doi:10.21077/ijf.2024.71.1.131145-06

Available online at: epubs.icar.org.in/index.php/IJF

Fishery, population dynamics and stock assessment of flat needlefish *Ablennes hians* (Valenciennes, 1846) from the south-eastern Arabian Sea off Kerala coast, India

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Abstract

The age, growth, mortality parameters and stock status of *Ablennes hians* (Valenciennes, 1846) were assessed by using length frequency, catch, and effort data collected from the commercial catches along the coast of Kerala (south-eastern Arabian Sea) during 2015-2017. The growth parameters, L_∞, K and t_0 were estimated at 133.9 cm TL, 0.72 yr^{-1} and -0.0026 yr, respectively. The instantaneous natural mortality (M), total mortality (Z), fishing mortality (F) and current exploitation rate (E_{cur}) were estimated as 0.95 yr^{-1}, 2.78 yr^{-1}, 1.83 yr^{-1} and 0.66, respectively. Length at capture (L_{c50}) was estimated at 77.58 cm TL, which is greater than L_{m50}. Beverton and Holt yield per recruit analysis, indicated that maximum Y/R could be obtained at an exploitation rate (E_{max}) of 0.75, suggesting scope for an increase in exploitation. In this analysis, spawning stock biomass (SSB) was not taken into consideration, which is essential for maintaining recruitment in the future. In the present study, $E_{0.1}$ (0.61) and E_{cur} (0.66) were nearly equal, indicating that the fishery is running at an economic reference point *i.e.,* maximum economic yield (MEY). Thompson and Bell prediction model showed that at the current level of exploitation, the SSB was reduced by 20.49% and hence, there is no scope for further increase in fishing efforts to maintain the SSB at a relatively safe and sustainable level. The analysis revealed the maximum sustainable yield (MSY) of this species as 90.26 t, which can be obtained by increasing the present level of fishing effort by 1.3 times but would result in the depletion of the SSB to a critically low level of 15.65%. Therefore, a precautionary safe level of exploitation ($E_{0.1}$), estimated at 0.61 for the species, is recommended.

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Keywords:
Belonidae, Fishery management, Population dynamics, Spawning stock biomass, Stock status

Received : 07.12.2022
Accepted : 29.03.2024

Introduction

Flat needlefish, *Ablennes hians* (Valenciennes, 1846), which belongs to the family Belonidae, has a worldwide distribution in tropical and warm temperate waters, inhabiting both coastal and offshore surface water but prefers inshore occurrences usually around islands than along the mainland (Collette, 1984). The species forms a commercially important pelagic fishery resource exploited throughout its distributional ranges. It is a carnivorous and active pelagic predator, predominately consuming teleost fishes and an opportunistic feeder and may undertake vertical migrations in search of food (Roul *et al.,* 2023). They are mostly captured by casting or trolling surface or near-surface lures and drift gill nets (Collette, 2003). Separate catch statistics for needlefishes are not reported on a global scale and are generally included as other miscellaneous groups. In India, needlefishes are also considered commercially important and form a bycatch all along the Indian coast. However, a targeted fishery for this species exists along the Tamil Nadu coast throughout the year and a monsoon fishery in the Lakshadweep islands. In Lakshadweep islands, tuna fishing is usually stopped during the monsoon season and when the fishing ban is in place, needlefishes are exclusively exploited using a specialised encircling gill net locally known as 'Oola Bala'. This net is operated close to the shore without the aid of any type of craft and the catch is used only for local consumption. Kasim *et al.* (1996) reported on the fishery of full beaks and half beaks along the Tuticorin coast, Gulf of Mannar (Tamil Nadu), by drift gill nets locally known as 'Mural Valai'.

The information on fish population dynamics is important to understand how fishes react under anthropogenic pressure. The management of exploited fish stocks is possible only if basic biological data is available, particularly reproduction and growth data. Thus, a proper management system based on sound biological information should be of interest for all sectors, as the wealth of the stocks benefits all of them (Trindade-Santos and Freire, 2015). Inspite of commercial value of this species, only limited reports on the fishery, biology, length-weight relationships, growth, mortality and stock assessment of flat needlefish from the Indian EEZ are available (Kasim *et al.,* 1996, 1997; Chellappan *et al.* 2013; Roul *et al.,* 2018, 2023). Therefore, the present study was undertaken to assess the population dynamics and stock status of *A. hians* in Kerala waters, India.

