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Research for development: evidence-based hilsa management improvements in Myanmar

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The hilsa (*Tenualosa ilisha*) fishery in Myanmar is of importance as it provides an income for around 1.6 million artisanal low-income fisher households and generated USD 237.32M in export earnings from 156,000 metric tons in 2021. Fisheries Performance Indicator assessments have shown that the fishery, both artisanal and industrial, is close to economic collapse. Research was undertaken to find ways to improve the management of the fishery including studies to establish the migration routes and spawning periodicity of hilsa in addition to socioeconomic assessments and business case valuations to recommend finance mechanisms for improved management and maintenance of the fishery. Results indicate that the closed season for hilsa fishing misses the main spawning period in September. In addition, the chemical analysis of hilsa otoliths shows the importance of upstream spawning grounds – some 800km from the sea. Recommendations were made, and enacted March 2022, regarding the need for a new September closed season in addition to no-take hilsa sanctuaries along the main migration routes. A value was placed on the hilsa fishery at close to USD800M per annum. A USD100M annual investment cost is suggested to ensure that the new and old closed seasons are respected by licensed and unlicensed fishers. This investment could be generated by recommended fiscal reforms to provide incentives for fishers to respect the new fishing restrictions. Transboundary fisheries management opportunities are being advanced by informal tripartite scientific collaboration between Bangladesh, India and Myanmar. Social aspects, involving fisheries co-management with artisanal fisher communities and local government authorities, need to be continued to demonstrate the benefits of improved fisheries management in terms of the expected sustainable yields and a move away from potential economic fishery collapse.

KEYWORDS

value, artisanal, hilsa, fisheries management, closed seasons, sanctuaries

1 Introduction

The Darwin Initiative[1] project entitled 'Carrots and sticks: incentives to conserve hilsa (*Tenualosa ilisha*) fish in Myanmar' was implemented in country from April 2017 to March 2021. The International Institute for Environment and Development (IIED) led the project in collaboration with the Myanmar Department of Fisheries; WorldFish; Network Activities Group (NAG); and University of Yangon Zoology Department. Scotland's Rural College (SRUC) assisted with incentive-based management work. Researchers from Charles Sturt University Australia conducted hilsa otolith chemical analyses to test for Barium (rich in freshwater) and Strontium (rich in saltwater) to determine fish migrations and whether there may be a landlocked hilsa stock as suggested in Bangladesh.

Comments from artisanal fisherfolk regarding the decline in landings, with an associated reduction in average size of fish caught, provided the justification for an analysis of this decline. A relatively new Fisheries Performance Indicator (FPI) assessment described by (Anderson et al., 2015) was used in conjunction with the research funded by the Darwin initiative. Furthermore, the fact that the hilsa fishery is transboundary, with significant catches in Bangladesh and India, justified the research into the performance of the artisanal sector of the hilsa fishery in Myanmar with FPI work findings for both the artisanal and industrial fisheries in the country on the premise that the health of the fishery in one country will have an impact on neighbouring countries.

In Myanmar there is one overall closed fishing season lasting three months May-July, this is not species specific in freshwater although the Department of Fisheries can and does place fishing bans as appropriate in marine waters which come under central government administration. The hilsa fishery has two main components: 1) artisanal (mainly coastal/estuarine, inland, and 2) Industrial (offshore). Around 1.6 million fishers are involved in the Myanmar hilsa fishery, the majority in the artisanal sector (https://www.iied.org/carrots-sticks-incentives-conserve-hilsa-fish-myanmar). The fishers are typically poor and would need an incentive to stop fishing at the peak autumn fishing period.

Hilsa is an anadromous fish in that after hatching and first feeding in freshwater the fish gradually migrate to the sea where they develop fast in the phyto and zooplankton rich continental-shelf waters in the Bay of Bengal off the Ayeyarwady Delta (Akester, 2019) (Figure 1).

The Darwin Initiative project in Myanmar set out to design a cost-effective and 'incentive-based' hilsa fishery management system for the country, based on scientific and participatory research. This consisted of the following five components of which 3 and 5 were action based:

1. Understand the biology and ecology of the hilsa fishery.
2. Understand the complex socioeconomics of the hilsa fishery and value chain.
3. Make a business case for investment in hilsa management.
4. Develop a sustainable financing mechanism.
5. Lay the foundation for the development of transboundary hilsa fisheries management in three of the eight Bay of Bengal Large Marine Ecosystem countries where hilsa is important.

