A Literature Review of Hawai‘i’s Bottomfish Fishery 2004–2014

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Western Pacific Regional Fishery Management Council
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1 INTRODUCTION AND FISHERY BACKGROUND

The following report describes 28 publications that were found in a search regarding Hawai‘i's bottomfish species, habitat and fishery. The Pacific Islands Fisheries Science Center has published the overwhelming majority of these. The project was undertaken at the request of the Western Pacific Regional Fishery Management Council. This review is segmented according to biophysical (24) and human dimensions (four) publications.

Hawai‘i bottomfish consist of 14 species (Martell and others 2011), seven of which are particularly valued economically. These species are primarily jacks, snappers and groupers (Zeller and others 2008) known in Hawai‘i as onaga, ehu, ‘ōpakapaka, lehi, hapu'upu'u, gindai and kalekale. Collectively, they are referred to as the Deep 7. Bottomfishing was economically and culturally very important to the indigenous peoples of Hawai‘i long before European contact. Today, Hawai‘i's bottomfish fishery is unique in the sense that it is difficult to simply and neatly categorize its fishermen as their motivations for fishing are diverse and overlapping.

A theme in the literature is concern over the accuracy of Deep 7 stock assessments. One issue is whether the commercial catch rates alone are a "realistic proxy for stock density," (Skillman 2009). From 1950 to 2005, commercial catches were suspected to have been 28 percent to 128 percent higher than reported at any given year. When noncommercial estimates were included, total catch increased 2.5 to 3.5 times (Zeller and others 2008). Bottomfish landings peaked at 1.2 million pounds in 1988 and in the following years saw steady declines. In 2006, 315 thousand pounds were landed, a 73 percent decline in the fishery from its peak (Hospital and Beavers 2014). In 2004, it was determined that the Main Hawaiian Islands (MHIs) were being overfished since the bottomfish mortality rate was above the maximum fishing mortality threshold (Moffitt and others 2006). In 2007, bottomfish stock assessments indicated that the mortality rate was estimated to be 24 percent above the overfishing threshold, which ultimately led to an emergency fishery closure from May to September, 2007 (Hospital and Beavers 2014). In 2010, using a baseline assessment scenario, the Deep 7 stock assessment for the MHIs indicated that bottomfish were not overfished and that overfishing did not have a high probability of happening (Brodziak and others 2011). There is however evidence that indicates, "both long-term and more contemporary declining trends," (Piner and Lee 2011) for all of the MHIs catch per unit effort (Piner and Lee 2011).

Historically, Hawai‘i's bottomfish fishery had been an open access fishery. However, with concerns of overfishing and stock depletion, management programs were created and put into effect to ensure the sustainability and longevity of Hawai‘i's bottomfish fishery (Hospital and Beavers 2014). In 2004, the State of Hawai‘i implemented a management method known as a total allowable catch limit, after the MHIs were determined to be experiencing overfishing by 24 percent. This was in line with the Magnuson-Stevens Fishery Conservation and Management Act's National Standard 1, which requires federally managed fish stocks be "maintained at levels of abundance that would allow for long-term maximum sustainable yield," (Moffitt and others 2006). This act requires that a threshold be defined in order to be able to determine when a stock is being overfished and if overfishing is happening. "Overfishing is determined to occur when current fish mortality is higher than the level at which maximum sustained yield is produced," (Moffit and others 2006). Once overfishing was recognized, an emergency closure of the bottomfish fishery was executed to be able to reduce the fish mortality rate by 24 percent.

In 2007, the Western Pacific Fishery Management Council recommended another emergency closure of the bottomfish fishery due to overfishing. The fishery was closed from May to September, which resulted in an approximate mortality reduction of 24 percent. The fishery reopened under a total allowable catch limit of 178 thousand pounds, which was a drastic cut for fishermen (Hospital and Beavers 2014). A study was published using an alternative production model known as the Bayesian statistical framework, to assess overfishing of Hawaiʻi's bottomfish. Using hypothetical results based on the alternative production model, it seemed that the Hawaiian bottomfish complex varied between fishing zones. As a whole, the fishery mortality rate was 36 percent above the threshold for 2004. When assessing the bottomfish complex using a multi-zone approach, the fishery mortality rate was only 21 percent above the threshold (Brodziak 2007).

