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FOOD AND GEAR LOSS FROM SELECTED GILLNET AND TRAMMEL NET FISHERIES OF INDIA

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Motorized gillnetters at Visakhapatnam Harbour, India. © FAO/ ICAR-CIFT.

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PREPARATION OF THIS DOCUMENT

This document presents information on loss and waste in gillnet and trammel net fisheries in India. It is based on the final report of a study implemented by the Central Institute of Fisheries Technology (CIFT) of the Indian Council of Agricultural Research in collaboration with Integrated Coastal Management (ICM), India, a development consultancy firm. The study was conducted from October 2016 to March 2018 and funded by FAO as part of the Food Loss Assessment and Waste Reduction Programme. It was a follow-up to a workshop on food loss organized by FAO and ICAR–CIFT in Cochin, India, in April 2015, which indicated that significant fish loss was occurring in gillnet and trammel net fisheries.

This document was prepared by Venkatesh Salagrama of ICM. Dr E. Vivekanandan, Consultant, Bay of Bengal Programme Inter-Governmental Organization, India provided technical guidance to the research team during the implementation of the study. Dr Yvette Diei-Ouadi, Products, Trade and Marketing Branch (FIAM), Fisheries and Aquaculture Department, FAO, managed the support for the study, and provided technical backstopping. Ansen Ward (FIAM), Susana Siar, and Pingguo He, Fishing Operations and Technology Branch, Fisheries and Aquaculture Department, FAO, assisted in the preparation of the study report. Grateful appreciation is given to Gloria Loriente, FAO, for the professional work in the layout design and publishing of this document.

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ABSTRACT

This document is based on an assessment of fish and fishing gear loss from selected gillnet and trammel net fisheries of India. It presents information on the types, causes and levels of losses, as well as technological, social, environmental and policy options to reduce losses from fishing and post-harvest operations.

A secondary data review provided a preliminary understanding of fish and gear losses in India. Data from state governments, fishers cooperative societies, and community centres was used to address some knowledge gaps. Research teams undertook primary data collection in 12 locations, and 583 fishing vessels were surveyed. Respondents in group and key informant interviews included vessel captains, crew, fish vendors and auction agents. Women respondents were interviewed where available.

The study found that gillnet fisheries were characterized by sizeable losses of both fish and gear, with a number of causes being highlighted. The combined loss of fish and nets amounted to almost one third of a motorized vessel owner's income, and was significantly higher than the household's expenditure on fishing, household maintenance, quality-of-life costs (healthcare, etc.), loan servicing, or leisure activities.

Conclusions seek to locate the fish and gear losses in the wider fisheries and macroeconomic context, and emphasize the need to address them as part of broader and holistic development and management agendas. This publication will be of interest to technical specialists and extension agents concerned with loss and waste prevention and reduction, and to those wishing to learn more about the topic and conduct similar research.

CONTENTS

ANNEXES

ABBREVIATIONS AND ACRONYMS

ALDFG	abandoned, lost or otherwise discarded fishing gear
DAHDF	Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture
DOF	Department of Fisheries
FIAO	Fishing Operations and Technology Branch (FAO)
FIAM	Products, Trade and Marketing Branch (FAO)
FRP	fibreglass reinforced plastic
GPS	Global Positioning System
hp	horsepower
ICAR–CIFT	Indian Council of Agricultural Research – Central Institute of Fisheries Technology
ICM	Integrated Coastal Management (consultancy firm based in India)
IOTC	Indian Ocean Tuna Commission
INR	Indian Rupee (INR 63 = USD 1, in 2018)
IUU	illegal, unreported and unregulated (fishing)
kg	kilogramme
LOA	length overall (of fishing vessel)
MCS	monitoring, control and surveillance
m	metre
mm	millimetre
NGO	non-governmental organization
nm	Nautical miles (1 nm=1.852 km)
NRIFSF	National Research Institute of Far Seas Fisheries
PA	polyamide
SSF	small-scale fisheries
USD	United States dollar
VGGT	Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security
VGSSF	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication
VHF	very high frequency

1. INTRODUCTION

The loss of fish during fish capture and landing has significant food-security implications, besides affecting the sustainability of fisheries, fishing economies, and fisheries-based livelihoods. The existence of sizeable losses of fish and fishing gear is acknowledged in many fisheries globally; however, the pattern and scale of food waste in fishing activities remain poorly understood.

The Fishing Operations and Technology Branch (FIAO) and the Products, Trade and Marketing Branch (FIAM) of FAO's Fisheries and Aquaculture Department implemented a programme to understand and address food loss and waste reduction in the whole fish supply chain. This involved developing a methodology to estimate the loss and wasted resources in fishing operations; applying it in selected countries; and identifying appropriate management and technological options to reduce losses in selected countries. As a beginning, the programme focused on gillnetting, a major fishing method in tropical and subtropical fisheries.

In India, FIAO collaborated with the Indian Council of Agricultural Research – Central Institute of Fisheries Technology (ICAR–CIFT) to implement the case study: Assessment of Fish and Gear Loss from Selected Gillnet and Trammel Net Fisheries of India and the Socio-Economic Implications of Losses on the Fishers' Livelihood. The objectives of the case study were:

- Estimate, in qualitative and quantitative terms, the fish loss and gear loss from selected gillnet and trammel net fisheries in India.
- Identify the potential for refinement of fish loss estimation methodology.
- Suggest technological, social, environmental and policy options to reduce loss of fish from fishing and post-harvest operations up to the first point of sale.
- Assess socio-economic implications of the losses on fishers' livelihoods.

ICAR-CIFT implemented the case study in the period from October 2016 to March 2018, undertaking technical and quantitative assessment of the fish and gear losses, in partnership with Integrated Coastal Management (ICM), a private sector development firm, which carried out the socio-economic assessment of the losses. Dr E. Vivekanandan, Consultant, Bay of Bengal Programme Inter-Governmental Organization, India, acted as advisor to the study from its inception through to its implementation and completion.

The CIFT and ICM reports of the India case study formed the basis of this publication. This report is targeted at technical experts and decision makers in the South Asia region and, more generally, those with an interest in gillnet fisheries. It aims to contribute to appropriate policies and national development plans linked to: strengthening small-scale fishers' food and nutrition security and livelihoods; improving their capacity to reduce food loss and protect their health; and strengthening the natural resource base.

2. BACKGROUND ON GILLNET FISHERIES AND VALUE CHAINS IN INDIA

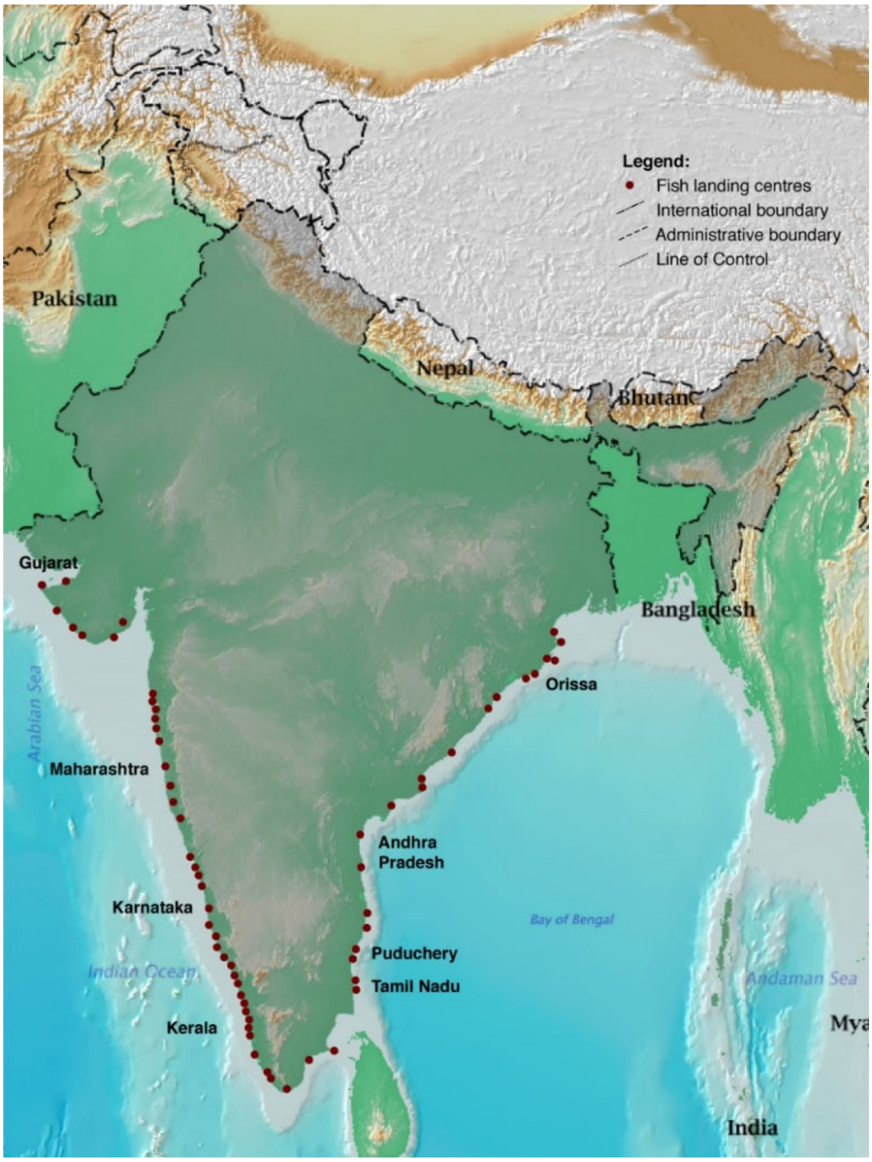
In India, gillnet and trammel net fisheries are a major constituent of capture fisheries. Historically, records of the use of gillnets in Indian fisheries date back to at least the latter half of the nineteenth century. Despite having undergone several changes over the century-and-a half of their existence, and despite competition from new fishing methods and external factors, gillnets have proved resilient as the mainstay of small-scale fisheries, and acquired a cultural importance among fishers similar to that a plough in farming communities. The economic importance of gillnets rests on two factors. First, there is their versatility in terms of supporting a large number of livelihoods in almost every kind of aquatic ecosystem; their ubiquity extends to areas where few other livelihood options exist, especially for the resource-poor. Second, gillnets are the chief source of fish supplies to the urban markets, which have grown so fast over the last three decades as to become the mainstay of the small-scale fishing economy.

Currently, gillnets provide livelihoods for an estimated 0.86 million people in fisheries, contribute significantly to fish catches, incomes and food security, as well as the local and national economy. Of the country's fishing fleet of 194 490 vessels in 2010, gillnet vessels constituted 67 percent, consisting of 19 850 mechanized, 61 873 motorized, and 49,435 non-motorized vessels (Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, 2010).[1] Of the 5.04 million units of fishing annually (i.e. number of fishing operations in a year), 83 percent comprised gillnets. Figure 1 shows a map of India highlighting the important fishing locations, most of which have sizeable gillnet fisheries.

In social terms, gillnetting is an affordable activity for a majority of small-scale fishers, who can access it with relatively small investments. The prevalent practice of sharing of returns, instead of fixed wages/salaries, ensures that the income distribution in the gillnet fisheries is largely equitable. It is also in the gillnet sector that the women's role remains more pronounced and mainstream. The informal settings – both physical and operational – characterizing gillnet operations help a number of poor, vulnerable, and marginalized people to make a living from their catches. These characteristics, together with their predominantly small-scale fisheries orientation, make gillnets important from a global perspective. Instruments such as the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (VGSSF) and the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT) apply more directly and immediately to the gillnet fisheries than any other fisheries in India, and any losses in this subsector have a wider relevance.

[1] In the Indian context, a fishing vessel with a wheelhouse and an inboard engine for propulsion is designated as a mechanized vessel; while those vessels fitted with outboard engines (which can be removed as and when required) for propulsion come under the motorized class. Non-motorized vessels are traditional vessels that do not use any engine power either for propulsion or for handling the gear.

Figure 1. Map of India showing important fish landing centres, January 2020



Source: Adapted from United Nations World map, 2020.
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

2.1 Gillnet fisheries in India

Table 1 shows that gillnet operations contributed more than 15 percent of the total landings in the period 2008–2012 (Sathianandan, 2013). The absence of detailed gear-wise data on the volume of landings and possible value of the gillnet catches remains a major information bottleneck to make confident assessments of the volumes and values of gillnet catches. Geographical and seasonal variations in the fishing practices and value chain actions, the involvement of a wide range of actors and marketing channels, and the informal market dynamics (including the credit–trade dependencies), compounded by the absence of regular data collection systems covering the fishery trade aspects, make it difficult to estimate the possible values and losses of gillnet catches.

Table 1. Gillnet production in India, 2008–2012

Gear type	Total landings (lakh[1] tonnes)	% of the total	Catch per unit of effort	
			kg/unit	kg/hour
Mechanized gillnet	1.92	5.48	547	17
Outboard (i.e. motorized) gillnet	3.08	8.79	76	13
Non-mechanized gear (include gillnets)	0.92	2.63	48	15
Total	**5.92**	**16.9**		

[1] 1 lakh = 100 000.
Source: Sathianandan, 2013.

2.2 Craft, gear and catch combinations in gillnet fisheries

An important characteristic of gillnets is their versatility. There exists a wide range of gillnets of varying mesh sizes for targeting different species seasonally. Table 2 summarizes the range of gillnets covered during this case study in different locations. Gillnets of varying mesh sizes are used to target different species (ranging from anchovies to rays) across different maritime states depending on the seasonality of target species (Luther *et al*., 1997; Thomas *et al*., 2005). Aside from the variations in the mesh size, there are significant differences in the length, depth, location and method of operation of these nets (surface drift, bottom-set, etc.), and the targeted species, which make the gillnet sector a very heterogeneous entity. Annex 1 provides the catch composition of gillnets in different subsectors.

Based on mesh size, gillnets can be classified into small mesh (14–45 mm) and large mesh (45–500 mm) nets. Mesh size up to 160 mm is common in the fishery. Another classification classifies nets of > 70 mm mesh size as large, those between 45 mm and 70 mm as medium, and those with mesh size below 45 mm as small (Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, 2005).

Table 2. Varieties of gillnets covered for the case study

Gillnet subsector	Location	Variety of gillnet used
Mechanized	Thoothoor, Tamil Nadu	Large mesh gillnets, for tuna (100–160 mm)
	Visakhapatnam, Kakinada, and Machilipatnam, Andhra Pradesh	Large mesh: for tuna and other large pelagics (70–150 mm)
	Veraval, Gujarat	Large mesh: for tuna and other large pelagics (130–160 mm)
Motorized multi-day	Kakinada and Machilipatnam, Andhra Pradesh	Large mesh: for seerfish, sailfish, tuna and shark (100–160 mm)
	Jaleshwar, Gujarat	Mackerel gillnet (46–56 mm)
		Pomfret gillnet (120–160 mm)
Motorized single-day	Chellanam mini-fishing harbour, Kerala	• Mackerel gillnet (48–54 mm) • Sardine gillnet (30–40 mm) • Shrimp gillnets (26–28 mm) • Pomfret gillnet (100–118 mm) • Trammel nets (inner: 50 mm; outer: 100–160 mm)
	Mangamaripeta, Andhra Pradesh	• Mackerel gillnet (40–50 mm) • Sardine gillnet (30–40 mm) • Trammel net (inner: 35–45 mm; outer: 70–120 mm)
	Kadiapatanam, Tamil Nadu	• Trammel net (inner: 40–70 mm; outer: 260 mm)
	Enayam, Tamil Nadu	• Lobster gillnet (80–160 mm)
Non-motorized	Puthuvype, Kerala	• Croaker gillnet (110–150 mm) • Crab gillnet (100–150 mm)
Non-motorized (inland reservoir fisheries)	Bhavanisagar, Tamil Nadu	• Catla gillnet (200 mm)

Source: Luther *et al.,*1997; Thomas *et al*., 2005; DAHDF, 2010.

2.2.1 Non-motorized subsector

The non-motorized gillnet subsector operates small and medium mesh gillnets, weighing 15–20 kg from *kattamarams*, plank-built canoes and dugout canoes (3.03–7.6 m length overall [LOA]). Fishing is confined to one-day operations in the coastal and nearshore waters, targeting sardine (*Sardinella longiceps*), mackerel (*Rastrelliger kanagurta*), different species of shrimp (*Penaeus monodon*, *Metapenaeus dobsoni*, *Fenneropenaeus indicus*, etc.), mullets (*Mugil cephalus*, *Liza tade*), catfish (*Arius* spp.), anchovies (*Stolephorus* spp.), crabs (*Scylla serrata*, *Portunus pelagicus*), and other species.

2.2.2 Motorized subsector

This subsector operates a variety of gillnets of all mesh sizes. Based on the size of operations, it can be classified into:

Motorized single-day vessels include plank-built canoes, dugout canoes, and *kattumaram* of 7.6–9.1 m LOA, fitted with outboard engines of up to 15 hp, for undertaking one-day fishing. These vessels carry 10–45 kg of small and medium mesh gillnets and trammel nets onboard, targeting mackerel (*Rastrelliger kanagurta*), sardine (*Sardinella longiceps*), anchovy (*Stolephorus* spp.), shrimp (*Penaeus monodon, Metapenaeus dobsoni*, *Fenneropenaeus indicus*, etc) and pomfret (*Pampus argenteus*, *Parastromateus niger*).

Motorized multi-day boats vessels, made of wood, plywood, and fibreglass reinforced plastic (FRP), of 7.6–12.1 m LOA, are fitted with 15–28 hp outboard engines. These vessels use large mesh gillnets of up to 400–900 kg for each operation, and undertake multi-day fishing lasting 3–5 days, targeting large pelagic species such as tuna (*Thunnus albacares*, *Euthynnus affinis*, *Katsuwonus pelamis*), seerfish (*Scomberomorus* spp.), sailfish (*Istiophorus* spp.), marlins (*Makaira indica*), swordfish (*Xiphias gladius*), snappers (*Lutjanus* spp.) and sharks (*Carcharhinus* spp., *Alopias* spp., *Sphyrna* spp.).

2.2.3 Mechanized subsector

The mechanized subsector employs large mesh gillnets. Vessels carry 300–3 000 kg of nets, targeting the same species as the motorized multi-day boats. The vessels (9.1–20 m LOA) are fitted with inboard diesel engines of 24–280 hp. Generally, mechanized gillnetters are built of wood, FRP or steel, and are further classified into small, medium and large.[2] Many vessels are equipped with electronic navigation and communication equipment such as Global Positioning System (GPS), echo sounders and very high frequency (VHF) transceivers. Large gillnetters are also fitted with gillnet haulers to assist the operation of the gear. They venture up to 400 nm out to the sea, and are equipped to stay there for longer, a month at a stretch.

