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Squid jig types, composition and CPUEs, utilized in diamondback squid (*Thysanoteuthis rhombus*) fishing along southern Tañon Strait, Philippines

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Key words: CPUE, Diamondback squid, *Thysanoteuthis rhombus*, Squid jig, Fishing gear, Tañon Strait

Abstract

The study examined the fishing practices and efficiency in catching *Thysanoteuthis rhombus*, or diamondback squid (DBS), in the southern Tañon Strait region of southwestern Cebu through a survey conducted in DBS fishing communities across seven municipalities. In the study's locality, DBS presence has been noted without comprehensive understanding of its fishery and technology. From responses of 105 DBS fishermen, the study found two primary gear types used: "single jig in a line" (SJL) and "multiple jig in a line" (MJL), both featuring manually crafted squid jigs with integrated sinkers, 151-200m monofilament nylon mainlines connected to buoyant polystyrene spools and brightly-colored flag markers, and attachments affixed to the mainlines such as blinkers and bait; with MJL being distinctly equipped with five jigs spaced every 1-10m. Among the two, SJL is predominantly used by respondents. CPUE analysis indicates SJL's overall higher efficiency, with CPUEs of 0.49 kg/jig/hr, 0.63 kg/jig/hr, 1.07 kg/jig/hr, and 0.67 kg/jig/hr during 1991-2000, 2001-2010, 2011-2020, and 2021-2022, respectively. MJL type showed CPUEs of 0.81 kg/jig/hr, 0.62 kg/jig/hr, 0.63 kg/jig/hr, and 0.75 kg/jig/hr during the same periods. Despite varying CPUEs, both gear types showed higher CPUEs in DBS fishing compared to previous DBS exploratory studies in the country. However, there's a notable decline in the average weight per caught individual over the decades, prompting respondents to increase fishing efforts since 2011. The study suggests that assessing the population dynamics of DBS along the Tañon Strait is crucial for ensuring the sustainability of this resource.

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Introduction

An uncommon squid species that occur in Philippine waters is the *Thysanoteuthis rhombus*, commonly known as the diamondback squid (DBS) and locally known in the Visayan region as "dalupapa". The *T. rhombus* is a large nektonic squid that is found in tropical and subtropical waters all over the globe. Despite *T. rhombus* having a fast growth rate and being one of the largest cephalopods for human consumption, this species is treated as a latent resource in the Philippines (Dickson *et al.*, 2000). Due to the underutilization of diamondback squid in the country, latest information on its fishing effort, production and other basic data are not readily available (Hernando and Flores, 1981).

In Japan, *T. rhombus* is valued as a commercial species with annual catches increasing from 339 t in 1989 to almost 6000 t in 2001 (Bower and Miyahara, 2005). In other places of the globe where *T. rhombus* is accessible, slow developments in its fisheries has been attributed to the lack of proper gear and the abundance of other resources (e.g. other squid species) to be exploited (Nimoho *et al.*, 2014). In Japan, the development of DBS fishery has been prompted by the development of an innovative fishing technology selective to DBS known as taru-nagashi and hata-nagashi (Bower and Miyahara, 2005; Nimoho *et al.*, 2014).

The development of DBS fishing technology offers an opportunity to potentially enhancing food production (Dickson *et al.*, 2000) and providing economic stimulus through both local and export trade markets. In the Philippines, *T. rhombus* was believed to be first caught by a few fishermen in Masbate. During 1988, diamondback squid fishing grew when its fishing technology transferred between the localities of Negros to Northern Cebu. It was during 1997-1999, when *T. rhombus* was caught extensively with an average of 82.69MT per year for export purposes by the fishers of Luyang, Carmen, Cebu (Lamayo *et al.*, 2008). Despite the high demand in both local and foreign markets, diamondback squid fishing reduced in the country, specifically in Cebu, that many export markets closed and its technology development remained stagnant.

