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Short-term forecast based on dominance of species in ring seines of central Kerala coast, India

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ABSTRACT

Among the artisanal fishing gear operated from the Kerala coast, ring seines are the single largest contributors towards pelagic fish landings. The major species captured are Indian oil sardines, Indian mackerels, and anchovies. But there appears to be a change in the species composition in the landings by this gear. The changing pattern of species composition of ring seine landings was studied using the Markov chain model to understand the response of the fishery to exploitation. We observed that Indian oil sardine is the major species caught during the ring seine fishing in Kerala when considering the overall quantity of fish landed. The transitional probability matrix was worked out for the different quantities of fish species caught in the ring seines. The result indicated that the Indian oil sardine, *Sardinella longiceps,* has a probability of retention level (0.7743) in terms of the total volume of fish species caught over the period of 10 years, followed by Indian mackerel, *Rastrelliger kanagurta,* which showed a very low retention level (0.0553). This indicates that sardine is the only fish species in this fishery showing higher persistence to fishing. Hence, the results of the present study point towards the need to devise appropriate management measures for the sustainable utilization of resources, which shows a very low retention level.

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1. Introduction

Intensive motorization of the traditional fishing vessels, which began in earnest from 1982 onwards in the Kerala state, paved the way for the introduction of innovative and efficient fishing techniques such as ring seining in the traditional sector (Boopendranath, 2000; Boopendranath & Hameed, 2012). Other than the introduction and popularisation by ICAR-CIFT in the Cochin and Kasaragod areas, other improvisations were initiated by the fishers (Rajan, 1993), which led to the easy acceptance of ring seines and has spread to the different parts of the country (Edwin & Das, 2015). The ring seines are mainly targeted at pelagic shoaling species like oil sardine, mackerel, anchovies, other sardines, etc. The maximum sustainable yield of oil sardine, Indian mackerel and anchovies in Kerala is estimated to be 2.42, 1.10 and 0.45 lakh tones, respectively (Anon, 2017). Ring seines contributed 14% of the marine fish landings of the country (Edwin & Das, 2015).

The real impact of ring seines was felt from 1987 onwards, with an increase in effort and resultant catch (Alagaraja et al., 1994; Srinath, 1996). During the course of time, it is observed that there has been a drastic increase in the size of the fishing vessel and the horsepower of the engine, and this has led to an increase in fishing effort (Edwin & Das, 2015). It has been reported that fishers are not satisfied with the power and performance of the engines and they are constantly on the lookout for more powerful marine engines. Similarly, there appears to be a change in the species composition of the landings from this gear since the time of its introduction. Widespread adoption of this technology has resulted in a substantial increase in the landings of small pelagic like oil sardine, mackerel and anchovies by the traditional sector (Edwin & Das, 2015).

Model formulation is an important tool for fishery stock assessment (Srinath, 2006). Saila & Erzini (1987) reviewed the models and methods for studying the fish assemblage and have made special reference to the Markov model. In fisheries, Markov chain analysis has been used to analyse population growth models (Renshaw, 1986) for the analysis of the assemblage of pelagic species (Formacion & Saila, 1994; Srinath, 1996; Edwin & Hridayanathan, 1998; Mini & Kuriakose, 2004; Kuriakose & Mini, 2006), harvest (Patterson, 1999; Schnute et al., 2000), juvenile salmon migration (Steel et al., 2001) and fish movements (Johnson et al., 2004; Adam & Hatton, 2012). The transition probabilities give fishery managers and biologists an index of how long a species/species group will dominate in the fishery (Kuriakose & Mini, 2006). The main objective of this study was to assess the pattern of dominance of species in the study area and to predict the dominance of major species for the short term in ring seine fisheries of the study area using Markov chain analysis.

2. Materials and Methods

For the purpose of studying the pattern of dominance/ occurrence of important species, secondary data were collected from the Chellanam Kandakadavu Fishermen Development Welfare Co-operative Society regarding the different species and quantity landed for each year from the period 2002 to 2011. During this period, only two types of ring seines viz, small meshed ring seines and large meshed ring seines, were operated from this area. Secondary data was also collected from previous studies conducted in the same area for comparison. The changing pattern of species composition of ring seine landings for the ten years from 2002-2011 was studied using the Markov chain model. The quantity landed was estimated for four groups: oil sardine, mackerel, anchovies and prawns and other miscellaneous fishes. Hence, the catch composition of all categories of

ring seines was added together, and the study was done as the total catch of ring seines from the study area.

