REVISTA BIO CIENCIAS
http://revistabiociencias.uan.edu.mx
https://doi.org/10.15741/revbio.12.e1946
ISSN 2007-3380

*Case report / Reporte de caso*

# First report of lordosis in the dolphinfish, *Coryphaena hippurus* (Linneaeus, 1758) (Caringiformes: Coryphaenidae), on the southern coast of Mexico.

# Primer reporte de lordosis en el dorado, *Coryphaena hippurus* (Linneaeaus, 1758) (Carangiformes: Coryphaenidae), en el sureste de la costa de México

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## ABSTRACT

The presence of lordosis in the caudal peduncle of a dolphinfish, *Coryphaena hippurus,* was reported for the first time in Mexican waters. During a fishing tournament in Puerto Angel, Oaxaca, an adult male measuring 93 cm in fork length was captured. This organism exhibited a significant deformity in caudal vertebrae 10 to 14. Despite the deformity, it was determined to be functional for the population. The allometric condition factor was 1.1. Its probable age is one to three years. The deformity is likely due to the teratogenic effects of hydrocarbon or agrochemical pollutants dumped on the coast. Continuous monitoring of fishery resources is recommended to detect cases of external anomalies and identify their causes, as these can be used to establish environmental mitigation measures. Both to reduce their prevalence and to make them as bioindicators of the health status of the ecosystem.

**KEY WORDS:** Dolphinfish, vertebral anomaly, teratogenic effects, Oaxaca coast, coastal pollution.

**Please cite this article as/Como citar este artículo:** Anislado-Tolentino, V., Rosales-Vásquez, J.I., Wakida-Kusunoki, A. T., Del Moral-Flores L. F. (2025). First report of lordosis in the dolphinfish, *Coryphaena hippurus* (Linneaeus, 1758) (Caringiformes: Coryphaenidae), on the southern coast of Mexico. *Revista Bio Ciencias*, 12, e1946. https://doi.org/10.15741/revbio.12.e1946

**Article Info/Información del artículo**
Received/Recibido: May 02th 2024.
Accepted/Aceptado: July 30h 2025.
Available on line/Publicado: August 18th 2025.

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Revista Bio ciencias
ISSN 2007-3380


## RESUMEN

La presencia de lordosis en el pedúnculo caudal en un dorado, *Coryphaena hippurus*, es reportada por primera vez en aguas mexicanas. Durante un torneo de pesca en Puerto Ángel, Oaxaca, fue capturado un ejemplar macho adulto de 93 cm de longitud furcal. Este organismo exhibió una deformidad significativa en las vértebras caudales 10 a 14. A pesar de la deformidad, se determinó que era funcional para la población. El factor de condición alométrica fue 1.1. Su edad probable fue de uno a tres años. La deformidad probablemente se debe a los efectos teratógenos de los contaminantes hidrocarburos o agroquímicos volcados en la costa. Se recomienda una vigilancia continua de los recursos pesqueros para detectar casos de anomalías externas e identificar sus causas, ya que se pueden utilizar para establecer medidas de mitigación ambiental. Tanto para reducir su prevalencia como para convertirlos en bioindicadores del estado de salud del ecosistema.


**PALABRAS CLAVE:** Dorado, anomalía vertebral, efectos teratogénicos, costa de Oaxaca, Contaminación costera.

## Introduction

The dolphinfish *Coryphaena hippurus*, Linnaeus, 1758 is a tropical and subtropical fish with high reproductive potential and rapid growth, which rapidly achieve sexual maturity at 4 or 5 months of age. It is often associated with floating objects, where it preys on other bony fish, crustaceans and squid (Randall, 1995). Reaching up to 30 kg in weight, the dolphinfish is highly appreciated for its taste and its large size, however, in Mexico this species can only be directly targeted by sport fishing, although there is a considerable volume of incidental fishing in the longline and coastal commercial fleets of both coasts (DOF, 2015; 2023). Given the high resilience of this species, the reported abnormalities, both occurring for Indian waters, includes one of hermaphroditism (Retheesh *et al*., 2017) and another with scoliosis and lordosis (Sudhan *et al*., 2018). Of these abnormalities, the most important are those affecting the skeleton, since the curvature of the spine affects the fish's ability to swim efficiently and capture food. This could cause greater susceptibility to diseases, with a reduction in life expectancy, and cause economic losses by reducing the commercial value of the fish. Although skeletal abnormalities in fish are more common in controlled environments, such as fish farms, in wildlife a combination of contaminants may result in changes of the vertical distribution of larvae in response to the oxygen concentration variations and exposure to ultraviolet light in the water column, that can lead to those type of abnormalities (Pasparakis, 2017). Other factors that should be considered are genetics. Parasitic

