Jumbo squid

Dosidicus gigas

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Mexico

Jig

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About Seafood Watch®

The Monterey Bay Aquarium Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the North American 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. The program's mission is to engage and empower consumers and businesses to purchase environmentally responsible seafood fished or farmed in ways that minimize their impact on the environment or are in a credible improvement project with the same goal.

Each sustainability recommendation 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 sustainability criteria to arrive at a recommendation of "Best Choice," "Good Alternative," or "Avoid." In producing the seafood reports, Seafood Watch utilizes 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 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. Both the detailed evaluation methodology and the scientific reports, are available on seafoodwatch.org.

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 or visit online at seafoodwatch.org.

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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 under assessment
2. Impacts on other species
3. Effectiveness of management
4. Habitat and ecosystem impacts

Each criterion includes:

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

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

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

Best Choice/Green: Are well managed and caught or farmed in ways that cause little harm to habitats or other wildlife.

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

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

Summary

This report provides recommendations for the species *Dosidicus gigas*, commonly known as the Humboldt or jumbo squid, imported from the Mexican fishery. The Mexican Humboldt squid fishery was reactivated in 1995 after over a decade of inactivity due to population collapse, the cause of which is unknown but believed to be a combination of fishing pressure and adverse ecological conditions. Since the population rebound, the fishery does not seem to be putting undue pressures on the population, mostly due to low demand for the product.

Dosidicus gigas is a mesopelagic species with an average lifespan of 1 to 1.5 years and, like most squid, is semelparous (breeding once in a lifetime). The life history strategies and population structure of this species are known to be heavily influenced by environmental factors. Though this means the population size can be fairly unpredictable, it also puts this species in an excellent position for rapid recovery, as shown by the recovery after the 1983 population collapse. Because of the low demand, this stock does not currently appear in danger of overfishing. However, if demand were to increase, this species could be at risk for overfishing.

The fishery operates primarily in three fleets, one made of shrimp trawlers out of Sonora and two made up mostly of pangas in Sonora and Baja California Sur. All three fleets exclusively use jigs as their catch method, and these operate with such exclusivity that they result in virtually no bycatch. The Humboldt squid does not seem to be overfished at this time. Several scientific studies have created models from tagging data to determine population structure and from landing data collected by the fishery to determine current population numbers and the impacts of the fishery. The studies have all provided evidence that the fishery is not putting significant pressure on the species at this time, but also highlight the need for more research on the population dynamics of the squid, which at this time are not well understood.

The fishery is managed through the National Commission of Aquaculture and Fishing (CONAPESCA). Management of the fishery is not optimal (because there is still some illegal fishing), but efforts to improve management are ongoing. Though all recent studies indicate that the fishery is operating well within the recommended values, the species' sensitivity to environmental fluctuations (particularly those associated with El Niño) means that it could experience a rapid population decline regardless of fishing practices. Recent changes in the life history traits and range expansion have drawn much attention to the Humboldt squid from the scientific community, which recognizes the importance of this species as both significant predators and prey in the Gulf of California. It seems likely that research into this species and possible effects of the fishery will continue and that the fishery management will continue to improve.

Table of Conservation Concerns and Overall Recommendations

Stock / Fishery	Impacts on the Stock	Impacts on other Spp.	Management	Habitat and Ecosystem	Overall Recommendation
Jumbo squid Mexico Gulf of California - Jig	Green (3.32)	Green (5.00)	Red (2.00)	Yellow (3.16)	**Good Alternative (3.200)**

Scoring Guide

Scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

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

- **Best Choice/Green** = Final Score >3.2, **and** no Red Criteria, **and** no Critical scores
- **Good Alternative/Yellow** = Final score >2.2, **and** neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern,[2] **and** no more than one Red Criterion, **and** no Critical scores, **and** does not meet the criteria for Best Choice (above)
- **Avoid/Red** = Final Score <=2.2, **or** either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern,[2] **or** two or more Red Criteria, **or** one or more Critical scores.

[2] Because effective management is an essential component of sustainable fisheries, Seafood Watch issues an Avoid recommendation for any fishery scored as a Very High Concern for either factor under Management (Criterion 3).

Table of Contents

Introduction

Scope of the analysis and ensuing recommendation

This report analyzes and provides a recommendation for the Humboldt squid (*Dosidicus gigas*) fishery in Mexico. In Mexican waters, the Humboldt squid is largely found in the Gulf of California. Three main fleets operate in this fishery in the Gulf of California: one comprising shrimp trawlers out of Sonora and two comprising many small pangas out of Baja California Sur and Sonora (Martinez-Aguilar et al. 2006). These fisheries all use squid jigs exclusively, so this was the catch method analyzed.

