Marine and Life Sciences

Journal Homepage: https://dergipark.org.tr/tr/pub/marlife

Research Article

Can brush parks aggregate species in lagoon systems? A case of Homa Lagoon, Aegean Sea, Turkey

Deniz Acarlı*[1], Semih Kale[2], Ali Kara[3]

*Corresponding author: denizacarli@comu.edu.tr

Received: 10.12.2019 Accepted: 24.12.2019

Affiliations

1 Department of Fisheries Technology, Gökçeada School of Applied Sciences, Çanakkale Onsekiz Mart University, 17760, Çanakkale, Turkey

2 Department of Fishing and Fish Processing Technology, Faculty of Marine Sciences and Technology, Çanakkale Onsekiz Mart University, 17020, Çanakkale, Turkey

3 Department of Fishing Technology and Seafood Processing Technology, Faculty of Fisheries, Ege University, 35100, İzmir, Turkey

Keywords
Fisheries management
Lagoon fisheries
Brush park fisheries
Fish attractive devices (FADs)

ABSTRACT

This study aimed to investigate the species aggregating performance of brush parks in Homa Lagoon, Aegean Sea, Turkey. The study was conducted in 100 m² area between June 2004 and January 2005 in Homa Lagoon. Alternative fishing gears (produced from Polyvinyl chloride (PVC) and sacks filled with bush bundles) were investigated for the first time by the present study besides commonly used fishing gears (fyke net, basket trap, and circled lift net) in traditional fisheries in lagoon systems in Turkey. The species composition was determined for each fishing gears for brush park fisheries. A total of 1855 individuals were caught and the highest yield was obtained from the basket traps (1018 individuals) followed by the sacks filled with bush bundles traps (324 individuals), PVC materials (313 individuals), and the circled lift nets (200 individuals). This study revealed that brush park fisheries can attract the species in lagoon systems. Therefore, socioeconomic assessment and appropriate fisheries management approaches for brush park fisheries and lagoon fisheries should be carried out and applied for sustainable use of fisheries resources in lagoon systems.

Introduction

Fish aggregating (or attracting) devices (FADs) as the form of man-made floating objects have been used worldwide by commercial, artisanal and recreational fishers for catching mainly pelagic fish species (Dempster and Taquet, 2004). FADs increase the catchability of fish species with regard to free swimming fish species (Guillotreaua et al., 2011). Moreover, they increase recruitment, sustainability and habitat of fish species (Kingsford, 1999). Brush park is a kind of FADs which make possible the aggregation and attraction of fish. Brush parks are underwater constructions made up of wooden materials that are usually fixed to the bottom of a shallow water body (COFAD, 2002). Brush parks provide substrate for the growth of periphyton and suitable habitats and shelter areas for several fish species. Therefore, brush parks have high level of nutrients (Welcomme, 2005). They also significantly increase the efficacy of fishing operations (Béné and Obirih-Opareh, 2009). Brush parks are commonly used in western part of Africa (Benin, Ghana, Ivory Coast, Nigeria, and Togo) where they are known as acadjas (Lalèyè, 2000), samrah in Cambodia (Ho, 1999), and katha in Bangladesh (Ahmed and Akther, 2008; Uddin et al., 2015).

Cite this article as
Acarlı, D, Kale, S. & Kara, A. (2019). Can brush parks aggregate species in lagoon systems? A case of Homa Lagoon, Aegean Sea, Turkey. *Marine and Life Sciences,* 1(1): 17-24.

Homa Lagoon is one of the most significant lagoons in the coasts of Aegean Sea of Turkey and it is a biodiversity hotspot (Çolak-Sabancı, 2012). Homa Lagoon was included within the list of wetlands of international importance (Ramsar Site) in Gediz Delta Ramsar Site. Homa Lagoon serves as a natural habitat and provides living space, protection from predators for many aquatic species that have high economic value and more than 200 bird species (Acarlı, 2007). Fish and birds prefer these areas for breeding, feeding, living, nursery, and growth (Alpbaz, 1990; Akyol, 1999; Elbek et al., 2003; Deveciyan, 2006; Acarlı, 2007).