There are currently no published studies concerning DBS fishery and its fishing technology in southern Cebu as well as in other regions along the Tañon Strait. Baez *et al.* (2015) reported that diamondback squid, along with various other squid species, frequents the Tañon Strait. With the migratory nature of *T. rhombus*, several fishers along the Tañon Strait have undocumented claims of capturing and trading of the species. Thus, this study aimed to document the fishing technology employed for capturing *T. rhombus* in the southern Tañon Strait and assess its effectiveness in capturing the species over the years of its utilization, through a survey conducted in identified DBS fishing communities situated in southwestern Cebu, particularly in the municipalities of Barili, Ronda, Moalboal, Badian, Alegria, Malabuyoc, and Ginatilan.

Materials and methods

Site of the study

The geographical scope of the survey encompassed the municipalities situated in the southwestern region of Cebu, mainly those that fall within the 7th Congressional District of Cebu province. The aforementioned municipalities include Barili, Dumanjug, Ronda, Alcantara, Moalboal, Badian, Alegria, Malabuyoc, and Ginatilan. Among these municipalities, seven were found to have fisherfolk engaged in *T. rhombus* fishing and its trade. The seven municipalities identified were Barili, Ronda, Moalboal, Badian, Alegria, Malabuyoc, and Ginatilan.

Research respondents

This study had conducted a survey on all identified local fishermen of the aforementioned municipalities found along Southern Tañon strait. A total of 105 respondents were characterized. Respondents were chosen based on having experienced catching diamondback squid at least once in their lifetime using a gear designed specifically for DBS fishing.

Research instrument

The data collection method employed in this study involved the use of purposive sampling via the administration of a survey questionnaire.

Data gathering procedure

A tailored survey questionnaire has been utilized to gather all the needed data for this study. The respondents have been visited in person and interviewed via the questionnaire. Interviews took a total of 5-10 minutes per respondent. The researcher has manually documented the responses of the respondents. Following the collection of data, the researcher has documented, tabulated, and analyzed all of the information acquired.

Statistical treatment

The research design consisted of seven areas that were surveyed. All identified fishermen involved in DBS fishing have been chosen as respondents. Results obtained have been analyzed using frequency distribution. Based on the survey and focus group discussion results, comparison between the catch efficiency of identified DBS jig types were analyzed using catch-per-unit-effort (CPUE). CPUE (kg/jir/hr) is computed by considering the weight of DBS caught in kilograms (kg) divided by the total number of gears cast (jig) and divided by the duration of time spent at sea (hr).

Results

DBS fishing gear anatomy used in southern Tañon Strait, Philippines

The 105 DBS fishermen respondents used squid jigs (100%) as the primary gear to catch *T. rhombus* (Fig. 1). For this study, there were two squid jig types identified that were used by the respondents which were made specifically to capture DBS: "single jig in a line" (SJL) and “multiple jig in a line” (MJL) (Fig. 2 and 3). Majority of the respondents preferred to use SJL (62.86%) (Fig. 4). Regarding those who utilize MJL (37.14%), respondents would attach more than five jigs with an interval of 1-10m between each jig (Fig. 5).

Fig. 1. Fishing gear type utilized for catching *T. rhombus*

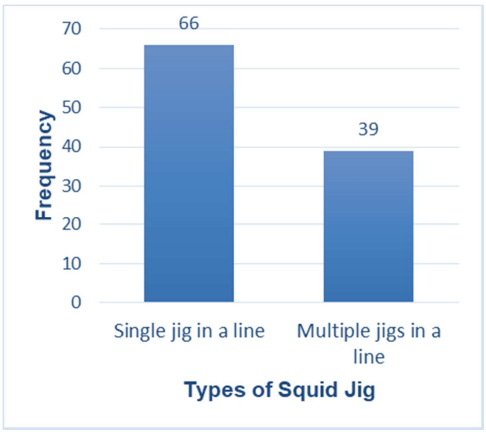

Fig. 2. Squid jig type used in the capture of *T. rhombus*

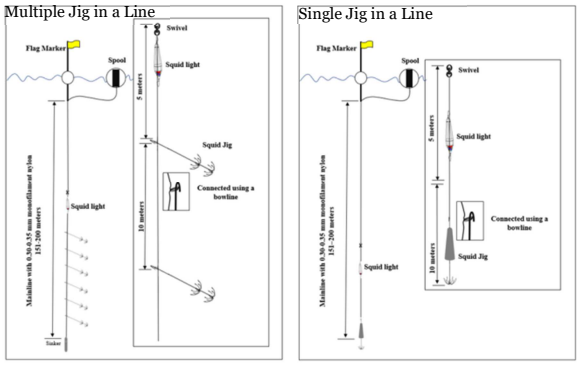

Fig. 3. Illustration of the general fishing gear anatomy used in the capture of *T. rhombus*

