Monterey Bay Aquarium
Seafood Watch

Environmental sustainability assessment of wild-caught jumbo squid (*Dosidicus gigas*) from the Southeast Pacific caught using jigs.

Species:	Jumbo squid *(Dosidicus gigas)*
Location:	Chile, China, Peru: Southeast Pacific
Gear:	Jig
Type:	Wild Caught
Author:	Seafood Watch
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Assessed using Seafood Watch Fisheries Standard v4

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About Monterey Bay Aquarium Seafood Watch

The mission of the Monterey Bay Aquarium is to inspire conservation of the ocean and enable a future where the ocean flourishes and people thrive in a just and equitable world. To do this, the Aquarium is focused on creating extraordinary experiences that inspire awe and wonder, championing science-based solutions, and connecting people across the planet to protect and restore the ocean. We know that healthy ocean ecosystems are critical to enabling life on Earth to exist, and that our very survival depends on them. As such, our conservation objectives are to mobilize climate action, improve the sustainability of global fisheries and aquaculture, reduce sources of plastic pollution, and restore and protect ocean wildlife and ecosystems.

The aquarium is focused on improving the sustainability of fisheries and aquaculture given the role seafood plays in providing essential nutrition for 3 billion people globally, and in supporting hundreds of millions of livelihoods. Approximately 180 million metric tons of wild and farmed seafood is harvested each year (excluding seaweeds). Unfortunately, not all current harvest practices are sustainable and poorly managed fisheries and aquaculture pose the greatest immediate threat to the health of the ocean and the economic survival and food security of billions of people.

The Seafood Watch program was started 25 years ago as a small exhibit in the Monterey Bay Aquarium highlighting better fishing practices and grew into one of the leading sources of information on seafood sustainability, harnessing the power of consumer choice to mobilize change. The program's comprehensive open-source information and public outreach raises awareness about global sustainability issues, identifies areas for improvement, recognizes and rewards best practices and empowers individuals and businesses to make informed decisions when purchasing seafood.

We define sustainable seafood as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems, minimize harmful environmental impacts, assure good and fair working conditions, and support livelihoods and economic benefits throughout the entire supply chain. As one aspect of this vision, Seafood Watch has developed trusted, rigorous standards for assessing the environmental impacts of fishing and aquaculture practices worldwide. Built on a solid foundation of science and collaboration, our standards reflect our guiding principles for defining environmental sustainability in seafood.

Seafood Watch Ratings

The Seafood Watch Standard for Fisheries is used to produce assessments for wild-capture fisheries resulting in a Seafood Watch rating of green, yellow, or red. Seafood Watch uses the assessment criteria to determine a final numerical score as well as numerical subscores and colors for each criterion. These scores are translated to a final Seafood Watch color rating according to the methodology described in the table below. The table also describes how Seafood Watch defines each of these categories. The narrative descriptions of each Seafood Watch rating, and the guiding principles listed below, compose the framework on which the criteria are based.

Green	Final Score >3.2, and either criterion 1 or criterion 3 (or both) is green, and no red criteria, and no critical scores	Wild-caught and farm-raised seafood rated green are environmentally sustainable, well managed and caught or farmed in ways that cause little or no harm to habitats or other wildlife. These operations align with all of our guiding principles.
Yellow	Final score >2.2, and no more than one red criterion, and no critical scores, and does not meet the criteria for green (above)	Wild-caught and farm-raised seafood rated yellow cannot be considered fully environmentally sustainable at this time. They align with most of our guiding principles, but there is either one conservation concern needing substantial improvement, or there is significant uncertainty associated with the impacts of the fishery or aquaculture operations.
Red	Final Score ≤2.2, or two or more Red Criteria, or one or more Critical scores.	Wild-caught and farm-raised seafood rated Red are caught or farmed in ways that have a high risk of causing significant harm to the environment. They do not align with our guiding principles and are considered environmentally unsustainable due to either a critical conservation concern, or multiple areas where improvement is needed.

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Guiding Principles

Monterey Bay Aquarium defines sustainable seafood as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems, minimize harmful environmental impacts, assure good and fair working conditions, and support livelihoods and economic benefits throughout the entire supply chain.

As one aspect of this vision, Seafood Watch has developed trusted, rigorous standards for assessing the environmental impacts of fishing and aquaculture practices worldwide. Environmentally sustainable wild capture fisheries:

1. **Follow the principles of ecosystem-based fisheries management**

   The fishery is managed to ensure the integrity of the entire ecosystem, rather than solely focusing on maintenance of single species stock productivity. To the extent allowed by the current state of the science, ecological interactions affected by the fishery are understood and protected, and the structure and function of the ecosystem is maintained.

2. **Ensure all affected stocks[1] are healthy and abundant**

   Abundance, size, sex, age and genetic structure of the main species affected by the fishery (not limited to target species) is maintained at levels that do not impair recruitment or long-term productivity of the stocks or fulfillment of their role in the ecosystem and food web.

   Abundance of the main species affected by the fishery should be at, above, or fluctuating around levels that allow for the long-term production of maximum sustainable yield. Higher abundances are necessary in the case of forage species, in order to allow the species to fulfill its ecological role.

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[1]"Affected" stocks include all stocks affected by the fishery, no matter whether target or bycatch, or whether they are ultimately retained or discarded.

3. **Fish all affected stocks at sustainable levels**

   Fishing mortality for the main species affected by the fishery should be appropriate given current abundance and inherent resilience to fishing while accounting for scientific uncertainty, management uncertainty, and non-fishery impacts such as habitat degradation.

   The cumulative fishing mortality experienced by affected species must be at or below the level that produces maximum sustainable yield for single-species fisheries on typical species that are at target levels.

   Fishing mortality may need to be lower than the level that produces maximum sustainable yield in certain cases such as forage species, multispecies fisheries, highly vulnerable species, or fisheries with high uncertainty.

   For species that are depleted below target levels, fishing mortality must be at or below a level that allows the species to recover to its target abundance.

4. **Minimize bycatch**

   Seafood Watch defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival and there is no documented evidence of negative impacts at the population level.

   The fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss and by efficiently using marine and freshwater resources as bait.

5. **Have no more than a negligible impact on any threatened, endangered or protected species**

   The fishery avoids catch of any threatened, endangered or protected (ETP) species. If any ETP species are inadvertently caught, the fishery ensures and can demonstrate that it has no more than a negligible impact on these populations.

6. **Are managed to sustain the long-term productivity of all affected species**

   Management should be appropriate for the inherent resilience of affected marine

and freshwater life and should incorporate data sufficient to assess the affected species and manage fishing mortality to ensure little risk of depletion. Measures should be implemented and enforced to ensure that fishery mortality does not threaten the long term productivity or ecological role of any species in the future.

The management strategy has a high chance of preventing declines in stock productivity by taking into account the level of uncertainty, other impacts on the stock, and the potential for increased pressure in the future.

The management strategy effectively prevents negative population impacts on bycatch species, particularly species of concern.

7. **Avoid negative impacts on the structure, function or associated biota of aquatic habitats where fishing occurs**

   The fishery does not adversely affect the physical structure of the seafloor or associated biological communities.

   If high-impact gears (e.g. trawls, dredges) are used, vulnerable seafloor habitats (e.g. corals, seamounts) are not fished, and potential damage to the seafloor is mitigated through substantial spatial protection, gear modifications and/or other highly effective methods.

8. **Maintain the trophic role of all aquatic life**

   All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web, as informed by the best available science.

9. **Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts**

   Fishing activities must not result in harmful changes such as depletion of dependent predators, trophic cascades, or phase shifts.

   This may require fishing certain species (e.g., forage species) well below maximum sustainable yield and maintaining populations of these species well above the biomass that produces maximum sustainable yield.

10. **Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks**

Any enhancement activities are conducted at levels that do not negatively affect wild stocks by reducing diversity, abundance or genetic integrity.

Management of fisheries targeting enhanced stocks ensures that there are no negative impacts on the wild stocks, in line with the guiding principles described above, as a result of the fisheries.

Enhancement activities do not negatively affect the ecosystem through density dependent competition or any other means, as informed by the best available science.

Abbreviations

Table 1

Abbreviation	Description
CALAMASUR	Committee for the Sustainable Management of the Jumbo Flying Squid
EEZ	Exclusive economic zone
FIA	Fisheries Industry Association
FIP	Fondo de Investigación Pesquero
FONDEPES	Fondo Nacional de Desarrollo Pesquero
IFOP	Instituto de Fomento Pesquero
IMARPE	Instituto del Mar del Perú
IUU	Illegal, unreported, and unregulated
MOA	Ministry of Agriculture
NMFS	National Marine Fisheries Service
PRODUCE	Ministerio de la Producción
PSA	Productivity-susceptibility analysis
SIFORPA II	Sistema de Información de Pesca Artesanal
SPRFMO	South Pacific Regional Fisheries Management Organisation
UBM	Unknown Bycatch Matrix
VMS	Vessel monitoring system

Summary

This document provides recommendations for the South American stock of jumbo squid (*Dosidicus gigas*). The analysis includes the Chilean and Peruvian fisheries as well as the Chinese fishery for jumbo squid in the high seas off the Chilean and Peruvian exclusive economic zones (EEZs). In Chile, the majority of the stock is reserved for artisanal fishers, and jigging (with or without lights) remains the primary method in most regions. In Peru, the stock is almost exclusively exploited by artisanal light jiggers. In international waters outside of Chilean and Peruvian EEZs, the Chinese fishery operates small vessels (< 50 m) with hand jiggers year-round and brings in large vessels (> 50 m) equipped with mechanized jiggers a few months of the year.

Dosidicus gigas has low inherent vulnerability, but its abundance is highly variable and appears to be linked to environmental conditions. Inside Peru's EEZ, the stock is not considered depleted and fishing effort does not exceed recommended levels. In Chile's EEZ, the stock is not overexploited. There are several regional stock assessments that model the stock outside EEZs and/or across EEZs, but they offer conflicting findings. Because there is not consensus on the stock structure or stock assessment methods, the various outcomes of the stock assessments are treated as conflicted indicators. Abundance and fishing mortality are both a moderate concern for all countries.

Though discard rates and bycatch information for the fishery are not available, jigging is highly selective for squid. The Unknown Bycatch Matrix identified sharks and finfish as possible bycatch categories. Impacts on other species are a moderate concern for all countries.

