The artisanal fishery for *Caulolatilus princeps* : Fishing effort data

The artisanal fishery of the ocean whitefish *"Caulolatilus princeps "* in the west coast of the Baja California Peninsula, Mexico

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INTRODUCTION

Coastal fishing in Mexico is an essential component of food security and the economic livelihood of coastal communities, but it faces growing sustainability challenges. National assessments have shown that nearly half of the fishery resources are being exploited to their maximum capacity and more than a quarter are overexploited, with a significant proportion of species experiencing collapse (Arreguín-Sánchez and Arcos-Huitrón, 2011).

The scale fishery, characterized by its multi-species and artisanal nature, requires detailed biological and fisheries information to guide adaptive management measures. In Mexico, the management of the scale fishery falls under the purview of the National Aquaculture and Fisheries Commission (CONAPESCA) and the Mexican Institute for Research in Sustainable Fisheries and Aquaculture (IMIPAS). These institutions are responsible for collecting and publishing data in the Fisheries Statistics Yearbooks, as well as for developing the National Fisheries Charter (CNP), a technical instrument that establishes benchmarks and recommendations for resource management. Both entities also participate in the design and implementation of Fisheries Management Plans specific to each fishery.

Within this group, the whitefish or legfish (*Caulolatilus prínceps*) is one of the most commercially important demersal species in Baja California Sur, where more than 90% of the national production is concentrated (Manríquez Ledezma, 2008; Melo Barrera, 2005). It is primarily caught using handlines and traps at depths of 80 to 150 m over sandy and muddy bottoms. Despite its importance, studies on its population dynamics have been scarce and fragmented, limiting the ability to assess its exploitation status.

The *whitefish (C. prínceps*) is distributed from Vancouver, Canada, to the Gulf of California and from Ecuador to Peru, including the Galápagos Islands, and is found on sandy or muddy

bottoms between 10 and 150 m deep (Fitch & Levenberg, 1971). Globally, Mexico is the main producer of whitefish (Gastélum-Nava et al., 2016). In particular, along the coastal zone of the Baja California Peninsula, *C. prínceps* represents an important resource for artisanal fisheries, as it is caught year-round (Elorduy-Garay et al., 2005). However, the months of greatest fishing effort are from July to September, after which the fishing efforts of the cooperatives shift towards lobster, abalone, and conch fisheries, which generate greater economic benefits for the community.

Recent research has provided key information about its biology. In Bahía La Paz and Bahía Magdalena, size structures dominated by narrow ranges (36–42 cm TL) have been described, with ages reaching up to 23 years and growth parameters that confirm a slow growth pattern and average longevity (Elorduy-Garay et al., 2005; Manríquez Ledezma, 2008). Differences in growth patterns and otolith morphometry have also been identified between the two locations, suggesting the possible existence of distinct populations (Melo Barrera, 2005). Regarding reproduction, recent histological studies in El Rosario show that *C. prínceps* is a gonochoric species, with partial spawning and a prolonged reproductive season from May to November, reaching its peak in June and July; the size at first sexual maturity is estimated at 390 mm TL (ASCIMAR-COBI Report, 2020).

The production of whitefish has been increasing, rising from 829 t in 2008 to 3,384 t in 2017 (SAGARPA, 2017). Leg catches on the west coast of the Baja California Peninsula (Fig. 1) were relatively low; however, starting in the 1990s, production increased to the point of becoming one of the most important species in the artisanal fishery of Baja California Sur (Díaz, 1989). According to catch reports from the Federal Fisheries Offices, the national production of *C. prínceps* in 2005 was 1,061 t, of which 1,022 t corresponded to Baja California Sur. Currently, in the Baja California peninsula, the capture of the white fish is carried out by different cooperatives and fishing actors, where the state of BCS is the one with the largest national production of *C. prínceps* , with a contribution of 95% in 2017 (DGSIAP, 2018).

