



FORK-LENGTH DISTRIBUTION OF HANDLINE-CAUGHT SKIPJACK TUNA (*Katsuwonus pelamis*) AT OEBA FISH LANDING BASE, KUPANG, 2018–2022

DISTRIBUSI PANJANG CAGAK IKAN CAKALANG (*Katsuwonus pelamis*) PANCING ULUR DI PPI OEBA, KUPANG, 2018–2022

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ABSTRACT

Skipjack tuna (*Katsuwonus pelamis*) is one of Indonesia's important fishery commodities with high economic value. However, limited information on length-based population characteristics, particularly from small-scale fisheries in Fisheries Management Area (FMA) 573, remains a challenge for evaluating stock utilization and supporting sustainable fisheries management. This study analyzed the fork length (FL) distribution of skipjack tuna caught by handline fisheries and landed at Oeba Fish Landing Base, Kupang, East Nusa Tenggara, during 2018–2022. A total of 33,568 individuals were measured using a structured sampling approach from handline landings. Fork length distributions were analyzed by year and fishing ground using descriptive statistics and inferential statistical tests. We used the Kruskal–Wallis test with pairwise comparisons to evaluate annual differences in fork length, and the two-sample Kolmogorov–Smirnov test to assess differences in length-frequency distributions among fishing grounds. The results showed that skipjack tuna had a fork length range of 15–80 cm during the study period. Fork length distributions differed significantly among years, indicating temporal variation in catch size composition. Significant differences were also observed among fishing grounds, demonstrating spatial variation in length-frequency structures of handline-caught skipjack tuna. These findings provide improved baseline information on the size structure of skipjack tuna catches and support length-based fisheries assessment and adaptive management strategies in eastern Indonesian waters.

Keywords: fisheries management, fork length distribution, handline fishery, length-based assessment, skipjack tuna

ABSTRAK

Ikan cakalang (*Katsuwonus pelamis*) merupakan salah satu komoditas perikanan penting Indonesia yang memiliki nilai ekonomi tinggi. Namun, keterbatasan informasi mengenai karakteristik populasi berdasarkan panjang ikan, khususnya dari perikanan skala kecil di Wilayah Pengelolaan Perikanan (WPP) 573, masih menjadi tantangan dalam mengevaluasi pemanfaatan stok dan mendukung pengelolaan perikanan yang berkelanjutan. Penelitian ini bertujuan untuk menganalisis distribusi panjang cagak (FL) ikan cakalang yang ditangkap oleh perikanan pancing ulur dan didaratkan di Pangkalan Pendaratan Ikan Oeba, Kupang, Nusa Tenggara Timur, selama periode 2018–2022. Sebanyak 33.568 ekor diukur menggunakan pendekatan pengambilan sampel terstruktur dari hasil tangkapan pancing ulur. Distribusi panjang cagak dianalisis berdasarkan tahun dan lokasi penangkapan menggunakan statistik deskriptif dan uji statistik inferensial. Uji Kruskal–Wallis yang diikuti dengan perbandingan berpasangan diterapkan untuk mengevaluasi perbedaan tahunan dalam panjang cagak, sedangkan uji Kolmogorov–Smirnov dua sampel digunakan untuk menilai perbedaan distribusi frekuensi panjang di antara wilayah penangkapan. Hasil menunjukkan bahwa ikan cakalang memiliki rentang panjang cagak 15–80 cm selama periode studi. Distribusi panjang cagak berbeda secara signifikan antartahun, yang mengindikasikan variasi temporal dalam komposisi ukuran tangkapan. Perbedaan yang signifikan juga diamati di antara wilayah penangkapan, yang menunjukkan variasi spasial dalam struktur frekuensi panjang ikan cakalang yang ditangkap dengan pancing ulur. Temuan ini memberikan informasi dasar yang lebih baik mengenai struktur ukuran tangkapan ikan cakalang serta mendukung penilaian perikanan berbasis panjang dan strategi pengelolaan adaptif di perairan timur Indonesia.

