MONTEREY BAY AQUARIUM®

Seafood WATCH

Indian Squid, Mitre Squid

(Loligo duvauceli), (Loligo chinensis)

Indo-Pacific

Otter trawl

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Disclaimer

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Final Seafood Recommendation

Mitre squid from China and Thailand and Indian squid from India and Thailand are ranked as **Avoid**

Stock	Fishery	Impacts on the Stock Rank (Score)	Impacts on Other Species Lowest scoring species Rank*, (Subscore, Score)	Manage-ment Rank (Score)	Habitat and Ecosystem Rank (Score)	Overall Recommendation (Score)
Indian Squid	Thailand	Yellow (2.64)	Turtles, Coral/Biogenic Habitat Red, (1.41,1.34)	Red (1.41)	Red (2)	**AVOID (1.78)**
Indian Squid	India	Yellow (2.64)	Turtles, Coral/Biogenic Habitat Red, (1.41,1.34)	Red (1.41)	Red (2)	**AVOID (1.78)**
Mitre Squid	Thailand	Yellow (2.64)	Turtles, Coral/Biogenic Habitat Red, (1.41,1.34)	Red (1.41)	Red (2)	**AVOID (1.78)**
Mitre Squid	China	Yellow (2.64)	Coral/Biogenic Habitat, Turtles Red, (1.41,1.34)	Red (1)	Red (2.12)	**AVOID (1.65)**

Scoring note – scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

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Executive Summary

This report provides recommendations for two major commercially imported squid species to the United States: the Mitre squid, *Uroteuthis (Photololigo) chinensis,* and the Indian squid, *Uroteuthis* (*Photololigo) duvauceli.* Both are inshore species ranging throughout the coastal waters of the Indo-Pacific and are fished in large and small scale fisheries using a variety of gears including otter trawls, purse seines, hook and line and artisanal fishing methods. However, epibenthic otter trawl, suspended just over the seabed, is the primary commercial gear type used, and is the only gear reviewed in this report. All imported squid assessed in this report Mitre squid from China and Thailand and Indian squid from India and Thailand—are ranked as Avoid.

Both *U. chinensis* and *U. duvauceli* exhibit one-year life histories with no annual biomass carryover, complex distributions, and may be heavily influenced by year to year environmental variability. This inherent volatility makes squid stocks both highly susceptible to overfishing, and conversely, also capable of rapid recovery. Overall, the short life history characteristics of squids confer a low inherent vulnerability; however stock status is largely unknown and fishing mortality is not defined by biological reference points.

Drift gillnets were, historically, a major gear type used in high seas squid fisheries, but their use has been restricted since a global moratorium in January 1993. Before this time, squid fisheries had significant, incidental ecosystem impacts on other fish stocks, marine mammals and seabirds. Today *U. chinensis* and *U. duvauceli* are largely caught commercially via epibenthic otter trawls, sometimes including light luring techniques. No reliable bycatch or discard data are available for these fisheries for the three main import countries (China, Thailand, or India). However, based on Seafood Watch criteria, the likely species interactions with this gear type include benthic invertebrates, forage fish, finfish, turtles, sharks, marine mammals, and corals/biogenic habitat.

There is no international or regional fishery management for squid; management and enforcement are left up to individual countries within their exclusive economic zones and on the high seas. Because squid stocks cannot be assessed prior to fishing seasons due to life history constraints, management efforts are challenging under the best of circumstances in terms of protecting fishery impacts upon target species and related ecosystems. Excess capacity, excessive fishing effort, and poor enforcement all contribute to the difficulties in effectively managing these squid fisheries. In some situations, open access fisheries also exacerbate the challenges.

Epibenthic otter trawls are the main commercial gear types used. Individual management bodies have instituted restrictions on the cod-end mesh sizes of trawl gear and area/seasonal closures; however, knowledge about the use or effectiveness of these measures is generally lacking. Inshore squid pelagic trawls are suspended just off the seabed to avoid fouling the gear, however, some contact with the seafloor is anticipated; therefore, squid trawls are considered

to come in contact with the benthos. The ecosystem impacts of removing squid from the coastal systems are not known, however, squid are known to serve both as influential predators and critical prey for shelf ecosystems.

Introduction

Scope of the analysis and ensuing recommendation

This report provides recommendations for two major commercially imported squid species to the United States: the Mitre squid, *Uroteuthis (Photololigo) chinensis*, and the Indian squid, *Uroteuthis* (*Photololigo) duvauceli.* Both species range throughout the coastal waters of the Indo-Pacific and are fished in large- and small-scale fisheries using a variety of gears including otter trawls, purse seines, hook and line and artisanal fishing methods; otter trawling is the primary commercial gear used (Jereb and Roper 2010). Thus, only epibenthic otter trawls, suspended just over the seabed, are reviewed in this report.

Overview of the species and management bodies

There are more than 300 known species of squids, distributed throughout almost every major marine habitat in the world and ranging from the intertidal to over 5000m in depth. Considered subdominant predators, squids feed on crustaceans, fishes and other cephalopods (Rodhouse and Nigmatullin 1996), and may consume as much as 3%−15% of their body weight daily (Jereb and Roper 2010). In turn, squids serve as prey for fishes, marine mammals, and seabirds (Piatkowski et al. 2001); cannibalism is also common (Ibanez and Keyl 2010). Squids are dioecious (separate sexes), with a life expectancy generally ranging from a few months to 1-2 years, usually ending in a single terminal spawning event. Due to the short life cycle and low generational overlap, population sizes are considered to be strongly variable and heavily influenced by temperature and other environmental conditions (Rodhouse 2010). However, the physiology and ecology of most squid species is still poorly understood.

Internationally, squid fisheries have increased dramatically over the last 25 years. As demand for marine resources increases, squid can provide a high protein alternative to fish stocks, particularly in those regions where other fish stocks may have become reduced by overfishing (Caddy and Rodhouse1998; Lu 2002). Commercial squid fishing operations are maintained by several countries in coastal waters worldwide and in international waters (FAO 2010). To date, there is no international or regional management of squid fisheries.

Despite some major species specific squid fisheries, a significant portion of international squid landings are only generally identified. This is due in part to regions with high species diversity and the prevalence of artisanal and small-scale components of world squid fleets (FAO, 2005). As a result, commercial US squid imports are largely not identified by species (National Marine Fisheries Service); the majority of squid imports into the U.S. are identified as either “Loligo NSPF” or “squid NSPF” (where NSPF stands for “not specifically provided for”). However, based on country of origin and major squid fishing areas, it can be concluded that squid species significant to the U.S. market include two inshore species prevalent in western Pacific and Indo-Pacific waters: the Mitre squid (*Uroteuthis chinensis*) and the Indian squid *Uroteuthis duvauceli*). Descriptions of each follow:

U. chinensis (Mitre squid) – *U. chinensis* ranges from the western Pacific to the Indian Ocean (Fig. 1), and from approximately 15-170m in depth. It is a moderately sized squid, common to 200mm in mantle length with an elongate slender, bluntly pointed mantle and long fins over two-thirds of the mantle length. Most basic biological information is lacking for the species; however, peak spawning occurs in the spring and autumn in dense aggregations. *U. chinensis* is one of the major species in the Chinese squid catch (along with the related species *U. edulis*), and a significant species in squid trawls in the Gulf of Thailand, the Philippine Islands, Malaysian and Northern Australian waters. It is also reported in the catches of India and Sri Lanka (Jereb and Roper 2010)

U. duvauceli (Indian squid) – *U. duvauceli* is an Indo-West Pacific species that ranges throughout the Indian Ocean to Malaysia and the South China Sea (Fig. 1), at depths between 30 and 170m. Mantles are commonly up to 150mm, moderately long and slender with broad fins approximately 50% of the mantle length; spawning occurs throughout the year but principally in spring and autumn. Along with *U. chinensis*, *U. duvauceli* constitutes up to 90% of the squid catches off of Thailand, and is also the major squid species in most Indian fisheries. *U. duvauceli* is also prevalent in the Philippines, Malaysia, the Java Sea and appears in the commercial Hong Kong fishery (Jereb and Roper 2010).

