



Advances in biology through agronomy, aquaculture, coastal and environmental sciences

— Volume II —

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**Advances in biology through
agronomy, aquaculture, coastal and
environmental sciences**
Volume II



Pantanal Editora

2026

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Catalog sheet

Cataloging in publication
Prepared by a Librarian Janaina Ramos – CRB-8/9166

A244

Advances in biology through agronomy, aquaculture, coastal and environmental sciences - Volume II /
Editors Leandris Argente-Martínez, Ofelda Peñuelas-Rubio, Joe Luis Arias-Moscato. – Nova
Xavantina-MT: Pantanal, 2026.
362p. ; il.

Book in PDF format

ISBN 978-65-85756-79-2

DOI <https://doi.org/10.46420/9786585756792>

1. Biology. 2. Agronomy. 3. Aquaculture. 4. Environmental sciences. I. Argente-Martínez, Leandris
(Editor). II. Peñuelas-Rubio, Ofelda (Editor). III. Arias-Moscato, Joe Luis (Editor). IV. Title.

CDD 570

Index to systematic catalog

I. Biology



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Advances in Biology through Agronomy, Aquaculture, Coastal and Environmental Sciences, Volume II, is an e-book that continues the work of the first version (<https://editorapantanal.com.br/ebooks/2023/advances-in-biology-through-agronomy-aquaculture-coastal-and-environmental-sciences/ebook.pdf>), published in 2023 by Leandris Argente-Martínez and Ofelda Peñuelas-Rubio.

Our e-book compiles 25 manuscripts that present scientific results and reviews based on biological aspects. All of them contribute to explaining the responses of living organisms to agricultural, aquaculture, and coastal ecosystems, as well as those facing fragility or threat of climate change. This e-book was edited by Leandris Argente-Martínez, Ofelda Peñuelas-Rubio, and Joe Luis Arias-Moscote, members of the Consolidated Academic Group ITVAYA-CA-3.

We appreciate the contribution of all authors for their careful attention to the editorial committee's recommendations. The review process was double-blind and conducted by internationally renowned researchers.

Special thanks to the members of the BioSecuraNet International Network for Biotechnology and Innovative Strategies for Global Food Security at the National Technological Institute of Mexico.

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Linkage among climatic variation and artisanal fisheries behavior of common snook (*Centropomus undecimalis*) in tropical Atlantic coast

Received: 14/04/2026

Accepted: 06/05/2026

doi 10.46420/9786585756792cap21

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ABSTRACT

The artisanal fishery of common snook *Centropomus undecimalis*, is of high socio-economic importance along the coasts of Tabasco, Mexico. Understanding its temporal dynamics is essential for sustainable management. This study aimed to analyze the temporal variability of catch per unit effort (CPUE) and its relationship with fishing effort, environmental factors (precipitation and temperature), and El Niño–Southern Oscillation (ENSO) anomalies. A directed sampling design was applied based on fishing cooperatives with the highest landings. Data from logbooks (September 1999 to June 2005) and direct vessel records were analyzed. CPUE was calculated as total catch (kg) per boat. Monthly variation was evaluated over a 19-month period, and correlation analyses were performed to examine relationships between CPUE, environmental variables, and ENSO anomalies. Marked seasonal fluctuations in CPUE and total catch were observed, associated with reproductive migration and life cycle patterns. The highest CPUE peaks occurred in January–February and July–October 2000 (86.43 kg and 37 kg, respectively), coinciding with increased fishing effort. Although no statistically significant correlations were found between CPUE and environmental variables, higher catches were associated with periods of increased precipitation and optimal temperatures (25–29°C). Negative ENSO anomalies corresponded with higher rainfall, which in turn was linked to increased fishing effort and CPUE. A decreasing trend in CPUE over time was observed, although it was not statistically significant ($r^2 = 0.14$). The common snook fishery in Barra San Pedro is influenced by the interaction between fishing effort, hydrological conditions, and climatic variability. These findings highlight the need for long-term monitoring and further research to support sustainable fisheries management.

