

CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA



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INCREASING GLOBALISATION OF CROAKER (SCIAENIDAE) FISH MAW TRADE
IS THREATENING TARGET SPECIES AND VULNERABLE BYCATCH

1. This document has been submitted by the United States of America on behalf of the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Croaker and Drum Fishes Red List Authority in relation to agenda item 24 of PC27 and item 29 of AC33 on *Identifying species at risk of extinction affected by international trade*.^{*} The document does not reflect the official position of the United States.
2. Decision 19.187, adopted under Resolution Conf. 19.2 on Capacity-building, directs the Animals and Plants Committees to develop draft recommendations for consideration by the Standing Committee to facilitate the implementation of Decision 19.186 to 19.188 on Identifying information on species at risk of extinction affected by international trade. This document has been prepared in this context by the IUCN Species Survival Commission Croaker and Drum Fishes Red List Authority for the consideration of the 33rd meeting of the Animals Committee. The following pages briefly summarise the emerging threat to at least eight species of teleost fish in the family Sciaenidae, the Croakers, which are increasingly being targeted to supply rising high value international trade demand. The increases in fisheries effort are additionally leading to high rates of fisheries mortality for species of small marine mammals (Cetaceans and Sirenians), sharks and rays (Elasmobranchs), and turtles (Testudines) that are globally threatened with extinction.

Introduction

3. Fish maw is the trade term for dried teleost swim bladders. Chinese cultures in Asia are the largest global consumers of fish maw¹. Croakers (Sciaenidae) have been the most consumed and highest valued species, due to their large, thick, and collagen rich swim bladders. In Hong Kong SAR of China, fish maw is now the most commonly used alternative to shark fin².
4. Recently, the need for management attention toward the global trade of croaker fish maw has increased^{1, 3, 4, 5}, and a motion for '*Controlling and monitoring trade in croaker swim bladders to protect target croakers and reduce incidental catches of threatened marine megafauna*' was adopted at the 2021 IUCN World Conservation Congress⁶. Of particular concern are the exceptionally high market prices driving targeted fisheries for large-bodied croakers^{3, 4} and other bony fishes with desirable maw traits, such as lates perches (*Lates* spp.)⁸, pike conger (*Muraenesox* spp.), and pufferfish (Tetraodontidae spp.)^{1, 4}. These fisheries, which endanger multiple aquatic fauna taxons, are emerging mostly in lower income nations with limited fisheries and trade management capacity^{3, 5}.
5. At least 110 nations export fish maw to Hong Kong SAR of China, and the global value and volume of maw is now comparable to each of shark fin and sea cucumber¹. Since fish maw lacks a specific commodity code in international trade databases, identifying global volume, value, and the source and sink nations of the trade is challenging^{1, 3, 4}. Only Hong Kong SAR of China's Census and Statistics Database has specified fish maw commodity codes since 2015.

^{*} The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.

Implications for target species

6. The emergence of intensifying croaker fish maw fisheries is having negative impacts on an increasing number of target species. For many of these species, knowledge on the population status is poor, and impacts from fisheries pressure in global source nations remain poorly understood.
7. Croakers are characterised by slow growth, longevity, and predictable spawning aggregations. A concerning trait of croaker fish maw fisheries is that the largest length classes are targeted, often during spawning aggregations when the mature proportion of the population is concentrated in a confined area around estuaries and adjacent shallow coastal habitats^{5, 9, 10}.
8. Targeted fishing of endemic Chinese bahaba (*Bahaba taipingensis*) has led to this species being listed as Critically Endangered on the IUCN Red List^{10, 11}, and there are now increasing conservation concerns for other species targeted for their maw, including Vulnerable totoaba (*Totoaba macdonaldi*), acoupa weakfish (*Cynoscion acoupa*)¹², and Near Threatened blackspotted croaker (*Protonibea diacanthus*)⁵. Gorman¹³ found that across 286 species of croakers, the 29 species present in the fish maw trade were at higher extinction risk on the IUCN Red List, due to exploitation (Table 1). Ongoing and increasing targeting of croakers for fish maw will likely amplify this pattern into the future^{4, 13}.
9. International trade value of croaker fish maw is driving exploitation in source nations⁴. For example, maw:meat price ratios can be as high as 26,025:1 in Papua New Guinea for scaly croaker (*Nibea squamosa*)³, 8,389:1 for totoaba in Mexico⁴, 1,718:1 for blackspotted croaker in Papua New Guinea³, and 2-115:1 (inclusive of four croakers and six catfishes [Siluriformes]) in Brazil¹². Increased rareness of specimens from depleted species populations appears to be driving increases in species-specific price and fishing effort, in turn exacerbating extinction risk^{3, 4, 5, 10}.
10. To assess the impact of international trade on the extinction risk of croaker species, data from 32 species of croaker used in analysis of IUCN Red List data by Challender et al.¹⁴ were examined. This analysis included 11 species identified by Gorman¹³ as being present in the international fish maw trade and indicated that eight (73%) of these are likely threatened by international trade, while three Data Deficient species were found to be unlikely threatened by international trade. The Challender et al.¹⁴ analysis considers a range of information and classification codes used by the IUCN Red List and does not specifically indicate that fish maw is the internationally traded product driving extinction risk. However, for these species with information on their maw being traded internationally, the value of their maw is most often driving present exploitation.

