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Decadal Shift in Fish Landings and Catch Composition in Brahmaputra River, Assam, India

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Abstract

Analysis of long-term (1987-2019) fish landing data showed that an average 191.93 t year^{-1} of fish landed at Uzanbazar (Guwahati) landing center of River Brahmaputra. The total landings registered peak landings of 471.8 t in 2002 and thereafter it declined to the lowest levels of 84.06 t in 2016. Fish landings suffered changes in the qualitative and quantitative aspects of River Brahmaputra fishery in Assam. Whereas average total landings during last decade declined by almost 60% as compared to the average landings of 234.97 t year^{-1} in the previous two decades (1987-2009), the contribution of Indian major carps (IMC) and minor carps towards total landings declined from 17.54% and 35.11% during 1987-2009 to only 4.86% and 8.94%, respectively during 2010-2019. Miscellaneous fishes group emerged as dominant group contributing 58.28% of the average landings in last decade (54.30 t year^{-1}) compared to 69.38 t year^{-1} during 1987-2009. Average landing of catfishes also decreased from 26.96 t year^{-1} in 1987-2009 to 19.77 t year^{-1} in 2010-2019, but percentage contribution increased from 11.47% to 21.28% over decades. Similarly, average landings of Hilsa declined from 8.24 t year^{-1} to 3.42 t year^{-1} but percentage contribution remained unchanged over the period. Such changes can be partly ascribed to climate change, habitat modification, over exploitation and other anthropogenic causes. The sharp decline in IMC landings as well as changes in landing composition from the river due to these alterations in the last decade is directly affecting the livelihood of the fishermen community.

Keywords: Brahmaputra, Catch composition, Fish landings, Hilsa, Indian major carps

Introduction

The riverine fisheries resources (the Ganges, the Brahmaputra, the Indus, the Peninsular east coast and west coast rivers) of India having a total catchment area of 3.12 million km^2, are categorized under 113 river basins (Vass and Moza, 2011). River Brahmaputra has a drainage area of 5,80,000 km^2 spread across China (50.5%), India (33.6%), Bangladesh (8.1%) and Bhutan (7.8%). Brahmaputra basin in India is shared by different states of the Northeast *viz*., Arunachal Pradesh (41.9%), Assam (36.3%), Meghalaya (6.1%), Nagaland (5.6%), Sikkim (3.8%) and West Bengal (6.3%). The Brahmaputra river ecosystem consisting of a number of tributaries and abandoned river beds (beels) both on the north and south bank, are rich habitats of fish fauna (Bhattacharjya *et al*., 2017; Borah *et al.*, 2020) and harbours many endemic species like snakeheads, *etc*. (Borah *et al.*, 2018). A total of 141 fish species from 29 families have been recorded from stretch of river Brahmaputra flowing through Assam (Bhattacharjya *et al.*, 2017).

Numerous studies relating to the riverine fisheries along Indian part of river Brahmaputra have been made. The present fish production from Brahmaputra river is 190 kg

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km^{-1} $year^{-1}$ against production potential of 900 kg km^{-1} $year^{-1}$ (Das *et al.*, 2018). The river has 42 fish landing centres in the Indian part, of which Uzanbazar (Guwahati) is one among the major ones. Commercially important fish group/ species of the River Brahmaputra comprised of Indian major carps (*Labeo rohita, L. catla, Cirrhinus mrigala*, *L. calbasu*), minor carps (*L. gonius, L. bata, L. dero* and *C. reba*), catfishes (*Wollago attu, Mystus seenghala, M. aor, Rita rita, Pangasius pangasius, Bagarius bagarius, B. yarelli, Eutropiichthys vacha, Ompok pabda, Clupisoma garua, Ailia coila, Setipinna phasa, M. tengera, M. bleekari, M. cavasius*), featherbacks (*Chitala chitala, Notopterus notopterus*), Hilsa (*Tenualosa ilisha*), and miscellaneous species including fresh water prawns (*Aspidoparia morar, Gudusia chapra, Barilius barilius, Puntius* spp., *Colisa* spp., *Macrobrachium* spp.). Fish landings suffered changes in the qualitative and quantitative aspects of River Brahmaputra fishery in Assam. The total landings have been dominated by small-sized miscellaneous group of fishes (40-50%) and a small-sized cyprinid species, *A. morar* has emerged as the most dominant fish species in all major landing centres in recent years indicating less favourable habitat conditions for major fishes (Borah *et al.*, 2014; Yadav *et al.*, 2022). Observable differences have been found in the fish species inhabiting the river stretches in Assam.

