Exploring the pole-and-line frigate tuna (*Auxis thazard*) catches in the Maldives tuna catch-effort dataset (2004-2015)

Mohamed Ahusan

Marine Research Centre, Malé, 20025, Republic of Maldives
PO Box 2074, Malé, Republic of Maldives

Abstract

Indian Ocean frigate tuna catch has increased steadily for the last 20 years, with a total catch of 102,000 t being reported in 2014. In Maldives, the catch, predominantly caught using PL gear, have been highly fluctuating without an obvious trend. In terms of data, Maldives has a long history of catch and effort data collection from its tuna fisheries. Vessel specific pole and line CPUE data available from 2004 onwards was standardized and used for stock assessments of Indian Ocean skipjack tuna and kawakawa. The frigate tuna catch records in the dataset were explored and is presented. Frigate tuna is important in the northern and central atolls where it is mostly caught by the mid-sized vessels that would operate within and in close proximity of the atolls. In contrast, significantly low catches were reported from the southern atolls where skipjack tuna fishery is well established. A clear pattern of reduced number of records, and in turn, reduced effort and frigate catch from 2010 onwards was also revealed. Similarly, the quarterly nominal CPUE showed contrasting trends in the pre and post 2009 data periods which suggests underlying issues with the explored frigate positive subset of the CPUE dataset rather than a true decline in nominal CPUE.

1. Introduction

Indian Ocean catches of frigate tuna (*Auxis thazard*), has increased steadily for the last 20 years, with the total catch being at 102,000 t in 2014 (IOTC-WPNT06, **Error! Reference source not found.**). It is an important species in the tuna fisheries of several coastal states, with four countries, Indonesia, India, Sri Lanka and I.R. Iran reporting 90% of the total Indian Ocean

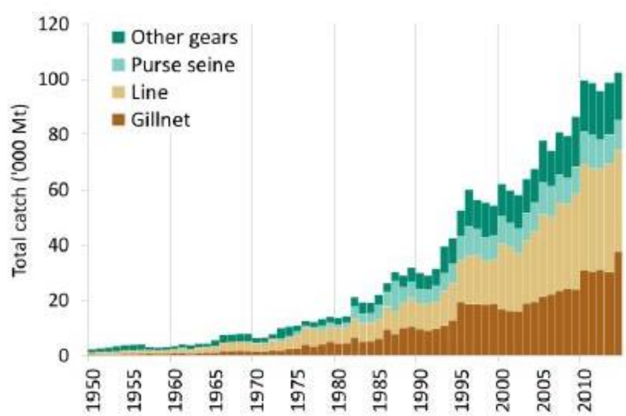

Figure 1. Frigate tuna annual catches by gear (source: IOTC-WPNT06)

catch. Indonesia alone accounts for up to two-thirds of the catch (IOTC-WPNT06-RE). It is also an important bycatch in the industrial purse sein fisheries (IOTC-WPNT06). Major gears for frigate tuna in the Indian Ocean are gillnets, coastal longline and trolling, handline and trolling, and to some extent coastal purse sein nets.

In the Maldives, frigate tuna is mostly caught using pole-and-line gear, from within the atoll lagoons and just outside the atoll rim reef. In the northern and central atolls, frigate tuna are sometimes targeted from conspecific schools during times of higher abundance. It is also regularly caught from anchored fish aggregating devices along with other tuna species. Frigate tuna, along with kawakawa, were the main target of the well-established troll fishery that existed prior to mechanization of the pole-and-line fleet (Adam, Anderson and Hafiz, 2003). Frigate tuna is also caught in minute quantities using handline gear (for instance, 8 t in 2015, Ahusan et al. 2016).