This study found a variety of modifications done by respondents to the general design of the gear. Among the alterations applied to the DBS jig involves the incorporation of sinkers and blinkers. Majority of the respondents used a jig with sinkers and blinkers (88.57%). Majority of respondents

(76.19%) indicated a preference for utilizing jigs equipped with built-in sinkers (Fig. 6). Respondents affix a single (96.19%), commercial multi-colored squid light (90.48%) onto the jig as blinker (Fig. 7 and 8).

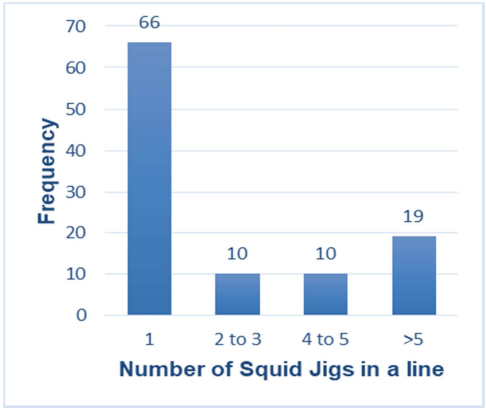

Fig. 4. Number of squid jigs affixed in a line used in the capture of *T. rhombus*

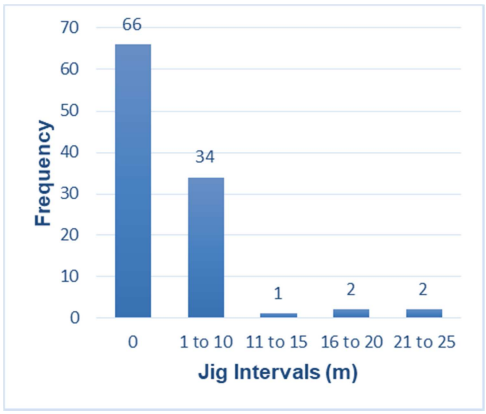

Fig. 5. Interval of jigs (m) attached in a line used in the capture of *T. rhombus*

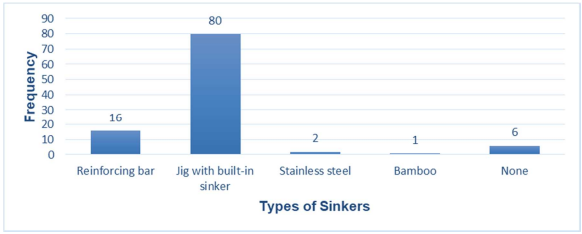

Fig. 6. Squid jig design based on the type of sinkers attached

Other modifications that some respondents would attach to the jig are: spring (0.96%), rubber (4.76%), ribbons (7.62%), and reflective stickers (1.90%) (Fig. 9).