Key words: common snook, Gulf of Mexico, CPUE, artisanal fisheries, ENSO

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INTRODUCCIÓN

The common snook (*Centropomus undecimalis*) is the most important commercial species of snook in Gulf of Mexico coast. This species represents an important incoming for artisanal fishermen of Tabasco, Veracruz and Campeche states, representing the 68% (Perera-García et al., 2012, Contreras-García et al., 2024). Common snook is an accessible resource for the most of fishermen; the reasons are related with its migratory habits along rivers of Tabasco and for the easiness to catch it. High technifications is not necessary, only are necessities small boats with or without outboard motor, seines named “robaleras” or special tarpons known locally as “fizga” (Caballero, 1995). Almost for Tabasco the capture per unit effort (CPUE) and total catch along year present a marked decline. This diminution in total catches and CPUE could be related with an accelerate increase in effort and probably to change in pluvial regimes, river curse modifications and water pollution (Quiroga, et al., 1996; Muhlia et al., 1994; Caballero, 2003, Perera-García, 2011).

On the other hand, total catch and CPUE of common snook in Tabasco present a noticeable seasonal fluctuation. These fluctuations are related with its life cycle and principally with its reproductive migration. However, from Tabasco aquatic ecosystems the life and reproductive cycle are not well known and it is probably that the size of reproductive school and migratory season could be related with change in environmental conditions. In certain form this variation could be related with local variation of environmental conditions but influenced strongly by global climatic anomalies. ENSO phenomena originating in the southeastern Pacific could directly influence fish assemblages and fisheries in rivers and coastal waters over a large portion of the earth (Fiedler et al., 1986, Swales et al., 1999, Sanchez-Velaso et al., 2000, Hernández-Vidal et al., 2014). For these reasons is very important to consider the possible relation among total catch, CPUE of common snook in Tabasco coast and local environmental variations as rain and sea surface temperature and its relation with global climatic anomalies.

MATERIALES Y MÉTODOS

Study site

The study was carried out at the fishing port of Barra de San Pedro, located in the municipality of Centla, in the state of Tabasco, Mexico. This municipality is situated in the hydrological region of the Grijalva and Usumacinta rivers, within the Pantanos subregion, with its municipal seat being the city and port of Frontera. Barra de San Pedro is located on the Gulf of Mexico coast, east of Frontera, approximately 22.3 km to the southeast. Its geographic coordinates are 18.6422° north latitude and - 92.47124° west longitude, and it lies at an approximate altitude of one meter above sea level, characterizing it as a low-lying coastal zone influenced by hydrological and marine processes (INEGI, 2022).

Data collection and analysis

Common snook fishery data were collected directly in a particular storage center located in San Pedro Port, Centla, Tabasco. A directed sampling design was implemented based on the cooperatives where the highest catches were recorded. At the landing site, the common snook (*Centropomus undecimalis*) is distinguished from other snook species under the local name 'common snook' (robalo blanco).

The monthly average sea surface temperature along the fishing area was estimated from weekly sea surface temperature images based on OI.v2 analysis (Reynolds et al., 2002). Weekly sea surface temperature images were obtained from the web site of the International Research Institute for Climate Prediction (2003). Monthly average precipitation of Grijalva-Usumacinta hydrological basin, which influences the hydrology and salinity of the fishing area, was estimated from monthly images (Adler et al., 2003). Images were acquired from the web site of the Global Precipitation Climatology Centre (2004).

For the purposes of this study, statistical information recorded (logbooks) on arrivals by cooperative from September 1999 to June 2005 was available, as well as data collected directly from the boats that arrived at the cooperative. Assuming that this value is proportional to the abundance of a resource, the following equation was applied:

$$CPUE = C/E$$

where: (C) is the total catch and (E) is the fishing effort.

In general terms, and due to the absence of more precise data, CPUE was expressed based on kilograms of snook caught per boat. The temporal variation (monthly variation over 19 months) was analyzed. The latter defined the variation in the abundance of these species over time, allowing inferences about the relationships between this abundance and local climatic variations (Sparre; Venema, 1995). A correlation analysis was estimated (Gulland, 1983; Sparre; Venema, 1995).