Overview of the species and management bodies

The Humboldt squid (*Dosidicus gigas*), also known as the jumbo flying squid, is a mesopelagic species with an average lifespan of 1 to 1.5 years and is semelparous (Nigmatullin et al. 2001). It is also distinctive in that its life history can be significantly influenced by environmental factors, particularly El Niño events (Hoving et al. 2013). Its range in the Eastern Pacific extends from the waters off Peru to the North American coast. In Mexican waters, the Humboldt squid is most commonly found in the Gulf of California, so the majority of the commercial squid fishing occurs there. The fishery is primarily managed through the National Commission of Aquaculture and Fishing (CONAPESCA) and the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). CONAPESCA administers permits to fishermen, who are required to fish for Humboldt squid commercially (CONAPESCA 2010), and weekly monitoring of the commercial catch is used to observe the population (Martinez-Aguilar et al. 2006).

Production Statistics

FAO data indicate no landings of Humboldt squid prior to the mid-1960s, and very little until the early 1990s (FAO 2014). Global landings steadily increased until 2004 and have varied since then between 650,000 and 950,000 mt. The highest landings ever recorded were in the most recent year with data (2012). Catches are dominated by South American countries and China's distant-water fleet. Peru accounted for 52% of landings in 2012, followed by China (27%) and Chile (15%). Mexico accounted for 2.4% of landings in 2012 (FAO 2014).

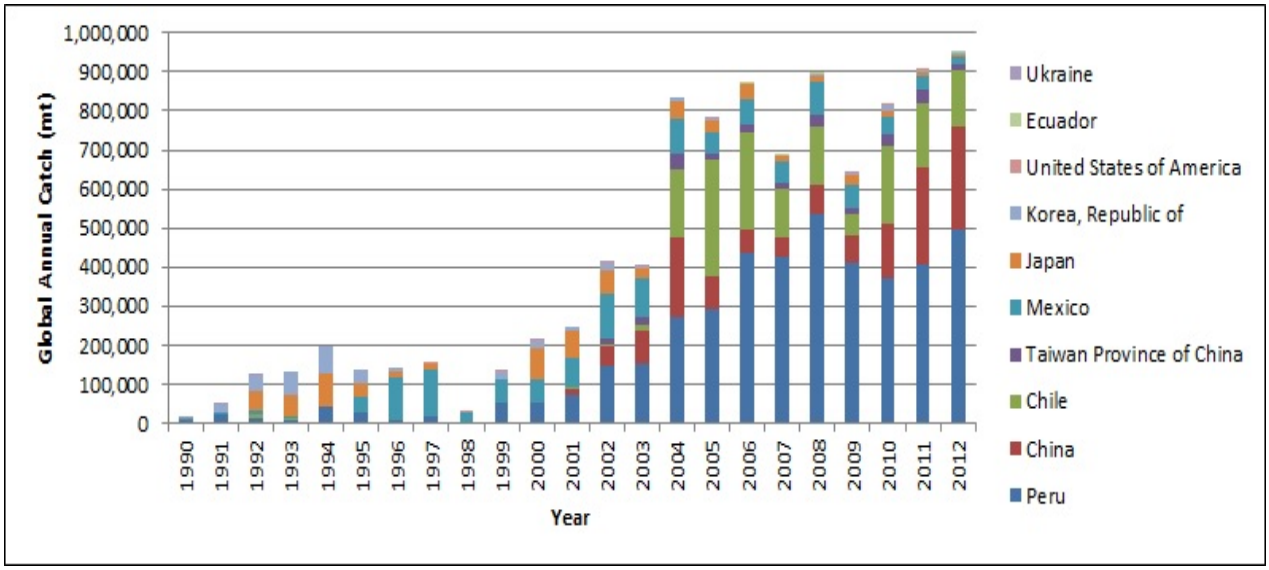

Figure 1: Global annual catch in tons of *Dosidicus gigas* (data from FAO 2014).

The Mexican Humboldt squid fishery was revitalized in 1995; the annual catch has since fluctuated between 23,000 and 140,000 t (CONAPESCA 2010) (CONAPESCA 2013), but has generally been on the decline. The 2012 catch was the lowest since 1995 (CONAPESCA 2014). As of 2013, the Humboldt squid fishery was the 7th-largest fishery by volume and the 20th-largest in value of all the Mexican fisheries (CONAPESCA 2013). The dramatic dips in catch are typically attributed to dramatic weather events such as El Niño (CONAPESCA 2010). Such a dramatic decline in population due to an unknown combination of environmental and fishing pressure resulted in a collapse of the fishery in 1982-1983 (CONAPESCA 2010).