Overview of management in China

Marine fisheries resources in China have been overfished since the late 1980s; since then, China has increased research and management measures to improve their fisheries and has expanded fishing efforts worldwide. General management strategies in Chinese fisheries include: attempted development of TACs (total allowable catch metrics), area closures, rationalization programs and gear modifications to reduce bycatch and habitat impacts. Nonetheless, fishing pressure remains high and management and enforcement are patchy. Ecosystem based management is recognized but not well implemented. China, on the whole, has demonstrated a record of cooperation with regard to sustainable fisheries management but regulates domestic fishing better than distant water fishing, in part because of the government's waning authority over private industry participants (Mallory 2012). The Chinese distant water fleet is the largest in the world and these fleets are largely unregulated and bound only to bilateral agreements with individual countries when fishing in their EEZs. Vessel monitoring (VMS) technology (Chang et al. 2010) and observer programs are in development, but catch statistics are often unreliable, and illegal, unreported and unregulated (IUU) fishing continues to occur (Mallory 2012).

Overview of management in India

India's coastal marine fisheries are open access. An inter-ministerial empowered committee looks after management and development of fisheries in the EEZ. Management varies by state and includes some seasonal/area closures and gear restrictions for trawls. Fisheries research in India is coordinated by the Indian Council of Agricultural Research (ICAR), an autonomous organization under the Ministry of Agriculture, the Agricultural Universities, and institutes under the Ministry of Agriculture (FAO India profile 2012). Ecosystem based management is not in practice, but there is a high emphasis by management on conservation and protecting marine biodiversity.

Overview of Management in Thailand

Management and development of the Thai fishing industry is the responsibility of the Department of Fisheries, which works closely with various organizations, both governmental and private in the management and development of fisheries as well as to promote the export of fish and fishery products (FAO Thailand profile 2012). The current policy for Thai waters is to manage fisheries resources effectively and to obtain a maximum sustainable production of 1.73 million tons a year (Thai Department of Fisheries website 2013). The majority of Thai fish stocks, including cephalopods, are considered over exploited and the Gulf of Thailand's marine ecosystem is reportedly skewed toward short-lived species and smaller size classes as a result of "fishing down the food web" (Chotiyaputta et al. 2002). Several factors may have contributed to this overfishing, notably: increased human population, increased pressure from Thai trawlers who lost access to foreign fishing grounds after neighboring countries declared EEZs, and increased numbers of industries that utilize trash fish (Janetkitkosol et al. 2003).

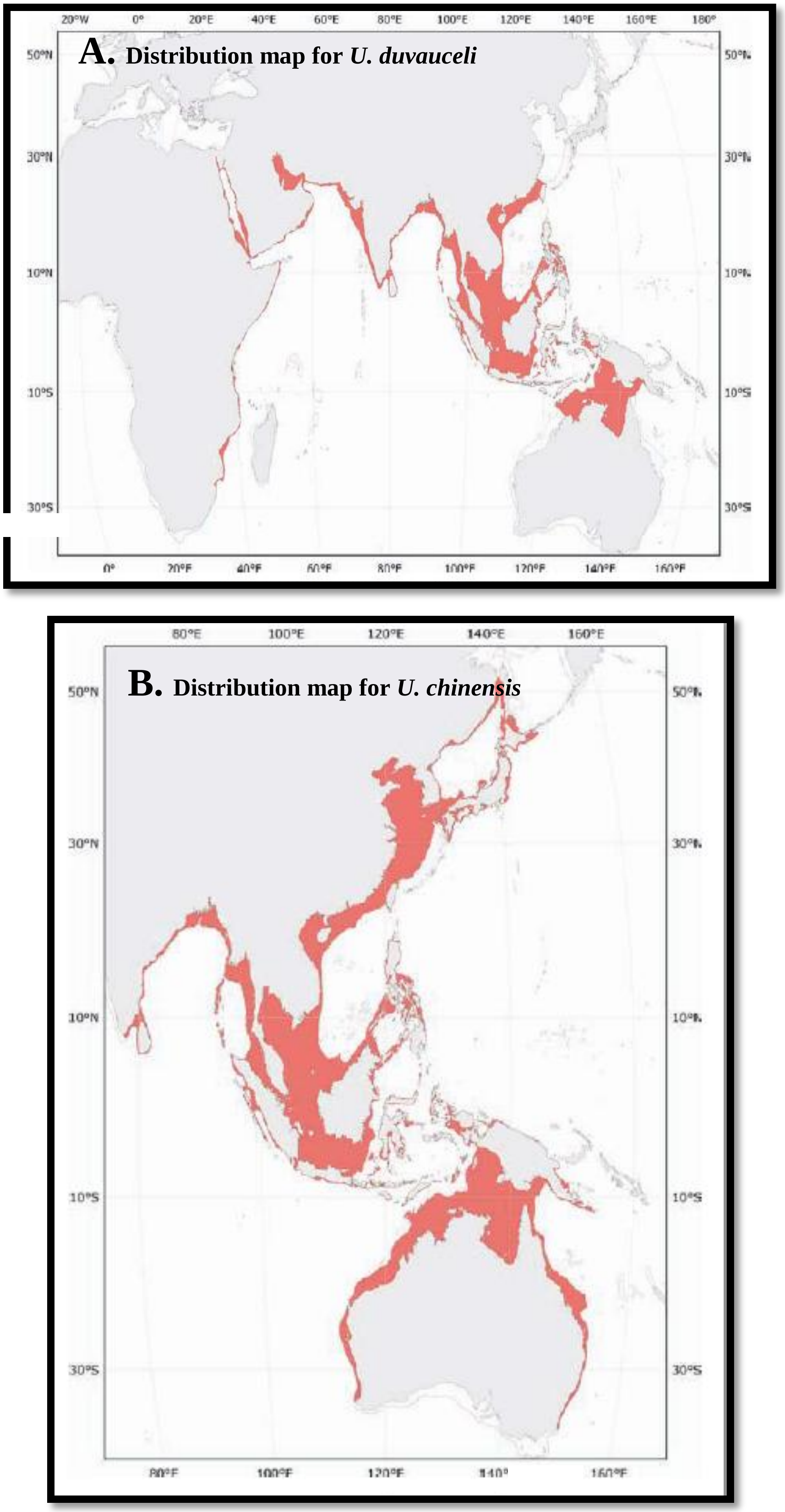

Figure 1. Distribution maps for *U. duvauceli* (A) and *U. chinensis* (B) (Figures from Jereb and Roper 2010)

Production statistics and importance to the US/North American market

Globally, cephalopod wild capture production has increased dramatically since the 1980s, due to depletion of finfish stocks and increased consumer popularity; today, annual cephalopod capture fisheries average above 3 million tonnes, comprising 4% of world fish trade (Figure 2; FAO 2010). In 2011, the U.S. imported 4,794 tonnes (~4,794,000 kilos) of squid (Figure 3). The majority of imports (~90% since 2008) come from five main countries: China (including Hong Kong and Taiwan), India, Thailand, Peru, and South Korea (Figure 4; NMFS). Descriptions of the major US squid-import source countries follow.

