Temporal Changes in species diversity in landings and emerging concerns in ring seine sector of Kerala

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Certificate

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Declaration

I hereby declare that the thesis entitled ***"Temporal Changes in species diversity in landings and emerging concerns in ring seine sector of Kerala"*** *is an authentic work carried out by me under the supervision and guidance of* ***Dr. Leela Edwin****, Head, Fishing Technology Division, ICAR-Central Institute of Fisheries Technology, Kochi, Kerala in partial fulfilment of award of Ph.D. degree under the Faculty of Marine Sciences, Cochin University of Science and Technology, Kochi, Kerala and no part of work has previously formed the basis for the award of any degree, diploma, associateship or any other title or recognition from any University/Institution.*

Kochi-682018
November 2018 ***Leena Raphael***

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Dedicated to all the fishermen heroes who rescued the flood victims in Kerala

Contents

Chapter I

1	INTRODUCTION
1.1	World fisheries scenario…………………………… 1
1.2	Indian fisheries scenario…………………………… 2
1.3	Kerala fisheries scenario……………………………7
1.4	Review of literature…………………………………10
1.4.1	Ring seine fisheries…………………………………11
1.4.2	Diversity of species and its importance……............13
1.4.3	Bycatch in fisheries…………………………………16
1.4.4	Overfishing and juvenile incidence………………... 19
1.4.5	Interaction of aquatic organisms and fisheries…….. 21
1.5	Rationale and objective of the study……………… 23

Chapter II

2 MATERIALS & METHODS

2.1 Introduction………………………………………………25

2.2 Data base……………………………………….……….. 25

2.3 Area of study………………………………….............. 25

2.4 Craft and gear survey……………………………………26

2.5 Sampling techniques…………………………………..27

2.6 Analytical techniques…………………………..…….. 29

2.6.1 Diversity study………………………………………….. 29

2.6.2 Bycatch studies………………………………............. 30

2.6.3 Juvenile incidence studies……………………….............31

2.6.4 Depredation and catch loss studies………………………… 32

Chapter III

3 CATEGORIZATION OF RING SEINE FISHING SYSTEMS AND TREND ANALYSIS

3.1 Introduction……………………………………………….. 41

3.2 Materials & Methods……………………….............. 44

3.2.1 Data source…………………………………………….44

3.2.2 Documentation of ring seine…………………….....44

3.2.2.1 Catch per unit effort………………………………...45

3.2.2.2 Growth rate in ring seines…………………………..45

3.2.2.3 Instability index……………………………………. 46

3.3 Results & Discussion………………………………. 46

3.3.1 Documentation of ring seine fishing system………..46

3.3.1.1 Ring seine fishing vessel……………………………47

3.3.1.2 Ring seine gear categorization……………………...49

3.3.1.2.1 Large meshed ring seines (LMRS)………………… 49

3.3.1.2.2 Small meshed ring seine type I (SMRS-I)……......... 51

3.3.1.2.3 Small meshed ring seine type II (SMRS-II)……….. 53

3.3.1.3 Fishing operation…………………………………... 55

3.3.1.3.1 Detection of fishing schools……………………….. 55

3.3.1.3.2 Indigenous traditional knowledge of fishers in fish detection………………………………….......... 55

3.3.1.3.3 Method of operation………………………………...57

3.3.1.3.4 Crew size……………………………………………57

3.3.2 Catch per unit effort (CPUE) in ring seines……….. 65

3.3.3 Growth rate and instability index………………….. 67

3.4 Conclusion……………………………………………..69

Chapter IV

4 SPECIES DIVERSITY IN RING SEINES

4.1 Introduction…………………………………………71

4.2 Materials & Methods………………………….......... 72

4.2.1 Data source…………………………………………72

4.2.2 Method of analysis…………………………………73

4.2.2.1 Measurement of richness…………………………... 74

4.2.2.2 Measurement of diversity…………………………...75

4.2.2.3 Measurement of evenness………………………….. 75

4.3 Results & Discussion………………………………76

4.3.1 Species assemblage…………………………………76

4.3.2 Variation in diversity indices………………………93

4.3.2.1 Richness index…………………………………….... 94

4.3.2.2 Diversity index……………………………………... 95

4.3.2.3 Evenness index…………………………………...96

4.4 Conclusion………………………………………. 101

Chapter V

5 SHORT TERM FORECAST BASED ON DOMINANCE OF SPECIES IN RING SEINES

5.1 Introduction………………………………………103

5.2 Materials & Methods………………………........ 105

5.2.1 Markov chain modeling……………………..........105

5.3 Results & Discussion…………………………........ 108

5.3.1 Species composition of ring seine landings and its changing pattern…………………………….108

5.3.1.1 Species composition during 2002-2011 in the study area…………………………......... 108

5.3.1.2 Species composition in ring seines of Kerala during 2002-2011…………………………... 111

5.3.2 Markov chain analysis……………………………... 113

5.4 Conclusion……………………………………………..115

Chapter VI

6 BYCATCH OCCURRENCE IN RING SEINES

6.1 Introduction………………………………………… 117

6.2 Materials & Methods………………………………. 119

6.3 Results & Discussion………………………………. 121

6.3.1 Bycatch occurrence in different categories of ring seines……………………………………….. 121

6.3.2 Mean trophic index in different categories of ring seines……………………………………….. 128

6.4 Conclusion……………………………………………..136

Chapter VII

7 JUVENILE INCIDENCE IN RING SEINE FISHERY

7.1 Introduction……………………………………….…... 139

7.2 Materials & Methods……………………….....….…. 141

7.2.1 Juvenile incidence analysis……………………….... 142

7.3 Results & Discussion……………………………….…... 144

7.3.1 Juvenile incidence in LMRS…………………………... 145

7.3.2 Juvenile incidence in SMRS-I…….………………... 149

7.3.3 Juvenile incidence in SMRS-II……………………... 152

7.3.4 Economic loss due to juvenile incidence................... 156

7.3.4.1 Economic loss in LMRS…………………………… 156

7.3.4.2 Economic loss in SMRS-I.…………………………..158

7.3.4.3 Economic loss in SMRS-II…………………………. 159

7.3.4.4 Total economic loss………………………………… 161

7.4 Conclusion…………………………………………..162

Chapter VIII

8 INTERACTION OF AQUATIC ORGANISMS WITH RING SEINES AND LOSSES

8.1 Introduction…………………………………………163

8.2 Materials & Methods………………………………..166

8.3 Results & Discussion………………………………. 166

8.3.1 Cetacean interaction………………………………...167

8.3.1.1 Species identified…………………………………... 167

8.3.1.2 Catch loss in different categories of ring seines due to cetacean attack…………..……………170

8.3.1.2.1 Economic evaluation of catch loss / instance

due to cetacean attack………………………………. 173

8.3.1.3 Fishing gear damage due to cetacean bite………….. 174

8.3.2 Pufferfish bite……………………………………..180

8.3.2.1 Species identified……………………………………180

8.3.2.2 Catch loss in different categories of ring

seines due to pufferfish bite…………..……………. 183

8.3.2.2.1 Economic evaluation of catch loss / instance

due to pufferfish bite ………………………………..186

8.3.2.3 Fishing gear damage due to pufferfish bite............... 187

8.3.2.3.1 Economic evaluation of gear loss due to pufferfish bite

……………………………………..………...189

8.3.3 Jellyfish entry……………………………………..191

8.3.3.1 Species identified……………………………………192

8.3.3.2 Catch loss /unit due to jellyfish entry……………….. 194

8.3.4 Ambassis entanglement…………………………….. 194

8.3.4.1 Species identified………………………................195

8.3.4.2 Catch loss /unit /incident of Ambassis entanglement ……………………………………….. 196

8.3.4.3 Economic evaluation of loss for each incident of Ambassis entanglement…………………. 196

8.3.5 Total estimated economic loss due to interaction of aquatic organisms…………………….. 196

8.4 Conclusion…………………………………..….......... 197

Chapter IX

9 SUMMARY & RECOMMENDATIONS

9.1 Summary……………………………………………..... 201

9.2 Recommendations……………………………........... 202

Reference……………………………….................. 205-231

List of publications

List of Figures

Fig.1.1: Sector-wise production (%) during 2016…………...5

Fig. 1.2: Species diversity from landings of different states… 15

Fig 2.1: Study area showing Chellanam and Kalamukku situated along the south west coast of India……….. 26

Fig 2.2: Fishermen taking fish for sorting…………………...28

Fig 2.3: Fish being sorted before auctioning………………...28

Fig 2.4: Fish kept ready for auctioning……………………... 29

Fig 2.5: Samples taken for identification…………………… 30

Fig 2.6: Juveniles of carangids from ring seines…………....31

Fig. 3.1: Design of 960m ring seine (LMRS) operated at Chellanam……………………………... 61

Fig.3.2: Design of 260m ring seine (SMRS-I) operated at Chellanam………………………………62

Fig.3.3: Design of 130m ring seine (SMRS-II) operated at Chellanam………………………......63

Fig.3.4: View of mechanized ring seiner operating large meshed ring seine…………………………………...64

Fig. 3.5: View of motorized ring seiner with skiff operating small meshed type I ring seines…………………… 64

Fig. 3.6: View of motorized ring seiner operating small meshed type II ring seines……………..……...65

Fig.3.7: Catch per unit effort of different categories during 2012-2016………………………………….. 66

Fig 4.1: Morphometric characters of fish……………………74

Fig 4.2: Number of species in each order…………………...77

Fig 4.3: Number of species composition percentage in dominant families…………………………………...77

Fig 4.4: Diversity of species landed in three categories of ring seines during the study period………………… 78

Fig 4.5: Percentage contribution of different types of ring seines during different season……………………… 78

Fig.4.6: Percentage of pelagic and demersal species caught in three categories of ring seines…………………….89

Fig 4.7: Richness indices for the three types of ring seines during the different seasons………………………... 93

Fig 4.8: Diversity indices for the three types of ring seines during the different seasons………………………... 96

Fig.4.9: Evenness indices for the three types of ring seines during the different seasons…………………………97

Fig. 5.1: Percentage contribution of oil sardine during 2002-2011 from the study area…………………….. 109

Fig. 5.2: Percentage contribution of mackerel during 2002-2011 from the study area…………………….. 109

Fig. 5.3: Percentage contribution of anchovy during 2002-2011 from the study area…………………….. 110

Fig. 5.4: Percentage contribution of prawns & miscellaneous during 2002-2011from the study area 110

Fig. 5.5: Species composition in ring seines during 2016……112

Fig. 6.1: Trophic levels in fisheries…………………………..120

Fig.6.2: Percentage of demersal and pelagic groups in bycatches of ring seines……………………………. 123

Fig.6.3: Percentage of bycatch in LMRS…………………..…125

Fig.6.4: Number of species in each family in LMRS………...125

Fig.6.5: Percentage of bycatch in SMRS-I…………………. 126

Fig.6.6: Number of species in each family in SMRS-I…….. 126

Fig.6.7: Percentage of bycatch in SMRS-II………………... 127

Fig.6.8: Number of species in each family in SMRS-II……. 127

Fig 7.1: Length characteristics……………………………… 142

Fig 7.2: Economic loss of juvenile species in LMRS………..157

Fig 7.3: Economic loss of juvenile species in SMRS-I…….. 159

Fig 7.4: Economic loss of juvenile species in SMRS-II..……160

Fig 8.1: Catch loss due to cetacean attack in different seasons…………………………………………….....173

Fig 8.2: Catch loss in terms of value in different categories....174

Fig.8.3: Average webbing lost annually in different categories of ring seines……………………………..175

Fig.8.4: Catch loss due to pufferfish bites in different seasons…………….…………………….............185

Fig.8.5: Catch loss in terms of value in different categories…187

Fig. 8.6: Average webbing lost annually in different categories of ring seines…………………………….188

List of Tables

Table 1.1: Marine fishery potential of Kerala………………… 8
Table 1.2: Export from marine products from India and Kerala…………………………………………..10
Table 3.1: Range of principal dimensions of main vessel and carrier vessels of mechanized ring seiners……. 48
Table 3.2: Range of principal dimensions of motorized vessels 49
Table 3.3: Indigenous traditional knowledge of fishers on occurrence of species……………………………….56
Table 3.4: Specifications of different categories of ring seines58
Table 3.5: Number of gears operated in different categories of ring seines………………………………………..58
Table 3.6: Growth rate in different categories of ring seines…. 68
Table 4.1: Diversity of species caught in the ring seines………78
Table 4.2: Comparison of occurrence of species in different categories of ring seines…………………………… 90
Table 4.3: Indices of species occurring in ring seines………… 98
Table 5.1: Dominant catch composition in the ring seines of Kerala (2002-2011)………………………………111

Table 5.2: Transition Probability Matrix for quantity of marine fish species catch in ringseine fishing vessels from 2002-2011………………………………………. 114

Table 6.1: List of species in ring seine bycatch in all categories from Chellanam………………………… …….. 128

Table 6.2: Number of species in each trophic levels………….. …….. 134

Table 6.3: Mean trophic indices of different seasons…………. …….. 135

Table 7.1: Constituents of juveniles occurring in LMRS……... …….. 147

Table 7.2: Constituents of juveniles occurring in SMRS-I…………... 151

Table 7.3: Constituents of juveniles occurring in SMRS-II…... …….. 155

Table 7.4: The economic deficit of juvenile species in LMRS...…….. 157

Table 7.5: The economic deficit of juvenile species in SMRS-I…….. 158

Table 7.6: The economic deficit of juvenile species in SMRS-II…….. 160

Table 7.7 Total economic loss……………………………………….. 161

Table 8.1: Species causing damage to ring seines……………………. 169

Table 8.2: Species associated with fish shoals…………………………169

Table 8.3: Catch loss in ring seines during pre-monsoon season………171

Table 8.4: Catch loss in ring seines during monsoon season…………. 171

Table 8.5: Catch loss in ring seines during post-monsoon season……. 172

Table 8.6: Catch loss in terms of value during different seasons………174

Table 8.7: Economic loss due to gear damage in LMRS…………….. 177

Table 8.8: Economic loss due to gear damage in SMRS-I…………… 178

Table 8.9: Economic loss due to gear damage in SMRS-II…………… 180

Table 8.10: Species causing damage to ring seines…………………….. 182

Table 8.11: Catch loss during pre-monsoon season……………………..183

Table 8.12: Catch loss during monsoon season………………………… 184

Table 8.13: Catch loss during post-monsoon season…………………… 185

Table 8.14: Economic loss due to fish loss…………………………….. 187

Table 8.15: Economic loss due to gear damage in LMRS……………… 190

Table 8.16: Economic loss due to gear damage in SMRS-I……………. 190

Table 8.17: Economic loss due to gear damage in SMRS-II…………… 191

Table 8.18: Species of jellyfish causing damage to ring seines………… 193

Table 8.19: Number of incidence of jellyfish entry in different categories of ring seines…………………………………… 194

Table 8.20: Species of ambassids causing damage in ring seines……… 195

Table 8.21: Number of incidence of ambassis entanglement in different categories of ring seines………………………..196

Table 8.22: Total economic loss in different categories of ring seines……………………………………………..197

List of Plates

Plate 1: Species occurring in all categories of ring seines…………. 89

Plate 2: Different types of fishes caught from the ring seines……… 98

Plate 3: Bycatches landed in the study area………………………… 136

Plate.4: Species of cetaceans causing damage to ring seines………. 169

Plate.5: Species of cetaceans found interacting with ring seines without causing damage…………………………….. 170

Plate.6: a. The hole occurred due to cetacean bite; b. the damage area been replaced by fresh piece of webbing…….. 176

Plate.7: Species of pufferfishes causing damage in ring seines……..182

Plate.8: Puffer fish depredation……………………………………...186

Plate.9: a. The hole occurred due to pufferfish bite; b. the damage area been replaced by fresh piece of webbing……..189

Plate. 10: Species of jellyfish causing damage to ring seines………...193

Plate. 11: Species of ambassids causing damage to ring seines………195

List of Annexures

Annexure I: Proforma for ring seine craft & gear survey……………….. 33

Annexure II: Proforma for species diversity analysis……………………. 36

Annexure III: Proforma for survey of interaction of aquatic organisms in ring seines…………………………………….38

ABBREVIATIONS

AFD	-	Accelerated Freeze Drying
BRD	-	Bycatch Reduction Device
CIFT	-	Central Institute of Fisheries Technology
CKFDWCS	-	Chellanam Kandakadavu Fishermen Welfare Co-operative Society
cm	-	Centimeter
CMFRI	-	Central Marine Fisheries Research Institute
CPUE	-	Catch per unit effort
DADF	-	Department of Animal Husbandry & Fisheries
EEZ	-	Exclusive Economic Zone
FAO	-	Food and Agricultural Organization
Fig	-	Figure
gm	-	Gram
GoK	-	Government of Kerala
GPS	-	Global Positioning System
HDPE	-	High Density Polyethylene
hp	-	Horse power

ICAR	-	Indian Council of Agricultural Research
IQF	-	Individually Quick Frozen
IUCN	-	International Union for Conservation of Nature
JFE-SSD	-	Juvenile Fish Excluder cum Shrimp Sorting Devices
kg	-	Kilogram
km	-	Kilometer
LOA	-	Length overall
LMRS	-	Large Meshed Ring Seine
m	-	Meter
MLS	-	Minimum Legal Size
MSM	-	Minimum Size at Maturity
mm	-	Millimeter
MPEDA	-	Marine Products Export Development Authority
MT	-	Metric Ton
NFDB	-	National Fisheries Development Board
OBM	-	Outboard motor
%	-	Percentage
PA	-	Polyamide

PP	-	Polypropylene
Q	-	Quantity
RED	-	Radial Escapement Device
Rs	-	Rupees
SIFFS	-	South Indian Federation of Fishermen Societies
SMRS	-	Small Meshed Ring Seine
UHMWPE	-	Ultra high molecular weight polyethylene
USD	-	United States dollar
V	-	Value

CHAPTER 1
INTRODUCTION

INTRODUCTION

Demand for fish has been increasing day by day since it has been proved to be an ideal health food having high protein content and is within the reach of common man. Fish consumption has increased 240 per cent since 1960 (Anon, 2002). Other than serving a significant source of protein, fish also contains minerals, essential fatty acids and amino acids. Because of its nutritional value fish has always remained mankind's preferred food. Fish and fishery products are considered to be the safest food of animal origin. With the result there has been a continuous rise in the percentage of fish eaters in all maritime nations (Pillai, 2011). Fish are generally unowned compared to other resources and all over the world and fishing is the livelihood of the populations of coastal areas and has been continuing for millennia.

1.1 World fisheries scenario

Marine fisheries play a crucial role in the livelihoods of millions of people around the world and contribute to food and nutrition security and also scarcity alleviation. Fishing is one of the oldest occupations of the primitive man, adopted for satisfying the food needs from the natural sources. The primitive man perhaps hunted for fish and other aquatic fauna as an alternate source of food when land based food was scarce to satisfy their needs. Earlier mankind utilized spears and arrows for hunting fish. With the modernization of fisheries a wide range of fishing gears and practices including small scale to large scale fishing systems has been adopted for fish capture. Most important fishing systems of the world include purse seining, trawling, gillnetting and longlining. Globally about 100 million people directly or indirectly depend on fishing industry. From this 50 million people directly depend on fishing and rest is involved in the ancillary activities such as processing, marketing and supporting activities (Anon, 1995a). World's per capita fish consumption increased from an average of 9.9 kg in 1960's to 14.4 kg in 1990's and 19.7 kg in 2013. It has reached a record of 20 kg in 2014, which now provides half of all fish for human consumption (Anon, 2016b).

World's marine catch have increased nine times from 18.5 million tonnes in 1950 to 170.9 million tonnes by 2016. During 2016 capture fish production contributed 90.9 million tonnes and inland fisheries contributed 80 million tonnes (Anon, 2018). An estimated 56.6 million people are engaged in primary sector of capture fisheries and aquaculture in 2014, of which 36% were engaged in full time, 23% part time and the remainder were either occasional fishers or of unspecified status (Anon, 2018). Therefore, maintaining the long-term prosperity and sustainability of marine fisheries is not only of political and social significance but also of economic and ecological importance (Anon, 2011a).

1.2 Indian Fisheries scenario

India has a coastline of 8118 km and 0.5 million sq. km continental shelf endowed with 2.02 million sq. km of Exclusive Economic Zone (EEZ). The southern peninsular extends into the Indian Ocean with Bay of Bengal in the east and the Arabian Sea in the west. The east coast is characterized by a narrow continental shelf and the west coast has a broad continental shelf and short swift-flowing rivers, with little delta formations (Najmudeen & Sathiadas, 2008). It has a catchable annual fisheries potential yield of 4.41

million tonnes occupying third rank in world marine fish production (Anon, 2013). The wind and the current pattern, together with the heavy runoff from several rivers flowing to the Arabian Sea makes it highly nutrient replenished which accounts for high productivity of waters (Najmudeen & Sathiadas, 2008). Primary and secondary productivity is higher on the west coast compared to the east coast due to the strong upwelling process with a consequent effect on fishery (Pillai, 2011). Fishing in India is a major activity employing about 14 million people and has emerged as a giant industry in the recent years. There are about 3827 fishing villages, 1914 fish landing centers in nine maritime states and two union territories. India stands in second position (5.43%) after China, globally with regard to annual fisheries and aquaculture production. The total fish production during 2015-16 is 10.79 million metric tonnes (Anon, 2017b). The development of marine fisheries has undergone a transformation from traditional fishing method to mechanized fishing all along the coast during last four decades.

India with 1.3 billion population (17% of the world's population) with the second most populous country in the world constitutes to about 6.3% of the global fish production, fisheries sector contribute 1.1% to the national Gross Domestic Product (GDP), and 5.15% to agricultural GDP (Anon, 2017e). As per marine fisheries census 2010, there are 39,99,214 million marine fisher folk in 8,64,550 households in 3288 marine fishing villages of maritime states and Union Territories of the mainland. Marine fisheries sector occupies a very important place in the socio-economic development of the country. The initial step of development and management of marine fisheries in India was the enactment of the Indian Fisheries Act of 1897. Different five year plans helped to increase the fish production by development of mechanization in craft and improvement in gears and establishment of infrastructure facilities for processing and storage (Zacharia & Najmudeen, 2012). Modernization in this sector was accomplished by the introduction of power driven fishing vessels or motorization of traditional boats and this eventually helped the fisher folks to venture to deeper seas and fish for longer time which resulted in high productivity and income to them.

The fishery resources of India is constituted by a large variety of species, nearly 1570 species of finfishes and about 1000 species of shellfishes co-existing in the same ground and among these only 200 species of finfishes and shellfishes are commercially important (Zacharia, 2012). With diverse resources ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species, the country has shown continuous and sustained increments in fish production since independence (Anon, 2017e). It provides the most balanced and most digestible protein to millions of population at reasonable and affordable price, raising their nutritional status (Devadasan, 2002). About 35% of Indian population consumes fish. Thus, annual per capita consumption of fish eating population is projected about 16.8 kg in 2010, and would rose to 18.5 kg by 2020 (Salim & Narayanakumar, 2012).

Marine fish production of India which was only 0.5 million tonnes in 1950, increased to eightfold in 2016. The multi- gear capture fisheries of India estimated provisionally at 3.63 million tonnes during the year 2016 which showed an increase of 6.6% compared to previous year. The annual exploitation of marine sector shows that pelagic dominate over demersals and fishes dominate over prawns and cephalopods. The pelagic finfishes contribute 52%, demersal 29%, crustacean 12% and molluscan 7%. The mechanized sector contributed 82%, motorized 17% and artisanal 1% of the catch. Among the mechanized section trawlers contributed highest landings with 57%. The west coast accounted for 64% and east coast 36% of the total landings. Among the maritime states Gujarat retained first position with 7.74 lakh tonnes followed by Tamil Nadu with 7.07 lakh tonnes and Karnataka with 5.30 lakh tonnes (Anon, 2017a). Among the species landed Indian mackerel occupied first position with an overall production of 2.49 lakh tonnes ahead of oil sardine (2.45 lakh tonnes) (Anon, 2017a). For the first time since 1998, oil sardine was not at top ranked species item in terms of catch as it fell below Indian mackerel (Anon, 2017a). The marine landings pattern of the country clearly reveals that during the past fifty years, the contribution by the artisanal sector was significant upto sixties and due to the popularization and expansion of mechanized sector along with motorization the contribution to the artisanal sector declined considerably (Zacharia, 2015).

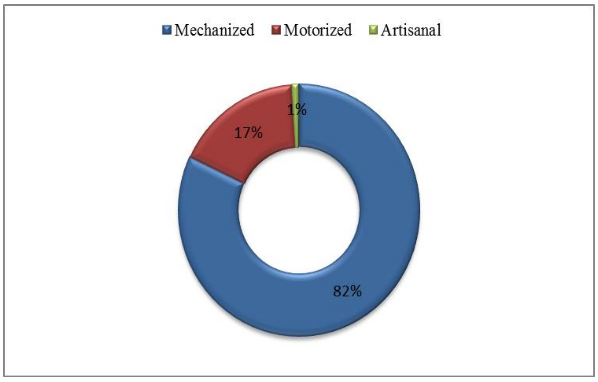


Fig. 1.1 Sector-wise production (%) during 2016 (Source: Anon, 2016e)

Over the period, the Indian seafood Industry has grown both qualitatively and quantitatively. The sector is one of the major contributors to foreign exchange through export and in India, the seafood export industry is mainly with the private sector (Anon, 2017d). The export of fish and fishery products have shown a steady growth from a humble level of seafood worth 25 million in 1950-51 to 945892 MT valued at Rs 304208.3 million (USD 4.7 million) during 2015-16 (Anon, 2016d). Frozen shrimp continued to be the major export item followed by frozen fish. USA and South East Asia continued to be the major importers as in previous year (Anon, 2016d). There has been a significant growth in the seafood processing sector which at present consists of 370 processing plants of which 246 are approved for exports to EU nations. Earlier the export was mainly dominated by shrimp, but now it has been diversified by frozen finfish, squid, cuttlefish, fillets and other products. The main sea foods processed in India includes frozen products, Individually Quick Frozen (IQF) products, pre-cooked products, breaded and battered products, Accelerated Freeze Dried (AFD) products, cooked and stuffed meat and surumi. More than fifty different fin fishes and shellfishes are exported to 75 countries around the world (Anon, 2017e).The Governments progressive policies and the industry's active role have helped to achieve positive growth in marine products export (Pillai, 2011). In India, waste from fisheries is also been utilized and made into different products which find application in human food, animal nutrition and other industrial products. Thus the fishing industry in the last five decades has undergone considerable development leading to improvements in the working conditions and reducing the workload of fishers.

1.3 Kerala Fisheries scenario

The state of Kerala popularly known as the “Gods own country” with about 10% of the country’s coastline is situated in the south-west corner of Indian peninsular between 8.5074° N, 76.9730° E and is blessed with vast resource potential. The state has diverse aquatic system such as lakes, rivers, backwaters which greatly support rich biodiversity of fish fauna. The state has an Exclusive Economic Zone of 1, 47,740 km^2 and Continental shelf area of 39139 km^2 which accounts for 9% of the Indian continental shelf. The state has 590km of surf beaten coastline which is considered to be among the most productive in the Indian Ocean. The catchable resource potential of the state is about 7.5 lakh metric tonnes (Anon, 2016c). The physio-chemical characteristic of the fishing grounds and the climatic events make most of the fisheries predictably repetitive every year although wide fluctuations occur. The Kerala waters are influenced by the monsoon which makes the dependent fisheries highly dynamic. The up welling and the mud bank formation are of importance in this respect during the period and these physical phenomena have high hand in the total fish production.

Fish and fisheries play a crucial role in the well-being of Kerala’s economy. The marine fisheries in the state are characterized by multi-species of fishery wealth, multi fleet and largely open access system. The state has been at forefront in attaining innovation and adopting new technologies which has ultimately led the fisheries sector to take a complex structure. Marine fishing fleet in Kerala consist of 4722 (21.7%) mechanized, 11175 (51.3%) motorized and 5884 (27.0%) non-motorized fishing vessels (Anon, 2012a). Kerala has been witnessed several technological changes from 1950 onwards

(Kurien, 1985). Different types of gears are used along the Kerala coast which is based on the fishing condition. The important gears used in the state are ring seines, purse seines, encircling nets, boat seines, shore seines, gillnets, drift nets, trawl nets, cast nets, hook and lines etc. There are about 222 marine fishing villages, 113 inland fishing villages and 187 marine fish landing centers across the state. The fisher population of the state is estimated to be 10.24 lakh, which constitute 3.1% of the state's population out of which 7.88 lakh fishers belong to the marine sector and 2.36 lakh fishers are from inland sector. The number of active and allied fishers during the year 2015-16 is considered to be 233126 and 77694 respectively (Anon, 2016a). The active fishers are those who are engaged in fishing for their livelihood and allied fishers are those who are engaged in fishery related activities for their livelihood and both are registered with the Kerala Fishermen's Welfare Fund Board (KFWFB). The introduction of outboard motors has transformed the face of traditional fishing activities and has brought about changes in the existing craft and gears operated in this sector (Gopal & Edwin, 2013).

Table 1.1 Marine fishery potential of Kerala

Stock	Depth zones			
	0-20m	**21-80m**	**81-200m**	**Total**
Pelagic	3,07,539 (26.1%)	7,32,908 (62.2%)	1,37,863 (11.7%)	**11,78,310** (100%)
Demersal	37,935 (26.1%)	90,432 (62.2%)	17,040 (11.7%)	**1,45,407** (100%)
Total	3,45,490	8,23,352	1,54,875	**13,23,717**

Source: Department of Fisheries, Anon, 2016c

Among the maritime states of south west coast, Kerala possesses the richest ground in the area. The marine fishery potential of Kerala is estimated to be 13.2 lakh tonnes. Kerala is having a maximum sustainable yield of 7.5 lakh metric tonnes (Anon, 2017c). Although the coastline is only about one-tenth of the whole coastline of India, the landings in Kerala contributed 5.23 lakh tonnes of the country's marine fish landings. Inspite of a continuing decline in oil sardine landings, the state has attained 8% increase in the total landings in 2016 with an upsurge in the landings of other resources such as scads and bulls eye (Anon, 2017a). The state ranks fourth among the maritime states of India in marine fish production next to Gujarat, Tamil Nadu and Karnataka. On the West coast of the country, Kerala was the major contributor with annual landings from 2.68 lakh tonnes in 1960 to 6.08 lakh tonnes. Major fishery resources of Kerala were contributed by 61% pelagic resources, 25% demersal resources 7% crustacean resources and 7% molluscan resources. The major resources landed were oil sardine, mackerel, anchovies, carangids, seerfishes, tuna, elasmobranchs, groupers, snappers, threadfin breams, lizardfishes, flatfishes, crustaceans and cephalopods.

The annual per capita consumption of fish and prawns in Kerala is highest among the Indian states, being 25.4 kg among rural population and 23.4 kg among the urban population (Edwin & Das, 2015; Das, 2015). Gross State Value Added (GSVA) is an important factor which contributes to the state's economy hence fisheries and aquaculture constitutes 8.9% from the primary sector (Anon, 2016a). Fish and fishery product from fisheries are considered to be a promising subsector from agriculture and other allied sectors and export from Kerala contributed 145193 MT with value of 4447.05 crores.

Kerala contributed 15.35% share to the countries total production (Anon, 2017d).

Table 1.2 Export from marine products from India and Kerala

Year		India	Kerala	% of Kerala's share
2009-10	**Q**	678436	107293	15.81
	V	10048.52	1670.02	16.62
2010-11	**Q**	813091	124615	15.33
	V	12901.47	2002.10	15.52
2011-12	**Q**	862021	155714	18.06
	V	16597.23	2988.33	18
2012-13	**Q**	928215	166399	17.93
	V	18856.26	3435.85	18.22
2013-14	**Q**	983756	165698	16.84
	V	30213.26	4706.36	15.58
2014-15	**Q**	1051243	166754	15.86
	V	33441.61	5166.08	15.45
2015-16	**Q**	945892	145193	15.35
	V	30420.83	4,447.05	14.62

Source: Anon, 2017d (Q: Quantity in metric tonnes, V: Value in crores)

1.4 Review of literature

Research and scientific investigation in marine fisheries is very important for the development and sustainability of this sector. The review regarding the past research studies will help a researcher to have adequate knowledge on the subject which in turn will help to modify and formulate the improved framework of new studies. In this view an attempt is made to review some studies on introduction, growth and development in ring seine fisheries, importance of species diversity, bycatch issues and bycatch reduction technologies, overfishing and juvenile incidence in fisheries and interaction of aquatic organisms with fisheries.

1.4.1 Ring seine fisheries

Ring seines were developed and introduced along the Kerala coast during 1982-83 by ICAR-Central Institute of Fisheries Technology (ICAR-CIFT) (Panicker et al., 1985). Intensive motorization of the traditional crafts which began in 1982 in Kerala paved way for the innovative and efficient fishing techniques such as ring seining in the traditional fishing sector (Boopendranath, 2000). The growing depletion of coastal resources, competition with the mechanized fishing boats, increasing price for fishes and the liberal import policies gave a major boost to the motorization of traditional crafts beginning from 1981 (Boopendranath, 2000). The ring seines introduced had an overall length of 250m and depth of 15m (Panicker et al., 1985). The ring seines are similar to purse seines which are surrounding gears operated in the surface waters. It is locally known by the names *Ringuvala*/ *Ranivala*/ *Kudukkuvala*/ *Choodavala* at different regions of Kerala and the special feature is that it is completely operated by the local fishers. During the time of introduction ring seines were operated from plank built canoes which had a length of 15m length propelled by 9.9hp engine. During the period 1985-1988 the length of the craft increased to 13-16m in the Allepey region (Anon, 1999). Motorization helped the innovative and newly introduced ring seines on par with purse seines (Balan & Sathianandan, 2007). Ring seines contributed 21.4% of the marine fish landings of Kerala during 1994 (Balan & Andrews, 1995) and over the years its share increased to 36.7% during 2000-2004 (Balan & Sathianandan, 2007). Anon (2005a) has reported that ring seines constitute about 8% of the states mechanized sector in fisheries.

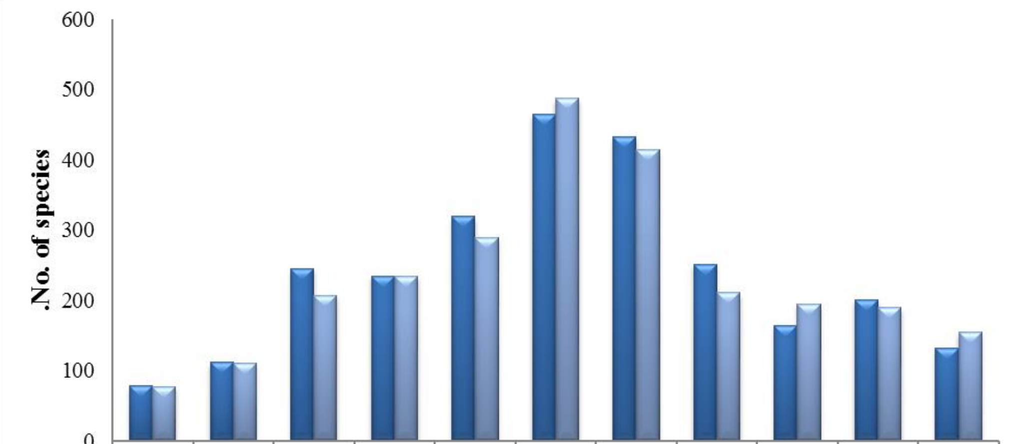
Many aspects of rings seines have been studied by various authors (Panicker et al., 1985; Anon, 1991; Rajan, 1993; Nayak, 1993; Sathiadas et al., 1993; Alagaraja et al., 1994; Edwin & Hridayanathan, 1996a&b,1997a&b, 1998,2003; Kurup & Radhika, 2003; Vijaykumaran & Chittibabu, 2005; Balan & Sathianandan, 2007; Rajeswari et al., 2013, Prajith et al., 2014, Shyam et al., 2014; Abdussamed, 2015; Edwin & Das, 2015, Das, 2015; Das & Edwin, 2016). Ring seines consist of wall of nylon webbing and are mainly intended to catch shoaling fishes like sardines, mackerel and anchovies. Rajan (1993) has described the features of ring seines operated in Kerala coast. Edwin & Das (2015) has described in detail regarding the structural as well as regional differences in the ring seines operated in the Kerala coast. Das (2015) has studied on the structural and operational changes in the ring seines of Kerala and its life cycle assessment (LCA). A number of changes have occurred in the design of ring seines due to the innovations by the traditional fishers (Rajan, 1993). The dimension of the gear during the time of introduction increased from 250m to 400-600m (D'cruz, 1998). Kurup & Radhika (2003) has reported the ring seines of length 800-1700m. Krishna et al. (2004) has reported large ring seines of dimension of 900m length operated in the Thrissur region. Edwin et al (2010) also reported the increase in dimension of 600-1010m in Cochin region. When the size of the gears increased the size of the craft increased two fold in these areas (Edwin & Das, 2015).