Implications for vulnerable bycatch

11. The severe population depletion and now seemingly imminent extinction of the vaquita (*Phocoena sinus*) is due to its incidental mortality in the targeted totoaba fish maw fishery¹⁵ – both endemic species to the Gulf of California, Mexico. Croaker fish maw fisheries are now also increasing extinction risks for a number of other globally threatened small marine mammals in other global regions (e.g., dolphins [Delphinidae] and porpoises [Phocoenidae] in the Bay of Bengal⁵ and dolphins and dugong [*Dugong dugon*] in Papua New Guinea^{3, 16}). There is a growing concern, with additional evidence to be quantified, that fish maw fisheries also pose a significant risk to globally threatened turtles^{3, 5}.
12. Croaker fish maw fishing effort is increasing mortality of Critically Endangered Indo-Pacific sawfishes (Pristidae) in Papua New Guinea, one of the last strongholds for all four Indo-Pacific species, which are now seldom observed in landings^{16, 19, 20}. Other coastal and estuarine shark and ray species are also vulnerable to fisheries targeting croakers, lates, perches, and other teleosts valued for their maws (e.g., Table 2)³. Presently, 76% of coastal shark and ray species and 65% of estuarine associated species are listed as threatened on the IUCN Red List^{17, 18}. An increase in croaker fish maw fisheries in priority habitats for globally threatened coastal and estuarine sharks and rays stands to compound their conservation risk. For example, in Papua New Guinea, Grant et al.¹⁶ observed a single fish maw fishing community landing 1,112 elasmobranch specimens in four months, 97.1% of which were of globally threatened species. The two main target fish maw species (scaly croaker and Barramundi [*Lates calcarifer*]) constituted 22% of landings in broader this fishery, while elasmobranchs constituted 49%.
13. Unmonitored and unmanaged croaker fish maw fisheries may also be undermining the effectiveness of present CITES trade regulations in countries lacking enforcement capacity. For example, in Papua New Guinea, landings and harvest of fins from CITES listed sharks and rays has notably increased within the fish maw fishery^{3, 19}. In Bangladesh, fish maw and shark fins are combined in export statistics, highlighting

their similarity and connectivity, while simultaneously creating a lack of transparency in trade for these commodities ⁵.

Implications for fishers in source nations

14. In lower income nations, market value can drive situations of a 'gold rush' mentality within croaker fish maw fisheries, and they are often associated with Illegal, Unreported, and Unregulated (IUU) fishing practices ^{1, 3, 7, 21}. This can result in overexploitation of target ^{9, 10, 11}, incidentally caught ^{5, 15}, and secondarily landed bycaught species ^{3, 16, 19, 20}, for short-term gain, which diminishes the ability of the species to fulfill their role in the ecosystem and undermines the availability of these resources for future food and economic security. Disparate value between maw and meat has also led to meat and deceased lower value bycatch being discarded due to issues with preservation capacity on fishing vessels, fishing camps, or in land-based storage facilities ^{1, 2, 21, 22}.
15. Croaker fish maw fisheries and trade also has increasing links to organised crime driven by high potential profits. For example, supply and trade of totoaba has been controlled by cartel networks, who facilitate overexploitation through increases in fisheries effort, violation of spatial and gear restrictions, illegal modification of the environment, and assertion of control over export market chains ⁷. A similar pattern is seemingly emerging in Papua New Guinea ³. The risks of informal market regulation are that upon overexploitation, fishers' risk being isolated with lost resources, while traders are able to relocate.

Conclusion

16. **Sustainability** – Fish maw is a dried seafood item for a predominantly Asian market sourced globally from fisheries that are generally poorly managed and unsustainably exploited. The exploitation of croakers valued for their large maw is driven by extremely high market value. Target species include large-bodied croakers with life history and ecological traits that render them vulnerable to overexploitation. The increased demand for croaker maw is threatening a wide range of other species that are incidentally caught or secondarily landed in the croaker fish maw fisheries, including globally threatened small marine mammals, sharks and rays, and turtles.
17. **Legality** – The requirement for international coordination in controlling the trade of high value croaker fish maws has been highlighted in 2021 by the IUCN urgent motion ⁶ and issues of ongoing trade in CITES Appendix I listed totoaba maws has been discussed at length within CITES documentation. Legality issues of fish maw source and trade extend beyond totoaba, with fish maw trading license applications having been suspended in Papua New Guinea, for example, owing to increased IUU fishing practices driven by high maw value on the global market. The emerging pattern is that sourcing and trade of maw is often facilitated by assertive or criminal trader activities and IUU fishing practices.
18. Fish maw needs to be recognised as a comparable commodity to other dried seafood products such as shark fin, sea cucumber, and abalone. As the most consumed and highest valued species, Including croaker fish maw in trade reports will enable the monitoring of volume, value, and species of this trade, and in identifying global sources and consumer markets. As such, CITES can contribute to ensuring the sustainability of the take and trade for implicit species before their wild populations become increasingly threatened with extinction.
19. There is an opportunity for CITES to increase the sustainability, legality, and traceability of international croaker fish maw trade through CITES Appendices, and their associated source, legal, and trade documentation requirements.
20. The following publication is appended to this document:
Amevou, Y., Chin, A., Foale, S., Sant, G., Smailes, O., & Grant, M. I. (2024). Maw money, maw problems: A lucrative fish maw fishery in Papua New Guinea highlights a global conservation issue driven by Chinese cultural demand. Conservation Letters, e13006. <https://doi.org/https://doi.org/10.1111/conl.13006>

Table 1. Croaker (Sciaenidae) species identified as occurring in the global fish maw trade by Gorman 2020. Common names and maximum size follow those used by the IUCN Red List. ‘International trade risk’ refers to results of the Challendar et al ¹⁴ method, which excludes species listed as Least Concern, while the Vulnerable gulf corvina *Cynoscion othonopterus* and three species assessed as Data Deficient that are identified by Gorman ¹³, were also not present in the data (indicated by N/A). Possible categories of this analysis include Likely, Unlikely, and Insufficient Information. CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient. TL, total length.