Highest recorded catch of frigate tuna from all gears, was observed during 1973-74 with an average catch of about 6,300 t (**Figure** 2). Similar catches were also observed in 1993 and 1996, with about 5,400 and 6,400 t respectively. Lower catches were observed during 1978-81 and 1986-88 periods, landing on average 1,600 and 1,700 t respectively. In general, frigate tuna catch trend was observed to be highly fluctuating without an obvious trend. Catch and catch rates of frigate tuna has been influenced by socio-economic factors, environmental and oceanographic conditions (Anderson and Waheed, 1998) and diversion of PL effort (Ahusan and Adam, 2015) in the recent period. Beginning 2010, record decline in reported catch was observed, with just 118 t reported in 2015. It is an almost 97% decline from 5,200 t in 2009. The observed trend in nominal catch in this period has been largely attributed to diversion of PL effort and non-reporting amidst the changeover from the former island based reporting to logbook reporting (Ahusan and Adam, 2015).

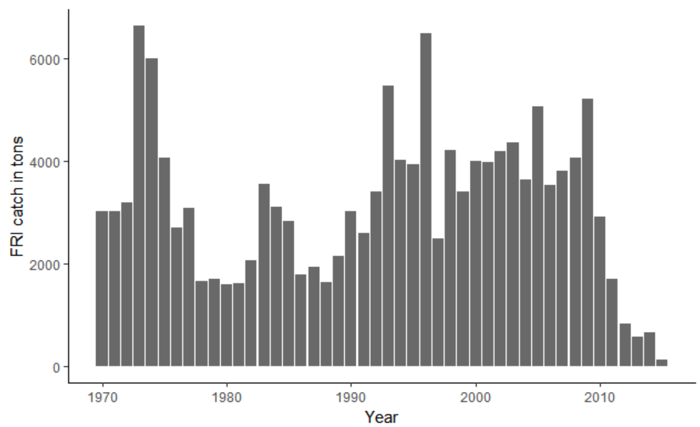

Figure 2. Nominal catch of frigate tuna (t), all gears combined.

In terms of fishery data, Maldives has the longest time series of tuna catch and effort data in the Indian Ocean (Adam, 2012, IOTC-2012-WPTT14). Fishery catch and effort data collection from the Maldives tuna fisheries began in 1959, with time series of disaggregated data useful for standardization from 1970 onwards (Adam, 2012). Abundance indices derived from the Maldives CPUE data (2004-2013) have been critical in conducting stock assessments for skipjack tuna in 2014 (OTC-2014-WPTT16-) and kawakawa in 2015 (IOTC-2015-WPNT05-20 Rev1). As frigate tuna is commonly caught and occasionally targeted in the pole-and-line fishery, the PL CPUE dataset could reveal important information on the fishery. This paper explores the frigate tuna catch records in the dataset.

2. Data source

Maldives employed an enumeration system for reporting tuna catches. Catches, which used to be landed at the home ports and reported in numbers, were reported through the island and atoll offices to the Ministry of Fisheries and Agriculture. This system of reporting still exists although reporting rates are on the decline and is being phased out since the introduction of tuna fishery logbooks in 2010.

Catch and effort data from 1970 is available as atoll and monthly aggregated data by vessel type and gear. Gear was only recorded post 1989 (Adam, 2012: IOTC-WPTT14). Prior to 1989, due to the homogenous nature and specialization of the fleet, gear was implicitly assigned based on vessel type (PL for *masdhoni* and troll line for *vadhudhoni*). The data collection was modified in 2004 to collect data by individual vessel. The dataset used is the vessels specific catch-effort data from 2004 – 20015.

3. Description of the dataset - Pole-and-line catch and effort data (2004-2015)

Adam (2012, IOTC-2012-WPTT14) describes the Maldives data collection system and the challenges and opportunities of using the vessel specific monthly CPUE data to derive an abundance index. Sharma, Geehan and Adam (2014, IOTC-2014-WPTT16) presents a standardized pole-and-line catch rate for the monthly vessel specific catch and effort dataset of 2004-2012. In the paper, the authors describe various issues with the dataset such as single day effort, zero skipjack catches with positive PL effort, issues with the registry number formats etc. Following the paper, Ahusan, Sharma and Adam (2015: IOTC-2015-WPNT05-INF0) presented an attempt to clean part of the dataset for the years 2004-2009. This paper presents the combination of two separate datasets: the cleaned dataset, which contains only mechanized pole-and-line vessel records with PL gear, and data for the remaining years (2010-2015) which contains records from both gears (PL and HL).

