainland China, accounting for 56% of all prepared eel exports from mainland China in 2017. At the same time, mainland China's number of trading partners increased steadily from 35 countries/territories in 2008 to 47 countries/territories in 2017, with the US and Russia becoming important destinations (Figure 3).

Figure 3: Prepared eel exports from mainland China in 2017, by weight.

Source: China Customs

3. Regional reports

3.1 East Asia - *A. japonica* (Japanese Eel)

3.1.1 *Anguilla* farming production and supply for eel farms

A. japonica and (and some tropical species in southern parts) are native to East Asia, however nearly all harvest, trade and farming focuses on *A. japonica* – *A. marmorata* will be discussed in more detail under the South East Asia region.

Together with *A. anguilla*, *A. japonica* has one of the longest histories of fishing, stocking and farming for consumption purposes of any *Anguilla* species (Jacoby and Gollock, 2014). *A. japonica* has been caught throughout its range, predominantly in Japan, mainland China, South Korea and Taiwan, with large eels caught destined directly for consumption or small eels destined for farming (Ringuet *et al*., 2002). Globally, these are also the main eel farming, trading and consuming countries/territories, with Japan in particular having a long tradition of consumption of *A. japonica* eels. An increase in demand and declines in the availability of *A. japonica* glass eels in the 1990s, however, resulted in *A. anguilla* and more recently some other *Anguilla* species being stocked for farming (Crook and Nakamura, 2013). However, *A. japonica* is still the preferred species for farming in the region, and high demand for this declining resource has resulted in dramatic increases in the price of glass eels over the last decade. According to FAO, global *A. japonica* catch production steadily declined over recent decades from more than 2000 t in 1986 to 136 t in 2016 (reported only by Japan and South Korea in 2016). These catches are considered not to include glass eels.

Annual *A. japonica* glass eel input into farms in mainland China, Japan, South Korea and Taiwan has decreased over the years with some fluctuations during 2004–2017 (Figure 4). *A. japonica* glass eel input was low for four consecutive years from 2009–2010 to 2012–2013 due to poor catch (Mochioka, 2014), which seems to have resulted in stocking other *Anguilla* species.

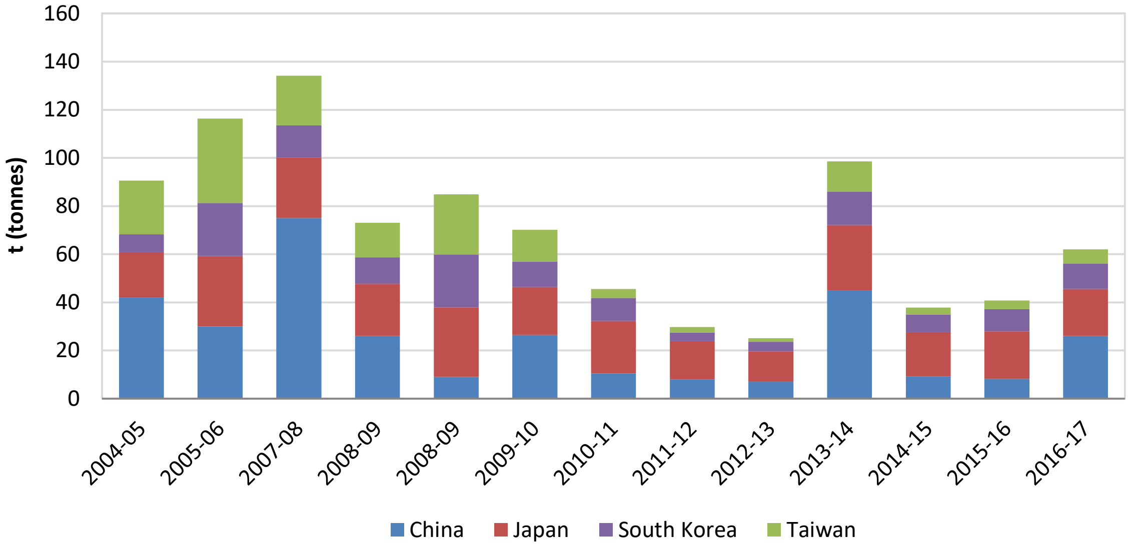


Figure 4: Annual A. japonica glass eel input in China, Japan, South Korea and Taiwan, 2004-2017, t.

Source: Joint Statement, Joint Press Release and Anon (2017a).

The average price per kilo of *A. japonica* glass eels traded in Japan is shown in Figure 5. The average price increased ten-fold from JPY270,000 (USD2,322)/kg in 2005–2006 to JPY2,480,000 (USD25,411)/kg in 2012–2013, after which it declined slightly to less than JPY920,000 (USD8,684)/kg in 2013–2014, then increased again above JPY1,000,000 (USD9,700–16,800) per kilo between 2014–2015 and 2016–2017 (See Figure 5).

The average price is considered to have surged again in 2017–2018 due to poor harvest in the region; *A. japonica* live eel fry was trading at JPY3,600,000 (USD32,520) per kilo as of 17th January 2018 in Japan (Anon, 2018). According to Japan Customs, Japan imported 2.6 t of live eel fry from Hong Kong in February 2018 costing approximately JPY3,850,000 (USD36,341)/kg. This equates to an estimated JPY770 (USD 7.2) per *A. japonica* glass eel if there are 5,000 eels per kilo, each weighing 0.2 g.

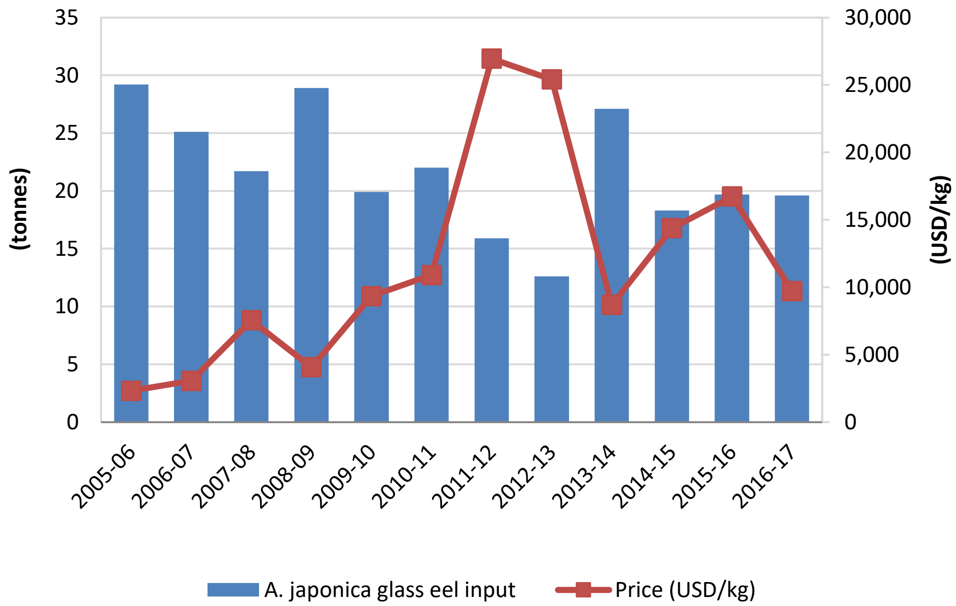


Figure 5: A. japonica *glass eel input and traded price in Japan, 2006–2017.*

Source: Fisheries Agency of Japan (2018)

3.1.2 Trade in *A. japonica* within East Asia and possible illegal trade

According to East Asian Customs, imports of live eel fry from mainland China, Japan, South Korea and Taiwan into these countries/territories reached a peak around at 105 t in 2009, after which they dropped to less than 7 t in 2013, increasing slightly again and ranging between 20 and 35 t in 2015–2017. Taiwan's imports accounted for 63% of all imports of live eel fry among these destinations during 2008–2017, most of which were young eels (between 11 and 500 eels per kg) imported from Japan. Up to 2010 Hong Kong also played an important import role, importing 39–47 t of live eel fry from mainland China during 2008–2010.

Despite the reported volume of live eel fry traded within East Asia, the full scale of *A. japonica* trade is unknown as a large number of *A. japonica* glass eels are considered to be traded via Hong Kong together with other *Anguilla* species. Imports into other East Asian countries/territories from Hong Kong increased from 22.5 t in 2008 to 43 t in 2016.

According to the Joint Press Release, approximately 230 t of *A. japonica* glass eels were harvested in East Asia between the 2011–2012 and 2015–2016 fishing seasons, with mainland China accounting for 61% of *A. japonica* glass eel harvesting in the region (Figure 6). Approximately the same amount of *A. japonica* (234 t) was input into eel farms in East Asia during the period, with Japan being the dominant user. Estimated *A. japonica* glass eel imports during the period were Japan (33 t), South Korea (23 t) and Taiwan (7.3 t), while mainland China's glass eel input was much lower than its glass eel harvest (by 66.5 t).

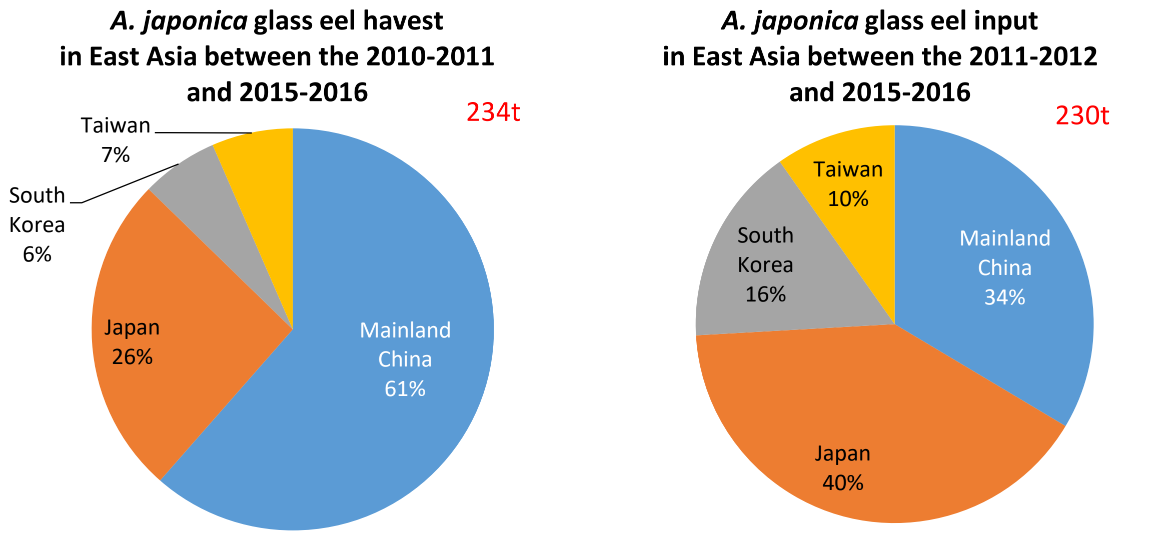


Figure 6: A. japonica *glass eel harvest and input in East Asia, 2011–2016, t.*

Source: Joint Press Release (2017).

As Japan does not have a Customs code for live eel fry exports, their quantity is not available in the Customs data, although Customs data from mainland China, South Korea and Taiwan's suggest that their combined live eel fry exports was always less than 3.5 t (including young eels) per year during 2008–2017 with none exported in 2015 and 2017 (Table 6). Exports of glass eels are strictly regulated in mainland China, Japan and Taiwan as *A. japonica* as they are important resources for eel farming. In Japan, exports of live eel fry between December and March are banned and exports between April and November need to be approved by authorities. In Taiwan, exports of all sizes of eel fry between November and March have been banned since October 2007. High tariffs (20%) are imposed on glass eel exports in mainland China[75] and based on China Customs data, annual exports of live eel fry were less than 700 kg between 2008 and 2017.

[75] http://www.qgtong.com/so/?ChannelID=1001&ArticleID=44134&keyword=030192

Table 6: Anguilla live eel fry exports from China, South Korea and Taiwan, 2008-2017, kg.

Exporter	Destination	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
China	Hong Kong	618	385	105						1	
	Japan			1				0**			
	Taiwan				60			1			
South Korea	Hong Kong		260					50		93	
	Japan	480		283							
	Taiwan		10					3,262 *		45	
Taiwan	Japan	935			14	262	2050*				
	Hong Kong	0			38	976	16	150		101	
Total		**2,033**	**655**	**389**	**112**	**1,238**	**2,066**	**3,463**	**0**	**240**	**0**

*Exports of young eels (>0.3 g and ≤50 g per unit, for aquaculture). ** Export quantity was less than 1 kg.
Source: East Asian Customs data.

This suggests that glass eels may be illegally exported from mainland China to other countries/territories as some sources claim (Ministry of Commerce of the People's Republic of China, 2016; Zou, 2017). However, trade in *A. japonica* glass eels within East Asia might be more complicated as illegal trade of glass eels from Taiwan to Japan (through Hong Kong) is also said to be prevalent (Anon., 2016; Noshima, 2018; Suzuki *et al*., 2015). Although Hong Kong is used as a transit hub, it is difficult for authorities there to take additional measures to combat illegal trade in *A. japonica* and other *Anguilla* species unless they are CITES listed (ADCD, pers. comm. to TRAFFIC, November 2017).
It should be noted that China reported exporting 9.5–19 t of *A. japonica* glass eels each year between 2009 and 2017 in the Joint Press Release, although this was not reflected in the Customs statistics (Table 7). The exports based on Joint Press Release were less than imports reported by other East Asian countries/territories (mainly Hong Kong) during 2009-2010 (40-46 t) and much more than those reported by other East Asian countries/territories in 2011-2017 (between zero and 4.2 t). It would be important to establish the reasons for these discrepancies, which may include illegal and unreported fishing and trade.
Table 7: *A. japonica* glass eel exports from mainland China, live eel fry exports from mainland China and live eel fry imports from mainland China reported by East Asian countries/territories from various sources, 2009–2017, t.

