

FIRST RECORD OF JUVENILES OF THE OCEANIC SQUID *THYSANOTEUTHIS RHOMBUS* (CEPHALOPODA: THYSANOTEUTHIDAE) IN THE GULF OF TEHUANTEPEC, NORTHEASTERN TROPICAL PACIFIC

María del Carmen Alejo-Plata^{1,*}, Juan Roberto F. Vallarta-Zárate²,
Víctor Hugo Martínez-Magaña³ & R. Isaac Rojas-González⁴

¹Instituto de Recursos, Universidad del Mar, Campus Puerto Ángel. Ciudad Universitaria, Puerto Ángel 70902, Oaxaca, México.

^{2,4}Dirección de Investigación Pesquera en el Atlántico, Instituto Nacional de Pesca y Acuicultura. Av. México, no. 190 Col. Del Carmen, Ciudad de México, México C.P. 04100.

²Posgrado en Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. Avenida Ciudad Universitaria 3000, C.P. 04510 Coyoacán, Ciudad de México, México

³Centro Regional de Investigación Acuícola y Pesquera Manzanillo, Instituto Nacional de Pesca y Acuicultura. Playa Ventanas s/n, Col. Carretera Manzanillo a Campos Colima, Colima, C. P. 28200.

*Corresponding author: plata@angel.umar.mx – ORCID ID: <https://orcid.org/0000-0001-6086-0705>

²roberto.vallarta@inapesca.gob.mx – ORCID ID: <https://orcid.org/0000-0001-8654-8728>

³victor.mmagana@inapesca.gob.mx – ORCID ID: <https://orcid.org/0000-0001-9371-8027>

⁴ramon.rojas@inapesca.gob.mx – ORCID ID: <https://orcid.org/0000-0002-7431-4833>

ABSTRACT

The diamond squid *Thysanoteuthis rhombus* Troschel, 1857 is a circum-global oceanic distributed squid, large-sized and notably rare to find; however, in some regions of Asia it is of interest to fisheries. We report here the first record of *T. rhombus* juveniles in the Gulf of Tehuantepec, Northeastern Tropical Pacific Ocean, along with *Dosidicus gigas* (d'Orbigny, 1835) juveniles and associated environmental data. The squid were collected in the oceanic zone with upwelling and thermohaline front, with a maximum level of chlorophyll-a (5.5 µg/L), unlike the neritic zone that is saltier, with a higher relative level of oxygen and lower level of chlorophyll-a.

Keywords. Diamond squid, *Dosidicus gigas*, fishery.

RESUMEN

Primer registro de juveniles de calamar oceánico *Thysanoteuthis rhombus* (Cephalopoda: Thysanoteuthidae) en el Golfo de Tehuantepec, Pacífico Tropical Nororiental

El calamar diamante *Thysanoteuthis rhombus* Troschel, 1857 es un calamar oceánico circum-global, de tamaño grande y relativamente raro de encontrar; sin embargo, en algunas regiones de Asia tiene interés pesquero. Aquí reportamos el primer registro de juveniles de *T. rhombus* en el Golfo de Tehuantepec, Pacífico Tropical Nororiental, junto con juveniles de *Dosidicus gigas* (d'Orbigny, 1835) y datos oceanográficos asociados. Los calamares fueron colectados en la zona oceánica con surgencia y frente termohalino y nivel máximo de clorofila-a (5.5 µg/L), a diferencia de la zona nerítica que fue más salada, con mayor nivel relativo de oxígeno y menor nivel de clorofila-a.

Palabras clave. Calamar diamante, *Dosidicus gigas*, pesquería.

Recibido/Received: 6/10/2022; **Aceptado/Accepted:** 19/07/2023; **Publicado en línea/Published online:** 11/10/2023

Cómo citar este artículo/Citation: Alejo-Plata, M.C., Vallarta-Zárate, J.R.F., Martínez-Magaña, V.H. & Rojas-González, R.I. 2023. First record of juveniles of the oceanic squid *Thysanoteuthis rhombus* (Cephalopoda: Thysanoteuthidae) in the Gulf of Tehuantepec, Northeastern Tropical Pacific. *Graellsia*, 79(2): e199. <https://doi.org/10.3989/graellsia.2023.v79.377>

Copyright: © 2023 SAM & CSIC. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International (CC BY 4.0) License.

