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IMPACTS OF MARINE FISHING BAN ON THE ECOLOGY OF HILSA IN THE NIJHUM DWIP SEASCAPE IN BANGLADESH

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Keywords: Fishing ban, ecological impact, water quality, hilsa shad, length-weight

Abstract

Bangladesh government has imposed a 65-day marine fishing ban since 2015 to conserve marine fisheries, particularly to boost hilsa (*Tenualosa ilisha*) production. However, the ecological impacts of the marine fishing bans on water quality and hilsa's growth are not assessed yet. Thus, this study aims to contribute here using data from coastal waters and fish from pre-contacted fishers in the Nijhum Dwip seascape during and outside the fishing ban in 2021 – 2022. Data were analyzed using R software. The measured mean dissolved oxygen, temperature, pH, electrical conductivity, total dissolved solids, and transparency of the sample water were 7.1 ± 1.13 mg/l, 31.1 ± 0.71°C, 8.45 ± 0.07, 40000 ± 2828 µS/cm, 18000 ± 1414 mg/L and 63.5 ± 2.12 cm at 1 week prior to the ban ends (July) and 8.45 ± 0.21 mg/l, 22.35 ± 0.49°C, 8.45 ± 0.07, 20500 ± 1060.66 µS/cm, 10350 ± 212.13 mg/l and 63.5 ± 7.78 cm before the ban starts (February). The values might be varied due to seasonal differences. The mean length (38 cm) and weight (601 g) of sampled hilsa during the ban period were comparatively larger than the mean length (29 cm) and weight (229 g) of hilsa which were sampled during the outside fishing ban period. Therefore, this study concludes that the marine fishing ban has positive impact on the growth and size of hilsa. This study suggests that further research is required to assess the fishing ban's impact on the growth and production of other coastal and marine fish species across the Bay of Bengal.

Introduction

The marine fisheries sector of Bangladesh has substantially contributed to national fish production, the country's economic returns, and employment opportunities for coastal fishing communities. In the 2020-2021 fiscal year, this sector contributed to 6,81,239 metric tons of fish which is 14.74% of the country's total fish production[(1)]. From the coastal and marine waters of Bangladesh, some particular fish species like hilsa (*Tenualosa ilisha*), the flagship fish species, are harvested largely as it has high market demands in national and international markets[(2)]. Hilsa constitutes the largest single-species fishery in Bangladesh, constituting 12.2% of the total catch, accounting for more than 1% of the total GDP, and employing 3 million fishers directly or indirectly in the country [(1)]. However, overexploitation and indiscriminate use of different fishing gear are adversely affecting the sector.

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Till now, to halt or reverse the declining trend of fisheries production, the government of Bangladesh has taken many types of management actions such as spatial (e.g. sanctuary, marine protected area), temporal (e.g. marine fishing ban in May - July), input (e.g. fishing gear ban and net mesh size limit) and output (e.g. fish size and species ban) controls[(1)]. Some studies reported that the fishing bans are effective in improving the ecological conditions significantly, especially the biodiversity of both commercially and ecologically important fish and shellfish would increase resulting in higher fish catch in the coastal and marine waters[(3,4,5,6)]. Thomas and Dineshbabu[(3)] found that there is an enhancement in the spawning populations during the post-ban period and the recruitment was high following the ban season, which indicates that the trawling ban helps to retain a healthy proportion of spawning population. The ecological impacts of the temporal fishing ban are proven to contribute substantially to future stock regeneration as reported by the 15/22 days fishing ban to protect hilsa spawning[(5,6)]. Through creating positive ecological impacts, the fishing ban has created net social and economic benefit of the resource-dependent fishers[(7)] which in turn contribute directly and indirectly to United Nation's sustainable development goals (SDGs) 1, 2, and 14[(8)].

The government of Bangladesh has imposed a 65-day marine fishing ban since 2015 to conserve marine fisheries, particularly to boost hilsa fisheries production[(9)]. Like other countries, Bangladesh has so far declared three marine protected areas (MPAs), one of which is the Nijhum Dwip marine reserves to ensure sustainable management of the marine system as well as to meet the Aichi targets of the Convention on Biological Diversity (CBD) and the targets of Sustainable Development Goal 14 (Life Below Water)[10]. The most important role of the Nijhum Dwip MPA is to safeguard the Hilsa shad's migration routes and highest priority spawning grounds[10]. However, there has no study to assess the ecological impacts of the 65 days marine fishing ban in the Nijhum dwip seascape though it is very important for Hilsa production[(5,6)]. It is now time to assess and produce evidence based on real data to assess whether the marine fishing bans create any impact on water quality and fishes, especially on hilsa in the Nijhum dwip seascape. So, the study aims to assess the ecological impacts of the 65 days marine fishing bans on water quality and growth of hilsa in the Nijhum Dwip seascape in Bangladesh.