The final dataset contain about 52,900 records of fishery data reported to Ministry of Fisheries and Agriculture by individual vessels from 2004-2015. The dataset contains vessel information, year and month, effort, catch in weights and numbers (see Table 1). Catch reported in numbers or weights were converted to the other using conversion factors for each species and species groups. Around 50% of the PL records (25,700) had positive frigate catch.

Table 1. Description of the variuos fields in the dataset.

Field	Comment
Vessel registry number	Unique registration number. The format has been changed.
Vessel length	retrieved from the vessel registry database using the registry number
Year	2004-2015
Month	
Atoll	The administrative home atoll the vessel.
Gear	Pole-and-line (PL) and Handline (HL)
Effort days	Number of days of fishing. This is accurate in the case of single day trips. In multi-day trips, especially for handline yellowfin tuna trips, this may include Fridays that fall within the trip or days spent on bait fishing.
Small and large skipjack (weight and numbers)	The data collection system used to differentiate small and large skipjack (the division of which was arbitrary but was roughly 55 cm FL).
Small and large yellowfin (weights and numbers)	Distinction between large and small yellowfin is also arbitrary. General rule is that PL gear catches small yellowfin while handline gear lands large yellowfin tuna. Occasionally, larger individuals are caught using double poles or assisted pole-and-lines.
Dogtooth tuna (weights and numbers)	For some reason, dogtooth tuna, despite being an incidental catch and small in quantity, is recorded separately.
Frigate tuna (Auxis thazard)	Frigate tuna catch in numbers and weights
Kawakawa (Euthynnus affinis)	Kawakawa catch in numbers and weights
Sailfish	Sailfish catch in weights and numbers
Sharks	Shark catch in weights and numbers
Groups 1, 2 and 3	Species other than those above are grouped based on the size.
Others	Any other fish that might be reported. This may have been aggregated catch from other fisheries such as grouper and reef fishery. The dataset has just one record with a catch in this group.

Spatial distribution of data

The atoll wise records were grouped by region, arbitrarily divided into north, centre and south (Figure 3), to encompass the similar geographic and fishery divisions. While there may not be much biogeographic differences between the northern and southern atolls, presence of Malé (the capital city and surrounding islands), where almost 1/3 of the population resides and the hub of economic activities, clearly affects the fishing pattern and fishermen behavior in the region. The southern region is clearly distinct from the central, separated by wide, *Huvadhu kandu*, or One and a Half Degree Channel. Anderson (1992) and Woodroffe (1992 in Anderson, Waheed and Adam (1998) suggest spatial variation in oceanographic conditions and abundance of tuna species distribution along the length of the country. They further suggest that *Veymandoo channel*, the next channel north, is the demarcation between the south and the northern parts in terms of species distribution. The divisions presented here are consistent with those used in previous CPUE standardizations of skipjack and kawakawa.

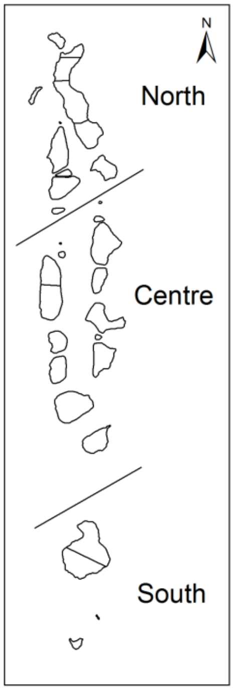

Figure 3. Maldives map showing the 3 regions used.

Regionally, northern and central atolls are similar in contribution to frigate catch data, indicated by the equal proportions of records from both regions (Figure 4). The smallest vessel class is an exception as these vessels have a significantly higher reporting rate than the center as there could be more vessels that fall into this size class than the rest of the country.