Some studies have been carried out in Homa Lagoon. These studies include different aspects, for instance, limnologic characteristics such as physicochemical characteristics (Ünsal et al., 2000), zooplankton (Pulat and Özel, 2003), algology (Çolak Sabancı and Koray, 2010; Çolak Sabancı et al., 2011; Çolak Sabancı, 2012), growth and survival rates of *Tapes decussatus* (Serdar et al., 2007) *Anadara inaequivalvis* (Acarlı et al., 2012), *Ostrea edulis* (Lok et al., 2005), reproductive activity of *O. edulis* (Acarlı et al., 2015), catch efficiency and catch composition of species (Acarlı et al., 2009), length-weight relationships of fish species (Acarlı et al., 2014) of Homa Lagoon. Heavy metal and pesticide concentrations in fish, molluscs, polychaete species were also studied by some authors (Atılgan and Egemen, 2001; Taş et al., 2009; Bilgin and Uluturhan Suzer, 2015, 2017; Sevgi and Uluturhan Suzer, 2019; Uluturhan et al., 2019). Moreover, fisheries management (Tosunoğlu and Ünal, 2012; Tosunoğlu et al., 2013) and some socioeconomic aspects of fisheries in Homa Lagoon were examined (Köken et al., 2019).

Traditional fishing gears such as fences trap, trammel net, veranda net, and fyke net are commonly used in Homa Lagoon where the most caught species have been Mugilid species including *Mugil cephalus, Liza saliens, Liza ramada, Liza aurata, Chelon labrosus*. Apart from these species, fishing efforts are also performing for *Sparus aurata, Dicentrarchus labrax, Solea solea,* and *Anguilla anguilla* species.

Several fishing gears are used in the lagoon fisheries. However, there is no study on the assessment of fish aggregating performance of brush parks in Homa Lagoon. In addition, there is a lack of information on the utilization of polyvinyl chloride (PVC) pipe materials as alternative fishing gears for brush park fisheries in Homa Lagoon. Therefore, the aim of this study was to investigate the species aggregating potential of brush parks in Homa Lagoon. PVC pipe materials and sacks filled with bush bundles were used for the first time as fishing gears in the present study.

Material and Methods

Homa Lagoon (Figure 1) covers 1852 ha area (Acarlı, 2007) and maximum depth of the lagoon is 1.8 m while average depth ranges between 0.5 m and 1.0 m (Acarlı, 2007). The study area is an active lagoon and spawning season for fish species is between June and October in this lagoon (Acarlı, 2007). At the end of the spawning period, fence traps are closed and fish are introduced into the lagoon voluntarily but prevented from leaving. In autumn season, high salinity is observed due to rainfall and evaporation (Çolak Sabancı, 2012).

Figure 1. The location of the study area in Homa Lagoon

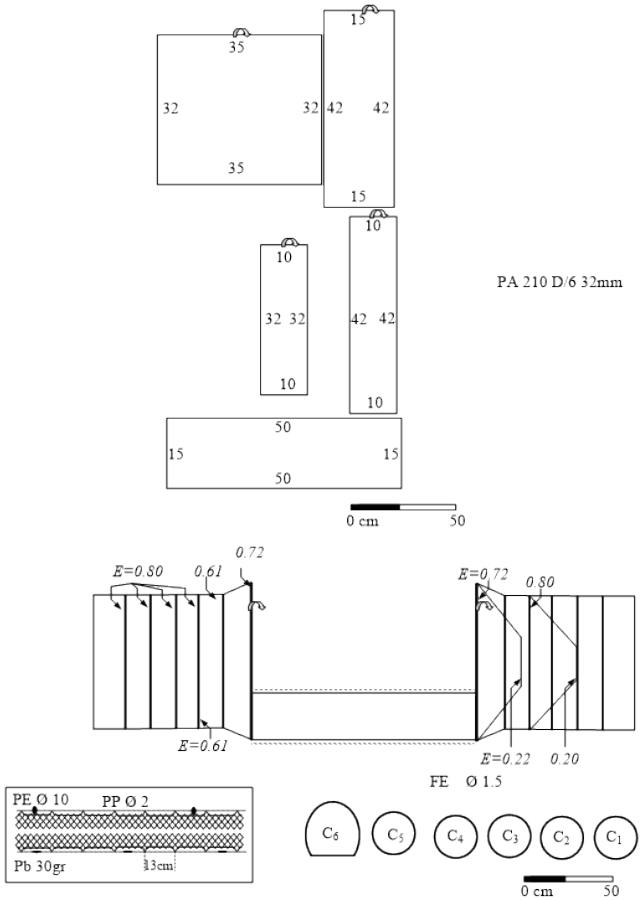

Figure 2. Technical measurements and characteristics of fyke nets (modified from Acarli, 2007)

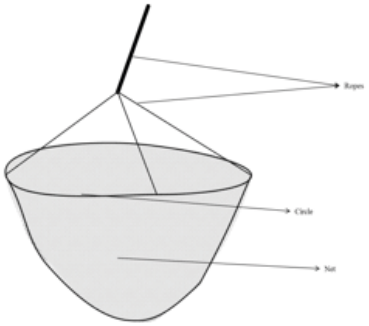

Figure 3. Circled lift nets (modified from Acarlı, 2007)