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infections can cause tissue damage and affect the structure of the spine. Trauma caused by collisions with objects, predators, or sudden changes in environmental conditions can also cause spinal cord injuries. Lack of nutrients, especially during times of food shortage, can weaken the bones and contribute to deformities (Eissa *et al*., 2021). This paper analyzes the anomalies in the axial skeleton of a male dolphinfish captured off the coast of Oaxaca, Mexico with the presence of caudal lordosis.

## Materials and Methods

During the Puerto Angel fishing tournament (96°11'28"W, 15°39'56"N) on January 27th 2012, a male dolphinfish *C. hippurus* (Linaeaus, 1758) was captured with an accentuated lordosis in the caudal peduncle. The capture area covers from "La Ventanilla" beach (96°11'28"W, 15°40'09"N) to "La Boquilla" beach (96°27'55"W, 15° 41'N) in the isobaths of 50 to 100 m (Figure 1).

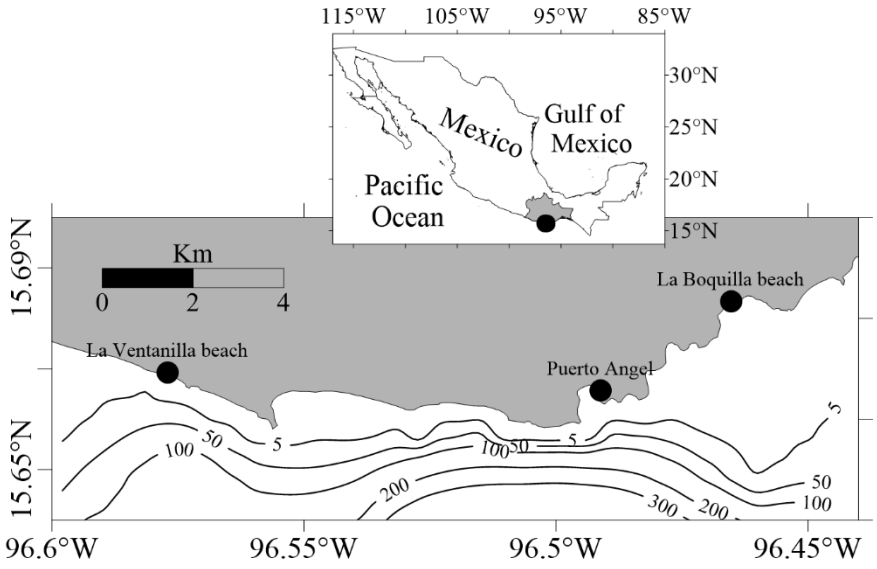


**Figure 1. Capture area at the coast of Oaxaca for the dolphinfish, *Coryphaena hippurus*, with lordosis.**

The capture occurred between the isobaths of 50 to 100 m.

Source: Own elaboration based on map vector of https://gadm.org/maps/MEX.html and deep data of https://download.gebco.net/

Different body lengths (standard [SL] and furcal length [FL]) were measured to the nearest centimeter using a flexometer, total weight (TW) was obtained with a WeiHeng hook scale with a capacity 10-50,000 g (±10 g) and photographs were taken with a Canon EOS Rebel 500D camera.