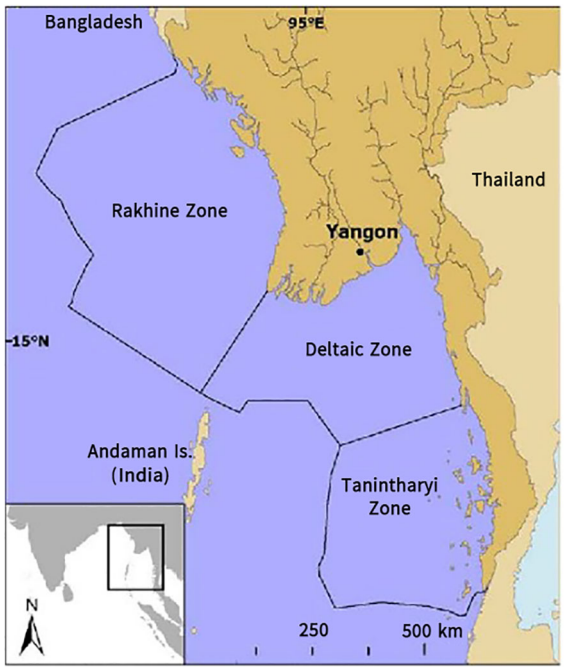

FIGURE 1
Map showing the location of Myanmar in the Bay of Bengal and the three main fishing zones for hilsa (source Harper et al., 2011).

A separate intervention by WorldFish, funded by the WorldBank, used the Fisheries Performance Indicator (FPI) analysis described by (Anderson et al., 2015) to assess the state of the hilsa fishery.

2 Materials and methods

A range of approaches were used to deliver the five components outlined above as a means of promoting improved hilsa fisheries management.

2.1 Fish sampling to determine periodicity of maturity (Spawning seasonality of hilsa (*Tenualosa ilisha*) in Myanmar's Ayeyarwady Delta)

An assessment of the spawning seasonality and migratory routes of hilsa was undertaken in order to demonstrate when closed seasons should be imposed and where hilsa sanctuaries should be placed. To

1 The Darwin Initiative competitively awards grants for activities that conserve biodiversity and reduce poverty in eligible low and middle income countries https://www.gov.uk/government/groups/the-darwin-initiative.

gain a better understanding of the biology and ecology of hilsa in Myanmar waters, fish samples were taken along the main branches of the Ayeyarwady River. Nine sampling sites were selected across the Ayeyarwady Region on the basis of their importance as habitats for hilsa and the accessibility of their landing sites. Although there are seasonal variations during dry and wet seasons, each of these sites falls within one of three ecological zones: fresh water, brackish water, or saline water (Bladon et al, 2019). Samples were taken on a monthly basis and fish were dissected to remove the gonads, which were then weighed and assessed for maturity. The gonadosomatic index (GSI) was used to provide information about gonad development and maturity (Wallace and Selman, 1981; West, 1990). In addition, otoliths were extracted and preserved for chemical and microscopic analysis in Australia to determine the age and migration periodicity. Otolith samples were taken from hilsa in the upper reaches of the Ayeyarwady and Chindwin Rivers with funding from a Crawford Fund - ACIAR[2] project (Bladon et al., 2019).

2.2 Socio-economic analysis of the hilsa fishery

A large-scale socioeconomic survey of hilsa fishing households in the Ayeyarwady Region was undertaken to understand their challenges and opportunities for socioeconomic improvement. 833 people from 298,925 households were sampled by asking village heads or informal community leaders to identify households in which someone fishes for hilsa. They were selected on the basis of multiple criteria, including social class, location in the village, and social networks. Enumerators used a semi-structured questionnaire to collect information from respondents on household demographics and characteristics, hilsa fishing activities, hilsa trends and status, hilsa management, and conservation. They also asked village administrators and village tract administrators to categorize sample households according to four social classes: *Chan Thar* ('better off'), *Ah Lae Ah Latt* ('middle class'), *Nwan Par* ('poor'), and *Ah Lon Nwan Par* ('very poor'). A choice experiment was also used to assess preferences for incentive packages, and the level of incentive required to offset the short-term economic cost of abiding by fishing regulations. Fisherfolk were asked to share their perspectives on what mechanisms would be most effective to encourage them to respect current regulations and proposed modifications to the closed seasons (Khaing et al., 2018).