2.3 People involved in gillnet fisheries

People dependent on the gillnet economy include the following:

2.3.1 Producers

Producers comprise the people who are directly involved in gillnet operations. They are a predominantly male group, women contributing an almost negligible proportion, confined to a few backwater and riverine fisheries. Sizeable differences exist within this group between: people working in the mechanized, motorized and non-motorized subsectors; owners and crew members; regular, part-time, and seasonal operators; and those depending on gillnets exclusively and those working in other fisheries.

[2] Small: < 12.0 m LOA; medium: 12.1–16.0 m LOA; and large: 16.1–20.0 m LOA.

2.3.2 Processors

People in this category include small-scale, traditional processors (many of them women) as well as large-scale, industrial processors and exporters. Gillnets are a major supplier of fish for drying and salting, and of lobsters for export, while trammel nets supply shrimp for export.

2.3.3 Traders

Traders in gillnet fisheries include local petty fish sellers (many women), motorcycle traders (mainly men), several trade intermediaries / fish aggregators, exporter-processors, and urban wholesalers and retailers.

2.3.4 Ancillary and supplementary workers

Ancillary workers in gillnet fisheries are the men and women working for wages or commission, but without a direct stake in the value chain. These include the transporters, processing assistants, engine mechanics, and ice and basket suppliers. **Supplementary workers** are those catering to the needs of the sector without direct involvement in the fisheries-related activities, e.g. moneylenders, grocery sellers.

2.3.5 Consumers

The consumers for the gillnet catches include a diverse range of social and economic groups. The range of species and the landing centres at which the gillnet vessels are landed mean that their catches cater to a wide range of consumers, ranging from the poorest to the most affluent sections of the society.

Each of these categories is a heterogeneous mixture of actors ranging across a wide spectrum of social and economic differences, but they are bound together in a complex web of dependence and interrelationships. Some of the factors influencing how a gillnet may be operated and its catches distributed are: caste, religion, gender, age, occupational linkages, economic dependence (the traders are as dependent on the fishers for their business as the latter are on the former for selling their catch as well as to meet their credit needs), inter- and intra-community relations (within and beyond the fishing communities), marital relations (within and across the households as well as the villages), and political affiliations.

2.4 Gillnets and fishery value chains

The wide diversity of the catches means that gillnets cater to a wide range of fishery value chains, their consumers ranging from the poorest local people to the affluent. For example, traditional consumers of dried and salted fish included several resource-poor and food-insecure groups such as the tribal communities of India. At the same time, the demand for fish by the growing urban middle-class in the country is largely met by the gillnet catches.

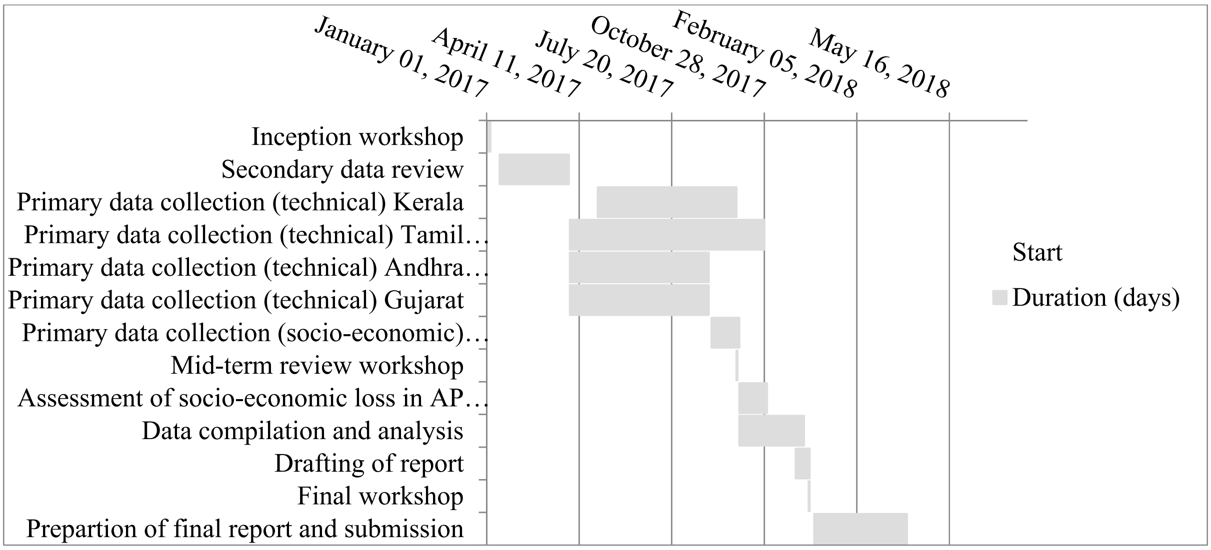
The value chains supported by gillnet fisheries include: (i) local fresh fish trade; (ii) traditional/processed trade; (iii) urban fresh fish trade; (iv) exports; and (v) fishmeal trade. Besides these, new value chains focused on some hitherto underutilized species or products or markets (e.g. jellyfish) appear from time to time, but their influence is transitory. However, they show the scope for further utilization of the gillnet catches with proper market support.

The horizontal divergence of the gillnet catch distribution is matched by its vertical differentiation along each value chain. The distance that the fish must travel before reaching the consumer determines the number of stages and intermediaries along its journey. Local fresh fish trade typically consists of just one woman trader carrying fish from the landing centre directly to the doorstep of the local consumer. In the urban and export fish value chains, fish pass through several intermediaries before reaching the consumers. The movement of fish along different value chains is also marked by differences in terms of: investments and returns; technology and infrastructure requirements; organization, communication, and distribution systems; and losses and loss-reduction strategies.

3. METHODOLOGY

The case study became operational on 18 October 2016, initially for a period of one year, subsequently extended until 31 March 2018. Chronologically, the implementation of the case study involved various activities (Table 3).

Table 3. Timeline of project activities



3.1 Field-testing and refining the questionnaire

In 2014–15, FIAO developed a hybrid methodology and questionnaire to understand food losses and waste reduction, based on FAO's ongoing work on the Informal Fish Loss Assessment Method and the Questionnaire Loss Assessment Method (FAO, 2014). In a collaborative initiative, ICAR–CIFT tested the questionnaire at five locations in India, one each in Tamil Nadu and Gujarat, and the rest in Kerala, covering 33 gillnet vessels in the mechanized, motorized and non-motorized subsectors. The field test report was presented at an expert workshop, jointly organized by FIAO and ICAR–CIFT, Estimating Food Loss and Wasted Resources from Gillnet and Trammel Net Fishing Operations, on 8–10 April 2015 in Kochi, India. The workshop helped to finalize the data collection questionnaire survey schedules (FAO, 2017). Previous post-harvest fish loss assessment studies along the Indian coast by Jeeva *et al.* (2006) and Srinath *et al.* (2008) also contributed to refining the field methodology to fit the Indian context. Annex 2 provides the final questionnaire used in the study.

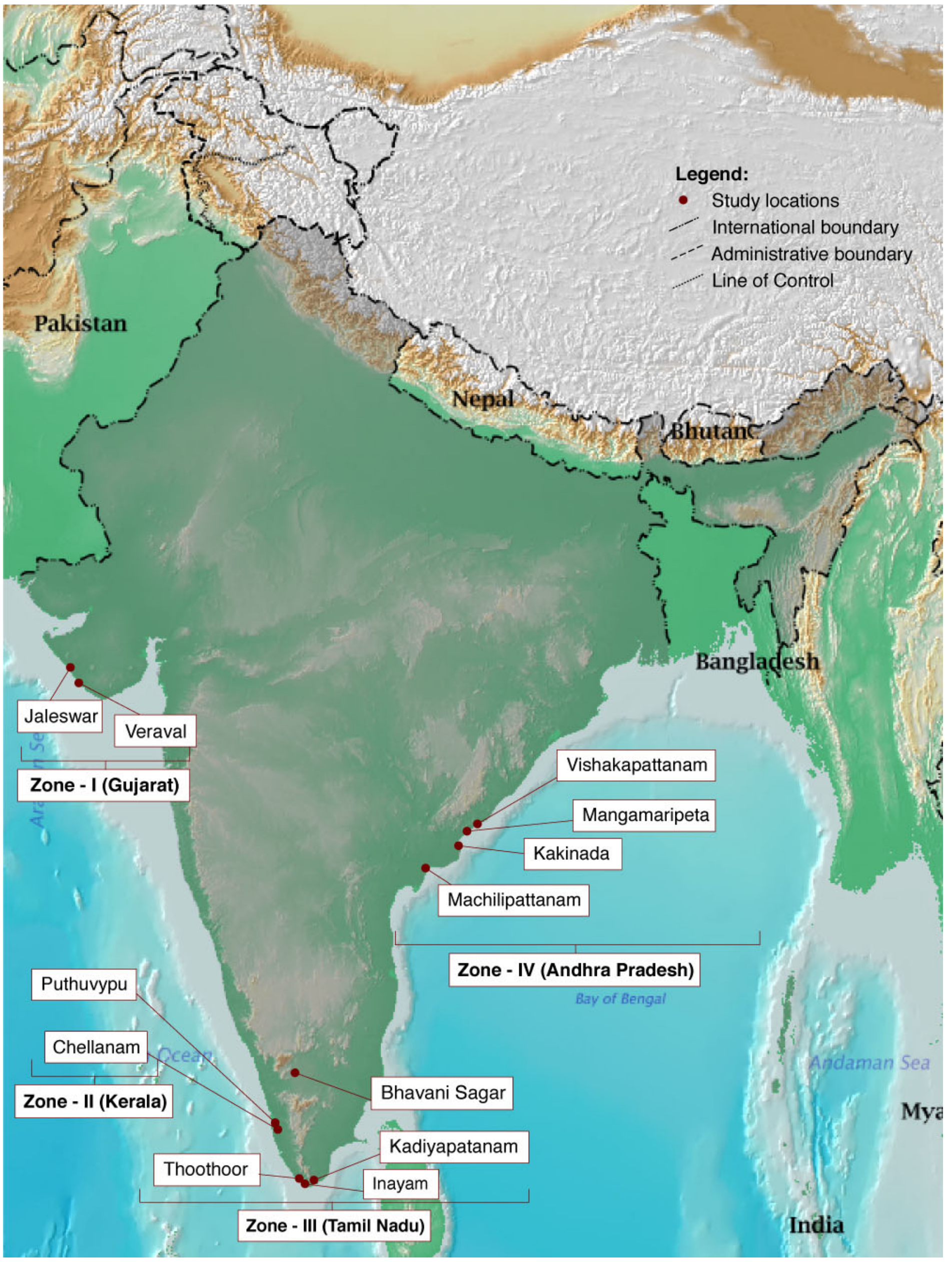
3.2 Secondary data review

A secondary data review covered reports, research articles and official publications, and provided a preliminary understanding of the fish and gear losses in India, along with the context in which they tended to occur. Operational data collected from the Department of Fisheries of the relevant state governments, fishers cooperative societies, and community centres helped to fill some knowledge gaps, while also highlighting where further gaps existed in the current understanding of the issue.

3.3 Primary data collection

Twelve field study locations were selected based on two criteria: (i) importance and scale of gillnet and trammel net fisheries; and (ii) adequate representation of the particular gillnet types where losses were likely to be significant. The field study locations were: in Gujarat: Veraval and Jaleshwar; in Kerala: Puthuvype and Chellanam mini-fishing harbour; in Tamil Nadu: Enayam, Kadiapatnam, Thoothoor and Bhavanisagar reservoir; and in Andhra Pradesh: Visakhapatnam, Mangamaripeta, Kakinada and Machilipatnam. Mechanized, motorized and non-motorized subsectors were covered in each of these locations depending on their existence in the area. Figure 2 provides a map showing the study locations.

Figure 2. Map of India showing study locations, January 2020



Source: Adapted from United Nations World map, 2020.
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Table 4 gives the details of the fishing centres covered by the study and the nature of gillnet fishery in each of the locations.

Three ICAR-CIFT-supported teams based at Cochin, Veraval and Visakhapatnam conducted the technical data collection. Each team consisted of five members (one project investigator and four trained enumerators), except in Cochin where the team had six members: three investigators, one research fellow and two trained enumerators.

For the study purposes, the fishing vessel was taken as the sampling unit. A total of 583 fishing vessels were surveyed, representing the non-motorized, motorized-single-day, motorized-multi-day, mechanized and inland non-motorized subsectors.

Table 4. Details of locations selected for loss assessment

State	Location	Subsector	Target fishery	Reasons for selection
Gujarat	Jaleshwar	Motorized multi-day	Mackerel gillnet	Motorized multi-day gillnetters predominate, with 160 vessels operating from this location.
	Veraval	Mechanized	Tuna gillnet	Veraval is a major harbour with an estimated 500 mechanized gillnetters operating from there.
Kerala	Chellanam mini fishing harbour	Motorized single-day	Gillnet and trammel net	More than 100 motorized and non-motorized gillnetters targeting sardine, mackerel, shrimp, etc. operate from this location.
	Puthuvype	Non-motorized single-day	Gillnet	Important fishing village where non-motorized and motorized gillnet and trammel net fishing is active. Selected as a representative of non-motorized gillnet fishing subsector.
Tamil Nadu	Enayam	Motorized single-day	Lobster gillnet	Major centre for lobster gillnet fishery. Selected as a representative of lobster gillnet fishery.
	Kadiapatanam	Motorized single-day	Trammel net	Trammel net fishing is predominant. Selected as a representative of a major trammel net fishing centre on the east coast of India.
	Thoothoor	Mechanized	Tuna gillnet	Representative of migratory gillnet fishers who undertake the longest fishing trips in the distant and deepest grounds with the largest nets. More than half of the 600 gillnetters based at Thoothoor operate from Cochin fisheries harbour (CFH). Both Thoothoor and CFH were selected to assess the loss assessment along different stages.
	Bhavanisagar reservoir	Non-motorized single-day	Catla gillnet	Large reservoir (7876 ha) with very high volume of fish landings. About 170 fishers operate gillnets in this reservoir.
Andhra Pradesh	Visakhapatnam	Mechanized	Tuna gillnet	A major gillnet fishing centre where mechanized, and motorized deep-sea gillnet fishing is in place. Selected for comparing tuna gillnet fishery of mechanized and motorized sector.
	Kakinada	Mechanized	Large mesh gillnet	A major fishing centre representing a wide diversity of fisheries – including gillnets and trammel nets.
		Motorized multi-day	Large and medium mesh gillnet	The largest fleet of motorized gillnetters in Andhra Pradesh operate from Kakinada.
	Machilipatnam	Mechanized	Large and medium mesh gillnets	Medium mesh gillnets are the main fishing gear at this major fishing centre.
	Mangamaripeta	Motorized single-day	Gillnets of all mesh sizes	Small-scale fish landing centre with sizeable gillnet fisheries of all varieties.

Fieldwork began with group meetings where community leaders, office holders of the fishers welfare/cooperative societies, and village leaders participated. This helped in obtaining information on the different drivers in each subsector. Key informants, i.e. people reputed to have long experience and knowledge of the gillnet operations and attendant losses in the local context, were interviewed to understand the trends in gillnet operations. Meetings with the key informants were followed by individual meetings with the individual gillnet vessel owners and crew, who formed the sampling unit. These meetings aimed to obtain more specific and detailed first-hand information on the quantitative and qualitative aspects of the losses. The respondents in each sampling unit included vessel captains, crew, fish vendors and auction agents. Women respondents, specifically fish vendors, were interviewed where available. Table 5 provides a summary list of the respondents involved in the case study.

Table 5. Summary list of respondents involved in the case study

Zone/ state	Location	Subsector	Target fishery	Respondents					
				Gillnet vessels		Category			
				P*	N*	Captain	Crew	Auctioneer	Vendor
Zone I Gujarat	Jaleshwar	Motorized multi-day	Mackerel gillnet	160	31	0	31	1	2
	Veraval	Mechanized	Tuna gillnet	500	97	27	70	1	3
		Motorized multi-day	Mackerel gillnet / tuna gillnet	290	70	10	50		
Zone II Kerala	Chellanam mini fishing harbour	Motorized single-day	Gillnets and trammel net	25	15	8	7	2	2
		Non-motorized single-day	Gillnets and trammel net	20	8	6	2		
	Puthuvype	Motorized single-day	Gillnets and trammel net	75	22	13	9	2	2
		Non-motorized single-day	Gillnets and trammel net	6	6	6	6		
Zone III Tamil Nadu	Enayam	Motorized single-day	Lobster gillnet	40	5	2	3	3	2
	Kadiapatanam	Motorized single-day	Trammel net	45	8	6	2	2	2
	Thoothoor / Cochin fisheries harbour	Mechanized	Tuna gillnet	600	60	10	50	-	-
	Bhavanisagar reservoir	Non-motorized single-day	Catla gillnet	165	31	29	2	-	2
Zone IV Andhra Pradesh	Visakhapatnam	Mechanized	Tuna gillnet	10	2	0	2	2	1
		Motorized single-day	Gillnet and trammel net	80	39	28	11		
	Mangamaripeta	Motorized single-day	Gillnet and trammel net	35	14	14	0	2	1
		Non-motorized single-day	Gillnet and trammel net	10	7	5	2		
	Kakinada	Mechanized	Tuna gillnet	10	7	2	5	2	1
		Motorized multi-day		520	55	17	38		
		Motorized single-day	Gillnet and trammel net	80	20	12	8		
	Machilipatnam	Mechanized	Tuna gillnet	102	30	2	27	2	1
		Motorized multi-day		40	11	4	7		

*P = total population and N = sample size.

Direct observations were made at the first point of sale, as the relatively short duration of the project did not permit direct measurement of the losses onboard the vessels. Information on losses was collected using the questionnaire survey format with the respondents (Annex 2). When the fishers were unable to provide quantitative data in standard units, proxy indicators or the locally appropriate units were used for conversion into standardized units such as kilograms to quantify the fish and net losses.

To assess the direct and indirect impact of gear loss on the gillnetters' fish catching potential, a separate study was conducted on the motorized mackerel gillnet fishery of Chellanam mini-fishing harbour, Kerala, and involved collection of one year's data on fish catch, gear loss, and gear replacement frequency.

3.4 Data Analyses

The weighted averages of data were calculated and used for analysis. Using R software, a non-parametric test (Kruskal–Wallis ANOVA by ranks test) was performed, followed by multiple comparisons of the Z value for different attributes that have an influence on losses. Correlation analysis was performed to understand the degree and strength of relationship between soaking time (hours) and losses by computing the Pearson's correlation coefficient using MS-Excel and R package. Annex 3 provides the statistical analyses.