The success of ring seines has made this technology spread to other parts of the country. Vijaykumaran & Chittibabu (2005) reported ring seines operated in the Odisha coast. Burayya (2006) has reported introduction of *ringvala* along Kakinada coast. Shiledar (2009) has reported the introduction of mini purse seines in Maharastra coast. Along the Puducherry coast the ring seine introduction was reported by Mohanraj et al. (2011). Rajeswari et al. (2013) has reported the three categories of ring seines *viz., pedda ringula vala* (large mesh size), *nadipi ringula vala* (medium mesh size) and *chiraga ringula vala* (small mesh size) operated in north Andra Pradesh coast. Arur et al. (2014) has reported the ring seines of 10-25mm mesh size along the Andaman and Nicobar Islands. Unlike other fishing gears, ring seines also have its impact on fisheries. The impact and harmful effects of ring seine fishery has been described by D'cruz (1998). The major concerns faced in ring seine fishery has been the uncontrolled increase in fishing effort , in terms of number of fishing units, increase in gear dimension , increase in size and horsepower of the craft and increase in the juvenile fishing (Singh et al., 2007; Kurup et al., 2009; Edwin et al., 2010). Bindhu (2011), has reported that fishing gears such as ring seines and mini fishing trawls cause concern for certain exploited species.

1.4.2 Diversity of species and its importance

The term biodiversity includes various forms of life on earth such as plants, animals and other microorganisms. Biodiversity is vital for the nutrition and food security since it interconnects several thousands of species that makes up the predominant web of biodiversity within the ecosystems upon which global food production depends (Anon, 2018). India is considered amongst the twelve mega diversity countries of the globe. The country is blessed with abundant aquatic resources from an EEZ of 2.02 million sq km in marine condition. The Arabian Sea is one of the most productive areas of the world which has highly composite ocean basin and are mainly characterized by eutrophic upwelling and oligotrophic stratified environmental conditions (Habeebrehman, 2009). Arabian Sea is rich in biodiversity and the waters possess about 1707 species out of which 200 fin fishes and shellfishes are commercially important species (Zacharia & Najmudeen, 2012; Zacharia, 2015). Species identification is very critical to the design of fisheries and conservation management plans, which ideally should be implemented on a species by species basis (Anon, 1997). One of the main threat to fish biodiversity in fisheries globally is the overexploitation of species. Biodiversity loss is one of the major issues and of global concern because the human life is mostly dependent on these biological resources.

Kerala waters yield massive finfishes and shellfishes. The Western Ghats are regarded as one of the 21 biodiversity hotspots of the world. Kerala is also rich rivers consisting of many rare and endemic species. There are around 175 fish species confined from 41 west flowing and 3 east flowing river systems of the state (Kurup, 2010). Considering the marine waters, there are around 800 species of marine fishes landed along the Kerala coast in which 200 are of commercial importance and are classified as pelagics, demersals, crustaceans and cephalopods (Pillai, 2011). Pelagic species are been dominated in the states landings compared to the demersal species. During the year 2016, Kerala topped with 487 species from the total number of species landed in India (709 species) (Fig. 1.2).



	Goa	Daman & Diu	Karnataka	Gujarat	Maharastra	Kerala	Tamil Nadu	Andra Pradesh	Odisha	Puducherry	West Bengal
2015	78	111	245	234	319	464	433	251	164	201	131
2016	77	110	207	234	289	487	414	211	195	189	154

Fig. 1.2 Species diversity from landings of different states (Source: Anon, 2017a)

The first account of biodiversity of fishes of Kerala was published in the book named *The fishes of Malabar* (Day, 1865). During 19th century taxonomic and biodiversity survey on deep sea fishes in the Indian Ocean has been conducted by A. Alcock (Alcock, 1899) and he has described a few deep sea fishes of Travancore. Studies on freshwater fishes of Travancore has done by certain authors Pillai (1929), Hora & Law (1941) and Silas (1951). Several other researchers have later reported on the deep sea fishes of Indian Ocean (James & Pillai, 1990; Zacharia et al, 1991; Venu & Kurup, 2002; Kurup et al., 2005; Jayaprakash et al, 2006; Sajeevan et al; 2009). Bijukumar & Rajeevan

(2015) has published the checklist of fishes of Kerala which recognized nine hundred and five of fish species from inland and marine waters which belongs to 41 orders and 172 families.

Marine, coastal and inland waters support rich potential aquatic biological diversity which contributes to the betterment of human population (Anon, 2018). Buckworth (1998) explained the condition of marine and freshwater resources which are being under stress due to the collapse of resources due to the overexploitation and habitat degradation. Hence the knowledge of the biodiversity resources of the nation is important for the future conservation of the same. Long term management plans should be implemented for the conservation of these resources.

1.4.3 Bycatch in fisheries

Bycatch and discards are potent threat to the biodiversity and long term sustainability of fishery resources. Looking towards global fisheries, bycatch and discards is a severe issue faced and has great impact on marine water bodies and is a matter of concern for sustainable management of fisheries resources. Bycatch includes all non-target animals and non-living materials (debris) which are caught while fishing (Eayrs, 2007). Discarding is the practice of returning an unwanted sector of catch back to the sea during fishing operations (Alverson et al., 1994). Other than the non-targeted finfishes and invertebrates, bycatch involves threatened and protected species like sea turtles, sea birds and cetaceans (Pitcher & Cheung, 2013). Bycatch quantity varies according to season, area of fishing operation, type of fishery, type of fishing vessels etc.

A comprehensive worldwide review covering 800 research papers during the period from 1980-1990 estimated about 17.9-39.5 (average of 27) million tonnes of bycatch fish being discarded by commercial fisheries each year, which is more than half of all fish, produced annually from marine capture fisheries for direct human consumption (Alverson et al., 1994). In 1998, FAO estimated a global discard level of 20 million tonnes (Anon, 1998). Globally, shrimp trawling contributes to the highest level of discard/catch ratios of any fisheries. Shrimp trawling is generally regarded as one of the least selective fishing methods because the bycatch may consist of over several hundred teleost species and outweigh the shrimp catch (Eayrs, 2007). Andrew and Pepperell (1992) estimated total global discards of 16.7 million tonnes bycatch from shrimp fisheries alone. The shrimp trawl is a non-selective gear that commonly has an associated catch of non-targeted organisms such as finfish and miscellaneous invertebrates, designated as bycatch (Boopendranath, 2003). Average annual global discards, has been re-estimated to be 7.3 million tonnes by Kelleher (2004).

In India, the first estimation of the quantity of bycatch associated with shrimp trawling by the Central Marine Fisheries Research Institute (CMFRI), Cochin in 1979 showed that 79.18% (315,902 tonnes) of the total landings is represented as bycatch; the percentage of bycatch was maximum in Gujarat (92.58), followed by Tamil Nadu (91.04) and Pondicherry (86.52). In India, the bycatch landed at fishing harbours are utilized mainly for the production of manure and animal feed (Bijukumar & Deepthi, 2006). According to the studies of Pillai et al. (2009) the deep-sea shrimp trawling operation often generate huge proportion of fish discards which ranges from 20-40% and sometimes exceed more than 80% in Kerala. Trawling is the most widespread method of capturing marine fishes and invertebrates in Kerala. Kurup et al. (2003) reported that incessant trawling operations in the coastal habitat slowly resulted in disproportionate destruction of non-target groups along with the juveniles and sub adults of commercially important fishes and shell fishes and a wide spectrum of benthic organisms. In the case of deep-sea shrimp fishing operation in Kerala it is not profitable considering the huge cost of ice and storage for the by catch fin fishes. In a study conducted by Shanis et al. (2014) on deep sea fishery operations in Kerala coast, all the bycatch fishes are dumped to the sea except for the sharks and few fins fishes. The positive effect of monsoon trawl ban had been reported by Kurup (2010) in which the closure period for bottom trawlers are very useful in the benthic food chain and it is essential to minimize unintentional catch of juveniles and non-targeted species and over fishing.

Various types of bycatch reduction technologies have been developed in the fishing industry around the world, in order to minimise the impact of fishing on non-target resources. There has been several bycatch reduction devices (BRD) developed in Indian waters also such as Oval Grid BRD, Rectangular Grid BRD, Bigeye BRD, Radial Escapement Devices (RED), Juvenile Fish Excluder cum Shrimp Sorting Devices (JFE-SSD) and Seperator Panel Devices to reduce bycatch in trawlers (Boopendranath et al., 2008). The study on bycatch constituents is helpful in improving the knowledge regarding the biodiversity of the region and is an important tool for fisheries management.

1.4.4 Overfishing and juvenile incidence

The concept of overfishing was not known before 19th century. But advancements in the industrial revolution paved way to increased capability of vessels to go to distant fishing grounds and catch large quantity of fish which ultimately led to overfishing in the present scenario. Juvenile fishing is the harvesting of young and newly hatched fish and sometimes accidental harvesting of eggs laid by fish (Sheriff et al., 2010). According to Hubbs (1943), juveniles are young fish mostly similar in the form of adult but not yet sexually mature. The size at first maturity females in stage III and above were considered as mature (Raje, 2000). The juvenile stage lasts until the fish is fully grown, sexually mature and interacting with other adult fish. Juvenile incidence is a major problem and is reported in fishing gears such as trawls, gillnets, purse seines and ring seines. In countries where there is inadequate fishing regulation, the ratio of targeted and non-targeted juvenile fishes to the overall catch is very large (Hall & Mainprize, 2005). The growth overfishing occurs when the fishery targets fishes of a size below the optimal harvestable size.

Luther and Sastry (1993) have reported the incidence of juveniles as the major portions of the landings in different fisheries in India. In India there are about 35 fish meal plants operating in the states of Karnataka, Kerala, Maharashtra, Gujarat and Tamil Nadu (Ponnusamy et al., 2012). To meet the demand of fish meal plants, a considerable amount of juveniles of small pelagic have been captured intentionally along the Kerala coast (Mohamed et al., 2014). The fishes which were usually preferred for preparing fish meal are oil sardine, stomatopods, silverbellies and other trash fishes (Aswathy &

Narayanakumar, 2013). The assessment of economic impact of juvenile fishing along Mumbai coast has been studied by Kamei et al. (2013) which showed the economic loss incurred from juvenile landings of *Otolithoides biauritus* was highest and *Johnieops sina* was least among the sciaenids. Anon (2017a) has reported heavy incidence of juveniles in bycatches of Gujarat, Maharastra, Karnataka, Kerala and Andra Pradesh.

The improvements made in the fishing gear and techniques have led to overfishing in the Kerala coast. Rajasenan (1996) has reported that increase in the fishing effort has eventually led to both economic and biological overfishing. Juvenile fishery in ring seines is reported by many authors. Juvenile fishery is detrimental and will reduce the future yield and subsequent recruitment to the fishery. Less capital investment gears such as mini trawl and ring seine have also substantially contributed towards high rate of juvenile harvesting. This is mainly because, these modified traditional craft and gear inflict more damage to the coastal ecosystem as the fishing grounds for them are well within the 50m depth range, which is considered as the nursery grounds for many marine fishes. The juveniles of fishes caught in ring seine comprised of anchovies (40%), oil sardine (30%) and mackerel (15%) of the total catch along the Kerala coast (Najmudeen & Sathiadas, 2008). Yohanan and Sivadas (1993) has stressed on the impact of ring seines in mackerel fisheries of Calicut during the period 1988, and pointed out that the small meshed ring seines will ultimately result in overfishing. Vijayan et al (2000), has explained the enormous change in the composition of species and the disappearance of earlier important species with an increase in small sized species and those which are not marketable are signs of overfishing. Lakshmi and Raju (2016) has emphasized on the importance of exploiting deep sea resources because of the current overexploitation of commercially important resources which may lead to saturation.

1.4.5 Interaction of aquatic organisms and fisheries

Interaction between fisheries and aquatic organisms is an age old process. Several organisms are found interacting with the fisheries. The most common aquatic organisms that interact are cetaceans such as dolphins, whales and porpoises. Interaction of cetaceans and fishing gears is as old when humans have attempted to catch fish by net. Fishers in different parts of the world has attempted to keep away dolphins by means of making loud noises, dynamite, weapons, modifications of fishing techniques and schedules, and large-mesh nets surrounding the fishing nets to protect them from dolphin incursions (Bearzi, 2002). Even small losses by depredation can affect the livelihood of several fishers. Depredation involves stealing or damaging bait or prey already captured by fishing gear (Powell & Wells, 2011). The removal of catch from the gear by cetaceans may result in loss of value of catch. Depredation can be considered as a conservation issue since its probability is higher in bycatch (Read, 2008). Marine mammals are found in several hundreds and thousands as bycatch mainly in gillnets (Read et al., 2006).

Interaction with pinnipeds and fisheries is also a common process worldwide. There are two types of interactions such as biological/ecological and direct/operational interaction. Biological interaction is the interaction of fisheries and pinnipeds uses same resources which is mutually disadvantages and direct interaction which causes damages to fisheries by pinnipeds

(Wickens, 1994). Several authors has done reviews on interactions between pinnipids and fisheries (Mate, 1980; Anon, 1981; Miller et al., 1983; Malouf, 1986; Young et al., 1993; and Wickens, 1994). Depredation by seals and gillnet fisheries has been reported by several authors (Matkin, 1978; Herder, 1983; Miller, 1983; Malouf, 1986 and Young et al., 1993).

Depredation by pufferfish has been reported in different areas of globe (Anon, 2012b). Pufferfish which is known by different names such as balloon fish, blowfish, toadfish are those which belongs to the family tetraodontidae which constitute 187 species (West, 2009; Anon, 2012b). Pufferfishes are well known for their characteristic feature of toxins produced in their body which is highly toxic and its consumption may lead to asphyxiation and death. Mohammed et al. (2013) has studied on the pufferfish menace of Kerala and stated that it has been due to the loss of predatory fishes of pufferfishes which has increased the biomass of these toadfishes in the Arabian Sea.

The huge occurrence of jellyfish in coastal waters has become very common (Mills, 2001). The interactions of jellybooms and fisheries have gained attention to the gelataneous organisms (Boero, 2014). The proliferation of these gelatinous zooplanktons is mainly due to the impact on trophic level changes (Pauly et al., 2002). In Indian waters the studies on jellyfish interactions with fisheries are very less. The jellyfish predominant in the Madras waters has been studied by Masilamoni et al. (2000). Panda and Madhu (2009) has reported the jellyfish occurrence from Veraval coast. Raphael et al. (2017) has reported on the jellyfish menace occurring in ring seines of Cochin region.

1.5 Rationale and objective of the study

In India ring seines have gained much popularity among the fishers and adopted by fishers different states. Ring seines are important artisanal gears intended to catch pelagic fishes. Many authors classified ring seine fishery. Several authors also have reported on the juvenile incidence of ring seines. There are many studies on bycatch occurrence in trawlers and gill nets but very few is regarding the bycatch in ring seines and it is very important to study the factors effecting ring seine fishery for its sustainability.

Growing marine fish production means that fishing technologies and catch characteristics have to be constantly monitored. Resource conservation sustainability of production in ring seine fisheries requires continual research to keep track of bycatch issues, juvenile fishing, introduction of high speed engines and so on. There has been a decline in the landings of pelagic species since 2012 and recent reports show an increase in number of species landed by ring seines (Das, 2015). Studies on species composition and temporal changes if any, in the landings of fishing gears will provide information for policy making with regard to mesh size, dimensions and design of new gears.

The main objectives of the study are the following:

- To quantify the Catch Per Unit Effort and the instability occurring in three different categories of ring seines
- To analyse the diversity of species caught in different categories of ring seines

- To analyse the trends in landings of different categories of ring seines and to predict the future landings of various resources
- To quantify the bycatch occurring in different categories of ring seines during different seasons
- To assess the juvenile incidence in the ring seine fishery and conformation with Minimum Legal Size (MLS)
- To study the loss occurring in different categories of ring seines due to depredation/ interaction by aquatic organisms

CHAPTER 2
MATERIALS & METHODS

MATERIALS & METHODS

2.1 Introduction

The present study on ring seines covers aspects such as ring seine categorization, CPUE and growth instability in different categories, diversity of species occurring in ring seines, emerging problems in ring seines such as depredation and catch loss due to different types of aquatic organisms and the dominance of species occurring in ring seines.

2.2 Data Base

Study required data on primary and secondary nature. The primary data were collected through field visits and interviews conducted by structured questionnaires. The secondary data were collected from The Department of Fisheries, Kerala, Chellanam Kandakadavu Fishermen Welfare Co-operative Society (CKFDWCS) and log books maintained by fishing vessel operators.

2.3 Area of study

The area selected for the study was Chellanam mini fishing harbour and Kalamukku fishing harbour situated in Ernakulam district of Kerala, South west coast of India. Chellanam is a fishing village in the southern part of Ernakulam district situated at 76 16’ N latitude and 9 58’ E longitude and is the centre of traditional ring seine activity. About 63% of the fishers in the fishing village are employed in the ring seine fishery sector. Single day fishery has been observed in the study area with only local fishers conducting fishing. The two types of fishing vessels such as motorized and mechanized are operated in Chellanam area. The motorized fishing vessels start their operation from the

Chellanam area and are land in the same area. The mechanized craft starts their operation from the Cochin fisheries harbour and are landed at Kalammukku fishing harbour. Kalammukku is a major fish landing centre in Southern part of Ernakulam district situated between 9°58’55.48"N ; 76°14’34.27"E and is also a major ring seine landing centre.

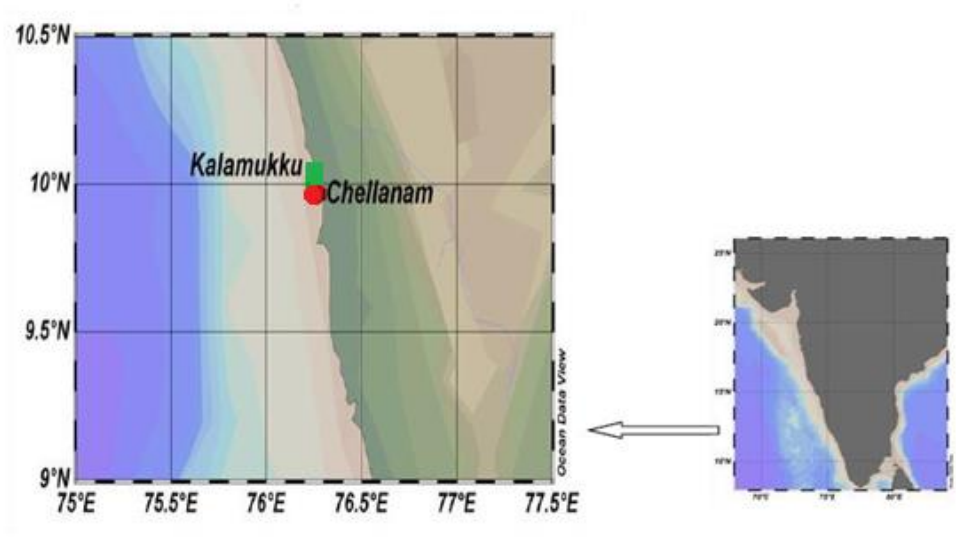


Fig 2.1 Study area showing *Chellanam* and *Kalamukku* situated along the south west coast of India

2.4 Craft and Gear survey

The survey of the craft and gear in the ring seine sector was undertaken to find out if any significant changes have occurred in the design and dimensions of the fishing unit and to categorize the units accordingly. The preliminary study of ring seines was started with a craft and gear survey conducted in the Chellanam mini fishing harbour during the period November

2014 to January 2015. The main tool to collect details on craft and gear was field visit and interviews using pre tested structured questionnaires prepared for this purpose. The fishers who were operating ring seines with different socio economic background were interviewed with open ended questions. In-depth questions were conducted among those fishers who were seen more knowledgeable among the groups. The questionnaires prepared for this purpose in given in Annexure I.

2.5 Sampling techniques

Sampling was done from two major centres such as Chellanam mini fishing harbour and Kalamukku fishing harbour twice and thrice a week, for a period of two years from November 2014 and October 2016. During sampling the specimens were collected from three different types of ring seine gears and stored in ice boxes and brought to the laboratory. Details of quantity of fish landings during other days were collected from the auctioneers, fishers and societies records of Chellanam Kandakadavu Fishermen Welfare Co-operative Society in that area. The proforma prepared for the sampling methods are given in Annexure II.

Fig 2.2 Fishermen taking fish for sorting

Fig 2.3 Fish being sorted before auctioning

Fig 2.4 Fish kept ready for auctioning

2.6 Analytical techniques

2.6.1 Diversity study

Identification of species was confirmed using standard monographs and fish identification books [FAO Fish Identification sheets (Fischer & Bianchi, 1984), Smith's sea fishes (Smith & Heemstra (1986) and Fishbase (Freose & Pauly, 2007)]. For analytical purpose months were classified in pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January).The morphometric and meristic characters were considered for the identification of species. The collected specimens were identified upto species level using standard keys. For the computation of different diversity indices such as Margalef's richness index, Shannon-Wiener index and Pielou's evenness index was done in Microsoft excel spreadsheet. The detailed methodology is given in the Chapter 4.

Fig 2.5 Samples taken for identification

2.6.2 Bycatch studies

The samples were collected from the three categories of ring seines in iceboxes and numbered when brought back to the laboratory. It was stored in the freezer and later identified using standard monographs and fish identification books. For the purpose of bycatch studies the months were classified into pre monsoon, monsoon and post monsoon seasons. The mean trophic index were calculated in was done in Microsoft excel spreadsheet. The detailed methodology is shown in the Chapter 5.

2.6.3 Juvenile incidence studies

The juvenile incidence was quantified using the method of Najumudeen & Sathiadas (2008). The juvenile incidence was calculated for the three categories of ring seines during a period of one year. Fifteen commonly occurring species in ring seines were used for the study of juveniles in ring seines. Juveniles were identified by comparing the minimum legal size (MLS) recommended by CMFRI (Muhammed et al., 2014). The calculations for juvenile incidence were done in Microsoft excel spreadsheet. The detailed methodology is described in the Chapter 6.

Fig 2.6 Juveniles of carangids from ring seines

2.6.4 Depredation and catch loss studies

The loss due to aquatic animals in three categories were studied from the information collected from the two areas of study during a period of one year. Catch loss in terms of quantity and value was been calculated from the three categories of ring seines. The questionnaires prepared for this purpose in given in Annexure III. The detailed methodology is given in the Chapter 7.

Annexure I

PROFORMA FOR RING SEINE CRAFT & GEAR SURVEY

Name of the fishing area/ landing centre :

Owners name :

Contact number :

Fishing season :

Date :

I. Structure of the vessel

Sl.No.	Particulars	
1.	Name of the vessel	
2.	Type of vessel	Motorized/ Mechanized
3.	Engine hp	
4.	LOA(m)	
5.	Depth (m)	
6.	Breadth (m)	
7.	Boat with/without skiff	
8.	Material for boat construction	
9.	Deck equipments	
10.	Other details	

II. Details of fishing gear

Sl.No.	**Particulars**	
11.	Length (m)	
12.	Breadth (m)	
13.	Construction material for webbing	
14.	Mesh size (mm)	
15.	Rope material	
16.	Diameter of rope	
17.	No. of fishing gear unit/vessel	
18.	Fishing accessories used	
19.	Material used for float	
20.	Shape of the float	
21.	Diameter of the float	
22.	Number of floats used	
23.	Material used for sinker	
24.	Shape of the sinker	
25.	Diameter of the sinker	
26.	Number of sinkers used	
27.	Purse rings material	
28.	Diameter of the ring	
29.	Number of rings used	
30.	Other details	

III. Fishing operation details

Sl.No.	Particulars	
31.	Area of operation	
32.	Depth of operation (m)	
33.	Shooting time	
34.	Active fishing (hrs)	
35.	Hauling time	
36.	Landing time	
37.	Landing centre	
38.	Duration of fishing	
39.	Fishing days/month	
40.	Other details	

Annexure II

PROFORMA FOR SPECIES DIVERSITY ANALYSIS

Area of study :

Type of vessel :

Type of gear :

Date :

I. Catch composition

II. Data sheet on length-weight analysis

Sl.No	Species	Total length (cm)	Fork length (cm)	Total weight (gm)	Sex
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Annexure III

PROFORMA FOR SURVEY OF INTERACTION OF AQUATIC ORGANISMS IN RING SEINES

Area of study :

Type of vessel :

Type of gear :

Date :

I. Interaction of aquatic organisms

1.	Wheather there is aquatic organisms interaction ?	Yes/No
2.	Which are they?	Cetaceans/pufferfish/jellyfish/ Ambassids/ seabirds/others
3.	Which month is the cetacean attack seen	
4.	How many days in a week cetacean attack noticed	
5.	Number of cetacean seen attacking a single net	
6.	Are they seen during the hauling time?	
7.	Which portion of net is affected most	
8.	Traditional methods used to avoid cetaceans	

9.	Any dolphin wall net (DWN) used?	
10.	Some other devices used to scare cetaceans	
11.	Which month is the pufferfish bite seen	
12.	How many days in a week pufferfish bite noticed	
13.	Number of pufferfish seen attacking a single net	
14.	Are they seen during the hauling time?	
15.	Which portion of net is affected most	
16.	Which month is the jellyfish menace seen	
17.	How many days in a week jellyfish bloom noticed	
18.	Number of jellyfishes entering a single net	
19.	Are they seen during the hauling time?	
20.	Which portion of net is affected most	
21.	Which month is the ambassis entanglement seen	
22.	How many days in a week entanglement occurs	
23.	Quantity of ambassis entangled	

24.	Which portion of net is affected most	
25.	Is there any seabird entanglement	
26.	Others if any	

II. Economic details

		Cetaceans	Pufferfish	Jellyfish	Ambassids
26.	How many quantity of net used to replace damaged portion?				
27.	Labour cost				
28.	How many persons are involved in repairing the net?				
29.	How many days are spent for repairing the damaged net				
30.	Other details				

CHAPTER 3
CATEGORIZATION OF RING SEINE FISHING SYSTEMS AND TREND ANALYSIS

CATEGORIZATION OF RING SEINE FISHING SYSTEMS AND TREND ANALYSIS

3.1 Introduction

Ring seines are one of the most important gears used to catch pelagic fish along the Kerala coast. Ring seining is most active and efficient fishing method intended to catch dense, mobile school of pelagic fishes and includes all the methods of searching, hunting and capture. The ring seines are very similar to purse seines which are surrounding gears operated in the surface waters. It is locally known by the names *ringuvala*/ *ranivala*/ *kudukkuvala*/ *choodavala*/ *manduvala*/ *discovala*/ *natholivala* at different regions of Kerala and the special feature is that it is completely operated by the local fishers. Depending on the target group the design of the ring seines vary. The pelagic fishery resources sustains the marine fisheries sector in the west coast of India contributing to more than 30% of the total marine fish landings of the country. The catch of pelagic fishes formed 61% of the total marine fish production (4.82 lakh tonnes) of Kerala during 2015. Ring seines contributed 25% of the total landings of the state (Anon, 2016e). The ring seine landings are much higher than the landings by other gears (Edwin & Das, 2015). In Kerala, nearly 80% of fish are landed by trawls and ring seines (Anon, 2016e). As per marine fisheries census 2010, a total of 988 ring seiners are operating in India. Since ring seiners were treated as traditional motorized vessels, and excluded from fishing ban, supply of fish was ensured by these vessels in Kerala during the monsoon ban period (Anon, 2014).

The size and CPUE of ring seines had changed over the years (Edwin & Hridayanathan, 1998; Balan & Sathianandan, 2007).The ring seines introduced by Panicker et al. (1985) had an overall length of 250m and a depth of 30m, but recent studies shows that the size of the ring seines have grown at least three to four times in proportion to the extent of about 1500m in length and 100m in depth in Cochin area (Edwin & Das, 2015). Currently the ring seine fishery contributes substantially to the marine landings of the country.The success of ring seines has made this technology spread to other parts of the country. Vijaykumaran & Chittibabu (2005) reported ring seines operated in the Odisha coast. Burayya (2006) has reported introduction of *ringvala* along Kakinada coast. Shiledar (2009) has reported the introduction of mini purse seines in Maharastra coast. Along the Puducherry coast the ring seine introduction was reported by Mohanraj et al. (2011). Rajeswari et al. (2013) has reported the three categories of ring seines viz., *peddaringulavala*, *nadipiringulavala* and *chiragaringulavala* operated in north Andra Pradesh coast. Arur et al. (2014) has reported the ring seines of 10-25mm mesh size along the Andaman and Nicobar Islands.

In fisheries the catch per unit effort (CPUE) is an indirect measure of abundance of targeted species. If the CPUE decreases it indicates the overexploitation and if it is unchanging then this indicates sustainability in fisheries. The CPUE is a much used ecological measure for the density of the stock and at the same time it is a proper indicator for the state of affairs in the fishery being a measure for physical and financial productivity (Hoof & Salz, 2001). It has been observed that excess effort exists in different forms in the ring seine sector (Edwin & Hridayanathan, 1996a). Declining catch per unit effort and increasing cost of operation have resulted in uneconomical operation of the fishing fleet, even forcing a few fishers out of the business (Narayanakumar et al., 2009). Hence the evaluation on the economic performance of the fishing fleet is an important factor in this sector.

Rapid economic growth and the resultant expansion of the domestic retail sector in India have created a large market for fresh, processed and value added fishery products within the country and also new opportunities for international trade in seafood (Dash & Patra, 2014). Hence growth and stability in fisheries is an important factor for the sustainability of the sector.Growth rates refer to the percentage change of a specific variable within a specific time period, given a certain context. The growth rates in marine fisheries of India have been studied by Kathuria et al. (1990). The study estimated the marine production was maximum during 1975 (1.42 million tonnes) and in 1981 (1.38 million tonnes). The measurement of instability is defined as "average year to year percentage change without regarding the sign in the irregular component of yearly or quarterly series remaining after removal of trend and seasonal variation" (Zachria et al., 1999). The instability index is unit free and very robust (Chand & Raju, 2008).The main objective of this chapter is to assess and compare the catch per unit effort (CPUE) and growth instability in three different categories of ring seines. Categorization of ring seines operating during the period of study was done for this purpose.

3.2 Materials & Methods

3.2.1 Data source

The study was undertaken during December 2015- November 2017 and the data pertaining the details of design and operation of different types of ring seines were collected from landing centers, net mending centers, auctioneers, and fishers of the Chellanam fishing village situated in the central Kerala. The second type of small meshed ring seine (SMRS-II) emerged during 2012 period. The data on the quantity of fish landed from ring seines were obtained from the fish landing records maintained at Chellanam Kandakadavu Fishermen Development Welfare Co-operative Society (CKFDWCS). For the purpose of comparison between different categories of ring seines information on ring seiners, ring seines and accessories were collected using pre tested structured schedules prepared for the purpose (Annexure I) from the study area as mentioned in Chapter 2.

3.2.2 Documentation of ring seine

The categorization of ring seines was done based on the dimensions and mesh size of the gear. The catch per unit effort, growth rate and growth instability in ring seines were calculated as per standard method. The designs of the three categories of gears were prepared as per FAO standards (Fyson, 1986). Data regarding the catch obtained from three different categories of ring seines are expressed in kg. The data on the total fish landings in Chellanam from different categories of ring seines during the period 2012-2016 have been utilized for studying the growth rates as well as instability index in ring seine fishery. These data have been compiled on the basis of fish catches recorded in the Chellanam Kandakadavu Fishermen Development Welfare Co-operative Society. Fishing units were selected on the basis of stratified random sampling and included five units from each of the three different categories of ring seines from the study area.

3.2.2.1 Catch per unit effort

Catch per unit effort (CPUE) is an important factor which helps in understanding the efficiency of a fishing unit. Catch per unit effort can be highly variable or compromised by management or environmental changes through time and it varies according to fishing platforms, seasons, fishing methods or evolving technologies in fishing operations (Gloucester, 2012). The effort was estimated in terms of boat days. Thus the CPUE was calculated in terms of kg per boat days for three different categories of ring seines

$$\text{CPUE} = \frac{\text{Catch in kg}}{\text{Effort in boat days}}$$

3.2.2.2 Growth rate in ring seines

The growth rate is the rate at which something in particular grows within a specific time period. The growth rates in ring seines were calculated using the formula:

$$\text{Grt} = [(Yt/Yt)^{l/n} - 1] \times 100$$

Where, Grt = Growth rate for the year t

Y_t = Production in the current year'‘t'

Y_{t-1} = Production in the previous year'‘t-1'1

n = Number of years

3.2.2.3 Instability index

The instability index measures the deviations from an underlying trend. The instability index (Chand & Raju, 2008) was calculated using the following formula:

$$I\,I = Std\,[\ln(Y_{t+1}/Y_t)]$$

Where I I = Instability Index

Std = Standard deviation

Ln = Natural logarithm

Y_{t+1} = Total production for the next year

Y_t = Total production in the current year

3.3 Results & Discussion

3.3.1 Documentation of ring seine fishing system

The documentation of ring seine fishing system includes different types of ring seine craft which consist of engine, deck equipment such as purse line reel, purse line winches installed onboard and fish detection and communication devices. It also includes the structural parts, length, breadth, mesh size and the gear accessories. It explains the method of operation, indigenous traditional knowledge of fishers for fish detection and the crew size in different categories of ring seines in the study area. The classification of the ring seine fishing vessel and gear and method of operation are detailed below:

3.3.1.1 Ring seine fishing vessel

Currently there are two types of fishing vessels operated based on the mode of propulsion in the study area. The large vessels known as *thanguvallom,* which are the inboard engine driven mechanized ring seiners and small vessels are known as *choodavallom,* which are the outboard engine driven motorized ring seiners.

Thanguvallom

The mechanized ring seiners (*thanguvalloms*) are mainly large vessels with an LOA of 20-24m are mainly constructed of wood, Fiberglass Reinforced Plastic (FRP) and steel. Its breadth ranged from 3.6-4.9m and the depth ranged from 2.1-3.3m. There were about 33 numbers of large meshed ring seines operated in the Chellanam village about a decade ago but now it has decreased to six in number due to high operational cost for fuel, labour, transportation, maintenance and repair. The numbers of large ring seiners are less when compared to the small type of ring seiners. These vessels are propelled with high powered marine diesel engines of horse power ranging from 98 to 440 hp. The fuel capacity for these vessels ranges from 1000-3000 litres.

Every vessel is having carrier vessels or skiff for assistance. The carrier vessels are small vessels with LOA of 9-13m, breadth of 2-3m and depth of 1-1.5m. Since storage facility of the ring seiners are inadequate the catch is been transferred to the skiff so that it can be reached to the landing centre. These vessels are equipped with echo sounder which helps in fish detection, GPS for position fixing and wireless communications and mobile phones for communication purposes. The principal dimensions of the main vessel and carrier vessels of mechanized ring seiners are given in Table 3.1.

Table 3.1 Range of principal dimensions of main vessel and carrier vessels of mechanized ring seiners

	Main vessel	**Carrier vessel**
LOA (m)	20-24	9-13
Breadth (m)	3.6-4.9	2-3
Depth (m)	2.1-3.3	1-1.5

Choodavallom

The motorized ring seiners (*choodavalloms*) are small vessels of LOA ranging from 10-15m. They have a breadth of 2-4m and a depth of 1.5-2m. They are mainly constructed of wood or FRP. The material used for wooden are made from jungle jack which in local parlance is called *Aini*. There are 55 number of ring seiners operated in the study area. These vessels have been widely accepted by the fishers. These vessels are propelled with engines of horse power 9.9hp. One or two engines are used in a single vessel. Two engines are necessary if the gear is large and catch is heavy and if more number of crew are present. These vessels are equipped with echo sounder which helps in fish detection, GPS for position fixing and mobile phones for communication. The principal dimensions of the main vessel and carrier vessels of mechanized ring seiners are given in Table 3.2.

