INVESTIGATING REDUCTION FISHERIES AND THEIR IMPLICATIONS IN INDIA

Final Report

Dakshin Foundation is a non-profit, non-governmental organisation and a charitable trust, with the mission to inform and advocate conservation and natural resource management, while promoting and supporting sustainable livelihoods and environmental justice. Dakshin achieves its mission by adopting interdisciplinary and transdisciplinary approaches in its research, drawing from the fields of ecology, conservation biology, sociology, economics and law. Their work aims at building community capacities for conservation and enhancing community stakes and rights in environmental decision-making, towards strengthening networks and supporting advocacy campaigns. Dakshin's goal is to promote ecologically and socially appropriate approaches to conservation and management in marine and coastal ecosystems in India.

WWF India is a charitable trust set up in 1969 with the mission to stop the degradation of the planet's natural environment and build a future in which humans live in harmony with nature. To achieve its mission, WWF India works on a range of conservation issues across both, terrestrial and aquatic habitats. In achieving its conservation objectives, WWF India works with a wide range of stakeholders including local communities, NGOs, government agencies, research institutions and industry, using strategies such as field projects, education, policy/advocacy, research and campaigns.

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Executive summary

Bycatch refers to the marine biomass that is incidentally caught along with commercial fish during fishing. This unwanted biomass can contain non-edible biota, juveniles of commercial fish, or even endangered fauna such as sharks and rays. Earlier discarded at sea as it had no economic value, it is now being increasingly caught and landed for its demand as raw material for the production of fish meal and fish oil (FMFO) - high-quality protein supplements for aquaculture and poultry industries. Such fisheries that divert fish from direct human consumption into the production of FMFO are called reduction fisheries.

Increasing demand for reduction fish incentivises indiscriminate, non-selective and destructive fishing practices like trawling to land higher bycatch - indicating a concerning shift from species-driven to biomass-driven fisheries. This can have implications for not just marine ecosystems, but also jeopardise the livelihood and nutritional security of dependent fishing communities. Although there are several studies indicating the use of low-value catch for FMFO production, there is a lack of evidence on the scale, functioning and dynamics of this sector, making it difficult to formulate management and policy actions.

Dakshin Foundation and WWF-India collaboratively undertook a project to generate baseline information on reduction fisheries and the implications of the reduction fisheries sector across six coastal states of India. Gujarat, Andhra Pradesh and Odisha were studied by WWF-India, while Maharashtra, Karnataka, and Tamil Nadu were studied by Dakshin Foundation. The study was conducted in 2022 adopting an interdisciplinary approach to understand the reduction fisheries supply chain, species utilisation, and actors' perspectives across the supply chain.

The reduction fisheries supply chain was found to be distinct across the six project states, in terms of both structure and functioning. The study suggests that many factors shape the supply chain of a local region, including quantity and quality of reduction catch, availability of resources (oil-rich fish species), access to FMFO processing plants and poultry farms, etc. In addition to the aquaculture and poultry sector, multiple linkages with other sectors such as dry fish, seafood exports, pharmaceutical, and cosmetic industries were also observed, lending a high level of complexity to the structure of the supply chain.

The study revealed that 64-89% of the observed faunal groups diverted to the FMFO sector were species that are otherwise used for direct human consumption. This overlap in utilisation, especially of the nutritious and affordable fish species, can severely undermine the livelihood and nutritional security of the dependent small-scale fishing communities and the coastal poor. This calls for an urgent need for policy actions and stringent measures. However, this study evidences that policy decisions need to be inclusive and socioeconomically just as the reduction fisheries sector provides direct/indirect livelihood support to different demographic sections, including women and migrants across the supply chain.

This study builds a baseline understanding of the reduction fisheries industry in India and locates knowledge gaps to be addressed for better policy and management of reduction fisheries. However, this was a relatively shorter study aimed at gaining a broad understanding. Deeper insights on various aspects of reduction fisheries are needed. Some recommendations for further consideration include long-term studies on bycatch and investigation of supply chain interlinkages. Policy and management actions informed by ecological evidence and socioeconomic realities will help achieve practical solutions to address the implications of the reduction fisheries sector and enhance the sustainability of Indian fisheries.

