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Submission date: 11-Jun-2020 09:57AM (UTC+0700)

Submission ID: 1341660639

File name: al_of_Sustainable_Fishery_Resources_at_Giam_Siak_Kecil-Bukit.pdf (1.6M)

Word count: 9716

Character count: 49937

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To cite this article: Prima Wahyu Titisari *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **298** 012025

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Potential of Sustainable Fishery Resources at Giam Siak Kecil-Bukit Batu Biosphere Reserve, Riau Province, Indonesia

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Abstract. Fisheries are fundamental part of human activities. Sustainable fishing is an important aspect in maintaining the fishery resources for the future generation. The main objective of this study is to estimate the maximum sustainable yield (MSY) of the fishing grounds for the sustainable harvesting. This study deploy the approximate estimation of abundance (biomass) and potential estimation of a type or group of fish species based on the analysis of production surplus to determine the sustainability of maximum catch rate. Results of the research identified about 35 species from the 17 families of fish. Based on the MSY calculation using the Schaefer method with a long line standard, the fish utilization status is in overfishing condition status at all sampling points, with the value above 98% above the standard capture limit of 70%. The results of the Schaefer model provide the baseline information on MYS for the freshwaters fish, which could be used as the basis for future fishery assessment and management of this biosphere reserve.

1. Introduction

The Giam Siak Kecil-Bukit Batu Biosphere Reserve (GSKBB-BR) is a combination of peat-swamp forest ecosystems, production forests and aquatic ecosystems located in Bengkalis and Siak districts in Riau Province. The core area covers 178,722 ha formed by two Wildlife Sanctuaries namely Bukit Batu Wildlife Sanctuary and Giam Siak Kecil Wildlife Reserve, with a buffer zone of 222,426 ha and a transitional area of 304,123 ha. GSKBB-BR is one of the eleven Biosphere Reserves in Indonesia, designated for the World Biosphere Reserve network on May 26, 2009 at the 21st session of the International Coordinating Council of the Man and the Biosphere Program (MABICC) -UNESCO in Jeju, South Korea. As the only private Biosphere Reserve in Indonesia, GSKBB-BR is owned by , the Asian Pulp & Paper (APP) with Sinar Mas Forestry (SMF) and its business partners/ stakeholders. Among the stakeholder involves are the Center for Resource Conservation Nature (BBKSDA) Riau, and Indonesian Institute of Sciences (LIPI). The area functions as a biodiversity bank, water reserves,



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mitigation efforts on climate change, and most importantly income generation for local people, private sector, and local government [1,2]. According to the MAB program (2008) GSKBB-BR is a protected area based on zoning consisting of core area, buffer zone and transition area.

One of the community activities that are perceived to threaten the core area of GSKBB-BR is the opening of palm oil plantations [3]. The land clearing area in Giam Siak Kecil Wildlife Reserve was identified in the core area reaches 6,788 ha [4]. A decrease in the area of secondary swamp forest in BC GSK from 60,051.27 ha to 51,167.41 ha was identified during the period 2010-2014 [5]. In contrary, the area of monoculture garden, which is dominated by oil palm (*Elaeis guineensis* Jacq.) and rubber (*Hevea brasiliensis* Muel Arg.) are increased from 667.76 ha to 1,198.73 ha and mixed plantation increased from 3,674.48 ha to 6,580.02 ha. This phenomenon continues and triggers the occurrence of large land and forest fires in the upstream of the small Siak River in Bukit Kerikil and Tasik Serai areas in 2014. In addition, the communities have also found to fish in hereditary rivers and tasik (lake) in the core area of CB GSK-BB [5]. Frequent and excessive fishing uncovered through the arrests are suspected to be the cause of declining fish populations thus threatening the sustainability of the fish resources.

2. Method

The research was conducted in July 2017 at GSKBB-BR located in Bengkalis Regency, Siak Regency, and Dumai City, Riau Province. Determination of research location divided by two groups based on access to the utilization of biological resources of GSKBB-BR that is core area and buffer zone. Sampling points in the core area include: (1) Tasik Betung, (2) Tasik Serai, (3) Tasik Serai Timur, (4) Tasik Tebing Serai, dan (5) Tasik Serai Barat. The sampling point in the buffer zone is (1) Bukit Kerikil, (2) Muara Kelantan, (3) Sungai Selodang, (4) Olak, and (5) Muara Bungkal (see Figure 1).

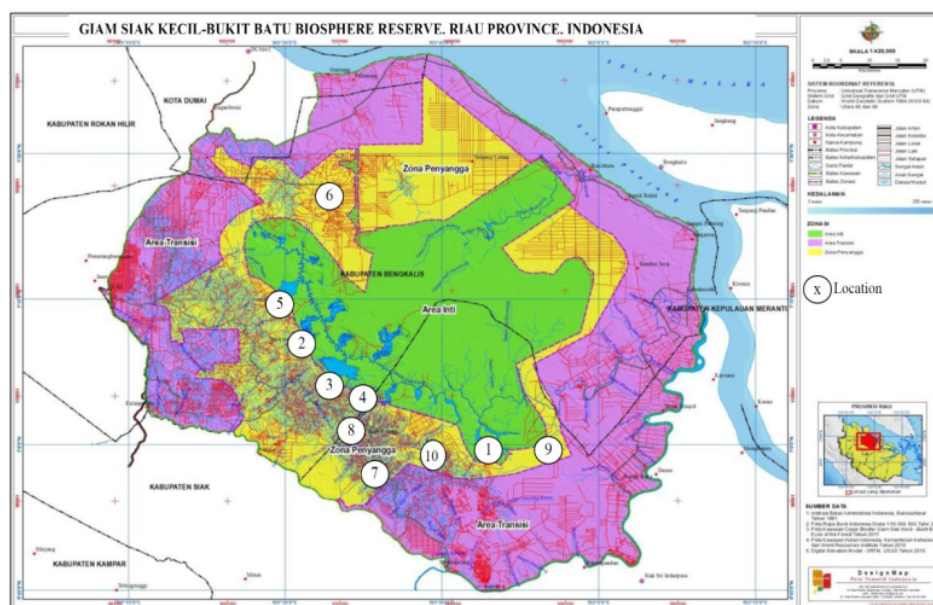


Fig.1. Location: Core zona: 1. Tasik Betung, 2. Tasik Serai, 3. Tasik Serai Timur, 4. Tasik Tebing Serai, and 5. Tasik Serai Barat; Buffer area: 6. Bukit Kerikil, 7. Muara Kelantan, 8. Sungai Selodang, 9. Olak, and 10. Muara Bungkal. (Source: National Committee of MAB Indonesia 2008; Directorate General of Forestry Planning and Environmental Management KLHK, 2015; Compilation of Thematic Map of Indonesia, 2015)

The observation included fishing in Siak Kecil River, Bukit Batu River, Tasik Betung, and Tasik Serai, Tasik Serai Timur, Bukit Kerikil, Muara Bungkal and Muara Kelantan and observing the daily

life of fishermen by living in representative fishermen's settlements in Bagan Benio in Tasik Serai, Kuala Tasik Ketialau in Tasik Serai Timur and Kuala Tasik Membalau in Tasik Betung. In-depth interviews were conducted with the fishermen and community leaders in relation to their fishing activities and intensities of catchment, catchment area and the local institutions co-utilize the water resources. Fishermen were asked to classify the frequency of species catching species into three categories, i.e. small, medium, and large.