A proper trend analysis of fish catches/ landings/ production will help in formulating plans and to take necessary measures according to the situation. Previous studies attempted trend of fish production in Assam (Chutia *et al.*, 2018; Yadav *et al.*, 2020) as well as enhancement of production and income of beel fishers from floodplain wetlands of river Brahmaputra in the state (Das *et al.*, 2017, 2022; Yadav *et al.*, 2021; Borah *et al.*, 2022a, 2022b, 2022c). However, the studies on fish production trends of river Brahmaputra are limited and sparse (Bhattacharjya *et al.*, 2017; Yadav *et al*., 2022; Yadav, 2022). In the present study, an attempt has been made to document the long-term trends in landings of major fish groups/ species (Indian major carps- IMC, minor carps, catfishes, featherbacks, Hilsa and miscellaneous fishes), which was landed in Uzanbazar (Guwahati), a major landing centre in the lower stretch of River Brahmaputra.

Materials and Methods

Study Area and Data Collection

Fish landings (in tonnes, t) of commercial fish groups/ species (Indian major carps- IMC, minor carps, catfishes, featherbacks, Hilsa and miscellaneous fishes) at Uzanbazar (Guwahati) (26°11'44.33'' N and 91°45'23.94'' E) landing centre of River Brahmaputra estimated by ICAR-CIFRI for the period from 1987 to 2019 was used for the study.

Statistical Analysis

The significant differences in landings (t) of fish groups/ species over the decades were tested using ANOVA. For post-hoc analysis, the DMRT (Duncan's Multiple Range Test) was used. The data is presented as mean ± standard deviation (S.D.). Further, we used LOWESS (Locally-weighted scatterplot smoother), a robust non-parametric regression technique (Cleveland, 1979), to visualize the temporal trends in landings of commercial fish groups/ species at Uzanbazar (Guwahati) landing centre of River Brahmaputra. This method consists of fitting a locally weighted polynomial to the observed data using a weighted least squares algorithm that gives local weights the most influence while minimizing the effects of outliers (Cleveland, 1979) and is appropriate for detecting trends in data where no predetermined model (*e.g.*, linear or nonlinear) is suitable (Cleveland and Devlin, 1988). In this procedure, each co-ordinate is smoothed using a defined proportion of the neighbours nearest to the target point, over parts of their ranges (Trexler and Travis, 1993). Based on the Akaike information criterion corrected for small sample size (AICC), the smoothing parameter (*q)* was estimated (SAS, 2002). The smoothing parameter, lies between between (x+1)/n and 1, where x denotes the local polynomial degree, controls the flexibility of the regression function. The optimum fitting was achieved by iteratively minimizing the residuals between the observed and estimated values. We used PROC LOESS in SAS (v 9.3) to fit the model.

Results and Discussion

Total Fish Landings

We compared the fish yield patterns of River Brahmaputra at Uzanbazar (Guwahati) landing centre during 1987-2019. Based on temporal patterns in fish landings, the study period was divided into three decades, *viz.* 1987-1999 (Period 1), 2000-2009 (Period 2) and 2010-2019 (Period 3), to understand the variation in average fish landings between the decades using ANOVA. During the study period, the maximum annual total landings was observed to be 471.8 tonnes (t) in the year 2002 and the minimum observed was 84.06 t in 2016. The average of total fish landings during this period was 191.9 t with a coefficient of variation (CV) of 52.3%. The average landings during 2000-2009 (272.6 t $year^{-1}$, CV = 42.7%) were significantly higher than during 1987-1999 (206 t $year^{-1}$, CV = 26.1%). However, the mean landings during the last decade 2010-2019 (92.9 t $year^{-1}$, CV = 7.1%) were significantly lower than for the previous decades (Table 1). This showed that mean landings during 2010-2019 declined by almost 60% as compared to the mean landings in the previous two decades. The contribution of commercial fish groups to the annual total landings of river Brahmaputra over the decades is presented in figure 1. Local polynomial regression (LPR) of degree one was fitted to the annual total landings of river Brahmaputra at Guwahati. The non-parametric model fitted well to the total fish landings data. The estimated smoothing parameter value for the model was 0.227 based on the minimum value of AICC. The number of points in the local neighbourhood was 7. The observed data on total fish landings of River Brahmaputra at Guwahati and fitted values by nonparametric regression approach are presented in figure 2(g).