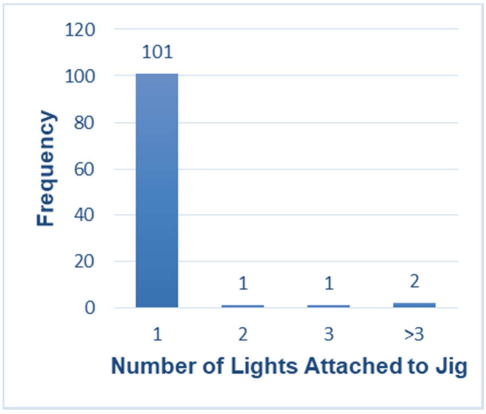

Fig. 7. Squid jig design on the number of lights affixed in a line

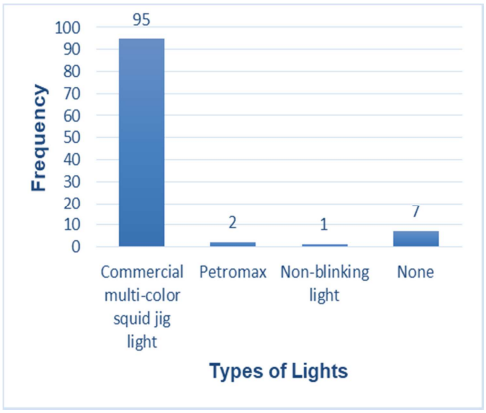

Fig. 8. Types of lights attached in a squid jig

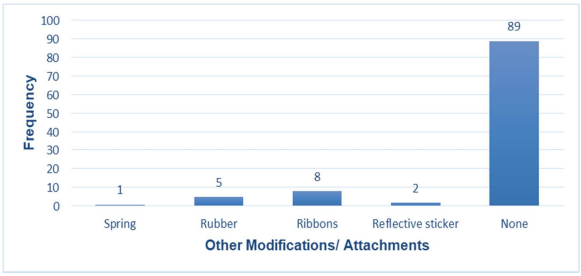

Fig. 9. Other squid jig modifications/attachments used by respondents

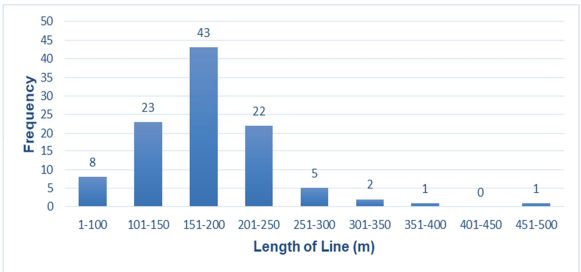

Fig. 10. Squid jig design based on the length (m) of the attached main line

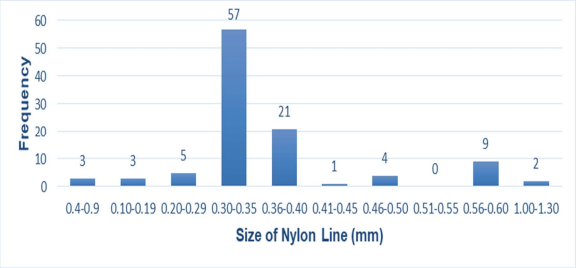

Fig. 11. Size (mm) of nylon mainline attached to the squid jig

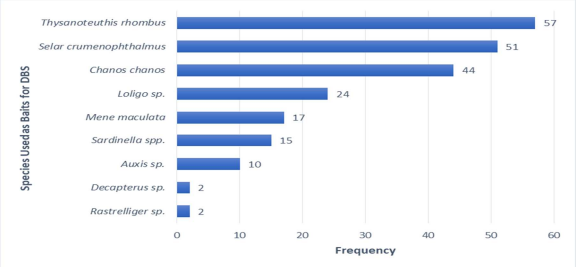

Fig. 12. Bait species used by respondents to attract *T. rhombus*

Another modification is variation in the length of the nylon fishing line with many respondents utilizing a line measuring 151-200m (40.95%) with a thickness of 0.30-0.35mm (54.29%) (refer to Fig. 10 and 11).

Another attachment with variation to the jig are the baits. Several species were used as baits with *T. rhombus* (25.68%), *S. crumenophthalmus* (22.97%) and *C. chanos* (19.82%) as the top three species used by the respondents (Fig. 12).

CPUE of DBS fishing gears during the peak season per one fishing operation in southern Tañon Strait, Philippines

The present study determined the Catch per Unit Effort (CPUE) of the two DBS fishing gears utilized in a single fishing operation during the peak season of *T. rhombus* along southwestern Cebu facing the Tañon Strait. The CPUE was computed by considering the weight of DBS caught in kilograms, the total number of gears cast, and the duration of time spent at sea (Fig. 13-17).

During 1980 to 1990, the exclusive utilization of the "single jig in a line" (SJL) gear type was reported. During the specified time frame, each fishing operation involved a total of 10hrs fishing time. DBS fishermen captured 4.33 individuals, each weighing an average of 6.33kg, using 9.67 jigs or 0.31kg/jig/hr.