	2009	2010	2011	2012	2013	2014	2015	2016	2017
A. japonica glass eel exports from mainland China, **Joint Press Release data**	18.0	14.0	19.0	14.0	9.5	10.0	11.2	12.8	10.0
Live eel fry exports from mainland China, **China Customs data**	0.4	0.1	0.1			0.0		0.0	
Live eel fry imports from mainland China into East Asia, **East Asian Customs data**	47.1	40.4	3.1	0.7	2.4	4.2	0.8		

Note: Values of 0.0 refer to unit value of less than 50 kg.
Source: East Asian Customs data and Joint Press Release

Table 8 shows exports of live eel fry from Japan based on Joint Press Release data and imports of live eel fry from Japan as reported by other East Asian countries/territories. It indicates that imports exceeded exports by more than 17 t in 2011 while exports exceeded imports by 4–5 t in 2015 and 2016. Other years are not directly comparable as the Joint Press Release includes quantities recorded by weight (t) and number of eels. A close examination of monthly East Asian Customs import data and relevant data held by the Japanese government for approval of live eel fry exports should be carried out in order to detect possible illegal exports.

Table 8: Live eel fry exports from Japan and live eel fry imports from Japan reported by East Asia, 2009–2017.

	Unit	2009	2010	2011	2012	2013	2014	2015	2016	2017
Exports of live eel fry from Japan, **Joint Press Release data**	t	17.8	4.6	9.6	5.7	1.6	30.2	25.9	23.7	5.3*
	No.	2,891,536	1,175,730	0	133,668	0	14,561,000	-	-	-
Live eel fry imports from Japan, **East Asian Customs data**	t	57.9	23.4	27.4	5.2	2.1	33.3	20.4	19.7	31.5

*Data for 2017 are preliminary (up to June 2017).
Source: East Asian Customs data and Joint Press Release

3.1.3 Illegal trade and use

Illegal fishing and trade mainly in glass eels still remain a big problem in East Asia. According to Japan Customs, an average of 7.4 t of glass eels was imported into Japan from Hong Kong during 2008–2017. Glass eel imports into Japan are considered to be mostly *A. japonica*, with a considerable proportion derived from Hong Kong where there are no glass eel fisheries – therefore all outward trade from Hong Kong is re-exports. Glass eels imports by Hong Kong from mainland China, South Korea and Taiwan, where *A. japonica* might conceivably be sourced, were not correspondingly reported as exports by these countries/territories. In addition, large discrepancies between domestic glass eel catch and glass eel input suggest that illegal or unreported glass eel catch potentially accounted for 43–63% of total glass eel catch in Japan (Figure 7). During 2014–2015 to 2016–2017, 57–69% of glass eels input into farms in Japan (11–12 t) were estimated to be sourced from illegal or unreported fishing and/or through illegal trade.

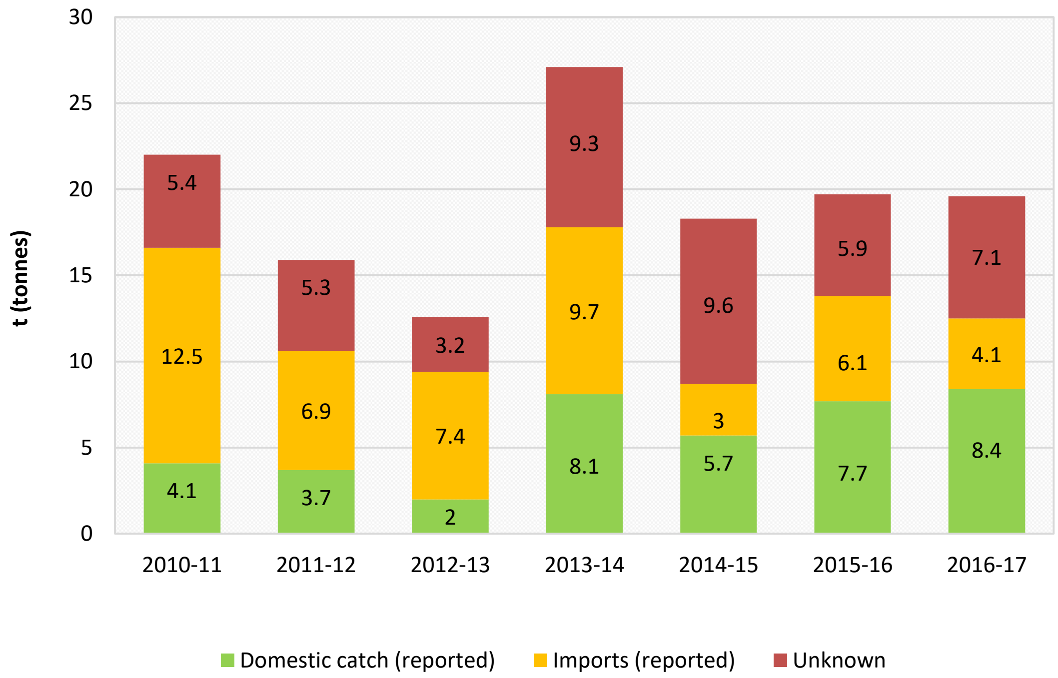


Figure 7: A. japonica *glass eel input for eel farms by source, 2010–2017, t.*

Note: Green indicates reported domestic catch, yellow indicates reported imports and red is from unknown potentially illegal sources (illegal harvest and import), as estimated from input and reported catch and imports.
Source: Fisheries Agency of Japan (2018).

A considerable number of glass eels are believed to be smuggled from Taiwan mainly to Japan after Taiwan banned the exports of live eel fry during the 2007 fishing season a ban that remains in place to this day. Glass eels caught in the early recruitment season in Taiwan are desirable for input by some Japanese eel farms (Hong, 2018). Taiwan Customs seized 320,000 *A. japonica* glass eels in 128 bags from check-in baggage from eight people at Taiwan Taoyuan International Airport in November 2016, which were bound for Hong Kong (Anon, 2016a). Media reported one of the trade routes through which glass eels are smuggled is Kinmen, Xiamen, and Hong Kong to Japan (Anon, 2016; Hong, 2018). Illegal fishing still exists in mainland China too (Zou, 2017). In April 2018, 32 suspects were arrested by police in Jingjiang City, Jiangsu Province for illegal harvest of glass eels. This group was involved in harvesting, collecting and selling glass eels; the collectors purchased glass eels from fishermen at CNY22–27 (USD3.5–4.3) per eel then sold them to wholesalers for 30% more than the purchase price (Ding, 2018). An estimated 7 t of elvers were smuggled to Japan and South Korea in 2011[76].

In South Korea, about 50 people were found to be engaged in illegal glass eel fishing in the Han river in 2013 (Seong and Hee, 2013). The president of a company was charged with purchasing 500,000 eels at KRW1 billion (USD913,000) that were illegally caught in rivers and selling them in 2017 (Anon., 2017b).

3.2 Americas - *A. rostrata* (American Eel)

For the purposes of this analysis the following countries/territories are considered to be *Anguilla rostrata* range States:

Anguilla, Antigua and Barbuda, Aruba; Bahamas, Barbados, Belize, Bermuda, Bonaire, Saint Eustatius and Saba; Canada, Cayman Islands, Colombia, Costa Rica, Cuba, Curaçao; Dominica, Dominican Republic; Greenland, Grenada, Guadeloupe; Haiti, Honduras; Jamaica; Martinique, Mexico, Montserrat; Nicaragua; Panama, Puerto Rico; Saint Barthélemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Saint Maarten; Trinidad and Tobago, Turks and Caicos Islands; USA; Venezuela and the Virgin Islands.

A. rostrata was analysed in more detail due to the increasing demand for this species in particular.

3.2.1 Anguilla rostrata production (FAO)

According to FAO production data, the USA (since 1950), Canada (since 1956), Mexico (since 1975), Cuba (since 1989), and the Dominican Republic (since 1995) have reported catch production of *Anguilla* spp. (assumed to be *Anguilla rostrata*). The Dominican Republic is the only American Eel range State to report farming production, starting in 1988, reaching 49 t in 1994 and dropping to zero during 1996–2016. Canada and the USA accounted for 93% of reported *Anguilla* catch production from *A. rostrata* range States during 2007–2016. Annual catch production in these countries exceeded 2600 t in 1975, after which it declined (with fluctuations) and ranged around 700–1200 t over the decade 2007–2016 (Figure 8). FAO catch production data do not differentiate life stages.

[76] "The hometown of eels in China" faces many challenges, how to save it? ("中国鳗鱼之乡"潜伏危机重重 要拿什么拯救). http://www.daynew.cc/CN/news/Sub.htm/2807

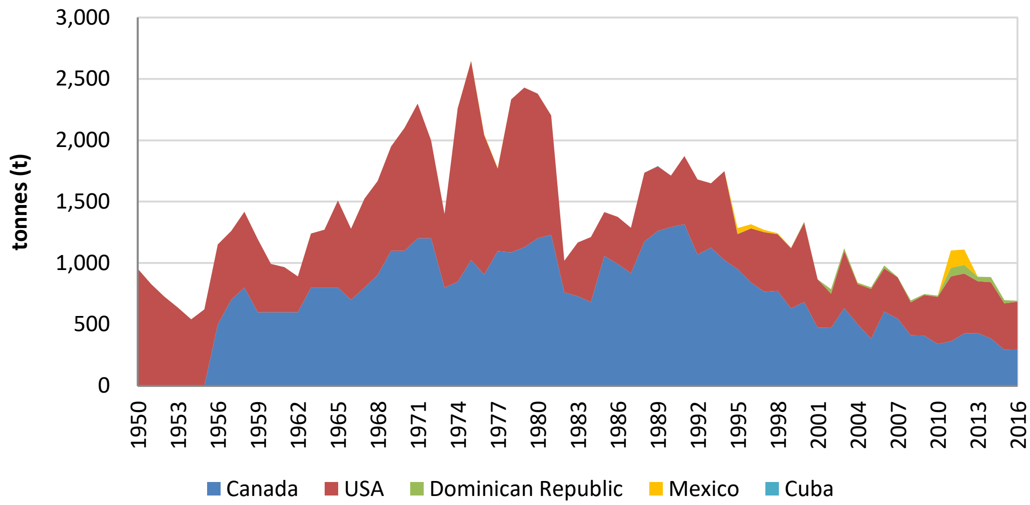


Figure 8: A. rostrata *catch production, by weight (t), 1950–2016.*

Source: FAO (2018).

3.2.2 Global *Anguilla* trade from *A. rostrata* range States (UN Comtrade)

According to data reported to UN Comtrade, exports of eel commodities (live, fresh, frozen and prepared eel) from *A. rostrata* range States gradually decreased over the last decade; they reached a peak of 4,113 t in 2011 (excluding prepared eels, as the global HS code was only introduced in 2012) and declined to 2,200 t in 2015. This overall decrease is due to a decline in exports of frozen eels from these countries over the years; live eel exports on the other hand increased from ~370 t in 2008 to over 1,200 t in 2013–2015. Canada and the USA accounted for 98% of all live eel exports from *A. rostrata* range States during 2007–2016. Panama and Costa Rica reported exporting ~50–85 t each in 2007–2012 (although these are range States for *A. rostrata* this is likely to involve Red Pike Conger eel, see look-alike section below, the Dominican Republic reported exporting live eels in 2007: there was then a gap until 2011, after which exports were consistently reported) and Jamaica since 2014. Live eel exports from the Dominican Republic reached over 4.5 t in 2013, after which exports dropped to less than 3 t during 2014–2016 (Table 9). It is important to note that two *A. rostrata* range States that are known to be involved in eel trade (see section 3) have not reported any trade of any commodity to UN Comtrade since 1994 (Haiti) and since 2007 (Cuba).

While the average price per kilo of live eels exported from the USA saw no significant change over the years (being less than USD45/kg), the average price of live eels exported from Canada increased from USD7/kg in 2009 to USD165/kg in 2012, and those from the Dominican Republic and Jamaica reached over USD1,000/kg in 2015 and USD200/kg in 2016. This suggests that recent exports from Canada, the Dominican Republic and Jamaica included a significant proportion of the higher value life stages (live eel fry or glass eels/elvers). Experts at the American Eel range State workshop held in Santo Domingo on 4–6th April 2018 confirmed this—all *Anguilla* exports from the Dominican Republic and Jamaica were glass eels and Canada is an important transit hub for glass eels being exported from American Eel range States to Asia (see section 3 for more details). Exports from the Dominican Republic were 2.4 t in 2017 and 0.8 t in the first few months of 2018[77]. South Korea and Hong Kong were the main destinations of live eel exports from *A. rostrata* range States by weight and value, respectively, between 2007 and 2016.

[77] Presentations by range States at the American Eel range State workshop held in Santo Domingo, 4–6th April 2018.