Materials and Methods

Study Sites Selection: For this study, an initial scoping study was conducted to select ecological sampling sites. Two sampling stations (S1 and S2) in the Nijhum Dwip seascape were selected for water sampling where 65 days fishing bans have been implemented since 2015 and two sampling stations (S3 and S4) were selected for fish sampling (Fig. 1).

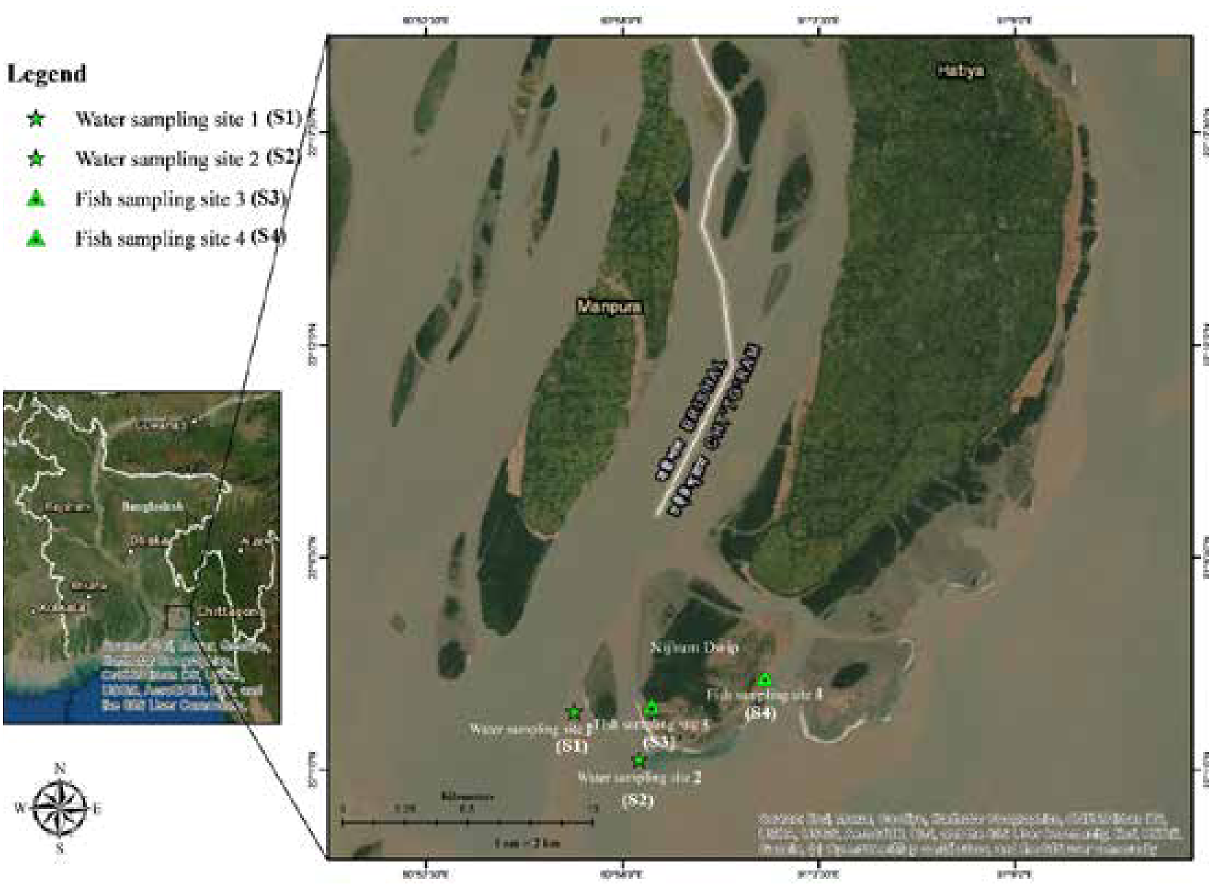

Fig. 1. Ecological study sites (S1 and S2 for water sampling and S3 and S4 for fish sampling) in the Nijhum Dwip seascape, Hatiya Upazila, Noakhali.