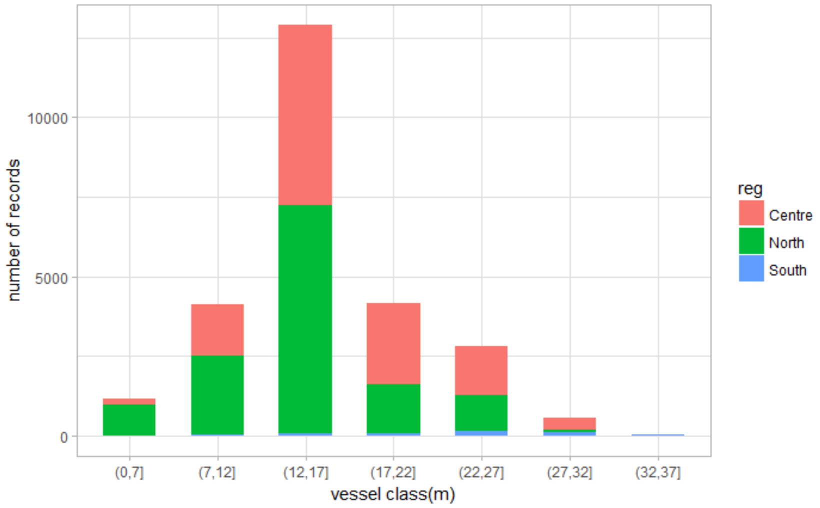

Figure 4. Distribution of FRI catch records across the vessel classes and regions

In terms of effort, there is a general declining trend in the amount of PL effort reported (**Error! Reference source not found.**). This decline is more prominent after 2009 than pre 2009 period. The pre-2009 period has an average about 99,000 effort days which declines to about 31,000 in the post 2009 period. In terms of locality of reporting, north and central atolls reported a higher effort (number of days) than the south. This observation can be explained by the fact that there is a higher number of, albeit smaller, vessels in the northern and central atolls compared to the south. Interestingly, reduced reporting is also strongest from the northern and central atolls. It is important to note that this data represent just part of the national catch-effort data and not the entire fleet.

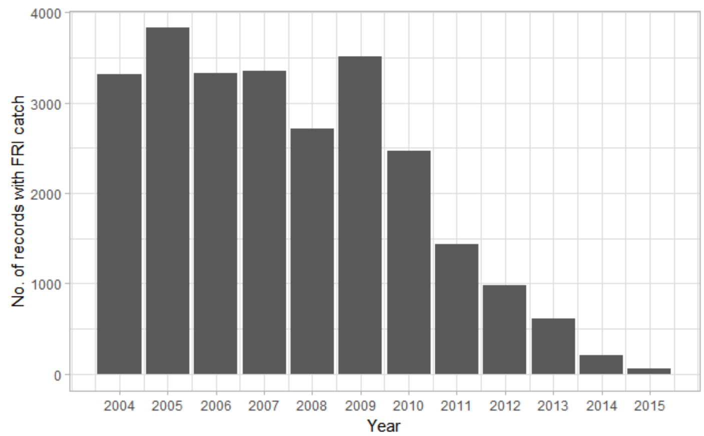

Figure 5. Trend in effort reported in the dataset.

4. Frigate tuna catches in the dataset

Catch trend

In terms of frigate catch, the number of records with positive frigate catch was somewhat similar for the period, 2004-2009 (**Error! Reference source not found.**) with an average of 3,300 records per year, which represented about 77% of records. Beginning 2010, reporting rates, or the number of records in the dataset declines substantially, from around 3500 records in 2009 to just 57 in 2015. The catch reported follows the same trend, with a mean catch of 3,100 t in the 2004-2009 period, and a drop in mean catch to 465t in the latter half of the data period (Figure 7).