Furthermore, the observations and verification through in-depth interviews were conducted to record the number and distribution of fishermen. The fishermen informants are domiciled in Tasik Betung, Tasik Serai, Tasik Serai Timur, Tebing Serai, Bukit Kerikil, Muara Bungkal and Muara Kelantan, while the fishkeys are found at the fishing grounds, when they buy / collect fish in Pinggir, Perawang, Kota Bengkalis, Duri City and Siak City of Sri Indrapura. The observation were also supported by the comprehensive literature study by tracking the reports of previous research results in GSKBB-BR and other relevant documents. The data tabulation conducted describe the number and distribution of fishermen, fish species, catching intensity as well as various permanent fishing gear used by fishermen.

Fish samples obtained from fishermen were documented in photographs and information given was recorded. The fish identification method adopt the method applied by several studies [6-12]. From the review of the methodology, data collected in this research include: i. the Aspects of fishing techniques such as (a) the size and number of units of transportation/sampan/pompong/seggol; (b) equipment and methods of operation of fishing units; (c) location of fishing unit operation; (d) fishing season; (e) the composition of the catch; and (f) catches per trip, per month and per year; ii. the economic aspects which covers (a) the selling price of fish by fishermen; and (b) investment of fishing units; (c) operational costs; and (d) marketing; iii. Unit and frequency of arrest are (a) Number of fishing units operating in each of the last 5 - 10 years; (b) Number of fishing trips.

The production surplus analysis was used to determine the maximum sustainable yield (MSY), which is the attempt to produce a maximum sustainable catch without affecting long-term stock productivity [13]. From this model, estimates of the amount of abundance (biomass) and potential estimation of a type or group of species (species group) of fish resources can be obtained [14]. The production surplus model is a very simple and low cost model [14]. This model is said to be simple because very little data is needed [15]. This is one of the reasons why the production surplus model is widely used in estimating fish stocks in tropical waters.

The production surplus model can be applied when it can be well-thought out about total catch (unit-based) and / or catch per unit effort (CPUE) per species and / or species-based CPUE and catching effort within a few years [13]. However, the number of arrest attempts that can describe a truly effective effort rather than a nominal one is difficult to determine. Therefore, the use of this model requires prudence and as much as possible accompanied by additional information and validation using several other methods [14].

The data of fishing effort can be analyzed by calculating the catch value per CPUE in order to estimate the abundance status and level of fish utilization based on the total catch with catch effort. Analysis to estimate the stock or potential of fish resources and to determine the optimum condition of the fishing effort level using the production surplus method or Maximum Sustainable Yield (MSY). In this study the model used is the Schaefer model which can be applied if the total catch (catch) based on the type of fish and effort of catching effort to get catch per unit effort (CPUE) is known for several years [13]. Hence, the determination of the optimum level of effort can be estimated, i.e an effort that an generate maximum sustainable catch without affecting long-term stock productivity. The maximum sustainable catch is done by analyzing the relationship between fishing effort (E) and catch per unit effort (CPUE).

An assessment of the stock of fishery resources becomes important to get the information of how much fish potential can be utilized by humans. The purpose of using the surplus production model is to determine the optimum level of effort, an effort that can produce maximum sustainable yield without affecting long-term stock productivity or MSY. Total Allowable Catch (TAC) is Allocable

Catch (TAC) is 70% of its MSY [16]. This is based on prudential principles where the stock estimation can be conducted to avoid over utilization of fish resources as to achieve sustainable fish catch in the long run.

Fisheries resources are generally open access, so anyone can utilise the information available without having difficulties. Under these free fishing conditions, there is freedom for fishermen perform over catching as there is a tendency for fishermen to catch as many fish as possible before being preceded by other fishermen. The balance point of a fishery under open access conditions will be accomplished at the level of effort of EOA, in which total revenue (TR) equals the total cost (TC) so that the profit gained from fishing is equal to zero ($\pi = 0$). Fishery actors only receive the opportunity cost and the economic resource rents or profit does not exist. The level of effort at this position is the level of balance effort that Gordon calls the "bioeconomic equilibrium of open access fishery" or the bioeconomic balance in open access conditions. Bioeconomic balance is a condition in which every effort under EOA, total revenue will exceed total cost, so that fishermen (fishermen) will be more interested (entry) to perform fishing. Conversely, on the condition of effort over the EOA, the total cost will exceed the total revenue so that many fishermen will exit from the fishing business. Thus, only at the level of effort EOA balance will be achieved so that the entry and exit process will not occur. In other words, open access balance will occur if all economic rents have been exhausted (drive to zero), so there is no incentive for entry or exit, and no change in existing level of effort [16].

Fish resources are one of the renewable but limited natural resources. These resources can be declining and even collapse if left uncontrolled. The stock assessment is intended to make quantitative predictions about the reaction of fish populations that are dynamic to a number of management alternatives using a number of methods and statistical and mathematical computations. Quantitative predictions such as permissible production limits, risks that can be incurred by overfishing of some spawning populations and the need for fish to grow to a certain desired size before being exploited.

