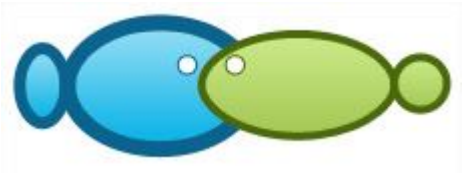

Status and trends in coastal fishery resources of Sarawak, Malaysia – a focus on a tropical deltaic estuary

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Abstract. The sustainable use of fisheries resources is a major concern for coastal resource management. Malaysia is endowed with vast coastal fisheries resources which contribute about 1% to national GDP. Sarawak is the major state of Malaysia having high potentials for coastal fisheries. This study was conducted from December 2018 to May 2019 to inquire the status of the coastal fisheries and to identify gaps for further research and measures for sustainable fisheries. The study was undertaken through desk-based review and analysis of secondary data along with a focus on the primary fish landing data collected directly from fishers' catches and *Gnian* (type of Estuarine Set Bag Net-ESBN) fish sampling. FAO production data (1950-2011) for fishing zone 71 (data of Sarawak-Sabah fishing zone) showed a sharp incremental trend (70100 to 682004 MT; R = 0.992). According to DoF data from 2000 to 2016, the Sarawak fishery was mainly contributed by coastal catches which is about 70% of the total catch, and a clear monthly fluctuation was observed in fish catches from Sarawak coast. In the same dataset (DoF 2000-2016), there was constant landing from March to August whereas declining trends from September to February. Data from case study site (*Daro*) exhibited 40.9 MT catch in 2018 and varied every month from the lowest 3004 kg (November) to the highest 3693 kg (March). Fishing efforts in terms of fishermen, vessels and gears were steadily increased over the period of year 2000 until 2016. The main contributing species/groups by weight were prawn and shrimp (39%) followed by Bornean grenadier anchovy (15%), and eeltail catfish, crabs and Gangetic anchovy (4%). There were 78 contributing species/group/guilds including fresh water, estuarine and coastal fishes showed in historic database of *Daro* via the catch assessment forms. However, there were only 34 species found to be contributing to catch during 2018. Out of 34 species, 23 were found contributing regularly (12 months) whereas the other 11 species were found contributing seasonally to catch. The study during surveys in *Daro* in April 2019 discovered 27 species. The ecological variation in seasonal pattern might be the driving factor for these species contributing variation to catch.

Key Words: coastal fisheries, catch and effort trends, species shiftiness, ecological drivers, East Malaysia.

Introduction. Over-exploitation of coastal water fisheries has become a challenging issue for its sustainable management around the world. Overfishing may result in the extinction of fish, particularly for the threatened and endangered species and create pressure on resources depletion (FAO 2020). According to Worm et al (2006), 29% of fish and seafood species have collapsed or are expected to collapse before 2048 unless immediate action is taken. Overfishing has a negative impact not only on open ocean or pelagic ecosystems, but also on coastal and intertidal zones (Thompson et al 2002). Global trend of overfishing is shown in Figure 1 (FAO 2020).

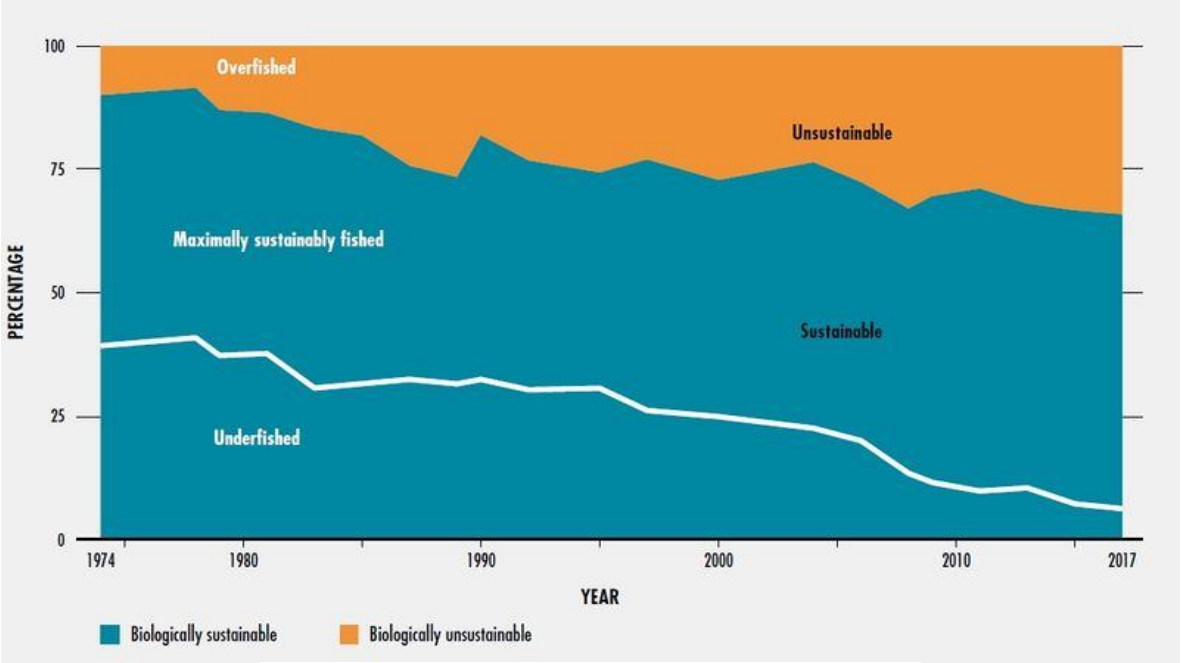


Figure 1. Global trend of overfishing (FAO 2020).