3.5 Qualitative / socio-economic assessment

A socio-economic assessment was included in the design of the case study to understand the impact of losses on the life and livelihoods of the gillnet-dependent communities. Integrated Coastal Management (ICM) was contracted to undertake the socio-economic assessment in two states – Andhra Pradesh and Gujarat – over a two-week period. The ICM team undertook a separate desk review to collect information on losses from a livelihood perspective, but the review concluded by highlighting the absence of literature on the losses and their impacts. The ICM team undertook primary data collection in the same villages in the two states where CIFT had implemented the loss assessment questionnaires. Primary fieldwork villages included: Mangamaripeta, Visakhapatnam, Uppada, Kakinada and Machilipatnam in Andhra Pradesh; and Veraval and Jaleshwar in Gujarat. In addition, the socio-economic assessment also covered a number of other villages in both states to validate the findings and obtain a more in-depth understanding of the losses. A checklist (Annex 4) was used to guide information collection through informal interviews by the team of researchers.

A team of researchers from ICM undertook fieldwork in the two states. Field data gathering included group discussions followed by individual and household interviews with different gillnet actors, covering both men and women. Alongside the interviews, physical observations of the fish landing centres and markets were undertaken to assess the losses from livelihood- and value-chain perspectives. The interactions attempted to: (i) locate the gillnet losses in the broader livelihood context of the fishers; (ii) assess the causes and consequences of losses on the household economy, social development, and well-being; and (iii) explore the fishers' perspectives on appropriate loss-reduction strategies.

Given the constraints of time and logistics, the selection of informants for interview had to be random, but efforts were made to validate key data by interviewing as many people as possible. Where possible, the fieldwork was supplemented by interactions with secondary actors (research and academic institutions, government and non-governmental organizations [NGOs]) which added to and validated the data. Visits were also undertaken to non-study areas to observe the similarity in conditions and to discuss the study findings for their relevance more widely.

3.6 Workshops: inception, review and validation

The project organized three workshops: (i) an inception workshop, to refine the loss assessment methodology and develop field plans with suggestions from experts and fisher participants; (ii) a mid-term workshop, to review progress and plan the next steps; and (iii) a final, to share and discuss the key findings from the study.

4. RESULTS AND KEY FINDINGS

The project resulted in two reports, CIFT (2018) and Salagrama (2017), summarizing the key activities and outputs of the projects. This section summarizes the key findings from the two reports.

4.1 Fish losses and gear losses: definitions

Two types of fish losses were assessed; physical loss (quantity) and quality loss.

4.1.1 Fish losses

In this study, the main terms used are defined below:

Physical loss: The portion of total catch that is physically lost during pre-harvest, harvest and post-harvest stages. Physical loss is assessed at the following stages:

- **Pre-harvest loss:** The fish lost due to attack by predators while fish are caught in the net but before the net is hauled. This loss was assessed based on the quantity of partially damaged fish left in the net. Underwater observation was not feasible so it was not possible to record the loss of whole fish due to predation.
- **Harvest loss:** The fish lost when fish that were caught in the net slipped from the net during hauling.
- **Post-harvest loss:** The fish lost from when the fish was taken onboard the vessel until it reached the first point of sale. Loss due to discards was included in this category.

Quality loss: The decrease in quality attributes of fish. There is no physical loss of the fish but the potential value of the fish is reduced.

4.1.2 Gear losses

Gear losses include fishing gear that is abandoned, lost, or discarded. “Abandoned fishing gear” means fishing gear over which that operator/owner has control and that could be retrieved by them, but is deliberately left at sea due to force majeure or other unforeseen reasons. “Lost fishing gear” means fishing gear over which the owner/operator has accidentally lost control and which cannot be located and/or retrieved by them. The term “discarded fishing gear” means fishing gear that is released at sea without any attempt for further control or recovery by the owner/operator.

4.2 Key findings

There were wide variations in the losses of fish and gear incurred in different gillnet operations, which also varied across subsectors, regions and seasons. Figure 3 provides a diagrammatic summary of losses, while Figure 4 offers a sector-wise summary of the losses.

On average, the annual physical loss of fish in gillnets amounted to 4.4 percent of the total catch per vessel while the quality loss was 5–20 percent. In the mechanized and motorized multi-day subsectors, 5–10 percent of the catch landed was of low quality, unfit for human consumption. The annual physical losses in the mechanized subsector amounted to INR 588 669 (USD 9 344) per vessel. In value terms, in different subsectors, fish losses eroded 12–20 percent of the annual income of a vessel owner, and 3–13 percent of the income of each crew member. Quality losses, although significant, were not easy to calculate in economic terms on account of differences in patterns of usage, markets and market intermediaries, as well as the consumers.

On average, the annual gear loss amounted to 24.8 percent of the total gear used per vessel, involving a financial loss of INR 61 255 (USD 972) per year.

Figure 3. Summary of losses in gillnet fisheries

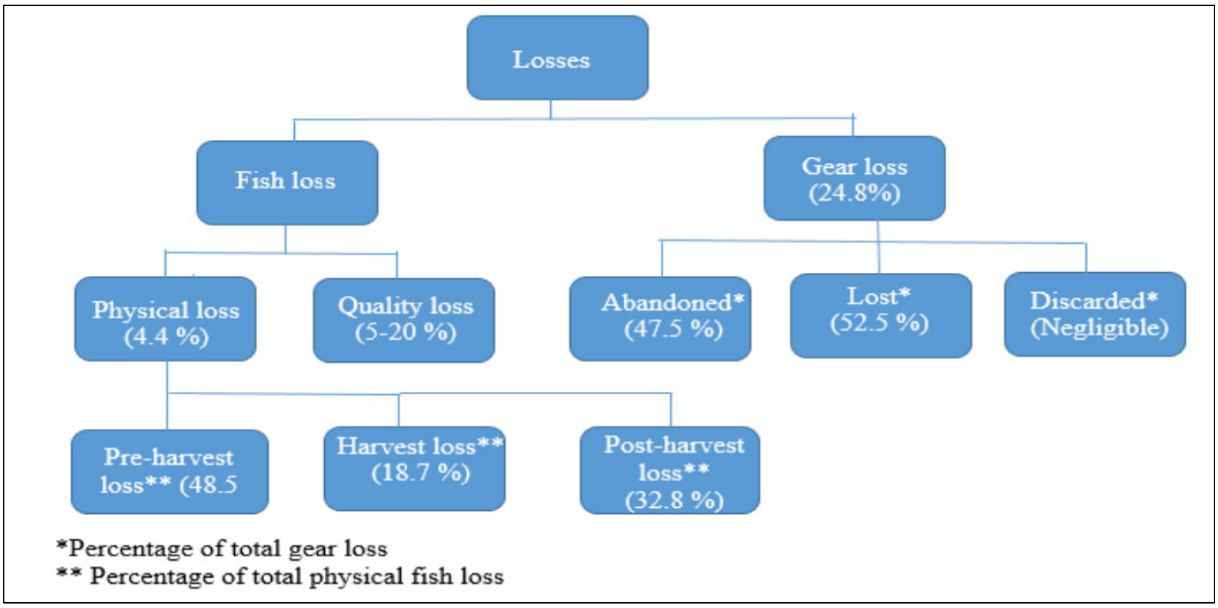
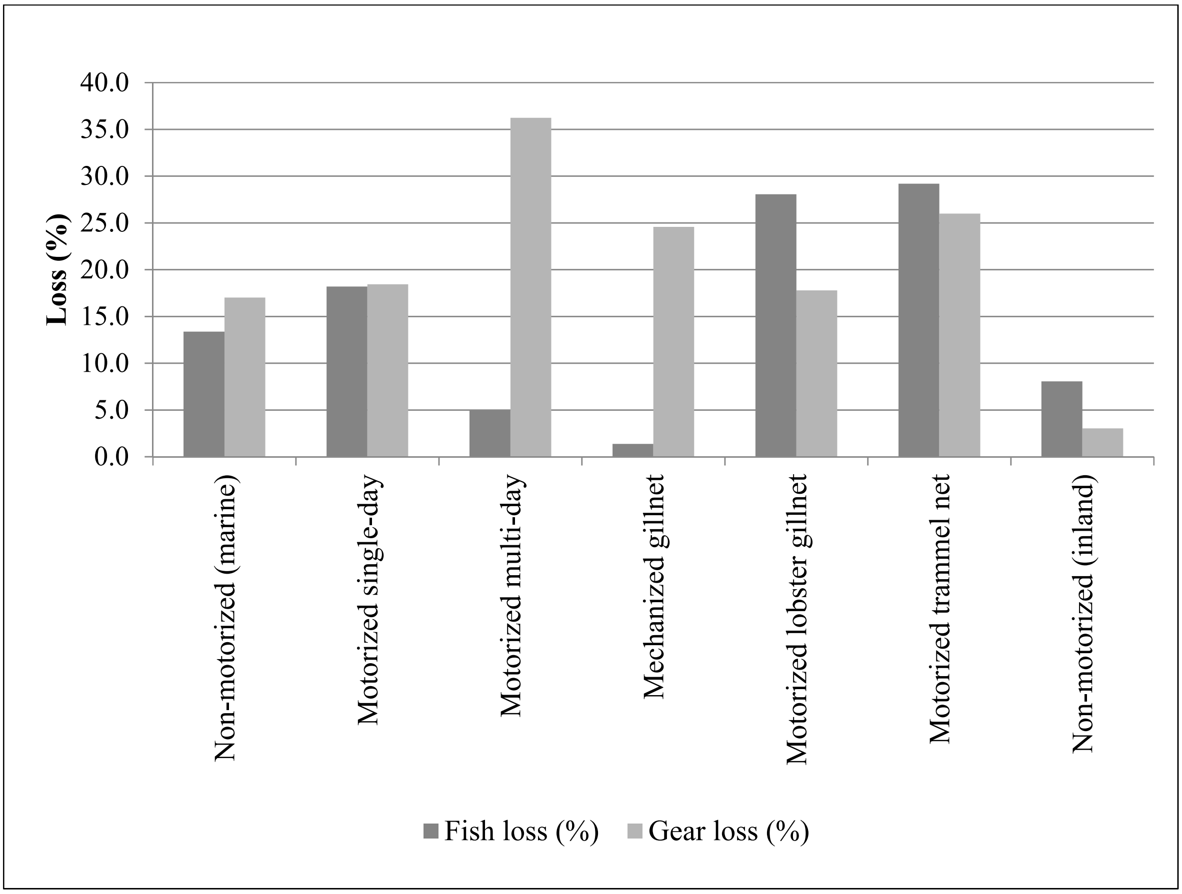


Figure 4. Sector-wise fish and gear losses in gillnet fisheries



4.3 Fish Losses in gillnet operations and their Implications

4.3.1 Physical losses

Fish losses varied significantly between fishing subsectors on account of the differences in fishing operation and target species ($H = 52.828$; $p < 0.01$). The annual loss per vessel from the mechanized subsector was 1.4 percent of the total catch while that from the non-motorized subsector was 13.4 percent. Among different nets, trammel nets incurred a loss of 29.2 percent, while lobster nets had a loss of 28.1 percent. Table 6 provides a summary of the physical fish losses in gillnet and trammel net fisheries.

Table 6. Physical fish losses in gillnet and trammel net fisheries

Annual fish loss in gillnet and trammel net fisheries							
Subsector	**Pre-harvest loss**	**Harvest loss**	**Post-harvest loss***	**Total fish loss**	**Total fish catch**	**% of total catch**	**Loss in value in INR (USD)**
(kg/vessel)							
Gillnets – marine							
Non-motorized	67±5.6	60±7.4	133±13	260±18.9	1 948±147.4	13.4	33 836 (537)
Motorized single-day	297±16	264±14.6	308±19.8	869±30.7	4 775±111.4	18.2	86 879 (1 379)
Motorized multi-day	1 102.8±30.2	412.4±19.9	164.3±54.1	1 679±68.7	33 860±781.7	5.0	167 948 (2 666)
Mechanized	735±33	140±4.5	160±11.0	1 036±34.3	76 128±2 577.5	1.4	126 345 (2 005)
Motorized lobster gillnet	174±31.8	63±11.1	418±45.5	655±61.2	2 335±259.8	28.1	98 257 (1 560)
Trammel net – marine							
Motorized	159±11.2	44±5.7	332±16.3	535±20.5	1 832±65.9	29.2	64 184 (1 019)
Gillnet – inland							
Non-motorized	179±46.3	64±7.1	318±41.9	561±72.5	6 973±968.3	8.0	11 221 (178)

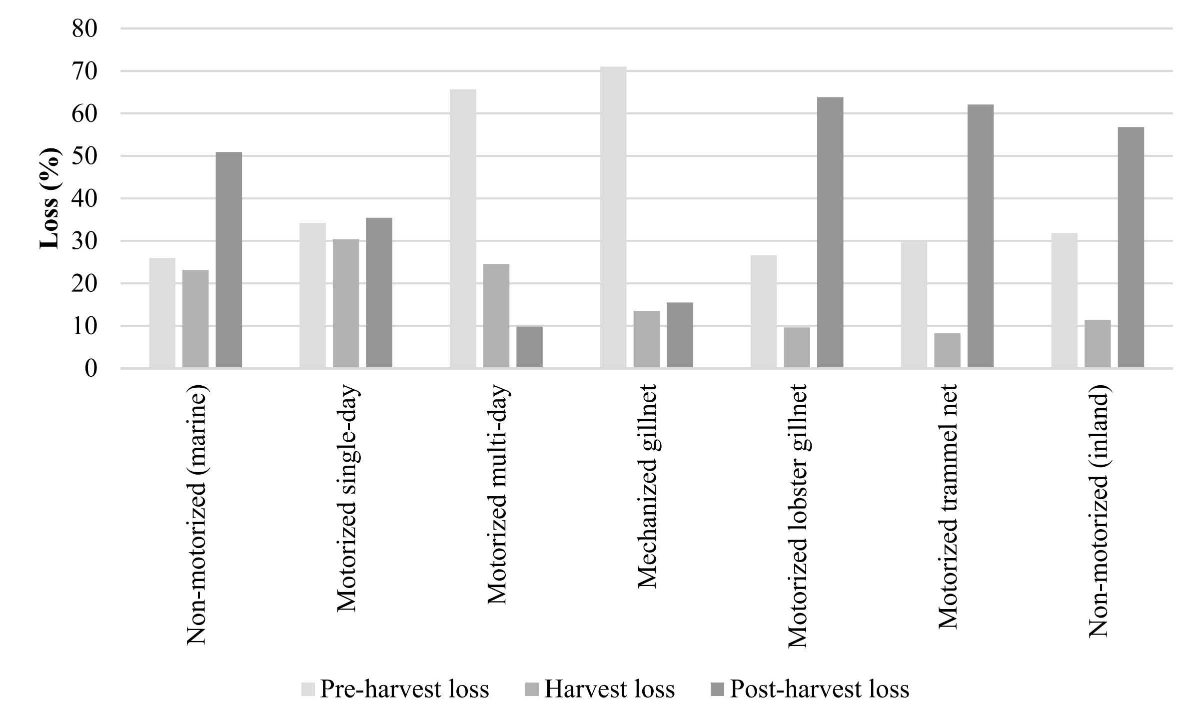
* Up to first point of sale.
Note: ± denotes standard error.

In terms of volume, the loss per vessel incurred by the motorized and mechanized fleets was substantially higher than that of the non-motorized vessels. The motorized multi-day fishing vessels incurred particularly heavy fish losses (1 679 ± 68.7 kg/vessel/year), almost double that of the motorized single-day vessels (869 ± 30.7 kg/vessel/year).

4.3.2 Physical loss at different stages of fishing

Pre-harvest losses were highest at 48.5 percent, followed by post-harvest losses (32.8 percent) and harvest losses (18.7 percent). Figure 5 provides a summary of the physical losses of fish in different subsectors.

Figure 5. Physical losses of fish in different gillnet subsectors



Pre-harvest losses

Pre-harvest losses incurred mainly due to depredation of catch by pufferfish, dolphins, squids, crabs, isopods and sharks, and ranged from 26 percent to 71 percent of the total physical loss. The average annual pre-harvest loss was between 67±5.6 kg and 1 102±30.2 kg/vessel in different subsectors.

Depredation was observed in most study locations. It was highest in the mechanized and motorized multi-day subsectors targeting tuna and other large pelagics (66 percent and 71 percent of the total fish loss, respectively). The non-motorized (marine) subsector had the lowest losses from depredation (26 percent of the total fish loss) owing to their short fishing times. Table 7 lists common predators in the gillnet fisheries.

Table 7. Common predators in gillnet fisheries

Study zones (state)	Common predators		
	Non-motorized subsector	Motorized subsector	Mechanized subsector
Zone I (Gujarat)	NA	Pufferfish, squid	Pufferfish, squid, jelly fish, crabs, eels, isopods
Zone II (Kerala)	Otters and Isopods	Cetaceans – particularly dolphins (throughout the year) Pufferfish (monsoon) Crabs	NK
Zone III (Tamil Nadu)	Birds, otters and very rarely crabs	Cetaceans, pufferfish, squid, crabs, sharks, jellyfish	Cetaceans – particularly dolphin (throughout the year), squid, pufferfish (Aug–Dec), sharks (depends on catch), crabs (rarely)
Zone IV (Andhra Pradesh)	Squid, crabs, sharks and pufferfish	Cetaceans, pufferfish, squid, crabs, sharks, jellyfish	Dolphins (rarely), jellyfish, crabs

NK: Not known.

In the inland reservoir subsector, the average annual loss due to depredation was 179 ± 46.3 kg/vessel, which was 2.6 percent of the total catch and 32 percent of the total loss. Freshwater otters, cormorants and crocodiles were the main predators, and the problem was severe during summer due to the reduced water level in the reservoir.

Differences in fish loss by soaking time indicated that long duration of soaking (> 7 h) had a significant effect on fish loss compared with very short (< 2 h) and short (2–7 h) durations. There was high positive correlation ($p < 0.05$) between soaking time and the loss of fish and gear in the non-motorized and mechanized subsectors.

Harvest losses

Annual harvest losses ranged between 44 ± 5.7 kg/vessel and 412 ± 19.9 kg/vessel in different subsectors. They were particularly severe (23–30 percent of the total physical losses) in the case of tuna gillnets deployed by the motorized multi-day boats and mechanized vessels. Night operations contributed to the easy slippage of fish during hauling. Slippage of fish was lowest in trammel nets (8.2 percent of the total fish loss) as the catch was entangled in the pockets formed by the triple wall that constituted the net.

Post-harvest loss

Discards contributed to the post-harvest losses and included: small fishes, invertebrates of little or no market value, and the depredated fish (Table 8). In the mechanized multi-day subsector, unwanted catch was discarded mostly at sea. In the motorized single-day and non-motorized subsectors, catch was discarded at the landing centres where the removal of catch from the nets and its subsequent sorting would take place.

