Monterey Bay Aquarium Seafood Watch

Draft Assessment for Review

September 2023

Mackerel, Pacific chub (Ecuador)

Scomber japonicus, Auxis thazard, Etrumeus acuminatus, Decapterus macrosoma

Pacific, Southeast

Purse seines

Report ID 28291

Seafood Watch Standard used in this assessment: Fisheries Standard v4

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About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the environmental sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Seafood Watch's science-based ratings are available at www.SeafoodWatch.org. Each rating is supported by a Seafood Watch assessment, in which the fishery or aquaculture operation is evaluated using the Seafood Watch standard.

Seafood Watch standards are built on our guiding principles, which outline the necessary environmental sustainability elements for fisheries and aquaculture operations. The guiding principles differ across standards, reflecting the different impacts of fisheries and aquaculture.

- Seafood rated Best Choice comes from sources that operate in a manner that's consistent with our guiding principles. The seafood is caught or farmed in ways that cause little or no harm to other wildlife or the environment.

- Seafood rated Good Alternative comes from sources that align with most of our guiding principles. However, one issue needs substantial improvement, or there's significant uncertainty about the impacts on wildlife or the environment.

- Seafood rated Avoid comes from sources that don't align with our guiding principles. The seafood is caught or farmed in ways that have a high risk of causing harm to wildlife or the environment. There's a critical conservation concern or many issues need substantial improvement.

Each assessment follows an eight-step process, which prioritizes rigor, impartiality, transparency and accessibility. They are conducted by Seafood Watch scientists, in collaboration with scientific, government, industry and conservation experts and are open for public comment prior to publication. Conditions in wild capture fisheries and aquaculture operations can change over time; as such assessments and ratings are updated regularly to reflect current practice.

More information on Seafood Watch guiding principles, standards, assessments and ratings are available at www.SeafoodWatch.org.

Guiding Principles

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

The following guiding principles illustrate the qualities that fisheries must possess to be considered sustainable by the Seafood Watch program (these are explained further in the Seafood Watch Standard for Fisheries):

- Follow the principles of ecosystem-based fisheries management.
- Ensure all affected stocks are healthy and abundant.
- Fish all affected stocks at sustainable levels.
- Minimize bycatch.
- Have no more than a negligible impact on any threatened, endangered, or protected species.
- Managed to sustain the long-term productivity of all affected species.
- Avoid negative impacts on the structure, function, or associated biota of aquatic 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.

These guiding principles are operationalized in the four criteria in this standard.Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and rating

Once a rating has been assigned to each criterion, Seafood Watch develops an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guides and online guide:

Best Choice/Green: Buy first; they're well managed and caught or farmed responsibly.

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

Avoid/Red: Take a pass on these for now; they're caught or farmed in ways that harm other marine life or the environment.

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

Summary

The following Seafood Watch report provides recommendations for four of the main species within the Ecuadorian Small Pelagic Fishery. It covers the Ecuadorian purse seiners operating in the Northwest area of the country, targeting mainly: Pacific chub mackerel (*Scomber japonicus*), Frigate tuna (*Auxis spp*), Shortfin scad (*Decapterus macrosoma*) and round herring (*Etremous acuminatus*).

In Ecuador, pelagic stocks are assessed by the National Institute of Fisheries; and management is conducted by the Subsecretary of Fishery Resources (Subsecretaria de Recursos Pesqueros). The Organic Law for the Development of Fisheries and Aquaculture of Ecuador, updated and published in 2020, regulates fishing activities in the country. The precautionary approach is assumed, and new monitoring, control, and surveillance (MCS) measures are implemented (PRE 2020).

Criterion 1: Impacts on the Species Under Assessment The most recent stock assessment for all the species in the country (conducted in 2023) indicated that biomass is above the target reference points for Eastern round herring, pacific chub mackerel, and shortfin scad, but frigate tuna species were showing signs of overfishing. Finally, managers reported that fishing mortality levels were too high for Frigate tuna and Pacific chub mackerel, which was not the case for Easter round herring and shortfin scad.

Criterion 2: The Small Pelagics Fishery in Ecuador targets several pelagic species included in the management plan. However, other species can also be found present as bycatch. Some of these include the Mexican moonfish (*Selene oerstedii*), Pacific bumper (*Chloroscombrus orqueta*), Pacific harvestfish (*Peprilus medius*), Pacific cornetfish (*Fistularia corneta*), Largehead hairtail (*Trichiurus lepturus*) and searobins (*Prionotus spp*). The catch composition, including the bycatch species, is routinely monitored, and the list and amount of each species are published by managers {INP 2020}. {Ponce et al 2022} analyzed the catch composition of the fishery sets between 2020 and 2022 using fishing activity records of the purse-seine fleet. The authors found that ~87% of the fishing sets were mono-specific (composed of only one species), or over 90% of the catch in volume. The observer's report from most recent years also notes that very few mammals, turtles, or seabirds are harmed during interactions with the fishery. In summary, Pacific chub mackerel and Auxis spp. hauls are considered to have no other 'main species' caught in them, while Pacific chub mackerel is the only Criterion 2 species for Eastern round herring and shortfin scad. No bait is used in purse seine fisheries.

Criterion 3: Management Effectiveness 3.1 - Management Strategy And Implementation. Several technical measures have been implemented and are part of Ecuador's Fishery Management Plan for the Small Pelagic Fishery. The document contains specific biological, ecological, and socioeconomic objectives. The FMP aims to achieve the MSY by 2025 and includes all the regulations directed to the industrial fishery that has a bycatch ceiling of 20% in biomass, a mandatory observers program (that covers at least 30% of the fleet), annual closures, spatial and temporal closures, and mandatory use of VMS. This strategy's effectiveness is uncertain, considering it has not been in place long enough to evaluate its effectiveness (presented within the action plan released in 2021){SRP 2021}. For this reason, this factor is scored as moderately effective. 3.2 - Bycatch Strategy Catch composition in the fisheries is well documented. Data and analyses from the observer programs suggest that there are no major bycatch issues (see Criterion 2). Their evidence shows that discards or impacts on species of concern are minimal. In addition, the Action Plan lays out several actions to reduce the catch of bycatch species by 2025. The Action Plan does not specify any measures for mitigating ghost gear impacts. However, this is likely because of the relatively low risk of ghost gear

impacts in purse seine fisheries for small pelagic; this factor receives a highly effective score for these reasons. 3.3 – Managers routinely conduct stock assessments that are considered relatively robust. Data collection and onboard observer programs are in and generate information that allows understanding of impacts on non-target species {Jurado et al 2019}. Due to these reasons, this factor receives a highly effective score. 3.4 – In Ecuador, enforcement and surveillance are under the jurisdiction of the Sub-secretariat of Fisheries Resources through the Directorate of Fisheries Control. Fisheries Inspectors are distributed along the landing site, continuously monitoring 365 days a year {DCP 2023}. Compliance with regulations is enforced through inspections at harbors and observers on board commercial vessels {DCP2023}. Some recently available reports regarding illegal fishing activities raise questions about the effectiveness of the protocols in place. Overall, enforcement and surveillance actions are in place, and although the efficacy of these may be uncertain (based on available information) for these reasons, this factor is a moderate concern. 3.5 - Stakeholder Inclusion and the decision-making process have become more robust in Ecuador. "Platforms of Dialogue or Dialogue Tables" increased the synergy and the participation of national and international stakeholders. The National Action Plan of the small pelagic fishery included the different stakeholders' perspectives on the future development of this fishing activity {SRP et al 2021}. The decision-making processes were carried out by equal approval or more than two-thirds of the representatives. For these reasons, this factor is scored as highly effective.

Criterion 4: Studies of the potential level of interactions of the nets with the bottom have been developed in recent years {Jurado et al 2019}{Ponce et al 2020}{Ponce et al 2021}. The study reported no interactions with fragile bottoms such as coral reefs. It showed that the fleet's activities were developed mainly on mixed bottoms of sand and silt on the Ecuadorian coast. Considering that purse seines generally do not encounter the seafloor (Chuenpagdee et al. 2003), no particular concerns with the impact of these fisheries on seafloor habitats are considered. In addition, the FMP includes measures to limit impacts with the bottom, like the prohibition of using the "double foot rope." A report evaluating the fishery's effects on the ecosystem was released in 2022. The food web model quantified the main trophic interactions, and results indicated the predators of the system would not depend significantly on the target species of the purse seine fishery. Finally, the FMP has a series of actions that aim to achieve an ecosystem approach and ecosystem-based fisheries' management {SRP et al 2021}. Spatial and temporal closures and technical restrictions like mesh size limits are in place. Since the small pelagic targeted by this fishery are key elements of the Eastern Pacific pelagic ecosystem, those fishery management tools may benefit the ecosystem as a whole.

Managers use an appropriate conservative, ecological harvest control rule consistent with the Lenfest Forage Fish Task Force recommendations {Pikitch et al 2012}. The HRC is defined before the opening of the fishing season using CPUE data as an abundance index, used to adjust fishing efforts for the upcoming season. The number of fishing days authorized {SRP et al 2021} defines the fishing effort.

The overall ratings are yellow (good alternative) for all the species within the fishery.

Final Seafood Recommendations

SPECIES | FISHERY	C 1 TARGET SPECIES	C 2 OTHER SPECIES	C 3 MANAGEMENT	C 4 HABITAT	OVERALL	VOLUME (MT) YEAR
Eastern Round Herring | Ecuador Stock | Southeast Pacific | Purse seines	3.413	1.526	3.000	3.000	**Good Alternative (2.617)**	4,906 (MT) 2022
Frigate tuna | Ecuador Stock | Southeast Pacific | Purse seines	1.000	5.000	3.000	3.000	**Good Alternative (2.590)**	40,133 (MT) 2022
Pacific chub mackerel | Ecuador Stock | Southeast Pacific | Purse seines	1.526	5.000	3.000	3.000	**Good Alternative (2.879)**	158,121 (MT) 2022
Shortfin scad | Ecuador Stock | Southeast Pacific | Purse seines	3.413	1.526	3.000	3.000	**Good Alternative (2.617)**	12,348 (MT) 2022

See Introduction ('Production Statistics') for references and further detail.

Scoring Guide

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

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

Best Choice/Green = Final Score >3.2, and no Red Criteria, and no Critical scores

Good Alternative/Yellow = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern2, and no more than one Red Criterion, and no Critical scores

Avoid/Red = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

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

Introduction

Scope of the analysis and ensuing recommendation

This assessment is of the main species caught by purse seine as part of the Small Pelagics Fishery in Ecuador: Pacific chub mackerel (*Scomber japonicus*), frigate/bullet tuna (*Auxis spp.*), Eastern round herring (*Etrumeus acuminatus*), and shortfin scad (*Decapterus macrosoma*). These species are used both for direct human consumption and fishmeal.

Species Overview

The Pacific chub mackerel (*Scomber japonicus*) is a species with worldwide distribution. Limited information about the species' stock structure around Ecuador's coast is available. Some authors state that in the SE Pacific, differences in growth patterns would suggest that the stocks in the Ecuadorian and Peruvian coastal regions would be distinct and separated by the Equatorial front {Patterson et al. 1993}. Other authors suggest the existence of one stock in the south of Ecuador and north of Peru (which is more intensively exploited by the Ecuadorian fleet) and another stock in the south of Peru and north of Chile {Cucalón-Zenck et al. 2000}.

Frigate/bullet tuna species (*Auxis spp.*) are distributed in the Atlantic, Mediterranean, Indian, and Pacific oceans)(Collette and Aadland 1996). The species' adults presents epipelagic behavior in the neritic and oceanic waters (Collette 1995). Due to their high levels of abundance, the species are considered an important element of the food web, particularly as forage for other species of commercial interest (Frimodt 1995), as is the case in the small pelagic fishery in Ecuador where it is considered one of the main target species (SRP et al 2021)

Round herring (*Etrumeus acuminatus)*,also known as Pacific Round Herring is a member of the Herring or Clupeidiea Family of herrings (Bowling 2012) . The Round Herring is a pelagic schooling species found over all types of terrain at depths up to 200 m (655 feet)(Bowling 2012).. The Round Herring is poorly studied, with limited information about their age, growth, longevity, movement patterns, diet, habitat use, and reproduction (Bowling 2012). For this reason, managers have estimated the growth parameters using modal component anaylsis (Canales and Jurado 2023)

Shortfin scad (*Decapterus macrosoma*), a species with adistribution from the Central Pacific Islands to the Gulf of California and Peru. The species can be found predominately with pelagic schooling species (Smith-Vaniz 1995) and occasionally in small groups along reef slopes (Kuiter and Tonozuka 2001).