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Introduction

Thriving and flourishing marine ecosystems are crucial for the sustenance of millions of people around the world and the economy of maritime nations, providing livelihoods and food security to billions of people worldwide. Seafood is among the highest-traded food commodities in the world (FAO, 2020). Fish is an affordable and excellent source of animal protein and essential micro-nutrients, and ensures the nutritional security of about 525 million people globally (Selig et al., 2019). The role of sustainable marine fisheries is even more emphasised in the case of developing countries like India, where the sector supports a population of more than 14 million people along a ~8,000 km coastline.

India is the third-largest fish-producing nation in the world and the second-largest in aquaculture production (PIB Delhi, 2023). The sector contributed to 8% of global fish production. The fisheries sector contributes to 7.56% of the agricultural GVA (gross value added) of the country (PIB Delhi, 2021). It provides promising avenues to fight widespread hunger and malnutrition in the country. However, multiple issues hinder this vision, including, climate change, pollution, habitat destruction and overfishing.

Unsustainable harvesting of incidental aquatic species while catching targeted species, called bycatch, is among the major concerns faced by fisheries worldwide (Davies et al., 2009; Lobo, 2012). It is more emphasised in a tropical biodiverse country like India, where the fisheries sector is characterised as multi-gear multispecies fisheries (Funge-Smith et al., 2005). Prevalent non-selective and intensive fishing practices like trawling haul huge quantities of bycatch along with the target catch, making them especially destructive for marine ecosystems (Kumar & Deepthi, 2006).

The trawl fisheries in India, starting from the 1950s, developed by exploiting then abundant and in-demand resources, like shrimp – to increase trade with developed countries and build foreign exchange. Trawl fisheries drove the mechanisation of the Indian fishing fleet and contributed significantly to India's total capture fisheries production (Bavinck, 2012; Bhat and Bhatta, 2006; Bhathal, 2005; Kurien, 1978). However, this happened at the cost of the health of marine ecosystems. In the last few decades, there has been a decline in the catches of commercial target species of trawlers, including shrimp. Over the years, the proportion of target catches and discards in trawlers has decreased, while both the volume and proportion of bycatch in trawlers have increased (Dineshbabu, 2014). Trawl bycatch in India can range from 60-80% of the total catch (Dineshbabu, 2014). Fuelled by aquaculture, an economy developed around the utilisation of bycatch for the production of fishmeal and fish oil in the country.

What are reduction fisheries?

Not all fish caught from the oceans are utilised for direct human consumption. Many fisheries land huge volumes of fish to be reduced into fish meal and fish oil (FMFO) – high-quality protein ingredients used in making feed for aquaculture, poultry, and other food-producing industries. These fisheries are also known as reduction fisheries (Marine Stewardship Council, 2017).

Globally, reduction fisheries accounted for 16 million tonnes of catch in just one year (2020), corresponding to 20% of total capture fisheries catch (FAO, 2022). Unregulated reduction fisheries can wreak havoc on marine ecosystems and are known to decimate entire fish populations and the associated fishery. An example of this from recent history is the California sardine. Fish with high-oil content, like sardines and anchovies, are crucial to producing high-quality fishmeal and fish oil. In the 1930s, factory ships were established to reap the benefits from seemingly abundant California sardines. However, the fish population entirely crashed by the late 1960s due to climate change and overfishing reduction and this crashed the entire fisheries dependent on California sardines (Radovich, 1982; Ueber & MacCall, 1992).

Furthermore, reduction fisheries are also known for diverting low-value, highly-nutritious fish away from many vulnerable and marginalised coastal communities, which is their only source of animal protein and essential micronutrients (Hicks et al., 2019). Studies and reports from African countries, like Ghana, South Africa, and Tanzania have highlighted this issue (Issacs, 2016; Nunoo et al., 2009; Pauly, 2019).