Markov chain modelling was employed to analyze the structural change in any system whose progress through time can be measured in terms of a single outcome variable (Dent, 1967). In the present study, the dynamic nature of fish catches patterns viz; the gains and losses in ring seine fishing in four groups caught were examined using the Markov chain model.

The fish catch from ring seine fishing amongst different species in any period depends only on the catch in the previous period and this dependence was the same among all the periods. This was algebraically expressed as:

$$F_{jt} = \sum_{i=}^{n} (F_{it-1})P_{ij} + e_{jt}$$

Where,

F_{jt} = Quantity of j^{th} fish species caught from ring seine in the year t

F_{it-1} = Quantity of i^{th} fish species caught during the year t-1

P_{ij} = the probability that catch will shift from i^{th} to j^{th} fish species

e_{jt} = the error term, which is statistically independent of E_{it-1}

n = the number of species caught in the ring seine fishing

The transitional probabilities P_{ij}, which can be arranged in a (c x n) matrix, have the following properties.

$$\sum_{i=}^{n} P_{ij} = 1 \qquad \text{Where, } O \leq P_{ij} \geq 1$$

The probability matrix was estimated for the period 2002 to 2011 (10 years). Thus, the transitional probability matrix (T) was estimated using a linear programming (LP) framework by a method referred to as minimization of Mean Absolute Deviation (MAD).

Min, OP* + Ie

Subject to

X P* + V = Y

GP* = 1

P* > 0

Where,

P* is a vector of the probabilities P_{ij}

O is the vector of zeros

i is an appropriately dimensional vector of areas

e is the vector of absolute errors

Y is the proportion of fish caught for each species.

X is a block diagonal matrix of lagged values of Y

V is the vector of errors

G is a grouping matrix to add the row elements of P arranged in P* to unity. Prediction of the quantity of marine fish species caught in ring seine fishing was made by using the Transitional Probability Matrix.

$$B_t = B_0 * T$$

$$B_{t+1} = B_{t+i-1} * T$$

Where,

B_0 = Quantity caught in Base years

B_{t+1} = Quantity caught in next year (prediction)

T = Transitional probability matrix

3. Results and Discussion

The ring seine landings from the Chellanam area for the period 2002-2011 showed that oil sardine contributed the highest landings throughout the ten years. Oil sardine contributed 81.4% 2002 and showed a decline to 55.9% in 2004 and showed an increase of 82% in 2008 and slightly decreased and reached 78.1% in 2011 (Fig. 1). Mackerel contributed 4.1% in 2002, which increased to 29.3% during 2004 and declined to 14% during 2011 (Fig. 2). Anchovies contributed 3.4% during 2002 and increased to about 15.6% during 2009 and showed a declining trend of 3.5% during 2011(Fig. 3). Prawns and miscellaneous contributed 10.9% during 2002 and declined drastically to 1.1% during 2008 and then showed an increasing trend to 4.2% during 2011(Fig. 4). Thus during the period of 10 years oil sardines were the dominating species in the study area.