RESULTS AND DISCUSSION

It was observed that the artisanal white snook fishery on the coasts of Tabasco exhibits seasonal fluctuations in total catch and catch per unit of effort (CPUE), associated with its life cycle and reproductive migratory habits. CPUE showed variations over the last seven years, with peaks in January–February and July–October 2000 (86.43 kg and 37 kg), related to higher fishing effort. Subsequently, in November–December, catch decreased to 7.9 kg per vessel, coinciding with a reduction in effort. In later years, catch increased to 67.80 kg in May–June 2001 and September–December 2002, then declined along with effort. Overall, CPUE shows a downward trend per vessel (Figure 1), although without a significant correlation with time ($r^2 = 0.14$).

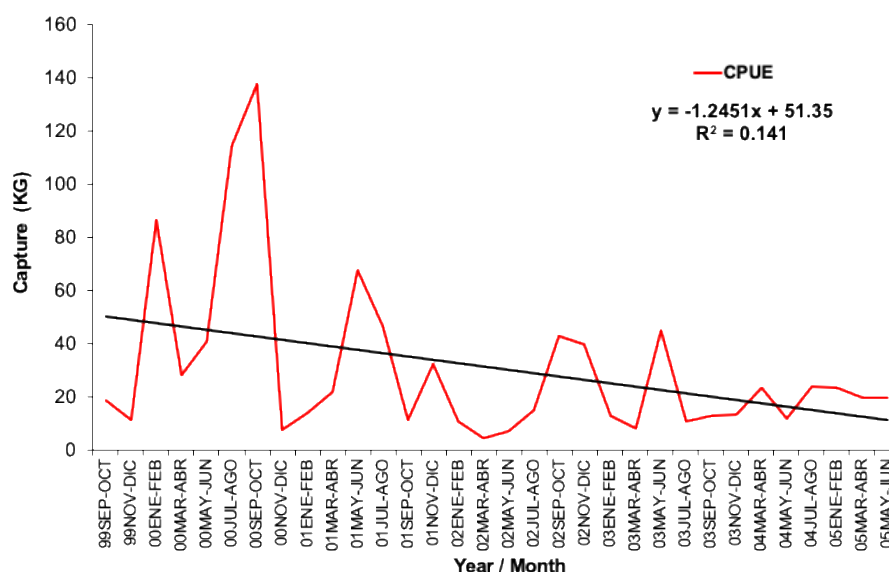


Figure 1. Bimonthly variation of catch per unit of effort (CPUE) for *C. undecimalis* observed from September 1999 to July 2005, at San Pedro Port, Centla, Tabasco.

These results coincide with the spawning and reproductive migration periods, particularly in the months of May, June, and July, suggesting a greater availability of the resource during these seasons. Considering CPUE as an indirect indicator of abundance (Yañez-Arancibia; Sánchez, 1988; França; Olavo, 2015), it is inferred that there was a greater availability of the resource in certain periods; however, catches did not follow a defined trend in subsequent years. This variability coincides with reports from fishermen, who indicate an increase in fishing pressure, as well as impacts derived from human activities such as pollution, sediment input, and alteration of coastal ecosystems—factors that have contributed to the decline in the biomass of *C. undecimalis* (Gilmore et al., 1983, Chávez, 1989, Quiroga et al., 1996, Farías-Tafolla et al., 2022).

Regarding the results relating ENSO (El Niño–Southern Oscillation) anomalies to rainfall peaks in Tabasco, it was observed that when ENSO anomalies are negative, higher rainfall peaks are recorded. In contrast, during positive anomalies, precipitation decreases or is distributed more evenly throughout the year, with even more than two rainy periods occurring, as observed between 1993 and 2003. Likewise, fishing effort shows a close relationship with these changes in the hydrological regime, as the highest effort peaks coincide with maximum precipitation. This behavior was reflected in both total catch and catch per unit of effort (CPUE), and a general decreasing trend in both parameters over time was also observed (Figure 2).