Materials and methods

Data on the catch, effort, and size composition of *A. hians* were collected every week between October 2015 and September 2017 from commercial catches at three fish landing centres *viz*., Cochin Fishing Harbour (09^{0}56'327"N, 76^{0}15'764"E), Munambam Fishing Harbour (10^{0}10'965"N, 76^{0}10'258"E) and Kalamukku (09^{0}59'924"N, 76^{0}14'564"E) along Kerala coast (India) (Fig. 1). The sampling sites were selected based on the landing intensity of the species and length-frequency data were collected randomly covering the available size ranges. The fishes were captured mostly by hook and line (40.3%), followed by gillnet (23.6%) and trawl (20.6%). Weekly length frequency data (TL) were raised to the estimated monthly catch following Srinath *et al*. (2005).

The von Bertalanffy's growth parameters, such as asymptotic length (L_∞) and growth coefficient (K), were estimated using the ELEFAN 1 module of FiSAT II (Gayanillo *et al.*, 2005). Age at length zero (t_0) was back-calculated using the modified von Bertalanffy growth equation suggested by Alagaraja (1984), $t_0 = 1/k \log_e[1 - (L_{t=0}/L_\infty)]$, where $L_{t=0}$ is the length at hatching. For calculation of t_0, 2.5 mm was used as the length at hatching ($L_{t=0}$) which was confirmed by the diameter of the largest egg observed in the ripe ovary. The modal class progression analysis (MPA) was performed to refine the growth parameters obtained from the ELEFAN-I. Using the Bhattacharya approach, the composite length frequency distribution for each month was divided into various cohorts (Bhattacharya, 1967). The mean lengths of the cohort across different months were used to generate 'length at age' data. The growth performance index (φ) was calculated as $\varphi = \log_{10}K + 2\log_{10}L_\infty$ (Pauly and Munro, 1984). Longevity was calculated from the equation, $t_{max} = 3/K + t_0$ (Pauly, 1983). The instantaneous total mortality rate (Z) was estimated by using the length-converted catch curve. The natural mortality rate (M) was estimated by Pauly's empirical formula (Pauly, 1980): $\ln (M) = -0.0152 - 0.279 \ln (L_\infty) + 0.6543 \ln(K) + 0.463 \ln (T)$, where the mean sea surface temperature was taken as 28^{0}C and fishing mortality rate (F) was estimated as (Z - M). The current exploitation rate (E_{cur}) was calculated as E = F/Z (Ricker, 1975). Length cohort analysis was used to obtain fishing mortalities per length class. The smallest length group in the catch during the study period was taken as length at recruitment (L_r). Length at first capture (L_{c50}) was estimated by the probability of capture routine in the FiSAT II package. The recruitment pattern of the stock was determined from length-frequency data. The relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) at different exploitation levels were estimated using relative yield per recruit analysis (Beverton and Holt, 1966). The equilibrium yield, *i.e.,* catch (Y) and revenue,

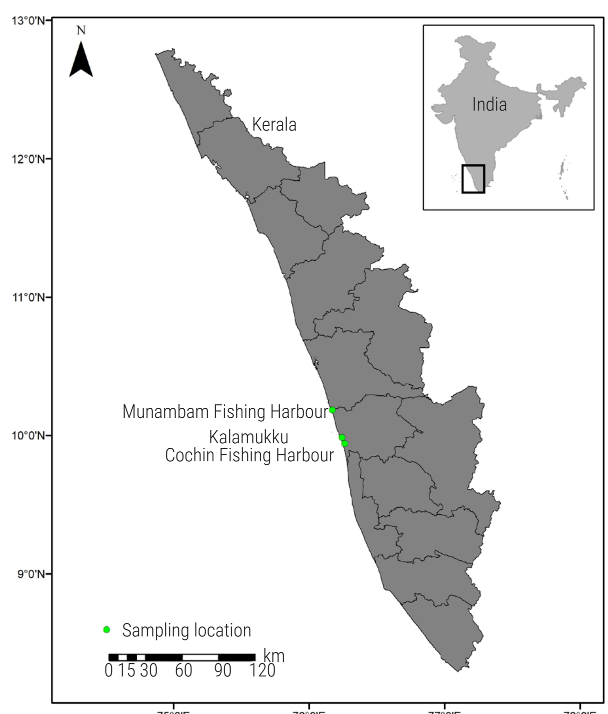

Fig. 1. Map showing the sampling sites of *A. hians* along the Kerala coast

standing stock biomass (B) and spawning stock biomass (SSB) at different fishing levels were predicted using the length-based Thompson and Bell bio-economic model (Thompson and Bell, 1934). The market price information for different length classes was used for the Thompson and Bell bio-economic model to estimate the equilibrium economic yield. The management advisories for the sustainable exploitation of needlefish were based on the biological reference points estimated.