The current strategy for managing the target species includes a landing registry, regulations (including established permits and fishing gear), a defined fishing zone, and a nominal authorized effort, all of which aim to maintain biomass above the Maximum Sustainable Yield (MSY) level. However, there is insufficient data on the population and the fishery to conduct regular stock assessments for establishing annual quotas or a fishery management plan for the octopus fishery off the west coast of the Baja California Sur Peninsula. Currently, six fishing cooperatives belonging to FEDECOOP operate in the northwestern coastal zone of the Mexican Pacific.

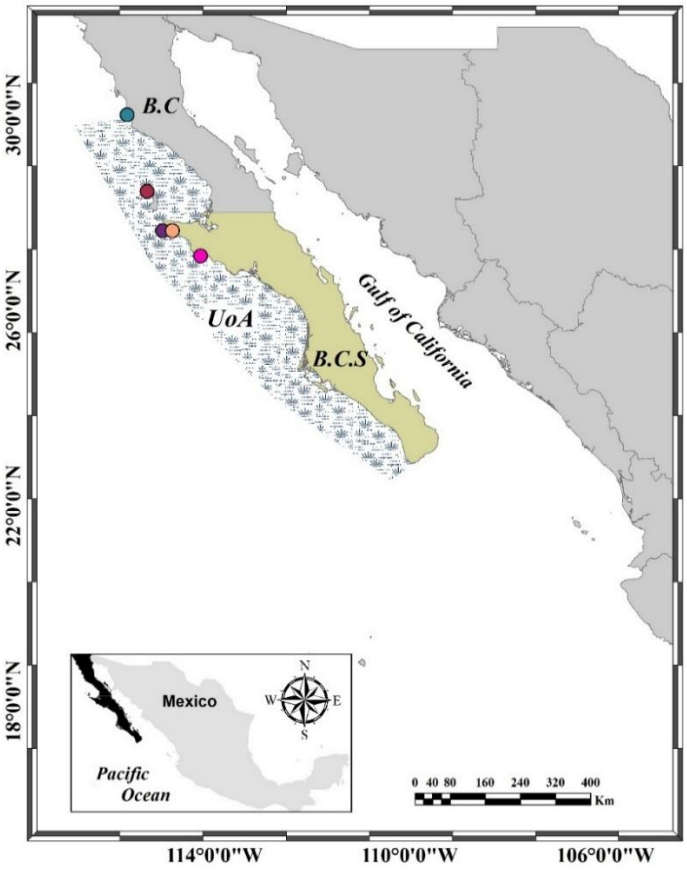

Figure 1. Location of the fishing area of *Caulolatilus prínceps* and of the fishing cooperatives participating in the Fisheries Improvement Project.

Integrating this background information with participatory management approaches, such as Fisheries Improvement Projects (FIPs), allows for progress toward more robust assessments in fisheries with limited data (García-Rodríguez et al., 2024). Their implementation represents a strategic opportunity to advance toward more inclusive and resilient fisheries governance models aligned with international standards such as the FAO Guidelines for Small-Scale Fisheries and the Marine Stewardship Council (MSC) criteria. In this regard, the analysis of fishing effort applied to *C. prínceps* is fundamental to understanding its exploitation dynamics, identifying signs of overfishing, and contributing elements for the sustainable and equitable management of coastal resources.

MATERIALS AND METHODS

Study area

The study area is located on the western coast of the Baja California Peninsula, Mexico, also known as the North Pacific, extending from Vizcaino Bay to Magdalena Bay (Fig. 1). The western

coast of the Baja California Sur peninsula represents an area of high biological productivity and ecological diversity within the Mexican Pacific. This region is part of the California Current (CC) system, one of the most efficient upwelling systems globally, where the interaction between seasonal upwellings, bathymetric gradients, and transitions between temperate and tropical water masses generates highly dynamic oceanographic conditions (Walsh et al., 1974, 1977; Gaxiola-Castro et al., 2010; Durazo, 2015). The presence of short-period variations in the anticyclonic circulation, with ocean gyres that intensify or relax according to the upwelling regime (Amador-Buenrostro et al., 1995), modulates the availability of nutrients and structures primary productivity in the region.