Brush parks were established on 100 m^2 area in the Homa Lagoon. Piles having 10m×10m and 8m×8m were fixed in the lagoon. FAO (2007) reported that many species live around these traps. Similarly, several authors also documented that these traps attracted animals (Buffe, 1958; Costa and Wijeyaratne, 1994; Welcomme, 2002). Hence, fyke nets, basket traps and polyvinyl chloride (PVC) materials were used and placed around brush parks. Two types of PVC materials were investigated in the study. The first one had 100 cm length and 8 cm diameter (named as PVC 100) while the other one had 300 cm length and 11 cm diameter (named as PVC 300). One of the entries of PVC materials was covered by nets. In addition, PVC materials were interconnected with each other by No.5 surface rope such as longline. The technical measurements and characteristics of fyke nets are given in Figure 2 while the characteristics of basket traps are presented in Table 1. Four different basket traps models were used in the study. The model#1 had blue colour and foldable characteristic in the shape of rectangular prism while model#2 was circle and foldable. The model#3 and model#4 had circular shape whereas the length of the model#3 was higher than model#4. The characteristics of basket traps are also summarized in Table 1. The sacks filled with bush bundles were used for the first time by the present study to investigate the fish attracting performance in the lagoon systems. The circled lift nets were placed around the brush parks. European pilchard (*Sardina pilchardus*) and the Mediterranean mussel (*Mytilus galloprovincialis*) were used as baits for the circled lift nets. The diameter was 50 cm and mesh size was 12 mm (210D/18N) for the circle of the lift net (Figure 3).

Results

Four different fishing traps were placed around the brush parks and 1855 individuals were caught by brush park fisheries. The highest yield was obtained with the model#1 basket trap. The most caught species was *Carcinus aestuarii* (741 individuals). In addition, 157 gastropod individuals (belonging to

15 different species including *Cerithium vulgatum, Nassarius incrassatus, Turritella communis, Epitonium commune, Osilinus sp., Pirenella conica, Nassarius mutabilis, Nassarius pygmaeus, Gibbula albida, Nassarius reticulatus, Bittium reticulatum, Gibbula adensonii adensonii, Cyclope neritea, Bolinus brandaris, Hexaplex trunculus*; Crustacean species *Paguristes syrtensis, Paguristes eremita, Diogenes pugilator, Pagurus forbesi, Pagurus cuanensis*), 107 *Palaemon sp. (P. serratus, P. adspersus, P. elegans)* specimens, 7 *Gobius niger*, 5 *Sepia officinalis,* 1 *Eriphia vericosa*, 1 *Solea solea* were captured by the traps. It was observed that model#2 basket trap caught mostly Solea solea while model#4 basket trap caught Sepia officinalis whereas model#1 basket trap intensely caught Carcinus aestuarii.

Traps	Height (cm)	Width (cm)	Length (cm)	Entry Diameter (cm)
Model#1	65	36	116	7
Model#2	40	70	193	10
Model#3	30	70	225	15
Model#4	25	55	169	11

Table 1. The characteristics of the basket traps used in the study

PVC materials caught 313 individuals belonging to 21 different species. PVC 100 aggregated *Palaemon sp.* (71 specimens), gastropods (63 specimens), *Carcinus aesturaii* (32 specimens), and *G. niger* while PVC 300 intensely collected *Palaemon sp.* (119 specimens) beside gastropods (15 specimens), *C. aestuarii* (2 specimens), *Blennius ocellaris* (7 specimens) and *G. niger* (2 specimens).

The sacks filled with bush bundle traps attracted commonly *Palaemon sp.* (324 individuals) in addition to Crustacean species *C. aestuarii* (87 individuals).

The circled lift nets were used for the first time in Homa Lagoon in the present study and they caught 200 individuals belong to 20 different species including gastropods (186 individuals from 15 different species), *Palaemon sp.* (11 individuals) and *Zosterisessor ophiocephalus* (2 individuals) and *G. niger* (1 individual).

Discussion

The lagoon fishery production have several activities: traditional fishing on lagoon canals and water areas, valley fishing; farm fishing (aquaculture) mussel farming and clam fishing (Rosetto, 2001). Brush parks in lagoon systems can improve fisheries production considerably although their small areas compared with the total surface areas of water bodies where they are hosted (Béné and Obirih-Opareh, 2009). Sugunan et al. (2007) indicated that well-managed brush parks can even be equivalent to intensive or semi-intensive aquaculture operations with regard to annual per-unit-area harvesting rates. Therefore, brush park fisheries can considerably contribute to the increase of water productivity.