Common name	Scientific name	IUCN Red List Category (Year assessed)	International trade risk ¹⁴	Maximum size (cm, TL)
Chinese Bahaba	<i>Bahaba taipingensis</i>	CR (2019)	Likely	~200
Large Yellow Croaker	<i>Larimichthys crocea</i>	CR (2016)	Likely	80
Dusky Meagre	<i>Argyrosomus japonicus</i>	EN (2018)	Likely	~200
Acoupa Weakfish	<i>Cynoscion acoupa</i>	VU (2021)	Likely	120
Gulf Corvina	<i>Cynoscion othonopterus</i>	VU (2021)	N/A	101
Totoaba	<i>Totoaba macdonaldi</i>	VU (2020)	Likely	~200
Blackspotted Croaker	<i>Protonibea diacanthus</i>	NT (2018)	Likely	150
Meagre	<i>Argyrosomus regius</i>	LC (2020)	N/A	200
Orange Croaker	<i>Atrubucca brevis</i>	LC (2018)	N/A	26
Blackmouth Croaker	<i>Atrubucca nibe</i>	LC (2018)	N/A	53
Smallscale Weakfish	<i>Cynoscion microlepidotus</i>	LC (2020)	N/A	95
Tonkin Weakfish	<i>Cynoscion similis</i>	LC (2019)	N/A	60
Smalltooth Weakfish	<i>Cynoscion steindachneri</i>	LC (2019)	N/A	110
Green Weakfish	<i>Cynoscion virescens</i>	LC (2020)	N/A	95
White Croaker	<i>Genyonemus lineatus</i>	LC (2019)	N/A	41
Ganges Croaker	<i>Johnius coitor</i>	LC (2020)	N/A	16
Little Yellow Croaker	<i>Larimichthys polyactis</i>	LC (2016)	N/A	40
White Flower Croaker	<i>Nibea albiflora</i>	LC (2016)	N/A	44
Soldier Croaker	<i>Nibea soldado</i>	LC (2016)	N/A	60
Scaly Croaker	<i>Nibea squamosa</i>	LC (2020)	N/A	60
Blotched Tiger-toothed Croaker	<i>Pterotolithus maculatus</i>	LC (2020)	N/A	45
Spine Bahaba	<i>Bahaba polykladiskos</i>	DD (2018)	Likely	40
Smallscale Croaker	<i>Boesemania microlepis</i>	DD (2021)	Likely	~100
Shortfin Weakfish	<i>Cynoscion parvipinnis</i>	DD (2019)	Unlikely	69
Cuja Croaker	<i>Macrospinosa cuja</i>	DD (2018)	Unlikely	152
Mi-iuy Croaker	<i>Miichthys miiuy</i>	DD (2016)	N/A	60
Bola Croaker	<i>Nibea coibor</i>	DD (2018)	N/A	120
Bronze Croaker	<i>Otolithoides biauritus</i>	DD (2020)	Unlikely	160
Bigmouth Croaker	<i>Pterotolithus lateoides</i>	DD (2018)	N/A	50

Table 2. CITES listed species caught in the Papua New Guinea fish maw fishery ^{3, 19, 20}. Listed shark and ray species have been increasingly landed and finned since the emergence of the fish maw fishery in southern Papua New Guinea in 2015, while listed dolphin, dugong, and turtle species have faced increased mortalities through their incidental catch.

Family	CITES Appendix	Species observed in Papua New Guinea fish maw fishery	IUCN Red List Category
Delphinidae (Dolphins)	Appendix I	<i>Orcaella heinsohni</i>	VU
		<i>Sousa sahalensis</i>	VU
Dermochelyidae (Leatherback turtles)	Appendix I	<i>Dermochelys coriacea</i>	VU
Dugongidae (Dugong)	Appendix I	<i>Dugong dugon</i>	VU
Pristidae (Sawfishes)	Appendix I	<i>Anoxypristis cuspidata</i>	CR
		<i>Pristis clavata</i>	CR
		<i>Pristis pristis</i>	CR
		<i>Carcharhinus amblyrhynchoides</i>	VU
Carcharhinidae (Requiem sharks)	Appendix II	<i>Carcharhinus amboinensis</i>	VU
		<i>Carcharhinus caudatus</i>	LC
		<i>Carcharhinus coatesi</i>	LC
		<i>Carcharhinus fitzroyensis</i>	LC
		<i>Carcharhinus leucas</i>	VU
		<i>Carcharhinus limbatus</i>	VU
		<i>Carcharhinus melanopterus</i>	VU
		<i>Carcharhinus sorrah</i>	NT
		<i>Carcharhinus tilstoni</i>	LC
		<i>Glyphis garricki</i>	VU
		<i>Glyphis glyphis</i>	VU
		<i>Negaprion acutidens</i>	EN
		<i>Rhizoprionodon acutus</i>	VU
		<i>Rhizoprionodon taylori</i>	LC
Carettochelyidae (Pig-nosed turtles)	Appendix II	<i>Carettochelys insculpta</i>	EN
Glaucostegidae (Giant guitarfishes)	Appendix II	<i>Glaucostegus typus</i>	CR
Rhinidae (Wedgefishes)	Appendix II	<i>Rhynchobatus palpebratus</i>	VU
Sphyrnidae (Hammerhead sharks)	Appendix II	<i>Eusphyrna blochii</i>	EN
		<i>Sphyrna lewini</i>	CR
		<i>Sphyrna mokarran</i>	CR