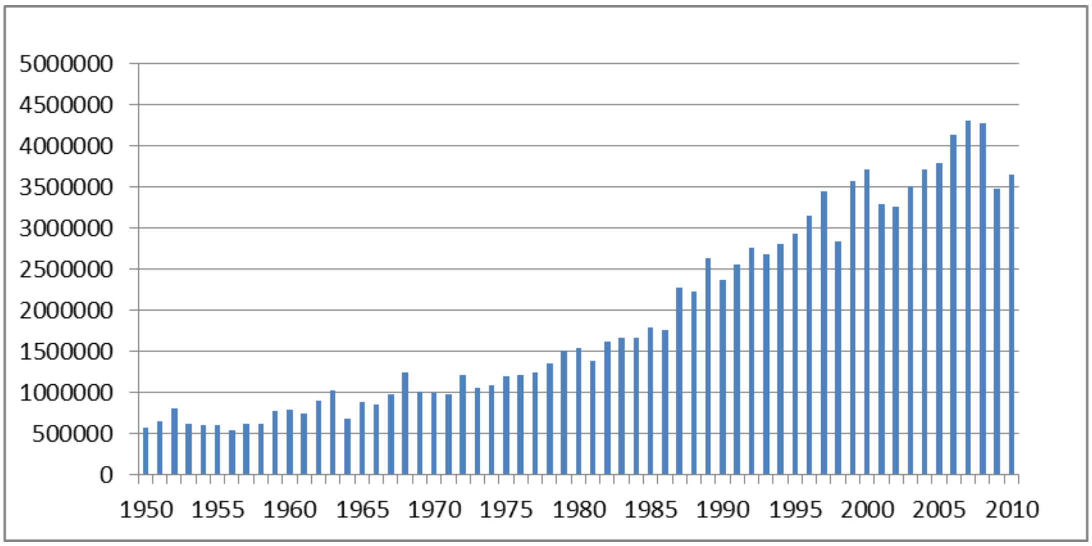

Figure 2. Global Cephalopod Capture Production (tonnes) (Data from FAO 2010)

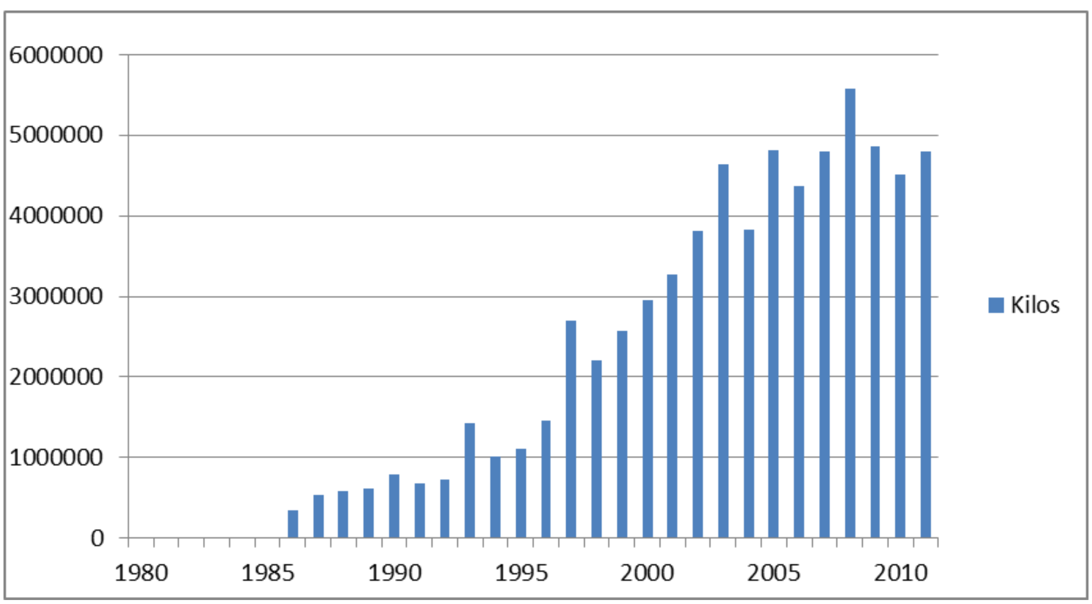

Figure 3. Total U.S. Squid Imports 1980 – 2011 (Data from NMFS 2012)

The following three countries represent the major contributors *of U. duvauceli* and *U. chinensis* to the U.S. market:

China: Since 1989, China has developed a major fishing fleet for oceanic squid, with an inshore fishery (including domestic *Loligidae* species such as *U. chinensis*), and more than 400 distant water squid jigging boats (Chen et al. 2008) that target a range of squid species across the world including *Ommastrephes bartramii* in the northwestern Pacific, *Illex argentinus* in the southwestern Atlantic, *Dosidicus gigas* in the southeastern Pacific, *Sthenoteuthis oualaniensis* in the northwestern Indian, and *Todarodes pacificus* in the Sea of Japan, among others. Cumulatively, China accounts for approximately a quarter of the global oceanic squid production: 26% in 2010, including Hong Kong and Taiwan (FAO, 2010). Chinese squid also constitute more than half of U.S. imports; in 2011, China contributed 1,219,278 kilos of "*Loligo* NSPF", 36,360 kilos of "*Loligo peleai*" (from the western Atlantic), and 2,268,107 kilos of "Squid NSPF" (NMFS).

India: India's squid fishing fleet accounted for 3% of the global squid production in 2010, and makes up approximately 5%−7% of U.S. squid imports. India's squid production is typically not identified to species in FAO statistics, listed only as "cephalopods nei" (where "nei" stands for "not elsewhere included"). However, it is caught entirely in Indo-Pacific waters and *U. duvauceli* is likely a significant proportion of that catch. U.S. imports for 2011 recorded 229,445 kilos of "Loligo NSPF" and 123,840 kilos of "Squid NSPF."

Thailand: Thai squid fishing accounted for 3% of global squid capture in 2010 (FAO 2010); the vast majority of this catch is caught in the Indo- and West Pacific and not reported at the species level. The Thai contribution to U.S. imports in 2011 was 8% of total squid imports; U.S. imports included 217,297 kilos of "Loligo NSPF" and 166,293 kilos of "Squid NSPF."

The following two countries, while major squid contributors to the U.S. market, do not contribute significant quantities of *U. chinensis* or *U. duvauceli* and are therefore not assessed in this report.

