Asian Fisheries Science **27** (2014): *274-285*

ISSN 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2014.27.4.004

Distribution, Abundance and Sustainable Yield of Cobia *Rachycentron canadum* (Linnaeus 1766) Occurring in Indian Waters

M.K. SAJEEVAN[1*] and B. MADHU SOODANA KURUP[2]

[1]Fishery Survey of India, Sir PM Road, Mumbai, India, 400001
[2]Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, India-682506

Abstract

Cobia *Rachycentron canadum* (Linnaeus 1766) is distributed widely in tropical and subtropical waters except in the eastern Pacific and the Pacific plate. Information on the distribution and abundance of cobia in Indian waters are limited. Results of the present study provided first hand information on the spatio-temporal distribution and biomass of the cobia along the east and west coast of India. Exploratory fishing data collected by the resource survey vessels along both east and west coasts for a period of January 1980 to December 2007 were utilised for this study. Results revealed that cobia occur along both east and west coast of India and are abundant along the northern latitudes of both coasts. Bathymetrically, they were caught between 33-229 m and found to be more abundant in near shore waters i.e. depth zone 30-50 m. Results of the present study indicated that cobia were caught along both east and west coast throughout the year. The present study estimated the potential yield of cobia from Indian waters as 798.66 tonnes.

Introduction

Cobia *Rachycentron canadum* (Linnaeus 1766) is distributed widely in tropical and subtropical waters except in the eastern Pacific and the Pacific plate (Butsch 1939; Briggs 1960; Shaffer and Nakamura 1989). In the Indian Ocean, they are distributed from east Africa to Australia and in Pacific from Hokkaido, Japan to Australia and East Indies (Sajeevan 2011).

Several studies have been carried out in different parts of the world to understand the distribution and abundance of cobia stock. Major works, in this regard, are Jordan and Seale (1906), Nichols and Breder (1926), Briggs (1958, 1960), Bearden(1961), Richards (1967), Dawson (1971), Monod (1973), Relyea (1981), Menni et al. (1984), Golani and Ben-Tuvia (1986), Shaffer and Nakamura, (1989), Bohlke and Chaplin (1993), Huang (2001) and Williams (2001). These

*Corresponding author. E-mail: sajeevanfsi@gmail.com

pioneering studies are vital in understanding the distribution and abundance of cobia occurring in different parts of the world except India.

In India, cobia is caught as incidental catch by hand lines, bottom trawls, drift gill nets, troll lines, purse-seine and trawl nets along the west and east coasts of India. Compared to major fishery resources that support marine fishing industry in India, landings of cobia are small, but their unit price and increased attention due to culture prospective make them an important fishery resource.

Information on the distribution and abundance of cobia in Indian waters are limited to Chacko (1949), Rajan et al. (1968), GOK (1968), Talwar and Kacker (1984) and Kapoor et al. (2002). They reported occurrence of cobia in different maritime states and lakes of India (Rajan et al. 1968).

A sound knowledge of its distribution and abundance is essential for ensuring the sustainable exploitation of any fishery resources. This vital information helps the scientists and planners to recommend an exploitation strategy that ensures the sustainable fishery.

Hence, an attempt has been made to understand the spatio-temporal distribution of cobia by utilising historical resource survey data collected by the Fishery Survey of India. The present study provides the first hand information on biomass of the cobia along the east and west coasts of India.

Materials and Methods

The Fishery Survey of India (FSI) conducted exploratory fishing surveys on the continental shelf and offshore regions of the Indian EEZ. Exploratory fishing data collected from the trawlers attached to the FSI (Table 1) along both east and west coasts between the depths of 30 to 200 m during January 1980 to December 2007 were utilised for this study. A total of 34,295 and 15,790 hauls were carried out along west and east coasts of India respectively. The surveys were conducted between latitude (Lat.) 07^0.00' and 22^0.00'N on the west coast and 10^0.00' and 20^0.00'N along the east coast. Three different fishing gears were used during the surveys: 34 m fish trawl, 45.6 m expo model fish trawl and 27 m fish trawl (FSI 2011).