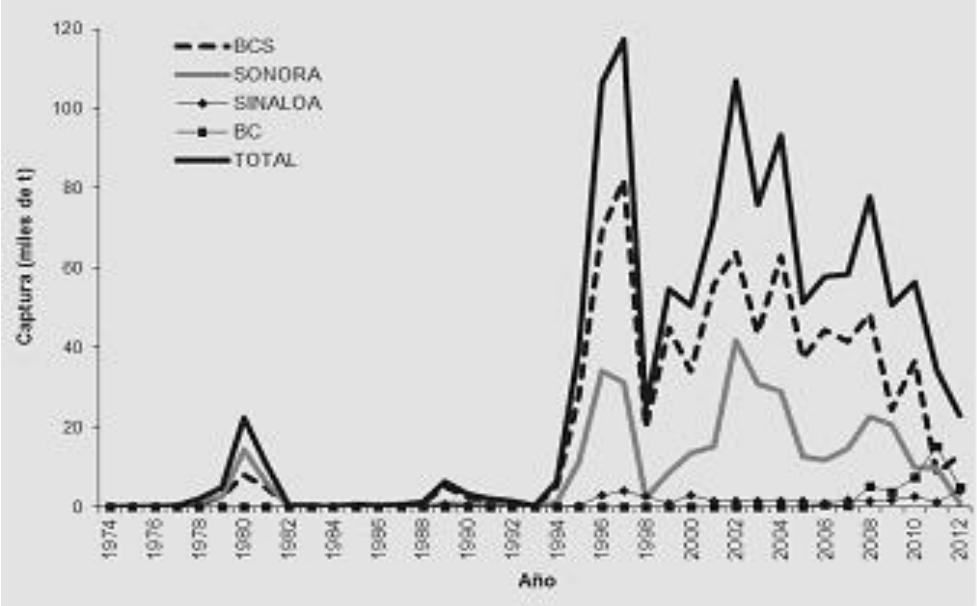

Figure 2: Annual catch in tons of Humboldt squid in Mexico (CONAPESCA 2014)

Importance to the US/North American market

U.S. imports of Humboldt squid from Mexico dramatically increased in 2 years from 539,000 kilos (1,188,292 lbs) in 2011 to 1,241,262 kilos (2,736,514 lbs) in 2012, and remained high through 2013 (NMFS 2014).

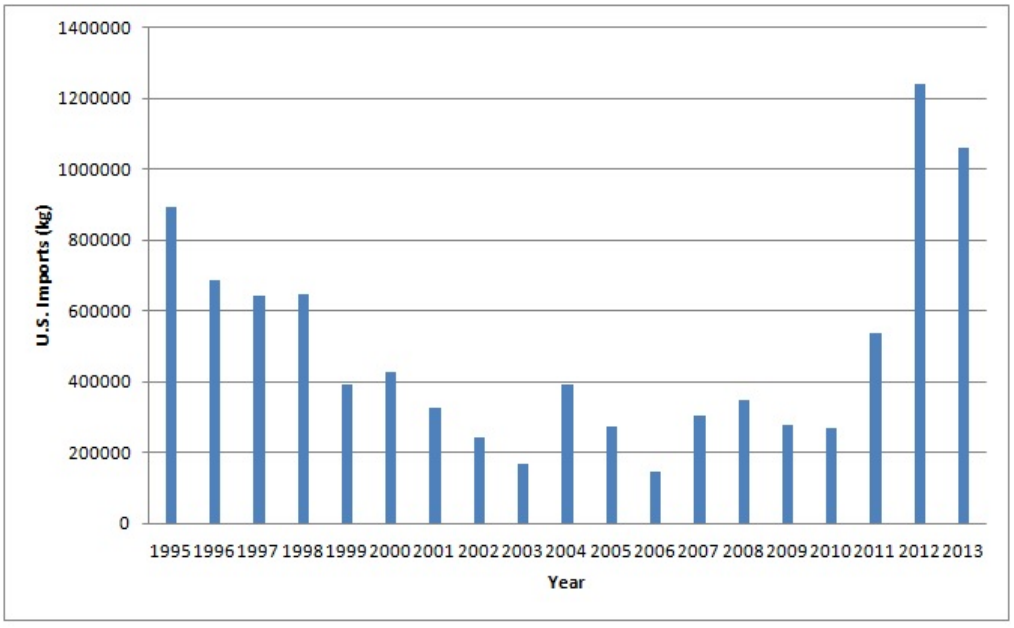

Figure 3: Total U.S. imports measured in kilograms of Humboldt squid from Mexico (Data from NMFS 2014).

However, with regard to total U.S. imports of all species of squid from across the globe, the percentage that comes from the Mexican Humboldt squid fishery remains comparatively low. But this percentage has been increasing over the past three years, and if this trend continues, this squid may become a more integral part of the U.S. market.