Table 3.2 Range of principal dimensions of motorized vessels

	Main vessels
LOA (m)	10-15
Breadth (m)	2- 4
Depth (m)	1.5-2

3.3.1.2 Ring seine gear categorization

Three categories of ring seines are operated in the study area viz; large meshed ring seine (LMRS), small meshed ring seine type I (SMRS-I) & small meshed ring seine type II (SMRS-II).

3.3.1.2.1 Large meshed ring seines (LMRS)

Dimension of the gear

The large meshed ring seines (LMRS), also known as *thanguvala* which is been operated from *thanguvallom* is having a dimension of about 600-1000m in length, 83-100m in depth and weight of about 1500-2500kg. These gears are mainly targeted to catch pelagic shoaling fishes such as sardine and mackerel. The main parts of the gear consist of the main body, bunt region, selvedge and the accessories such as rings, floats and sinkers. Design of a typical LMRS with 960m is described below:

Main body

The main body is otherwise known as the wing region/ *kaivaram*. The main body of the ring seines are constructed with Polyamide (PA) webbing and are having a mesh size of 20mm. It is arranged vertically to maintain the desired shape of the net. The main body is made up of 86 panels of webbing. Each vertical piece of webbing consists of 4600 meshes in depth and 600 meshes in width. The length of the main body is reduced 50 meshes from the 20^{th} piece onwards till the end of the wing to maintain a particular shape.

Bunt region

This is the region where the catch is concentrated and is situated at the centre. Bunt is last part of the net to be hauled in. In local parlance it is denoted as *adivala*. The top webbings are made up of stronger netting materials like High Density Polyethylene (HDPE) to withstand the strain due to the catch. The rest of the webbings are made up of Polyamide (PA) webbing. The webbings are been horizontal placed for better strength. The webbings are having a mesh size of 20mm. Each horizontal piece of webbing is 4000 meshes in length and 500 meshes in depth and about nine such pieces are placed in the bunt region.

Selvedges

Selvedges/ *changali* are found at the top and bottom of the net. They are usually constructed of few rows which are added with thicker twines so as to get more strength and to protect the other parts of webbing from damage. The top selvedge has a mesh size of 40mm and is made up of polyethylene. It consist of about 10 meshes in depth and it is been hung to a PP rope of 4mm diameter. The bottom selvedge is with a mesh size of 40mm and 7 meshes in depth.

Gear accessories

The gear accessories in LMRS include floats, sinkers and purse rings. Apple shaped plastic floats of diameter 90mm which weighs about 35g each are used in the gear. The numbers of floats used are 7000 and are hung to a polypropylene rope of 14mm diameter. Spindle shaped lead weighing 200g each are being hung to polypropylene rope of 10mm diameter. Around 3700 sinkers are being used. Ring seines have purse rings in the lower edge of the gear which is made up of brass and it weighs about 1.5kg each. It is usually having a diameter of 160mm and total of 60 numbers of rings are used in LMRS.

3.3.1.2.2 Small meshed ring seines type I (SMRS-I)

Dimension of the gear

The small meshed ring seines type I (SMRS-I), also known as *choodavala* which is been operated from c*hoodavallom* is having a dimension of about 250-500m in length, 45-75m in depth and weight of 700-1300kg. These gears are known as *natholivala* since it is mainly targeted to catch anchovies. It also targets sardine, mackerel and prawns. The structure of *choodavala* consists of bunt area, the wings, selvedges and accessories such as rings, floats and sinkers. Design of a typical SMRS-I with 230m is described below:

Main body

The main body of the ring seines are constructed with Polyamide webbing and are having a mesh size of 10mm and this portion is with thicker twines. It is been arranged vertically to maintain the desired shape of the net. Each vertical piece of webbing consists of 3000 meshes in length and 600 meshes in width. The main body consist of 52 panels. The length of the main body is reduced 50 meshes from the 21st piece onwards to maintain a particular shape.

Bunt region

Bunt is situated in the central region of webbing where the catch is concentrated and has a mesh size of 10mm. The webbings are made up of polyamide material. The webbings are been horizontally placed as in *thanguvalloms*. This is the region where the catch is concentrated and is situated at the centre. Bunt is last part of the net to be hauled in. The webbings are been horizontal placed for better strength. The webbings are having a mesh size of 20mm. Each horizontal piece of webbing is 6000 meshes in length and 600 meshes in depth and about 10 such pieces are placed in the bunt region.

Selvedges

Selvedges are found at the top and bottom of the net and are made up of polyethylene. The top selvedges have a mesh size of about 20mm and bottom selvedges have a mesh size of 80mm.

Gear accessories

The gear accessories include floats, sinkers and purse rings. Apple shaped plastic floats of diameter 65mm which weighs about 35g each are used in the gear. The numbers of floats used are 1000 and are hung to a polypropylene rope of 12mm diameter. Spindle shaped lead weighing 100g each are being hung to polypropylene rope of 10mm diameter. Around 800 sinkers are being used. Ring seines have purse rings in the lower edge of the gear which is made up of brass and it weighs about 500g each. It is usually having a diameter of 130mm.

3.3.1.2.3 Small meshed ring seines type II (SMRS-II)

Dimension of the gear

The small meshed ring seines type II (SMRS-II), is the modified version as *choodavala* which is been recently emerged and is operated from c*hoodavallom*. This small version of *choodavala* is widely accepted by the fishers since it is operated near to the shore. The total number of fishing units in the study area is shown in Table 3.5. It is a modified form of SMRS-I which has been recently emerged during the year 2012 from the study area. It has a mesh size of 10mm, length of 130- 240m, depth of 25-45m and weight of 500-700kg. This gear is mainly targeted to catch anchovies, sardine, mackerel and prawns. The structures of SMRS-II with 130m are described below:

Main body

The main body of the ring seines are constructed with Polyamide webbing and are having a mesh size of 10mm and this portion is with thicker twines. It is been arranged vertically to maintain the desired shape of the net. Each vertical piece of webbing consists of 3500 meshes in length and 600 meshes in width. There are 30 panels used in the main body. The length of the main body is reduced 100 meshes from the 7th piece onwards to maintain a particular shape.

Bunt region

Bunt is situated in the central region of are made up of PA material. The webbings are been horizontally placed as in LMRS and SMRS-I. The webbings are having a mesh size of 10mm. Each horizontal piece of webbing is 3000 meshes in length and 600 meshes in depth and about 10 such pieces are placed in the bunt region.

Selvedges

Selvedges are found at the top and bottom of the net. They are made up of polyethylene. The top selvedges have a mesh size of about 20mm and bottom selvedges have a mesh size of 80mm.

Gear accessories

The gear accessories include floats, sinkers and purse rings. Apple shaped plastic floats of diameter 65mm which weighs about 35g each are used in the gear. The number of floats used is 700 and are hung to a polypropylene rope of 12mm diameter. Spindle shaped lead weighing 100g each are being hung to polypropylene rope of 10mm diameter. Around 800 sinkers are being used. Ring seines have purse rings in the lower edge of the gear which is made up of brass and it weighs about 500g each. It is usually having a diameter of 13mm.

3.3.1.3 Fishing operation

3.3.1.3.1 Detection of fishing schools

This is a major step in ring seine fishing and there will be an experienced person in the vessel who can identify what kind of shoal is seen. Fish shoal is also detected with the help of GPS. Different colours are seen in the GPS for different species.

3.3.1.3.2 Indigenous traditional knowledge of fishers in fish detection

The indigenous traditional knowledge (ITK) is widely practised and is passed through generations. Traditional knowledge regarding the sea water colour , current strength and direction, lunar phase, cloud cover and intensity of wind, presence and absence of sea birds etc are been applied by the fishers for locating the fish grounds. Fishers possess rich knowledge on the indications of fish availability and abundance in the sea. The treasure of indigenous traditional knowledge in fisheries sector of India assumes significance in view of the threat of possible illegal erosion of the wealth of our ancient knowledge (Pillai, 2011). Detection of fish shoals by the experienced fishers in ring seine sector on their indigenous knowledge is as follows:

Table 3.3 Indigenous traditional knowledge of fishers on occurrence of species

Fish expected	Species	Colour	Odour	Nature
Sardine	*Sardinella longiceps, S.albella, Dussumieria acuta*	Black/ dark blue in clear water and red when the water is turbid	Inherent fishy smell traditionally known as *choorumanam/Ulumbumanam*	Like a slight breeze on the surface of water and small bubbles seen as water splashes. There will be an oily appearance on the surface of the water. They swim under water and not at the top. Mostly during monsoon season black seabirds known as 'karikaakka' seen flying over the shoals
Mackerel	*Rastrelliger kanagurta*	Brick Red	No particular odour	Swims on the water surface and open up their gills and come on the top of the water. Mostly shoals are seen in the evening hours
Seer fish	*Scomberomorus guttatus, S.commersonnii*	Red	No specific odour	Shoals shows a behavior of going up and down
Tuna	*Thunnus albacore*	Black or dark green in colour on water surface	No peculiar odour	Jumps over the surface and is very noisy from long distance
Pampus	*Pampus argenteus, P. chinensis*	The water shines in bright white colour	No specific odour	Shoal moves slowly compared to other types of shoals
Anchovies	*Stolephorus indicus, S.commersonii, S.weitti*	The water shines in bright white colour	No specific odour	Shoal moves under the vessel

3.3.1.3.3 Method of operation

Ring seine operations are usually restricted to single day. The crew starts their vessel from the Chellanam area at early 5.00 am. Encirclement of shoal is the principle of operation of ring seine gear. The shoal is detected either visually or with the help of fish finding equipment such as echo sounder. Visual detection of the shoal is done by an experienced fisher member (*aryakaran*) in the vessel. Once the shoal is detected from the vessel by the main crew gives the instructions for the purpose of shooting and in turn the vessel increases its speed towards the shoal. One of the crew member jumps from the vessel with one end of the net. In case of mechanized vessels the remaining portion of the net is carried by the craft surrounding the fish school and finally returns to the starting point. The bottom of the ring seine is pursed after the encircling of the shoal. Pursing is done with the help of purse line winches. After the hauling the purse rings are taken on to the deck so as that the purse lines are taken out from the rings. This is been taken from the bunt region where it is concentrated with the help of scoop net. The catch is then transferred to the carrier boat incase of *thanguvalloms* or directly to the main vessel in case of *choodavallom*. Then it is carried to the landing centre. The *choodavalloms* complete their operation within 1 o’ clock in the afternoon and *thanguvalloms* finish their operation by 4 o’ clock in the evening.

3.3.1.3.4 Crew size

The average crew size of the *thanguvala* (LMRS) units is larger than the *choodavala* (SMRS) units because of the high labour requirements for hauling of *thanguvala* due to the larger size of the gear. Whereas in *choodavala* units the size of the gear is small and hence the labour required is less. The *thanguvala* is manned by a complement of 40 to 60 fishers and the skiff by 6 to 8 fishers. In SMRS-I the crew size range from 10 to 15 and SMRS-II it is 8 to 10.

Table 3.4 Specifications of different categories of ring seines

Specifications	**LMRS**	**SMRS-I**	**SMRS-II**
Length of webbing (m)	600-1000	250-500	130-240
Mesh size (mm)	20	10	10
Hung depth (m)	83-100	45-75	25-45
Crew	40-60	10-15	8-10
Depth of operation (m)	30-50	10-20	8-12
Vessel	Mechanized	Motorized	Motorized

Table 3.5 Number of gears operated in different categories of ring seines

Type of gear	**Number of gear operated**
LMRS	6
SMRS-I	30
SMRS-II	25

At present, ring seiners of Kerala can be classified into motorized (using outboard motor, OBM) ring seiner and mechanized (using inboard motor, IBM) ring seiner (Edwin & Das, 2016). During the time of introduction ring seines were operated from small canoes with only low powered engines but now it has been totally replaced by high powered motorized and mechanized vessels (Das & Edwin, 2016). Ring seines introduced was for new resources that could be seen exploited in the marine fisheries of the state. In view of this scientist recommended 200 nets having an average length of 300m, but on contrary around 2500 units of ring seines were enumerated (Kurup, 2009).

A number of modifications have been made in the design of ring seine gear as an innovation by the traditional fishers (Edwin & Hridayanathan, 1996b; D’cruz, 1998; Anon, 1999; Das et al., 2012). Edwin & Hridayanathan (1996a) has reported the main parts of the ring seines of Kerala are the central bunt portion (*adivala*) and two wing portions (*kaivaram*) on either side of the bunt region. Jadhav et al. (2011) has studied the design characteristics and operational aspects of the ring seine with pocket operated in Ratnagiri coast with a total length of 570±84m, where the bunt region is locally known as *mand*, the main body is known as *kan* and the selvedge known as *palgi*. In Ratnagiri, the nets were operated generally at depths less than 25m while the nets along the Kerala coast were operated up to a depth of 45m (Sathiadas et al., 1993; Jadhav et al., 2011). Ring seines introduced in Kakinada coast known as “ring vala” for pelagic fishing is made of silk yarn having a total length of 315-350m and breadth of 34-40m. This gear is been operated from motorized fiberglass teppa/beach landing craft with 10 to 20hp engines fitted on it (Burraya, 2006).

The large scale introduction of ring seine boats of commercial exploitation of pelagic fish resources were reported by Mohanraj et al. (2011) along the coast of Puducherry. These ring seines known as “*surrukuvala*” in local parlance (tamil) is operated from boats with wood or fiberglass having a length of 38-43 feet. The gear has a size of 400-600m length and breadth of 50m. Rajeswari et al. (2013) has reported the three categories of ring seines viz., *peddaringulavala* (large mesh size), *nadipiringulavala* (medium mesh size) and *chiragaringulavala* (small mesh size) operated in north Andra Pradesh coast. Das (2015) has studied the regional variations and designs of ring seines and their operation along the Kerala coast. It is observed that there has been a drastic increase in size of ring seines with an increase in size of vessels and horse power (Edwin & Das, 2015).

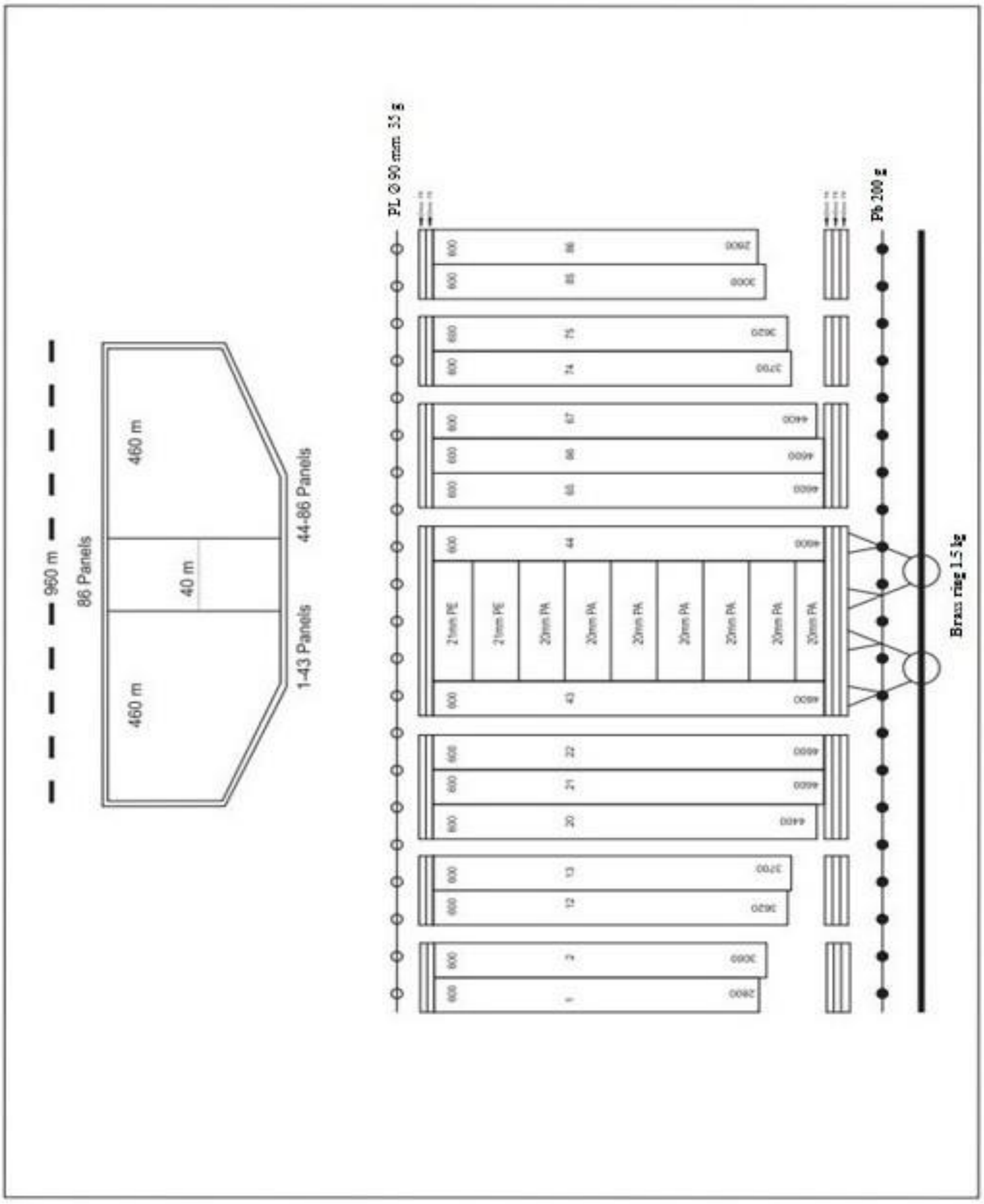


Fig 3.1 Design of 960m ring seine (LMRS) operated at Chellanam

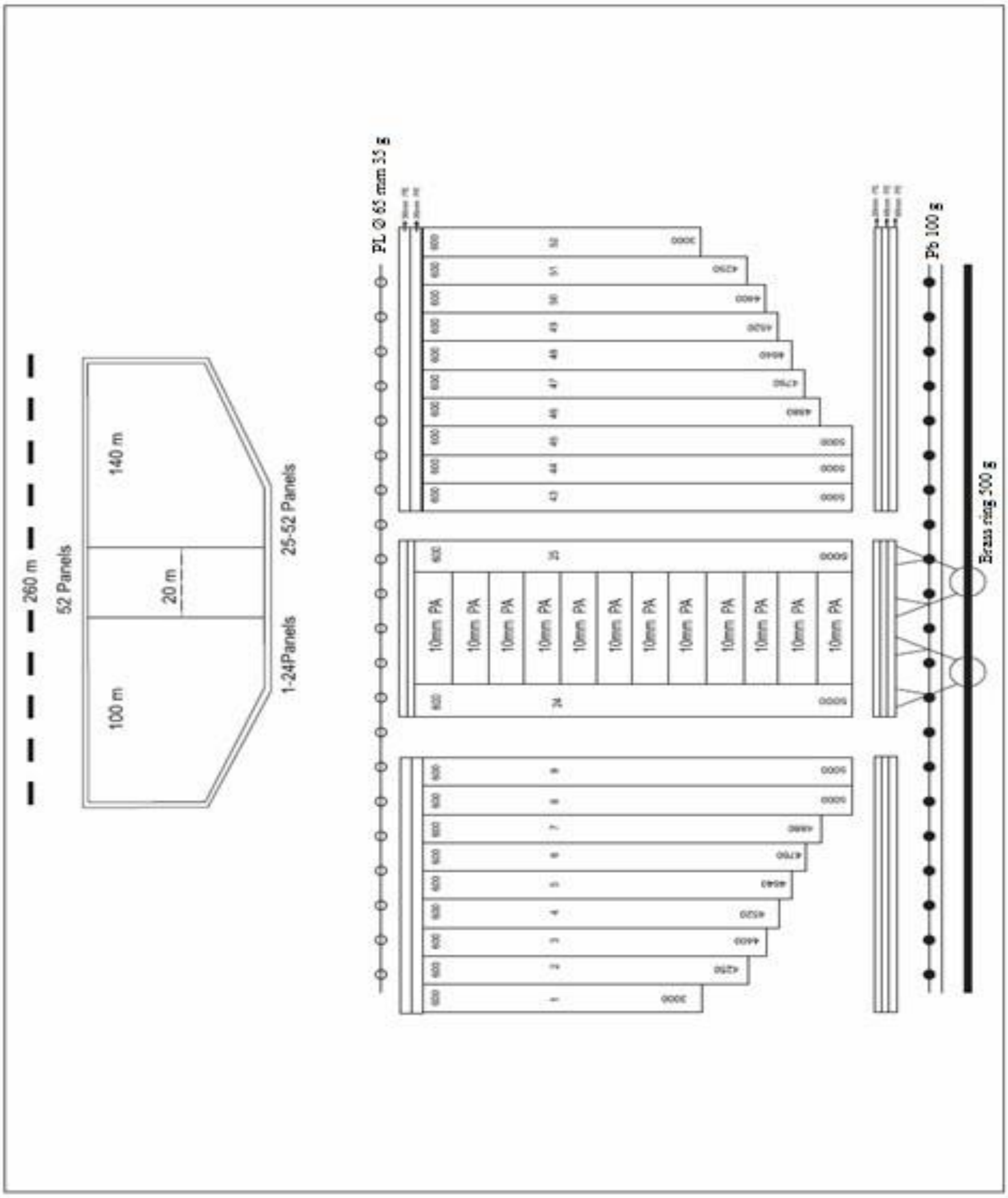


Fig 3.2 Design of 260m ring seine (SMRS-I) operated at Chellanam

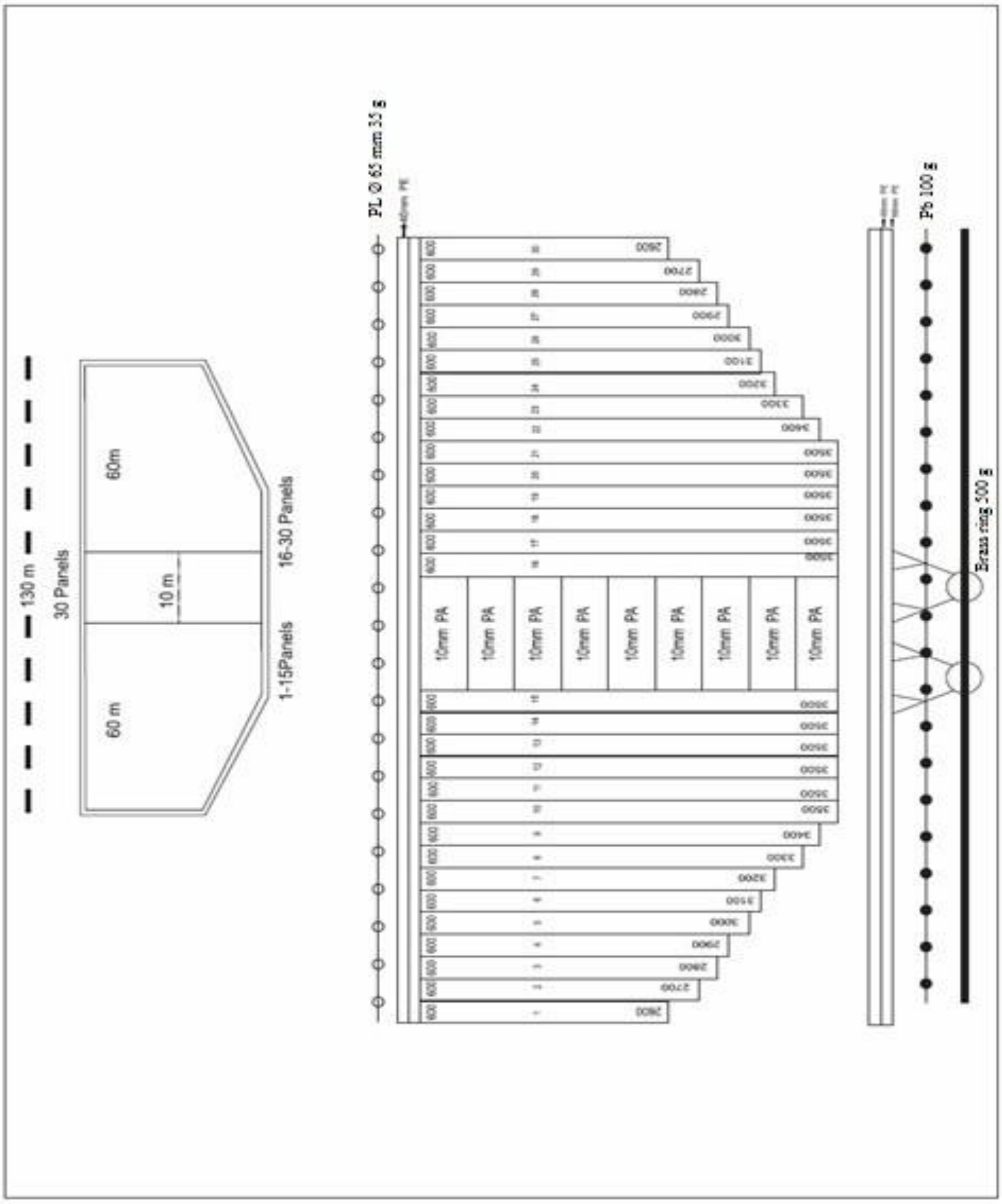


Fig 3.3 Design of 130m ring seine (SMRS-II) operated at Chellanam

Fig 3.4 View of mechanized ring seiner operating LMRS

Fig 3.5 View of motorized ring seiner with skiff operating SMRS-I

Fig 3.6 View of motorized ring seiner operating SMRS-II

3.3.2 Catch per unit effort (CPUE) in ring seines

From the secondary data obtained the catch per unit effort in different categories were calculated for the past five years (2012-2016). With respect to the three different categories LMRS performed best. The CPUE ranged from 1503 to 4297kg in LMRS, 840 to 2785kg in SMRS-I and 725 to 2704kg in SMRS-II. LMRS showed highest value during the year 2013 and lowest value was during 2015.SMRS-I showed highest value during 2012 and lowest value during 2015. SMRS-II showed highest value during 2013 and lowest value during 2015. The mean catch per year in LMRS was estimated to be 2891kg, SMRS-I was estimated to be 1683kg and SMRS-II was estimated to be 1507kg.

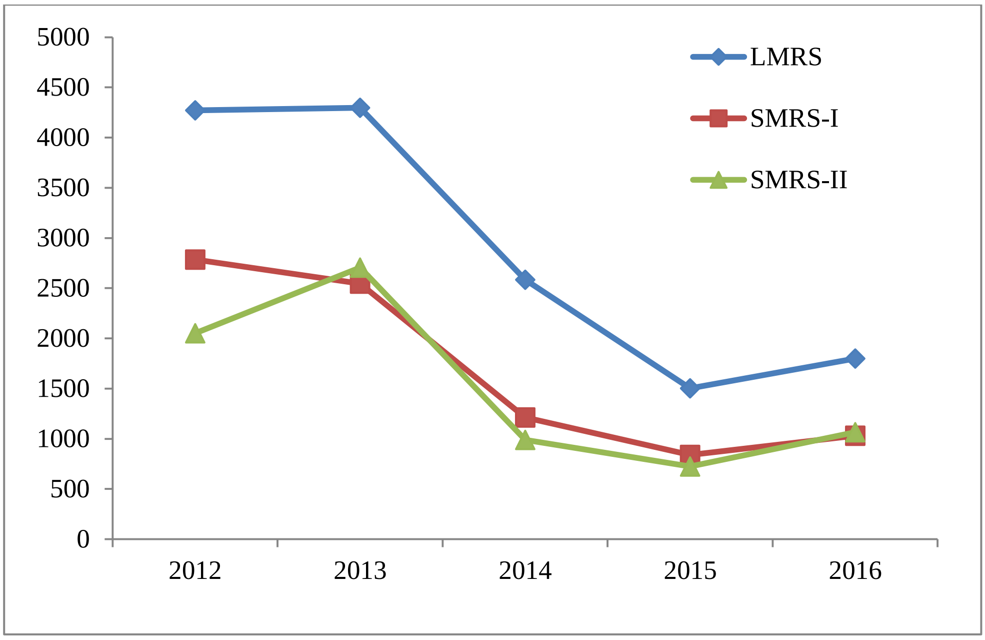


Fig 3.7 Catch per unit effort (in kg) of different categories during 2012-16

Balan & Andrews (1995), has studied the catch and effort analysis of ring seines which has shown a downward trend by a decrease from 1031kg in 1990 to 581kg in 1993.The status of the stocks exploited by ring seines (mainly oil sardine and mackerel) was considered best during the period 1993 (Balan & Sathianandan, 2007). Edwin & Hridayanathan (1997a) has reviewed the fishery in *thanguvallom* and *choodavallom* with reference to the catch contribution and conflict between the two and the result confirmed that the smaller units which use lesser engine power, smaller crew size and single boat operation is more energy efficient. Edwin & Hridayanathan (1997b) has studied the operational efficiency of two major artisanal fishing gear (mini trawl and ring seine) of Kerala and found out that the operating ratio is higher for the mini trawl when compared to the ring seine units by three times. This was found due to the higher percentage of occurrence of penaeid prawns in the landings. Kurup & Radhika (2003) have studied the performance of inboard engine fitted canoes operating ring seines along Kerala coast. During the study the average annual CPUE was estimated to be 1826kg.

There is a trend of decline in CPUE was observed from the present study during the period from 2012-2016. The reason for the decline in ring seines is mainly due to the excess effort expended in this fishery. During the time of introduction the recommended number of ring seines were 300 of size 250 x 30m (Panicker, 1985) and at present there 2800 number of ring seines operated in Kerala (Anon, 2005b) and the size of the gear has increased to about 1500m (Edwin & Das, 2015).

3.3.3 Growth rate and instability index

Growth in ring seine landings analysis during the period 2012-2016 was calculated. LMRS, SMRS-I and SMRS-II showed a negative growth of 9.4, 22.2 and 12.82% respectively. This clearly indicated that the catch rates in all the categories of ring seines have declined when compared to the previous years. The instability index was estimated for the three different categories of ring seines. During the period 2012-2016 it was found that instability index was1, 0.53 and 1.07 for LMRS, SMRS-I and SMRS-II respectively. It was found highest index in SMRS-II and lowest in SMRS-I. SMRS-II showed more unstable may be due to the reason of fishing near the shore and catching whatever species are being seen.

Table3.6. Growth rate in different categories of ring seines

	Growth rate (%)	Instabilty index
LMRS	-9.43	1.00
SMRS-I	-22.23	0.53
SMRS-II	-12.82	1.07

Instability in production is a major factor in price volatility which in turn affects the economy of the country (Raju et al, 2014). Chand and Raju (2008) has discussed about the instability in case of food grains and agricultural production in India. The study explains the change in stability after the introduction of improved technology and there has been huge difference in the period compared to pre green revolution and first two decades of green revolution in the country. Similarly in the case of fisheries the fish production in India recorded tremendous growth during the post independence era (Pillai, 2011). Earlier study conducted by Das et al. (2018), has estimated the growth rate and instability index of mechanized and motorized ring seiners during the period 2002-2011 from the Chellanam area for three different seasons. The result showed that there existed a positive growth rate of 25% in mechanized ring seiners and a negative growth rate of 2.3% in motorized ring seiners and the instability index observed was 37, 61 and 46% for pre monsoon, monsoon and post monsoon seasons respectively in mechanized ring seiners whereas in motorized ring seiners it was 92, 75 and 97% in pre monsoon, monsoon and post monsoon respectively. The results from the present study shows close similarity between the earlier study conducted by Das et al. (2018) in the case of instability in ring seines.

3.4 Conclusion

Ring seining is considered as one of the most efficient and effective fishing method in the coast of Kerala. The study area Chellanam fishing village is known for its active ring seine fishery. At present there are three types of fishing gears operated in the study area. They are classified on their length viz; large meshed ring seines (LMRS), small meshed ring seine type I (SMRS-I) and small meshed ring seine type II (SMRS-II). The LMRS is operated from the mechanized vessels of LOA 20-24m and SMRS-I and SMRS-II are operated from the motorized vessels of LOA 10-15m.There are about 61 ring seiners of which 6 numbers are mechanized and 55 are of motorized. Single day fishery with local fishers is observed in all types of fishery. These vessels are seen operated throughout the year and does not have any closed seasons. Monsoon season is considered as peak season and pre monsoon season is considered as lean season in ring seine fishery. The main targeted species are the pelagic shoaling and migratory fishes. The LMRS is seen decreasing and SMRS- I & II are seen increasing and gaining popularity among the fishers. The CPUE in ring seine were studied which showed that LMRS have highest value and SMRS-II is with lowest value. The growth rate in ring seines showed that there was a negative growth rate in all the categories of ring seines. This is mainly due to the over exploitation of fish resources. The instability calculated showed that the SMRS-II was more unstable than LMRS and SMRS-I due to fishing very near to the shore.

CHAPTER 4
SPECIES DIVERSITY IN RING SEINES

DIVERSITY OF SPECIES CAUGHT IN RING SEINES

4.1 Introduction

The term biological diversity or biodiversity is a term which is used to describe the number, variability and variety of living organisms in a given assemblage (Anon, 1995b) and this term is used to mean species diversity, ecosystem diversity and genetic diversity. It is important to understand the fish species diversity to examine the factors influencing the structure of fish community and it is helpful in developing management and conservation programs (Hashemi et al., 2015). Biodiversity performs a number of ecological services for mankind that have commercial and recreational or resources management purpose (Rajakumaran & Vaseeharan, 2014).The fish populations show migration, distinct spawning and feeding and according to the seasonal changes in the conditions there results a shift in the resources available to the fisheries (Jin & Tang, 1996). Biodiversity loss is often viewed as the most undesirable consequence of human activities on earth (Jennings & Reynolds, 2000).

Fish being a very commercial commodity it is been exploited at a high level. India accounts to about 7.4% of marine fishes from the total number of fishes around the world (Bijukumar & Rajeev, 2015). The Indian marine waters harbours around 1707 species of which about 200 species of finfishes and shellfishes are commercially significant. The important groups of marine resources of the country are constituited by pelagic resources viz; oil sardine, mackerel, seer fish, tuna, lesser sardines, anchovies and ribbonfishes; demersal resources viz; perches, sciaenids, cat fishes, polynemids, flat fishes, pomfrets, eels, midwater resources viz; bombay duck, silver bellies and horse mackerel; crustacean resources viz; prawns, shrimps, lobsters and crabs; molluscan resources viz; oysters, mussels, clams, chanks, squids and cuttle fishes; and seaweed resources (Zacharia & Najmudeen, 2012; Zacharia, 2015).

The fisheries sector which is considered as one of the productive sectors of the state contributes to about three percent to the economy of the state (Anon, 2011b). The total marine fish landings in Kerala were 482499 tonnes in 2015 registering a decline of 16% compared to the previous year. During the year 2016, the total marine species landed along the Indian coast was 709 in numbers and among the maritime states, Kerala is at the top with landings of 487 species (Anon, 2017a). The study of fish assemblage in the marine system is an important factor and increased research of species assemblages will improve the existence of fisheries management system.

The main objective of the study is to analyse the diversity of species caught in ring seines in the study area in different seasons from different categories of ring seines based on indices of species richness, diversity and evenness. The pattern of occurrence of dominant species is also studied in comparison with present catch data.

4.2 Materials & Methods

4.2.1 Data source

The species assemblage study was conducted from February 2016-January 2017 from three categories of ring seines viz., LMRS, SMRS-I and SMRS-II, as mentioned in the Chapter 3. Simple random sampling method was used to collect the samples. A total of about 180 observations were made during the study. Catch composition from one vessel was considered as one observation. Sampling was conducted two or three days in a week from Chellanam mini fishing harbour and Kalamukku harbour situated in Ernakulam district. The fish samples were collected from the commercial ring seine catch landed before auctioning. Sub samples were taken from the total catch landed. The catch was recorded on the daily basis and computed monthwise and seasonwise for comparison. Details of the location of the fishing ground were collected from each vessel. Freshly caught samples were transported to the laboratory in iced condition and individual fish were sorted with respect to size and later identified using morphometric and meristic characters.