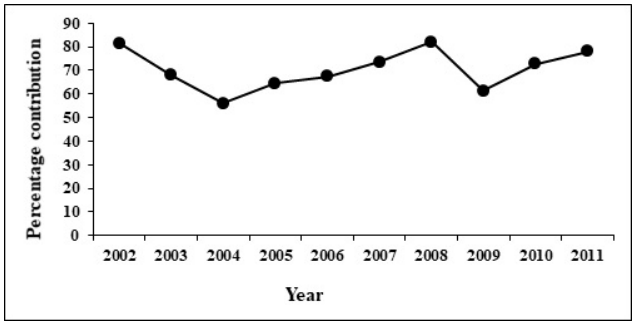

Fig. 1. Percentage contribution of oil sardine during 2002-2011 from Chellanam

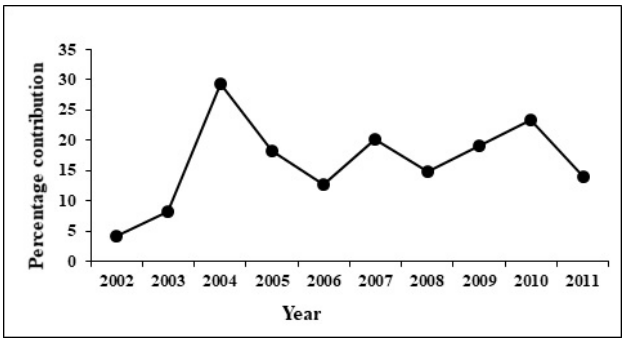

Fig. 2. Percentage contribution of mackerel during 2002-2011 from Chellanam

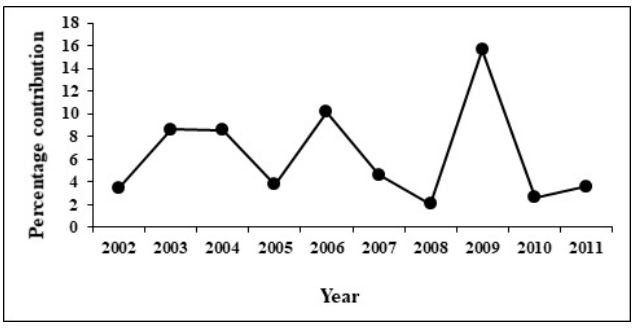

Fig. 3. Percentage contribution of anchovy during 2002-2011 from Chellanam

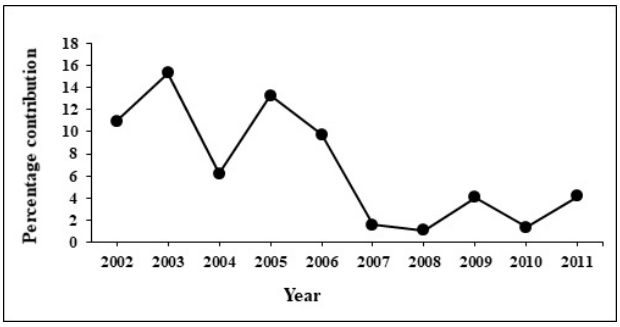

Fig. 4. Percentage contribution of prawns & miscellaneous during 2002-2011 from Chellanam

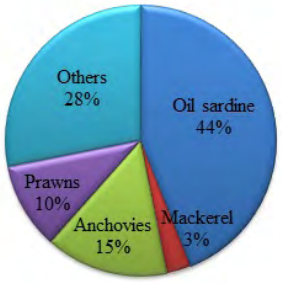

Fig. 5. Species composition in ring seines during 2016

During the period 2002-2011, the dominant catch composition in ring seines of Kerala showed a similar trend from that of the study area. During 2002, oil sardine contributed 81.8% of landings, which later showed a decreasing trend and reached 62.2% in 2008. It again increased and reached 78.6% from the total landings during the period 2011. Mackerel landings contributed 5.2% of landings during 2002 and increased to 16.5% in 2007 and later showed a decrease to 9.8% during 2011. Anchovies contributed 2.3% during 2002, which showed an increase of 16.2% during 2008 and later decreased to 5.3% during 2011. Prawns and miscellaneous contributed 10.7% during 2002 and showed an increasing trend till 2008 (12.6%) and later showed a decline to 6.3% during 2011.

During the present study (2016), oil sardine contributed 44% of the landings, followed by miscellaneous (28%), anchovies (15%), prawns (10%) and mackerel (3%). The miscellaneous groups constituted fishes such as croakers, carangids, pomfrets, silver biddies, catfishes, thryssa, ponyfishes, threadfin breams, groupers, perchlets, mullets, flatfishes, flying fishes, eels, crabs and cephalopods. The prawns landed were penaeids such as kadal shrimp (*Metapenaeus dobsonii*), kiddi shrimp (*Parapenaeiopsis stylifera*), corromandal shrimp (*Parapenaeiopsis coromandalica*), Indian white prawn (*Penaeus indicus*) and tiger prawn (*Penaeus monodon*). Anchovies constituted species such as Commerson's anchovy (*Stolephorus commersonii*) Indian anchovy (*Stolephorus indicus*), buccaneer anchovy (*Stolephorus punctifer*), shorthead anchovy (*Stoliphorus heterolobus*), spotfaced anchovy (*Stolephorus waitie*), insular anchovy (*Stolephorus insularis*), davis anchovy (*Stolephorus devisi)*.