Sampling method

The area under study i.e. between Lat. 07^0.00' and 22^0.00'N along west coast and 10^0.00' and 20^0.00'N along east coast from 30 to 200 m depth zone was divided into 81 strata based on the latitude and depth contours of 30 m, 50 m, 100 m, and 200 m. Each 1^0 Lat. x 1^0 longitude (Long.) was further divided into 100 squares of 6'x 6' area. Hauls were allocated to this subset of 6'x 6' squares following the stratified random sampling procedure. Habitat differences, catch rate recorded during previous exploratory data and area available for trawling were considered for the allocation of hauls. The trawling operation was carried out at a speed of 3 knots for 90 min duration per haul. Cobia catches were sorted out immediately after each haul following Pauly (1980) and weight of each cobia caught was recorded.

Table 1. Specifications of survey vessels, fishing gears and area of operation.

Name of Vessel/Type	Overall length (m)	Gross tonnage (t)	Break horse power (BHP)	Area of operation (latitude)	Fishing gear used
Matsya Nireekshani/ Stern trawler	40.5	329.26	2030	18^0-22^0 N (West coast)	34 m Fish trawl
Matsya Mohini/ Stern trawler	42.5	345	1100	18^0-22^0N (West coast)	45.6 m Expo model fish trawl
Matsya Vishwa/ Stern trawler	36.5	327.18	825	10^0-18^0N (West coast)	27 m Fish trawl
Sagarika/ Stern trawler	28.8	189	650	10^0-18^0N (West coast)	27 m Fish trawl
Matsya Varshini/ Trawler-cum-Purse-seiner	36.5	268.80	1160	07^0-10^0N (West coast)	45.6 m Expo model fish trawl
Matsya Jeevan/ Stern trawler	36.5	327.18	825	10^0-16^0N (East coast)	27 m Fish trawl
Samudrika/ Stern trawler	28.8	189	650	10^0-16^0N (East coast)	27 m Fish trawl
Matsya Shikari/ Stern trawler	39.5	352	1740	16^0-20^0N (East coast)	34 m Fish trawl

Distribution and biomass estimation

Catch recorded on board the vessel during each haul was converted to catch per effort in kilogram per hour ($kg{\cdot}h^{-1}$) by dividing the quantity in kg with effort in hours (actual haul duration). ‘Swept area’ or the ‘effective path swept’ by the trawl net during each haul was calculated by using the formula

$$a = D * h * x_2,$$

$$D = V * t$$

Where,
a = the swept area; D= distance trawled (m), V = the velocity of the trawl over the ground when trawling
h = the length of the head rope; t = the time spent for trawling
x_2= that fraction of the head rope which is equal to the width of the path swept by the trawl, (the ‘wing spread’, h * x_2).

Fraction of the head rope which is equal to the width of the path swept by the trawl, (the ‘wing spread’, h*x_2) was taken as 0.4 following Somvanshi et al. (2004). Based on experiments Somvanshi et al. (2004) have arrived at the value of $x_2 = 0.4$ to be the best compromise for the FSI vessels, and this value has been used for the present study. Catch per unit effort (CPUE) for each haul estimated by dividing catch per effort with the area swept during each haul following swept area method (Gulland 1975) was calculated. Estimation of swept area and CPUE in kg per square nautical mile for each haul minimises the variation in the estimate due to differences in the catch ability of fishing gears and vessels. Average CPUE for each stratum was estimated following arithmetic mean. The variance and confidence interval of each stratified mean was estimated following Cochran (1977).

Generalised linear model (GLM) was used to understand cobia distribution in time and space by employing SYSTAT 13 software. Catch per unit efforts of four Lat. were merged as Lat. range class to understand the horizontal distribution. Data were fitted into the model by taking CPUE as dependant variable. Lat. and depth zones as main plot and sub plot respectively were taken as independent variables. The model was repeated thrice by taking three levels of time periods i.e. decades (1980's, 1990's and 2000's) as independent variable. Four levels of Lat. (07-11^{0}N, 11-15^{0}N, 15-19^{0}N and 19-23^{0}N) and three levels of depth zones (30-50 m, 50-100 m and 100-200 m) were subjected to statistical testing to understand the distribution in space of cobia inhabiting the west coast of India. Three levels of latitudes (10-14^{0}N, 14-18^{0}N and 18-22^{0}N) and three levels of depth zones were used in the case of cobia inhabiting the east coast.