Results and discussion

Fishery and seasonal abundance

The annual average landing of *A. hians* along the Kerala coast was estimated at 102.6 t with an average catch rate (CPUE) of 0.24 kg per unit during the years 2015-2017 (Table 1). The species contributed 19.4% of the total needlefish landings along the coast, but the contribution of the flat needlefish to the total marine fish landings in Kerala was <1%, as they are not a targeted resource, evidenced by very low catch rates (CPUE). The needlefish were fished throughout the year, with a peak landing in January and declining to the lowest level in July due to the monsoon fishing ban period, after which the catch increased substantially. Fishery and seasonal fluctuations in abundance along the coast of Tuticorin, Gulf of Manner, have been reported by Kasim *et al.* (1996).

Length structure

The length measurements (TL) of 1194 specimens of *A. hians* were collected in the field for the present study. The total length ranged between 35.5 and 127 cm, with a mean of 84.37±0.35 cm (mean±SE). Length-frequency distribution was not found to be normally distributed (one sample Kolmogorov-Smirnov test, $p<0.05$). The length range covered in this study is much less than the greatest length (L_{max}) of the species (140 cm TL) reported in the FishBase database (Froese and Pauly, 2024). Such differences in length composition between various geographical regions may be attributed to the different strengths of the year-class, differential mortality rates and growth patterns (Bilgin *et al.*, 2014). Overall length-frequency distribution indicated the dominance of individuals in the length group of 80-85 cm (Fig. 2), which could be attributed to the selectivity of the fishing gear, as most of the fishes were caught either by hook and line or gill nets.

Growth parameters

The growth parameters of *A. hians* estimated using ELEFAN–I and MPA are given in Table 2. The L_∞ and K estimated in ELEFAN–I were found to be 133.9 cm TL and 0.72 yr^{-1} respectively, with a t_0 of -0.0026 yr (Fig. 3). The MPA was also conducted; L_∞ and K values were estimated at 130.5 cm TL and 0.66 yr^{-1}, respectively, using t_0 of –0.0026. In the present study, the growth parameters estimated by ELEFAN–I was found to be a more reliable estimate than MPA. The t_0 estimated from the growth parameters obtained from ELEFAN–I also differed from the previous report where the estimated t_0 was -0.1178 yr (Kasim *et al.*, 1996). In general, t_0 is considered the proxy of hatching time. The age at maturity (t_m) was estimated at 1.16 and 1.3 years by ELEFAN–I and MPA, respectively. The inverse von Bertalanffy growth equation indicated the fishes attained 68.8, 102.2, 118.5 and 126.4 cm TL in the first, second, third and fourth years, respectively. Kasim *et al.* (1996) reported 60.6, 89.1, 104.6 and 113.1 cm FL for the same age. The growth performance index (φ) used to measure the overall growth performance was estimated at 4.11. Direct estimation of length at hatching (L_0) was difficult in the present study. Hence, the largest egg size in the ripe ovary was used to determine the L_0. The length at hatching (L_0) in the present study was estimated at 2.5 mm for the flat needlefish. The longevity (t_{max}) of the species obtained in the present study was 4.16 years, like the reported t_{max} of 4 years (Kasim *et al.,* 1996).

Mortality and exploitation parameters

The instantaneous natural mortality (M) of flat needlefish was estimated at 0.95 yr^{-1} by Pauly's empirical formula. Similarly, the instantaneous total mortality (*Z*) was estimated at 2.78 yr^{-1} using the length-converted catch curve method and the instantaneous fishing mortality (F) was computed as 1.83 yr^{-1} (Fig. 4). The estimated mortality rate indicates that a 34% reduction in stock is contributed by natural mortality due to predation, shortage of prey, disease and senility, whereas the remaining 66% reduction in stock was due to

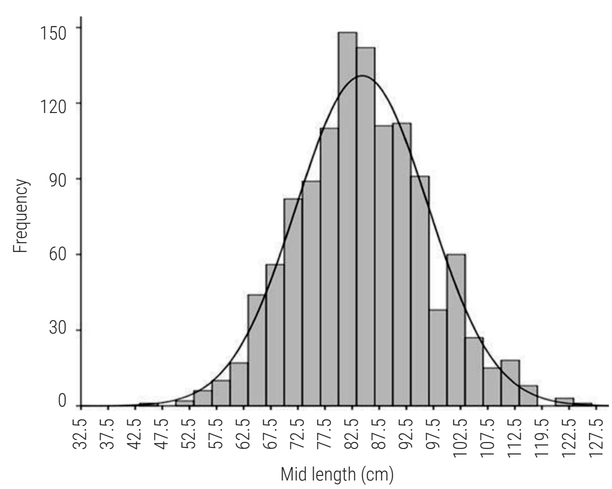

Fig. 2. Length frequency distribution of *A. hians* collected between 2015 and 2017 along Kerala coast

Table 1. Catch and effort of *A. hians* landed along Kerala coast during 2015–2017