Chile's management of the stock is moderately effective because it bases management on defined reference points, but there is a need for increased precaution when setting catch limits. Peru and China are both ineffective for management. Peru has appropriate management measures in place, but there are serious concerns about the management agency's ability to carry out those measures. China operates under SPRFMO management measures and there is essentially no system in place to curtail catch.

Bycatch strategy is highly effective for all three countries because jigging is highly selective. Scientific analysis is moderately effective for all three countries. They each conduct stock assessments, but data sharing between the countries is limited, and this has hampered efforts to determine the stock structure. Chile is highly effective at enforcing regulations within its EEZ. China's enforcement of its distant water fleet is ineffective. There are concerns about the fleet participating in illegal, unreported, and

unregulated (IUU) fishing and operating without the proper permitting from SPRFMO. Peru's enforcement is also ineffective because the enforcement scheme is inadequate, there is systematic noncompliance from Peruvian fishers, and China routinely violates Peru's regulations. Chile has a highly effective framework for stakeholder inclusion. Peru has a similar framework, but artisanal fishers struggle to contribute to the management process, so it is only moderately effective. China's stakeholder inclusion is ineffective. The country's management has historically been top-down, with little room for input. This is slowly shifting, but comanagement is still in its infancy.

Jigging has a minimal impact on marine ecosystems, though the ecological role of *D. gigas* and the potential effects of its depletion are poorly understood. As a result of these factors, jumbo squid from Chile is rated yellow, while jumbo squid from Peru and China are rated red.

Introduction

Scope of the analysis and ensuing rating

This report provides recommendations for the South American stock of jumbo squid (*Dosidicus gigas*), a major commercially imported squid species in the United States. The analysis includes the Chilean and Peruvian fisheries as well as the Chinese fishery for jumbo squid outside the Chilean and Peruvian exclusive economic zones (EEZs). In Chile, the majority of the stock is reserved for artisanal fishers, where jigging (with or without lights) on vessels < 15 m is the primary method in most regions. In Peru, the stock is almost exclusively exploited by artisanal light jiggers on vessels < 15 m. The Chinese fishery operates small vessels (< 50 m) with hand jiggers year-round and brings in large vessels (> 50 m) equipped with mechanized jiggers a few months during the year (Li et al. 2016).

Species Overview

Dosidicus gigas is an ommastrephid squid, subfamily Ommastrephinae. The species is restricted to the Eastern Pacific Ocean, historically ranging between subtropical North and South America, with temporary excursions to the north and south (Nigmatullin et al. 2001). In the past few decades, it has also become a common presence off the coast of southern Chile and the west coast of the United States, extending as far north as Alaska (Keyl et al. 2008)(Zeidberg and Robison 2007). The species is capable of traveling ≈30 km/day and undergoes daily vertical migrations, spending days below 250 m and ascending nearly to the surface at dusk, while diving periodically below 300 m (Gilly et al. 2006)(Stewart et al. 2012).

As with other ommastrephids, *D. gigas* has a lifespan of 1 to 2 years (Argüelles et al. 2001). Rapidly reaching mantle lengths of 1.2 m and weights of 50 kg, it is the largest nektonic squid, though individuals are variable in size (Nigmatullin et al. 2001). The species is semelparous and highly fertile, with year-round reproduction typically producing two cohorts a year (autumn/winter and spring/summer hatchings) (Argüelles et al. 2001), but little else is known about its reproductive biology. Environmental conditions appear to have a large influence on recruitment (Ibáñez et al. 2015)(Rodhouse 2001).

D. gigas feeds on a wide variety of small pelagic and demersal fishes, crustaceans, and squids, in some cases also targeting larger, economically important species such as hake (Alarcón-Muñoz et al. 2008)(Field et al. 2007)(Markaida and Sosa-Nishizaki 2003). Primary predators are tuna, billfish, sharks, pinnipeds, and toothed whales

(Nigmatullin et al. 2001)(Field et al. 2007). Cannibalism is widely observed but likely overreported (Ibáñez et al. 2008).

Globally, *D. gigas* constitutes the world's largest invertebrate fishery (FAO 2014)(Rosa et al. 2013), supporting major fisheries off the coast of Chile and Peru and in the Gulf of California, an occasional fishery off the Costa Rica dome, and a sport fishery on the west coast of the United States. The North and South American stocks constitute genetically distinct subpopulations (Sandoval-Castellanos et al. 2007)(Staaf et al. 2010).

The stock delineation has not been determined for jumbo squid in South American waters. Genetic studies found that there is low genetic diversity across jumbo squid found within the EEZs of Chile and Peru as well as squid in international waters (Ibáñez et al. 2022). There is evidence of intraspecific subpopulations that display phenotypic differentiation (Csirke et al. 2018)(IMARPE 2022)(SPRFMO 2022b). These phenotypic groups differ in size at sexual maturity and geographic distribution. The groups may each be part of one or more stocks (IMARPE 2022).

Sensitivity to environmental factors and a relatively short lifespan lead to high volatility for jumbo squid biomass. Traditional stock assessment methods are not suitable for highly volatile stocks. It is also difficult to determine biological reference points for short-lived stocks. Chile, Peru, and China have each proposed stock assessment methods based on assumptions about stock delineations (IMARPE 2022)(Li et al. 2022)(IFOP 2022). The SPRFMO has determined that the limitations and uncertainties for each method are too high for any of them to be used for management purposes (SPRFMO 2023).

Chilean management

Fisheries are under the aegis of the Ley General de Pesca y Acuicultura, adopted in 1989 and most recently updated in 2023 (SUBPESCA 2023). The executive policy-making branch of Chilean fisheries governance is Subpesca, under the Ministry of Economy, Development and Reconstruction, which incorporates national, zonal, and regional fisheries councils. The separate Sernapesca acts as a control and enforcement body. The Instituto de Fomento Pesquero (IFOP) is a nonprofit corporation, founded both by the Ministry and by the private sector organization Sonapesca, which provides fisheries analysis. The Fondo de Investigación Pesquero (FIP), under the umbrella of Subpesca, also funds fisheries research.

Chilean fishery managers make use of quotas (global, individual, and, in some cases, individual transferable), gear restrictions, seasonal/area closures, establishment of bycatch limits, and size limitations. Regular stock assessments are conducted and

management measures are set in place by Subpesca according to recommendations made by IFOP and the regional scientific committees. Artisanal fishers have formal recognition: all are officially registered by Sernapesca, are apportioned separate quotas, and have exclusive access to the 5 miles adjacent to the coastline. Chile is a signatory to most major international treaties and a member of the South Pacific Regional Fisheries Management Organisation (SPRFMO) (FAO 2010b) (OECD 2009).

Chile makes use of onboard and dockside observers to collect catch data (SUBPESCA 2021)(SUBPESCA 2022a). Vessel monitoring systems (VMS) are currently mandatory on all large-scale fishing vessels (FAO 2010b).

Peruvian management

Fisheries are governed by the General Law on Fisheries (Decreto No. 25977) and managed by the office of the Deputy Minister of Fisheries, a branch of the Ministry of Production (PRODUCE). The Minister is responsible for developing and managing national fisheries policies. The Minister also oversees the Instituto del Mar del Perú (IMARPE), which conducts fisheries research, and the Fondo Nacional de Desarrollo Pesquero (FONDEPES), responsible for developing artisanal fisheries (FAO 2010b).

Peruvian fishery managers make use of seasonal/area closures, reductions in the permitted fishing fleet, size limitations, gear restrictions, and establishment of bycatch limits. Regular stock assessments are conducted and management measures are set in place by the Minister according to recommendations made by IMARPE and its regional branches. IMARPE has a well-established onboard observer program to monitor discards and bycatch (PRODUCE 2012a). Peru is a signatory to most major treaties and a member of the SPRFMO.

Chinese management

Historically, management of Chinese distant-water fisheries has been largely nonexistent (Yu and Wang 2021). The Distant Water Fleet Supervisory Regulation, introduced in 2003 and revised in 2020, aims to improve the situation (Regulations on the Administration of Pelagic Fisheries 2020). Previously controlled by the government, China's distant-water fisheries are now at least 70% owned by private enterprises, thus adding to the secrecy of operations and management (Mallory 2012). But Shanghai Ocean University maintains an active research program that investigates *D. gigas* biology, with research spanning across habitat, stock assessment, and life history (age, growth, population, reproduction, and feeding ecology) of the species. China remains an active member of many international RFMOs, including the SPRFMO, which is starting to improve the accountability of China's distant-water fisheries (Yu and Wang 2021).

SPRFMO management

Regulation of this fishery by SPRFMO is still developing. Each country is required to report landings data for its fleet and meet minimum observer coverage requirements. Vessels fishing in the convention area are required to be registered with SPRFMO and have VMS (SPRFMO 2020). Currently, there is no quota system or closed fishing season for the fishery outside the Chilean and Peruvian EEZs. A stock assessment has not been adopted for management purposes because the limitations and uncertainty are too high for each proposed assessment method (SPRFMO 2023).

Production Statistics

Dosidicus gigas capture has expanded dramatically in recent years, due both to increased fishing effort and to the species' population growth and range expansion, potentially tied to climate change and/or the decline of finfish competitors (Gilly et al. 2013)(Keyl et al. 2008)(SPRFMO 2022c)(Zeidberg and Robison 2007). Based on catch data from the FAO's FishStatJ, the recent catch primarily derives from Peru, China, and Chile, with negligible captures by other nations.

Fishery in Chilean waters

Jumbo squid has been caught incidentally off the Chilean coast since at least 1957, and was caught sporadically at low levels until the 1990s (Rocha and Vega 2003). The Chilean artisanal jig fishery was initially centered in Coquimbo (Region IV), beginning in the late 1990s or early 2000s (Cortés 2012)(pers. comm., Patricio Galvez, IFOP 2018), and slowly expanded into Regions V and VIII after the 2002 spike in squid landings (Keyl et al. 2008)(SUBPESCA 2012a). Primary fishing grounds are nearshore between 36° to 38.5° S. and 29° to 34° S. Japanese, Korean, and Chinese vessels also operate in international waters off the Chilean coast (Arkhipkin et al. 2015).