2.3 Make a business case for investment in hilsa management

The economic value of Myanmar's artisanal hilsa fishery (use and non-use value) was estimated using a combination of primary and secondary data, with a focus on the Ayeyarwady Region (Bladon, 2020). This was supplemented with data from the socioeconomic survey, and secondary data from Bangladesh, to estimate the costs and benefits of implementing an incentive scheme for artisanal fishers in the region. The cost-benefit analysis was used to make a compelling business case as to why the government of Myanmar and the private sector should make sufficient investments to restore the fishery.

2.4 Develop a sustainable financing mechanism (Financing incentive-based hilsa fisheries management in Myanmar through fiscal reform

The project explored and promoted innovative financing mechanisms for sustainable fisheries management, focusing on fiscal reform, which was identified early on as a promising tool available to government at decentralized and national levels. A diagnostic study was conducted to explore whether fiscal reform could generate a significant and long-term source of finance for this incentive scheme, and if so, what this reform should look like. The study used a mixed-methods value chain approach to build an understanding of how fiscal tools are currently used to collect revenues from the hilsa value chain, and how they could be reformed to raise additional revenues for investment into a more sustainable and inclusive fishery. Further exploration of how these reforms could be implemented and how revenues could be better managed was undertaken during multi-stakeholder workshops (Silvester et al., 2020).

2.5 Lay the foundation for the development of transboundary hilsa fisheries management (workshop report iied-WorldFish)

Migrating between marine and freshwater, the hilsa presents a transboundary fisheries management challenge for Bangladesh, India and Myanmar, which together account for over 85% of hilsa production. An important component of the project was therefore to create an opportunity for co-learning and establish a platform for transboundary dialogue, in order to catalyse the development of a transboundary hilsa fisheries management plan between the three main hilsa fishing nations in the Bay of Bengal Large Marine Ecosystem area (Figure 2).

More than 75% of global hilsa fish production comes from Bangladesh and Myanmar – 60% from Bangladesh and 15% from Myanmar (Rahman et al., 2012). In Bangladesh, hilsa accounts for about 12% of total fish production and 1% of national gross domestic product (GDP) (DoF Bangladesh 2017). It also provides direct employment for 0.5 million professional fishers and 2.5 million people engaged in part-time fishing and related activities Rahman et al. (2012). In Myanmar, the capture fishery sector accounts for 10% of GDP (DoF Myanmar 2017). While hilsa accounts for just 4.5% of the total national catch, hilsa fishery employs 1.6 million people in the country's most impoverished communities (IIED 2017). Hilsa is increasingly subject to

2 The Australian Centre for International Agricultural Research https://www.crawfordfund.org/news/sustaining-fisheries-in-laos-myanmar-and-vietnam/.

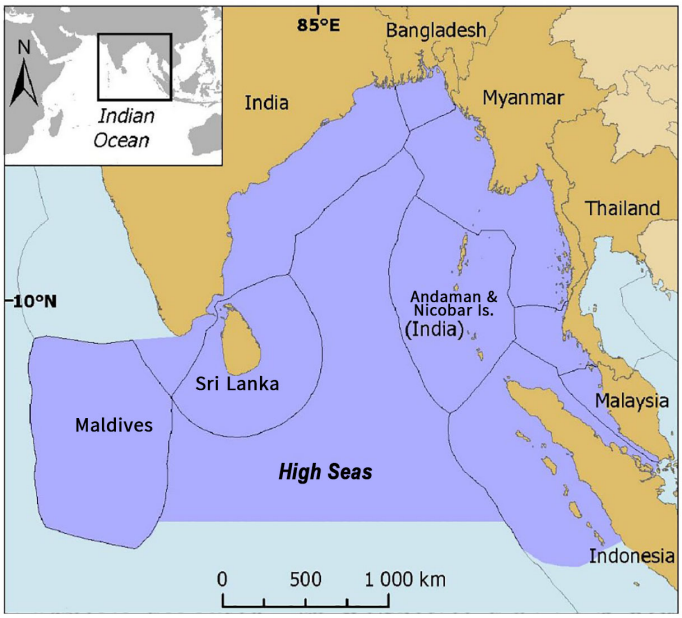

FIGURE 2
Territorial waters for India, Bangladesh and Myanmar in relation to the other five countries in the Bay of Bengal Large Marine Ecosystem (source Harper et al., 2011).

overfishing and habitat degradation, however, threatening millions of livelihoods, exacerbating poverty and limiting access to the food that many communities rely on for survival.