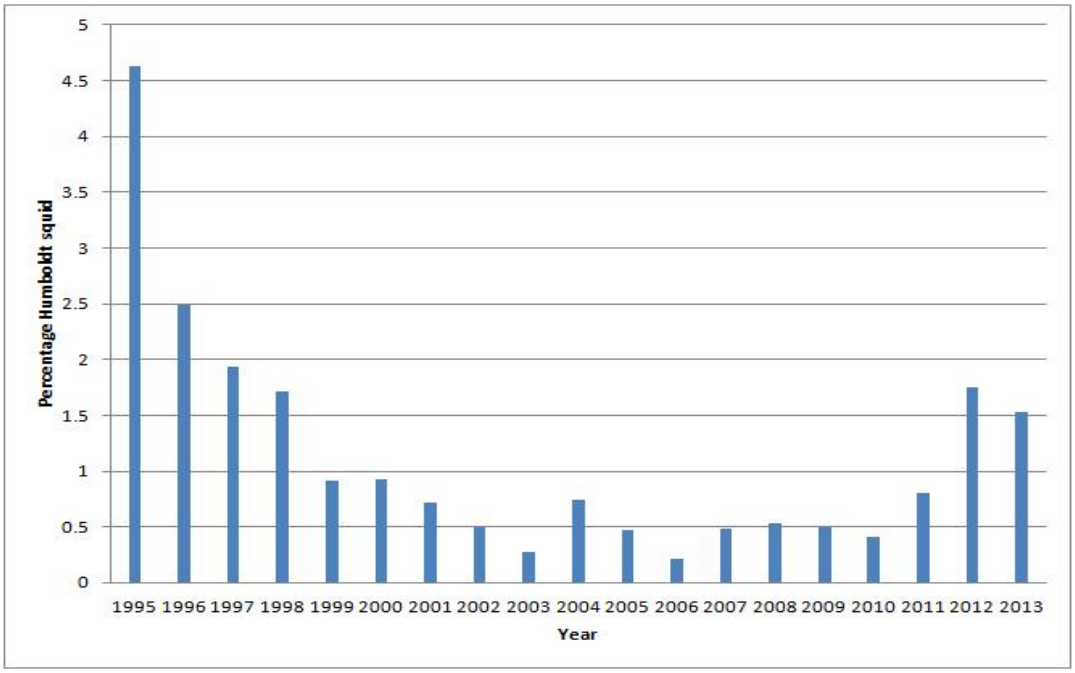

Figure 4: The percentage of all U.S. global squid imports that comes directly from the Mexico Humboldt squid fishery (data from NMFS 2014).

Common and market names

Squid is typically sold as “calamari” in the U.S. Though this particular species is not commonly used to make calamari rings, it is often served or sold as a calamari steak. It can also be found sold as abalone-style calamari or imitation abalone.

Primary product forms

Almost all of the squid is imported as either frozen, dried, salted, or brined, but may also be imported fresh (NMFS 2014).

Assessment

This section assesses the sustainability of the fishery(ies) relative to the Seafood Watch Criteria for Fisheries, available at http://www.seafoodwatch.org.

Criterion 1: Stock for which you want a recommendation

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. The inherent vulnerability to fishing rating influences how abundance is scored, when abundance is unknown. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

- *Score >3.2 = Green or Low Concern*
- *Score >2.2 and <=3.2 = Yellow or Moderate Concern*
- *Score <=2.2 = Red or High Concern*

Rating is Critical if Factor 1.3 (Fishing Mortality) is Critical.

Criterion 1 Summary

JUMBO SQUID				
Region / Method	**Inherent Vulnerability**	**Stock Status**	**Fishing Mortality**	**Subscore**
Mexico Gulf of California Jig	3.00:Low	3.00:Moderate Concern	3.67:Low Concern	**Green (3.318)**

Criterion 1 Assessment

JUMBO SQUID

Factor 1.1 - Inherent Vulnerability

Scoring Guidelines

- *Low—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing (*
- *Medium—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).*
- *High—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make is particularly vulnerable to fishing, (e.g., long-lived*

(>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator).
Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling, aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.

Mexico Gulf of California, Jig

Low

Dosidicus gigas is a short-lived species, with an average lifespan of 1 to 1.5 years (Nigmatullin et al. 2001), though the age at which it becomes sexually mature and reproduces may vary with environmental conditions (Hoving et al. 2013). *Dosidicus gigas* is a monocyclic multiple spawner, with somatic growth between egg batches deposition at the last period of its life (Rocha et al. 2001). However, females have an estimated minimum of 8 to 12 spawning events (Rosa et al. 2013), and lay 18 to 21 million oocytes before they die, making this the most fecund species of cephalopod (Nigmatullin and Markaida 2009). So even if the population is temporarily depleted due to overfishing, the potential for recovery is very high.

Table 1.

Criteria		Score
Average age at maturity	<5 years	3
Average maximum age	<10 years	3
Reproductive strategy	Pelagic egg mass	2
Density dependence	No depensatory or compensatory dynamics demonstrated or likely	2
Mean score		2.5

Factor 1.2 - Stock Status

Scoring Guidelines

- *5 (Very Low Concern)—Strong evidence exists that the population is above target abundance level (e.g., biomass at maximum sustainable yield, BMSY) or near virgin biomass.*
- *4 (Low Concern)—Population may be below target abundance level, but it is considered not overfished*
- *3 (Moderate Concern) —Abundance level is unknown and the species has a low or medium inherent vulnerability to fishing.*
- *2 (High Concern)—Population is overfished, depleted, or a species of concern, OR abundance is unknown and the species has a high inherent vulnerability to fishing.*
- *1 (Very High Concern)—Population is listed as threatened or endangered.*

Mexico Gulf of California, Jig

Moderate Concern

The biomass of jumbo squid in the Gulf of Mexico from three separate studies from 1993 to 2010 is shown in the figure below (CONAPESCA 2014). Biomass is highly variable, and appears to be driven primarily by environmental factors. In particular, the amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area (i.e., “recruitment”) appears to be lower during El Niño conditions (warmer than usual sea surface temperatures) and higher during La Niña (cooler than usual waters) (Neverez-Martinez et al. 2010)(Robinson et al. 2013). There are no biomass reference points set by managers (instead, they are set for fishing mortality---see below), so the state of the stock is deemed unknown and therefore scored “moderate.”