Data collection: Water quality data: In this study, water quality variables such as dissolved oxygen (DO) (mg/l), temperature (°C), pH, total dissolved solids (TDS) (mg/l), electrical conductivity (EC) (µS/cm), and transparency (cm) were measured before fishing ban starts and 1 week prior to the end of the 65 days fishing bans from the two selected stations (Fig. 1). DO was measured on spot by Hanna DO-5510 instrument and pH, EC, TDS, and temperature were measured by HI9811-5 instrument. A Secchi disk was used to measure the transparency of the water in each site. A weight was attached to the Secchi disk while measuring the transparency.

Hilsa length-weight data: Fishers in Nijhum Dwip usually bring their catch in Namar Bazar (S3) and Bondortila Ghat (S4) (Fig. 1). In this study, hilsa samples were collected toward the end of the fishing season February 2022 (i.e. before the fishing ban starts) and 1 week prior to the end of the fishing ban July 2021 from two sampling sites of S3 and S4 adjacent to the Nijhum Dwip seascape (Fig. 1). Total length and weight of all individuals were measured and recorded carefully.

Data analysis: Descriptive statistics were used to analyze water quality and fish length-weight data. Hilsa length-weight relationship was measured following the methods of Le Cren[11]:

$W = aL^b$

Where W = weight of fish, L = length of fish, a = constant (intercept) and b = an exponent indicating isometric growth when equal to 3

Moreover, the degree of the well-being of the fish in their habitat was determined following the method of Le Cren[11]:

$K_n = W/W^a$

Where K_n = relative condition factor, W = observed weight and W^a = calculated weight.

R software (version 4.1.3) was used to perform two-way ANOVA and chi-squared tests. Analyzed data were presented in tabular and graphical forms.

Results and Discussion

*Water quality variables: T*his study found that the measured mean DO, temperature, pH, EC, TDS, and transparency of the sample water were 7.1 ± 1.13 mg/l, 31.1 ± 0.71°C, 8.45 ± 0.07, 40000 ± 2828 µS/cm, 18000 ± 1414 mg/l and 63.5 ± 2.12 cm at 1 week prior to the ban ends and 8.45 ± 0.21 mg/l, 22.35 ± 0.49°C, 8.45 ± 0.07, 20500 ± 1060.66 µS/cm, 10350 ± 212.13 mg/l and 63.5 ± 7.78 cm before the ban starts, respectively (Table 1).

Table 1. Water quality variables of two sampling sites at 1 week prior to the ban ends and before the ban starts in the Nijhum Dwip seascape.

Sampling time	Sampling sites	Value of water quality variables					
		DO (mg/L)	Temp. (°C)	pH	EC (µS/cm)	TDS (mg/L)	Transparency (cm)
1 week prior to ban ends, July 2021	S1	7.9	30.6	8.5	38000	17000	65
	S2	6.3	31.6	8.4	42000	19000	62
Mean ± SD		7.1 ± 1.13	31.1 ± 0.71	8.45 ± 0.07	40000 ± 2828	18000 ± 1414	63.5 ± 2.12
Before ban starts, February 2022	S1	8.3	22.0	8.5	20700	10200	69
	S2	8.6	22.7	8.4	21200	10500	58
Mean ± SD		8.45 ± 0.21	22.35±0.49	8.45 ± 0.07	20500 ±1060.66	10350 ± 212.13	63. 5± 7.78

DO, is an important ecological component that helps determine the overall health of water bodies and maintains a healthy ecosystem for aquatic life[12]. The present study showed that DO levels in marine water change with changing water temperature. The relation between DO and temperature is significant in this study since cold water holds much DO and vice-versa which supported the study by Barnett *et al.*[(13)] and Sharma *et al.*[(14)]. Bhuyan *et al.*[(15)] assessed the water quality in the Meghna river estuary and reported that during monsoon, the lowest DO was 1.5 mg/L at Sandwip and the highest DO was 2.8 mg/l at Chandpur. In another study, the lowest level of DO (5.37 - 11.66 mg/l) was recorded during the summer season in the Meghna river estuary, whereas the highest value (8.6 - 13.42 mg/l) was reported in winter (16) The findings of the present study are in line with Bhuyan *et al.*[(14)] and Rahman *et al.*[(16)].