While industrial hake trawlers had opportunistically pursued squid in the past, a directed industrial trawl fleet targeting jumbo squid developed in 2011. The first global quota for jumbo squid was established in 2012 (SUBPESCA 2012a). These efforts were primarily focused in the south (Regions VIII–XII), and constituted midwater trawls conducted in short trips with low storage volumes (pers. comm., Patricio Galvez 2018) (pers comm., Pablo Lizana 2018). New regulations on fishing gear were introduced in 2020, which specified that jumbo squid could only be caught with handlines and jigging (SUBPESCA 2022a). This effectively ended the directed industrial trawl portion of the fishery. The artisanal fishery for jumbo squid remains strong. In 2021, there were 1,647 vessels participating in the artisanal fleet, and 6.6% of the vessels were smaller than 12 m (SUBPESCA 2022a).

Annual landings inside Chile's EEZ ranged from 143,716 to 183,123 tonnes (MT) for 2014–18. Landings dipped to 58,042 MT in 2019 and remained at that level through 2021 (SPRFMO 2022c). Starting in 2020, squid could only be targeted using handlines and jigging. This effectively ended the industrial fleet's participation in the fishery (SUBPESCA 2022a). The 2023 quota is set at 200,000 MT, with 4,000 MT set aside for bycatch in the industrial fleet and 1,000 MT set aside for scientific collection (SUBPESCA 2022c).

Fishery in Peruvian waters

In the late 1980s, trawlers from the then-USSR reported jumbo squid as bycatch off the coast of Peru, but the species was of low economic importance until the industrial fishery, which comprised Japanese and Korean mechanized jigging fleets, began in 1991 (IMARPE 1996). Japanese and Korean ships continued to operated in the Peruvian EEZ until 2011, when new regulations excluded foreign vessels from participating in the fishery within Peru's EEZ (IMARPE 2021). Japanese, Korean, and Chinese vessels also operate in international waters off the Peruvian coast (Arkhipkin et al. 2015). Catches by the Peruvian artisanal fleet, active primarily in the southern half of the country, were not significant before 1996 (Estrella Arellano and Swartzman 2010). The number of artisanal jigging vessels has increased since 1998, exceeding 4,000 in 1998, while the number of participating industrial vessels has concurrently decreased. The artisanal fleet had taken approximately 90% of the catch from 2004 to 2012 (Arkhipkin et al. 2015). The artisanal fleet has been responsible for all targeted jumbo squid landings since 2012 (Mariátegui et al. 2021). Annual landings have consistently been between ≈400,000 and ≈560,000 MT since 2006, except for a short period in 2016–18 when landings dipped to 290,933 to 362,200 MT (SPRFMO 2022c).

Chinese fishery outside Chilean and Peruvian waters

Most prominently, the Chinese distant-water mechanized jigging fleet, redistributing after declines in *Illex argentinus* stock, has been operating outside the Chilean and Peruvian EEZs from 7° to 20° S. since 2001 (Chen et al. 2008). From 2005 to 2010, the Chinese catch stayed below 142,000 MT, increased to 250,000 to 264,000 MT in 2011 to 2013, and peaked at 325,000 MT in 2014 before falling slightly to 323,600 MT in 2015 (Arkhipkin et al. 2015)(Li et al. 2016). Landings dipped in 2016 to 223,300 MT and steadily increased to 358,000 MT by 2020 (SPRFMO 2022c). There is a high risk of IUU fishing in the Chinese fleet, and it is likely that the reported landings do not represent the full volume that the fleet is landing (GFW 2021).

Other

A number of other nations exploit South American *D. gigas* stock. Japanese and Korean fleets are permitted to fish within the SPRFMO High Seas area (SPRFMO

2022c). Taiwan has also operated a smaller, high-seas mechanized jigging fleet in the southeast Pacific since 2002 (SPRFMO 2013a), with annual catch dwindling to less than 2,000 MT (SPRFMO 2022c). Ecuador's official *D. gigas* fishery was authorized in 2014, allowing for 30 artisanal and 6 industrial vessels (Subsecretario de Recursos Pesqueros 2014) in coastal waters (Morales-Bojórquez & Pacheco-Bedoya 2016) and off EEZ waters (Liu et al. 2017).

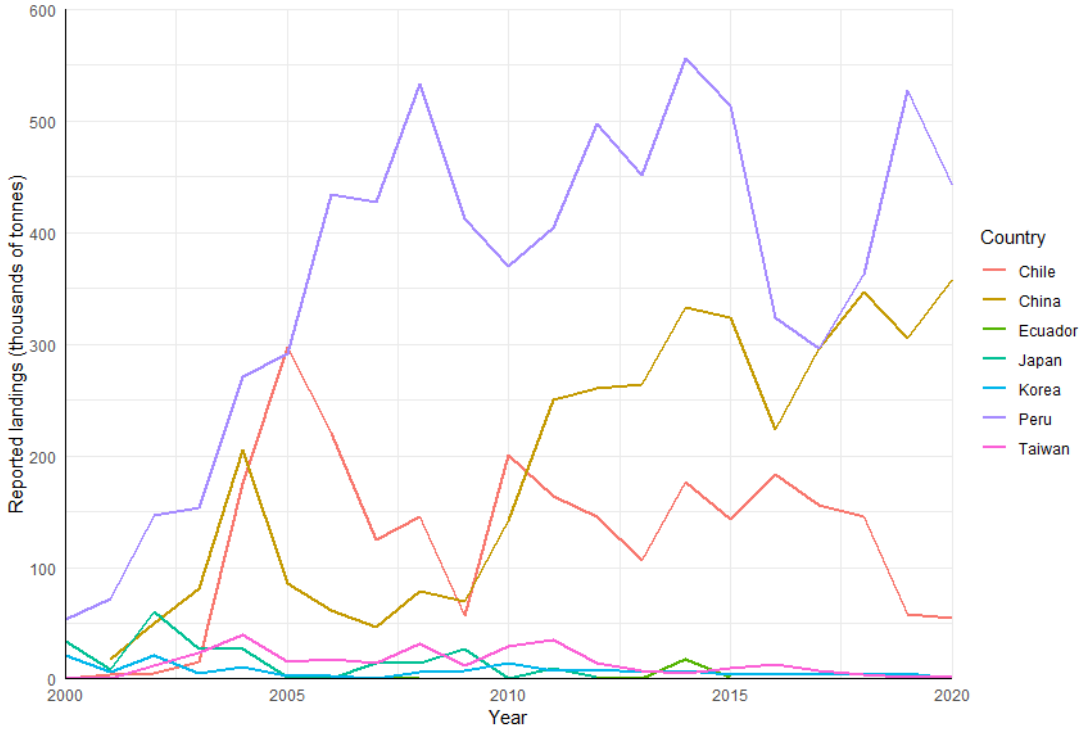

Figure 1: Annual landings reported to SPRFMO by country in all fishing areas including EEZs, high seas, and FAO 87 (SPRFMO 2022c).

Importance to the US/North American market.

Complete data on jumbo squid imports into the United States are not available: the National Marine Fisheries Service (NMFS) identifies commercial U.S. squid imports as either "Loligo NSPF" or "squid NSPF," where NSPF stands for "not specifically provided for."

According to NMFS data, "squid NSPF" imports are overwhelmingly Chinese in origin. But China's fishing statistics are complicated by historical underreporting of catches in its distant-water fleet (Pauly et al. 2014) and the failure to distinguish *D. gigas* captures from often significant catches of other squids. Chinese trade statistics are similarly

complicated by the importation, processing, and re-exports of other squid species (see the Seafood Watch report on California market squid).

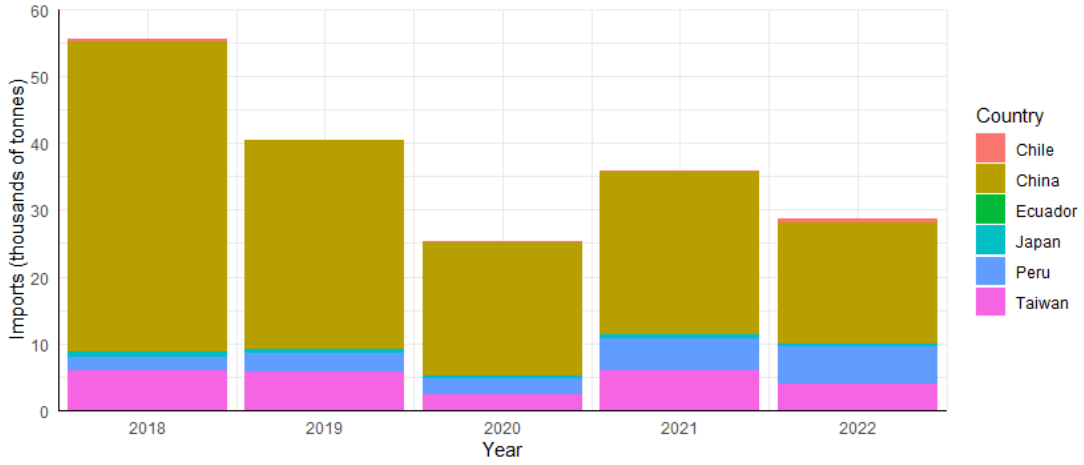

Figure 2: U.S. imports of "Squid" (squid of unspecified species) by exporting nation for 2018–22 (NMFS 2023).

Common and market names.

Humboldt squid, jumbo squid, jumbo flying squid, calamar gigante, pota (Peru), jibia (Chile). May also be sold in the U.S. simply as squid or calamari.

Primary product forms

The majority of squid products for human consumption are imported frozen, either whole, in fillets, or rings. Jumbo squid is also sold boiled, pickled, as jerky (or "sakiika"), salted and fermented ("shiokara"), and mixed with other seafood, although these forms are less common in North American markets.

Final Ratings

Ratings Details	C 1 Target Species	C 2 Other Species	C 3 Management	C 4 Habitat	Rating
Jumbo squid Chile | Southeast Pacific Ocean | Jig | 98323 mt	2.644	5.000	3.000	3.873	Yellow (3.520)
Jumbo squid High Seas | Southeast Pacific Ocean | Jig | 508964 mt	2.644	2.236	1.000	3.873	Red (2.187)
Jumbo squid Peru | Southeast Pacific Ocean | Jig | 492363 mt	2.644	5.000	1.000	3.873	Yellow (2.675)

Annual catch data are reported to SPRFMO (SPRFMO 2024c).

Chile's catch is all in its EEZ from 2022 (98,323 MT).