Most of the hilsa landings in Bangladesh are from freshwater; the opposite is true in Myanmar. This means that artisanal fishers catch more hilsa in Bangladesh, while the industrial fleet dominates in Myanmar. This will have an important bearing on fisheries management and transboundary aspects. Illegal, unreported and unregulated fishing is always very difficult to control at sea (Merayo, 2019).

The social aspects are complicated, as fisher associations are generally weak and, in Myanmar, only just being formed. Compensation funds to encourage artisanal fishers to respect closed seasons and to meet other legal requirements are insufficient in terms of amount and coverage. Hilsa presents a transboundary fisheries management challenge between Myanmar and Bangladesh.

2.6 Fisheries Performance Indicator assessment

The Fisheries Performance Indicator (FPI) analysis described by (Anderson et al., 2015) recognizes that three aspects of a fishery (economic, environmental and social conditions as performance dimensions) need to be studied together as they are interrelated in terms of the sustainability of fish stocks, fishing effort and fishing communities. In other words each of the three components alone cannot provide benefits without the others. A FPI analysis was undertaken for both industrial and artisanal sectors of the hilsa fishery.

3 Results

3.1 Fish sampling to determine periodicity of maturity (Spawning seasonality of hilsa (*Tenualosa ilisha*) in Myanmar's Ayeyarwady Delta)

The male and female hilsa specimens caught in fresh water were significantly smaller and lighter than those caught in brackish and saline water, indicating that hilsa spawn in fresh water, which provides a nursery area for juveniles before they migrate towards the coast, where they grow larger (Bladon et al., 2019).

On average, fish caught in brackish and saline water were heavier and larger, indicating that they migrate from the saline zone through the brackish zone to fresh water where they spawn (resulting in significant weight loss). In these areas, females were heavier than males, owing to their greater gonad weight.

On average, the lowest values for length–weight relationship parameter were observed in September, followed by August. In both months, they showed negative size-shape growth, indicating a loss of gonad mass after the female fish have released their eggs and the male fish have released their sperm. This suggests that September is the main spawning season.

The steep drop in mean freshwater Gonadosomatic Index (GSI) values between the highest peak in July to the lowest trough in September, combined with a parallel observed decline in length–weight relationship indicates that September is the main spawning month.

Mean female GSI values were least variable in the saline zone, with peaks in February and November 2018, which could be an

indication that gonads have begun to grow with the initiation of spawning migration.

Findings from assessing the maturity of hilsa samples indicated that within the saline zone, mature fish (80%) were much more abundant than immature fish, whereas in fresh water, immature fish predominated (77%). This highlights the importance of fresh water as a favorable habitat for spawning and as nursery grounds for immature hilsa before they migrate downstream through brackish waters to reach maturity in coastal waters.

Across all ecological zones, the percentage abundance of immature hilsa peaked in December (59%) and November 2018 (55%), and was lowest in June (6%), which is consistent with a main spawning season of July–September. In the freshwater zone, where most spawning activity occurs, immature hilsa were most abundant in August (93%) and September (94%), declining to a low of 27% in April. This could be evidence of additional spawning seasons in January–February and April–May.

The percentage abundance of immature hilsa peaked in November 2018 in brackish water, probably reflecting the migration path of immature hilsa towards the sea, following a main spawning season in July–September.

3.2 Socio-economic analysis of the hilsa fishery

The 833 fishing households surveyed totaled 3,849 people. Of these people, 68% were of working adult age (15–64), while 30% were children (<15) and 2% were 65 and older. The dependency ratio (number of household members of working age compared to those not of working age) had a mean of 58%. Household size ranged from two to 12, with a mean size of 4.6, and the survey population was 53% male and 47% female (Khaing et al., 2018).

The majority of surveyed households were living in houses made of wood (65%) and bamboo (31%), while only 2% lived in reinforced concrete or brick houses. This is much lower than the national average for concrete and brick housing (16%) (DoP, 2014)

Almost every surveyed household said they owned a net (99%) and a boat (98%). While boats are an important means of transportation in the Ayeyarwady Delta, this fact, along with the net ownership, indicates that nearly every household engages in fishing activities.

On average, annual household income (US$2,640) is not high enough to cover annual expenditure (US$2,764). This is particularly the case for 'poor' households, for whom expenditure is 6.8% higher than income. To cover the deficit, many households rely on informal loans to meet their needs, but encounter challenges in paying them back (Glenk et al., 2015).