Introduction

The diamond squid *Thysanoteuthis rhombus* Troschel, 1857 (Cephalopoda: Thysanoteuthidae) is a large oceanic squid. The adults reach a maximum mantle length of 130 cm and can weigh up to 30 kg (Jereb & Roper, 2010). They are animals with a high growth rate, but low energy consumption (Nigmatullin & Arkhipkin, 1998).

This squid is unique insofar as it is monogamous, living in stable couples throughout most of its life cycle (Nigmatullin *et al.*, 1995), and spawning almost year round in oceanic tropical and subtropical ocean waters (Nigmatullin & Arkhipkin, 1998). This species spawn large (1-2 m) pelagic egg masses, with small pink violet eggs placed around the surface of a gelatinous mucous cylinder (Escánez-Pérez *et al.*, 2012).

Diamond squid have firm meat of very high quality for human food consumption; this has increased interest in the species as a fishery resource (Jereb & Roper, 2010). A significant fishery exists in the coastal waters of the Sea of Japan and around Okinawa; however, their catches are not reflected in FAO statistics (Arkhipkin *et al.*, 2015). Recently, *T. rhombus* has represented a latent fishery resource and has been caught by jigging at a depth range of 145 m to 720 m in the Philippines where it is a source of food and livelihood for small-scale fishers (De Chavez *et al.*, 2021). In addition, an emerging small-scale fishery is reported from the Canary Islands, the eastern Atlantic, and Jamaica in the Caribbean (Escánez Pérez *et al.*, 2012).

Records of adult individuals are becoming more frequent around the world (e.g., Jereb & Roper, 2010; Arkhipkin *et al.*, 2015; De Chavez *et al.*, 2021). To date there are several records for egg masses (see review in Brown *et al.*, 2022), paralarvae (e.g., De Silva-Dávila *et al.*, 2019), and juveniles (e.g., Fernández-Álvarez *et al.*, 2021). We report here the first record of juveniles of *T. rhombus* in the Gulf of Tehuantepec, Northeastern Tropical Pacific, along with *Dosidicus gigas* (d'Orbigny, 1835) juveniles and environmental data.

Material and methods

SAMPLE COLLECTION

The *Thysanoteuthis rhombus* specimens were collected in April 2022, during a fishery and oceanographic cruise (JCFINP/2204) on the research vessel Dr. Jorge Carranza Fraser of the Instituto Nacional de Pesca y Acuicultura of the Mexican Government that systematically covered the Gulf of Tehuantepec (Fig. 1). Specimens of *T. rhombus* were identified based on the diagnostic characteristics described by Jereb & Roper (2010). Squid specimens were placed in bags to keep frozen at. For histological

processing, fresh squid were fixed in Davidson solution. In the laboratory,

The squid samples were obtained from 50 midwater fishing hauls, four of which were positive for *T. rhombus* (Fig. 1). The hauls were made with a midwater net, which consists of four equal caps (top and bottom footrope length: 48.17 m) that was towed at an average speed of 6.5 km h⁻¹ during 45 min, at an average depth of 20 m.