Water temperature is one of the most significant external elements that can affect the survival of aquatic life[(17)]. Aken[(18)] reported that the dissolution-precipitation, adsorption-desorption, oxidation-reduction, and physiology of the biotic community in an aquatic environment are influenced by water temperature. This study has found higher mean water temperature which was 31.1 ± 0.71 °C during 1 week prior to the ban ends in July 2021 (rainy season) and lower mean water temperature which was 22.35 ± 0.49°C before the ban started in February 2022 (late winter season). The temperature variation might be occurred due to the seasonal variation as sampling was done during two different seasons. Rahman *et al.*[(16)] reported that the average water temperature were 26.5°C in the Meghna river estuary area. In the Bay of Bengal, the usual water temperature ranges from 25 to 30°C throughout the year[(19)]. Samsad *et al.*[(19)] observed the maximum sea surface temperature (SST) anomalies were noticed (1.5 to 2°C) in January, February, May and September which supports the recorded temperature values of the present study.

The pH in estuaries fluctuates from 7.8 to 8.3 because of the buffering capability of seawater[(20)]. The mean pH in the present study was 8.45 ± 0.07 in both times before the ban starts and before the ban ends which indicated that the water in the fishing ban area is slightly alkaline. As higher primary production is stimulated by alkaline water[(21)], the 65 days fishing ban has a positive impact on water pH. Bhuyan *et al.*[(15)] reported that the maximum concentration of pH (7) was found at Sandwip and Hatiya while the minimum (6.5) was recorded at Bhola and Chandpur which partially supports the findings of the present study.

The EC indicates the presence of overall ions in the water. In this study, the mean EC were 40000 ± 2828 μS/cm and 20500 ± 1060.66 μS/cm during the fishing ban period and during the fishing period, respectively. Whereas, TDS (Total Dissolved Solid) shows the combined total of inorganic and organic substances in water[(22)]. The mean TDS were 18000 ± 1414 mg/l and 10350 ± 212.13 mg/l observed during the fishing ban period and during the fishing period, respectively. In the present study, there was a positive correlation (correlation coefficient, r = 0.98) found between EC and TDS (i.e. values of EC increase with values of TDS) which supports the study by Essien-Ibok *et al.*[(23)] and Alam *et al.*[(24)]. In the

Rupsha river, the values of EC and TDS were 16705 μS/cm and 8638 mg/l, respectively[25] which were lower compared to the findings of the present study, because the water of the Nijhum Dwip seascape is more saline compare to the water of the Rupsha river. On the contrary, a negative correlation was found between TDS and transparency. Some studies mentioned that the presence of phytoplankton was increased as a result of the increased transparency[26,27,28]. The secchi depth found by Bhuyan *et al.*[15] was lower than the recorded value in the current study.

However, assessment of water quality is critical for determining the quality of an ecosystem, which has a large impact on the occurrence of aquatic organisms[29]. The recorded values of water quality variables might be varied mainly due to seasonal variations. TDS and EC values were lower during the fishing period which might be occurreds due to human interfernces during this period. Overall, this study found that the marine fishing ban in the Nihjum dwip seascape does not have so much impact on the water quality variables.

Hilsa length-weight relationship: This study found that 65 days marine fishing ban has a positive impact on hilsa production. Table 2 showed that the mean length and weight of sampled hilsa during fishing ban periods were comparatively larger than the mean length and weight of hilsa that was sampled during the fishing period (before the ban starts). This might have happened because of fishing restrictions. This study found a strong relationship between body length and body weight of sampled hilsa fish species (coefficient of determination, $r^2 = 0.9821$) (Fig. 2).

Table 2. Length and weight of Hilsa, Tenualosa ilisha, sampled from two sites at 1 week prior to the ban ends and before the ban starts in the Nijhum Dwip seascape.

Sampling time	Sampling sites	Length (cm)		Weight (g)	
		Mean ± SD	Range	Mean ± SD	Range
1 week prior to ban ends, July 2021	Namar Bazar	37.2 ± 3.7	31.0-52.0	565.0 ± 171.4	309-1543
	Bondortila	38.9 ± 4.5	32.0-51.5	667.5 ± 257.1	324-1570
	Combined	37.7 ± 4.0	31.0-52.0	601.2 ± 211.2	309-1570
Before ban starts, February 2022	Namar Bazar	31.4 ± 1.5	30.5-33.5	274.3 ± 44.9	248-340
	Bondortila	26.4 ± 2.3	24.5-31.5	193.2 ± 60.1	150-339
	Combined	28.6 ± 3.2	24.5-33.5	228.7 ± 66.8	150-340

