INNSPUB

Journal of Biodiversity and Environmental Sciences | JBES
ISSN: 2220-6663 (Print); 2222-3045 (Online)
Website: https://www.innspub.net
E-mail contact: info@innspub.net
Vol. 27, Issue: 1, p. 61-70, 2025

RESEARCH PAPER OPEN ACCESS

Fishing ground and seasonal availability of diamondback squid (*Thysanoteuthis rhombus*) along southern Tañon Strait: Local fishermen's insights

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Key words: Cephalopod, Latent fishery resource, Fishing seasonality, Fishing operations, Municipal fishing, Catch decline

DOI: http://dx.doi.org/10.12692/jbes/27.1.61-70 [Published: July 16, 2025]

ABSTRACT

This study documented the fishing grounds and seasonal availability of the diamondback squid (DBS) (*Thysanoteuthis rhombus*) along the southern Tañon Strait region of southwestern Cebu, Philippines, using purposive sampling of 105 fishermen across seven municipalities. All respondents had prior experience in capturing *T. rhombus* using a gear specifically designed for the species. Findings revealed that DBS fishing grounds spanned from the Municipality of Barili to Santander, with Barili emerging as the most prominent site. DBS fishing was also noted in Carcar, marking the first fisher-reported records of DBS in Cebu Strait. Respondents commonly used motorized boats (0.3–0.39 GT) with 6–10 HP gasoline engines, consuming 1–2L of fuel per trip. Fishing lasted 7–11 hours, typically conducted solo during daylight hours. The peak DBS season was observed from March to early August, with May yielding the highest catches—typically 1–10 pieces per trip, each weighing 1–10 kg. A lean season occurred from late August to February, with October having the lowest catch rates and most operations reporting no catch. Respondents noted a general decline in DBS catches from 2021 to 2022, coinciding with the COVID-19 pandemic. However, some fishermen linked the decline from 2011 to 2020 to excessive fishing effort and the use of the "multiple jigs in a line" method. While various causes were proposed, most attributed the decline to the species' natural seasonal behavior. The findings offer baseline data for resource assessment and highlight the need for adaptive, season-based management to ensure sustainable catches.

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INTRODUCTION

Among the many squid species found worldwide, the diamondback squid (*Thysanoteuthis rhombus*) remains relatively uncommon and underexploited in global fisheries (Arkhipkin *et al.*, 2015). Despite its commercial importance in certain regions, particularly in Japan and in some parts of the Philippines, most scientific knowledge on this deep-sea squid has come from incidental discoveries rather than targeted research (Roper *et al.*, 1984; Bower and Miyahara, 2005; Lamayo *et al.*, 2008).

Thysanoteuthis rhombus, the only member of the genus *Thysanoteuthis* and part of the family Thysanoteuthidae, is currently classified as Least Concern (LC) by the IUCN (De Chavez *et al.*, 2021; Rajikumar *et al.*, 2022). It has a short lifespan of approximately one year (Nigmatullin *et al.*, 1995; Bower and Miyahara, 2005), and is characterized by its thick, muscular mantle tapering to a blunt posterior and long, rhombic fins that extend along the full mantle length (Roper *et al.*, 1984). This large nektonic squid is mainly found at around 200-1000m deep during the day and migrates to 0-200m to feed at night (Yano *et al.,* 2000). The species can reach up to 100 cm in mantle length and weigh up to 20 kg, and typically follows warm ocean currents such as the Kuroshio, Tsushima, Agulhas, Brazil Current, and Gulf Stream (Nigmatullin *et al.*, 1995).

The species has been caught in several major marine regions. In East Asia, it is harvested for commercial purposes in the Sea of Japan and around Okinawa (Bower and Miyahara, 2005). In the Indian Ocean, its presence is recorded in Indian waters, including the Chennai coast and Gulf of Mannar (Batcha *et al.*, 2009; Rajikumar *et al.*, 2022), and off Sulawesi in Indonesia (Billings *et al.*, 2000). In the Mediterranean, including the Adriatic, it has been documented by Bello (1999) and Marčić *et al.* (2009). Records from the Atlantic Ocean include sightings along the Brazilian coast (Cunha and Oliveira, 2014) and in the Caribbean Sea (Pulido-Lopez and Lopez-Pinto, 2002; Salvat-Torres *et al.*, 2009). In the Pacific Ocean, the species has been reported in the Northeastern Tropical Pacific (Alejo-Plata and Urban-Alonso, 2018). Additionally, egg masses of *T. rhombus* have also been reported globally, with several sightings recorded in Moalboal, Cebu-whose waters are part of the southern Tañon Strait (Brown *et al.*, 2022).