In 2008, an overfishing risk assessment was completed using the most recent stock assessments from 2004. The assessment stated that if a total allowable catch was set at 61 klb, there would be a 25 percent chance of overfishing, and if it was set at 99 klb, there would be a 50 percent chance of overfishing. A 25 percent chance of overfishing was considered low risk, and a 50 percent chance was considered neutral (Brodziak 2008). On an archipelagic scale, assessments suggested that the bottomfish aggregate stocks were below the biomass maximum sustainable yield but most likely not below the minimum stock size threshold. The maximum sustainable yield, averaged over the nine alternative hypotheses for bottomfish was 371 tons (Martell and others 2011). However, as the process for determining catch limits became more refined, the catch limit for the 2011–2012 season was set at 325 thousand pounds (Hospital and Beavers 2014).

With the total allowable catch management technique, once the limit has been reached, the fishery, commercial and recreational, is shutdown for the season to prevent overfishing from happening. Agencies have found it somewhat difficult to implement, regulate and enforce this mandate. In the initial years of the total allowable catch management system, final cumulative bottomfish season catch actually exceeded the limit by 10 percent, 8 percent, 6 percent and actually fell short by 18 percent one year. This could be attributed to not accurately monitoring total commercial landings, correctly forecasting when the total allowable catch limit was expected be reached, and the time it requires to actually shutdown the fishery (Hospital and Beavers 2014).

In 2011, fishermen were surveyed for their perspectives on the effectiveness of total allowable catch limits on Hawaiʻi's bottomfish fishery. A majority of 54 percent found that total allowable catch limits were necessary to maintain a sustainable bottomfish fishery. However, the majority of highliners – commercial fishermen landing more than 2,500 pounds – held the exact opposite view, due to a higher reliance on the fishery. Most fishermen wanted separate total allowable catch quotas for commercial and recreational and 49 percent of fishermen wanted separate catch limits for each island, taking into account habitat, fish population, and marketing success or failure (Hospital and Beavers 2011).

2 BIOPHYSICAL STUDIES

The use of a baited stereo-video camera was successful in 2011 as a means to monitor and study deep-water fish species and their habitat. The cameras were "designed to survey distribution, relative abundance, and size composition of bottomfish, and associated biological and physical characteristics of their habitat," (Merritt and others 2011). They effectively deployed, with an 80 percent success rate of hitting their target locations and recording for the planned timeframe. It was this initial research that opened the door for a later study of individual deep-water species habitat preference (Merritt and others 2011).

A study was completed in 2013 using the baited stereo-video cameras to attempt to determine the preferred habitat of ʻōpakapaka, kalekale, onaga and ehu. Habitat was classified into four categories, substrate that was hard or soft and slope that was high or low. ʻōpakapaka had a dominant presence in shallower depths (<200m), the other three species had a much stronger presence in depths greater than 200m. Ehu and ʻōpakapaka seemed to prefer hard substrate with low slope, while onaga was observed in both hard substrate with low slope and hard substrate with high slope. Kalekale did not show any significant habitat preference. ʻōpakapaka, onaga and kalekale all showed an ontogenetic habitat shift to hard substrate with high slope when their size increased. This could be the result of a reproductive trigger since it seems to "coincide with the length at sexual maturity of each species," (Misa and others 2013). It seems that, depending upon the lifecycle stage of the fish, their habitat preference differs.

Bottomfish species are typically associated with distinct benthic features such as high relief, hard bottom, slope of greater than 20 percent, and a depth of 100–400 meters (Parke 2007). Areas that fit within these criteria were determined to be suitable adult bottomfish habitat and essential fish habitat. High quality bottomfish habitat was set-aside in 1988 by the Department of Land and Natural Resources (DLNR) as bottomfish restricted fishing areas (BRFAs) to try and ensure the long-term sustainability of the bottomfish stocks. DLNR later reduced the number of BFRAs from 19 to 12, while increasing the size and quality of the remaining BRFAs (Parke 2007).