These conditions favor the presence of fish species with tropical, temperate, and temperate-warm transitional affinities (Hubbs, 1960; Walker, 1960; Castro-Aguirre & Torres-Orozco, 1993; Gutiérrez-Sánchez et al., 2007). Climate change is characterized by its persistent variability at different spatial and temporal scales in its physicochemical parameters, induced by oceanographic climate changes (Lynn, 1967; Bernal, 1981; Chelton, 1982). This variability influences biological processes at all trophic levels and, of course, commercially exploited marine populations (Lluch Belda et al., 1989, 1991; Bakun, 1996). Among these, *C. prínceps stands out as* a target species of a high socioeconomic value artisanal fishery for various coastal communities. The interaction between oceanographic processes and essential habitats makes this region a natural laboratory for studying ecological resilience and fisheries sustainability. This area is affected by interannual variability phenomena that impact the abundance of fishery resources; among the most important are warming events such as El Niño and cooling periods such as La Niña (Murphree and Reynolds, 1995).

Caulolatilus princeps fishery

Coastal fishing for whitefish on the western coast of the Baja California peninsula is a highly significant socioeconomic activity for the fishing sector dedicated to its harvesting, management, and commercialization. This resource not only represents an accessible and nutritious food source, but it has also generated direct and indirect employment that benefits hundreds of residents in coastal communities of the region. Whitefish fishing has become a fundamental pillar for subsistence and regional economic development, while also contributing to food security and strengthening the value chains linked to the fishing sector.

The artisanal whitefish fishery is carried out using small fiberglass boats (22-30 feet in length) with outboard motors. The fishing gear commonly used on the Pacific coast consists of traps and handlines (Fig. 1), while in the Gulf of California, fishermen primarily use gillnets. This fishery is practiced with varying intensity at different times of the year. Although fishermen report that the resource is available year-round, greater fishing effort is observed during the months of July through September. After this period, the whitefish fishery is superseded by the lobster,

abalone, and conch fisheries, which generate greater economic benefits for the cooperative.

In the region, 569 fishing permits for marine scale fish have been granted, 116 of which correspond to Baja California and 453 to Baja California Sur. These permits cover a total of 2,358 small vessels (Source: CONAPESCA Arrival Notices). Of the total permits, 142 authorize the use of traps, 68% of which correspond to the western coast of the peninsula and are assumed to potentially use traps and line fishing for target species (Table I).

Table I. Vessels and number of permits that have authorized traps, by locality or coast of the Baja California peninsula region (CONAPESCA, 2020).

Locality	Permit Holders / Fishing Cooperatives	Number of Vessels	NUMBER of Traps
Ejido Villa de Jesús María	3	21	180
Black Warrior	11	43	215
Turtle Bay	7	50	288
Asunción Bay	1	20	160
Cedros Island	2	8	97
Eye Opener Point	1	56	448
Delgadito Field	1	18	90
Saint Ignatius	2	15	75
The Ravines	3	43	155
San Juanico	2	10	34
The Immaculate Conception	1	2	6
The Big Pool	3	24	80
Mary Help of Christians	2	2	6
Santo Domingo	1	15	75
Adolfo López Mateos Port	26	105	329
San Carlos Port	26	65	326
Constitution City	2	5	21
Insurgentes City	2	8	36
TOTAL	**96**	**510**	**2,621**

The traps used on the west coast of the Baja California peninsula for whitefish fishing are rectangular frames covered with plastic-coated galvanized wire and have escape holes to allow undersized fish to escape and prevent ghost fishing. The external structure has two cone-shaped entrances (16 cm in internal diameter) and a post-type chamber for bait (fish guts or sardines). During the day, 5 to 10 casts are made per trap. After each cast, the trap is left to rest on the substrate for 20 to 45 minutes, and then retrieved manually or hydraulically. The traps have biodegradable staples, which allow for their destruction if one is lost on the seabed. Handlines, or lines and hooks, are another fishing method used by fishing cooperatives for whitefish fishing. This fishing technique involves dragging a tackle (an artificial bait) that simulates the swimming of a small fish and has a hook at the end, while on a handline, up to 5 hooks can be used per line.