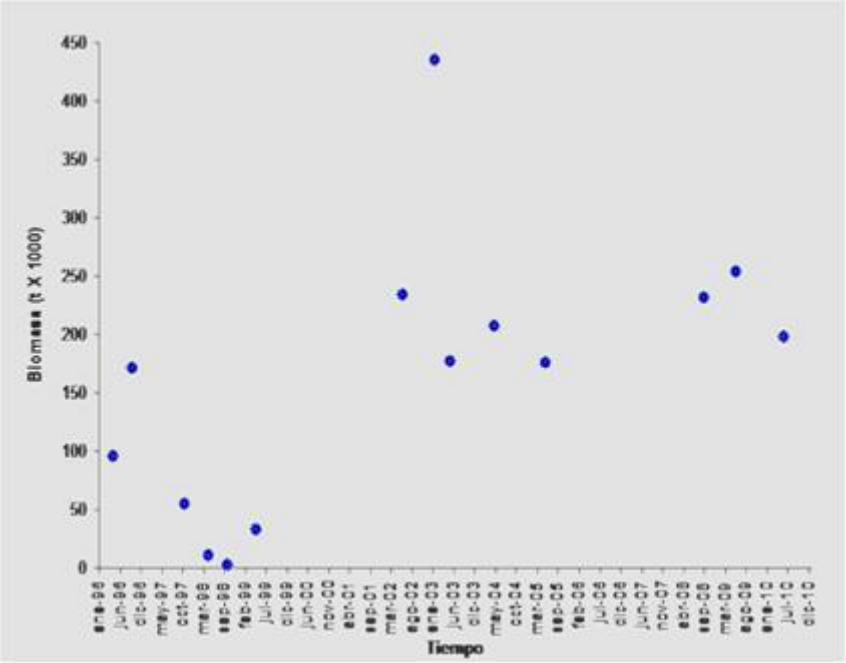

Figure 5. Seasonal biomass of giant squid in the Gulf of California (CONAPESCA 2014).

Factor 1.3 - Fishing Mortality

Scoring Guidelines

- *5 (Very Low Concern)—Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY), OR fishery does not target species and its contribution to the mortality of species is negligible (≤ 5% of a sustainable level of fishing mortality).*
- *3.67 (Low Concern)—Probable (>50%) chance that fishing mortality is at or below a sustainable level, but some uncertainty exists, OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible, OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught).*
- *2.33 (Moderate Concern)—Fishing mortality is fluctuating around sustainable levels, OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery and, if species is depleted, reasonable management is in place.*
- *1 (High Concern)—Overfishing is occurring, but management is in place to curtail overfishing, OR fishing mortality is unknown, species is depleted, and no management is in place.*
- *0 (Critical)—Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

Mexico Gulf of California, Jig

Low Concern

Catches of jumbo squid in the Gulf of Mexico have been declining since 2004, triggering stock assessments and studies to understand better if overfishing was occurring (Robinson et al. 2013). The assessments measured the impact of fishing on the jumbo squid population through the calculation of proportional escapement values (the number of surviving animals at the end of the season divided by how many animals would have survived without fishing), using catch per unit effort and survey data. From 2002 through 2008, the proportional escapement was estimated between 59% and 89% (Neverez-Martinez et al. 2010)---well above the target of 40%, which is considered a level that will result in minimal negative impacts on the population (Morales-Bojorquez et al. 2001a) (Morales-Bojorquez et al. 2001b). Dorsal mantle length at capture was also within the mature range of length for this species. For the period through 2008, researchers concluded that it was unlikely that overfishing was causing the declines, and that environmental factors are the major contributor (see abundance discussion above) (Neverez-Martinez et al. 2010) (Robinson et al. 2013).

Since then, catches have continued to decline, and the fishery in Sonora in the Gulf of Mexico collapsed in 2011 (Robinson et al. 2013). The catch has increased in other areas (primarily on the west coast of Baja California, outside the Gulf of Mexico), but the total catch in Mexico in 2012 (the most recent year with catch data) was the lowest since the fishery began again in 1995 (except perhaps for 1998) (CONAPESCA 2014). Given earlier studies, it seems likely that environmental changes may be the main driver of this decline, although changes in the markets and even behavioral changes in the squid leading to lower catchability are probably also contributors (CONAPESCA 2014). Fishing mortality is still a contributor, of course, especially since there is no biomass “floor” below which fishing is prohibited---a precautionary management strategy that would protect the stock during periods of low productivity (see Criterion 1.3: Management Strategy and Implementation). Declining catches, uncertainty in the stock assessments (including the lack of assessments for other areas of the Gulf of Mexico and the west coast of Baja California (Neverez-Martinez et al. 2010)), and a lack of protections when stock abundance is low preclude a rating of “very low” concern; thus, fishing mortality of jumbo squid in the Mexican fishery is deemed a “low concern.”