Production Statistics

The small pelagic fisheries date back to the late 1970s. During the early stages of the fishery, the most important species were the mackerel (*Scomber japonicus*), herring (*Opisthonema spp*), eastern round herring (*Etrumeus acuminatus*) and Pacific anchoveta (*Cetengraulis mysticetus*). By 1998, the *Auxis spp* species (botella) acquired relatively greater importance, while from 2004 it was evidenced a redirection of fishing efforts to other species such as shortfin scad (*Decapterus macrosoma*). The fishery has three main periods, the first between 1980 and 1990, when total catches exceeded 600,000 metric tons (mt); the second between 1991 and 2010, with average catches of no more than 160,000 mt; and the most recent period, 2011-2017 of apparent recovery with an average of 230,000 mt (see figure below) (Canales and

Jurado 2022)

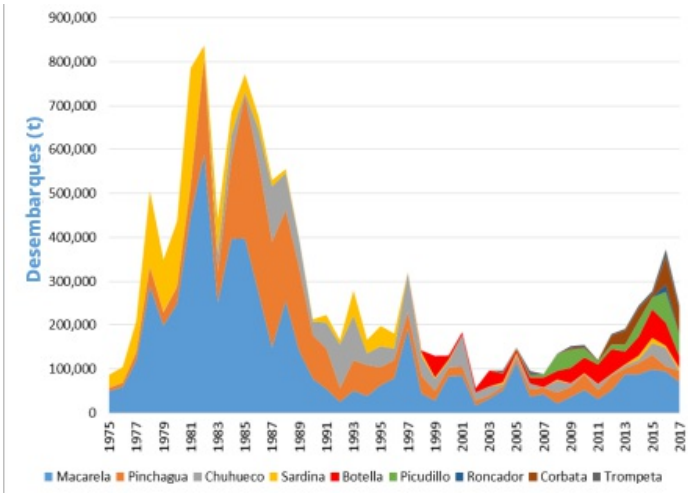

Figure 1: Landings of small pelagic fishery in Ecuador {Jurado et al 2019}

Small Pelagic fishery landings in most recent years have been increasing from ~140,000 mt to 247,000 mt in 2022 (see table below) (IPIAP 2023)(IPIAP 2023)

Species	2018	2019	2020	2021	2022
Pacific chub mackerel	**31,932.54**	**30,932.67**	**65,461.70**	**164,706.63**	**158,121.40**
Auxis spp	64,096.63	63,896.56	56,693.30	30,972.26	40,133.10
Shortfin scad	13,375.25	9,041.50	8,612.59	15,587.28	12,348.40
Herrings	17,382.67	23,370.83	10,444.62	7,127.05	22,064.42
Pacific anchoveta	9,170.05	12,196.72	3,195.60	6,184.04	9,249.85
Eastern round herring	3,737.89	5,968.09	508.54	2,678.95	4,906.11
Other (five species)	245.56	327.48	252.91	180.04	272.36
Total	**139,940.89**	**145,753.86**	**145,169.58**	**227,436.25**	**247,095.63**

Importance to the US/North American market.

Some 18,000mt of mackerel and 11,300mt of herring was imported into the United States in 2022. The imports from Ecuador were around 1,200 mt of mackerel and no recorded imports of herring that year.

U.S. imports of mackerel and herring, 2010-2022 (NOAA FOSS 2023). All product names with 'Mackerel' have been combined into 'Mackerel'; all product names with 'Herring' have been combined in to 'Herring.' Product names with multiple species including herring or mackerel are left as is.

Imported species or product	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022

Mackerel	20177	22679	20040	17516	18755	21908	24854	25166	25373	25847	28689	28236	18031
Herring	23760	18623	16943	17804	15748	16859	17886	15696	14445	14072	15592	18521	11314
HERRING,PILCHARD MEAL UNFIT FOR HUMAN CONSUMPTION	3120	2823	2641	1889	3083	3668	2433	3840	1815	1547	2748	12758	8716
HERRING, ANCHOVY, SARDINE, SPRAT, MACKEREL, INDIAN MACKEREL, SEERFISH, JACK AND HORSE MACKEREL, JACKS, CREVALLES, COBIA, SILVER POMFRETS, PACIFIC SAURY, SCAD, CAPELIN, SWORDFISH, KAWAKAWA, BONITO, MARLIN, SAILFISH, SPEARFISH DRIED								260	150	232	225	316	275
Grand Total	47057	44124	39624	37210	37586	42436	45173	44962	41783	41699	47254	59832	38336

U.S. imports of 'Mackerel' and 'Herring' by country, 2010-2022, top 15 countries only (NOAA FOSS 2023).

Species/Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Mackerel													
CHINA	2500	5827	5722	6131	6693	6909	8853	8248	9269	5775	4988	3787	3419
NORWAY	4261	2950	2618	3224	3460	4749	3846	5539	5587	6190	6877	8070	4240
THAILAND	4099	4092	4193	2129	2417	3023	2556	2690	2247	4223	4964	4955	3474
VIETNAM	323	530	1279	1256	1389	2074	1805	2174	1838	2337	2792	2178	1212
SOUTH KOREA	885	1076	935	1134	815	1394	1244	786	954	1159	1471	1327	819
CANADA	2114	1673	806	728	694	578	547	542	571	615	509	514	252
TAIWAN	774	641	583	690	571	435	519	571	838	1044	296	227	126
JAPAN	608	1088	982	615	722	283	512	386	345	343	360	563	209
CHILE	982		114	53	132	224	335	496	428	589	1353	1595	693
MEXICO	123	575	446	86	173	79	1093	507	658	352	931	224	253
ECUADOR	72	189	204	93	33	311	400	129	100	343	847	1192	1202
PHILIPPINES	1038	1626	873	172	62	84	106	71	41	62	137	107	68
ICELAND	43	67	145	34	156	505	664	505	662	499	465	335	217
INDIA	1377	1020	265	171	190	59	161	114	69	252	29	53	22
MOROCCO	19	80	33	53	20	58	103	115	170	375	678	744	550
Herring													
CANADA	14262	12055	10995	10949	10445	11188	13160	10976	9196	9232	9375	10999	5985
GERMANY	1202	1362	2072	2866	986	1358	1213	1028	1287	1228	1684	1306	749

NORWAY	3543	2026	669	668	546	648	552	567	464	728	672	695	663
POLAND	524	547	407	732	741	869	491	683	536	470	563	531	236
BELARUS	202	274	318	349	493	424	426	422	427	440	510	492	261
CHINA	1103	373	709	383	381	332	220	158	422	98	127	66	27
PHILIPPINES	347	495	332	178	121	177	224	100	104	137	246	404	223
ECUADOR	6	158	81	166	930	672	318	42	84	42			
ICELAND	19	49	61	123	181	209	172	253	287	188	224	144	564
LITHUANIA	60	76	65	121	175	189	209	316	275	256	319	221	177
RUSSIAN FEDERATION	64	89	105	81	35	50	40	54	89	116	383	813	461
NETHERLANDS	470	254	118	105	121	112	138	216	101	171	161	178	193
LATVIA	51	92	76	116	98	91	93	85	160	156	517	499	159
ESTONIA							47	245	115	351	167	509	338
MEXICO	43	94	174	20	16	7	10		36			611	668

Common and market names.

Pacific chub mackerel is also referred to as mackerel or chub (FDA 2023)

Primary product forms

Pacific chub mackerel is sold fresh, frozen, and preserved {NOAA Foreign Trade data 2023}. In Ecuador, it is mostly used to produce fishmeal (Canales and Jurado 2023)

Assessment

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

EASTERN ROUND HERRING			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Ecuador Stock | Southeast Pacific | Purse seines	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

FRIGATE TUNA			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Ecuador Stock | Southeast Pacific | Purse seines	1.000: High Concern	1.000: High Concern	Red (1.000)

PACIFIC CHUB MACKEREL			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Ecuador Stock | Southeast Pacific | Purse seines	2.330: Moderate Concern	1.000: High Concern	Red (1.526)

SHORTFIN SCAD			
REGION / METHOD	ABUNDANCE	FISHING MORTALITY	SCORE
Ecuador Stock | Southeast Pacific | Purse seines	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

Determination of key forage species

Of the species and species groups included in this Seafood Watch assessment, Pacific chub mackerel meets the criteria for a key forage species in the Ecuador marine ecosystem (see Appendix 1 for more information). Scoring of abundance and fishing mortality of key forage species is more conservative than for species that do not meet the criteria. Seafood Watch considers forage stock biomass and fishing mortality highly uncertain for these stocks, with the best possible score of 2.33 (Moderate Concern) for C1.1 Abundance and 3 (Moderate Concern) for C1.2 Fishing Mortality. Specific measures that account for the highly fluctuating nature of the species can moderate this uncertainty and allow for better scores (see Appendix 1 for more information).

Criterion 1 Assessments

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.*

Eastern Round Herring

Factor 1.1 - Abundance

Ecuador Stock | Southeast Pacific | Purse seines

Moderate Concern

The Eastern round herring (locally named "sardina redonda") is a species with a distribution along the Eastern Pacific, from Monterey Bay to Chile {Fishbase 2023}. The species stock structure is not well-defined. The species is assessed as a single stock in Ecuador. The species is also considered a target species of the Small pelagic fishery in Ecuador. Assessments have been conducted on an annual basis for several years (Canales et al 2020) (Canales and Jurado 2021) (Canales and Jurado 2022) (Canales and Jurado 2023) According to (Canales and Jurado 2023) the resource has not had major episodes of overexploitation, the level of population reduction by 2022 was estimated at 76% of virgin biomass (B0) and above the target reference point for the species (which is 40% of Bo) (Canales and Jurado 2023). Considering that the species is above the limit reference point but below 75% of the target reference point 76% of Bo), this factor is scored as a moderate concern.

Justification:

The species population has had variations mainly related to recruitment, followed by a downward trend probably related to a change in productivity regime (Canales and Jurado 2023). Regarding biomass variation, it decreased steadily until 2017, reaching its lowest value close to 8.7 thousand tons and below the value considered as a reference (40% B0). The Kobe diagram and the confidence intervals indicate that the population would be at no risk of overfishing and a slight risk of overexploitation (Canales and Jurado 2023).

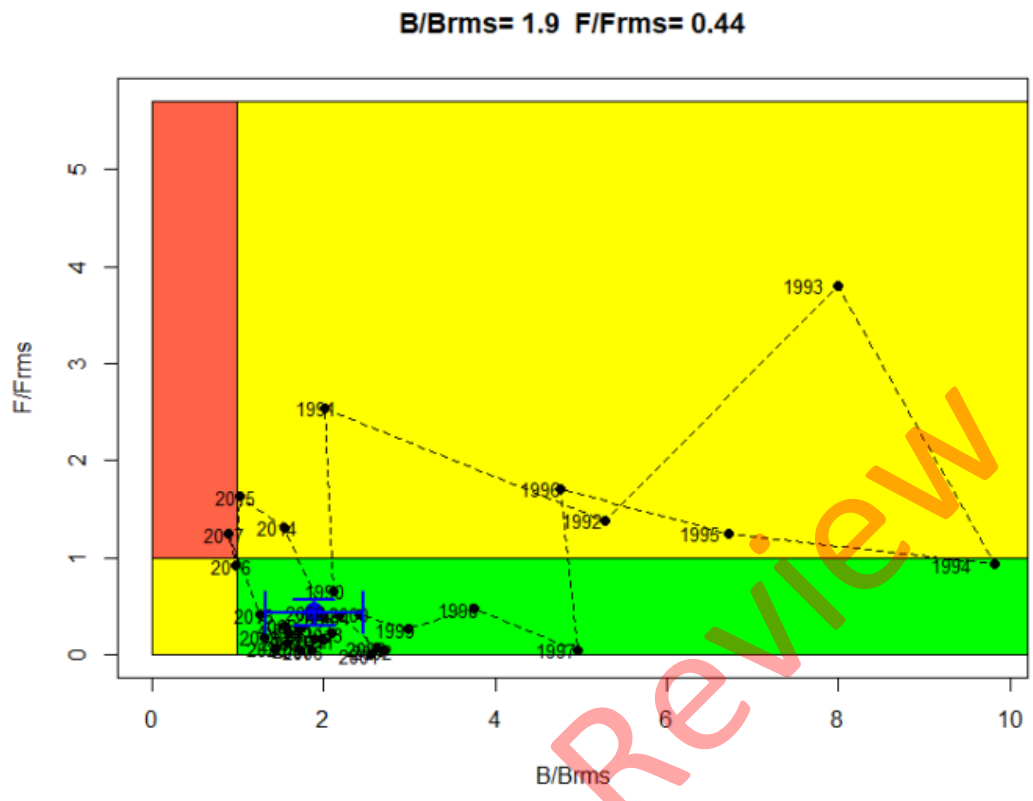

Figure 3: Kobe plot for the round herring (blue dot presents the most recent status (Canales and Jurado 2023)

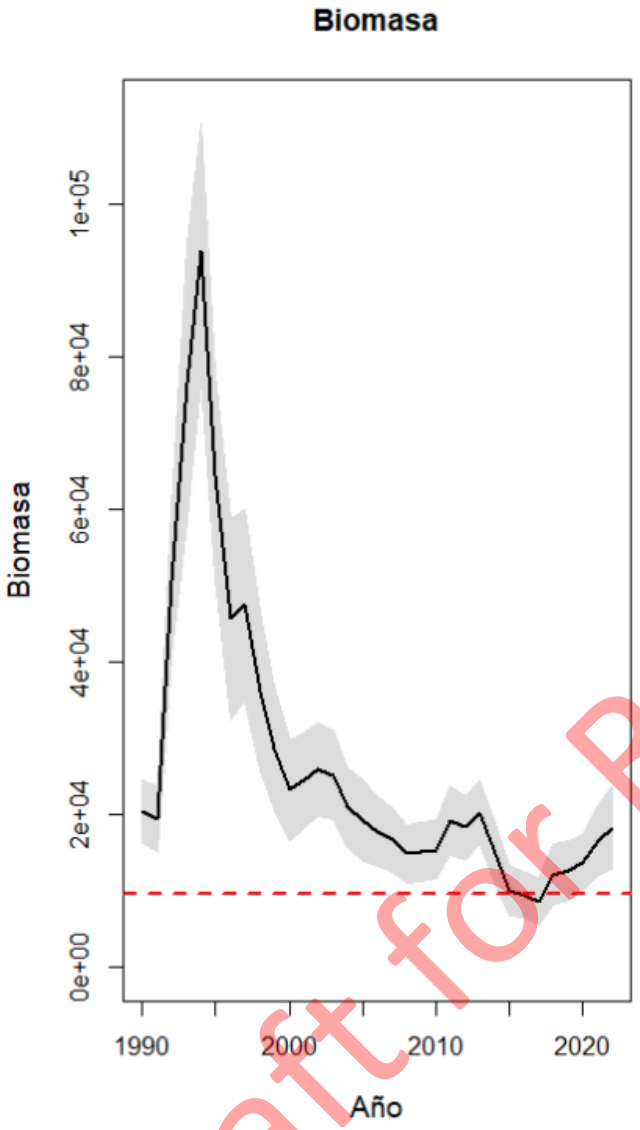

Figure 4: Round herring biomass levels (red line represents the B_{MSY}) (Canales and Jurado 2023)