4.2.2 Method of analysis

Data on total length (cm), fork length (cm), total weight (kg), sex, maturity stages (immature, maturing, ripe and spent) were recorded and photographs were taken. Identity of species was confirmed using standard monographs and Fish Identification books (FAO Fish Identification sheets, Species Catalogue, Fishbase, Smith's Sea fishes). To obtain the length-weight characters on seasonal variation on the different species the study period (1 year) was divided into 3 seasons viz; Pre-monsoon (February-May), Monsoon (June-September) and Post-monsoon (October-January).The data collected were compiled in Microsoft Excel spreadsheet. All the indices were computed manually. Since the individual size of the fish differed, the indices in the following equations were expressed in terms of biomass rather than numbers.

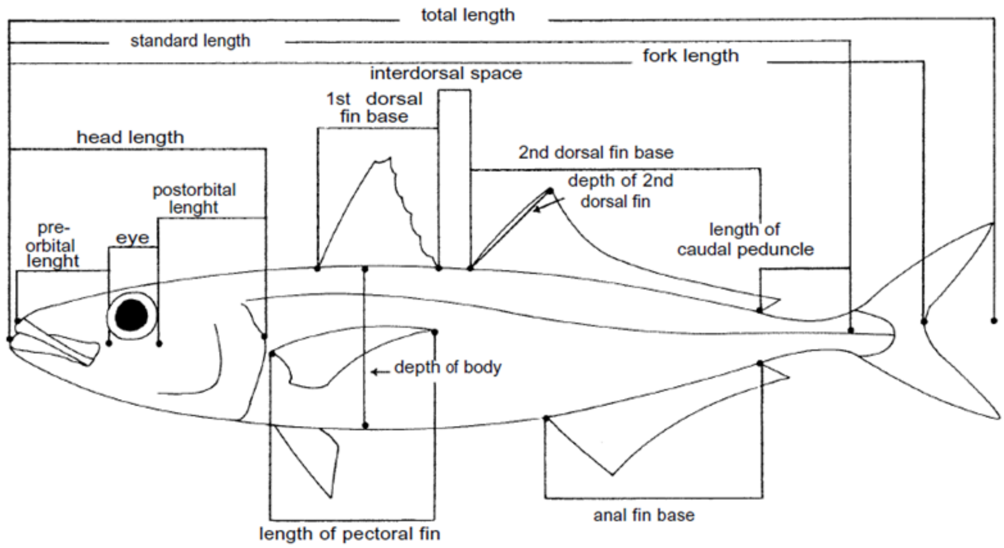


Fig 4.1 Morphometric characters of fish (Source: Fischer & Bianchi, 1984)

4.2.2.1 Measurement of richness

Richness is the simple measure of different types of dataset. Species richness (S) is the dataset of number of different species in the corresponding species list. This measure is strongly dependent on sampling size and effort.

The richness index was calculated using the Margalef's richness index (Margalef, 1958) as follows:

$$\text{Margalef's index} = R = (S-1) / \ln W$$

Where, S = Species

W = Biomass

ln = logarithm to base e

4.2.2.2 Measurement of diversity

A diversity index is the quantitative measure of species diversity in a community. It is been used to summarize a diversity of a population in which each member belongs to a unique group. Shannon-Wiener (Shannon & Weiner, 1949) and Simpson (Simpson, 1949) indices are the simple mathematical equations, widely used for the calculation of alpha diversity (Sagar & Gyan, 2012). The larger the value of Shannon index, the greater the species diversity. The Shannon diversity index (Shannon & Weiner, 1949) was calculated as:

$$\text{Diversity index} = H = -\sum Pi \ln Pi$$

Where pi = the proportion of biomass belonging to i^{th} species

ln = logarithm to base e

4.2.2.3 Measurement of evenness

Species evenness refers to how evenly the biomass is distributed among the species. The Pielou index (Pielou, 1966) was used to calculate the evenness index in the species caught in the ring seines. The species evenness ranges from zero to one, with zero signifying no evenness and one denotes a complete evenness. It is computed as follows

$$\text{Pielou's Evenness Index} = E = H / \ln S$$

Where H = Shannon - Wiener diversity index

S = total number of species in the sample

ln = logarithm to base e

4.3 Results & Discussion

4.3.1 Species assemblage

The study revealed the presence of 86 fish species belonging to 54 genera, 34 families, 14 orders and 5 classes from the all the categories of ring seines (Table 4.1). There were about 40 numbers (47%) of pelagic species and 46 numbers (53%) of demersal species (Fig 4.6). A total of 15 species showed single occurrence during the study period. In LMRS, 50 species of fishes were recorded and they were included in 37 genera, 23 families, 10 orders and 5 classes. In SMRS-I, 72 species of fishes was recorded and they were included in 47 genera, 31 families, 13 orders and 5 classes. In SMRS-II, 67 species of fishes were recorded and they were included in 44 genera, 31 families, 14 orders and 5 classes. The occurrences of each species in different categories are depicted in Table 4.2. Number of species in each order is shown in Fig 4.2. The percentage of species composition with dominant family with more than 4 species is shown in Fig 4.3. The species which showed single occurrence were *Nematalosa nasus*, *Scomberoides commersonianus*, *Gerres poieti*, *Gerres filamentosus*, *Lactarius lactarius*, *Scatophagus argus*, *Polynemus plebeius*, *Acanthurus pyroferus*, *Epinephelus ongus*, *Cynoglossus bilineatus*, *Arius caelatus*, *Arius dussumieri*, *Arius maculates*, *Scomberomorus guttatus*, *Ostracion cubicus* and *Pisodonophis concrivorus* . None of the species were reported threatened or endangered.

In LMRS a total of about 112379kg of fishes were landed in which the highest catch was observed during the monsoon season which constituted about 46422kg (42%), followed by post-monsoon season which was 38406kg (35%) and pre-monsoon season which was 27551kg (25%). In SMRS-I the total catch observed was 146520kg and the highest was observed during monsoon season which constituted about 96057kg (66%), followed by pre-monsoon season which was 33195 (23%) and post-monsoon season 17268kg (12%). SMRS-II constituted 167311kg of fishes and the highest catch was observed during the monsoon season which was 113372kg (68%), followed by pre-monsoon 36441kg (22%) and post-monsoon 17498kg (11%).

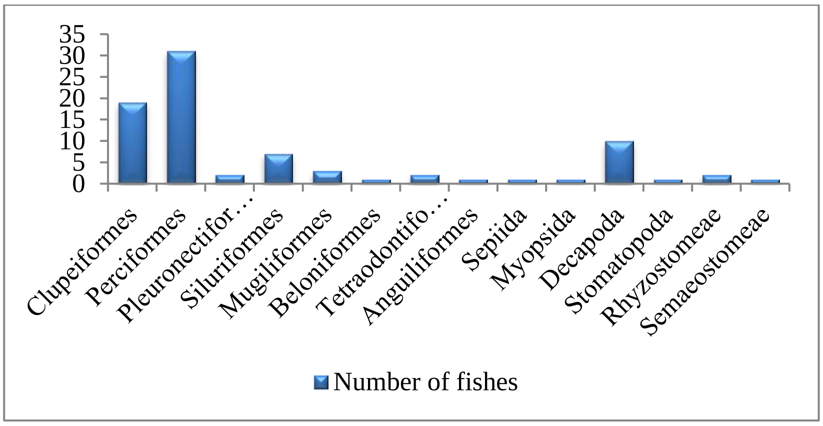


Fig 4.2 Number of species in each order

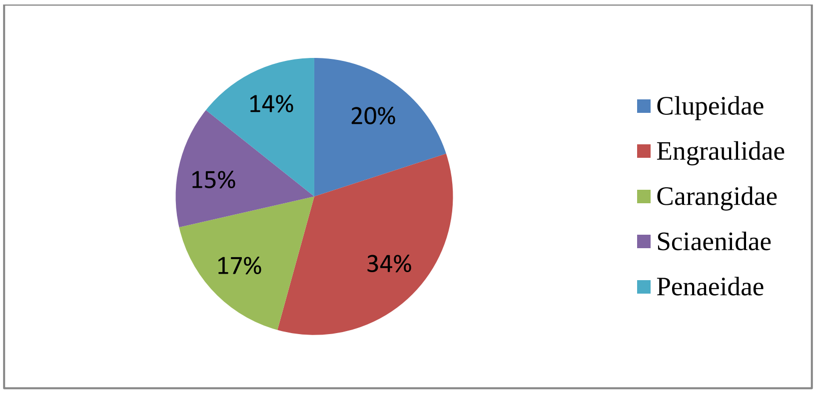


Fig 4.3 Number of species composition percentage in dominant families

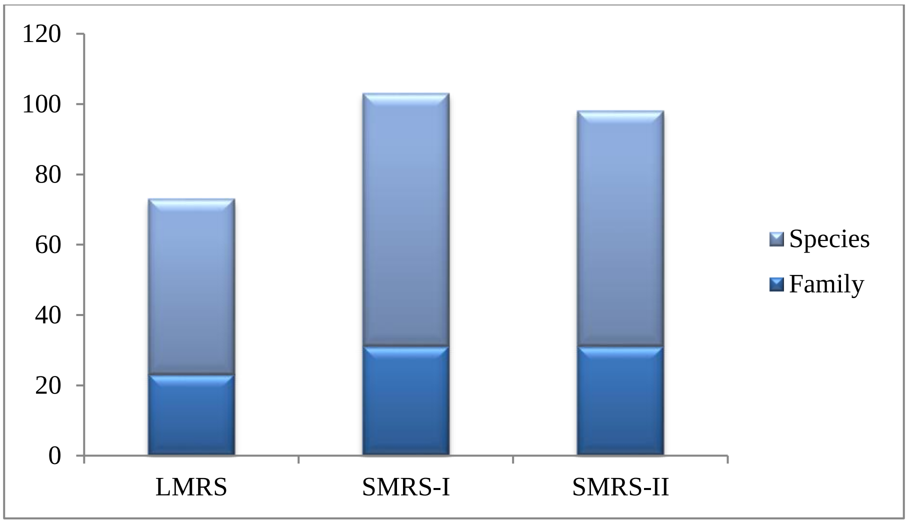


Fig 4.4 Diversity of species landed in three categories of ring seines during the study period

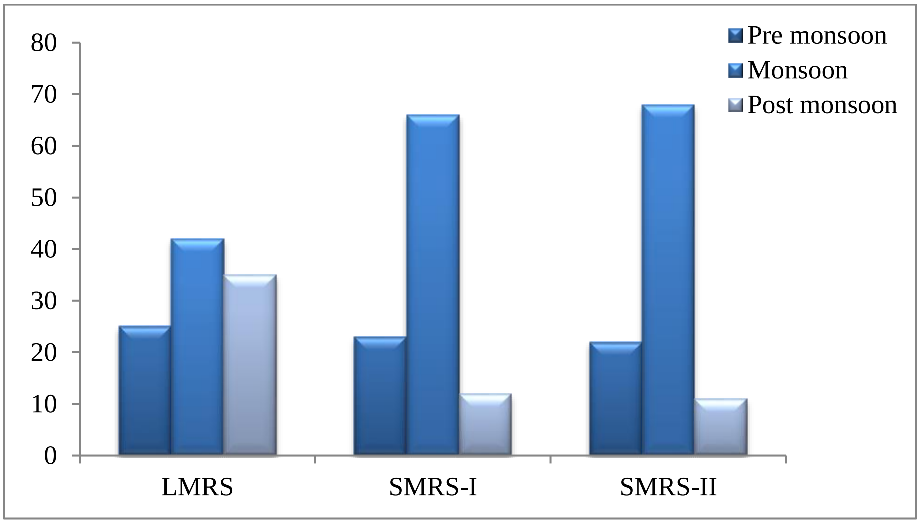


Fig 4.5 Percentage contribution of different types of ring seines during different season

Table 4.1 Diversity of species caught in the ring seines

Group	**Name**	**Common name**	**Vernacular name**
Class	**ACTINOPTERYGII**		
Order	**CLUPEIFORMES**		
Family	**Clupeidae**		
1	*Sardinella longiceps*	Indian oil sardine	*Chala*
2	*Sardinella gibbosa*	Goldstripe sardinella	*Vattachala*
3	*Dussumieria acuta*	Rainbow sardine	*Kokaanchala*
4	*Escualosa thoracata*	White sardine	*Veluri*
5	*Nematalosa nasus*	Bloch's gizzard –shad	*Noolchirakannuna*
6	*Opisthopterus tardoore*	Tardoore	*Thaada*
7	*Anodontostoma chacunda*	Chacunda gizard-shad	*Thodi*
Family	**Engraulidae**		
8	*Thryssa dussumieri*	Dussumier's thryssa	*Managu*
9	*Thryssa hamiltonii*	Hamilton's thryssa	*Managu*
10	*Thryssa mystax*	Moustached thryssa	*Managu*
11	*Thryssa vitrirostris*	Orangemouth anchovy	*Managu*
12	*Thryssa purava*	Oblique-jaw thryssa	*Managu*
13	*Stolephorus commersonii*	Commerson's anchovy	*Vellakozhuva*
14	*Stolephorus indicus*	Indian anchovy	*Aanakozhuva*
15	*Stolephorus punctifer*	Buccaneer anchovy	*Natholi/Kozhuva*
16	*Stolephorus heterolobus*	Shorthead anchovy	*Natholi/Kozhuva*
17	*Stolephorus waitei*	Spotfaced anchovy	*Vellachooda*
18	*Stolephorus insularis*	Insular anchovy	*Choodakozhuva*
19	*Stolephorus devisi*	Devis' anchovy	*Natholi/Kozhuva*
Order	**PERCIFORMES**		
Family	**Carangidae**		
20	*Megalaspis cordyla*	Torpedo scad	*Vangada*
21	*Caranx hippos*	Crevalle jack	*Vatta*

22	*Caranx ignobilis*	Giant trevally	*Vatta*
23	*Alepes djedaba*	Shrimp scad	*Vattapaara*
24	*Alepes klenii*	Razorbellyscad	*Paara*
25	*Scomberoides commersonianus*	Talang queenfish	*Neimeen*
26	*Parastromateus niger*	Black pomfret	*Maachan*
Family	**Gerreidae**		
27	*Gerres poieti*	Strong spine silver biddy	*Praanjil*
28	*Gerres filamentosus*	Whipfin silver biddy	*Praanjil*
Family	**Stromateidae**		
29	*Pampus argenteus*	White pomfret	*Veluthaaavoli*
30	*Pampus chinensis*	Chineese silver pomfret	*Aavoli*
Family	**Lactariidae**		
31	*Lactarius lactarius*	False trevelly	*Parava*
Family	**Sphyraenidae**		
32	*Sphyraena obstusata*	Obtuse barracuda	*Sheelavu*
Family	**Scatophagidae**		
33	*Scatophagus argus*	Spotted scat	*Nachakka*
Family	**Leiognathidae**		
34	*Secutor ruconius*	Deep pugnose ponyfish	*Mullan*
35	*Secutor insidiator*	Pugnose ponyfish	*Mullan*
36	*Leiognathus splendens*	Splendid ponyfish	*Mullan*
37	*Leiognathus brevirostris*	Shortnose ponyfish	*Mullan*
Family	**Polynemidae**		
38	*Polynemus plebeius*	Striped threadfin	*Vazhmeen*
Family	**Trichiuridae**		
39	*Lepturacanthus savala*	Small-head hairtail	*Paampada*
Family	**Siganidae**		
40	*Siganus canaliculatus*	White-spotted spinefoot	*Karadumeen*
Family	**Gobiidae**		

41	*Trypouchen vagina*	Burrowing gopi	*Thondi*
Family	**Acanthuridae**		
42	*Acanthurus pyroferus*	Surgeonfish	*Paalameen*
Family	**Sillaginidae**		
43	*Sillago sihama*	Silver sillago	*Kathiran*
Family	**Serranidae**		
44	*Epinephelus ongus*	White- streaked grouper	*Kalava*
45	*Epinephelus diacanthus*	Spiny cheek grouper	*Kalava*
Family	**Sciaenidae**		
46	*Johnius belangerii*	Belanger's croaker	*Kuttan*
47	*Johnius glaucus*	Pale spotfin croaker	*Kuttan*
48	*Kathala axillaris*	Kathala croaker	*Kuttan/kora*
49	*Otolithes ruber*	Tiger tooth croaker	*Pallikora*
50	*Otolithes cuvieri*	Lesser tiger tooth croaker	*Pallikora*
Family	**Ambassidae**		
51	*Ambassis gymnocephalus*	Bald glassy perchlet	*Nandan*
Order	**PLEURONECTIFORMES**		
Family	**Cynoglossidae**		
52	*Cynoglossus macrostomus*	Malabar tongue sole	*Maandhal/Nangu*
53	*Cynoglossus bilineatus*	Fourlined tongue sole	*Maandhal/Nangu*
54	*Cynoglossus arel*	Largescale tonguesole	*Maandhal/Nangu*
Order	**SILURIFORMES**		
Family	**Ariidae**		
55	*Arius caelatus*	Engraved catfish	*Koori*
56	*Arius arius*	Threadfin sea catfish	*Koori*
57	*Arius dussumieri*	Blacktip sea catfish	*Veliyaetta*
58	*Arius maculates*	Spotted catfish	*Etta koori*
Family	**Scombridae**		
59	*Rastrelliger kanagurta*	Indian mackerel	*Ayila*

60	*Scomberomorus guttatus*	IndoPacific king mackerel	*Neymeen*
Order	**MUGILIFORMES**		
Family	**Mugilidae**		
61	*Valamugil cunnesius*	Long arm mullet	*Maalan*
62	*Valamugil seheli*	Blue-spot mullet	*Maalan*
63	*Mugil cephalus*	Flathead grey mullet	*Kanambu*
Order	**BELONIFORMES**		
Family	**Exocoetidae**		
64	*Exocoetus volitans*	Tropical two wing flying fish	*Parakkum chala*
Family	**Hemiramphidae**		
65	*Hyporhamphus limbatus*	Congaturi halfbeak	*Kolaan*
Order	**TETRAODONTIFORMES**		
Family	**Tetraodontidae**		
66	*Lagocephalus inermis*	Smooth blaasop	*Thavala*
Family	**Ostraciidae**		
67	*Ostracion cubicus*	Yellow box fish	*Pettymeen*
Order	**ANGUILLIFORMES**		
Family	**Ophichthidae**		
68	*Pisodonophis concrivorus*	Longfin snake-eel	*Aarel*
Class	**CEPHALOPODA**		
Order	**SEPIIDA**		
Family	**Sepiidae**		
69	*Sepia pharaonis*	Pharaoh cuttlefish	*Kanava*
Order	**MYOPSIDA**		
Family	**Lolignidae**		
70	*Loligo duvauceli*	Indian squid	*Koondhal*
Class	**MALACOSTRACA**		
Order	**DECAPODA**		
Family	**Penaeidae**		

71	*Metapenaeus dobsonii*	Flowertail shrimp	*Poovalan*
72	*Parapenaeiopsis stylifera*	Kiddi shrimp	*Karikadi*
73	*Parapenaeiopsis coromandalica*	Coramandal shrimp	*Chemeen*
74	*Penaeus indicus*	Indian white prawn	*Naranchemeen*
75	*Penaeus monodon*	Tiger prawn	*Kara chemeen*
Family	**Hippolytidae**		
76	*Exhippolysmata ensirostris*	Hunter shrimp	*Chemeen*
Family	**Portunidae**		
77	*Charybdis lucifera*	Yellowish brown crab	*Njandu*
78	*Charybdis feriatus*	Crucifix crab	*Njandu*
79	*Portunus sanguinolentus*	Three-spot swimming crab	*Njandu*
80	*Portunus pelagicus*	Flower crab	*Njandu*
Class	**MALACOTRACA**		
Order	**STOMATOPODA**		
Family	**Squillidae**		
81	*Miyakella nepa*	Mantis shrimp	*Chelli/pehchemeen*
Class	**SCYPHOZOA**		
Order	**RHYZOSTOMEAE**		
Family	**Cepheidae**		
82	*Netrostoma setouchina*		*Neelachorri*
Family	**Rhizostomatidae**		
83	*Rhizostoma pulmo*	Barrel jellyfish	*Chorri*
Order	**SEMAEOSTOMEAE**		
Family	**Pelagidae**		
84	*Chrysaora caliparea*		*Thee Chorri*
85	*Chrysaora hydroscella*	Compass jellyfish	*Thee Chorri*
Family	**Cyaneidae**		
86	*Cyanea lamarckii*	Blue jellyfish	*Chorri*

Sardinella longiceps

Sardinella gibbosa

Anadontostoma chacunda

Escualosa thoracata

Dussumieria acuta

Nematolosa nasus

Opisthopterus tardoore

Thryssa dussumieri

Thryssa hamiltonii

Thryssa mystax

Thryssa vitrirostris

Thryssa purava

Stolephorus commersonii

Stolephorus indicus

Stolephorus punctifer


Stolephorus heterolobus


Stolephorus waitei


Stolephorus insularis


Stolephorus devisi


Megalaspis cordyla


Caranx hippos


Caranx ignobilis


Alepes djedaba


Alepes klenii


Scomberoides commersonianus


Gerres poieti


Gerres filamentosus


Pampus argenteus


Pampus chinensis


Parastromateus niger

Lactarius lactarius

Sphyraena obstusata

Scatophagus argus

Secutor ruconius

Secutor insidiator

Leiognathus splendens

Leiognathus brevirostris

Polynemus plebeius

Lepturacanthus savala

Siganus canaliculatus

Trypouchen vagina

Acanthurus pyroferus

Sillago sihama

Epinephelus ongus

Epinephelus diacanthus

Johnius belangerii

Johnius glaucus

Kathala axillaris

Otolithes ruber

Otolithes cuvieri

Ambassis gymnocephalus

Cynoglossus macrostomus

Cynoglossus bilineatus

Cynoglossus arel

Arius caelatus

Arius arius

Arius dussumieri

Arius maculates

Rastrellige kanagurta

Scomberomorus guttatus

Valamugil cunnesius

Valamugil seheli

Mugil cephalus

Exocoetus volitans

Hyporhamphus limbatus

Lagocephalus inermis

Ostracion cubicus

Pisodonophis concrivorus

Sepia pharaonis

Loligo duvauceli

Metapenaeus dobsonii

Parapenaeiopsis stylifera

Parapenaeiopsis coromandalica

Penaeus indicus


Penaeus monodon


Exhippolysmata ensirostris


Charybdis lucifera

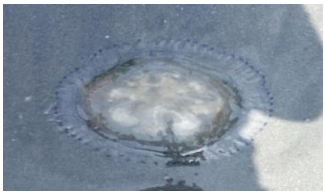

Charybdis feriatus


Portunus pelagicus

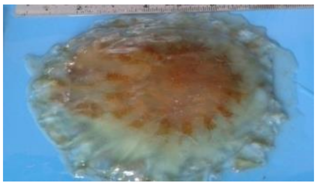

Portunus sanguinolentus


Miyakella nepa


Netrostoma setouchina


Rhizostoma pulmo


Chrysaora caliparea


Chrysaora hydroscella


Cyanea lamarckii

Plate 1.Species occurring in all categories of ring seines

Table 4.2 Comparison of occurrence of species in different categories of ring seines

Sl. No.	Species	Demersal (D)/ Pelagic (P)	IUCN Status	LMRS	SMRS-I	SMRS-II
1	*Sardinella longiceps*	P	LC	✓	✓	✓
2	*Sardinella gibbosa*	P	NE	✓	✓	✓
3	*Dussumieria acuta*	P	NE	✓	✓	✓
4	*Escualosa thoracata*	P	NE	✓	✓	✓
5	*Nematalosa nasus**	P	LC	×	✓	×
6	*Opisthopterus tardoore*	P	NE	✓	✓	✓
7	*Anodontostoma chacunda*	P	NE	×	✓	✓
8	*Thryssa dussumieri*	P	NE	×	✓	✓
9	*Thryssa hamiltonii*	P	NE	×	✓	✓
10	*Thryssa mystax*	P	LC	×	✓	✓
11	*Thryssa vitrirostris*	P	NE	✓	✓	×
12	*Thryssa purava*	P	NE	✓	✓	✓
13	*Stolephorus commersonii*	P	NE	✓	✓	✓
14	*Stolephorus indicus*	P	NE	✓	×	✓
15	*Stolephorus punctifer*	P	NE	×	✓	✓
16	*Stolephorus heterolobus*	P	NE	✓	✓	✓
17	*Stolephorus waitei*	P	NE	×	✓	✓
18	*Stolephorus insularis*	P	NE	✓	✓	✓
19	*Stolephorus devisi*	P	NE	×	✓	✓
20	*Megalaspis cordyla*	P	LC	✓	✓	✓
21	*Caranx hippos*	P	LC	✓	✓	✓
22	*Caranx ignobilis*	P	LC	✓	✓	✓

23	*Alepes djedaba*	P	LC	✓	✓	✓
24	*Alepes klenii*	P	LC	✓	✓	✓
25	*Scomberoides commersonianus* *	P	LC	✓	×	×
26	*Gerres poieti**	D	NE	×	✓	×
27	*Gerres filamentosus* *	D	NE	×	✓	×
28	*Pampus argenteus*	D	NE	✓	✓	✓
29	*Parastromateus niger*	D	NE	✓	✓	✓
30	*Pampus chinensis*	D	NE	✓	✓	✓
31	*Lactarius lactarius**	D	NE	×	✓	×
32	*Sphyraena obstusata*	P	NE	✓	✓	✓
33	*Scatophagus argus**	D	NE	×	×	✓
34	*Secutor ruconius*	D	NE	✓	✓	✓
35	*Secutor insidiator*	D	NE	✓	✓	✓
36	*Leiognathus splendens*	D	NE	✓	✓	✓
37	*Leiognathus brevirostris*	D	NE	✓	✓	✓
38	*Polynemus plebeius**	P	NE	×	×	✓
39	*Lepturacanthus savala*	P	NE	✓	✓	×
40	*Siganus canaliculatus*	D	NE	×	×	✓
41	*Trypouchen vagina*	D	NE	✓	✓	✓
42	*Acanthurus pyroferus**	D	NE	✓	×	×
43	*Sillago sihama*	D	NE	✓	✓	✓
44	*Epinephelus ongus* *	D	NE	✓	×	×
45	*Epinephelus diacanthus*	D	NE	×	×	✓
46	*Johnius belangerii*	D	NE	✓	✓	✓
47	*Johnius glaucus*	D	NE	✓	✓	✓
48	*Kathala axillaris*	D	NE	✓	✓	×
49	*Otolithes ruber*	D	NE	×	✓	✓
50	*Otolithes cuvieri*	D	NE	×	✓	✓

51	*Ambassis gymnocephalus*	D	NE	×	✓	✓
52	*Cynoglossus macrostomus*	D	NE	×	✓	✓
53	*Cynoglossus bilineatus**	D	NE	×	×	✓
54	*Cynoglossus arel*	D	NE	×	✓	✓
55	*Arius caelatus**	D	NE	×	✓	×
56	*Arius arius*	D	NE	×	✓	✓
57	*Arius dussumieri**	D	NE	×	×	✓
58	*Arius maculates **	D	NE	×	×	✓
59	*Rastrelliger kanagurta*	P	NE	✓	✓	✓
60	*Scomberomorus guttatus **	P	NE	✓	×	×
61	*Valamugil cunnesius*	P	NE	×	✓	✓
62	*Valamugil seheli*	P	NE	×	✓	✓
63	*Mugil cephalus*	P	NE	×	✓	✓
64	*Exocoetus volitans*	P	NE	✓	×	✓
65	*Hyporhamphus limbatus*	P	NE	✓	✓	✓
66	*Lagocephalus inermis*	D	NE	✓	✓	✓
67	*Ostracion cubicus**	D	NE	×	✓	×
68	*Pisodonophis concrivorus**	D	NE	×	×	✓
69	*Sepia pharaonis*	D	NE	✓	✓	✓
70	*Loligo duvauceli*	D	NE	✓	✓	✓
71	*Metapenaeus dobsonii*	D	NE	✓	✓	✓
72	*Parapenaeiopsis stylifera*	D	NE	✓	✓	✓
73	*Parapenaeiopsis coromandalica*	D	NE	✓	✓	×
74	*Penaeus indicus*	D	NE	✓	✓	✓
75	*Penaeus monodon*	D	NE	✓	✓	✓
76	*Exhippolysmata ensirostris*	D	NE	×	✓	×
77	*Charybdis lucifera*	D	NE	×	×	✓

78	*Charybdis feriatus*	D	NE	×	✓	×
79	*Portunus sanguinolentus*	D	NE	×	✓	✓
80	*Portunus pelagicus*	D	NE	×	✓	×
81	*Miyakella nepa*	D	NE	✓	✓	✓
82	*Netrostoma setouchina*	P	NE	✓	✓	✓
83	*Rhizostoma pulmo*	P	NE	✓	✓	✓
84	*Chrysaora caliparea*	P	NE	✓	✓	✓
85	*Chrysaora hydroscella*	P	NE	✓	✓	✓
86	*Cyanea lamarckii*	P	NE	✓	✓	✓

✓ = Present, × = Absent, * = Single occurance, LC= Least Concern, NE= Not Evaluated

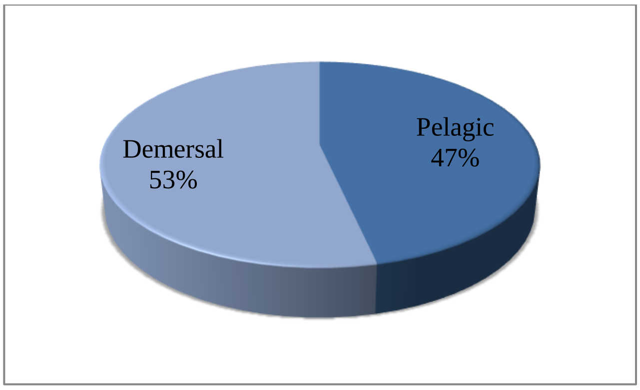


Fig.4.6 Percentage of pelagic and demersal species caught in three categories of ring seines

4.3.2 Variation in diversity indices

Based on the catch composition by weight from three categories of ring seines such as LMRS, SMRS-I and SMRS-II in three seasons, the indices of fish richness, diversity and evenness were calculated (Table 4.3).The study revealed that there were significant changes in the diversity of fishes caught in the three different types of ring seines.

4.3.2.1 Richness index

N indicates the total number of species in a community. The number of species category is a measure of richness and more the species present in a category, the richer the category. In LMRS, ***R*** showed the highest value 3.61during the pre-monsoon season (***N***=38) followed by post monsoon season.

In SMRS-I, the richness indices ***R*** was highest in the pre-monsoon season with ***R*** value 5.66, where the number of species were 60 followed by post-monsoon season with ***R*** value 5.02, where ***N*** was 50 number of species and the lowest was recorded in the monsoon season where ***R*** value was 3.66 (***N***=43).

In SMRS-II, ***N*** was highest (59 numbers) during the pre-monsoon season. The Margalef richness indices (***R***) showed the highest value 5.52 during this pre-monsoon season followed by post-monsoon season in which ***R*** value was 4.29 where the number of species ***N***= 43. The lowest number of species (***N***= 43) in this category was observed during post-monsoon season and the value of ***R*** was 4.29.

Comparing the various Margalef richness indices calculated for the three different types of gears (Fig.4.7), it was found that the maximum value was recorded for the SMRS-I (***R***=5.66) and lowest in LMRS (***R***=2.69). In all the three types of ring seines the maximum number of species occurrence and the highest richness value was observed during the pre-monsoon period and the minimum number of species occurrence and the richness indices was found minimum during the monsoon season.

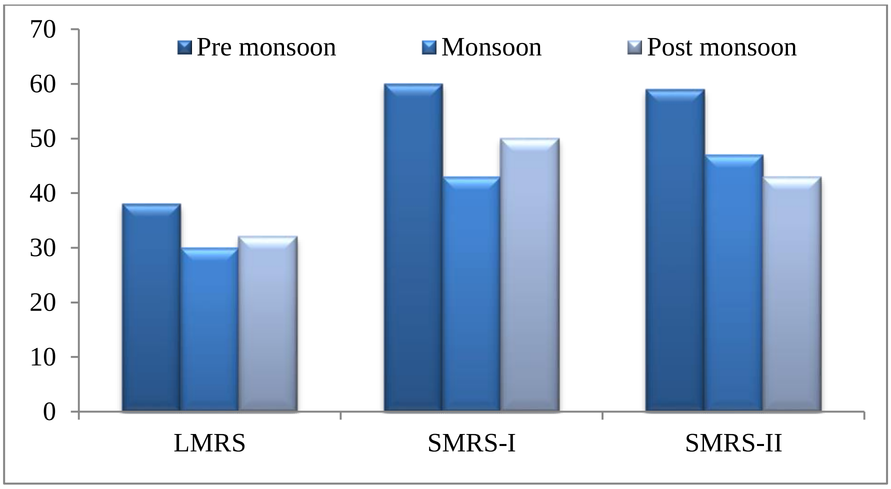


Fig 4.7 Richness indices for the three types of ring seines during the different seasons

4.3.2.2 Diversity index

If the value of the Shannon index (***H***') is larger, then the species diversity will be greater. During the study in LMRS, the highest value was 1.65 observed during the post monsoon season followed by monsoon (1.23) and lowest (1.17) in the pre-monsoon period.

In SMRS-I, the highest value (2.39) was also observed during the post monsoon period, followed by 1.91 during the pre-monsoon period and lowest (1.32) during the monsoon period.

In SMRS-II, the highest diversity index was 2.20 during the post-monsoon period, followed by 1.99 in the pre-monsoon period and lowest (1.54) during the monsoon period. In the present study the Shannon-Weiner diversity clearly showed that higher number of species and their abundance was during the study period was in SMRS-I. ***H***' ranged from 1.17 to 2.39 during the present study. Comparing the various Shannon indices (Fig.4.8) calculated for the three different types of gears, it was found that the maximum value was recorded for the SMRS-I (***H***'= 2.39) and LMRS (***H***'= 1.17).

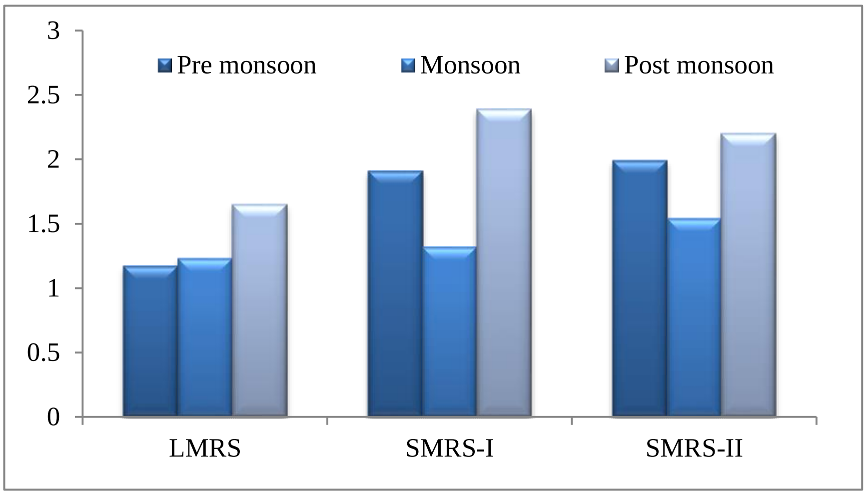


Fig 4.8 Diversity indices for the three types of ring seines during the different seasons

4.3.2.3 Evenness index

Evenness index (***E***) shows the biomass distribution of fish species and when all the species in a sample are equally abundant it shows its maximum value (Jin & Tang, 1996).If the species diversity is higher then, larger will be the species evenness. In LMRS, the highest value (0.47) was found during post-monsoon period like the other two types, followed by monsoon (0.36) and lowest during pre-monsoon period.

In SMRS-I, the highest value was observed during the post-monsoon period (0.61), followed by pre-monsoon period (0.46) and lowest (0.35) during the monsoon season.

In SMRS-II, ***E*** showed highest value during the post-monsoon period (0.58), followed by pre-monsoon period (0.48) and lowest (0.40) during the monsoon season. Thus the result shows that the evenness was high during the post-monsoon season in SMRS-I and lowest in LMRS during the pre-monsoon season (Fig.4.9). Evenness describes how equally individuals are distributed amongst the species.