China's reported catch is all in the high seas area from 2022 (508,964 MT).

Peru's catch is all from its EEZ from 2020 (492,363 MT).

Summary

Jumbo squid from Chile is rated yellow, while jumbo squid from Peru and China are rated red.

Assessments

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at www.seafoodwatch.org. The specific standard used is referenced on the title page of all Seafood Watch assessments.

Criterion 1: Impacts on the Species Under Assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species' inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. 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.

Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level*

Criterion 1 Summary

Jumbo squid			
Region / Method	**Abundance**	**Fishing Mortality**	**Score**
Chile | Southeast Pacific Ocean | Jig | 98323 mt	2.330 Moderate Concern	3.000 Moderate Concern	**Yellow (2.644)**
High Seas | Southeast Pacific Ocean | Jig | 508964 mt	2.330 Moderate Concern	3.000 Moderate Concern	**Yellow (2.644)**
Peru | Southeast Pacific Ocean | Jig | 492363 mt	2.330 Moderate Concern	3.000 Moderate Concern	**Yellow (2.644)**

Criterion 1 Assessment

Scoring Guidelines

Factor 1.1 - Abundance

Goal: Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity.

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate target abundance level (given the species' ecological role), or near virgin biomass.*
- *3.67 (Low Concern) — Population may be below target abundance level, but is at least 75% of the target level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.*
- *2.33 (Moderate Concern) — Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.*
- *1 (High Concern) — Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.*

Factor 1.2 - Fishing Mortality

Goal: Fishing mortality is appropriate for current state of the stock.

- *5 (Low Concern) — Probable (>50%) that fishing mortality from all sources is at or below a sustainable level, given the species ecological role, OR fishery does not target species and fishing mortality is low enough to not adversely affect its population.*
- *3 (Moderate Concern) — Fishing mortality is fluctuating around sustainable levels, OR fishing mortality relative to a sustainable level is uncertain.*
- *1 (High Concern) — Probable that fishing mortality from all source is above a sustainable level.*

Jumbo squid *(Dosidicus gigas)*

1.1 Abundance

Southeast Pacific | Chile | Jig
Southeast Pacific | High Seas | Jig | China
Southeast Pacific | Peru | Jig

Moderate Concern

China has completed stock assessments in 2017, 2021, 2022, and 2024 using a state-space surplus production model. It uses catch per unit effort (CPUE) and fishery-dependent data from China, Korea, and Chinese Taipei's distant-water fleets. The 2024 stock assessment estimated abundance from 2012 to 2021 at annual and monthly timesteps under various environmental scenarios (Li et al. 2024). Both annual timestep models found the stock to be healthy, with a 51% to 61.1% probability that the findings are accurate. The monthly timestep model estimated that abundance was above B_{lim} in every month (ibid). No probability was provided for the accuracy of the estimate that $B > B_{lim}$. In most months, abundance exceeded B_{MSY}; however, there is a 37.4% probability that abundance in the final month of the model was below B_{MSY} (ibid).

Peru completed a stock assessment in 2022 that covers the exploitable biomass that exists inside its EEZ (IMARPE 2022). The stock assessment uses a state space model, tuned with landings data and fishery-independent survey data. The index of abundance is reported as the number of individuals and converted to biomass based on the average size of individuals. For 2021, MSY is estimated at 151.5 million individuals, or 651,450 MT. This is considered the limit reference point. The index of abundance in 2021 is above MSY, and the estimated abundance has been above MSY since 2006 (IMARPE 2022). An update to the stock assessment estimated that there is a 58.2% probability that the stock is above the limit reference point (IMARPE 2024). But there is considerable uncertainty around this estimate, with the 95% confidence interval exceeding 1.5 N_{MSY} and extending below 0.75 N_{MSY} (ibid).

Chile completed a stock assessment in 2021 using a surplus production model in continuous time. The input data came from landings data from the industrial and artisanal fleets, mantle length-frequency data, and abundance indices from the artisanal fleet's catch rates. Because the stock structure is still unknown, the stock

assessment modeled two stock structure scenarios: a stock isolated to Chile's EEZ (national stock) and a stock for the entire region (regional stock). The national stock was found to be overexploited (B_{2021}/B_{MSY} = 0.76) and the regional stock was determined to be collapsed/depleted (B_{2021}/B_{MSY} = 0.39). There was greater uncertainty around the estimates of abundance for the regional stock structure than for the national stock structure (IFOP 2022). Updated stock assessment results were presented in 2024 (IFOP 2024). The national stock is estimated to be healthy (B_{2023}/B_{MSY} = 2.2), while the regional stock is still below the target reference point (B_{2022}/B_{MSY} = 0.70) (ibid). The results have not been formally published, so the amount of uncertainty around the most recent estimates is still unclear.

The industry group CALAMASUR funded a regional stock assessment. The assessment uses a generalized depletion model and a population dynamics model with data from the Chinese, Korean, Chilean, Peruvian, and Ecuadorian fleets (Roa-Ureta and Wiff 2023). Catch data were compiled into 10-year (2012–21) databases with catch, effort, and mean weight per month. The databases were split into Peruvian data, Chilean data, and "Asian" data from the SPRFMO (ibid). The population dynamics model introduced environmental regime data and determined that the stock has entered a period of wide fluctuations. They conclude that this high level of variability means that MSY and B_{MSY} are inadequate reference points (ibid). Instead, the stock assessment uses average latent productivity, though it notes that the statistical precision of this estimate is still poor. Ultimately, the stock assessment determined that the regional stock is not overfished (ibid)

Because the stock delineation is unknown, there are conflicting indicators of stock status, and there is high uncertainty around some of the results, a productivity-susceptibility analysis (PSA) was completed for the stock. The PSA determined that the stock has a vulnerability score of 3.13, which corresponds with a medium vulnerability. Therefore, abundance scores a "moderate concern."

Supplementary Information

Table 2

Productivity Attribute	Value	Score (1 = low; 2 = medium; 3 = high)	Reference
Average age at maturity	1–2 year lifespan	1	(Argüelles et al. 2001)

Average maximum age	1–2 year lifespan	1	(Argüelles et al. 2001)
Von Bertalanffy growth coefficient (K)	Von Bertalanffy growth model shows poor fit and lack of convergence. It is not suitable for this species.	N/A	(Goicochea-Vigo et al. 2019)
Fecundity	0.3 to 1.3 million eggs	1	(Nigmatullin et al. 2001)
Reproductive strategy	Internal fertilization of large egg masses	2	(Nigmatullin et al. 2001)
Density dependence	Density dependent factors have been noted as a possible factor in population abundance, but the specific mechanism has not been explored further. Therefore, it is unclear whether the factors are compensatory or depensatory at low population sizes.	2	(Ibáñez et al. 2016)
Productivity subscore		**1.4**	

Table 3

Susceptibility Attribute	**Value**	**Score (1 = low; 2 = medium; 3 = high)**	**Reference**
Areal overlap	Fleets within the EEZ fish close to shore, where abundance is highly concentrated. The high seas fleet follows jumbo squid as they migrate.	3	(GFW 2022) (Csirke et al. 2015)
Vertical overlap	Can be found at 0–1,200 m depths. They typically inhabits depths of 250–600 m during the day and < 120 m at night. Peruvian fishers report catch at 0–250 m depths.	2	(Csirke et al. 2015)
Seasonal availability	The fleet targets jumbo squid year-round.	3	(Li et al. 2016) (GFW 2022)
Selectivity of fishery	Species is targeted and vessels use high-powered lights to attract individuals near the surface. They usually live for 1 year, are reproductive year-round, and are targeted year-round.	3	(Csirke et al. 2015)

Post-capture mortality	Retained species	3	
Susceptibility subscore		**2.8**	

Productivity-Susceptibility score: 3.13
Vulnerability rating (high, medium, low): medium vulnerability

1.2 Fishing Mortality

Southeast Pacific | Chile | Jig
Southeast Pacific | High Seas | Jig | China
Southeast Pacific | Peru | Jig

Moderate Concern

China's 2024 stock assessment estimated fishing mortality F_{2021} and compared it to F_{MSY} (Li et al. 2024). Various values of F_{MSY} were estimated based on various environmental regimes, and in all cases, F_{2021} was below F_{MSY} (Li et al. 2024).

Peru's 2024 stock assessment estimated that there is a 41.8% probability that fishing is below the target reference point (IMARPE 2024). But the 95% confidence interval is wide, extending from less than 0.5 F_{MSY} to greater than 1.25 F_{MSY} (ibid).

Chile's 2024 stock assessment estimated fishing mortality under two stock structure hypotheses (a national and a regional stock). The national stock scenario determined that fishing mortality was below F_{MSY}, with $F_{2023}/F_{MSY} = 0.33$. The regional stock scenario found the stock to be experiencing overfishing, with $F_{2022}/F_{MSY} = 1.59$ (IFOP 2024). The CALAMSUR-sponsored stock assessment did not estimate F (Roa-Ureta and Wiff 2022). Because the fishing mortality was shown to be both above and below F_{MSY} under various stock structure scenarios and with different input data for each stock assessment, it is scored a "moderate concern."

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated under Criterion 2. 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. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery's potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait 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 is Critical if Factor 2.3 (Fishing Mortality) is Crtitical

Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*
- *Minimize bycatch.*

Criterion 2 Summary

Criterion 2 score(s) overview

This table(s) provides an overview of the Criterion 2 subscore, discards+bait modifier, and final Criterion 2 score for each fishery. A separate table is provided for each species/stock that we want an overall rating for.

Jumbo squid			
Region / Method	**Sub Score**	**Discard Rate/Landings**	**Score**
Chile | Southeast Pacific Ocean | Jig | 98323 mt	5.000	1.000: < 100%	Green (5.000)
High Seas | Southeast Pacific Ocean | Jig | 508964 mt	2.236	1.000: < 100%	Yellow (2.236)
Peru | Southeast Pacific Ocean | Jig | 492363 mt	5.000	1.000: < 100%	Green (5.000)

Criterion 2 main assessed species/stocks table(s)

This table(s) provides a list of all species/stocks included in this assessment for each 'fishery' (as defined by a region/method combination). The text following this table(s) provides an explanation of the reasons the listed species were selected for inclusion in the assessment.