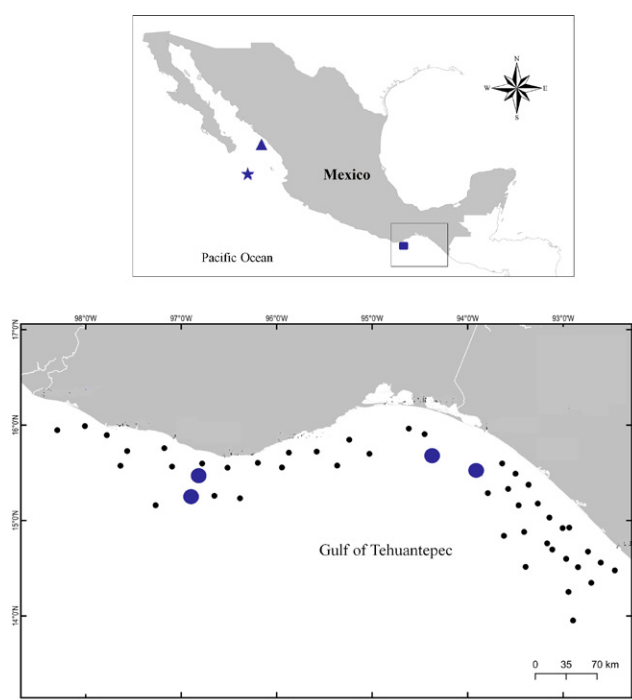


Fig. 1.— Grid sampling stations for cruise JCFINP/2204, gray dots (April 2022) in the Northeastern Tropical Pacific; showing collection localities of *Thysanoteuthis rhombus* juveniles (blue dots). Literature records: star, egg mass; triangle, paralarvae (De Silva-Dávila *et al.*, 2019); square, adult female (Alejo-Plata & Urbano-Alonso, 2018).

Fig. 1.— Cuadrícula de estaciones de muestreo puntos grises (abril de 2022), crucero JCFINP/2204, Pacífico tropical nororiental, se muestran las localidades de recolección de juveniles de *Thysanoteuthis rhombus* (puntos azules). Registros bibliográficos: estrella, masa de huevos; triángulo, paralarvas (De Silva-Dávila *et al.*, 2019); cuadrado, hembra adulta (Alejo-Plata & Urbano-Alonso, 2018).

The hauls were carried out following prior visualization of detections in echograms recorded 24 hours a day with a Simrad EK60 scientific echo sounder equipped with five split-beam transducers (18, 38, 70, 120 and 200 kHz).

The oceanographic sampling was carried out using a thermosalinograph Sea-Bird which uses a continuous flow pumping system of seawater approximately 3 m deep, directed towards a CT SBE-21 sensor that records temperature and salinity every 10 s. This system was equipped with a fluorometer for chlorophyll-a measurement at the same sampling rate.

In the laboratory, morphometric data for *T. rhombus* were taken according with the guidelines by Roper & Voss (1983). The sex was recorded by examination of gonads and annexes inside the mantle cavity. Stomach contents weight was measured to the nearest 0.1 mg. For *Dosidicus gigas*, the dorsal mantle length (ML, measured to nearest mm) and total weight (W, measured to the nearest 0.1 mg) were recorded. The maturity stage for each squid was based on Lipinski (1979).

The length-weight relationship was estimated for each gonadic stage based on the equation $W = aML^b$, where a is the intercept of the regression model and b is the coefficient of allometry. The estimated value of b was tested with Student's t-test to determine whether growth was isometric or allometric.

The diamond squids used for this study are housed in the Collection of Cephalopods of Mexican Pacific in the Universidad del Mar (UMAR), Puerto Angel, Oaxaca, Mexico (reference number MHNUMAR-CEPHA 5102-505, and collected under permit PPF/DGOPA-004/22).

Results

THYSANOTEUTHIS RHOMBUS AND *DOSIDICUS GIGAS*

Four juvenile *T. rhombus* were found amongst hauls of *Dosidicus gigas* juveniles (Fig. 2). A total of 106 *D. gigas* juveniles were collected, with sizes ranging from 32.8 to 70 mm ML and from 1.1 to 5.8 g W. The length-weight relationship of the *D. gigas* juveniles, indicate isometric growth ($b = 3$, $p < 0.05$). *T. rhombus* individuals were heavier than *D. gigas*, as seen in the size-weight curve (Fig. 3).