IMCs Landing

Indian major carp (IMC) is one among the important commercial fish group of River Brahmaputra. During the period 1980-2019, the contribution by IMC towards total

Table 1: Decadal changes in average landings (t year^{-1}) of commercial fish groups/ species of Brahmaputra river at Uzanbazar (Guwahati)

Groups	Average decadal landings (t year^{-1})		
	1987/1999	2000/2009	2010/2019
Indian major carps (IMC)	41.4^{a}±13.1	40.9^{a}±19.3	4.5^{b}±11.6
Minor carps	69.2^{a}±34.0	99.7^{a}±82.0	8.3^{b}±2.4
Catfishes	25.5^{ab}±7.9	28.9^{a}±9.6	19.8^{b}±2.3
Hilsa	7.0^{b}±1.7	9.8^{a}±2.7	3.4^{c}±0.9
Featherbacks	9.2^{a}±4.9	3.4^{b}±1.4	2.6^{b}±0.6
Miscellaneous fishes	53.6^{b}±20.0	89.8^{a}±38.2	54.3^{b}±7.2
Total	206.0^{b}±53.7	272.6^{a}±116.4	92.9^{c}±6.5

Note: Data is expressed as mean ± sd, means followed by the same letter are not significantly different at 5% level of significance

fish landings in the River Brahmaputra at Guwahati reached 31.4% in the year 1989. Fluctuation in the IMC landings over the period was observed to be very high so that the minimum contribution by IMC came to 3.16% in the year 2010. The maximum observed annual IMC landings during this period was 72.519 t in 2002 and the minimum observed