Coastal and marine fisheries are key resources that contribute to the long-term prosperity and sustainability of coastal communities' food security, economics, and overall well-being (FAO 2011). Coastal and marine fisheries contribute to the economy in different ways, from capturing fish to the provision of support services for the fishing industry (Teh & Sumaila 2013). The contribution of fisheries and aquaculture to food security and nutrition is driven by many issues such as environment, development, policy, and governance. FAO (2012) reported that capture fisheries and aquaculture provide 3 billion people with almost 20% of their average per capita intake of animal protein and provide 1.3 billion more people with about 15% of their per capita intake. It is estimated that globally more than 120 million people of whom a majority are from developing and emerging countries depend directly on fisheries-related activities, i.e., fishing, processing, trading (FAO 2012). Small-scale fisheries as compared to larger scale fisheries account for 90% of fisher folk (FAO 2020) and overshadowed in fisheries science and policy by the concerns and perceived importance of the industrial sector (Smith & Basurto 2019). The combination of urbanization, rising levels of development, living standards and income as well as world population expansion are the key factors for growing fish and seafood demand and fisheries development (FAO 2020).

The South China Sea (SCS) large marine ecosystem (LME) contains significant biodiversity and habitats with vital impact on the global marine fisheries (Teh et al 2019). Sarawak lying within the Indo-Malay-Philippine archipelago with around 1035 km long coastline is one of the mega-diversity regions of the world (Long 2014).

Climate change impacts are already visible with modifications of the geographic distribution of species and warmer water species moving towards the poles, ocean acidification and changes in coastal conditions affecting habitats. This has various impacts on open water fisheries production (Barange et al 2018).

Malaysia is endowed with vast coastal fishery resources. The fishing sector in Malaysia remained almost steady in the last five years which contributes 1.0 to 0.9% during 2015 to 2019 to national gross domestic product (GDP) (Hirschmann 2020) and 12% in agricultural GDP (DoSM 2020). Like other developing countries, Malaysia is one of the high fish consuming countries (Teh 2012). National per capita fish consumption rate was 20 kg in 1970 (Teh 2012), 52.1 kg in 2005 (FAO 2019) that increased to 54 kg in 2010 (Teh 2012) which is further increased by 56.8 kg (SEAFDEC 2017). Malaysian fisheries are exclusively dominated by capture fisheries production where coastal and marine sector productions are the main shared sectors (FAO 2020).

Sarawak is the major state in Malaysia having high potential coastal resources. The state is situated in northern Borneo Island of East Malaysia endowed with South China Sea. Tropical coastal and estuarine ecosystems are playing a vital role for fishery resources regeneration process. Fish production most of which was contributed by coastal and marine capture fisheries in Malaysia increased steadily at 4.5% per annum (Ahmad et al 2003). Marine fisheries significantly contributed to employment in Peninsular Malaysia in comparison to Sabah and Sarawak (Ahmad et al 2003). Nonetheless, research studies, statistical records and proper management are either scanty or unseen in Sarawak.

Coastal ecosystems particularly the estuaries of tropical regions are considered as primary nursery grounds for many aquatic species (Jaureguizar et al 2004; Dolbeth et al 2010; Sreekanth et al 2015). World conservation strategy sets the goals to achieve three strategies, i.e., maintaining ecological process and life support systems, preservation of genetic diversity and assuring sustainable utilization of species and ecosystems (Salm & Clark 1984). Governance is particularly important to determine access to fisheries resources, integrity of fisheries resources and distribution of fish benefits. For a better governance and management of coastal fishery resources, status and trends of production, efforts and species contribution are primarily important elements. Considering these issues, current study was undertaken along with the purpose of identifying gaps for further research. This study was designed to investigate the status of the coastal fisheries in Sarawak focusing on Batang Lassa estuary, Northern Borneo Island in the South China Sea. The specific objectives were to assess the status and trends of fish production, fishing efforts, species/group shiftiness in catch and to investigate the nexus among production-efforts-fish diversity over the decades. The outcome of the existing status and historical trends of fishery resources would be helpful to identify the gaps of information for future research and management aspects of the case study area in particular and for the nation in general for resilient fisheries.

Material and Method. Present study was conducted from December 2018 to May 2019. The study was undertaken through review and analysis of the available secondary data and information for Sarawak as well as for Malaysia. Focus supported by retrieving real time information from field visits was given on the primary fish landing data to collect additional subjective and possible quantitative data. Primary data were collected from catches of fishermen and key informants, e.g., landing centre supervisors, officials, and old fishermen.

