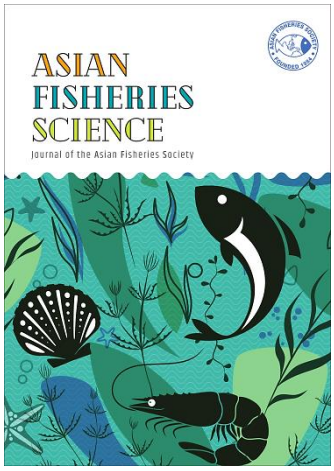

Present Status of Fishery Resources Utilisation in the Panama Lagoon, Sri Lanka

KASUN RANDIKA DALPATHADU*, SISIRA HAPUTHANTRI
Marine Biological Resources Division, National Aquatic Resources Research and Development Agency (NARA), Crow Island, Colombo – 15, Sri Lanka

*E-mail: kasun.randika@yahoo.com | Received: 18/05/2020; Accepted: 13/12/2020

ISSN: 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2020.33.4.005

Abstract

The Panama Lagoon situated on the east coast of Sri Lanka is a relatively small brackish water lagoon. The lagoon ecosystem currently indicates signs of degradation that is apparently due to the continuous development and economic activities such as fisheries, agriculture and tourism. This study was undertaken with the aim of assessing the present status of fishery resources utilisation in Panama Lagoon. Accordingly, the lagoon fishery was monitored from February 2017 to December 2017 at three major landing sites where the daily catches brought by the fishers were sampled on a monthly basis (n = 119). During the study, a total number of 54 fish species from 30 families were recorded among which the members of the family Mugilidae contributed 28 % of the total catch. Fibreglass canoe with an outrigger was the only fishing craft used in the lagoon. Gill nets, cast net and pole and line were the fishing gears used in the lagoon. Around 80 % of the total catch had come from gill nets. The catch per unit effort (CPUE) for the gill nets was 3.53 ± 2.13 kg.boat^{-1}. It was 10.90 ± 6.02 kg.boat^{-1} and 1.10 ± 0.89 kg.boat^{-1} for the cast nets and the pole and line, respectively. The average CPUE during the study period was calculated at 4.85 ± 2.94 kg.boat^{-1}. In 2017 the total annual fish production of the Panama Lagoon was estimated as 1742.9 kg.km^{-2} yr^{-1}. The fisheries productivity in Panama Lagoon has declined when compared with previous studies.

Keywords: fisheries, productivity, catch per unit effort, gill net

Introduction

The number of lagoons on the coastal belt of Sri Lanka is estimated to be 45 and covers about 158,000 ha of the land area (Silva et al., 2013; Department of Census and Statistics (DCS), 2018). These lagoons support the livelihoods of some 500,000 people which is 2 % of the population of Sri Lanka (Samarakoon and Samarawickrama, 2012). Majority of these lagoons are either permanently separated from the sea or temporarily connected with coastal water bodies during a certain period of the year (Silva et al., 2013; Ellepola et al., 2014).

Among the lagoons in Sri Lanka, the relatively deep lagoons and estuaries are approximately 80,000 ha and are important sites for fisheries (Silva et al., 2013). Many edible shellfish and finfish are found in lagoons, estuaries and their associated habitats such as mangroves and seagrasses (Miththapala, 2013; Ellepola et al., 2014). According to Joseph (1993), about 125 species of finfish are harvested from the lagoons in Sri Lanka. In addition to the importance in fishery, the lagoons act as an important breeding and nursery grounds for many finfish and shellfish species and help to fortify the fishery resources especially in coastal waters (Able, 2005; Miththapala, 2013; Silva et al., 2013).

Although Sri Lanka has a tradition in lagoon fishery dating back to several centuries, statistics on fish production from the lagoons are often incorporated into those for coastal marine fisheries. Thus, it is difficult to make a complete picture of lagoon fishery production, and fishing effort or catch composition (Joseph, 1993). However, fish fauna and species composition in certain lagoons (e.g., Batticaloa, Periya Kalapuwa, Rekawa, Bolgoda Lake, Negombo, Chilaw,

Mundel, Puttalam) have been reported and the annual yields have also been predicted for some large lagoons such as the Puttalam, Chilaw and Negombo (Silva et al., 2013). The estimated average fishery productivity of Sri Lankan lagoons is around 28 $kg.ha^{-1}$ yr^{-1} (FAO/ADB, 1988).