Southeast Pacific | Chile | Jig			
Sub Score: 5.000	**Discard Rate: 1.000**		**Score: 5.000**
Species	**Abundance**	**Fishing Mortality**	**Score**
Jumbo squid	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Southeast Pacific | High Seas | Jig | China			
Sub Score: 2.236	**Discard Rate: 1.000**		**Score: 2.236**
Species	**Abundance**	**Fishing Mortality**	**Score**
Sharks	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Jumbo squid	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Finfish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Southeast Pacific | Peru | Jig			
Sub Score: 5.000	**Discard Rate: 1.000**		**Score: 5.000**
Species	**Abundance**	**Fishing Mortality**	**Score**
Jumbo squid	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Jigging is generally considered a highly selective method of fishing that generates minimal bycatch (Arkhipkin et al. 2015). A catch composition survey was conducted in Peru that confirms that the hand jigs in the artisanal fishery are highly selective. Bycatch accounted for 0.4–0.6% of the total catch (IMARPE 2019). Because no species accounted for at least 5% of the catch, there are no species included in Criterion 2 for the artisanal fleet of Peru. A study of seabird interactions with the Peruvian artisanal fishery recorded a bycatch incident with a Chatham albatross. The bird was released alive (Moreno and Quiñones 2022). A single incident with live release does not indicate substantial impact from the fishery, so Chatham albatross is not included as a Criterion 2 species. These findings are also being applied to the Chilean artisanal fleet, because catch composition data are not readily available for that fleet and both fleets have similar gear, vessels, and fishing conditions. The Chinese high seas fleet fishes in slightly different conditions using mechanized jigs, so the Peruvian data do not apply to that fleet.

Catch composition data are not readily available for the Chinese high-seas fleet, so the Unknown Bycatch Matrix (UBM) was used to determine whether this fishery has any notable bycatch concerns. The results of the UBM were overridden in cases where studies provide additional insight. The UBM categories used for this assessment are LHM (mechanized lines and pole-and-lines) and TP (troll/pole and line) in the Eastern Pacific. Although these gear types are not an exact match for the impacts from mechanical jigging, they are sufficiently similar in specificity to be used as a substitute for determining species of concern. The UBM determined that finfish and sharks may show up as bycatch in the Chinese high-seas fishery.

The SPRFMO reports provide an annual summary of seabird, mammal, reptile, and species of concern bycatch. The high-seas jumbo squid fishery started reporting this data to the SPRFMO in 2021, so the data are rather limited. The only bycatch record for this fishery was a loggerhead sea turtle (*Caretta caretta*) that was captured and released alive in 2021 (SPRFMO 2022d). This single bycatch incident with live release does not indicate that there is a substantial impact from the fishery. As a result, loggerhead sea turtle is not included as a Criterion 2 species.

Criterion 2 Assessment

Scoring Guidelines

Factor 2.1 - Abundance

(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality

(same as Factor 1.2 above)

Factor 2.3 - Modifying Factor: Discards and Bait Use

Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

Ratio of bait + discards/landings	Factor 2.3 score
<100%	1
>=100	0.75

Finfish *(Unknown finfish spp.)*

2.1 Abundance

Southeast Pacific | High Seas | Jig | China

Moderate Concern

Finfish were identified as a main species in this fishery by using the Unknown Bycatch Matrix. Because this is not a highly vulnerable taxon, abundance scores a “moderate concern.”

2.2 Fishing Mortality

Southeast Pacific | High Seas | Jig | China

Moderate Concern

Following the scoring in the Unknown Bycatch Matrix, this taxon scores a “moderate concern.”

Sharks *(Selachimorpha)*

2.1 Abundance

Southeast Pacific | High Seas | Jig | China

High Concern

Sharks were identified as a main species in this fishery by using the Unknown Bycatch Matrix. Because this is a highly vulnerable taxon, abundance scores a “high concern.”

2.2 Fishing Mortality

Southeast Pacific | High Seas | Jig | China

Low Concern

Following the scoring in the Unknown Bycatch Matrix, this taxon scores a “low concern.”

2.3 Discard Rate/Landings

Southeast Pacific | Chile | Jig
Southeast Pacific | High Seas | Jig | China
Southeast Pacific | Peru | Jig

< 100%

Discard rates are largely unavailable, but jig fisheries are typically highly selective (Boyle and Rodhouse 2005), with a discard rate of 0.1% (Kelleher 2005).

Supplementary Information

Chile has onboard observers for the industrial and artisanal fleets, as well as dockside observers (SUBPESCA 2021)(SUBPESCA 2022a)(IFOP 2022). In Peru, scientific observers are placed on the artisanal fleet within the EEZ, though coverage is low. Observer coverage averaged 0.59% of sea days for 2015–19 (Mariátegui et al. 2021). China has onboard observers for the industrial distant-water fleet to fulfill SPRFMO observer requirements (SPRFMO 2022a)(SPRFMO 2020). Although bycatch and discard rates are low for this fishery, SPRFMO's goal for such an observer program focuses on collecting biological data on *D. gigas*, including length, weight-at-length, sex, and maturity (Argüelles et al. 2016).

Criterion 3: Management Effectiveness

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

- *5 (Very Low Concern) — Meets the standards of 'highly effective' for all five factors considered.*
- *4 (Low Concern) — Meets the standards of 'highly effective' for 'management strategy and implementation' and at least 'moderately effective' for all other factors.*
- *3 (Moderate Concern) — Meets the standards for at least 'moderately effective' for all five factors.*
- *2 (High Concern) — At a minimum, meets standards for 'moderately effective' for Management Strategy and Implementation and Bycatch Strategy, but at least one other factor is rated 'ineffective.'*
- *1 (Very High Concern) — Management Strategy and Implementation and/or Bycatch Management are 'ineffective.'*
- *0 (Critical) — Management Strategy and Implementation is 'critical'.*

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 = **Red** or High Concern

Rating is Critical if Management Strategy and Implementation is Critical.

Guiding principle

- The fishery is managed to sustain the long-term productivity of all impacted species.

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

Criterion 3 Summary

Fishery	Management Strategy And Implementation	Bycatch Strategy	Scientific Data Collection and Analysis	Enforcement of and Compliance with Management Regulations	Stakeholder Inclusion	Score
Southeast Pacific | Chile | Jig	Moderately Effective	Highly effective	Moderately Effective	Highly effective	Highly effective	Yellow (3.000)
Southeast Pacific | High Seas | Jig | China	Ineffective	Moderately Effective	Moderately Effective	Ineffective	Ineffective	Red (1.000)
Southeast Pacific | Peru | Jig	Ineffective	Highly effective	Moderately Effective	Ineffective	Moderately Effective	Red (1.000)

Illegal activity and IUU fishing practices are serious concerns in this fishery. The Seafood Watch Fisheries Standard v4 considers illegal fishing and noncompliance in the scoring for Factors 3.1 and 3.4. To ensure that a fishery is not penalized under two factors for the same infractions, scoring for these factors considers the different impacts that illegal activity has on the fishery.

For Factor 3.1, the score may be negatively affected if illegal activity impacts or otherwise impairs the management organization's ability to carry out the management strategy that it has enacted. This includes any illegal activity or corruption within the management organization. Illegal activity from the fishing industry would not impact the scoring for Factor 3.1 unless it is substantial and widespread. For Factor 3.4, noncompliance and illegal activity from the fishing industry can negatively impact the score.

Criterion 3 Assessment

Scoring Guidelines

Factor 3.1 - 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? Do manages follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

Factor 3.2 - Bycatch Strategy

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and when applicable, to minimize ghost fishing? How successful are these management measures? To achieve a Highly Effective rating, the fishery must have no or low bycatch, or if there are bycatch or ghost fishing concerns, there must be effective measures in place to minimize impacts.

Factor 3.3 - Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the fishery's impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.

Factor 3.4 - 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.

Factor 3.5 - 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, if high participation by all stakeholders is encouraged, and if there a mechanism to effectively address user conflicts.

3.1 Management Strategy And Implementation

Southeast Pacific | Chile | Jig

Moderately Effective

Management of the jumbo squid fishery in Chile's EEZ began in 2012. Starting in 2020, squid could only be targeted using handlines and jigging. This effectively ended the industrial fleet's participation in the fishery (SUBPESCA 2022a). In 2021, the artisanal fleet comprised 1,647 vessels. All vessels are smaller than 18 m and 96.6% of them are smaller than 12 m (SUBPESCA 2022a). In 2019, Chile stopped granting licenses to new users who wish to enter the fishery because the stock was determined to be fully exploited (SUBPESCA 2022a). This measure to reduce fishing effort has seen positive results. The annual catch for 2019–21 was ≈55,000 MT. The 2021 recommended BAC (biological allowable catch) from the scientific advisory body was 83,000–114,000 MT (SUBPESCA 2021). The scientific advisory body provides annual recommendations for the BAC and determines the stock status. Its recommended BAC range for both 2022 and 2023 was 160,000–200,000 MT (SUBPESCA 2021)(SUBPESCA 2022b). This was based on a model using the status quo fishing effort (SUBPESCA 2021)(SUBPESCA 2022b). But the stock status for both years was overexploited, so a status quo fishing effort is likely not precautionary enough to improve the status of the stock (SUBPESCA 2021) (SUBPESCA 2022b). In fact, when the scientific advisory body applied the ICES advisory rule, the recommended BAC was 108,000 tons (SUBPESCA 2022b).

Although catch levels have been below the BAC in recent years, management has consistently set the BAC at the highest recommended levels. The established BAC has been held at 200,000 MT over the past several years (SUBPESCA 2020) (SUBPESCA 2022a)(SUBPESCA 2022c). Some of the reticence to change the BAC seems to stem from disagreement about the conclusions of the stock assessment findings, because the stock assessments are considered "data poor" (SUBPESCA 2020). But the inability of management to modify the BAC in response to the best available scientific information reveals a shortcoming in management effectiveness.

Regulations and management measures are in place that are effectively curtailing catch of the species. Landings in recent years have remained well below the recommended BAC. But the actual BAC is not sufficiently precautionary, given the overexploited status of the stock. There is inertia to maintain the BAC at 200,000 MT rather than reduce it in response to the stock status. Therefore, management strategy and implementation scores "moderately effective."

Supplementary Information

The BAC for 2023 was set at 200,000 MT, with 4,000 MT set aside for bycatch and 1,000 MT set aside for scientific collection purposes. This leaves 195,000 MT for the commercial fishery (SUBPESCA 2022c).