Geographical location of the study area. The study mainly focused on Sarawak coastal fisheries by comparing with overall status in Malaysia. Sarawak is the major province of East Malaysia having high potential coastal resources. Dataset of FAO was collected for the FAO fishing zone 71 (Pacific-western-central region). According to the LME category, the area falls under LME 36 (South China Sea) which is an exclusive economic zone (EEZ) of East Malaysia. Finally, the study was pointed in Daro estuarine zone, Sarawak, Malaysia as a case study area for primary sampling and data collection. The glimpses of areal focus for the present study are given in Table 1 and Figure 2.

Table 1

Overall geographical locations of pointing present study area

Fishing zones	*Area coverage*
FAO major fishing area	71: Pacific – Western-Central (Sabah-Sarawak segment)
Large marine ecosystem (LME)	LME 36 – South China Sea
EEZ Focus	EEZ of East Malaysia
Focus/case study	Batang Lassa estuarine, Daro, Sarawak, Malaysia (Sarawak fishing district no. 09)

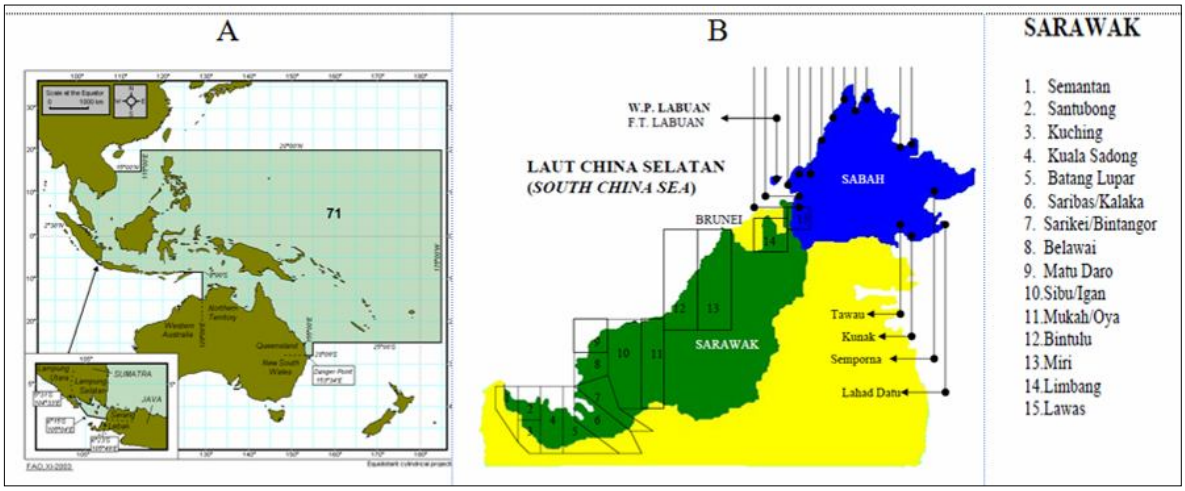


Figure 2. (A) FAO fishing zone 71 (Sabah-Sarawak coastal fishing territory), and (B). Sarawak fisheries districts (Source: FAO (2011) and DoF (2019)). Sarawak is divided into 15 fisheries districts and the case study site is located in district 9.

Secondary data collection. Secondary data were collected from FAO data bank for Sabah-Sarawak coastal fishing area (FAO fishing zone-71). Temporal scale of FAO data was from year 1950 to 2011. Data from the Department of Fishery (DoF 2019) of the Govt. of Malaysia were collected for 17 years (2000-2016). The nature of data was mainly catch (production) of fish and shrimp by species/group and other efforts like crafts, gears, fishermen etc.

Primary data collection. Primary data were collected in two ways. i.e., (i) one year monthly fish landings data in the year of 2018 from Daro fisheries office, and (ii) sampling catch during February and April 2019 from Batang Lassa Estuary, Daro using a type of Estuarine Set Bag Net (ESBN) and a local gear called '*Gnian*'.

Analysis. The analyses were focused on overall production trends over the decades, species shiftiness in production composition, and trends of fishing efforts in terms of fishermen, gears, and crafts.

Results

Production trends. Production of Sabah-Sarawak fishery (FAO fishing zone-71) sharply increased from 70,100 MT to 682,004 MT (R = 0.992) during 1950 to 2011. Figures 3 and 4 show the trends of fish capture over the six decades. Figure 5 shows that the Sarawak fishery was mainly contributed by coastal catches (70,000 to 110,000 MT).