Gill nets, cast nets, trammel nets, hook and lines, traps and stake nets are the most common fishing gear in the lagoon fishery in Sri Lanka (Joseph, 1993). Small canoes (Kalapu Oru) are the most common type of craft used in lagoon fisheries while dugout crafts without outrigger (Vallams) and fibre reinforced plastic (FRP) boats are also used for fishing in the lagoons (Joseph, 1993; Ekaratne and Vidanage, 2013).

The Panama Lagoon (6° 45′- 6° 46′ N; 81° 48′- 81° 49′ E) is located in Ampara District in the east coast of Sri Lanka (Fig. 1). It is a relatively small brackish water lagoon with the water surface area of 14.76 km^2 and watershed area of 480 km^2 (Silva et al., 2013). Its average depth is recorded as 1.48 m and maximum depth is 4.26 m (Ellepola et al., 2014). The salinity varies from 4.5 ppt–26.6 ppt (Ellepola et al., 2014) and has never been reported to become hyper-saline even in the dry period (Silva et al., 2013). The Panama Lagoon is situated in the dry semi-arid climatic zone of Sri Lanka receiving a mean annual rainfall of 500–775 mm (Ellepola et al., 2014; Ellepola and Ranawana, 2015; Perera and Kariyawasam, 2016). Most of the rain comes from the north-east monsoon from December to February. The lagoon mouth closes during September to mid-November and it remains open during the rest of the year from December to August (Ellepola et al., 2014; Ellepola and Ranawana, 2015). The main freshwater input comes to the lagoon through Wilo Oya, a tributary of the Heda Oya (Ellepola et al., 2014; Ellepola and Ranawana, 2015).

Few studies have been carried out in recent past about the fisheries resources in Panama Lagoon (Ekaratne and Vidanage, 2013; Ellepola et al., 2014). For several decades, fisheries and tourism have been the major economic activities providing a livelihood for fisher populations residing around the Panama Lagoon (Ekaratne and Vidanage, 2013; Silva et al., 2013). Due to the continuous development activities coupled with the increased potential of human induced threats to the Panama Lagoon ecosystem, it is imperative to undertake a systematic study to ascertain the status of the fishery in the lagoon.

Therefore, this study was conducted to understand the present status of fishery resources in Panama Lagoon, and also, to investigate the current trends in the sustainable utilisation of the fishery resources in the lagoon. The information received by conducting such a study could be used for management plan of the lagoon to ensure the sustainable utilisation of the resources as well functioning of the lagoon ecosystem.

Materials and Methods

Baseline survey

Before starting the survey on the fishery resources, a baseline survey was conducted in January, 2017 in the area associated with Panama Lagoon to select the best landing sites for the fishery survey and to get an overall idea about the lagoon, its features, its background and the interactions between the lagoon and the local communities. Accordingly, lagoon fishers including the relevant officials of the Panama Lagoon Fisheries Society (PLFS) were interviewed to obtain relevant information about the lagoon and their dependency on the lagoon.

Study area

Three major landing sites situated in Panama Lagoon namely; "Waththawela Thotupola", "Kohumola Thotupola" and "Panikkiya Thotupola" were selected for this study (Fig. 1).

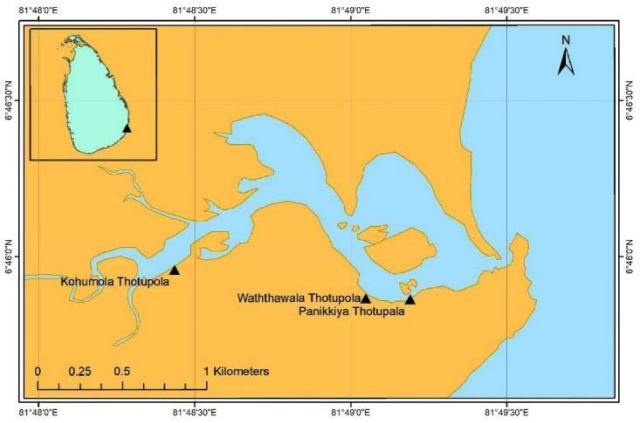

Fig. 1. Panama Lagoon (Sri Lankan map inset) showing the three landing sites that were used for data and sample collection of the study.