Peru: Peru's squid fishery, based entirely off the coast of South America, constituted 15% of the global squid production in 2009. The two major squid species targeted are *Docidicus gigas* and *Loligo gahi* (FAO). U.S. imports of Peruvian squid in 2011 were comprised of 20,412 kilos of "Loligo NSPF" (presumably *L. gahi*) and 134,020 kilos of "Squid NSPF" (presumably *D. gigas*), making up 3.3% of total U.S. squid imports for the year.

South Korea: South Korea's squid fishery is broadly distributed and captures a variety of squid species worldwide; major species include *Illex argentines*, *D. gigas*, *Todarodes pacificus*, and various *Loligidae* species. S. Korea captured 7% of global squid landings in 2010 (FAO 2010). Most recently, the country represented less than 3% of squid imports to the U.S. in 2011: 5,400 kilos of "Loligo NSPF" and 121,956 kilos of "Squid NSPF."

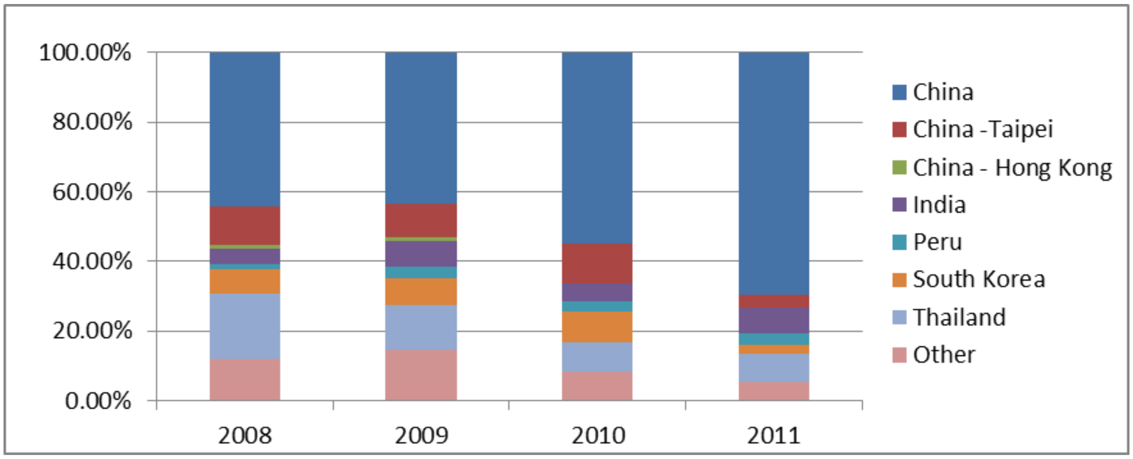

Figure 4. U.S. Squid Imports By Country, 2008-2011 (Data from NMFS 2012)

Common and market names

Squid is commonly sold in the U.S. under the name calamari.

Primary product forms

The majority of squid products for human consumption are imported frozen as whole, fillets or rings.

Analysis

Criterion 1: Stock for Which You Want a Recommendation

Summary

Similar to most squid species, *U. chinensis* and *U. duvauceli* exhibit one-year life histories with no annual biomass carryover, complex distributions, and may be heavily influenced by year to year environmental variability. This inherent volatility makes squid stocks both highly susceptible to overfishing, and conversely, also capable of rapid recovery. Overall, the short life history characteristics of squids confer a low inherent vulnerability, however stock status is largely unknown and fishing mortality is not defined by biological reference points.

Stock	**Fishery**	**Inherent Vulnerability** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Criterion 1** Rank (Score)
Indian Squid	India	Low	Moderate Concern (3)	Moderate Concern (2.33)	Yellow (2.64)
Indian Squid	Thailand	Low	Moderate Concern (3)	Moderate Concern (2.33)	Yellow (2.64)
Mitre Squid	China	Low	Moderate Concern (3)	Moderate Concern (2.33)	Yellow (2.64)
Mitre Squid	Thailand	Low	Moderate Concern (3)	Moderate Concern (2.33)	Yellow (2.64)

Justification of Ranking

Factor 1.1 Inherent Vulnerability: Low Vulnerability; score average = 2.5 (SFW 2011)

CRITERIA		SCORE
Average age at maturity	<1 year	3
Average maximum age	~1 year	3
Reproductive strategy	Demersal or pelagic egg mass	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
MEAN SCORE		**2.5**

Both *U. duvauceli* and *U. chinensis* are characterized by short life spans (i.e. Sukramongkol et al. 2007), semelparous (one-time) reproduction, and variable population dynamics influenced by environmental variability (i.e. Pierce et al., 2008; Rodhouse 2010). This inherent volatility makes squid stocks both potentially susceptible to overfishing, and conversely, also capable of rapid recovery (Pierce and Guerra 1994).

Factor 1.2 Stock Status: Moderate Concern

Information is generally unavailable about the stock status of Indo-Pacific squid species—the short life histories and variable growth rates of squids makes it difficult to assess recruitment strength and stock size of the next generation (Pierce and Guerra 1994). Populations are highly variable from year to year, and may be more strongly related to environmental variation than to fishing efforts; however, efforts to predictively link environmental parameters to cephalopod biomass have not met with major success (Pecl and Jackson 2008). Cephalopod resources are thought to be fully fished, and perhaps overfished, in the waters of countries including Thailand and India (Chotiyaputta et al. 2002; Thomas and Kizhaukudan 2006; FAO 2011). However, with the overall lack of data on stock heath for all of the regions assessed in this report, stock status is defined as a moderate concern.

Factor 1.3 Fishing Mortality: Moderate Concern

Biological reference points for fishing mortality are not defined. Mid-season estimates of biomass for stocks are sometimes calculated using acoustic techniques or catch depletion models. Additionally, during spawning periods, squids typically form dense aggregations, which are targeted by commercial fisheries; it is unclear how removing individuals during such events affects overall reproductive success (Iwata et al. 2010).

Criterion 2: Impacts on Other Retained and Bycatch Stocks

Summary

Drift gillnets were historically a major gear type used in high seas squid fisheries, but their use has been restricted since a global moratorium in January 1993 (United Nations Resolution 46/215). Before this time, squid fisheries had significant incidental ecosystem impacts on other fish stocks, marine mammals and seabirds. Today *U. chinensis* and *U. duvauceli* are largely caught commercially via epibenthic otter trawls, sometimes including light luring techniques (Jereb and Roper 2010; FAO 2005). No reliable bycatch or discard data are available for these fisheries for the three main import countries (China, Thailand, or India), however, based on gear type, fishing area, regional expert opinion, and scientific studies of the region and the Seafood Watch criteria, the likely species interactions with this gear type include benthic invertebrates, forage fish, finfish, turtles, sharks, and corals/biogenic habitat.

