Dynamics of Pama Croaker (*Otolithoides pama*) Fishery in the Gulf of Mottama, Myanmar: Based on Size Categories Data from a Fish Processing Buying Station

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Size category sorting box

Different sizes of Croaker

Prices for 8 size categories

Invoice

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Abstract

Fisheries are very important in Myanmar for both income and local consumption. There are, however, very limited data, especially on inshore fisheries. The Gulf of Mottama Project (GoMP) has worked with inshore fishers in the Gulf of Mottama (GoM) to assist in data collection and fisheries co-management since 2015. One of the major fish species landed in the GoM is Pama Croaker (*Otolithoides pama),* which is primarily purchased by processers who freeze the fish and export to China and other Asian countries. We have collected data on this species from one processing plant's sub-station in Kyaikto Town, Mon State.

Data were obtained on total landings from March 2016 to December 2022, and starting in 2018 we obtained data broken down by eight size categories. We determined weight for each size category

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initially by estimating average weight and then calculating length using an equation established by others in the nearby Bay of Bengal. Additionally, we carried out a one-time sampling to obtain length and weight for each size category to cross-check our estimates. These allowed us to estimate number of fish landed, estimated age, and value.

These estimates shed light on the state of the fishery since 2016. The total landings showed a five-fold increase of 115 metric tons (mt) from 2016 to 2019 with a slight increase in landings to 2022 in spite of COVID-19 and political troubles. The size category data indicated that in 2018 and 2019 the landings were dominated by small fish assumed to be 1 and 2 years old. In 2019 there was a very large recruitment of 1 and 2 year-old fish. Since 2020, medium sized fish of 3 to 5 years old have dominated the landings, suggesting the growth of the 2019 recruitment. This along with additional information suggests that this fishery may not have a steady state recruitment but periodic high recruitment and subsequent dominance by the successful year class. As a result, while fish landings in weight have increased since 2019 the estimated number of fish landed has declined from over 566,000 in 2019 to less than 450,000 in 2022. This is of considerable concern as there has been little recruitment of small fish since 2019.

Possible threats to successful recruitment are identified with the major one the capture of small and juvenile Pama Croaker by illegal small mesh (6mm) stake nets that are 1.5 to 4 km in length. Coordinated patrolling by stakeholders reduced the number of boats by 85% in 2018-19, however the illegal fishing has subsequently increased due to the current political situation. We suggest that a continuation of these patrols to reduce this fishing pressure is the most practical management measure.

Price information broken down by size categories was also obtained. We estimated the value of the landings in 2019 at over US$700,000. We also examined the economic impact of COVID-19 and showed a possible loss of US$290,000 at this one buying station.

Additional data is summarised to suggest that Pama Croaker undertakes a migration in May-June to spawn in low salinity waters at the mouth of the Sittaung River.

The application of the size disaggregated data from fish buyers suggests this approach has further application to Pama Croaker management. Given the current weakness of the Department of Fisheries it is difficult to foresee their application of this approach but it could, however, be used by companies, village and township fisheries committees, and other bodies to track the status of the fishery and implement management measures. There is also potential application to other species where the buyers separate the fish into different size categories.

1. Introduction

Fisheries in Myanmar are very mportant for local consumption, income and export earnings (Tezzo et al., 2018). There is, however, very little reliable official information on catch and landings while the reported FAO landing data appear to reflect the planning targets rather than actual catches (BOBLME, 2014). For example, Belton et al. (2015) estimated that Myanmar's national marine fisheries catch in 2010 was less than half the reported 2.1 million tons. Additionally, there is little detailed research on important species, their fisheries and ecology. What does exist is often hidden in student thesis that are difficult to access. There are a few notable exceptions. WorldFish through several projects in the Ayeyarwady River system have documented migrations, obtained indication of catch and value for the major species, River Hilsa (*Tenualosa ilisha*) (Baran et al., 2015: Bladen et al., 2019). While Hosch et al. (2021) were able to access logbook records for the offshore fishing in Thanintharyi Region in the south of Myanmar and determined some long-term trends in catch and effort.

The Swiss-funded Gulf of Mottama Project (GoMP)[2] has been working with coastal villages in the Gulf of Mottama (GoM), Myanmar since 2015 to develop a coastal management plan with a focus on the development of fisheries co-management. The GoM stretches from the Andaman Sea in the south to the mouth of the Sittaung River in the north. It is over 100-km wide at the mouth of Bilu Island and narrows to a 1-km funnel at the entrance of the Sittaung River. The GoM is bounded by Bago Region and Yangon Region on the west and Mon State on the east (Figure 1.1). The GoM has several unique features including 7-metre diurnal tides that are some of the highest in the world. The GoM is influenced directly by the Sittaung River that originates in central Myanmar and in the southeast by the Thanlwin (Salween) River that flows from Tibet. The Ayeyarwady River system also contributes sediment due to the west to east oceanic circulation. As a result, the GoM has a very high suspension load and high turbidity (Ramaswammy et al., 2004; Robinson et al., 2007). This produces very large tidal mud flats that are ecologically important to fish, crabs, and migratory shorebirds, including the Critically Endangered Spoon-billed sandpiper (*Calidris pygmeus*) *(*Zochler et al., 2014). The gulf also experiences rapid changes in erosion and deposition patterns that have resulted in land loss and relocation of villages (Steijn et al., 2018) particularly on the western shore (Bago Region). Salinity varies with the monsoon season but in general is in the range of 28-24 ‰ at the mouth and from 0 to 4.5 ‰ at the entrance of the Sittaung River. The estuary and major rivers are important spawning and nursery grounds for fish and crustacean species that are economically important for small and medium scale fisheries that support numerous coastal villages.