Although some studies suggest that women's involvement in fisheries in Myanmar is limited (Joffre and Aung, 2014), we found that women play a key role in the hilsa fishery, not only in selling and packaging, but also in fishing itself. Discussions suggested that they fish both with their husbands and independently. Salagrama (2015) also found that during the low season, when men might not consider it worth their time to go fishing, women often go fishing to ensure a supply of food for their family.

Sixty-nine per cent of household survey respondents ranked hilsa the dominant species in terms of catch, while 95% ranked hilsa the dominant species in terms of fishing income. Generally, the period from September to January was the most active fishing period in all townships. Households most often sell their fish to local (village) fish collectors (64%). Nineteen per cent said they sell directly to consumers in the village, particularly when they catch small fish, which are not accepted by fish collectors.

Myanmar's hilsa value chain has four levels: village or local level, township level, Yangon level and international level through exports. Marketing relationships in Myanmar are informal and based on trust and personalized economic relations (ILO, 2015).

Ninety-seven per cent of survey respondents said they would face difficulties if they had to stop fishing during certain months. However, when asked what they actually do during the closed fishing season, 98% of respondents reported livelihoods other than or in addition to fishing. This could be an indication of strategic bias: respondents might have wanted to emphasize the hardship which fishing bans impose, with the hope of influencing policy. The most common livelihood activity in the closed fishing season, particularly for the 'poor' and 'very poor', was casual labor (mostly labor for rice farmers). Daily incomes from rice field labor amount to USD2.60.

Although the fishing communities have some knowledge of hilsa spawning and migratory behavior and perceive a decline in abundance, in the face of livelihood hardship, conservation is not a priority for them. Effective implementation of co-management systems could provide an opportunity to build awareness and a more sustainable and inclusive fishery.

Most household survey respondents (91%) were aware of a decline in hilsa stocks, perceptions that are reflected in other studies (Joffre and Aung, 2014; Salagrama, 2015). The major reason that fishers provided for this decline was industrial fishing activities, which include offshore and inshore fishing using powered boats, as well as the use of large fixed bag nets (stow nets) in estuaries. For example, PRA participants in Labutta said that juvenile hilsa are overfished as bycatch by industrial fishers and discarded. They also said that use of stow nets to target other species in coastal areas can destroy hilsa fry and juveniles, because they often use very small sized net mesh.

3.3 Make a business case for investment in hilsa management

While the importance of hilsa to the national economy is recognized, particularly in terms of export revenues (US$237 million in 2021), the value of Myanmar's artisanal fishery is much less visible to policymakers. This has led to limited investment in its sustainable management. As a result, catch rates are too high, with too many juveniles and egg-laden females caught. Although hilsa also face the threat of overexploitation by offshore vessels, ecological research indicates that protection of hilsa should be prioritized in key spawning and nursery grounds, some of which are in coastal and delta areas where artisanal fishers operate (Bladon, 2020).

This project estimated the economic value of Myanmar's artisanal hilsa fisheries to be between US$731.4 million and US $867 million per year (Burcham et al., 2020). Over ten years, investing around US$100 million in an incentive scheme for artisanal fishers could generate a net benefit of up to $1.1 billion. The expected economic benefits outweigh estimated costs by between six and nine times; i.e. every US$1 invested in incentive-based hilsa fisheries management generates a benefit estimated at US$6–9.

3.4 Develop a sustainable financing mechanism (Financing incentive-based hilsa fisheries management in Myanmar through fiscal reform)

A presentation of the research findings made at the central government level in March 2020 was met with a request to involve the Ayeyarwady Regional government and its parliamentarians. A subsequent meeting held with the local level parliament endorsed the research findings with requests made for fiscal reforms, a modification of the closed seasons and the establishment of hilsa sanctuaries in the branches of the Ayeyarwady River within the delta area. Unfortunately, the global Covid-19 pandemic led to restricted travel and contact with local government throughout 2020. After February 1, 2021, the political situation led to the disbandment of the Ayeyarwady Regional parliament. Nevertheless, the research results continued to be consulted by DoF scientists and in March 2022, legal reforms were agreed in terms of a new closed season and the establishment of hilsa eleven sanctuaries (Silvester et al., 2020).