Survey on fishery resources

Survey on fishery resources was carried out from February to December 2017 at three landing sites as shown in Figure 1. Monthly field visits were made to the respective landing sites for fisheries data collection. Daily catches of the fishers were monitored and the data on species of fish caught, the total weight of the catch and weight of the catch by families were recorded. In addition, type of the fishing gear used with the size (mesh size, size of the net), number of net pieces used and duration of the fishing were recorded. At the end of the study, total number of 119 fishing boats with the commercial catch was studied for the analysis. Species identification was done up to the species level with the aid of available fish identification guides (Munro, 1955; Pethiyagoda, 1991; De Bruin et al., 1994; FishBase, 2017).

Other data collection

Other data collection involved relevant information through interviewing the fishing community (e.g., the retail price of fish) and direct observations (e.g., possible threats to the lagoon ecosystem).

Results

Community based management system in fishery

The fishers who were involved in the fishing activities in the Panama Lagoon had established an organisation called Panama Lagoon Fisheries Society (PLFS) with the aim of managing the fishing activities in the lagoon to ascertain sustainable utilisation of the fishery resources in the lagoon. There were 47 registered fishers in the society of which 35 were males and 12 were females. On average, 17 men and 6 women were engaged in fishing activities per day. However, involvement of women in fishing activities was not on a regular basis and they were only involved in collection of large sized giant tiger shrimps (*Penaeus monodon* Fabricius, 1798) and mud crab (*Scylla serrata* (Forsskål, 1775)) by hand picking from mangrove roots and shallow areas of the lagoon without using a craft. It is a traditional method practised in Sri Lanka during the day time. The society had declared some regulations such as restricting mesh size, number of net pieces per fisher, period for use of some fishing nets.

Crafts, gears, fishing operations and target species

Fibreglass canoe with an outrigger was the only fishing craft used in the Panama Lagoon. In most cases, the canoe was operated by a single fisher. According to the regulations of the PLFS, fishing using motorboats is prohibited in the lagoon.

Gill net was the main fishing gear used in the lagoon. According to the regulations imposed by the PLFS, minimum stretched mesh size of gill net allowed for catching fish and shrimps were 6.4 cm and 3.2 cm, respectively. The allowable maximum net pieces per operation were three. However, gill nets having mesh sizes of 2.5 cm, 3.2 cm, 5.7 cm, 6.4 cm, 7.0 cm, 7.6 cm and 8.9 cm were still being used and some fishers used up to four net pieces. Other than gill nets, cast nets (Veesi dela) and pole and line were also allowed in the lagoon. The cast net or pole and line were however used sporadically. Moreover, it was a common practice to use two or three mesh sizes of gill nets for fishing operation.

Considering the fishing gears used in the shrimp fishery in the lagoon, gill nets of 5.7 cm mesh size was particularly used to catch giant tiger shrimps (*P. monodon*) and the cast net was specially used to catch Indian white shrimps (*Penaeus indicus* H. Milne-Edwards, 1837). The gill net with the mesh sizes of 3.18 cm is only operated when the PLFS grants permission to use. Generally, it was permitted to operate for a period of one week in July or August. During the study, it was observed that these rules were sometimes violated by the fishers and some used even smaller mesh sizes gill nets of 2.5 cm. Furthermore, fishers did not comply with the time restrictions implemented for fishing. The cast net was operated especially at the lagoon mouth targeting fish belonging to family Mugilidae. The fishing gear types used in other lagoon fishery of Sri Lanka such as stake net, fyke net and trammel net are not used in the Panama Lagoon.