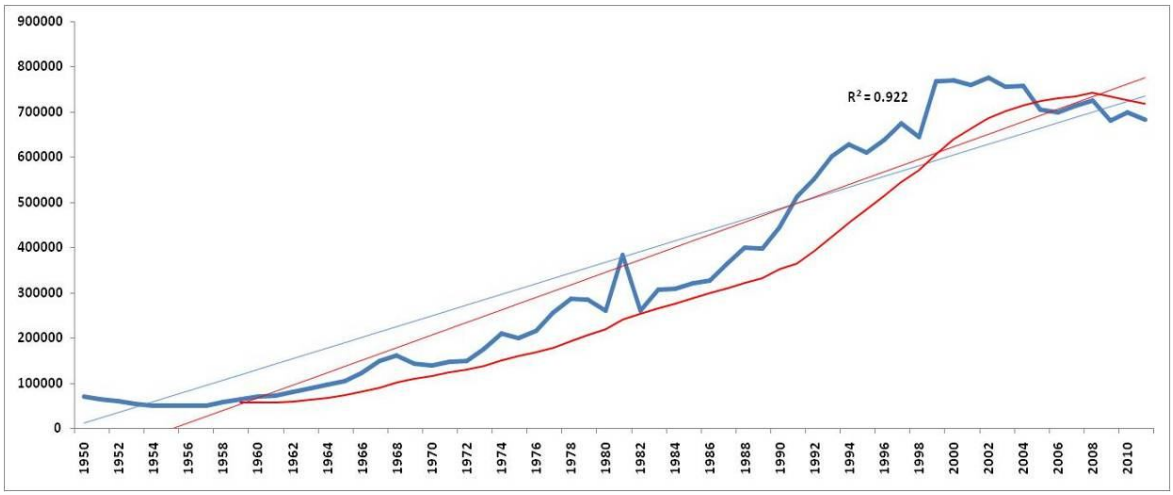


Figure 3. Production (MT) trends from 1950 to 2010. Blue line showed the original data trends while red line showed the 10-years moving average (based on FAO 71 fishing area data).

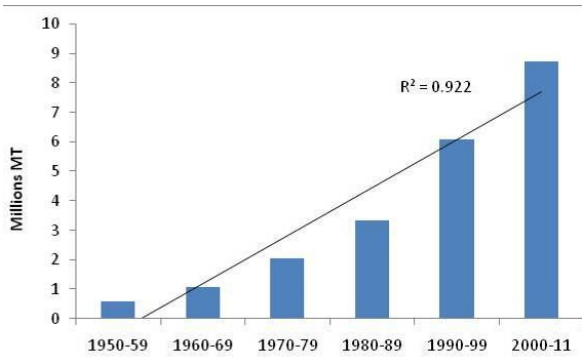


Figure 4. Decadal production trends based on FAO fishing area 71 data (1950-2010).

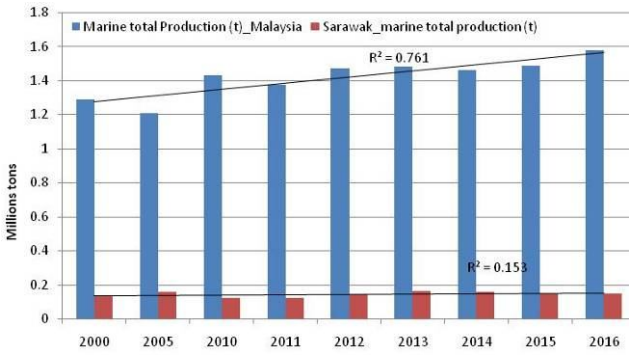


Figure 5. Comparison of Malaysian National vs Sarawak production (analysis based on DoF data).

DoF (2019) data analysis showed about 80% of total fisheries production in Malaysia was contributed by marine landing of which around 70-80% were comprised with coastal catches and the rest 20-30% were shared by deep sea catches. The total marine landing showed incremental trends (1.29 to 1.57 million MT) over the period of 16 years (2000–2016). In the case of Sarawak, the production trend was slightly incremental (0.134 to 0.148 million MT) for the same period of analysis because of the decremented trend in deep sea landing of Sarawak (0.05 to 0.036 million MT) (Figure 6).

A distinct monthly fluctuation was found in fish catches from Sarawak coast. There was a steady landing from March to August whereas declining trends from September to February. Data from case study area (*Daro*) exhibited 40.9 MT catch in 2018 and varied every month from the lowest 3,004 kg in November to the highest 3,693 kg in March (Figure 7).