There are numerous fiscal tools used by the Myanmar Department of Fisheries (DoF), as well as other institutions such as the Ministry of Planning, Finance and Industry (MoPFI), Yangon City Development Committee (YCDC) and the Ministry of Commerce (MoC), to collect revenues from hilsa value chain actors. DoF revenues collected from the marine fishery (inshore and offshore) are managed at union (national) level, whereas revenues collected from the freshwater fishery are decentralized by region or state. There is room to improve revenue-collection efficiency across many of these tools could increase revenues by nearly two and a half times.

Aspects which could be modified include: 1) Artisanal fisher registration and license fees; 2) Offshore vessel fishing and license fees; 3) Collector's license fees; 4) Personal income tax; 5) Corporate income tax; 6) Commercial tax; 7) City fees; 8) Export taxes and other charges.

Not only should these fees and taxes be distributed more equitably across the value chain (i.e. to better target those actors with greater ability to pay), it is clear from the value chain analysis that more revenues could be collected from actors nearer the top of the chain without affecting their business models.

The reforms identified for increasing current revenue-collection efficiency could generate annual revenues in the region of US$56.9 million for the DoF and government of Myanmar more broadly (more than twice our estimate of current annual revenues). Combining this increase in revenue-collection efficiency with the proposed revisions to fee and tax rates could generate revenues nearer US$91 million per year (more than three and a half times current annual revenues), by better targeting actors nearer the top of the hilsa value chain.

3.5 Lay the foundation for the development of transboundary hilsa fisheries management

A similar research project in Bangladesh funded by the Darwin Initiative provided the government with scientific evidence for the establishment of hilsa sanctuaries and modified fishing closed seasons. Since these were instigated, hilsa landings have increased and the average fish size caught increased (Rahman et al., 2020). The fact that the hilsa stock is transboundary by nature indicates that improved fisheries management in one country should benefit neighboring states. Clearly, improvements in all states should see the stock benefit at the Bay of Bengal large marine ecosystem scale.

Evidence from Bangladesh suggests that there may be more than one stock of hilsa in the country's waters with both freshwater non-migratory and anadromous meta populations of the same species. Work studying the chemistry of hilsa otoliths in Myanmar, focusing on relative proportions of strontium (marine domain) and barium (freshwater), indicates that all fish sampled are born in freshwater in different parts of the river systems with the Chindwin River, confluence with the Ayeyarwady River approximately 800km north from the marine area of the Delta (Figure 3, Shannon, 2010) appears very important. Juvenile fish migrate downstream and return when they are ready to spawn again.

However, in the Ayeyarwady Delta some fish had estuary saltwater signatures when they were born, so there may be spawning in the Delta. Background water quality testing needs to be finalized. There may be two spawning stocks.

An FPI analysis of the hilsa fishery in Myanmar, carried out in 2020 (both artisanal and industrial) indicated that the overall fishery is not far from economic collapse. The results need to be further verified as they are based on intuitive comment from those who know the fisheries sector in Myanmar.

4 Discussion

Hilsa is the national fish of Bangladesh and is also important to fishers and the general population in Myanmar. Earlier work in Bangladesh has shown how improvements to fisheries management can have a positive impact on the availability of fish and an increase in the average size of fish caught. This was achieved through modifications to the closed season, the establishment of fish sanctuaries in both marine and freshwater areas and the creation of community 'police' to monitor and discourage illegal fishing practices.

The results of the research described here carried out in Myanmar, have confirmed the hilsa spawning periodicity, the

FIGURE 3
Map of the Ayeyarwady River basin showing the confluence of the Chindwin and Ayeyarwady (Irrawaddy) Rivers to the southwest of Mandalay in central Myanmar (Shannon, 2010).

main migration routes and the importance of riverine spawning grounds within the Delta and 800km inland from the sea. Clearly, an anadromous fish species like hilsa has a difficult route to and from spawning grounds, especially as fishing pressure is high and some fishing gears, like fixed bag nets, non-selective taking adults and juveniles alike.

The timing of spawning is important, as the previous closed season, May to July, did not cover the main spawning peak, which occurs towards the end of the monsoon season in September. A peak in the hilsa landings by the artisanal sector occurs in the autumn coinciding with the spawning period. This makes adherence to the new closed season difficult as it is the main fishing period for fishers who often fish on a seasonal basis due to the reduced availability of fish prior to the autumn peak. FPI analysis confirmed what many fisherfolk have been saying: year-on-year reductions in landings, hence the ability to fish year-round has gone.