[2] GoMP funded by Switzerland through the Swiss Agency for Development and Cooperation (SDC) involves three main partners HELVETAS, International Union for Conservation of Nature (IUCN), and the Myanmar NGO, Network Activities Group (NAG).

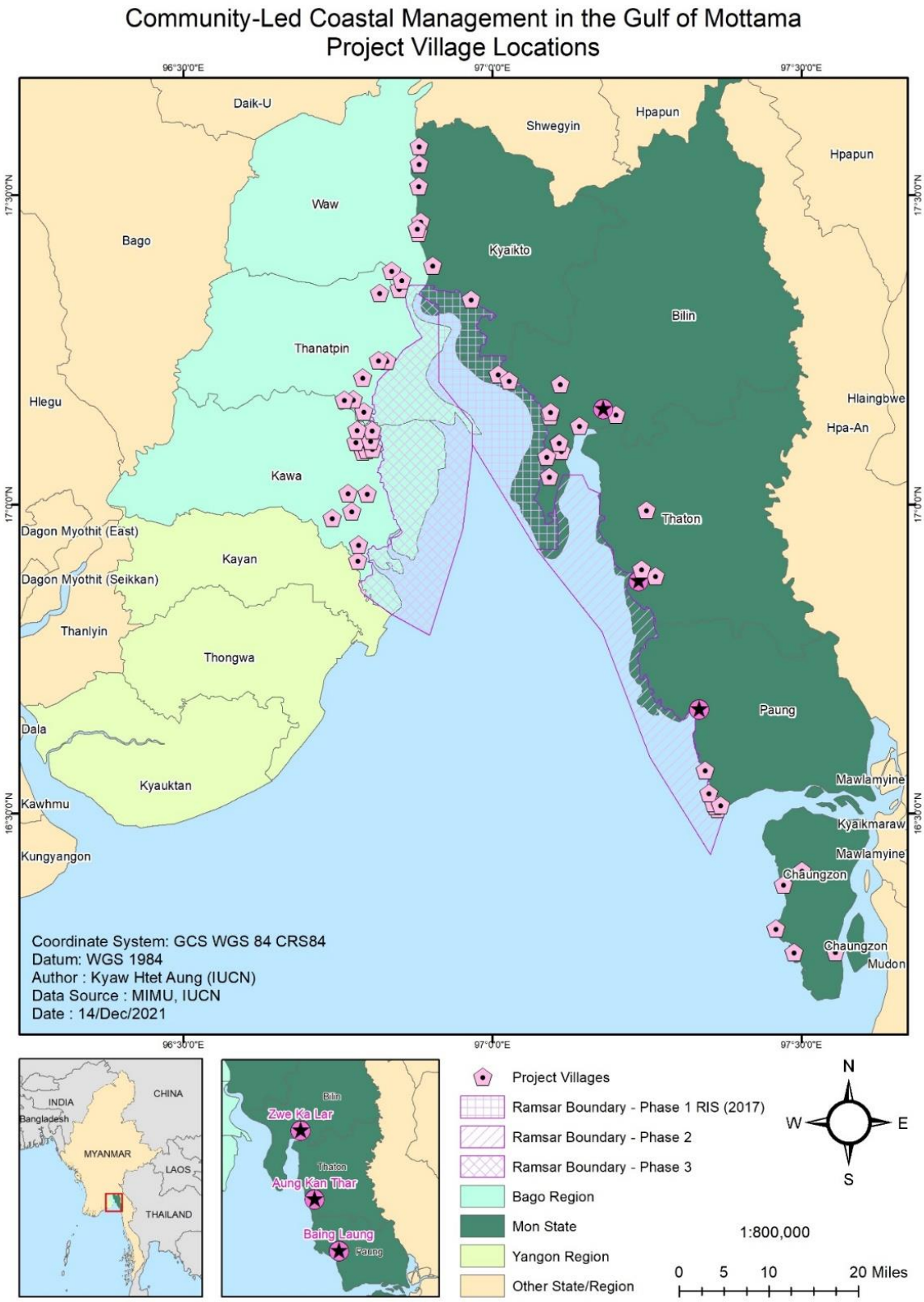

Figure 1.1: Gulf of Mottrama and Project Villages

At project initiation there was little systematic information available on the fishery and ecology in the GoM. Several approaches were used to collect fisheries data (MacKay et al., 2022). This paper focuses on Pama Croaker (*Otolithoides pama*), one of the major fish species landed in the GoM. We described a unique data collection system in which one fish buyer supplied data on total landings that was disaggregated into eight size categories. These size categories allowed us to estimate total landings in terms of size, age distribution and value over a 5-year period that suggests detailed dynamics of the fishery. We suggest that the collection of such size disaggregated data directly from fish buyers has considerably potential for use in fisheries management particularly in data deficient fisheries. We also summarised additional project related research on spawning and migration and suggested possible conservation measures.

Figure 1.2: Pama Croaker Fish

Croaker (Fig 1.2) are captured by fishers throughout the GoM using mainly mid-sized boats of 7.6-10.6m length range, normally powered by outboard long tail motors in the 15-35 hp range. The fishing is carried out primarily using drifting trammel nets, ranging from 0.5- to 2-km in length and 3.8-7.6 cm (1.5-3") in mesh size. Some beach seines and fence nets are also used. Fishing in the GoM requires considerable local knowledge due to the shallowness and frequent changing mudflats as such all fishers are local residents.