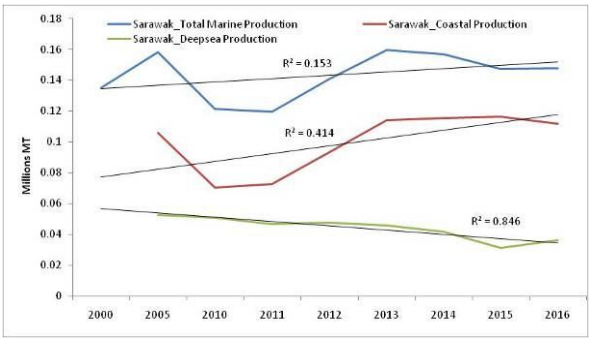


Figure 6. Trends of Sarawak Total, Coastal and Deep sea production

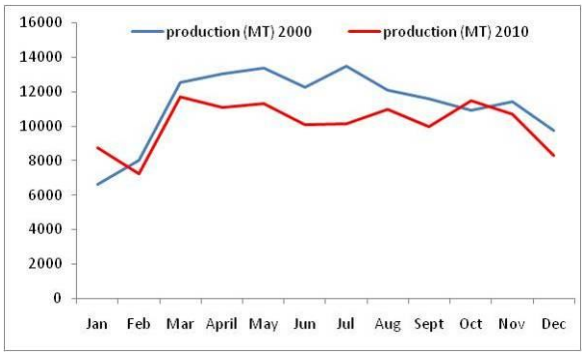
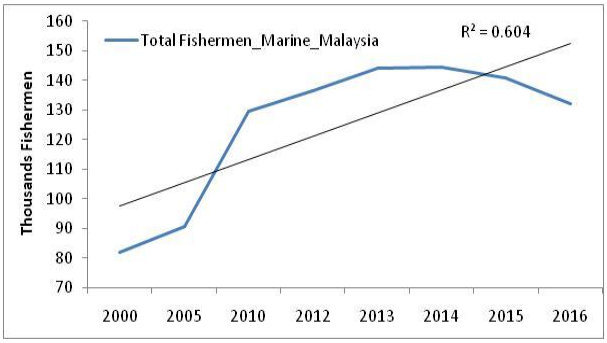


Figure 7. Trends for a decade of monthly fluctuation pattern of Sarawak coastal fishery catch between year 2000 and 2010.

Trends of fishing efforts. Fishing efforts in terms of fishermen, vessels and gears increased steadily between 2000 and 2016. Engagement trends of fishermen in coastal fishing both in the national scale and in Sarawak are shown in Figure 8. A total of 47 fishermen (units) were engaged across the year 2018 against this catch. Fishing efforts in terms of fishermen, vessels and gears increased steadily for 17 years (2000-2016). Numbers of fishermen increased from 81,994 to 132,305 in Malaysian marine landing and 9,406 to 16,905 in Sarawak. Fishing vessels trends doubled (31,531 to 53,190) in Malaysian marine catch whereas it tripled (2,348 to 7,285) in Sarawak. Whereas fishing gears in marine catch doubled (24,722 to 48,645) in Malaysia. Comparative trend status of fishing gears and vessels are shown in Figure 9 and 10. Unparallel trends were clearly observed during 2000-2016 between national and provincial status in terms of catch (production) and fishing efforts (fisher, crafts and gears), and within the production and efforts (Table 2).



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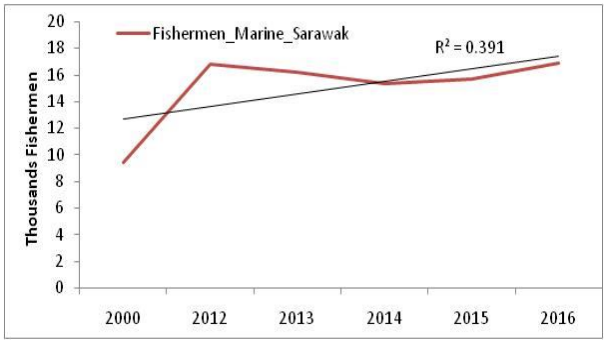

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Figure 8. (a) National (Malaysia) and (b) Sarawak trends of number of fishermen over the period 2000-2016 (based on DoF (2019) data).

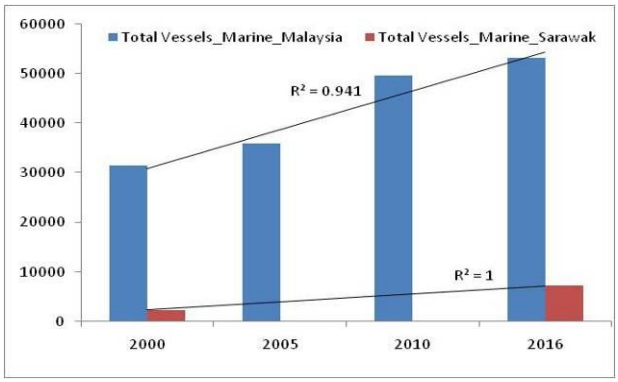

Figure 9. Comprative status of fishing vessels over the period of 2000-2016 in Malaysia and Sarawak.

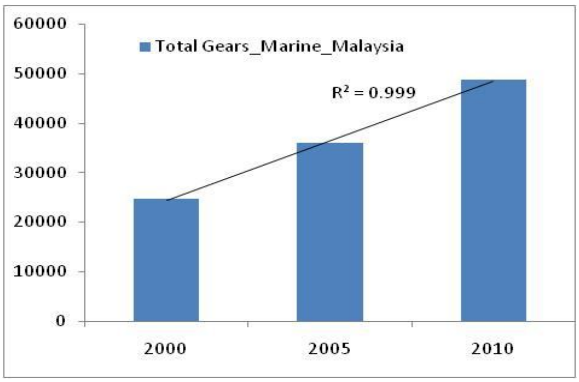

Figure 10. Trend of fishing gears over 2000-2016 in Malaysia coastal fishery.