Kata kunci: distribusi panjang cagak, ikan cakalang, pengelolaan perikanan, penilaian berbasis panjang, perikanan pancing ulur

INTRODUCTION

Skipjack (*Katsuwonus pelamis*) is a pelagic tuna species and one of the most important fishery commodities in Indonesia, both in terms of catch volume and export value (Sari *et al.* 2022). Indonesia contributes more than 16% to global *Tuna-Mackerel-Skipjack* (TMS) production, placing it among the leading producers worldwide (Khan *et al.* 2020). During the 2017–2021 period, the export value of TMS commodities increased at an average annual rate of 6.08% despite a 2.52% decline in export volume. This paradox suggests an increase in market price and product value (MMAF RI 2022). Notably, skipjack ranked among the top ten fish species in global landing value in 2019, with the tuna group as a whole generating approximately USD 20 billion in global landings between 1960 and 2019 (Food and Agriculture Organization (FAO) 2022).

The waters of East Nusa Tenggara are the key migratory routes for skipjack and other tuna species. These waters, particularly in areas such as the Ombai Strait, the Timor Sea, and the Sawu Sea, are critical habitats for pelagic fishes. Marpaung *et al.* (2025) emphasized the significance of TMS resources in the Ombai Strait, which lies along the border between Indonesia and Timor-Leste. Previous spatial modeling studies have also confirmed high skipjack distribution in Fisheries Management Area (FMA) 573 and 713, including the Flores and Timor Seas (Wang *et al.* 2016; Nurani *et al.* 2022). Additional distribution hotspots include the Banda Sea, Maluku Sea, Sulawesi Sea, and Indian Ocean (Khan *et al.* 2020).

Fishing methods for skipjack in Indonesia are diverse and adapted to both geographic and ecological conditions. Common fishing gear types include handlines, longlines, and purse seines. In East Nusa Tenggara, handline fishing is the dominant method, especially in small-scale fisheries. Studies conducted by Kurniawan *et al.* (2020) and Danial *et al.* (2023) demonstrated that handline fishing contributes substantially to skipjack and tuna landings in East Flores, highlighting the method's continued relevance in local fisheries.

Despite its economic importance, skipjack fisheries face sustainability concerns. The FAO (2022) has reported that the status of global tuna stocks, including skipjack, remains uncertain due to data limitations and the potential for overfishing. Given the economic reliance on tuna fisheries in East Nusa Tenggara, it becomes imperative to adopt management strategies that reflect the

migratory nature of these fish. Overfishing poses a prominent threat to their populations, with various assessments indicating declines in biomass due to unsustainable practices. Pressures such as increasing global seafood demand, climate variability, and weak monitoring systems further threaten stock sustainability. These challenges underscore the need for improved data collection and adaptive management approaches that consider both ecological and socio-economic factors.

Although skipjack tuna fisheries have an important economic role in eastern Indonesian waters, information regarding the length structure of catches from small-scale handline fisheries remains limited, particularly in Oeba Fish Landing Base, Kupang. Length-based information is essential because changes in the size composition of catches can provide an initial indication of fishing patterns, recruitment characteristics, and the potential pressure exerted on exploited populations. Previous studies on skipjack tuna in Indonesia have mainly focused on distribution patterns, catch dynamics, or oceanographic relationships, whereas detailed temporal and spatial evaluation of fork length composition from handline fisheries remains limited.

The waters around East Nusa Tenggara are part of important tuna fishing areas within Indonesia's Fisheries Management Area (FMA) 573. Therefore, information on the size structure of skipjack tuna catches from this region can contribute to a better understanding of local fisheries characteristics and support evidence-based management approaches. This study differs from previous studies by focusing on long-term fork length observations from small-scale handline fisheries during 2018–2022 and evaluating variations in catch size composition among years and fishing grounds.

This study addressed the following research question: whether the fork length distribution of skipjack tuna catches differs among years and fishing grounds at Oeba Fish Landing Base. The working hypothesis was formulated as follows: H0, there is no difference in the fork length distribution of skipjack tuna among years and fishing grounds; H1, there is a difference in the fork length distribution among years and fishing grounds.

To answer this research question, fork length data of skipjack tuna collected from handline landings at Oeba Fish Landing Base during 2018–2022 were analyzed. The analysis included descriptive statistics and length-frequency distribution to evaluate temporal and spatial variation in catch size structure. The results are expected to provide baseline

information for length-based assessment and support adaptive management of skipjack fisheries in eastern Indonesian waters.