Stock	**Inherent Vulnerability** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Subscore**	**Score** (subscore*discard modifier)	**Rank** (based on subscore)
Coral/Biogenic Habitat	Low	High Concern (2)	High Concern (1)	1.41	1.34	Red
Turtles	Low	High Concern (2)	High Concern (1)	1.41	1.34	Red
Sharks	Low	High Concern (2)	Moderate Concern (2.33)	2.16	2.05	Red
Benthic Invertebrates	Low	Moderate Concern (3)	Moderate Concern (2.33)	2.64	2.51	Yellow
Finfish	Medium	Moderate Concern (3)	Moderate Concern (2.33)	2.64	2.51	Yellow
Forage Fish	Medium	Moderate Concern (3)	Moderate Concern (2.33)	2.64	2.51	Yellow

Justification of Ranking

Factor 2.1 Inherent Vulnerability

-***Medium vulnerability species:*** finfish, forage fish
-***Low vulnerability species:*** benthic invertebrates, sharks, turtles, corals/biogenic habitat

*Based on Seafood Watch Criteria, Appendix 3, for unknown bycatch for "tropical shrimp bottom trawl."

Without reliable bycatch data, the significant species at risk for bycatch in epibenthic trawl fisheries were identified above using Seafood Watch criteria. Much like shrimp trawls, squid bottom trawls are not designed to drag along the bottom; trawls are usually shallow (i.e. in India, typical squid trawls occur between 18 m and 55 m depth; Sasikumar and Muhamad 2012), are suspended just off the seabed, and generally have a higher head rope than would be usual for finfish (FAO 2005). However, it is likely that this gear type does sometimes come in direct contact with the benthos and causes some disturbance and bycatch of benthic organisms (Stobutzki et al. 2006; Thomas et al. 2006), therefore, because of the lack of information, we err on the side of caution and assume bottom contact.

Turtles, one of the species that limits the score in Criterion 2, were included as potential bycatch due to the severe threat posed by bottom trawling in tropical regions (Wallace et al. 2010). Reports identify six sea turtle species in Southeast Asia, many of which are listed as endangered, critically endangered, or vulnerable on the IUCN Redlist (Project GloBAL). Five species of sea turtles are also identified in China, all listed as critically endangered in the China Species Red List (Chan et al. 2007). Interaction rates between these species and the squid fisheries are unknown. The fisheries under discussion are not within major albatross range and seabird interactions are reported to be minor, therefore seabirds were excluded.

Factor 2.2 Stock Status

TAXA	*STOCK STATUS
Benthic Invertebrates	Moderate Concern
Finfish	Moderate Concern
Forage Fish	Moderate Concern
Sharks	High Concern
Turtles	High Concern
Corals/Biogenic Habitat	High Concern

*Based on Seafood Watch Criteria for use when bycatch is unknown

Factor 2.3 Fishing Mortality

TAXA	*SFW IMPACT Score	FISHING MORTALITY
Benthic Invertebrates	2	Moderate Concern
Finfish	2	Moderate Concern
Forage Fish	2	Moderate Concern
Sharks	2	Moderate Concern
Turtles	1	High Concern; India—TEDs are required on trawlers, but enforcement is lacking (Mathews 2009). High Concern; Thailand—Mandatory TEDs and protected areas, but enforcement is lacking (Project GloBAL). High Concern; China—turtles are protected; however, illegal fishing occurs, and gear modifications are under consideration but not currently required (Chan et al. 2007)
Corals/Biogenic Habitat	1	High Concern; India–a monitoring network for corals is in place, and some spatial management exists but is not well managed (FAO 2011b). High Concern; Thailand—fisheries operations are banned in protected areas of coral reefs, but enforcement is lacking (Project GloBAL) High Concern; China–some reserves exist, but success is hindered by lack of enforcement and monitoring (Jones et al. 2011).

*Based on Seafood Watch Criteria

Although finfish are treated as bycatch, mixed stock catches in this region are common and often entirely retained and utilized either for commercial use, local consumption, or fishmeal (i.e. Janekitkosol et al. 2003). Data on catch composition in these fisheries is extremely limited, but can be quite varied: squid fisheries are sometimes targeted at dense aggregations, which may or may not suggest less bycatch than found in other trawl fisheries. However, cephalopods are frequently caught in mixed otter trawl catches such as those in Thailand, which report high proportions of trash fish (including juveniles of commercial species) at about 45.4%−62.5%

(Janekitkosol et al. 2003).

Factor 2.4 Overall Discard Rate: 20-40%

Exact data on discard rates is largely unavailable. Based on FAO discard reports (FAO 2005b), discard rates in cephalopod trawl fisheries range from 3% for pelagic species (*Loligo, Ilex*) in the Falkland Islands (Malvinas) to 45% in fisheries for octopus (Morocco, Mauritania, Japan). In total, FAO concludes that cephalopod trawl fisheries produce approximately 35,000 tonnes of discards and have a weighted discard rate of 22.8%; therefore, discards are scored as 20%–40%.

Criterion 3: Management Effectiveness

Summary

There is no international or regional fishery management for squid; management and enforcement are left up to individual countries within their EEZs and on the high seas. Because squid stocks cannot be assessed prior to fishing seasons due to life history characteristics, management efforts are challenging under the best of circumstances in terms of protecting fishery impacts upon target species and related ecosystems. Excess capacity, excess fishing effort, and poor enforcement all contribute to the difficulties in effectively managing these squid fisheries. In India and Thailand, open access fisheries also exacerbate the challenges.

Fishery	**Management: Retained Species** Rank (Score)	**Management: Non-retained species** Rank (Score)	**Criterion 3** Rank (Score)
China	Very High Concern (1)	Very High Concern (1)	Red (1)
India	Very High Concern (1)	High Concern (2)	Red (1.41)
Thailand	Very High Concern (1)	High Concern (2)	Red (1.41)

3.1 Summary

Fishery	**Critical?**	Mgmt Strategy and Implement	Recovery of Stocks of Concern	Scientific Research and Monitoring	Scientific Advice	Enforce	Track Record	Stakeholder Inclusion
China	No	Ineffective	N/A	Ineffective	Ineffective	Ineffective	Ineffective	Ineffective
India	No	Ineffective	N/A	Moderately Effective	Ineffective	Ineffective	Ineffective	Ineffective
Thailand	No	Ineffective	N/A	Ineffective	Ineffective	Ineffective	Ineffective	Ineffective

3.2 Summary

Fishery	All Species Retained?	Critical?	Mgmt Strategy and Implement	Scientific Research and Monitoring	Scientific Advice	Enforce
China	No	No	Ineffective	Ineffective	Ineffective	Ineffective
India	No	No	Moderately Effective	Ineffective	Ineffective	Ineffective
Thailand	No	No	Moderately Effective	Ineffective	Moderately Effective	Ineffective

Justification of Ranking

China

Factor 3.1 Management of Fishing Impacts on Retained Species: Very High Concern

Management Strategy and Implementation: Ineffective
The top administrative level of fisheries in China consists of the Bureau of Fisheries, and the Ministry of Agriculture, followed by a local fisheries bureau at provincial or municipal level as the base institutes. The fisheries administrations for each level are responsible for the implementation of the fisheries laws and regulations. There are local fisheries administrations established in every province, major fishery cities and counties that are under the supervision of local governments. Moreover, there are fisheries law enforcement agencies or fisheries resource management commissions in large inland water areas and major ports. (FAO, China profile 2012).