Year	Effort (units)	Total marine landings (t)	Total needlefish landings (t)	Percentage of needlefish landings in total landings	*A. hians*		
					Catch (t)	CPUE (kg U^{-1})	% of total needlefish landings
2015	475974	482499	478	0.10	121.0	0.25	25.3
2016	383740	522000	351	0.07	71.5	0.19	20.4
2017	410992	581379	754	0.14	115.2	0.28	15.3
Average	423569	528626	528	0.10	102.6	0.24	19.4

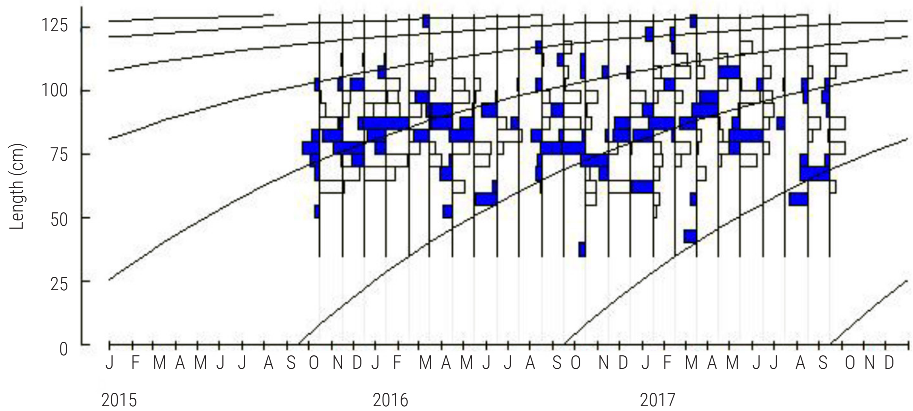

Fig. 3. von Bertalanffy equation fitted growth curve of *A. hians* using ELEFAN–I

Table 2. Estimated growth parameters of *A. hians* from Kerala coast

VBGF parameters	ELEFAN–I	MPA
L_∞ (cm)	133.9 TL	130.5 TL
K (yr^{-1})	0.72	0.66
t_0 (yr^{-1})	-0.0026	-0.0026
VBGF fitted L_0 (mm)	2.5	2.5
t_{max} (yr)	4.16	4.54

#ELEFAN–I: Electronic Length Frequency Analysis–I; MPA: Modal class progression analysis; VBGF: von Bertalanffy growth function; L_∞: Maximum theoretical length the animal can grow; K: Growth coefficient; t_0: Time when the length of the animal is theoretically zero; L_0: Length of the animal at hatching time; t_{max}: Longevity of the fish

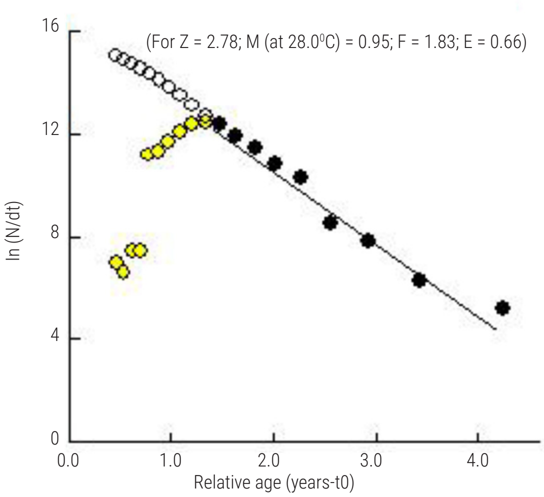

Fig. 4. Length converted catch curve showing the mortality parameters *i.e.*, M, F, Z and exploitation rate, E of *A. hians* from Kerala coast

fishing mortality. The M/K ratio was 1.32 for flat needlefish, within the range of 1.0-2.5 suggested by Beverton and Holt (1956). Off the Tuticorin coast in the Gulf of Mannar, M, Z and F were estimated at 0.81, 3.23-3.87 and 2.43-3.07, respectively for flat needlefish (Kasim *et al.,* 1996). Differences in mortality rates among the studies may be due to different fishing pressures, environmental factors and local predation effects (Pepin *et al*., 2002). Gulland (1971) suggested that F_{opt} = M, which corresponds to the optimum level of exploitation rate, E_{opt} = 0.5 (Pauly, 1984). The fishing mortality (F) in this study was higher than the natural mortality (M) and the current exploitation rate (E_{cur} = 0.66) was higher than the optimum (E_{opt} = 0.5). The length-based cohort analysis showed that F exceeded M when the needlefish attained 105 cm TL (Fig. 5). Such top predatory fish often play a crucial role in regulating the populations of their prey species. When these predators are overfished, their prey populations can increase unchecked, leading to imbalances in lower trophic levels. This can result in cascading effects throughout the food web, affecting the abundance and distribution of other species.