Species composition in the fish catch

During the study, a total number of 54 species belonging to 30 families were recorded from the fisheries catch. Among them, species of eight families were dominant in the catch (Table 1). The catch was composed of brackish water species, fresh-brackish water species and marine-brackish migratory species. About two-third of the food fish species in the Panama Lagoon consisted of typical brackish water species such as Scats (*Scatophagus argus* (Linnaeus, 1766)), Spine foots (*Siganus* spp.), Sillagos (*Sillago sihama* (Forsskål, 1775)), Pony fishes (*Leiognathus* spp.), Green chromide (*Etroplus suratensis* (Bloch, 1790)) and some species of family Mugilidae (Mullets). Fresh-brackish water species mainly comprised of Nile tilapia (*Oreochromis niloticus* (Linnaeus, 1758)), Tank goby (*Glossogobius giuris* (Hamilton, 1822)) and Long whiskers catfish (*Mystus gulio* (Hamilton, 1822)). The marine-brackish migratory species mainly comprised of Snappers (*Lutjanus* spp.), Groupers (*Epinephelus* spp.), Trevally (*Caranx* spp.), Silver biddy (*Gerres* spp.), Surgeonfish (*Acanthurus* spp.) and Barracudas (*Sphyraena* spp.). In addition, two brackish water prawn species were recorded; Indian white shrimp (*P. indicus*) and giant tiger shrimp (*P. monodon*). There was only one crab species; mud crab (*S. serrata*) found in the fisheries catch of the Panama Lagoon.

The species of the family Mugilidae which comprised of *Planiliza macrolepis* (A. Smith, 1846), *Planiliza melinopterus* (Valenciennes, 1836), *Crenimugil seheli* (Forsskål, 1775) and *Valamugil speigleri* (Bleeker, 1858) (locally known as Godaya) contributed 28 % of the total catch. In addition, sea catfish of family Ariidae (*Arius jella* Day, 1877) and *Arius maculatus* (Thunberg, 1792)) contributed 6 % of the total catch (Table 1). However, availability of sea cat fish was seasonal, which commenced soon after opening of the lagoon mouth due to heavy rain in November. Only one crab species; *S. serrata* contributed 10 % of the total catch. There was a considerable shrimp catch (*P. indicus* and *P. monodon*) in the lagoon fishery especially from late March to October but, the peak harvest season was from March to May.

Table 1. Percentage abundance (by weight) of species belonging to dominant families in the fisheries catch of Panama Lagoon from February to December 2017.

Family	Species	Common name	% abundance in the catch
Cichlidae	*Etroplus suratensis* (Bloch, 1790)	Green chromide	5.95
Scatophagidae	*Scatophagus argus* (Linnaeus, 1766)	Spotted scat	2.63
Mugilidae	*Planiliza* spp. *Crenimugil seheli* (Forsskål, 1775) *Valamugil speigleri* (Bleeker, 1858)	Mullets	28.24
Ariidae	*Arius* spp.	Sea catfish	5.47
Lutjanidae	*Lutjanus* spp.	Snappers	1.27
Siganidae	*Siganus* spp.	Spinefoots	4.32
Portunidae	*Scylla serrate* (Forsskål, 1775)	Mud crab or mangrove crab	10.28
Penaeidae	*Penaeus* spp.		1.23
	Other species		40.61

Catch per unit effort (CPUE) and annual production

The catch per unit effort (CPUE) was expressed in terms of total catch landed per boat. Accordingly, monthly CPUE was estimated as average monthly catch in kg.boat^{-1} (Fig. 2). There was a large fluctuation in the monthly average catch rate. The highest and lowest monthly average CPUE were 10.60 kg.boat^{-1} in March and 2.10 kg.boat^{-1} in August, respectively. Catch rates were higher during February–May and thus this period could be considered as the best fishing season in the lagoon fishery. The average CPUE for the whole period was calculated as 4.85 ± 2.94 kg.boat^{-1}.