In 1999, China adopted a “zero growth” objective for coastal marine capture fisheries to address overfishing issues; in 2001 this goal was shifted to “minus growth,” to be attained largely through the reallocation of fishing efforts to distant waters. General management strategies in Chinese fisheries include seasonal/area closures (i.e., a mid-summer fishing moratorium), and input controls such as rationalization programs and gear modifications to reduce bycatch and habitat impacts. Since the adoption of the 2000 Amended Fisheries Law, three official certificates (a fishing license, a fishing vessel inspection document and a fishing vessel registration document) have been required for engaging in marine fishing activities, which also regulate vessel motor type and the use of certain fishing gear and methods, as well as setting the minimum mesh size and percentage of juvenile bycatch. By implementing this system, China has moved its marine capture fisheries from a condition of open access to that of regulated open access (Yu and Yu 2008). Fishing quota systems have been considered to provide output controls via development of TACs (total allowable catch metrics), but these have not yet been implemented. China has some management as described above, but it is insufficiently precautionary for the squid fishery; therefore, management strategy and implementation is considered ineffective.

Recovery of Stocks of concern: N/A
No species of concern are target in the squid fishery.

Scientific Research and Monitoring: Ineffective
The concept of sustainable development has been increasingly adopted for the macro-management of different resources, and fisheries authorities continue to strengthened science-based management of marine fisheries resources. TACs are in development for some species, but have not yet become common features of management plans. Fisheries statistics collected by the state are increasingly collected by privately owned fishing enterprises; these entities provide landings and some other limited catch data. Although China's "zero growth" objective has reduced over-reporting of catches, fishery statistics and other data collection remain somewhat vague and/or unreliable.

Scientific Advice: Ineffective
MSY recommendations are used to modify some management strategies such as buy-back programs. Ecosystem based management is recognized but not implemented. The mid-summer fishing moratorium was implemented to protect spawning seasons of major commercial fish stocks, but does not cover the spawning seasons of all stocks of interest (i.e. *U. chinensis*, which exhibits peak spawning in the spring and autumn). In addition, management does not follow scientific advice and is therefore ineffective.

Enforcement: Ineffective
Enforcement is patchy. Vessel monitoring (VMS) technology (Chang et al. 2010) and observer programs are in development but some illegal, unreported and unregulated (IUU) fishing continues to occur (Yu and Yu 2008; Mallory 2012). A 2000 census of fishing vessels showed that of all China's fishing vessels, 28% were identified as without the above three mandated permits; another 21% lacked at least one certificate (Yu and Yu 2008).

Track Record: Ineffective
Marine fisheries resources in China have been overfished since the late 1980s; since then China has increased research and management measures to improve their fisheries and expanded fishing efforts worldwide to reduce pressure on domestic resources. The domestic ''zero growth'' and ''minus growth'' policies represent a strategic shift from a quantified expansion of the fishing industry to quality and efficiency motivated fisheries (Yu and Yu 2008). However, large domestic overcapacity remains.

Stakeholder Inclusion: Ineffective
Rationalization programs and subsidies do take small scale fishermen into account, since overcapacity due to large numbers in the small vessel fleets is a major concern. However,

industry participation in decision-making is minimal and lack transparency, as the majority of commercial domestic fisheries are privately operated.

Factor 3.2 Management of Fishing Impacts on Bycatch Species: Very High Concern

Management Strategy and Implementation: Ineffective
Minimum mesh sizes and fishing gear limits have been implemented by fisheries management agencies to reduce bycatch, along with quotas for allowable catch of juveniles, however, the effectiveness of these measures is uncertain. Illegal harvesting of protected species such as sea turtles persists, and although the use of environmentally sustainable gear modifications are under consideration, they are not currently required, therefore, there are no effective bycatch management measures in place (Chan et al. 2007)

Scientific Research and Monitoring: Ineffective
Most bycatch is not discarded, and catch statistics are present but somewhat lacking due to the privatized nature of a large proportion of China's commercial fisheries; therefore, there is no regular collection or analysis of bycatch data. Biodiversity monitoring surveys are needed to assess and track fisheries impacts; some area and seasonal closures are in place to aid in biodiversity conservation (Liu 2013).

Scientific Advice: Ineffective
Gear restrictions and regulations limiting juvenile catch are associated with fishing permits and represent the major restrictions to bycatch, due to an emphasis on economic output in the fisheries. Adherence to these restrictions is somewhat unknown because of insufficient enforcement.

Enforcement: Ineffective
Weak legal awareness by the fleet and enforcement limitations due to budgetary constraints, restrict the success of bycatch measures. Two of the most common types of IUU fishing in China include illegal gear usage and catches of illegal or undersized species (Yu and Yu 2008), both of which negatively influence bycatch.

India

Factor 3.1 Management of Fishing Impacts on Retained Species: Very High Concern

Management Strategy and Implementation: Ineffective
India's coastal marine fisheries are open access. Management varies by state and includes some seasonal/area closures and gear restrictions for trawls. Cephalopods are caught as bycatch of trawl nets along the Indian coast except along the Vizhinjam-Kanyakumari area where there is a targeted fishery for cuttlefish. Trawl nets operating up to 100 m depth account for 85% of the cephalopod landings. Since there is no targeted fishery for the cephalopods in India except

along the Vizhinjam-Kanyakumari coast, it is difficult to set any management options exclusively for cephalopods (Meiyappan and Mohamed 2003); rather management is largely achieved by regulating overall fishing effort (Meiyappan et al. 2000). Management varies by state and includes seasonal/area closures (e.g., during monsoon season) and gear restrictions, but is insufficiently precautionary for squid stocks.

Recovery of Stocks of concern: N/A
No species of concern are target in the squid fishery.

Scientific Research and Monitoring: Moderately Effective
Exploratory stock assessments are conducted and maximum sustainable yields have been calculated for cephalopods (Meiyappan and Mohamed 2003; FAO 2011a); however, this science is used primarily to formulate forecast models rather than set output controls; therefore, although some data are collected they are insufficient to maintain squid stocks.

Scientific Advice: Ineffective
Current cephalopod fishing effort is above optimum precautionary targets for several regions (Abdussamad and Somayajulu 2004; Thomas and Kizhakudan 2006; Sasikumar and Mohammad 2012). Mesh size regulations and vessel restrictions are the only major protections employed for fishery stocks. Trawl licenses have been withheld and gear conversions have been encouraged in recent years to help rationalize the trawl fleet, but there is no indication that management follows scientific advice.

Enforcement: Ineffective
Shore-based landing inspections occur, but overall enforcement is lacking, due in large part to budgetary constraints. Illegal fishing in Indian waters by neighboring countries is a regular concern.

Track Record: Ineffective
Catch-per-unit-effort for fishery resources as a whole continues to fall despite management measures. However, cephalopod catches have not been as heavily impacted as other species, presumably due to their high resilience and ability to fill vacant ecological niches (Sasikumar and Muhamad 2012). India is actively working to reduce illegal fishing by neighboring countries.

Stakeholder Inclusion: Ineffective
Catch statistics are collected and published, and stakeholder participation in management occurs to some extent through consultations. However no explicit consideration is given toward balancing the interests of different sectors and communities in management plans.