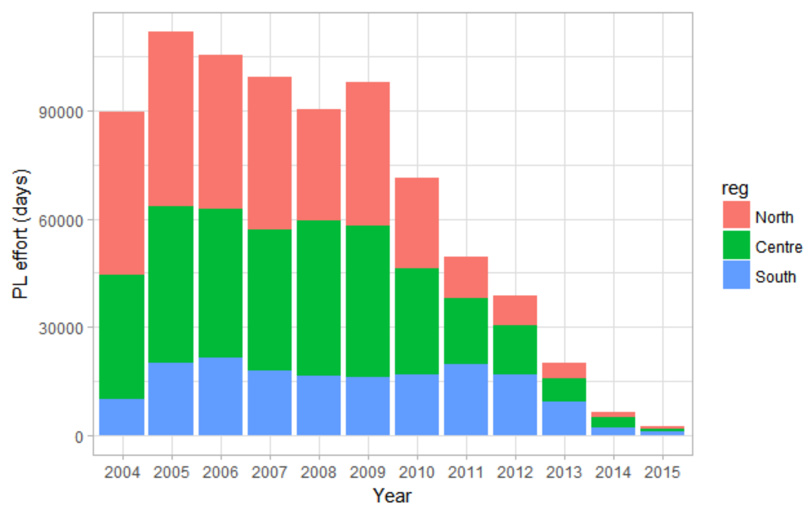

Figure 6. Number of records reporting FRI.

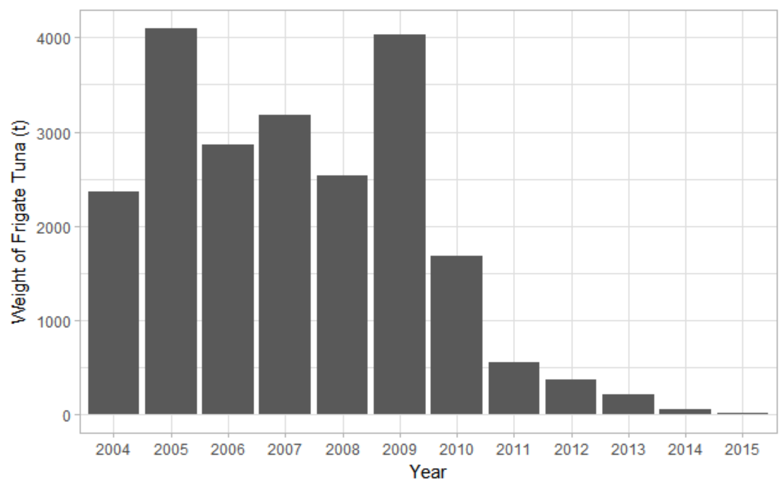

Figure 7. Trend in reported catch of FRI (t).

The differences between the two data periods is expected as the system shifted to a logbook reporting scheme in 2010 and the island office reporting is being phased out. Ahusan (2015) reported that logbook data submission was a requirement for the fishing license, which was essential to dispose the catch to an exporter. The paper further reports of decreased logbook reporting rates from the vessels that conduct fishing for subsistence and sale to locals in the north and central regions. Such a trend will likely have a greater impact on frigate tuna data as there is a higher contribution of frigate tuna from the respective regions.

Spatial distribution of frigate tuna catch

Maldives tuna fishery used to be a single day fishery, leaving home port early in the morning and returning to the same at the end of the day. Thus catches were almost always from close vicinity of the island. Developments to the fleet, larger vessels with increased range and better conditions for the crew allowed the vessels to venture further. However still, most fishermen still prefer to stay close to their island, regularly returning home. Hence, the catch reported can be associated to the general area of the vessel home island. This is especially true for the smaller vessels with limited range.

Higher frigate catches are consistently reported from the northern atolls, compared to the central atolls, with very small amount of catch reported from the south (**Error! Reference source not found.**). The differences indicate the abundance and targeting of frigate tunas in the respective regions. Further, the catch-effort plot suggest higher catch rates in the northern atolls. These observations are similar with those previously reported for the species (e.g. Anderson et. al., 1998).

