Population stock of the white shrimp *Litopenaeus vannamei* in Marismas Nacionales, Nayarit

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I. Introduction

Shrimp fishing is one of the most important fisheries in Mexico, with the Mexican Pacific being the region where the largest share of the total shrimp catch (~92%) is extracted (SAGARPA, 2021). This fishery ranks third in terms of production volume; however, it ranks first in Mexico in terms of commercial value. Shrimp catches in the Mexican Pacific consist mainly of three species: blue shrimp *Litopenaeus stylirostris* (Stimson 1871), white shrimp *L. vannamei* (Boone 1931), and brown shrimp *Farfantepenaeus californiensis* (Holmes 1900), as well as other penaeid shrimp species. Shrimp of the genus *Litopenaeus* spend most of their time in areas influenced by or closely associated with river deltas, estuaries, or coastal lagoons. Migratory movements are due to the nature of their life cycle, which is dependent on estuaries or coastal lagoons, which they use as areas for protection, feeding, and growth.

The white shrimp (*L. vannamei)* is distributed from Sonora, Mexico, to Peru. In Mexico, the highest catches in marine and protected waters are obtained in southern Sinaloa, Nayarit, and the Gulf of Tehuantepec. It is a species that also inhabits sandy and clay bottoms (Hendrickx, 1996). Data from the industrial fleet indicate that this species has been caught at depths of up to 50 fathoms, although the greatest abundance is found between 5 and 15 fathoms deep in the open sea.

The white leg shrimp fishery that takes place within the Biosphere Reserve Marismas Nacionales in Nayarit (from now on BRMN) is one of the most important economic activities within the federal protected area. Fishing activities are the main source of food and livelihoods for the local communities. According to Carvajal-Rascon et al. (2017), between 12,000 and 14,000 fishers participated in fishing activities that generated up to $170 million pesos (~$ 9 million USD). The average production of white leg shrimp ranged between 4 and

6 thousand tons, which represented ~55% of the total annual fisheries' production in the region (Carvajal-Rascon et al. 2017).

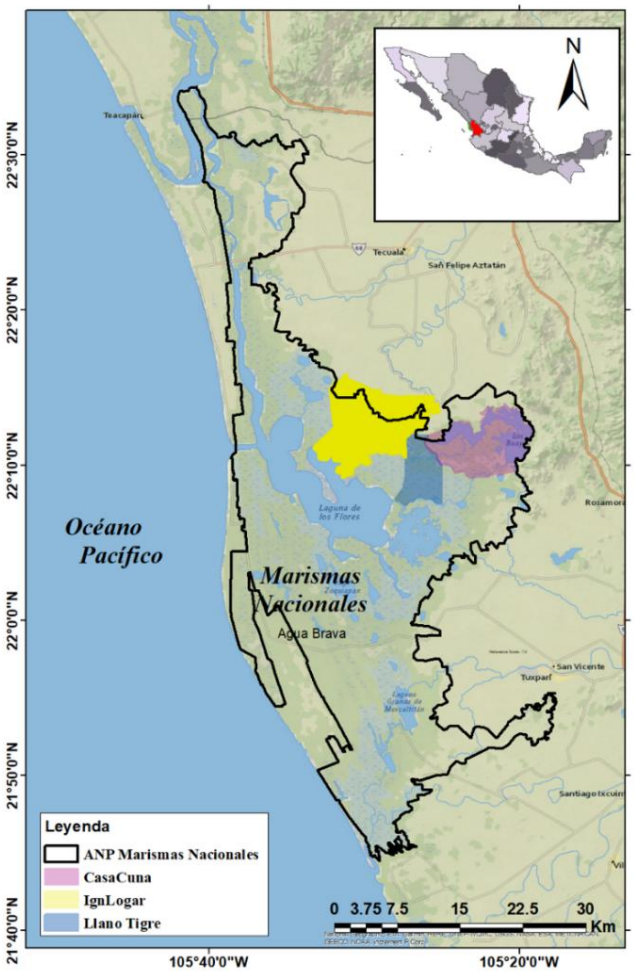


Figure 1. Location of the Marismas Nacionales Biosphere Reserve and fishing areas corresponding to the fishing cooperatives participating in the FIP.