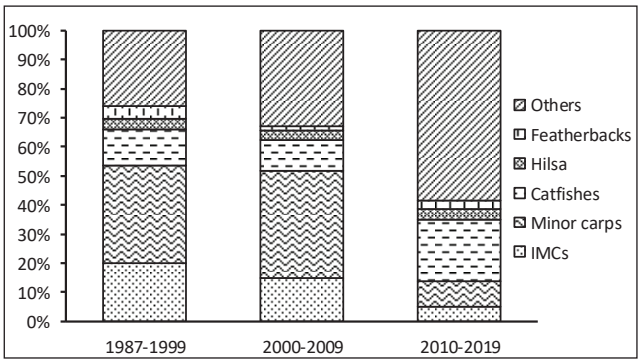
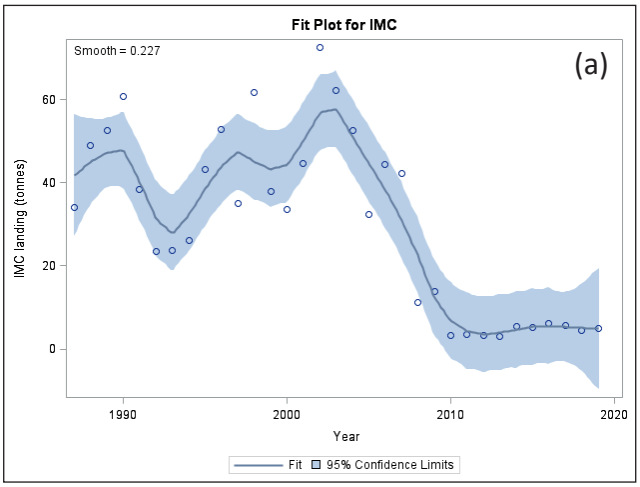
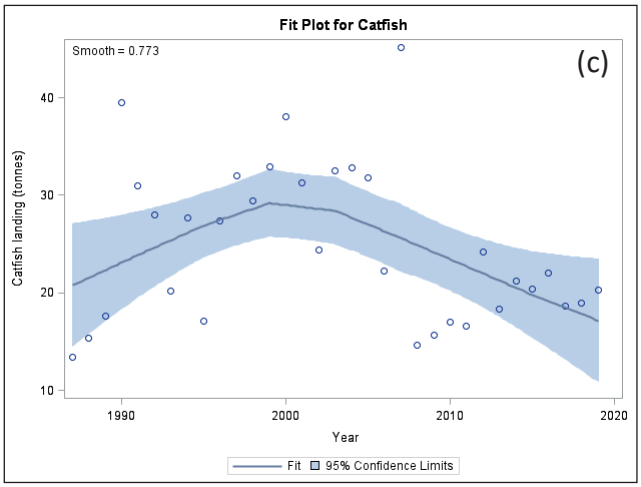
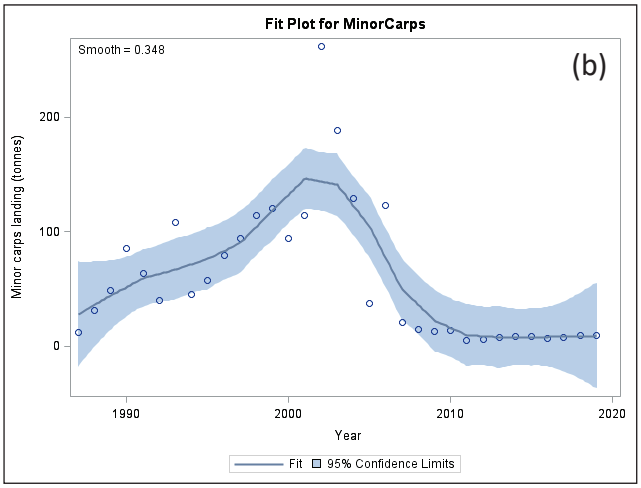


Figure 1: Decadal changes in fish landings (in %) at Uzanbazar (Guwahati) fish landing centre of River Brahmaputra

was 3.143 t in the year 2013. The mean IMC landing was 30.1±21.5 t year^{-1} during the period. The average IMC landing did not differ significantly between the decades 1987-1999 (41.4±13.1 t year^{-1}) and 2000-2009 (40.9±19.3 t year^{-1}). However, the IMC landings declined during the last decade 2010-2019 and stabilised to an average of 4.5±11.6 t year^{-1}, significantly lower than for the previous decades (Table 1), a decline by almost 89% as compared to the average landings in the previous two decades. Average contribution of IMC to total landing decreased from 20.1% during 1987-1999 to a meager 4.86% during 2010-2019 (Figure 1). Debnath *et al.* (2015) reported that IMC landings declined from 13.68%







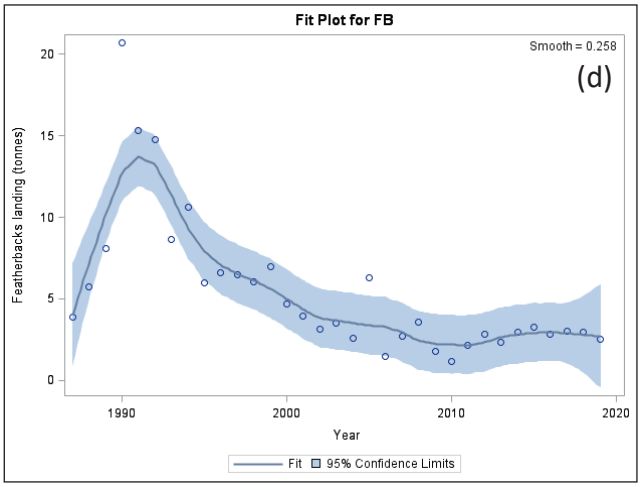


Figure 2: Continue...