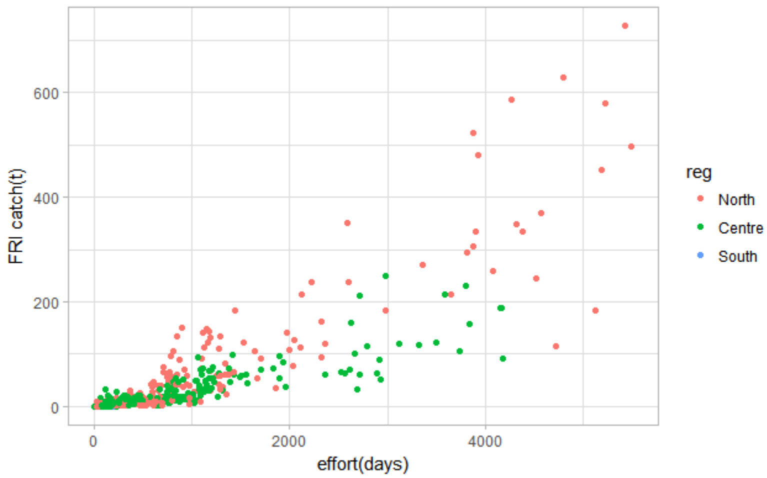

Figure 8. Catch (t) and effort (days) for FRI in the dataset.

Vessel length and frigate tuna catch

The importance of vessels from the 12-17 m length class in frigate tuna contribution is clearly evident (Figure 9). These represent the mid-sized sized vessels with limited range that fish within the atolls or does not venture too far out. The reported catch of frigate tuna decreases towards the upper end of vessel lengths, indicating their preference or ability to venture far in search of other tuna species, namely skipjack and yellowfin. Figure 10 presents the north-south evolution of vessel lengths frigate catch, with retracting proportions of records from the small and mid-sized vessels and increasing number of larger vessels.

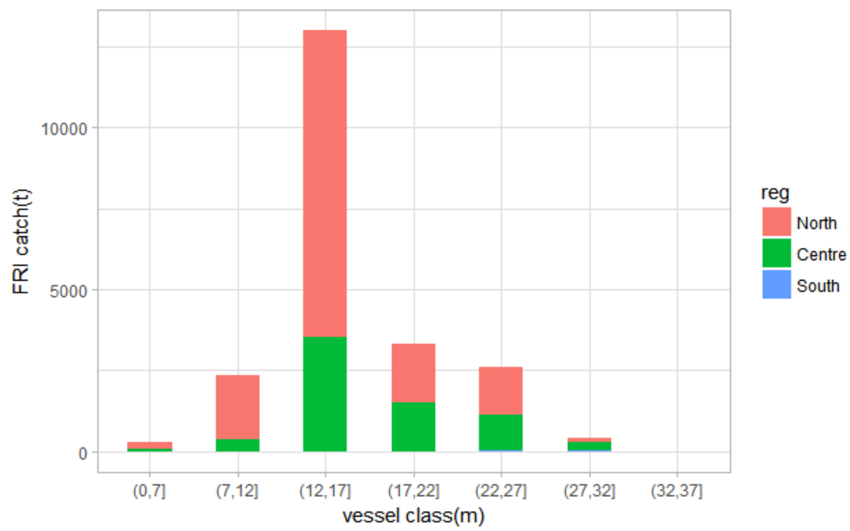

Figure 9. FRI catch (t), reported by vessel length and region.