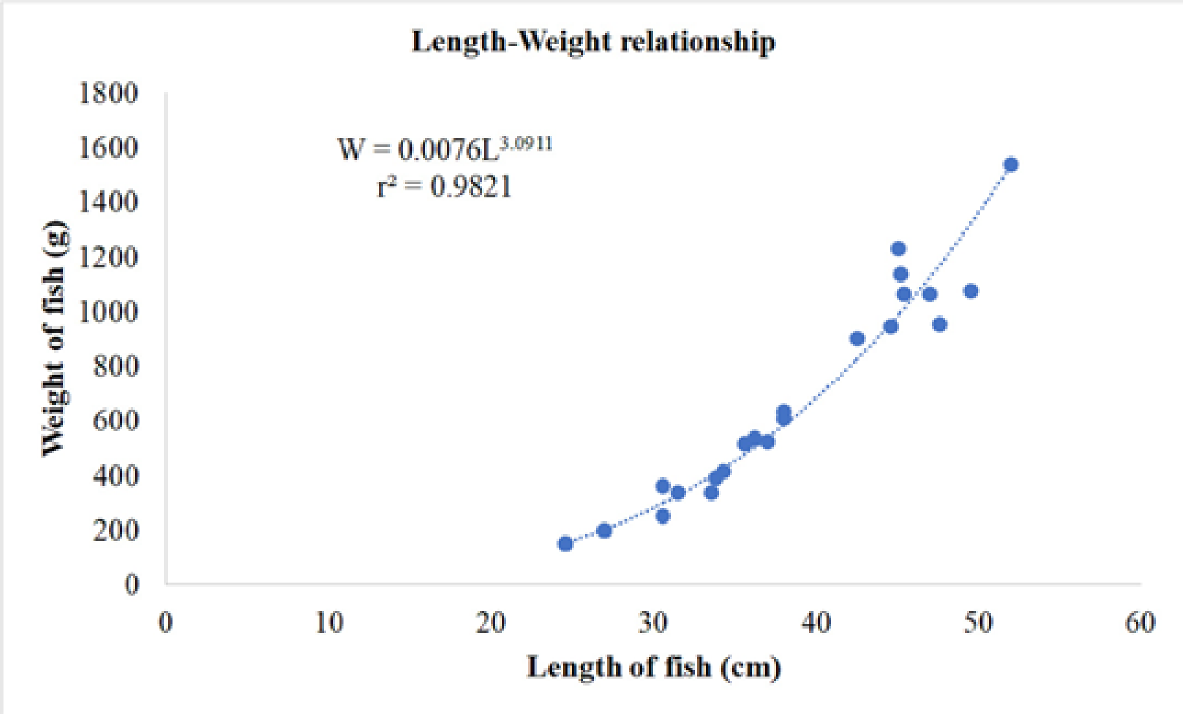

Fig. 2. Length-weight relationship of sampled hilsa fish species collected from two sites at 1 week prior to the ban ends and before the ban starts adjacent to the Nijhum Dwip seascape.

From the length-weight relationship, this study found positive allometric growth (b = 3.0911) of the sampled hilsa (Fig. 2). Amin *et al.*(30) reported that when the growth is isometric, the b value will be exactly 3. Flura *et al.*(31) reported that the value of b varies not just between species, but also between stocks of the same species based on sex, maturity, seasons, and even time of day due to variations in stomach fullness.

Relative condition factor is a valuable indicator for evaluating feeding intensity, age, and growth rates in fish(32). As reported by Abobi and Ekau(33), the relative condition factor specifies the fish's level of well-being and reflects some information on the fish's physiology through changes. It is considered that the greater the value of the relative condition factor, the better the fish's state of wellbeing. In the present study, the average relative condition factor, K_n was higher than 1 (K_n = 1.0281) indicating the robustness or wellbeing of sampled hilsa fish. Nima *et al.*(34) were also reported a similar finding stating that K_n values for hilsa ranged between 0.99-1.01 in the Meghna river.

From the Fig. 3, it is seen that there is a larger abundance of hilsa > 30 cm caught during the ban period when compared with the fishing period which is corroborated by the results of the two-way ANOVA which results in weight being significantly dependent by the time of year (p = 3.99e-07) caught, meaning that the null is rejected. The site was shown to have no significance in the weight or length variables as confirmed by the chi-squared test for independence yielding a $p > 0.05$. Fig. 3 gives us an understanding of the size of fish being caught with the average size during the ban being > 500 g and during the fishing period < 200 g. This, alongside the results representing the productivity of the two sites sampled, leads us to believe that the ban period provided a significant buffer/renewal period for the hilsa stock.