Southeast Pacific | High Seas | Jig | China

Ineffective

A number of ordinances from China's Ministry of Agriculture (MOA) and the Fisheries Management Board of China provide the regulatory structure for the distant-water fleet. The regulations focus mainly on vessel compliance as opposed to specifics for fishery management (Regulations on the Administration of Pelagic Fisheries 2020). Any regulations on fisheries themselves, such as catch quotas, vessel numbers, and recommended fishing levels, come from regional fishery bodies in which China is an active partner. The management measures for the high-seas jumbo squid fishery outside of Peruvian and Chilean EEZs are stipulated by the South Pacific Regional Fisheries Management Organisation (SPRFMO). There is no catch limit in place. The only management measure that may influence the level of catch is a cap on the number of active vessels and total gross tonnage for each country (SPRFMO 2024a). This vessel limit is based on historical fishing effort until the end of 2020. The vessel limit is set at the highest historical level of fishing effort (ibid). The effort limit is so high that it essentially does not curtail effort. There are functionally no measures to manage the catch of jumbo squid in the SPRFMO High Seas area. Other SPRFMO management measures focus on procedural concerns such as data reporting, observer coverage, vessel inspections, and stipulations for transshipment.

There is essentially no management to curtail catch; however, the status of the stock (see Criterion 1) indicates that it is unlikely that the fishery is having serious, negative impacts on any retained populations. Therefore, management strategy and implementation scores "ineffective."

Supplementary Information

The directed guidelines given by the Chinese management strategy come from the Regulations on Distant Water Fisheries adopted by MOA in 2003 and revised in 2020 (Regulations on the Administration of Pelagic Fisheries 2020). They provide requirements for vessel license application, catch reporting duties, vessel surveillance, and penalties for violations (Regulations on the Administration of

Pelagic Fisheries 2020). China regularly conducts stock assessments for jumbo squid, though a unifying stock assessment has yet to be accepted by SPRFMO (Li et al. 2022).

The SPRFMO has implemented measures to standardize reporting and documentation of catch data, fishing effort/activity, and biological data for all parties taking squid in the convention area (SPRFMO 2020).

Southeast Pacific | Peru | Jig

Ineffective

Peru's commercial fishery for jumbo squid started in 1991. Foreign vessels were allowed to fish in Peruvian waters until 2011. After the foreign vessels were excluded, the artisanal fleet became the dominant driver of catch (IMARPE 2021). Peru has established some management measures to control the harvest of jumbo squid within its territorial waters. The management agency conducts annual stock assessments, and catch limits are set using a precautionary approach (Cordue et al. 2018)(IMARPE 2022). Peru regularly monitors landings of jumbo squid and has the authority to close the fishery if the quota is exceeded or is expected to be exceeded. Furthermore, they have the authority to prosecute violations of fishing regulations (PRODUCE 2021).

On paper, these management measures are expected to be effective at controlling exploitation of the stock. But these measures have not been implemented effectively, and the artisanal jumbo squid fishery is better characterized as an informal fishery: one that does not fully adhere to the regulations of the state (CEPLAN 2016)(Lozano et al. 2023). Peruvian fisheries management is embroiled with issues of corruption, bribery, and irregular administrative procedures that are difficult to adhere to (Schorr 2022). Several scandals in other Peruvian fisheries highlight that bribery and corruption are large issues within the management body (La República 2021a)(La República 2021b)(Carrere 2020)(Guirkinger et al. 2021) (Schorr 2022). These issues are compounded by high turnover and volatility within the management agency (Gozzer-Wuest et al. 2021).

Fishers have expressed concerns about bribery, corruption, and irregular enforcement of regulations in the jumbo squid fishery (Gozzer-Wuest et al. 2021). In addition, NGOs have highlighted issues of corruption in this fishery (Koch and Serkovic 2019). While some of these issues are the result of poor enforcement (see factor 3.4), problems that arise from informality of a trade sector are ultimately

policy failings (Gozzer-Wuest et al. 2022)(CEPLAN 2016)(La Mula 2016)(Guirkinger et al. 2021).

A 2012 census of the fleet found that 60% of fishers lacked a fishing permit and 84% of vessels did not have proper registration (PRODUCE 2020b). Action is being taken to address informality in this fishery. Starting in 2016, a pathway toward formalization was opened by allowing fishers to obtain the necessary permits and registration through fishing cooperatives. In 2018, the Sistema de Información de Pesca Artesanal (SIFORPA II) program provided a new pathway for independent fishers, not affiliated with cooperatives, to obtain permits and registration. As of May 2024, 91% of independent fishers and 67% of fishers in cooperatives have received both registration for their vessel and permits to fish (PRODUCE 2024a).

The formalization process is slowing down the implementation of effective effort controls in the fishery. The fishery is considered fully exploited (PRODUCE 2024b). The management agency cannot reduce fishing effort because it does not know the full extent of effort in the fishery, and that information will only be available once all the vessels are properly registered and permitted.

Peru has established regulations to manage the fishery based on information from the stock assessment process. Concerns have been raised regarding corruption, bribery, and informality of the fishery. These concerns suggest that the management agency does not have the necessary tools to effectively implement the management measures and that there is noncompliance at many levels. Therefore, management strategy and implementation scores “ineffective.”

3.2 Bycatch Strategy

Southeast Pacific | Chile | Jig
Southeast Pacific | Peru | Jig

Highly effective

Jig gear is highly selective and there are no bycatch concerns in this fishery (Arkhipkin et al. 2015). Therefore, bycatch strategy is “highly effective.”

Southeast Pacific | High Seas | Jig | China

Moderately Effective

There are currently no bycatch management measures in place for the Chinese

industrial jig fishery. Jig gears are generally considered a highly selective gear type (Arkhipkin et al. 2015). The lack of catch composition data to validate this assumption means that it was necessary to utilize the UBM, which identified a risk to finfish and sharks in this fishery (see the Criterion 2 Summary). Because there is a potential risk to species of concern, some bycatch management may be necessary. But the risk is likely minimal due to the selective nature of the gear. Thus, bycatch strategy is “moderately effective.”

3.3 Scientific Data Collection and Analysis

Southeast Pacific | Chile | Jig

Moderately Effective

Chile conducts annual stock assessments using a state-space in continuous time (SPiCT) model (IFOP 2022)(SUBPESCA 2022b). The model is adjusted based on estimated indices of abundance under two stock scenarios (SUBPESCA 2022b). The first is a national stock that exists within the EEZ of Chile. The second scenario is a regional stock that moves in and out of Chile’s EEZ (IFOP 2022). Chile does not have biological reference points for either of their modeled stock scenarios because biological reference points are difficult to set for species, like jumbo squid, that have a highly variable biomass (SUBPESCA 2014f).

Chile has onboard observers and dockside observers that collect biological data (SUBPESCA 2021)(SUBPESCA 2022a)(IFOP 2022). In 2021, onboard observer coverage was 6.69% of the total trips, which fulfills the SPRFMO observer requirements (SUBPESCA 2022a)(SPRFMO 2020). In addition to biological data on jumbo squid, Chile began collecting discard data from the artisanal fleet in 2020 (SUBPESCA 2021).

The SPRFMO is in the process of reviewing the stock assessment methods used by Peru, Chile, and China. None of the methods have been accepted as the standard for assessing the stock or stocks. A major hurdle for the stock assessment process is that the countries are not effectively sharing data (Cordue et al. 2018). Though they are required to share landings data with the SPRFMO, the countries are not sharing landings or biological data with each other (SPRFMO 2020). The result is that each country’s stock assessment only focuses on the area where their fleets are fishing (i.e., within their respective EEZs for Chile and Peru; in international waters for China) (Cordue et al. 2018)(Li et al. 2022)(IFOP 2022). Because the stock(s) likely moves in and out of the EEZs, this makes it more difficult to assess the stock structure for the species (Cordue et al. 2018).

Chile conducts annual stock assessments, has onboard and dockside observers, and collects biological data and discard data. But the lack of data sharing between countries involved in this fishery hampers efforts to delineate the stock and to conduct more robust stock assessments. Therefore, scientific data collection and analysis scores “moderately effective.”

Southeast Pacific | High Seas | Jig | China

Moderately Effective

China began conducting stock assessments in 2017 using a Bayesian state-space surplus production model (Xu et al. 2017). It has continued to conduct routine stock assessments using similar methods, with the latest one published in 2022 (Li & Xu 2021)(Li et al. 2022). Catch data for the stock assessments come from the Food and Agriculture Organization’s Fisheries and Aquaculture global capture production database. Indices of abundance are calculated with data from the SPRFMO (Li et al. 2022).

The SPRFMO is in the process of reviewing the stock assessment methods used by Peru, Chile, and China. None of the methods have been accepted as the standard for assessing the stock or stocks. A major hurdle for the stock assessment process is that the countries are not effectively sharing data (Cordue et al. 2018). Though they are required to share landings data with the SPRFMO, the countries are not sharing landings or biological data with each other (SPRFMO 2020). The result is that each country’s stock assessment only focuses on the area where their fleets are fishing (i.e., within their respective EEZs for Chile and Peru; in international waters for China) (Cordue et al. 2018)(Li et al. 2022)(IFOP 2022). Because the stock(s) likely moves in and out of the EEZs, this makes it more difficult to assess the stock structure for the species (Cordue et al. 2018).

The SPRFMO requires observer coverage on the vessels fishing for jumbo squid in the high-seas convention area (SPRFMO 2020). Minimum observer coverage is five full-time observers or coverage for 5% of fishing days (SPRFMO 2020). With only two full-time at-sea observers deployed on the jumbo squid distant water fleet for 2020–21, China did not meet the requirements for observer coverage in that period (SPRFMO 2022a). China noted difficulties meeting the requirement due to travel restrictions and port lockdowns related to the COVID-19 pandemic. The Chinese fleet did meet the observer requirements for 2022–23 (SPRFMO 2024d).

China conducts annual stock assessments, has onboard observers, and collects

biological data. But the lack of data sharing between countries involved in this fishery hampers efforts to delineate the stock and to conduct more robust stock assessments. Therefore, scientific data collection and analysis scores “moderately effective.”