The landed fish are sold to either local (village) fish buyers or to representatives (sub-stations) of the main export companies. The local buyers sell the fish fresh to local fish markets or transport them to major centres like Mawlamyine or Yangon. The export companies freeze the fish whole and export to China and other Asian countries under the label Rosy Jew Fish. Swim bladders are also extracted, dried and marketed separately initially to Yangon and then to China. In Mon State there are five major processors. We have obtained long term data from one fish buying sub-station of one of the major export companies (Mawlamyine Holdings Limited - MHL).

2. Methods

Data has been collected from one substation of MHL in Kyaikto Town, Mon State (Figure 1.1) from March 2016 to December 2022. This sub-station buys fish from about 150 mid-sized boats who land their fish in Kyaikto Town. Fishing trips are in the range of 3 days to over a week with captured fish normally stored on ice. Fishers tend to sell to the same buyer and MHL sub-station gives advances to about half the boats to ensure they sell fish to MHL. Unfortunately, it was not possible to obtain data on individual fishers or effort.

At the sub-station the data on daily total catch in Viss[3] is recorded into data sheets that are collected monthly by GoMP field staff and entered into Excel for analysis. MHL, like other Croaker buyers, pay different prices for different size categories of fish. They sort the incoming fish by eye in boxes using eight size categories. These range from <100 g to over 800g[4] (Figure 2.1 & Table 3.1) and then weigh the boxes to determine weight for each category. This is then transferred to an invoice and the payment is calculated. Landings for 2016 and 2017 were total landings only but from 2018 on size disaggregated data was shared with GoMP. Size data was available for only about 40% of the catch in 2018-2019 while full data was available for 2020-2022.

Figure 2.1: Sorting Fish MHL Sub-station, Kyaikto Town

[3] Viss is a Myanmar measure of weight (1 viss = 0.612 kg)

[4] The fish are not weighed individually but the skilled staff assumes weigh primarily by eyeballing the lengths. In some case the fishers who are present during sorting can challenge the category and then the fish are weighed and if necessary reassigned. This occurs infrequently and primarily for larger fish.

Detailed price information was only available for 2022. For previous years prices per viss for each size category were periodically recorded from a whiteboard on the premises (Figure 2.2). The prices differ depending on the presence or absence of swim bladders. These prices are recorded and used to calculate the value of the catch (Table 3.3).

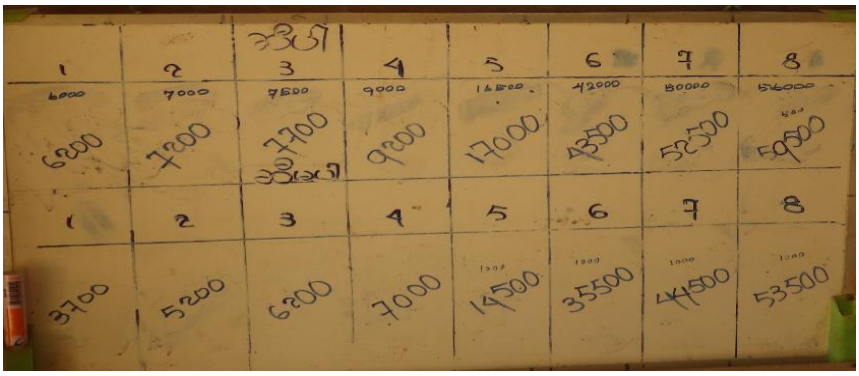

Figure 2.2: Croaker prices (as of March 2019) per Viss (1 Viss = 0.612 kg) at MHL Sub-station for each size category with (top) and without (bottom) swim bladder

The size disaggregated data has allowed us to estimate additional parameters. Initially an estimated average weight was assigned to each size category based on guesses of approximate size category weights (Table 3.1). This allowed an estimate of numbers of fish by dividing the landed weight for each size category by our estimated weight. It was then possible to estimate average total length per size category using a length-weight regression $WT = 0.0036\ TL^{3.2136,}$ which was calculated from Pama Croakers sampled from the GoM (Htet, 2017). Additionally, fish age data from the nearby Bay of Bengal Hooghly Estuary (Bhakta et al., 2021) allowed us to estimate fish age from the measured TL.

One-time detailed measurements were undertaken to obtain more precision on the weight and length estimates. Ten fish from each of the eight size categories were sampled for length and weights (Table 3.1). We have used these values in subsequent calculations although as discussed in Section 4.5 the rough weight estimates will still allow us to estimate the fishery dynamics.

The GoMP has collected additional data on Pama Croaker at other sites through baseline surveys, frequent interviews with fishers, catch data from fish buyers and fishers, and University staff and student research studies. These additional data are being summarised but some are reported here to confirm the MHL data and add information on spawning, migration and possible conservation approaches.

3. Results

3.1. Annual landings

The annual landings from March 2016 to 2022 at MLH are shown in Figure 3.1 and Table 3.2. There was a doubling from 2017 to 2018 and a threefold increase between 2018 and 2019. In 2020, 2021 and 2022, despite COVID-19 and political troubles, landings are slightly higher than 2019. There was an increase of 117 mt from 25 mt in 2017 to 142 mt in 2020 and 2021 and a further 7 mt increase to 149 mt in 2022.