3. Findings and Discussion

3.1. Fish Diversity at CB GSK-BB

Most of the GSKBB-BR areas have high conservation value of peat swamp ecosystem include the Siak Kecil River Basin and Bukit Batu River Basin [17, 18]. The Siak Kecil River and Bukit Batu River are the main rivers in the region, each linking the surrounding Tasikside complex, totaling ± 26 Tasiks [19]. The complex of Tasik located in the vicinity of small Siak River among others (from upstream to downstream) are: Tasik Air Hitam, Tasik Pesingin, Tasik Ungus, Tasik Bunian, Tasik Membalu Kecil, Tasik Membalu Besar, Tasik Rumpit, Tasik Betung, Tasik Katialau, Tasik Serai, Tasik Tombatu Sonsang, Tasik Baru, and Tasik Pangkalan Siam. The Tasiks complex is located in the vicinity of Bukit Batu River, among others (from upstream to downstream): Tasik Bungsu, Tasik Baru, Tasik Kemenyan, Tasik Anggun, Tasik Rantau Panjang, Tasik Pangkalan Bukit, and Tasik Sembilan.

The watershed area of GSKBB-BR is known as the banjiran swamp ecosystem as its regularly get an abundance of water from the river and / or rainwater due to the fluctuation of water level [20]. In South Sumatra, this type of ecosystem is known as lebak lebung (Ditya et al., 2013). This region includes rivers and Tasiks (tasik), as one of the ecosystems on the island of Sumatra [21]. Monitoring conducted by [22] shows that the water level fluctuations in the waters of GSKBB-BR are around ± 1.5 m. However, the result of our interview with the community and observations by researchers in 2015, found the water level fluctuations in the small Siak River are ± 5 m, even some of the Tasik drought for several months.

Based on the information collected through interviews, the identification results showed that fish inhabiting waters in the 10 observations of the core area and the buffer zone of CB GSK-BB, consisting of 35 species from 17 families of fishes. Somewhat different from the results of research [23] who found 37 species, as well as the results of [24] study that found 42 species. But it should be understood that the results of research [23, 24] research territories including the GSK-BB CB

transition zone, whereas in this study the research territory is only in the core area area and the buffer zone of CB GSK-BB. The diversity and some examples of the fish species found are presented in Table 1 and Figure 2. Of the 35 identified species all found in the core area. This can certainly be explained by the character of water and human activity in both zones. The core area that is conservation land is certainly not disturbed by human activities, and the pressure of environmental change is more due to natural changes, while the diversity of fish in buffer zones, of the 35 species found only 17 species.

Several types of fish in the waters of GSKBB-BR are economical. The 10 species with high captured is due to high economic values and easy to process despite different peak catching season for each species according to water level. Although the price is expensive, some species are rarely caught because the population has decreased, for example the Tapah Fish (*Wallago attu* Bloch & Schneider). In fact, Arwana / Kayangan fish (*Scleropages formosus* Müller & Schlegel) are very expensive as ornamental fish declared extinct by GSK-BB fishermen due to intensive arrests in the 1980s. According to fishermen's recognition, in general the fish catch is decreasing while the size of the fish has been captured before reaching its optimum size. These symptoms indicate an over exploitation of the overfishing resources in this area.



Figure 2. Existence of fishery biological resources utilized as a source of livelihood (sold and used by the community) between 2000 and 2015 in the core area and zone of GSKBB-BR

Referring to Figure 3, the existence of biological fishery resources used as a source of livelihood (sold and utilized by the community) between 2000 and 2015 in the core area and buffer zone of CB GSK-BB, there are 35 species of fish used as a source of livelihoods (sold and used) by communities in the core areas and buffer zones of GSKBB-BR between 2000 and 2015. Since 2007, the presence of Arwana (*Scleropages formosus* Müller & Schlegel), turmeric Baung (*Hemibagrus nemurus* Kottelat & Whiten), Belida (*Notopterus notopterus* Pallas), Silok (*Lepidocephalichthys hasselti* Valenciennes), Tapah (*Wallago attu* Bloch & Schneider) are very difficult to find in any catchment are although some type of fish is very difficult to catch due to its high economic value that forces the fishermen continously to catch it.

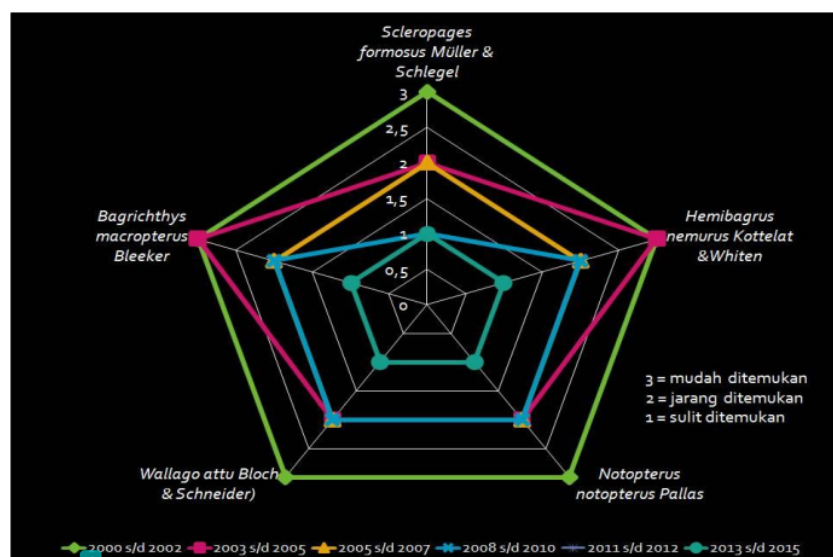


Figure 3. The existence of 5 species of fish used as a source of livelihood (sold and used by the community) between 2000 and 2015 in the core area and zone of CB GSK-BB

The expensive fish values and sensitivity caused extra treatment for post fish catchment such as cool box to keep the fish in fresh condition. For example, Baung kunyit (*Hemibagrus nemurus* Kottelat & Whitten), Belida (*Notopterus notopterus* Pallas), Tapah (*Wallago attu* Bloch & Schneider) immediately need to store in the cold box before exported to Singapore through the middleman in Bengkalis City. For fish export to Melaka, the middleman are located in Dumai City. Tengkulak or token fish in Bengkalis City states that the price of Belida (*Notopterus notopterus* Pallas) which known as rare and protected fish reach Rp. 150.000 - 180.000/kg. This scarcity of fish makes its status threatened that must be protected. In the Decree of the Minister of Agriculture No.716/Kpts/UM/10/1980 and PP. Number 7 of 1999 contains about the protection of fish from the genus *Chitala* ie from species *Chitala lopis* and *Notopterus notopterus*. Tapah (*Wallago attu* Bloch & Schneider) in Dumai City is sold for Rp. 80.000 - 110.000/kg. Arwana (*Scleropages formosus* Müller & Schlegel), and Silok (*Lepidocephalichthys hasselti* Valenciennes) are ornamental fish, and sold in living conditions. Based on the market price of fish in Bengkalis City and Dumai City, the price of Arwana (*Scleropages formosus* Müller & Schlegel) of natural catch is around Rp. 300.000 - Rp. 500.000 / per tail. Based on Government Regulation No. 7/1999 on the Preservation of Plant and Animal Species, Arwana (*Scleropages formosus* Müller & Schlegel) are included in the group of fish protected list. The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) has classified the Arwana (*Scleropages formosus* Müller & Schlegel) as a highly protected fish.