Welcomme (2002) indicated that the detrimental or beneficial status of brush parks for natural fish stocks depends to a great range on the ecology of the fish species existing in the water body. Some fish species are attracted for their shelter and food needs while others for reproduction (Anis et al., 2015). If brush parks were used by fish species for breeding, they could serve as a shelter for young fish species and improve the growth and survival of the species. Thus, brush parks have a positive impact on the growth and survival rate of the natural fish stocks. Furthermore, opportunistic predators are attracted to brush parks as stated by Malone et al. (2011). Gammanpila et al. (2017) have revealed that ecomorphology of the fish species in the brush parks is associated with diet. Knowledge on feeding ecology of the fish species in a fish assemblage makes the understanding of trophic interactions possible (Gammanpila et al., 2019a). The understanding of these interactions has a great importance for fisheries managers to decide on ecosystem based management (Pikitch et al., 2004).

In Turkey, lagoon fishermen have been using fishing materials and methods such as trammel nets, fyke nets, longlines, nets (seine or etc.) and fences since many years (Deveciyan, 2006). The fences traps (“kuzuluk” in Turkish) are the most basic fishing gear types for the whole operational lagoons in the coasts of Aegean Sea (Kaykaç and Tosunoğlu, 2015). On the other hand, despite brush parks were used in numerous countries such as Bangladesh (Kapetsky, 1979; Wahab and Kibria, 1994; Ahmed and Hambrey, 1999; Ahmed and Akther, 2008; Uddin et al., 2014, 2015), Benin (Buffe, 1958; Lalèyè 2000; Niyonkuru and Lalèyè 2010), Cambodia (Fily, 1966; Ho, 1999; Lamberts,

2001; Baran, 2005), Cameroon (Stauch, 1966, 1976), China and Mexico (FAO, 1962), Egypt (Ben-Tuvia, 1979), Ghana (Mensah, 1979; Béné and Obirih-Opareh, 2009), India (Mann and Aftabuddin, 2009), Madagascar (Kiener, 1960), Nigeria (Kapetsky, 1981), Sri Lanka (Senanayake, 1981; Costa and Wijeyaratne, 1995; Amarasinghe et al., 2002; Rupasinghe and Asanthi, 2007; Anis et al., 2015; Gammanpila et al., 2016a, 2016b, 2019a, 2019b), and Togo (Welcomme, 1971; Everett, 1976), they were used for the first time in Turkey in this present study. Therefore, this paper provides the first findings for the species aggregating performance of brush parks in lagoon systems in Turkey.

An investigation of brush park fishing in Lagos lagoon of Nigeria has been carried out by Solarin and Udolisa (1993). Positive correlations were found between the fish caught in the brush park and the period of establishment (Solarin, 1998) and between the fish and density of establishment (Solarin and Kusemiju, 2003). Abdul et al. (2004) reported that brush park fisheries presented a respectable catch to the fisherman in Iwopin Lagoon area, Nigeria. In addition, brush park fishing was found profitable and it had supported to development of fisheries and had reduced the poverty among the Nigerian rural inhabitants. Gammanpila et al. (2016b) reported that the optimal time period for fishing was about 30 days after the establishment to reach maximum yield in brush park fisheries.

Atar et al. (2002) have investigated the catching efficiency and catch rates of three different traps in Beymelek Lagoon of Turkey. They reported that traps were particularly effective in crustacean fisheries and that the most caught species was Carcinus aestuarii. In addition, they documented that Lyngbya majuscuta, blue-green algae, caused the closure of traps and circled lift net meshes. Thus, it allows the intensive fishing of crustacean and gastropod species. The results of the present study are similar to the findings of Atar et al. (2002).

Different species have been observed around the brush parks. The adherence of macroalgae to the piles by the currents might be possible providing a feeding and sheltering area for species. Hence, animals were attracted to the piles. Moreover, thigmotropism behaviour of animals (the attraction of animals to a solid object) was efficiently and effectively monitored in brush park fisheries. Therefore, fish behaviour mechanisms should also be investigated for species observed in lagoon system in future researches.

Brush parks have been accepted to be a comparatively effective fishing method to improve the productivity of fisheries. They could efficiently contribute to the improved food productivity in the rural areas where they are established. Thus, brush parks can play an important role in fisheries productivity ensuring the food availability, rural development, and poverty alleviation.

An appropriate management of brush park fisheries can be used as a potential tool to ensure the sustainability of fisheries resources in lagoon systems. Establishment of brush parks may possibly help to develop biodiversity and habitats in Homa Lagoon. Fish population can get benefits of food and shelter in the brush parks throughout the dry season. Furthermore, the fish population can gain sexual maturity for spawning in the next breeding season which is clearly vital for the sustainability of fisheries resources to the next generations.

Conclusion

The present study revealed that brush park can aggregate and attract species in lagoon systems. Brush park fisheries contribute to sustainable fisheries and ecosystem approach to fisheries management by using less harmful fishing gears for habitat and fish stock.