In the Philippines, *T. rhombus* is considered a latent fishery resource and remains one of the uncommon squid species targeted for fisheries (Dickson *et al.*, 2000). Although there are 47 known fishing grounds nationwide, most squid fisheries focus on the capture of neritic species (Hernando and Flores, 1981). Comprehensive data on the distribution, abundance, and stock status of many Philippine cephalopods, including *T. rhombus*, are still lacking (Hernando and Flores, 1981).

Nevertheless, occurrences of diamondback squid (DBS) have been reported in various parts of the country, including Tañon Strait and Camotes Sea in Cebu province, Isabel and Ormoc City in Leyte province, Calauag Bay in Quezon Province, and in Marinduque province (Dickson *et al.*, 2000; Lamayo *et al.*, 2008; Chavez *et al.*, 2021; Amihan and Daita, 2025). Additionally, Dickson *et al.* (2000) documented a specimen from the South China Sea (Western Philippines).

Given its known presence in Tañon Strait and its potential as a fishery resource, identifying the fishing grounds and seasonal patterns of *T. rhombus* is a crucial step toward informed management and potential stock assessment. Therefore, this study aims to document the fishing grounds and seasonality of *T. rhombus* in Tañon Strait, based on the knowledge and observations of local fishermen. Such baseline information is essential for developing sustainable utilization strategies for this uncommon but valuable species.

MATERIAL AND METHODS

Site of the study

This study was conducted in 2022-2023 in the southwestern coastal municipalities of Cebu Province, specifically within the 7th Congressional District. The municipalities included in the survey were Barili,

Dumanjug, Ronda, Alcantara, Moalboal, Badian, Alegria, Malabuyoc, and Ginatilan. Among these, seven were confirmed to have active fishers engaged in DBS fishing: Barili, Ronda, Moalboal, Badian, Alegria, Malabuyoc, and Ginatilan.

Research respondents

The study surveyed local fishermen from the previously identified municipalities along the southern portion of Tañon Strait. A total of 105 respondents participated. Selection was based on their firsthand experience in catching *T. rhombus* at least once, using a DBS jig.

Research instrument

Data were collected using a structured survey questionnaire administered through purposive sampling. The instrument was designed to elicit information specifically related to the fishing practices and observations of DBS fishers.

Data gathering procedure

A customized survey questionnaire was employed to collect the necessary data for this study. Each respondent was visited personally and interviewed using the questionnaire, with interviews lasting approximately 5 to 10 minutes. Responses were manually recorded by the researcher. After data collection, all responses were carefully documented, tabulated, and subjected to analysis.

Statistical treatment

The study covered seven municipalities where DBS fishing activity was reported. All identified fishermen engaged in *T. rhombus* fishing were included as respondents. Data obtained through the survey and focus group discussions were analyzed using frequency distribution to identify common patterns and trends. Microsoft Excel was used for data tabulation and statistical analysis.

RESULT AND DISCUSSION

Respondents

There was a total of 105 fishermen involved in the capture of *T. rhombus* in seven municipalities of southern Cebu with its municipal waters situated along southern Tañon Strait that were chosen as respondents in this study. All respondents were male (100%), with the majority aged 41 years and above (67.62%). Most had attained an elementary level of education (56.19%) and reported a monthly income of less than PHP 4,000 (56.19%). Household size varied, with the highest proportion (30.48%) having 5 to 6 family members. The majority of respondents were residents of the municipality of Barili (50.48%) (Table 1).