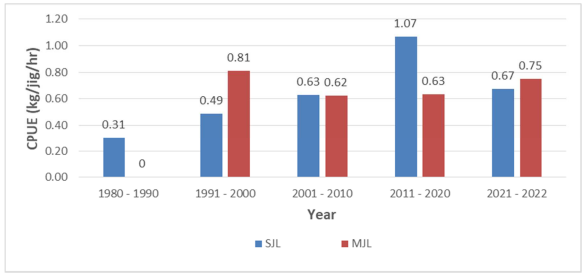

Fig. 13. Catch Per Unit Effort (CPUE) of the two DBS fishing gear types used in Southern Tañon Strait per one fishing operation

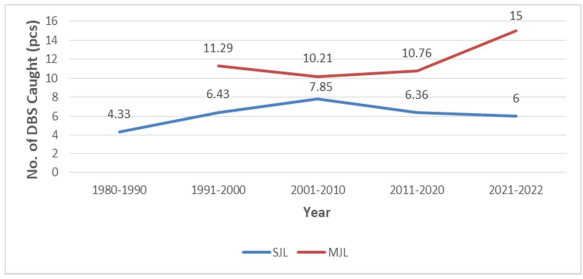

Fig. 14. Quantity of individuals caught per one fishing operation by the two DBS fishing gear types

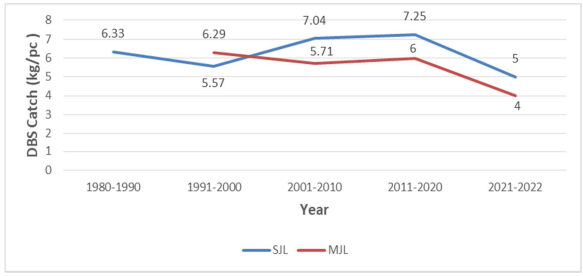

Fig. 15. Weight (kg) per individual of *T. rhombus* catches of the two DBS fishing gear types per one fishing operation

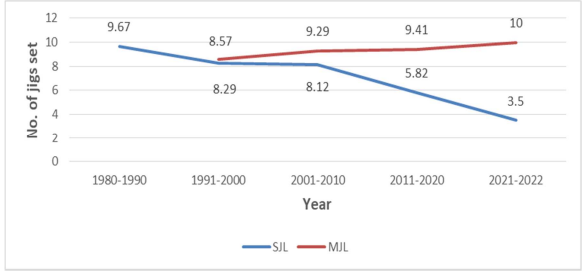

Fig. 16. Difference in the number of jigs set per fishing operation of the two DBS fishing gear types

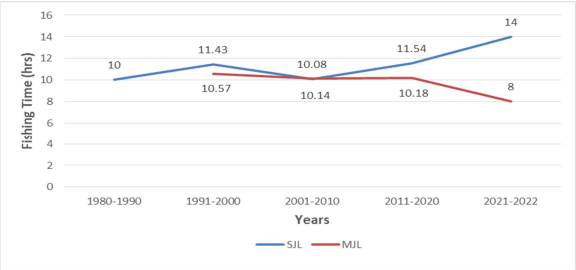

Fig. 17. Comparison on the fishing time spent using the two DBS fishing gear types per fishing operation

The gear type known as "multiple jigs in a line" (MJL) emerged later on from 1991 to 2000. In this decade, the MJL gear type captured 11.29 individuals, weighing an average of 6.29kg per individual, using 8.57 jigs for 10.57 fishing time or 0.81 kg/jig/hr. In contrast, the SJL gear type yielded a lower catch rate at 0.49 kg/jig/hr. The SJL caught an average of 6.43 individuals, each weighing 5.57kg, using 8.29 jigs for 11.43hrs fishing time.

From 2001 to 2010, fishermen utilizing SJL gear reported a rise in their *T. rhombus* catches, as compared to the previous decade, with 7.85 individuals caught, each weighing 7.04kg, using 8.12 jigs set for a duration of 10.08hr fishing time or at 0.63 kg/jig/hr. While MJL users observed decreases in their catch rate by this period at 0.62 kg/jig/hr with 10.21 individuals, each weighing an average of 5.71kg, caught by 9.29 jigs for 10.14hr fishing time.

In the following decade, from 2011-2020, SJL users witnessed a substantial rise in their fishing yields per operation. With 11.54hrs fishing time, fishermen employing the SJL gear type achieved a catch of 6.36 individuals, each weighing an average of 7.25kg, per 5.82 jigs or 1.07 kg/jig/hr. On the other hand, MJL users allocated 10.18hrs fishing time and gathered 10.76 individuals, with an average weight of 6kg/pc, per 9.41 jigs or 0.63 kg/jig/hr.