A study of four deep-water BRFAs in the MHIs was interpreted to show an increase in mean fish length, which in turn may improve fish fecundity and increased fish abundance. This was seen most consistently in the Penguin Bank and Makapuʻu BRFAs. The Pailolo Channel BRFA had varied results amongst species, due to limited habitat availability. The Niʻihau BRFA showed the most positive results, which was attributed to the 14 years of protection this area has received with minimal disturbance (Sackett and others 2013). This BRFA was the only place of study in which "four of the five species tested had >98 percent maturity inside," (Sackett and others 2013). It was also the only area to have evidence of the spillover effect, with increased species richness in adjacent habitat and not inside the Niʻihau BRFA. It is likely to take around four years in order to see the effects that the protection of BRFAs provides on the fish (Sackett and others 2013). Variations between BRFAs could be attributed to proximity to people. BRFAs that are easier to access, have higher population pressures and are difficult to enforce are much more susceptible to outside influence (Moore and others 2013).

The MHIs bottomfish species are assumed to have relatively similar life history patterns, however not much is known regarding their early and juvenile stages. They are recognized for having relatively low productivity and slow growth (Brodziak and others 2009). Bottomfish populations tend to be geographically limited by fish movement since the adults have a benthic lifestyle. However, it is the pelagic larval dispersal that connects the various populations throughout Hawai‘i (Skillman, 2009). There is evidence suggesting that the North Hawaiian Ridge Current facilitates larval dispersion towards the Northwest, supporting the hypothesis that the MHIs are a source for bottomfish species, while the Northwest Hawaiian Islands act as a sink (Rivera and others 2011). However, recent genetic analysis has discovered a divergent population of four bottomfish species in the middle of the archipelago, compared to the little to no genetic structure seen in the rest of the archipelago (Andrews and others 2014).

The ‘ōpakapaka, hapu’upu’u, onaga and ehu that are found in the middle of the Hawaiian chain are unique in that they are genetically divergent compared to fish of the same species found elsewhere in the archipelago. The only other genetically divergent population of fish for these four species has been found in an onaga population located near Kaua‘i. These species otherwise show high connectivity throughout Hawai‘i. An influx of fish from Johnston Atoll could be the reason behind the genetic distinction; however, no genetic analysis of fish found at Johnston Atoll has been done to directly test this hypothesis (Andrews and others 2014). There is evidence through biophysical simulations of larval dispersal that does support this hypothesis.

The larval stage is probably when most species dispersal happens. Hapu’upu’u, ‘ōpakapaka, onaga and ehu are broadcast spawners and have similar spawning periods between six and ten months, peaking in the summer, except for hapu’upu’u, which peaks in the springtime. The eggs of these fish stay in the water column for approximately 48 hours before hatching, but it is unclear how long the larvae remain in the water column. Biophysical modeling shows that the eggs alone have the potential to travel up to 50 km, and species that have pelagic larval durations of more than 40 days would be able to travel, with ocean currents, from Johnston Atoll to the Hawaiian Archipelago (Andrews and others 2014). The hapu’upu’u has a 35–45 day pelagic larval dispersal timeframe (Rivera and others 2011), and the ‘ōpakapaka has a pelagic duration of approximately 60–80 days (Gaither and others 2011).

A significant amount of research has focused on ‘ōpakapaka in recent years. ‘Ōpakapaka are characterized as slow growing and long-lived. They tend to reach sexual maturity between 3–5 years. The mass majority of tagged ‘ōpakapaka have been shown to be fairly static; moving between 0–22 km while some other tagged ‘ōpakapaka have swam long distances of more than 400 km (Gaither and others 2011). Age estimation has proven to be difficult because “otoliths of this species lack well-developed annual growth zones,” (Andrews and others 2011). It was originally thought that the maximum observed age of ‘ōpakapaka was 18 years (Andrews and others 2011), but due to lead-radium and bomb radiocarbon dating, the mean age for the largest sized group tested was 45.6 years, with a range of 34.4 to 64 years (Andrews and others 2012).

3 HUMAN DIMENSIONS STUDIES

In a recent study (Hospital and Beavers 2012), MHI bottomfish fishermen were most likely to identify themselves as Asian or Native Hawaiian/Pacific Islander. Thirty-four percent of participants in the bottomfish fishery tend to fish alone, while 82 percent have two person operations. Only 30 percent of the small boat fleet is considered bottomfish-only. However, the bottomfish highliners are highly motivated by bottomfishing. Of bottomfish trips taken, approximately 66 percent occurred in state waters, 7 percent occurred in federal waters, and 15 percent claimed they occurred in both federal and state waters. Bottomfish highliners accounted for 45 percent of total fish landings during the course of the survey (Hospital and Beavers 2012). The primary method of fishing for bottomfish is from small boats using deep handline equipment (Moffitt and others 2006).