Despite limited revenues, fishermen are still benefited by the lack of operational costs to sell fish catches. This is due to every two days or three days the middleman / token / fish buyers from Perawang City, Duri, Bengkalis, Dumai and even Pekanbaru come to the fisherman's settlement to get the fish. The price of fish in place (fisherman's settlement) is varied, such as Tapah (*Wallago attu* Bloch & Schneider) live per kilogram range of Rp. 45,000 up to Rp. 60,000/kg. Baung Kunyit (*Hemibagrus nemurus* Kottelat & Whitten) and Selais (*Kryptopterus* *latis* Bleeker) ranges from Rp 40,000 to Rp. 50,000/kg. While the price of salai (smoked fish) is quite expensive. For example salut fish Fish

Baung Kunyit (*Hemibagrus nemurus* Kottelat & Whiten) and Selais (*Kryptopterus lois* Bleeker) price can reach Rp. 120,000 up to Rp. 160,000/kg. Prices of salted fish, generally of the Black Sopek (*Parambassis macrolepis* Bleeker), Black Sopek (*Pristolepis fasciata* Bleeker), Sopek Batik (*Sphaerichthys osphromenoides* Canestrini), Sopek Mujair (*Helostoma temminckii* Cuvier), Tabak (*Luciocephalus pulcher* Gray), Betok (*Anabas testudineus* Bloch), and Cork/Haruan (*Channa bankanensis* Bleeker) Rp. 25,000 to Rp. 40,000/kg.

3.2. Characteristics of Fishermen Community CB GSK-BB

The fishing village comprises of several groups of cottages scattered along the main river adjacent to aquatic or tributary estuaries (Figure 4). This is a strategy to shorten the distance between the resource location and their home so that it is more efficient than reaching every day from the parent settlement. Charts are the property of each person, but only a few huts are fully occupied with fishermen's wife and children. School-age children usually live with a host family in permanent settlements with the educational facilities. Within a year, this fishing chart is occupied for 6-9 months. In flood season, some fishermen go back to the original settlement areas because the fish catch drops dramatically. As the waters begin to recede, they return to the chart as the catch increases. Here, the chart is only a place to stay and cultivate fish catches, not a symbol of control over water resources, because all waters are public property. Every fisherman may install fishing gear in one place along with other fishermen, as there are no specific territorial control by individual.

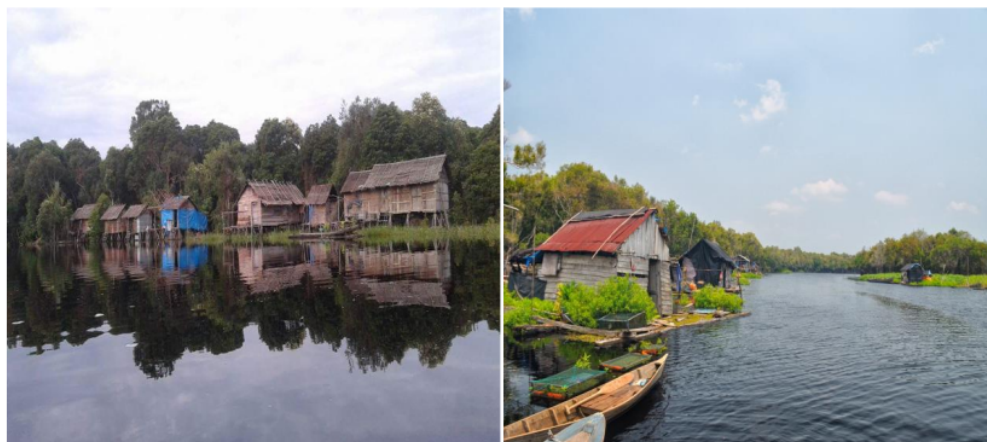


Figure 4. *Bagan* fishermen in Hamlet Bagan Benio Tasik Serai and Dusun Pulau Bungkok Tasik Serai Timur CB core area GSKBB-BR

Fishermen's settlements on the small Siak Kecil River are located in Kuala Tasik Pepagar, Kuala Sungai Pesingin, Kuala Tasik Ungus, Kuala Tasik Ketialau, Kuala Tasik Serai, Benio Chart, and Pulau Bungkok. Most of the fishermen who live in some of the down-streaming charts to Kuala Tasik Ketialau come from the inhabitants - downstream of the small Siak River, from Lubuk Gaung and Langkat, Siak Kecil Subdistrict, Bengkalis Regency. Meanwhile, fishermen who settled in Kuala Tasik Serai, Bagan Siam and some charts in the upper part of the river are predominantly local residents plus residents - downstream of the Siak Kecil river. In addition to those who live in the chart, some fishermen live in the parent settlements in Tasik Betung and Tasik Serai because the fishing sites in the Tasik can still be reached daily from their homes.

Fish is an important ¹source of protein for the fishermen household consumption and also a source of income for the fishermen lives surrounds the waters area of CB GSK-BB. As per population, the number of fishermen is small because fish catches tend to decrease. Its due to decrease of fishermen populations switches their livelihoods on plantation business. Short fishing season (generally only four month per year), also among the factors affect the uncertainty of household income as the fishing season ends. Most of the fishermen came from the Malay Siak tribe, the name for the Malay group spread in the coastal areas of Riau which was previously part of the territory of Siak Kingdom. However, the high migration of inhabitants entering GSKBB-BR affects the heterogeneity of fishermen in the region. Some non-Malay people participate in fishermen in Tasik Serai Timur, and participate in seasonal fish catches as fish populations increase in Tasik Betung and Tasik Serai.

Bagan that is located on the edge of the Little Siak River are semi-permanent, except in Bagio Benio and Pulau Bungkok. The Benio and Pulau Bungkok charts are permanent settlements located at the edge of the small Siak River, which has been growing since 1942. It is the oldest hamlet of Tasik Serai with the elementary school built in 1978. These two settlements are located adjacent to a stretch of mineral soil surrounded by peat swamp forest. Because it has resources other than fish, the number of fishermen in these two settlements is more than the other settlements. Aside from being fisherman, the villagers are also rubber farmers with limitation to extend the area due to the peat swamp ¹surrounds the land. Moreover, the rubber plant is not able to grow in deep peat so that some people have moved to other areas that have the type of mineral soil and close to the road for better accessibility.