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The maturity status was determined by the space occupied by the gonads and its macroscopic appearance, according to the established criteria by Brown-Peterson *et al*., (2011). After the filleting process of the fish made by the anglers who caught it, the abnormal spine was collected. The collected spine was cleaned, in a first stage, using boiling water baths and being brushed every 5 minutes for 40 minutes. Subsequently, a sodium hypochlorite bath (3.2 %) was performed for one hour followed by vigorous brushing. After that, a neutralizing bath with sodium hydroxide at 0.3 % for 4 hours was done, followed by two 20-minute rinses using running water and a final process of drying in the shade. The affected area of the axial skeleton was reviewed using the terminology of Potthoff (1980) which defines that the caudal complex (caudal skeleton) is sustained in the four preurals. The curvature index (CI) was calculated using the formula proposed by Louiz *et al*., (2007): $CI = \left({}^{CD}/_{SL}\right)100$, where CD is the curvature depth, measured from the dorsal part of the apical vertebra to the tangency line to the ventral part of the two vertebrae that limit the curvature.

The health condition of the specimen was compared with the theoretical value of the allometric condition factor ($K = {}^{observed\ weigth}/_{theorical\ weigth}$; Froese 2006). In addition, the possible age of the specimen was estimated to assess its resilience indirectly. For both cases, the functions were used: $TW = 4\,X\,10^{-6}FL^{3.1435}$ and $FL = 126.3\left(1 - e^{-1(t+0.0385)}\right)$, where "*t*" is the age, both proposed by Alejo-Plata *et al*., (2011) for the dolphin fish of the Oaxaca coast.

## Results y Discussion

The collected organism was a male measuring 93 cm FL, 87 cm SL (Figure 2) with a total weight of 6.2 kg. The maturity state was determined as "spawning capable" (III), expelling semen with gentle abdominal pressure. A significant contusion was observed in the front occipital part of the head, caused by the anglers at the time of extraction, which disqualified the fish from the tournament. Externally, the fish presented lordosis at the beginning of the caudal peduncle.

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ISSN 2007-3380

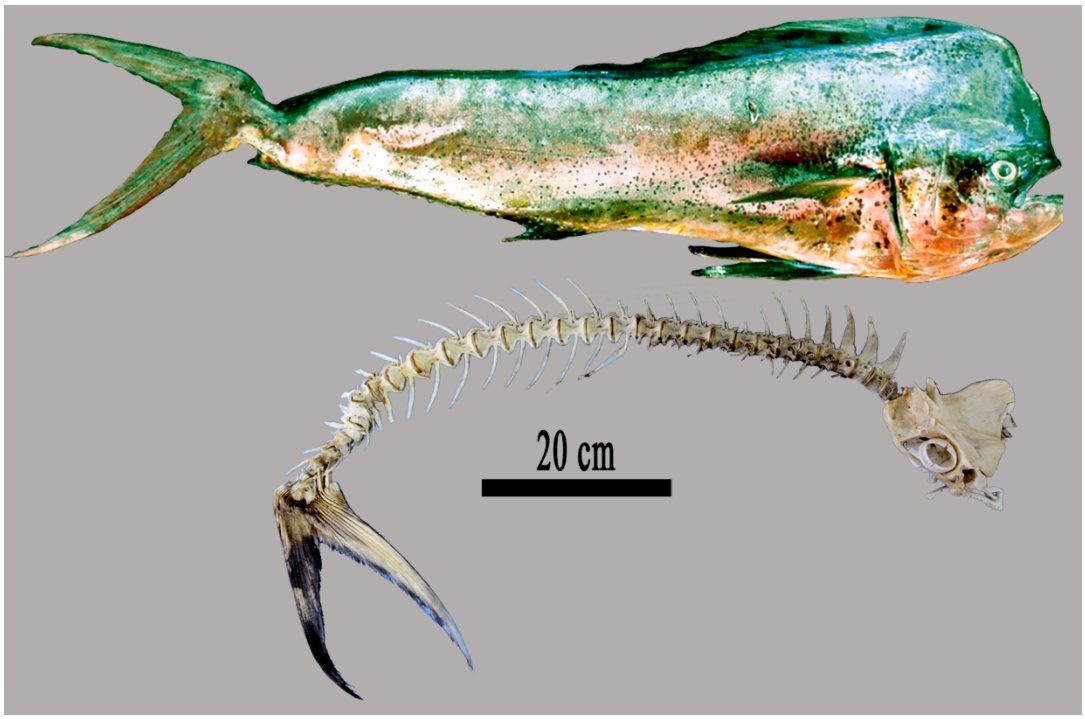


**Figure 2. Dolphinfish specimen (*Coryphaena hippurus*) with lordosis in the caudal peduncle captured on the Oaxaca coast.**

Up, fresh; down, axial skeleton of the same specimen. Photos by Vicente Anislado-Tolentino.
Source: Own elaboration based on photos by Vicente Anislado-Tolentino.