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated in the same way as the species under assessment were evaluated in Criterion 1. Seafood Watch® defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard rate score (ranges from 0-1), which evaluates the amount of non-retained catch (discards) and bait use relative to the retained catch. The Criterion 2 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2=Red or High Concern*
  Rating is Critical if Factor 2.3 (Fishing Mortality) is Critical.

Criterion 2 Summary

Jumbo squid: Mexico Gulf of California, Jig

Subscore:: **5.000** **Discard Rate:** **1.00** **C2 Rate:** **5.000**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
JUMBO SQUID	Low	3.00: Moderate Concern	3.67: Low Concern	**3.318**

All accounts state that there is no significant bycatch associated with this fishery, most likely because the fishery uses squid jigs as its exclusive catch method (the old shrimp seine vessels also use jigs exclusively) (CONAPESCA 2010) (Martinez-Aguilar et al. 2006).

Criterion 2 Assessment

Factor 2.4 - Discard Rate

Mexico/Gulf of California, Jig

<20%

All reports suggest discard levels are very low in this fishery (CONAPESCA 2010)(Martinez-Aguilar et al. 2006). Globally, the range of discard rates for squid jig fisheries is 0-1% (Kelleher 2005).

Criterion 3: Management effectiveness

Management is separated into management of retained species (harvest strategy) and management of non-retained species (bycatch strategy).

The final score for this criterion is the geometric mean of the two scores. The Criterion 3 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2 or either the Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern = Red or High Concern*
  Rating is Critical if either or both of Harvest Strategy (Factor 3.1) and Bycatch Management Strategy (Factor 3.2) ratings are Critical.

Criterion 3 Summary

Region / Method	Management of Retained Species	Management of Non-Retained Species	Overall Recommendation
Mexico Gulf of California Jig	2.000	All Species Retained	Red(2.000)

Factor 3.1: Harvest Strategy

Scoring Guidelines

Seven subfactors are evaluated: Management Strategy, Recovery of Species of Concern, Scientific Research/Monitoring, Following of Scientific Advice, Enforcement of Regulations, Management Track Record, and Inclusion of Stakeholders. Each is rated as 'ineffective,' 'moderately effective,' or 'highly effective.'

- *5 (Very Low Concern)—Rated as 'highly effective' for all seven subfactors considered.*
- *4 (Low Concern)—Management Strategy and Recovery of Species of Concern rated 'highly effective' and all other subfactors rated at least 'moderately effective.'*
- *3 (Moderate Concern)—All subfactors rated at least 'moderately effective.'*
- *2 (High Concern)—At minimum, meets standards for 'moderately effective' for Management Strategy and Recovery of Species of Concern, but at least one other subfactor rated 'ineffective.'*
- *1 (Very High Concern)—Management exists, but Management Strategy and/or Recovery of Species of Concern rated 'ineffective.'*

- *0 (Critical)—No management exists when there is a clear need for management (i.e., fishery catches threatened, endangered, or high concern species), OR there is a high level of Illegal, unregulated, and unreported fishing occurring.*

Factor 3.1 Summary

Factor 3.1: Management of fishing impacts on retained species							
Region / Method	**Strategy**	**Recovery**	**Research**	**Advice**	**Enforce**	**Track**	**Inclusion**
Mexico Gulf of California Jig	Moderately Effective	Highly Effective	Moderately Effective	Moderately Effective	Ineffective	Moderately Effective	Moderately Effective

Subfactor 3.1.1 – Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? To achieve a highly effective rating, there must be appropriate management goals, and evidence that the measures in place have been successful at maintaining/rebuilding species.

Mexico Gulf of California, Jig

Moderately Effective

The jumbo squid fishery in Mexico is managed through a strategy based on constant proportional escape, which allows a percentage of residual biomass to spawn. The target is set at 40% (i.e., the number of surviving animals at the end of the season divided by how many animals would have survived without fishing = 40%), a level that researchers deem will result in minimal negative impacts on the population (Morales-Bojorquez et al. 2001a) (Morales-Bojorquez et al. 2001b) (Neverez-Martinez et al. 2010). This management strategy depends on effort controls (Neverez-Martinez et al. 2010), which are implemented through the distribution of permits (CONAPESCA 2010) (CONAPESCA 2014). The effectiveness of these measures in controlling effort is not yet known, because the main driver behind the relatively low catches (compared to the target) is low market interest (Neverez-Martinez et al. 2010). Overall, the strategy is deemed “moderately effective” for this fishery, since it could better regulate fishing during years of low abundance (i.e., set a minimum biomass below which fishing should not occur) and conduct annual pre-fishing surveys to better estimate that year’s exploitable biomass (as strongly recommended for cephalopod fisheries by researchers, e.g. (Rodhouse et al. 2014)).