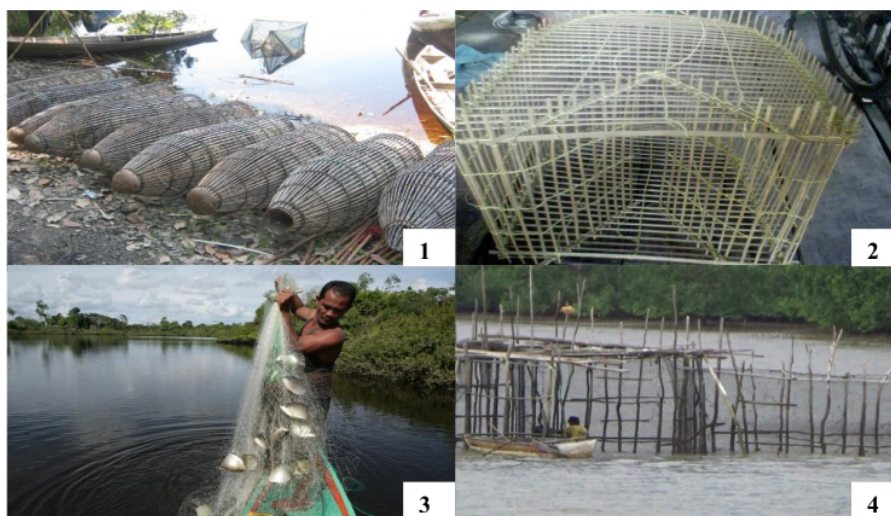


Figure 5. Fishing equipment (1) Lukah, (2) Lukah, (3) Jalo tarik, (4) Hambat used by fishermen in core zone area and buffer area B GSKBB-BR

¹Most of the fishermen in Sungai Bukit Batu and in Sungai Siak Kecil use motorized boats to wade through rivers and Tasiks. The use of paddle boats is limited to catching fish around the lodge. Owners of motorized boats have ¹a hauling range of >5 km from the hut, while the roaming distance of the rowing boat owners <2 km. The locations visited are usually close to the rasau plant (*Pandanus helicopus*) growing on the banks of the river and the Tasik, where the fish gather. Next, they will install fishing gear around it. Fishing equipment used is still traditional, namely: lukah, fishing line, net, floating net, splint and resistor. Lukah (pot trap) is a fish trap tool which can be differentiate based on the material to make and the type or size of fish to be caught. Lukah lying is made of bamboo and

rattan to catch all medium-sized fish. Lukah rope made of rope, has many variations of size depending on the size of the frame, the size of the rope or mesh size used, and the type and size of the fish to be caught. Lukah rope is more widely used than lying because it is easier to get the raw materials and workmanship. Larger-sized ropes are usually used for catching tapah, Lukah rope with medium-sized rope for catching baung fish, and a dense eye to catch fish selais and other small fish. Especially in the Tasik, the fishermen usually use splint, paint, and inhibition to catch fish. Splint is a series of wooden stakes arranged stretched in the mouth of the Tasik to direct the fish that will come out of the Tasik to the river through the door provided on the deep groove. In the small Tasik, the door is closed with a painting, while in large Tasiks are usually installed inhibition as a tool trap. In addition to the mouth of the Tasik, the inhibition is also installed on several deep tributaries.

The catchment area of GSKBB-BR fluctuate in water level and fishing gear used. In the Little Siak River, especially in the annual season, the water began to recede in February and reached its lowest low in July - August. Waterfront to rise in September and peaked in December - January [23] in 14 observation points scattered in the river and some of the Tasiks connected with the Siak Kecil River indicate that the use of the paint at high water level is more effective than the gill net, and vice versa when the low water level is more effective by using the net.



Figure 6. Aquatic biophysical waters when the normal tide of 2015-2016 in Tasik Serai Timur and Tasik Ketialau GSKBB-BR

According to Tasik Betung and Tasik Serai fishermen, fish harvest in tasik occurs twice, i.e. at the beginning and end of the rainy season. At a time when the water level is high, the fish spread to the marshes far from river water bodies and Tasik. When the water level gradually declines, many fish that were originally trapped in the swamps reentered the bodies of river water and Tasik. At the beginning of the wet season and the marsh water level begin to rise, the drag is installed at the door of the splint to catch the fish that will enter the Tasik, usually in October - November. At the end of the rainy season and the water level of the swamps begin to recede, the paintings and drags are installed in the opposite direction to catch the fish that will come out of the Tasik to the river, usually in May - June. Siak Kecil River fishermen admitted that the catch of fish is declining because of the duration of floods in the Tasik and the surrounding area is getting shorter, ie less than 3 months. They suspect this

is due to the ¹influence of the construction of the sodetan canals in Langkat, downstream of the Little Siak River, which was created in 1978 to prevent the flood of the Linau River transmigration area.

The water area in the core area of GSKBB-BR is part of a wildlife reserve whose ownership rights are controlled by the state. The Center for Natural Resources Conservation or BBKSDA Riau is the most powerful actor by using a rights-based access mechanism in controlling the use of resources in the region. BBKSDA Riau is a management unit of the Wildlife Reserve (SM) of Giam Siak Kecil and SM Bukit Batu which is responsible to the Directorate General of Natural Resources Conservation and Ecosystem Ministry of Environment and Forestry. This institution has considerable power because the legality of legal juridical power usage limits others to enter and utilize resources within the wildlife reserve area.

To respect the existence of local communities, it gives local communities the right to utilize water resources in the core area of GSKBB-BR traditionally. They are not only granted access rights to enter the area and enjoy non-subtractive benefits only, but also the right to utilize fish resources called the withdrawal right is the right to take/harvest the resource unit [25]. BBKSDA Riau's attitude is inseparable from the high cost of exclusion, where the ¹cost to prevent people from using resources far greater than its value. In addition, BBKSDA Riau also does not have sufficient information about the condition of resources in this region due to the limited personnel and management facilities it possesses so that thorough and in-depth inventorying is never done.