The vertebral column presented 13 pre-caudal and 18 caudal vertebrae (including the ural + preural vertebrae 1). The deformity of the vertebrae begins at the caudal vertebrae (CV) 10 (Figure 3), which exhibits a significant reduction in length posteriorly, while the posterior part of CV 11 is similarly reduced. This reduction is more pronounced ventrally, causing a deviation that forces the anterior part of the CV12 to deform, thereby interposing the CV11. The CV12 is amorphous, oriented to the ventral part of the fish, and is partially fused with the CV13 in its dorsal part. The neural spines of the CV12 and CV13 are fused with the dorsal prezygoapophysis of the CV13. The dorsal prezygoapophysis of the CV14 is thickened, reduced to almost half the length at its posterior part, and fused in its apex with the neural arc of the CV13. For CV11, no ventral postzygoapophysis is observed, and in CV12, the ventral zigoapophysis is absent, while in CV13, the ventral postzigoapophysis is rudimentary. The CV15 presents a normal vertebral body, but with the absence of the neural spine. In the CV17 (Preural 2 of the caudal complex), it is observed that the special neural arc (“Na”) is fused at its apex with the dorsal prezigoapophysis of the ural vertebra (Ur = Ur + P1 = CV17).

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ISSN 2007-3380

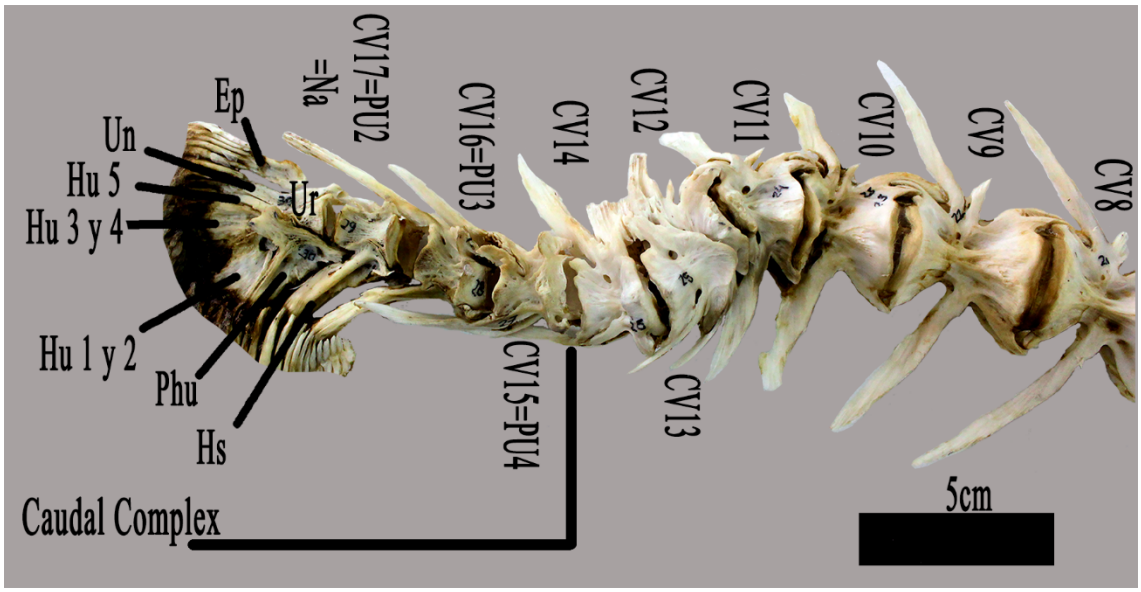


**Figure 3. Axial view of the affected area with lordosis for the dolphinfish (*Coryphaena hippurus*) captured on the Oaxaca coast.**

Caudal vertebra (CV), special neural arc (Na), Preural vertebra (Pu), Ural vertebra (Ur), Hemal spine (Hs), Uro neural (Un), Parhypural (Phu), Hypoural (Hu). Source: Own elaboration based on photos by Vicente Anislado-Tolentino.