Acknowledgement

An earlier version of this study was presented at XV. National Fisheries Symposium in Rize, Turkey on July 2009. This paper also includes a part of the Ph.D. thesis of the first author who granted by Ege University Scientific Research Projects Coordination with project number 2005/SÜF/010. Authors declare that there is no conflict of interest.

References

Abdul, W. O., Omoniyi, I. T., Udolisa, R. E. K. & Alegbeleye, W. O. (2004). Economic potentials of Iken brush park fishing practice in Iwopin Lagoon, Ogun State, Nigeria. *18th Annual Conference of the Fisheries Society of Nigeria (FISON), 8-12 December 2003, Owerri, Nigeria*, pp. 126-130.

Acarlı, D. (2007). Studies on fisheries and improving its fishery in Homa Lagoon. Ph.D. Dissertation. Ege University, İzmir, Turkey. 153p.

Acarlı, D., Kale, S. & Kara, A. (2019). New alternative fishing gear suggestions for trap fisheries from the waste recycle materials: Case study for Muricidae (Mollusca: Gastropoda). *Marine Science and Technology Bulletin,* 8(2): 92-97.

Acarlı, D., Kara, A. & Bayhan, B. (2014). Length-weight relations for 29 fish species from Homa Lagoon, Aegean Sea, Turkey. *Acta Ichthyologica et Piscatoria,* 44: 249-257.

Acarlı, D., Kara, A., Bayhan, B. & Çoker, T. (2009). Catch composition and catch efficiency of species caught from Homa Lagoon (Izmir Bay, Aegean Sea). *Ege Journal of Fisheries and Aquatic Sciences,* 26(1): 39-47.

Acarlı, S., Lök, A. & Yigitkurt, S. (2012). Growth and survival rates of *Anadara Inaequivalvis* (Bruguiere, 1789) in Homa Lagoon, İzmir (Turkey). *The Israeli Journal of Aquaculture - Bamidgeh,* 64(691): 1-7.

Acarlı, S., Lök, A., Kırtık, A., Acarlı, D., Serdar, S., Kucukdermenci, A., Yigitkurt, S., Yildiz, H. & Saltan, A. N. (2015). Seasonal variation in reproductive activity and biochemical composition of flat oyster (*Ostrea edulis*) in the Homa Lagoon, İzmir Bay, Turkey. *Scientia Marina,* 79(4): 487-495.

Ahmed, K. K. & Hambrey, J. B. (1999). Brush shelter: a recently introduced fishing method in the Kaptai Reservoir fisheries in Bangladesh. *NAGA,* 22: 20-23.

Ahmed, M. D. S. & Akther, H. (2008). Brush and vegetation park fishery in the River Titas, Brahmanbaria, Bangladesh. *South Pacific Studies,* 29(1): 63-71.

Akyol, O. (1999). Demecology of grey mullets (mugilidae) in the Homa Lagoon. Ph.D. Dissertation. Ege University, İzmir, Turkey. 124p.

Amarasinghe, U. S., Amarasinghe, M. D. & Nissanka, C. (2002) Investigation of the Negombo Estuary (Sri Lanka) brush park fishery, with emphasis on commuinity-based management. *Fisheries Management and Ecology,* 9(1): 41-56.

Anis, M. U. M., Ellepola, G. & Ranawana, B. (2015). Brush park fishery targeting ornamental fish in Negombo Estuary, Sri Lanka. *International Journal of Fisheries and Aquatic Studies,* 2(4): 378-381.

Atar, H. H., Ölmez, M., Bekcan, S. & Seçer, S. (2002). Comparison of three different traps for catching blue crab (*Callinectes sapidus* Rathbun 1896) in Beymelek Lagoon. *Turkish Journal of Veterinary and Animal Sciences,* 26(5): 1145-1150.

Atılgan, İ. & Egemen Ö. (2001). A comparative investigation on the levels of carbon, flammable substance and some heavy metals (Cu, Zn) accumulated in Sediment of Güllük and Homa Lagoons. *Ege Journal of Fisheries and Aquatic Sciences,* 18(1-2): 225-232. (In Turkish)

Baran, E. (2005). Cambodian inland fisheries: Facts, figures and context. World Fish Center, Penang, Malaysia and Inland Fisheries Research and Development Institute, Phnom Penh, Cambodia. 49 pp.

Béné, C. & Obirih-Opareh, N. (2009). Social and economic impacts of agricultural productivity intensification: The case of brush park fisheries in Lake Volta. *Agricultural Systems,* 102(1-3): 1-10.