Southeast Pacific | Peru | Jig

Moderately Effective

Peru conducts annual stock assessments using a method that accounts for stock structure uncertainty and quick fluctuations in abundance (Cordue et al. 2018). Squid biomass is assessed within a given area associated with fishing over timeframes that would make the biomass relatively stable. By combining assessments for multiple areas over multiple time periods, the assessment covers the biomass being targeted in Peru’s EEZ. This method is able to set reference points for the targeted biomass even though the biomass most likely comprises several stocks (Cordue et al. 2018).

Observer coverage in this fishery is low. The SPRFMO requires each member state to have a minimum of five full-time at-sea observers or observer coverage for 5% of fishing day (SPRFMO 2020). Mean annual observer coverage for the artisanal fleet in 2015–19 was 0.59% of sea days (Mariátegui et al. 2021). At-sea observer coverage is far below the requirement because exceptions to the requirement can be made for vessels < 15 m (SPRFMO 2021a). The artisanal fleet, which has been responsible for all jumbo squid landings since 2012, comprises > 4,000 vessels and many of them are < 15 m (Mariátegui et al. 2021)(IMARPE 2021). Peru has proposed a method for expanding observer coverage on artisanal vessels (Mariátegui et al. 2021).

The SPRFMO is in the process of reviewing the stock assessment methods used by Peru, Chile, and China. None of the methods have been accepted as the standard for assessing the stock or stocks. A major hurdle for the stock assessment process is that the countries are not effectively sharing data (Cordue et al. 2018)(Roa-Ureta and Wiff 2022). Though they are required to share landings data with the SPRFMO, the countries are not sharing landings or biological data with each other (SPRFMO 2020). The result is that each country’s stock assessment only focuses on the area where their fleets are fishing (i.e., within their respective EEZs for Chile and Peru; in international waters for China) (Cordue et al. 2018)(Li et al. 2022)(IFOP 2022). Because the stock(s) likely moves in and out of the EEZs, this makes it more difficult to assess the stock structure for the species (Cordue et al. 2018).

Peru conducts regular stock assessments using the best methods, given the data available to the assessors. But the lack of data sharing between countries involved in this fishery hampers efforts to delineate the stock and to conduct more robust stock assessments. Observer coverage in the Peruvian artisanal fleet is low, though there are efforts to increase coverage. Peru scores “moderately effective” for scientific data collection and analysis.

3.4 Enforcement of and Compliance with Management Regulations

Southeast Pacific | Chile | Jig

Highly effective

Licensing and vessel monitoring systems (VMS) are required on all vessels, including those that participate in transshipments (SPRFMO 2020). In 2019, Chile stopped granting new licenses. This measure was taken to curb fishing effort because the stock was determined to be fully exploited (SUBPESCA 2022a). Also, jumbo squid can only be caught with handlines and jigs (SUBPESCA 2021). Between gear restrictions and license restrictions, the industrial fleet is functionally prohibited from fishing in Chile’s EEZ.

Satellite tracking of the foreign industrial fleet through AIS and satellite imaging that can detect vessels with AIS turned off shows that no foreign vessels crossed Chile’s EEZ to fish for jumbo squid in 2021 (GFW 2022). Furthermore, the high-seas jumbo squid fleet stopped the practice of fishing right next to the EEZ boundaries. In 2021, the high-seas fleet stayed an average of 100 nm away from any EEZ boundary (GFW 2022). Within Chile’s EEZ, Chile publishes the vessel tracking information from the artisanal fleet to allow for independent verification (GFW 2022).

Onboard and dockside observer programs are in place for the fishery (SUBPESCA 2021)(SUBPESCA 2022a)(IFOP 2022). These measures help to verify reported catch and bycatch.

Chile has licensing in place, requires vessel monitoring for all participants, has mitigated risks of IUU from the foreign industrial fleet, and has a observer program in place. Therefore, enforcement scores “highly effective.”

Southeast Pacific | High Seas | Jig | China

Ineffective

China's enforcement of its distant-water fleet is based on the Distant Water Fleet Supervisory Regulation, introduced in 2003 and revised in 2020 (Regulations on the Administration of Pelagic Fisheries 2020). The 2003 regulations laid down substantial groundwork for enforcement and penalties in case of violations (Xue 2006). The regulations outline vessel license qualifications, specifically concentrating on previous track records. Similar to regulations adopted by the SPRFMO in 2016, vessels are required to report their catches, species, landings, and value (Argüelles et al. 2016). In addition, vessels are expected to complete logbooks, carry VMS, and participate in observer programs. The 2020 revision of the Distant Water Fleet Supervisory Regulation aimed to improve enforcement by adding more tools to discourage IUU fishing, such as blacklisting noncompliant vessels and skippers (Shen & Huang 2021)(Regulations on the Administration of Pelagic Fisheries 2020). But there is criticism that these regulations were not being effectively enforced (Macfadyen & Hosch 2021).

Chinese vessels account for > 95% of vessels participating in the high-seas jumbo squid fishery (GFW 2021)(GFW 2022). A large number of these vessels are not registered with the SPRFMO. In 2020, 522 vessels were reported to the SPRFMO as active vessels, but AIS analysis identified an additional 82 vessels actively fishing in the high seas convention area (GFW 2021). Furthermore, only 12 carrier vessels used for transshipments were reported to the SPRFMO, yet 29 additional carrier vessels were identified as operating in the convention area (GFW 2021). A number of vessels on the SPRFMO's 2020 list of active vessels have historic links to IUU cases. In 2020, there were 10 active vessels with links to IUU cases, and in 2021 there were 6 active vessels with links to IUU cases. These vessels sailed under the Chinese flag and, despite their dubious history, the SPRFMO authorized them to fish in the convention area (GFW 2021)(GFW 2022).

Foreign vessels have been banned from fishing for squid in Peru's EEZ since 2012 (IMARPE 2021). In 2020, Peru made it more difficult for foreign vessels to access Peruvian ports, in an effort to combat IUU fishing (PRODUCE 2020). Chinese vessels have started to utilize "forced arrivals" to circumvent these new stipulations. A forced arrival allows a vessel to dock in a port that it might otherwise not be allowed to access. The vessel is allowed to make a forced arrival if it is experiencing an emergency, such as an injured crew member or serious mechanical failure. There are two Peruvian ports that are particularly important for the jumbo squid fishery. In 2020, there were only two documented instances of forced arrivals to these ports. The following year, it rose to 7 instances, and in 2022, there were 14 forced arrivals (Oceana 2023). This increase in forced arrivals suggests an attempt to circumvent the new regulations, and there is a distinct risk that the vessels are

using the journey from the high seas into port as an opportunity to illegally fish within Peru's EEZ (Oceana 2023).

Although China and the SPRFMO have regulations in place to combat IUU fishing, the regulations are not being effectively enforced. There are indicators that IUU fishing from China's distant-water fleet is a significant concern. Therefore, enforcement scores "ineffective."

Southeast Pacific | Peru | Jig

Ineffective

The jumbo squid fishery has been characterized as an informal fishery, and efforts at formalization have not been fully effective. There is systematic noncompliance with the established regulations. There are systems in place to enforce regulations, such as requiring VMS and officers patroling the waters where the fishery occurs (Koch and Serkovic 2019). But the amount of resources devoted to monitoring and control in the fishery is a key area for improvement (Gozzer-Wuest et al. 2021). When fishers are cited for infractions, it does not necessarily lead to improvement of compliance. For one, a sizable portion of the fishers do not fully understand the regulations and legal provisions of a citation (Gozzer-Wuest et al. 2021). It is hard to expect behavior to change when individuals do not know what they did wrong. Inn addition, enforcement is carried out in an inconsistent and discretionary manner due to corruption and bribery (Gozzer-Wuest et al. 2021)(Freitas 2021). As a result, there is a perception among fishers that the enforcement entities are illegitimate (Guirkinger et al. 2021).

Beyond noncompliance by fishers, there are larger systemic issues. There are boatbuilders that are making new vessels without the proper paperwork or licensing (De la Puente et al. 2020). These boats are sometimes sold to fishers without the fishers knowing that these are off-the-books vessels (La Mula 2016). This is occurring on such a large scale that the fishery has become de facto open access (Gozzer-Wuest et al. 2022)(Lozano et al. 2023). Also, some processing plants are operating illegally (Lozano et al. 2023). Though noncompliance in the broader supporting industries is outside the scope of scoring for this factor, it highlights that noncompliance is occurring at many levels throughout the fishery.

Peru has also had problems ensuring that foreign vessels do not fish for jumbo squid within its territorial waters. Foreign vessels have been banned from fishing for squid in Peru's EEZ since 2012 (IMARPE 2021). In 2020, Peru made it more difficult

for foreign vessels to access Peruvian ports, in an effort to combat IUU fishing (PRODUCE 2020). Chinese vessels have started to utilize “forced arrivals” to circumvent these new stipulations. A forced arrival allows a vessel to dock in a port that it might otherwise not be allowed to access. The vessel is allowed to make a forced arrival if it is experiencing an emergency, such as an injured crew member or serious mechanical failure. There are two Peruvian ports that are particularly important for the jumbo squid fishery. In 2020, there were only two documented instances of forced arrivals to these ports. The following year, it rose to 7 instances, and in 2022, there were 14 forced arrivals (Oceana 2023). This increase in forced arrivals suggests an attempt to circumvent the new regulations, and there is a distinct risk that the vessels are using the journey from the high seas into port as an opportunity to illegally fish within Peru’s EEZ (Oceana 2023). In addition, Chinese vessels have turned off or failed to broadcast VMS when journeying to port for crew changes and certificate renewals (Carrere 2023).

The monitoring and control schemes in place are believed to be inadequate to ensure compliance with the relevant regulations. Fishers may not fully understand the regulations in place, and enforcement actions may not lead to improved compliance. Also, foreign vessels have increasingly made use of forced arrivals to circumvent regulations aimed at reducing IUU fishing. On the whole, enforcement is inadequate and compliance is poor. Therefore, enforcement is “ineffective.”

3.5 Stakeholder Inclusion

Southeast Pacific | Chile | Jig

Highly effective

Artisanal fishers have formal recognition, are officially and nontransferably registered by Sernapesca, and have protected quotas and a 5-mile exclusive fishing zone near shore. The adoption of measures such as TURFs (Áreas de Manejo y Explotación de Recursos Bentónicos) in some fisheries has led to more stakeholder inclusion (Gelcich et al. 2010). Chile’s artisanal jumbo squid fishery utilizes a comanagement framework (Gozzer-Wuest et al. 2022). Fishers are well organized and represented throughout the decision-making process (ibid).