Of bottomfish fishermen surveyed in 2010, approximately 63 percent of them considered themselves either part-time of full-time commercial fishermen, 19 percent of fishermen had multiple motivations for participating in the fishery, and 14 percent classified themselves as subsistence fishermen. However, approximately 30 percent of respondents who were commercially licensed considered themselves as purely recreational fishermen, but 40 percent of these commercially licensed respondents reported selling bottomfish in the past 12 months, fitting state and federal definitions of commercial fishing (Hospital and Beavers 2014). Of the survey respondents, about 24 percent of bottomfish catch was consumed at home, roughly 33 percent was given away and approximately 39 percent was sold. Sixty-four percent indicated that their bottomfish catch was an important source of food for their families. As a whole, it seems that the bottomfish fishery not only supplies fish for purchase, but also as a way to maintain social and community networks, preserve fishing traditions, cultural stability and personal food security (Hospital and Beavers 2014). All of which have some associated financial cost.

There are often up-front costs to participate in a fishery. According Hospital and Beavers (2012), approximately 92 percent of bottomfish fishermen surveyed were the owners and operators of the vessel they fished from. A typical boat used for bottom fishing was built in the late 1980s, bought in the 1990s and is around 23 feet with 201 horsepower, with an average cost around $35,940.00. Electronics are an important aspect of bottom fishing, with the average value found on a fishing vessel being around $3,671.00. These costs are averages, the more avid fishermen's costs would probably be higher and the less enthusiastic fishermen's costs would probably be lower. In 2009 and 2010, the average fishing trip cost approximately $212.00, with boat and truck fuel accounting for most of that cost. The average annual fishing related expenditure was found to be $8,211.00, with a median of $4,875.00. The more avid fishermen have higher levels of expenditures, averaging $14,186.00 with a median of $9,273.00. These expenditures include repair/maintenance, fees, fishing gear, oil, lube and safety equipment. Ninety-one percent of people surveyed held a $50.00 Hawai‘i Commercial Marine License.

In 2009, Hawai‘i's bottomfish fishery was valued at $2.09 million; in 2010, it was valued at $1.70 million. For the more valuable Deep 7 species, the average cost of fish was $5.93/lb., a less desirable non-Deep 7 fish was valued at $3.94/lb., and other bottomfish sold at $1.79/lb. on average. Bottomfish are sold a number of different ways – at fish auctions (26 percent), to various markets and stores (21 percent), restaurants and wholesale (33 percent), directly from the boat, word of mouth or even on the side of the road. There seems to be little difficulty in selling bottomfish, as 88 percent of fishermen surveyed said they had no difficulties selling all the catch they intended to. Almost all highliners reported being able to sell all their catch, most likely due to established market relationships.

Market conditions seemed to be a limiting factor for fishermen selling their catch, as 55 percent indicated prices were too low or the market was flooded and therefore not buying. Other reasons included the size of the fish being too small, or being of an unfavorable species.

The majority of fishermen indicated that the price they receive for their fish remained relatively steady (Hospital and Beavers 2012). However, in 2009, research did find “negative and statistically significant own-quantity price flexibilities indicating that Hawai‘i bottomfish prices increase as own-supply declines” (Hospital and Pan 2009). It seems that the aggregate market supply plays a substantial role in controlling the price for Hawai‘i’s bottomfish fishery (Hospital and Pan 2009) and ultimately how the overall fisheries’ profit is dispersed.

In terms of crew compensation, the most common breakdown of profit seems to be a third to the captain, a third to the crew and a third to the vessel. Almost 25 percent indicated that they pay their crew by giving them a percentage of the fish caught. Roughly 30 percent of fishermen reported keeping a percentage of fish, about 30 percent for personal use. Another 20 percent of boat owners that sold their fish stated that they give the crew about 30 percent of the revenue. An additional 22 percent of fishermen indicated that compensation varied from trip to trip. On average, 2 percent of fish goes towards community and cultural events across the State of Hawai‘i (Hospital and Beavers 2012). Thirty-eight percent of those crew surveyed said that they received no compensation, suggesting that they were family or friends who simply wanted to go fishing (Hospital and Beavers 2012).