The curvature depth was measured from the apex of the CV11 to the tangent line between CV9 and CV14, resulting in a CI value of 5.67. Based on the allometric condition factor (K = 1.1), the specimen would be above the theoretically expected values, indicating excellent health. Additionally, the estimated age is approximately one year and three to four months.

There is only one previously documented case of lordosis in a male of this species: an individual with a fork length (FL) of 101 cm (Sudhan *et al*., 2018). The calculated allometric condition index (K = 0.861) was very close to the lower threshold for normal specimens (K = 0.86). However, in this case, the analyzed specimen exhibited values consistent with a completely healthy and sexually mature individual, with fully developed and spawning-capable testicles. Jawad & Ibrahim (2018) report five species of wild fish from the same area in the Persian Gulf with axial skeleton deformities. They hypothesize that hydrocarbon pollution may be responsible for altering the chemical composition and the biological processes leading to the vertebrae formation, or by affecting neurological processes that can deform hard structures without necessitating changes.

Mariasingarayan *et al*. (2024) found that in six Indian species of wild fish with different habitats, food, and natatory activity, the cause of axial skeleton deformities shared the same

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ethology as the specimens were collected in the same area. Pasparakis (2017) has previously mentioned that changes in the vertical distribution of oxygen and UV radiation due to hydrocarbon pollution promote alterations of fish chemical and physical processes. This type of pollution can decrease the dissolved oxygen concentration to levels that can generate hypoxia in fish, a condition known to be one of the main teratogenic factors in the axial skeleton abnormal development within aquaculture (Bagowski *et al*., 2011). Being a highly migratory species, the dolphinfish is hypothesized that the studied specimen may have been exposed to the effects of hydrocarbons pollution near Salina Cruz, Oaxaca, where the “Ing. Antonio Dovali Jaime” refinery and the “Salina Cruz” oil well are known to have been responsible for high emissions of Sulphur dioxide and hydrocarbon waste into the sea. Another possible sources of teratogens are the agrochemical compounds dragged by the rain drains to the coast. The effects and impacts on the swimming capability and metabolism of the dolphinfish as a result of oil industry-related incidents in the Gulf of Mexico are well documented (Stieglitz *et al*., 2016). These contaminants can persist in the pelagic zone and affect the fish during its early life stages. Under controlled tests, most dolphinfish larvae and embryos exposed to high concentrations of pesticides and biocides (e.g., copper chloride and tributyltin chloride) presented high lethality and teratogenic effects (Adema-Hannes & Shenker, 2008).

## Conclusion

Abnormal fishes can serve as bioindicators of negative environmental impacts. The presence of abnormalities on commercially and sport important fishes must be studied in more detail in order to determine the causes and to design strategies to minimize them. On the other hand, abnormality induced weight reduction can lead to consumer rejection, leading to a decrease in value of the catch and even the rejection of the fishing zone, reducing tourism and general welfare of the local communities.

## Author contributions

Work conceptualization: VAT, JIRV, ATWK. LFDMF. Methodology development: VAT, JIRV, ATWK. LFDMF. Software management: VAT. Data analysis: VAT, JIRV, ATWK. LFDMF. Data management: VAT, JIRV, ATWK. LFDMF. Manuscript writing and preparation: VAT, JIRV, ATWK. LFDMF. Writing, revising, and editing: VAT, JIRV, ATWK. LFDMF. Project manager: VAT. Fund acquisition: VAT, JIRV, ATWK. LFDMF.

All authors of this manuscript have read and accepted the published version of this manuscript.

## Financing

This research was funded by own funds.

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## Ethical declarations

This investigation did not involve the handling of regulated animals and did not require the approval of an Ethical Committee.

## Statement of Informed Consent

Informed consent was obtained from all subjects involved in the study.

## Acknowledgement

We extend our gratitude to the organizers of the sports fishing tournament for the invitation to be part of the jury and for their support in collecting data and biological samples. We also appreciate the assistance of Marine biologist Nancy Elizabeth Ruiz Perez in cleaning the specimen's skeleton, and Marcella Lucente for the English style correction.

## Conflict of interest

The authors declare that they have no conflict of interest.

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