In order to understand the seasonal variation in the distribution of cobia, the calendar year was divided into four quarters by pooling subsequent three months data. The CPUE data of each haul were initially pooled on monthly basis by taking monthly average CPUE, and further the data were merged on quarterly basis. The statistical analysis of CPUE data of cobia caught from west coast proved that there was no significant difference on the bathymetrical distribution of cobia. Hence, the data was fitted to the GLM model by taking independent variables Lat. and quarters of the year as main and sub plot respectively. In contrast, there was no significant difference on the catch per unit effort of latitudes (horizontal distribution), hence data were fitted to GLM by taking depths zone as main plot and quarters as sub plot independent variable respectively. Standard statistical procedures (Courtney et al. 1996; McDonald 2009) were followed to ensure precision in the estimate.

Biomass of cobia from the study area was estimated by using the 'swept area method' (Gulland 1975). Fraction of the biomass in the effective path swept, which is actually caught was taken as 0.5 (Pauly 1979). Biomass per unit area for each stratum was estimated separately and then summed up to find out the total biomass of the area (Sparre et al. 1989). Maximum sustainable yield was estimated using the Cadima's formula (Sparre et al. 1989). Total mortality (Z) was taken as 0.76 (Sajeevan 2011).

Results

Distribution

The cobia was caught all along the coast of India from 33-229 m depth. Lat.-wise depth-wise and decade wise abundance of cobia based on trawl catches recorded during the period January 1980 to December 2007 from west coast are furnished as Figs. 1, 2 and 3. As shown in Fig. 1, abundance was highest along the northern Lat. (19-23^{0}N) followed by southern Lat. (07-11^{0}N). ANOVA table of GLM showed that there are significant differences among the CPUE of the latitudes (p-Value= 0.032 and R= 0.889). Depth-wise distribution is shown in Fig.2, which showed that the abundance decreases towards deeper waters. However, the ANOVA table showed that there is no significant difference in the bathymetrical distribution of cobia along the west coast (p- value=0.108). Decade-wise analysis (Fig.3) showed that there is a decreasing trend of catches since the 1980's. ANOVA table of GLM showed that there is significant difference in the CPUE recorded during the last three decades.

Lat-wise and depth-wise distribution of cobia inhabiting along east coast of India are furnished as Figs.4, 5 and 6. Lat-wise abundance of cobia furnished in Fig. 4 showed that the CPUE increases towards northern latitudes from 10-14^0 N to 18-22^0 N. However, ANOVA table of GLM shown that there is no significant differences between the CPUE of Lat. (p-Value = 0.335, R=0.854). Depth-wise, lowest CPUE recorded from 100-200 m than other two depth zones (Fig.5). ANOVA table of GLM shown that there is significant difference among the CPUE recorded from different depth zones (p-Value = 0.008). Tukey's Honest-Significant-Difference Test showed that catch rate of 100-200 m depth zone is significantly different from the catch rate of 30-50 m (p- value = 0.017) and 50-100 m (p- value = 0.014).

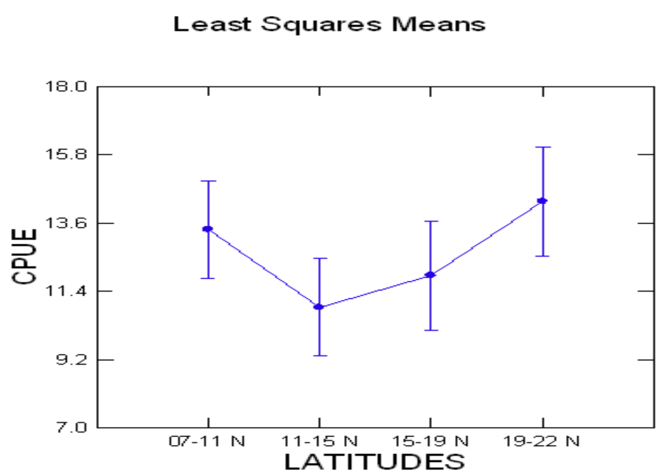

Fig.1.. Latitude-wise CPUE of cobia *Rachycentron canadum*in kg per square nautical miles recorded from west coast of India during 1980-2007.