Table 1. Dominant catch composition in the ring seines of Kerala (2002-2011) (Source: Anon, 2016)

Year	Oil sardine (%)	Mackerel (%)	Anchovies (%)	Prawns and miscellaneous (%)
2002	81.8	5.2	2.3	10.7
2003	79.2	8.2	3	9.6
2004	66.2	14.1	7.1	12.6
2005	74.2	13.9	1.3	10.6
2006	75.8	12.9	1.1	10.2
2007	68	16.5	4	11.5
2008	62.2	9	16.2	12.6
2009	67.7	14.5	6.1	11.7
2010	72.3	11.3	10.9	5.5
2011	78.6	9.8	5.3	6.3

3.1 Markov Chain analysis

The direction of species catch has been explored by Markov chain analysis using the quantity of fish species catch data from the period of 2002 to 2011 in the ring seine fishery along the Chellanam area. The transitional probability matrix has been worked out by using the annual marine fish species catch, which provides a broad indication of directional change in the quantity of species catch, namely, sardine, mackerel, anchovy, prawns and miscellaneous has been presented in Table 2.

In the overall quantity of fish species caught in the ring seine fishing method in the study area, sardine catch is more dominant in the ring seines. In Table 2, a transitional probability matrix for different quantities of fish species caught in the ring seines is provided. As far as the quantity of fish species catch is concerned, sardine (0.7743) has a probability of retention level in terms of the total volume of fish species caught over the period of 10 years in the ring seines. In other words sardine is the only major fish species holding 76% of persistence in the catch by ring seining. Due to catching the sardine fish by the ring seine fishing vessel in the Kerala coast, an extended loss share percent in the mackerel and anchovy is about 87% and 51%. On the contrary, all others have zero probability of retention, indicating that they are unstable in the quantity of catch in the ring seine fishing method.

Formacion & Saila (1994), has conducted a study using the Markov chain for pelagic fish stocks in Phillippines and observed that the family Clupeidae would probably be the dominant family among the 6 families being exploited. Srinath (1996) has studied the changing pattern of pelagic species in the Kerala coast with the introduction of ring seines. The study showed that the chances of oil sardine being dominated in the ring seine fishery landings will decrease considerably if the effort is left unregulated. Another study conducted by Edwin & Hridayanathan (1998) observed the changing pattern of species composition in ring seines during the period 1989-95. During their study, it was found that the probability of dominance of oil sardine

Table 2. Transition Probability Matrix for quantity of marine fish species catch in ring seine fishing vessel from 2002-2011

	Oil sardine	Mackerel	Anchovy	Prawns	Others
Oil sardine	**0.7743**	0.8902	0.2253	0	0
Mackerel	0.1358	**0.0553**	0.7747	0	0.2542
Anchovy	0.0403	0	**0**	0	0.1548
Prawns	0.0052	0.0545	0	**0.0026**	0
Others	0.0444	0	0	0.2036	**0.591**

was in the declining stage, and it was observed due to the excess effort. Mini & Kuriakose (2004) has observed the long-term projection of the marine fish landings along the southwest coast of India using a four-state Markov chain model, and the projection indicates that there will be a decline in the landings in the long run if the mode of exploitation was continued. Kuriakose & Mini (2006) has analysed the pelagic fishery dominance along the Karnataka coast. The study observed that oil sardines have the maximum probability of occurring along the Karnataka coast when considering all the gears being operated and this is due to the mass harvesting of ring seines and purse seines.

4. Conclusion

In India, only a few works have been carried out using Markov chain analysis for studying the resource status (Kuriakose & Mini, 2006). The knowledge on the dynamics of dominance of species over a certain period under varying exploitation patterns is necessary for the proper assessment of the exploited stocks (Srinath, 1996). In Kerala, the pelagic fisheries play an important role and ring seines are the most efficient gear employed to catch the pelagic species. In recent years, 90% of the oil sardines and 60% of the mackerel landed in Kerala were caught in ring seines (Abdussamad et al., 2015). Hence, the study regarding the probabilities of resources that would dominate in future is important. During 2002-2011, oil sardine dominated ring seine catch of the study area, followed by mackerel, anchovies and prawns and other miscellaneous. A similar trend was seen in the landings of the state at the same period. In 2016 also, oil sardine dominated with 44%, followed by miscellaneous (28%), anchovies (15%), prawn (10%) and mackerel (3%). From Markov chain analysis of present study, it was found oil sardine was the dominating species and the probability in the coming years the catch of ring seines would be dominated by oil sardine.