Table 9: Exports of live Anguilla *spp. from* A. rostrata *range States, as reported by weight (t), 2007–2016.*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
USA	355.7	368.7	284.5	260.7	476.1	628.4	1,041.6	1,181.0	1,114.3	
Canada	334.8		272.1	214.9	176.6	228.6	273.3	174.1	158.5	171.1
Costa Rica	1.0	0.8	15.2	28.1	28.2	8.9		1.1		
Panama					53.8					
Dominican Republic	0.6				1.4	1.6	4.7	1.6	1.3	2.8
Jamaica								0.0	0.0	0.1
Nicaragua		0.0						0.0		
Total	**692.1**	**369.5**	**571.8**	**503.7**	**736.1**	**867.4**	**1,319.6**	**1,357.8**	**1,274.2**	**174.0**

Note: Values of 0.0 refer to unit value of less than 50 kg. At the time of writing, the USA has not reported any live eel exports for 2016 by weight (only by value).
Source: UN Comtrade (2018).

In addition to exports, Canada, Jamaica and the USA reported re-exports of eel commodities in 2007–2016, with the USA being the principal re-exporter of live eels. As Table 10 shows, re-exports of live *Anguilla* spp. from the USA, Canada and Jamaica increased gradually and reached ~100 t in 2014, which suggests the USA and Canada currently play important roles as re-exporters (and importers, see below) of live eels. While the average price per kg of live eels re-exported from the USA was below USD35/kg (except for in 2012), live eels re-exported from Canada and Jamaica had an average price of USD200–350/kg. The majority of live eels re-exported from the USA and Canada during 2008–2015 were destined for East Asia, including Hong Kong, South Korea and mainland China. Jamaica did not report any live eel imports during 2012–2016, however live eels were re-exported to Canada in 2016.

Table 10: Re-exports of live Anguilla *spp. from* A. rostrata *range States, as reported by weight (t), 2007–2016.*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
USA	3.7	1.3		1.0	39.3	0.1	18.5	97.8	63.5	
Canada					1.7				2.6	1.1
Jamaica										0.1
Total	**3.7**	**1.3**	**0**	**1.0**	**41.0**	**0.1**	**18.5**	**97.8**	**66.1**	**1.2**

Note: At the time of writing, the USA has not reported any live eel re-exports for 2016 by weight (only by value).
Source: UN Comtrade (2018).

Imports of live *Anguilla* spp. into Canada and the USA from *A. rostrata* range States during 2008–2016 are shown in Table . The majority of live eel trade occurred between Canada and the USA, however imports have declined over the years; imports from the USA into Canada declined from 250 t in 2008 to 14 t in 2015 and imports from Canada into the USA declined from 142 t in 2008 to 35 t in 2015. Both Canada and the USA started to report imports of live eels from other *A. rostrata* range States from 2011 onwards; from Cuba in 2011, Haiti and Dominican Republic in 2013, and Dominica and Jamaica in 2014. The average price of live eels imported from these countries ranged between USD250/kg and USD1400/kg during 2014–2016 (highlighted in grey in Table), while the price of imported live eels traded between Canada and the USA was on average less than USD50/kg. This suggests that most imports from these emerging countries were likely to be live eel fry. According to UN Comtrade, in 2011–2016 live eel imports into Canada from Caribbean countries exceeded live eel re-exports from Canada; furthermore, East Asian Customs did not report any imports from Dominican Republic and Jamaica until 2017 (see Table 12 and Figure). Therefore, it is likely that some re-exports from Canada to East Asia of live eels originating in the Caribbean/Central America were in fact reported as exports originating in Canada (see section 3).

Table 11: Imports of live Anguilla *spp. from* A. rostrata *range States, as reported by Canada and the USA, by weight (t), 2007–2016.*

Importer	Source	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Canada	USA	124.9	250.3	98.9	117.8	114.6	57.9	23.7	8.7	14.0	13.5
	Cuba					3.2	13.2	4.8	1.5	2.0	0.1
	Haiti							2.2	8.6	6.9	2.8
	Dominican R.							0.7	1.0	2.9	1.9
	Dominica								0.0	0.2	0.0
	Jamaica										0.1
	Canada total	**124.9**	**250.3**	**98.9**	**117.8**	**117.9**	**71.1**	**31.4**	**19.8**	**26.0**	**18.4**
USA	Canada	225.8	141.9	166.2	69.7	4.3	15.8	10.9	20.8	35.0	
	Haiti							7.9			
	Dominican R.							3.3			
	Jamaica								0.0		
	USA total	**225.8**	**141.9**	**166.2**	**69.7**	**4.3**	**15.8**	**22.2**	**20.8**	**35.0**	**0.0**

Note: Values of 0.0 refer to unit value of less than 50 kg. Grey cells indicate the average price was over USD250/kg and may include trade in live eel fry. At the time of writing, the USA has not reported any live eel imports for 2016 by weight (only by value).
Source: UN Comtrade (2018).

3.2.3 East Asian imports and farming of *A. rostrata* from *A. rostrata* range States (East Asian Customs, glass eel/elver landings, farming input, B2B trade platforms)

i) Live eel fry supply and imports

According to East Asian Customs agencies, total East Asian imports of live eel fry from *A. rostrata* range States gradually increased from 2008, reached a peak around at 47 t in 2013 (when the annual input of *A. japonica* in East Asia was particularly low, ~25 t in total[78]), and ranged between 18 t and 25 t between 2014 and 2017 (Figure 9). South Korea's reported imports of live eel fry increased dramatically in 2013, mainly due to the import of ~17 t of larger sized young eels (not glass eels, see methods). Back and Park (2017) noted that although South Korean eel farmers have experimented with several *Anguilla* species as substitutes for *A. japonica*, including *A. anguilla*, *A. rostrata* and *A. bicolor,* only *A. bicolor* appears to be well suited to Korean eel farming methods. Hong Kong has been the principal importer every year; mainland China has not reported any glass eel imports from the Americas since 2015.

East Asian countries/territories imported more than 210 t of live eel fry from at least five countries in the Americas over the last decade (2008–2017), 95% of which came from Canada and the USA. Imports of live eel fry from Cuba and the Dominican Republic started in 2012, and from Haiti and Central America (unknown countries) in 2013 (Table 12). According to these data, Haiti has become the main supplier of life eel fry to East Asia from the Caribbean region since 2014 (1.5–2.4 t annually), while imports from the Dominican Republic and Cuba reached a peak of 1.5 t in 2013 and dropped to less than 0.3 t from 2014 onwards. It should be noted that Haiti has not reported any *Anguilla* spp. catch production to FAO, nor has Cuba since 1995.

[78] Joint Press Release on the occasion of the Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species (https://cites.org/sites/default/files/eng/com/ac/29/inf/E-AC29-Inf-13.pdf)

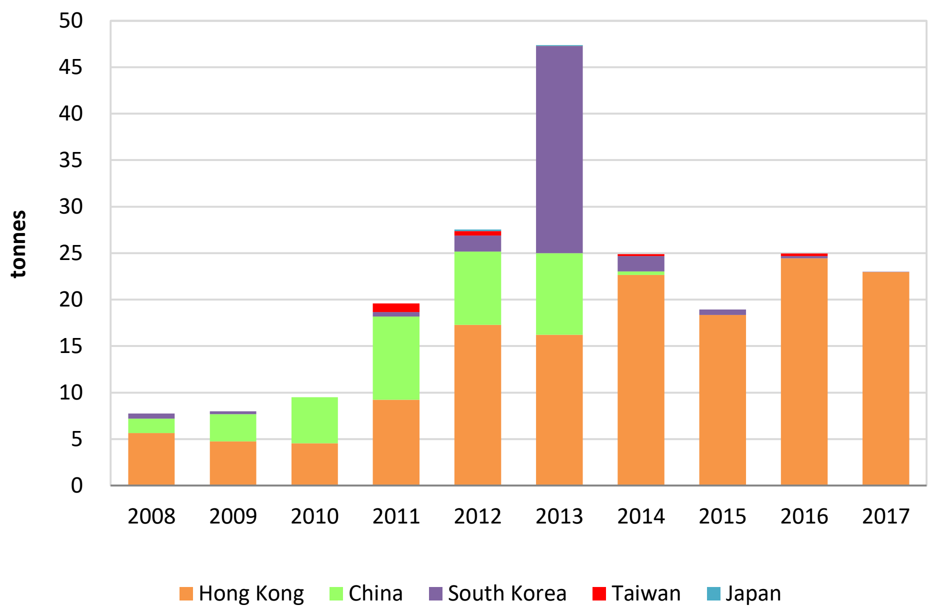


Figure 9: Annual imports of live eel fry into mainland China, Japan, South Korea, Hong Kong and Taiwan from A. rostrata *range States, by weight (t), 2008–2017.*

Source: East Asian Customs.

Table 12: Imports of live eel fry from A. rostrata *range States reported by East Asian Customs, kg, 2008–2017.*

Source	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Canada	5,420	6,536	8,146	13,836	14,751	18,609	10,904	7,403	8,221	9,134
USA	2,319	1,461	1,367	5,764	12,188	26,593	12,043	9,707	14,366	11,956
Haiti						626	1,476	1,704	2,340	1,908
Dominican R.					351	875	183	103	40	
Cuba					264	628	106			
C&S America						20	60			
Total	**7,739**	**7,997**	**9,513**	**19,600**	**27,554**	**47,351**	**24,772**	**18,917**	**24,967**	**22,998**

Note: C&S America indicates unknown Central/South American country.
Source: East Asian Customs.

Hong Kong import data are available in two formats – by origin (used for the principal analysis above) and supplier (i.e. (re-)exporting country/territory, which may be different from the commodity's origin). When comparing these two data sources, it becomes apparent that live eel fry originating in the Americas are traded via several other countries prior to reaching Hong Kong. For example, Hong Kong reported importing more than 630 kg and 580 kg of live eel fry originating in the USA, having been traded via Italy and the UK in February 2016 and via Japan and Italy in May 2016, respectively. Hong Kong data also suggest that some exports of live eel fry from the Caribbean and Central American countries are transited via the USA and Canada: Hong Kong imported 2,257 kg and 1,873 kg of live eel fry from Haiti in 2016 and 2017 respectively, 60% and 94% of which were reportedly traded via the USA and Canada (Table).

According to Hong Kong's monthly origin data for 2016 and 2017, imports from the USA and Canada between March and July (the principal glass eel/elver fishing season in these countries) accounted for less than 50% of total annual imports into Hong Kong from the USA and Canada in 2016 and 2017 (Figure 10). The remaining imports occurred in months outside the US and Canadian glass eel/elver fishing season; imports between October and February (the principal glass eel fishing season in the Caribbean and Central America) exceeded 10 t both in 2016 and 2017. This suggests that even more live eel fry caught in the Caribbean region are being traded via the USA and Canada, but do not appear as such in origin/re-exporter data. Toronto is known to be a major hub for American Eel glass eel trade, including those originating in the Caribbean and the USA. Most shipments clear Customs and are transported to glass eel holding facilities near the airport. These eels are then exported at a later date to Hong Kong, often being declared as of Canadian origin[79].

Table 13: Live eel imports from USA, Canada and Haiti reported by Hong Kong Customs by origin and by supplier, kg, 2017.

	USA	Canada	Haiti
Imports by origin (a)	11,956	9,134	1,873
Imports by supplier (b)	13,405	9,438	120
(b) – (a)	1,449	304	-1,753

Source: Hong Kong Trade Development Council http://bso.hktdc.com/bso/jsp/bso_home.jsp

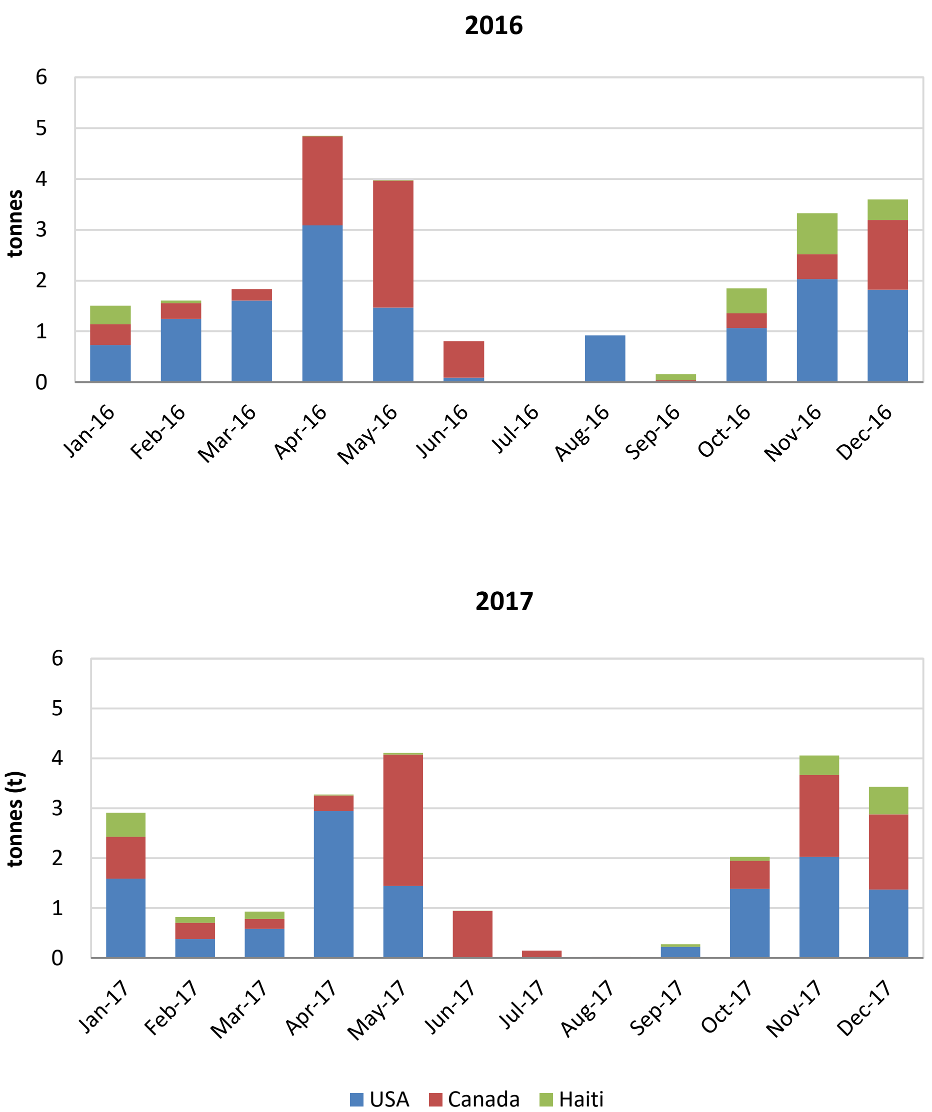


Figure 10: Reported monthly Hong Kong SAR live eel fry imports (by origin) from A. rostrata *range States, by weight (t), 2016–2017.*

Source: Hong Kong Trade Development Council

[79] Presentations by range States at the American eel range State workshop held in Santo Domingo, 4–6th April 2018.