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PERSPECTIVE

Maw money, maw problems: A lucrative fish maw fishery in Papua New Guinea highlights a global conservation issue driven by Chinese cultural demand

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Abstract

Fish maw (teleost swim bladder) is a dried seafood product valued highly by Chinese cultures in East Asia, though global supply chains are poorly understood. Here, we describe the rapid development of a fish maw fishery in a low-income nation to illustrate how globalization can affect sustainability. In Papua New Guinea (PNG), fish maw developed into a fishery valued at ~\$831,000 USD annually between 2014–2018. Its development has been driven by Asian expatriates, who provide market access and fishing gear to local communities. The highest valued local species, scaly croaker *Nibea squamosa*, has a maximum value of \$15,615 USD kg⁻¹ (dried) at first-point-of-sale, potentially the highest first-point-of-sale fish maw product globally. Its value has led to high incidental catch rates of threatened species in an area that is a globally significant conservation stronghold. International trade databases need to recognize fish maw as a high value and globally traded product and consider a specific fish maw commodity code to assist nations in identifying emerging fish maw fisheries. Additionally, the Convention on the International Trade of Endangered Species of Flora and Fauna (CITES) could assist in protecting vulnerable fish maw species and facilitate management practices for incidentally caught threatened species.

KEYWORDS

Asian markets, dried seafood products, fish maw, international trade, sustainability, swim bladder

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1 | INTRODUCTION

China's Belt and Road Initiative development strategy has led to increased maritime investments and establishment of trade infrastructure in low-income nations (Song & Fabinyi, 2022). This has led to increased exploitation and import of fisheries resources to Chinese markets, although the fisheries sustainability and local livelihood impacts in source nations are poorly understood (Barclay et al., 2019; Song et al., 2022). One increasingly traded product is "fish maw" (teleost swim bladder), a fibrous organ used by fishes for buoyancy control and communication. Dried fish maw is a product mainly valued in East Asia, particularly within Chinese cultures who are the main consumers, and China itself is the largest consumer (Sadovy de Mitcheson et al., 2019). Fish maw is comparable to other luxury seafood items such as sea cucumber and shark fin in the volume, value, and number of countries contributing to global trade (Sadovy de Mitcheson et al., 2019). The value of high-end maw products can range from thousands to tens-of-thousands USD kg⁻¹, while reports exist of exceptional prices; \$475,000 USD for a single large Chinese bahaba *Bahaba taipingensis* (Moore, 2012). End uses of fish maw are diverse, but are mostly consumptive, mainly culinary or traditional Chinese medicines (Ben-Hasan et al., 2021; Sadovy de Mitcheson et al., 2019). Among Chinese cultures, fish maw is believed to reflect status, wealth, prestige, and honor and it is comparable to "shark fin" with respect to these same values (Ho & Shea 2015; 2021).

Chinese cultural demand for fish maw has led to development of high value global supply chains, with Hong Kong Special Administration Region (hereafter "Hong Kong SAR") being the main importer and re exporter. Sadovy de Mitcheson et al. (2019) found that 3144–3882 ton (t) of dried fish maw were imported annually to Hong Kong from 2015–2018, from 110 source nations with a value of \$264–394 million USD. Croaker (Sciaenidae) maws are the most abundant and generally highest valued, while other common taxa includes Lates perches (Latidae), pufferfish (Tetraodontidae), catfishes (Siluriformes), and pike conger (Muraenesocidae). Certain species possess particularly desirable maw traits (e.g., size, thickness, shape), leading to the development of targeted "fish maw fisheries" (Sadovy de Mitcheson et al., 2019). Owing to the exceptional prices and high demand, fish maw fisheries can be characterized by high and rapidly increasing fishing effort and unsustainability. These fisheries are increasingly linked to impacts on threatened species and negative social impacts for fishers (Ben-Hasan et al., 2021; Constant et al., 2021). For example, the impending extinction of the vaquita *Phocoena sinus* due to targeted illegal fishing in Mexico for totoaba *Totoaba macdonaldi* (Taylor et al., 2017) is a widely known negative consequence of a fish maw fishery.

Most studies have focused on source, trade, and consumption of fish maw, although there is paucity of information on the development and characteristics of fish maw fisheries in low-income nations (Constant et al., 2021). Here, first, we describe the rapid development and characteristics of a fish maw fishery in southern Papua New Guinea (PNG) by drawing on recent literature and anecdotal observations made by the Piku Biodiversity Network (a PNG non-government organization). Second, we examine trade data from the Fisheries and Agriculture Organization (FAO), Hong Kong's Census and Statistics Database (Hong Kong CSD), and United Nations International Comtrade database (UN Comtrade) to contextualize PNG's contribution to the global fish maw trade. Third, we highlight the conservation implications that PNG's fish maw fishery is having on an Indo-Pacific threatened species stronghold. Lastly, we discuss how this PNG case study illustrates a global pattern of emergent unsustainable fish maw fishery impacts. We argue the need for FAO and UN Comtrade to include a fish maw specific category to improve national level trade data, and we discuss the potential role that international agreements such as the Convention on the International Trade of Endangered Species of Wild Flora and Fauna (CITES) could have on achieving sustainable fish maw fisheries with flow on benefits to threatened bycatch.