The cultural and social aspects of Hawai‘i’s bottomfish fishery make it unique. Cultural motivations run deep within the fishing community and some techniques pre-date European contact. Red snappers for example are a symbol of good luck and very popular around the holidays (Hospital and Beavers 2014). A large portion of noncommercial bottomfish fishermen costs can be attributed to food and drinks, indicating an important social aspect while fishing. The fact that fishermen reported 2 percent of their catch goes towards community and cultural events across Hawai‘i corroborate the significance of bottomfish fishing in perpetuating traditions, and building and sustaining community and social relationships. Furthermore, 62 percent of fishermen surveyed considered bottomfish as an important food source for their families, creating a strong connection between the family and the fishery (Hospital and Beavers 2012). Fishermen, having mixed motivations for participating in the fishery, indicate that fishing is not just for profit. There is a strong consensus amongst bottomfish fishermen regarding their involvement in managing and influencing regulation on the bottomfish fishery.

Hospital and Beavers (2011) found only 25 percent of fishermen were satisfied with Federal management of the fishery and only 24 percent indicated they were satisfied with State management. When a catch share system was suggested in the survey, 59 percent were strongly opposed.

4 DISCUSSION

The literature over the past ten years has covered many aspects of the bottomfish fishery in Hawai‘i. The biophysical, economical, social and managerial components make this fishery unique and a challenge to fully understand. There are some concerns surrounding the fishery. The issue of greatest concern is whether or not the estimated standardized catch per unit effort data is a “realistic proxy for stock density” (Skillman 2009). There are requests that other factors be taken into consideration as well, such as improved fishing technology like power-assisted reels, fish-finders and global positioning system or GPS that have undoubtedly influenced the relationship between catchability per unit of effort and fish abundance (Moffitt 2006). Also, the fact that noncommercial fishermen are not required to report their catch leads some to question the accuracy of stock assessments (Skillman 2009). Additionally, not enough is known about the life history and population dynamic of Hawai'i's bottomfish and, therefore, require further investigation and research (Skillman 2009). There is still much to be learned to properly and effectively manage the fishery. However, there has been much research in the past ten years. Recent research has focused almost exclusively on the Deep 7 species due to their high economic value, but more research is needed for the less desirable but still impacted species.