The four juveniles of *T. rhombus* were identified as three females and one male; data are reported in Table 1. The diamond squid juveniles showed one photophore on the ink sac (Fig. 4). The ingested items removed from the stomachs were highly macerated, belonging to bony fishes and crustaceans.



Fig. 2.– *Thysanoteuthis rhombus* and juveniles *Dosidicus gigas*.
Fig. 2.– *Thysanoteuthis rhombus* y juveniles de *Dosidicus gigas*.

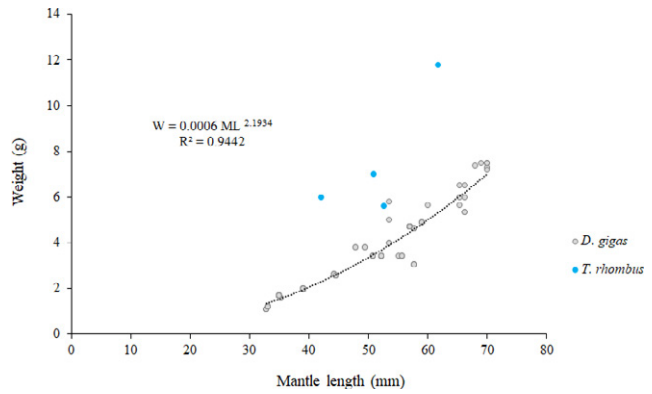


Fig. 3.– *Dosidicus gigas* juveniles, length-weight relationships (gray dots); record *Thysanoteuthis rhombus* are indicated by blue dots.

Fig. 3.– Juveniles de *Dosidicus gigas*, relación longitud-peso (puntos grises); registro de *Thysanoteuthis rhombus* (puntos azules).

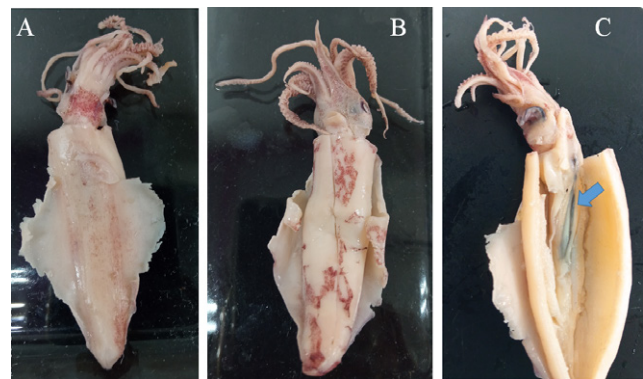


Fig. 4.– *Thysanoteuthis rhombus* female (42 mm ML). A. Dorsal view. B. Ventral view. C. Photophore on the ink sac (arrow).

Fig. 4.– Hembra de *Thysanoteuthis rhombus* (42 mm ML). A. Vista dorsal. B. Vista ventral. C. Fotóforo sobre el saco de tinta (flecha).

OCEANOGRAPHIC CONDITIONS

Thysanoteuthis rhombus juveniles were collected in the oceanic zone with upwelling and thermohaline front, with a maximum level of chlorophyll-a (5.5 µg/L), unlike the neritic zone that is saltier, with a higher relative level of oxygen (Fig. 5A–B) and lower level of chlorophyll-a (Fig. 5D).

In the oceanic and neritic zone (only the temperature and chlorophyll profiles are shown, Fig. 5D), surface water intrusion of lower relative salinity (34.3 psu) was observed. In the oceanic zone, the saline intrusion was interrupted by an anticyclonic eddy with a halocline uplift between oceanographic stations (OS) 12 and 21. This process created the maximum chlorophyll-a observed in OS 24, but not in OS 27. The stations of the neritic zone contrast with the oceanic zone with a cyclonic eddy of lower sinking intensity, but the effects were similar. The distribution of chlorophyll-a detected at different levels of this