A number of offers for sale of *A. rostrata* live eel fry were found on Business to Business (B2B) trade platforms (Alibaba, EC21, F&B Online, Weiku, Infocomercial and Espaceagro) in March 2018. Advertisements provide variable amounts of information, such as product origin and availability (by quantity and month), however the publication dates were not always provided so it was difficult to determine if advertisements were recent. The origin of live eel fry offered for sale included Canada, the Dominican Republic, Haiti, Jamaica and the USA. According to the advertisements, live eel fry from the Caribbean are smaller (6,000–8,000 eels/kg) than those from Canada and the USA (5,000 eels/kg). B2B advertisements suggest that live eel fry are available from Caribbean countries between August and February, and from North America between March and July. A study carried out in Xiamen in China in 2009 (Zhou *et al.*, 2012), using glass eels reportedly imported from Ecuador (not an *A. rostrata* range State, see section on look-alikes below), the Dominican Republic and Nicaragua via Hong Kong, noted the same differences between sizes and harvesting times between the regions, and that these two distinct supply seasons are an advantage to farmers who generally have to deal with huge variations in supply (either glass eel shortages or over production due to eels all reaching marketable sizes at the same time) between years.

ii) Glass eel catches in* A. rostrata *range States

Figure 11 and Figure 12 shows annual commercial elver landings for Canada (2012–2016) and the USA (2010–2017)[80] compared with live eel fry imports from these countries into East Asia. In both cases, and in all years but 2010, live eel imports exceed the quantity of elver landings. This again suggests that significant quantities of eel fry may have been sourced from other range States and re-exported from the USA and Canada (see above) or that exports include unreported (and potentially illegal) landings. It is important to note that these data are not directly comparable, however, as imports may include a variety of sizes of live eel fry. There are marked differences between the landing and trade data shown in Figures 11 and 12, for Canada in 2013, and for the US from 2013 onwards partially due to the fact that South Korea reported imports of larger juvenile eel fry (i.e. young eel >0.3 g and ≤50 g per unit) from 2013 onwards.

Maine and South Carolina are the only two States in the USA which currently allow elver fisheries, for which annual quotas are set. In 2017, Maine's quota was set at 9,688 lbs, and total reported catch was 9,282 lbs[81] (~4.2 t, compared to 12 t eel fry imported into East Asia from the USA). According to Atlantic States Marine Fisheries Commission definitions[82], a glass eel is an un-pigmented or partially pigmented miniature eel less than 1.8 to 2.5 inches (4.8 to 6.5 cm) long and an elver is a wholly pigmented eel less than 6 inches (15.25 cm) long. However, catches of glass eels and elvers are not reported separately; according to the Maine Eel Regulation[83], an elver is defined as an *A. rostrata* eel that will pass through a 1/8 inch non-stretchable mesh net.

In Canada, the commercial elver fishery is conducted in the Maritimes Region, in the provinces of New Brunswick and Nova Scotia, in addition to there being a small aquaculture and experimental elver Fishery in the Newfoundland and Labrador region. Elvers are defined as eels with a maximum length of 10 cm[84].

Information provided by Canada suggests that the average unit price for elvers landed in Canada has been in decline since 2012 (Figure 11). The price reached around USD5,500/kg in 2012, after which it declined to approximately USD2,000/kg in 2014.

Information provided by the USA suggests that the average unit price of elvers landed in Maine (the principal US State for elver fisheries) has been increasing since 2010 (Figure 12). Prices reached around USD4,800/kg in 2015, after which they decreased slightly and ranged between USD2,800/kg and USD3,200/kg in 2016–2017. Both Canada and the USA data show the unit price was relatively high in 2012, 2013 and 2015. Average prices during the first week of the current elver fishing season in Maine

[80] Datasets provided in Canada's and the US response to CITES Notification No. 2018/018.
[81] US response to CITES Notification No. 2018/018.
[82] http://www.asmfc.org/uploads/file/tcMinutesSept06.pdf
[83] Maine Eel Regulation: http://www.maine.gov/dmr/laws-regulations/regulations/documents/Chapter32_03122017.pdf
[84] Canada's response to CITES Notification No. 2018/018.

(end of March 2018) were over USD5,000/kg, after a very poor *A. japonica* catch season in East Asia and hence very high demand for *A. rostrata* (Chase, 2018).

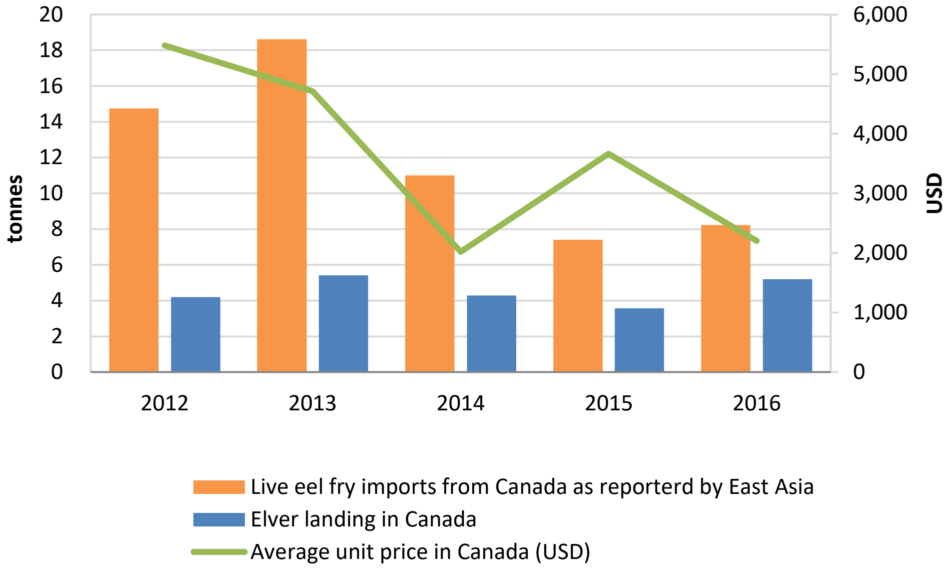


Figure 11: Live eel fry imports from Canada as reported by East Asia Customs and annual elver landings in Canada, 2012–2016, by weight (t).

Sources: Canada's response to CITES Notification 2018/018; East Asian Customs.

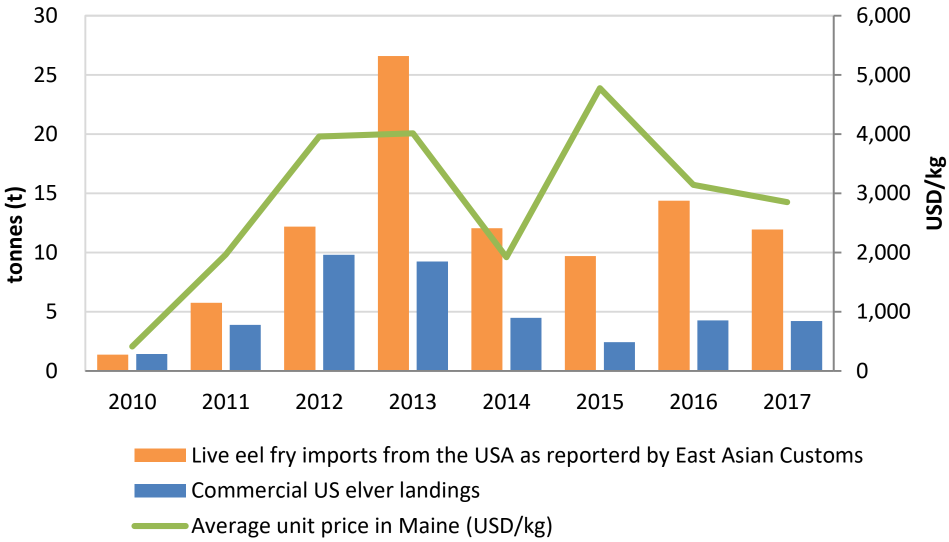


Figure 12: Annual US elver landings and live eel fry imports from the USA as reported by East Asia Customs, by weight (t), 2010–2017.

Note: Elver landings in South Carolina for 2010–2012 and 2016–2017 are not included.
Sources: US response to CITES Notification 2018/018; East Asian Customs.

There are known glass eel fisheries in the Dominican Republic, Haiti and Cuba. Anecdotal information suggests perhaps 4 t per year for each country or 5–6 t per year total for Hispaniola are landed (Benchetrit and McCleave, 2015). In recent years there are also reports of a developing glass eel fishery in Jamaica, and in 2013 a research licence was granted to assess the distribution and harvest levels around the island[85]. A total of only 362 kg was harvested under this programme in 2013–2018,

[85] http://www.moa.gov.jm/Ministry%20Papers/2015/Capture%20_Fishery_Development_Ministry_Paper.pdf

and of this only 85 kg was exported (to Hong Kong via Canada) as the remainder were considered of low quality due to them already starting to pigment (i.e. converting from glass eels to older juveniles)[86].

2013 appeared to be a peak year for interest and investment in glass eel fishing in the Dominican Republic, with many press releases, studies (such as those on salinity levels and population densities, supported by the Technical Mission of Taiwan[36]) and regulations published. In January 2013, there were reportedly 80 foreign companies (from Spain, South Korea, mainland China, Japan, the UK and Argentina) requesting permission to harvest and export *Anguilla* in the Dominican Republic. It was estimated that thousands of jobs would be created as a result, mainly in the north-east and north-west of the country where the majority of the glass eels are found. A press release from the time suggested that CODOPESCA (the Dominican Republic's Fisheries authority) was not authorising more permits (only two companies had acquired them at the time) and as a result the glass eels were being harvested by local fisherman without any controls and being exported illegally, across the border to Haiti, and to Europe and Asia via cargo, from Las Américas airport and Multimodal Caucedo port in Santo Domingo[87].

In November 2013, CODOPESCA declared a ban on fishing, processing and trade/sale of the species (all life stages) between 1st April and 14th September every year, via Resolution 80-2013[88]. The details of this resolution have been updated annually, with the most recent in 2017 (Resolution 003-2017) extending the closed season to 31st October. The resolutions cover aspects such as licences, holding stations and quotas—each licensed company is allowed to harvest and export a maximum of 150 kg and the maximum total quota for the Dominican Republic per fishing season is 2,500 kg (although CODOPESCA has the right to change these quotas based on their monitoring studies). In addition, eels can only be exported from certain airports (in 2017 these were set as Juan Bosch, Las Americas, and Gregorio Luperon); all other exports are considered illegal and are seized[89]. In the 2014–2015 glass eel fishing season, 12 companies were granted licences to export glass eels[90] and there appeared to be further investment in the fishery, such as the construction of a new laboratory for receiving live glass eels in Sosua, Puerto Plata[91]. The new project planned to inject oxygen into the water and lower temperatures to improve conditions and reduce mortality of glass eels prior to exporting them to Asia (via the UK), for growing out. However, catches were reportedly not sufficient to enable a viable business in this area (Peter Wood, *in litt* to authors, 2018). Caribbean glass eels can reportedly fetch USD4,000–8,500 per kg in East Asia (Peter Wood, *in litt* to authors, 2018). In 2013, fishermen in the Dominican Republic were being paid USD140–300/kg and intermediaries reported selling the eels on/exporting them for USD1,000/kg[92] [93].