In addition to the fishermen community, the actors utilizing the water resources of GSKBB-BR are collecting traders. They gain access in this area by implementing a structural and relational access mechanism based on a bundle of power. Fishermen have access to social identity as communities that have traditionally caught fish in these waters. Meanwhile, collecting traders have access to capital in the form of finance, equipment (means of transportation), and the markets it uses to accommodate and market fish catches of fishermen. Here, collecting traders have greater access because they have many sources of power. Nevertheless, collecting traders do not use their access to reduce the price of fishermen because they generally have social relationships with the fishermen so that the culture of mutual help becomes a more prominent value.

Fish catches of Bukit Batu River fishermen ¹are usually sold to traders or residents in. Meanwhile, the catch of small Siak River fishermen are sold to collecting traders who come to fisherman's huts. There are four merchant collectors who come regularly once a week using wooden boats (pompong) along the small Siak River. In addition, there are merchant collectors coming from Duri and Perawang using cars to accommodate Tasik Serai fishermen who live in the parent settlement of Tasik Serai Timur. Collecting traders usually also carry staple goods and materials or fishing gear needed by fishermen.

3.3. Potential and Utilization of Fishery Biological Resource at CB GSK-BB

Limitation of fish catches in GSKBB-BR in the Tasik and river, shows the limited potential of fish/fishery due to high catching intensity. Its resulted in the pressure on the fish resource which cause overfishing. There is a need for an appropriate potential estimation as the basis for the policy in utilization and management efforts for the maximum sustainable catch in CB GSK-BB. Fisheries resources as a common resources and open access has no restriction from public utilize it. By using time series data of production and effort over 16 years (2000-2015) the analysis of the potential value of sustainable fishery resources using the Schaefer's maximum sustainable yield (MSY) model and the Gordon-Schaefer model adopt to estimate the economic viability or maximum economic yield (MEY).

Based on the catchment area which is limited to stretch of river waters (Siak Kecil River and Mandau River and its tributaries) and the Tasik, it shows that the area of operation is very limited, so the intensity of catching is high causing the pressure on the fish resources is very big in the end there is overfishing. Based on the international agreement on fisheries contained in the code of conduct for responsible fisheries (CCRF), only 70% of potential resources are available [26].

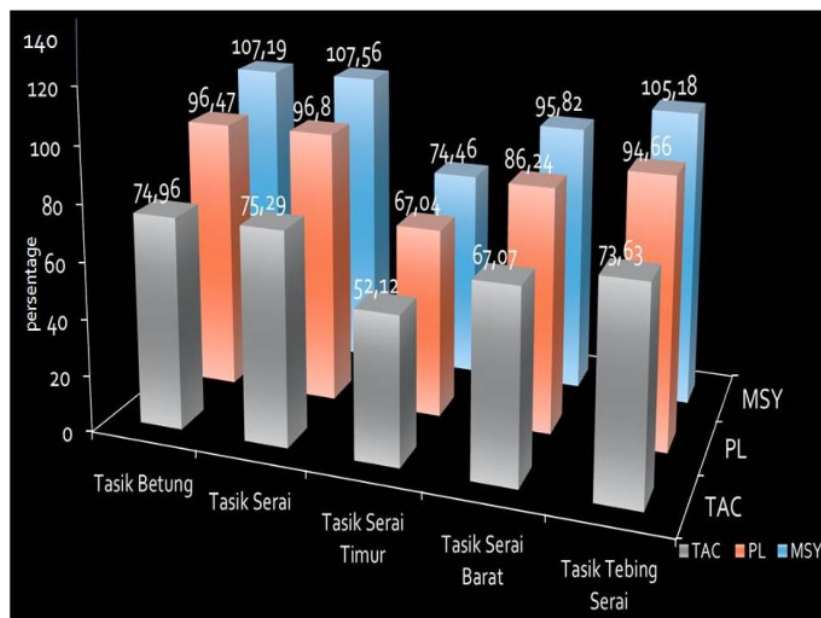


Figure 7. The value of MSY, PL, and TAC of fish catches for 15 years (2000 s / 2015) in Tasik Serai, Tasik Serai Timur and Tasik Betung and 10 years (2005 to 2015) in Tasik Serai Barat and Tasik Tebing Serai Village area core CB GSK-BB

Referring to Figure 7, the utilization level of fishery biological resources in Tasik Serai Timur is 76.46%. This shows that the utilization rate of fish biological resources at five in the core area has exceeded 70% so that it can be said that its utilization status is in overfishing condition. The result of this calculation by the Schaefer method obtained alleged magnitude of the potential of sustainable fish resources at five in the core area ranged from 0.590 - 2 / ton / year. The MSY calculation based on the Schaefer method assumes that the fish stock at five in the core area is in overfishing or overfishing conditions. So that natural fishing at five in the core area is advised not to overfishing or overfishing. Figure 7 shows that there has been overfishing since 2008 in Tasik Serai Timur, Tasik Serai, Tasik Betung, Tasik Serai Barat, and Tasik Tebing Serai in the core waters of GSKBB-BR core area. The picture shows that the trend (trend) level of fish resource utilization decreased every year. This indicates that the fish resources have begun to decrease and allegedly happened overfishing. According [27] that one of the characteristics of overfishing is the graph of arrest in units of time fluctuate or erratic and decreased production significantly. The relationship between catching effort and CPUE shows the value of CPUE tends to decrease with the increasing effort as shown in Figure III.17. This is in accordance with the statement [28] stating that, in general, total effort shows a linear relationship to the rate of catch or effort comparable to the mortality of the capture. The relationship of CPUE to effort is linear but negative, in the sense that any addition of fishing effort will decrease the value of CPUE. If connected between CPUE and effort (catch time / year) then the greater the effort then CPUE decreases, so the production decreases, meaning that CPUE is directly proportional to the effort where with each additional effort, the lower catch per business unit.

Referring to Figure 7, the CPUE of fish in Tasik Serai East was highest in 2000 at 2.0 tons per year and the lowest was in 2015 at 0.2 tons per year. The relationship of the catch with the catching effort with the Schaefer model as follows $Y = 0.8191 - 0.000017 X$. According to the above equation it can

be explained that each addition of catching 1 unit effort (year) then there will be a reduction of CPUE fish of 0.000017 units CPUE (Ton/catch period/year). Based on the MSY value of 76.46%, when compared with the PL of 68.81%, then the TAC amounted to 53.52% of the MSY value of 76.46%, it is based on prudential principles in the estimation of stock so that the utilization of resources fish can continue to be sustainable.