Table 1.— Body dimensions of formalin-fixed juveniles of *Thysanoteuthis rhombus* caught in the Gulf of Tehuantepec. Material examined. 1: One male. 10/04/2022, at night. 15.2343° N, 96.9611° W. 2: One female. 11/04/2022, at night. 15.4532° N, 96.8104° W. 3-4: Two females. 26/04/2022, at night. 15.6858° N, 94.3719° W. Fished by a mid-water fishing hauls with an average depth of 20 m. biological reference Collection of Cephalopods of Mexican pacific in the Universidad del Mar (reference number MHNUMAR-CEPHA 5102-505), formalin fixed. Abbreviations: W, weight; ML, dorsal mantle length; VML, ventral mantle length; MMW, maximum mantle width; FL, Fin length; FW, fin width; HL, Head length; HW, Head width; A, Arm I-IV (R, right/ L, left); RTL, right tentacle length; *, broken. Weight in grams, lengths in mm.

Tabla 1.— Dimensiones corporales de juveniles de *Thysanoteuthis rhombus* fijados en formalina capturados en el Golfo de Tehuantepec. Material examinado. 1: Un macho. 04/10/2022, por la noche. 15.2343° N, 96.9611° W. 2: Una hembra. 04/11/2022, por la noche. 15.4532° N, 96.8104° W. 3-4: Dos hembras. 26/04/2022, por la noche. 15.6858° N, 94.3719° W. Capturados por una red de media agua con una profundidad promedio de 20 m. Referencia biológica Colección de Cefalópodos del Pacífico Mexicano de la Universidad del Mar (número de referencia MHNUMAR-CEPHA 502-505), fijado en formalina. Abreviaturas: W, peso; ML, longitud dorsal del manto; VML, longitud ventral del manto; MMW, ancho máximo del manto; FL, Longitud de la aleta; FW, ancho de la aleta; HL, Longitud de la cabeza; HW, Ancho de la cabeza; A, Brazo I-IV (R, derecho/ L, izquierdo); RTL, longitud del tentáculo derecho; *, roto. Peso en gramos, longitudes en mm.

Variable	1	2	3	4
Date	10/04/2022	11/04/2022	26/04/2022	26/04/2022
Hauls	L10	L11	L43	L44
sex	M	H	H	H
W	7.0	6.0	5.6	11.8
ML	50.9	42.0	52.6	61.6
VML	52.0	44.1	55.14	64.4
MMW	20.0	18	15.4	19.6
FL	45.4	43.0	42.4	46.9
FW	43.0	40.0	33.3	19.6
HL	13.3	11.2	9.8	14.4
HW	14.6	12.2	10.7	18.2
AI (R, L)	27.2/29.5	24.1/24.0	11.7/18.6	19.5/21.1
AII (R, L)	21.0/24.3	18.0/20.4	21.8/20.9	26.6/30.1
AIII (R, L)	40.6/51.8	38.1/*	35.2/37.2	44.1/45.2
AIV (R, L)	24.4/*	22.1/*	17.1/18.3	19.9/20.2
RTL	*	*	47.4	61.0
Gonad weight	0.02	0.2	0.3	0.4
Stomach weight	0.01	0.02	0.01	0.05

parameter in the neighboring stations was affected with a level relatively high (3 µg/L) presence in OS 59 but 50% lower in OS 62 (Fig. 5D). The gyres detected in both sampling zones did not affect the relatively high oxygen levels (Fig. 5B). The temperature in the area of interest was only affected by the oceanic eddy with a rise of up to 5°C, but not by the neritic. These processes are consistent with a depth of the mixed layer between 17 and 15 m, for the oceanic and neritic zones, respectively (Fig. 5E).

Discussion

Due to its mid ocean habitat *T. rhombus* is difficult to detect (Fernández-Álvarez et al., 2021). In Mexico, records of *T. rhombus* are limited to an egg mass fragment and one paralarva found in the Northeastern Tropical Pacific and Gulf of California (De Silva-Dávila et al., 2019), and records of two adult females in the Gulf of Tehuantepec (Alejo-Plata & Urbano-Alonso, 2018). To these records, the findings reported here have to be added.