The most important economic activity is the shrimp fishery, which is carried out by fishers who are divided into two categories: free fishers (those who work with individual fishing permits or engage in the activity illegally) and members of one of the local cooperatives (Carvajal-Rascon et al. 2017). In addition to the authorized gear (cast nets), local producers in the region use a traditional system of wooden piles (mostly mangrove) that are placed on the sea bottom across the estuary channels, known as tapos.

Artisanal fishing techniques and areas

The management program identifies ~15 different areas for shrimp extraction within the BRMN, which are utilized by around 25 fishing cooperatives that hold authorization for the extraction of various species. The three most important species groups are white leg shrimp (WLS), finfish (or Escama), and oysters (SEMARNAT-CONANP 2013).

The artisanal shrimp fishery in Nayarit is carried out in the lagoon and estuary systems of Marismas Nacionales using small boats (<12 m in length). This fishery comprises 636 vessels belonging to 25 fishing cooperatives. The cast net is the traditional fishing gear and is constructed with monofilament nylon line of 0.20 to 0.25 mm in diameter and a maximum height of up to 6 meters (Fig. 2). Mexican Official Standard NOM-002-PESC-93 establishes that the cast net used for shrimp fishing within lagoon systems must have a mesh opening of 1.5 inches (38.1 mm).

Figure 2. Cast net fishing gear used in the shrimp fishery in Marismas Nacionales, Nayarit.

The shrimp fishery in Marismas Nacionales is governed by Mexican Official Standard NOM-002-PESC-1993 (DOF, 1993) and its subsequent amendments (DOF, 1997; DOF, 2006) to regulate the harvesting of shrimp species in federal waters of the United Mexican States. Among the main features regulated by NOM-002-PESC-1993 is the protection of

breeding and juvenile populations through the establishment of closed seasons and areas, in order to ensure a sufficient number of individuals for subsequent life cycles. The National Fisheries Charter (CNP) is also in place, a legal and regulatory instrument that contains, among other aspects, the status of populations and their fisheries, as well as the guidelines and management strategies for fisheries in Mexico by region.

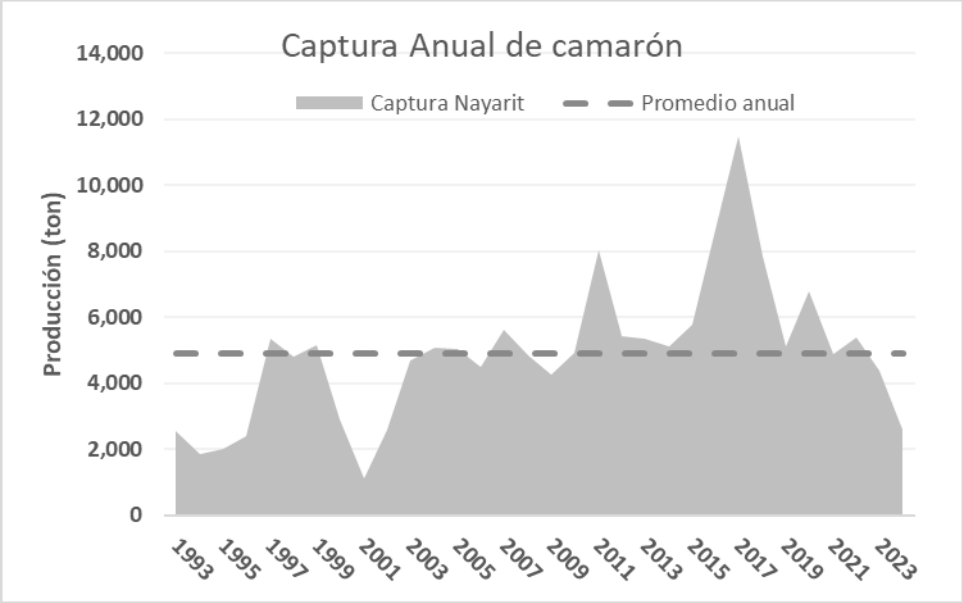


Figure 3. Catch and annual average of *Litopenaeus vannamei* for the state of Nayarit. The dashed line corresponds to the annual average of catches during the period 1993-2024.