While these are some of the recorded threats from reduction fisheries, a bigger threat looms in the form of under/unreported, but increasing volumes of bycatch from fishing practices like bottom trawling being used for reduction. This lack of information makes reduction fisheries invisible in the policy sphere. This is seen as an emerging and alarming trend across tropical fishing countries posing a serious threat to the sustainability of fisheries and the health of oceans (Gupta et al., 2019; Leadbitter, 2019). In India, the trawl bycatch can contain more than 100-150 aquatic animals, including protected fauna such as sharks (Dineshbabu et al., 2014).

The utilisation of otherwise discarded bycatch for reduction might give the false impression of a win-win situation for both reduction plants and trawl fishers. While reduction plants will be able to fulfil growing FMFO demand from the booming aquaculture industry, the trawl fishers will utilise and sell the ‘waste’ bycatch and earn some additional income. However, this practice has led to the commodification of bycatch and incentivised increased landings of bycatch in trawl fishing all along the Indian coast (Lobo, 2012; Aswathy et al., 2012). In addition, the recent decline in the overall production of Indian oil sardine (CMFRI, 2019) can further increase the demand and the price of bycatch, feeding this unsustainable vicious value chain by encouraging fishers to land higher volumes and even marketable fish as bycatch for reduction. This is facilitating an alarming transition from the conventional target- (or species-) driven fisheries towards biomass-driven fisheries, which seek to extract everything from the ocean that has organic biomass to convert it into FMFO. Such unregulated transitions will lead to irreversible consequences for the ecological integrity of our oceans and the livelihood security of millions, particularly those in small-scale fisheries (SSF).

Collaboration to understand the landscape of reduction fisheries in India

Previous work on FMFO done by WWF-India and Dakshin Foundation independently at multiple sites across coastal India suggested an urgent need for holistic investigation of reduction fisheries in India. Therefore, both organisations collaborated to conduct an investigation into the reduction fisheries and explore their implications across six coastal states of India - Gujarat, Maharashtra, and Karnataka on the west coast; Tamil Nadu, Andhra Pradesh, and Odisha on the east coast.

WWF-India covered Gujarat, Andhra Pradesh, and Odisha components of the project, while Maharashtra, Karnataka, and Tamil Nadu components were covered by Dakshin Foundation. The six states represent over 75% of marine capture fisheries production in India (Fisheries Statistics Division, 2023). In addition, they represent diversity in terms of marine ecosystems, diversity of fishing practices, demography, and reduction fisheries infrastructure – ensuring an extensive coverage of reduction fisheries and their implications across India.

The implications of reduction fisheries are not limited to ecology but cascade across the socioeconomic fabric of Indian fisheries, including cross-cutting aspects such as gender, migration, etc. Although there are many studies on the impact of bycatch and its utilisation for the production of FMFO (Aswathy et al., 2012; Behera et al., 2017; Dineshbabu et al, 2014), there is a lack of evidence on the scale, functioning, and dynamics of reduction fisheries, which makes it difficult to capture the implications. To fill this gap, we took an interdisciplinary research approach with a focus on the reduction fisheries supply chain and its actors to generate rich, demographically disaggregated information to inform ecologically sustainable and socioeconomically inclusive solutions for its management.

This collaboration is the first attempt in India to understand and address the implications of the unsustainable harvesting of aquatic organisms as biomass to manufacture FMFO at this scale. Over the course of one year (2022), we collected data on the current state and functioning of reduction fisheries in six states. We were able to gain insights on species utilisation by the reduction industry, and structures of reduction fisheries supply chains across the project sites, including the various types of actors working across the reduction fisheries supply chains, from fishers to FMFO producers. In the following sections of the report, we present preliminary documentation of reduction fisheries in each project state. It will help locate the gaps and move towards viable and just solutions that are rooted in evidence.

Important terms and their definitions

The definitions of many terms used while conducting the study vary based on context. Terms such as 'bycatch', 'trash fish', and 'low-value fish', for example, are often seen to be interchangeable in both their colloquial and academic usage. Although many local terms needed to be incorporated for field implementation of the framework and questionnaires, we used mutually agreed-upon terms and their definitions to maintain consistency among different project teams. It helped in smoothly executing the study and synthesising results. Following are definitions of commonly used terms in the report:

Target catch: The portion of fish (or multiple species) that are targeted during a fishing operation. It generally includes high-value species such as tuna, pomfret, mackerels, etc.