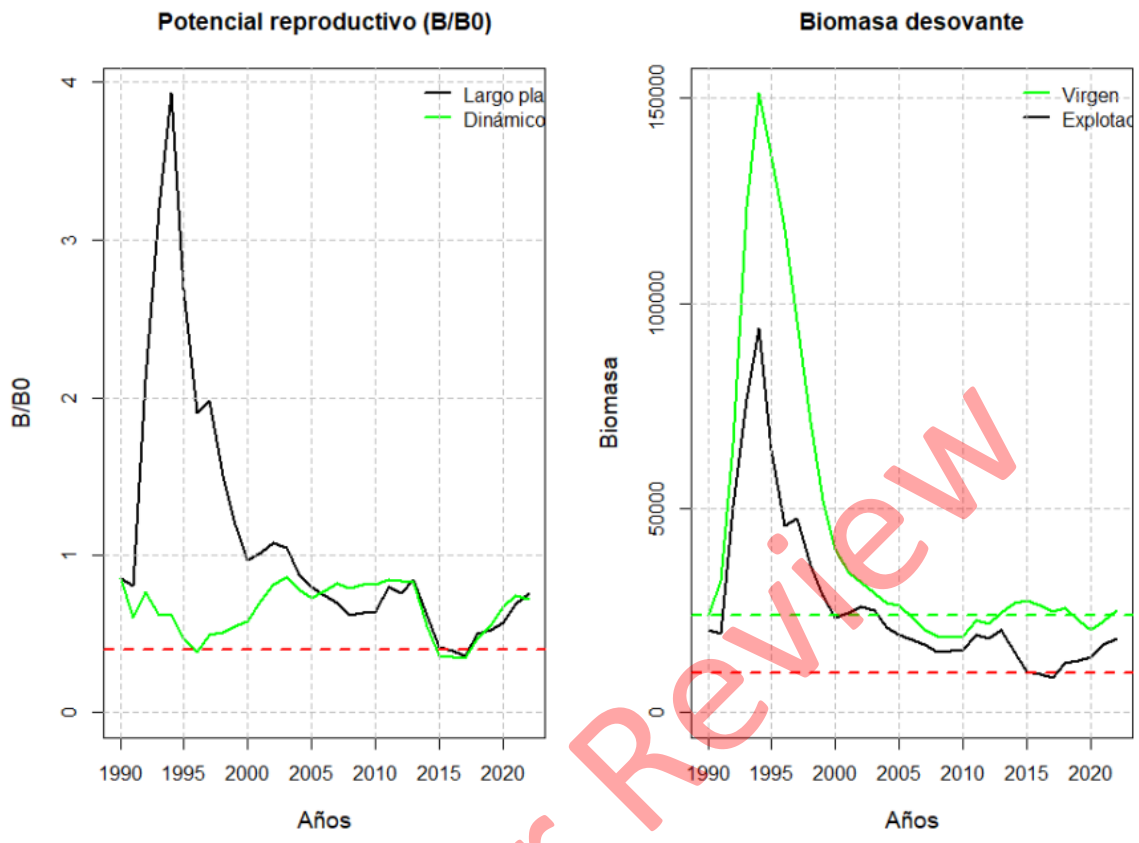

Figure 5: Spawning reproductive potential and recruitment biomass for round herring in Ecuador (Canales and Jurado 2023)

Factor 1.2 - Fishing Mortality

Ecuador Stock | Southeast Pacific | Purse seines

Low Concern

During the most recent stock assessment, fishing mortality values were estimated for the species. In general, values were below the target $F_{MSY,}$ for most of the time series (see image below).

According to the estimates, fishing pressure during the 1990s was excessive, but the levels decreased. Since the beginning of the 2000s, fishing mortality has been below its reference value (F40%), except for 2014-2017 (Canales and Jurado 2023). A recent stock assessment that finds the current F below the F_{MSY} proxy with an estimated zero risk of overfishing to be occurring allows for a score of 5 (Low Concern).

Justification:

The 2023 stock assessment estimates fishing mortality (F) from the 1990s to 2020 (see figure below). In the early portion of this time series, F peaked around 1994 and the second part of the 90s, then declined and remained under the reference point (F_{MSY}) until the 2014-2017 period, when overfishing was reported. Since then, values remained below the reference (Canales and Jurado 2023).

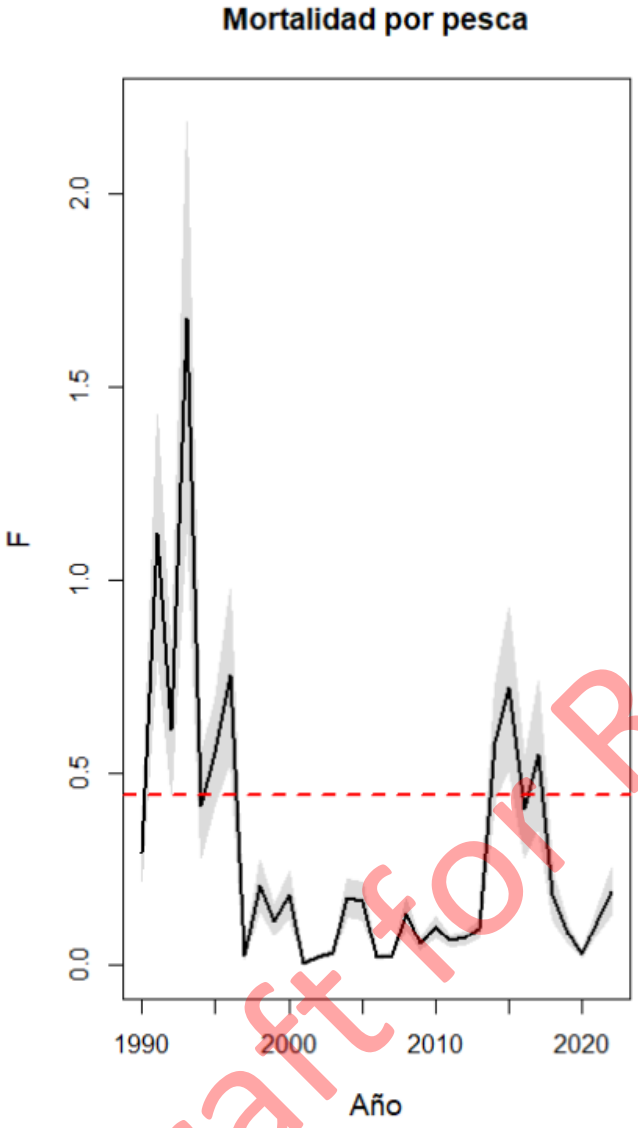

Figure 6: Fishing mortality value estimates for round herring in Ecuador (Canales and Jurado 2023)

Frigate tuna

Factor 1.1 - Abundance

Ecuador Stock | Southeast Pacific | Purse seines

High Concern

The frigate tuna is composed by two species with a distribution along the Eastern Pacific, from Monterey Bay to Chile {Fishbase 2023}. The species stock structure is not well-defined. The species is assessed as a single stock in Ecuador. The species is also considered a target species of the Small

pelagic fishery in Ecuador. Assessments have been conducted on an annual basis for several years (Canales et al 2020) (Canales and Jurado 2021) (Canales and Jurado 2022) (Canales and Jurado 2023) According to (Canales and Jurado 2023) the resource is showing signs of overexploitation, the level of population reduction by 2022 was estimated at 14% of virgin biomass (B0) and below the target reference point for the species (which is 40% of Bo) (Canales and Jurado 2023). Considering that the species is below the limit reference point, this factor is a high concern.

Justification:

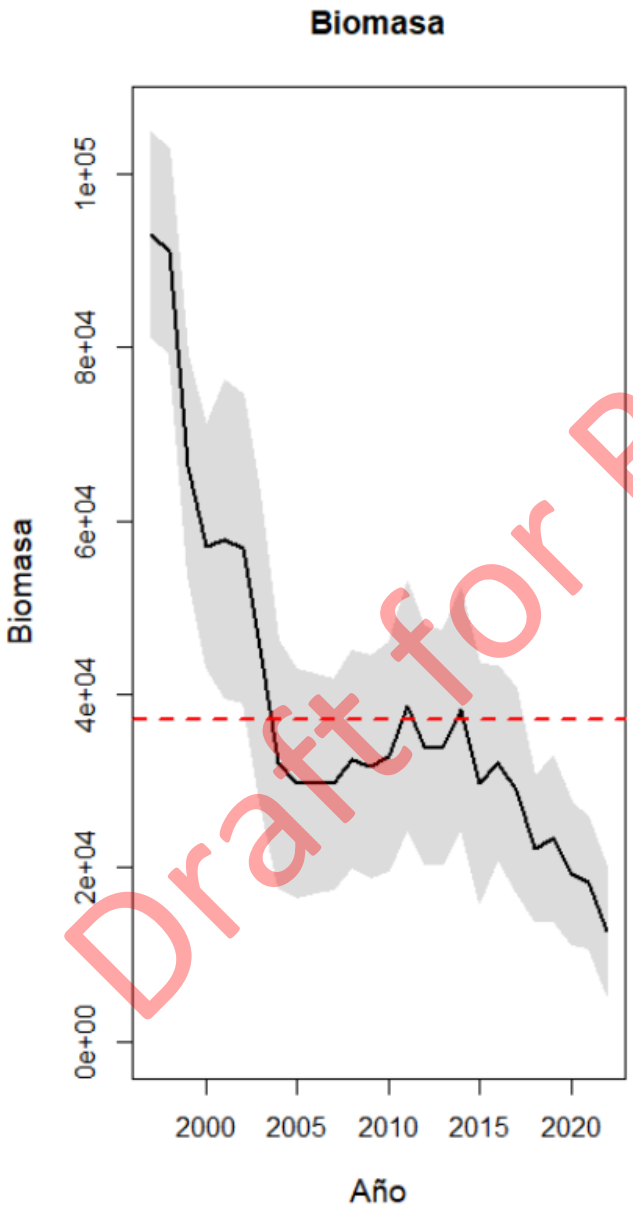

Figure 7: Botella estimated biomass (Canales and Jurado 2023)

Factor 1.2 - Fishing Mortality

Ecuador Stock | Southeast Pacific | Purse seines

High Concern

During the most recent stock assessment, fishing mortality values were estimated for the botella resource. The estimates showed that starting around 2016, F values were above $F_{MSY,}$ for most of the time series (see image below) (Canales and Jurado 2023). Authors included that during the 2021-2022 season, there was a high report on landings of the species that contributed in part to the decline in abundance (see abundance). Since overfishing is occurring and the fishery is a substantial contributor to mortality, this factor is scored as a high concern.

Justification:

The 2023 stock assessment report estimated fishing mortality (F) from the 1990s to 2020 (see figure below). F peaked around 2016 and remained above the reference point (F_{MSY}) (Canales and Jurado 2023).

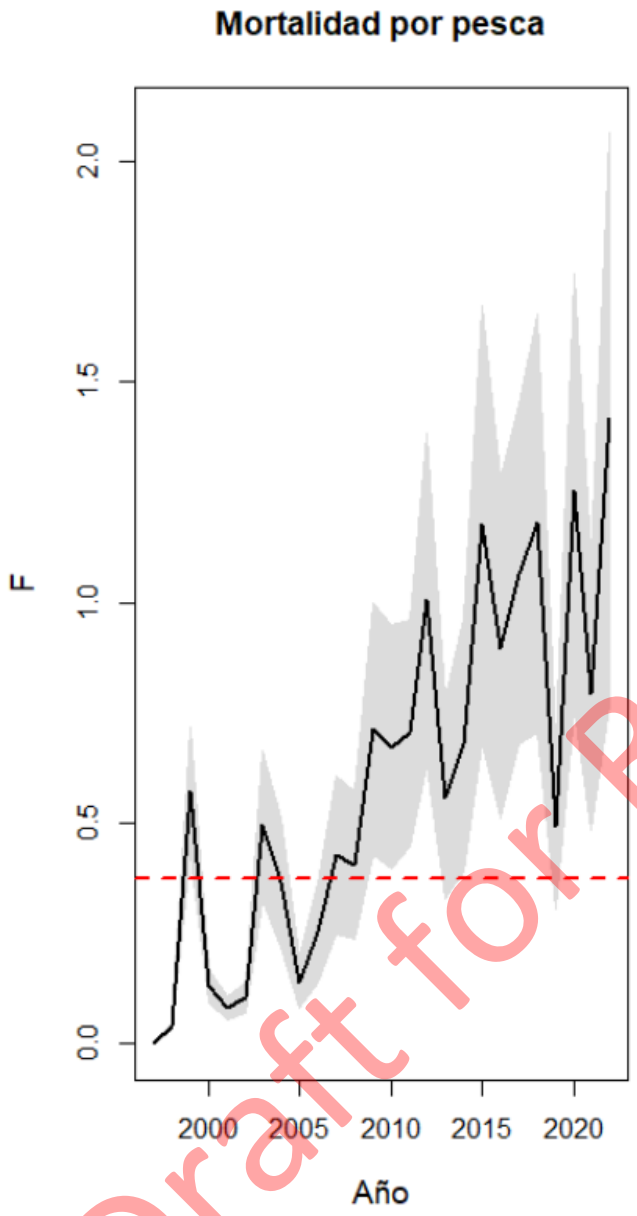

Figure 8: Fishing mortality estimates for "botella" (Canales and Jurado 2023)

Pacific chub mackerel

Factor 1.1 - Abundance

Ecuador Stock | Southeast Pacific | Purse seines

Moderate Concern

Recent assessments for Pacific chub mackerel have been developed on an annual basis in most

recent years in Ecuador {Canales et al 2019} et al 2019}(Canales et al 2020)(Canales and Jurado 2021)(Canales and Jurado 2022)(Canales and Jurado 2023). During the most recent evaluation (2023), authors concluded that the level of population reduction by 2022 was estimated to be close to the target and around 36% of the virgin B0 biomass (the management target is ≥40% Bo). The dynamic reproductive potential (SPR) was estimated at 53% of the virgin condition; based on this, the authors confirmed that the mackerel population was below the reference biomass (Canales and Jurado 2023) similar to their findings on the 2022 evaluation (Canales and Jurado 2022).