Most households in the rural area of the Ayeyarwady Delta own a boat (typically a canoe capable of carrying a net and one or two people) and a fishing net. Many are in the lowest income bracket making their dependence on fisheries, and hilsa in particular, an important livelihood activity. During periods of low fish yields, the only livelihood alternative to fishing is casual labor in the rice fields where a daily wage amounts to around USD2.60.

Recommendations made to the Myanmar Ayeyarwady parliament in early 2020 drew on the research results and called for a modification to the closed season and the setting up of sanctuaries in close liaison with community fisher groups. In addition, a presentation was made regarding the possibility of fiscal reforms to generate funding to allow fishers to respect the new closed season i.e. incentives in the form of food to permit the 1.6 million families to limit their fishing activities while not going hungry due to reduced incomes. The cost of the incentive was calculated to be in the order of USD70 million per annum. The annual benefit in terms of increased hilsa yields is expected to be between six and nine times the investment.

Work to address systemic constraints faced by women along the hilsa value chain are at the core of the incentive-based scheme's design. The socioeconomic survey report demonstrated that both men and women generate income from hilsa through fishing, but that women tend to be more involved in other activities such as net repair and selling hilsa, as well as domestic activities and education. Access to and preferences for hilsa markets and loans can also differ significantly by gender, as can access to alternative sources of income. These findings confirmed that any incentives for compliance with fisheries regulations in the Ayeyarwady Region should be designed to mitigate impacts on and address the needs of both men and women. The socioeconomic report enhanced the understanding of women's roles in the hilsa fishery and therefore their visibility in a sector that is so often associated with men.

On 22 March 2022 the recommendations made by WorldFish to the Ayeyarwady Regional Government in 2020 were acted upon. A decree, No- 3/6-307 (379)/, signed by the Minister, Ministry of Security and Border Affairs, Ayeyarwady Regional Government, was issued to the effect that there will be a new closed season from 15 September to 15 October along the 4 main rivers in the Ayeyarwady Delta Region. In addition, approximately 1,000 hectares of sanctuaries across 11 sites have been established in the four main Ayeyarwady channels.

The next step will be the strengthening of community fisher groups in an attempt to encourage the adherence to the closed seasons with no fishing year-round in the assigned sanctuaries. A combined result of the Covid-19 pandemic and the political situation has made it impossible to implement the recommended fiscal reforms. It is recommended that the newly designed fisheries co-management guidelines from 2021 are introduced with fisher associations.

Joint transboundary management of the shared stock would clearly be positive. However, there is a need to continue research on the nature of the shared stock, since migratory and landlocked populations are likely to have different spawning seasons and will therefore require different management approaches.

The hilsa research is linked to the delivery of Sustainable Development Goal 14: life below water.

The findings challenge previous understanding (that there is one spawning peak from May to July) by providing evidence of major hilsa spawning activity between July and September in fresh water, with a peak in September. Among other findings, the research demonstrates that current fishing restrictions do not coincide with the main spawning season (Bladon et al., 2019). Recommendations were made for improved hilsa fisheries

management on the basis of this enhanced understanding (Merayo et al., 2020). Recommendations involving a closed season in September and the establishment of fish sanctuaries were endorsed in March 2022. The Darwin Initiative work on the artisanal hilsa fishery in Myanmar has demonstrated the value of fisheries research encompassing both social and biological aspects. The task now is to build on this science through collaborative monitoring of fish landings at the fisher association levels.

5 Conclusions

The research work outlined above demonstrates the urgent need for improved management of the valuable hilsa fishery in Myanmar. Part of the recommendations have been acted upon in that a new closed season has been decreed and hilsa no-take sanctuaries have been established. However, the social aspects required for artisanal fisherfolk to adhere to the modified regulations need to be strengthened via the implementation of fisheries co-management guidelines and the suggested fiscal reforms to provide funding to enable fisherfolk to cease fishing operations during the new closed season and to respect the sanctuaries. One fisher association operating under the name of 'helmsman' has instigated its own no-take zone and reports hilsa landings in 2023 five times those from 2018.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The manuscript presents research on animals that do not require ethical approval for their study.

Author contributions

MA: Conceptualization, Supervision, Visualization, Writing – original draft, Writing – review & editing. AB: Conceptualization, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing. JC: Investigation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer MN declared a shared consortium Worldfish with the author MA to the handling editor.

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