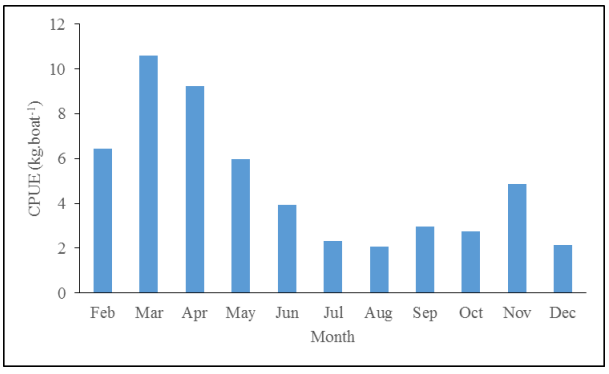

Fig. 2. Monthly variation of the estimated average catch per unit effort of the Panama Lagoon fishery from February to December 2017.

Considering fish catch in terms of total weight, with respect to the use of different fishing gears, 79.90 % of the total catch came from gill nets. Catch using the cast net and pole and line were 18.90 % and 1.20 %, respectively. The average CPUE in gill net fishery during the study period was 3.53 ± 2.13 kg.boat^{-1}. It was 10.90 ± 6.02 kg.boat^{-1} and 1.10 ± 0.89 kg.boat^{-1} for the cast net and the pole and line, respectively.

As the area of the lagoon is 14.76 km^2 (Silva et al., 2013) the total annual fish production was estimated as 1742.9 kg.km^{-2} yr^{-1} under the present study.

Fish prices and income

The price of one kilogram of finfish ranged from LKR250.00 to LKR300.00 (In October 2020, USD1.0 = LKR184.2). However, fishers get a better price for shrimps and crabs and the average price per kilogram could be as high as LKR600.00. Two fishers and two villagers purchased the fish catch and sold them to the consumers living in adjacent villages and nearby sub town called 'Ulla'.

Discussion

Coastal lagoons are nursery areas, feeding grounds and pathways for the diadromous migration of many fish species (Cataudella et al., 2015). As Panama Lagoon is located in the tropical climate region, the fish species richness tends to be higher than in the temperate and boreal system (Yanez-Arancibia et al., 1994). During this study, total number of 54 species belonging to 30 families were recorded from the fisheries catch in the Panama Lagoon. Thus, Panama Lagoon recorded about 40 % of the total number of commercially important species (~125) in Sri Lankan lagoon and estuary systems (Joseph, 1993;

Miththapala, 2013). The species richness of the Panama Lagoon, despite its small area, was higher than that of some similar size lagoons such as Mundel Lake in which 30 species were reported (Dayaratne et al., 1997). However, the species richness of the Panama Lagoon was less than those in the larger productive lagoons in Sri Lanka such as Puttalam Lagoon (70 species; Dayaratne et al., 1995) and Batticaloa Lagoon (85 species; Harris et al., 2013).

Considering the species composition of the fishery catch, the migratory species included many marine-brackish migratory species such as snappers (*Lutjanus* spp.), groupers (*Epinephelus* spp.), trevally (*Caranx* spp.), silver biddy (*Gerres* spp.), surgeonfish (*Acanthurus* spp.) and barracudas (*Sphyraena* spp.). They represented about one-third of the catch. Moreover, those species in the catch comprised of either juveniles or subadults (Fig. 3), because the Panama Lagoon acts as a nursery ground for migratory marine fish species.

Fig. 3. Subadult specimen of *Epinephelus malabaricus* found from the catch of Panama Lagoon.

Around 39 % of the total catch comprised of brackish water species, which were regularly contributed to the total fish catch. According to a previous study conducted in this lagoon, two fresh-brackish water species namely Nile tilapia (*O. niloticus)* and Long whiskers catfish (*M. gulio*) substantially contributed to the total catch with 16 % and 8 %, respectively (Ellepola et al., 2014). However, during this study, their contribution was about 1 % each in the total catch thus was categorised under the 'other fish' category (Table 1). During this study, some anthropogenic activities were taking place, such as clearing of mangroves in the lagoon bank for peanut cultivation (Fig. 4). Moreover, the use of agrochemicals for the peanut cultivation may also have a considerable adverse effect on this lagoon ecosystem (Miththapala, 2013; Silva et al., 2013). Those harmful practices may have made the lagoon environment unfavourable for the fresh-brackish water species such as Nile tilapia (*O. niloticus)* and Long whiskers catfish (*M. gulio*). On the other hand, over-harvesting of fisheries resources might be another possible reason for declining the relative contribution of such species in the fisheries catch.