In the next years, 2021 to 2022, a decrease in DBS fishing activity occurred due to the prevailing protocols during the global pandemic which restricted the mobility of respondents. SJL users at this time spent 14hrs fishing time and caught 6 individuals per 3.5jigs or 0.67 kg/jig/hr at 5kg/pc. While MJL users spent 8hrs fishing time and caught 15 individuals per 10 jigs or 0.75 kg/jig/hr at 4kg/pc.

Discussion

Respondents

A total of 105 individuals were identified as respondents for this study which consisted of fishermen with prior experience in catching diamondback squid (DBS) at least once in their lifetime using a fishing gear specifically designed to target this species. All respondents were male fishermen; most were aged above 50yrs old (35.24%) and majority were located in the fishing community situated in the Municipality of Barili, Cebu (50.48%). Respondents had a family size of 5-6 members (30.48%); a monthly income below Php4,000 (56.19%); and had received elementary education (56.419%).

DBS fishing gear anatomy used in southern Tañon Strait, Philippines

DBS fishermen respondents use squid jigs as the primary gear for the capture of *T. rhombus*. In the Northwest Pacific region, *T. rhombus*, along with other squid species, is captured with a diverse range of fishing methods such as angling, jigging, trolling, bait fishing, trawl nets, set nets, and purse seine (Arkhipkin *et al.*, 2015). The utilization of squid jigs exhibits enhanced efficiency, species selectivity, and is not environmentally destructive.

The study has found that in southwestern Cebu facing the Southern Tañon Strait, there are two primary varieties of squid jigs for use in capturing *T. rhombus*: the "single jig in a line" (SJL) type and the "multiple jigs in a line" (MJL) type.

In general, both squid jig types identified in the study exhibit consistent gear composition. Both consist of a manually crafted squid jig with integrated sinkers, which may be affixed cement or reinforcing bars and is equipped with one or two layers of hooks, with uniform sizes at one end. The jig is fastened to a mainline measuring 151-200m in length, composed of

monofilament nylon with a thickness ranging from 0.30mm to 0.35mm.

Sinkers are one of the key components to the gear to effectively submerge the lengthy fishing line to the appropriate depths where DBS is known to occur. In the study conducted by Dickson *et al.* (2000), the squid jig used for the capture of *T. rhombus* was attached with a lead weight, which functioned as a sinker. Respondents employing sinkers rely on tactile perception to gauge the weight, thus rendering the specific data regarding the optimal weight for sinkers indefinable. *T. rhombus* is an elusive species mainly found at around 400-650m deep during the day and migrates to 50-100m to feed at night (Alejo-Plata and Urbano-Alonso, 2018). In the context of hooks, respondents predominantly employ uniformly smaller-sized hooks though they claim that the size of the hooks do not inherently influence the efficacy of the catch. Conducting test fishing with various hook sizes to validate the accuracy of this information is preferable.

Majority of the respondents use a lengthy mainline measuring 151-200m. In the study of Lamayo *et al.* (2008) in Northern Cebu, *T. rhombus* had a higher catch rate with lines reaching 100-200m water depth. Respondents determine the length of their fishing lines through test fishing. One approach they practice is to utilize DBS gears with varying line lengths, while another method involves the usage of a single DBS gear and making manual adjustments to the line length, either lengthening or shortening it, until a successful catch was achieved. Afterwards, the individuals proceed to affix their fishing lines to either the length that resulted in a successful catch or the length that yielded the greatest number of catches. The aforementioned length would be employed for the specific fishing ground they had conducted the test in. Changes to the fishing line length are applied when there is a shift in fishing grounds or a decline in catch quantities is observed.

The thickness of the mainlines should have enough tensile strength to accommodate its attachments as well as resist breakage during the capture of DBS, which is known for its strong jet propulsion and large sizes, and resist potential damage caused by other species (e.g. sharks) inhabiting the water column where the gear is deployed. *T. rhombus* adult specimens can reach weights up to 24-30kg (De Silva-Dávila *et al.*, 2019).