Table 1. Socio-demographic profile of DBS fishermen respondents

Profile	Frequency (f)	Percentage (%)
Gender		
Male	105	100
Age		
21-30	14	13.33
31-40	20	19.05
41-50	34	32.38
>50	37	35.24
Address/Municipality		
Barili	53	50.48
Ronda	4	3.81
Moalboal	2	1.90
Badian	6	5.71
Alegria	27	25.71
Malabuyoc	9	8.57
Ginatilan	4	3.81
Educational Background		
None	1	0.95
Elementary	59	56.19
Secondary	36	34.29
College	9	8.57
Household Size		
1-2	13	12.38
3-4	23	21.90
5-6	32	30.48
7-8	26	24.76
>9	11	10.48
Monthly Income (Php)		
<4,000	59	56.19
4,000-6,000	32	30.48
6,000-8,000	8	7.62
8,000-10,000	4	3.81
>10,000	2	1.90

***T. rhombus* fishing grounds in southern Cebu, Philippines**

The Tañon Strait Protected Seascape is widely recognized as the largest marine protected area in the Philippines and holds significant importance as one of the primary fishing grounds in the nation. The Tañon Strait is narrow with a width of 27 kilometers, exhibits considerable length spanning 160 kilometers and possesses significant depth reaching up to 500

meters. This strait is renowned for its role as a migratory pathway for large aquatic species, including whale sharks and diamondback squid. Sightings of *T. rhombus* egg masses in Moalboal, at the southern end of the strait (Brown *et al.*, 2022), and recent documentation of specialized DBS fishing gear in this area (Amihan and Daita, 2025) underscore the strait's role as a reproductive and fishing hotspot for the species.

Nationally, squid fisheries receive limited research attention, leaving critical gaps in information on distribution, abundance and seasonality—gaps that impede reliable stock assessments. To help address this, the present study interviewed DBS fishers operating along southern Cebu.

The majority of interviewed DBS fishermen reported fishing for *T. rhombus* primarily within the municipal waters adjacent to their respective localities or neighboring municipalities. In southern Cebu, along the Tañon Strait, DBS fishing was reported across several areas, ranging from the Municipality of Barili (21.40%) to the southernmost part of the strait, the Municipality of Santander (0.78%) (Fig. 1). The municipal waters of Barili (21.40%) emerged as the primary DBS fishing ground, consistent with the highest number of respondents originating from the municipality. These observations suggest that *T. rhombus* may also inhabit the strait's northern reaches or adjoining waters to the south.

Additional fishing grounds identified was the municipal waters of Carcar (0.78%) and Oslob (3.89%). Previous work has documented commercial catches of *T. rhombus* off northern Cebu in the Camotes Sea (Lamayo *et al.*, 2008); the present study is the first to record fisher-reported catches from Cebu Strait, indicating that the species likely traverses both straits while following warm-current pathways. Systematic sampling across these areas is therefore essential to delineate the full spatial extent of the stock and to inform management within the Tañon Strait Protected Seascape and beyond.