Table 2

Comparison among the fishery components during 2000-2016 at national and provincial level

Fishery components	*Malaysian coastal fishery*		*Sarawak coastal fishery*	
	2000	*2001*	*2000*	*2001*
Catch/production (mMT*)	1.29	1.57	0.134	0.148
Fisher persons (no)	82,000	132,000	9,500	17,000
Vessels (no)	31,500	53,000	2,348	7,285
Gears (no)	24,722	48,648	-	-

*mMT = million metrics tones.

Species composition and shiftiness in historical changes. Analyses based on FAO capture production data for fishing zone 71 (Pacific western central) for Malaysia (Sarawak-Sabah) showed that there are around 86 groups/species/guilds contributing to the production over the 60 years. Of them, 9 groups/species showed declining production trends to zero whereas 12 groups/species showed newly entering in catch during the year 2000 to 2011 (Table 3). At least two non-traditional groups/species entered in the catch since the year 1980. According to the primary data-based output, the main contributing species/groups by weight were prawn/shrimp (39%) followed by Bornean Grenadier Anchovy (*Coilia borneensis*) (15%), and eeltail catfish (Plotosidae family), crabs and Gangetic anchovy (*Setipinna phassa*) (4%). There were 78 contributing groups/guilds/species shown in the historic database of *Daro* in the catch assessment system tool. However, there were only 34 species found to be contributing to catch during the year 2018. Out of 34 species, 23 were found contributing regularly (12 months) whereas the other 11 species contributed seasonally to catch. We have also found 27 species in the sample survey in *Daro* estuary during April 2019 (Table 4). Table 5 shows the key commercial species and over taxa status of the study location whereas Figure 11 displays the species shiftiness in production contribution from 1950 to 2010.

Table 3

Sixty years changes pattern of species/group in catch composition of Sarawak coastal fishery resources (Based on FAO 1950-2011)

Species/groups	*1950-59*	*1960-69*	*1970-79*	*1980-89*	*1990-99*	*2000-11*
Auxis thazard, *A. rochei*	0	0	0	0	0	6883
Crustacea	4600	25400	60300	81506	0	0
Engraulidae	0	300	2810	3932	0	0
Gerres spp.	0	0	0	0	0	4571
Holothuroidea	0	1000	1200	4972	0	0
Katsuwonus pelamis	0	0	0	0	0	16127
Lethrinidae	0	0	0	261	0	4245
Mollusca	2700	4100	6479	4385	0	0
Octopodidae	0	0	0	1391	3773	11113
Panulirus spp.	0	0	0	3970	9016	15203
Perciformes	13500	22900	44744	69986	0	0
Perciformes	20000	27500	51887	69205	0	0
Percoidei	0	100	703	1685	431	0
Platycephalidae	0	0	0	0	0	35
Priacanthus spp.	0	0	0	0	0	64565
Scombridae	21500	17400	38255	47760	0	0
Scombroidei	0	3500	9318	19768	0	45
Selar crumenophthalmus	0	0	0	0	0	157513
Thunnus albacares	0	0	0	0	0	3638
Thunnus obesus	0	0	0	0	0	1442
Thunnus tonggol	0	0	0	0	0	187258
Tylosurus spp	0	0	0	0	0	36
Xiphias gladius	0	0	0	0	0	1175

Legend: Non-traditional entry | Declined | New entry

Table 4

Comparative status of fish taxa in case study area, Rajang River and overall Malaysia

Level	*No. of species recorded*	*Sources*
Overall Malaysia (marine and estuarine species)	1951	Chong et al (2010)
Rajang River	164 (12 spp (7.3%) are euryhaline/ brackish water)	Parenti & Lim (2005)
Daro District	78	DoF, Daro office database (2019)
Study site (Daro coastal area)	34	Present study (one-year monthly data from fishers' catch for 2018)
Sampling site (Daro/ Batang Lassa estuary)	27	Present study (ESBN sampling February and April 2019)

Table 5

Key commercial fish species stocks in Sarawak coastal area of Malaysia

Major exploited fish species	*Major exploited crustacean species*	*Non-conventional resources*
Coilia spp.	*Penaeus monodon*	*Sepia offininalis*
Satiphina spp.	*Macrobrachium* spp.	*Loligo* spp.
Pampus argenteus	*Penaeus japonicus*	*Octopus* sp.
Pampus chinensis	*Penaeus indicus*	*Scoliodon walbeehmii*
Lutjanus spp.	*Penaeus merguiensis*	*Scoliodon sorrakowah*
Polynemus spp.	*Metapenaeus monoceros*	*Carcharhinus borneensis*
Lepturacanthus savala	*Acetes*	
Arius spp.	*Scylla serrata*	
Johnius spp.		
Otolithoides argenteus		