Fig. 4. Peanut cultivation adjacent to the Panama Lagoon marked in the red circle.

Since around 80 % of the catch has come from gill nets, the estimated monthly catch rates largely depend upon the gill net landings. Whereas, the use of other gears such as cast net are seasonal and gear operation area is also restricted to a few locations such as the lagoon mouth. However, among different gear types, cast net reported the highest CPUE value (10.9 kg.boat^{-1}). This gear is mostly operated at lagoon mouth targeting juvenile shrimps (*P. indicus*) which migrate to the sea for maturation and reproduction. Also, this gear operates for larger size fish of the family Mugilidae targeting fish schools. As mentioned above, stationary fishing gear such as stake net and fyke net, which are frequently used in other lagoons in Sri Lanka, are not used in the Panama Lagoon. This could be due to the reason that wild elephants often cross Panama Lagoon, and may cause damage to the stationary fishing gears.

A strong variation in the average monthly CPUE of the Panama Lagoon was observed and higher values were recorded from February to May (Fig. 2). The Panama Lagoon area receives a higher rainfall during the north-east monsoon from December to February (Ellepola et al., 2014; Ellepola and Ranawana, 2015). In 2017, during the study period, the north-east monsoon started in mid-November and with the onset of the rain, the sand barrier at the lagoon mouth was washed away gradually. Hence during this period, most of the marine-brackish migratory species as well as fresh-brackish water species entered into the lagoon. Thus, the increase of fish abundance soon after lagoon was connected to the sea may have resulted in the higher CPUE values from February to May. Furthermore, fishers received a good shrimp harvest during the same period which also contributed to higher CPUE. The gradual decrease in the CPUE from May could be due to the decline of fish abundance in the Panama Lagoon due to exploitation by the fishers.

The Panama Lagoon is a small lagoon with an area of 14.76 km^2 (Silva et al., 2013) when compared to larger productive lagoons in Sri Lanka such as Puttalam Lagoon (Area: 327 km^2)(Dayaratne et al., 1997) and the Batticaloa Lagoon (Area: 135.5 km^2)(Harris et al, 2013). The estimated annual production of the Puttalam Lagoon and Batticaloa Lagoon were 20,884 $kg.km^{-2}$ yr^{-1} (Department of Fisheries and Aquatic Resources (DFAR), 2013) and 10,272 $kg.km^{-2}$ yr^{-1} (Silva et al., 2013), respectively. According to FAO/ADB (1988), the average natural production of Sri Lankan lagoons was around 2,800 $kg.km^{-2}$ yr^{-1}. In Panama Lagoon, the estimated annual production in 2017 was 1,742.9 $kg.km^{-2}$ yr^{-1}. Accordingly, it could be concluded that the Panama Lagoon is a less productive lagoon when compared to average fish production of Sri Lankan lagoons. Further, the Negombo Lagoon is also a highly productive ecosystem in Sri Lanka and its fisheries productivity is in the range of 7,300 – 15,000 $kg.km^{-2}$ yr^{-1} although it is a smaller lagoon (Area: 35.02 km^2) (Department of Fisheries and Aquatic Resources (DFAR), 2012). From the findings of this study, it also was evident that the current fishery productivity of the Panama Lagoon is much lower than the previously estimated productivity of 7,405.00 $kg.km^{-2}$ yr^{-1} by Ellepola et al. (2014). The significant reduction of the fishery productivity of the Panama Lagoon at present may be due to overfishing.