Uncertainty is relatively high, but all estimates indicate biomass is above 50% of the management target (based on 95% confidence intervals; see Justification below). A score of 3.67 (low concern) would be normally be awarded in this situation, but it is downgraded to 2.33 (moderate concern) because the stock is a key forage species and dynamic B_0 reference points are not used.

Justification:

The Kobe diagram locates the population with evidence of slight overexploitation ($B/B_{MSY}<0.4$) and overfishing ($F>F_{MSY}$) (see figure below). The uncertainty estimates indicate that the risk of overexploitation by 2022 was 59%

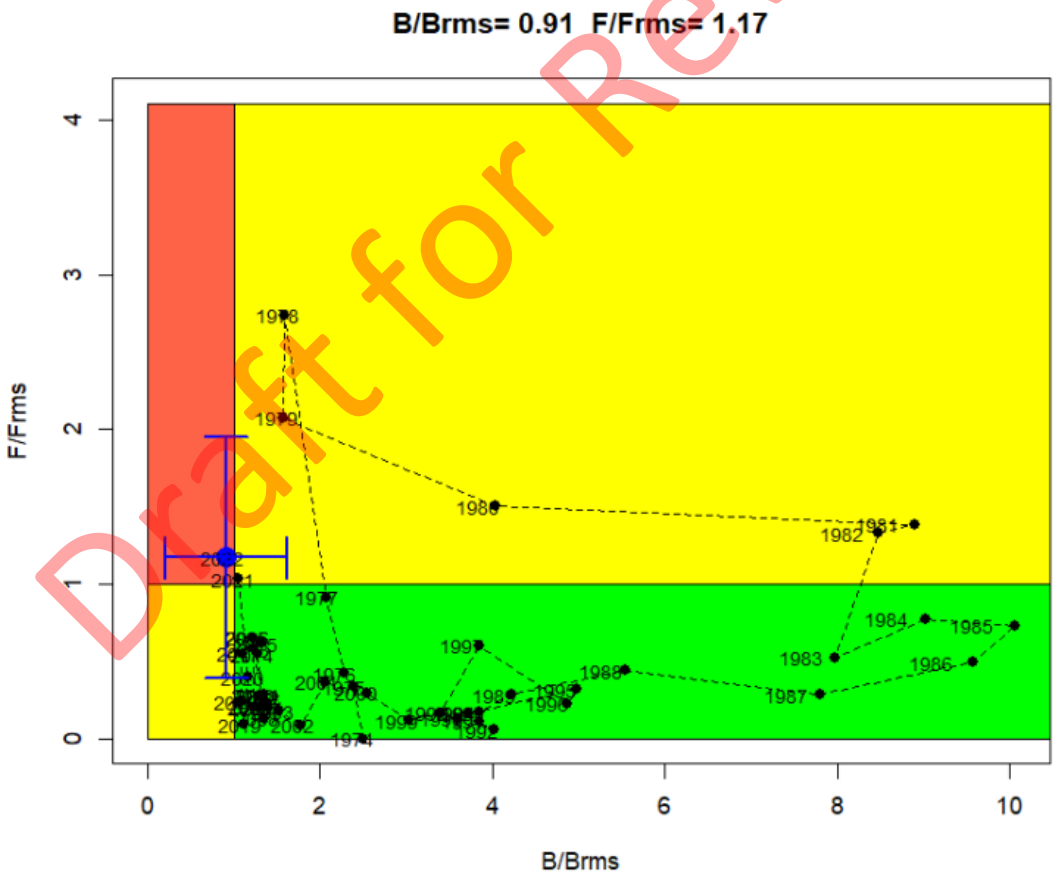

Figure 9: Kobe plot for the Pacific chub mackerel. The blue dot represents the 2022 (the cross represent the error potential) condition for the species (Canales and Jurado 2023)

Stock assessments for the Pacific chub mackerel consider a single stock in Ecuadorian waters. Still, there is some evidence of a single population throughout the specie's distribution along the Chilean and Peruvian coasts (Minte-Vera 2019). In recent years, improvements in population evaluation have been made, but the estimates keep showing a decline in biomass (see image below). Similar to the dynamic reproductive potential and the spawning biomass levels included in the 2023 assessment (Canales and Jurado 2023)

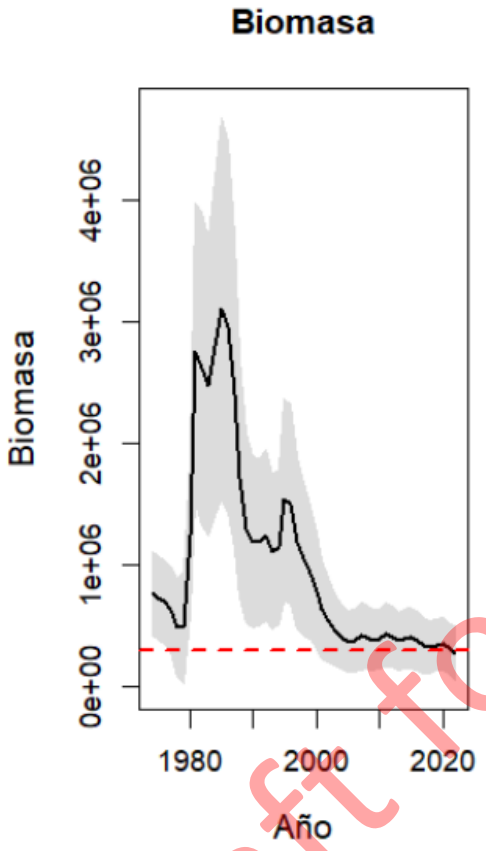

Figure 10: Plot represents the biomass estimates for Pacific chub mackerel (Canales and Jurado 2023)

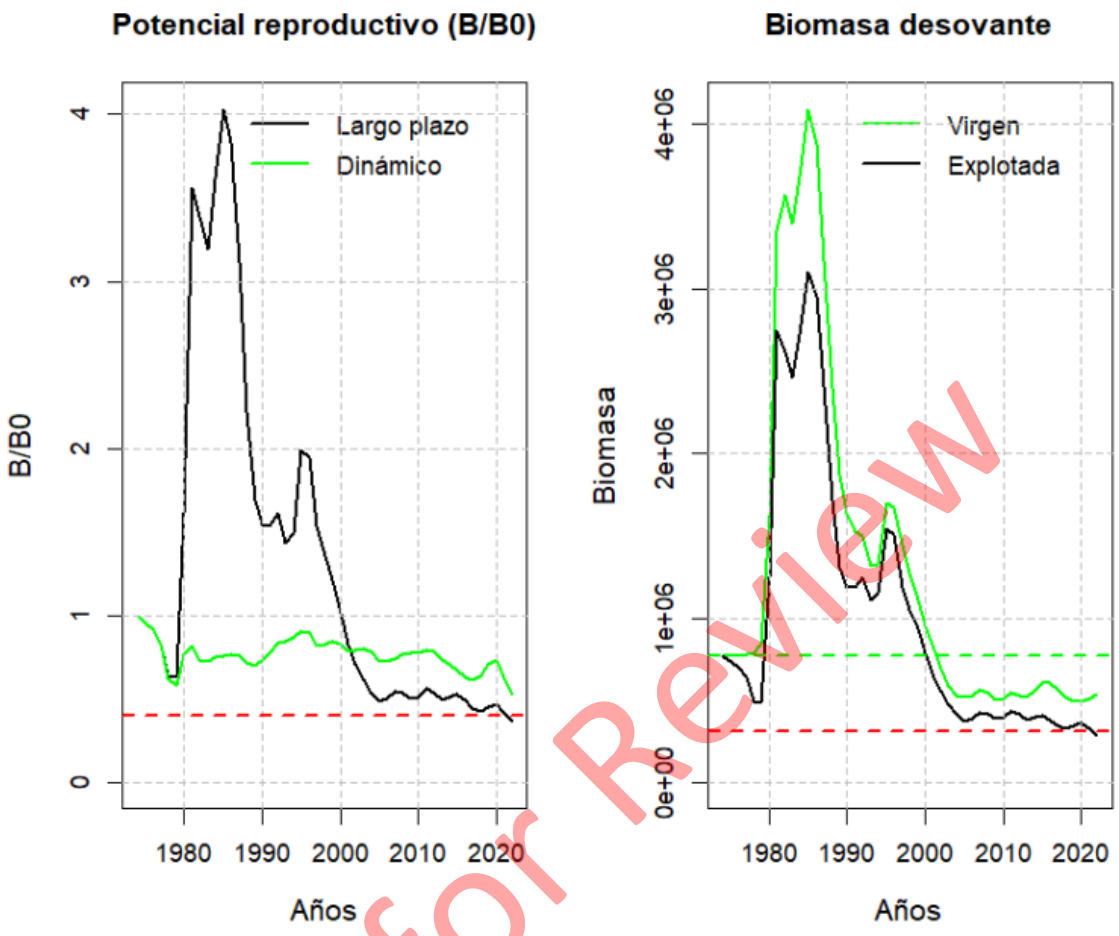

Figure 11: Spawning recruitment potential (left) and recruitment biomass (right) levels for Pacific chub mackerel (Canales and Jurado 2023)

Factor 1.2 - Fishing Mortality

Ecuador Stock | Southeast Pacific | Purse seines

High Concern

During the most recent stock assessment, fishing mortality values were evaluated. In general, values were found to be below the target $F_{MSY,}$ however, fishing mortality levels increased, starting in 2020, and were right above the target level advised in the last stock assessment report (Canales and Jurado 2023). During this assessment, the authors indicated that fishing mortality was above sustainable levels, with an estimated 17% above the recommended level and an overfishing risk of 66% (Canales and Jurado 2023). Therefore, fishing mortality is deemed a "high" concern.

Justification:

The 2023 stock assessment estimates fishing mortality (F) from the 1980s to 2020 (see figure below). In the early portion of this time series, F peaked around 1980, then declined and remained under the reference point (F_{MSY}= 0.24) until 2020 (Canales and Jurado 2023).

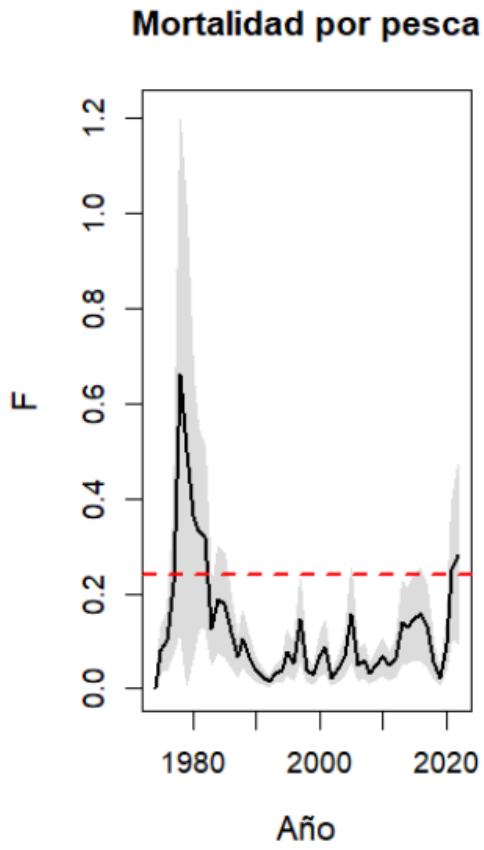

Figure 12: Fishing mortality for Pacific chub mackerel in Ecuador (Canales and Jurado 2023)

Shortfin scad

Factor 1.1 - Abundance

Ecuador Stock | Southeast Pacific | Purse seines

Moderate Concern

The shortfin scad (locally named "picudillo") is a species with a distribution along the Indo-Pacific and Southeast Atlantic and in the Central Pacific Islands {Fishbase 2023}. The species is a target species of the Small pelagic fishery in Ecuador. Assessments have been conducted on an annual basis for several years (Canales et al 2020) (Canales and Jurado 2021) (Canales and Jurado 2022) (Canales and Jurado 2023). According to (Canales and Jurado 2023) the resource has not had episodes of overexploitation. Population reduction by 2022 was estimated at 46% of virgin biomass (B0) and with spawning recruitment biomass of up to 70% of the virgin biomass (Canales and Jurado 2023). Considering that the species is above the limit reference point but below 75% of the target reference point, this factor is scored as a moderate concern.

Justification:

The species population has had variations mainly related to recruitment, although biomass, SPR, and virgin biomass levels have remained above reference points (see images below) (Canales and Jurado 2023). The Kobe diagram and the confidence intervals indicate that the population would be at no risk of overfishing, but there are negative trends on these values (Canales and Jurado 2023).