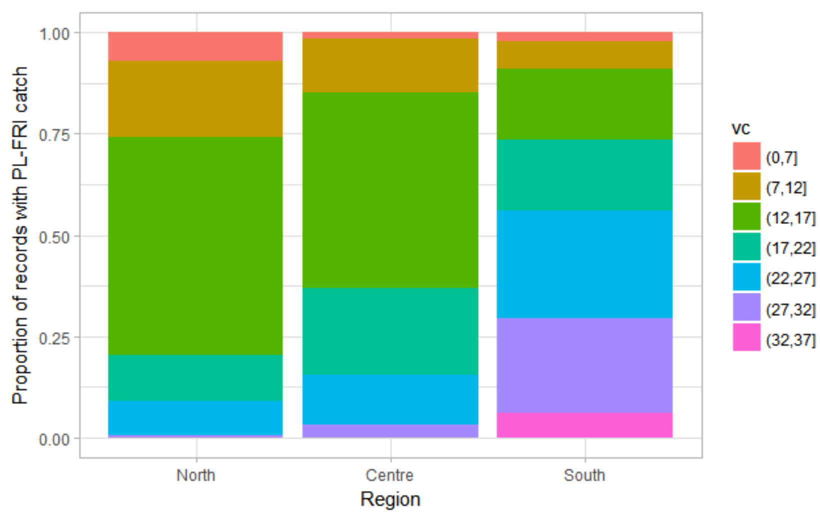

Figure 10. Evolution of catch records with vessel length and region.

Nominal CPUE

Catch per unit effort is commonly used as an index of abundance in stock assessments. Standardized CPUE data from the Maldives PL catch-effort dataset has in the past, been used as input for stock assessments of skipjack tuna and kawakawa. In the case of kawakawa, the Maldives dataset has the issue of non-representativeness of the Indian Ocean catch (IOTC-2013-WPNT03).

Frigate tuna CPUE could be further worse in this regard. Neritic tunas, particularly frigate tuna, are of low importance in the Maldives. They are not favored as food or for processing and thus, demand can considered to be low. As a result, frigate tuna schools are sometimes not fished by Maldivian fishermen, especially if good catches of other species can be made (Anderson, Waheed and Nadheeh, 1998). This situation can be assumed to be much worse since introduction of alternative fisheries (such as HL large YFT fishery and reef fish fishery) which are much more profitable.

Error! Reference source not found. presents the nominal quarterly CPUE in weight (kg/day) for PL caught frigate tuna. Catch rates fluctuated, with a general increasing trend, between 21 and 87 kg/day in the period, 2004-2009. This was followed by a steep decline to as low as 3.2 kg/day reported in the second quarter of 2015, with the exceptions of Q1 of 2012 to Q3 of 2013. It is possible that the exceptions could have been the effect of subsidizing fuel to incentivize logbook reporting. Additionally, the very high CPUE in Q4 of 2014 is suspicious and needs further checking.

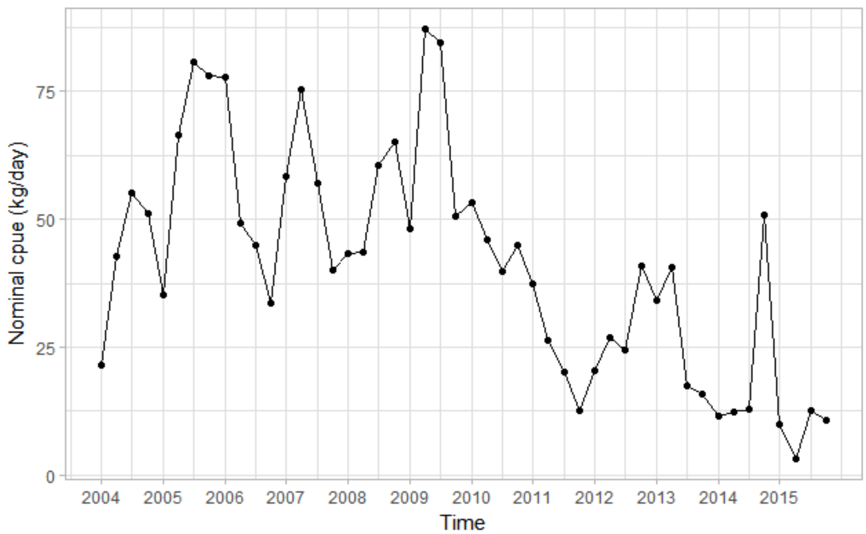

Figure 11. Nominal CPUE (kg/day) for frigate tuna

The CPUE trend does not show a clear quarterly trend in catch rates. For example, CPUE peaked in quarter 3 in 2004 and 2005 while in 2006, the peak in CPUE was seen in quarter 1. This could be an indication of a failure of quarterly steps to reflect the seasonality in catches. The quarterly CPUE used here is in consistent with that of skipjack and kawakawa catch rate standardizations (Sharma et. al. 2014, IOTC-2014-WPTT16-42 and Sharma et. al. 2013, IOTC-2013-WPNT03-23 respectively). On the other hand, Anderson et al., (1998) reports fairly consistent seasonal distribution of frigate tuna across the Maldives, with it being more abundant in the western side in the north-east monsoon and on the eastern side during south-west monsoon. Similarly, catch rates were also shown to vary depending on the geographic location and season. Time steps and regional segregation of atolls to better reflect the seasonal and geographic distributions may yield a more meaningful CPUE trend.