Shrimp fishery in Nayarit

In Mexico, between 1993 and 2024, an average of approximately 60,000 tons of wild shrimp were recorded, reaching a record high of approximately 84,000 tons in the 2015 season. Generally, shrimp catches fluctuated around 46,000 tons annually during the 1990s. From the 2000s onward, shrimp catches showed an upward trend, exceeding 50,000 tons annually, possibly due to the expansion of the fishing fleet and fishing grounds. However, since reaching its historical peak in 2015, catches have shown a downward trend (Fig. 3).

The shrimp fishing season lasts between six and seven months, beginning in August or September and ending between March and April. Approximately 70% of the total catch is obtained in September, October, and November alone; the rest of the year, the catch decreases to about a third of the initial amount.

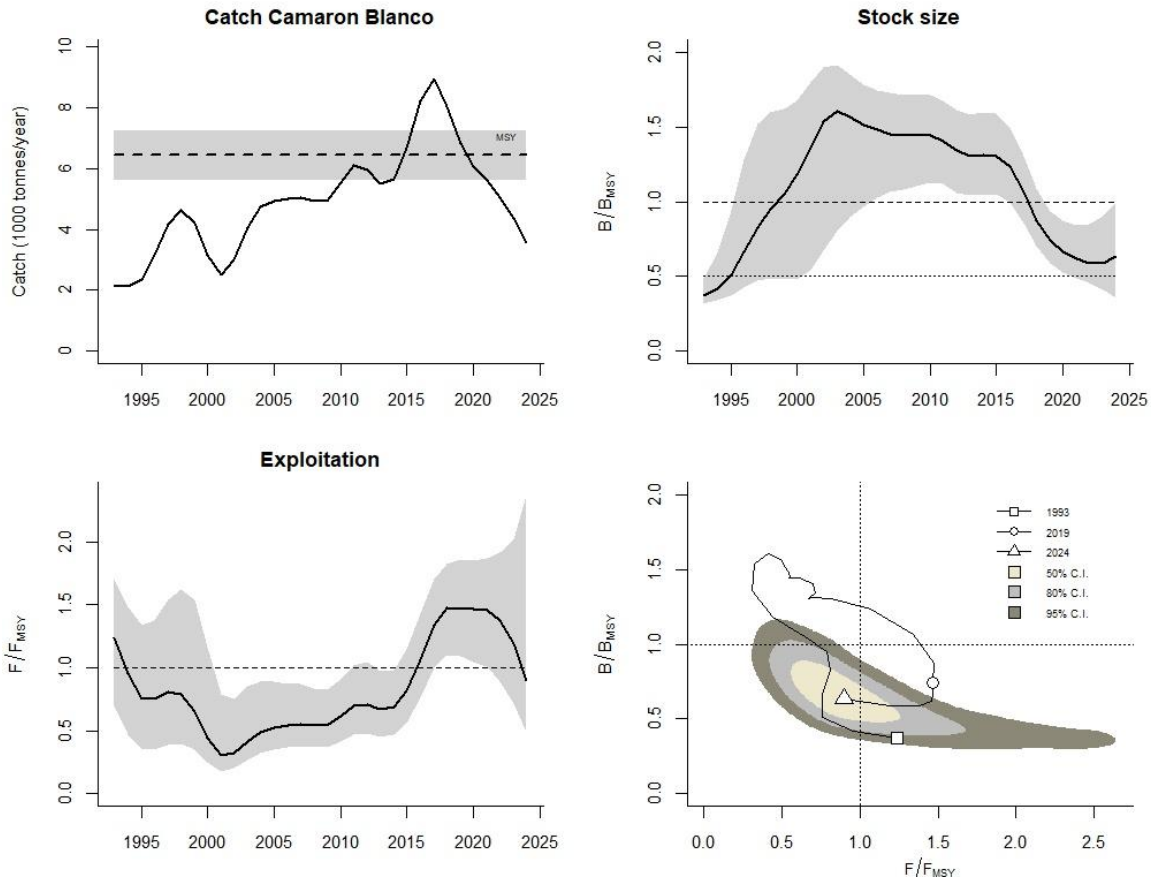


Figure 4. Reference Points, results of the CMSY model (UoA). a) annual catch (2006-2025) of white shrimp, b) stock size, c) exploitation level rate, d) Kobe diagram, trajectory, and current state of the resource. The dashed lines represent the maximum sustainable yield point (MSY).