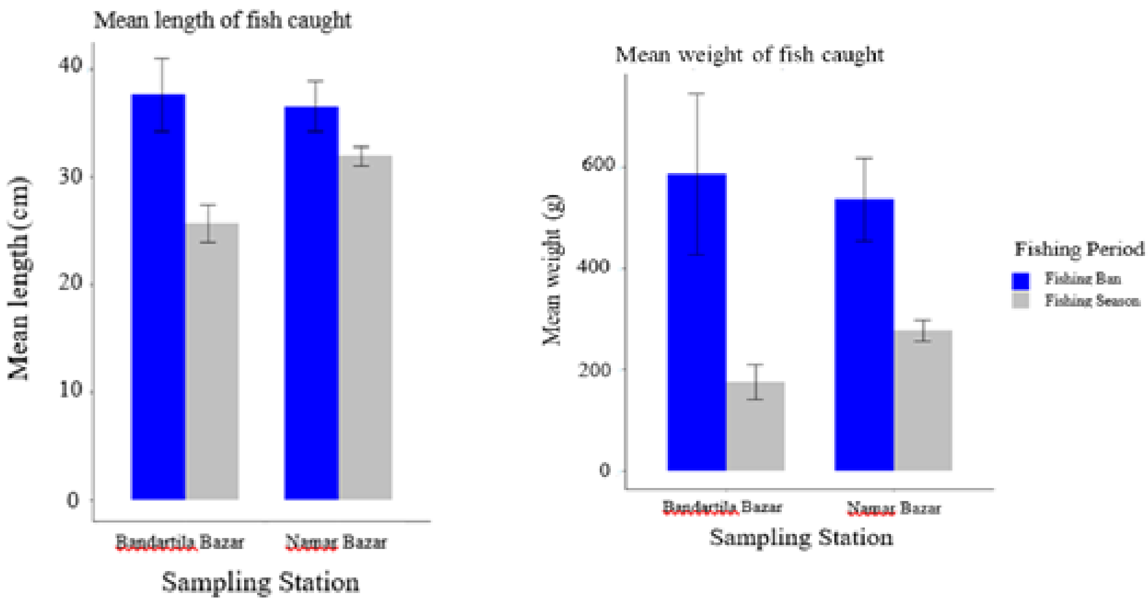

Fig. 3. Mean length and weight of collected hilsa from sampling sites of coastal waters, Nijhum Dwip seascape.

Based on the findings, this study found that the 65 days ban period is having a positive impact on the size of the hilsa stock and as such large individuals are carrying into the start of the fishing period. The findings of the present study are supported by Rahman *et al.*[5,6] who reported that 15/22 days fishing ban in the major spawning grounds of hilsa is very effective and helpful for hilsa spawning and *jatka* production. A higher percentage of hilsa with length group greater than 35 cm was observed in the downstream areas of Monpura and Hatiya which support the finding of the present study[6]. Another study reported that during the post-ban period, the spawning populations of *Nemipterus japonicus*, *N. randalli*, and *Metapenaeus monoceros* all got better as well as in the case of *Saurida tumbil*, recruitment was higher after the ban season, which shows that recruitment got better for a short time after the ban period[3].

The present study sheds light on catch data provided by the small-scale fishermen in Nijhum Dwip seascape and to account for bias and the difference in the effort used when collecting the data, a random sample of 29 measurements was taken from the ban period to match with data length taken in 2022 for the fishing period. This allowed for a more even spread of the data and gave comparatively new insight into how the fisheries sector is coping.

Hence, from the above discussion, it could be concluded that the marine fishing ban is more effective for the growth of hilsa. So, the fishing ban should be continued in order to ensure long-term hilsa reproduction and to reduce *jatka* harvesting, which in turn contribute to SDGs 14. By ensuring long-term hilsa production, the fishing ban can improve the socio-economic condition of hilsa fishers which ultimately directly and indirectly contribute to SDGs 1 and 2[(8)].

The findings of the study indicate that the marine fishing ban might have positive impacts on the abundance and maintenance of other coastal and marine fish species biodiversity. So, the impact of fishing ban on the growth and production of other fish species needs to be assessed. This study suggests that further research should be focused on ensuring the same catch per unit effort. Future surveys should encompass longer trips, i.e. 1 week, with multiple sampling locations to reduce the standard deviation seen in the means. This paper provides key results that illuminate the reality across the country's small-scale fisheries that the ban period is a step in the right direction and is vital to maintaining successful future stocks.