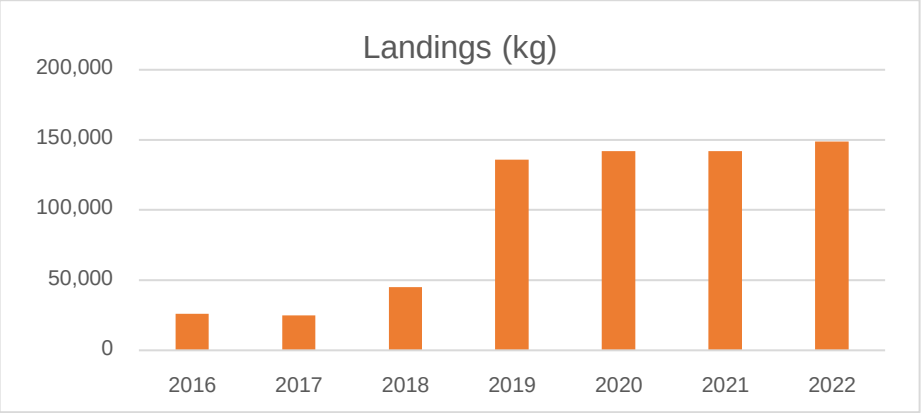

Figure 3.1 Pama Croaker Landings at MHL Sub-station, Kyaikto Town, Mon State

Landing data from the nearby Sut Pa Nu Village (Figure 3.2) (MacKay et al., 2021) show a similar pattern whereby there is a substantial increase in Croaker landings in 2019 with an even greater increase in 2020. The 2021-22 landings were greatly affected by both COVID-19 and the political problems that adversely affected local markets.

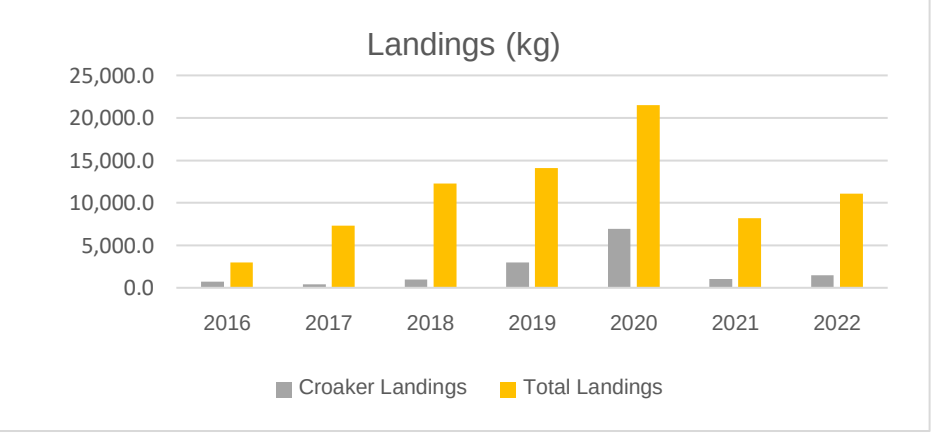

Figure 3.2: Total & Pama Croaker landings at Sut Pa Nu, Kyaikto Township, Mon State

3.2. Size categories

The data broken down by size categories allows a unique opportunity to exammine the catch in much greater detail. Critical to this is to determine an average weight for each size category. Intially we used estimates of weight based on the buying station's suggested weight ranges. A more accurate measure was determined from the subsequent sampling for length and weight. This data is summarised in Table 3.1. .

Table 3.1: Measured weights, lengths & estimated ages of Pama Croaker size categories. (The number in the parenthesis represents standard deviation)

Size Category		1	2	3	4	5	6	7	8
Weight (g)	Range MHL	<100	100-200	200-300	300-400	400-500	500-600	600-800	>800
	Range Measured	110-155	175-240	260-310	320-385	430-500	525-600	635-795	825-1265
	Mean Estimated	75	150	250	350	450	550	700	900
	Mean Measured	129.5 (±17.55)	209.5 (±27.83)	280.5 (±16.24)	342.5 (±19.61)	460.5 (±26.61)	540.8 (±26.93)	722 (±55.35)	1029 (±34.99)
Total Length (cm)	Range Calculated [5]	<24	24-30	30-34	34-37	37-40	40-42	42-44	>44
	Range Measured	24.5-27	28-31	31.5-35-5	33.5-36	35.5-39.5	37.5-42	41.5-47.5	48.5-54
	Mean Estimated	22	27.4	32.1	35.6	38.5	41	44.2	47.8
	Mean Measured	25.6 (±1.21)	29,2 (±1.32)	33,3 (±1.23)	35.0 (±0.88)	37.5 (±1.06)	39.7 (±1.4)	44.1 (±1.68)	50.4 (±2.09)
	Size at Age West Bengal	20.2	29.7	35.0	38.0	39.7			
Age (year)	Presumed Age	1	2	3	4	5			

[5] Total Length was calculated from the MHL estimated weight using LW regression $WT=.0036TL^{3.2136}$

Our initial estimates of weights for the smallest size categories 1 and 2, were lower than the measured weights, and for Size 1 the measured weights were above the MHL suggested size of <100g. The weights of all other size categories were within the range of the estimated weights. We use the mesured weights and lengths in subsequent calculation and discussion.

Size at age for Bay of Bengal Pama Croaker (Bhakta et al., 2020) are also shown in Table 3.1. These sizes are close to the range of TL for the various sizes classes. As such we suggest the buying stations size classes are an acceptable surrogate for age.

3.3. Estimated Landing by numbers of fish

To obtain a closer look at the fisheries dynamics we estimated the number of fish landed for each size category calculated from the the average weights for each size category. As for 2018-2019 there was size disaggregated data for only 5-6 months, we calculated the percent for each size category and then applied that to the total catch. Figure 3.3 and Table 3.2 shows the estimated numbers of fish landed during 2018-2022.