According to several scientific studies, community-based management systems for lagoon fisheries especially in the developing countries may provide better solutions for resource management averting common-pool resource dilemma (Aguero and Lockwood, 1986; Amarasinghe et al., 1997). The Panama Lagoon Fisheries Society implemented several regulations to maintain sustainable fishery resources as well as to ascertain the equitability of resource sharing among the fishers. However, it was observed during the study that some fishers attempt to violate the fisheries management regulations imposed by Panama Lagoon Fisheries Society. During the interviews with the fishers, it was noted that their daily catch has significantly decreased over time. Most of the fishers now get involved in alternative occupations such as farming or casual labour to maintain their livelihoods. The declining daily catch has affected their income, thus fishing pressure has increased in an unsustainable way on the remaining fishery resources in the lagoon (Silva et al., 2013; Ellepola et al., 2014). The decline of fisheries resources could be mainly attributed to the violation of the regulations imposed by the fisheries society. This is seen with the illegal use of more net pieces than the recommended number, use of smaller mesh sizes, and extensive use of the gears other than the permitted period of the year. With good community cooperation-based management system, the fishers could benefit high fish capture yields and good income. (Amarasinghe et al., 1997; Pushpalatha et al., 2020). Violation of the regulations imposed by the Society may lead to collapse of the community-based management system and may result in further decline of the fisheries resources in Panama Lagoon. In addition, some fishers have cleared the mangrove areas for cultivation of peanuts. These human interventions may contribute to further degradation of the fisheries resources.

Conclusion

The Panama Lagoon has become a less productive lagoon in Sri Lanka. The fishery resources as well as the lagoon ecosystem have drastically degraded at present and artisanal fishers who depend on Panama Lagoon struggle to sustain the livelihood. The species composition and fishery production have decreased considerably. Therefore, appropriate management measures are needed to restore the lagoon environment and resources and thereby to enhance the living standard of the fishers who depend on this lagoon.

Acknowledgements

Authors are grateful to the staff members of the Marine Biological Resources Division of National Aquatic Resources Research & Development Agency (NARA), Sri Lanka, who assisted in the fieldwork and office work. We would further like to express our great appreciation for the fishers and villagers in Panama who supported us in the field.

References

Able, K.W. 2005. A re-examination of fish estuarine dependence: Evidence for connectivity between estuarine and ocean habitats. Estuarine, Coastal and Shelf Science 64:5–17. https://doi.org/10.1016/j.ecss.2005.02.002

Aguero, M., Lockwood, B.A. 1986. Resource management is people management. In First Asian Fisheries Forum. (eds. Maclean, J. L., Dizon, L. B., Hosillos), pp. 345–347. Asian Fisheries Society, Manila, Philippines.

Amarasinghe, U.S., Chandarasekara, W.U., Kithsiri, H.M.P. 1997. Traditional practices for resource sharing in an artisanal fishery of a Sri Lankan estuary. Asian Fisheries Science 9: 311–323.

Cataudella, S., Crosetti, D., Ciccotti, E., Massa, F. 2015. Unstainable management in Mediterranean coastal lagoons: interactions among capture fisheries, aquaculture and the environment. In: Mediterranean coastal lagoons: Sustainable management and interactions among aquaculture, capture fisheries and the environment: Studies and Reviews No. 95, Cataudella, S., Crosetti, D., Massa, F. (Eds.), FAO, Rome, pp. 7–49.

Dayaratne, P., Gunaratne, A.B.A.K., Alwis, M.M. 1995. Fish resources and fisheries in a tropical lagoon system in Sri Lanka. Ambio 24:402–410.

Dayaratne, P., Linden, O., De Silva, M.W.R. 1997. The Puttalam/Mundel estuarine system and associated coastal waters: A report on environmental degradation, resource management issues and options for their solution. NARA, Colombo. 98 pp.

De Bruin, G.H.P., Russel, B.C., Bogussh, A. 1994. The marine fishery resources of Sri Lanka. FAO species identification field guide for fishery purposes. FAO, Rome. 400 pp.

Department of Census and Statistics (DCS). 2018. http://www.statistics.gov.lk/agriculture/fishery/index.htm (Accessed 30 April 2019).

Department of Fisheries and Aquatic Resources (DFAR). 2012. Fisheries development and management plan of Negombo lagoon. Regional Fisheries Livelihoods Programme for South and Southeast Asia (GCP/RAS/237/SPA): Field Project Document 2012/LKA/CM/12. DFAR, Colombo. 36 pp.