Based on Customs data and press releases, Haiti appears to have become the principal glass eel fishing nation and exporter in the Caribbean region in recent years. There are reports from 2013 of buyers from Taiwan controlling the glass eel fishery in the Petite-Rivière-de-Nippes area. They were paying intermediaries USD250/kg for glass eels and then shipping these to Port-au-Prince, where they boarded a flight to Miami, via Los Angeles to Taipei[94]. In 2015, residents of the Grande Saline area killed at least three fishers from La Grange as a result of competition over glass eel fishing areas. Glass eel fishing has reportedly become the main economic activity in that region due to the lack of financial resources for agricultural activities[95]. An article from April 2016 reports that every year, 8 t of glass eels are exported from Haiti, without counting the quantity that goes undetected across the border

[86] Presentations by range States at the American Eel range State workshop held in Santo Domingo, 4–6th April 2018.
[87] http://elnacional.com.do/empresas-ofertan-explotacion-rd-del-pez-anguila/
[88] http://elnacional.com.do/establecen-veda-pesca-y-comercio-de-la-anguila/
[89] Resolucion que regula captura de anguila rostrata 2017-2018, CODOPESCA, Resolucion No. 003-17, Most recent publically available Resolution is 06-2015: http://www.codopesca.gob.do/noticias-2/99-resolucion-no-06-15
[90] http://www.codopesca.gob.do/noticias-2/61-empresas-con-permisos-de-explotacion-de-anguilas
[91] http://www.idiaf.gov.do/noticias/detallemain.php?ID=1825
[92] https://www.youtube.com/watch?v=Em4eesYKzK0
[93] http://hoy.com.do/las-anguilas-se-convierten-en-buen-negocio-en-la-isabela/
[94] http://lenouvelliste.com/lenouvelliste/article/124715/Y-a-t-il-anguille-sous-roche-a-Petite-Riviere-de-Nippes.html
[95] http://www.metropolehaiti.com/metropole/full_poli_fr.php?id=27345

to the Dominican Republic; eel is reportedly in the top seven national products being exported[96]. There is no legislation currently governing eel harvesting or trade in Haiti, however in 2017 an eel exporters' association was set up to try and control harvesting levels. The number of exporters has consequently reduced from 30 to nine, each having a quota of 700 kg per fishing season[97].

Experimental glass eel fishing and farming occurred in Cuba in 1974–1977, after which there was no fishing again until the late 1990s. Legislation covering use and management of eels came into force in 1996. Since 2000, on average 3 t of glass eels have been caught and exported (a mix of live and frozen) every year, however catches have been particularly low in Cuba during the last two fishing seasons (~0.2 t both in 2016–2017 and 2017–2018) due to the impacts of Hurricane Irma. The majority of glass eels are fished in the remote north of the country, and there is a high mortality of glass eels in transport to the airport—a Spanish company is currently working in the region to improve transport conditions and potentially initiate farming operations. Only one company is currently permitted to export fisheries products from Cuba.

In addition to target glass eel fisheries, glass eels are caught as bycatch from the "Teti" (*Chriodorus atherinoides*) fishery in the east of Cuba. Previously, live glass eels caught in this way were released and dead glass eels were either discarded or used in animal feed, however in the last three years live glass eels from this fishery have also been retained and exported[98].

iii) Live eel fry farming

The Japanese, Chinese, South Korean and Taiwanese Fisheries authorities released trade and input data for eel farming in a joint statement on the occasion of the "Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species" in June 2017[99]. According to the statement, China and South Korea reported imports and input of *A. rostrata* for farming (A. *bicolor* live eel fry input into eel farms in China and South Korea during 2008–2017 as reported in the Joint Press Release is shown in Table 11 and imports of live eel fry for 2013–2017 from the Philippines and Indonesia to South Korea and Taiwan are shown in Table 12. South Korea and Taiwan's Customs codes differentiate life stages of live eel fry, which shows that South Korea and Taiwan imported glass eels whose size was smaller than permitted trade (highlighted in grey). The Philippines limits exports of live eel by length, which makes it difficult to compare the datasets to determine whether imports of live eels into South Korea were the permitted size under Philippine law. All young eel imports from Indonesia were less than 91 g per piece, less than is permitted by Indonesia for export.

). Japan and Taiwan only provided species-specific farming data for *A. japonica*, all remaining input was grouped together as "other eel". Data suggest that mainland China is the main East Asian farmer of *A. rostrata* and farming input of this species has increased from 3.5 t in the 2008–2009 fishing season to a peak of 32 t in 2014–2015. South Korea began using *A. rostrata* for farming in 2010–2011 and the quantity of input increased to 5.6 t in 2012–2013, after which it declined again, totalling less than 1.5 t during 2013–2017. In the same statement, China also reported exports of broiled (prepared) *A. rostrata* eels from 2014 onwards, which increased from 16,296 t in 2014 to 22,110 t in 2016, which was more than double the exports of broiled *A. japonica* in 2016 (10,140 t), highlighting the importance of American Eel to recent production in mainland China.

Table 14: Live eel fry input into eel farms in mainland China and South Korea, reported as A. rostrata, by weight (t), 2008–2017.

[96] https://challengesnews.com/le-juteux-commerce-des-anguilles/

[97] Presentations by range States at the American eel range State workshop held in Santo Domingo, 4-6 April 2018.

[98] Presentations by range States at the American eel range State workshop held in Santo Domingo, 4-6 April 2018.

[99] Joint Press Release on the occasion of the Tenth Meeting of the Informal Consultation on International Cooperation for Conservation and Management of Japanese Eel Stock and Other Relevant Eel Species (https://cites.org/sites/default/files/eng/com/ac/29/inf/E-AC29-Inf-13.pdf)

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
China	3.5	5.5	8.5	9.0	13.0	18.5	32.0	27	input not complete
South Korea			0.5	1.7	5.6	0.5	0.1	0.7	0.035

Note: The period of the data relates to the glass eel fishing season, from 1st November to 31st October the following year.
Source: Joint Press Release

Mainland China began to import small quantities of *A. rostrata* from North America for farming trials in 1994 (Fan and Qin, 2016). *A. rostrata* input into farms stayed constantly low for many years until 2010 when farming of Caribbean and Central American glass eels became more successful; and in 2016 the input volume of *A. rostrata* live eel fry reportedly exceeded those of *A. anguilla* and *A. japonica*. According to another data source (Anon., 2017c), annual input of *A. rostrata* glass eels from the Caribbean and Central America into Chinese farms has ranged between 10 and 20 t in 2015–2017. *A. rostrata* has been used for farming in Fujian Province for more than ten years and in Guangdong Province in more recent years. The farming technique for *A. rostrata* is similar to that for *A. japonica* in mainland China, but they grow out slower, in approximately 18–24 months (Anon., 2016b; Moriyama, 2016).

3.2.4 Illegal fishing and trade

Considerable levels of poaching and illegal trade, driven by the ever increasing prices offered for *A. rostrata* glass eels, have been reported in the USA. "Operation Broken Glass," a multi-jurisdiction U.S. Fish and Wildlife Service investigation to combat the trafficking of *A. rostrata* resulted in 19 people having pleaded guilty in Maine, Virginia and South Carolina as of January 2018, with more than USD4.5 million worth of elvers illegally traded (DJUS, 2018).

iv) Other live eels

East Asian countries/territories reported importing 405 t of "other live eels" (live eels other than fry) from *A. rostrata* range States between 2008 and 2017. South Korea imported over 77% of other live eels; there were no reported imports into Taiwan from *A. rostrata* range States during this time. While East Asia reported imports from five *A. rostrata* range States (Canada, Cuba, the Dominican Republic, Haiti and the USA), imports from Canada and the US accounted for 99% of all other live eel imports (Figure 13). South Korea was the only importer recording imports of other live eel from Haiti, Cuba and the Dominican Republic. Other live eel imports fluctuated between 2008 and 2017; after declining to less than 30 t in 2009, imports of other live eels from *A. rostrata* range States increased again and reached a peak of ~76 t in 2013, after which they gradually declined again to less than 15 t in 2017. According to experts, there is minimal fishing and consumption of larger American Eel life stages in Caribbean and Central American range States, and no exports[100].

[100] Presentations by range States at the American eel range State workshop held in Santo Domingo, 4–6th April 2018.

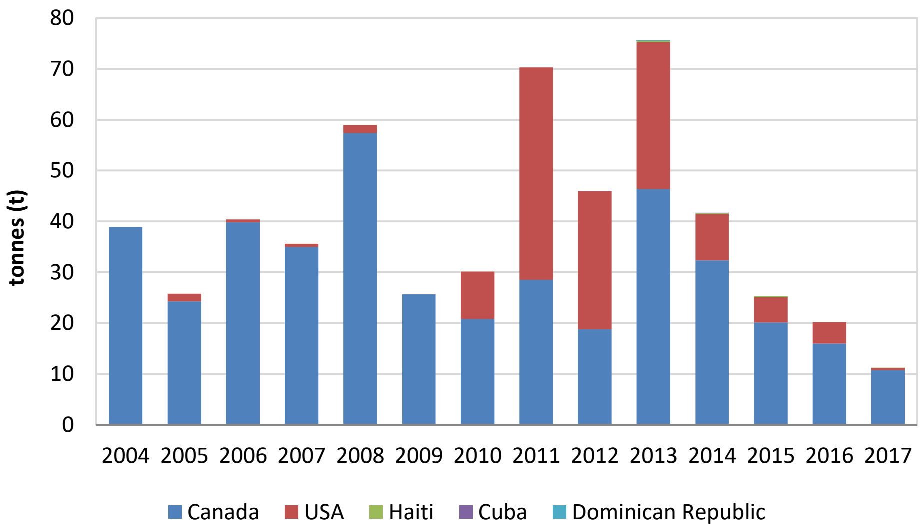


Figure 13: Annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from A. rostrata *range States, by weight (t), 2004–2017.*

Source: East Asian Customs data

3.3 South East/South Asia – *A. bicolor* and other species (*bicolor+)*

3.3.1 *Anguilla bicolor+* production

As there are several *Anguilla* species distributed in South East/South Asia including *A. bicolor, A. marmorata* and *A. bengalensis* depending on the country, catch and exports/imports from these countries may contain several *Anguilla* species. According to FAO, in South East Asia, Indonesia has reported catch and farming production of *Anguilla* spp. and the Philippines has reported catch production. Although eels are caught in Myanmar, Thailand and Viet Nam as well as being farmed in Cambodia, Myanmar, Thailand and Viet Nam, there are no catch statistics in these countries (SEAFDEC, unpublished data, 2018).

The combined eel catch production for Indonesia and the Philippines increased gradually from less than 1,400 t in 2007 to over 5,400 t in 2013, after which it dropped to ~2,400 t in 2016. Indonesia's eel farming production declined from ~5,800 t in 2008 to ~30 t in 2012, increasing again to ~16,700 t in 2016. However, other information sources suggest Indonesia's *Anguilla* farming production was 200 t in 2014 and 355 t in 2015 (SEAFDEC, unpublished data, 2018), lower than the quantities reported to FAO. Many South East Asian countries do not have official statistics of *Anguilla* catch and farming production (SEAFDEC, unpublished data, 2018), which is yet to be collected and reported to FAO.

3.2.2 Global *Anguilla* trade from South East/South Asia

According to UN Comtrade, exports of eel commodities (live, fresh, frozen and prepared eel) from South East and South Asian countries[101] increased from ~8,420 t (excluding prepared eels whose global HS code was introduced in 2012) in 2008 to 32,640 t in 2016 with live and frozen eels being the main commodities for export.

Live eel exports from South East and South Asia increased from 1,625 t in 2007 to 22,124 t in 2013, after which they slightly declined during 2014–2016 (Figure 18). Exports from the Philippines increased considerably in 2011 onwards, accounting for approximately 47% of live eel exports from the region. However, non-*Anguilla* species are known to be traded under HS codes for *Anguilla* eels. Live eel exports from South East Asian countries include *Monopterus albus* (Swamp Eels) and *Pisodonopsis* sp. (snake eels) (SEAFDEC, 2018, unpublished data; the Philippines' response to CITES Notification 2018/018). In Myanmar, catch production of *Monopterus albus* (approximately 50%) and *Pisodonopsis*

[101] South East and South Asian countries include Bangladesh, Brunei Darussalam, Cambodia, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Viet Nam.

sp. (40%) are much larger than *Anguilla* spp. (10%) (SEAFDEC, unpublished data, 2018). Also see look-alike section below.

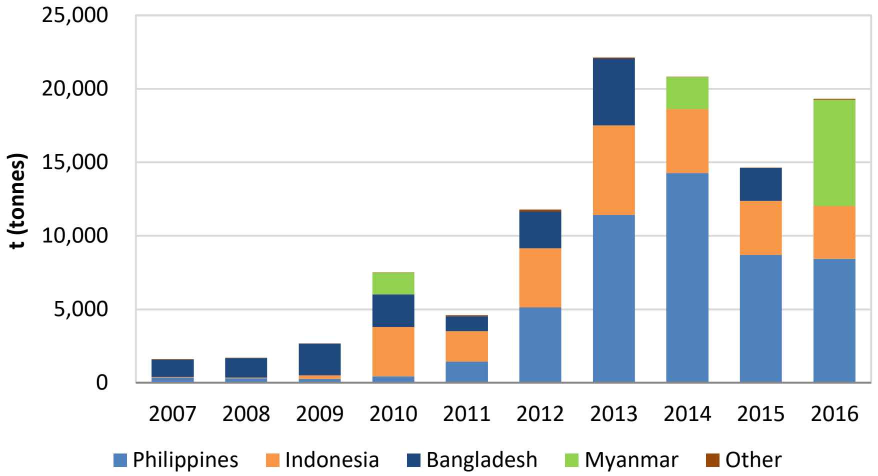


Figure 14: Exports of live Anguilla *spp. from South East and South Asia, as reported by weight (t), 2007–2016.*

Source: UN Comtrade (2018).