METHODS

Time and location of research

This study was conducted from January 2018 to December 2022 at Oeba Fish Landing Base (FLB), Kupang City, East Nusa Tenggara Province, Indonesia (Figure 1). The study focused on skipjack tuna (*Katsuwonus pelamis*) caught by small-scale handline fisheries and landed at Oeba FLB. Biological measurements from landed catches were used to evaluate temporal and spatial variation in fork length (FL) composition. Spatial information was available from the I-Fish database as fishing-ground grid categories rather than vessel-level GPS tracks; therefore, this study did not reconstruct vessel tracks or identify fine-scale fishing hotspots.

Data collection

Biological data were obtained through the structured I-Fish landing-sampling program at Oeba Fish Landing Base during 2018–2022. Sampling covered approximately 20% of vessel landings during the study period. The sampling unit was an individual handline vessel landing, while the biological unit was an individual skipjack tuna. For each sampled landing, skipjack tuna were selected from the landed catch and measured for fork length (FL), from the tip of the upper jaw to the fork of the caudal fin, using a measuring board with 1-cm precision. Measurements were recorded

using standardized I-Fish forms by trained landing-site enumerators. Although the I-Fish database contains additional operational and catch variables, the present analysis used only individual fork length together with sampling year and the fishing-ground grid code required for temporal and spatial grouping. Fishing-ground information was recorded at grid level; the six grid categories represented in the analytical dataset were coded U, V, W, X, Y, and Z.

Sampling design

A stratified sampling approach was used by grouping observations by sampling year and I-Fish fishing-ground grid. Approximately 20% of vessel landings were included in the biological sampling program during each sampling period. Each sampled landing was treated as a sampling unit, and individual fork-length measurements from the sampled catch were used for analysis. Spatial grouping followed the six fishing-ground grid codes available in the dataset (U–Z), rather than three named geographic regions or vessel-level coordinates.

Data analysis

Fork length data were summarized using the number of individuals measured (n), minimum and maximum fork length, mean, standard deviation, median, and length-frequency distributions. Annual and fishing-ground distributions were visualized using frequency plots to describe temporal and spatial variation in the size composition of handline-caught skipjack tuna.

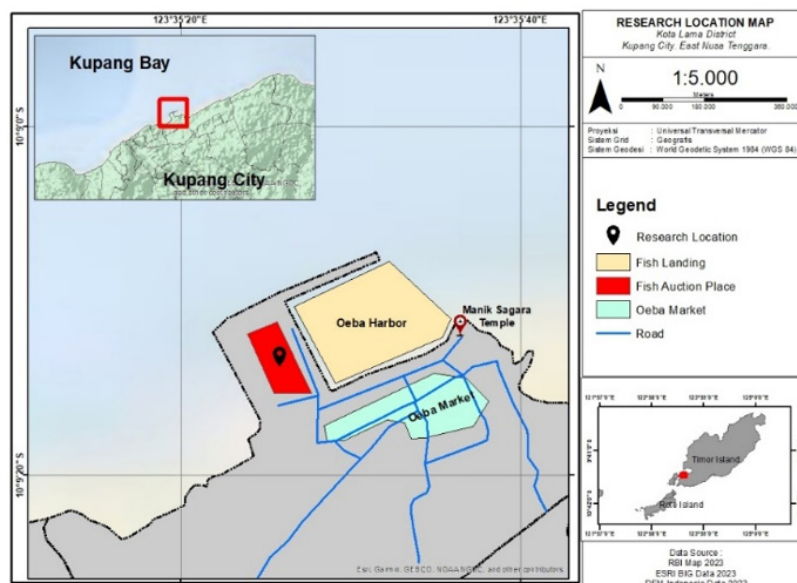


Figure 1. Location of Oeba Fish Landing Base (FLB), Kupang, East Nusa Tenggara, Indonesia.