The model was applied to Maximum Sustainable Yield to assess the shrimp population stock and determine benchmarks in the shrimp fishery, as well as estimate biomass and maximum sustainable yield. The results from the analysis according to CMSY can be important not only in terms of assessment but also for promoting sustainable fisheries management. The objective of this study was to determine the commercial exploitation status of the population. *Litopenaeus vannamei*, in the coastal region of Nayarit, according to catch data from the small fleet.

Regarding annual shrimp catches in Nayarit, these averaged approximately 4,890 thousand tons, with a historical maximum of approximately 11,490 tons of annual catch in

2017. In general, during the period studied, an upward pattern of catches was observed; however, in recent years, catches have fallen below the maximum sustainable yield (Fig. 4).

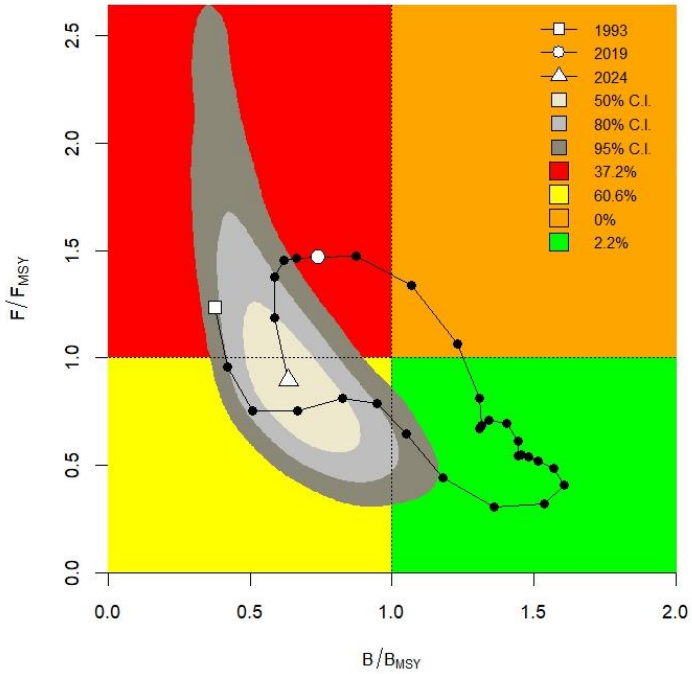


Figure 5. Status of the *Litopenaeus vannamei resource*, According to the CMSY model output. Kobe diagram, with 1993-2024 trajectories of fishing mortality (F) and biomass (B) corresponding to MSY (green quadrant = favorable, yellow quadrants = need for caution with effort reduction measures, red quadrant = unfavorable with need for management).

The Kobe diagram (Fig. 5), which describes the fishery's trajectory based on the relationship between biomass and fishing activity, shows that the fishery remained in a favorable state from 1999 to 2014 without population depletion or overfishing ($F/F_{MSY} < 1$ and $B/B_{MSY} > 1$). During 2015 and 2016, there were no serious signs of depletion ($B/B_{MSY} > 1$), but there were signs of maximum fishing activity and overfishing ($F/F_{MSY} > 1$). After 2017, the state of the fishery has been unfavorable, with indicators of overfishing ($F/F_{MSY} > 1$) and biomass depletion ($B/B_{MSY} < 1$).