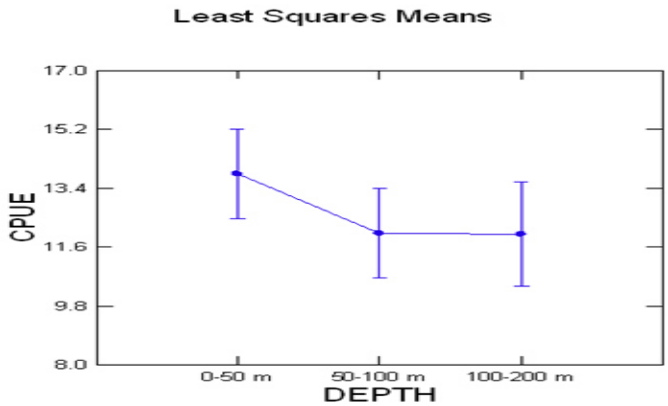

Fig.2. Depth-wise CPUE of cobia *Rachycentron canadum*in kg per square nautical miles recorded from the west coast of India during 1980-2007.

Decade-wise CPUE values (Fig.6) showed that catch recorded during 2000's were lower than the other two decades. However, there is no significant differences among the CPUE values (p-value=0.886).

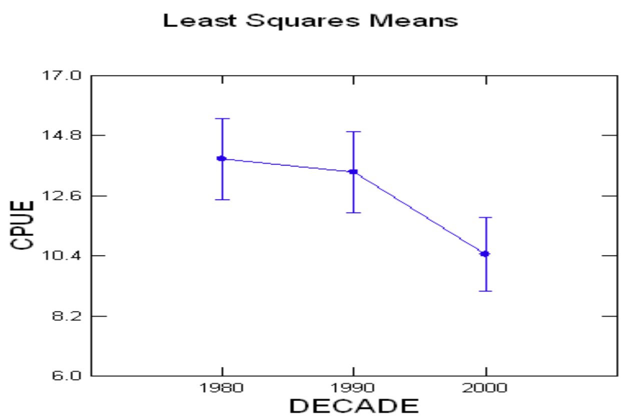

Fig.3. Decade-wise CPUE of cobia *Rachycentron canadum* in kg per square nautical miles recorded from the west coast of India during 1980-2007.

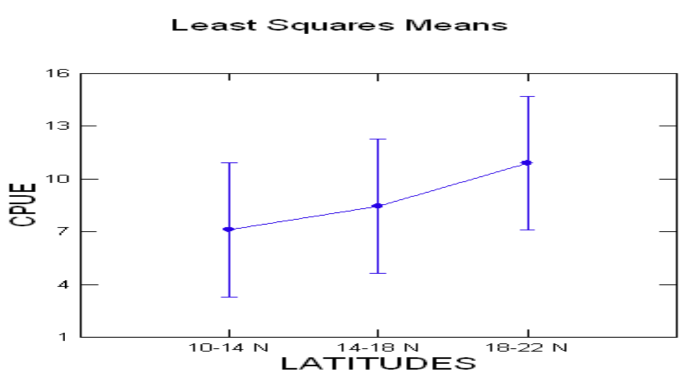

Fig.4. Latitude-wise CPUE of cobia *Rachycentron canadum* in kg per square nautical miles recorded from the east coast of India during 1980-2007.

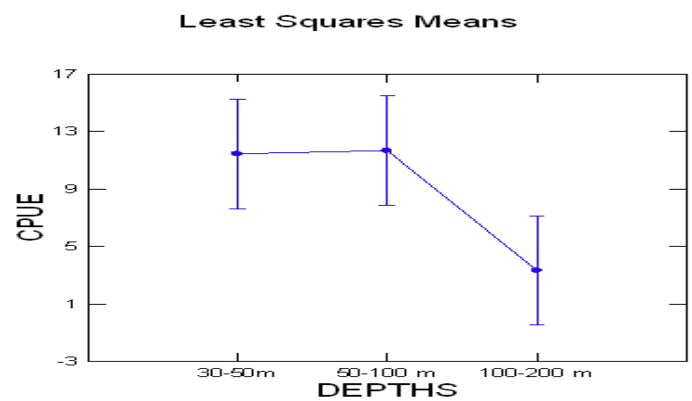

Fig.5. Depth-wise CPUE of cobia *Rachycentron canadum* in kg per square nautical miles recorded from the east coast of India during 1980-2007.