5 LITERATURE PUBLICATION TIMELINES

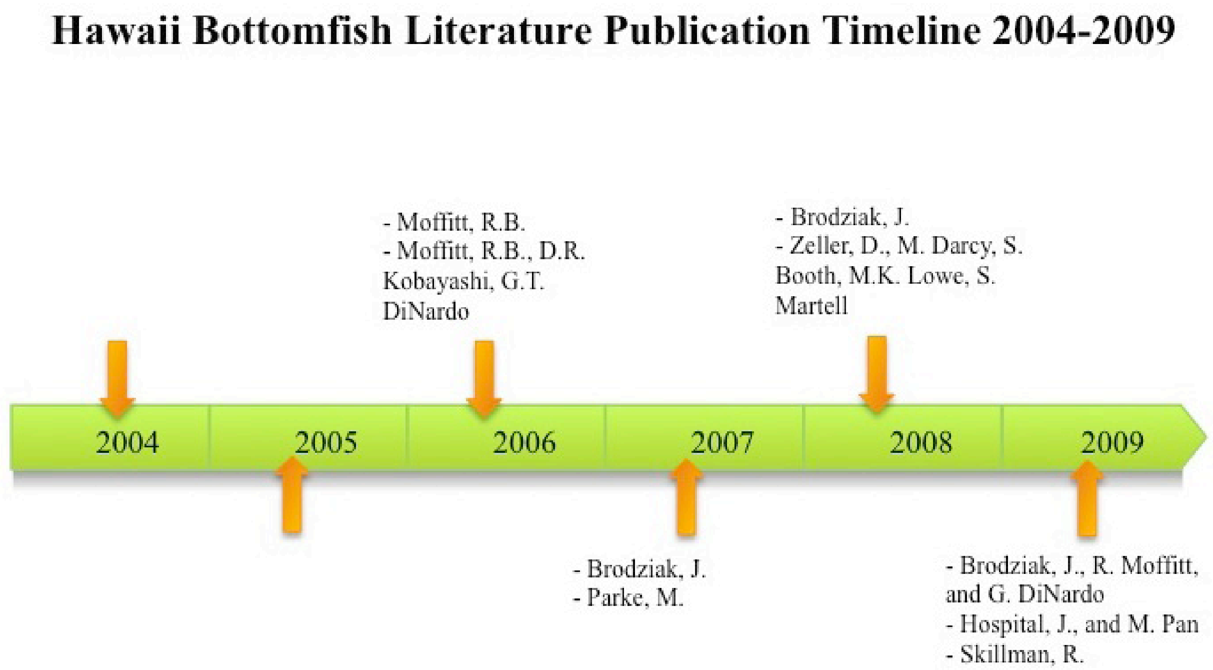

Figure 1 Literature published between 2004 and 2009.

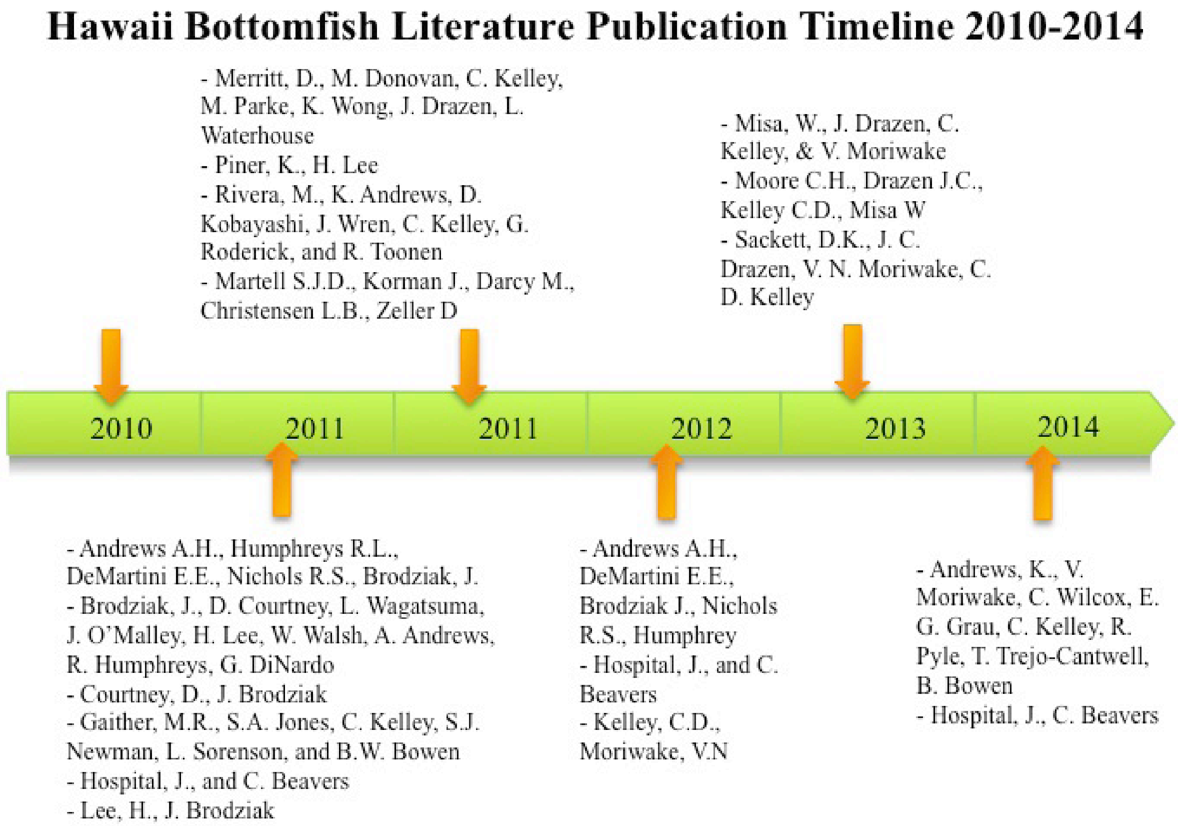

Figure 2 Literature published between 2010 and 2014.

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