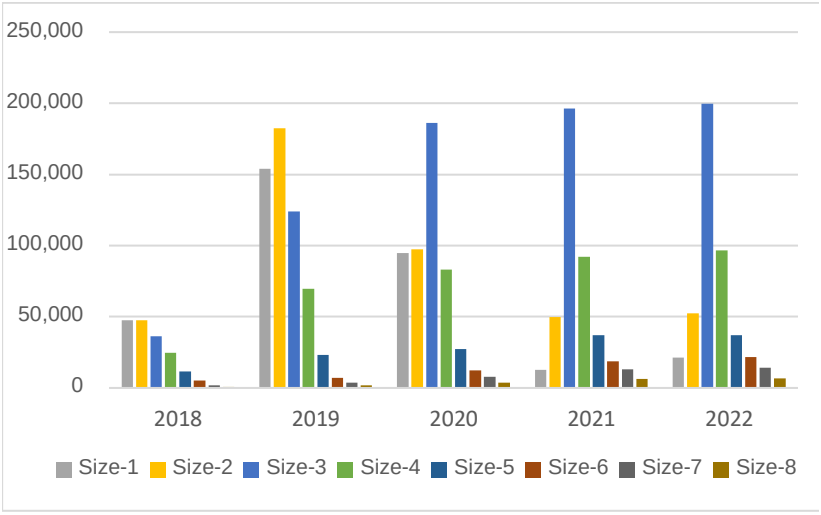

Figure 3.3 Estimates of number of Pama Croaker landed at MHL Kyaikto Sub-station

As indicated in Section 3.1 there was a large increase in landinged weights between 2018 and 2019. This appears to be the result of a large recruitment of Sizes 1 and 2 fish making up 59% of the catch. In subsequent years, the proportion of these small fish declines (Figure 3.3 and Table 3.2) to 38% and then to 15-16% in 2021-2022. While Size 3 fish have increased in the catch being the dominant size class in 2020-2022. Size 4 has also increased such that Sizes 3-4 make up 50% to 68% of the catch from 2020 to 2022. Fish larger than Size 4 have also increased in the catch and in 2021-22 comprised 18% of the landings.

Table 3.2: Weight, number, average weight and percent size class/age of Pama Croaker landed at MLH Sub-station

Year	Landing weight (kg)	Estimated number	Average weight (g)	Size classes/ages (%)		
				1-2	3-4	>4
2018	44,925	175,562	256	54.2	34.8	11.0
2019	136,038	565,888	240	59.4	34.2	6.4
2020	141,859	512,365	277	37.5	52.6	9.9
2021	141,975	426,297	333	14.7	67.7	17.7
2022	148,711	449,872	330	16.0	65.9	17.7

From 2019 to 2022 there was a continued increase in the landed weights while the estimated number of fish have declined (Table 3.2). We estimated that 566,000 fish were landed in 2019, which fell slightly to 512,000 in 2020 and to 450,000 in 2022. The landing weight has increased due to an increase in the average weight of the landings from 240 g to 330 g. This appeared to be the result of the growth of the dominant 2017 and 2018 cohorts (Age 1 & 2) in subsequent years as ages 3 plus fish now dominated the landings. The low number of small fish in 2021 and 2022 is of considerable concern for future catches as this suggests that catches may decline in the future.

3.4. Value of Landings

Prices were obtained periodically for each size category in Myanmar Kyat (MMK) from March 2018 to December 2022 (Figure 2.2 & Table 3.3). The prices for 2018 only are listed with and without swim bladder for comparison and were 33% higher for fish with swim bladder. We have used the with swim bladder prices in subsequent calculation. These with swim bladder prices varied considerably between size categories, with a substantial reward for larger fish. For example in 2018 and 2019 the largest fish were eight times the price per viss of the smallest fish. There is also considerable variability in prices from year to year. The highest prices were in 2019 to early 2020 just prior to the COVID-19 outbreak. The prices subsequently declined by over 50% due to COVID-19 (see Section 3.6) and political troubles affecting markets.

Table 3.3: Pama Croaker prices (MMK) per Viss (1 Viss = 0.612 kg) by size category at MHL Sub-station, Kyaikto, Mon State

Date	Swim Bladder	Size - 1	Size - 2	Size -3	Size - 4	Size - 5	Size - 6	Size – 7	Size - 8	Average Price
2018 April to November	with	4,750	6,000	7,000	8,500	14,750	27,000	34,500	40,000	17,813
	without	*3,650*	*4,350*	*5,350*	*6,750*	*12,750*	*24,000*	*31,500*	*37,000*	*12,890*
2019 to March 2020	with	6,200	7,200	7,700	9,200	17,000	43,500	55,500	59,500	25,725
2020 April to August	with	4,500	5,000	5,500	6,000	8,000	11,000	13,000	18,000	8,875
2020 September to December	with	3,500	3,500	5,000	6000	9000	11000	13500	17000	8,563
2021 December	with	4,000	4,500	6,500	10,000	12,500	16,000	20,000	26,000	12,437
2022 January to December (Average)	with	3,992	5,156	7,039	9,634	12,388	15,186	19,963	25,297	12,332

We have used this size disaggregated price information to estimate the value of the landings. In the absence of data on percent of landings with swim bladders we have used the with-swim bladder price but admit this will yield an overestimation of values. The estimated (MMK) values (Table 3.4) for 2019 are 230% of the 2018 values. There was a slight decrease in value in 2020 (see Section 3.6). While values in 2021 and 2022 have increased slightly, the values in US$ have decreased by 33% from 2020 to 2021 due to the devaluation of the MMK.