Gear selectivity and recruitment

The length at capture (L_{c50}), or the length at which 50% of the fishes in the stock become vulnerable to fishing gear, was estimated at 77.58 cm TL (Fig. 6); the L_{c25} and L_{c75} for the species were estimated at 73 and 82 cm TL, respectively. The recruitment pattern (Fig. 7) revealed that flat needlefish juveniles are recruited to the fishery throughout the year, with peaks during April (23%) and May (22%). Length at recruitment (L_r) for the needlefish was estimated at 35.5 cm TL. The estimated length at capture (L_{c50} = 77.58 cm TL) is slightly higher than the length at 50% maturity (L_{m50} = 75.9 cm TL), which indicates that the peak phase of exploitation occurs immediately after completion of 1 year of birth, and heavy exploitation of mature individuals can cause recruitment overfishing, which reduces future yield levels. Therefore, precautionary management measures need to be adopted.

Stock assessment

The flat needlefish is exploited by both selective and non-selective gears. The relative Y/R and B/R of flat needlefish were estimated using the knife edge selection procedure of FiSAT II. The estimated L_{c50}/L_∞ (0.58) and M/K (1.32) values were used as the input parameters for this analysis. The analysis indicated that the exploitation rate that maximises the yield per recruit (E_{max}) was found to be 0.75, indicating the scope for increasing the exploitation rate (Fig. 8). However, the fact that the SSB is essential for maintaining recruitment in the future (Clark, 1991) is not taken in to consideration by this model and E_{max} usually corresponds to very