2 | CASE STUDY: DEVELOPMENT OF THE GULF PROVINCE FISH MAW FISHERY

The Piku Biodiversity Network has been conducting and facilitating research on fisheries and cultural activities in the Gulf Province, PNG, for over a decade. In 2012, various fish species were being sold whole in small-scale markets for mean prices of \$0.3–5.8 USD (1 Papua New Guinea Kina = \$0.29 USD) (Eisemberg & Berra, 2016). In 2014–2015, two commercial seafood buyers, owned by Chinese expatriates, commenced operations in the Kikori District, coinciding with the emergence of a fish maw fishery. Companies made arrangements with local fishing communities whereby gillnets, boats, outboard engines, and side (insulated cooler boxes) were provided to fishers on the condition that fishery products were sold back to them (this practice continues presently) (Grant et al., 2022; Grant et al., 2021b). No knowledge of prices for commercial fish products exists for this early period. In 2018–2019, the concerted targeting of stone fish *Nibea squamosa* and barramundi *Lates calcarifer* for fish maw was first documented (Grant et al., 2021a; Grant et al., 2021b). Maximum dried maw prices (first-point-of-sale) at this time were

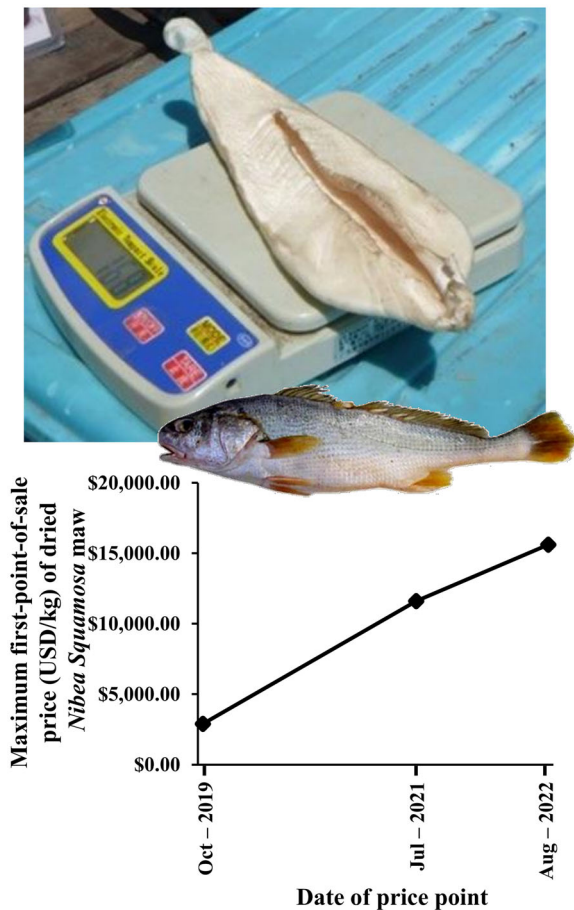


FIGURE 1 (Top) harvested scaly croaker “stone fish” *Nibea squamosa* maw with wet weight of 168 grams. Reportedly, dried maw weight is about half wet weight. (Bottom) Maximum local value of dried *N. squamosa* maw from 2019 to 2022 in the Gulf Province.

\$2900 USD kg⁻¹ for *N. squamosa*. Owing to COVID-19, field activities were restricted from 2019 to 2021. By July 2021, the maximum *N. squamosa* maw price had reached \$11,600 USD kg⁻¹ (Figure 1).

In September 2021, the National Fisheries Authority announced a closure to new license applications for fish maw, citing the occurrence of illegal, unregulated, and unreported activities pertaining to this fishery (https://www.fisheries.gov.pg/_files/ugd/2c6676_269e9667735a4a08b73e5342a8c05943.pdf). This closure is in place until a fish maw management plan is developed and to protect presently operating businesses. At the time of the closure, six companies in the Gulf Province were associated with fish maw, and collectively there were 15 active buyer licenses (Figure 2). Each of the companies are owned by Asian expatriates. Licensed buyers associated with each company include at least one expatriate, while other licensees are local community members. Most of the companies presently engaging in fish maw trading were licensed in 2017–2019. This

included the opportunistic adaptations of several companies that trade in other products or services (e.g., groceries and accommodation) to also engage in fish maw trade.

In August 2022, product price lists were obtained from public notice boards at two companies. The maximum *N. squamosa* dried maw price was \$15,615 USD kg⁻¹ at KW Veraibari Seafood (maw > 130 g), while maximum price of *N. squamosa* maw at Kikori Seafood LTD was \$8120 USD kg⁻¹ (maw up to 100 g). Black jewfish *Prontonibea dicanthus* maw had a maximum value of \$1547 USD kg⁻¹ (maw > 300 g) at Kikori Seafood LTD (Supplementary Information). Meanwhile, fish meat was \$1.5 USD kg⁻¹ for *L. calcarifer*, and \$0.6 USD kg⁻¹ for *N. squamosa*. Of the two species with meat and maw prices provided, the maximum ratio of meat:maw price was 1:26,025 for *N. squamosa*, and 1:1718 for *P. dicanthus*.

3 | VOLUME AND VALUE OF PNG'S FISH MAW TRADE

PNG fish maw export data were taken from the FAO (available data 2014–2020), while data on fish maw imports from PNG were taken from UN Comtrade (China, Hong Kong SAR and Singapore only) and Hong Kong CSD for 2014–2021. In both the FAO and UN Comtrade databases, fish maw is listed within an amalgamated commodity, hereafter “amalgamated fish maw commodity,” while Hong Kong CSD has a fish maw specific commodity (Supplementary Information).

PNG's reported exports of the amalgamated fish maw commodity to FAO increased from 0 in 2013, to 13.61 metric tonnes (mt) in 2019, and declined to 3.83 mt during the height of the COVID-19 pandemic (Figure 3). The largest increase in volume (600%) occurred between 2017 (2.0 mt) and 2018 (12.0 mt), with export value peaking at \$831,000 USD in 2018 (Figure 3). In 2019 and 2020, FAO trade partner countries indicated that China Hong Kong SAR (primary) and Singapore (secondary) were the largest importers of PNG's amalgamated fish maw commodity (Supplementary material).