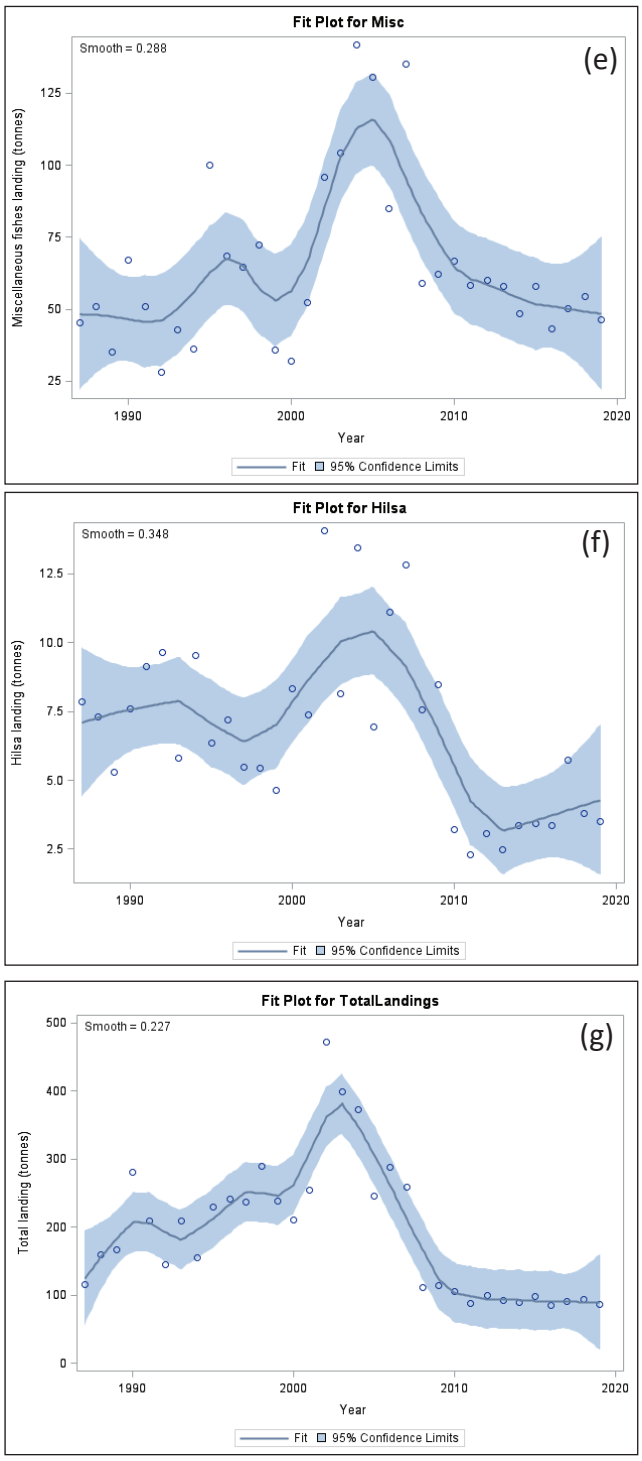


Figure 2: Actual landings (t year^{-1}) and LOWESS trend fit to the landings of commercial fish group/ species (IMC, minor carps, catfishes, featherbacks, hilsa, miscellaneous fishes and total landing) from 1987 to 2019 at Uzanbazar (Guwahati) landing centre of River Brahmaputra

(in 1975) to only 3.85% (2010) with actual catch of 7.72 t (1975) and 4.02 t (2010) in this landing centre. The decline in IMC landings has also been reported for Ganga River system at Allahabad (Vass *et al.*, 2009; Jha *et al.*, 2020), reduced from 90.85 t (1956-1967) to 25.61 t (2005-2018) (Jha *et al.*, 2020). Local polynomial regression (LPR) of degree one was fitted to the annual IMC landings of river Brahmaputra at Guwahati. The estimated smoothing parameter value for the model was 0.227 based on the minimum value of AICC. The number of points in the local neighbourhood was 7. The observed data on IMC landings of River Brahmaputra at Guwahati and fitted values by nonparametric regression approach are presented in figure 2(a).