The contrasting "trends" (increasing CPUE before 2009 and decreasing CPUE after 2009) in the nominal CPUE series mirrors the other patterns in the dataset of reduced number of records, catch as well as effort after 2009, and in all likelihood, indicate serious issues in the dataset rather than a true change in nominal CPUE.

5. Conclusion

Exploratory analysis of the PL caught frigate tuna records in the Maldives tuna catch and effort dataset (2004-2015) revealed some interesting patterns in the fishery. The dataset obviously do not solely represent frigate tuna targeted trips. Nevertheless, it is useful due to the importance of PL gear in the FRI catches of the Maldives. Since frigate tuna are occasionally targeted during times of higher abundance, the dataset can be meaningful in some aspects.

The results showed the spatial distribution in frigate tuna catch and the relation between vessel size and frigate catch across the country. Frigate tuna is mostly caught, and reported from the northern and central atolls, where it has a higher abundance and is predominantly caught by the small to medium sized vessels. These vessels have a limited range and therefore mostly operate within or in close proximity to the atolls. Larger vessels, which are dominant in the southern atolls, are able to venture further offshore in search of skipjack and yellowfin tuna, two species that fetch higher prices than neritic tunas.

The patterns in the dataset, including those of reported effort, catch, number of records with frigate tuna and nominal CPUE suggest the underlying issues with the frigate-positive subset of the data. The results further reveal the effect of logbook introduction on the time series and highlights the importance of efficaciously replacing the data collection process with the newly introduced logbook. This is more so important for skipjack and possibly yellowfin tuna as the Maldives CPUE dataset is significant for the stock assessments.

6. References

Adam, M. S. 2012. Challenges and Opportunities for Standardization of Maldivian Skipjack CPUE. IOTC-2012-WPTT14-28 Rev_1.

Adam, M. S., Anderson, R. C., Hafiz, A. 2003. The Maldivian Tuna Fishery. IOTC Proceedings no.6 (2003). pp 202-220.

Ahusan, M., Adam, M. S. 2015. Further investigations into the decline in neritic tuna (*Euthynnus affinis* and *Auxis thazard*) catches from 2010-2013. IOTC-2015-WPNT05-11

Ahusan, M., Adam. M.S., Ziyad, A., Khadeeja, A., Sinan, H. and Jauharee, A.R., 2016. Maldives National Report to the Scientific Committee of the Indian Ocean Tuna Commission, 2015. IOTC-2016-SC19-NR17 Rev_1.

Ahusan, M., Sharma R. G., and Adam, 2015. Cleaning the Maldives Catch and Effort dataset (2004-2009). IOTC-2015-WPNT05-INF0.

Anderson, R.C., Z. Waheed, M.S. Adam (1998). The tuna fishery resources of the Maldives. Marine Research Bulletin 3: 180pp.

IOTC-SC16-2013. Report of the Sixteenth Session of the IOTC Scientific Committee. Busan, Rep. of Korea, 2-6 December 2013. IOTC-2015-SC16-R[E]:312 pp.

IOTC-2015-WPNT05-20 Rev1. Indian Ocean Kawakawa Tuna Stock Assessment 1950-2013 (Stock Synthesis). IOTC Working Party on Neritic Tunas, 2015.

IOTC-2013-WPNT03. Report of the Third Session of the IOTC Working Party on Neritic Tunas. Bali, Indonesia, 2–5 July 2013. IOTC–2013–WPNT03–R[E]: 75 pp.