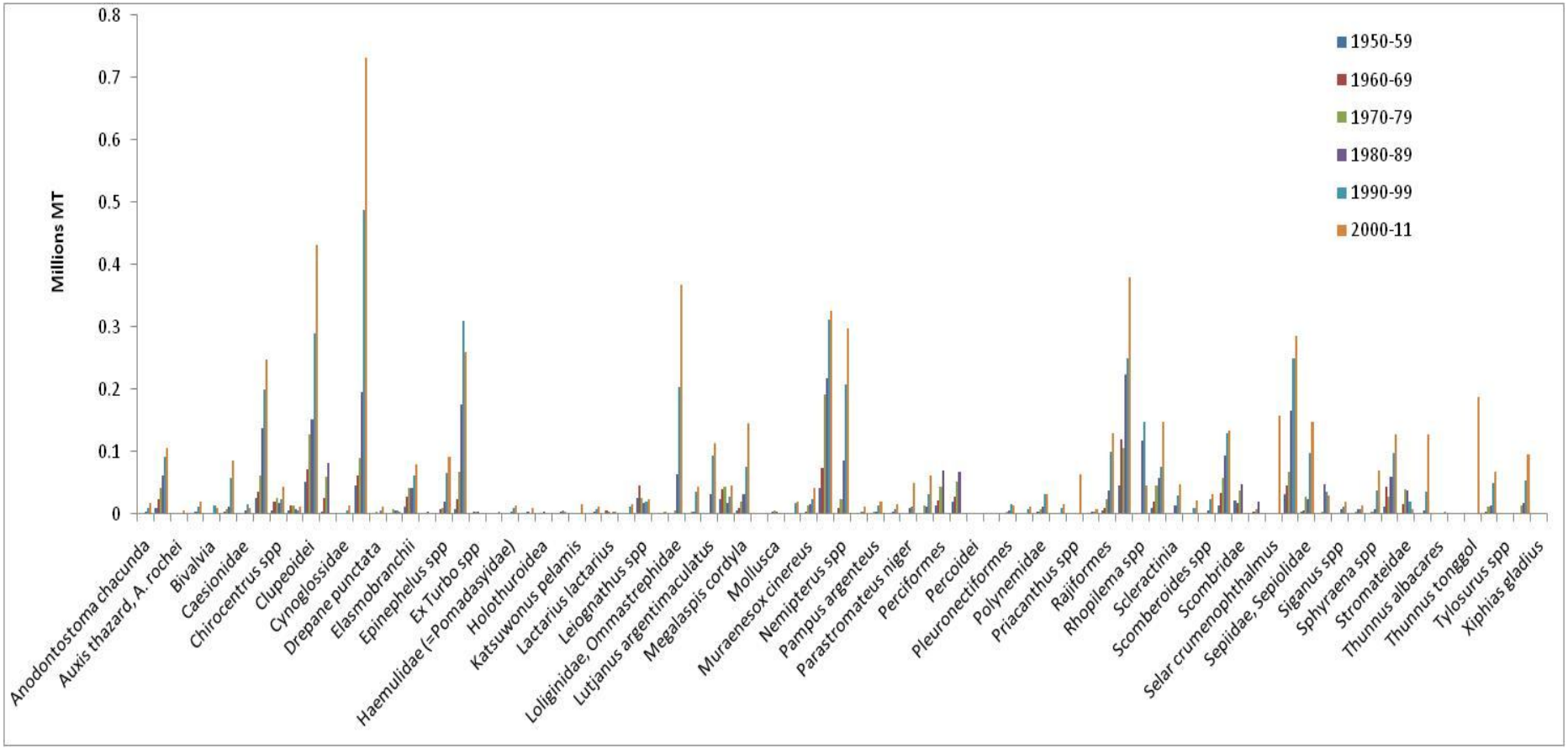

Figure 11. Species shifting decadal based on FAO fishing zone 71 data (1950-2010).

Discussion

Production trends. Production trends of Malaysian and Sarawak fishery were shown sharply increased (R = 0.992) in both FAO data from 1950 to 2011 and DoF (2019) data from 2000 to 2016. It is supported by a study that fishery is an emerging sector with the highest growth rate and a major part of economy in many developing countries (Ahmed et al 1999). This result is also in line with the global fisheries production trends that have been increasing since records commenced, except during the two World Wars (Garcia & Rosenberg 2010). Results of this study showed that Sarawak fishery is mainly contributed by coastal catches which followed the national trends of Malaysia where about 80% of total fisheries production was contributed by marine landing. Around 70-80% out of 80% total Malaysian fisheries production were comprised with coastal catches and the rest of 20-30% were shared by deep sea catches. According to FAO (2019), Malaysian fisheries are exclusively dominated by capture fisheries production where coastal and marine sector productions are the main contributing sectors. It is also supported by a study that interpreted that fish production in Malaysia increased steadily at 4.5% per annum (Ahmad et al 2003) where most of the production was contributed by coastal and marine capture fisheries. It is assumed that the trends affect developing countries more than the developed world (Pauly et al 2005).