Minor Carps Landing

The average annual landings of minor carps in river Brahmaputra at Guwahati during the period 1980-2019 was 60.022 t with a coefficient of variation of 101.22%. This on an average was about 24.93% of the total fish landings in the stretch during this period. The maximum and minimum landings of minor carps during this period were 5.088 t in 2011 and 261.726 t in 2002, respectively. There was no significant difference observed in the average minor carps landing between decades 1987-1999 (69.2±34 t year^{-1}) and 2000-2009 (99.7±82 t year^{-1}). However, the average landings during the last decade 2010-2019 were significantly lower than for the previous decades. The minor carps landing averaged 8.3±2.4 t year^{-1}, declined steeply than landings from 1987-1999 (88%) and 1987-1999 (92%) (Table 1). Average contribution of minor carps to total landing decreased from 33.62% during 1987-1999 to a meager 8.94% during 2010-2019 (Figure 1). The maximum percentage contribution by minor carps to total landings in this landing centre of river Brahmaputra was 55.47% in the year 2002 and the minimum was 5.7% in 2011. Local polynomial regression (LPR) of degree one was fitted to the annual minor carp landings of river Brahmaputra at Guwahati. The estimated smoothing parameter value for the model was 0.348 based on the minimum value of AICC. The number of points in the local neighbourhood was 11. The observed data on minor carp landings of River Brahmaputra at Guwahati and fitted values by nonparametric regression approach are presented in figure 2(b).

Catfishes Landing

The average contribution of catfish landings towards total landings in this landing centre of Brahmaputra River was 14.98% during 1980-19. The maximum contribution of 25.96% to the total landings was observed in the year 2016 and the minimum was 5.18% in 2002. The average annual landings by catfishes during this period was 24.783 t (CV = 32.46%) with a maximum of 45.15 t in 2007 and a minimum of 13.415 t in 1987. The mean catfish landing did not differ significantly between the decades 1987-1999 (25.5±7.9 t year^{-1}) and 2000-2009 (28.9±9.6 t year^{-1}). However, the average landings for the last decade 2010-19 (19.8±2.3 t year^{-1}) was significantly lower (32%) than landings from 2000-2009 (Table 1). However, the average contribution of catfishes landing to total landings of River Brahmaputra at Guwahati increased from 12.37% during 1987-1999 to 21.28% during the last decade (Figure 1). Local polynomial regression (LPR) of degree one was fitted to the annual catfish landings of river Brahmaputra at Guwahati. Based on the AICC procedure, the LOWESS regression with a smoothing parameter (q) of 0.7 and 9 numbers of points in the local neighbourhood was fitted to the observed data

(Figure 2(c)).

Featherbacks Landing

The average contribution by featherback landings towards total landings in River Brahmaputra at Guwahati during 1980-2019 was 2.84% with a maximum of 10.21% in the year 1992 and the minimum was 0.51% in 2006. The average annual featherback landings during this period was 5.443 t (CV = 80.56%) with a maximum of 20.71 t in 1990 and a minimum of 1.167 t in 2010. The average featherbacks landing during 1987-1999 was 9.2±4.9 t year^{-1}. Following this period of high landings, a significant decline (63%) in the average landings was observed during 2000-2009 (3.4±1.4 t year^{-1}). However, the mean landings stabilized during the last decade 2010-2019 (2.6±0.6 t year^{-1}), were significantly lower (72%) than landings from 1987-1999 (Table 1). Average contribution of featherbacks to total landings decreased from 4.5% during 1987-1999 to 2.8% during 2010-2019 (Figure 1). Local polynomial regression (LPR) of degree one was fitted to the annual featherback landings of river Brahmaputra at Guwahati. The estimated smoothing parameter value for the model was 0.2576 based on the minimum value of AICC. The number of points in the local neighbourhood was 8. The observed data on featherback landings of River Brahmaputra at Guwahati and fitted values by nonparametric regression approach are presented in figure 2(d).