Pufferfish and triggerfish were the main finfish species discarded, and the invertebrate discards included: inedible crabs, squilla and molluscs. Turtles, sea snakes, dolphins and seagrass were also discarded, the first two generally in live condition.

In the non-motorized subsector, where the vessels operate from open beaches, attacks on the catch by land animals such as dogs were rampant. Handling low-value or small-sized fish was laborious and unprofitable, and their removal from the gear haphazard. The depredated fish as well as the damaged /poor-quality fish would be thrown on the beaches, attracting animals and birds.

The mechanized gillnet vessels were harbour-based and, hence, loss due to stealing by animals was not always a problem. Besides, the catch largely consisted of large fish, which were difficult for animals to steal and, being expensive, were more carefully handled.

Among specific gear types, discards in the lobster gillnets and the trammel nets operated in rocky areas and coral reefs were significantly higher ($p < 0.01$) compared with mackerel gillnet operated in waters with a sandy bottom. The post-harvest losses in the inland (reservoir) gillnet and lobster gillnet subsectors constituted 57 percent and 62 percent, respectively, of the total fish loss in these nets. In the non-motorized sector, the losses did not show a statistically significant difference across inland or marine subsectors.

Table 8. Discards of finfish, invertebrates and other organisms

Subsector	Finfish and invertebrate discards			Other catch discarded	
	Finfish	Invertebrates	No. of fish (range) discarded per vessel per year	Type	% released alive
Marine gillnet (non-motorized)	Triggerfish, pufferfish, scorpionfish, juveniles of queenfish, catfish and carangids	Small inedible crabs, bivalve shells, shank, small gastropods, murex, squilla, jellyfish, sea cucumber	38–94	Snake and rarely turtle	50–60
Marine gillnets (motorized)	Triggerfish, pufferfish, juveniles of carangids, croaker, ponyfish, catfish, grouper, scats, goatfish, *Ambassis*	Jellyfish, inedible crabs, squilla, sponges, sea urchin, chank, cyprea, anadara, conus, oysters, mussels, star fish, gorgonians, coral pieces	80–240	Snake and rarely turtle, dolphin, seagrass	40–50
Marine gillnets (mechanized)	Pufferfish, suckerfish, juveniles of skipjack tuna, mackerel	Inedible crabs, jellyfish, deep sea squid	2–86	Dolphin, marine turtle, sea snake	40–90
Inland gillnets (non-motorized)	Catfish, barbs and juveniles of Indian major carps	Molluscan spp.	83	Snake, crocodile and tortoise	50–80
Marine trammel net (motorized)	Triggerfish, pufferfish, juveniles of sciaenid, goatfish, eel, parrotfish, rays	Jellyfish, small and inedible crabs, squilla, sea urchin, chank, cyprea, anadara, conus, oysters, mussels, starfish, gorgonians, coral pieces, sponges	60–140	Sea snake and rarely turtle	30–50

4.3.3 Quality loss

In most fisheries, the landed catch would be usually graded according to its quality. Fish in all but the last grades were considered fit for human consumption (although catering to different strata of customers), while those in the last grade were converted into fishmeal. Table 9 provides estimates of fish going into different grades in Andhra Pradesh.

Table 9. Estimates of fish going into different grades in Andhra Pradesh

Landing category	Motorized single-day (by quantity)	Mechanized (by quantity)	Non-motorized
Premium quality (for human consumption)	85%	80% 70% in the case of deep-sea gillnets where soaking time is 10–12 h	90%
Second quality (for human consumption)	10%	10% 20% in the case of deep-sea gillnets where soaking time is 10–12 h	10%
Third quality (for fishmeal)	5%	10%	nil

In the motorized and mechanized subsectors, 5–10 percent of the catch belonged to the last category, although the proportions – based on species, size and season – could vary significantly. As much as 20 percent of the catch landed by the mechanized subsector in Veraval and the motorized multi-day subsector in Jaleshwar was not fit for human consumption and sent to fishmeal plants; the percentage held valid across most landing centres. Table 10 provides estimates of loss in value due to quality loss in the mechanized gillnet subsector in Veraval, Gujarat, while Table 11 provides the same information for the motorized multi-day gillnet subsector.

Table 10. Loss in value due to quality loss in the mechanized gillnet subsector (per trip per vessel) Veraval, Gujarat

Fish species	Grade	Volume (kg)	Price (INR/kg)	Value (INR)	Value based on Grade 1 (INR)	Loss in value (INR)	Loss in value (%)
Tuna	1	47.5	110	5 225	5 225	0	0
	2	104.5	70	7 315	11 495	4 180	36.4
	3	38	50	1 900	4 180	2 280	54.5
	Subtotal	*190*		*14 440*	*20 900*	*6 460*	*30.9*
Seerfish	1	19	450	8 550	8 550	0	0
	2	41.8	250	10 450	18 810	8 360	44.4
	3	15.2	150	2 280	6 840	4 560	66.7
	Subtotal	*76*		*21 280*	*34 200*	*12 920*	*37.8*
Barracuda	1	28.5	100	2 850	2 850	0	0
	2	63	70	4 389	6 270	1 881	30
	3	23	30	684	2 280	1 596	70
	Subtotal	*114*		*7 923*	*11 400*	*3 477*	*30.5*
Total		**380**		**43 643**	**66 500**	**22 857**	**34.4**

Table 11. Loss in value due to quality loss in the motorized multi-day gillnet subsector (per trip per vessel), Jaleshwar, Gujarat

Fish species	Grade	Volume (kg)	Price (INR/kg)	Value (INR)	Value based on Grade 1 (INR)	Loss in value (INR)	Loss value (%)
Mackerel	1	29.52	90	2 656.8	2 656.8	0	0
	2	9.84	50	492	885.6	393.6	44.4
	3	9.84	20	196.8	885.6	688.8	77.8
	Subtotal	*49.2*		*3 345.6*	*4 428*	*1 082.4*	*24.4*
Sardine	1	12.3	40	492	492	0	0
	2	4.1	30	123	164	41	25.0
	3	4.1	15	61.5	164	102.5	62.5
	Subtotal	*20.5*		*676.5*	*820*	*143.5*	*17.5*
Lizardfish	1	29.52	45	1 328.4	1 328.4	0	0
	2	10	35	344.4	442.8	98.4	22.2
	3	10	25	246	442.8	196.8	44.4
	Subtotal	*49.2*		*1 918.8*	*2 214*	*295.2*	*13.3*
Total		**118.9**		**5 940.9**	**7462**	**1 521.1**	**20.4**

However, the conventional understanding of the quality losses masked a more significant issue. During the long, convoluted movement of fish to the distant urban centres, the loss in value owing to its poor quality would be distributed along the value chain in a way that would be hard to quantify. Most gillnet fishers supplying urban markets consider that no more than 5–10 percent of their landed catch is of poor quality, which they feel to be an acceptable loss. However, interactions further along the value chains indicate that this 5–10 percent loss is prevalent at **each level in the value chain**, i.e. from the fishers to the village-level traders and collection agents, from them to the larger traders in the nearby towns, from there to the urban wholesalers, and on to the urban retailers and consumers. The dissipation of the losses at 5–10 percent at each level means that no single value chain actor finds it a significant loss, despite the overall loss amounting to a much higher proportion of the final value. This case study was able to identify this crucial gap in the current understanding of the losses, but it will require more detailed load-tracking studies to determine the exact quantum of the quality losses along the value chains and their financial implications.

4.3.4 Summary of the key reasons for food loss

The main reasons for fish losses in gillnets included:

1. No/poor market demand

Catches having no commercial value and those coming under the “retention ban” were discarded. Squilla, small crabs, seagrass and jellyfish are routinely discarded.

2. Juveniles and mixed catches

A sizeable proportion of fish catches, especially in the small-mesh gillnetters operating in the nearshore waters, frequently consist of a variety of juveniles and mixed species that are frequently discarded.

3. Predation by other fish

Pufferfish, dolphins, sharks, cephalopods and crabs feed upon the catches in the net.

4. Long soaking time

Long soaking time allows the fish in the nets to be spoiled, damaged, scavenged or predated upon, or to escape.

5. Long fishing trips

The medium and large mesh gillnet operations were long, motorized vessels in Tamil Nadu making trips of 18 h to 3 days, while mechanized vessels spent10–35 days in fishing voyages. The long fishing trips contributed to losses, especially of low-value fish as high-value fish received better care and were kept in iceboxes / insulated fish holds.

6. Inadequate storage space onboard

Long fishing trips by mechanized vessels face the problem of insufficiency of ice onboard to preserve the catch. At times of large catches, shortage of ice onboard results in spoilage of catch. Inadequate space onboard also forces the fishers to throw overboard low-value catches to make space for higher-value fishes.

7. Improper preservation/icing facilities

None of the non-motorized vessels and only a few motorized single-day vessels use ice and iceboxes onboard. Problems associated with non- (or irregular) availability of ice and its quality, poor thermal efficiency of the iceboxes, and improper preservation practices lead to less usage and consequent quality losses.

8. Improper handling onboard and at landing centre

Exposure of fish to the sun for extended periods on open-decked vessels and at the landing centre causes loss in quality. Transporting ice and fish in uncovered vehicles is also fairly prevalent.

9. Delays at the landing centres

Long delays attend fish landings. Delay in auctioning, settlement of payments, and post-auction arrangements add to the quality losses. Delayed handling leads to fish being exposed to infestation and contamination, in addition to natural processes of spoilage.

4.4 Fishing gear losses and implications

In the marine gillnet and trammel net fisheries, a considerable amount of gear is abandoned and lost, but intentional discarding of gear is minimal. In the mechanized subsector, the total amount of net lost per vessel per year is 589 ± 18.7 kg (24.6 percent of total gear onboard). The motorized multi-day subsector in Andhra Pradesh targeting tuna has the highest annual loss of 36.2 percent of the total gear per vessel. This is owing to the rough sea conditions on this coast during the monsoon months. Loss is also substantial in trammel nets (26 percent). In the inland subsector, gear loss is comparatively lower (2.7 ± 0.3 kg, or 3 percent of all gear used). Table 12 provides the gear loss in gillnet and trammel net fisheries.

Table 12. Gear loss in gillnet and trammel net fisheries

Sector/ subsector	Abandoned	Lost	Discarded *	Total gear loss	Total gear used	% of total gear used	Loss value in INR (USD)
	(kg/vessel/year)						
Gillnets – marine							
Non-motorized	6.6±0.2	8.6±0.3	0.12	15±0.5	90	17.0	10 721 (170)
Motorized single-day	20±0.7	26±1	0.14	46±1.3	248	18.4	32 005 (508)
Motorized multi-day	80±3.7	80.5±2.4	Nil	160.5±4.9	443	36.2	80 235 (1 274)
Mechanized	275±10.1	314±17.7	Nil	589±18.7	2 400	24.6	29 4726 (4 678)
Motorized lobster gillnet	2.5±0.4	2.8±0.5	0.05	5.3±0.4	30	17.8	3 735 (59)
Trammel net – marine							
Motorized	6±0.5	2±0.1	0.1	8±0.4	30	26.0	5 457 (87)
Gillnet – inland							
Non-motorized	2.7±0.3	0	0.1	2.7±0.3	90	3.0	1 906 (30)

* Discarded on beach.
Note: ± denotes standard error.

4.4.1 Discarded gear

Small and medium meshed nylon monofilament gillnets, 0.16–0.20 mm diameter, used mainly to catch sardines and mackerels in the non-motorized and motorized subsectors, need replacement after 3–4 months owing to wear and tear, including from attacks by pufferfish, cetaceans, and crabs.

Box 1
The multiple uses of damaged gillnets

Damaged gear do not automatically become discards. The fishers, or the village women, carry out minor repairs to make nets last as long as possible. Partially damaged nets are sold to poorer fishers, who repair them and put them to use again. Nets with more damage are sold for recycling, fetching INR 10–25 per kg. Damaged nets serve as a fence around fishers' houses, as a protective layer over their thatched habitations, as cover over drying fish to prevent animals and birds from reaching them, and as support for plants in kitchen gardens.

When a net is too damaged to be of further use (Box 1), it is discarded on the beach. The amount of gear thus discarded on the beach is small (0.05–0.14 kg/vessel/year). The discards, when they happen, are mostly limited to nets, while gear accessories such as rope, floats and sinkers are retained for a longer period of use as these are not damaged so frequently as net material.

The fishers' practice of storing their nets on the beaches leads to the nets being accidentally dragged into the sea. Heavy weather conditions also contribute to high waves resulting in the nets drifting into the sea. Erosion of the coast restricts the space for net storage on the beaches, increasing the risk of nets being washed away. In the mechanized and motorized multi-day subsectors, the risk is less as their operations are harbour-based and the gear is stored onboard the vessels.

4.4.2 Abandoned gear

At times, fishers are forced to abandon the gear in toto when retrieval is impossible, owing to rough sea and weather conditions, or when the gear become entangled with objects or projections on the seafloor. The quantity of abandoned gear varies between the subsectors owing to the differences in the volume of net taken and the areas of operation, and averaged from 2.7 ± 0.3 kg gear per vessel per year in the inland gillnet subsector to 275 ± 10.1 kg in the mechanized subsector (Table 12).

4.4.3 Lost gear

Loss of gear at sea is a regular and widespread phenomenon in all field study locations. All respondents incurred the loss of gear at sea either wholly or partially several times a year. Mechanized gillnetters also have cases of complete loss of net owing to cyclones, especially along the east coast. Besides the gear, the losses included gear accessories such as floats, rope, and sinkers, and ranged from 3 percent to 49.1 percent of the investment in gear per vessel per year. The loss of gear at sea has the most serious economic implications for the fishers, both in terms of replacement costs as well as the lost fishing opportunities. After the cost of fuel, the replacement of lost fishing gear ranks highest among their recurring costs.

4.4.4 Reasons for gear losses

1. *Overrunning by fishing trawlers and ships*

The fishers prioritized ships, trawlers and other fishing vessels overrunning their fishing gear as a most significant cause of loss. Lengthy gillnets running to several kilometres, and laid at night with no markers or adequate indicators to denote their presence in the sea, aggravate this condition.

2. *Entangling with large fish*

Gear is damaged when large fishes such as sharks, whale sharks, rays, dolphin, sawfish, sailfish and swordfish become entangled in the net. In Gujarat, the whale shark is particularly dreaded for the extensive net damage it causes, frequently resulting in the loss of all or a substantial portion of the gear.

3. *Pufferfish depredation*

In all zones, pufferfish are reported to bore large holes in the gear. Long soaking times mean significant losses, as gear run the risk of being damaged by pufferfish.

4. *Rough weather*

Rough weather (especially during monsoon) leads to the need to abandon gear. Along the east coast of India, where high waves and cyclones are frequent, this is a major cause of gear loss.

5. *Natural and artificial obstructions on the fishing ground*

Gear becoming entangled with submerged tree stumps is a cause for gear loss in the reservoirs. In the lobster fishery, gear is entangled in rocks on the seafloor. Artificial obstructions snagging the gillnets include oil rigs and other constructions on the seafloor.

6. *Losses of gear stored on the beaches*

Fishers keep their gear on the beaches owing to lack of space in their houses, and also to avoid the drudgery of carrying them back and forth. Heavy winds, cyclonic weather, and incessant rains lead to such gear being washed out to the sea.

7. Length of the fishing gear

The mechanized and motorized multi-day gillnetters use long gillnets – exceeding 6 000 m – and the longer the fishing gear, the more gear losses they incur. Thus, the mechanized vessels of Thoothoor, which use the longest gillnets in the country, also have the highest gear losses, amounting to 41 percent of all the gear used in a year, while the numbers are 14 percent and 17 percent for their counterparts in Andhra Pradesh and Gujarat, respectively.

8. Usage of monofilament yarn

The proliferation of polyamide (PA) monofilament material has led to what one fisher characterized as a "use and throw" culture. In Chellanam, a trammel net will be replaced every month, which was not the case earlier when PA multifilament gear had been in use. The monofilament material is not robust, and requires frequent replacement. It is particularly not suitable for trammel nets and lobster nets deployed at the bottom in rocky and coral grounds, contributing to high levels of gear loss and abandonment in those fisheries.

4.5 Location-wise fish and gear losses

The case study attempted to estimate location-wise fish and gear losses according to the subsector and the following is a brief summary of the subsector-wise findings. Not all parameters were studied uniformly across all study sites owing to the differences in fishing systems, seasonality and disposal patterns, which makes comparisons across the board difficult.

4.5.1 Mechanized gillnet subsector

Fish loss in the mechanized tuna gillnet subsector in three locations – Thoothoor in Tamil Nadu, Visakhapatnam in Andhra Pradesh, and Veraval in Gujarat – indicated the following.

The highest gear loss was experienced by the Thoothoor fishers who lost, on average, 41 percent of the total gear annually, while the Visakhapatnam and Veraval fishers lost 14 percent and 17 percent, respectively, of their gear. Thoothoor fishers also used larger volume of gear compared with others, although the latter also used nets of more than 6 000 metres. Long soaking times of more than 7 h contributed to depredation and spoilage. Table 13 summarizes fish losses in the mechanized subsector in the three locations, while Table 14 summarizes gear losses in the same locations.

Table 13. Fish loss in mechanized tuna gillnet subsector

Location	Pre-harvest loss	Harvest loss	Post-harvest loss	Total loss	% of total catch
	(kg/vessel/year)				
Thoothoor	1 390	130	618	2 138	0.89
Vishakhapatnam	565	297	90	952	1.95
Veraval	552	360	106	1 017	5.16

Table 14. Gear loss in mechanized tuna gillnet subsector

Location	Abandoned	Lost	Total loss	% of loss
	(kg/vessel/year)			
Thoothoor	565	690	1 255	40.71
Visakhapatnam	200	300	500	16.67
Veraval	125	330	455	22.75

4.5.2 Motorized multi-day gillnet subsector

In Andhra Pradesh, fish loss due to slippage of fish is estimated to be 3–29 kg per trip per vessel. The small size of the vessel and night operations lead to frequent slippage of fish. Fish loss due to depredation is also substantial, at 12–22 kg per trip. Total loss at pre-harvest and harvest stages comes to about 1 500 kg/vessel annually. Fish loss at the post-harvest stage is minimal, at about 165 kg/vessel annually, owing to the low level of discards. Quality loss due to long soaking time and inadequate icing is high; only 70 percent of the catch is of grade 1 quality, and 20 percent falls into grade 2. The remaining 10 percent of the catch is salted and dried or converted to fishmeal. Abandoned and lost gear comes to about 64 kg per year. Most gear loss occurs during the heavy monsoon (June–October), while the passage of trawlers and cargo ships, and heavy catches also contribute to sizeable losses. Almost 28 percent of all gear used is lost or abandoned at sea.