The utilization rate of fish resources in Tasik Serai is 107.56%, it shows that the utilization rate of fish biological resources in Tasik Serai exceeds 70% so it can be said that its utilization status is in overfishing condition. The result of calculation by Schaefer method with long line standard is obtained alleged magnitude of the potential of sustainable fish resources in Tasik for 720/kg/year. The MSY calculation based on the Schaefer method assumes that fish stock in Tasik Serai is in over-fishing condition or overfishing. So that the natural fishing in Tasik Serai is advised not to make over-fishing or overfishing. Based on the MSY value of 107.56%, compared to the PL of 96.8%, the TAC is 75.29% of the MSY value of 107.56%, this is based on prudential principles in the estimation of stock so that the utilization of fish resources can be sustainable. The utilization rate of fish biological resources in Tasik Betung is 107.19%. This shows that the utilization rate of fish biological resources in Tasik Betung exceeds 70% so that it can be said that its utilization status is in overfishing condition. The result of calculation by Schaefer method with long line standard is obtained the estimation of the potential of sustainable fish resources in Tasik Betung for 1835/kg/year.

The MSY calculation based on the Schaefer method assumes that the fish stock in Tasik Betung is in over-fishing condition or overfishing. So that the natural fishing in Tasik Betung advised not to make over-fishing or overfishing. In the picture above can be seen that the fish cultivation in Tasik Betung highest in the year 2000 amounted to 3.0 tons per year and the lowest in 2014 and Year 2015 of 0.9 tons per year. Relationship of the catch with catching effort with the Schaefer model as follows $Y = 0.7827 - 0.00366 X$. In accordance with the above equation it can be explained that each addition of catching 1 unit effort (year) then there will be a reduction of fish CPUE of 0.00366. Based on the MSY value of 107.19%, compared to the PL of 96.47%, the TAC amounted to 75.03% of the MSY value of 107.19%, this is based on prudential principles in the stock estimation so that the utilization of resources fish can continue to be sustainable.

The utilization rate of fish biological resources in Tasik Serai Barat is 95.82%. This indicates that the utilization rate of fish biological resources in Tasik Serai Barat exceeds 70%. This values shows the status of utilization in overfishing condition. The result of calculation by Schaefer method is obtained allegation of the potential of sustainable fish resources in Tasik Serai Barat 609,09/kg/year. The calculation of MSY based on the Schaefer method assumes that fish stocks in Tasik Serai Barat are in overfishing or overfishing conditions. So that natural fishing in Tasik Serai Barat is advised not to overfishing or overfishing. In the figure above can be seen that the CPUE of fish in Tasik Serai Barat highest in the year 2000 of 1.0 tons per year and the lowest in 2014 and Year 2015 of 0.3 tons per year. Relationship of the catch with catching effort with Schaefer model as follows $Y = 0.7112 - 0.00311 X$. According to the above equation it can be explained that every addition of catching 1 unit effort (year) then there will be a reduction of fish CPUE of 0.00311. Based on the MSY value of 95.82%, when compared with the PL of 86.24%, then the TAC amounted to 67.07% of the MSY value of 95.82%, it is based on prudential principles in the estimation of stock so that the utilization of fish resources can continue to be sustainable.

Furthermore, the utilization rate of fish biological resources in Tasik Tebing Serai was 105.18%. This shows that the utilization rate of fish biological resources in Tasik Tebing Serai exceeds 70% so it can be said that the utilization status is in overfishing condition. The result of calculation by Schaefer method is obtained alleged magnitude of the potential of sustainable fish resources in Tasik Tebing Serai of 590/kg/year. The MSY calculation based on the Schaefer method assumes that fish stocks in Tasik Tebing Serai are in overfishing or overfishing conditions. So that the natural fishing in Tasik Tebing Serai is advised not to make over-fishing or overfishing. In the picture above can be seen that the fish cultivation in Tasik Tebing Serai highest in the year 2000 of 0.8 tons per year and the lowest in the Year 2014 and Year 2015 of 0.4 tons per year. The relation of the catch with catching

effort with Schaefer model as follows $Y = 0.6772 - 0.00488 X$. According to the above equation it can be explained that each addition of catching 1 unit effort (year) then there will be reduction of CPUE of fish equal to 0.00488. Based on the MSY value of 105.18%, compared to the PL of 94.66%, then the TAC amounted to 73.63% of the MSY of 105.18%, this is based on prudential principles in the estimation of stock so that the utilization of resources fish can continue to be sustainable.

Based on Figure 8, overfishing cases also occurred since 2008 in Bukit Kerikil, Muara Kelantan, Muara Bungkal, Sungai Selodang and Olak in the watershed zone of CB GSK-BB, the average rate of fish resource utilization of tela above 76.46 %. This indicates that the rate of utilization of fish biological resources in overfishing conditions. The utilization of fish biological resources in Selodang River is 116,31%, it shows that the utilization rate of fish biological resources in Sungai Selodang exceeds 70% so it can be said that its utilization status is in overfishing condition. The result of calculation by Schaefer method with long line standard is obtained alleged magnitude of fish sustainable potential resources in Selodang River amounted to 462/kg/year. The MSY calculation based on the Schaefer method assumes that fish stocks in Muara Kelantan are in over-fishing or overfishing conditions. So that the natural fishing in the River Selodang advised not to make over-fishing or overfishing. The magnitude of the catch with the catching effort with the Schaefer model is as follows $Y = 0.8366 - 0.00427 X$. In accordance with the above equation it can be explained that each addition of catching 1 unit effort (year) then there will be a reduction of CPUE fish of 0.00427 units CPUE (Ton/catch period/year). Based on the value of MSY of 116.31%, when compared with the PL of 104.68%, then the TAC amounted to 81.42% of the MSY of 116.31%, this is based on prudential principles in the estimation of stock so that the utilization of resources fish can continue to be sustainable.