Hilsa Landing

The average contribution by hilsa landings towards total landings in river Brahmaputra at Guwahati during 1980-19 was 3.53% with a maximum of 7.39% in the year 2009 and the minimum was 1.87% in 1998. The average annual hilsa landings during this period was 6.781 t (CV = 46.36%) with a maximum of 14.063 t in 2002 and a minimum of 2.305 t in 2011. The landings were relatively stable with an average catch of 7.0±1.7 t year^{-1} during 1987-1999. Following this period, a significant increase (40%) was observed in the average landings during 2000-2009 (9.8±2.7 t year^{-1}) with wide variations. However, the landings declined steeply during the last decade 2010-2019 to an average of 3.4±0.9 t year^{-1} (Table 1), a decline by almost 58.44% as compared to the average Hilsa landings in the previous two decades (1987-2019). However, average percentage contribution of Hilsa to total landings remained unchanged over the decades (Figure 1). Local polynomial regression (LPR) of degree one was fitted to the annual hilsa landings of river Brahmaputra at Guwahati. Based on the AICC procedure, the LOWESS regression with a smoothing parameter (q) of 0.3485 and 11 numbers of points in the local neighbourhood was fitted to the observed data (Figure 2(f)).

Miscellaneous Fishes Landing

During the period 1980-2019, the average annual landing by miscellaneous fishes in River Brahmaputra at Guwahati was 64.809 t with a coefficient of variation of 45.18%. This on an average is about 33.76% of the total landings in this landing centre. During this period the maximum miscellaneous fish landings observed was 141.849 t in the year 2004 (38.08% of total landings) and the minimum landings of miscellaneous fish observed was 28.183 t (10.21% of total landings) in the year 1992. The minimum percentage contribution by miscellaneous fishes towards the total landings in the landing centre was 14.98% in 1999 and maximum percentage contribution to the total landings was 66.41 in 2011. The mean landings during 2000-2009 (89.8±38.2 t year^{-1}) were significantly higher (68%) than during 1987-1999 (53.6±20.0 t year^{-1}). However, the mean landings during the last decade 2010-2019 (54.3±7.2 t year^{-1}) were significantly lower than for the previous decade (Table 1). This showed that mean landings during 2010-2019 declined by almost 40% as compared to the mean landings in 2010-19. However, the average contribution of miscellaneous fish species to the total landing increased from 26.03% during 1987-1999 to 58.43% during 2010-2019 (Figure 1). Earlier studies also observed a surge in dominance of small-sized miscellaneous fish species (40%-50% of total landing) and a marked decline in landings of prized IMC and Hilsa (Vass and Moza, 2011). Vass *et al.* (2009) observed increased landing of miscellaneous and catfish species in the middle stretch of river Ganga in the last two decades whereas a decreased contribution of IMC from 41.4% to 8.3%. Fish production in the Brahmaputra valley have been affected considerably due to anthropogenic pressure, climate change and other environmental factors (Debnath *et al.*, 2015; Bhattacharjya *et al.*, 2017, 2021). Local polynomial regression (LPR) of degree one was fitted to the annual miscellaneous fish landings of river Brahmaputra at Guwahati. The estimated smoothing parameter value for the model was 0.2879 based on the minimum value of AICC. The number of points in the local neighbourhood was 9. The observed data on miscellaneous fish landings of River Brahmaputra at Guwahati and fitted values by nonparametric regression approach are presented in figure 2(e).

Conclusion

Fish landings as well as composition in the river Brahmaputra fishery suffered changes in the last decade. The study attempted to capture trends in fish landing of River Brahmaputra in Assam using LOWESS regression technique. The observed fish landings and forecasts values by the fitted LOWESS regression showed a fair agreement. Climate change, habitat modification, over exploitation and other anthropogenic causes can be important factors influencing such changes. Specific studies are needed to analyze the association of changes in fish composition and these factors. These studies can be helpful to local environmental management. If alterations continue, the river Brahmaputra fishery future could be seriously threatened. The sharp decline in fish landings from the river due to these alterations in the last decade is directly affecting the livelihood of the fishermen community.

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