Hong Kong CSD and UN Comtrade import data had variable correspondence with PNG's FAO exports (Figure 3). The reported import values corresponded to PNG's reported exports values for 2014–2017, and 2019. This indicates that most of the amalgamated fish maw commodity in these years was imported by China, Hong Kong SAR. In other years import and export data did not correspond, highlighting issues in the transparency of traded products within the amalgamated fish maw commodity. For example, in 2015 17.7 mt of the amalgamated fish maw product was imported by China, Hong Kong SAR, though the lower import value (\$267,689 USD) indi-

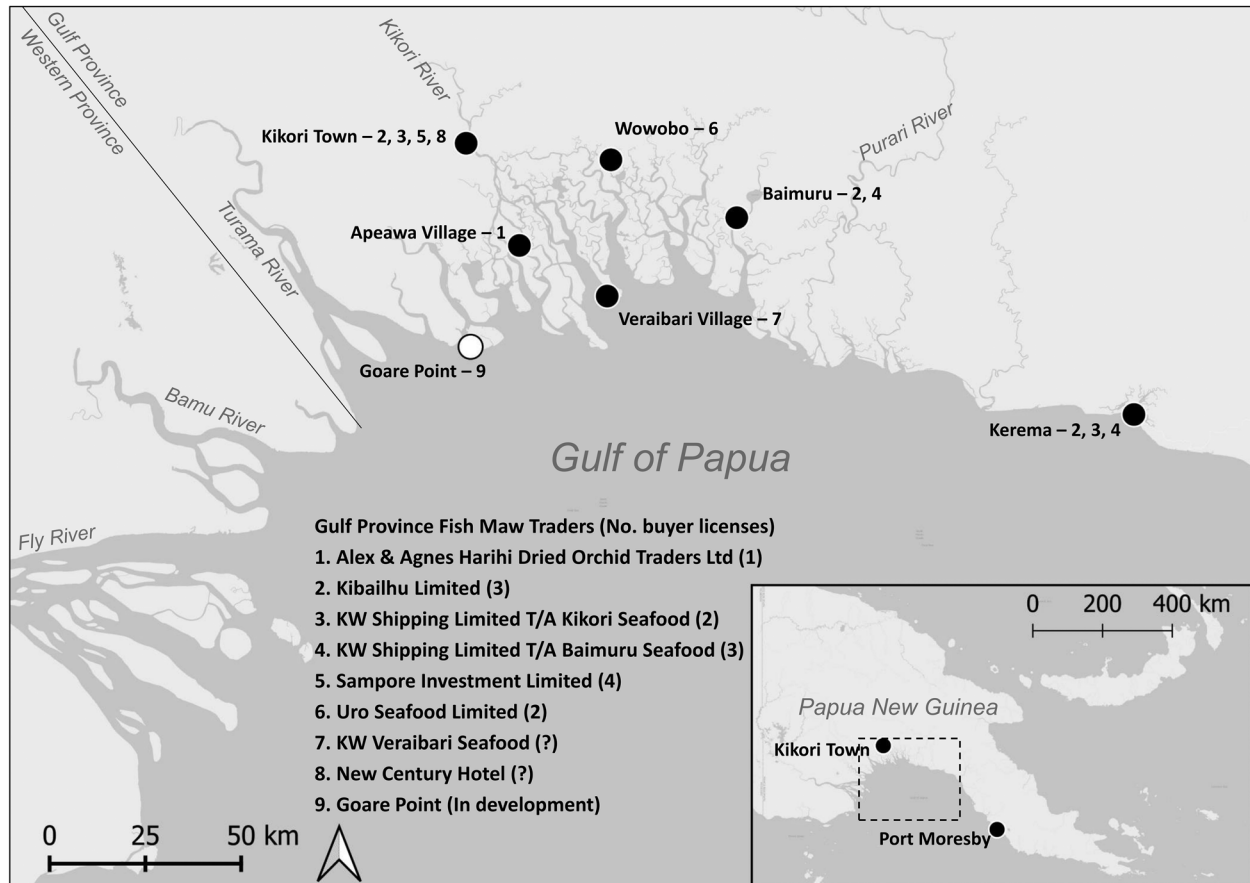


FIGURE 2 Location of commercial fish maw buyers in Gulf Province. Companies engaged in the fish maw trade are listed and the sites of their business operations are given in parenthesis. Number of buyer licenses associated with each company are also given.

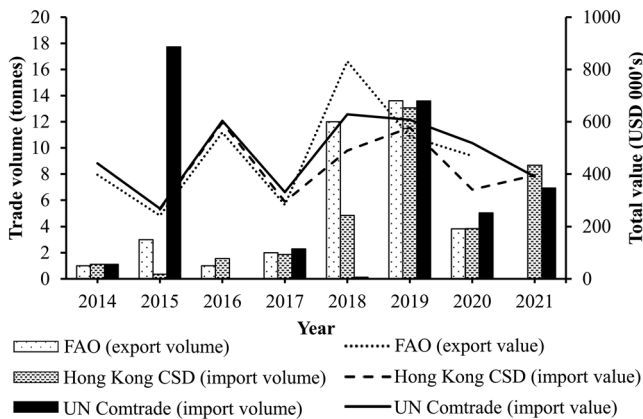


FIGURE 3 Fish maw volume and value statistics for PNG exports (FAO, FishStatJ database; 2014–2020), China, Hong Kong SAR imports (Hong Kong Census and Statistics Database; 2014–2021), and UN Comtrade imports for China, Hong Kong SAR and Singapore (United Nations International Trade Statistics Database; 2014–2021).

ory should show equal or higher volumes and values to amounts reported on Hong Kong CSD and UN Comtrade.