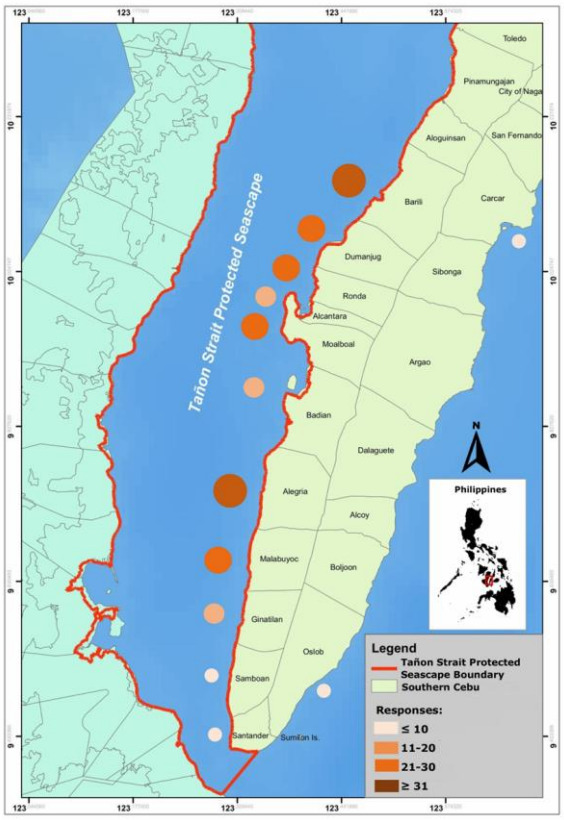

Fig. 1. DBS fishing grounds identified by respondents

DBS fishing operations of respondents

As a species commonly found in relatively deep waters, *T. rhombus* in southern Tañon Strait is typically caught at depths ranging from 151 to 200 meters (Amihan and Daita, 2025). To access these offshore fishing grounds, all respondents reported using motorized fishing vessels (100%) with a capacity of 0.3-0.39 GT (33.33%) (Table 2). The majority of these vessels are powered by gasoline engines (90.48%), with engine outputs of 6–10 HP (57.89%), which takes up 1-2L (48.42%) of gasoline for a two-way travel. The size of the fishing boat used by the respondents and the distance of their fishing ground from the shoreline categorizes DBS fishing to be part of municipal fishing (RA 8550).

Being a marine protected area, it is strictly prohibited to conduct commercial fishing in the Tañon Strait (RA 10654). However, municipal fishing is allowed in these waters. In the case of *T. rhombus*, being a relatively latent resource in the area, there are currently no existing laws and regulations at a national or local level relevant to the harvesting and

marketing of the species. Currently, there are neither existing laws nor local regulations that prevent the fishing activities of *T. rhombus* along the strait.

One-way travel time to the chosen fishing grounds varies, with 22.86% of respondents reporting travel durations of 20 to 30 minutes for nearby locations; while 21.90% indicated travel times exceeding 60 minutes when fishing grounds are located in other municipalities (Fig. 2). These fishing grounds generally extend just before or into the midline of the strait.

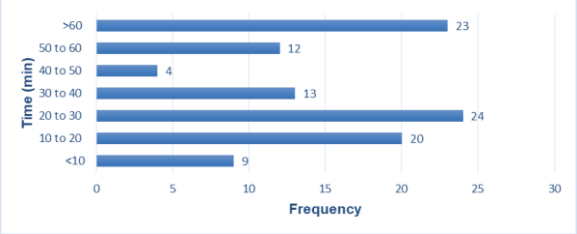

Fig. 2. Respondent's one-way travelling time to their respective DBS fishing ground

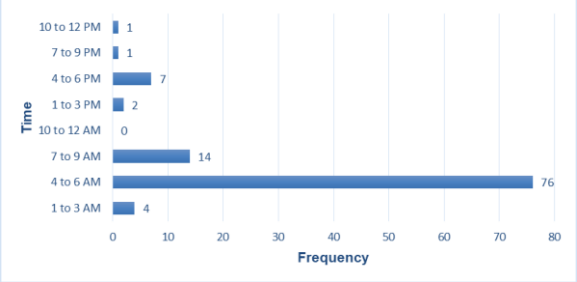

Fig. 3. Respondent's departure time from port for DBS fishing

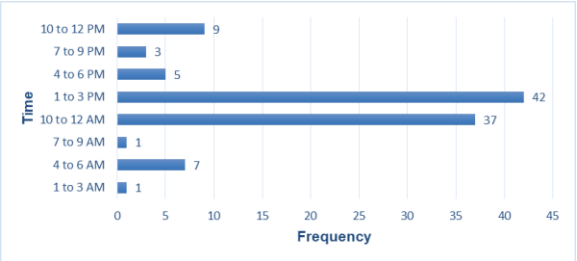

Fig. 4. Respondent's arrival time to port from DBS fishing

According to the respondents, DBS fishing typically lasts between 7 to 11 hours, with most operations beginning between 4:00 AM and 6:00 AM (72.38%) (Fig. 3). The return to port commonly occurs between 1:00 PM and 3:00 PM (40.00%) (Fig. 4), coinciding with the period when the sun's intensity becomes unbearable.

The respondents exhibit a preference for engaging in DBS fishing during daylight hours, particularly in the morning, when the ambient temperature is conducive for fishing. Despite *T. rhombus* migrating to shallower waters at 50-100m (Alejo-Plata and Urbano-Alonso, 2018) at night, DBS fishermen still prefer daytime avoid any visual impairments. Moreover, Japan, the only country recognized with a major fishery for *T. rhombus*, also considers DBS fishing as a daytime fishery (Arkhipkin *et al.,* 2015).