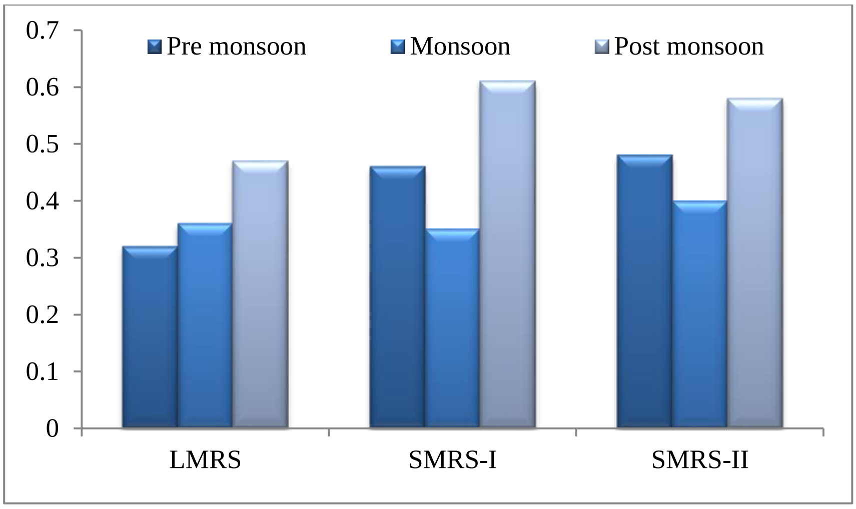


Fig.4.9 Evenness indices for the three types of ring seines during the different seasons

Table 4.3 Indices of species occurring in ring seines

2016	Richness index		Diversity index	Evenness index
	N	***R***	***H'***	***E***
Pre monsoon				
LMRS	38	3.61	1.17	0.32
SMRS-I	60	5.66	1.91	0.46
SMRS-II	59	5.52	1.99	0.48
Monsoon				
LMRS	30	2.69	1.23	0.36
SMRS-I	43	3.66	1.32	0.35
SMRS-II	47	3.95	1.54	0.40
Post monsoon				
LMRS	32	2.93	1.65	0.47
SMRS-I	50	5.02	2.39	0.61
SMRS-II	43	4.29	2.20	0.58

Plate.2 Different types of fishes caught from the ring seines

In the present study a total of 86 species were recorded from the three types of ring seines in all the seasons. All the species caught in ring seines were finfishes, shell fishes, cephalopods, stomatopods and cnidarians and none of the species were reported as threatened in the IUCN list (Table 4.2). The highest number of species were represented in the Order Perciformes (32 species), which constituted 37% of the total population. Other dominant orders having more number of species are Clupeiformes (19 species) and Decapoda (10 species). The maximum number of species occurred in small meshed ring seine type II (60 numbers) which was recorded during the pre-monsoon season. The minimum number of species was noticed in large mesh ring seines (30 numbers) which was recorded during the monsoon season. The highest number of species was caught in the small mesh ring seines type II during the pre-monsoon season.

The richness indices of all the three categories viz; the LMRS, SMRS-I and SMRS-II was highest during the pre-monsoon period and lowest during the monsoon period. During this season the small ring seiners mainly targets anchovies and catches mixed quantity and this season is considered as lean season. Any shoal is surrounded and caught for economic reason and this may be the reason for the diversity of fishes more during the pre-monsoon season. The operation of small meshed ring seines is very near to the coast (23-45m SMRS-I and 10-20m depth for SMRS-II) and this may be another reason for incidence of large number of species. During the pre-monsoon season most of the large mesh ring seiners do not operate, since it is not profitable. During the pre-monsoon season the vessels and gears are usually taken for repair and the fishers opine that they get only less fishes in large meshed gears and the ambassis entanglement is more and it takes several days to take away those entangled fishes (Raphael et al, 2017) and this may be the reason for the lowest number of species observed in the study. Edwin &Hridayanathan (2003) has also earlier reported that the glossy perchlet or *Ambassis sp.* of size below 60 mm got entangled in the large mesh ring seine causing much difficulty to the fishers.

The diversity indices (**H'**) and the Evenness indices (**E**) were highest during the post monsoon for all the three types of ring seines viz; LMRS,SMRS-I and SMRS-II. The evenness shows its maximum value when the species in a sample are equally abundant. If the species diversity is higher than the larger will be the species evenness. So the species were distributed equally during the post monsoon season. During the pre-monsoon period they catch mostly juveniles and mixed group of fishes but more catch is observed during the monsoon and post-monsoon period. During monsoon season the fishers usually targets species like sardine and mackerel which are plenty during these months. During 2015, in Kerala the most productive season was August-September (44%) (Anon, 2016e).Similar trend has been reported during 1986-1994 ring seine landings in which maximum landings were reported during the monsoon and post-monsoon season (Edwin & Hridayanathan, 2003).

Ring seines are fishing gears intended to catch pelagic fish only (Panicker et al., 1985) i.e., fish living in the upper water layers, mostly far from shores and in high seas, often above great depths and they mainly includes most commercially important species from Clupeidae and Scombridae which rarely approaches the shallow waters near the coast. But this study reveals that both pelagic are demersal species are being caught in the ring seines. It is seen that 47% of species in ring seine is contributed by pelagic fishes and about 53% consisted of demersal species which clearly shows that there is a change in the species composition of ring seine landings.

4.4 Conclusion

Marine biodiversity in its simplest form can be described as "life in the seas and ocean". All the species plays crucial role and is important in the ecosystem and the loss of these species have significant influence in the whole ecosystem. The study was an attempt to identify some aspects of biodiversity of fish fauna along the study area which has been caught in ring seine fishery. Earlier ring seines were mostly targeting oil sardines and mackerels. But now it is clearly seen that both pelagic and demersal fishes are occurring in ring seines and a change is seen in the species occurrence in the ring seine fishery. During the study 86 species were identified from ring seines (targeted to catch pelagic fish) in which 47% was pelagic species and 53% was demersal species. SMRS-I had highest number of species (72 species), followed by SMRS-II (67 species) and LMRS (50 species). Richness index (R) showed highest value in SMRS-I (5.66) during the pre-monsoon period and lowest in LMRS (2.69) during monsoon season. Diversity index (H) showed highest value in SMRS-I (2.39) during the post-monsoon season and lowest value in LMRS (1.17) during the pre-monsoon season. Evenness index (E) showed highest value in SMRS-I (0.61) during post-monsoon season and lowest value in LMRS (0.32) during the pre-monsoon season. None of the species were reported threatened or endangered but the highest value of biodiversity indices indicates presence of non targeted species in the catch.

CHAPTER 5
SHORT TERM FORECAST BASED ON DOMINANCE OF SPECIES IN RING SEINES

SHORT TERM FORECAST BASED ON DOMINANCE OF SPECIES IN RING SEINES

5.1 Introduction

Among the artisanal gear operated from Kerala coast, ring seines are the single largest contributors towards pelagic fish landings. Intensive motorization of the traditional fishing vessels which began in earnest from 1982 onwards in the Kerala state, paved way for the introduction of innovative and efficient fishing technique 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, 2017a). 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 horsepower of the engine and this has led to an increase in fishing effort (Edwin & Das, 2015). It has 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 species composition of the landings from this gear since the time of its introduction. Widespread adoption of this technology has resulted in substantial increase in the landings of small pelagic like oil sardine, mackerel and anchovies by the traditional sector (Edwin & Das, 2015).

Markov chains are sequence of random variables in which the future variable is determined by the present variable, but is independent of the way in which the present state arose from its predecessors (Kuriakose & Mini, 2006). Model formulation is an important tool for fishery stock assessment (Srinath, 2006). Saila & Erzini (1987) have reviewed on the models and methods for studying the fish assemblage and have done special reference to Markov model.

In fisheries, Markov chain analysis has been used to analyse population growth models (Renshaw, 1986), for the analysis of 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 chapter is to assess the pattern of dominance of species in the study area and to predict the dominance of major species for short term in ring seine fisheries of study area using Markov chain analysis.

5.2 Materials & 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 2003 to 2011. During this period only two types of ring seines viz; SMRS-I and LMRS 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 Markov chain model. The quantity landed was estimated for four groups such as oil sardine, mackerel, anchovies and prawns and other miscellaneous fishes. Hence the catch composition of all categories of ring seines were added together and study is done as total catch of ring seines from the study area.

5.2.1 Markov chain modelling

This modeling technique was employed to analyze the structural change in any system whose progress through time can be measured in terms of single outcome variable (Dent, 1967). In the present study, the dynamic nature of fish catch patterns viz; the gains and losses in ring seine fishing in four groups caught was 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 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 catch from ring seine in the year t

F_{it-1} = Quantity of i^{th} fish species catch 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.

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

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

$$\text{Min, } OP^* + Ie$$

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 vectors of areas

e is the vector of absolute errors

Y is the proportion of fish caught to 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 quantity of marine fish species caught in from ring seine fishingwas made by using the Transitional Probability Matrix.

$$B_t = B_0 * T$$

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

Where,

B_0 = Quantity caught in Base years

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

T = Transitional probability matrix

5.3 Results & Discussions

5.3.1 Species composition of ring seine landings and its changing pattern

5.3.1.1 Species composition during 2002-2011 in the study area

The ring seine landings from the Chellanam area for the period 2002-2011 showed that oil sardine contributed highest landings throughout the ten years. Oil sardine contributed 81.4% during 2002 and showed a decline to 55.9% during 2004 and showed an increase of 82% during 2008 and slightly decreased and reached 78.1% during 2011 (Fig.5.1). Mackerel contributed 4.1% during 2002 which increased to 29.3% during 2004 and declined to 14% during 2011 (Fig.5.2). 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.5.3). 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.5.4). Thus during the period of 10 years oil sardines were the dominating species in the study area.

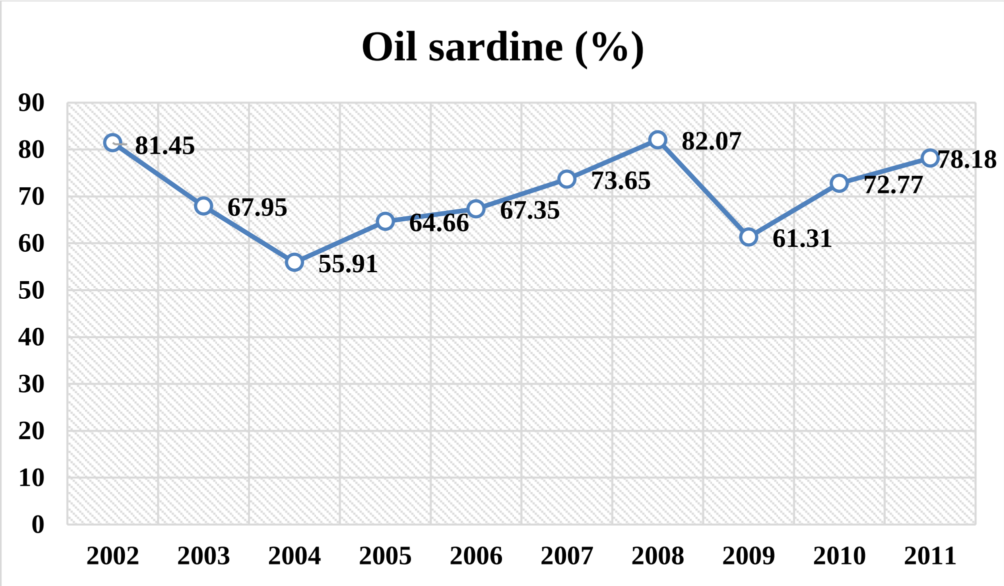


Fig. 5.1 Percentage contribution of oil sardine during 2002-2011 from the study area

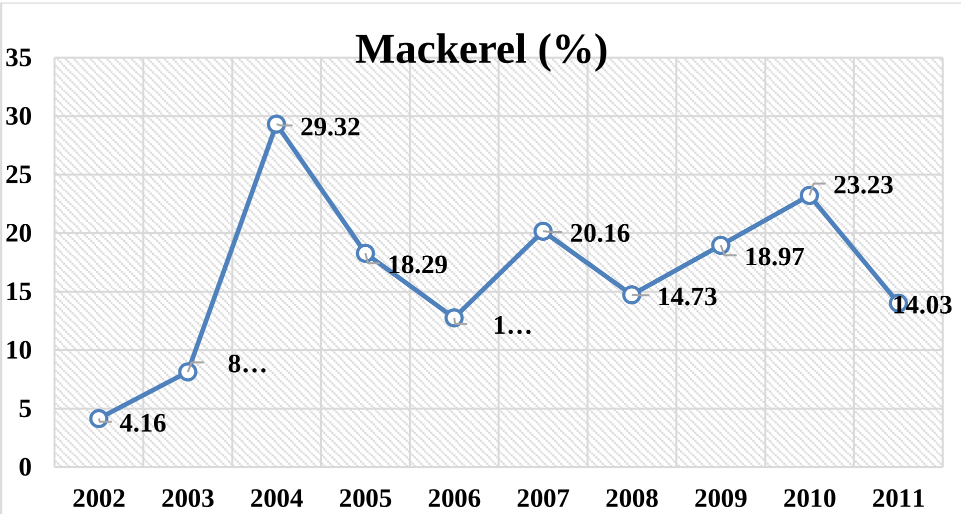


Fig.5.2 Percentage contribution of mackerel during 2002-2011 from the study area

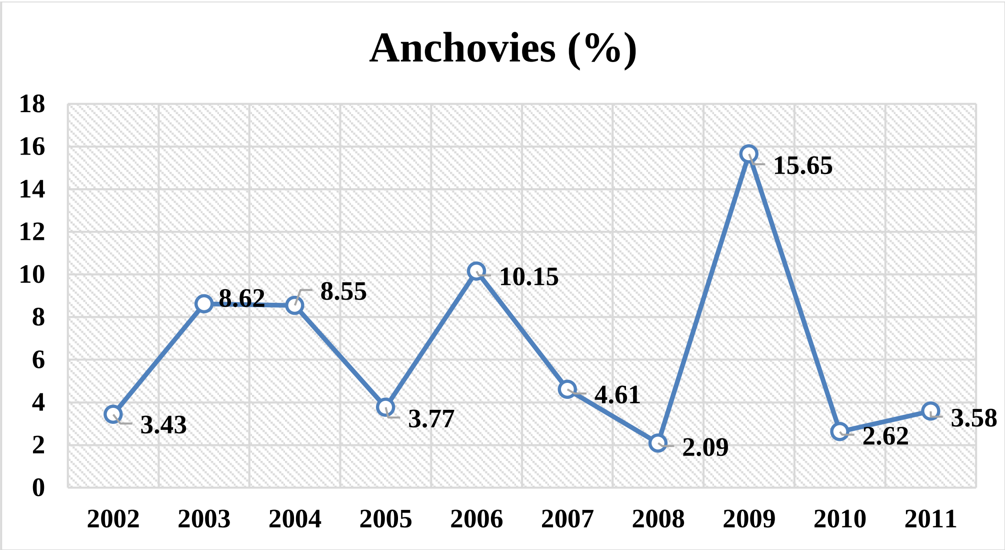


Fig. 5.3 Percentage contribution of anchovy during 2002-2011 from the study area

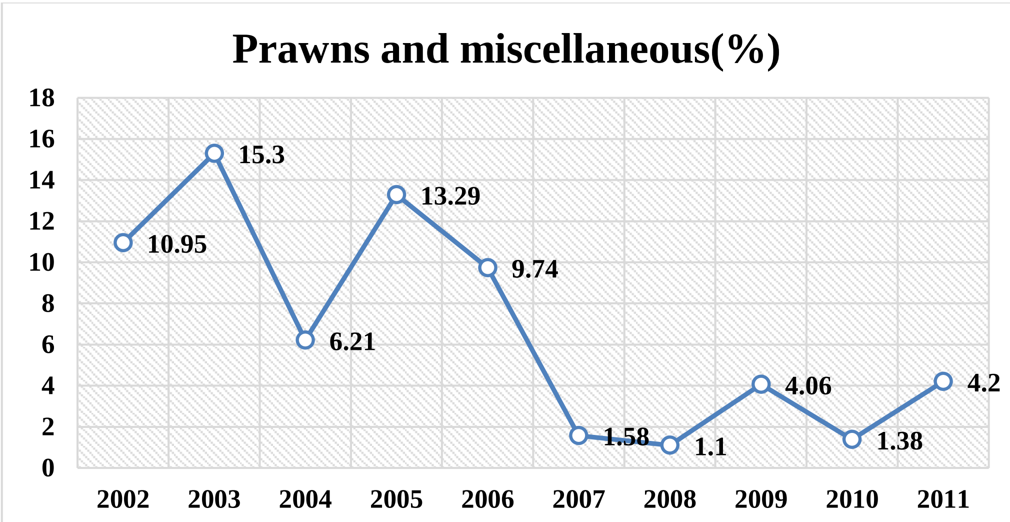


Fig.5.4 Percentage contribution of prawns & miscellaneous during 2002-2011 from the study area

5.3.1.2 Species composition in ring seines of Kerala during 2002-2011

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% during 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% during 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.

Table 5.1 Dominant catch composition in the ring seines of Kerala (2002-2011) (Source: Anon, 2016c)

Year	Oil sardine (%)	Mackerel (%)	Anchovies (%)	Prawns and miscellaneous (%)
2002	81.8	5.2	2.3	10.7
2003	79.2	8.2	3.0	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	68.0	16.5	4.0	11.5
2008	62.2	9.0	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

5.3.1.3 Species composition in ring seines of Chellanam during the study period (2016)

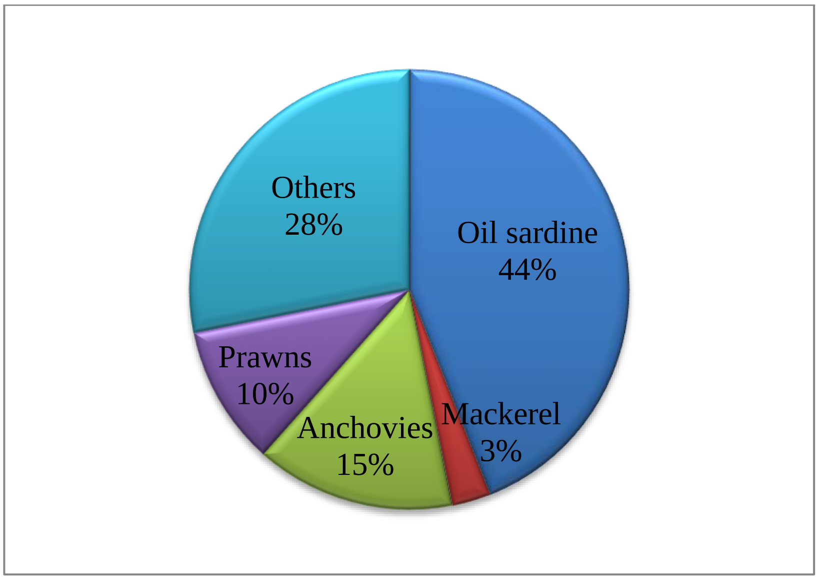


Fig.5.5. Species composition in ring seines during 2016

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 flowertail 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).*

5.3.2. Markov Chain analysis

The direction of species catch has been explored by Markov chain analysis using 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 worked out by using the annual marine fish species catch which provides a broad indicating of directional change in the quantity of species catch namely, sardine, mackerel, anchovy, prawns and miscellaneous has been presented in Table 5.2.

Table 5.2 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	**0.5910**

In the overall quantity of fish species caught in the ring seine fishing method in thestudy area, sardine catch is more dominating in the ring seines. In the Table 5.2 were worked out transitional probability matrix for different quantity of fish species caught in the ring seines. As per the quantity of fish species catch is concern, sardine (0.7743) has more probability of retention level in terms of 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 extend loss share percent in the mackerel and anchovy is about 87% and 51%. On the contrary, all other are 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 study using Markovs chain for pelagic fish stocks in Phillippines and observed that the family Clupeidae will probably be the dominant family among the 6 families being exploited. Srinath (1996) has studied the changing pattern of pelagic species in 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 has found to be in 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 south west coast of India using a four state Markovs chain model and the projection indicates that there will be decline in the landings in 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 is having the maximum probability of occurring along the Karnataka coast when considering all the gears been operated and this is due to the mass harvesting of ring seines and purse seines.

5.4 Conclusion

In India only few works has been carried out using Markovs 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 pattern is necessary for the proper assessment of the exploited stocks (Srinath, 1996).In Kerala, the pelagic fisheries play animportant 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 was 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. 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.

CHAPTER 6
BYCATCH OCCURRENCE IN RING SEINES

BYCATCH OCCURRENCE IN RING SEINES

6.1 Introduction

Bycatch and discards are one of the major problems faced in the fishing industry globally. Bycatch is defined as that portion of catch other than targeted species caught while fishing which are either retained or discarded. Discarding is the practice of returning an unwanted portion of the catch back to the sea during fishing operations (Alverson et al., 1994). Fish are discarded for various reasons at sea, representing a waste of fishery resources and potential food (Clucas, 1997). Bycatch is recognized as unavoidable in fisheries but the quantity varies according to the gear operated (Riedel & DeAlteris, 1995; Clucas, 1998; Pillai, 1998; Ortiz et al., 2000; Hall et al., 2000; Gibin, 2008). Bycatch and discards pose a threat to biodiversity and long term sustainability of fishery resources. About 30% of the world's marine fishery resources is over exploited, 60% fully exploited and only 10% moderately exploited (Anon, 2014). Overexploitation of bycatch and target species in marine capture fisheries is the most widespread and driver of change and loss of global marine biodiversity (Gilman, 2011).

In tropical countries like India bycatch issue is more complex due to the multi species nature of fisheries and bycatch is brought back to the landing centres because of its economic utilities. The first report of bycatch in India was by CMFRI in 1979, which showed that shrimp trawling brought larger quantities of bycatch. According to George et al. (1981) bycatch in Indian shrimp trawl fisheries constituted about 79.18% of total shrimp trawl landings.

Gorden (1990) reported that bycatch landings in east coast of India was 90,000 to 130,000 tonnes per annum. Kurup et al. (2003) has done the characterization and quantification of bycatch in the Kerala coast which estimated that 262000 tonnes of fishes were discarded during 2000- 2001 and 225000 tonnes of fishes was discarded during 2001-2002. Kelleher (2004) has estimated total bycatch discards in Indian fisheries at 58,000 tonnes, which formed about 2% of the total landings. In Indian scenario, it is estimated that about 56.3% of the total catch of shrimp trawlers is bycatch (Pramod, 2010). In India bycatch is considered as a major threat and has been reported by several authors (Boopendranath, 2003; Sivasubramanyam, 1990; Gorden, 1991; Menon, 1996; Rao, 1998; Madhu et al., 2017). A large number of bycatch reduction devices are designed for the Indian waters.

"Fishing down marine food webs" is the phenomenon in which the fishing has impact on ecosystem in which the destruction of large, long lived fishes are replaced by small short lived fishes (Pauly & Christensen, 1995). Marine fish species have actually been in decline since 1988 and the current level of declining capture fisheries production has been reached only by fishing harder and by targeting smaller and less-valuable species, as the large fish species have disappeared and fishers continue to "fish down the food chain" (The World Bank, 2004). The existence of the 'fishing down' was first been documented globally with FAO landings data from 1950-1994 (Pauly & Christensen, 1995; Christensen, 1998).Thus the Convention of Biological Diversity's (CBD) developed Mean Trophic Index (MTI) to measure overall ecosystem health and stability, and also serve as an alternate measure for overfishing. This phenomenon can be avoided through effort reduction which will reduce pressure on the target stocks with a consequent reduction of effort on non-target species and discards (Pillai, 2011).

Ring seines are usually defined as mobile gears intended to catch pelagic fishes are showing a changing pattern in its species diversity as described in Chapter 4. Ninety percent of the ring seine catch comprises of targeted species like sardine, mackerel, anchovies and tunas along with 10% of non targeted species like Thryssa *spp*, lesser sardine, carangids and seer fish in Andra Pradesh region (Rajeswari et al., 2013). Bycatch studies in ring seines are scarce and in the present study an attempt has been made to understand the bycatch occurrence in ring seines. The main objective of this chapter is to identify the bycatch in different categories of ring seines during three seasons and to understand the mean trophic index in different categories during different seasons.

6.2 Materials & Methods

The catch was categorized as targeted and non- targeted species and in the present study the non-targeted species was considered as bycatch. The species were classified as pelagic and demersal. The months were grouped into three seasons such as pre monsoon, monsoon and post monsoon. Each fish species in the ring seine bycatch was identified upto species level, following Fischer & Bianchi (1984), Smith & Heemstra (1986) and FishBase (Freose & Pauly, 2007). The trophic level of individual fish in the bycatch was gathered from FishBase (Freose & Pauly, 2007). The study was conducted from February 2015 to January 2016.

Bycatch species of cnidarians and cephalopods were excluded due to unavalaible data on trophic index and finfish alone was used for the study. Trophic levels are often used to understand how an organism fits into the food web. One of the main characteristic of an ecosystem is the flow of energy through various trophic levels of food webs. Food webs can be defined in terms of trophic levels. The trophic levels for marine organisms range between 2 (for herbivores/detritivores) and 5 (for predators of marine mammals), which explains the relative position of an animal in the food web that nourishes them (Pauly et al., 2002).

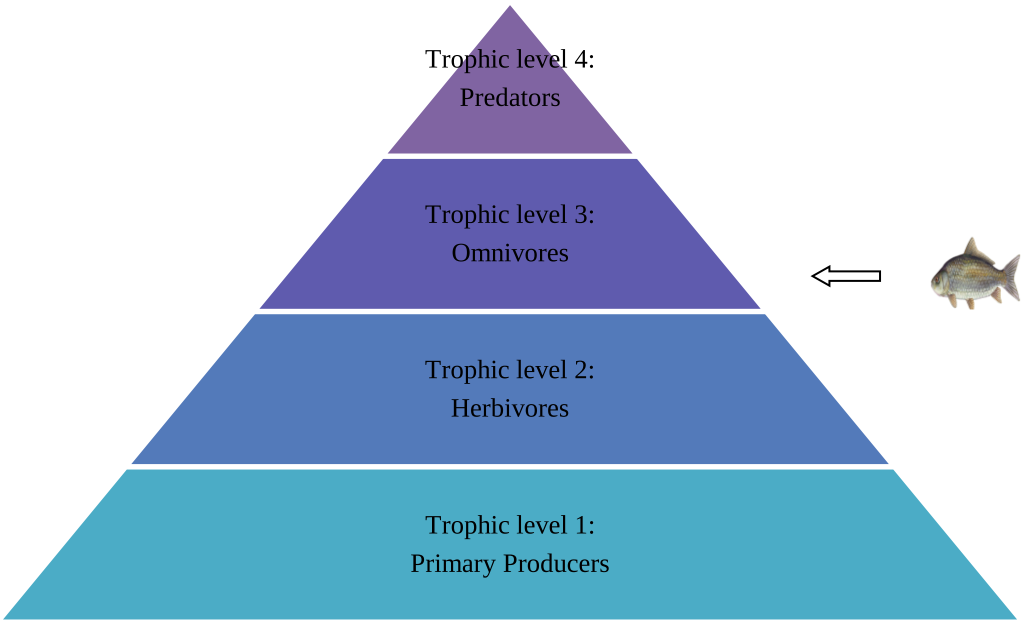


Fig. 6.1 Trophic levels in fisheries

Mean Trophic index

The values for the individual species was obtained from fish base and the Mean Trophic index (MTI) of bycatch was calculated by multiplying the bycatch of each species with their corresponding trophic level and then by taking the weighed mean (Pauly et al., 1998). The following formula was used:

$$MTI= \frac{\sum ijTLjYij}{\sum Yij}$$

Where, TLj = Trophic level of individual species j

Yij = Biomass of that species

∑ ij = Summation of all values of TLj x Yij

∑Yij = Total landings of all species

6.3 Results & Discussion

6.3.1 Bycatch occurrence in different categories of ring seines

The bycatch occurrence was calculated from the three different categories of ring seines. In LMRS the targeted catch was 112379kg and bycatch constituted 8677kg during the study period. In SMRS-I, the targeted catch was146520kg and bycatch accounted 50222kg. In SMRS-II the targeted catch was 167311kg and bycatch was 59812kg.The targeted groups were sardine, mackerel, anchovies and prawns and the non targeted groups were mullets, ambassids, half beaks, pomfrets, sciaenids, carangids, catfishes, silver bellies and miscellaneous (mixed group) of fishes. In the present study 57 species of fishes were identified from the bycatch constituent which belonged to 27 family and 37number of genera.

The major pelagic resources constituted in bycatch were *Escualosa thoracata*, *Nematalosa nasus*, *Opisthopterus tardoore*, *Anadontostoma chacunda*, *Thryssa dussumieri*, *Thryssa hamiltonii*, *Thryssa mystax*, *Thryssa vitrirostris*, *Thryssa purava*, *Megalaspis cordyla*, *Caranx hippos*, *Caranx ignobilis*, *Alepes djedaba*, *Alepes klenii*, *Parastromateus niger*, *Scomberoides commersonianus*, *Sphyraena obstusata*, *Polynemus plebeius*, *Lepturacanthus savala*, *Scomberomorus guttatus*, *Valamugil cunnesius*, *Valamugil seheli*, *Mugil cephalus*, *Exocoetus volitans*, *Hyporhamphus limbatus*.

The major demersal resourcesconstituited in bycatch were *Gerres poieti*, *Gerres filamentosus*, *Pampus argenteus*, *Pampus chinensis*, *Lactarius lactarius*, *Scatophagus argus*, *Secutor ruconius*, *Secutor insidiator*, *Leiognathus splendens*, *Leiognathus brevirostris*, *Siganus canaliculatus*, *Trypouchen vagina*, *Acanthurus pyroferus*, *Sillago sihama*, *Epinephelus ongus*, *Epinephelus diacanthus*, *Johnius belangerii*, *Johnius glaucus*, *Kathala axillaris*, *Ambassis gymnocephalus*, *Cynoglossus macrostomus*, *Cynoglossus bilineatus*, *Cynoglossus arel*, *Arius caelatus*, *Arius arius*, *Arius dussumsieri*, *Arius maculates*, *Lagocephalus inermis*, *Ostracion cubicus*, *Pisodonophis concrivorus*.

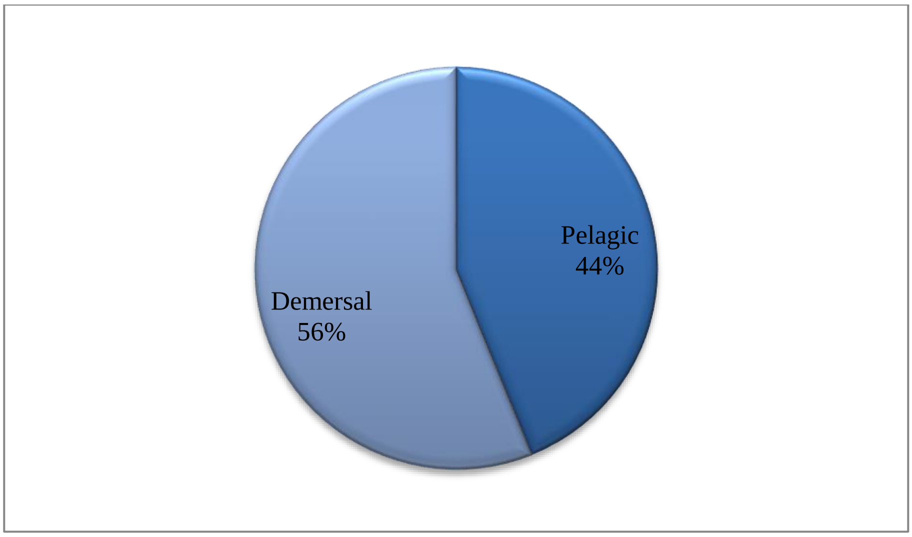


Fig 6.2 Percentage of demersal and pelagic groups in bycatches of ring seines

In LMRS, bycatch constitued 7.7% of the total catch. There were 29 species belonging to 22 genera, 16 families and 5 orders. The major families constituting the bycatch in LMRS were Clupeidae, Engraulidae, Carangidae, Stromateidae, Sphyraenidae, Leiognathidae, Trichiuridae, Gobiidae, Acanthuridae, Sillaginidae, Serranidae, Sciaenidae, Scombridae, Exocoetidae, Hemiramphidae and Tetraodontidae. In SMRS-I, bycatch constituted 34.2 % of the total catch. There were 45species belonging to 26 genera, 19 families and 6 orders. The major families constituting the bycatch were Clupeidae, Engraulidae, Carangidae, Gerreidae, Stromateidae, Lactariidae, Sphyraenidae, Leiognathidae, Trichiuridae, Gobiidae, Sillaginidae, Sciaenidae, Ambassidae, Cynoglossidae, Ariidae, Mugilidae, Hemiramphidae , Tetraodontidae and

Ostraciidae. In SMRS-II, bycatch constituted 35.7 % of the total catch. There were 44 species belonging to 28 genera, 18 families and 7 orders. The major families constituting the bycatch were Clupeidae, Engraulidae, Carangidae, Stromateidae, Polynemidae, Sphyraenidae, Leiognathidae, Siganidae, Gobiidae, Sillaginidae, Sciaenidae, Serranidae, Ambassidae, Cynoglossidae, Ariidae, Mugilidae, Exocoetidae and Hemiramphidae.