Table 3.4: Value of Pama Croaker landings. Exchange rate 1 US$ =1,300 MMK (2018-2020) = 1800 MMK (2021) = 2300 MMK (2022)

Date	Landings (kg)	Value (MMK)	Value (US$)	Difference MMK (%)
2018	44,925	280,575,632	$215,827	
2019	136,038	922,095,942	$709,305	228.6%
2020	141,859	801,702,975	$616,695	-13.1%
2021	141,975	896,391,950	$497,996	11.8%
2022	148,711	952,336,125	$414,059	6.2%

3.5. Impact of COVID-19

The Pama Croaker market was greatly affected by the COVID-19 pandemic and starting in March 2020 exports to Asia declined and at least one plant in Mon State closed. MHL stopped buying fish from April to June with buying resuming in July 2020. Prices decreased as a result (Table 3.3). The average price decline was 60% from March to August and there was a further decline in September of 67%. There was considerable difference in the decline between the different size classes (Table 3.3). The lowest price decline was in the smaller sizes 1-2 that declined 44-51% in from March to September while the large sizes 7-8 had an over 70% decline in price. +

Effect of COVID -19				
2020 January to March	74,693	517,966,350	$398,436	
2020 April to December	67,166	283,736,625	$218,259	
2020 Total	141,859	801,702,975	$616,695	
Assuming Pre COVID Prices				
2020 April to December (with 2019 prices)	67,166	657,319,560	$505,630	
Difference		-373,582,935	-$287,371	-131.7%

Despite the effects of COVID-19, landings for 2020 (Figure 3.1 & Table 3.4) increased slightly over 2019. This was, however, the result of record landings in January before COVID appeared, accounting for over 40% of the yearly landings. There was a 33% decline in landings during the period affected by COVID-19 (March to December 2020) compared to 2019, primarily due to cessation of buying during April to June.

The detailed information on catch and price changes (Tables 3.3 & 3.4) from the MHL substation indicated the magnitude of the changes in price and value in 2020. The value of the landings in 2020 was 13% lower than 2019. This, however, does not account for the large January catch prior to COVID. We examined the April-December 2020 period and compared the actual prices to what would have been received if the 2020 January-March prices had continued (Table 3.4). We estimated there was a potential reduction of 132% in the value of the landings in 2020 compared to 2019. This represents a possible loss of over 371,000,000 MMK (US$287,000) due to COVID at one buying station. The loss was probably greater as this did not account for the decrease in landings from April to June when the buying station was closed.

3.6. Migration and Spawning

The distribution of catch by season[6] is shown in Figure 3.4. There is considerable variability in the landings between years and there is no clear pattern although on average the post monsoon and cool season (September-February) accounted for 64% of the landings. As mentioned in Section 3.5, the very high landings in January 2020 were four times that of January 2019.

This large variability does not give any indication of fish migration or seasonal abundance. As the boats landing at MHL were mobile and moved around the GoM this may mask localised migration patterns.

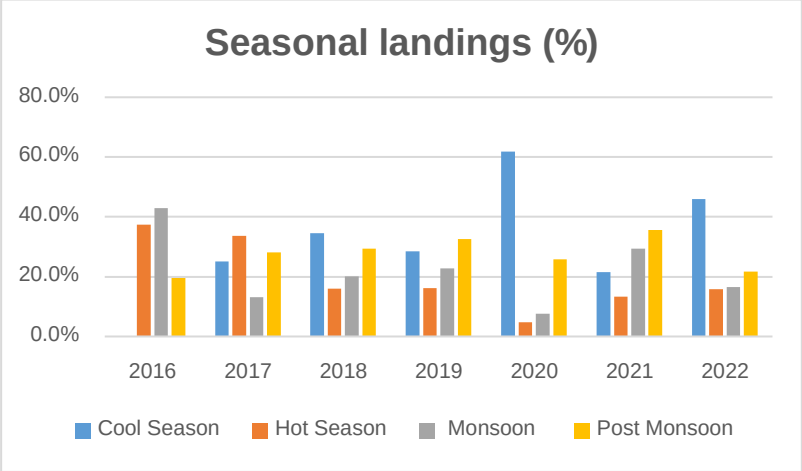

Figure 3.4: Seasonal landings at MHL Substation Kyaikto Town. Mon State

The seasonal landings of Pama Croaker (Figure 3.5) from Sut Pa Nu, however, offers a clearer picture of possible migration. Sut Pa Nu fishers fish adjacent to their village at a narrow section of the Gulf and up to the mouth of the river and they also catch other anadromous fish particularly *Polynemus paradiseus* (Paradise threadfin) during their May-June spawning migration (MacKay 2021).