In Gujarat, pre-harvest losses contributed most to the physical losses in the motorized multi-day gillnetters on account of depredation (6.2 kg/vessel/trip) and fish slipping out of the net while hauling (1.7 kg/vessel/trip). Pufferfish are the main predator in this area. As there is good demand for even spoiled and low-quality fish from the drying and fishmeal industries, physical loss at the post-harvest stage is negligible. Total gear loss came to about 95 kg/vessel/year; abandonment to 10–150 kg/vessel/year while lost fishing gear was in the range of 3–50 kg/vessel/year.

4.5.3 Motorized single-day gillnet subsector

The location-wise assessment indicated the following.

Soaking times are long in the mackerel and sardine gillnets of Mangamaripeta (Andhra Pradesh), which attract high depredation and gear loss. Trammel nets in all locations suffered high incidence of fish loss and gear loss. Polyamide monofilament material is not suitable for trammel nets and lobster nets, which are deployed at the bottom in rocky and coral grounds. Gear loss and abandonment is very high in this fishery. In Chellanam, trammel net is replaced every month, which was not the case earlier when PA multifilament nets were in use. The other major reason for gear loss is trawlers and ships passing through the shipping channel where fishers deploy their gear.

4.5.4 Non-motorized gillnet subsector

In non-motorized gillnet operations in marine fisheries, both fish loss and gear loss are comparatively low owing to the short soaking times. In contrast, the non-motorized operations in the Bhavanisagar reservoir are characterized by long soaking times of 10–24 h, resulting in heavy losses in both quality and quantity of the fish catches.

4.6 Seasonality of losses

Seasons had a direct influence on losses. The tropical temperatures of India (averaging 30–36 °C, reaching > 40 °C in summer) hastened spoilage of the catch when the catch was handled on the open deck or at the landing centres, exposed to sun. Summer was also the period when high demand for ice was matched by its reduced availability owing to frequent electricity failures, leading to sizeable losses.

The monsoon months were when most gear losses occurred, especially on the east coast. Besides the heavy weather and rough seas, monsoons were characterized by flood waters and unpredictable currents, high levels of turbidity and marine debris in the fishing grounds, which resulted in gear losses. Fishers usually avoid fishing during the monsoon months, but two factors – the prevalence of higher catches in the nearshore waters during that period and the arrival of monsoons coinciding with the lifting of the two-month annual ban on fishing (on 15 June) – cause them to take to the seas during the rough-weather seasons.

4.7 An indicative assessment of the value of losses

4.7.1 Fish losses

Although quality was an important consideration, fish values are also influenced by several market-related factors, and notoriously difficult to attribute to any one particular criterion. Adding to the difficulties in assessing the value of losses were: the informal nature of most fisheries-related business transactions; the heterogeneity and the temporal, seasonal, and geographical diversity of the gillnet fisheries; the long and intermediary-driven, value chain actions; and the unwillingness of the trade-intermediaries to share accurate figures.

An assessment of the quality losses in three dominant species at the first point of sale in Gujarat (Table 10 and 11) indicated that, owing to poor quality, tuna incurred a loss of 30.9 percent in value, while for seerfish and barracuda the corresponding losses in value were 37.8 percent and 30.5 percent, respectively. This translated into an average loss of INR 22 857 per vessel per trip, or INR 685 710 (USD 10 884) per year. There were 500 tuna gillnetters based at Veraval, whose combined losses in value would be INR 342 855 000 (USD 5 442 143). For Gujarat, with its 4 125 tuna gillnetter fleet, this would amount to a loss of INR 2 828 553 750 (USD 44 897 679) on account of quality deterioration.

In Chellanam, based on the available data, the value loss owing to quality deterioration for the 50 local gillnetters amounted to INR 4 545 400 (USD 72 149) per year. In the reservoir fisheries of Tamil Nadu, data showed that, owing to spoilage, the 161 fishing vessels had lost catch to the tune of 10 280 kg (20 percent of the total), worth INR 294 008 (USD 4 667).

4.7.2 Gear losses

Indicative estimates showed that, in Gujarat, total gear loss per vessel ranged wildly between 13 kg and 1 100 kg per annum. This was contributed to by abandoned gear (3–400 kg) and lost gear (10–700 kg). On average, an annual direct financial loss of about INR 150 000 per year was incurred due to loss of gear alone. Assuming that the 500 gillnet vessels in Veraval incurred similar levels of loss, the total financial loss would amount to INR 82 000 000 (USD 1 301 587) per year. The potential environmental impact of the loss of 328 kg of fishing gear per vessel, adding up to 164 000 kg of plastic from the 500 gillnetters of Veraval, must be sizeable, although unstudied.

In Chellanam, the trammel net operations incurred a loss of 2–22 kg of netting in the sea per season. The higher estimate would mean a financial loss of INR 77 000 per vessel per season, or INR 3 850 000 (USD 61 111) for the 50-strong fleet.

4.8 Socio-economic impacts of fish and gear losses

The study findings suggest that the physical and quality losses in gillnets account for a sizeable proportion of the productivity of the fisheries and the incomes of the fishers. Driving the losses upward is a sort of perverse logic. Declining productivity and incomes require the fishers to invest more for higher returns. Larger investments, in turn, give rise to the need for quicker returns to service the loans and reduce risk. This leads to the gillnets, fishing trips and soaking times growing longer, which adds to the losses, depresses incomes, and leads to further indebtedness all round – achieving the exact opposite of what is intended.

The fishers calculated that the losses could represent one third or more of their income, which impacted the vessel owners more adversely than the crewmembers on account of the former's higher investments and risk bearing.

The economic implications of the gear losses included: loss of income and asset base; dead capital in the form of damaged gear lying idle; increased dependence on traders and the loss of trade independence; reliance on moneylenders, and high cost of loan servicing; opportunity costs (loss of investment that might have been used for some other purpose; fishing days lost on account of the time taken to replace the lost gear); and exhausting savings to finance emergencies and other important needs. The economic implications of the fish losses were equally severe, albeit less apparent. In a condition where every fish must be sold in good condition for the fishing operations to break even, the existence of sizeable losses was a major handicap for the fishers.

4.8.1 *Estimate of losses as a proportion of incomes*

The socio-economic assessment of the impact of losses on the annual income of the owner and crew of gillnetters in three subsectors (mechanized, motorized and non-motorized) in Andhra Pradesh indicated that the losses eroded 9–19 percent income of vessel owners and 3–13 percent of the crew's income (Table 15). Moreover, the owners incurred an additional loss of 12–20 percent of their income owing to gear loss (Box 2). In mechanized vessels, the loss in income to vessel owners due to fish and gear loss was 39 percent of their annual income (19 percent on account of fish loss, and 20 percent due to gear loss) while for the crew it was 8 percent. It was not possible to make such estimates for the other states, but the findings were consistent with the observations in Gujarat, the only other state where the socio-economic assessment was carried out.

Table 15. Effect of fish and gear losses on fishers' income in Andhra Pradesh

Andhra Pradesh	**Mechanized**		**Motorized**		**Non-motorized**	
	Owner	**Crew (n=9)**	**Owner**	**Crew (n=5)**	**Owner**	**Crew (n=2)**
Annual income per individual (INR)	600 000	130 000	450 000	200 000	150 000	60 000
Annual net loss (INR)		120 000		55 000		20 000
Average fish loss per year (INR)		210 000		70 000		30 000
Fish loss as a proportion of income* (%)	19	8	9	3	15	13
Gear loss as a proportion of income* (%)	20	NA**	12	NA	13	NA

* Percentages rounded.
** Net loss has no direct impact on crew as the owners have the responsibility to replace the lost gear.

Box 2
Case study: impact of losses on household income and expenditure

Nageswara Rao owned a 32-foot FRP boat and employed four crewmembers. His annual income for the previous 12 months amounted to INR 400 000. During the year, he lost gear worth INR 55 000 at sea (200 kg, or 30 percent of the gear in his boat), or 13.75 percent of his net income. His estimate of physical losses of fish for the year amounted to INR 70 000, or 17.5 percent of his net income. The following table provides the losses as a proportion of the income and expenditures of the Rao household:

Type of loss	**As a percentage of…**						
	Income	**Expenditure**					
		Fishing	**Household costs**	**Quality of life**	**Loan service**	**Leisure**	**Savings**
Gear	13.75	46	46	138	69	275	275
Fish	17.5	58	58	175	88	350	350
Together	31.25	104	104	313	156	625	625

Together, the losses of fish and gear were a little under one third (31.25 percent) of Rao's income. The combined loss of gear and fish was significantly higher than Rao's expenditure on fishing, household costs, social development, loan servicing, or leisure, and exceeded his yearly savings by several times.

If Rao could reduce his losses, he would save enough to cover his entire expenditure on fishing or household expenses, spend three times as much on improving his quality-of-life investments (healthcare, housing, sanitation facilities, education for children), reduce the burden of loan servicing by up to a third, or save over five times as much as he now.

4.8.2 Estimate of gear loss on the catch potential of the vessel

The direct loss incurred on gear and its indirect economic impact were assessed from the fishing data of ten fishing vessels of Chellanam, which showed, on average, 31 kg of net was lost per year per vessel. It was estimated that this caused an indirect loss of 21.4 kg of fish that could have been caught had that net not been lost. Before replacing the lost gear, each vessel would have lost fishing days during which 86.1 kg of fish could have been caught. Thus, the loss of 31 kg net could cause a loss of 107.7 kg of fish, or a financial loss of INR 30 046 per vessel (direct loss: INR 17 136, or 57.03 percent; indirect loss: INR 12 910 or 42.96 percent). This indicated that for the loss of every unit of gear, the owner and each crew member incurred a loss in their income of 55.5 percent and 17.9 percent, respectively. Table 16 shows the financial impacts of gillnet losses to Chellanam fishers.

Table 16. Financial implications of gillnet losses to Chellanam fishers

Month	Gear loss		Indirect fish loss*		Opportunity cost on account of gear loss**		Total fish loss on account of gear loss	Total financial loss on account of gear loss
	kg	INR	kg	INR	kg	INR	Kg	INR
Aug-15	2.2	1 232	0.1	14.2	0.5	56.8	0.6	1 303
Sep-15	2.8	1 568	0.9	109.4	3.7	437.5	4.6	2 115
Oct-15	3.8	2 128	3.6	427.2	14.2	1 708.9	17.8	4 264
Nov-15	0.8	448	0.8	100.2	3.3	400.9	4.2	949
Dec-15	4.2	2 352	2.6	306.5	10.2	1 225.9	12.8	3 884
Jan-16	2.2	1 232	2	240	8	960.1	10	2 432
Feb-16	3.8	2 128	2.6	317	10.6	1 267.8	13.2	3 713
Mar-16	2.2	1 232	1.9	231.7	7.7	926.9	9.7	2 391
Apr-16	2	1 120	2.6	316.9	10.6	1 267.5	13.2	2 704
May-16	0	0	0	0	0	0	0	0
Jun-16	3.3	1 848	0.8	99.3	3.3	397.3	4.1	2 345
Jul-16	3.3	1 848	3.5	419.6	14	1 678.4	17.5	3 946
Total	30.6	17 136	21.4	2 582	86.1	10 328	107.7	30 046

* Extrapolated loss of fish that might have been caught with the lost net assuming that fish is caught uniformly in the whole net on any day of operation.
** Opportunity costs extrapolated in terms of fish lost on account of lost fishing days due to the time taken to replace the lost nets.

4.8.3 importance of losses to livelihoods and food security

While the straightforward case can be made to address the physical losses of fish immediately, the issue of quality losses needs to be handled more sensitively. The socio-economic assessment indicates that fish losses from a quality perspective may **not** always be considered as losses from a livelihood- and food-security perspective. This is because, while the best-quality catches go into the export and urban markets, the lower-quality fish cater to the local petty trade, home consumption, and drying. Only extreme spoilage leads to discards or fish being diverted to animal feed. Fish going into local markets, petty trade and processing are mostly handled by women and poorer people. **This implies that their livelihood security depends on some part of the fish catches being of a lower quality.** Moreover, the main consumers for the cheaper fish tend to be the poorer consumers, while those for dried fish include marginalized groups such as the tribal communities or the fishers themselves. Given the importance of dried fish as a staple food item during the non-fishing months (which vary from area to area) and as the chief source of protein for the poorer households, **the poorer quality of a part of the catch may be significant to ensuring the food security of such consumers.** The point is that any measure to improve the quality of fish may have to take account of these poorer sections and ensure that their livelihood and food-security needs are not adversely affected.

4.9 Summary of fish and gear losses

The study found that, in gillnet and trammel net fisheries in India, losses exist in terms of fish and gear, and that these losses can be substantial and have implications for the economic, social and ecological sustainability of the sector. The physical fish loss associated with gillnets was about 4.4 percent of the total catch, working out to 800 kg of fish per vessel per year, with a monetary loss of INR 84 096 (USD 1 335) per year. As a proportion of the incomes earned by the vessel owners and crew, the loss was significant; and in the context of declining catches, it acquired additional emphasis. The gear loss in gillnets worked out to roughly one quarter (24.8 percent) of the total weight of gear used, and in the context of consistent increases in volume of gear used over the years, this loss would probably increase.

Table 17 provides a summary of the key issue relating to losses, and some broad suggestions to address them. Table 18 summarizes the types of losses and their impacts, as well as the fishers' perceptions about how to address the losses. Finally, Table 19 presents the losses from a national perspective.

Table 17. Key issues relating to losses and suggested solutions (applicable to all study sites)

Type of loss	Value chain stage	Losses	Cause of loss	Seasonality	Suggested solutions
Fish loss* (Physical)		Overall physical loss: P: 1.4 – 29.2%; Q: 260 – 1679 kg			
	Pre-harvest	P: 1.0 – 8.7% Q: 11.2–46.3 kg	Depredation	Throughout the year; more during monsoon	Create awareness to reduce net soaking time
	Harvest	P: 8.2 – 30.4% Q: 44 – 412kg	Slip out during net hauling	Throughout the year; more during monsoon	Careful hauling operation especially during rough weather
	Post-harvest	P: 0.2 – 8.1%; Q: 133 – 418 kg	Discard of by catch, juveniles; insufficient space for storage; land animals poaching catch	Throughout the year; more during monsoon and heavy landings	Authorities to create storage facilities at landing centre
Fish loss (Quality)	Harvest	P: 5-20% (not fit for human consumption);	Long net soaking time	Throughout the year; more during summer (March-May)	Reduce net soaking time
Fishing gear loss**	Harvest	P: 3.0-36.2%; Q: 2.7-589 kg	Abandoning and accidental loss		

* Fish loss: % of total catch.
** Fishing gear loss: % of total gear used.
Note: P: percentage; Q: quantity, kilograms/vessel/year.

Table 18. Types of losses, impact of losses, and stakeholders' perceptions (applicable to all study sites)

Type of losses	Stakeholders affected	Impact of loss	Trends	Stakeholders' perceptions
Fish loss (physical)	Vessel crew Vessel owners Traders Consumers	• Reduction in catch • Reduction in fishers' and traders' income • Loss of protein food	Loss is increasing due to substantial increase in fishing effort.	• Fishers are concerned about depredation problem. But they do not know how to prevent loss.
Fish loss (quality)	Vessel crew Vessel owners Traders Consumers	• Reduction in fishers' and traders' income (5–10% of catch is of low quality fetching 20–80% of premium value)	Loss is increasing with use of very large gear resulting in long hauling time	• Fishers are aware of the loss in price due to spoilage, but fail to take measures. • Consumers are aware of quality, but unable to take measures.
Fishing gear loss	Fishers Fishing gear owners	• Loss of assets • Reduction in income and profit • Ghost fishing, marine litter and other environmental impact due to lost gear. • Indirect loss of 3.5 kg fish for every 1 kg of net lost in small mesh gillnet.	Loss is increasing as the trend is to use very thin nylon monofilament nets and to use large volume of net.	• Fishers consider it as a serious financial loss, but treat it as part of the risk involved with fishing profession. • More experienced fishers have lower losses. • Fishers unhappy with government for not enforcing the ban on night trawling.

Table 19. Losses and their national-level impact

Fishery	Fish loss			Gear loss	
	Physical loss % (estimated tonnes per year)	Quality loss % (estimated tonnes per year)	Macro impact for the country (million)	Loss % (estimated tonnes per year)	Macro impact for the country (million)
Mechanized drift gillnet (tuna, and other large pelagics)	P: 1.4% Q: 3 236	P: 10–20% Q: 23 115	USD 50 INR 3 162	P: 24.6% Q:11 690	USD 92 INR 5 845
Motorized gillnet (mackerel, sardine, shrimp and pomfret)	P: 5–18% Q: 14 990	P: 5–10% Q: 14 990	USD 47 INR 2 997	P: 18.4% Q: 2 846	USD 27 INR 1 707
Non-motorized gillnet (sardine, shrimp, crab)	P: 13.4% Q: 12 853	P: Nil Q: Nil	USD 24 INR 1 542	P: 17% Q: 740	USD 7 INR 445
Reservoir gillnet (Indian major carps)	P: 8% Q: 7 492	P: 5.6% Q: 4 683	USD 4 INR 244		

In different gillnet subsectors, on account of fish loss, in terms of their annual income, the owner of a vessel incurred a 12–20 percent loss, and each member of the crew suffered a 3–13 percent loss. Moreover, the owners incurred an additional loss of 9–19 percent of their income due to gear loss. The impacts of such losses on household income and expenditure patterns are likely to be significant, although more work needs to be done in order to quantify them.

5. SUGGESTIONS FOR LOSS REDUCTION

This case study has found losses of fish, or gear, or both in all subsectors studied. In a context of dwindling fish catches, the further loss of fish along the value chains is an important gap from the perspective of conservation, livelihoods and food security.

It needs to be highlighted that the extent and magnitude of these losses are not fully appreciated at the policy and development levels. The literature review undertaken by CIFT indicated that the few studies on fish losses – both in marine and inland fisheries – focused mostly on post-harvest losses (Ward *et al*., 1996; CIFT, 2004; Jeeva *et al*., 2006; Srinath *et al*., 2008; Sharma *et al*., 2016; Sivagnanam, 2016; Jeeva *et al*., 2011) or on trawl fisheries (Gordon, 1991). The review concluded that the evidence base on the losses in pre-harvest and harvest stages of capture fisheries remained a critical gap, and required more detailed work. The review also noted that the little information that did exist on gillnet losses showed the prevalence of sizeable amount of discards (Kelleher, 2005; Kumar, 2011; Kumar *et al*., 2013), depredation (IOTC and NRIFSF, 2007; Kumar *et al*., 2016; Raphael et al., 2017; Sherief *et al*., 2015), and gear losses (consisting of abandoned, lost or otherwise discarded fishing gear [ALDFG]) (Kumar, 2011; Harsha, 2016). The review concluded that more information and greater understanding are necessary in order to understand the type, scale, causes and impacts of these losses, as well as the potential options to reduce them. More in-depth, detailed studies covering a wider geographical area will thus be a prerequisite for more effective actions to address the losses in gillnet fisheries.