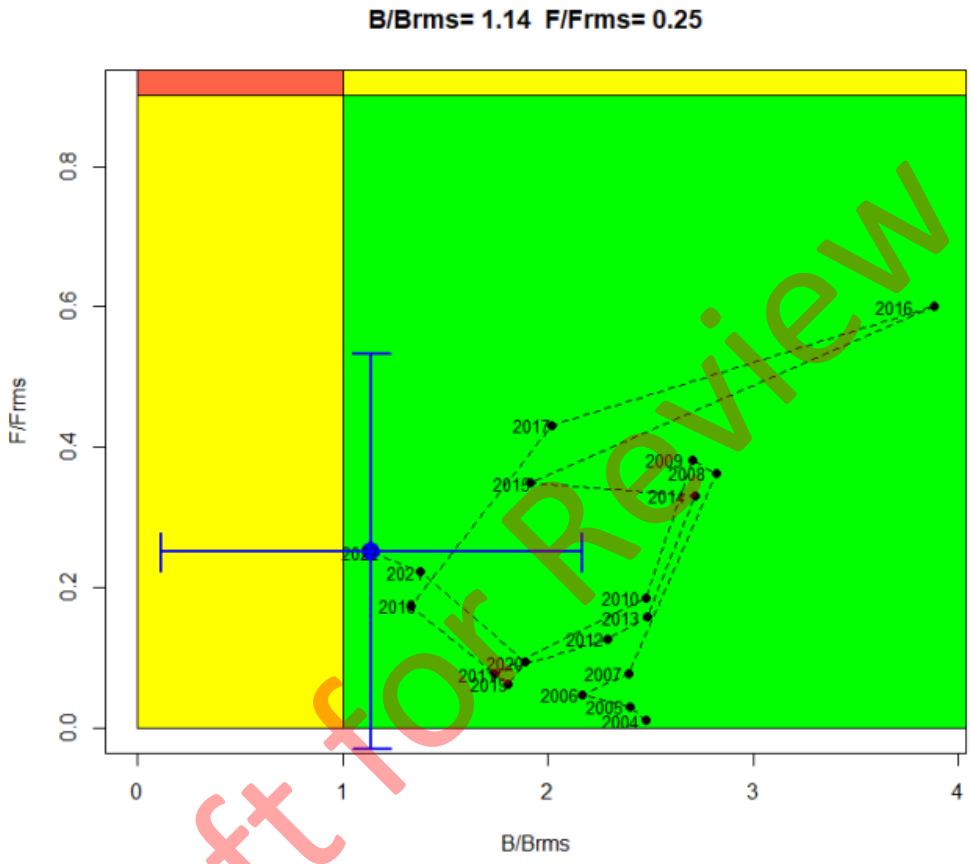

Figure 13: Shortfin scad status estimated by (Canales and Jurado 2023)

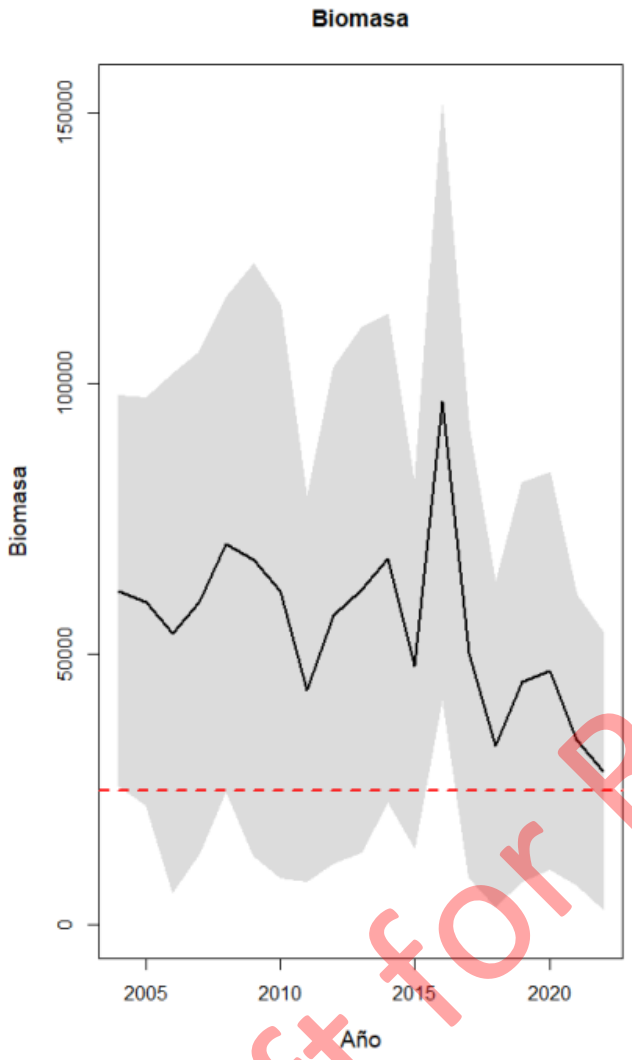

Figure 14: Biomass levels for shortfin scad in Ecuador (Canales and Jurado 2023)

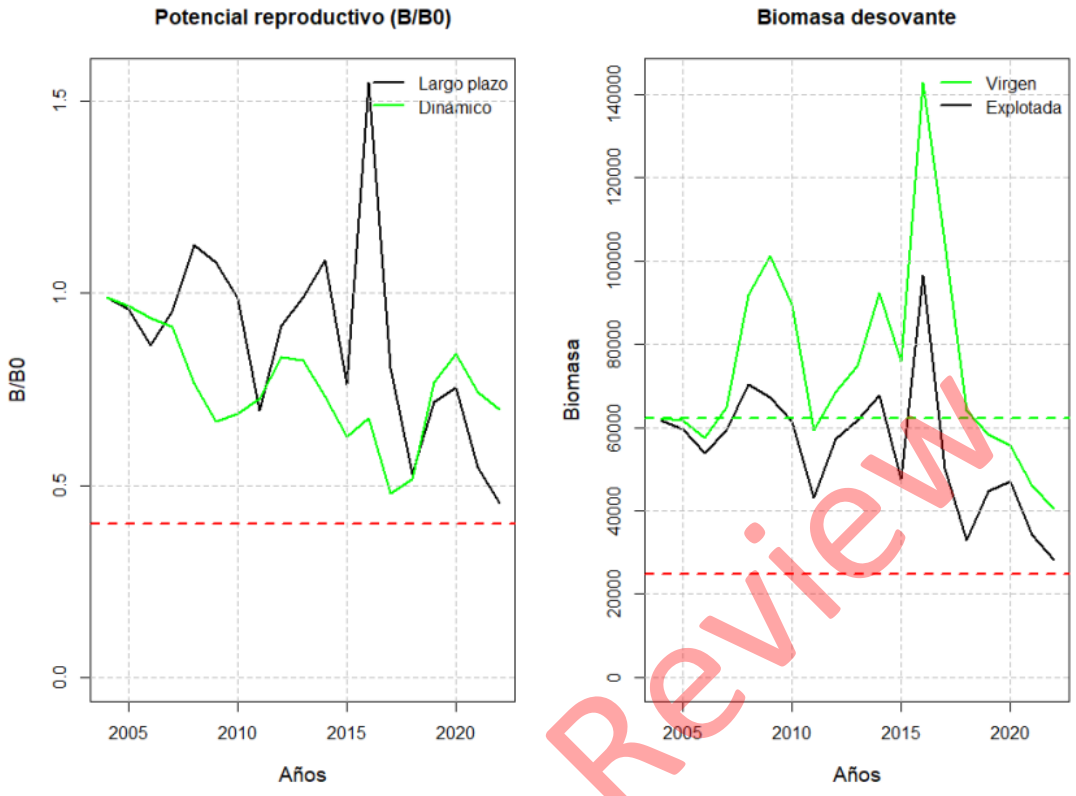

Figure 15: SPR (left) and recruitment biomass (right) levels for shortfin scad in Ecuador (Canales and Jurado 2023)

Factor 1.2 - Fishing Mortality

Ecuador Stock | Southeast Pacific | Purse seines

Low Concern

During the most recent stock assessment, fishing mortality values were estimated for the shortfin scad. The estimates showed F values have been below the $F_{MSY,}$ for all the time series (see image below) (Canales and Jurado 2023). A recent stock assessment that finds current F below the F_{MSY} proxy with an estimated zero risk of overfishing to be occurring, allows for a score of 5 (Low Concern).

Justification:

The 2023 assessment estimated fishing mortality (F) values from the early 2000s to 2022 (see figure below). The values of F have remained below the reference point (F_{MSY}) (Canales and Jurado 2023).

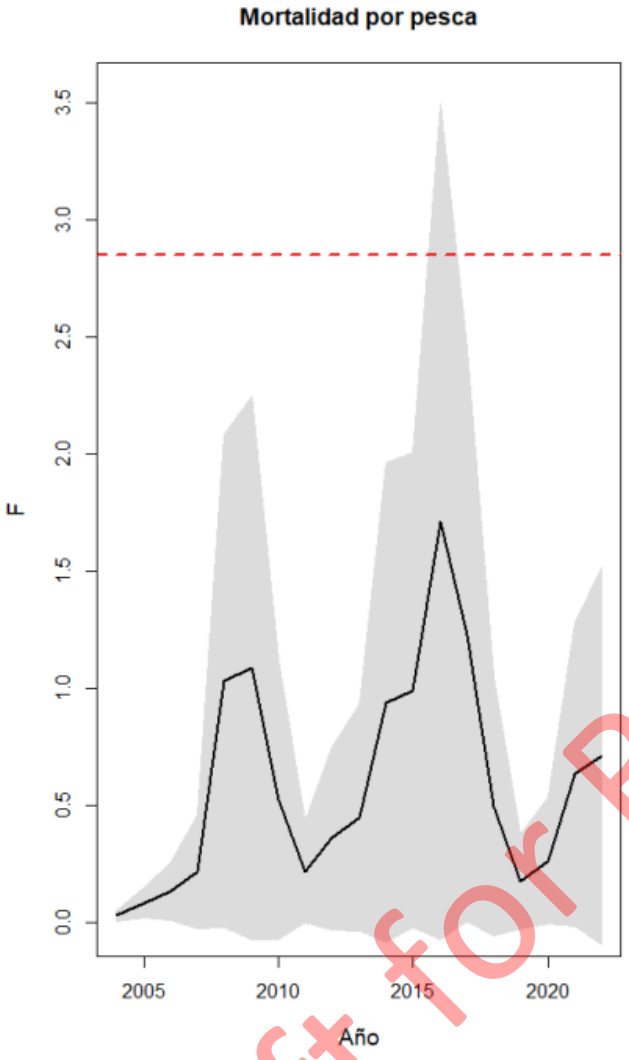

Figure 16: Fishing mortality estimates for Shortfin scad in Ecuador (Canales and Jurado 2023)

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.

EASTERN ROUND HERRING			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Ecuador Stock | Southeast Pacific | Purse seines	1.526	1.000: < 100%	Red (1.526)

FRIGATE TUNA			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Ecuador Stock | Southeast Pacific | Purse seines	5.000	1.000: < 100%	Green (5.000)

PACIFIC CHUB MACKEREL			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Ecuador Stock | Southeast Pacific | Purse seines	5.000	1.000: < 100%	Green (5.000)

SHORTFIN SCAD			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Ecuador Stock | Southeast Pacific | Purse seines	1.526	1.000: < 100%	Red (1.526)

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 | PURSE SEINES | ECUADOR			
SUB SCORE: 5.000	DISCARD RATE: 1.000	**SCORE: 5.000**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Pacific chub mackerel	2.330: Moderate Concern	1.000: High Concern	Red (1.526)

SOUTHEAST PACIFIC | PURSE SEINES | ECUADOR			
SUB SCORE: 5.000	DISCARD RATE: 1.000	**SCORE: 5.000**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Frigate tuna	1.000: High Concern	1.000: High Concern	Red (1.000)

SOUTHEAST PACIFIC | PURSE SEINES | ECUADOR			
SUB SCORE: 1.526	DISCARD RATE: 1.000	**SCORE: 1.526**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Pacific chub mackerel	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Eastern Round Herring	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

SOUTHEAST PACIFIC | PURSE SEINES | ECUADOR			
SUB SCORE: 1.526	DISCARD RATE: 1.000	**SCORE: 1.526**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Pacific chub mackerel	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Shortfin scad	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

The Small Pelagics Fishery in Ecuador targets several species using purse seine nets. The main target species are the Pacific chub mackerel (*Scomber japonicus*), thread herring (*Opisthonema spp.*), Pacific anchoveta (*Cetengraulis mysticetus*), frigate tuna (*Auxis spp.*), round herring (*Etrumeus acuminatus*), sardine (*Sardinops sagax*), anchovy (*Engraulis ringens*) and jack mackerel (*Trachurus murphyi*), that are used both for direct human consumption and fishmeal (PUND 2019). As part of the published Fishery Management Plant (SRP et al 2021), the authorized species that the purse-seine fleet in Ecuador can capture were listed as follows:

- Small pelagic species: Peruvian anchoveta (*Engraulis ringens*), frigate and bullet tuna (*Auxis spp.*), Pacific anchoveta (*Cetengraulis mysticetus*), anchovies (*Anchoa spp.*), thread herrings (*Ophistonema spp.*), longnose anchovy (*Anchoa nasus*), red-eye round herring (*Etrumeus teres*), South American pilchard (*Sardinops sagax*), chub mackerel (*Scomber japonicus*), leatherjacket (*Oligoplites spp.*), Chilean jack mackerel (*Trachurus murphyi*) and shortfin scad (*Decapterus macrosoma*)
- Other species that may occupy the pelagic environment: Mexican moonfish (*Selene oerstedii*), Pacific bumper (*Chloroscombrus orqueta*), Pacific harvestfish (*Peprilus medius*), Pacific cornetfish (*Fistularia corneta*), Largehead hairtail (*Trichiurus lepturus*) and searobins (*Prionotus spp*).

In the fishery, catch composition, including the bycatch species, is routinely monitored, and the list and amount of each species are published by managers {INP 2020}. In recent years, only five target species represented more than 5 of the weight. (Ponce et al 2022) analyzed the catch composition of the fishery

sets between 2020 and 2022 using fishing activity records of the purse-seine fleet. The authors found that ~87% of the fishing sets were mono-specific (composed of only one species), or over 90% of the catch in volume.

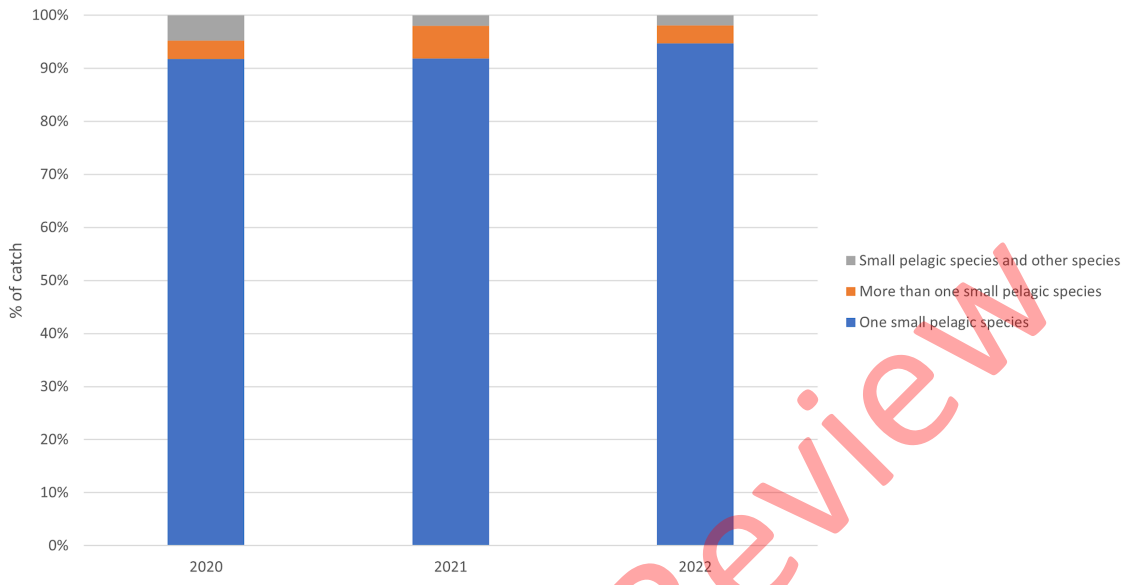

Figure 18: Observed catch in the Ecuador small pelagics fishery 2020 to 2022 (by volume). Chart recreated from (Ponce et al 2022).