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References

1. DoF 2022. National Fish Week 2020 Compendium (in Bangla). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, pp. 160.
2. Islam MM, EY Mohammed and L Ali 2016. Economic incentives for sustainable hilsa fishing in Bangladesh: An analysis of the legal and institutional framework. Mar. Policy. **68**: 8-22.
3. Thomas S and AP Dineshbabu 2014. Impact of trawl fishing ban on stock renewal of some demersal resources off Mangalore Coast, Eastern Arabian Sea. *In*: second International Symposium on Marine Ecosystem: Challenges and Opportunities, Marine Biological Association of India, Kochi, pp. 2-5.
4. Nahiduzzaman M, Islam MM and Wahab MA 2018. *In*: Nishat B, S Mandal and G Pangare (Eds), Conserving Ilish, Securing Livelihoods: Bangladesh-India Perspectives. Impacts of Fishing Bans for Conservation on Hilsa Fishers' Livelihoods. Challenges and Opportunities. Academic Foundation, The International Water Association, pp. 62-68.
5. Rahman MA, Flura, T Ahmed, MMH Pramanik and MA Alam 2015. Impact of fifteen days fishing ban in the major spawning grounds of hilsa (*Tenualosa ilisha* Hamilton 1822) on its spawning success. Res. Agric. Livest. Fish. **2**(3): 491–497. https://doi.org/10.3329/ralf.v2i3.26173.

6. Rahman MA, MMH Pramanik, AT Flura, MM Hasan, MH Khan and Y Mahmud 2017. Impact assessment of twenty-two days fishing ban in the major spawning grounds of *Tenualosa ilisha* (Hamilton, 1822) on its spawning success in Bangladesh. J. Aquac. Res. Dev. **8**(6): 1-12. https://doi.org/10.4172/2155-9546.1000489.

7. Narayanakumar R, J Jayasankar, SS Shyam, U Ganga and E Vivekanandan 2017. Economic valuation of net social benefit of seasonal fishing ban in selected maritime states of India. Indian J. Fish. **64**(3): 85-92.

8. UN (United Nations) 2015. Sustainable Development Goals (SDGs). United Nations. www. https://sdgs.un.org/goals (accessed 18 April 2022).

9. MoFL (Ministry of Fisheries and Livestock) 2015. Circular SRO No 97-Law/2015. Bangladesh Gazette (Extra). Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh, Dhaka.

10. DoF (Department of Fisheries) 2019. National Fish Week 2020 Compendium (in Bangla). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, pp. 160.

11. Le Cren ED 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol. **20**(2): 201-219.

12. Chang H 2005. Spatial and temporal variations of water quality in the Han River and its tributaries, Seoul, Korea, 1993-2002. Water. Air. Soil Pollut. **161**: 267-284. https://doi.org/10.1007/S11270-005-4286-7.

13. Barnett T, R Malone, W Pennell, D Stammer, B Semtner and W Washington 2004. The effects of climate change on water resources in the West: introduction and overview. Clim. Change **62**: 1-11. https://doi.org/10.1023/B:CLIM.0000013695.21726.B8.

14. Sharma RK and V Rathore 2000. Pollution ecology with reference to commercially important fisheries prospects in rural-based water body: The Lake Sarsai Nawar, Etawah (Uttar Pradesh). Pollut. Res. **19**: 641-644.

15. Bhuyan MS, MA Bakar, A Akhtar, MB Hossain and MS Islam 2017. Analysis of water quality of the Meghna River using multivariate analyses and RPI. J. Asiat. Soc. Bangladesh Sci. **43**: 23-35. https://doi.org/10.3329/jasbs.v43i1.46241.

16. Rahman MS, ASS Ahmed, M Rahman, OF Babu, S Sultana, SI Sarker, R Awual, MM Rahman and M Rahman 2021. Temporal assessment of heavy metal concentration and surface water quality representing the public health evaluation from the Meghna River estuary, Bangladesh. Appl. Water Sci. **11**: 1-16. https://doi.org/10.1007/s13201-021-01455-9.

17. O'Connor MI, JF Bruno, SD Gaines, BS Halpern, SE Lester, BP Kinlan and JM Weiss 2007. Temperature control of larval dispersal and the implications for marine ecology, evolution, and conservation, in: Proceedings of the National Academy of Sciences of the United States of America, pp. 1266-1271. https://doi.org/10.1073/pnas.0603422104.