In the context of the global fish maw imports by China, Hong Kong SAR, PNG's contribution ranged from 0.01% to 0.40% during 2015–2021, with the greatest contribution occurring in 2019. PNG's contribution by measure of value ranged from 0.1% to 0.22%, with the greatest contribution occurring in 2016. Reported values for price kg^{-1} varied considerably with respect to the global average. In 2015, the import price kg^{-1} from PNG was 862% higher than the global average, while in 2019 the import price from PNG was 54% lower than the global average (Table 1). However, we suggest these values reported to the FAO are an underestimate, as reported values do not appear to reflect prices being reported by fishers on the ground (Supplementary Information).

4 | CONSERVATION IMPLICATIONS OF FISH MAW FISHERIES IN PNG

cated this only included fish maw in part. This volume is not represented in FAO export data, which in the-

The rapid development of PNG's fish maw fishery is having large impacts on its populations of threatened

TABLE 1 Volume and value of fish maw imports for all countries (global) and Papua New Guinea as reported on the Hong Kong Census and Statistics Database.

	2015	2016	2017	2018	2019	2020	2021
Global							
Volume (mt)	3144.06	3319.77	3272.05	3882.08	3294.18	3175.71	3460.91
Value	\$264,159	\$266,861	\$262,202	\$391,521	\$316,804	\$279,881	\$261,377
(USD 000's)							
Price kg ⁻¹	\$84.02	\$80.39	\$80.13	\$100.85	\$96.17	\$88.13	\$75.52
Papua New Guinea							
Volume (mt)	0.37	1.56	1.87	4.83	13.07	3.85	8.67
Value	\$264,346	\$596,975	\$294,284	\$489,326	\$577,484	\$340,273	\$395,308
(USD)							
Price kg ⁻¹	\$724.23	\$383.91	\$157.04	\$101.25	\$44.20	\$88.50	\$45.62

Note: Only data for the commodity 03057210, fish maws, dried, was included (available range was 2015–2021). Metric tonnes, mt; kilogram, kg.

marine megafauna. Southern PNG has been identified as a stronghold for threatened Indo-Pacific sawfishes (Pristidae) and river sharks *Glyphis* sp. (Fordham et al., 2018; Grant et al., 2021a). Other incidentally caught elasmobranchs in elevated extinction risk categories (Endangered or Critically Endangered) include three hammerhead sharks (winghead *Eusphyrna blochii*, scalloped hammerhead *Sphyrna lewini*, and great hammerhead *Sphyrna mokarran*), giant guitarfish *Glaucostegus typus*, and bottlenose wedgefish *Rhynchobatus australiae* (Grant et al., 2021a). It is likely that the Gulf of Papua region and associated rivers would qualify for several recently produced Important Shark and Ray Area criteria (Hyde et al., 2022). Additionally, southern PNG hosts an IUCN Important Marine Mammal Area, with two vulnerable inshore dolphin species, Australian snubfin dolphin *Orcaella heinsohni*, and Australian humpback dolphin, *Sousa sahuensis*, known from the area (Parra et al., 2017a; Parra et al., 2017b). Southern PNG is an important part of the Endangered pig-nosed turtle *Carettochelys insculpta* range (Eisemberg et al., 2018), while leatherback turtles *Dermochelys coriacea* and dugong *Dugong dugong*, both listed as vulnerable, are also present.

The emergence of the fish maw fishery has rapidly increased pressure on these species, and now threatens PNG's regional biodiversity heritage value. Sawfishes are already locally depleted (Grant et al., 2021b), while river sharks and *E. blochii* are currently being caught in large volumes (Grant et al., 2022; Grant et al., 2021a). Grant et al. (2022) recently observed the two main target fish maw species (*N. squamosa* and *L. calcarifer*) to constitute 22% of landings, while elasmobranchs constituted 49% of landings. In the Western Kikori River Delta, a single fish maw fishing community landed 1112 elasmobranchs over four months, 97.1% of which were from

species listed as threatened on the IUCN Red List. These sharks and shark-like-rays are usually finned, though meat is not commonly used for consumption or sale (Figure 4). Owing to significant increases in fishing effort due to fish maw, shark and ray landings and the volume of harvested fin have increased from pre-fish maw fishery levels. This includes CITES Appendix I (Pristidae) and II (e.g., Carcharhinidae, Rhinidae, Sphyrnidae) listed species. Furthermore, 69 inshore dolphin mortalities in the fish maw fishery were recorded from November 2021–May 2022 (I. Beasley, Unpubl Data). These species occur in small, localized populations, indicating that the present fisheries mortality presents a significant local extinction risk. The fish maw fishery also threatens turtles, with the first observations of entangled *D. coriacea* observed in 2022, while capture in gillnets is an ongoing issue for *C. insculpta* (Eisemberg et al., 2015).