The results of this study align with those of De Chavez *et al.* (2021), who reported that DBS fishers in Marinduque typically spend 8 to 10 hours or longer- at sea to target *T. rhombus*.

However, a notable distinction is that in southern Tañon Strait, DBS fishers do not return to port until their daily operations are completed. Instead, they remain at the fishing site, continuously monitoring their deployed buoys and marker flags. This practice minimizes fuel consumption and operational costs.

Another difference lies in the fishing crew composition. In southern Tañon Strait, the majority of respondents (80.00%) conduct fishing operations alone to reduce expenses and maximize income (Table 2). Occasionally, they are accompanied by their sons who assist during fishing activities.

Despite operating individually, these fishers often deploy their gear alongside other solo vessels during the peak fishing season. The study's results coincide with the practices in the Sea of Japan wherein *T. rhombus* fishers utilize boats smaller than 5GT with usually one personnel to operate the fishing activity (Arkhipkin *et al.,* 2015).

Table 2. Fishing boat characteristics and operation profiles of respondents during DBS fishing

Profile	Frequency (f)	Percentage (%)
Usage of fishing boat		
Yes	105	100
No	0	0
Fishing boat size (by GT)		
1.02-1.98	2	1.90
0.88	1	0.95
0.75-0.78	3	2.86
0.60-0.67	5	4.76
0.50-0.56	7	6.67
0.40-0.48	10	9.52
0.30-0.39	35	33.33
0.20-0.29	29	27.62
0.02-0.17	13	12.38
Usage of boat engine		
Yes	95	90.48
No	10	9.52
Horsepower (HP) of engine attached to fishing boat		
1-5	3	3.16
6-10	55	57.89
11-15	30	31.58
16-20	7	7.37
Fuel (L) consumed in a two-way travel by engine per DBS fishing operation		
1-2	46	48.42
3-4	39	41.05
5-6	7	7.37
7-8	2	2.11
9-10	1	1.05
Number of personnel aboard one fishing vessel during a DBS fishing operation		
1	84	80.00
2	20	19.05
3	1	0.95

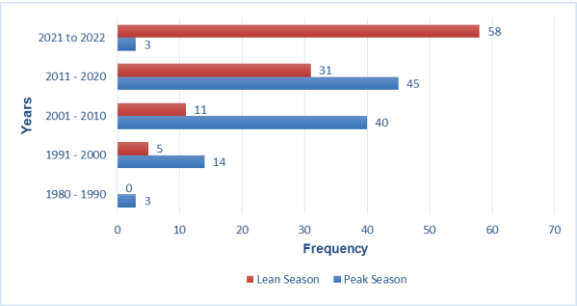

Fig. 5. Annual seasonal availability of T. rhombus along southern Tañon Strait

Seasonal availability of *T. rhombus* along the southern Tañon Strait

The respondents have made observations regarding the presence of seasonality in DBS captures. In a yearly basis, a majority of respondents reported a higher incidence of DBS captures throughout the timeframe of 2001-2020 (80.95%), whilst the lowest number of DBS captures was seen between the years 2021-2022 (55.24%) (Fig. 5).