Information on *Anguilla* harvest, farming, import and export in Cambodia, Indonesia, Myanmar, the Philippines, Thailand and Viet Nam based on the data collected by SEAFDEC is shown in Table 15. Much of the *Anguilla* harvest, farming and export in these counties is still unknown and this suggests that *Anguilla* production (catch and farming) and export in South East and South Asia might be much less than reported to FAO and UN Comtrade. For instance, while the total amount of Indonesia's *Anguilla* eel catch production and farming production was 1,501 t in 2015 based on SEAFDEC's data, according to UN Comtrade ~3,700 t of live eels were exported from Indonesia.

Table 15: Anguilla *harvest, farming, import and export of* Anguilla *spp. in Cambodia, Indonesia, Myanmar, Philippines, Thailand and Viet Nam.*

	Cambodia	Indonesia	Myanmar	Philippines	Thailand	Viet Nam
Statistics	No	Yes	No	Yes with swamp eel	No	No
Anguilla harvest	No	Yes	Yes	Yes	Yes	Yes
Glass eel		Yes	No	Yes	No	Yes
Species		*A.bicolor* & *A. marmorata*		*A. marmorata* (90%) & *A. bicolor* (10%)		*A. marmorata* & *A. bicolor*
Annual catch				varies (approximately 10 t in 2015)		600-750 kg
Destination (purpose)		domestic grow-out		domestic grow-out		domestic grow-out
Yellow eel		Yes	Yes	unknown	Yes	unknown
Species		*A. bicolor* and *A. marmorata*	*A. bicolor* (90%) & *A. bengalensis* (10%)	unknown	Unknown	Unknown
Annual catch		1,146 t (in 2015)	12.48 t (in 2017)	unknown	Unknown	Unknown
Anguilla regulation	need permission for eel farming	Export ban (<150g) since 2012	No	Export ban (<15cm) since 2012	No	Export & import ban except for farmed eels
Anguilla farming	Yes	Yes	Yes	Yes	Yes	Yes
Species farmed	*A. marmorata* & *A. bicolor*	*A. bicolor* & *A. marmorata*	*A.bicolor*	*A. marmorata* & *A. bicolor*	A. bicolor & A. marmorata	Unknown
Life stage of Anguilla used	elvers	glass eel	elver & yellow eel	glass eel	Yellow eel	Unknown
origin of eel seeds	Philippines (imported)	Indonesia	Myanmar	Philippines	Indonesia (imported)	Unknown
No. of eel farms	1	11	1	29	3	Unknown
Annual farming production	900 kg/year (elver)	200 t (in 2014) 355 t (in 2015)	15t	93.9 t	2t	Unknown
Destination of farmed eels	Domestic consumption	Export and domestic consumption	Exported to China	Japan, Korea, Taiwan and domestic consumption	Exported to China	China and domestic consumption
Import	Philippines (1t) (2017)	None	None	None	Indonesia (1t yellow eel)	None
Export	No	Japan, China, Korea, Taiwan	China (17t) (in 2017)	Japan, Korea, Taiwan	China (2t)	China

Source: SEAFDEC, unpublished data, 2018.

3.3.3 East Asian imports and farming of *A. bicolor*+ from South East Asia/South Asia

i) Live eel fry supply and imports

According to East Asian Customs data, East Asian countries/territories imported ~220 t of live eel fry from eight countries in South East/South Asia over the decade 2008–2017, 73% of which came from the Philippines. Imports of live eel fry from Malaysia and Thailand began in 2012, from Viet Nam and East Timor in 2013 and from Bangladesh in 2014.

Imports of live eel fry from South East Asian/South Asian countries gradually increased from 2010 and reached a peak at around 64 t in 2013, after which it decreased and ranged between 21–26 t in 2014–2016 before further declining in 2017 (10 t) (Table 16). Hong Kong, followed by South Korea was the main importer of live eel fry from South East Asia during 2008–2017. South Korea's imports of live eel fry reached ~26 t in 2013 due to ~18 t of imports of larger sized eels (young eels).

Table 16: Imports of live eel fry from South East/South Asian countries reported in East Asian Customs data, kg.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Philippines	13,774	1,993	3,347	16,379	34,831	32,388	10,086	16,782	21,081	8,265
Malaysia					402	9,354	3,813	2,796	2,301	1,782
Viet Nam						13,739	48		85	
Thailand					498	3,569	1,398	1,579	2,360	444
Bangladesh							7,594			
Indonesia	182	87	868	636	1,045	2,008	10	95	194	
Singapore						3,304	7	36		
Timor Leste						10				
Total	**13,956**	**2,080**	**4,215**	**17,015**	**36,776**	**64,372**	**22,956**	**21,288**	**26,021**	**10,491**

Note: *Green cells indicate import records from the country where neither glass eel fishing or farming exist. Grey Shading indicates import records from the country where glass eel exports are regulated (Indonesia: export ban for eels ≤150 g each, Philippines: export ban for eels ≤15 cm; Viet Nam: export ban for eels taken from wild).*
Source: East Asian Customs authorities.

It should be noted that exports of glass eels from South East Asian countries are not permitted[102]. Singapore and Timor Leste are not presently listed as range States of *Anguilla* spp. (Jacoby and Gollock, 2014). Additionally, glass eel fishing or farming does not exist in Malaysia and Thailand, and in Viet Nam *Anguilla* eel export is banned except for farmed eels (SEAFDEC, unpublished data, 2018) (highlighted in grey in Table 16). There are several ways imports of live eel fry are not fully recorded in East Asia including:

- live eel fry exported illegally or from countries that do not regulate fishing and trade in eels;
- trade in non-*Anguilla* spp. are included;
- these countries are used as a transit point from other South East Asian countries and/or other parts of the world to East Asia. For example, Hong Kong Customs data show Hong Kong imported 78 kg of live eel fry originating in the Philippines via Thailand in 2013.

As the Philippines has banned exports of *Anguilla* eels 15 cm or less since 2012 and Indonesia has banned exports of *Anguilla* spp. =<150 g per individual since 2012, imports from the Philippines and Indonesia into East Asia may include illegally exported live eel fry (see below).

A. bicolor live eel fry input into eel farms in East Asia during 2008–2017 has been calculated based on the Joint Press Release shown in Table 17. According to the statement, mainland China and South Korea reported imports and input of *A. bicolor* for farming. Japan and Taiwan only provided species-specific farming data for *A. japonica*, all remaining input was grouped together as "other eel".

[102] Information provided by range States at the CITES International technical workshop on eels (*Anguilla* spp.) held in the UK, 18-20th April 2018.

Although imports from South East Asia countries reported by East Asia include larger sized eels and reporting periods differs between import and input data, there are still large differences between imports and input data (e.g. annual imports of live eel fry were 21–26 t in 2015 and 2016 whereas annual input in 2014–2015 and 2015–2016 was less than 12 t).

Table 17: A. bicolor *live eel fry input into eel farms in East Asia, 2008–2017, t.*

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Japan*	0.1	0.03	0.01	0.4	1.3	3.5	0.0	0.2	0.1
China	0.3	1.1	3.5	5.5	7.0	13.5	3.5	8	not finished
South Korea			0.8	3.7	6.7	2.4	5	3	0.58
Taiwan*	-	-	-	5.5	10.0	1.5	0.2	0.08	0.1

*Input for Japan and Taiwan may include other non-*A. japonica* spp.
Note: The period of the data relates to the glass eel fishing season, from 1st November to 31st October the following near.
“0” means data were identified as zero.
Source: Joint Press Release.

Imports of live eel fry for 2013–2017 from the Philippines and Indonesia to South Korea and Taiwan are shown in Table 18. South Korea and Taiwan’s Customs codes differentiate life stages of live eel fry, which shows that South Korea and Taiwan imported glass eels whose size was smaller than permitted trade (highlighted in grey). South Korea’s glass eel imports from the Philippines reached 6.4 t in 2013 and 5.4 t in 2015 but declined to less than 1 t in 2017. The Philippines limits exports of live eel by length, which makes it difficult to compare the datasets to determine whether imports of live eels into South Korea where of the permitted size under Philippine law. All young eel imports from Indonesia were less than 91 g per kg, less than permitted by Indonesia.

Table 18: Imports of live eel fry from the Philippines and Indonesia to South Korea and Taiwan, 2013-2017, kg.

Importer	Source	Commodity	2013	2014	2015	2016	2017
South Korea	Philippines	Glass eel	6,409	1,582	5,367	2,072	584
		Young eel	4,217	385	6,634	14,481	4,751
	Indonesia	Glass eel	807		33	194	
		Young eel	320				
Taiwan	Philippines	Glass eel	44				
		Elver	220				168
		Young eel	865	3,565		1,077	2,003
	Indonesia	Glass eel	2				
		Elver	92				

Note: Glass eel indicates live eel fry ≤0.3 g per unit while young eel indicates live eel fry >0.3 g and ≤51 g per unit for South Korea and glass eel, elver, young eel indicates live eel fry over 5,000 eels per kg, not less than 501 eels, less than 5000 eels per kg and not less than 11 eels, less than 500 eels per kg respectively for Taiwan.
Source: Korea International Trade Association http://global.kita.net/ and Taiwan Bureau of Foreign Trade http://cus93.trade.gov.tw/ENGLISH/FSCE/. Downloaded in February 2018.

A number of offers for sale for *A. bicolor* live eel fry were found on Business to Business (B2B) trade platforms (Alibaba, EC21, F&B Online, Weiku) in April 2018. Advertisements for businesses located in Malaysia and Thailand offered live eel fry of several species (*A. bicolor*, *A. japonica* and *A. marmorata*) originating in several countries such as Indonesia, the Philippines, Malaysia and Thailand.

ii) Other live eels

East Asian countries/territories reported importing ~9,100 t of other live eels (live eels other than fry) from South East/South Asian countries between 2008 and 2017. Hong Kong imported approximately 83% of other live eels during the period. The main sources were Indonesia, followed by the Philippines and Bangladesh (Figure 15). Other live eel imports from South East/South Asia declined with fluctuation between 2008 and 2017; imports of other live eels remained more than 1000 t until 2013 (except for 2011), after which they dropped to less than 350 t in 2014–2017.

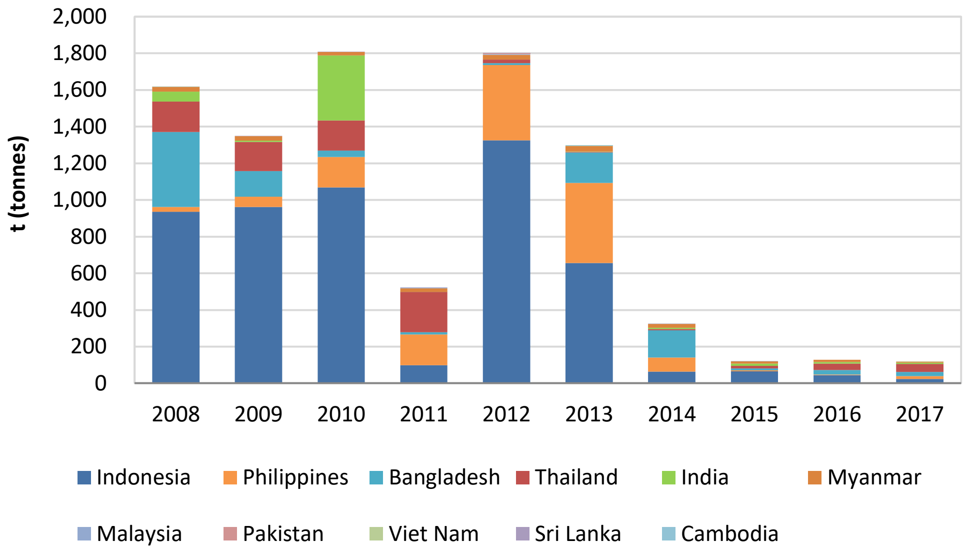


Figure 15: Total annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from South East Asia, 2004–2017, t

Source: East Asian Customs agencies.

According to Hong Kong Customs data which are available by origins and by supplier, Hong Kong reportedly imported 3.3 t of other live eels originating in Indonesia and 4.9 t of other live eels originating in Pakistan via the Philippines in 2012. South East/South Asian countries seemed to be used a transit from other regions as well; 10 t of other live eels originating in Bulgaria via Bangladesh in 2012 and 93 t of other live eels originating from Madagascar were traded via Thailand in 2013.

3.1.4 Trade in *A. marmorata*

A. marmorata is a widely distributed species with approximately 40 countries/territories with Pacific and Indian Ocean coastlines specified as range States of the species (Jacoby and Gollock, 2014). Trade in *A. marmorata* can be obscure as it is widely distributed and the range overlaps with other well-known species (e.g. *A. bicolor* and *A. bengalensis*).

A. marmorata has been used in Southern Africa and as medicine in East Asia (Jacoby and Gollock, 2014). This species occurs but is relatively rare in Northeast Asia and included in the list of endangered and protected species as a Class II species[103] in mainland China and designated as a "Natural monument (protected animals)" in some areas in Japan (Jacoby and Gollock, 2014).

A. marmorata farming is relatively new in East Asia, and most of the *A. marmorata* live eel fry seem to be imported from South East Asia, especially the Philippines (Huang *et al.*, 2016). Eel farmers in Taiwan began farming of *A. marmorata* targeting a large commercial market in mainland China and Taiwan after the Council of Agriculture lifted the conservation status of the species in April 2009 due to recovery of the resources (FBCA, 2009; Huang *et al.*, 2016). According to the Joint Press Release,

[103] http://zdx.forestry.gov.cn/portal/bhxh/s/645/content-334732.html

South Korea also input 500 kg and 300 kg of *A. marmorata* live eel fry for farming in 2011–2012 and 2012–2013. Some Chinese eel farmers use *A. marmorata* as a certain percentage of *A. bicolor pacifica* is included in imported live eel fry, which cannot be distinguished at early life stages. Farmed *A. bicolor* can be sold to Japan at a good price whereas *A. marmorata* can be sold within mainland China (Anon., 2016c). In 2017, some 700,000 *A. marmorata* were input for farming in Fujian province, China (Anon., 2017d).