The mainlines should also be light enough as respondents gather the gear manually. The mainline is connected to a polystyrene ball that serves both as a buoy and a spool. This ball is then linked to a wooden flag marker with a brightly colored cloth attached to it. Flags play a crucial role in indicating the location of fishing equipment and ensuring its visibility over a significant distance. The flag maker also serves the purpose of indicating the occurrence of a catch. Upon deployment of the DBS fishing gear, the flag initially lies flat on the sea surface. As the jig descends to its intended depth—determined by the length of the mainline—the attached sinker causes the flag to stand upright. When T. rhombus or bycatch get ensnared by the jig, the flag momentarily submerges and subsequently moves in a bobbing motion, indicating a catch.

The mainline is equipped with several attachments and attractants, including a commercially available multi-colored squid light used as a blinker, bait, as well as other items like springs, rubber, ribbons, and reflective stickers.

Blinkers are used to attract the squid (Arkhipkin *et al.*, 2015). These multicolor LED lights are commercially bought and are specifically designed to endure the heightened pressures encountered in greater depths of water. A subset of participants chose to make their own blinkers due to the frequent susceptibility of commercially available ones to damage. However, purchasing the blinkers was more convenient as individual parts used to assemble handmade blinkers had limited availability.

Several species were used as baits with *T. rhombus* flesh, whole *S. crumenophthalmus*, and whole *C. chanos* as the top three species used by the

respondents. DBS fishermen have a preference for utilizing bait options that have been established as natural prey for *T. rhombus*. These options include using *T. rhombus* flesh as bait; using species that can be withstand depths with minimal breakage as possible, such as *C. chanos*; or species that are readily available and abundant in the locality, such as *S. crumenophthalmus*. Baits (e.g. *C. chanos*) were typically dry-salted to enhance their durability when employed in deep-sea environments. Although some fishermen would rather use them in their fresh state, depending on the species used as bait. Examination on the gut content of *T. rhombus* caught in Camotes Sea, situated in Northern part of Cebu, revealed small squids and milkfish (Lamayo *et al.*, 2008). Milkfish was also used as bait in the study of Dickson *et al.* (2000).

Other attachments such as spring or rubber in close proximity to the swivel on the fishing line induce a bouncing motion of the jig upon capturing *T. rhombus*. This movement penetrates the *T. rhombus* and guarantees the successful capture. According to the respondents who employed these alterations, they observed that *T. rhombus* tends to exhibit caution when approaching the bait of the jig, leading to instances when only their limbs or legs would become ensnared. Thus, the DBS could escape while leaving a cut arm or leg. The ribbons and reflective sticker serve as attractants when affixed to the jig. These attachments operate in a manner to similar to blinkers. The quantitative efficiency of these attachments remains unquantified, with the study solely documenting respondents' subjective opinions; conducting test fishing to assess the effectiveness of these attachments could provide empirical validation.

The MJL type exhibits a similar basic design, albeit with the inclusion of many jigs affixed to the mainline. These jigs are spaced at intervals ranging from 1 to 10 meters.

The general design of the DBS fishing gear used by the respondents bears resemblance to the design utilized by Lamayo *et al.* (2008) in Northern Cebu, used by Dickson *et al.* (2000) in their exploration for *T. rhombus* in Area III (Western Philippines) of the South China Sea, as well as the "taru-nagashi" and "hata-nagashi" employed in Japan (Arkhipkin *et al.*, 2015).

Among the two gear types identified in this study, the SJL type is predominantly utilized by the majority of the participants. The preference of using SJL type was primarily driven by the costs associated with the production of the squid jig. According to the respondents, those who employed the MJL type said that they made modifications to the SJL type to maximize the quantity of DBS catch per fishing expedition. This is also why MJL type emerged later than the SJL type. Coincidentally, in Marinduque, at least 20% of fishers engaged in *T. rhombus* fishing have also made modifications to their fishing gear for similar purposes (De Chavez *et al.,* 2021).

CPUE of DBS fishing gears during the peak season per one fishing operation in southern Tañon Strait, Philippines

The present study revealed the CPUE of the two DBS fishing gears utilized in a single fishing operation during the peak season of *T. rhombus* along southwestern Cebu facing the southern Tañon Strait from 1980-2022.