Chile is a part of SPRFMO. Artisanal fishers from Chile, Peru, Ecuador, and Mexico formed the Committee for the Sustainable Management of the Jumbo Flying Squid in the South Pacific (CALAMASUR). This industry group has been formally recognized by SPRFMO since 2019 and contributes to the SPRFMO decision-making process (Labraña-Cornejo et al. 2023).

Chile's involvement in SPRFMO and CALAMASUR provide avenues for stakeholder engagement on the international stage. Chile's comanagement systems include major user groups in the decision-making process, have committees and decision-making bodies for addressing user conflicts, encourage participation, make transparent decisions, and foster strong relationships between stakeholders. Therefore, stakeholder inclusion is "highly effective."

Southeast Pacific | High Seas | Jig | China

Ineffective

China is a commission member of SPRFMO. The country supplies data, contributes reports, and votes on relevant management measures (SPRFMO 2024b). Chinese scientists have provided stock assessments for the SPRFMO's consideration. The stakeholders' participation in this process is a bit murkier.

China's fisheries management has traditionally taken on a top-down, command-and-control approach (Cao et al. 2017)(Su et al. 2019)(Su et al. 2022). Decisions were made by the central government and there was little room for input from stakeholders (Cao et al. 2017). In fact, fishers' power was taken away when communes, a form of fisher organization that allowed for collective advocacy from individual fishers, were dissolved in the second fishery management policy phase (1979–99) (Su et al. 2019). Comanagement was introduced as a pilot program in 2017, and this moved the needle toward more stakeholder engagement (Su et al. 2022). Alongside this policy, fishers were encouraged to start organizing again through fisheries industry associations (FIAs) (ibid). FIAs have been dominated by companies, with little involvement from individual fishers, so it is not a full replacement for communes (ibid). But China's distant-water fleet is dominated by small- and medium-sized companies, so the drawbacks of FIAs do not necessarily affect this fishery as much (Gutiérrez et al. 2020).

There has been movement toward including scientific input in management decisions, but it is not a legal mandate in China to use the best available scientific information (Su et al. 2022). Scientists can provide input and data for consideration; however, the actual process of policymaking is opaque (ibid). So it is unclear how those pieces of information are weighed in the process, if at all. There are limited opportunities for scientists to participate in the opaque policymaking process. The main way is through appointments to the policymaking body (ibid). These appointments are competitive, and they can blur the line between science and politics (ibid).

China is involved in the major governing body that oversees the management of the high-seas jumbo squid fishing area. Within China's management process, there are some avenues for stakeholders to voice their opinions and concerns and to provide input. There is still room for growth in stakeholder engagement, because stakeholder groups are being reformed, comanagement is still in the pilot phase, and using the best available science is not legally mandated. Ultimately, it is unclear how stakeholder input affects the decision-making process, because the process is not transparent. Therefore, stakeholder inclusion is "ineffective."

Southeast Pacific | Peru | Jig

Moderately Effective

Peru is a part of SPRFMO. Artisanal fishers from Chile, Peru, Ecuador, and Mexico formed the Committee for the Sustainable Management of the Jumbo Flying Squid in the South Pacific (CALAMASUR). This industry group has been formally recognized by SPRFMO since 2019 and contributes to the SPRFMO decision-making process (Labraña-Cornejo et al. 2023).

Peru lacks a comanagement framework for the artisanal fishery within its EEZ (Gozzer-Wuest et al. 2022). Combined with the informality of the fishery, there is a power imbalance between management and fishers (ibid). This leads to a top-down management system. The problems with this power imbalance are exacerbated because fishers are not effectively organizing (Lozano et al. 2023). There is a perception among fishers that it is illegal for them to organize, even though that is not the case (ibid). There is a patchwork of organizations that some fishers belong to, but their goals and focus are fragmented (ibid). There is a need to increase ways that fishers can meaningfully participate in the management process (ibid).

Peru's involvement in SPRFMO and CALAMASUR provides avenues for stakeholder engagement on the international stage. Within the national artisanal fishery, there are opportunities for stakeholder engagement in the management process. But there is a power imbalance within Peru's artisanal fishery that means that fishers' concerns are not being effectively voiced or addressed. Therefore, stakeholder inclusion is "moderately effective."

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 (factor 4.1 + factor 4.2) and the Ecosystem Based Fishery Management score. The Criterion 4 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

Guiding principles

- Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.
- Follow the principles of ecosystem-based fisheries management.

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Fishery	Physical Impact of Fishing Gear on the Habitat/Substrate	Modifying Factor: Mitigation of Gear Impacts	Ecosystem-based Fisheries Management	Forage Species?	Score
Southeast Pacific | Chile | Jig	Score: 5	Score: 0	Moderate Concern	No	Green (3.873)
Southeast Pacific | High Seas | Jig | China	Score: 5	Score: 0	Moderate Concern	No	Green (3.873)
Southeast Pacific | Peru | Jig	Score: 5	Score: 0	Moderate Concern	No	Green (3.873)

Criterion 4 Assessment

Scoring Guidelines

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate

Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

- *5 - Fishing gear does not contact the bottom*
- *4 - Vertical line gear*
- *3 - 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. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 - Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.*
- *1 - Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 - 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.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

- *+1 —>50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very low/limited and for trawled fisheries, expansion of fishery's footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of 'moderate' mitigation measures.*
- *+0.5 —At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery's footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.*
- *0 —No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in factor 4.1*

Factor 4.3 - Ecosystem-Based Fisheries Management

Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

- *5 — Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.*
- *4 — Policies are in place to protect species' ecological roles and*

ecosystem functioning but have not proven to be effective and at least some spatial management is used.

- *3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 — Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 — Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

4.1 Physical Impact of Fishing Gear on the Habitat/Substrate

Southeast Pacific | Chile | Jig
Southeast Pacific | High Seas | Jig | China
Southeast Pacific | Peru | Jig

Score: 5

Jumbo squid is a pelagic organism, and jigs rarely contact the seafloor. Jigging is a low-impact gear type with no bottom contact (Arkhipkin et al. 2015).

4.2 Modifying Factor: Mitigation of Gear Impacts

Southeast Pacific | Chile | Jig
Southeast Pacific | High Seas | Jig | China
Southeast Pacific | Peru | Jig

Score: 0

No mitigation necessary.

4.3 Ecosystem-based Fisheries Management

Southeast Pacific | Chile | Jig
Southeast Pacific | High Seas | Jig | China
Southeast Pacific | Peru | Jig

Moderate Concern

Management of jumbo squid is still struggling to develop a unified, single-species approach. These struggles can be traced to challenges in delineating the stock and multiple, contradictory stock assessments (Ibáñez et al. 2022). Chile and Peru have implemented TACs, but the SPRFMO does not have a harvest target or quota in place for the convention area (IMARPE 2022)(SUBPESCA 2022c)(SPRFMO 2020). Regardless of these challenges, there is not evidence that the jumbo squid fishery is causing serious detrimental impacts to the food web. Therefore, ecosystem-based fisheries management scores a “moderate concern.”

Supplementary Information

Chile

Chile has been making steady progress toward ecosystem-based fisheries management (EBFM). The largest leap in implementation came with the 2013 Fisheries and Aquaculture Law. This overhauled the fisheries management system and included provisions for EBFM. Unfortunately, many of the provisions that focused on EBFM are outlined in general terms, and specific regulations for EBFM often focus on bycatch mitigation (Gelcich et al. 2018). Fisheries management still largely focuses on single-species management using individual quotas, and it does not account for the effect of more complex ecosystem interactions on population variability (Estévez and Gelcich 2021).

Peru

The Northern Humboldt Current ecosystem in Peru's EEZ was ranked ninth out of 22 ecosystems evaluated for status and governance effectiveness (Bundy et al. 2017). In a previous similar study, it ranked 20th out of 22 (Pitcher et al. 2009). The improvement was attributed to improvements in fisheries management implementation (Bundy et al. 2017). Despite these improvements, management of jumbo squid within Peru's EEZ is based around a single-species TAC (IMARPE 2022).

China

Management in the SPRFMO convention area is nascent. Because the SPRFMO chose not to adopt any of the stock assessments for management purposes, there are no harvest targets or TACs in place for the convention area (SPRFMO 2024a).

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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: 2024 Rating Review

Key changes

Peru's Management Strategy and Implementation decreased to "ineffective." The changes in Factors 3.1 and 3.4 stem from issues with systematic noncompliance and from corruption in the management agency.

Chile's Enforcement was upgraded to "highly effective" based on the scoring guidelines for version 4 of the Fisheries Standard.

China's bycatch species were expanded based on the UBM. This reduced the overall score for Criterion 2 from 5 to 2.236.

The previous report was assessed using version 3 of the Fisheries Standard and was reassessed using version 4 of the Fisheries Standard.

Criterion 1

Factors 1.1 and 1.2 were updated to reflect new stock assessments and there was no score change. All countries were grouped together under one answer. The countries were scored as one because the stock delineation is unresolved and the populations move in and out of EEZs.

Criterion 2

Finfish and sharks were added as Criterion 2 species for China based on scoring from the Unknown Bycatch Matrix.

Factor 2.3 was updated with new information on observer coverage and requirements. No score change.

Criterion 3

Factor 3.1

The answers and scores for each country were separated in this update based on the countries implementing separate management strategies.

Peru's score decreased to "ineffective." Systemic issues of bribery, corruption, and volatility within the management agency mean that the agency does not have the tools to successfully implement the management regulations that are in place.

No score change for Chile. Information updated on the stock assessment process, recommended BAC, and actual BAC.

Factor 3.2

No updates.

Factor 3.3
Peru information updated, no score change.

Chile information updated, no score change.

China information updated, no score change.

Factor 3.4
Peru's score decreased to "ineffective." Fishers do not fully understand the relevant regulations and they view the enforcement body as illegitimate. There is also systemic noncompliance within the industries that support the fishery, such as boatmaking and seafood processing.

Chile score upgraded to "highly effective." The information in the answer did not substantially change, but moving the report from v3 to v4 of the Fisheries Standard led to a score change.

China information updated, no score change.

Factor 3.5
Chile and Peru information updated, no score change.

No changes for China.

Criterion 4
No score changes or updates for Factors 4.1, 4.2, or 4.3.