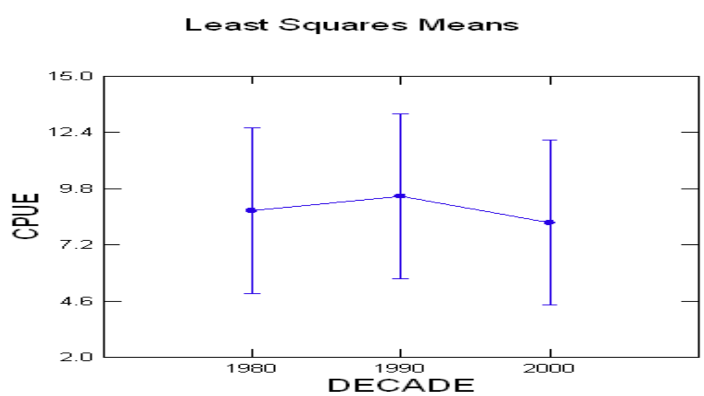

Fig.6. Decade-wise CPUE of cobia *Rachycentron canadum* in kg per square nautical miles recorded from East coast of India during 1980-2007.

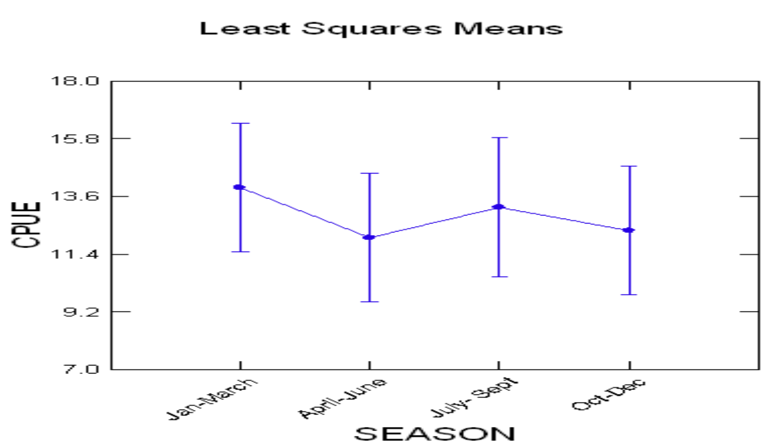

Fig.7. Quarter-wise CPUE of cobia *Rachycentron canadum* in kg per square nautical miles recorded from the west coast of India during 1980-2007.

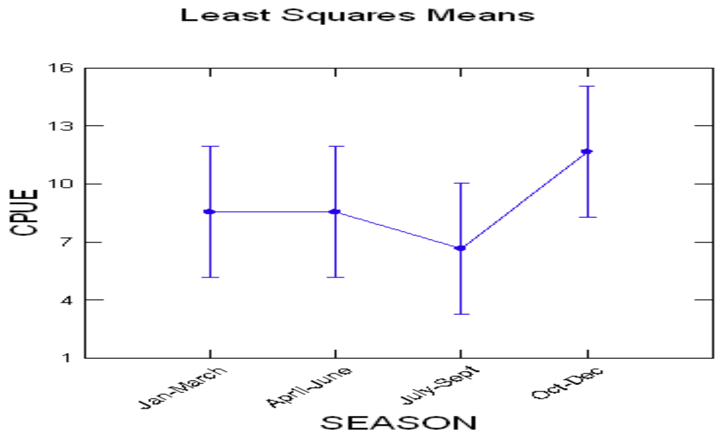

Fig.8. Quarter-wise CPUE of cobia *Rachycentron canadum* in kg per square nautical miles recorded from the east coast of India during 1980-2007.