Landings at Sut Pa Nu in the monsoon (May-July) period during 2016-2018 were less than 10% of the total. A major change, however, occurred in 2019 and 2020 when the landings during this period increased to 70% to 80% of the total. This pattern continued during 2021 and 22 with around 40% of the landings occurring during this period. Reports from the fish buyer

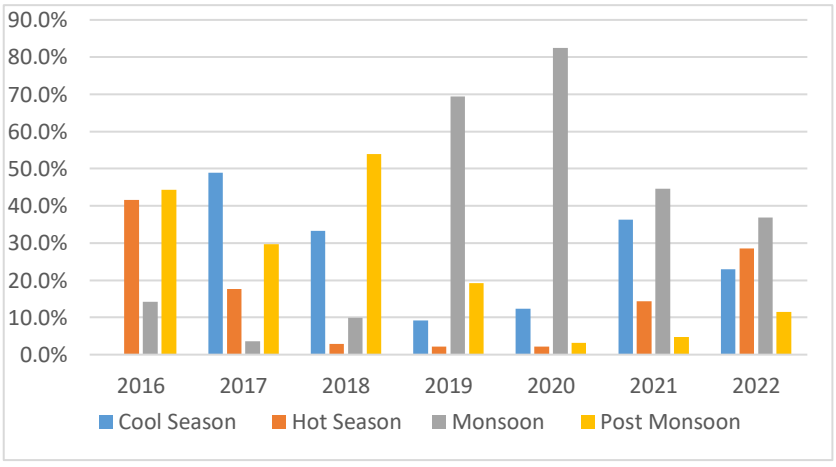

Figure 3.5: Seasonal landings of Pama Croaker at Sut Pa Nu, Kyaikto Township, Mon Sate

[6] Seasons are Cool = December-February; Hot = March-May; Monsoon= June-August; Post monsoon=September-November.

and fishers indicated that most of the females during this period had eggs. Fishers also indicated that this pattern of large catches during this season had been observed over 10 years ago. This suggests that at least from 2019-2022 spawning fish were present May-July at the mouth of the Sittaung River.

A separate survey was carried out by Mawlamyne University staff (Oo et al., 2019). They sampled for larvae and juveniles at Sut Pa Nu just below the river mouth and at Kha Wa Chaung 15 km upstream every two months from July 2018 to May 2019 (Table 3.5). The salinity ranged from 3-4 ppt in both months and temperatures were 28.5^{o} C in May and 20-21^{o} C in July

Table 3.5: Occurrence of Pama Croaker larvae and juveniles at the mouth of the Sittaung River

Location	2018			2019		
	Jul	Sept	Nov	Jan	Mar	May
Kha War Chaung	larvae/ juveniles 2.5-5.1 cm					larvae
Sut Pa Nu	larvae/ juveniles 2.5-5.1 cm	juveniles5. 1-7.6 cm	Juveniles 8.9-10.2 cm			larvae

Pama Croaker larvae were present in May and July while juveniles were present during July (2.5-5.1 cm TL). This would appear to confirm the Sut Pa Nu data that spawning occurs in May-July at the mouth of the Sittaung River Additionally larger juveniles were only found at Sut Pa Nu in September and November suggestive of a juvenile migration from the river back to the GoM.

Table 3.6: Size Distribution and % of fish with eggs at MHL Sub-station, June 2022

Size Category N=10	Average Total Length (cm)	Estimated Age	% with Eggs
1	25.6	1	20
2	29.2	2	20
3	33.3	3-4	20
4	35.0	4-5	30
5	37.2	5-6	90
6	39.7		90
7	44.1		30
8	50.4		50
Average			43.8

Additional sampling at MHL in June 2020 (Table 3.6) indicated 44% of the samples had eggs[7] including the smallest size. This agrees with data from the Hooghly-Matlah Estuary in nearby West Bengal (Bhakta et al 2021) that first spawning occurs in year 1 fish. The West Bengal data, however, suggests that Pama Croaker had three peak spawning periods (February-March, June, and September-November) whereas we have only identified one spawning season in the Sittaung River.

4. Discussion and Conclusions

4.1. Annual Catch

Seven years of data from MHL substation in Kyaikto Town show a 500% increase in Pama Croaker landings from 25 mt in 2017 to 149 mt in 2022 (Figure 3.1). Unfortunately, we do not have data on yearly variation in number of boats or number of trips that could indicate effort, nor do we have data on type of gear used. Several pieces of information, however, suggest that there has been a considerable increase in abundance of Pama Croaker in 2019-2022. The MHL sub-station manager indicated that 2019-2020 period was the highest landings in 12 years. The data from the fishery at nearby Sut Pa Nu village (Figure 3.2) shows a large increase in catch of over 4 times in 2019 and in 2020 almost 10 times the average for 2016-2018. This increase was primarily due to the large increase in catch of fish during May-July (Figure 3.5). This is further discussed below in Section 4.2.

4.2. Size Category Data

We have also established that the size classes are a useful surrogate for age especially for size 1-3. The detailed picture of the fishery (Figure 3.3) shows a peak in recruitment occurring in 2019 of Age 1 and 2 fish (sizes 1-2) probably 2017 and 2018 year cohorts. These cohorts still dominated the landings but now as Age 3 and older fish. What is also obvious is that there has been very little new recruitment of small fish in 2021 and 2022. Despite the decrease in recruitment there has been a continued increase in landed weights while the number of fish has declined (Table 3.2). This is due to the growth of the dominant 2019 cohorts rather than new recruitment. If we had only examined increase in landings, we would have assumed the fishery is in good shape, but the size category data suggests that this lack of recent recruitment is cause for concern.

The use of the size categories and price per category also allowed a detailed picture of the value of the fishery that would have been difficult to obtain using total catch and average price data. The estimated value of the catch in 2019 from only one fish buyer at one buying station of over US$700,000 indicates a substantial contribution of the Pama Croaker fishery to the local economy. The size

[7] Unfortunately, this sampling did not identify males and only indicated females with eggs.

category data and price information also allowed us to do a detailed estimation of the effect of COVID-19 on the fishery and incomes, which shows a potential 130% decrease in income due to the impact of the pandemic.