Bilgin, M. & Uluturhan, E.S. (2015). Assessment of heavy metal accumulation in *Mytilus galloprovincialis* and *Tapes decussatus* (Bivalvia) distributed in the Homa Lagoon (İzmir Bay). *Ege Journal of Fisheries and Aquatic Sciences,* 32(1): 1-8. (In Turkish)

Bilgin, M. & Uluturhan-Suzer, E. (2017). Assessment of trace metal concentrations and human health risk in clam (*Tapes decussatus*) and mussel (*Mytilus galloprovincialis*) from the Homa Lagoon (Eastern Aegean Sea). *Environmental Science and Pollution Research,* 24 (4): 4174-4184.

Buffe, J. (1958). Les pecheries en branchages “acadja” des lagunes du Bas-Dahomey. Bois et Forets Tropicales, 59: 19-24.

COFAD, (2002). Back to basics: Traditional inland fisheries management and enhancement systems in Sub-Saharan Africa and their potential for development. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH: Eschborn, Germany. 203p.

Çolak Sabancı, F. & Koray, T. (2010). Four new records for the benthic diatoms (genera Cocconeis, Seminavis, Synedra, and Trachysphenia) from the Aegean Sea. *Turkish Journal of Botany,* 34: 531-540.

Çolak Sabancı, F. (2012). Taxonomic survey of benthic diatoms on natural substrata from coastal lagoon (Aegean Sea, Turkey). *Turkish Journal of Fisheries and Aquatic Sciences,* 12(4): 841-849.

Çolak Sabancı, F., Sapancı, M., Koray, T. & Büyükışık, B. (2011). A qualitative study of the microphytobenthic communities of Homa Lagoon (İzmir-Turkey). *Fresenius Environmental Bulletin,* 20: 346-353.

Costa, H. H. & Wijeyaratne, M. J. S. (1995). The effects of leaving central bare areas in traditional circular brushparks on the yield of fish in the brushpark fishery in Negombo estuary, Sri Lanka. *ECOSET’95 Japan International Marine Science and Technology Federation,* 784-789.

Dagorn, L., Holland, K.N., Restrepo, V. & Moreno, G. (2013). Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? *Fish and Fisheries,* 14(3): 391-415.

Dempster, T. & Taquet, M. (2004). Fish aggregation device (FAD) research: gaps in current knowledge and future directions for ecological studies. *Review in Fish Biology Fisheries,* 14(1): 21-42.

Deveciyan, K. (2006).Türkiye’de Balık ve Balıkçılık. Aras Yayıncılık, İstanbul, Türkiye. 776 s.

Elbek, A.G., Emiroğlu, D. & Saygı, H. (2003). Present status of coastal lagoons in Aegean Region. *Ege Journal of Fisheries and Aquatic Sciences,* 20 (1-2): 173-183. (In Turkish)

FAO. (2007). Non-regulatory management of lagoon and estuarine fisheries. In: Kapetsky, J.M., Some considerations for the management of coastal lagoon and estuarine fisheries. Food and Agriculture Organization of the United Nations, Rome, Italy. FAO Fisheries Technical Paper, (218):47 p. Retrieved on November 16, 2019 from http://www.fao.org/docrep/003/X6855E/X6855E03.htm

Gammanpila, M., Amarasinghe, U. S. & Wijeyaratne, M. J. S. (2016a). Community-Based Management Strategies in The Brush Parks Fishery of Negombo Estuary, Sri Lanka. *Proceedings of the International Postgraduate Research Conference 2016,* IPRC/16/244: 165.

Gammanpila, M., Amarasinghe, U. S. & Wijeyaratne, M. J. S. (2016b). An evaluation of the effect of structural properties of construction materials on the brush parks fishery in the Negombo Lagoon, Sri Lanka. *Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions* 2016: 4-8.

Gammanpila, M., Amarasinghe, U.S. & Wijeyaratne, M.J.S. (2017). Morphological correlates with diet of fish assemblages in brush park fisheries of tropical estuaries. *Environmental Biology of Fishes,* 100(10): 1285-1299.

Gammanpila, M., Amarasinghe, U. S. & Wijeyaratne, M. J. S. (2019a). Dietary guild structure in fish assemblages and trophic position of constituent species in brush parks of a tropical estuary. *Asian Fisheries Science,* 32: 8-18.

Gammanpila, M., Wijeyaratne, M. J. S., Amarasinghe, U. S. (2019b). The dwindling community-based management strategies in the brush park fishery of a tropical estuary: Need for co-management. *Ocean & Coastal Management,* 167: 145-157.

Gomma, A. (2015). A comparative study of the profitability of brush parks in two states in Nigeria. *International Journal of Fisheries and Aquaculture,* 7(10): 160-166.

Guillotreaua, P., Salladarré, F., Dewals, P., & Dagorn, L. (2011). Fishing tuna around fish aggregating devices (FADs) vs. free swimming schools: skipper decision and other determining factors. *Fisheries Research,* 109(2-3): 234-242.