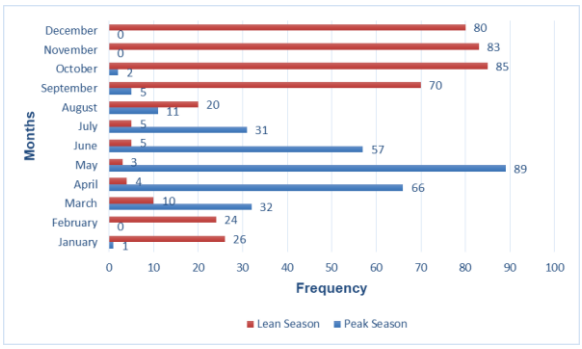

Fig. 6. Monthly seasonal availability of T. rhombus along southern Tañon Strait

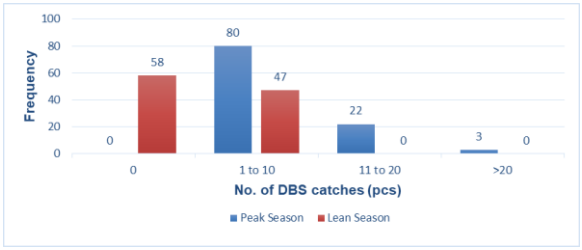

Fig. 7. Number of T. rhombus catches based on seasonality

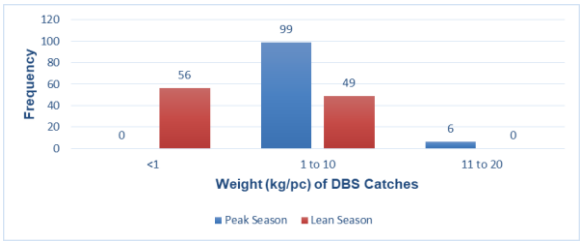

Fig. 8. Weight of T. rhombus catches based on seasonality

According to the respondents, there is a higher incidence of DBS being discovered and captured in their fishing grounds on a monthly basis, particularly from March to early August, peaking during the month of May (30.27%) (Fig. 6). During the peak season, on average, a fisherman normally catches approximately 1 to 10 pieces (76.19%) of DBS weighing 1 to 10 kilograms (94.29%) per piece during each fishing operation (refer to Fig. 7 and 8).

On a monthly basis, the respondents noted that the lean season of *T. rhombus* occurred starting from late

August and extending until February (Fig. 6). The month of October exhibited the lowest capture rates (20.48%). The majority of DBS fishing operations experience a lack of catches during the lean season, resulting to mostly zero (55.24%) catches. However, a tiny portion of operations manage to catch a limited quantity of DBS, ranging from 1 to 10 pieces (44.76%) (Fig. 7). The lean season is characterized by a prevalence of smaller catches, with the majority of catches weighing less than 1kg per piece (53.33%) (Fig. 8).

The seasonal occurrence for *T. rhombus* in southern Tañon Strait aligns with the summer season in the area. This timing is consistent with its characterization as a low-activity migrant that rides warm currents and spawns during the warmest months in tropical waters (Nigmatullin *et al.*, 1995; Brown *et al.*, 2022).

The seasonal patterns observed in this study generally align with the DBS fishing season reported in northeastern Cebu, which also begins in March (Lamayo *et al.*, 2008). Nevertheless, there is a distinction among the months when catches peak. In the present study, conducted in southern Cebu along the Tañon Strait, DBS catches peaked in May. In contrast, catches in the Camotes Sea, northeastern Cebu, were highest in July. Notably, both studies recorded the largest individuals during their respective peak months, corresponding to the peak season of *T. rhombus*.

Seasonal variability is likewise evident in adjacent waters. In the Visayan Sea, located northwest of Tañon Strait, cephalopods are available year-round. However, seasonal peaks vary spatially, with the upper region near Masbate Island peaking from March to May, and the central to southern region near Panay Island peaking from November to March (Hernando and Flores, 1981).

Elsewhere in the Philippines, seasonal availability of *T. rhombus* also varies. In Calauag Bay, Quezon Province, the species is present from June to October, with peak catches from August to September. Meanwhile, in Ormoc Bay, Leyte Province, the season extends from March to December, with the highest catch per unit effort (CPUE) recorded in August and September (Dickson *et al.*, 2000).

The seasonality of *T. rhombus* in southern Tañon Strait in the Philippines exhibit contrasting findings when compared to the DBS fishing seasonality research conducted in Japan. In the Sea of Japan, DBS fishing season commences during July to February and peaks during September to December. In the Okinawa Prefecture, DBS fishing season starts from November to June, whereas in the Bonin Islands, DBS fishing season spans from November to March (Bower and Miyahara, 2005). According to the findings of this study, the DBS fishing season in Japan, as noted earlier, can be characterized as the lean season for DBS fishing in southern Tañon Strait.

Decline of DBS captures

The respondents collectively agreed that there has been a gradual decline in the volume of *T. rhombus* catches on an annual basis. Catches had a significant decline during the period of 2021-2022, coinciding with the COVID-19 pandemic. Presented in Table 3 are the primary factors that respondents believe contributed to the decline in catches, with a majority of respondents attributing it to the "seasonal characteristic of DBS" (37.14%).