DNA analysis on prepared eels found *A. marmorata* in Japan in 2015 (Yoshinaga, 2015) and in the UK in 2014–2015 (Vandamme *et al*., 2016).

3.4 Oceania – *A. australis* and other species

There are several *Anguilla* species distributed in Oceania including *A. australis*, *A. reinhardtii* and *A. dieffenbachii*. According to FAO production data, Australia and New Zealand have reported catch production of *Anguilla* spp. and Australia has reported farming production of *Anguilla* spp. since 1950. Catch production in these countries reached ~2,800 t in 2014, after which it declined gradually to 535 t in 2016. *A. australis* accounted for approximately 70–80% of the commercial catch and is often exported live for direct consumption, while *A. dieffenbachii* accounted for the remaining 20–30% in recent years and is exported frozen due to difficulties in ensuring its survival[104]. Of catch production for New Zealand in 2016, it is estimated that 336–384 t were *A. australis* and 96–144 t were *A. dieffenbachii*.

Of five species distributed in Australia, only *A. australis* (Southern Shortfin Eel) and *A. reinhardtii* (Longfin Eel) are harvested in Australia[105]. Australia's farming production steadily declined after reaching 315 t in 1997 and 1998, and farming production has not been reported since 2012. According to Australia's response to the Notification 2018/018, a small aquaculture industry exists for *A. australis* and *A. reinhardtii*.

According to data reported to UN Comtrade, exports of eel commodities (live, fresh, frozen and prepared eel) from Oceania were reported by New Zealand, Australia and Samoa (in the case of the latter only 3 kg of frozen eels were recorded in 2010) during 2007–2016. Live eels and frozen eels were the main export commodities and New Zealand was the dominant exporter, accounting for 74% of exports of eel commodities from Oceania.

According to New Zealand Customs data, New Zealand exported 3,636 t of frozen eels and 2,818 t of live eels during 2008–2017. Frozen eel exports ranged between 152 t and 380 t during 2008–2017 except for 2010 when these exceeded 1,189 t with sudden increases in frozen eel exports to South Korea (926 t). Except in 2010, the main destinations of frozen eels were Belgium, the UK and Germany. Live eel exports reached a peak of 517 t in 2011, after which they declined gradually to 133 t in 2016. The main destinations of live eels were South Korea until 2013, mainland China (2014–2016) and Canada in 2017.

According to UN Comtrade, Australia exported 2,635 t of eel commodities during 2007–2016, 91% of which were live eel exports. Live eel exports reached a peak of ~370 t in 2012, after which they gradually decreased to 96 t in 2016. Hong Kong was the dominant destination of live eels from Australia, accounting for 84% of live eel exports from the country between 2007 and 2016.

Based on East Asian Customs data, East Asia recorded imports of live eel fry only from Australia in Oceania during 2008–2017, 2.2 t in total. Imports ranged zero to 270 kg except for 2015 when imports exceeded 1.5 t (Table 19). Hong Kong was the main importer and accounted for 80% of all live eel fry imports from Australia in the region. There were no imports of live eel fry into Japan and Taiwan from the Oceania region during the period. There was no information suggesting these species are currently used in eel farms in East Asia.

[104] New Zealand' response to CITES Notification 2018/018
[105] Australia's response to CITES Notification 2018/018

Table 19: Imports of live eel fry from Australia reported in East Asian Customs data, kg.

Importer	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Hong Kong							217	1,544		
China	263									
South Korea								3	177	
Total	**263**	**0**	**0**	**0**	**0**	**0**	**217**	**1,547**	**177**	**0**

Source: East Asian Customs data

East Asian countries/territories reported importing approximately 2,300 t of other live eels (live eels other than fry; all *Anguilla* spp.) in total from Oceania (Australia and New Zealand) between 2008 and 2017. Other live eel imports from the region increased gradually and reached a peak of 416 t in 2012, after which they dropped to less than 130 t in 2016 and 2017 (Figure 16). While Hong Kong was the main importer of other live eels from Oceania during 2008–2013, China took the top position during 2014–2017. As China rarely reported other live eel imports until 2011, traders may have begun importing other live eels directly into mainland China around that time. South Korea also imported other live eels constantly during the period.

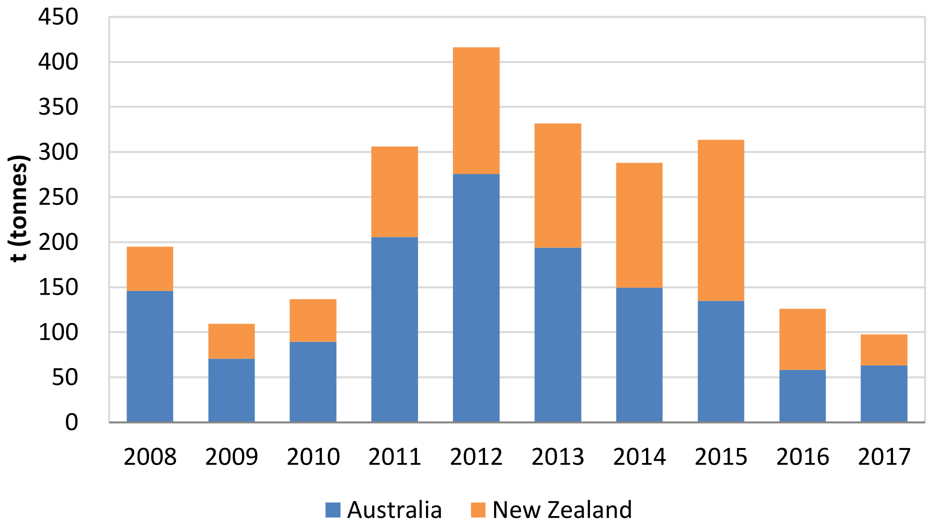


Figure 16: Total annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from Oceania, 2004–2017, t

Source: East Asian Customs data

3.5 East/Southern Africa – *A. mossambica* and other tropical species

There are several *Anguilla* species distributed in East/Southern Africa including *A. mossambica* and *A. marmorata* (and *A. bicolor* and *A. bengalensis* depending on the country), therefore catch and exports/imports from these countries may contain several *Anguilla* species. Any country in the region has not reported *Anguilla* catch/farming production to FAO while according to UN Comtrade, Madagascar and South Africa exported live *Anguilla* eels from 2007 to 2016, with 98% of exports reported by Madagascar. Live eel exports from Madagascar to all countries/territories increased from 95 t in 2007 to 515 t in 2013, after which these declined gradually to ~74 t in 2016 (Table 20). While France was the main destination of live eels from Madagascar until 2009, exports to East Asia (especially Hong Kong and mainland China) increased after that; Exports of live eels to Hong Kong reached a peak of 344 t in 2013.

Table 20: Live eel exports from Madagascar to other countries/territories by destinations, as reported by weight (t), 2007–2016.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hong Kong	2	5	42	133	175	333	344	87	52	11
France	90	117	125	95	32	60	24	62	67	24
China						18	117	117	147	40
Netherlands				236	16					
Other	3	2			32	15	29	3		
Total	**95**	**123**	**167**	**464**	**257**	**426**	**515**	**269**	**266**	**74**

Source: UN Comtrade

According to East Asian Customs data, East Asia imported live eel fry from Madagascar, Mauritius and South Africa between 2008 and 2017. More than 99% (~14 t) were imported from Madagascar. Imports from Mauritius and South Africa were recorded in 2011 and 2013 respectively and the quantity was less than 30 kg each. Imports from Madagascar reached a peak of 5.6 t in 2013, after which they dropped to less than 600 kg in 2014 and 2015, with no imports recorded in 2016–2017 (see Table 21). Hong Kong was the leading importer, accounting for 67% of imports from these countries. South Korea imported 3.5 t in 2013 alone and Japan imported 73 kg in 2012 and 2013.

Table 21: Imports of live eel fry from East/Southern African countries reported in East Asian Customs data, t.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Madagascar	0.4	1.4	0.0	1.8	3.8	5.6	0.5	0.5		
Mauritius				0.0						
South Africa						0.0				

Note: Values of 0.0 refer to unit value of less than 50 kg.

Source: East Asian Customs data

Based on the Joint Press Release, South Korea input 0.5 t of *A. mossambica* in 2012–2013 while other East Asian countries/territories did not report any input of *A. mossambica* between 2008 and 2017. South Korea tried farming of *A. mossambica* and *A. bicolor* when the price of *A. japonica* glass eels increased dramatically due to their shortage during 2011–2013, most of which was unsuccessful (Baek and Bak, 2017; Kim, 2015). The price of *A. mossambica* and *A. bicolor* was KRW200–300 (USD0.2–0.3) per individual while *A. japonica* was approximately KRW7,000 (USD 6.2) per individual (Kim, 2015).

There was a case in which *A. mossambica* was sold as a different *Anguilla* species. In mainland China, Fujian Inspection and Quarantine Bureau found glass eels sold as *A. rostrata* were actually *A. mossambica* from Mozambique using DNA identification (Li, 2017). A small portion of *A. mossambica* was found by DNA analysis in prepared eels sold in Japan in 2015 (Yoshinaga, 2015).

East Asian countries/territories reported importing 106 t of other live eels (live eels other than fry) in total from East/Southern African countries (Madagascar, Mauritius, Mozambique and Comoros) during 2008–2017. Other live eel imports gradually increased and reached a peak of 26 t in 2013, after which they declined gradually to 4.7 t in 2017 (Table 22). Madagascar was the main source of other live eels, accounting for 86% of imports from these countries. Mainland China and Hong Kong were the main importers, accounting for 99% of other live eel imports from the region during the period.

Table 22: Total annual imports of other live eels into mainland China, Japan, South Korea, Hong Kong and Taiwan from East/Southern African, 2008–2017, t

	2008	2010	2011	2012	2013	2014	2015	2016	2017
Madagascar	0.0	0.8	9.3	5.8	26.1	14.5	20.5	9.3	4.5
Mauritius		7.5	5.3	0.2					
Mozambique								1.2	0.2
Comoros							0.5		
Total	**0.0**	**8.3**	**14.6**	**6.0**	**26.1**	**14.5**	**21.0**	**10.5**	**4.7**

Source: East Asian Customs data

4. Look-alike species

Look-alike species under CITES are described as those which resemble CITES-listed species in the forms they are traded, i.e. specimens of the look-alike species resemble those of a listed species, making identification by enforcement officers difficult or impossible without more sophisticated techniques such as DNA analysis[106]. *Anguilla* species are traded in a number of forms such as live, fresh, frozen and prepared products. Experts have advised that on-the-spot identification of live juvenile eels and eel products of *Anguilla* to the species level cannot be accurately carried out using keys and photos, and although geographical provenance can provide a good indication of the species in some cases this is further complicated in the case of eels by farming of non-native species around the world (EC, 2012).
There are a number of products of other "eel-like" species (i.e. non-*Anguilla* spp.) in international trade which may be difficult to differentiate from *Anguilla*, for example after processing into fillets for consumption or skin products. However, in addition to this, there are cases where these eel-like species are being traded incorrectly under Customs codes for *Anguilla* eels or reported as "eel" catch in some countries.
Live eel exports from South-east Asian countries are known to include *Monopterus albus* (Swamp Eels) and *Pisodonophis* sp. (snake eels) (SEAFDEC, 2018, unpublished data; the Philippines' response to CITES Notification 2018/018; Crook, 2014). In the Philippines, all eel catch is recorded as "Igat". Prior to and including 2011, *Anguilla* spp. composed 100% of Igat production. However, catch and trade in *M. albus* has been encouraged in recent years due to this species becoming a pest and in 2012, *Anguilla* made up 95% and *M. albus* 5% of Igat production and in 2013 *Anguilla* only 30% and *M. albus* 70%, all being reported under the same catch code. These were all exported using the live *Anguilla* spp. Customs code; however significant quantities of imports from the Philippines into Taiwan were declared as Swamp Eel (as Taiwan has a species-specific code for this; Crook, 2014). Myanmar reports a similar situation, with catches and exports reported together as "eel", but including *Anguilla* (10%), snake eel (40%) and Swamp Eel (50%) (SEAFDEC, 2018, unpublished data).
There are also reports of misuse of the *Anguilla* Customs code in other regions. For example, Ireland has reported cases where exports declared as *Anguilla* spp. were in fact Conger Eel *Conger conger* (Ireland's response to CITES Notification No. 2018/018). Catch/trade to and from some countries in the Americas reported as *Anguilla* spp. is believed to include Hagfish, Conger and Moray Eels, Red Pike Conger *Cynoponticus coniceps,* Marbled Swamp Eel *Synbranchus marmoratus*[107] and Snake Eel *Ophichthus remiger* (United States' response to CITES Notification 2018/018; Bustamante and Segovia, 2006; UN Comtrade, 2018).
The potential for reporting other eel-like species as *Anguilla* in catch and trade is even greater in the Spanish-speaking countries of the Caribbean and Central and South America as the common name for any type of eel in Spanish is "anguila". In some cases countries are both range States for *A. rostrata* and these other species and therefore it is unknown which species is included in reported catch and trade. For example, according to UN Comtrade data there are reported exports of over 130 t of

[106] https://cites.org/sites/default/files/document/E-Res-09-24-R17.pdf
[107] http://museohn.unmsm.edu.pe/docs/pub_ictio/235.pdf, http://www.trinidadexpress.com/commentaries/Of_zangies_and_eels-115384264.html

Anguilla from Costa Rica, Panama and Nicaragua in the last decade (see Table 9 above). These are considered to be *A. rostrata* range States, however little is known about their *Anguilla* population numbers and no *Anguilla* fisheries are currently in existence[108]. Therefore these exports are likely to involve other commercially important species such as Red Pike Conger and Marbled Swamp Eel for which there are increasing reports of exports to Asia[109].