This section summarizes the key suggestions for loss reduction obtained from the fieldwork and from the interactions with relevant experts.

5.1 Technical options

Pre-harvest (depredation) and post-harvest (discards and handling practices) losses can be addressed through capacity development in technical areas, but harvesting losses (slippage of fish while removing from nets) require local improvisations. Similarly, while net losses owing to running over by ships and other fishing vessels can be addressed, the losses owing to discarded and abandoned gear require more self-discipline on the part of fishers. Some technical options to reduce losses are given below.

5.1.1 Fish losses

There is a need for better awareness raising and capacity development in order for small-scale fishers to explore and adopt short fishing hauls, shorter fishing durations, and better practices of onboard handling, icing and preservation. Awareness raising should include: good handling, preservation and management practices on board and at the landing sites, including promotion and support for effective fish storage.

The Department of Fisheries (DOF) and the community groups will need to be involved in participatory testing and development of innovative strategies for loss assessment and loss reduction using locally acceptable, low-cost and sustainable strategies. Examples may include the recent practice in some parts of Andhra Pradesh where several vessels operate in tandem as a unit, sharing their gear and reducing the hauling times with more efficient catch rates. Another example might be the practice in the same state of several fishers contributing small lengths of net for beach seining, and sharing the returns based on both labour and the net contributed. This has the advantage of spreading the loss over a larger number of people, none of whom will be particularly handicapped by loss of a small piece of net.

There is a need to develop and promote new market options and processes for bycatch utilization, such as production of fishmeal or protein hydrolysate, chitin or chitosan; new products – targeting the new urban consumer class – to utilize the cheaper or unutilized species require attention not only to reduce discards but also to divert attention from the commercial species, which require large investments and long-distance travel to be caught. New marketing channels include the urban supermarkets, where efforts are already under way to promote the health benefits of fish, and to stock products that offer ease of preparation to the consumers.

Given the ever-increasing size of the gillnets in the vessels, it will be necessary to test the viability of mechanical hauling devices in vessels using large number of gillnets in order to reduce hauling time and losses.

5.1.2 Gear losses

Implementing an effective monitoring, control and surveillance (MCS) and vessel monitoring system will be an urgent priority to prevent/reduce gear loss on account of trawlers and ships straying into coastal waters and overrunning the gillnets. FAO gear-marking guidelines should be implemented in order to make it mandatory to report loss and abandonment of fishing gear, and so reduce deliberate discarding of gear at sea.[3]

The state DOFs may be encouraged to undertake awareness campaigns among fishers to keep away from shipping lanes while fishing, and provide them with the necessary technical gadgets to avoid straying into dangerous waters. It is also necessary to promote the mandatory display of markers, lights or other indicators on vessels and gear to avoid being overrun by other vessels.

There is a need to implement lost-gear retrieval programmes at sea and at the community level; cooperative societies and school children need to be encouraged to collect and recycle used net materials. Alongside this, a campaign to discourage the use of nylon monofilament yarn (0.16 mm and less) for gillnets may have benefits. Finally, a time-release mechanism incorporated into the gear may help to stop ghost fishing by lost nets.

5.2 Policy options

5.2.1 Fish losses

The DOF and the coast guard must enforce the existing legal provisions to curb and control illegal, unreported and unregulated (IUU) fishing, especially in the context of capture of the juveniles and other sensitive species. The state marine fisheries regulation acts have provisions for this, but are not fully implemented.

It is also necessary to explore legal and technical mechanisms to implement the existing mesh size regulations. Measures to avoid discards – by placing bans on bringing the bycatch to the shore, as in Visakhapatnam – may prove to be counterproductive unless the fishing operations have been improved to avoid catching them altogether. Long-term strategies, which take account of the meaningful concerns of the fishers and accommodate their interests (or, failing that, at least convince them of the need for restrictions), are needed to address the issue of discards.

It is a curious challenge that, while there is growing demand for fish all the time in the markets, a sizeable proportion of the catch is still discarded on account of poor uptake. There is a need for the DOF and other relevant bodies, such as the Marine Products Export Development Authority, working in conjunction with central research institutes such as CIFT, to focus on domestic market development for the undervalued fish and fishery products.

Finally, there is a need for the coastal infrastructure – for landing and marketing the fish catches – to be established and/or strengthened, and hygienically maintained for reducing losses and discards once the fish have been landed. Where feasible, public–private partnerships may be explored to improve the conditions.

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[3] The State of Kerala incorporated this provision into its Marine Fishing Regulation Act and Rules as an amendment in 2018.

5.2.2 Gear losses

Effective enforcing of the prevailing bans under various state marine fishing regulation acts is important to prevent night fishing and inshore incursion by trawlers.

Fishing gear marking should be made a mandatory requirement to discourage deliberate discarding of gear into the sea. It is equally necessary to make it mandatory to employ certified/qualified persons with basic navigational skills to run the vessels and operate the gear. Initially, as the small-scale fishers are unable to cope with this requirement, sufficient time and adequate facilities for training must be provided for the purpose.

Regular, landing-centre-wise, data collection systems need to be maintained by the relevant department (DOF) to monitor the non-motorized, motorized and mechanized vessels, and to keep better track of their operations, including the use of different gear types and the losses occurring therein.

The DOF also needs to ensure effective enforcement of the local laws upon the interstate (i.e. trawlers) and international (i.e. shipping) traffic in a binding manner. As necessary, the department will need to develop and harmonize cross-sectoral linkages with other relevant government bodies and departments (e.g. shipping) to stop encroachment by ships into the gillnet fishing waters and damaging the gear.

There should be appropriate redress mechanisms established to help fishers obtain assistance and compensation for the loss of their gear; the existing mechanisms remain largely informal, arbitrary and ad hoc, and will need strengthening. Moreover, there is a need for measures to help fishers undertake protective measures against their gear being overrun, by installing markers, lights or other indicators.

Insurance or other kinds of welfare support, currently applicable to losses owing to natural disasters, may be applied also to gear losses in order to help fishers replace lost gear through a streamlined process of institutional support and reduce their dependence on the traders for the purpose.

5.3 Livelihood-related options

Despite the long history and continued economic importance of the gillnets, the study observed an overall weakening trend in gillnet-based livelihoods. In the context of diminishing returns and limited alternative opportunities, the ready accessibility and affordability of the gillnets allowed the fishers to continue fishing, even as they lacked the ability to address the gaps and losses within the systems. The markets, while keeping the fishers in business by absorbing almost any fish irrespective of variety, volume, quality or size, also contributed to the intensification of fishing effort, the fishers' urgency to catch more overriding any concern for the health of the resources or the prevailing losses. Gillnet losses would need to be addressed as part of the wider context of improved fisheries governance and livelihood support, rather than as a stand-alone issue.

The socio-economic assessment discusses how losses often arose out of a complex set of social and economic contingencies and compulsions, which were driven by actors located further along the value chain. This implies that the responsibility for the losses of fish or gear at sea cannot always be laid at the fishers' door only, nor can the answers to the losses come from technical improvements alone. While this study has made a beginning in understanding the losses, there is need to undertake a more comprehensive and participatory assessment of the losses and their implications, and to suggest more livelihood-centred ways to address the losses and their impacts.

There is evidence that the fishers are well aware of the losses, why they are occurring, and how they impact their livelihoods and investments. There are a few indicators – that need further studies to be validated – that the fishers have developed their own strategies to mitigate the losses or their impacts. There is scope to explore such community-based adaptations and best practices to reduce/regulate losses, such as the practice of rotation in allotting fishing rights according to fishing gear, days of the week, fishing area etc., to strengthen the fishers' ability to implement them more effectively. The DOF, working alongside local NGOs, can harness the social capital in the communities and mobilize them to take effective measures.

From a livelihood perspective, a good starting point may be to support measures to ensure assured use rights for small-scale fishers to avoid encroachment by trawlers and ships into traditional small-scale fishing areas, with the VGSSF and VGGT as potential pathfinders. The fishers can also address the losses sustainably with assured access to investments and technical support necessary to implement effective loss reduction/mitigation measures (iceboxes, infrastructure, larger-meshed nets). However, care must be taken to ensure that all such support flows into the community on the understanding that: (i) it is meant to bring positive changes in the fishers' practices; and (ii) the support is given on a self-sustaining basis, i.e. the fishers must be made to repay the cost of investment eventually.

New market-based options are a necessary requirement for reducing wastage and discards at sea; these will include examples such as: promoting new products or consumers for the undervalued fish that are currently discarded; and support with ecolabelling for responsibly harvested fish in urban supermarkets. Moreover, by bringing the fish traders under the ambit of fisheries management, measures need to be put in place to restrict their power to encourage overfishing and destructive fishing.

The poorer traders and consumers are dependent on a certain quantity of the catches not being good enough for urban/export markets, and any measures to improve the quality of all the landed catch should take account of their needs and ensure that they do not lose out as a result.

5.4 Fisheries management

Fisheries management programmes must incorporate elements of losses – discards, ALDFG, restriction on gear – into the action agendas as part of the conservation strategies, and take measures to reduce them.

External factors such as offshore development and shipping are beyond the scope of fisheries legislation, and make any sector-based measures to reduce the losses largely ineffective. Ecosystem-based approaches need to be in place to ensure that the law encompasses such external factors as much as it does the fishers.

Co-management initiatives will need to be fostered for effective MCS operations and enforcement of existing regulations in the inshore waters. The fishers must be empowered in order to take any measures to improve their livelihood context, and the co-management mechanisms go some way towards achieving this.

5.5 Environmental legislation

Many fishers suggest that there is need for a legislation to discourage manufacture of the fishing gear using monofilament nylon material, and of mesh sizes that have clear implications for the health of the resource. As long as the material is available, so their reasoning goes, they cannot stop using it. One fisher in Gujarat put it this way: "If I stop using it, my neighbour will still use it. I will end up being the loser then." If the material itself is no longer available on the market, then everybody will have lost access to it and revert to more sustainable gear.

The fishers also suggest the need to develop appropriate alternatives to nylon and small-meshed gillnets. Their contention was that there has been no new research on improving the fishing gear in more than two decades, which results in their depending upon old, fishing gears. It is possible that new research into appropriate materials – effective, long-lasting, affordable and sustainable – might provide alternatives to the monofilament nets.

Practical measures need to be put in place to ensure the avoidance by the fishers of those areas and seasons where high incidence of bycatch and juvenile fishes is prevalent. This is important in reducing discards, which seasonally are dominated by juveniles of commercial species. In the markets, appropriate legislation to discourage the procurement and sale of undersized and sensitive species is required. Options to promote measures such as ecolabelling to encourage sustainable capture, handling, preservation and marketing practices in gillnet fisheries may also need to be explored.

6. REFINED METHODOLOGY TO ASSESS HARVEST LOSS

The experience and insights gained from the study gave rise to the following suggestions to improve the methodology.

Considering the diversity of gillnet subsectors in the country, it is necessary that more areas be covered over a longer period in order to obtain a better understanding of the losses, their consequences, and potential coping mechanisms. Questionnaire surveys, such as that followed for the present study, are effective enough for rapid estimation of the losses; however, more accurate estimation of losses will require large-scale sampling, accompanied by repeated observations over a longer period.

The harvest losses have been quantified based on the interactions with the fishers. More empirical approaches will be necessary in order to improve the quantification of losses. Experimental studies on different net types will need to be attempted, using suitable research vessels. Underwater cameras and/or drones fitted on the gear, or fully or partly uncrewed vehicles (Stone, 2017) will provide a good handle on quantification of the losses. However, the main concern is that such technologies are currently expensive and out of reach even for national research bodies.

In the immediate term, placing researchers on board the commercial fishing vessels to undertake observations of the fishing operations using digital means of recording the data could be a reliable means to assess losses. Such information could be weighted to provide estimates on losses over longer time and spatial scales.

Proxy indicators such as the amount of money spent by fishers to replace gear would help in calculating the economic loss to the fishers due to gear loss. In the informal settings that characterize small-scale fisheries operations in India, there is a need to develop a list of robust proxy indicators to assess losses in consultation with the fishers themselves. Marking the fishing gear with a permanent mark or stamp to indicate its legal status would be a practical means to trace it back to the original owner, and thus track the quantum of losses more efficiently, although the process may be a little tedious. Fishers should be encouraged to use logbooks and to register losses alongside other information on a regular basis. The electronic logbook or electronic recording and reporting system may be an option for keeping track of catch and fishing gear used and/or lost (Girard and Du Payrat, 2017).

7. SCOPE FOR ESTIMATION OF FOOD LOSS IN FISHERIES OTHER THAN GILLNET AND TRAMMEL NET

In India, in addition to gillnet and trammel nets, trawl nets, bag nets, seines and lines are other major fishing gear types used. Less selective gear such as trawls contribute about 44 percent to the total landings, followed by purse seines and lines. Bag nets and trawls fish indiscriminately. Juveniles form 80–90 percent of the catch in bag nets, and about 50 percent in trawls (Thomas *et al*., 1999; Thomas *et al*., 2007; Madhu *et al*., 2017; Dineshbabu *et al*., 2014). There has been no attempt to devise a standard protocol for assessing losses from these gear types. For a comprehensive assessment of the losses in the marine fisheries sector, it is important that estimates on losses from these fisheries also be made.

Compared with the gillnet, which is simple in design and operation, other gear types such as purse seines and trawl nets are more intricate. In such active gear, food loss estimation is difficult and, hence, a modified methodology needs to be devised. The pre-harvest studies need to take account of issues such as the crushing effect on catch, collateral damage, and destruction caused by chains and otter boards, which play a significant role in causing losses in these fisheries.

8. CONCLUSIONS

This study reveals that in the gillnet and trammel net fisheries in India there exist losses in terms of fish and gear. The physical fish loss is about 4.4 percent of the total catch. This amounts to 800 kg of fish per vessel per year, incurring a monetary loss of INR 84 096 (USD 1 335) per vessel per year. The losses, both physical and quality-related, occur at pre-harvest, harvest and post-harvest stages, and they have impacts in terms of food security, incomes, livelihood support, and ecological sustainability.

The gear loss is almost one quarter (24.8 percent) of the total weight of gear used, and in the context of consistent increase in volume of gear used over the years, this is likely to increase. The direct impact of the gear loss is the cost of the lost gear, while the indirect cost includes the opportunity cost of the lost fishing opportunities/days on account of the gear loss.

In different gillnet subsectors, on account of fish loss, in terms of their annual income, the owner of a vessel incurs a 12–20 percent loss and each member of the crew suffers a 3–13 percent loss. The owners also incur an additional loss of 9–19 percent of their income due to gear loss. Considering the large number of vessels (194 000) operating in the marine fisheries sector in India, the ecological impacts of gear loss are thus likely to be quite substantial.

This study has offered several recommendations covering technical interventions, policy- and livelihood-related measures, and effective enforcement of fisheries management and environmental legislation. Some of these will involve awareness raising and capacity building at the community level, others require systemic changes in the prevailing practices, while still others require an improvement in the enforcement of the existing legal instruments. Such changes can be possible provided the two major actors in the equation – the fishers and the government – are willing to take up the issue with the attention that it deserves and give it their full support.

Thus, for example, several aspects of fish and net losses in gillnet fisheries – whether intentional or not – could be attributed to the actions of the fishers. These included: long fishing distances and net soaking times; increasing volume and length of gear; poor handling and management practices at different stages of operation; and the perception of the losses as involving no costs (being freely caught) or as an acceptable cost. Many of these practices and perceptions were influenced by complex motivations and processes, which went beyond simplistic explanations that blame the losses on the fishers' lack of awareness or technical failure. As the study has shown, the fishers are clearly aware of the importance of the losses on their lives and livelihoods, and yet, in a context of overall stress (discussed in detail in the socio-economic assessment report [Salagrama, 2017]), the issue of losses remains subsumed by more pressing priorities demanding the fishers' attention and investments. Issues such as declining access to fish, increasing capital needs for the vessels and engines (along with fuel costs), labour scarcity, market fluctuations, and weakening social support for the fisheries sector in macroeconomic policies, force the fishers to ignore the gillnet losses, or at best accept them as the norm. This calls for action on improving the fishers' capacity to undertake improvements to their practices in a more confident manner. That is not to absolve them of their own contribution to the current state of affairs or to help them pass the responsibility of dealing with the problems to someone else. The fishers must be made to reform their practices in line with the broader objectives of loss reduction, which will however be possible only if they are not made to bear the entire burden of paying for it.

This brings the government into the picture in a major way. Most of the solutions identified to reduce losses can be implemented only by making substantial interventions to support as well as regulate the fishers' practices along more sustainable directions. For this to happen, there is a major need to improve the government's own understanding about, and responses to, the losses, their causes and consequences, and appropriate adaptive/mitigating strategies to address them. This study has made a beginning, but with the realization that more will need to be done to understand and address the issue more meaningfully in the coming years. This latter responsibility for making the losses better and more widely understood rests with research institutes and universities, which have to work on the issue more intensively and provide a better understanding of the losses as well as the policy measures to address them.

Table 20 summarizes the key actions needed on the part of different actors in the gillnet and trammel net fisheries.

Table 20. Key actions and actors/organizations responsible for their implementation

Need	Key suggested actions	Relevant actors/organizations
Knowledge about losses (macrolevel, quantitative, market-related, loss reduction, etc.)	• Research • Field testing of potential interventions • Information dissemination	• Research institutes
Awareness generation about losses	• In government/policy circles • At the community level • At the value chain level (i.e. covering various actors along the value chain) • At the consumer level	• Research institutes • Department of Fisheries • NGOs • Community organizations
Capacity building	• Institutional capacity raising to implement loss assessment and reduction methodologies • Community capacity development for loss reduction (training as well as support and infrastructure creation for sustainable uptake)	• Department of Fisheries • NGOs • Community organizations
Development and enforcement of appropriate legal instruments	• Enforce existing legal provisions (both enabling and constraining) • Enhance interdepartmental/ministry/sectoral cooperation for enforcement • Identify policy/legislative gaps that need to be filled and support processes to address them. • Explore possibilities for co-management.	• Department of Fisheries • Coast guard • Ministry of Environment, Forest and Climate Change • NGOs
Livelihood support	• Ensure SSF's access rights to fishing grounds. • Promote technical options to reduce losses. • Enhance awareness, skills and knowledge to undertake more responsible and profitable fishing activities. • Improve access to institutional credit and support systems to adopt new practices and reduce dependence on traders. • Promote community-based systems to adopt loss-reduction strategies. • Explore market options for new products using undervalued products.	• Department of Fisheries • NGOs • Community-based organizations • Research institutes

9. REFERENCES

Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture. 2005. *Marine Fisheries Census 2005 Part I*. New Delhi, Government of India. 104 pp.

Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture. 2010. *Marine Fisheries Census 2010 Part I*. New Delhi, Government of India. 98 pp.

Central Institute of Fisheries Technology (CIFT). 2004. *Assessment of harvest and post-harvest losses of marine fisheries*. NATP Project report. Cochin, India, CIFT.

Central Institute of Fisheries Technology (CIFT). 2018. *Final Report: Assessment of fish and gear loss from selected gillnets and trammel nets of India and the socio-economic implications of losses on the fishers' livelihood*. Draft. Cochin, India, CIFT.

Dineshbabu, A.P., Radhakrishnan, E.V., Thomas, S., Maheswarudu, G., Manojkumar, P.P., Kizhakudan, S.J., Pillai, S.L., Chakraborty, R., Jose, P.J., Sarada, T., Sawant, P.B., Philipose, K.K., Deshmukh, V.D., Jayasankar, J., Ghosh, S., Koya, M., Purushottama, G.B. & Dash, G. 2014. An appraisal of trawl fisheries of India with special reference on the changing trends in bycatch utilization. *Journal of the Marine Biological Association of India*, 55(2): 69–78.

FAO. 2014. *Definitional Framework of Food Loss* [online]. Working Paper. Rome. [Cited 22 November 2019]. http://www.fao.org/fileadmin/user_upload/save-food/PDF/FLW_Definition_and_Scope_2014.pdf

FAO. 2017. *Proceedings of the Expert Workshop on Estimating Food Loss and Wasted Resources from Gillnet and Trammel Net Fishing Operations, 8–10 April 2015, Cochin, India*, by Petri Suuronen, Susana V. Siar, Leela Edwin, Saly N. Thomas, P. Pravin and Eric Gilman, eds. FAO Fisheries and Aquaculture Proceedings No. 44. Rome. (also available at http://www.fao.org/3/a-i6675e.pdf).

Girard, P. & Du Payrat, T. 2017. *An inventory of new technologies in fisheries: challenges and opportunities in using new technologies to monitor sustainable fisheries*. Issue Paper. Paris, Norwegian Ministry of Trade, Industry and Fisheries, OECD. 30 pp.

Gordon, A. 1991. *Bycatch from Indian trawlers in Bay of Bengal*. Bay of Bengal Programme BOBP/WP/68. 29 pp.

Harsha, K. 2016. *Analysis of design, operation and performance of gillnets of Tharuvaikulam fishing village, southeast coast of Tamil Nadu*. Department of Fishing Technology and Fisheries Engineering, School of Harvest and Post-Harvest Technology. Fisheries College and Research Institute, Tamil Nadu Fisheries University. 96 p. (MFSc thesis).

Indian Ocean Tuna Commission (IOTC) and National Research Institute of Far Seas Fisheries (NRIFSF). 2007. *Workshop on the depredation in the tuna longline fisheries in the Indian Ocean*. 50 pp.

Jeeva, J.C., Gopal, N., Balasubramaniam, S., Arathy, A. & Chandrasekar, V. 2011. *Post-harvest losses in aquaculture sector – issues and strategies*. Poster presented at the Asian-Pacific Aquaculture 2011 and Giant Prawn 2011, organized by the World Aquaculture Society and hosted by the College of Fisheries, Panangad, Kochi, 17–20 January 2011.

Jeeva, J.C., Khasim, D.I., Srinath, K., Unnithan, G.R., Rao, M.T., Murthy, K.L.N., Bathla, H.V.L. & Ahmad, T. 2006. Harvest losses at various resources of inland fisheries. *Fishery Technology*, 43(2): 218–223.

Kelleher, K. 2005. *Discards in the world's marine fisheries.* FAO Fisheries Technical Paper No. 470. Rome, FAO. 131 pp. (also available at http://www.fao.org/3/a-y5936e.pdf).

Kumar, A. 2011. *Analysis of bycatch of bottom set gill nets of Thoothukudi*. Chennai, India. 75 pp. (post-graduate thesis submitted to Tamil Nadu Veterinary and Animal Sciences University).

Kumar, A., Sundaramoorthy, B. & Jakhar, J.K. 2013. Standardization of crab bottom set gillnet for reduction of bycatch at Thoothukudi coast, Tamilnadu, India. *Archives of Applied Science Research*, 5: 74–81.

Kumar, K. A., Pravin, P., & Meenakumari, B. 2016. Bait, Bait loss, and depredation in pelagic longline fisheries–A review**.** *Reviews in Fisheries Science & Aquaculture*, 24(4), 295–304**.**

Luther, G., Pillai, P.P., Jayaprakash, A.A., Gopakumar, G., Satianandan, T.V., Molly, V., Sathiadas, R. & Sivsakami, S. 1997. Gill Net Fisheries of India, *Mar. Fish. Infor. Serv. T & E Ser.*, 150: 1–23.

Madhu, V.R., Raphael, L., Jeevan, J., Antony, V.T. & Edwin L. 2017. Status of bycatch from commercial trawlers operated off central Kerala. *Fishery Technology*, 54: 162–169.

Raphael, L., Joseph, R., & Edwin, L. 2017. Depredation and Catch Loss due to the Interaction of Aquatic Organisms with Ring Seines off Cochin Region. *Fish. Technol. 54: 66 – 70*.

Salagrama, V. 2017. *Assessment of the socio-economic characteristics of the losses from selected gill net and trammel net fisheries: a case study of two coastal states of India, Integrated Coastal Management, Kakinada*.

Sathianandan, T.V. 2013. *Status of Marine Fisheries Resources in India – An Overview*. Winter School on ICT-oriented Strategic Extension for Responsible Fisheries Management, CMFR, Kochi. pp. 11–22.

Sharma, H., Swain, M. & Kalamkar, S.S. 2016. *Evaluation and assessment of economic losses on account of inadequate post-harvest infrastructure facilities for fisheries sector in Gujarat State*. AERC Report 163. Gujarat, India, Agro-Economic Research Centre (Ministry of Agriculture and Farmers Welfare, Government of India) Sardar Patel University Anand. 283 pp.

Sherief, M.P.S., Dhiju, D.P.H., Thomas, S.N. & Edwin, L. 2015. Food loss from gillnets operated in Lakshadweep waters. ICAR-Central Institute of Fisheries Technology, Cochin. *Fish Tech Rep*.; I(2): July-December.

Sivagnanam, J. 2016. *Evaluation and assessment of economic losses on account of inadequate post harvest infrastructure facilities for fisheries sector in Tamil Nadu*. Research Report No. 157. Chennai, India, Agro Economic Research Centre University of Madras. 125 pp.

Srinath, K., Nair, R.V., Unnithan, G.R., Gopal, N., Bathla, H.V.L. & Ahmad, T. 2008. Post-harvest losses in marine fisheries. *Fishery Technology*, 45(1): 109–112.

Stone, Z. 2017. *These six luxury underwater drones are disrupting fishing and fun* [online]. [Cited 22 November 2019]. https://www.forbes.com/sites/zarastone/2017/06/15/these-six-luxury-underwater-drones-are-disrupting-fishing-and-fun/#198c4c2dd978

Thomas, S.N., Edwin, L. & Meenakumari, B. 2007. *Stake nets of Kerala*. CIFT Golden Jubilee series. Cochin, India, Central Institute of Fisheries Technology. 35 pp.

Thomas, S.N., Meenakumari, B., Pravin, P. & Mathai, P.G. 2005. Gill nets in the Marine Fisheries of India, Monograph, Central Institute of Fisheries Technology, Cochin, India. 45 pp.

Thomas, S.N., Edwin, L., George, V.C. & Iyer, H.K. 1999 Size composition and abundance of penaeid shrimps in stake nets with reference to lunar phase. *In: Proceedings 4th Indian Fisheries Forum, 24–28 November 1996, Kochi*, pp. 463–466.

Ward, A.R., Papadopulos, V., Khasim, D.I. & Damle, S.P. 1996. Report on a survey of fresh fish marketing between Visakhapatnam and Madras. *In: Workshop on Rapid Rural Appraisal Techniques*, organised by Central Institute of Fisheries Technology, Cochin, India and Natural Resources Institute, Chatham, UK.

ANNEX 1. CATCH COMPOSITION IN DIFFERENT SUBSECTORS

A. Major species caught in large mesh gillnets operated in mechanized sub-sector

Scientific name	Common name	Price (INR / kg)
Katsuwonus pelamis	Skipjack tuna	120
Thunnus albacares	Yellow fin tuna	160
Euthynnus affinis	Kawakawa	100
Coryphaena hippurus	Dolphin fish	110
Istiophorus spp.	Sail fish	100
Xiphius gladius	Sword fish	120
Makaria spp.	Marlin	125
Mobula japonica	Manta ray	80
Alopias spp., Sphyrnae spp. etc.	Sharks	60

B. Major species caught in monofilament gillnets operated in motorized/non-motorized sub-sector

Scientific name	Common name	Price (INR / kg)
Rastralliger kanagurta	Mackerel	120
Sardinella longiceps	Sardine	80
Stolephorus spp.	Anchovy	70
Pampus spp.	Pomfret	500
Esculosa thoracata	White sardine	75
Panilurus, Pleurulus and Thenus spp.	Lobster	750
Fenneropanaeus indicus, Metapenaeus dobsoni, Penaeus monodon	Shrimp	350
Sciaenid spp.	Croakers	150
Arius spp.	Cat fishes	100
Etroplus suratensis	Pearl spot	300

C. Major species caught in monofilament gillnets operated in non-motorized sector (reservoir)

Scientific name	Common name
Catla catla	Catla
Labeo rohita	Rohu
Cirrhinus mrigala	Mrigal
Wallago attu, Mystus spp.	Cat fishes
Mastacembalus armatus	Eel

ANNEX 2. QUESTIONNAIRE FOR PRIMARY DATA COLLECTION USED IN THE CASE STUDY – ESTIMATING FOOD LOSS FROM GILLNET AND TRAMMEL NET FISHING

Step 0:	Secondary data collection
Step 1:	Measurement of fishing gear
Step 2:	Group interview or key informant interview
Step 3:	Individual fisher interview
Step 4:	Direct observation of pre-catch mortalities
Step 5:	Quality Assessment (on-board, during travel to landing center, and at the landing center) and direct observation. This step includes information on weather, temperature, facilities including storage facilities on board.

STEP 1: MEASUREMENT OF FISHING GEAR

1. Gear type

☐ Gillnet
☐ Trammel net
☐ Combination gillnet/trammel net[1]

2. Panel

a. Length of float line:______________meters or fathoms
b. Height: ________________________meters or meshes
c. Number of layers in trammel net: _________________
d. Trammel net ratio of stretched length of inner to outer panels (vertical slack): ____
e. Tie down line? YES/NO If yes, height:________meters

3. Mesh

a. Whole stretched mesh length[2]: _________________ cm
b. Netting type[3]: _______
c. Twine material[4]________________________________
d. Twine ply number/diameter ______________mm
e. Color ____________________________
f. Distance between 'pickups'[5]__________________ cm
g. Number of meshes between pickups[5]: ______________

4. Float line

a. Material ______________________________________
b. Length _____________________________________ m
c. Diameter _________________________________ mm
d. Color ____

5. Float

a. Material _____________________________________
b. Length ____________________________________ cm
c. Width at thickest section ______________________ cm
d. Color ____
e. Shape _______________________________________
f. Distance between floats _______________________ cm

g. Number of meshes between floats ____________________

[1] For trammel nets and combination gillnets/trammel nets, complete separate forms for the interior and exterior layers.
[2] From center of knot to center of knot. Square measure is one-half of whole stretch mesh length.
E.g., multifilament (several small filaments twisted together), monofilament (single strand), multi-strand monofilament (multimonofilament, multiple strands of monofilament twisted loosely together), super multimonofilament (constructed the same as multimonofilament but the threads are thinner and more numerous).
E.g., nylon (polyamide), polyester, gel spun polyethylene
A 'pickup' is a point on the head rope where the webbing is attached.

6. Master float characteristics (if used)

a. Material____________________________
b. Length ______________________________________ cm
c. Width at thickest section _______cm
d. Color ____
e. Shape ____
f. Number of master floats per panel ____________________

7. Leadline/sinkerline

a. Material ____
b. Diameter ___________________________________ mm
c. Color ____
d. Lead core or weights/sinkers attached? ____________________
e. Distance between weights (if weights attached): ____cm
f. Meshes between weights (if weights attached): ____
g. Number of weights per panel (if weights attached): ____
h. Weight of 1 weight/sinker: ____________________ g
i. Weight of 1 meter of leadline _______g

8. Weight characteristic per panel (if weights attached)

a. Material ____
b. Weight amount: ________________________________ kg

9. Anchor characteristics (if used)

a. Material ____
b. Weight amount: ________________________________ kg

STEP 2. GROUP INTERVIEW OR KEY INFORMANT INTERVIEW

1. Fishing Grounds

a. Typical light levels at fishing grounds: _____________________
b. Typical sea state at fishing grounds: ______________________
c. Typical current speed at fishing grounds: ___________________
d. Substrate type(s): ______________________________________
e. Do you frequently encounter debris that entangles in nets? YES/NO
f. Do your nets get entangled on subsurface features? YES/NO
g. List gear types or other gears used at your fishing grounds:

____

2. Fishing Gear and Methods

a. Sketch the gear when soaking. Identify location in the water column (in relation to sea surface and substrate), number of panels per fleet, location of anchors if used, if attached to vessel or other object (sweeping), if drifting, location and length of tiedowns if used, height and length of panel, number of floats per panel, number of weights per panel if used, and how panels in a fleet are joined together. (Use separate page)
b. Are fleets parallel, perpendicular, other? ________________________
c. Distance between fleets: _________ meters
d. Main fishing ground: ____
e. Most common fishing depth: __________________________________
f. Method to set and haul (e.g., hauling equipment power, hauling speed):
____
g. Number of days per fishing trip: _________
h. Number of fleets set per trip: ___________
i. Number of fleets set per day:____________
j. Number of trips per year: _______________
k. Number of panels fished per fleet: ________
l. No of panels Mesh size

	No of panels	Mesh size
i.	–	--
ii.	–	--
iii.	--	--

m. Average soaking time:___________hours
n. Net patrolled? YES/NO
o. Source of purchase of gear materials: _________

3. Abandoned, Lost and Discarded Fishing Gear

a. List gear components that you typically discard (throw gear overboard):
____

b. Material:
____

c. How much gear do you discard (identify amount of each gear component that is discarded)?

Per trip or year: ___________________________kg or panel or (measurement in local terms)

d. What is the main reason you discard gear?

____

e. List gear components that you typically abandon (gear set for fishing left on purpose):____
f. How much gear do you abandon (identify amount of each gear component that is discarded)?
Per trip or year: ___________kg or panel or (measurement in local terms)
g. What is the main reason you abandon gear?

____

h. Does season have an effect on abandoning of gear? If yes, how?
____

i. How much gear do you lose (gear set for fishing is left and can't locate and retrieve it)? Per trip or year: __kg or panel or (measurement in local terms)
j. What is the main reason you lose gear?

____

k. Does season have an effect on loss of gear? If yes, how?

____

4. Selling of catch, sharing arrangement, and loss of catch

a. Where do you sell your catch?
   ☐ Landing center
   ☐ At sea
b. Type of selling
   ☐ Public auctioning
   ☐ Middlemen
c. What is the sharing arrangement for the catch?

_____Boat owner
_____Skipper/captain
_____Crew
_____Other

d. Have you experienced loss of catch due to capsizing? YES/NO If YES:

How many panels per year? ______________
What season? ______________________
What is the reason for capsizing? ____________________________

STEP 3. INDIVIDUAL FISHER INTERVIEW

Date:

Interviewer name: **Fisher name**:

Fishing vessel name (if vessel is used):

Length and horsepower of vessel: Based from seaport(s)/landing center:

1. Gear type

☐ Gillnet
☐ Trammel net
☐ Combination gillnet/trammel net[6]

2. Fisher Experience in this Fishery

a. Position on vessel (e.g., captain, first mate) (if vessel is used): ____________
b. Number of years fishing using this gear type:______
c. Years in gillnet or trammel net fishing from this seaport/landing center: ______

3. Gear attachment

☐ Anchored
☐ Staked
☐ Drifting (both ends unattached)
☐ Sweeping (one end free, one end attached, e.g. to a vessel)

4. Setting depth

☐ Surface ☐ Midwater
☐ Bottom

5. Setting of net

☐ Float line at the surface
☐ Float line within _____m of the surface
☐ Midwater

☐ Leadline within a few cm but not on the bottom
☐ Leadline on the bottom

6. Typical soak time: ________hours

7. Total fish landing per trip: ________kg

Most common species: ____

☐ Sold at sea
☐ Sold at landing site

[6] For trammel nets and combination gillnets/trammel nets, complete separate forms for the interior and exterior layers.

8. Discarded and Released Catch

a. How many finfish are discarded per trip/haul: ____number/kg/ use local measurement like basket, crate etc.
   Most common species: ____
b. How many live finfish are released per trip/haul: ______number/kg/ use local measurement like basket, crate, etc.
   Most common species: ____
c. How many invertebrates (crustacean, mollusks, etc) are discarded per trip/haul? _____ number/kg/ use local measurement like basket, crate etc.
   Most common species: ____
d. How many live invertebrates are released per trip/haul? _____number/kg/ use local measurement like basket, crate etc.
e. Most common species: ____
f. Identify causes of discarding/releasing catch, and assign score from most to least important (1=most important)

_______No market demand
_______Retention ban
_______Over quota
_______Spoiled upon hauling

________Damaged from the fishing method or gear
________Damaged from partial depredation
________Could damage the rest of the catch during storage
________Insufficient room for storage

g. Other catch that are caught and released, please specify:

Other catch caught and released	Number typically caught per trip/haul	Percent alive upon hauling/retrieval	Most common species

h. What are the predators on catch?

Species Season

- ☐ Seals YES/NO
- ☐ Seabirds YES/NO
- ☐ Cetaceans YES/NO
- ☐ Squid YES/NO
- ☐ Crab YES/NO
- ☐ Sharks YES/NO
- ☐ Pufferfish YES/NO
- ☐ Isopods YES/NO
- ☐ Jelly fish YES/NO
- ☐ Other – please identify: ________________________________

i. Number/kg/ use local measurement like basket, crate etc. of catch depredated per trip/haul/year: ______________

9. Fish lost during hauling of the net

a. Kg of fish slipped out during hauling (typical): ________

Most common species: ____

10. Abandoned, Lost and Discarded Fishing Gear

a. List gear components that you typically discard (throw gear overboard):

b. Material: ____
c. How much gear do you discard (identify amount of each gear component that is discarded)?

Per trip or year: ___________________________kg or panel or (measurement in local terms)

d. What is the main reason you discard gear?
____

e. List gear components that you typically abandon (gear set for fishing left on purpose):
____
____

f. How much gear do you abandon (identify amount of each gear component that is discarded)?