The seasonal abundance of cobia along west and east coasts are furnished as Figs. 7 and 8 respectively. As shown in Figs. 7 and 8, cobia caught from both the coasts throughout the year had little variation in their CPUE. Better average CPUE value was recorded during the first quarter of the year along the west coast, followed by the third quarter. However, analysis showed that there is no significant differences among the CPUE values (p-value=0.661 and R= 0.766). The trend was different along the east coast, as a higher CPUE was recorded during the last quarter followed by the third quarter. However, ANOVA of GLM on seasonal abundance of cobia along the east coast showed that there is no significant differences between the CPUE during different quarters of the year (p-value = 0.213 and R=0.896).

Biomass and sustainable yield

Biomass of *R.canadum* estimated following the swept area method along the west and east coasts were 1,757.7981±0.0022 tonnes (standard error of variance=1.169) and 343.9323±0.0002 (standard error of variance=0.119) tonnes respectively. Total biomass of cobia obtained by summing up of estimated biomass from both the coasts was 2,109.73 tonnes. Percentage compositions of cobia biomass along east and west coasts of India were 83.64% and 16.36% respectively. Maximum Sustainable Yield (MSY) of cobia occurring in Indian waters was estimated at 798.66 tonnes (667.962 and 130.694 tonnes along west and east coasts of India respectively).

Discussion

Distribution

Analysis of catch and effort data of cobia recorded by FSI fleet revealed that the cobia occurs along both east and west coasts of India. Latitude wise, they were available in all the latitudes of Indian EEZ. In general, cobia was more abundant in northern latitudes along both coasts, a distribution pattern similar to those of spotted Spanish mackerel *Scomberomorus guttatus* (Bloch &

Schneider 1801) (Sudarsan et al. 1989). Bathymetrically, they were caught between 33-229 m. Along the west coast, abundance was more in 30-50 m depth zone followed by 50-100 m, but along the east coast the CPUE recorded from 30-50 m and 50-100 m was almost equal. In both cases catches were less in 100-200 m depth zone. This indicates that the cobia is more abundant along near shore waters. Availability of more prey in the near shore waters due to more productive and nutrient rich nature of coastal waters (Jennings et al. 2001) may be the reason for the rich concentration of cobia along near shore waters.

Study on fishing season of cobia revealed that the cobia can be fished throughout the year. Fluctuation in their abundance during different season and coast was noticed. However, results of the present study indicates that there is no significant difference among the CPUE of cobia recorded during different quarters of the year,

Analysis of catch and effort data over time indicates that cobia catch rates recorded during the present decade from both west and east coasts were less than the catch rates recorded during the1980's and 1990's. Increased fishing pressure exerted on the stock may be the reason for this decreasing trend in the catch rates. Reduction in catch rates of cobia during 2000's indicates that conservation measures need to be taken to ensure sustainable cobia fishery (Sajeevan 2011).

Biomass and sustainable yield

Biomass of cobia occurring in Indian waters estimated by the present study was 2,109.73 tonnes. Compared to the biomass of other pelagic fishes occurring in Indian waters, the quantum of cobia is less, but high demand in the market and better unit cost of the fish make them an important resource. Estimation of biomass by the present study was based on bottom trawl survey; hence fishes found in the bottom column of water only came into the purview of estimation. Since cobia is a pelagic, neretic species occurring throughout the water column, the total biomass of the species will be more than the estimated value from the present study.

In India, cobia is caught by various gears like hook and line, troll line, drift gill net and trawlers (Pillai 1982). In bottom trawls they are caught as by-catch and most of the fishes caught by trawlers are of smaller size. Due to the high unit price in the local market most of the fishes were sold fresh locally. Being a good table fish they are susceptible to high fishing pressure and hence exploited heavily.

Information on sustainable yield of cobia available in Indian waters is meager. MOA (2000) estimated the sustainable yield of cobia at 727 tonnes. The present study estimated the potential yield of cobia from Indian waters as 798.66 tonnes. Both studies considered fishes that are vulnerable to bottom trawling; hence the actual potential may be more than estimation made by the present study. A concerted effort to assess the biomass and potential of cobia vulnerable to pelagic gears is crucial to ensure the sustainable exploitation of cobia available in the Indian EEZ.