Because fork-length data did not satisfy the assumptions required for parametric analysis, differences among years (2018–2022) were tested using the Kruskal–Wallis test. When the overall test was significant, pairwise Mann–Whitney U comparisons with Bonferroni correction were used to identify year pairs that differed. Differences in length-frequency distributions among the six fishing-ground grids (U–Z) were evaluated using two-sample Kolmogorov–Smirnov tests. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Characteristics of handline fishing gear

Handline fishing is a passive fishing tool. This tool is often used in small-to-medium-scale fisheries, especially in tropical waters such as Indonesia. It typically employs natural or artificial bait to attract pelagic fish species, such as skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*). Fish Aggregating Devices (FADs) are often deployed to increase catch efficiency by concentrating target species in fishing areas. The fishing boats used in handline operations range from non-motorized boats to motorized fishing boats with capacities of up to 30 gross tonnage (GT), commonly operating in both shallow and offshore waters (Regulation of the Minister of Marine Affairs and Fisheries Number 36 of 2023).

According to Yapanto and Nursinar (2020), handlines are categorized into two types, i.e., baited and unbaited. Baited handlines use live or artificial bait, while unbaited handlines rely on the movement and shine of the hook to attract fish. The basic components of the gear include the mainline, branch lines, hooks, spool, and sinkers, which together offer flexibility in targeting various pelagic species. Studies conducted by Kurniawan *et al.* (2020) and Danial *et al.* (2023) reported that handline gear remains dominant in East Nusa Tenggara, reflecting its effectiveness and adaptability in the region.

A total of 33,568 skipjack tuna individuals were measured during the 2018–2022 observation period at Oeba Fish Landing Base. The measured specimens originated from handline vessel landings represented across six I-Fish fishing-ground grid categories (U–Z). The number of measured individuals varied among years, reflecting differences in

sampled landings and fishing activity during the observation period. These data were used to evaluate temporal and grid-level spatial variation in fork-length distributions.

Temporal variation in skipjack body size

Monitoring the size distribution of skipjack over time is essential for assessing stock conditions and detecting ecological changes, as body size reflects recruitment success and environmental influences such as temperature and food availability (Yen *et al.* 2016; Nataniel *et al.* 2021; FAO 2022). Changes in the length frequency distributions of skipjack tuna can signal significant variations in stock health, and studies have shown that size metrics correlate closely with environmental factors (Siregar *et al.* 2025). For instance, research conducted by Nurdin *et al.* (2025) demonstrated that juvenile skipjack exhibited a size range primarily between 315–337 mm, indicating that these fish were relatively youthful and had yet to reach maturity, which raises concerns regarding recruitment overfishing if these trends persist. Ecological influences such as prey availability and ocean conditions significantly shape the growth parameters of skipjack tuna. Aoki *et al.* (2017) noted that the energy costs associated with prey acquisition vary based on environmental conditions, particularly during migrations when food density is higher. This relationship between food supply and body condition emphasizes the importance of monitoring these parameters, as they directly impact the size distribution and overall health of skipjack populations. Additionally, Chang *et al.* (2022) identified that dietary shifts of skipjack from predominantly consuming Cephalopods to a higher proportion of Teleosts were associated with changes in body size, highlighting a complex interaction between trophic dynamics and size metrics. Figure 2 illustrates the body size distribution of skipjack landed at Oeba FLB, from 2018 to 2022. The measured fish ranged from 15 to 80 cm FL, indicating a wide size composition of handline catches landed at Oeba Fish Landing Base. The mean fork length, standard deviation, median, and sample size differed among years (Figure 2). The observed variation indicates changes in the size composition of landed catches throughout the study period. The highest proportion of individuals was concentrated within the dominant length classes observed in each year, suggesting differences in catch composition among sampling periods.

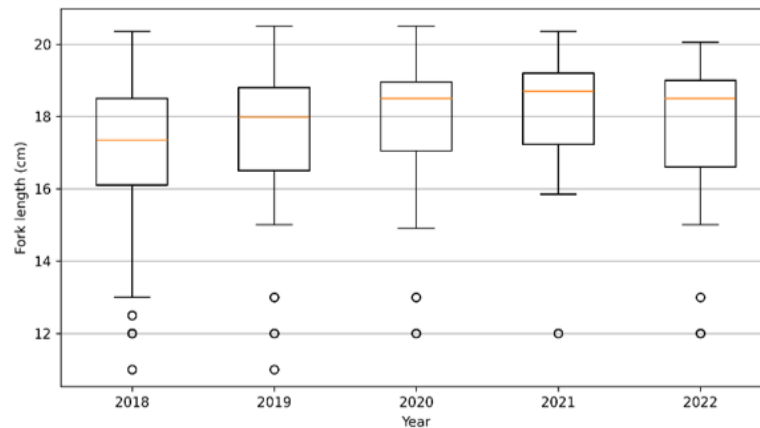


Figure 2. Annual variation in fork length distribution of skipjack tuna (*Katsuwonus pelamis*) landed at Oeba Fish Landing Base during 2018–2022.