Ho, S.C. (1999). The brush park (Samrah) fishery at the mouth of the Great lake in Kampong Chhnang province, Cambodia. In: "Present status of Cambodia's freshwater capture fisheries and management implications". Annual Meeting of the Department of Fisheries of the Ministry of Agricultre, Forestry and Fisheries, 19-21 January 1999 pp. 67-79.

Kapetsky, J.M. (1981). Some considerations for the management of coastal lagoon and estuarine fisheries. Food and Agriculture Organization of the United Nations, Rome, Italy. *FAO Fisheries Technical Paper,* (218). 47p.

Kaykaç, M. H. & Tosunoğlu, Z. (2015). Artisanal fisheries in Karina and Akköy coastal lagoons. *Ege Journal of Fisheries and Aquatic Sciences,* 32(4): 173-182. (In Turkish)

Kingsford, M. J. (1999). Fish attraction devices (FADs) and experimental designs. Scientia Marina, 63: 181-191.

Köken, S., Ceyhan, T. & Tosunoğlu, Z. (2019). Evaluation of the lagoon fishery on occupational health and safety. Ege Journal of Fisheries and Aquatic Sciences, 36(2): 171-179. (In Turkish)

Lalèyè, P. (2000). Acadja fisheries enhancement systems in Benin: their productivity and environmental impacts. In: "Biodiversity and sustainable use of fish in the coastal zone" (Eds. E.K. Abban, C.M.V. Casal, T.M. Falk and R.S.V. Pullin), ICLARM Conference Proceedings No. 63. International Centre for Living Aquatic Resource Management, Manila, Philippines. pp. 51-52.

Lamberts, D. (2001). Tonle Sap fisheries: A case study on floodplain gillnet fisheries in Siem Reap, Cambodia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. RAP Publication 2001/11. 133 p.

Lök, A., Acarlı, S. & Serdar, S. (2012). Growth performance of different sizes of oysters (*Ostrea edulis* Linne, 1758) placed in the field of Homa (Sufa). *Proceedings of XIII. National Fisheries Symposium. 1-4 September 2005, Çanakkale, Turkey,* pp.34. (In Turkish)

Malone, M. A., Buck, K. M., Moreno, G. & Sancho, G. (2011). Diet of three large pelagic fishes associated with drifting fish aggregating devices (DFADs) in the western equatorial Indian Ocean. *Animal Biodiversity and Conservation,* 34(2): 287–294.

Manna, R. K. & Aftabuddin, M. (2009). Comparative limno-chemical study of brush park (Katal) and macrophyte free area in a wetland of Assam. *Environment and Ecology,* 27(4a): 1796-1800.

Mordoğan, H., Yaramaz, Ö. & Alpbaz, A. (1990). Investigation of concentrations of some heavy metals (Fe, Ni, Co, Mn, Sb) in Homa Lagoon sediments. *Ege Journal of Fisheries Aquatic Sciences,* 8(29-30): 44-50. (In Turkish)

Niyonkuru, C. & Lalèyè, P. A. (2010). Impact of acadja fisheries on fish assemblages in Lake Nokoué, Benin, West Africa. *Knowledge and Management of Aquatic Ecosystems,* 399: 05.

Pikitch, E. K., Santora, C., Babcock, E. A., Bakun, A., Bonfil, R., Conover, D. O., Dayton, P., Doukakis, P., Fluharty, D. & Heneman, B. (2004). Ecosystem-based fishery management. *Science,* 305: 346-347.

Pulat, I. & Özel, İ. (2003). The plankton fauna of the northern lagoonary system of İzmir Bay. *Ege Journal of Fisheries and Aquatic Sciences,* 20(3-4): 399-403. (In Turkish)

Rosetto, L. (2001). The management of fishery in the Lagoon of Venice. *IIFET 2000 Proceedings,* 1-10.

Rupasinghe, J. W. & Asanthi, H. B. (2007). Socio-economic status of brush park fishing communities in Negombo Estuary and Rekawa Lagoon in Sri Lanka. *Proceedings of the 25th Anniversary Scientific Conference of NARA on Tropical Aquatic Research Towards Sustainable Development, 15-16 February 2007, Colombo, Sri Lanka,* pp.94.

Senanayake, F.R. (1981). The athkotu (brush-park) fishery of Sri Lanka. *ICLARM Newsletter,* 4: 20-21.

Serdar, S., Lök, A., Köse, A., Yıldız, H., Acarlı, S. & Goulletquer, P. (2007). Growth and survival rates of carpet shell clam (*Tapes decussatus* Linnaeus, 1758) using various culture methods in Sufa (Homa) Lagoon, İzmir, Turkey. *Aquacultural Engineering,* 37(2): 89-99.