18. Aken HM van 2008. Variability of the water temperature in the western Wadden Sea on tidal to centennial time scales. J. Sea Res. **60**: 227-234. https://doi.org/10.1016/J.SEARES.2008.09.001.

19. Shamsad M, MA Farukh, MJR Chowdhury and SC Basak 2012. Sea surface temperature anomaly in the Bay of Bengal in 2010. J. environ. sci. nat. resour. **5**(2): 77-80.

20. Millero FJ 1986. The pH of estuarine waters. Limnol. Oceanogr. **31**: 839-847. https://doi. org/10.4319/lo.1986.31.4.0839.

21. Kumar PM and C Prabhahar 2012. Physico-chemical parameters of river water: A review. Int. J. Pharm. Biol. Arch. **3**: 1304-1312.

22. Wilson JM, Y Wang, SM Asce, JM Vanbriesen and M Asce 2014. Sources of High Total Dissolved Solids to Drinking Water Supply in Southwestern Pennsylvania. J. Environ. Eng. **140**(5): B4014003. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000733.

23. Essien-Ibok MA, AW Akpan, MT Udo, LA Chude, IA Umoh and IE Asuquo 2010. Seasonality in the physical and chemical characteristics of Mbo River, Akwa Ibom State, Nigeria. Niger. J. Agri. Food Environ. **6**(1): 60-72. 23.

24. Alam MT, MA Hussain, S Sultana, MT Hasan, MZ Haque, KD Simon and SK Mazumder 2015. Water quality parameters and their correlation matrix: a case study in two important wetland beels of Bangladesh. Cien. e Tec. Vitivin. **30**: 463-89.

25. Islam MS, SC Mohanta, MAB Siddique, M Abdullah-Al-Mamun, N Hossain and UH Bithi 2018. Physico-chemical assessment of water quality parameters in Rupsha river of Khulna region, Bangladesh. Int. J. Eng. Sci, **7**(1).

26. Ezra AG 2000. A study of planktonic algae in relation to the physicochemical properties of some freshwater ponds in Bauchi. Nigeria, Niger. J. Exp. App. Biol. **1**: 55-60.

27. Venkateswarlu N and PM Reddy 2000. Plant Biodiversity and Bioindicators in Aquatic Environment, ENVIRO NEWS Aug-Sep.4., Int. J. Pharma. Biol. Arch. **3**: 1304-1312.

28. Haruna AB, KA Abubakar and BMB Ladin 2006. An assessment of physicochemical parameter and productivity status of Lake Geriyo, Yola Adamawa State, Nigerian. Best J. **3**: 18-23.

29. Chang H 2008. Spatial analysis of water quality trends in the Han River basin, South Korea. Water Res. **42**: 3285-3304. https://doi.org/10.1016/J.WATRES.2008.04.006.

30. Amin SM, A Arshad, SS Siraj and BJ Sidik 2009. Population structure, growth, mortality and yield per recruit of segestid shrimp, *Acetes japonicus* (Decapoda: Sergestidae) from the coastal waters of Malacca, Peninsular Malaysia. Indian J. Mar. Sci. **38**(1): 57-68.

31. Flura MZ, BS Rahman, MA Rahman, M Ashraful, M Alam and MH Pramanik 2015. Length-weight relationship and GSI of hilsa, *Tenualosa ilisha* (Hamilton, 1822) fishes in Meghna river, Bangladesh. Int. J. Nat. Soc. Sci. **2**(3): 82-88.

32. Ndimele PE, KCA Johnson, NF Aladetohu and OA Ayorinde 2010. Lengthweight relationship, condition factor and dietary composition of *Sarotherodon melanotheron*, Ruppell, 1852 (Pisces: Cichlidae) in ologe lagoon, lagos, Nigeria. Agric. Biol. J. North. Am. **1**(4): 584-590.

33. Abobi SM and W Ekau 2013. Length-weight relationships and condition factors of *Alestes baremoze*, *Brycinus nurse* and *Schilbe intermedius* from the lower reaches of white volta river (Yapei), Ghana. Int. J. Fish. Aquac. **5**(6): 152-165.

34. Nima A, M Hossain, M Rahman, Z Mawa, M Hasan, M Islam, S Tanjin, W Sabbir, M Bashar and Y Mahmud 2020. Temporal variations of length, weight, and condition of Hilsa shad, *Tenualosa ilisha* (Hamilton, 1822) in the Meghna River, Southeastern Bangladesh. Egypt. J. Aquat. Biol. Fish. **24**(2): 481-94.

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