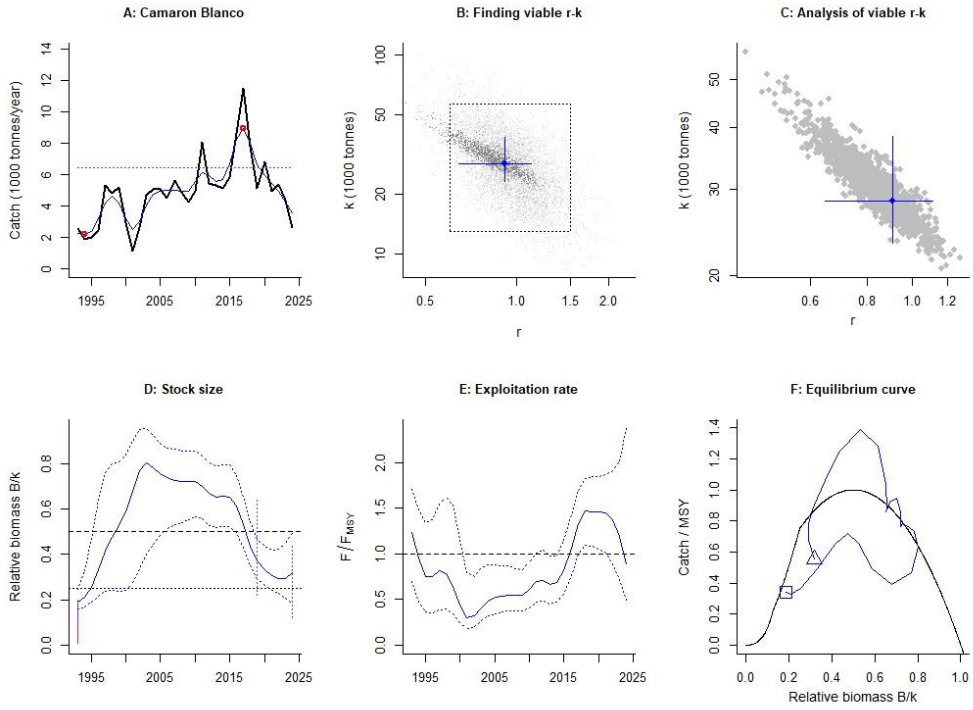
Determining age, estimating growth, and conducting reproductive and mortality studies are necessary for using fisheries assessment models, such as population dynamics and age-structured models, to establish the most effective management measures. In multispecies fisheries, fisheries management is complicated by the highly uncertain and complex interactions between fish populations and between fishers and fish populations, as well as by the high data requirements.

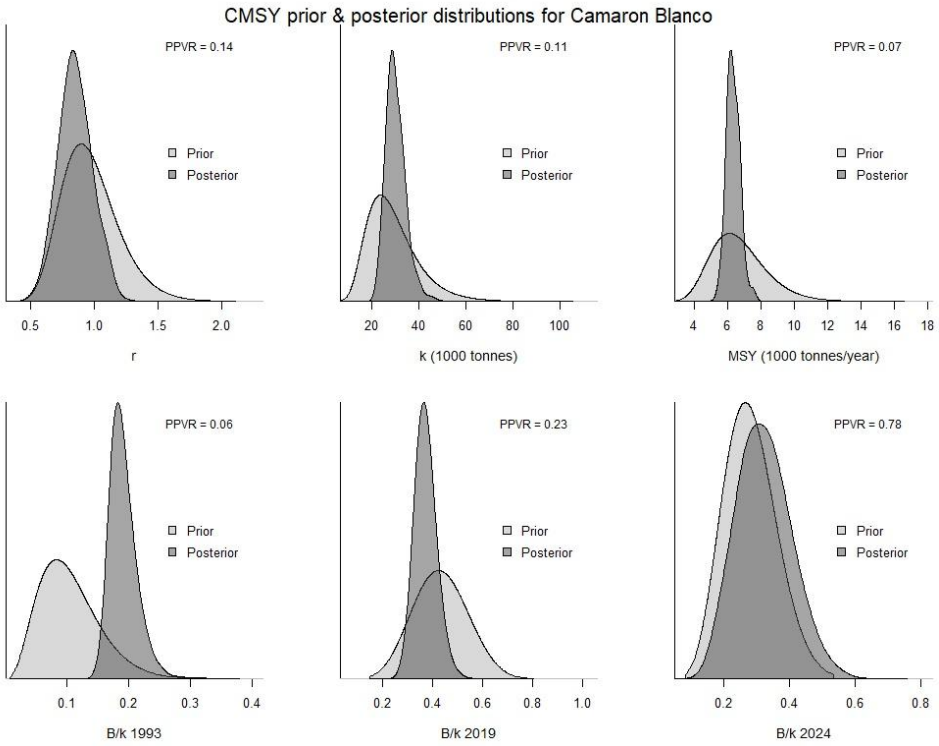
Conclusions

The application of the CMSY model allowed us to estimate the main population and exploitation parameters for the species *Litopenaeus vannamei* in the fishing areas of UoA (Marismas Nacionales, Nayarit).

The results indicate a situation of overfishing and relative depletion of biomass, which requires urgent management measures.

Exhibit.





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