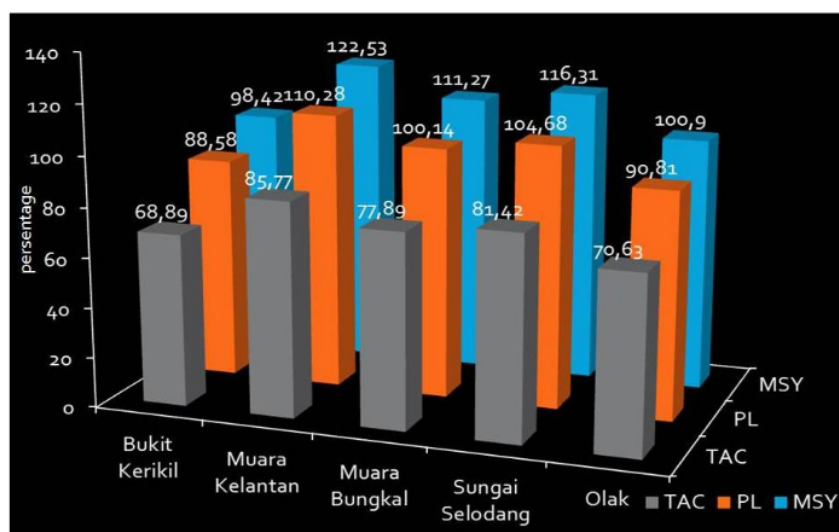


Figure 8. The value of MSY, PL, and TAC of fish catches for 15 years (2000 to 2015) in Bukit Kerikil, Sungai Selodang, Muara Kelantan, and Muara Bungkal and 10 years (2005 to 2015) in Olak buffer zone GSKBB-BR

Furthermore, the utilization rate of fish biological resources in Muara Bungkal is 122,53%. This shows that the utilization rate of fish biological resources in Muara Bungkal exceeds 70% so that it can be said that its utilization status is in overfishing condition. The result of calculation by Schaefer method with long line standard obtained the estimation of the potential of sustainable fish resources in

Muara Bungkal of 1835 / kg / year. The calculation of MSY based on the Schaefer method assumes that the stock of fish in Muara Bungkal is in over-fishing condition or overfishing. So that the natural fishing in Muara Bungkal is advised not to overfishing or overfishing. In the picture above can be seen that the fish cultivation in Muara Bungkal highest in the year 2000 to 2004 of 2.5 tons per year and the lowest in 2014 and Year 2015 of 0.7 tons per year. The relation of the catch with catch effort with Schaefer model as follows $Y = 0.9266 - 0.00622 X$. According to the above equation it can be explained that each addition of catching 1 unit effort (year) then there will be a reduction of CPUE fish of 0.00622 units CPUE (Ton/catch period/year). Based on the value of MSY of 122.53%, when compared with the potential sustainable (PL) of 110.28%, then the amount of TAC of 85.77% of MSY value of 122.53%, it is based on prudential principles in the estimation stock so that the utilization of fish resources can be sustainable.

The utilization rate of fish biological resources in Olak is 100.90%. This shows that the utilization rate of fish biological resources in Olak exceeds 70% so it can be said the status of its utilization in overfishing condition. The result of calculation by Schaefer method is obtained alleged magnitude of the potential of sustainable fish resources in Olak of 725 / kg / year. The calculation of MSY based on the Schaefer method assumes that the stock of fish in Olak is in overfishing condition. So that the natural fishing in Olak is urged not to overfishing or overfishing. can be seen that the highest CPUE fish in Olak in 2005 amounted to 0.5 tons per year and the lowest in Year 2015 of 0.2 tons per year. The relation of the catch with catch effort with Schaefer model as follows $Y = 0.8221 - 0.00512 X$. According to the above equation it can be explained that each addition of catching 1 unit effort (year) then there will be a reduction of fish CPUE of 0.00432. Based on the value of MSY of 100.90%, when compared with the PL of 90.81%, then the TAC amount of 70.63% of the MSY value of 100.90%, it is based on prudential principles in the estimation of stock so that the utilization of resources fish can continue to be sustainable.

Referring to Figure 8, the utilization rate of fish biological resources in Bukit Kerikil is 98.42%. This shows that the utilization rate of fish biological resources in Bukit Kerikil exceeds 70% so it can be said that its utilization status is in overfishing condition. The result of calculation by Schaefer method with long line standard is obtained the estimation of the potential of sustainable fish resources in Bukit Kerikil at 630 / kg / year. MSY calculations based on the Schaefer method assume that fish stock in Bukit Kerikil is in overfishing condition. So that the fishing of nature in Bukit Kerikil is advised not to overfishing or overfishing. it can be seen that the highest CPUE fish in Bukit Kerikil in 2009 was 1.7 tons per year and the lowest was in 2015 at 0.7 tons per year. The relationship of the catch with the catching effort with the Schaefer model as follows $Y = 0.8441 - 0.00432 X$. According to the above equation it can be explained that each additional capture of 1 unit effort (year) then there will be a reduction of CPUE fish of 0.00432 units CPUE (Ton/catch period/year). Based on the MSY value of 98.42%, when compared with the PL of 88.58%, then the TAC amounted to 68.90% of the MSY value of 98.41%, it is based on prudential principles in the estimation of stock so that the utilization of resources fish can continue to be sustainable. Based on the fishing conclusions in 5 areas of buffer zone of GSKBB-BR including overfishing, because it is above the capture limit of 70%.

Based on research in banjiran swamp in South Sumatera, cases of over-fishing also occur, especially in the catch of Baung Kurut (*Hemibagrus nemurus* Kottelat & Whiten), Selais (*Kryptopterus lais* Bleeker), Black Sopek (*Parambassis macrolepis* Bleeker), Black Sopek (*Pristolepis fasciata* Bleeker), Sopek Batik (*Sphaerichthys osphromenoides* Canestrini), Sopek Mujair (*Helostoma temminckii* Cuvier), Tabak (*Luciocephalus pulcher* Gray), Betok (*Anabas testudineus* Bloch), and Gabus/haruan (*Channa bankanensis* Bleeker), this indicates a negative effect on the existence of these three types of fish to the economic resources of the community. Seen from the aspect of the existence of its existence must be maintained with the pattern of wise and responsible capture, in order to be maintained on an ongoing basis [29]. Based on the case in the Lempuing River, due to overfishing, since 2000 there has been a change in the Lempuing River ecosystem which has an impact on fishing activities conducted by fishermen, so that the social phenomenon indicates that the fishermen's welfare

decreases in economic [30]. Foodplain fisheries are a key livelihood resource too in some regions, such as Africa, Asia and South America. They are a major source of income and employment [31].

4. Conclusion

The result of calculation Schaefer method has identified that several area has high utilization rate and overfishing or overfishing conditions in Muara Bungkal, Bukit Kerikil, Sungai Selodak and Olak in the core zone. This contradicts with the concept of sustainable fishing as an important function in the maintaining the fishery resources for the future generation. The study provides solid baseline data for further monitoring and management of core zone of the Giam Siak Kecil-Bukit Batu Biosphere Reserve (GSKBB-BR) as a combination of peat-swamp forest ecosystems, production forests and aquatic ecosystems.

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