Department of Fisheries and Aquatic Resources (DFAR). 2013. Fisheries development and management plan of Puttalam lagoon, Regional Fisheries Livelihoods Programme for South and Southeast Asia (GCP/RAS/237/SPA): Field Project Document 2013/LKA/CM/2. DFAR, Colombo. 35 pp.

Ekaratne, K., Vidanage, S.P. 2013. Small grants, large gains: Lessons from MFF small grant facility projects in Sri Lanka (2011–2013). IUCN Sri Lanka Country Office, Colombo. 115 pp.

Ellepola, G., Ranawana, K.B., Harischandra, S. 2014. Utilization of fishery resources in the Panama lagoon, Ampara District, Sri Lanka. International Journal of Fisheries and Aquatic Studies 1:32–37.

Ellepola, G., Ranawana, K.B. 2015. Panama Lagoon: A unique mangrove ecosystem in the east coast of Sri Lanka. Wetlands Sri Lanka 2:10–19.

FAO/ADB. 1988. Sri Lanka fisheries sector study report of the FAO/ADB cooperate program. FAO, Rome. 30 pp.

FishBase 2017. http://www.fishbase.se/search.php (Accessed 30 March 2018).

Harris, J.M., Vinobaba, P., Deepananda, K.H.M.A. 2013. Ichthyo diversity of Batticaloa Lagoon, Sri Lanka and needs for their conservation. Journal of Environment 02:25–33.

Joseph, L. 1993. Coastal fisheries and brackish water aquaculture in Sri Lanka. Coastal resource management project. Colombo, Sri Lanka. 46 pp.

Miththapala, S. 2013. Lagoons and estuaries. Coastal ecosystems series. Volume 4. IUCN Sri Lanka Country Office, Colombo. 73 pp.

Munro, I.S.R. 1955. The marine and freshwater fishes of Ceylon. Department of External Affairs, Canberra. 349 pp.

Perera, P.K.P., Kariyawasam, L.U. 2016. An ecological assessment of the Panama Lagoon Complex, Eastern Province, Sri Lanka. In Proceedings of the international forestry and environment symposium 2016. (eds. Ranasinghe, D.M.H.S.K., Singhakumara, B.M.P., Amarasekara, H.S., Bandara, N.J.G.J., Gunawardena, U.A.D.P., Subasinghe, S.M.C.U.P., Perera, P.K.P., Jayawardana, D.T., Pathirana, C.D.K.), pp. 25. Department of Forestry and Environmental Science, University of Sri Jayawardanapura, Sri Lanka. https://doi.org/10.31357/fesympo.v21i0.3069

Pethiyagoda, R. 1991. Freshwater fishes of Sri Lanka. Wildlife Heritage Trust, Sarvodhaya Vishvalekha Press, Colombo. 362 pp. https://doi.org/10.2307/1446131

Pushpalatha, K.B.C., Kularatne, M.G., Amarasinghe, U.S. 2020. Institutional robustness of culture based fisheries in perennial reservoirs of Sri Lanka. Asian Fisheries Science 33: 91–105. https://doi.org/10.33997/j.afs.2020.33.2.002

Samarakoon, J., Samarawickrama, S. 2012. An appraisal of challenges in the sustainable management of the micro-tidal barrier-built estuaries and lagoons in Sri Lanka. IUCN Sri Lanka Country Office, Colombo. 171 pp.

Silva, E.I.L., Katupotha, J., Amarasinghe, O., Manthrithilake, H., Ariyaratna, R. 2013. Lagoons of Sri Lanka: From the origins to the present. International Water Management Institute (IWMI), Colombo, pp. 3–113. https://doi.org/10.5337/2013.215

Yanez-Arancibia, A., Dominguez, A.L.L., Pauly, D. 1994. Coastal lagoons as fish habitats. In: Coastal lagoon processes, Kjerfve, B. (Ed.), Elsevier Science Publishers, Amsterdam, pp. 363–376. https://doi.org/10.1016/S0422-9894(08)70017-5