The SJL was the sole type utilized from 1980-1990. Only three respondents were identified that practiced DBS fishing during this timeframe. Coincidentally, it was also during this time that DBS technology was introduced by Negros DBS fishermen to Northern Cebu fishermen (Lamayo *et al.,* 2008). As respondents were neophytes at applying the technology, their catch rates were the lowest among the years at 0.31kg/jig/hr.

During 1991-2022, the use of MJL type was observed. Among the two, the total CPUE of SJL (2.86 kg/jig/hr) during this period is higher than that of MJL (2.81 kg.jir/hr), thus is considered to be the more efficient gear type. However, it is notable that the catch rates of MJL type have been affected due to the SJL users pushing for exclusive

fishing rights on their respective municipal waters from 2001 onwards. These entry restrictions, albeit not codified into law but were adhered to by the local fishermen, compelled MJL users to engage in DBS fishing activities inside their designated municipal waters, while a portion of them ventured to fish in the northern part of the Strait. Infightings between the DBS fishermen started right after the emergence of the MJL types due to the much higher catch rate of MJL from 1991-2000. Despite the imposed constraints, there was a noticeable rise in the number of MJL users throughout the succeeding years.

The duration of DBS fishing for both gear types has fluctuated over time; nonetheless, the trend is that users of SJL allocate a greater amount of fishing time to fish for *T. rhombus* in comparison to MJL users. The fishermen that utilize SJL demonstrate a smaller quantity of DBS captures but these catches are heavier in weight compared to MJL catches. Despite the fact that MJL users have a higher number of catches and spend less time fishing, they are restricted to specific DBS fishing grounds and incur greater financial expenses due to their increased utilization of jigs in comparison to SJL users. It is pertinent to acknowledge that the actual CPUE of the MJL type without constraints remains undetermined.

Regardless of gear types, this study reports a much higher CPUE for DBS fishing compared to previous published exploratory studies targeting *T. rhombus* in the country. Dickson *et al.* (2000) reported that the exploratory activity conducted for *T. rhombus* in Calauag Bay, Quezon Province yielded a CPUE of 0.018 kg/jig/hr. Similarly, in Ormoc Bay, Leyte, the exploratory activity resulted in a CPUE of 0.0051 kg/jig/hr.

For both gear types, while catch trends on the quantity of individuals caught do not exhibit a universal downward trajectory, it is noteworthy that there is a general declining trend of the average weight per caught individual throughout the decades. Hence majority of the respondents, specifically SJL users, have allocated increased fishing times and deployed more jigs since 2011. Assessing population dynamics of *T. rhombus* along the Tañon Strait would be beneficial for ensuring the sustainability of this latent and understudied resource.

Conclusion

This study analyzed the fishing gear used in the Southern Tañon Strait, Philippines, for capturing *Thysanoteuthis rhombus*, focusing on variations in jig types and their effectiveness. Two primary types of DBS squid jigs were identified: "single jig in a line" (SJL) and "multiple jigs in a line" (MJL). MJL is charachterized by placing five jigs spaced at 1–10m intervals.

Both jig types consist of manually crafted jigs with integrated sinkers, monofilament nylon mainlines measuring 151–200 meters in length and 0.30–0.35 mm in diameter, buoyant polystyrene spools, colorful flag markers, and attachments, including multi-colored blinkers and bait such as *Thysanoteuthis rhombus*, *Selar crumenophthalmus*, and *Chanos chanos*. Additionally, some jigs incorporate supplementary attractants, such as rubber and ribbons, to enhance their effectiveness.

CPUE analysis from 1980 to 2022 reveals fluctuations in fishing efficiency. MJL initially exhibited higher catch rates (0.81 kg/jig/hr, 1991–2000) but declined over time, whereas SJL improved significantly, peaking at 1.07 kg/jig/hr (2011–2020). Both gear types show a decreasing trend in individual catch weight, leading to extended fishing durations and increased gear deployment.

Despite a generally high CPUE compared to other local exploratory studies, the sustainability of DBS fishing in the Tañon Strait remains uncertain.

Recommendation(s)

Future research should focus on assessing *T. rhombus* population dynamics to ensure long-term viability and resource management in this region.

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