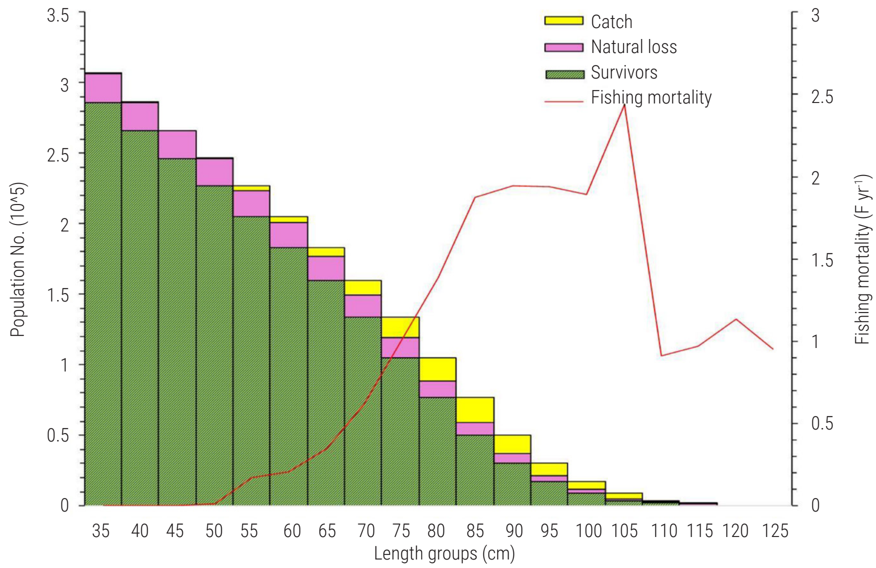

Fig. 5. Length structured cohort analysis of *A. hians* from Kerala coast

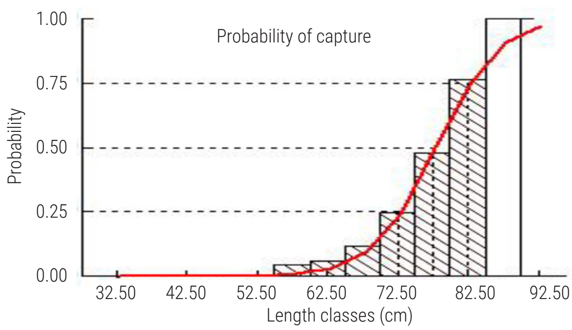

Fig. 6. Length at capture (L_{c50}) of *A. hians* from Kerala coast

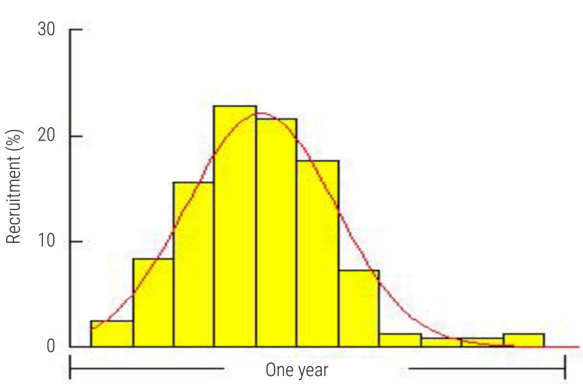

Fig. 7 Recruitment pattern of *A. hians* from Kerala coast

low levels of B/R. Hence, it is recommended that exploitation be reduced to a precautionary level ($E_{0.1}$), where the level of exploitation is limited to a level when the marginal increase in yield per recruit reaches 1/10 of the marginal increase computed at a very low value of E. The $E_{0.1}$ was estimated at 0.61 for the species. Therefore, E_{max} and $E_{0.1}$ can be considered as a proxy for maximum sustainable yield (MSY) and maximum economic yield (MEY), respectively, and set as a target reference point (TRP) (Jakubaviciute *et al*., 2011). In the present study, $E_{0.1}$ (0.61) and E_{cur} (0.66) had similar values, indicating that the flat needlefish fishery is running at an economic reference point (MEY). The $E_{0.5}$ was estimated at 0.38, which represents the exploitation rate at which B/R reduces by 50% compared to virgin stock, *i.e.,* to the level that theoretically maximises surplus production (Pauly, 1984). This can be used as a proxy for the optimum sustainable yield (OSY) (Dadzie *et al*., 2005). In the present study, the optimum biomass of flat needlefish can be maintained at $E_{0.5}$ of 0.38, whereas a high E_{cur} of 0.66 depletes the B/R considerably.

Thompson and Bell yield and stock prediction model was employed to assess the impact of the increase in effort on yield (Y), total biomass (B), SSB, and revenue generated from the fishery (Thompson and Bell, 1934) (Table 3, Fig. 9). This analysis indicated that MSY of 90.26 t can be obtained from the current equilibrium yield of 89.53 t by increasing the fishing efforts (F-factor) 1.3 times higher than the current level, after which the yield decreases. However, this high level of fishing efforts could decrease the SSB to a critically low level of 15.65% which is not advisable. The analysis also revealed that the revenue generated from the fishery could be maximised to ₹115.98 lakhs (MEY), from the current equilibrium revenue of ₹115.44 lakhs by reducing the fishing effort (F-factor) by 0.1 times the current level of fishing effort. The SSB at current equilibrium revenue and MEY were found to be 20.49 and 22.73%, respectively. The long-term sustainability of the stock is to be considered as they are relatively low-fecund fish, and recruitment overfishing due to lack of an adequate population of spawners should be avoided by keeping adequate levels of SSB. Additionally, fishing beyond MEY may lead to economic overfishing, as revenue generated from the fishery will not increase despite the increase in catch.

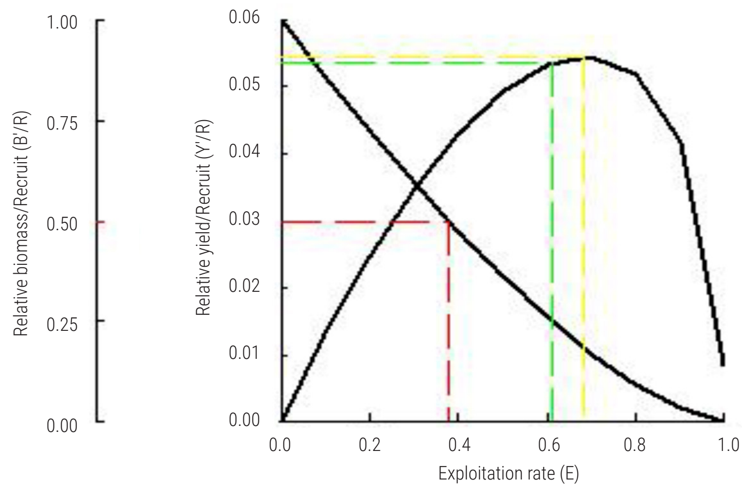

Fig. 8. Stock status of *A. hians* using Beverten and Holt"s relative Y/R model.

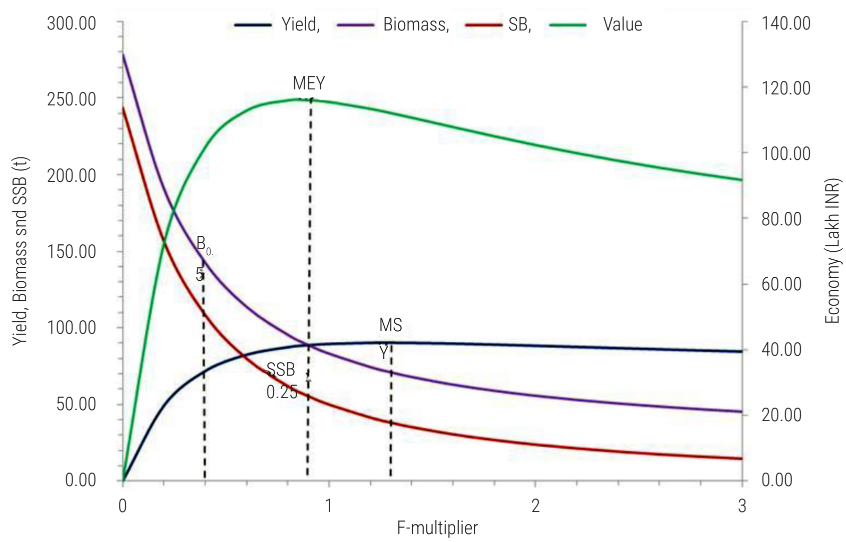

Fig. 9. Prediction of stock status of *A. hians* at different exploitation levels using Thompson and Bell bioeconomic model