Factor 3.2 Management of Fishing Impacts on Bycatch Species: High Concern

Management Strategy and Implementation: Moderately Effective
There is management emphasis on conservation and protecting marine biodiversity, and multiple measures are in place to conserve protected species such as sharks, marine mammals,

corals and turtles. Nonetheless, with minimal enforcement these measures are likely inefficient. Bycatch is incentivized by its economic value to the fishmeal industry. Maritime states in India have regulations fixing the cod-end mesh size of trawls at 35 mm; however, in reality, this is not practiced and the mesh sizes of trawls in India commonly range from 10 to 25 mm (Mohamed et al. 2009).

Since, India requires TEDs on their trawlers in turtle distribution areas (FishSource 2012) there is some emphasis on conservation and protecting marine biodiversity. However, with minimal enforcement, there is uncertainty that these measures are effective; therefore, management strategy and implementation is moderately effective.

Scientific Research and Monitoring: Ineffective
Research into the protection of species of concern such as turtles and sharks has led to the recommendation of turtle excluder devices (TEDs) and mesh size regulations, and their mandatory use for trawlers in vulnerable areas; however, monitoring is severely lacking. Under the National Marine Fishing Regulation Act, fisheries legislation and regulations are the responsibility of individual regional state governments, and the U.S. Coast Guard is vested with powers for policing the EEZ, although there is no regular collection of data.

Scientific Advice: Ineffective
Capture of non-targeted species and rejection of bycatch are discouraged through stakeholder awareness programs and there requirement of TEDs in some mechanized trawl gear. However, discards are not regulated and the marketability of "trash fish" as fishmeal encourages the capture and retention of high bycatch levels and bycatch measures are not enforced.

Enforcement: Ineffective
Overall enforcement and compliance is insufficient, in large part to budgetary constraints.

Thailand

Factor 3.1 Management of Fishing Impacts on Retained Species: Very High Concern

Management Strategy and Implementation: Ineffective
In general, Thai fisheries are open access, and catch compositions are multispecies. Certain gear and area restrictions apply, such as seasonal spawning closures and prohibited fishing by trawlers and push nets within a distance of 3km from the shoreline to protect the productivity of nearshore waters. The Department of Fisheries has issued multiple management measures to control fish resources, but regulations are difficult to enforce due to budgetary limitations, socioeconomic impacts and political interventions (Janetkitkosol et al. 2003). In addition, data-limited cephalopod populations are considered fully or over exploited (e.g., Ahmed et al. 2007) and recovery plans are lacking.

Recovery of Stocks of concern: N/A
No species of special concern are target in the squid fishery.

Scientific Research and Monitoring: Ineffective
Simple resource assessments and ecosystem analyses have been conducted in the past, yielding rough estimates of maximum sustainable yield for some major species. Catch statistics are not well reported, but the available catch-per-unit-effort data show a decline in abundance of overall fishery resources over the last several decades, though these are not specific to squid. Landings are not well monitored and therefore there is no regular collection of fishery data.

Scientific Advice: Ineffective
Total fishing effort in the Gulf of Thailand ecosystem has been estimated at approximately double the appropriate effort to harvest at maximum sustainable yield (Kongprom et al. 2003). Efforts are underway to reduce fishing effort and capacity, but fishing pressure remains high.

Enforcement: Ineffective
Enforcement is not effective. No observer scheme exists and dockside inspections are patchy. Regulations prohibiting trawlers and push-net boats from operating within 3 km of shore have not been successfully enforced.

Track Record: Ineffective
Efforts to rationalize the fisheries are attempted via required licenses for commercial trawl and push-net gears. But excess fishing capacity, small mesh sizes, and illegal fishing by the Thai fleet (both in restricted domestic areas and in the waters of neighboring nations) remains a concern.

Stakeholder Inclusion: Ineffective
The need for participation by stakeholders in natural resource and environmental management has received increased recognition within Thailand (Janetkitkosol et al. 2003). Although small scale fishermen are recognized as a major component of Thai fisheries, transparency is lacking and there is a history of conflict between commercial and artisanal squid fishermen (i.e., Flaherty and Karnjanakesorn 1993; Janetkitkosol et al. 2003).

Factor 3.2 Management of Fishing Impacts on Bycatch Species: High Concern

Management Strategy and Implementation: Moderately Effective
Management strategies in place to address bycatch issues include mandatory TEDs, restrictions regarding marine mammals and coral protected areas, and bans on trawl gear in inshore breeding areas. Capture and sale of sea turtles and marine mammals is illegal. Implementation of mitigation measures is unknown due to poor enforcement and data collection, but discards are likely very low since almost all of the catch is utilized either for commercial purposes, local consumption, or fishmeal. However, due to the lack of data on management strategy and implementation for bycatch, this factor is moderately effective.

Scientific Research and Monitoring: Ineffective

Catch statistics are poorly reported; habitat and bycatch impacts of trawl fisheries are not well documented but considered high. Artificial reef programs are in effect to provide additional spawning and juvenile habitat. Research on marine mammals has been very limited due to lack of manpower and budget support.

Scientific Advice: Ineffective
Despite recommendations that larger mesh ends would reduce bycatch, the cod end mesh size used for most otter trawls remain at 25 mm and catches are reportedly abundant in bycatch fish species (Janetkitkosol et al. 2003).

Enforcement: Ineffective
Enforcement is generally poor and IUU fishing is an issue. Despite the ban on trawling in some inshore areas and the presence of some marine protected areas, frequent incursions occur.

Criterion 4: Impacts on the Habitat and Ecosystem

Summary

Several gear types are used within the small scale squid fisheries, but epibenthic otter trawls are the main commercial gear types used. Restrictions on the cod-end mesh sizes and area/seasonal closures are the main mitigation measures recommended by management bodies for the commercial fisheries, however, enforcement is often lacking (see Criterion 3). The substrate impacts of otter trawling can be classified as moderate because, although the trawl gear is designed to fish just above the bottom, there is reason to believe that this gear commonly touches the bottom. The ecological impacts of removing squid from the coastal systems are not known, however, squid are known to serve both as influential predators and critical prey for shelf ecosystems.

Fishery	**Gear type and substrate** Rank (Score)	**Mitigation of gear impacts** Rank (Score)	**EBFM** Rank (Score)	**Criterion 4** Rank (Score)
China	Moderate Concern (2)	Minimal mitigation (0.25)	High Concern (2)	Red (2.12)
India	Moderate Concern (2)	No mitigation (0)	High Concern (2)	Red (2)
Thailand	Moderate Concern (2)	No mitigation (0)	High Concern (2)	Red (2)

Justification

Factor 4.1 Impact of the Fishing Gear on the Substrate: Moderate Concern

Commercial fisheries for species such as *U. duvauceli* and *U. chinensis* most often employ shallow bottom trawls that catch epibenthic populations during the day when squid vertically migrate downward. Conventional otter trawls fish directly on the bottom; however, over a spatially complex benthos such as the habitats favored by inshore squids, pelagic trawls are suspended just off the seabed to avoid fouling the gear. Trawls designed for squid fishing generally have a higher head rope than would be usual for finfish (FAO 2005). Light luring is also often used to aggregate individuals. Little is known about the cumulative impacts this trawl gear has had on benthic or ecosystem resources in the region since research is lacking and bycatch statistics are rarely available; but it is likely that this gear type does come in direct contact with the benthos and causes some disturbance (Stobutzki et al. 2006; Thomas et al. 2006).