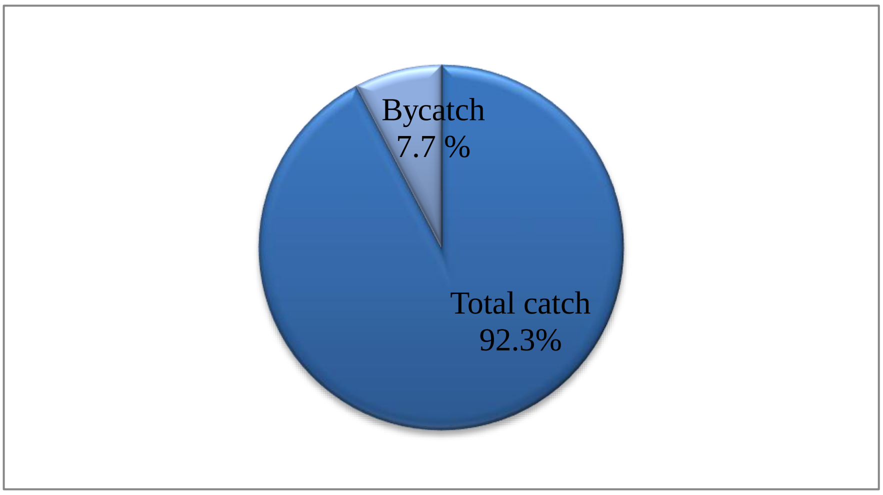


Fig.6.3 Percentage of bycatch in LMRS

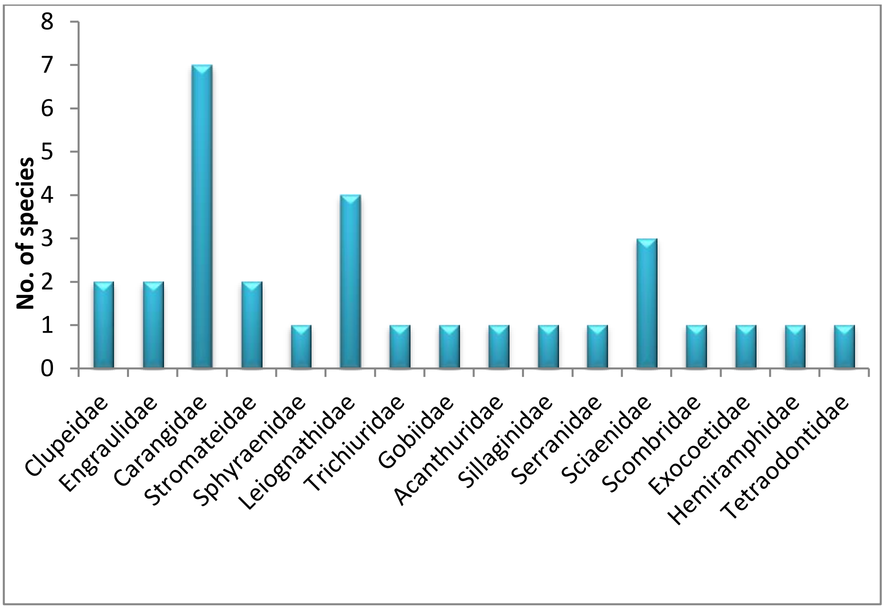


Fig.6.4 Number of species in each familyin LMRS

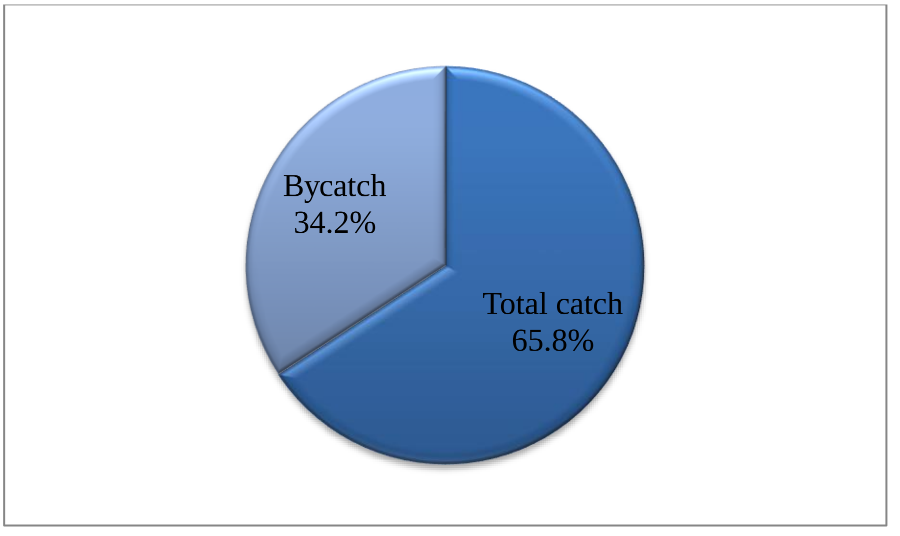


Fig.6.5 Percentage of bycatch in SMRS-I

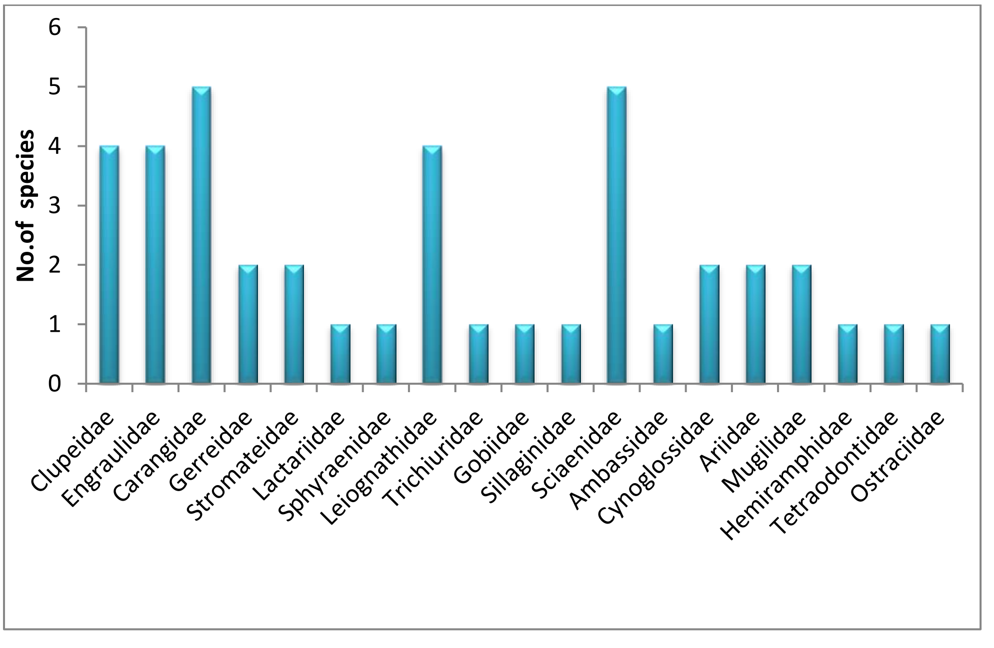


Fig.6.6 Number of species in each family in SMRS-I

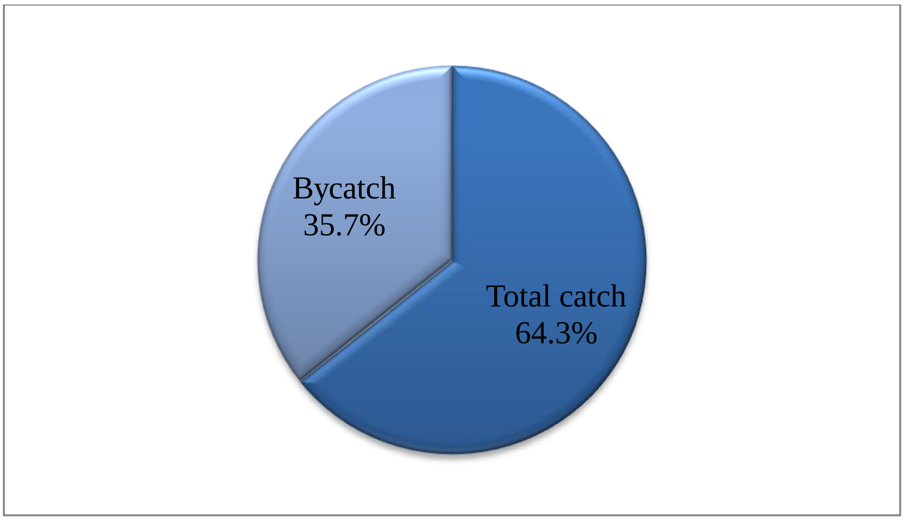


Fig.6.7 Percentage of bycatch in SMRS-II

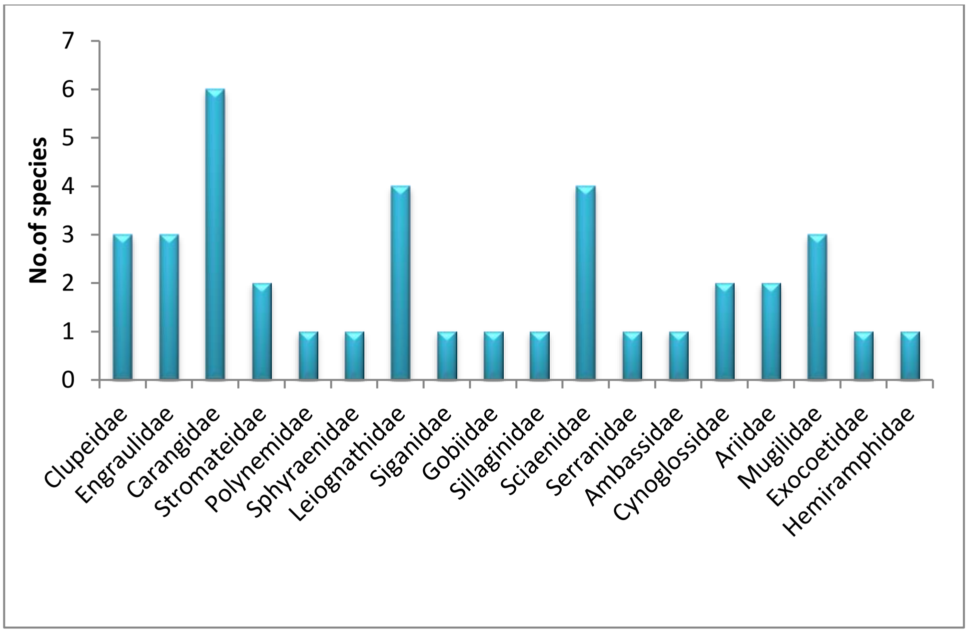


Fig.6.8 Number of species in each familyin SMRS-II

6.3.2 Mean trophic index in different categories of ring seines

Mean trophic index of the different species occurring in the three different categories of ring seines were calculated during the three different seasons. The list of species occurring in all categories of ring seines, mean length, mean weight, maximum size at growth, trophic index and the depth range in shown in the Table 6.1.

Table 6.1 List of species in ring seine bycatch in all categories from Chellanam

Species	**Mean length with SD (cm)**	**Mean weight with SD(gm)**	**Maximum size of growth**	**Trophic index**	**Depth range (m)**
Family: Clupeidae					
Escualosa thoracata	9.5±1.23	11.4±2.20	11.9	3.2	0-50
Nematalosa nasus	11.2	14.07	25.2	2.2	0-30
Opisthopterus tardoore	7.4±1.69	2.9±1.99	20	3.4	0-50
Anodontostoma chacunda	8±1.40	6.4±1.56	22	2.8	50
Family: Engraulidae					
Thryssa dussumieri	9.7±0.20	7.6±0.32	11	2.8	0-50
Thryssa hamiltonii	9.9±1.01	7.1±2.46	27	3.5	10-13
Thryssa mystax	12.4±3.2	10.2±6.25	15.5	3.6	0-50

Thryssa vitrirostris	10.1±2.74	8.6±8.83	20	3.3	0-50
Thryssa purava	10.1±1.67	7.7±4.52	15.5	3.5	0-50
Family: Carangidae					
Megalaspis cordyla	11±0.95	14.9±3.2	80	3.0	20-100
Caranx hippos	7.6±1.68	6.8±4.63	124	3.6	1-350
Caranx ignobilis	9±2.1	10.1±7.9	170	4.2	100
Alepes djedaba	10.40±2.2	11.86±5.6	40	3.3	-
Alepes klenii	10.53±1.23	11.64±6.3	16	3.5	-
Scomberoides commersonianus	10.6	7.05	120	4.4	0-50
Parastromateus niger	5.2±1.3	2.5±2.7	75	2.9	15-105
Family: Gerreidae					
Gerrespoieti	9.3	15.55	44.5	3.5	-
Gerresfilamentosus	8.4	14.60	35	3.3	1-50
Family: Stromateidae					
Pampus argenteus	4.5±1.2	1.82±0.80	60	3.3	5-110
Pampus chinensis	4.2±1.3	1.35±0.74	40	3.6	10
Family: Lactariidae					
Lactarius lactarius	9.5	12.2	40	4.2	15-100

Family: Sphyraenidae					
Sphyraena obstusata	11.5±1.2	9.55±2.5	55	4.5	5-100
Family: Scatophagidae					
Scatophagus argus	14.1±1	30.2±4.2	38	3.0	0-5
Family: Leiognathidae					
Secutor ruconius	5.9±0.96	3.1±1.24	8	2.7	3-60
Secutor insidiator	5.3±1.69	2.3±1.98	11.3	2.8	10-150
Leiognathus splendens	3±0.56	3.17±0.19	17	2.9	10-100
Leiognathus brevirostris	3.3±0.52	3.24±0.21	13.5	3.0	1-40
Family: Polynemidae					
Polynemus plebeius	7	3.27	45	3.6	>122
Family: Trichiuridae					
Lepturacanthus savala	45±0.20	27.12±1.25	100	4.3	0-100
Family: Siganidae					
Siganus canaliculatus	4.15±0.34	0.95±0.20	30	2.8	1-50
Family: Gobiidae					
Trypouchen vagina	13±0.50	11.18±1.34	22	3.5	-
Family: Acanthuridae					
Acanthurus pyroferus	4.5	2.1	29	2.0	5-40

Family: Sillaginidae					
Sillago sihama	10.5±1.20	8.25±0.86	31	3.3	0-60
Family: Serranidae					
Epinephelus ongus	4	4.81	40	4.0	20-60
Epinephelus diacanthus	4.2±1.2	4.96±1.5	55	3.8	10-120
Family: Scianidae					
Johnius belangerii	9.06±2.64	9.41±11.73	30	3.3	40
Johnius glaucus	9±2.20	9.21±10.52	30	3.5	1-30
Kathala axillaris	8.6±2.4	8.34±8.56	27	3.5	-
Otolithes ruber	9.5±3.07	11.03±13.9	90	3.6	10-40
Otolithes cuvieri	9.4±2.9	11±11.25	39	3.9	-
Family: Ambassidae					
Ambassis gymnocephalus	7.1±0.6	3.4±0.97	16	3.9	-
Family: Cynoglossidae					
Cynoglossus macrostomus	7.2±2.28	3.15±3.15	17.3	3.3	-
Cynoglossus bilineatus	7.6	3.25	44	3.5	40-100
Cynoglossus arel	6.5±1.9	2.90±2.98	40	3.3	9-125
Family: Ariidae					

Arius caelatus	5.5	1.25	45	4.0	-
Arius arius	4.2±0.2	0.95±0.9	40	3.5	-
Arius dussumieri	6.5	1.65	62	4.0	20-50
Arius maculates	19.6	90.6	80	3.4	5-100
Family: Scombridae					
Scomberomorus guttatus	14	19.34	76	4.3	50-200
Family: Mugilidae					
Valamugil cunnesius	13.5±1.24	27.65±3.25	41	2.3	0-3
Valamugil seheli	12±0.29	25.58±1.89	60	2.4	0-3
Mugil cephalus	14.20±1.54	29.65±2.32	100	2.5	0-10
Family: Exocoetidae					
Exocoetus volitans	13.4±0.54	19.4±4.25	30	3.0	0-20
Family: Hemiramphidae					
Hyporhamphus limbatus	15.18±3.04	11.68±6.94	35	3.1	-
Family: Tetraodontidae					
Lagocephalus inermis	9.5±0.56	17.24±1.58	90	3.9	20-100
Family: Ostraciidae					
Ostracion cubicus	1.79	1.38	45	3.4	1-280
Family: Ophichthidae					

Pisodonophis concrivorus	35	30	108	3.8	1-20

In food web the large long lived fishes which are at the top level, when being exploited heavily declines faster than the smaller and short lived species which occupies the lower end of trophic levels. This phenomenon known as "fishing down marine food webs" (Christensen, 1996; Pauly et al., 1998) is been happening in different parts of the world. In India this phenomenon has been studied by several authors (Vivekanandan et al., 2005; Bhathal and Pauly, 2003; Bijukumar & Deepthi, 2009). Presence of species with higher trophic level in the bycatch could have far reaching consequences for sustaining the fisheries (Bijukumar & Deepthi, 2009).

Table 6.2 Number of species in each trophic levels

Trophic levels	Number of species		
	LMRS	SMRS-I	SMRS-II
2.0-2.49	1	3	2
2.5-2.99	4	7	8
3.0-3.49	11	14	14
3.5-3.99	8	16	17
4.0-4.5	5	5	3

During the present study a total of 57 numbers of species were identified in all categories of ring seines of which 29, 45 and 44 number of bycatch fishes are from LMRS, SMRS-I and SMRS-II respectively. In LMRS only one species constituted in the trophic level 2.0-2.49. About 13 % (4 species) was observed in trophic level 2.5-2.99. In the next trophic level 3.0-3.49 about 37% (11species)was observed. In trophic level 3.5-3.99 around 27% (8 species) was observed. And 17% (5species) was observed in 4.0-4.5 trophic level.

In SMRS-I, about 6.7% of the fishes (3 species) constituted in the trophic level 2.0-2.49. About 16% was observed in trophic level 2.5-2.99. In the next trophic level 3.0-3.49 about 31% (14species) was observed. In trophic level 3.5-3.99 about 35% (16 species) was observed. Around 11% (5species) was observed in 4.0-4.5 trophic level.

In SMRS-II, two species constituted in the trophic level 2.0-2.49. About 18% (8 species) was observed in trophic level 2.5-2.99. In the next trophic level 3.0-3.49 around 31% (14species) was observed. In trophic level 3.5-3.99 about 38% (17species) was observed. About 6% (3species) was observed in 4.0-4.5 trophic level. So in LMRS, SMRS-I and SMRS-II the dominance of species was seen highest in the mid level carnivores (trophic level 3.0-3.99).

Table 6.3 Mean trophic indices of different seasons

Types of ring Seines	Pre monsoon	Monsoon	Post monsoon
LMRS	3.4	3.4	3.3
SMRS-I	3.3	3.4	3.4
SMRS-II	3.3	3.2	3.2

During the present study in LMRS twenty nine species were identified during the pre-monsoon period and the MTI observed during this season was 3.4. During monsoon period twenty four species were identified and the MTI observed was 3.4.Twenty five species were identified during the post-monsoon period and the MTI observed was 3.3. In SMRS-I forty one species were identified during the pre-monsoon period and the MTI observed during the pre-monsoon season was 3.3. Thirty one species were identified during the monsoon period and the MTI observed during the monsoon season was 3.4. Thirty seven species were identified during the post-monsoon period and the MTI observed during the monsoon season was 3.4. In SMRS-II forty four species were identified during the pre-monsoon period and the MTI observed during the pre-monsoon season was 3.3. During the monsoon period thirty nine species were identified and the MTI observed during the monsoon season was 3.2. Thirty four species were identified during the post-monsoon period and the MTI value observed was 3.2. This indicates that low level fishes are present in the ring seine bycatch in LMRS, SMRS-I and SMRS-II in all the three seasons.

"Fishing down of food web" was not seen from the present study since it is not a long term study. But it is seen that there are both pelagic and demersal species occurs as bycatch and the higher number of juvenile fishes in the bycatch is a major concern in the ring seine fishery.

Plate 3. Bycatches landed in the study area

6.4 Conclusion

On global basis the majority of the exploited fisheries are in declining phase due to fishing pressure due to overfishing, pollution and habitat degradation and possibly global warming which in turn is detrimental to the stock. The marine exploited fisheries in India is also facing similar crisis due to overcapitalization, overcapacity, over exploitation and the consequent reduced rate catch rates (Pillai, 2011). Fishing may affect species diversity by killing target and non target species of fish or invertebrates, by changing habitat structure and by altering the ecological relationships between species (Jennings & Reynolds, 2000).It is clearly understood that bycatch occurrence is very high in ring seine fishery. The fishes that were of smaller sizes indicates that juveniles were landed mostly in the bycatches which is a serious issue for the sustainability of fisheries. The mesh size of LMRS is 20mm and SMRS-I and SMRS-II is 10mm. Even though 10mm meshsize (*natholivala*) is meant for catching anchovies, many species of young ones are been caught by the fishers intentionally in ring seines. Thus the young ones are not allowed to grow and mature. So the 10mm mesh size i.e. SMRS-I and SMRS-II should be restricted solely for catching the anchovies only and further proliferation of these vessels operating small meshed ring seines should be checked. Better management measures should be adopted for the restriction of fleet size, mesh size and closed season and awareness should be created among the fishers regarding the sustainability of fisheries.

CHAPTER 7
JUVENILE INCIDENCE IN RING SEINE FISHERY

JUVENILE INCIDENCE IN RING SEINES

7.1 Introduction

In the coast of Kerala the improvements made in the fishing gear and techniques have lead to overfishing. Enormous changes in the species composition of the catch and the disappearance of formerly important species with an increase in small sized species or fishes that are not marketed are signs of overfishing (Vijayan et al., 2000). In India there are about 35 fish meal plants operating in the states of Karnataka, Kerala, Maharashtra, Gujarat and Tamil Nadu. The fishes which are usually preferred for preparing fish meal are oil sardine, stomatopods, silverbellies and other trash fishes (Aswathy & Narayanakumar, 2013). To meet the demand of fish meal plants, a considerable amount of juveniles of small pelagic have been captured intentionally along the Kerala coast (Mohamed et al., 2014). Overfishing is the single process that contributes significantly to the problems of fisheries management because it results in damage to stocks which may be sometimes irreparable (Pillai, 2011). Although there had been many changes in the techno-harvesting pattern of inshore fisheries in India which has led to increase in fish landings, the problem of bycatch and targeted juvenile fishing is ever increasing (Najmudeen & Sathiadas, 2008).

Juvenile fishing is the harvesting of young and newly hatched fish and sometimes accidental harvesting of eggs laid by fish (Sheriff et al., 2010). According to Hubbs (1943), juveniles are young fish mostly similar in the form of adult but not yet sexually mature. The juvenile stage lasts until the fish is fully grown, sexually mature and interacting with other adult fish. Juvenile incidence is a major problem and is reported in fishing gears such as trawls, gillnets, purse seines and ring seines. In countries where there is inadequate fishing regulation, the ratio of targeted and non targeted juvenile fishes to the overall catch is very large (Hall & Mainprize, 2005). Growth overfishing happens when the fishes are been harvested at a smaller size, but if they had an opportunity to grow to a larger size which would have produced maximum yield per recruit.

Ring seines are the important gears employed to catch pelagic fishes in Kerala coast, but recently the reduced mesh size and fishing near to the shore has led to an increase quantity of juvenile landings in ring seines. Several authors have reported juvenile incidence in ring seines. The juveniles of fishes caught in ring seine comprised of anchovies (40%), oil sardine (30%) and mackerel (15%) of the total catch along the Kerala coast (Najmudeen & Sathiadas, 2008). Juveniles are mainly caught in small meshed ring seines (*choodavala*) as the mesh size of the gear is small (8-10 mm) and Edwin et al (2010) has reported the incidence of juveniles in small mesh ring seines in the range of 20-30% and the large meshed ring seine (*thanguvala*) in the range of 5-15%. Pramod (2010) reported the excess juvenile catch in ring seine fishery due to small mesh ring seine operation and ring seines of Kerala catch 0 and 1 year class of sardine and mackerel in high quantity every year.

Hence the main aim of this chapter is to study the juvenile incidence in the three categories of ring seines by comparing with the MSM/MLS (Minimum size at maturity/Minimum legal size) recommended for each species. Fifteen frequently occurring species in the ring seines were selected for the study. The study also assesses economic loss due to juvenile incidence in different categories of ring seines.

7.2 Materials & Methods

This study was conducted from January- December 2016. Samples were taken weekly from commercial ring seines catch of three categories of ring seine. Morphometric and meristic characteristics taken from the samples were:

- ✓ Total length (cm)
- ✓ Fork length (cm)
- ✓ Weight, number,sex and maturity stages of commercially important species
- ✓ Total weight of the catch (kg)
- ✓ Total weight of juveniles (kg)

The minimum size at which advanced matured ovary was found is considered as Minimum Size at first Maturity (MSM). Minimum size at maturity of individual species found from the individual species studies. The minimum legal size (MLS) recommended by CMFRI was used for the comparison (Mohamed et al, 2014)

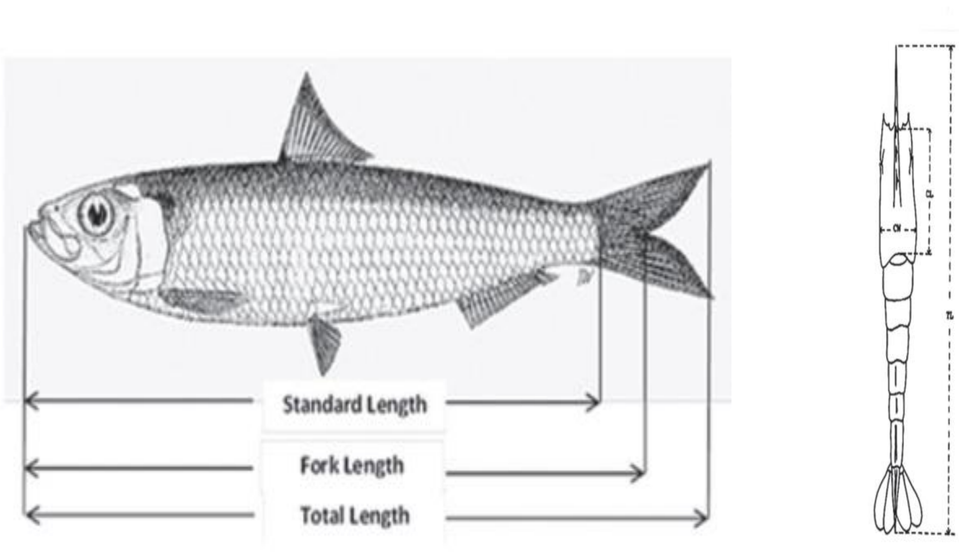


Fig 7.1 Length characteristics (Source: Mohamed et al., 2014)

7.2.1 Juvenile incidence analysis

To calculate the adult quantity that corresponds to 1 kg of juveniles were calculated using the formula of Najmudeen&Sathiadas (2008) as follows:

$$Q_A = \left(\frac{(1000/w)W}{1000}\right)(1 - M)$$

Where,

QA = The quantity of adult fish corresponding to 1kg of juvenile fish after a period of ‘t’ years

W = Individual adult fish weight after a period of ‘t’ years

w = Individual weight of juvenile fish

M = Natural mortality

The length weight relationship was used to calculate the weight of the fish with the corresponding length of each species using the formula as follows:

$$W = a\,L^{b}$$

Where,

W = Weight of the fish

L = length of the fish

a = constant

b = exponent

The economic loss due to juvenile incidence in ring seines was calculated as follows:

$$EL = \left(\frac{\sum_{i=1}^{n} C_i Q_i / (1+\delta)^t}{n} \right) - \left(\frac{\sum_{i=1}^{n} c_i q_i}{n} \right)$$

Where,

EL = the average economic loss for the quantity of juveniles landed per unit fishing trip

C_i = the annual average wholesale price of the adult fish of same species of juveniles

Q_i = the estimated quantity of the adult fish corresponding to the quantity of juvenile fish

q_i = is an assumption that if juveniles were grown

n = total number fishing tripper boat

δ = is the standard discount rate

7.3 Results & Discussion

The fifteen fishes that were selected for the analysis of economic loss due to juvenile incidence were oil sardine (*Sardinella longiceps*), rainbow sardine (*Dussumieria acuta*), Indian mackerel (*Rastrelliger kanagurta*), commerson’s anchovy (*Stolephorus commersonni*), insular anchovy (*Stolephorus insularis*), torpedo scad (*Megalaspsis cordyla*), oblique-jaw thryssa (*Thryssa purava*), white sardine (*Escualosa thoracata*), tiger tooth croaker (*Otolithes ruber*), belanger’scroaker (*Johnius belangerii*), pale spotfin croaker (*Johnius glaucus*), flowertail shrimp (*Metapenaeus dobsonii*), kiddi shrimp (*Parapenaeiopsis stylifera*), Indian white prawn (*Penaeus indicus*) and tiger prawn (*Penaeus monodon*). In the present study the mean length was compared with the MLS for the criteria of determining the juveniles in the three categories of ring seines. For the species whose MLS is not available the MSM was taken as the criteria for determining the juveniles.

7.3.1 Juvenile incidence in LMRS

In the present study the dominant species in LMRS with highest quantity of juveniles was rainbow sardine (*Dussumieria acuta*) which constituted a total catch of 62000kg of fishes in which 14600kg (23.55%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 14.91± 1.7cm and 30.02 ±9.3gm respectively which was less than that of the MSM (16cm). Indian mackerel (*Rastrelliger kanagurta*) was the second dominant species in LMRS in which the highest percentage of juveniles was found. The species constituted a total catch of 4500kg of fishes in which 2500kg (55.56%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 13.27±3.56cm and 31.18±33.95gm respectively which was less than that of the minimum legal size (MLS) (14cm).Mackerel landings in Kerala was 47020 tonnes and it has contributed to 9% of the states marine landings during the year 2016 (Anon, 2017a). Along the Kerala coast fishing season for mackerel is from August to December and juveniles of mackerel are mostly landed during the lean season.

The third dominant species which constituted highest percentage of juveniles was flowertail shrimp (*Metapenaeus dobsonii*) with a total catch of 5600kg in which 1800kg (32.14%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 5.8±1.22cmand 2.5±1.52gmrespectively which was less than that of the MSM (6cm). The fourth dominant species recorded was torpedo scad (*Megalaspsis cordyla*). This species constituted a total catch of 800kg of fishes in which 100% were juveniles and the observation the mean length and mean weight of the species was 11.05±0.95cm and 14.94±3.2gm respectively which was less than that of the minimum legal size (19cm). Carangids landings in Kerala was 15% of the states marine landings during the year 2016 (Anon, 2017a).

The fifth dominant species with highest quantity of juveniles was kiddi shrimp (*Parapenaeiopsis stylifera*) and the species constituted a total catch of 1700kg of fishes in which 640kg (37.65%) were juveniles. The mean length and weight of the species was 7.5±1.02cm and 3.2±1.44gm respectively which was less than that of the MLS (7cm). The sixth dominant species which recorded highest quantity of juveniles was oblique-jaw thryssa (*Thryssa purava*). The species constituted a total catch of 630kg in which 250(39.68%) were juveniles and the mean length and mean weight of the species was 10.15±1.67cm and 7.75±4.52gm respectively. The MSM of the species was 14.5cm.

The seventh dominant species was pale spotfin croaker (*Johnius glaucus*) and this species constituted a total catch of 120kg of fishes in which 45kg (37.5%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 14.5±1.69 and 30.4±4.1respectively which was less than that of the MLS (15cm). The eighth dominant species constituted highest quantity of juveniles were insular anchovy (*Stolephorus insularis*). Anchovies are important pelagic resources along Kerala coast and the genus *Stolephorus* are dominant catches along the south west coast of India. The species constituted a total catch of 900kg of fishes in which 40(4.44%) were juveniles.The MSM of this species is 6cm and the mean length of the species was 6.2±0.72and the mean weight was 1.8±0.23.

The ninth dominant species was *Otolithes ruber*. The species constituted a total catch of 135kg of fishes in which 20(14.81%) were juveniles. The MLS recommended for the species is 14cm. The mean length of the species was 15± 1.6 and the mean weight was 32.5± 4.36. The tenth dominant species was commerson's anchovy (*Stolephorus commersonni*). The species constituted a total catch of 595kg of fishes in which 14(2.35%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 9.4±2.29 and 7.3±4.08 respectively which was less than that of the MSM (11cm). The other species selected such as oil sardine (*Sardinella longiceps*), white sardine (*Escualosa thoracata*), belanger's croaker (*Johnius belangerii*), Indian white prawn (*Penaeus indicus*) and tiger prawn (*Penaeus monodon*) did not constitute any juveniles. Thus in LMRS there was a total catch of 152285kg of fishes in which 20709kg constituted juveniles (13.60%).

Table.7.1 Constituents of juveniles occurring in LMRS

Species	**Minimum size at maturity (MSM) (cm)**	**Minimum legal size (MLS) (cm)**	**Mean length with SD (cm)**	**Mean weight with SD (gm)**	**Total catch (kg)**	**Total juvenile catch (kg)**	**% juvenile in catch**
Sardinella longiceps	15	10	14.47± 1.70	26.86 ±9.83	74350	0	0
Dussumieria acuta	16	-	14.91± 1.7	30.02 ±9.3	62000	14600	23.55
Rastrelliger kanagurta	17	14	13.27± 3.56	31.18± 33.95	4500	2500	55.56

Stolephorus commersonni	11	-	9.4± 2.29	7.3± 4.08	595	14	2.35
Stolephorus insularis	6	-	6.2± 0.72	1.8± 0.23	900	40	4.44
Megalaspsis cordyla	19	19	11.05± 0.95	14.94± 3.2	800	800	100
Thryssa purava	14.5	-	10.15± 1.67	7.75± 4.52	630	250	39.68
Escualosa thoracata	8.2	-	10.5± 1.23	11.4± 2.20	170	0	0
Otolithes ruber	17	14	15± 1.6	32.5± 4.36	135	20	14.81
Johnius belangerii	17	14	17± 1.2	41± 4.0	80	0	0
Johnius glaucus	15	15	14.5± 1.69	30.4± 4.1	120	45	37.50
Metapenaeus dobsonii	6	6	5.8± 1.22	2.5± 1.52	5600	1800	32.14
Parapenaeiopsis stylifera	7	7	7.5± 1.02	3.2± 1.44	1700	640	37.65
Penaeus indicus	13	-	14.6± 0.23	18.9± 2.35	405	0	0
Penaeus monodon	16.3	-	16.8± 0.56	21.7± 2.55	300	0	0
Total					**152285**	**20709**	**13.60**

7.3.2 Juvenile incidence in SMRS-I

In the present study was the dominant species in SMRS-I was was rainbow sardine (*Dussumieria acuta*) which constituted a total catch of 99400kg of fishes in which 29870kg (30%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 15.45±1.2 and 30.76±9.6 respectively which was less than that of the MSM (16cm). The second dominant species was torpedo scad (*Megalaspsis cordyla*) in which the highest quantity of juveniles was found. The species constituted a total catch of 50248kg of fishes in which 100% were juveniles. From the observation it was noted that the mean length and mean weight of the species was 10.05±0.76 and 13.54±3.3 respectively which was less than that of the minimum legal size (19cm). Commerson's anchovy (*Stolephorus commersonni*) was the third dominant species in SMRS-I in which the highest quantity of juveniles was found. The species constituted a total catch of 40305kg of fishes in which 9068kg (22.5%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 9.7±2.46 and 7.9± 4.96 respectively which was less than that of the MSM (11cm).

The fourth dominant species which constituted highest quantity of juveniles were insular anchovy (*Stolephorus insularis*). The species constituted a total catch of 40250kg of fishes in which 8070kg (20.05%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 5.86±0.60and 7.9±4.96 respectively which was less than that of the minimum size at maturity (MSM) (6cm). The fifth dominant species was kadal shrimp (*Metapenaeus dobsonii*). This species constituted a total catch of

18015kg in which juveniles constituted 4665kg (25.9%). The MLS recommended for this species is 6cm and the mean length of the species was 5.4± 0.74 and the mean weight was 2.39±0.79. The sixth dominant species was kiddi shrimp (*Parapenaeiopsis stylifera*)which constituted a total catch of 12000kg of fishes in which 2580kg (25.9%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 7.2±1.14 and 3.7±1.46 respectively which was less than that of the minimum legal size (7cm).

The seventh dominant species was Indian mackerel (*Rastrelliger kanagurta*). The species constituted a total catch of 10236kg of fishes in which 2867 (27.8%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 13.88±3.60 and 36.35±36.19 respectively which was less than that of the minimum legal size (14cm). The eighth dominant species constituted quantity of juveniles were tiger tooth croaker (*Otolithes ruber*) and this species constituted a total catch of 1280kg of fishes in which 110kg (8.6%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 15.9±1.6 and 34.8±6.2 respectively which was less than that of the minimum legal size (14cm).

The ninth dominant species was oblique-jaw thryssa (*Thryssa purava*), which constituted a total catch of 1020kg of fishes in which 320kg (31.37%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 10.12±1.75and 7.25±4.47respectively which was less than that of the MSM (14.5cm). The tenth dominant species was white sardine (*Escualosa thoracata*). The species constituted a total catch of 520kg of fishes in which 78kg (15%) was juveniles. From the observation it was noted that the mean length and mean weight of the species was 9.6±1.23 and 10.6±2.16 respectively which was less than that of the MLS (8.2cm). The next dominant species was pale spotfin croaker (*Johnius glaucus*) which constituted a total catch of 500kg of fishes in which 12kg (2.4%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 14±1.5 and 28.6±4.3 respectively which was less than that of the minimum legal size (15cm). The other species selected such as *Sardinella longiceps*, *Johnius belangerii*, *Penaeus indicus* and *Penaeus monodon* did not constitute any juveniles. Thus in SMRS-I there was a total catch of 367473kg of fishes in which 107868kg constituted juveniles (29.35%).