The fork length distribution of skipjack tuna varied among sampling years (Figure 2). The Kruskal–Wallis test indicated significant differences in fork length among years ($H = 610.036$, $df = 4$, $p < 0.001$). Post-hoc pairwise comparisons using Mann–Whitney U tests with Bonferroni correction showed significant differences among most year combinations ($p < 0.001$), except between 2018 and 2020 (adjusted $p > 0.05$). The largest median fork length was observed in 2019, whereas the smallest median length occurred in 2021.

In 2018, fork length ranged from 19 to 75 cm, with an average of 44.1 cm. In 2019, the observed range was 21–80 cm, whereas in 2020 the minimum decreased to 15 cm while the maximum remained 79 cm. These changes describe year-to-year differences in the size composition of sampled landings; the present analysis did not test environmental or market-related causes of those differences.

In 2021, the observed minimum fork length increased to 28 cm, and in 2022 the recorded range was 28–70 cm. Sampling intensity and fishing activity were affected by external disturbances during 2020–2021, including the COVID-19 period and Tropical Cyclone Seroja; however, these factors were not quantitatively analyzed. Consequently, annual differences should be interpreted as variation in sampled catch composition rather than direct evidence of changes in stock abundance or population recovery.

Spatial differences in fork length–frequency distributions among fishing-ground grids are presented in Figure 3. The curves show distinct size-composition patterns among grids U–Z. Two-sample Kolmogorov–Smirnov tests confirmed significant differences among fishing-ground distributions ($p < 0.05$), indicating that the size composition of handline catches was not homogeneous across the grid categories represented in the I-Fish dataset.

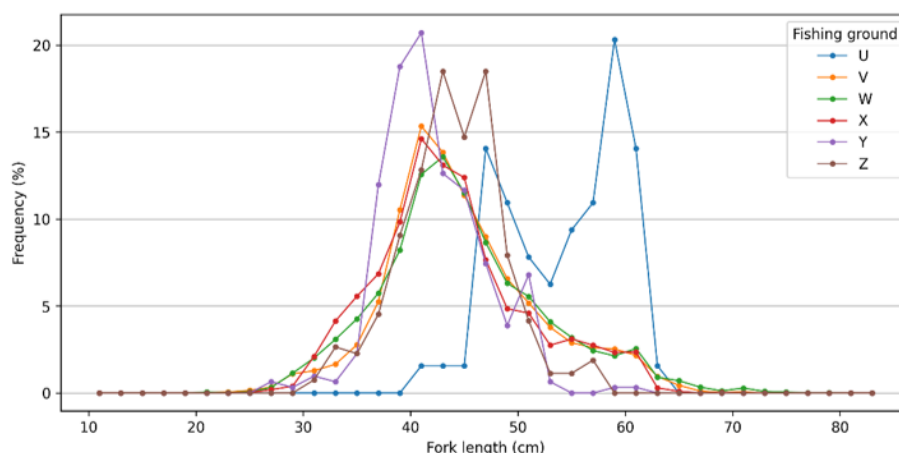


Figure 3. Spatial variation in fork length–frequency distributions of skipjack tuna (*Katsuwonus pelamis*) among I-Fish fishing-ground grids U–Z.

Spatial variation in skipjack body size

The spatial analysis was restricted to the fishing-ground grid codes available in the I-Fish dataset. Because these records do not provide vessel-level GPS tracks, the observed differences among grids should be interpreted as broad spatial variation in landed catch size composition. The analysis does not identify precise fishing hotspots and does not test relationships with sea-surface temperature, chlorophyll-a, depth, or other oceanographic variables.