This is the first work that reports juveniles in the Eastern Tropical Pacific, consisting of three females and one male with mantle length less than 70 mm. Notably, the distributions of *T. rhombus* and *D. gigas* overlap to some extent (Jereb & Roper, 2010), which explains the joint capture of juveniles of both species in the Gulf of Tehuantepec. Similarly, in the Peruvian Sea, there are isolated data on the by-catch of diamond squid in fisheries targeting *D. gigas* (Roque-Sánchez & Donayre-Salazar, 2021).

The FAO global production database is relied upon for collecting sightings of ocean species. While all wild catches are recorded as “target species” (Blasco et al., 2020), catches from fishing areas that are reported but not identified to species level are identified only as “not elsewhere included” (NEI). Their relatively rare collection suggests that *T. rhombus* squids are included among the various squids in “NEI category” (Boyle & Rodhouse, 2005).

Thysanoteuthis rhombus is an epipelagic to mesopelagic species that inhabits open ocean water, rarely approaching the coast (Jereb & Roper, 2010). Previous studies have reported that the passive migration

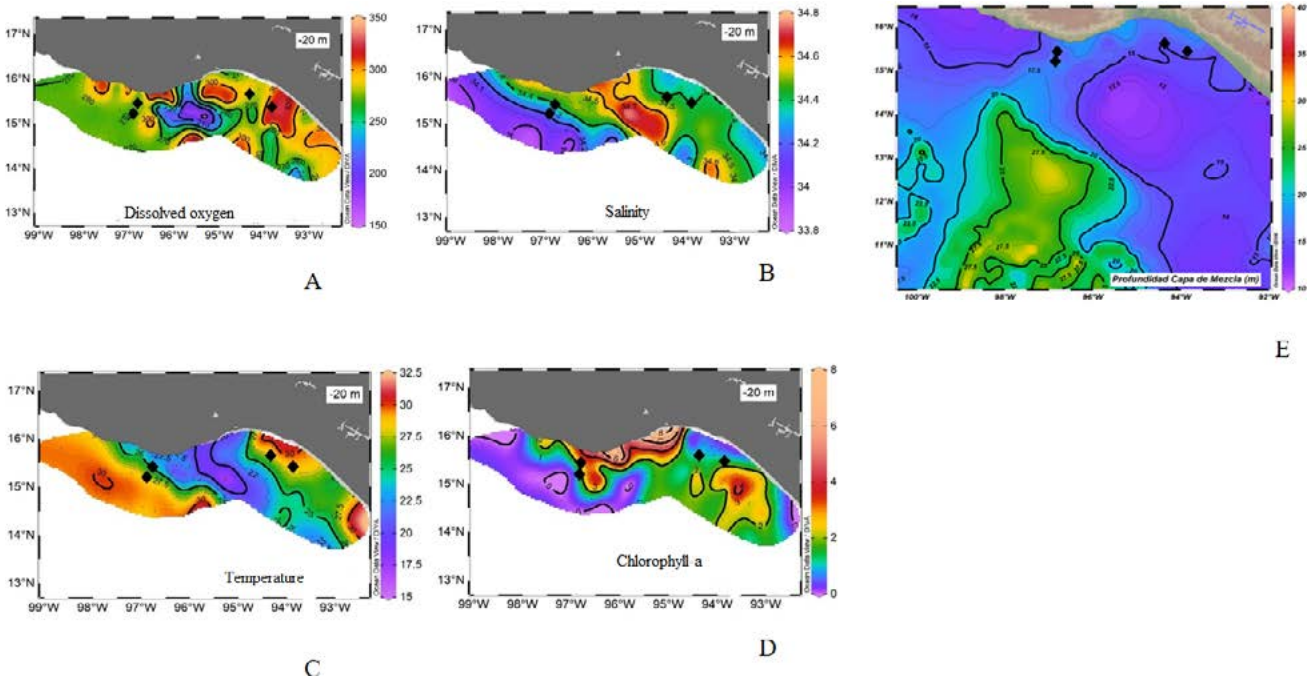


Fig. 5.– Spatial distribution of oceanographic variables at a depth of 20 meters in the survey sampling area. The rhombus indicate the presence of *Thysanoteuthis rhombus*.