Table.7.2 Constituents of juveniles occurring in SMRS-I

Species	Minimum size at maturity (MSM) (cm)	Minimum legal size (MLS) (cm)	Mean length with SD (cm)	Mean weight with SD (gm)	Total catch (kg)	Total juvenile catch (kg)	% juvenile in catch
Sardinella longiceps	15	10	14.34± 1.75	27.32± 10.15	121914	0	0
Dussumieria acuta	16	-	15.45± 1.2	30.76± 9.6	99400	29870	30
Rastrelliger kanagurta	17	14	13.88± 3.60	36.35± 36.19	10236	2847	27.8
Stolephorus commersonni	11	-	9.7± 2.46	7.9± 4.96	40305	9068	22.5
Stolephorus	6	-	5.86±	7.9±	40250	8070	20.05

insularis			0.60	4.96			
Megalaspsis cordyla	19	19	10.05± 0.75	13.54± 3.3	50248	50248	100
Thryssa purava	14.5	-	10.12± 1.75	7.25± 4.47	1020	320	31.37
Escualosa thoracata	8.2	-	9.6± 1.23	10.6± 2.16	520	78	15
Otolithes ruber	17	14	15.9± 1.6	34.8± 6.2	1280	110	8.6
Johnius belangerii	17	14	17.5± 1.6	43.6± 5.36	540	0	0
Johnius glaucus	15	15	14± 1.5	28.6± 4.3	500	12	2.4
Metapenaeus dobsonii	6	6	5.4± 0.74	2.39± 0.79	18015	4665	25.9
Parapenaeiopsis stylifera	7	7	7.2± 1.14	3.7± 1.46	12000	2580	21.5
Penaeus indicus	13	-	14.6± 0.28	18.5± 2.34	800	0	0
Penaeus monodon	16.3	-	16.4± 0.50	21.9± 2.55	495	0	0
Total					**367473**	**107868**	**29.35**

7.3.3 Juvenile incidence in SMRS-II

In the present study was the dominant species in SMRS-II was rainbow sardine (*Dussumieria acuta*) which constituted a total catch of 32476kg of fishes in which 10619kg (32.7%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 15.21±1.7 and

31.02±9.8 respectively which was less than that of the MSM (16cm). The second dominant species was torpedo scad (*Megalaspsis cordyla*) in which the highest quantity of juveniles was found. The species constituted a total catch of 24648kg of fishes in which 100% were juveniles. From the observation it was noted that the mean length and mean weight of the species was 11.15±1.25 and 15.30±3.10 respectively which was less than that of the minimum legal size (19cm). Commerson's anchovy (*Stolephorus commersonni*) was the third dominant species in SMRS-I in which the highest quantity of juveniles was found. The species constituted a total catch of 10567kg of fishes in which 1109kg (10.5%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 9.9±2.98 and 8.2±5.23 respectively which was less than that of the MSM (11cm).

The fourth dominant species was flowertail shrimp (*Metapenaeus dobsonii*). This species constituted a total catch of 4355kg in which juveniles constituted 2504kg (57.5%). The MLS recommended for this species is 6cm and the mean length of the species was 5.6±1.20 and the mean weight was 2.4±1.42. The fifth dominant species was Indian mackerel (*Rastrelliger kanagurta*). The species constituted a total catch of 4102kg of fishes in which 233kg (5.7%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 13.71±3.91 and43.9±39.14 respectively which was less than that of the minimum legal size (14cm).The sixth dominant species was kiddi shrimp (*Parapenaeiopsis stylifera*) which constituted a total catch of 1020kg of fishes in which 335kg (32.8%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 7.9±1.02cm and 3.9±1.44gm respectively which was less than that of the minimum legal size (7cm). The seventh dominant species which constituted highest quantity of juveniles were insular anchovy (*Stolephorus insularis*). The species constituted a total catch of 600kg of fishes in which 28kg (4.7%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 6.1±0.61 and 1.8±0.20 respectively which was less than that of the minimum size at maturity (MSM) (6cm).

The eighth dominant species constituted quantity of juveniles was oblique-jaw thryssa (*Thryssa purava*), which constituted a total catch of 180kg of fishes in which 85kg (47.2%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 9.82±2.02 and 6.98±5.30 respectively which was less than that of the MSM (14.5cm).The ninth dominant species was tiger tooth croaker (*Otolithes ruber*) and this species constituted a total catch of 80kg of fishes in which 10kg (12.5%) were juveniles. From the observation it was noted that the mean length and mean weight of the species was 15.6±1.2 and 31.5±5.75 respectively which was less than that of the minimum legal size (14cm).The other species selected such as *Sardinella longiceps*, *Escualosa thoracata*, *Johnius belangerii*, *Penaeus indicus* and *Penaeus monodon* did not constitute any juveniles. Thus in SMRS-II there was a total catch of 106315kg of fishes in which 39571kg constituted juveniles (37.22%).

Table 7.3 Constituents of juveniles occurring in SMRS-II

Species	Minimum size at maturity (MSM) (cm)	Minimum legal size (MLS) (cm)	Mean length with SD (cm)	Mean weight with SD (gm)	Total catch (kg)	Total juvenile catch (kg)	% juvenile in catch
Sardinella longiceps	15	10	14.75± 1.87	28.98± 10.73	27000	0	0
Dussumieria acuta	16	-	15.21± 1.7	31.02± 9.8	32476	10619	32.7
Rastrelliger kanagurta	17	14	13.71± 3.91	43.9± 39.14	4102	233	5.7
Stolephorus commersonni	11	-	9.9± 2.98	8.2± 5.23	10567	1109	10.5
Stolephorus insularis	6	-	6.1± 0.61	1.8± 0.20	600	28	4.7
Megalaspsis cordyla	19	19	11.15± 1.25	15.30± 3.10	24648	24648	100
Thryssa purava	14.5	-	9.82± 2.02	6.98± 5.30	180	85	47.2
Escualosa thoracata	8.2	-	9.6± 1.14	9.71± 1.34	120	0	0
Otolithes ruber	17	14	15.6± 1.2	31.5± 5.75	80	10	12.5
Johnius belangerii	17	14	17.2± 1.5	41.8± 6.48	120	0	0
Johnius Glaucus	15	15	15± 1.7	32.5± 6.32	57	0	0
Metapenaeus dobsonii	6	6	5.6± 1.20	2.4± 1.42	4355	2504	57.5

Parapenaeiopsis stylifera	7	7	7.9± 1.02	3.9± 1.44	1020	335	32.8
Penaeus indicus	13	-	14.6± 0.23	18.9± 2.35	470	0	0
Penaeus monodon	16.3	-	16.8± 0.56	21.6± 2.50	520	0	0
Total					**106315**	**39571**	**37.22**

7.3.4 Economic loss due to juvenile incidence

The economic deficit occurred due to the capture of juvenile fishes in three categories viz; LMRS, SMRS-I and SMRS-II of ring seines were worked out. In the study area the wholesale rate and juvenile rate in terms of money varied annually.

7.3.4.1 Economic loss in LMRS

From the selected fifteen species, it was found that ten species constituted juveniles. The percentage of economic deficit caused by the ten species in LMRS in shown in Table 7.4. Among the ten species *Dussumieria acuta* recorded the highest loss of Rs.5288226 (58.45%) and *Megalaspsis cordyla* the least of Rs.24000 (0.27%) annually.

Table 7.4 The economic deficit of juvenile species in LMRS

Species	Quantity (Rs.)	Economic deficit (%)
Dussumieria acuta	5288226	58.45
Rastrelliger kanagurta	2359419	26.08
Metapenaeus dobsonii	512537	5.67
Stolephorus commersonni	208880	2.31
Stolephorus insularis	147899	1.63
Thryssa purava	131836	1.46
Johnius glaucus	129290	1.43
Otolithes ruber	124413	1.38
Parapenaeiopsis stylifera	120388	1.32
Megalaspsis cordyla	24000	0.27

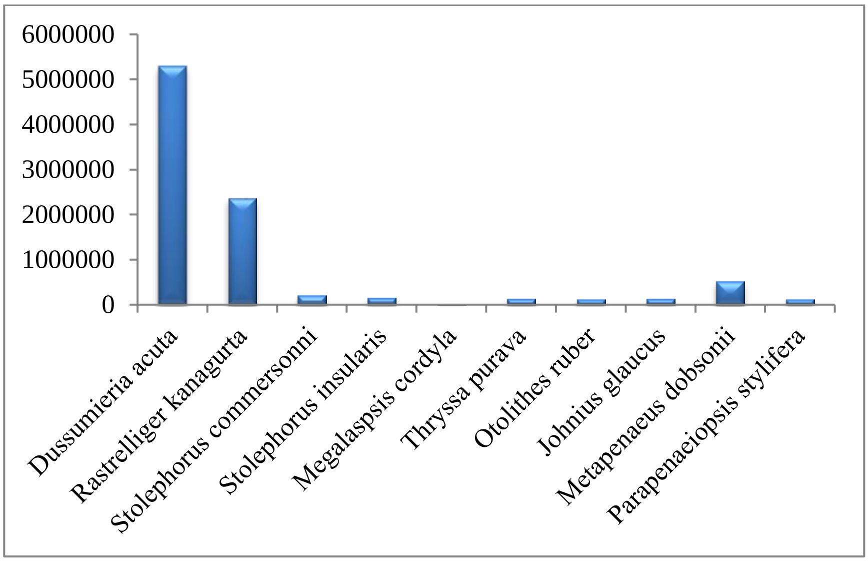


Fig 7.2 Economic loss of juvenile species in LMRS

7.3.4.2 Economic loss in SMRS-I

From the selected fifteen species, it was found that eleven species constituted juveniles in SMRS-I. The percentage of economic deficit caused by the eleven species in SMRS-I is shown in Table 7.5. Among the eleven species *Stolephorus commersonni* recorded the highest loss of Rs.9821464 (26.89%) and *Escualosa thoracata* the least of Rs.46071 (0.13%).

Table 7.5 The economic deficit of juvenile species in SMRS-I

Species	Quantity (Rs.)	Economic deficit (%)
Stolephorus commersonni	9821464	26.89
Rastrelliger kanagurta	7936909	21.72
Dussumieria acuta	7585654	20.76
Stolephorus insularis	5139791	14.07
Megalaspsis cordyla	1507440	4.13
Metapenaeus dobsonii	1351760	3.7
Otolithes ruber	1168555	3.2
Johnius glaucus	905807	2.48
Thryssa purava	266726	0.73
Parapenaeiopsis stylifera	798656	0.19
Escualosa thoracata	46071	0.13

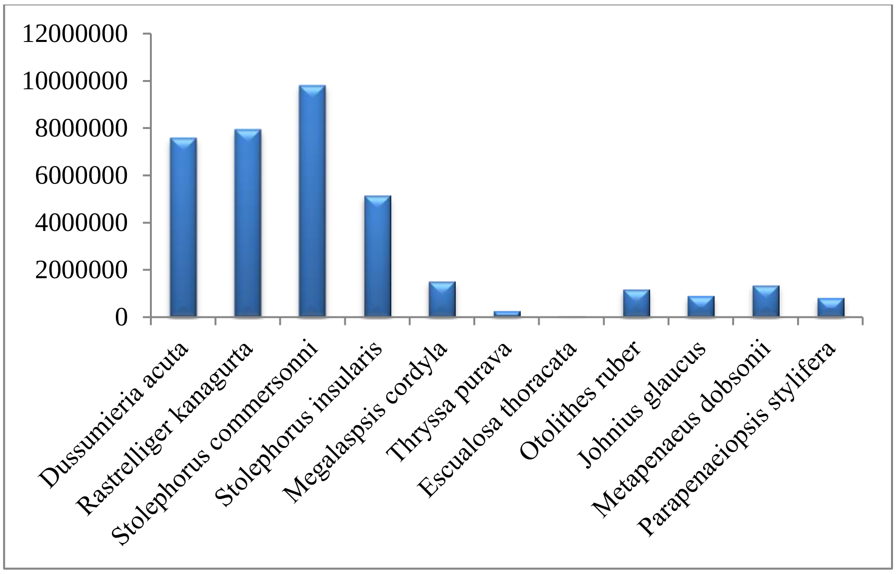


Fig 7.3 Economic loss of juvenile species in SMRS-I

7.3.4.3 Economic loss in SMRS-II

From the selected fifteen species, it was found that nine species constituted juveniles in SMRS-II. The percentage of economic deficit caused by the nine species in SMRS-II is shown in Table 7.6. Among the nine species *Rastrelliger kanagurta* (35.21%) recorded the highest loss of Rs.3541292 (26.89%) and *Thryssa purava* the least of Rs.36527 (0.37%).

Table 7.6 The economic deficit of juvenile species in SMRS-II

Species	Quantity (Rs.)	Economic deficit (%)
Rastrelliger kanagurta	3541292	35.21
Stolephorus commersonni	3124970	31.07
Dussumieria acuta	2320194	23.06
Megalaspsis cordyla	739440	7.35
Stolephorus insularis	98286	0.98
Otolithes ruber	75860	0.75
Metapenaeus dobsonii	75049	0.75
Thryssa purava	36527	0.37
Parapenaeiopsis stylifera	45677	0.46

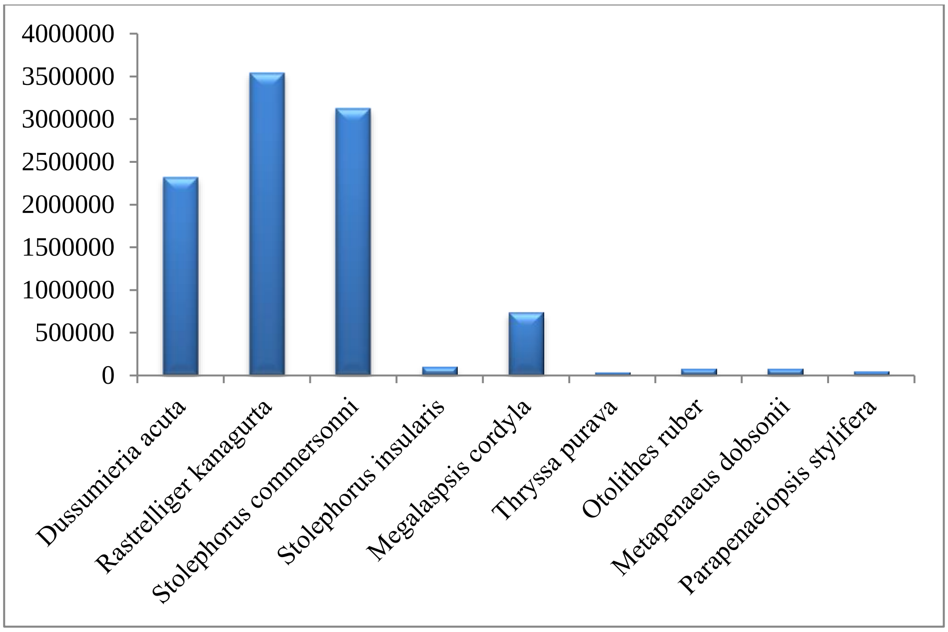


Fig 7.4 Economic loss of juvenile species in SMRS-II

7.3.4.4 Total economic loss

The total annual economic loss due to juvenile fishing in three categories of ring seines was estimated to be Rs.55632956 in which SMRS-I recorded highest economic loss of Rs.36528833 followed by SMRS-II (Rs.10057235) and LMRS (Rs.9046888).

Table 7.7 Total economic loss

Types of ring seine	**Economic loss (Rs.)**
LMRS	9046888
SMRS-I	36528833
SMRS-II	10057235
Total	**55632956**

The uncontrolled increase in fishing effort in terms of number of fishing units, dimensions of the gear and size and horsepower of the craft, accompanying increasing investment requirements and increase in the proportion of juveniles and sub adults in the commercial landings have been major concerns in the ring seine fishery (Singh et al., 2007; Kurup et al.,2009). Juveniles are mainly caught in small meshed ring seines (*choodavala*) as the mesh size of the gear is small (8-10mm) and Edwin et al (2010) has reported the incidence of juveniles in small mesh ring seines in the range of 20-30% and the large meshed ring seine (*thanguvala*) in the range of 5-15%. Pramod (2010) reported the excess juvenile catch in ring seine fishery due to small mesh ring seine operation and ring seines of Kerala catch 0 and 1 year class of sardine and mackerel in high quantity every year. Oil sardines ranging from 1.8-3 tonnes are dumped into Cochin backwaters every year as excess production of ring seine. A short term study in 2016 was conducted by ICAR-CIFT on the juvenile incidence in the small mesh ring seine fishery of Chellanam which showed that *Sardinella longiceps* (oil sardine) was the most dominant species landed. Total juvenile landings from the study were 6.70 t of which oil sardine juveniles formed 76.11% (Gomathi, 2016). According to CMFRI (2017), during the period 2013-2015, the juvenile fish catches of oil sardines in Kerala had an estimated loss of 48 crores. In the present scenario it is highly important to quantify the economic loss occurred due juvenile fishing in order to find solutions to minimize this process.

7.4 Conclusion

During the present study only fifteen commonly occurring and which are commercially utilized were selected. The result showed that juvenile incidence occurred in all categories of ring seines and highest was observed in SMRS-II (37.22 %) followed by SMRS-I (29.35%) and LMRS (13.60%). Economic loss ranged from Rs.9046888 to Rs.36528833 which was highest in SMRS-I followed by SMRS-II and LMRS. It is necessary that strict regulations should be adopted for the effective control of juvenile catching in ring seines. Identification of spawning and nursery grounds of fishes caught in ring seines and enforcing seasonal ban during the particular season can be done for controlling of juvenile incidence. Fishers should get proper awareness regarding the consequences of catching juveniles in the future so that they themselves take an initiative in preventing the catch of juveniles.

CHAPTER 8
INTERACTION OF AQUATIC ORGANISMS WITH RING SEINES AND LOSSES

INTERACTION OF AQUATIC ORGANISMS WITH RING SEINES AND LOSSES

8.1 Introduction

Depredation is the removal of, or damage to captured fish or bait (commercial or recreational), caused by predators and thus causing damage to fishing gear. This in turn decreases the value of fishes causing loss to fishers. There are several aquatic organisms which causes depredation such as whales, dolphins, porpoises, seals, sea lion, sea otters, puffer fishes, crabs, squids etc. Depredation is reported in long lines (Mandelman, 2008; MacNeil et al., 2009; Werner et al., 2015; Passadore et al., 2015; Aneesh et al., 2016), gill nets (Read, 2005; Buscaino et al., 2009; Lauriano et al.,2009; Mcpherson & Nishida, 2010; Carretta & Barlow, 2011; Rafferty et al., 2012; Barbieri et al., 2012; Dawson et al., 2013; Cosgrove et al., 2015; Shereef et al., 2015), purse seines (Gilman 2011; Goetz et al., 2015) and ring seines (Prajith et al., 2014; Das, 2015; Raphael et al., 2017, Edwin et al., 2017). Depredation results in economic, social and ecological impacts and thus decreasing the fishery landings and threatening marine predator population through increased risk of entanglement (Rafferty et al., 2012).

Purse seine, an important bulk catching method of the world was first evolved in the Atlantic coast during the last quarter of the 19th century. The interaction between purse seines and mammalian/aquatic organisms is a subject discussed worldwide. Dolphins are killed in large numbers by purse seine fishing operations for tuna. In the Eastern Tropical Pacific region it is estimated that between 1959 and 1972 nearly five million dolphins were killed in purse seine fisheries for catching tuna (Wade, 1994). While bycatch issues of marine mammals exist, the depredation caused by them is also a major problem to fishers around the world. Dolphins depredate or steal the catch of fishers. Humpback dolphins are the most common cetaceans found in Indian waters and are known to cause damage and depredation of fish from certain fishing gears (Sutaria et al., 2015). The major problem associated with the operation of the ring seine is the attack of dolphins and other cetaceans during the time of aggregation and brailing the catch (Prajith et al., 2014). Due to the direct interaction of marine mammals with the fisheries, these animals remove or damage the fish captured in the gear through their behavior known as depredation and thus decreasing the value of catches and this in turn make the fishers to take retaliatory measures against the mammals (Read, 2005).These interactions may also result in the process known as ‘‘bycatch” which possess threat to several species of small cetaceans with extinction (Reeves et al., 2013).

Puffer fish otherwise known as blowfish, globefish, baloonfish, blowies, bubblefish, swellfish and toadfish are the organisms which belongs to the family Tetraodontidae and are seen both in coastal and estuarine waters. The majority of the fishes are highly toxic since their body contains tetrodotoxin which is highly toxic when consumed. They are also considered as a menace by fishers when entered the net since they cause damage to the webbing. The significant socio-economic impact of pufferfish on the local fisheries of the Eastern Mediterranean countries was reported by Kaligirou, 2010.Complaints from local fishers have become frequent in Egypt, Lebanon, Cyprus, Turkey and Greece amongst others where the destruction of nets due to entangling or to predation by *Lagocephalus sceleratus* on already entangled fish is common. *L. sceleratus* is considered a major nuisance by fishers since it damages fishing gear by attacking fish caught in nets and lines, along with reducing local stocks of squids and octopus through predation (Anon, 2012b).

Increase in jelly fish blooms all over the world is also a major concern. Its impact on fisheries and human activities have gained much attention on the gelatinous organisms, the Scyphozoa (Boero, 2013; Piraino et al., 2014). Pollution has been a major factor in increase of jelly fish and Tett & Mills (2001) has said that a shift from diatom to flagellate dominance in phytoplankton communities could lead to the replacement of crustacean zooplankton and fish by cnidarians such as jelly fish as primary predators. The increase in jellyfish population along the southwest coast of India in recent years has been found to match with the increase in the occurrence of algal blooms in the coastal waters, a consequence of the nutrient run off from land (Nandakumar, 2013). Jelly fish tend to thrive in polluted waters due to lack of competition posed by other aquatic organisms. Over-fishing has also caused the reduction of natural jelly predators like the tuna and sea turtle and probable reduction of small pelagics has reduced its competition for food leading to increase of jelly fish population.

The main objective of this study is to identify the major groups of aquatic organisms (up to species level) causing damage to ring seines, to quantify the catch loss caused in each category of ring seine, to assess the level of damage through estimation of gear loss and economic loss.

8.2 Materials & Methods

The study was conducted from November 2015 - October 2016 by collecting data from Chellanam mini fishing harbour and Kalamukku harbour. Information was collected from 240 observations made from three categories of ring seines (6 LMRS, 7 SMRS-I & 7 SMRS-II).Information was collected on the major species involved in the interactions. The fishers were shown coloured photographs of cetaceans and asked to identify the species. Details regarding the damage caused to ring seines were collected from fishers (crew members), boat leaders and boat owners from the landing centres through structured pre-tested questionnaires prepared for the purpose. Average catch loss by all types of aquatic organisms was quantified as the percentage of the total catch lost per depredation or scattering event. At the end of each interview, fishers were asked to give their general opinion about the cetacean interaction, puffer fish attack, jelly fish menace and ambassis entanglement.

8.3Results & Discussion

The operational hazards faced by the ring seine fishers include:

- Attack of cetaceans
- Pufferfish bites
- Jellyfish blooms which may enter ring seines
- Entanglement of small fish like ambassids
- The damage caused to the net, results in loss of fishing days and additional expenditure for repair

8.3.1 Cetacean interaction

About 90% of the fishers interviewed reported of having faced cetacean attack during the pre-monsoon and post-monsoon period. The positive side of cetacean interaction is that when cetacean occurrence is noticed the fishers can ascertain the presence of pelagic fish shoals nearby. The negative impacts are the damages caused to the net and catch loss. Dolphins and other cetaceans come within the vicinity of the ring seines during the time of aggregation and brailing of the catch and attack. The cetacean attacks in small meshed ring seines are frequent during the month of August-May. Fishers believe that dolphins come near the shore from the deeper waters due to the scarcity of fish in the sea. During each month 10 to 15kg of webbing are replaced by the fishers and in some cases the whole net is irreparably damaged due to cetacean attack.

Conventional methods used to deter cetaceans

The conventional methods employed by the fishers to deter the cetaceans are fireworks, throwing stones, throwing bait fish to distract and fishers jumping into the water to scare them away. With the dual intentions of conserving dolphins and reducing the operational hazard to ring seine fishers developed a special type of net that forms an outer protective wall to the ring seines known as "*Pannivala*"/Dolphin Wall Net (DWN) (Prajith et al., 2014).

8.3.1.1 Species identified

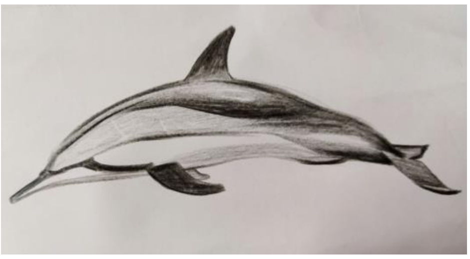
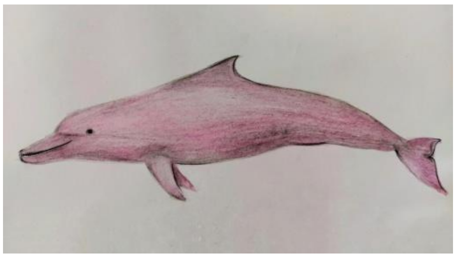
The spinner dolphin (*Stenella longirostris*) is the dominant species observed in Cochin region. In local language (Malayalam) this species is known as *meliyanedi* and they have a characteristic feature of spinning high in the air and are often seen near the shore. The humpback dolphin (*Sousa chinensis*) is another species causing damage to the gear and the fishers call it as *paandanpanni*. Other species are also seen associated with pelagic shoals but do not cause any depredation and damage to the gear. They are bottlenose dolphin (*Turisops aduncus*), long-beaked common dolphin (*Delphinus capensis*) and rissos dolphin (*Grampus gristeus*) (Table 8.2).

In India, cetaceans are classified as endangered and protected under the Wildlife Protection Act, 1972 (Afsal et al., 2008). Within the country the knowledge on cetaceans are limited and generally confined only to the reports of accidentally caught species and from the stranding specimens. Mohan (1988) has observed bycatches of dolphins such as *Stenella longirostris*, *Tursiops aduncus*, *Sousa chinensis* and *Delphinus delphis* in gillnets of Calicut coast. Humpback dolphins (*Sousa spp*.) are the most common cetaceans found in Indian waters and are highly vulnerable to a number of anthropogenic pressures (Sutaria et al., 2015).

Several authors have researched on humpback dolphins (Sutaria & Jefferson, 2004; Bijukumar & Smrithy, 2012; Panicker et al., 2018; Sutaria et al, 2015). Anon (2011b) has reported the occurrence of *Stenella longirostris* and *Sousa chinensis* in Cochin area and *Delphinus capensis* from Kollam area. The occurrence and interaction of spinner dolphin with ring seine fisheries in Cochin area has been reported by Prajith et al (2014). Depredation and catch loss in ring seines due to cetacean attack has been reported by Raphael et al.,2017 and Edwin et al .,2017.

Table 8.1 Species causing damage to ring seines

Sl.No	Family	Scientific name	Common name
1	Delphinidae	*Stenella longirostris*	Spinner dolphin
2	Delphinidae	*Sousa chinensis*	Humpback dolphin

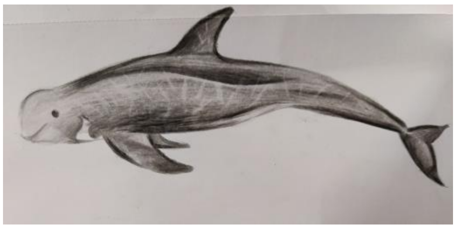
Stenella longirostris ***Sousa chinensis***

Plate.4 Species of cetaceans causing damage to ring seines

Table 8.2 Species associated with fish shoals

Sl.No	Family	Scientific name	Common name
1	Delphinidae	*Turisops aduncus*	Bottlenose dolphin
2	Delphinidae	*Delphinus capensis*	Long-beaked common dolphin
3	Delphinidae	*Grampus gristeus*	Rissos dolphin


Turisops aduncus ***Delphinus capensis***



Grampus gristeus

Plate.5 Species of cetaceans found interacting with ring seines without causing damage

8.3.1.2. Catch loss in different categories of ring seines due to cetacean attack

Catch loss/ Unit/ attack during pre-monsoon season

During pre-monsoon season, in LMRS a total of six number of attacks by cetaceans were noticed in the study period which resulted in an average catch loss of approximate 137kg of fishes and the percentage loss estimated is 16.54%. Similarly in SMRS-I fishers reported four number of attacks during this period which resulted in a catch loss of approximately 26kg of fishes and had a loss of 35.45%. In SMRS-II the number of cetacean attack noticed was also four times which resulted in an average catch loss of 22kg of fishes and which was estimated to be 14.75% of loss. Thus the highest catch loss was reported in SMRS-I and the lowest was observed in SMRS-II (Table 8.3).

Table 8.3 Catch loss in ring seines during pre-monsoon season

Types of ring seines	No. of cetacean attack	Average catch loss approximate. (kg)	Percentage catch loss
LMRS	6	137	16.54
SMRS-I	4	26	35.45
SMRS-II	4	22	14.75

Catch loss/ Unit/ attack during monsoon season

During monsoon season, in LMRS attack by cetaceans were noticed twice which resulted in an average catch loss of approximate 66kg of fishes and the percentage loss estimated is 5.38%. Similarly in SMRS-I fishers reported cetacean attack only once during this period which resulted in a catch loss of approximately 13kg of fishes and had a loss of 2.56%. In SMRS-II cetacean attack was noticed only once, which resulted in an average catch loss of 10kg of fishes and which was estimated to be 1.76% of loss. Thus the highest catch loss during monsoon season was reported in LMRS and the lowest was observed in SMRS-II (Table 8.4).

Table 8.4 Catch loss in ring seines during monsoon season

Types of ring seines	No. of cetacean attack	Average catch loss approximate. (kg)	Percentage catch loss
LMRS	2	66	5.38
SMRS-I	1	13	2.56
SMRS-II	1	10	1.76

Catch loss/ Unit/ attack during post-monsoon season

During post-monsoon season, in LMRS cetacean attacks were noticed nine times which resulted in an average catch loss of approximate 227kg of fishes and the percentage loss estimated is 23.66%. Similarly in SMRS-I fishers reported five number of cetacean interaction during this period which resulted in a catch loss of approximately 53kg of fishes and had a loss of 16.76%. In SMRS-II the number of cetacean attack noticed was thrice, which resulted in an average catch loss of 31kg of fishes and which was estimated to be 3.25% of loss. Thus the highest catch loss was reported in LMRS and the lowest was observed in SMRS-II (Table.5).

Table 8.5 Catch loss in ring seines during post-monsoon season

Types of ring seines	No. of cetacean attack	Average catch loss approximate. (kg)	Percentage catch loss
LMRS	9	227	23.66
SMRS-I	5	53	16.76
SMRS-II	3	31	3.25

Thus when comparing the loss of fishes caught due to cetacean attack shows that the highest loss was observed in LMRS (23.66%) during the post-monsoon period and the lowest was observed in SMRS-II (1.76%) during the monsoon period.

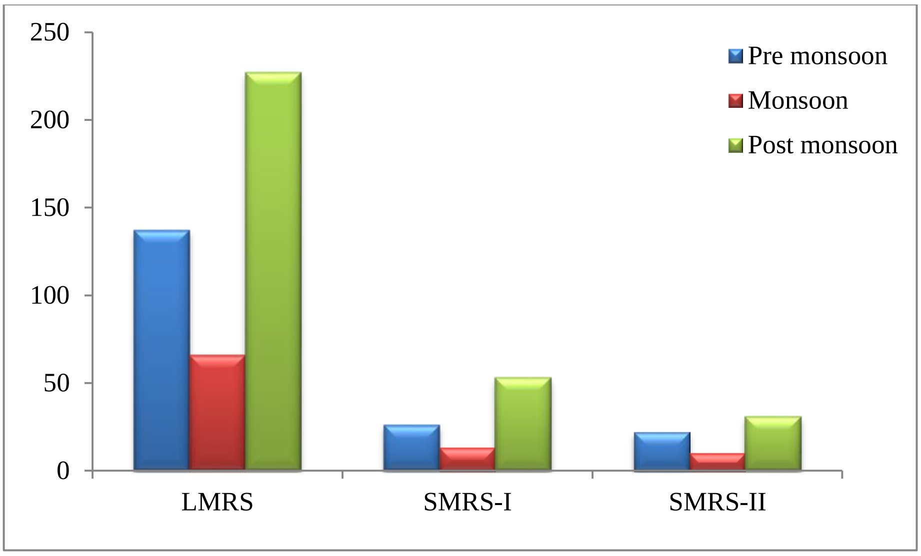


Fig 8.1 Catch loss due to cetacean attack in different seasons

8.3.1.2.1Economic evaluation of catch loss/instance due to cetacean attack

When catch loss was estimated in terms of value it was observed that LMRS had highest loss of money of Rs. 27,266 during the post-monsoon, followed by pre-monsoon (Rs.16,382) and monsoon season (7,921). In SMRS-I the loss was maximum (Rs.6,304) during the post-monsoon season, followed by pre-monsoon (Rs.5,583) and monsoon (Rs.1,586). In SMRS-II, the loss was maximum (Rs.3,763) during post-monsoon, followed by pre-monsoon (Rs. 2,672) and monsoon (Rs.1,284). Thus a total loss of Rs.51,569, Rs.13,473 and Rs.7,719 occurred in LMRS, SMRS-I and SMRS-II respectively. Comparing the different categories highest loss of Rs.27,266 occurred in LMRS during post-monsoon season and lowest value of Rs.1,284 occurred in SMRS-II during the monsoon period.

Table8.6 Catch loss in terms of value during different seasons

Type of ring seines	Pre-monsoon (Rs)	Monsoon (Rs)	Post-monsoon (Rs)	Total (Rs)
LMRS	16382	7921	27266	51569
SMRS-I	5583	1586	6304	13473
SMRS-II	2672	1284	3763	7719

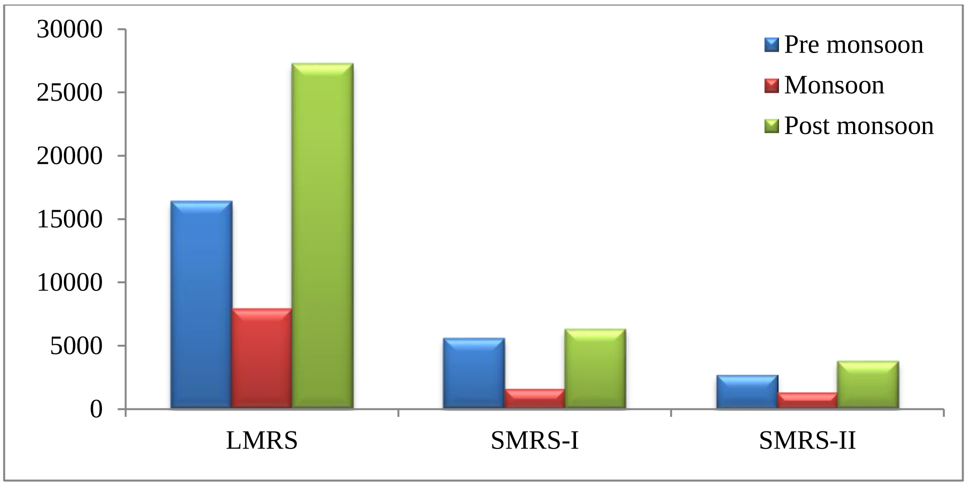


Fig 8.2 Catch loss in terms of value in different categories

8.3.1.3 Fishing gear damage due to cetacean bite

To estimate the loss due to fishing gear damage caused by cetacean attack in different categories of ring seines, different parameters such as type of hole and diameter, number of holes, area of webbing replaced, weight of webbing needed to replace the damage portion and the cost of webbing was calculated. The holes were classified as small (<20 cm), medium (20-50cm), large (50-100cm) and very large (>100cm). When there were holes greater than 100 cm, the damaged area was divided into units of 100cm.

About 10 to 20kg of webbing are replaced monthly and in some cases the whole net is irreparably damaged.Cetacean bites were minimum during the monsoon season.Usually dolphins are sighted in groups of about 2-10 (sometimes upto 30) in number and bite the bunt region where the catch is concentrated. The number of holes/ tears ranged from 75-250 in a single incident and hole diameter ranged mostly from 10-100cm. The average number of webbings replaced in LMRS is 180kg, in SMRS-I is 90kg and SMRS-II is 67kg.