Factor 4.2 Modifying Factor: Mitigation of Fishing Gear Impacts
India and Thailand – No mitigation
China – Minimal mitigation

In India and Thailand, no effective mitigation is in place for *U. chinensis* and *U. duvauceli* trawl squid fisheries. Mesh size controls and various seasonal/area closures are the primary mitigation measures; actual implementation of these restrictions is largely unknown due to poor enforcement (Jereb and Roper 2010). Despite recommendations, small mesh sizes are sometimes intentionally used by fishermen to increase the capture of "trash fish" and juveniles for sale to the fishmeal industry (i.e., Mohamed et al. 2009; Janekitkosol et al. 2003).

In China, minimal mitigation is in place; fishing effort is controlled, although overcapitalization is still present. Management is continuing to develop and update science-based strategies for domestic fisheries including efforts toward area closures and fleet rationalization.

Factor 4.3 Ecosystem and Food Web Considerations: High Concern

Very little is known about the ecology of squid species assessed in this report, so it is difficult to gauge the impact of squid removal from resident ecosystems. However, in other parts of the world, squid are deemed species of exceptional importance. For example, longfin and shortfin (*Doryteuthis pealeii* and *Illex illecebrosus*) squid are key forage species in the North Atlantic ecosystem, and their ecological roles are considered exceptional. These squid prey upon a vast variety of copepods, crustaceans, pelagic and benthic finfish, and other cephalopods throughout their different life stages (Dawe and Beck 1997; Hanlon et al. 2012; O'Dor and Dawe 2012). Fishing mortality impacts on squid abundance could have ecological spillover effects for a wide range of squid prey species. Both longfin squid and shortfin squid are important sources of standing biomass in their ecosystem, and are subject to both predation pressure and commercial harvesting (O'Dor and Dawe 2012; Hanlon et al. 2012). Because there are no ecosystem impact data on the species assessed this reports, we assume they are 'exceptionally important species' based on other squid populations and the above example.

In general, due to their variable population dynamics year-to-year, the influence of squid on their prey populations is probably equally variable (Piatkowski et al. 2001). Squid are opportunistic feeders focusing upon pelagic crustaceans, other cephalopods (including cannibalism), and several species of pelagic and mesopelagic fishes (i.e. Rodhouse and Nigmatullin 1996; Piatkowski et al. 2001); however, they may feed "unnaturally" in the presence of sampling gear, eating the contents of the net during sampling (Rodhouse and Nigmatullin 1996). Meanwhile squid serve as prey themselves to larger predatory fishes such as tuna, seabirds and marine mammals (i.e., Smale 1996; Piatkowski et al. 2001). Global estimates of consumption of squid and other cephalopods by higher predators have projected that they far exceed global or regional catches by the commercial fisheries; although, due to variability in cephalopod populations, this estimate must be taken with caution (FAO 2005). As a result, squid fisheries are urged to proceed following precautionary principles since fishery exploitation of squid populations in productive continental shelf ecosystems could have significant impacts on ecosystems (Hunsicker et al. 2010; FAO 2010).

There is strong circumstantial evidence that cumulative fishing impacts have already caused shifts in ecological conditions in coastal pelagic systems (Pauly 2011). FAO catch statistics suggest that as global ground fish landings have declined, cephalopod landings have increased, presumably as a result of their relatively fast growth rates, short life spans and correlated decreases in predation and resource pressure on squid populations (Caddy and Rodhouse, 1998; Lu, 2002). Climate changes to oceanographic conditions may also have significant current and future impacts on squid populations (i.e. Pecl and Jackson 2008; Rodhouse 2010).

Overall Recommendation

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

The overall recommendation is as follows:

- **Best Choice** = Final Score >3.2, **and** no Red Criteria, **and** no Critical scores
- **Good Alternative** = Final score >2.2, **and** Management (Criterion 3) is not Red, **and** no more than one Red Criterion, **and** no Critical scores, **and** does not meet the criteria for Best Choice (above)
- **Avoid** = Final Score <=2.2, **or** Management (Criterion 3) is Red, **or** two or more Red Criteria, **or** one or more Critical scores.

Stock	**Fishery**	**Impacts on the Stock** Rank (Score)	**Impacts on Other Species** Lowest scoring species Rank*, (Subscore, Score)	**Manage-ment** Rank (Score)	**Habitat and Ecosystem** Rank (Score)	**Overall** Recommendation (Score)
Indian Squid	Thailand	Yellow (2.64)	Turtles, Coral/Biogenic Habitat Red, (1.41,1.34)	Red (1.41)	Red (2)	**AVOID (1.78)**
Indian Squid	India	Yellow (2.64)	Turtles, Coral/Biogenic Habitat Red, (1.41,1.34)	Red (1.41)	Red (2)	**AVOID (1.78)**
Mitre Squid	Thailand	Yellow (2.64)	Turtles, Coral/Biogenic Habitat Red, (1.41,1.34)	Red (1.41)	Red (2)	**AVOID (1.78)**
Mitre Squid	China	Yellow (2.64)	Coral/Biogenic Habitat, Turtles Red, (1.41,1.34)	Red (1)	Red (2.12)	**AVOID (1.65)**

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Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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Appendix A: Review Schedule

There are no regular assessments of the squid species or other incidental catch species in these fisheries, and no pertinent new information is expected in the next few years. Seafood Watch will review the status of this fishery three years from publication to ascertain whether any significant changes have taken place.

About Seafood Watch®

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch®'s sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

Disclaimer
Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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Guiding Principles

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished[1] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that capture fisheries must possess to be considered sustainable by the Seafood Watch program:

- *Stocks are healthy and abundant.*
- *Fishing mortality does not threaten populations or impede the ecological role of any marine life.*
- *The fishery minimizes bycatch.*
- *The fishery is managed to sustain long-term productivity of all impacted species.*
- *The fishery is conducted such that impacts on the seafloor are minimized and the ecological and functional roles of seafloor habitats are maintained.*
- *Fishing activities should not seriously reduce ecosystem services provided by any fished species or result in harmful changes such as trophic cascades, phase shifts, or reduction of genetic diversity.*

Based on these guiding principles, Seafood Watch has developed a set of four sustainability **criteria** to evaluate capture fisheries for the purpose of developing a seafood recommendation for consumers and businesses. These criteria are:

1. Impacts on the species/stock for which you want a recommendation
2. Impacts on other species
3. Effectiveness of management
4. Habitat and ecosystem impacts

Each criterion includes:

- Factors to evaluate and rank
- Evaluation guidelines to synthesize these factors and to produce a numerical score
- A resulting numerical score and **rank** for that criterion

Once a score and rank has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ranks and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide:

Best Choices/Green: Are well managed and caught or farmed in environmentally friendly ways.

1 “Fish” is used throughout this document to refer to finfish, shellfish and other invertebrates.

Good Alternatives/Yellow: Buy, but be aware there are concerns with how they're caught or farmed.

Avoid/Red: Take a pass on these. These items are overfished or caught or farmed in ways that harm other marine life or the environment.