A more granular analysis suggests hauls that caught *Scomber japonicus* caught only that species 88% of the time, and that species accounted for over 97% of the total catch of those hauls, by volume. Hauls that caught Auxis spp. were similarly selective (84% of hauls, 93% of volume), while those for Eastern round herring and shortfin scad were less so (60% and 47% of hauls, respectively (see Table 2-1: below).

Table 2-1: Catch composition of hauls by main species in haul, 2020-2022 (by volume). Only species that accounted for >0.1% of the catch are included. Data from (Ponce et al 2022). Blue cells account for over 5% of the catch (see Determining 'main species' below).

Species	% of catch by main species in haul			
	S. japonicus	***Auxis spp.***	***E. acuminatus***	***D. macrosoma***
Pacific chub mackerel - *Scomber japonicus*	97.03	4.69	31.01	41.38
Shortfin scad - *Decapterus macrosoma*	1.01	0.14	4.66	55.26
Frigate tuna - *Auxis* spp	0.95	93.19	0.24	0.4
Eastern round herring - *Etrumeus acuminatus*	0.29		63.98	1.55
Pacific harvestfish - *Peprilus medius*	0.21	0.13		
Lumpfish Searobin - *Prionotus stephanophrys*	0.19	1.1		0.59
Whitesnout searobin - *Prionotus albirostris*	0.13			0.44

Pacific cornetfish - *Fistularia corneta*		0.24		
Black skipjack - *Euthynnus lineatus*		0.19		
Thread herring - Opistonema spp.			0.12	
Pacific moonfish - *Selene peruviana*				0.17

Additionally, in 2019, catch composition and interactions with other species data was collected as part of the onboard observer's program. (Jurado et al 2019)(Ponce et al 2020) and (Ponce et al 2021) reported the fishery interactions with seabirds, mammals, and sea turtles. Very few species are harmed during the interaction (Table 2-2).

Table 2-2: Mammal, bird and turtle species observed interacting with the small pelagics fishery in 2021, the IUCN category (LC=Least Concern, NT=Near Threatened, VU=Vulnerable, EN=Endangered), condition after interaction and interaction rate per trip (data from (Ponce et al b 2021).

Scientific name	Common name (Spanish)	Common name (English)	IUCN category	Condition after interaction				Interaction rate per trip
				Unharmed	Minor injuries	Serious wounds	Dead	
Fregata magnificens	Fragata común o fragata real	Magnificent frigatebird	LC	11327		3		8.41
Pelecanus occidentalis californicus	Pelícano pardo de California	Brown pelican	LC	6				8.27
Pelecanus occidentalis	Pelícano pardo	Brown pelican	LC	11143				8.27
Otaria flavescens	Lobo marino sudamericano	Sea American sea lion	LC	4797				3.56
Chroicocephalus ridibundus	Gaviota encapuchada	Black-headed gull	LC					0.31
Sula variegata	Piquero peruano	Peruvian booby	LC	370				0.27
Sula nebouxii	Piquero patas azules	Blue-footed booby	LC	339				0.25
Chelonia mydas	Tortuga verde	Green turtle	EN	78	2	1	1	0.06
Fregata minor	Fragata grande	Great frigatebird	LC	70				0.05
Lepidochelys olivacea	Tortuga golfina/tortuga olivácea	Olive Ridley turtle	VU	37	1			0.03
Pelecanus thagus	Pelícano peruano	Peruvian pelican	NT	42				0.03
Rhincodon typus	Tiburón ballena	Peruvian pelican	EN	1				0.03
Aetobatus laticeps	Raya águila	Pacific eagle ray	VU	22				0.02
Tursiops truncatus	Delfín nariz de botella común	Common bottlenose dolphin	LC	25				0.02

Leucophaeus atricilla	Gaviota reidora americana	Laughing gull	LC	20				0.01
Oceanodroma tethys	Paíño danzarín o golondrina de tormenta de Galápagos	Wedge-rumped storm-petrel	LC	15				0.01
Rhinoptera steindachneri	Raya dorada	Pacific cownose ray	NT	20				0.01
Ardenna grisea	Pardela oscura o fardela negra	Sooty shearwater	NT	6				< 0.01
Creagrus furcatus	Gaviota tijereta o gaviota de cola bifurcada	Swallow tail gull	LC	6				< 0.01
Dermochelys coriacea	Tortuga laúd	Leatherback turtle	VU	3				< 0.01
Thalasseus maximus	Charrán real	Royal tern	LC	3				< 0.01

Determining 'main species'

The Criterion 2 score for the stock-fishery combination being rated (i.e. Pacific chub mackerel caught by purse seines in Ecuadorian waters) is the lowest abundance-fishing mortality score of all the other main species caught (including both target and non-target, retained, and discarded species), multiplied by the discard + bait use rate. In v4 of the Seafood Watch Standard for Fisheries (Seafood Watch 2020) a species is a main species if it meets any of the following conditions ("catch" here includes landings plus discards):

- A common component of the catch (as guidance, >5% of the catch in most cases), or
- Overfished, endangered, threatened, undergoing overfishing, or otherwise a species of concern, where catch occurs regularly and may significantly contribute to the conservation concern (i.e., more than a negligible and/or sporadic catch level). As guidance, the mortality of the species caused by this fishery is >5% of a sustainable level, or
- Fishery under assessment is one of the main sources of fishing mortality for the species, including bait species if known (as guidance, approx. 20% or more of total fishing mortality), and
- In fisheries that use bait, the bait species should be treated as a bycatch species if it meets the abovementioned main species criteria. If the species used as bait are unknown but account for greater than 5% of the catch and no other main species have been identified, then add "unknown finfish" with abundance and fishing mortality both scored as "moderate concern".

In sets for Pacific chub mackerel and Frigate tuna, no other species/stock accounts for >5% of the catch, whereas Pacific chub mackerel account for >5% of the catch when hauling Eastern round herring and shortfin scad. The other targeted species (including *Auxis* spp., which is of concern as it is considered overfished with overfishing occurring (Canales and Jurado 2023)) are also subject to directed sets so it is assumed those sets are not a main source of mortality. The remaining species are considered Least Concern by the IUCN, including 3 of 4 possible species of Opistonema - the Galapagos thread herring O. berlangai is considered Vulnerable (IUCNRedList.org). Bait is not used in purse seine fisheries.

Very few mammals, turtles, or seabirds are harmed during interactions with the fishery.

In summary, Pacific chub mackerel and Auxis spp. hauls are considered to have no other 'main species' caught in them, while Pacific chub mackerel is the only Criterion 2 species for Eastern round herring and shortfin scad

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

Pacific chub mackerel

Factor 2.1 - Abundance

Ecuador Stock | Southeast Pacific | Purse seines

Moderate Concern

Pacific chub mackerel are considered 'main species' in hauls for Eastern round herring and shortfin scad. See Criterion 1 for scoring justification.

Factor 2.2 - Fishing Mortality

Ecuador Stock | Southeast Pacific | Purse seines

High Concern

Pacific chub mackerel are considered 'main species' in hauls for Eastern round herring and shortfin scad. See Criterion 1 for scoring justification.

Factor 2.3 - Discard Rate/Landings

Ecuador Stock | Southeast Pacific | Purse seines

< 100%

The small pelagic fishery in Ecuador is developed along the Ecuadorian coast. As stated earlier, the fishery targets mackerel (Scomber japonicus), herrings (Opisthonema spp), Pacific anchoveta (Cetengraulis mysticetus), two species of the genre Auxis, eastern round herring and short fin scad (*Decapterus macrosoma*), which composed most of the catch.

However, other small pelagic species are sometimes present with less than 5% of the total catch and can be considered as bycatch species based on the SFW Fisheries Standard 4.0. However, other demersal or epipelagic species sometimes may be present as bycatch.

The catch composition analysis developed by {Ponce et al., 2022} shows the results of the composition of the associated catch with small pelagic authorized to produce fishmeal during 2020-2022. The data analyzed were obtained from the record of the fishing activity of the vessels of the purse-seine fleet. The incidence of small pelagic fishing sets and catches has increased, reaching maximum values in 2022 (89.4% of the total volume and 74.6% of the total sets). On the other hand, it was observed that the catches recorded of other small non-pelagic species gradually decreased during the period analyzed, being 10.6% in 2022.

When analyzing only the sets with small pelagic catches, on average, 87% of the fishing sets were monospecific. In addition, the associations between species in the sets categorized as PPP+PPP and PPP+OTHERS were identified around the main species studied, resulting in the sets of Scomber japonicus, Decapterus macrosoma, Auxis spp. and Etrumeus acuminatus, that showed a similarity of presence and volume of species >60%. When characterizing the catch composition of the main

small pelagic species authorized to produce fishmeal, it was observed that 97.38% of the catch of the set of species analyzed is concentrated in the species Scomber japonicus, Auxis spp. and Decapterus macrosoma, while the remainder (greater than 0.1%) by Cetengraulis mysticetus, Etrumeus acuminatus, Prionotus stephanophrys, Peprilus medius and Prionotus albirostris. Among these species, Peprilus medius is only authorized for direct human consumption.

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	BYCATCH STRATEGY	DATA COLLECTION AND ANALYSIS	ENFORCEMENT	INCLUSION	SCORE
Southeast Pacific | Purse seines | Ecuador	Moderately Effective	Highly effective	Highly effective	Moderately Effective	Highly effective	**Yellow (3.000)**
Southeast Pacific | Purse seines | Ecuador	Moderately Effective	Highly effective	Highly effective	Moderately Effective	Highly effective	**Yellow (3.000)**
Southeast Pacific | Purse seines | Ecuador	Moderately Effective	Highly effective	Highly effective	Moderately Effective	Highly effective	**Yellow (3.000)**

Southeast Pacific | Purse seines | Ecuador	Moderately Effective	Highly effective	Highly effective	Moderately Effective	Highly effective	**Yellow (3.000)**

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.

Factor 3.1 - Management Strategy And Implementation

Southeast Pacific | Purse seines | Ecuador

Moderately Effective

The government body responsible for fisheries management in Ecuador is the Vice Ministry of Aquaculture and Fisheries (Vice -Ministerio de Acuacultura y Pesca, VMAP). The VMAP was separated from the old Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) by Executive Decree No. 6 of May 24, 2017, and currently is part of the Ministry of Production, Foreign Trade, Investments, and Fishing by Executive Decree No. 636 of January 2019. The management of the Small Pelagic fishery is conducted by the Subsecretary of Fishery Resources (Subsecretaria de Recursos Pesqueros), which belongs to the Ministry of Aquaculture and Fisheries (Ministerio de Acuacultura y Pesca; MAP). The Law of Fisheries and Fisheries Development (Gobierno de Ecuador 1974), recently updated and published on 2020, April 14th, regulates fishing activities in Ecuador and created a National Fund for Aquaculture and Fisheries Research and the Public Institute for Aquaculture and Fisheries Research.

Most recently, Ecuador's National Action Plan and Management for the Small Pelagic Fishery (FMP) was officialized (MPCEIP 2020). The plan has specific objectives centered around biological, ecological, and socioeconomic factors. The FMP aims to achieve the MSY for the target species by 2025, including all actions and measures in place for the fishery (SRP et al 2021). Some of these measures are:

- To limit bycatch up to 20% of the total biomass.
- Mandatory observers program for at least 30% of the purse seine fleet.
- Annual closure to be fixed each year after the National Fisheries Institute advises. The last closure started on December 21, 2020, and lasted until February 3, 2021 {MPCEIP and SRP 2020}. In addition to having in place emergency closures when juveniles are found in high proportions
- A fishing ban is in place three days before and three days after the full moon (lunar off-seasons)
- A ban on double foot lines ("doble relinga inferior").
- To have spatial and temporal closures if a high abundance of juveniles is detected.
- Mandatory use of satellite vessel monitoring systems.
- Control (no increase) of the fleet capacity

In addition, fishing is not allowed within the first mile of the shoreline (PRE 2020). The first eight miles from the coast are reserved for artisanal fisheries (PRE 2020) and a minimum mesh size of 1 1/8 inches for purse seiners targeting chub mackerel and other small pelagic species in Ecuador {MAGAP 2011}.

The Action Plan reflects the challenges in managing the fishery such that MSY is attained for all stocks, and lays out a system of focused measures on one flag species at a time (or centinela in Spanish) with the goal that improvements will positively impact the ensemble of species (SRP et al 2021). Managers used a combination of species vulnerability, the status of the stock as well the importance of the species in terms of value, volume, and final market to decide a management prioritization (see Justification below). This model is supposed to adapt and rotate the flag species

as progress is made, or new information allows focusing management in a different species. The controls in place limit fishing efforts that are directly related to CPUE that produce the MSY (CPUEMSY) (SRP et al 2021)

This strategy's effectiveness is uncertain, considering that it has not been in place long enough to evaluate its effectiveness (presented within the action plan released in 2021){SRP 2021} for this reason, this factor is scored as moderately effective.