5 References

Abdusammad, E.M., Ganga, U., Said, K.K.P., Prakasan, D. and Gireesh, R. (2015) Ring seine fishery of Kerala: An overview. Mar. Fish. Infor. Serv., T & E. Ser., 225: 3-7

Adams, S.N. and Hatton, T.W. (2012) A Markov Chain Analysis of movement of juvenile salmonids, including Sockeye Salmon in the Forebay of McNary Dam, Washington and Oregon, 2006-09. UCGS. Open-File Report 2012. Prepared in cooperation with the US army Corps of Engineers

Alagaraja, K., Sciariah, K.S., Andrews J., Vijayalakshmi, K. and Beena, M.R. (1994) Recent trends in marine fish production in Kerala with special reference to conservation and management of resources, Kerala Fisheries Society, Trivandrum 43p.

Anon (2016) Department of Fisheries. Government of Kerala. www.fisheries.kerala.gov.in

Anon (2017) CMFRI Annual Report (2016-2017). Central Marine Fisheries Research Institute, Cochin. 344p

Boopendranath, M.R. (2000) Studies on Energy Requirements and Conservation of Selected Fish Harvesting Systems, Ph.D. Thesis, Cochin University of Science and Technology, Cochin, India

Boopendranath, M.R. and Hameed, M. S. (2012) Energy analysis of the ring seine operations, off Cochin, Kerala. Fishery Technology 49:141-146

Dent, W. T. (1967) Application of Markov Analysis to International Wool Flows, Review of Economics and Statistics, 49(2):613-616

Edwin, L and Das, D.P.H. (2015) Technological changes in ring seine fisheries of Kerala and management implications. Central Institute of Fisheries Technology, Cochin: 104p

Edwin, L. and Hridayanathan, C. (1998) Catch per unit effort of ring seines of South Kerala coast. Proc. Symp. on Advances and priorities in fisheries technology, SOFT(I) and CIFT, Cochin, 11-13 Feb: 180-184

Formacion, S.P. and Saila, S.B. (1994) Markov chain properties related to temporal dominance change in the Philippine pelagic fishery. Fish. Res. 19: 241-256

Johnson G, E., Hedgepeth, J, B., Skalski, J.R. and Giorgi, A, E. (2004) A Markov chain analysis of fish movements to determine entrainment zones. Fisheries Research. 69:349-385

Kuriakose, S. and Mini, K G. (2006) A Stochastic model to analyse pelagic fishery resource dominance along the Karnataka coast (west coast of India). Indian Journal of Marine Science. 35(3):257-262

Mini, K.G. and Kuriakose, S. (2004) Long term projection of the marine fish landings along southwest coast of India using Markov chain model.J. mar.biol. Ass. India, 46 (2):209-214

Patterson, K. (1999) Evaluating uncertainty in harvest control law catches using Bayesian markov chain Monte Carlo virtual population analysis with adaptive rejection sampling and including structural uncertainty. Can.J.FisheriesAqua.Sc. 56:208-221

Rajan, J. B. (1993) A techno-socio-economic study in ring seine fishery of Kerala. Programme for community organization centre, Trivandrum. 55p

Renshaw, E. (1986) A survey of stepping stone models in population dynamics. Adv. Appl. Probability 18: 581-627

Saila, S.B. and Erzini, K. (1987) Empirical approach to multispecies stock assessment. Trans. Am. Fish. SOC., 116: 601-611

Schnute, J., Cass, A. and Richards, L. (2000). A Bayesian decision analysis to set escapement goals for Fraser River sockey salmon (*Oncorhynchus nerka*). Can.J.Fisheries Aquatic.SCI.57:962-979

Srinath, M. (1996) Markov chain application to the dynamics of the pelagic fishery along Kerala coast. Indian J. Fish. 43(2):115

Steel, E., Guttorp, P., Anderson, J. and Caccia, D. (2001) Modeling juvenile Salmon migration using a simple Markov chain. J. Agric. Biol.Environ. Stat. 6 (1):80-8