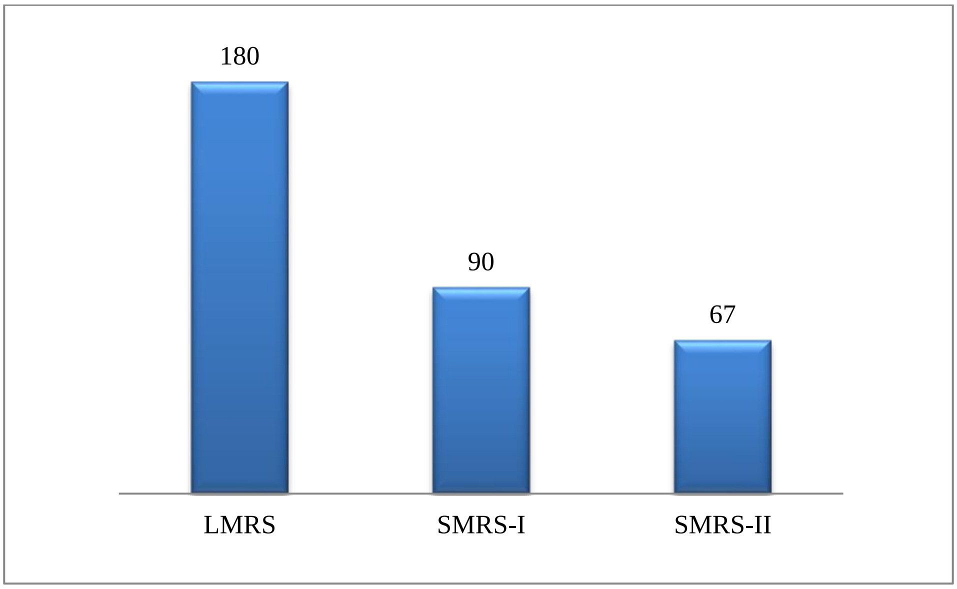


Fig.8.3Average webbing lost annually in different categories of ring seines

Plate.6a. The hole occurred due to cetacean bite; b. the damage area been replaced by fresh piece of webbing

Economic loss due to fishing gear damage due to cetacean attack in LMRS

During the study period there were 1045 small holes observed and the area needed to replace the small holes (<20cm) was 697m^2 and 10.5kg of webbing was needed. The cost of webbing to replace the small holes was Rs. 55. The medium holes (20-50cm) were observed 2019 in numbers and the area needed to replace was 2692m^2. The webbing needed to replace the medium holes was estimated to be 40.4kg and Rs. 21,280 was the cost for replacing webbings for the medium holes. There were 2985 large holes (50-100cm) observed in LMRS and the webbing needed to replace the damage portion was 3383m^{2}and it needed 50.7kg of webbing . The cost for repairing the large holes were estimated Rs.26,742. There were 2304 very large holes (>100) observed in LMRS and the area needed to replace was 5222m^2 and the weight of the webbing was 78.34kg. The cost of webbing was Rs.41,283. Thus the total area needed to replace the damaged area in LMRS was estimated to be 11995m^2. The total webbings needed were estimated to be 180kg and the cost of webbing to replace the damaged area in LMRS was estimated to be Rs. 94,813 (Table 8.7).

For mending the gear 20 mandays are required. The average daily wage is Rs. 800 /person. Hence the cost of repair was estimated to be Rs. 16,000. Thus a total cost of Rs.1,10,813 was estimated to occur due to gear damage alone annually. In addition there will be a loss of fishing days which is estimated to be 0-60,00,000 per vessel/year.

Table8.7 Economic loss due to gear damage in LMRS

Type of hole and diameter (cm)		**Number of holes**	**Area of webbing replaced (m^2)**	**Weight of webbing (kg)**	**Cost of webbing (Rs.)**
Small	<20	1045	697	10.5	5507.15
Medium	20-50	2019	2692	40.4	21280.26
Large	50-100	2985	3383	50.7	26742.60
Very large	>100	2304	5222	78.34	41283.07
Total			11995	180	94813

Economic loss due to fishing gear damage due to cetacean attack in SMRS-I

During the study period there were 534 small holes observed and the area needed to replace the small holes (<20cm) was 356m^2 and 5.34kg of webbing was needed. The cost of webbing to replace the small holes was Rs. 4,426. The medium holes (20-50cm) were observed 1467 in numbers and the area needed to replace was 978m^2. The webbing needed to replace the medium holes was estimated to be 14.67kg and Rs.12,161 was the cost for replacing webbings for the medium holes. There were 1678 large holes (50-100cm) observed in SMRS-I and the webbing needed to replace the damage portion was 2237.3m^{2}and it needed 33.56kg of webbing. The cost for repairing the large holes were estimated Rs.27,821. There were 1207 very large holes (>100) observed in SMRS-I and the area needed to replace was 2414m^2 and the weight of the webbing was 36.21. The cost of webbing was Rs.30,018. Thus the total area needed to replace the damaged area in SMRS-I was estimated to be 5985.3m^2. The total webbings needed were estimated to be 90kg and the cost of webbing to replace the damaged area in SMRS-I was estimated to be Rs.74,427.

For mending the gear 10 mandays are required. The average daily wage is Rs. 800 /person. Hence the cost of repair was estimated to be Rs. 8,000. Thus a total cost of Rs.82,427 was estimated to occur due to gear damage alone annually. In addition there will be a loss of fishing days which is estimated to be 0-10,00,000 per vessel/year.

Table 8.8 Economic loss due to gear damage in SMRS-I

Type of hole and diameter		**Number of holes**	**Area of webbing replaced (m^2)**	**Weight of webbing (kg)**	**Cost of webbing (Rs.)**
Small	<20	534	356	5.34	4426.86
Medium	20-50	1467	978	14.67	12161.43
Large	50-100	1678	2237.3	33.56	27821.24
Very large	>100*	1207	2414	36.21	30018.09
Total			5985.3	90	74427

Economic loss due to fishing gear damage due to cetacean attack in SMRS-II

During the study period there were 456 small holes observed and the area needed to replace the small holes (<20cm) was 304m^2 and 4.56kg of webbing was needed. The cost of webbing to replace the small holes was Rs. 3780. The medium holes (20-50cm) were observed 1098 in numbers and the area needed to replace was 732m^2. The webbing needed to replace the medium holes was estimated to be 10.96kg and Rs.9,102 was the cost for replacing webbings for the medium holes. There were 1234 large holes (50-100cm) observed in SMRS-II and the webbing needed to replace the damage portion was 1645.3$m^2$and it needed 24.68kg of webbing. The cost for repairing the large holes were estimated Rs.20,459. There were 876 very large holes (>100) observed in SMRS-II and the area needed to replace was 1752m^2 and the weight of the webbing was 26.28. The cost of webbing was Rs. 21,786. Thus the total area needed to replace the damaged area in SMRS-II was estimated to be 4433m^2. The total webbings needed were estimated to be 67kg and the cost of webbing to replace the damaged area in SMRS-II was estimated to be Rs. 55,128.

For mending the gear 7.5 mandays are required. The average daily wage is Rs.800 /person. Hence the cost of repair was estimated to be Rs.6,000. Thus a total cost of Rs.61,128 was estimated to occur due to gear damage alone annually. In addition there will be a loss of fishing days which is estimated to be 0-2,00,000 per vessel/year.

Table 8.9 Economic loss due to gear damage in SMRS-II

Type of hole and diameter		Number of holes	Area of webbing replaced (m^2)	Weight of webbing (kg)	Cost of webbing (Rs.)
Small	<20	456	304	4.56	3780.24
Medium	20-50	1098	732	10.96	9102.42
Large	50-100	1234	1645.3	24.68	20459.72
Very large	>100*	876	1752	26.28	21786.12
Total			4433	67	55128

8.3.2 Pufferfish bite

Puffer fish bite is another major problem faced by fishers during the monsoon and post-monsoon seasons. In the present study 75% fishers reported puffer fish bite mainly in the bunt region of the ring seine. When more puffer fish gets caught inside the gear along with the targeted species they eat the flesh of the fishes and tear the webbing. Fishers opined that the puffer fish menace started in Kerala coast after the 2004 tsunami. Mohamed et al., (2013) reported that one of the reasons for the increase in puffer fish is due to the decline of predatory fishes such as Cobia (*Rachycentron canadum*). Puffer fish attacks are often reported from different parts of the world (Anon, 2012).

8.3.2.1 Species identified

The dominant species occurring in ring seines are blassop fish (*Lagocephalus inermis*). Other species occurring are Diamondback puffer (*Lagocephalus guentheri*), lunartail puffer (*Lagocephalus lunaris),* blackedged blaasop (*Arothron immaculatus) and* milkspotted puffer (*Chelenodon patoca).*

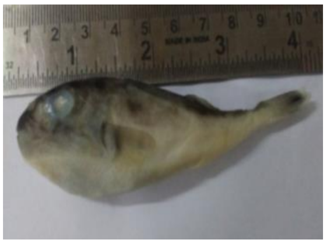
In India several authors has carried out studies in family Tetraondontidae (Russel, 1803; Day, 1878; Annandale & Jenkins, 1910; Jones & Kumaran, 1980; Talwar & Jhingran, 1991; Sujatha, 1995; Arunachalam et al., 1999; Bineesh et al., 2014; Sujatha & Padmavathy, 2015; Padmavathy et al., 2017).

Lagocephalus inermis is widely distributed in Indo-West Pacific from Algoa Bay, South Africa to the coast of Yellow Sea, East China Sea, South China Sea and Taiwan (Su & Li, 2002) and in the Western Indian Ocean and Eastern Indian Ocean (Mahapatra & Pradhan, 2016). *Lagocephalus inermis* and *Lagocephalus lunaris* are the two most common species in Bay of Bengal, comprising of 90-95% of the total catch and are mostly seen during the monsoon season (Ghosh et al., 2005; Shao et al., 2014).In India there is increasing interest in developing the *L. inermis* fishery and it has been used in dried and salted for export, or consumed fresh after proper processing (Pillai, 2009; Shao et al., 2014).

Day (1878) has reported *Chelenodon patoca* from the seas of India, and it is very common on the coromandal coast of India. Arunachalam et al., (1999), has also reported the marine pufferfish, *Chelenodon patoca* from the western ghats of India. Karunanidhi et al., (2017) has conducted studies on pufferfishes such as *Lagocephalus guentheri*, *Arothron immaculatus*, *Chelenodon patoca* from the Mandapam region.

Table 8.10 Species causing damage to ring seines

Sl.No	Family	Scientific name	Common name
1	Tetraondontidae	*Lagocephalus inermis*	Blaasop fish
2	Tetraondontidae	*Lagocephalusguentheri*	Diamondback puffer
3	Tetraondontidae	*Lagocephalus lunaris*	Lunartail puffer
4	Tetraondontidae	*Arothron immaculatus*	Blackedgedblaasop
5	Tetraondontidae	*Chelenodon patoca*	Milkspotted puffer



Lagocephalus inermis

Lagocephalus guentheri

Lagocephalus lunaris

Arothron immaculatus

Chelenodon patoca

Plate.7 Species of pufferfishes causing damage in ring seines

8.3.2.2 Catch loss in different categories of ring seines due to pufferfish bite

Catch loss/ unit due to Pufferfish bite during pre-monsoon

During pre-monsoon season, in LMRS a total of 3 times the pufferfish bite was noticed which resulted in an average catch loss of approximate 33kg of fishes and the percentage loss estimated is 4.84%. Similarly in SMRS-I fishers reported only 1 instance of pufferfish bites during this period which resulted in a catch loss of approximately 9kg of fishes and had a loss of 7.31%. In SMRS-II the number of pufferfish bites noticed was thrice which resulted in an average catch loss of 22kg and which was estimated to be 17.76% of loss. Thus the highest catch loss was reported in SMRS-II and the lowest was observed in LMRS during the pre-monsoon season due to the pufferfish bite (Table 8.11).

Table 8.11 Catch loss during pre-monsoon season

Types of ring seines	No. of pufferfish bites	Average catch loss approximate. (kg)	Percentage catch loss
LMRS	3	33	4.84
SMRS-I	1	9	7.31
SMRS-II	3	22	17.76

Catch loss/ unit due to Pufferfish bite during monsoon

During monsoon season, in LMRS a total of 8numbers of bites by pufferfish were noticed which resulted in an average catch loss of approximate 152kg of fishes and the percentage loss estimated is 13.16%. Similarly in SMRS-I fishers reported 4 number of attacks during this period which resulted in a catch loss of approximately 40kg of fishes and had a loss of 8.01%. In SMRS-II the number of attack noticed was 6 times which resulted in an average catch loss of 114kg of fishes and which was estimated to be 19.11% of loss. Thus the highest catch loss was reported in SMRS-II and the lowest was observed in SMRS-I (Table 8.12).

Table 8.12 Catch loss during monsoon season

Types of ring seines	No. of pufferfish bites	Average catch loss approximate. (kg)	Percentage catch loss
LMRS	8	152	13.16
SMRS-I	4	40	8.01
SMRS-II	6	114	19.11

Catch loss/ unit due to Pufferfish attack during post-monsoon

During post-monsoon season, in LMRS a total of 8 numbers of bites by cetaceans were noticed which resulted in an average catch loss of approximate 168kg of fishes and the percentage loss estimated is 17.55%. Similarly in SMRS-I fishers reported twice the pufferfish bites during this period which resulted in a catch loss of approximately 43kg of fishes and had a loss of 16.79%. In SMRS-II the number of pufferfish bites noticed was 6 times which resulted in an average catch loss of 128kg of fishes and which was estimated to be 13.35% of loss. Thus the highest catch loss was reported in LMRS and the lowest was observed in SMRS-II (Table 8.13).

Table 8.13 Catch loss during post-monsoon season

Types of ring seines	No. of pufferfish bites	Average catch loss approximate. (kg)	Percentage catch loss
LMRS	8	168	17.55
SMRS-I	2	43	16.79
SMRS-II	6	128	13.35

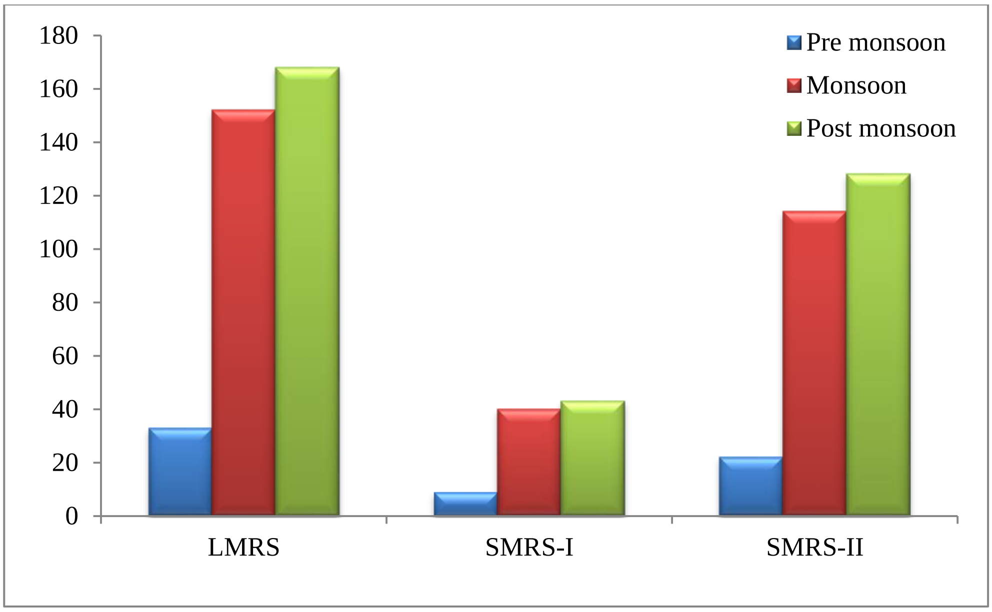


Fig.8.4 Catch loss due to pufferfish bites in different seasons

Plate.8 Pufferfish depredation

8.3.2.2.1 Economic evaluation of catch loss/instance due to pufferfish bite

When catch loss was estimated in terms of value it was observed that LMRS had highest loss of money of Rs.20,160 during the post-monsoon season, followed by monsoon (Rs.18,240) and pre-monsoon (3,960). In SMRS-I the loss was maximum (Rs.5,160) during the post-monsoon season, followed by monsoon (Rs.4,800) and pre-monsoon (Rs.1,080). In SMRS-II, the loss was maximum (Rs.15,360) during post-monsoon, followed by monsoon (Rs. 13,680) and pre-monsoon (Rs.2,640). Thus a total loss of Rs.42,360, Rs.11,040 and Rs.31,680 occurred in LMRS, SMRS-I and SMRS-II respectively. Comparing the different categories highest loss of Rs.20,160 occurred in LMRS during post-monsoon season and lowest value of Rs.1,080 occurred in SMRS-I during pre-monsoon period.

Table 8.14 Economic loss due to fish loss

Type of ring seines	Pre-monsoon (Rs)	Monsoon (Rs)	Post-monsoon (Rs)	Total (Rs)
LMRS	3960	18240	20160	42360
SMRS-I	1080	4800	5160	11040
SMRS-II	2640	13680	15360	31680

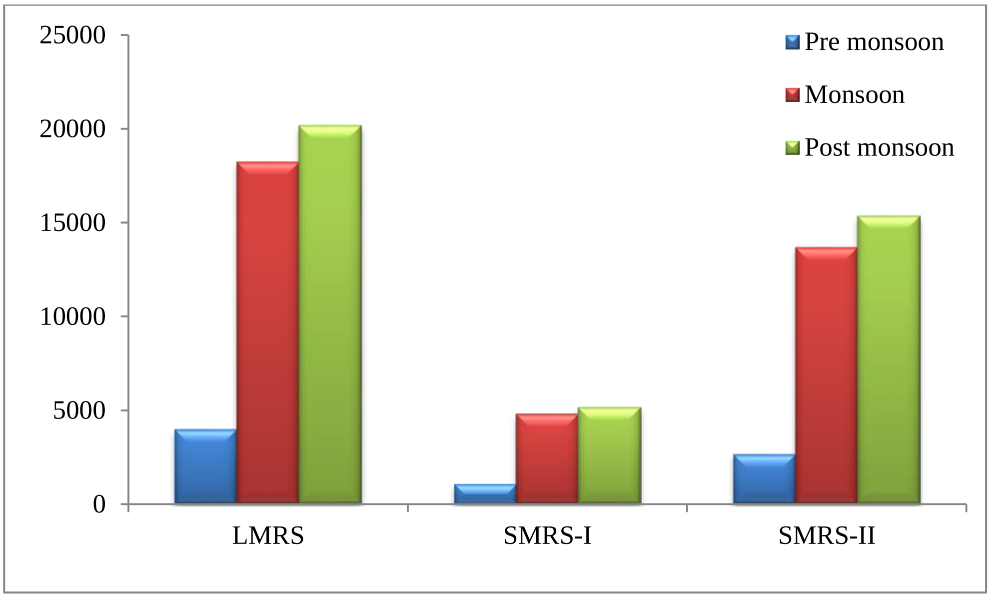


Fig.8.5. Catch loss in terms of value in different categories

8.3.2.3 Fishing gear damage due to puffer fish bite

To estimate the loss due to fishing gear damage due to pufferfish bite in different categories of ring seines, different parameters such as type of hole and diameter, number of holes, area of webbing replaced, weight of webbing needed to replace the damage portion and the cost of webbing was calculated. The holes were classified only as small (<20cm).

Due to pufferfish bites in LMRS an average of 53kg of webbings are replaced annually. In SMRS-I in a year an average of 25kg of webbings are replaced whereas in SMRS-II 38kg of webbings are replaced. Pufferfish bites was maximum reported during the monsoon and post-monsoon season.The number of holes/ tears ranged from 100-300 in a single incident and hole diameter ranged from 8-20cm. The average number of webbings replaced in LMRS is 53kg, in SMRS-I is 25kg and SMRS-II is 38kg

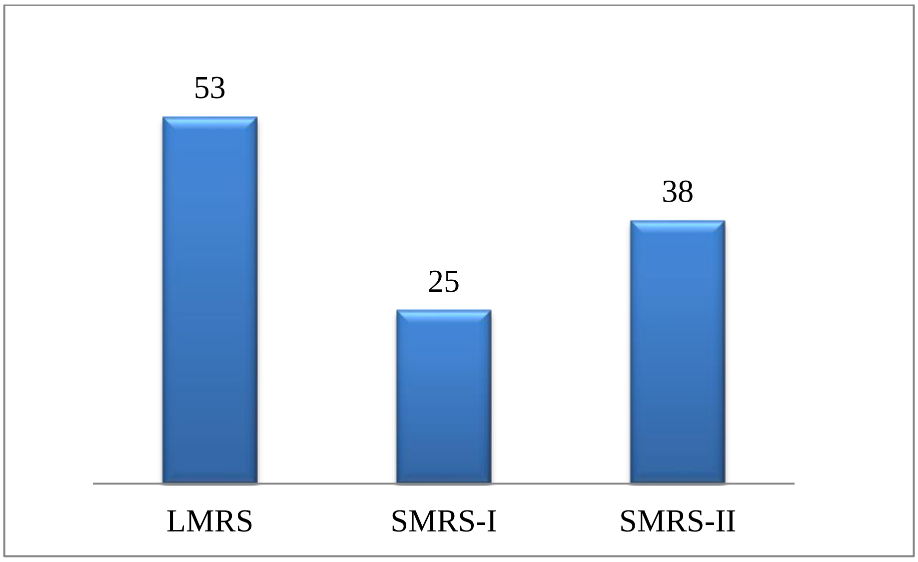


Fig. 8.6. Average webbing lost annually in different categories of ring seines

Plate.9 a. The hole occurred due to pufferfish bite; b. the damage area been replaced by fresh piece of webbing

8.3.2.3.1 Economic evaluation of gear loss due to pufferfish bite

Economic loss due to fishing gear damage due to pufferfish bite in LMRS

During the study period there were 5235 small holes observed due to pufferfish bite and the area needed to replace the small holes (<20cm) was 3490m^2 and 52.35kg of webbing was needed. The cost of webbing to replace the small holes was Rs.27,557 (Table 8.15).

For mending the gear 6 mandays are required. The average daily wage is Rs.800 /person. Hence the cost of repair was estimated to be Rs.4,800. Thus a total cost of Rs.32,357 was estimated to occur due to gear damage alone annually. In addition there will be a loss of fishing days which is estimated to be 0-20,00,000 per vessel per year.

Table 8.15 Economic loss due to gear damage in LMRS

Type of hole and diameter		Number of holes	Area of webbing replaced (m^2)	Weight of webbing (kg)	Cost of webbing (Rs.)
Small	<20 cm	5235	3490	52.35	27557

Economic loss due to fishing gear damage due to puffer fish bite in SMRS-I

In SMRS-I there were 2412 small holes observed and the area needed to replace the small holes (<20cm) was 1608m^2 and 24.12kg of webbing was needed. The cost of webbing to replace the small holes was Rs.19,995 (Table 8.16). For mending the gear 3 mandays are required. The average daily wage is Rs.800 /person. Hence the cost of repair was estimated to be Rs.2,400. Thus a total cost of Rs.22,395 was estimated to occur due to gear damage alone annually. In addition there will be a loss of fishing days which is estimated to be 0-3,00,000 per vessel per year.

Table8.16 Economic loss due to gear damage in SMRS-I

Type of hole and diameter		Number of holes	Area of webbing replaced (m^2)	Weight of webbing (kg)	Cost of webbing (Rs.)
Small	<20 cm	2412	1608	24.12	19995

Economic loss due to fishing gear damage due to pufferfishbite in SMRS-II

In SMRS-II there were 3795 small holes observed and the area needed to replace the small holes (<20cm) was 2530m^2 and 37.95kg of webbing was needed. The cost of webbing to replace the small holes was Rs.31,460 (Table8.17). For mending the gear 4.5mandays are required. The average daily wage is Rs.800/person. Hence the cost of repair was estimated to be Rs.3,600. Thus a total cost of Rs.35,060 was estimated to occur due to gear damage alone annually. In addition there will be a loss of fishing days which is estimated to be 0-9,00,000 per vessel per year.

Table 8.17 Economic loss due to gear damage in SMRS-II

Type of hole and diameter		**Number of holes**	**Area of webbing replaced (m^2)**	**Weight of webbing (kg)**	**Cost of webbing (Rs.)**
Small	<20 cm	3795	2530	37.95	31460

8.3.3 Jellyfish entry

Jellyfish are free-swimming marine animals occurring from the surface to the deep sea with a gelatinous umbrella-shaped body and trailing tentacles and they can deliver a painful sting that could prove fatal in some cases. The umbrella shaped body pulsates for locomotion, while the stinging tentacles are used to capture prey by emitting toxins. Jelly fish capture is another nuisance in the fishing industry and during the study about 82% fishers reported jellyfish interaction. It is reported that several hundreds of jelly fish enter along with the catch into the gear. The fishermen had to sometimes intentionally give up the entire catch to prevent heavy damage of the net. They sometimes cut portions of the net inorder to release the jellyfish into water fearing random tearing of the net.

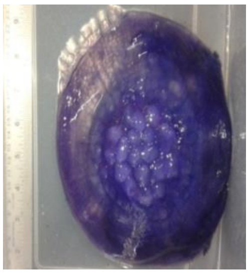
8.3.3.1 Species identified

The major species identified are *Netrostoma setouchina, Chrysaora hysoscella, Chrysaora caliparea, Pelagia noctiluca, Rhizostoma pulmo* and *Cyanea lamarckii*, *Chrysaora hysoscella* causes heavy sting when coming in contact with the body and when it enters the net this species is mixed up with the catch the fishers fully releases the catch back to the sea. Jelly fish occurrence is more during the month of September-October and dominance of species (*Netrostoma setouchina*) leads to the retraction of other species like *Rhizostoma pulmo, Pelagia noctiluca, Chrysaora caliparea* and *Chrysaora hysoscella.* When jelly fish is occurrence is noticed by the fishers they do not encircle the catch even if the shoal is seen and they return back to the shore which results in loss of fuel.

The compass jellyfish *Chrysaora hysoscella* is a saucer shaped marine invertebrate with yellowish white colour with brown markings which are found in Indian waters. *Chrysaora caliparea* was described by Reynauld (1820) from specimens observed in India (Pondichery).*C. caliparea*, is one of the most abundant medusae species in India and an important predator in the coastal waters of Bay of Bengal (Kanagaraj et al., 2011). *Pelagia noctiluca* is widely distributed in warm waters and also seen in temperate waters. The barrel jellyfish, *Rhizostoma pulmo* is described as one of the commonly found jellyfishes on the South- Goan coast of India (Rastogi et al., 2017). The blue jellyfish/ bluefire jellyfish (*Cyanea lamarckii*) are clear jellyfish which glows in dark waters and mostly found near the shores.

Table 8.18 Species of jellyfish causing damage to ring seines

Sl.No	Family	Scientific name	Common name
1	Cepheidae	*Netrostoma setouchina*	Crown jellyfish
2	Pelagiidae	*Chrysaora hysoscella*	Compass jellyfish
3	Pelagiidae	*Chrysaora caliparea*	-
4	Pelagiidae	*Pelagia noctiluca*	Purple- striped jellyfish
5	Rhizostomatidae	*Rhizostoma pulmo*	Barrel jellyfish
6	Cyaneidae	*Cyanea lamarckii*	Blue jellyfish

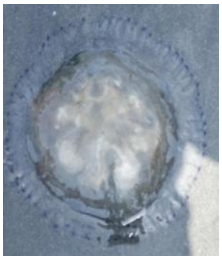


Netrostoma setouchina

Chrysaora caliparea

Chrysaora hysoscella

Pelagia noctiluca



Rhizostoma pulmo

Cyanea lamarckii

Plate.10 Species of jellyfish causing damage to ring seines

8.3.3.2 Catch loss/ unit due to Jellyfish entry

During the course of study out of 240 observations taken there were 9 instances of Cnidarian groups entering the net along with the target fish. This was during July, August, September and October. The fishermen lowers the net and allows the jellyfish to escape to prevent tearing of net. This results in loss of targeted fish shoal and fishermen move to fresh grounds.

Table 8.19 Number of incidence of jellyfish entry in different categories of ring seines

Types of ring seine	No. of incidents of jellyfish entry
LMRS	1
SMRS-I	5
SMRS-II	3

8.3.4 Ambassis entanglement

Ambassis is a genus of fish in the family Ambassidae which includes fish known commonly as glassies, perchlets, and common glassfishes. Entanglement of Ambassis species is another problem faced by fishermen operating large meshed ring seines (*thanguvala*) during the monsoon and post-monsoon season. Twenty five percent fishers had reported this problem during the study. The large mesh ring seines usually target sardines and mackerel. When Ambassids are gilled/entangled it requires lot of time and labour for removing each fish from the net. There are no reports of entanglement in small meshed ring seines (*Choodavala*) (Edwin, 1997b).

8.3.4.1 Species identified

Ambassis gymnocephalus and *Ambassis ambassis* are the two common species found entangled in the ring seines. Ambassis are species which are found widely in the Indo-Pacific region, with species in fresh, brackish and marine waters. Several authors have studied on Ambassis species in Indian waters (Raman et al., 1975., Talwar & Jhingran, 1991). Seven species of the glassfish genus Ambassis occur in brackish to marine habitats of the western Indian Ocean, mostly along the sandy shores, mangrove stands and in estuaries (Anderson & Heemstra, 2003). These species are having less commercial importance and are mostly used in aquarium trade and otherwise used as baits, dried fish or as fertilizers in India (Talwar & Jhingran, 1991., Anderson & Heemstra, 2003).

Table8.20 Species of ambassids causing damage in ring seines

Sl.No	Family	Scientific name	Common name
1	Ambassidae	*Ambassis gymnocephalus*	Bald glassy perchlet
2	Ambassidae	*Ambassis ambassis*	Commersons glassy perchlet

Ambassis gymnocephalus

Ambassis ambassis

Plate.11 Species of ambassids causing damage to ring seines

8.3.4.2 Catch loss/ unit/ incident of Ambassis entanglement

During the course of study there were 8 instances of ambassis entanglement reported in the LMRS. This was during July, August, September and October. The fisherman lowers the net and allows the jellyfish to escape to prevent tearing of net. This results in loss of targeted fish shoal and fishermen move to fresh grounds.

Table8.21Number of incidence of ambassis entanglement in different categories of ring seines

Types of ring seine	**No. of incidents of ambassis entanglement**
LMRS	8
SMRS-I	0
SMRS-II	0

8.3.4.3 Economic evaluation of loss for each incident of Ambassis entanglement

The economic loss estimated for the ambassis entanglement showed that the cost of disentanglement ranged from 10,500-14,000. The loss of fishing days was Rs.3,31,250 (average income/day x No. of days). So a total loss of 3,43,500 was been estimated.

8.3.5 Total estimated economic loss due to interaction of aquatic organisms

From the above results it was found that four categories of aquatic organisms such as cetaceans, pufferfishes, jellyfishes and ambassis are causing menace in ring seines. From that the total economic loss was calculated and the total loss occurring in LMRS is estimated to be Rs.5,75,640. In SMRS-I the total loss is estimated to be Rs.1,18,936. In SMRS-II the total loss is estimated to be Rs.1,25,988.

Table 8.22Total economic loss in different categories of ring seines

Types		Cetaceans	Pufferfish	Jellyfish	Ambassis	Total
LMRS	Catch loss	51569	42360	-	343500	5,80,599
	Gear loss	110813	32357	-		
SMRS-I	Catch loss	13473	11040	-	-	1,29,355
	Gear loss	82427	22395	-	-	
SMRS-II	Catch loss	7719	31680	-	-	1,35,587
	Gear loss	61128	35060	-	-	

8.4 Conclusion

From the study it was estimated that the average weight of webbing replaced due to interaction/ depredation of aquatic organisms in a year in was highest in LMRS (233kg), followed by SMRS-I (115kg) and SMRS-II (105kg).Total economic loss in ring seines due to interactions/depredation was found highest in LMRS (Rs.5,80,599) followed by SMRS-II (Rs.1,35,587) and SMRS-I (Rs.1,29,355).

One of the interventions to reduce the dolphin attacking ring seines is the use of acoustic deterrent devices such as pingers. Pingers are often referred to as acoustic alarms, as they are designed to alert marine mammals of the presence of nets without causing pain or damage to the animal's auditory system (Kraus, 1999). Ketten (1998) has given a thorough review on different types of acoustic devices to deter mammals. In European Union, the use of pingers has become mandatory to limit the cetacean bycatch (Culik et al., 2001).The standard pinger emits a signal of 10kHz (with harmonics to at least 60kHz) with a source level of 132 dB re 1 micro Pascal at 1 m, which is within the hearing range of most cetaceans and pinnepeds (Reeves et al., 1996; Edwin et al., 2017). In order to avoid damage to cetacean fishes in net ICAR-CIFT introduced pingers in Kerala. During the study from a total of 44 fishing operations reduction of marine mammal entanglement and depredation of the target fish caught was seen (Edwin et al., 2017). Hence acoustic pingers can be fitted in the bunt region of the ring seines where heavy attack is noticed.

Another measure to reduce the puffer fish attack is the use of stronger netting material such as UHMWPE (Ultra-high-molecular weight polyethylene) for construction of bunt portion of ring seines. UHMWPE is three times stronger than nylon of equal dimension and its abrasion resistance is also very good (Thomas & Edwin, 2012), which can prevent nets damaged due to bites. Special escape panels (Madina panels)which are sections of fine mesh prevents dolphins from becoming entangled in the gear (Ben-Yami, 1994), can also be experimented in the Indian conditions.

Blooms of large gelatinous zooplanktons such as jellyfishes are increasing frequently in global scenario as a result of eutrophication, species introduction, climate change and other factors (Mills, 2001; Purcell et al., 2007; Richardson et al., 2009; Purcell, 2012; Boero, 2013; Cruz-Rivera & El-Regal, 2016). The jellyfish blooms are causing very much nuisance to ring seine fishers and hence studies should be undertaken regarding the frequent occurrence of different kinds of jellyfishes which may provide key information on the reasons for consequence of these changes. Further studies should be conducted to use these jellyfishes which can be converted into useful byproducts. Since ambassis entanglement is reported only in LMRS, these species shoal should be carefully avoided by the fishers when it is observed in the echosounders. It is the only possible way to reduce the loss due to ambassis entanglement.

In Kerala, non-motorized/motorized traditional fishing vessels play a major role in ensuring livelihood of the fisher folk. The interaction of aquatic organisms and pelagic fishery has been a major issue in this small scale sector. Depredation by cetaceans and puffer fish is a growing problem in other fishing gears also, that has serious economic implications for fisheries. The loss incurring due to interactions can be mitigated by using some of the measures mentioned here. In-situ underwater studies on the behavior of the cetaceans and other species that depredate the catch, can help in developing suitable interventions to reduce the menace caused by these species in the Indian waters.

CHAPTER 9
SUMMARY & RECOMMENDATIONS

SUMMARY & RECOMMENDATIONS

9.1 SUMMARY

Ring seines are one of the most important gears operated in Kerala for the exploitation of pelagic resources and widely accepted among the traditional fishers. Ring seines rapidly spread in the south west coast of India among traditional fishers and so the studies in such an important sector are very relevant today. Under the doctoral programme studies were conducted on the different categories of ring seines and their growth rate, diversity of species landed, bycatch and juvenile incidence and depredation and menace caused by other aquatic organisms and the changing pattern of species landed in ring seine fishery. The work done can be summerized as follows:

- In the study area three categories of ring seines were found operating viz; large meshed ring seines (LMRS), small meshed ring seine type I (SMRS-I) and small meshed ring seine type II (SMRS-II) based on the length of the gear and the depth of operation.The catch per unit effort (CPUE) was observed highest in LMRS and lowest in SMRS-II. The growth rate showed a negativepattern in all the three categories of ring seines and the instability calculated showed that SMRS-II was the unstable when compared to LMRS and SMRS-I.

- Among the 86 species of fish recordedfrom three categories of ring seines ofwhich 47% was pelagic and 53% was demersal species during the study period. As per IUCN none of the species were found vulnerable. The high values of biodiversity indices indicates presence of non targeted species in the catch of small meshed ring seines (SMRS I & II).

- Since 2002 oil sardine dominated ring seine landing, following mackerel, anchovies and prawns.Dominance of oil sardine is expected to continue in the coming years as per Markov chain analysis conducted.

- It was observed that the highest quantity of bycatch occured in SMRS-I followed by SMRS-II and LMRS. This indicated that the bycatch incidence is more in 10mm mesh size which operates near to the shore.

- Juvenile incidence studies for fifteen commonly occurring species in all categories of ring seines showed that the juveniles occurred in all categories of ring seines and highest was observed in SMRS-II (37.22 %) followed by SMRS-I (29.35%) and LMRS (13.60%).

- Catch loss due to the depredation/ interaction of aquatic organisms with ring seines was mainly by attack of cetaceans, pufferfish bites, jelly fish blooms and entanglement of ambassids. Total economic loss in ring seines due to interactions/depredation was found highest in LMRS followed by SMRS-II and SMRS-I.

9.2 RECOMMENDATIONS

- In the light of the above observations a seasonal ban for small meshed ring seines during pre monsoon season is recommended due to the high occurrence of non targeted catch and juvenile incidence.

- The depth of operation of SMRS-II is 8-12 meters causing heavy incidence of juveniles. The operational depth of ring seines may be increased beyond 20 meters

- Special escape panels, stronger netting materials and use of deterrent devices may help to reduce loss in ring seines by depredation

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