Subfactor 3.1.2 – Recovery of Species of Concern

Considerations: When needed, are recovery strategies/management measures in place to rebuild overfished/threatened/ endangered species or to limit fishery's impact on these species and what is their likelihood of success? To achieve a rating of Highly Effective, rebuilding strategies that have a high likelihood of success in an appropriate timeframe must be in place when needed, as well as measures to minimize mortality for any overfished/threatened/endangered species.

Mexico Gulf of California, Jig

Highly Effective

All current evidence of the total fishing mortality and current population numbers indicate that this species is in no danger of being overfished or becoming threatened or endangered (Neverez-Martinez et al. 2006) (Neverez-Martinez et al. 2010). This is mostly due to the squid's life-history traits that make it well poised for rapid recovery (Pierce and Guerra 1994). This inherent ability for population rebound has previously been demonstrated by the recovery of the Humboldt squid population in the Gulf of California after its crash in 1984-1985, which led to a renewed fishery in 1995 (CONAPESCA 2010).

Subfactor 3.1.3 – Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the health of the population and the fishery's impact on the species? To achieve a Highly Effective rating, population assessments must be conducted regularly and they must be robust enough to reliably determine the population status.

Mexico Gulf of California, Jig

Moderately Effective

Catch data is tracked weekly (Martinez-Aguilar et al. 2006) and published to the public monthly (CONAPESCA 2013). Because the population and the fishery rebounded from the crash in 1982-1983, scientists have also striven to research the population structure and fluctuations to better assess and manage the fishery's effects on the species (Morales-Bojorquez et al. 2001b) (Morales-Bojorquez et al. 2012) (Neverez-Martinez et al. 2006) (Neverez-Martinez et al. 2010). These studies also highlight how little is known about the local Humboldt squid population and the need for further research into the possible effects of the fishery.

Subfactor 3.1.4 – Management Record of Following Scientific Advice

Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g. do they set catch limits at recommended levels)? A Highly Effective rating is given if managers nearly always follow scientific advice.

Mexico Gulf of California, Jig

Moderately Effective

Management sets the target reference point for fishing mortality at a proportional escapement value recommended by scientists (Neverez-Martinez et al. 2010). Management has indicated that it is eager to use scientific advice to better the fishery, but has admitted that it is currently not established enough to fully utilize and enforce these recommendations (CONAPESCA 2010).

Subfactor 3.1.5 – Enforcement of Management Regulations

Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

Mexico Gulf of California, Jig

Ineffective

Over the past half-century, Mexican fisheries (and those of many nations) have suffered high levels of unreported catches, which may be illegal, of unregulated species, or simply not monitored due to logistical barriers (Cisneros-Montemayor et al. 2013). For the period 1950-2010, total catches are thought to be twice as high as reported catches. In the last year of available data, official and total catches were 1.5 million and 2.2 million t, respectively (Cisneros-Montemayor et al. 2013). Although there has been an increased effort to track annual catch of jumbo squid, an unspecified amount of illegal fishing still needs to be addressed (CONAPESCA 2010). The present assessment did not uncover an actual estimate of the amount of IUU (illegal, unreported, and unregulated fishing) for the jumbo squid fishery, but the broader study of Mexican fisheries by (Cisneros-Montemayor et al. 2013) used an estimate of 10% for their calculations.

Subfactor 3.1.6 – Management Track Record

Considerations: Does management have a history of successfully maintaining populations at sustainable levels or a history of failing to maintain populations at sustainable levels? A Highly

Effective rating is given if measures enacted by management have been shown to result in the long-term maintenance of species overtime.

Mexico Gulf of California, Jig

Moderately Effective

Since the Humboldt squid fishery in Mexico was reactivated, there does not appear to be a significant impact on the population (Morales-Bojorquez et al. 2012) (Neverez-Martinez et al. 2010). However, inherent variability in the Humboldt squid population makes it difficult to judge the exact degree of the fishery's influence (Morales-Bojorquez et al. 2012) (Neverez-Martinez et al. 2006). Though the fishery seems to be strongly driven by the influence of the Asian market (Rosa et al. 2013), the greatest limiting factor in catch rate appears to be low market demand and not catch limits enforced by management (CONAPESCA 2010). Ergo, the effectiveness of management on enforcing catch limits has not yet truly been tested.

Subfactor 3.1.7 – Stakeholder Inclusion

Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent and includes stakeholder input.

Mexico Gulf of California, Jig

Moderately Effective

In Sonora, where much of the commercial fishing of Humboldt squid takes place, bimonthly meetings are held among members of the National Chamber of the Fishery and Aquaculture Industry (CONAPESCA) section squid; the Center for Biological Research of the Northwest SC, Guaymas Unit; fishing heads of the Bureau of Fisheries, and the directors of the CRIP, in order to better understand the biology of this species. Meetings between fishermen, members of the private industry, Heads of Fisheries office, the Mayor of Santa Rosalia, BCS, and National Fisheries Institute (INP) are held through the Regional Center of Fisheries Research (CRIP) of La Paz, BCS, as well as relevant authorities as part of the joint subcommittee on Fisheries and Fisheries Resources of the Municipality of Mulege. Baja California Sur has also implemented the State Committee Squid Product system, promoted by CONAPESCA (Martinez-Aguilar et al. 2006). In the 1990s, the National Consultative Committee for Sustainable Fisheries was created to institutionalize the involvement of stakeholders such as fishermen, scientists, local authorities, and NGOs (SEMARNAP 1998). However, objective analysis of these changes revealed them to be ineffective (Hernandez and Kempton 2003), and given the history of marginalization of fishermen from the decision-making process throughout various Mexican

fisheries (Cinti et al. 2010a) (Cinti et al. 2010b), Stakeholder Inclusion is scored as Moderately Effective.