Justification:
The management plan prioritization scheme combined the species' vulnerability and susceptibility characteristics with the most recent information of the status of the stocks, and the importance of the species in terms of market, value, information availability, and even cultural importance to define the "order" of which should be considered the flag species for the fishery (see image below)

Figura 2. Árbol de priorización de especies clave en la pesquería de PPP del Ecuador, donde se muestran: los criterios de priorización (verde, azul y naranja), los subcriterios (en el caso de la vulnerabilidad inherente) mostrado en verde claro y los componentes representados en blanco con el borde del color del criterio al que corresponde.

Elements considered by managers in terms of vulnerability, status, and importance to identify flag species for management within the Action Plan (SRP et al 2021)

As a result, in 2021, Pacific chub mackerel was designed the flag species, followed by herrings (Pinchagua), shortfin scad (Picudillo), Pacific anchoveta (Chuhueco), frigate tuna (Botella) and round herring (Sardina redonda)(see image below).

Nombre común	Vulnerabilidad	Estado del shock	Importancia de manejo	Ranking
Macarela	4,1	2,5	4,3	3,62
Pinchagua	3,5	2,0	4,2	3,23
Picudillo	3,2	3,3	3,0	3,16
Chuhueco	2,8	3,0	3,4	3,08
Botella	3,3	1,5	4,0	2,94
Sardina redonda	3,3	2,0	1,6	2,31

Species results on vulnerability, stock status, and management importance used to rank them (SRP et al 2021)

Especie	BRMS (t)	RMS (t)	FRMS	CPUERMS
Macarela	155,912	78,996	0.28	0.49
Pinchagua	74,626	37,320	0.41	0.70
Chuhueco	33,537	15,430	0.32	3.70
Sardina	5,176	3,539	0.67	1.34
Botella	42,310	27,091	0.43	0.31
Picudillo	19,970	10,912	0.20	1.79
Total		**173,288**		

The combination of the biological references of these species was calculated and used by (Canales et al 2020), and CPUEMSY was used as a condition to control fishing mortality on the different species using the following formula, and management decisions will be made based on the result (see table below) (SRP et al 2021)

$$Et = pt\ Et - 1$$

$$Pt = 0.5\ (CPUEs, t-1 + CPUEs, t-2) / CPUEs, MSY$$

Condition	Action
If p > 1 but average landings are < MSY	The number of fishing days increased "p" times
If p > 1 but landings are > MSY	The number of fishing days increased "p" times
If p > 1 but average landings are < MSY	The number of fishing days increased "p" times
If p < 1 but average landings are > MSY	The number of fishing days increased "p" times

Factor 3.2 - Bycatch Strategy

Southeast Pacific | Purse seines | Ecuador

Highly effective

The small pelagic fishery in Ecuador catches several target species which vary by area, season and

year. There is good evidence that discards or impacts on species of concern are minimal (see Criterion 2). Even so, the Action Plan lays out several actions to reduce the catch of bycatch species by 2025. These include limiting bycatch to 20% of the catch, spatial and temporal closures where juveniles are found in high proportions, and implementing good practices to reduce impacts on species of concern (SRP et al 2021). The Action Plan does not specify any measures for mitigating ghost gear impacts. However, this is likely because of the relatively low risk of ghost gear impacts in purse seine fisheries for small pelagics (see Justification below; (Gilman et al 2021)). A score of 5 (Highly Effective) is given,

Justification:

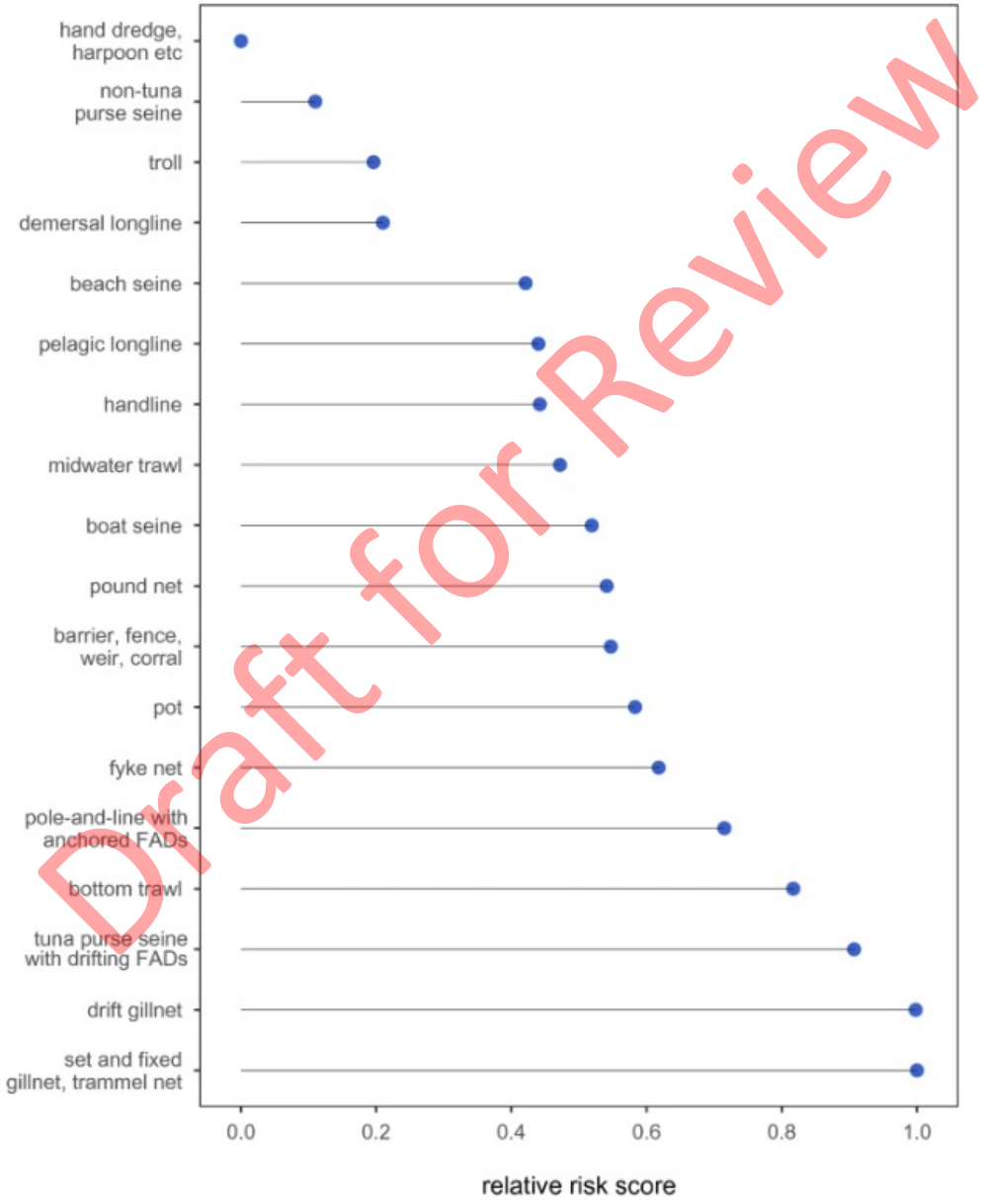

Figure 17: Gear-specific relative risk from abandoned, lost and discarded fishing gear (ALDFG). From the top of the *y*-axis, fishing gears are listed from lowest overall relative risk score, which accounts for: (**a**) rate of production of ALDFG, (**b**) fishing effort

(accounts for gear-specific weight of total catch and geospatial area of fishing grounds), and (**c**) adverse ecological and socioeconomic impacts of ALDFG (accounts for: ghost fishing, dispersal and transfer of toxins and microplastic into marine food webs, dispersal of invasive alien species and microalgae that cause harmful algal blooms, habitat degradation, obstruction and safety risks to navigation and in-use fishing gear, and reduced socioeconomic, aesthetic and use values of coastal and nearshore habitats). The higher the relative risk score, the larger the amount of global adverse effects from ALDFG the gear is estimated to be causing, based on the quantity of derelict gear that gear leaks into the oceans and the relative adverse effects caused by ALDFG from that gear type. The first gear category includes boat and shore-based hand dredge, harpoon, spear, lance, tongs, rakes, and hand-collected, including diving. Chart and text from (Gilman et al 2021).

Factor 3.3 - Scientific Data Collection and Analysis

Southeast Pacific | Purse seines | Ecuador

Highly effective

The fishery has in place a monitoring and analysis of the landings since 1981 by the National Fisheries Institute (INP) through the Small Pelagic Fishes Program. In addition, stock abundance is monitored using CPUE as an index of the status of the stock. The data is collected and analyzed, especially before the opening of the fishing season {INP 2023}. Most recently, the management plan for the fishery established a series of actions that aim to improve the collection system to include monitoring impacts on associated species, impacts on the habitat, and the ecosystem (SRP et al 2021).

In recent years, more robust stock assessments were completed annually (e.g. (Canales and Jurado 2021)(Canales and Jurado 2022)). These exercises passed a peer-reviewed scientific process (Minte-Vera 2019), and the assessment included the major, relevant sources of fishing mortality and contains both fishery-independent data, including abundance data, and appropriate fishery-dependent data. In addition, the data collection program has in place a catch composition plan that allows understanding of impacts on non-target species (Jurado et al 2019), and an onboard observers program is in place with a mandatory coverage of 30% of the fishing effort (SRP et al 2021).

As robust stock assessments are conducted with sufficient frequency to account for the dynamic nature of these species and recognize fluctuations in biomass and/or productivity, and both target catches are adequately monitored through an observer program with sufficient coverage, a score of 5 (Highly Effective) is given.

Factor 3.4 - Enforcement of and Compliance with Management Regulations

Southeast Pacific | Purse seines | Ecuador

Moderately Effective

The Under secretariat of Fisheries Resources, through the Directorate of Fisheries Control, executes the Monitoring, Control, and Surveillance (MCS) program, in which fisheries Inspectors are distributed at different points of disembarkation at the national level, carrying out continuous monitoring 365 days a year (DCP 2023) Ecuador has a vessel monitoring system implemented in the purse-seiners since 2020 (SRP et al 2021). The Law of Fisheries and Fisheries Development sets the penalties for violations of the regulations and acts included in that Law, including economic fines, withdrawal of fishing permits, or imprisonment. Compliance with regulations is enforced through inspections at harbors and observers on board commercial vessels {DCP2023}.

Based on these systems in place, it may look like the level of compliance might be enough. However, some recently available reports regarding the existence of illegal fishing activities raise some questions about the effectiveness of the protocols in place. For example, (Ormaza et al 2019) and {PNUD 2019} reported that some irregular activities are common for the small pelagic fishery, such as fishing in closed areas, including the first eight and one nautical miles where purse seines cannot be deployed. Also, details on purse seines sets, that took place within the first eight miles in 2019 (Ponce et al 2020)(Jurado et al 2019). In addition, (Loaiza 2023) reported that local residents of the Cantagallo-Machalilla Marine Reserve have seen industrial ships enter the waters and illegally harvest small pelagic, despite the government order prohibiting this practice. In the same report, the author includes the fact that more than 150 alerts of unauthorized fishing actions were registered within the first eight nautical miles between November 2020 and March 2022 (Loaiza 2023). This unauthorized fishing was carried out by 16 industrial ships for which alerts were issued for unauthorized fishing too close to the Manabí province shore, of those, 14 are dedicated to fishing for small pelagic with purse seines (Loaiza 2023).

Overall, enforcement and surveillance actions are in place, although the effectiveness of these may be uncertain (based on available information) for these reasons we scored this factor as a moderate concern.

Factor 3.5 - Stakeholder Inclusion

Southeast Pacific | Purse seines | Ecuador

Highly effective

In recent years, the Ecuadorian government, in close collaboration with United Nations National Development Program (UNDP), started implementing the Global Marine Commodities Program (GMC) for the small pelagic fishery. The Ministry of Production led the project through the Under secretariat of Fisheries Resources. One of the project's main goals was to include the different stakeholders in the supply and establish "Platforms of Dialogue or Dialogue Tables" for fisheries that increase the synergy and the participation of national and international (retailers, buyers, processors, producers, and authorities). As part of the process, the "Dialogue Table for the small pelagic fishery of Ecuador" was formalized in 2020 under agreement No. MPCEIP-SRP-2020-0054-A.

Through this dialogue table, participants worked together to build the governance scheme, designing and validating, collaboratively, a mechanism for the operation of the table of dialogue

with an emphasis on the representativeness of the interested parties of the fishery for the decision-making. The development of strategic guidelines for the National Action Plan of the small pelagic fishery was considered based on the existing management system. It included the different stakeholders' perspectives on the future development of this fishing activity (SRP et al 2021). The final version of the action plan was socialized and analyzed through sectoral meetings and later appropriate and validated at the dialogue table. The decision-making processes were carried out by equal approval or more than two-thirds of the representatives.

Based on the data available, it seems that the management process is transparent and includes stakeholder input, that a mechanism to address user conflicts effectively is in place, that participation in both the assessment and management process is encouraged, decisions process is transparent, and managers, scientists, and fishers have an effective and constructive relationship. For these reasons, this factor is scored as highly 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	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	FORAGE SPECIES?	SCORE
Ecuador Stock | Southeast Pacific | Purse seines	Score: 3	Score: 0	Moderate Concern	Yes	**Yellow (3.000)**
Ecuador Stock | Southeast Pacific | Purse seines	Score: 3	Score: 0	Moderate Concern	Yes	**Yellow (3.000)**
Ecuador Stock | Southeast Pacific | Purse seines	Score: 3	Score: 0	Moderate Concern	Yes	**Yellow (3.000)**
Ecuador Stock | Southeast Pacific | Purse seines	Score: 3	Score: 0	Moderate Concern	Yes	**Yellow (3.000)**

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.*

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

Southeast Pacific | Purse seines | Ecuador

Score: 3

The four types of vessels that target chub mackerel in Ecuador use purse seine nets with similar operation processes {Jurado & Romero, 2011}. Since the fishery began in the late 1960s, the biggest difference was in changes in the vessel's capacity and autonomy {González 2010}. The fleet operated in both coastal and oceanic areas, especially considering that they aim to cover the vertical distribution of the species schools that live up to 70 fathoms deep (128.16 m) {Okonsky & Martini, 1987}. Studies related to the Ecuadorian continental shelf have been conducted, and a general understanding of the ranging depth from 0 to 200 m represents ~10% of the country's surface {Jimenez & Bearez, 2004}.