Fig. 5.– Distribución espacial de las variables oceanográficas en el área de prospección, a 20 m profundidad. El rombo indica la presencia de *Thysanoteuthis rhombus*.

of this species can be regulated by the oceanographic conditions (Miyahara *et al.*, 2008; Sajikumar *et al.*, 2020). In the Gulf of Tehuantepec, the high seasonal productivity and low sea-surface water temperature are due to strong vertical mixing and entrainment associated with strong winds called ‘Tehuano’ that originate in the Gulf of Mexico and blow across the Isthmus of Tehuantepec (Trasviña & Barton, 2008), mainly from November to April. The occurrence of the *T. rhombus* juveniles (as well as those of *D. gigas*) reported in this work may in fact be related with this upwelling.

The diamond squid has the potential for a fishery resource in the different parts of its distributional range as bycatch whenever squid and finfish pelagic trawl fisheries develop in slope and oceanic areas, especially in highly productive zones (Jereb & Roper, 2010). The egg masses of *T. rhombus* have not been observed in the Gulf of Tehuantepec, probably due to lack of targeted study. Nonetheless, the previous record of a mature female (Alejo-Plata & Urbano-Alonso, 2018) in the Gulf of Tehuantepec as well as the occurrence of paralarvae (De Silva-Dávila *et al.*, 2019) in close by areas, and newly reported juveniles here, suggest that *T. rhombus* is most probably is a common resident in this gulf.

Acknowledgements [bold]

MCAP and RIRG thank the Sistema Nacional de Investigadores (SNI-CONAHCyT). We also thank the National Institute of

Fisheries and Aquaculture for the support with the R/V Dr. Jorge Carranza Fraser. We thank the anonymous reviewers for their helpful comments that improve this manuscript. English translation by Karen Englander.

References

Alejo-Plata, M.C. & Urbano-Alonso, B., 2018. The finding of diamond squid *Thysanoteuthis rhombus* in the Gulf of Tehuantepec, Northeastern Tropical Pacific. *Hidrobiológica*, 28 (1): 147-150. <https://doi.org/10.24275/uam/izt/dcbs/hidro/2018v28n1/Alejo>

Arkhipkin, A.I., Rodhouse, P.G.K., Pierce, G.J., Sauer, W., Sakai, M., Allcock, L., et al., 2015. World squid fisheries. *Reviews in Fisheries Science & Aquaculture*, 23 (2): 92–252. <https://doi.org/10.1080/23308249.2015.1026226>

Blasco, G.D., Ferraro, D.M., Cottrell, R.S., Halpern, B.S. & Froehlich, H.E., 2020. Substantial gaps in the current fisheries data landscape. *Frontiers in Marine Science*, 7: 612831. <https://doi.org/10.3389/fmars.2020.612831>

Boyle, P. & Rodhouse, P., 2005. *Cephalopods: Ecology and Fisheries*. Blackwell Science. Oxford. 464 pp. <https://doi.org/10.1002/9780470995310>

Brown, T.W., Izaguirre, A. & De Silva-Dávila, R., 2022. Planktonic egg masses of the diamondback squid *Thysanoteuthis rhombus* in the Western Caribbean, Honduras; a comprehensive review of global observations. *Caribbean Journal of Science*, 5 (1): 34–49. <https://doi.org/10.18475/cjcs.v52i1.a4>

De Chavez, J., Calderon, G., Santos, A., Vera Cruz, E. & Santos, M., 2021. Vulnerability to climate change of