4.3. Recruitment and Management

The high recruitment in 2019, yet low recruitments in 2021 and 2022, along with the Sut Pa Nu fisher's observation of similar peaks being seen in the past suggests this fishery may not have a steady state recruitment but periodic high recruitment and subsequent dominance by the successful year class. This suggests a possible inverse relationship between the stock size and subsequent recruitment. This does make it difficult to carry out conventional fisheries analysis using the classic catch curve and von Bertalanffy growth function (Gallucci et al., 1996) that requires steady state recruitment for analysis.

It is interesting to speculate on the reason for the successful 2019 recruitment. In general, estuarine fisheries recruitment is influenced by stock size, environmental conditions (temperature and salinity) on the spawning grounds and subsequent mortality of the juveniles. We do not have long term environmental data, but we do have some information on potential threats to egg and larval survival. There is occasional sand mining in the vicinity of the spawning area that could destroy eggs and spawning habitat. There are also two fishing methods that capture juveniles. Near the spawning there are legal staked Stowe Nets targeting small shrimps that have very small mesh cod ends. They catch juvenile Hilsa and may also catch larva and juvenile Croaker. More seriously are the use of illegal small mesh nets (called Than Za Gar Pike in Burmese) (MacKay & Soe Min Oo, 2017). These nets 1.5 to 4 km in length use very small mesh (6mm; 0.24"). They are staked on the mud flats and harvested on the next low tide. There were about 40 operators mainly from Kyaikto village in 2016-2017. They catch a large number and wide range of small and juvenile fish, including Pama Croaker juveniles. This catch is used mainly for fish paste. Coordinated patrolling by government and local fishers that burned nets and fined fishers reduced the number of operators by 85% by 2020.but the illegal fishing has Increasing subsequently due to the political troubles.

All fisheries stakeholders interviewed assigned the increase in fisheries catch to the reduction in illegal fishing. While this may have played a role, an alternative suggestion is that this fishery may have recurrent periodic high recruitment events, possibly governed by environmental conditions rather than fisheries dynamics. Pama Croaker are heavily fished in the GoM yet current landing data suggests there has been a continuing increase in landing weight although the number of fish has declined and the absence of new recruits is cause for concern.

Details on the possible approach to fisheries management are outlined in Mackay et al (2022). Given the current political situation in Myanmar the most practical approach to management of the fishery

would be to decrease the fishing on the juveniles by limiting the use of the Than Za Gar Pike nets by continuing to carry out patrols working through the Township Fisheries Committees[8] and the fishing companies.

4.4. Future Use of Size Category Data

The use of size disaggregated data may have wider application and could be applied to other buying station as the eight size categories are used by other stations and individual buyers in Mon State. As an example, May Thaw Khin (Khin, 2019) in her Master's Thesis collected monthly data on size category along with lengths and weights for Pama Croaker from 3 villages in the southern GoM, in 2019. Table 4.1 compares her data to our data from MHL Kyaikto Town. In general, there is close agreement for total length with the MHL sampling slightly but not significantly larger for sizes 1-3. There are, however, differences between the weights for the two smallest categories with the Kyaikto samples being significantly heavier. Of interest is that our rough estimated weights are in close agreement with Khin's measurement except for Category 1 while the lengths are within the ranges of both the sampling locations. This suggests that the use of this approach, at other sites using only assumptions of weight for each category can yield reliable estimates.

Table 4.1: Comparison of Total Length and Weight per Size Category from 3 Villages in the Southern GoM (N=612) and Kyaikto Town, Northern GoM (N=80).

(The number in the parenthesis represents standard deviation)

Location	Size Category	1	2	3	4	5	6	7	8
Southern GoM	**Mean Weight measured (g)**	86.7 (±13.50)	157.7 (±30.16)	243.8 (±28.35)	344.6 (±39.28)	437.8 (±21.67)	535.7 (±30.47)	712 (±60.88)	831.7 (±268.21)
Kyaikto Town		129.5 (±17.55)	209.5 (±27.83)	280.5 (±16.24)	342,5 (±19.61)	460.5 (±26.61)	540.8 (±26.93)	722 (±55.49)	1029 (±134.99)
	Estimated Weight (g)	75	150	250	350	450	550	700	900
Southern GoM	**Mean Total Length**	24.6 (±2.32)	28.4 (±2.51)	32.1 (±2.03)	36.3 (±2.44)	38.2 (±3.57)	42.7 (±1.21)	44.8 (±3.24)	46.8 (±6.34)

[8] The GoMP has assisted in the establishment of Village and Township Fisheries Development Associations that have a mandate to assist with sustainable fisheries management.

Kyaikto Town	**measured (cm)**	25.6 (±1.21)	29.2 (±1.32)	33.3 (±1.23)	35.0 (±0.88)	37.5 (±1.06)	39.7 (±1.4)	44.1 (±1.68)	50.4 (±2.09)
	Estimated Total Length (cm)	22.0	27.4	32.1	35.6	38.5	41.0	44.2	50.4

As such we suggest that the use of this size category data could have much wider use in tracking the status of the Pama Croaker fishery. Given the current weakness of the Department of Fisheries in fisheries management it is difficult to foresee their application of this approach. It could, however, be applied by individual companies, village and township fisheries committees to track the status of the fishery and possibly implement management measures. This approach may also be applicable to other species such as mud crab (*Scylla olivacea)*, and Hilsa (*Tenualosa ilisha*) as buyers separate the landings by size and have different pricing for each size categories. Although care needs to be applied as different buyers often use different size categories. For example, the mud carb buyers in the GoM use at least four different size categories (Imbach, 2022).

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