In Mexico, fisheries management is governed by the General Law of Aquaculture and Sustainable Fisheries (LGPAS) (DOF, 2007). The LGPAS establishes the national policy for fisheries regulation through the Official Mexican Standards for Fisheries (NOM-PESC), which describe specific management measures for each species or group of species. The National Fisheries Charter (CNP) is another legally binding instrument used in Mexico for the management of all the country's fisheries, with annual updates (DOF, 2007). The CNP outlines the strategies and actions that must be implemented to regulate fishing in Mexico, including information on fishing sites and gear, the status of stocks, and fishing effort (DOF, 2018). In addition, researchers from the Mexican Institute for Research in Sustainable Fisheries and Aquaculture (IMIPAS) develop and update fisheries management plans (PMP). Fisheries management plans include actions aimed at developing fishing activity in a sustainable manner and are based on biological, ecological, environmental, economic, cultural and social knowledge.

RESULTS AND DISCUSSION

Annual production of whitefish in the Baja California Peninsula between 2010 and 2024 shows marked interannual variability, with significantly higher volumes in Baja California Sur compared to Baja California (Fig. 2). During this period, Baja California Sur reached peak production exceeding 4,000 tons in 2017, while Baja California registered lower and more fluctuating values, with lows of 250 tons in 2016 and highs of 651 tons in 2010. The Unit of Analysis (UoA) reflects this dynamic with a production range that oscillated between 600 and 1,500 tons, highlighting the importance of this resource for the coastal communities of the Baja California Peninsula's west coast. These trends suggest the influence of environmental factors, fishing effort, and regulatory measures, and underscore the need to strengthen monitoring and adaptive management systems to ensure the long-term sustainability of the whitefish fishery.

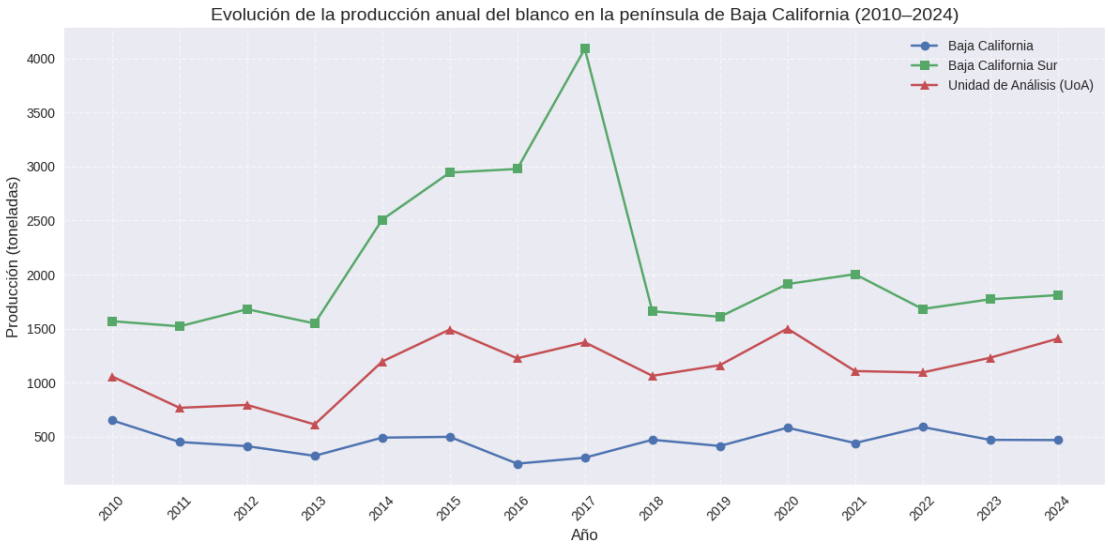

Figure 2. Annual production of white wine in the Baja California peninsula between 2010 and 2024.