However, in other cases countries that are known to be non-range States for *A. rostrata* (with Pacific coasts) report the export of important quantities of *Anguilla* spp. in their Customs data; according to UN Comtrade, Chile, Ecuador and Peru reported total exports of 163 t of *Anguilla* eels in 2008–2016, see Table 23. The equivalent quantities of commodities are not reported by importers (only ~ 8 t of were reportedly imported between 2008 and 2017 from these three countries). Chile, Ecuador and Peru do not report any eel re-exports in 2008–2017.

Country	Commodity	2008	2009	2010	2011	2012	2013	2014	2015	2016
Chile	Frozen eel					11.6	61.2	4.6		
	Prepared eel								0.1	0.0
Ecuador	Live eel						21.0			
	Frozen eel						26.4			0.0
	Prepared eel						1.1			
Peru	Live eel	0.9	0.9	1.5	0.9	0.9	2.1	1.1	1.7	1.2
	Fresh eel								0.0	
	Frozen eel					0.0		0.0		0.0
	Prepared eel					24.8	0.4	0.2	0.4	0.5
Total		**0.9**	**0.9**	**1.5**	**0.9**	**37.3**	**112.2**	**6.0**	**2.2**	**1.8**

Table 23: Reported exports of Anguilla *commodities from Chile, Ecuador and Peru, by weight (t), 2008–2016.*

Note: Values of 0.0 refer to unit value of less than 50 kg. Source: UN Comtrade (2018).

Reported exports fluctuate greatly between years, apart from live eel trade from Peru which was reported annually. A large amount of trade was reported in 2013 by both Ecuador and Chile. Nearly all trade from Chile was in frozen eel (77 t in total in 2012–2014, all to South Korea), and trade from Ecuador in 2013 involved 21 t of live eels (to South Korea), 26 t of frozen eel (to Viet Nam) and 1 t of prepared eels (to the USA).

Peru reported regular annual exports of live eels for 2008–2016, with quantities ranging between 0.9 t in 2008 and 2.1 t in 2013. The principal destinations for live exports were Japan (2 t), the USA (1.8 t) and Hong Kong (1.7 t), and average prices ranged from USD4/kg to USD8/kg. In addition to these live eel exports, in 2012 nearly 25 t of prepared eel was reportedly exported to mainland China (the year this new HS code was introduced). From 2013 onwards, however, Peruvian exports of prepared eel were much smaller, ranging between 0.2 and 0.5 t, the majority going to Spain. The average price of prepared eels was higher than that for live eels– around USD25/kg between 2013 and 2016. Fresh and frozen eel exports were minimal.

Chile, Ecuador and Peru are not *Anguilla* range States; they are however range States for the Punctuated Snake Eel *Ophichthus remiger*, which is commonly termed "anguila comun". There are been several reports of increased fishing, processing and trade in this species, to markets in East Asia, in particular from Peru. A press release from December 2014, reported that Peru exported USD16.3 million of "eel" between January and September 2014, an increase of >40% when compared with 2013, due to increasing demand from Asia. Average prices were USD6–7/kg. Japan was the principal destination of these eels, followed by South Korea, mainland China, the USA, Thailand, Canada,

[108] Presentations by range States at the American eel range State workshop held in Santo Domingo, 4-6 April 2018.
[109] https://www.incopesca.go.cr/mercado/documentos/catalogo-pesca.pdf, http://salva-mar.com/productos/anguila-zafiro/

Germany, Singapore, Chile and the UK[110]. This press release states that Peruvian eels are similar to the "Japanese eel" and are therefore in increasing demand in Asia as a substitute. The eels are reportedly processed in China and then re-exported to other destinations; Peru hopes to start processing itself soon. Peru has introduced restrictions and annual quotas for the species since 2011[111] (5,800 t in 2017–2018[112]) due to concerns over illegal and excessive fishing, in particular in 2008 and 2009 when demand from East Asia began to increase.

References to the similarities between Peruvian and Japanese eels, and the fact that alternatives are being sought due to declines in eel fishing in Japan (which is also the case for *A. japonica*) cause even more confusion in relation to reporting of the species in trade. Another Peruvian article (from April 2014) states that there are two types of eel consumed in Japan and apparently *Ophichthus remiger* is more similar to that consumed in the west of Japan[113]. The species name is not provided in the article, however this may refer to Daggertooth Pike Conger *Muraenesox cinereus* which is consumed mainly in the Kansai area of Japan (especially Kyoto, as "Hamo") (Tsunokuni, 2004).

In Ecuador, there have been several recent studies into the sustainability[114] and economic feasibility[115] of exporting *Ophichthus remiger* eels to East Asia (one study presenting Customs trade data reported using *Anguilla* Customs codes, again suggesting an incorrect use of the code), and in 2012 Ecuador also introduced legislation with regards to fishing this species[116]. Furthermore, in Chile, a research project focusing on closed-cycle reproduction and growing out of "Pacific eel" fry was initiated in 2015 in the University of Antofagasta. The project description states that the species found off the Antofagasta coast is very similar to the "japonica", but with a lower lipid content. The project focused on producing juvenile eels for export to mainland China, South Korea, Japan and Taiwan[117][118]. Reports from Japan suggest that *Ophichthus remiger* is being used as substitute for conger eel (Anon., 2016d) and not *Anguilla* species; an in-flight meal in mainland China was identified as being *Ophichthus* spp., as part of a recent DNA identification project looking into the various *Anguilla* species being consumed in East Asia (T. Yoshinaga, unpublished data, 2016). Species currently being used in Japan instead of the traditional Conger Eel *Conger myriaster* include *Ariosoma meeki* and *Gnathophis nystromi* (conger/garden eels), *Synaphobranchus kaupii* (Kaup's Arrowtooth Eel) and *Ophichthus remiger* (Fujiwara, 2013).

5. Concluding remarks / Recommendations

The trade data analysis of *Anguilla* spp. over the last 10 years shows that there were substantial shifts in trade related to live eels, especially live eel fry. According to East Asian Customs data, annual imports of live eel fry from Europe and North Africa (likely to be *A. anguilla*) accounted for 64% of all live eel fry imports from outside East Asia in 2008 (39 t). Imports from those sources declined to 7 t in 2011, while imports from other regions, increased from 14 t in 2010 to 38 t in 2011, and reached a peak of 112 t in 2013. The Americas and South East Asia became increasingly important live eel fry source regions for East Asian farms during this time. These fluctuations coincided with the CITES listing of *A. anguilla* coming into force in 2009, the banning of all trade in *A. anguilla* from and to the EU in 2010, and low harvest of *A. japonica* for four consecutive years in 2010–2013. This shift in demand also seems to be closely related to East Asian farms developing new farming techniques for different *Anguilla* species/populations. Once techniques for farming glass eels coming from previously un-exploited regions are successfully developed, the demand for eel fry of other *Anguilla* species could also increase in the future.

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[110] http://www.perushimpo.com/noticias.php?idp=6414
[111] http://aempresarial.com/web/solicitud_nl.php?id=144122
[112] http://www.perupesquero.org/web/establecen-regimen-de-captura-de-la-anguila/
[113] https://exportacionesdelperu.blogspot.com.uy/2014/04/peru-exporta-anguila-japon-china.html
[114] http://institutopesca.gob.ec/wp-content/uploads/2017/07/Informe-Final-anguila-2013.pdf
[115] http://www.dspace.espol.edu.ec/bitstream/123456789/5561/1/D-36924.pdf
[116] http://www.agricultura.gob.ec/se-oficializa-y-regula-la-pesca-industrial-de-anguila/
[117] http://www.aqua.cl/2015/05/12/cultivo-de-anguilas-surge-como-alternativa-para-dinamizar-acuicultura-de-la-region-de-antofagasta/
[118] http://www.conicyt.cl/wp-content/themes/fondef/encuentra_proyectos/PROYECTO/09/I/D09I1160.html

The trade analysis also highlights possible illegal trade in live eel fry from/to East Asia, South East Asia and the Americas. While exports of live eel fry were rarely recorded in East Asia, many countries/territories seem to have imported live eel fry from other East Asia countries/territories. Although many South East Asian countries do not allow the export of glass/juvenile eels, a significant volume of imports of live eel fry was reported by East Asia. Imports of live eel fry from Canada and the USA reported by East Asia exceeded elver landings recorded in Canada and the USA.
Considering that many populations of *Anguilla* spp. are believed to have declined over the last few decades and *A. japonica* and *A. rostrata* are both currently listed as Endangered on the IUCN Red List, regional and/or global coordinated adaptive management and conservation measures are essential in order to ensure sustainable use of all *Anguilla* species into the future. The benefits and challenges of available mechanisms for facilitating co-operation between source, transit, farming and consumer countries/territories, as well as to ensure legal, sustainable and traceable trade and combat illegal trade, should be considered by Parties. Such mechanisms could include, but should not be limited to, a genus wide CITES listing for all *Anguilla* spp. or an international Memoranda of Understanding or Action Plan for *Anguilla* species in trade.

A number of specific recommendations related to trade issues and results of the trade analysis presented in this study, are provided here:

- Use standardised or comparable definitions/codes for reporting trade in the different eel life stages (e.g. live eel fry and other live eels), and ensure any future changes to Customs codes are coordinated so they are applicable across all *Anguilla* range States.
- Ensure that Customs codes for *Anguilla* spp. are only used to report trade in *Anguilla* species; countries/territories should check their national reporting systems to verify that other eel-like species (non-*Anguilla,* i.e. look-alikes) are reported under their equivalent Customs codes.
- Develop a guide to other eel-like/look-alike species in trade, with common names and photos, to raise awareness, and ensure accurate reporting, of the different eel species in trade.
- Analyse Customs and farming data on a regular basis to identify any new species/source regions for live eel fry in East Asian farms in the future.
- Carry out further research on consumption/demand for consumption, especially in emerging and/or lesser-known markets such as China, South Korea and Russia, in order to identify any changes in the potential drivers of global *Anguilla* trade.
- Strengthen multi-lateral and bilateral cooperation between exporting and importing countries in particular between enforcement agencies to control imports of glass eels from countries/territories which have fishing/export restrictions in place.

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Annex

Live eel input into farms in East Asia, 2007-2017, t. *Source: Joint Statement and Joint Press Release*

Country/territory	Species	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Input limits from 2015-16
Japan	**Total**	**21.7**	**29.0**	**19.9**	**21.8**	**16.3**	**13.9**	**30.6**	**18.3**	**19.8**	**18.6**	
	A. japonica	21.7	28.9	19.9	21.8	15.9	12.6	27.1	18.3	19.7	18.5	21.7
	Other species	0.0	0.14	0.03	0.01	0.43	1.3	3.5	0.0	0.2	0.1	3.5
China	**Total**	**83.5**	**57.8**	**43.6**	**41.5**	**22.5**	**27.0**	**77.0**	**44.8**	**47.7**		
	A. japonica	26.0	9.0	26.5	10.5	8.0	7.0	45.0	9.3	8.2	16.5	36.0
	A. anguilla	57.5	45.0	10.5	19.0	0.0	0.0	0.0		4.5		32.0
	A. rostrata		3.5	5.5	8.5	9.0	13.0	18.5	32.0	27.0	not finished	
	A. bicolor		0.3	1.1	3.5	5.5	7.0	13.5	3.5	8.0	not finished	
South Korea	**Total**	**11.0**	**23.5**	**12.1**	**11.1**	**9.5**	**16.2**	**16.8**	**12.5**	**13.0**	**11.2**	
	A. japonica	11.0	22.0	10.6	9.5	3.6	3.0	13.9	7.4	9.3	10.6	11.1
	A. bicolar				0.8	3.7	6.7	2.4	5.0	3.0	0.6	13.1
	A. rostrata				0.5	1.7	5.6	0.5	0.1	0.7	0.0	
	A. anguilla		1.5	1.5	0.3	0.1						
	A. mamorata					0.5	0.3					
	A. mossambica						0.5					
Taiwan	**Total**	**14.3**	**25.0**	**13.1**	**3.8**	**7.7**	**11.5**	**14.0**	**3.0**	**3.7**	**5.0**	
	A. japonica	14.3	25.0	13.1	3.8	2.2	1.5	12.5	2.8	3.6	4.9	10.0
	Other *Anguilla* spp.	-	-	-	-	5.5	10.0	1.5	0.2	0.1	0.1	10.0

Source: Joint Statement (2014) , Joint press release (2017) and Fisheries Agency of Japan (2018).

Note 1:"20XX-XX+1" means season of input of glass eel for farming from 1 November 20XX to 31 October 20XX+1.

Note 2: The numbers of 2016-2017 glass eel season are provisional.