Conclusion

In-depth studies on the distribution and abundance of cobia round the world have been reported from different marine ecosystems of the world. But information on the spatio-temporal distribution of cobia inhabiting Indian waters is meager. The present study confirms that cobia *R. canadum* occur along both east and west coasts of India and are abundant in northern latitudes along both coasts. Bathymetrically, they were found to be more abundant along near shore waters. Results of the present study indicated that cobia can be fished along both coasts throughout year. Biomass of cobia occurring in India is estimated by the present study as 2,109.73 tonnes. 83.64% of biomass was from the west coast and 16.36% along the east coast. The present study estimated the potential yield of cobia from Indian waters as 798.66 tonnes. Results of the present study are the first records in the Indian Ocean. Hence this will help fisheries managers to formulate exploitation and fishery management strategy for this highly valued pelagic fish.

Acknowledgement

The authors are grateful to Prof. (Dr.) A. Ramachandran, Director, School of Industrial Fisheries for granting permission and providing necessary facilities for the successful conduct of the research work. Authors are thankful to Dr. K. Vijayakumaran, Director General, Fishery Survey of India, Mumbai; Dr, V.S Somvanshi, Former Director General, Fishery Survey of India, Mumbai for the facilities provided. Extra efforts of the officers and crew of M.V. *Matsya Nireekshani* are also acknowledged.

References

Bearden, C.M. 1961. Common marine fishes of South Carolina.Contributions of Bears Bluff Laboratory 34:1-47.

Bohlke, J.E. and C.C.G. Chaplin.1993.Fishes of the Bahamas and adjacent tropical waters.University of Texas Press, Austin. 316 pp.

Briggs, J. C. 1958.A list of Florida fishes and their distribution. Bulletin of the Florida State Museum Biological Science 2:221-318.

Briggs, J.C. 1960. Fishes of worldwide (circumtropical) distribution. Copeia 3:171-180.

Butsch, R.S. 1939. A list of Barbadian fishes. Journal of the Barbados Museum and Historical Science 7:17-31.

Courtney, A. J., D.J. Die and J.G. McGilvray, (1996).Lunar periodicity in catch rate and reproductive condition of adult eastern king prawns, *Penaeus plebejus*, in coastal waters of southeastern Queensland, Australia Marine Freshwater Research 47**:** 67-76.

Chacko, P.I.1949. Food and feeding habits of the fishes of the Gulf of Mannar. Proceedings of the Indian Academic Science Section B Biological Sciences 29:83-97.

Cochran, W.G. 1977. Sampling techniques.John Wiley &Sons, New York. 428 pp.

Dawson, C.E. 1971. Occurrence and description of pre juvenile and early juvenile Gulf of Mexico cobia, *Rachycentron canadum*. Copeia 1971:65-71.

FSI.2011. Fishery resource survey, assessment and research programme 2011-2012.(Fishery Survey of India, Mumbai). 49 pp.

GOK. 1968. Kerala fisheries (facts and figures). Kerala Superintendent Government Press, Govt. of Kerala, Trivandrum. 63 pp.

Golani, D. and A. Ben-Tuvia. 1986. New records of fishes from the Mediterranean coast of Israel including Red Sea immigrants. Cybium 10:285-291.

Gulland, J.A. 1975. Manual of method for fisheries resource survey and appraisal.Part 5.Objectives and basic methods. FAO Fisheries Technical Paper No.145.Food and Agriculture Organisation of the United Nations, Rome. 29 pp.

Huang, Z. 2001. Marine species and their distribution in China's seas.Vertebrata. Smithsonian Institution, Florida. 598 pp.

Jennings, S., M.J. Kaiser and J.D. Reynolds. 2001. Marine fisheries ecology. Oxford Blackwell Science Ltd., London. 417 pp.

Jordan, D.S. and A. Seale. 1906. The fishes of Samoa; description of the species found in the archipelago, with a provisional check-list of the fishes of Oceania. Bulletin of the U.S Bureau of Fisheries 25: 173-455.

Kapoor, D., R. Dayal and A.G. Ponniah,. 2002. Fish biodiversity of India. National Bureau of Fish Genetic Resources, Lucknow. 775 pp.