Monthly fluctuation was observed in the present study of fish catches from Sarawak coast. There was steady landing from March to August whereas declining trends from September to February. This catch fluctuation might have been influenced by seasonal variation of the coastal ecosystem. Seasonal variation of ecological variables particularly salinity and temperature (Sreekanth et al 2017) would have a great impact on fish abundance and hence, on total catch. According to local fishermen and fisheries officials, extreme weather conditions like storm and wave rolling could cause limitation in fishing activities on a local scale. In contrast, some fleets' catches, and values were reported to fall due to the overall biomass decline in the ecosystem (Teh et al 2019).

Trends of fishing efforts. Several factors, such as fishing efforts, fishing methods, fishing equipment, fisher's behavior, management and economic factors, can influence the stability of the catch per unit effort (CPUE) when preparing a fish stock management (Polacheck et al 1993; Maunder & Punt 2004). Based on the national database of DoF (2019), it indicated that fishing efforts in terms of number of fishermen, vessels and gears increased between 2000 and 2016. An unparalleled trend was observed between national and provincial status in terms of catch (production) and fishing efforts (fishers, crafts and gears), and within the production and efforts during this period. Contribution is increasing with time in national and provincial scale, though the rate of trends in Sarawak is much lower than the national figure of Malaysia. There is an unparalleled nature existing in terms of number of fishermen as well.

Although this study did not deeply examine about fisheries management practices, the policies and acts at state and national level, there could be some reasons that contribute to the different nature between state and national level. Though the number of fishermen increased, fishing hours, demands of fishers livelihoods, involvement of fishers in other income generating activities (IGA) might be different in Sarawak compared to national level.

Species composition and shiftiness in historical changes. Over the 60 years of FAO data observation, 9 groups/species among 86 groups indicated declining trends close to zero. Due to high demand and commercial values some species and weak law enforcement are the reasons for overfishing of specific species (Khatib 2015). The destruction of fish habitats and climate change issues could also be the reasons for overfishing in a specific area. On the other hand, 12 groups/species were found entering newly in catch during the last decade. It was observed that two non-traditional group/species were found in the catch during this time frame as well. Moreover, because of the existing situation of food habits and globalization effects, non-traditional seafood like squids, octopuses and many mollusks, sharks etc. are getting preference in both

local and global scale. Hence, fishermen are coming with new gears and efficient technologies to catch newer species as well as to collect more revenues. This shiftiness of global trends might have the reflection on fish production, consumption and trading behaviors (Ahmed & Delgado 2000).

Our primary data in the case study site of Daro, Sarawak exhibited prawn and shrimps were the major contributing groups while other significant groups are anchovies, catfishes and crabs. There are 78 contributing groups/guilds/species found in the database of catch assessment in the locality across the year. We found 23 species were regularly contributing (12 months) whereas the other 11 species contributed seasonally in catch of our samples of April 2019. It is partially supported by a large-scale simplification and concentration of its catches and revenues into two functional groups: crabs and shrimps (Teh et al 2019). Vidthayanon (1999) reported a total of 518 species from 24 orders and 111 families through research cruise and market surveys from various coastal towns in Sarawak.

Way forward. When fisheries management is based only on official data that are highly aggregated, alarming trends at low aggregation levels cannot be effectively addressed by assigning regulations to problem areas only and regional restrictions will affect fishers in healthy fisheries unnecessarily (Pet-Soede et al 1999). Ecosystem approach in the development of conservative species management could be more effective than traditional approach. Implementation of marine protected areas along with sufficient institutional capacity would add more efficiency to that management approach. Apart from these, reduction of fishing capacity, using eco-friendly technology and socioeconomic incentives towards fishermen would certainly facilitate success. Finally, a continuous process of combined management should be maintained for information about ecosystems and long-term databases. Kyvelou & Ierapetritis (2020) observed a strong correlation between artisanal fisheries, tourism, and environmental protection. Implementation of marine protected areas resulting manifolds may help achieve sustainable development goals (SDGs), especially SDG1 (no poverty) and SDG14 (conservation and sustainable use of the ocean, seas and marine resources) (UNSDGs 2015; Papadakis & Kyvelou 2017).

Conclusions. The aim of this study was to provide some insights on the status and trend in catch, effort and species fluctuations. Majority of the catch was contributed by coastal resources in comparison to deep sea. There is an unparalleled nature found in production trends between national and provincial (Sarawak) production over the decades. A new management system is required for sustainable exploitation of coastal fishery resources in Sarawak. The change in species/fish guilds over the time is occurring due to demand of local consumers and export markets and technological fishing efficiencies. The ecological variation in seasonal pattern might be the driving factors for these species contributing variation to catch. Continuous increment of all fishing efforts needs to be properly checked to control overfishing and progress towards halting the current decline in fish stocks. Actions should be taken to redevelop resource assessment tools and governance concepts suitable for increasing the contribution of fish to food security and nutrition by developing new approaches for the multispecies, multi-gear fisheries and more adapted to the specific characteristics of small-scale fisheries. Finally, it could be helpful to achieve SDG1 that focuses on food security and SDG14 that leads to conserving and sustainable use of the oceans, seas and marine resources for an ultimate sustainable development.

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