Table 3. Prediction of stock status of *A. hians* at different exploitation levels using the Thompson and Bell bio-economic model

F-multiplier	Yield (t)	Value (` Lakhs)	Biomass (t)	SSB (t)	B/Bi	SSB/SSBi
0	0.00	0.00	278.41	243.72	100.00	100.00
0.2	49.23	72.25	190.84	156.45	68.54	64.19
0.4	71.81	101.66	142.53	108.43	51.19	44.49
0.6	82.44	112.83	113.78	79.98	40.87	32.81
0.8	87.39	115.94	95.50	61.99	34.30	25.43
0.9	88.71	115.98	88.78	55.40	31.89	22.73
1	89.53	115.44	83.18	49.95	29.88	20.49
1.2	90.22	113.38	74.44	41.48	26.74	17.02
1.3	90.26	112.07	70.98	38.15	25.49	15.65
1.4	90.17	110.69	67.96	35.27	24.41	14.47
1.6	89.72	107.83	62.96	30.53	22.61	12.53
1.8	89.08	105.02	58.97	26.81	21.18	11.00
2	88.34	102.35	55.72	23.81	20.01	9.77
2.2	87.56	99.87	52.99	21.34	19.03	8.75
2.4	86.77	97.57	50.67	19.26	18.20	7.90
2.6	86.00	95.45	48.66	17.50	17.48	7.18
2.8	85.24	93.50	46.89	15.98	16.84	6.56
3	84.52	91.72	45.33	14.65	16.28	6.01

Flat needlefish are not a targeted fishery resource along the Kerala coast, and controlling fishing efforts in such fisheries can be difficult, particularly in a multi-species, multi-gear scenario in India. The current equilibrium revenue is almost equal to MEY; therefore, exploitation can be continued at the present level of fishing effort for a sustainable fishery. The size range investigated in this study is not entirely comprehensive, as individuals below 45 cm TL were not included due to constraints related to the selective nature of commercial catches. Consequently, future research employing standardised sampling methods is warranted to capture an unbiased sample that encompasses the entire size spectrum of the species. The findings of this study offer initial insights into the stock status of flat needlefishes within the study area, serving as a foundational data set for informed management and conservation efforts aimed at safeguarding the species throughout the region.

Acknowledgements

The authors are grateful to Dr. A Gopalakrishnan, Director, ICAR-CMFRI, Kochi for providing all necessary facilities and constant support during the entire study period. The authors thank Dr. Gyanaranjan Dash for his help in data analysis and D. Prakasan, T. B. Retheesh and A. R. Akhil for their help on field work.

References

Alagaraja, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish*., 31(2): 177-208.

Beverton, R. J. H. and Holt, S. J. 1956. A review of methods for estimating mortality rates in exploited populations, with special reference to sources of bias in catch sampling, *Cons. Int. Explor. Mer.*, 140: 67-83. https://doi.org/10.1016/j.fishres.2022.106489.

Beverton, R. J. H. and Holt, S. J. 1966. Manuals of methods for fish stock assessment: Part II Tables of yield function, *FAO Fish. Biol. Tech. Pap.,* 38(4), *Version 1*, Food and Agriculture Organisation of the United Nations, Rome, Italy, 67 pp.

Bhattacharya, C. G. 1967. A simple method of resolution of a distribution into Gaussian components. *Biometrics*, 23: 115-135. https://doi.org/10.2307/2528285.

Bilgin, S., Tasci, B. and Bal, H. 2014. Population dynamics of the garfish, *Belone euxini* (Belonidae: *Belone*) from the south-east Black Sea. *J. Mar. Biol. Ass. UK*, 94(8): 1687-1700. https://doi.org/10.1017/S0025315414000769.

Chellappan, A., Pawar, N., Bagade, D. and Jaokar, A. 2013. Heavy landing of needlefish, *Ablennes hians* (Valenciennes, 1846) at Sassoon Dock, Maharashtra. *Mar. Fish. Infor. Serv. T & E Ser.,* 218: 18-19.

Clark, W. G. 1991. Groundfish exploitation rates are based on life history parameters. *Can. J. Fish. Aquat. Sci*., 48: 734-750. https://doi.org/10.1139/f91-088.