Discussion

The present study demonstrates that fork-length composition of handline-caught skipjack tuna landed at Oeba Fish Landing Base varied significantly among years and among the I-Fish fishing-ground grids represented in the dataset. The overall observed range of 15–80 cm FL was wider than ranges reported for several other Indonesian skipjack fisheries. Restiangsih and Amri (2018) reported 25–74 cm FL in the Flores Sea and adjacent waters, while Setiawan *et al.* (2021) recorded 26–69 cm FL for a pole-and-line fishery in Maumere-Sikka. Jatmiko *et al.* (2015), whose reproductive samples included Oeba among several eastern Indian Ocean landing sites, reported 35–68 cm FL. These comparisons indicate that the Oeba handline landings encompassed a broad mixture of size classes, although differences in gear, sampling design, season, and fishing area limit direct comparison among studies.

The significant annual differences should therefore be interpreted primarily as changes in the size composition of sampled landings rather than as direct evidence of changes in stock abundance. Skipjack tuna is highly mobile, and the size structure accessible to a local fishery may vary with recruitment, migration, fishing location, and operational patterns. The lower number of observations during disturbance periods may also affect annual distributions. Consequently, the statistical differences detected here identify temporal heterogeneity in landed sizes but do not, by themselves, establish the biological mechanism responsible for that heterogeneity.

The grid-level differences shown in Figure 3 likewise indicate spatial heterogeneity in catch size composition. This result is consistent with the expectation that different fishing areas can encounter different components of a highly migratory skipjack population. However, the spatial information available in the present dataset consisted of I-Fish fishing-ground grid

codes (U–Z), not vessel-level GPS tracks. The analysis therefore supports inference at the grid level only and should not be interpreted as evidence of precise fishing hotspots or fine-scale habitat associations.

The occurrence of small fish in the catches is relevant to fisheries sustainability when considered against published estimates of size at maturity. Jatmiko *et al.* (2015) estimated female length at first maturity at 42.9 cm FL in the eastern Indian Ocean, Restiangsih and Amri (2018) reported 41.1 cm FL in the Flores Sea, and Chodriah *et al.* (2020) reported approximately 41.0 cm FL in Toli-Toli waters. More recent length-based assessment in Cenderawasih Bay reported a higher estimate of 50.7 cm FL (Nurdin *et al.* 2025), showing that maturity benchmarks can vary among areas and studies. Because the Oeba dataset included fish below these published maturity sizes, the landings included individuals that may have been immature. Nevertheless, maturity status was not measured directly in this study, so the proportion of immature fish and the presence of recruitment overfishing cannot be concluded from fork length alone.

From a management perspective, routine monitoring of length-frequency distributions can provide a practical indicator for small-scale fisheries where age, gonad, and fishery-independent data are limited. The broad length range and the significant temporal and grid-level variation observed at Oeba suggest that monitoring should retain both time and fishing-ground strata and, where possible, be complemented by fishing effort, catch rate, reproductive condition, and standardized spatial information. Such integration would allow future assessments to distinguish changes in catch composition from changes in abundance, recruitment, or fishing behavior.

This study has several limitations. First, sampling was landing-based at a single fish landing base and covered approximately 20% of vessel landings; therefore, the data represent sampled Oeba handline landings rather than the entire skipjack stock in FMA 573. Second, sample intensity varied among years, and external disruptions during 2020–2021 were not quantitatively modeled. Third, fishing-ground information was available only as grid categories, preventing vessel-track reconstruction and fine-scale georeferencing. Fourth, sea-surface temperature, chlorophyll-a, depth, fishing effort, and other operational variables were not analyzed, so environmental explanations for temporal or spatial patterns cannot be tested here. Finally, sex, age, and gonad maturity were not available for the

analyzed fish. These constraints should be considered when interpreting the results and define priorities for subsequent length-based and reproductive assessments.

CONCLUSION

This study provides an updated assessment of fork-length distribution of handline-caught skipjack tuna (*Katsuwonus pelamis*) landed at Oeba Fish Landing Base during 2018–2022. Fork length ranged from 15 to 80 cm, and statistical analysis confirmed significant temporal variation among years and significant differences in length-frequency distributions among I-Fish fishing-ground grids U–Z. The results describe heterogeneity in the size composition of sampled landings and provide a baseline for length-based monitoring of small-scale skipjack fisheries in eastern Indonesia. Continued monitoring should be combined with standardized fishing-effort, reproductive, and finer-resolution spatial data to strengthen future stock and management assessments.

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