Bycatch Strategy

Factor 3.2: Management of fishing impacts on bycatch species						
Region / Method	**All Kept**	**Critical**	**Strategy**	**Research**	**Advice**	**Enforce**
Mexico Gulf of California Jig	Yes	N/A	N/A	N/A	N/A	N/A

The Mexican Humboldt squid fishery uses squid jigs as its exclusive catch method which is such a selective gear type that it results in no significant bycatch (CONAPESCA 2010)(FAO 2003).

Criterion 4: Impacts on the habitat and ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment.

The final score is the geometric mean of the impact of fishing gear on habitat score (plus the mitigation of gear impacts score) and the Ecosystem Based Fishery Management score. The Criterion 2 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2=Red or High Concern*
  Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region / Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Overall Recomm.
Mexico Gulf of California Jig	5.00:None	0.00:Not Applicable	2.00:High Concern	**Yellow (3.162)**

Justification of Ranking

Factor 4.1 – Impact of Fishing Gear on the Habitat/Substrate

Factor 4.1 – Impact of Fishing Gear on the Habitat/Substrate

Scoring Guidelines

- *5 (None)—Fishing gear does not contact the bottom*
- *4 (Very Low)—Vertical line gear*
- *3 (Low)—Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Bottom seine on resilient mud/sand habitats. Midwater trawl that is known to contact bottom occasionally (*
- *2 (Moderate)—Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Bottom seine except on mud/sand*

- *1 (High)—Hydraulic clam dredge. Dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 (Very High)—Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*

Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

Mexico Gulf of California, Jig

None

The Mexican Humboldt squid fishery exclusively uses lines and jigs, which have no virtually no contact with the substrate (CONAPESCA 2010) (Rodhouse 2005).

Factor 4.2 – Mitigation of Gear Impacts

Scoring Guidelines

- *+1 (Strong Mitigation)—Examples include large proportion of habitat protected from fishing (>50%) with gear, fishing intensity low/limited, gear specifically modified to reduce damage to seafloor and modifications shown to be effective at reducing damage, or an effective combination of 'moderate' mitigation measures.*
- *+0.5 (Moderate Mitigation)—20% of habitat protected from fishing with gear or other measures in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing.*
- *+0.25 (Low Mitigation)—A few measures are in place (e.g., vulnerable habitats protected but other habitats not protected); there are some limits on fishing effort/intensity, but not actively being reduced.*
- *0 (No Mitigation)—No effective measures are in place to limit gear impacts on habitats.*

Mexico Gulf of California, Jig

Not Applicable

Factor 4.3 – Ecosystem-Based Fisheries Management

Scoring Guidelines

- *5 (Very Low Concern)—Substantial efforts have been made to protect species' ecological roles and ensure fishing practices do not have negative ecological effects (e.g., large proportion of fishery area is protected with marine reserves, and abundance is maintained at sufficient levels to provide food to predators).*
- *4 (Low Concern)—Studies are underway to assess the ecological role of species and measures are in place to protect the ecological role of any species that plays an exceptionally large role in the ecosystem. Measures are in place to minimize potentially negative ecological effect if hatchery supplementation or fish aggregating devices (FADs) are used.*
- *3 (Moderate Concern)—Fishery does not catch species that play an exceptionally large role in the ecosystem, or if it does, studies are underway to determine how to protect the ecological role of these species, OR negative ecological effects from hatchery supplementation or FADs are possible and management is not place to mitigate these impacts.*
- *2 (High Concern)—Fishery catches species that play an exceptionally large role in the ecosystem and no efforts are being made to incorporate their ecological role into management.*
- *1 (Very High Concern)—Use of hatchery supplementation or fish aggregating devices (FADs) in the fishery is having serious negative ecological or genetic consequences, OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.*

Mexico Gulf of California, Jig

High Concern

One study that used a predictive model based on data from 1980-2002 concluded that the Humboldt squid is one of the most important predators in the Gulf of California, and is also the main food source for another important predator, the sperm whale (Rosas-Luis et al. 2008). Though this must be taken into account when planning for management of the fishery, at this time the Humboldt squid population undergoes such drastic annual fluctuations (CONAPESCA 2013) that more research is needed on the potential effects of the Humboldt squid fishery on the ecosystem. As there is evidence that Humboldt squid are an "exceptional species" (they play a key role in the ecosystem) and there are no explicit efforts to incorporate that role into management, this factor is deemed a high concern.

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