Collette, B. B. 2003. "Family Belonidae Bonaparte 1832–needlefishes." *California Academy of Science Annotated Checklists of Fishes*, 16: 1-22.

Collette, B. B. 1984. Family Belonidae. In: Fischer, W. and Bianchi, G. (Eds.), *FAO species identification sheets for fishery purposes. Western Indian Ocean (Fishing Area 51),* Vol. 1. Food and Agriculture Organisation of the United Nations, Rome, Italy.

Dadzie, S., Manyala, J. O. and Abou-Seedo, F. 2005. Aspects of the population dynamics of *Liza klunzingeri* in the Kuwait Bay. *Cybium*, 29(1): 13-20.

Froese, R. and Pauly, D. 2024. *FishBase 2024, version (March, 2024)*. World Wide Web electronic publication. http://www.fishbase.org.

Gulland J. A. 1971. *The fish resources of the oceans*. FAO Fishing News (Books) Ltd., West Byfleet, UK, 210 p.

Jakubaviciute, E., Putys, Z., Dainys, J. and Lozys, L. 2011. Perch (*Perca fluviatilis*) growth, mortality and stock exploitation by 40-45 mm mesh-sized gillnet fishery in the Curonian Lagoon. *Acta Zool. Lituan*., 21(3): 215-220. https://doi.org/10.2478/v10043-011-0026-y.

Gayanillo, F. C. Jr., Sparre, P. and Pauly, D. 2005. FAO-ICLARM Stock Assessment Tools II (FiSAT II). User's guide. *FAO Computerized information Series (Fisheries). No. 8, Revised version,* Food and Agriculture Organisation of the United Nations, Rome, Italy, 126 p.

Kasim, M. H., Ameer Hamsa, K. M. S., Balasubramanian, T. S. and Rajapackiam, S. 1996. The fishery of full beaks and half beaks with special reference on the growth, mortality and stock assessment of *Ablennes hians* (Valenciennes) along the Tuticorin coast, Gulf of Marmar. *Indian J. Fish.,* 43(1): 51-59.

Kasim, M. H., Ameer Hamsa, K. M. S., Rajapackiam, S. and Balasubramanian, T. S. 1997. Length-weight relationship of three species of belonids and a hemiramphid from the Gulf of Mannar. *J. Mar. Biol. Ass. India*, 38: 146-149.

Pauly D. 1983. Length converted catch curves. A powerful tool for fisheries research in tropics (Part -I). *ICLARM Fishbyte*, 1(2): 9-13.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, 39: 175-192. https://doi.org/10.1093/icesjms/39.2.175.

Pauly, D. 1984. Fish population dynamics in tropical waters: A manual for use with programmable calculators. *ICLARM Stud. Rev.,* 8: 325 p.

Pauly, D. and Munro, J. L. 1984. Once more, on the composition of growth in fish and invertebrates. *ICLARM Fishbyte*, 2(1): 21.

Pepin, P., Dower, J. F., Helbig, J. A. and Leggett, W. C. 2002. Regional differences in mortality rates of a larval fish, the radiated shanny (*Ulvaria subbifurcata*): Estimating the relative roles of dispersal and predation. *Can. J. Fish. Aquat. Sci.*, 59: 105-114. https://doi.org/10.1139/f01-198.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Can.,* 191: 382 p.

Roul, S. K., Ganga, U., Abdussamad, E. M., Jaiswar, A. K. and Rohit, P. 2023. Diet composition and feeding habits of flat needlefish *Ablennes hians* (Valenciennes, 1846) (Beloniformes: Belonidae) in the Southeastern Arabian Sea. *Indian J. Geo-Mar. Sci*., 52(1): 24-35. https://doi.org/10.56042/ijms.v52i01.5440.

Roul, S. K., Retheesh, T. B., Ganga, U., Abdussamad, E. M., Rohit, P. and Jaiswar, A. K. 2018. Length-weight relationships of five needlefish species from Kerala waters, south-west coast of India. *J. Appl. Ichthyol.,* 34(1): 190-192. https://doi.org/10.1111/jai.13527.

Srinath, M., Kuriakose, M. and Mini, K. G. 2005. Methodology for estimation of marine fish landings in India. *CMFRI special publication No. 86*, ICAR-Central Marine Fisheries Research Institute, Kochi, India, 57 p.

Thompson, W. F. and Bell, F. H. 1934. Biological statistics of the Pacific halibut fishery. Effect of changes in intensity upon total yield and yield per unit of gear. *Rep. Int. Fish. (Pacific halibut) Comm*., 8: 49 p.

Trindade-Santos, I. and Freire, K. D. M. F. 2015. Analysis of reproductive patterns of fishes from three large marine ecosystems. *Front. Mar. Sci.,* 2: 38. https://doi.org/10.3389/fmars.2015.00038.