According to the responses of the DBS fishermen, there is still a substantial quantity DBS that can be caught in the strait, though after the pandemic, the number of DBS fishers venturing to catch the species has declined. However, certain fishermen have claimed that the observed decline in DBS populations prior to the pandemic, specifically from 2011 to 2020, can be attributed to an excessive fishing effort (11.43%) exerted in their selected fishing grounds. These fishermen, in conjunction with others, have asserted that this decline was primarily caused by the utilization of the MJL fishing method (14.29%). This method resulted in the capture of a considerable number of DBS during each fishing operation, consequently

depleting the stock during the aforementioned years. A similar decrease of *T. rhombus* catches, although unrelated to the type of gear used, was also observed by Marinduque fishermen for the past 5 to 10 years (De Chavez *et al.*, 2021).

According to the respondents in this study, there has been a consistent upward trend in DBS catches on an annual basis since the 1980s, with the highest number of catches occurring in the early 2010s. Nevertheless, there was a noticeable decrease in the late 2010s that persisted until 2022. While respondents provided several explanations for this decline, the majority agreed that it can be attributed simply to the seasonal characteristic of *T. rhombus*.

Table 3. Fishermen's perspectives on the decline of DBS catch over the years

Reason	Frequency	Percentage (%)
Seasonal trait of *T. rhombus*	39	37.14
Climate Change	7	6.67
Overfishing	6	5.71
T. rhombus is migratory	8	7.62
Decline in food availability for *T. rhombus*	4	3.81
Too much fishing effort in the area	12	11.43
Due to the introduction of "multiple jigs in a line" (MJL) fishing method	15	14.29
Strong typhoons	2	1.90
Depends on the month's tides and temperature	4	3.81
Changes in the tides	1	0.95
Use of new gear accessories	1	0.95
Presence of commercial fishing in the area	4	3.81
Absence of market	1	0.95
Presence of predators of *T. rhombus*	1	0.95

At present, a comprehensive study on the stock assessment for *T. rhombus* has not been conducted in the Philippines, thereby hindering the determination of on the actual condition of *T. rhombus* stock and its underlying causes for the observed decline. Nigmatullin and Arkhipkin (1998) conducted a global assessment and determined that the estimated biomass of *T. rhombus* is at least 1.5 to 2.5 MT. However, the global standing stock of this species remains unknown.

There is presently a lack of effective measures to stabilize the catches in the subsequent years. Rigorous management practices implemented during the fishing season might effectively mitigate the issue of over exploitation of juvenile *T. rhombus* populations (Arkhipkin *et al.*, 2015).

CONCLUSION

This study identified key fishing grounds of *Thysanoteuthis rhombus* along southern Tañon Strait, with Barili emerging as the most active site. Fishing was typically conducted solo using motorized boats (0.3–0.39 GT), lasting 7–11 hours during daylight. Seasonal patterns were evident, with peak catches from March to early August—particularly in May—and a lean season from late August to February. While respondents observed a marked decline in catches during 2021–2022, they believe viable stocks remain. The decline was attributed to the squid's seasonal behavior, pandemic-related disruptions, and increased fishing pressure, especially from the use of the MJL method. Understanding fishers' insights and operational practices provides essential baseline information for future resource assessments and supports the development of targeted, seasonal, and gear-based management strategies.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support provided by Cebu Technological University Moalboal Campus through the GAA Research Fund. We acknowledge with gratitude the support of the Local Government Units from District 7 in southwestern Cebu, the Department of Environment and Natural Resources–Tañon Strait Protected Seascape (DENR-TSPS), and the Bureau of Fisheries and Aquatic Resources Regional Office 7 (BFAR RO-7).

Sincere thanks are extended to Dr. Anthony Ilano, Dr. Ma. Helian Lamayo and Dr. Roberto Lamayo for their invaluable guidance throughout the study. We also thank Mr. Jomar Tabano, Ms. Ailyn Tapales, Ms. Joe-an Badonio, Ms. April Joy Calvario, Ms. Jay Ann Deluvio, and Ms. Floraniel Tancogo for their assistance during the conduct of the experiment proper.

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