5 | GLOBAL INSIGHTS FROM PNG'S FISH MAW FISHERY

The present case study highlights the rapid development of a high value fish maw fishery, driven by Chinese cultural demand. In five years, fish maw developed into a national commodity worth over \$800 000 USD annually (FAO value). The Gulf Province fish maw fishery is being driven by Asian expatriates facilitating steep increases in on-the-ground fisheries pressure and controlling value and export networks. Of concern is their supply of high-capacity fishing gears to local communities under leasing arrangements, and financial incentives for fishers to target the largest length classes. The engagement of locals in the fish maw fishery is further driven by prevalent issues with poverty, education standards, and general lack of alterna-



FIGURE 4 On February 3, 2020, 51 discarded carcasses were observed on the beach of a single fishing village community. Among these carcasses were five endangered narrow sawfish *Anoxypristis cuspidata*. All sharks and shark-like-rays had been finned. A large king threadfin salmon with only its swim bladder harvested (for fish maw trade) was also observed among the carcasses.

tive livelihood options (e.g., Allen et al., 2005; Wiltshire et al., 2020; Magury, 2022).

Much of the globe's fish maw product is sourced from low-income nations with limited fisheries management (Ben-Hasan et al., 2021; Constant et al., 2021). This is the case in PNG's Gulf Province. There is presently no management of PNG's fish maw fisheries, and consequently there is a lack of data on volume, trade, spatial scale, the economic and social impacts of fisher communities, and there are no population status indicators for target and incidentally caught species (Grant et al., 2021a). The absence of a fisheries management plan means there is no impetus for companies or associated fish maw buyers to record transaction data (purchase volumes and value) or abide to any other information lodging requirements that would ordinarily assist managers. As such, along with threatened species issues, there are serious concerns for the sustainability of target species, which lack information to inform sustainable harvest strategies (Grant et al., 2022; Grant et al., 2021a). It is known that croakers (*N. squamosa* and *P. diacanthus* in the present study region) are generally slow growing and vulnerable to over exploitation (Cheung et al., 2005; Kinch, 2006). The increasing global value of fish maw has driven the rapid expansion of croaker fisheries in neighboring Queensland, Australia, causing fisheries managers to enact a regulation that whole fish (with swim bladder naturally attached) must be landed and a Total Allowable Catch of 26 mt has been imposed, which is typically reached within the first few months of the year (following commencement of annual fishery allotment). The absence of similar fisheries management regulations in PNG risks creating a scenario whereby companies purchasing fish maw can exploit the fishery resources in the highest capacity possible, before requisite information becomes available for managers to enact controls. The decision of the National Fisheries Authority to close new fish maw trading license applications in response to

a clearly unsustainable fishery is a positive step, while it deliberates on management options.

Given the exceptional prices of fish maw on the global market, it is possible that fish maw traders are intentionally targeting high value maw species in low-income nations with limited fisheries management such as PNG, as rapid and unregulated exploitation is possible. The present case study has illustrated the need for the international community to recognize the sustainability, conservation, and social risks of fish maw fisheries, and develop systems for the early detection of detrimental exploitation in low-income nations that lack management resources and capacity. This will also facilitate international assistance for low-income nations in developing national level policy and providing resources and capacity to effectively manage and monitor their fish maw fisheries.

6 | MANAGEMENT PRIORITIES FOR THE GLOBAL FISH MAW TRADE

The collection of catch data for species entering the fish maw trade is limited, but given fish maw is primarily traded internationally, international trade databases offer a good indicator and monitoring point to infer catch. Historically, in the development of data categories for monitoring fisheries trade there appears to have been priority given to high value products that drive fishery production, such as meat in the case of teleosts. Therefore, lower value by-products were amalgamated into single categories, such as the case with fish maws in FAO and UN Comtrade categories. Owing to changing demand in global markets, this amalgamation is inappropriate for fish maws, which are increasingly driving fishery effort, such as in the present case study. The present ambiguity of global fish maw export and import statistics limits our ability to understand trends in global trade and value, inhibiting our

ability to globally manage fish maw and its associated fisheries. Presently, the most reliable data source of fish maw trade is Hong Kong CSD (the only database with a specific fish maw commodity code), although this potentially means that contributions of other fish maw market hubs (e.g., Vietnam, Singapore) are being overlooked. There is now sufficient evidence that concerted high value fish maw fisheries exist, and that they are generally poorly understood and managed (Ben-Hasan et al., 2021; Sadovy de Mitcheson et al., 2019). There is an opportunity for international trade databases to collate fish maw data as a single product category, preferably at a species level. This will assist in (1) identification of emerging fish maw fisheries; (2) add much needed transparency to the global trade and implicit species; and (3) facilitate management actions at the appropriate national, regional, or international scales.

Benefits may also be achievable from international trade agreements such as CITES. Species listed within Appendix II of CITES can be traded when accompanied with export permits issued by the exporting country that indicate legal acquisition (Legal Acquisition Finding) and non-detrimental harvest to the population (Non-Detriment Finding). Given the extinction risk for a number of species harvested for international trade of their fish maws (Ben-Hasan et al., 2021; Sadovy de Mitcheson et al., 2019), additional species may meet the listing criteria for CITES Appendix II. This could be an effective policy tool to facilitate improved national management and monitoring of targeted fish maw fisheries, and would likely have positive flow on effects for incidentally caught threatened species. Further, as we have observed in our case study in PNG, fish maw trade may be facilitating the capture and trade of species already listed on CITES Appendices I and II. We acknowledge that such listings would require a concerted effort from the international community to assist implicated low-income nations to meet CITES obligations and supplement affected fisher livelihoods.

Ultimately, the global fish maw trade represents a complex challenge, but without skilled assessment and management, the risk of negative impacts could be significant. Chinese cultural demand for luxury dried seafood products is a sustainability and conservation challenge that has arisen many times before (Fabinyi, 2012; Fabinyi & Liu, 2014). It is likely that lessons can be learnt from the international trade management of other products, to set in motion policy and management actions that will facilitate targeted sustainable harvest of fish maw and conserve species that are incidentally caught in these fisheries.

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DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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