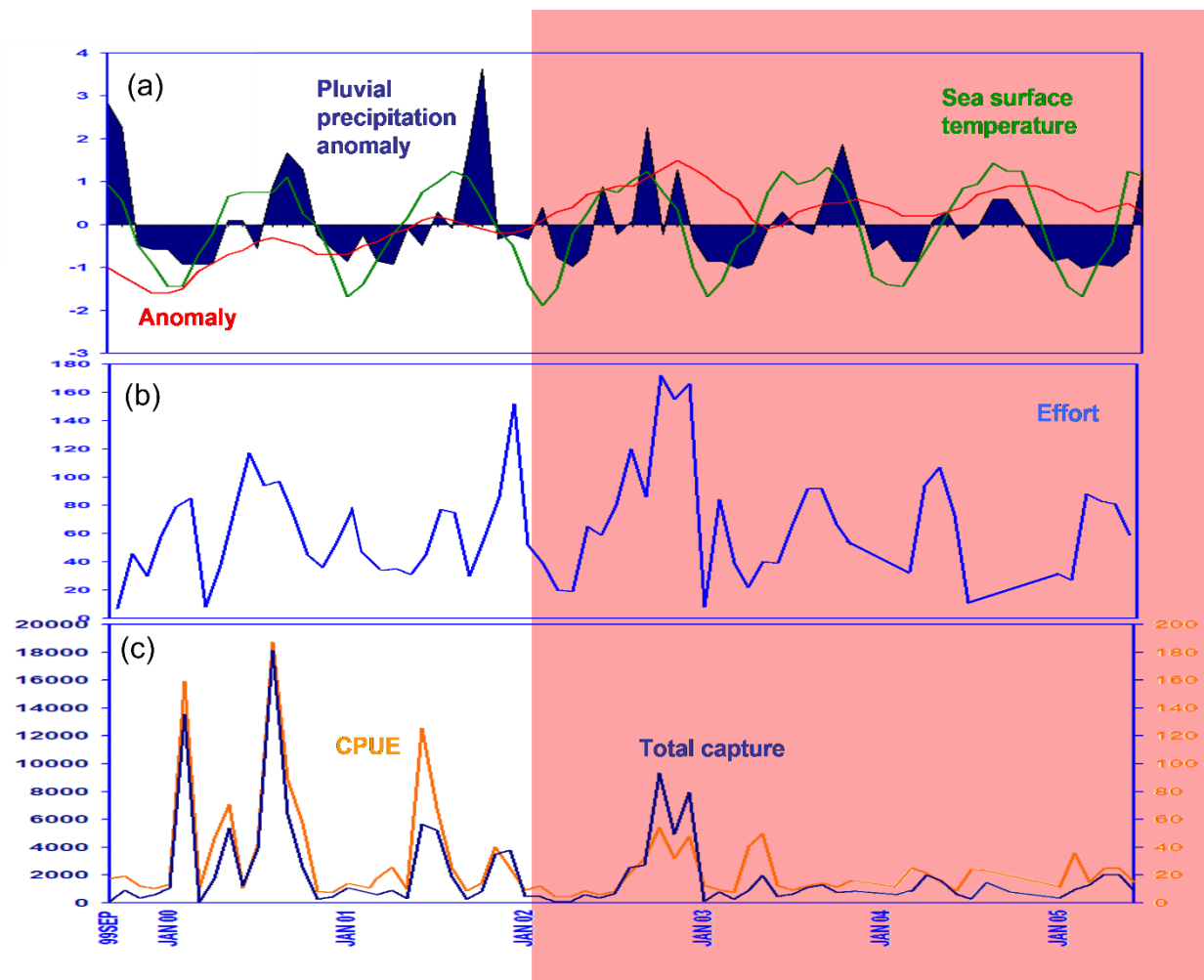


Figure 2. Annual values for (a) anomalous rainfall at the Barra San Pedro port, Centla, Tabasco, (b) fishing effort, and (c) catch per unit of effort (CPUE). The shaded areas show the relationship between fishing effort, rainfall regime, and CPUE from 1999 to 2005, respectively.

A relationship was established between effort and CPUE over three different time periods (Figure 3). Prior to the El Niño event, there is an exponential increase in CPUE in response to increased effort. During the El Niño event, effort increases twice but no significant increase in CPUE is observed. After the El Niño event, the effort-CPUE relationship becomes negative. It is important to note that in two particular cases before the El Niño event, effort is very high but CPUE is too low, breaking the mathematical relationship; these points correspond to the beginning and end of the fishing season. This is related to fisher behavior and seasonal variation in the abundance of snook