Sevgi, S. & Uluturhan Suzer, E. (2019). Assessment of Hg, Cd, Pb and Cr accumulations in razor clam (*Solen marginatus*) from the Homa Lagoon. *Ege Journal of Fisheries and Aquatic Sciences,* 36(1): 31-39. (In Turkish)

Solarin, B. B. & Udolisa, R. E. K. (1993). An investigation of brush park fishing in Lagos lagoon, Nigeria. *Fisheries Research,* 15(4): 331-337.

Stauch, A. (1966). Le bassin Camerounais de la Benoue et sa peche. Orstom, Paris. 152p.

Sugunan, V., Welcomme, R., Béné, C., Brummett, R. & Beveridge, M. (2007). Inland fisheries, aquaculture and water productivity. In: Molden, D. (Ed.), Water for Food, Water for Life-Comprehensive Assessment for Agricultural Water. Earthscan, London, pp. 459–484.

Sunlu, U. & Egemen, Ö. (1998). Homa Lagoon and the Gulf of Izmir (Aegean Sea) Investigation of heavy metal pollution levels in some fish species by economic conditions in different regions. *Ege Journal of Fisheries and Aquatic Sciences,* 15(3-4): 241-261. (In Turkish)

Taş, E. Ç., Ergen, Z. & Sunlu, U. (2009). Investigation of heavy metal levels (Cd, Cu, Pb, Zn, Cr, Fe) in Hediste diversicolor and in their habitat sediment collected from Homa Lagoon (Izmir Bay) between 2002-2004. *Ege Journal of Fisheries and Aquatic Sciences,* 26(3): 179-185.

(In Turkish)

Tosunoğlu, Z. & Ünal, V. (2012). Management of lagoon systems: A case of Homa Lagoon Turkey. *FAO Subregional Office for Central Asia (SEC). Regional Training on the Aquaculture Production Systems Including Cage Culture. 2-5 October 2012, İzmir, Turkey,* pp. 342.

Tosunoğlu, Z., Ünal, V., Korkut, A. Y. , Özden, O. & Önen, M. (2013). Towards sustainable management of the last lagoon Homa of the İzmir Bay Aegean Sea Turkey. *Proceedings of the First International Fisheries Symposium, Turkish Republic Northern Cyprus, 24-27 March 2013, Girne, Cyprus.*

Uddin, K. B., Basak, S. S., Moniruzzaman, M., Islam, A. K. M. S. & Mahmud, Y. (2015). Impact of brush shelter - A fish aggregating device (FAD) on the production potentiality of Kaptai Lake in Bangladesh. *World Journal of Fish and Marine Sciences,* 7(4): 288-294.

Uddin, K. B., Islam, A. K. M. S., Basak, S. S., Rahman, M. M., Bashar, M. A. & Mahmud, Y. (2014). Species composition and abundance of fishes in the brush shelter fishery of Kaptai Lake. *Bangladesh Research Publication Journal,* 10(3): 233-237.

Uluturhan, E., Darılmaz, E., Kontas, A., Bilgin, M., Alyuruk, H., Altay, O. & Sevgi, S. (2019). Seasonal variations of multi-biomarker responses to metals and pesticides pollution in *M. galloprovincialis* and *T. decussatus* from Homa Lagoon, Eastern Aegean Sea. *Marine Pollution Bulletin,* 141: 176-186.

Uluturhan, E., Kontaş A. & Can, E. (2011). Sediment concentrations of heavy metals in the Homa Lagoon (Eastern Aegean Sea): Assessment of contamination and ecological risks. *Marine Pollution Bulletin,* 62: 1989–1997.

Ünsal, S., Büyükışık, B. & Akyol, O. (2000). Discussions on the primary results of the sea parameters in Homa Lagoon (İzmir Bay, Aegean Sea). *Ege Journal of Fisheries and Aquatic Sciences,* 17: 85-94. (In Turkish)

Wahab, M. A. & Kibria, K. G. (1994). Katha and kua fisheries-unusual fishing methods in Bangladesh. *Aquaculture News,* 18: 24.

Welcomme, R. L. (2002). An evaluation of tropical brush and vegetation park fisheries. *Fisheries Management and Ecology,* 9(3): 175-188.

Welcomme, R. L. (2005). Traditional brush park fisheries in natural waters. In: Azim, M.E., Verdegem, M.C.J., van Dam, A.A., Beveridge, M.C.M. (Eds.), Periphyton: Ecology, Exploitation and Management. CABI Publishing, Oxfordshire, UK. pp. 140-158.

Welcomme, R. L. (1971). A description of certain indigenous fishing methods from Southern Dahomey. *African Journal of Tropical Hydrobiology and Fisheries,* 2: 128-140.