McDonald, J.H. 2009. Handbook of Biological Statistics, Sparky House Publishing. Maryland, USA. 293 pp.

Menni, R.C., R.A. Ringuelet and R.H. Aranburu.1984. Peces marinos de la Argentina y Uruguay. Edit. Hemisferio sur, S.A. 359 pp.

MOA. 2000. Report of the working group for revalidating the potential fishery resources in the Indian EEZ. Department of Animal Husbandry and Dairying, Ministry of Agriculture, Government of India, New Delhi. 66 pp.

Monod, T. 1973. Rachycentridae. In: Checklist of the fishes of the northern-eastern Atlantic and of the Mediterranean, vol. I (eds. J.C. Hureau and T. Monod). pp. 371-372. UNESCO, Paris.

Nichols, J.T. and C.M. Breder Jr. 1926. The marine fishes of New York and southern New England. Zoologica 9:1-192.

Pauly, D. 1979. Theory and management of tropical multispecies stocks: a review with emphasis on the south-east Asian demersal fisheries. ICLARM Studies and Reviews 1:1-35.

Pauly, D. 1980.A selection of simple methods for the assessment of tropical fish stocks.FAO Fisheries Circular No.729.Food and Agriculture Organisation of the United Nations, Rome, 54 pp.

Pillai, P.K.M. 1982. Black king fishes. Marine Fishery Information Service Technical Extension Series: 39. Central Marine Fisheries Research Institute, Cochin. 12 pp.

Rajan, S., S. Patnaink and N.C. Basu. 1968.New records of fishes from the Chilka Lake.Journal of Zoological Society of India 20:80-93.

Relyea, K. 1981. Inshore fishes of the Arabian Gulf. George Allen & Unwin, London. 149 pp.

Richards,C.E.1967. Age,growth, and fecundity of the cobia, *Rachycentron canadum*, from Chesapeake Bay and adjacent mid-Atlantic waters.Transactions of American Fisheries Society 96:343-350.

Sajeevan, M.K. 2011. Systematics, life history traits, abundance and stock assessment of cobia *Rachycentron canadum* (Linnaeus, 1766) occurring in Indian waters with special reference to the northwest coast of India. Ph.D. Thesis, Cochin University of Science and Technology, Kochi. 271 pp.

Shaffer, R.V. and E.L. Nakamura. 1989. Synopsis of biological data on the cobia, *Rachycentron canadum* (Pisces: Rachycentridae).National Oceanic and Atmospheric `Administration Technical Report, National Marine Fisheries Service: 82. U.S. Department of Commerce, Springfield, WA. 21 pp.

Somvanshi, V.S., D.K. Gulati, M.E. John and S. Vargese. 2004. Stock recruitment relationship of *Nemipterus japonicus* along north-west coast of India. Proceedings of the International Symposium on Large Marine Ecosystems: Exploration and Exploitation for Sustainable Development and Conservation of Fish stocks, 1998. Fishery Survey of India, Mumbai, pp. 59-68.

Sparre, P., E. Ursin and S.C. Venema. 1989. Introduction to tropical fish stock assessment. Part 1.Manual. Food and Agriculture Organisation of the United Nations Fisheries Technical Paper No.306. Food and Agriculture Organisation of the United Nations, Rome. 337 pp.

Sudarsan, D., T.E.Sivaprakasam, V.S. Somvanshi and M.E. John. 1989. Assessment of oceanic tuna and other fish resources of Indian EEZ based on exploratory surveys. Proceedings National Conference. Central Marine Fisheries Research Institute, Kochi, pp. 44-46.

Talwar, P.K. and R.K. Kacker.1984. Commercial sea fishes of India. Zoological Survey of India, Calcutta. 997 pp.

Williams, E.H. 2001.Assessment of cobia, *Rachycentron canadum*, in the waters of the U.S. Gulf of Mexico. National Oceanic and Atmospheric `Administration Technical Memorandum, National Marine Fisheries Service: 469. National Oceanic and Atmospheric `Administration National Marine Fisheries Service, Seattle, WA.61 pp.

Received: 25/03/2014; Accepted: 24/11/2014 (MS14-42)