Whitefish production shows significant contrasts between states . In Baja California Sur, positive growth and high variability are observed, with peaks of over 4,000 tons in 2017. In Baja California, on the other hand, the trend is negative, with an average annual reduction of −2.33% and lows of only 250 tons in 2016. The Analysis Unit (AU) reflects an intermediate trend, with a positive growth rate (+2.06%) and less variability than BCS. These results suggest that the whitefish fishery is strongly influenced by environmental factors, fishing effort, and local regulations , generating marked differences between states. The high variability in BCS indicates a greater dependence on external conditions and the need for more robust monitoring , while the negative trend in BC suggests potential problems of overexploitation or reduced fishing effort.

Although both catch series, UoA and global (BCS), showed a linear upward trend (Fig. 2 and Fig. 4), the global catch (BCS) exhibited high variability, with a sustained increase from 2010 to 2017 (4090 t) and a drastic drop in 2018 (1661 t), 59% of the 2017 catch. This is not explained by the greater interannual variability and consistency (R2 = 0.46) of the Pacific catches (UoA). This points to two very different fisheries dynamics and motivated the analysis of the interannual variability of whitefish catches in the Gulf of California and their relationship with the global catch (Fig. 2).

The regionalization of whitefish (*Caulolatilus princeps*) fishing grounds and areas is a strategic input for advancing towards adaptive spatial management schemes (Fig. 3). By integrating information on operating areas, relevant habitats, and fishing gear used, it facilitates the identification of interactions between the artisanal fleet and ecosystems, as well as the assessment of impacts on species of conservation interest (SCEs). This approach allows for linking

fishing activity with international sustainability criteria, such as the FAO Guidelines for Small-Scale Fisheries and the Marine Stewardship Council (MSC) principles, promoting practices that reduce the risk of serious or irreversible habitat damage. Consequently, regionalization not only strengthens the monitoring and planning capacity of cooperatives but also constitutes a fundamental step towards consolidating more inclusive and resilient fisheries governance models.

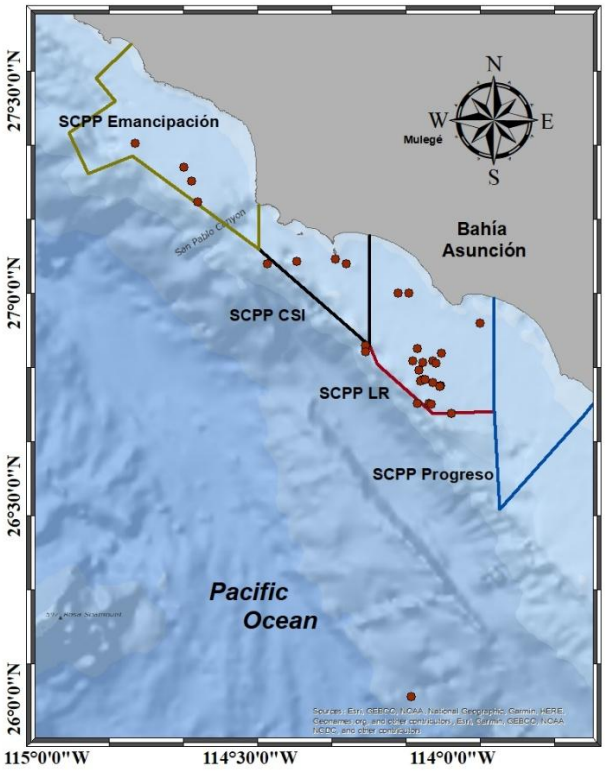

Figure 3. Regionalization of the regions and fishing points of the white (*Caulolatilus prínceps*) corresponding to the cooperatives that participate in the Fisheries Improvement Project.

Continuous monitoring and systematic collection of fisheries, biological, and bioeconomic data are essential for generating robust evidence and establishing comprehensive management plans that ensure no fishing activity causes serious or irreversible damage to habitats. Furthermore, the recorded bioeconomic data allows fishing cooperatives to analyze the efficiency of their operations, design adaptive management strategies, and set sales prices that reflect production costs. This type of information is also valuable for documenting habitat changes over time, as it enables the assessment, at the fishing sites themselves, of the impact of the gear used and its cumulative effect on the ecosystem.

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