- “Giant Squid” (*Thysanoteuthis rhombus*) fishery in Marinduque, Philippines. *The Philippine Journal of Fisheries*, 28 (2): 171-180. <https://doi.org/10.31398/tjpf/28.2.2021-0002>
- De Silva-Dávila, R., Avendaño-Ibarra, A., Palomares-García, R., Markaida, U., 2019. First records of an egg mass and a paralarva of *Thysanoteuthis rhombus* (Cephalopoda: Thysanoteuthidae) in the Northeastern Tropical Pacific. *Pacific Science*, 73 (4): 475-491. <https://doi.org/10.2984/73.4.4>
- Escáñez-Pérez, A., Riera-Elena, R., González-González, A.F. & Guerra-Sierra, A., 2012. On the occurrence of egg masses of the diamond-shaped squid *Thysanoteuthis rhombus* Troschel, 1857 in the subtropical eastern Atlantic (Canary Islands). A potential commercial species? *ZooKeys*, 222: 69-76. <https://doi.org/10.3897/zookeys.222.2835>
- Fernández-Álvarez, F., Colmenero, A. & Barria, C., 2021. First record of the elusive oceanic squid *Thysanoteuthis rhombus* Troschel, 1857 (Cephalopoda: Thysanoteuthidae) in the Catalan coast. *Graellsia*, 77 (1): e122. <https://doi.org/10.3989/graelisia.2021.v77.284>
- Jereb, P. & Roper, C.F.E., 2010. *Cephalopods of the world. An annotated and illustrated catalogue of cephalopod species known to date. Vol. 2. Myopsid and Oegopsid Squids*. FAO. Roma. 649 pp.
- Lipiński, M.R. & Underhill, J.G., 1995. Sexual maturation in squid: quantum or continuum? *South African Journal of Marine Science*, 15: 207-223. <https://doi.org/10.2989/02577619509504844>
- Miyahara, K., Ota, T., Hatayama, J., Mitsunaga, Y., Guto T. & Onitsuka, G., 2008. Tagging studies on diamond squid (*Thysanoteuthis rhombus*) in the western Sea of Japan. *Bulletin of the Japanese Society of Fisheries Oceanography*, 72 (1): 30-39.
- Nigmatullin, C.M. & Arkhipkin, A.I., 1998. A review of the biology of the diamondback squid, *Thysanoteuthis rhombus* (Oegopsida: Thysanoteuthidae). In: T. Okutani (ed.). *Contributed papers to International symposium on large pelagic squids. Japan Marine Fishery Resources Research Center*. Tokyo: 155-181.
- Nigmatullin, C.M., Arkhipkin, A.I. & Sabirov, R.M., 1995. Age, growth and reproductive biology of diamond-shaped squid *Thysanoteuthis rhombus* (Oegopsida: Thysanoteuthidae). *Marine Ecology Progress Series* 124: 73-87. <https://doi.org/10.3354/meps124073>
- Roper, C.F.E. & Voss G.L., 1983. Guidelines for taxonomic descriptions of Cephalopod species. *Memoirs of National Museum of Victoria*, 44: 49-63. <https://doi.org/10.24199/j.mmv.1983.44.03>
- Roque-Sánchez, M.A. & Donayre-Salazar, S., 2021. *Thysanoteuthis rhombus* Troschel, 1857 (Teuthida: Thysanoteuthidae) calamar diamante, registro en la zona costera de Ica, Perú. *Revista peruana de Biología*, 28 (1): e18055. <https://doi.org/10.15381/rpb.v28i1.18055>
- Sajikumar, K.K., Sasikumar, G., Venkatesan, V., Vidya, R., Alloyious, P. S., Jestin Joy, K.M., Karamathullah, P.S., Nataraja, G.D. & Mohamed, K.S., 2020. Distribution, age and growth of the diamondback squid, *Thysanoteuthis rhombus* (Cephalopoda: Thysanoteuthidae) from the tropical Arabian Sea. *Fisheries Research*, 224: 105478. <https://doi.org/10.1016/j.fishres.2019.105478>
- Trasviña, A. & Barton, E.D., 2008. Summer circulation in the Mexican tropical Pacific. *Deep-Sea Research Part I* 55: 587-607. <https://doi.org/10.1016/j.dsr.2008.02.002>