Per trip or year: ___________________________kg or panel or (measurement in local terms)

g. What is the main reason you abandon gear?

____

h. Does season have an effect on abandoning of gear? If yes, how?

____

i. How much gear do you lose (gear set for fishing is left and can't locate and retrieve it)?

Per trip or year: _____________________kg or panel or (measurement in local terms)

j. What is the main reason you lose gear?

---

k. Does season have an effect on loss of gear? If yes, how?
l. Frequency of periodical replacement of fishing gear parts

- Webbing
- Ropes
- Floats
- Sinkers

11. SORTING, STORAGE ON BOARD AND TRANSPORT
a. Do you sort your catch? YES/NO

If YES:
☐ By size
☐ By species ☐By price
☐ By quality

b. How do you store the catch on board?
☐ Insulated boxes
☐ Fish hold
☐ Storage on deck
Other: _______________
Storage capacity: ______kg

c. How do you preserve your catch on board?
☐ Ice
☐ Salt ☐Drying
☐ Other: ____

d. What is the average time it takes to transport the fish from the fishing ground to the landing site: ______hours

ANNEX 3. STATISTICAL ANALYSES

1. Weighted average

The weighted averages of losses were calculated using the formula,

$\bar{y} = \sum_{i=1}^{L} W_i \, \bar{y}_i$ i=1,2,.......L,
where L is the number of strata/ groups,
W_i is the i^{th} stratum weight and it is defined as $W_i = N_i/N$,
where N_i is the total number of vessels in the i^{th} stratum
N is the total number of vessels
$\bar{y}_i$ is the average of i^{th} strata and it is defined as
$\bar{y}_i = 1/n_i \sum_{j=1}^{n_i} y_{ij}$ i=1, 2,.......L, j=1, 2,....... n_i
where n_i, is the number of vessels selected from i^{th} strata

2. Relationship between losses and different attributes

Data on gear loss and fish loss were collected from 583 different fishing units (vessels) from marine and inland sectors.

To differentiate the losses between type of gear, three types of nets *viz.*, (i) lobster gillnet; (ii) trammel net (both are assumed to incur substantial losses); and (iii) mackerel gillnet were selected.

Sample size for various gillnet sub-sectors is given below:

Marine sector						***Inland sector***
Non-motorized	**Motorized - single day**	**Motorized - multiday**	**Mechanized**	**Lobster gillnet**	**Trammel net**	**Non-motorized**
21	121	156	196	13	45	31

Correlation analysis was performed to understand the degree and strength of relationship between soaking time and loss of fish (kg/1000 sq. m of net/hour of soaking) and gear loss (kg/hour of soaking) by computing the Pearson's correlation coefficient using MS-Excel and R software.

The non-parametric (Kruskal Wallis ANOVA by ranks test) was performed for analysis of variance and pair wise comparisons of the Z value. Fish loss worked out as % of the total catch per vessel per year; and gear loss as % of the total gear per vessel per year were used for analysis.

(i) Difference in average loss between Non-motorised, Motorised Single day, Motorised Multiday and Mechanised sub-sectors

The Kruskal-Wallis test statistic computed for fish and gear loss as H =52.82858 ($p < 0.01$) & H =104.1262 ($p<0.01$) respectively. This indicates that both fish and gear loss significantly vary according to the fishing sub-sector which varies in terms of the scale of fishing operation and the target fishery. Pairwise comparison test performed revealed that the motorized single day fishing has significantly different effect on fish loss compared to non-motorized, motorized multiday and mechanized sub-sectors (Figure 5.1).

Pairwise comparison test for gear loss revealed that motorized multiday fishing has significantly different effect compared to non-motorized and motorized single-day fishing (Figure 5.2).

(ii) Non-motorised (marine) vs non-motorised (inland) fishing

The fish loss and gear loss was compared across marine and inland sectors in case of non-motorized fishing. The Kruskal-Wallis test statistic computed as H=1.0353 which was not significant in case of fish loss whereas when computed for gear loss percentage, the statistic was H=7.69 which was highly significant ($p<0.01$)

(iii) Mackerel gillnet vs Lobster gillnet

There was significant difference ($p<0.01$) between mackerel and lobster gillnets in fish loss and gear loss viz., H-statistic values were 0.012 and 27.20 respectively.

(iv) Gillnet vs Trammel net

The average fish loss and gear loss data recorded for gillnet and trammel net fishing was subjected to Kruskal-Wallis test. The test statistic was H=0.002 for fish loss and H=49.11 ($p<0.01$) for gear loss which is in consistence obtained for the previous type of comparison for the species.

The results of Kruskal-Wallis analysis of variance indicate that the gear loss varies significantly among the fishing types, fishing sector (inland or marine) and species (mackerel or lobster. The fish loss did not vary across inland or marine sector in case of non-motorised fishing and the gillnet or trammel net fishing types.

(v) Soaking time

Data on fish loss and gear loss which were grouped under three categories of soaking time viz. very short (< 2 h), short (2-7 h), and long (>7 h) was analysed for its effect on fish and gear loss using Kruskal-Wallis test.

Loss (% of total /vessel/year)	Kruskal-Wallis statistic H	p-value
Fish	17.04	0.002
Gear	20.24	0.000

The soaking time had a significant effect on the fish loss. The mean values were significantly different from each other. Pairwise comparison of means indicated that very short and short duration did not exhibit significant difference in mean fish loss but long duration of soaking was having a significant effect on fish loss compared to very short and short durations.

In case of gear loss, the results show that the effect of soaking time was significantly different which was also confirmed by a pairwise comparison test.

3. Correlation between soaking time and losses

Assuming that the quantity of fish lost increases over soaking time, correlations were worked between the soaking time (hours) and (i) loss of fish (kg/1000 sq. m of net/hour of soaking); and (ii) gear loss kg/hour of soaking) by computing the Pearson correlation coefficient using MS-Excel and R software. The following table gives the correlation coefficients between soaking time and fish and gear loss:

S No	Gillnet Sub-sector	Correlation of soaking time vs Loss of	
		Fish loss (% of total catch/vessel/year)	Gear loss (% of total weight of gear used / vessel/year)
1	Non-motorized (Marine)	0.6284*	0.9318*
2	motorized – single day	-0.4208*	0.3259*
3	Motorized – multi day	-0.0646	0.2099*
4	Motorized-Lobster gillnet	-0.2124	0.1773
5	Motorized-Trammel net	-0.1926	-0.1473
6	Mechanized	0.5049*	-0.2085*
7	Non-motorized-Inland	-0.1022	-0.5134*

* denotes significance at 5%

High positive correlation ($p<0.05$) between soaking time and fish & gear loss was found in the case of non-motorized and mechanized sub-sectors. In the case of motorized – single day sub-sector, gear loss has positive significant ($p<0.05$) correlation but there was no correlation with fish loss and soaking time. In other sub-sectors, there was no correlation between soaking time and losses.

Figure 5.1. Kruskal Wallis ANOVA by ranks test of different attributes that cause fish loss

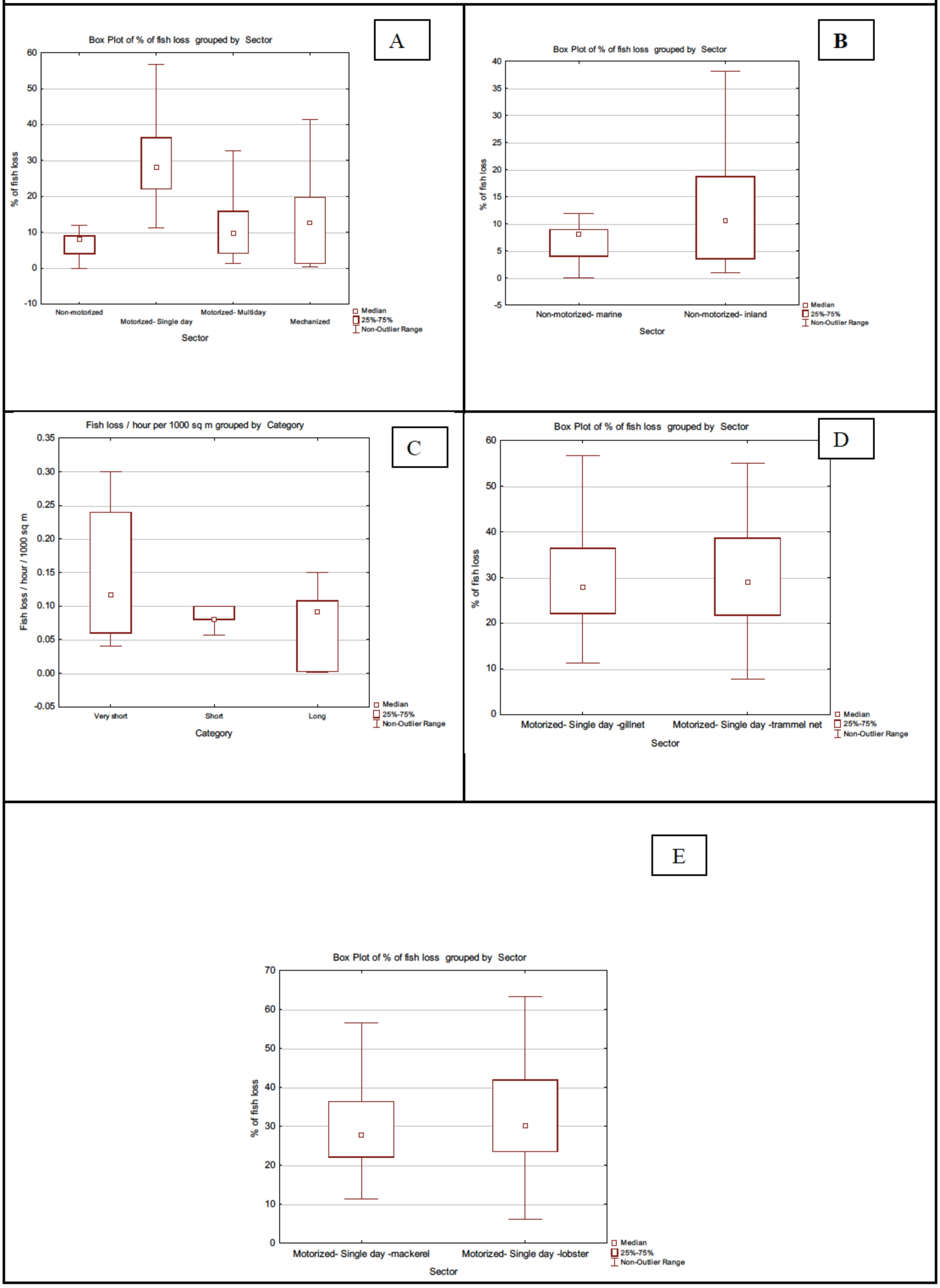
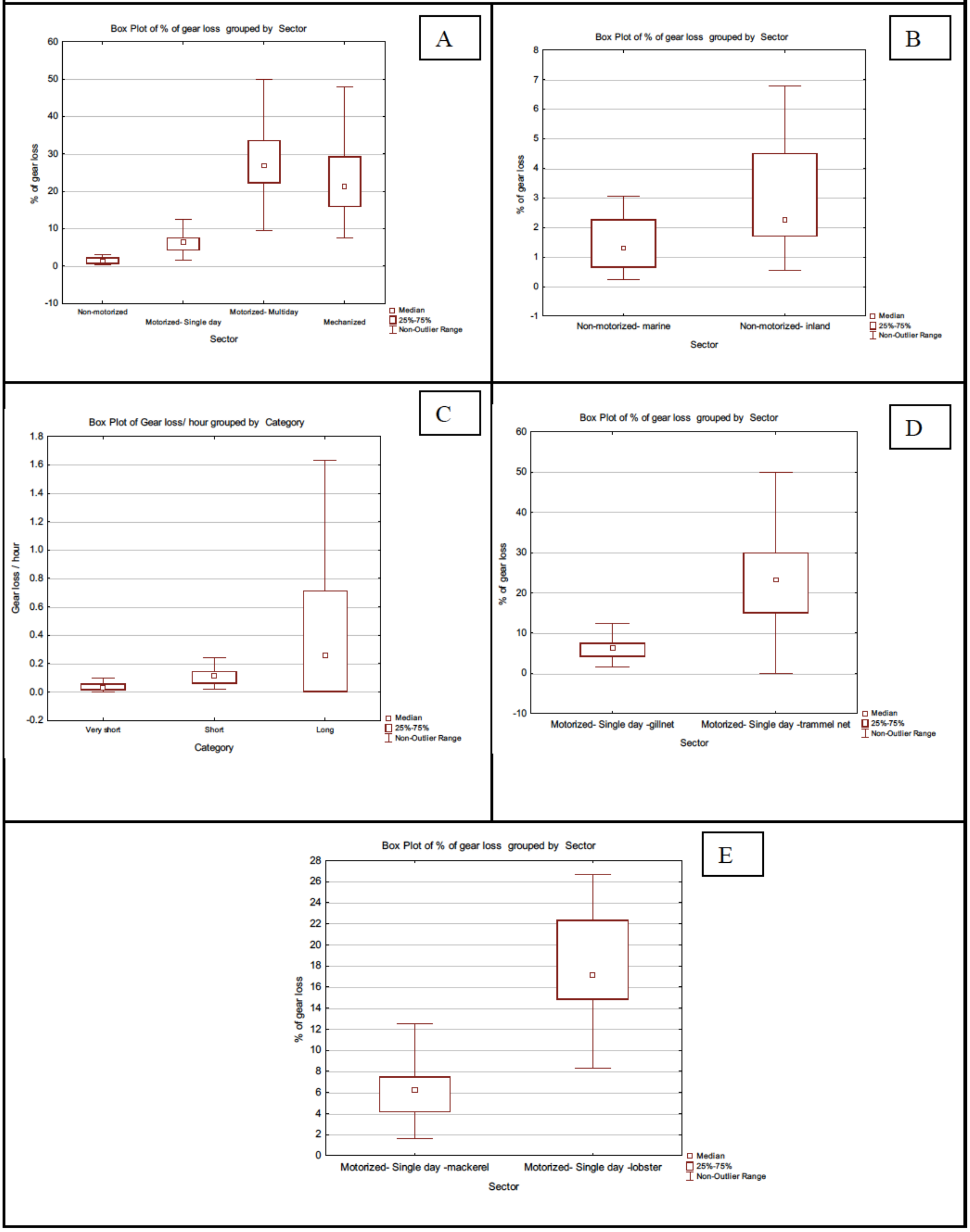


Figure 5.2 Kruskal Wallis ANOVA by ranks test of different attributes that cause fishing gear loss



ANNEX 4. CHECKLIST FOR ASSESSMENT OF SOCIO-ECONOMIC CHARACTERISTICS OF FOOD LOSS

A. Characteristics of the fisheries
   1. Different livelihood groups and their socio-economic characteristics in gillnet and trammel net fisheries (including production, processing and trade activities)
   2. Fishing craft and gear, species and seasonality;
   3. Trends in production patterns
   4. Characterisation of the different value chains to which the local catches contribute; intermediaries involved in each value chain and their activities relating to the gillnet and trammel net catches
   5. Economic context (production relations, credit and investments, trader linkages and/or influence on production and marketing etc.)
   6. Social context (caste/religion/gender/age/etc., characteristics having influence on fisheries)
   7. Policy/political/institutional context relevant to/influencing the fisheries in the region

B. Validation and elaboration of the gillnet and trammel net loss information obtained from CIFT's fieldwork
   1. To understand the losses from an economic and food security perspective
   2. To identify the key stakeholders along the gillnet/trammel-net value chains who might be affected by the losses and their socio-economic characteristics (with emphasis on vulnerability and marginalisation issues)
   3. To further understand the proportion of the losses at each level in the value chain – production, processing and handling, and trade – and their reasons

C. Social and economic factors contributing to the losses: what factors hinder the fishers from undertaking appropriate means to reduce/avoid losses? (Lack of adequate incentives or access to investments, labour issues, market access/demand, poor infrastructure, weak support systems, trade/trader compulsions etc.)

D. Putting the food/economic losses into the livelihood perspective:
   1. Assessment of the income for a family (a) from all sources and (b) gillnet fisheries
   2. Assessment of the expenditures incurred by the family for different purposes:
      i. For subsistence needs (food, shelter, clothing and other basic needs)
      ii. For social development needs: healthcare, education, food/nutritional security, quality-of-life investments – housing, water, toilets, etc., entertainment, family occasions and so forth.
      iii. For savings, i.e., future security needs, including old age support
      iv. For livelihood needs (fishing and other related activities)
      v. For servicing credit (both production-related and subsistence/social-related)
   3. Assessing the food value of the fish from the domestic fish consumption perspective: (In the absence of opportunities to explore the broader consumer context relating to the losses, this information will help to contextualise the loss from a food security perspective, by taking the fishers themselves as a major consumer of their product).
      i. How much of a fishing household's consumption needs are met by the catches from the gillnets and trammel nets?
      ii. What proportion of the gillnet and trammel net catches contribute to the domestic food needs? Trends over the years in terms of fish consumption by the fishers themselves – and causes
      iii. Assess the monetary value of the fish consumed by the household as a proportion of overall income
   4. Fisheries management implications (ecological costs of losses)

5. Based on the above, develop a general picture of the income-expenditure pattern – including the non-monetised benefits such as household food security – for the selected households on a daily (i.e., fishing trip wise), monthly or annual basis
6. Quantification of fish losses – in economic terms – as a proportion of (i) the incomes (ii) the expenditures and (iii) the domestic food security of the fishers themselves
7. Quantification of losses at a broader level, as a proportion of income being generated by (i) different fishing systems and (ii) the overall local fishing economy on a daily, monthly and/or annual basis
8. Potential implications of reducing losses at the household level as a proportion of the current expenditure on:
    i. Subsistence (including food security)
    ii. Social development investments
    iii. Savings and asset creation
    iv. Livelihood enhancement and diversification (including better market access)
    v. Credit dependence and servicing needs
9. Potential implications of reducing losses at the local economy level in terms of:
    i. Improved economic performance
    ii. food security
    iii. market access
    iv. infrastructure and collective endeavours
    v. fisheries management

E. Fishers' own ideas/prescriptions for reducing the losses:
1. Actions needed at the level of the specific activities in the gillnet/trammel net fisheries (and their value chains) – i.e., actions at the fishers'/processors'/traders' level
2. Actions needed at the community level: infrastructure, institutional organisation, social support systems etc.
3. Actions needed at the policy level: awareness raising, training and skill improvement, technological improvements, credit and other support to access better technologies, enhanced standards and their implementation for reducing losses along the production and value chain activities.

F. Institutional actors' (i.e., government and CSOs) ideas/prescriptions for reducing the losses in gillnet and trammel net fisheries

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