In 2019, authorities started to monitor the level of interactions of the gear with the main encountered habitats in Ecuador. To achieve this, the first classified the fleet into four main categories based on their capacity. This was also a factor in estimating the net height that was also categorized for each type of vessel.

Class	T.R.N. (capacity in metric tones, mt)	Theoretical purse seine net height range (meters)
I	1 - 35.9	32 - 55
II	36 - 70.9	46 - 55
III	71 - 105.9	64 - 100
IV	>106	64 - 100

Researchers used the onboard observer's program data to overlap fishing zones with the bathymetric information to evaluate the potential level of interactions of the nets based on the type of vessel and the theoretical height of the net. This study was developed for the 2019, 2020, and 2021 fishing seasons (Jurado et al 2019)(Ponce et al 2020)(Ponce et al 2021). As part of the results, more than 982 sets were analyzed in the 2019 season, 1,620 in 2020, and 1,944 in 2021. Based on the results,

The authors found that interaction with the seabed by class I vessels generally persists, especially since these vessels operate in areas less than 25 m deep (all of them located within 8 nm) or ~17.2% of all the sets analyzed in 2021. About vessels on the class III and IV, a lower interaction was observed in areas with a range between 25-64 m than in areas smaller than 25 m. Compared to what was reported for 2020, the percentages of interaction for both zones (<25 m and 25 - 64 m) showed an increase of 50% and 11%, respectively; this may be largely due to the increase in the number of the sample. Similar to 2020, there was evidence of vessels operating within the first eight nautical miles, areas with little depth and where there would be an interaction with the habitat when making the fishing hauls. Particularly in class I, a large percentage of sets is maintained within 8 nm, representing more than 90% of them during this period.

For this study, sets on fragile bottoms such as coral reefs are not reported (part of the Machalilla National Park Reserve). Within the periods analyzed, it has been shown that the fleet's activities were developed mainly on mixed bottoms made up of sand and silt on the Ecuadorian coast.

The purse seine as a gear generally does not encounter the seafloor (Chuenpagdee et al. 2003). This holds in the Canadian Atlantic mackerel fishery, since they target Atlantic mackerel in midwater (T. DoniolValcroze, personal communication 2019).

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Southeast Pacific | Purse seines | Ecuador

Score: 0

The fishery action plan was officialized in 2021; the document used information on the potential impacts of fishing activity in the habitats. Based on the studies conducted by (Jurado et al 2019), managers recommended keeping carrying out technical studies to fulfill gaps related to the diversity and richness of species that inhabit the habitats most likely to interact with the fishery. In addition, the plan has in place a series of actions to monitor changes in catch composition and the interactions with endangered species via the onboard observers' program (SRP et al 2021).

The fishery management contains a specific goal to "Reduce the interactions with the bottom by 2025" (SRP et al 2021) by using the monitoring program that collects information related to fishing effort, CPUE, size structure, bycatch, and ***habitat impacts.*** Managers aim to assess this goal by *"Defining a maximum limit of acceptable interaction between each class of vessels and the habitat"* and *"Strengthen the control of restrictions on fishing gear, specifically what is stipulated in the Ministerial Agreement No. MPCEIP-SRP-2020-056-A"* which prohibits the use of the "double footrope, skirt or anti-mud" (netting panels arranged along the lead edge of the footrope to protect the net from damage), a measure that has been in place since 2019 under the decree #MPCEIP-SRP-2019-0160-A (MPCEIP 2019).

No information was found on the effectiveness of the measures implemented to date in reducing interaction with seafloor habitats, precluding a modifier to the 4.1 score.

Factor 4.3 - Ecosystem-based Fisheries Management

Southeast Pacific | Purse seines | Ecuador

Moderate Concern

In 2022 (Neira et al 2022) completed an evaluation of the impact of the Small pelagic fishery in the Ecuadorian marine ecosystem. The researchers tested a food web model using Ecopath with Ecosim software (EwE) to quantify the main trophic interactions, and which the species involved underpin Ecuador's small pelagic fishery and assess the potential ecological impacts of exploiting the target species. The results indicated that not all species that sustain the small pelagic fishery would be considered species of low trophic level (their trophic levels varied between TL=2 for herrings and TL=4 for Pacific cornet fish). Predators would not consider them as key prey species. In terms of the species dynamics, it was observed that the changes in their biomass were explained by the fishing mortality (F) but also by trophic interactions through vulnerability to predation and potential changes in the primary productivity of the system in the last 25 years.

Dynamic simulations indicated that applying the target fishing mortality (F_{target}) of each one of the target species (of the Small Pelagic Fishery)(both individually and collectively) did not negatively affect the biomass of their predators. The authors considered a decrease of <25% of their original biomass of the predators as not significant. The results indicated that the predators of the system would not depend significantly on the target species of the purse seine fishery, but on miscellaneous and mesopelagic fish (see the image in justification).

The authors mentioned that results may be affected by the uncertainty in the input data to build the eco-trophic model. In this sense, it was calculated that 34% of the input data to the model is obtained using high-precision quantified methods ("pedigree" analysis) and recommended that future studies aim to improve information on abundances (biomass), rates of production and consumption, and diets of the functional groups of the ecosystem, especially those that most closely interact with the target species of the purse seine fishery. In addition, another source of uncertainty was related to the structure of the model in terms of the groups/species considered and their interactions. In this sense, the structure of the model was conceived from a bibliographical review and then agreed with the counterpart technique in a workshop. However, the current knowledge about the system (especially diets) also influences the structure and interactions. The authors conclude that the assessment needs to be reviewed as new and better ecological information becomes available (Neira et al 2022).

Finally, the FMP has a series of actions that aim to achieve an ecosystem approach and ecosystem-based fisheries' management (SRP et al 2021). Spatial and temporal closures and technical restrictions like mesh size limits are in place. Since the small pelagic targeted by this fishery are key elements of the Eastern Pacific pelagic ecosystem, those fishery management tools may benefit the ecosystem as a whole. In addition, fishing in marine protected areas is also prohibited (SRP et al 2021)

Considering that the fishery is a substantial contributor to forage species fishing mortality, some temporal and spatial management rules seem appropriate to the scale of the fishery and ecology of the stock that is likely to be effective with little scientific controversy (see C1 abundance).

Finally, managers use an appropriate conservative, ecological harvest control rule consistent with the Lenfest Forage Fish Task Force recommendations (Pikitch et al 2012). Managers use a harvest control rule for Pacific chub mackerel (the flag species for the fishery). This HRC is defined before the opening of the fishing season using CPUE data as an abundance index, used to adjust fishing efforts for the upcoming season. The number of fishing days authorized (SRP et al 2021) defines the fishing effort. For these reasons, we deem it a moderate concern.

Justification:

Acknowledgements

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: Key Forage Fish determination

Version 4 of the Seafood Watch Standard for Fisheries (Seafood Watch 2020) updated requirements around 'forage species' thus (Seafood Watch 2020a):

- Criterion 1: Acknowledges the high level of uncertainty associated with static reference points and lower the score where B>Bmsy for forage species (relative to non-forage species). Specifically, static reference points with stationary parameters such as unfished biomass and B_0 are not considered to meet this requirement for forage species, due to those species' dynamic productivity that shifts in response to environmental conditions.
- Criterion 3: Requires adaptive and flexible management to account for environmental driven biomass and fluctuating populations (not just for forage species).
- Criterion 4: Requires a greater understanding of forage species role in the ecosystem to get a moderate concern or better. Addition of a critical score for when there is evidence of fisheries impacting the ecosystem e.g. trophic cascades

According to the glossary to the Version 4 of the Seafood Watch Standard for Fisheries (Seafood Watch 2020):

"Forage species play an important role in food webs because they 1) exhibit high connectance to other organisms in the ecosystem and 2) a large amount of energy is channeled through that species. Forage species typically exhibit highly variable productivity, such that there may be high uncertainty in their reference points, making it difficult to evaluate their stock status. The drivers of this variability in productivity may be environmental forcing and/or other factors. As a result of their importance in food webs these stocks require management that is tailored to their specific life histories and ecological roles. Species that generally qualify as forage species include sandeels, sandlances, herrings, menhaden, pilchards, sardines, sprats, anchovies, krill, lanternfish, smelts, capelin, mackerels, silversides, sand smelts, Norway pout (adapted from MSC Fisheries Standard V2.01, p. 14). Other species or stocks may qualify if they meet the definition above."

In order to determine whether a species within a particular ecosystem is defined as a 'forage species,' it must fulfill both of the criteria in the glossary term: 1) exhibits high connectance and 2) serves as a channel for a large amount of energy. To identify their potential key role, a forthcoming white paper commissioned by Seafood Watch computed three indices using data and food webs applied to existing static ecosystem models. The connectance index and the SUpportive Role to Fishery ecosystems (SURF) index were calculated from mass-balanced models and an energy index from energy-balanced models. Excerpts from that study are presented below. The supporting data are available upon request.

Ecuador marine ecosystem

Neira et al. (2022) developed a food web model to represent the marine ecosystem that supports the small pelagic fisheries in Ecuador. The model area is in the central east Pacific Ocean, ranging from approximately 1°N to 4°S and 82°W to 79°W and includes the entire coastline of Ecuador. It comprises a total area of approximately 44,566 km^2 (Fig. A1) and contains six Marine Protected Areas with a total surface of 1,478 km^2. The model area inhabits all the species that make up the small pelagic fishery off the coast of Ecuador (Fig. A1). The area is affected by the Humboldt Current on the south and exhibits a high

species richness with the highest species richness occurring in the southern part of the model area, the Gulf of Guayaquil (Cruz et al. 2003). Habitat types within the area are diverse and include sandy beaches, estuaries with mangroves, lagoons, rocky shores, mixed substrates, and coral reefs. Neira et al. (2022) developed the food web model to assess the trophic marine food web off the coast of Ecuador, focusing on small pelagic fish species and their role in the ecosystem, and potential impacts by different fishing scenarios. The year 1995 was selected as the model's baseline year as most biomass estimates of the small pelagic stocks and environmental variables were assessed for the first time in that year. Diet data was taken from published literature.

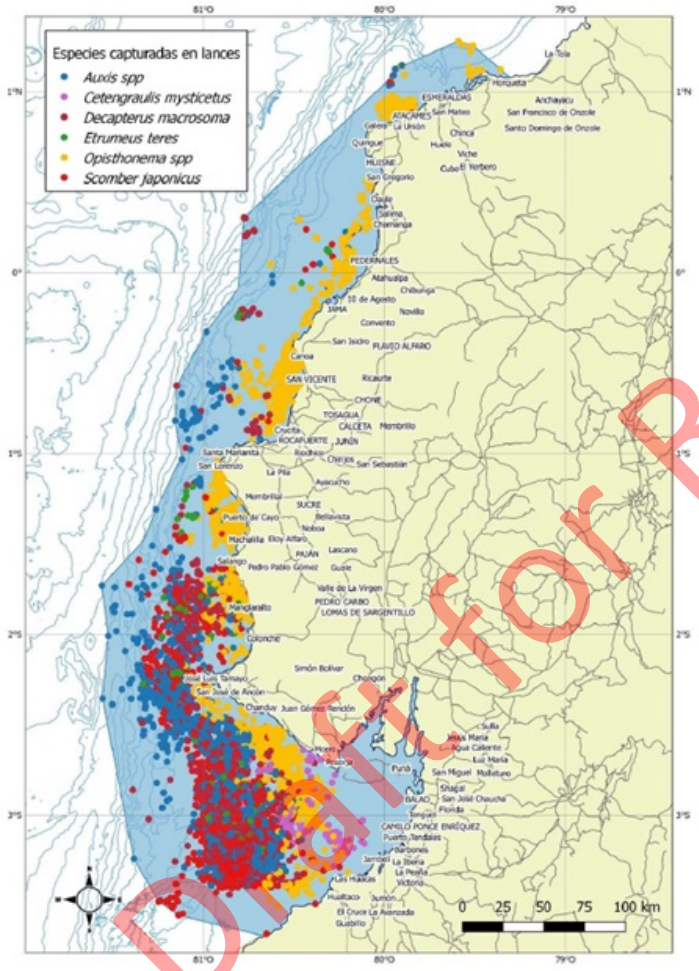

Figure 2: Fig A1. The model area (shaded blue) off the coast of Ecuador as considered in the food web model by Neira et al. (2022). Also shown is the region's bathymetry and catches by the small pelagic fisheries between 2017 and 2021. Image copied from Neira et al. (2022).

Results

Of the species and species groups included in this Seafood Watch assessment, only Pacific chub mackerel meets the criteria for a key forage species in the Ecuador marine ecosystem. * The high occurrence of species' keyness according to the connectance index is due to the fact that this index is affected by species

aggregation in general, whilst SURF is mainly affected by aggregation of forage species (Plaganyi and Essington 2014). The SURF index is used here to determine whether a species meets the connectance requirement.

Species or group name	Connectance*	SURF	Energy
South American sea lion	KEY		
Seabirds	KEY		
Orca and sperm whale	KEY		
Bottlenose dolphin	KEY		
Sharks	KEY		
Humboldt squid	KEY	KEY	KEY
Mahi Mahi	KEY		
Swordfish	KEY		
Tuna spp.	KEY	KEY	
Spotted rose snapper	KEY		
South Pacific hake	KEY		
Other fish (mainly Clupeidae, Nomeidae, Blaistidae and Ostraciidae)	KEY	KEY	KEY
Frigate tunas (Auxis spp.)	**KEY**	**KEY**	
Pacific cornetfish and beltfish	KEY		
Chub mackerel	**KEY**	**KEY**	**KEY**
Mesopelagics (mainly Myctiphidae - lanternfishes)	KEY	KEY	KEY
Eastern round herring	**KEY**		
Pacific anchoveta	KEY		
Thread herring spp.	KEY		
Shortfin scad			
Zooplankton	KEY	KEY	KEY
Phytoplankton	KEY	KEY	KEY
Detritus			KEY
Import			