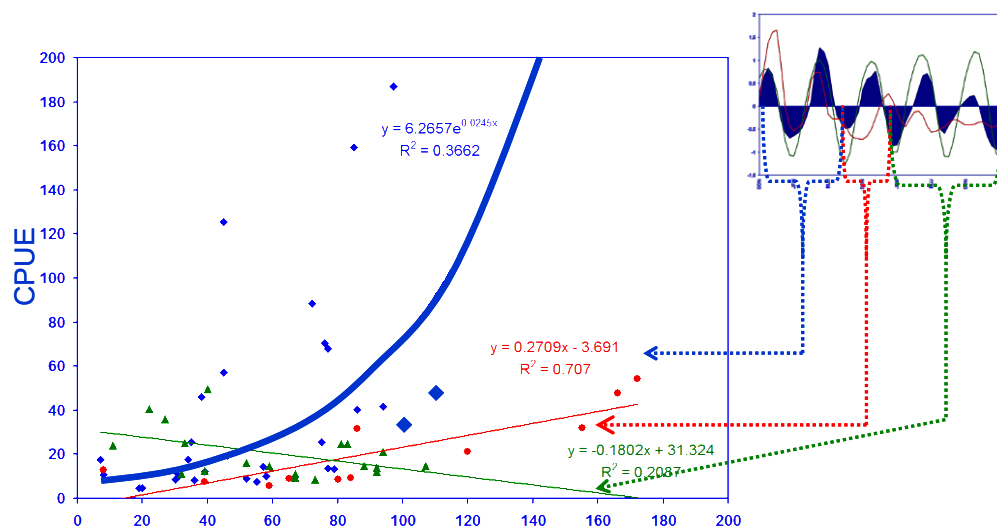


Figure 3. Relationship between fishing effort and CPUE of *C. undecimalis* before, during, and after the El Niño event at Barra San Pedro, Centla, Tabasco.

Although no statistically significant correlations were found between CPUE and environmental variables, a biological relationship with precipitation and temperature is possible (similar result in Matsunaga, 2017). The highest catches occur under heavy rainfall and temperatures of 25–29 °C, which favor recruitment and growth. Nutrient-rich riverine inputs have positive effects on recruitment, growth, and mortality, enhancing the productivity of *C. undecimalis*, while temperature directly affects its recruitment and spawning (Gilmore et al., 1983; Ramírez-Rodríguez et al., 2006). Likewise, enrichment from the river mouth, micro-upwellings (Díaz et al., 1999), nutrients from the upper basin, and coastal upwelling influence growth, mortality, and recruitment, thereby reinforcing fishery production (Grimes, 2001; Gamboa-García; Galván-Duque, 2023). These factors partially explain the spatiotemporal differences in catch and CPUE. Together, the findings reveal the complexity of the fishery system at Barra San Pedro, where fishing effort, environmental conditions, and ecological processes interact. As indicated by Weng and Sibert (2000), areas with high CPUE are relevant when they contribute significantly to total production, whereas areas with high effort and low CPUE may indicate excessive pressure or resource degradation, underscoring the need for science-based sustainable management strategies.

CONCLUSIONS

Given the social and economic importance of this resource, it is necessary to continue research on its biological and fishery aspects in order to achieve sustainable use. Selectivity studies of the fishing gear used to capture these species should be carried out, using appropriate mesh sizes, with special attention to those that cause the least environmental damage and, above all, retain organisms with average sizes close to the size at first capture. In Tabasco, the magnitude of the fishing effect on *C. undecimalis*

populations is unknown. It is necessary to establish permanent monitoring programs in order to obtain reliable data for decision making based on the biology and fishery dynamics of the resource.

It is advisable to expand knowledge about the population structure of this species through age and growth studies using indirect techniques (reading of bony structures and modal progression of sizes), systematically collecting data on this fishery. Studies on the magnitude of mortality through mark recapture experiments could constitute a fruitful field of collaboration with research institutions and higher education institutions along the entire Gulf of Mexico coastline.

ACKNOWLEDGEMENTS

We are especially grateful to the fishermen of the Pantanos region and the port of San Pedro. To the BioSecuraNet International Network—International Network for Biotechnology and Innovative Strategies for Global Food Security.

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9786585756792



BioSecuraNet

**Red Internacional de Biotecnología y
Estrategias Innovadoras
para la Seguridad Alimentaria Global**

Pantanal Editora

Rua Abaete, 83, Sala B, Centro. CEP: 78690-000

Nova Xavantina – Mato Grosso – Brasil

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