Bycatch: Fish or other aquatic species that are caught unintentionally along with the target catch. Bycatch can either be discarded at sea or landed and utilised (Changing Markets Foundation, 2019).

Discards: The portion of bycatch that is discarded at sea during fishing. It can include low-value or non-edible marine organisms, including protected animals like turtles and whale sharks.

High-value catch: The portion of fisheries catch with high consumer preference and high commercial value in local and export markets for direct consumption. The term 'target catch' is interchangeably used with 'high-value catch'. The slight difference is between the disciplinary lens through which the fisheries catch is described. From an economic utilisation perspective, terms such as 'low-value', and 'high-value' are used, while through a fisheries management perspective, 'target catch', 'bycatch ', and 'discards' are used to describe fisheries catch. In India, fishers generally use the economic value of fish to sort their catch.

Low-value catch: includes incidental catch, juveniles of the commercial species, or damaged portion of landed catch. This catch has low direct consumer preference and is utilised in the dry fish sector or reduction fisheries sector (Funge-Smith et al., 2005).

Trash fish: The term is often used interchangeably with 'bycatch' and 'low-value bycatch' to refer to the portion of catch to be used for reduction. It generally includes low-quality, low-preference, and rotten catch unfit for human consumption. Even though locally a prevalent term, we have refrained from using it in this document as it may associate negative connotations with the utilisation of nutritious food fishes and thus, have policy implications. We have retained the usage while stating direct quotes from respondents.

Reduction Fisheries: The process of making fishmeal and fish oil using whole fish or offal is called reduction. Fisheries that divert their catch for the production of fish meal and fish oil, rather than for direct human consumption are called reduction fisheries (Cashion et al., 2017; Changing Markets Foundation, 2019).

Supply chain: People and businesses involved in the production, processing, brokering, and distribution of seafood from fishers to consumers. The seafood can be transformed multiple times throughout the supply chain till it reaches end consumers (Future of Fish, 2015).

Actor: In this report, it refers to the participants who make a supply chain work and ensure the flow of fish/seafood. Here, these actors include fishers, intermediaries (traders, aggregators), FMFO processors, fish workers, etc (Hugos, 2022).

Supply chain nodes: Nodes represent the different types of actors in a supply chain (Liotine & Ginocchio, 2020).

Trader: An intermediary or mid-chain actor in a supply chain who buys either fresh or processed fish and sells it to the next actor at a commission. Traders are important in the flow of material across the supply chain.

Aggregator: An intermediary in a supply chain that buys and aggregates either fresh or processed fish from small traders and sells in bulk to the next actor.

Processor: Any actor that transforms the fish by drying, curing, cutting, cleaning, and adding value to the final product is called a processor.

Fish-worker: Fish-workers here refers to the crew members, workers working at the fish landing site, both women and men, including the migrants, etc.

Fishmeal: A high-calorie and protein-rich powder produced from fish. It can be made either by industrial processing methods, including mincing, cooking, and pulverising the catch or by drying and grinding into a fine powder (Changing Markets Foundation, 2019).

Fish oil: Oil extracted from fish along with fishmeal during the process of reduction. It is a high-value product used in aquafeed, pharmaceutical, and healthcare industries (Changing Markets Foundation, 2019).

Fish feed/ aquafeed: A range of products used to feed aquatic organisms raised in aquaculture farms, such as shrimps. These products are a mix of various ingredients such as soy meal, bone meal, etc. Fish meal and fish oil are crucial growth ingredients in formulating aquafeed. Fish forms a major component of the natural diet of marine organisms, especially carnivores like cobia (Changing Markets Foundation, 2019).

Poultry feed: The products used to feed the poultry sector, both layers and broilers. It can include the combination of animal-origin ingredients, such as FMFO and plant-based ingredients, like soybean cake (Changing Markets Foundation, 2019).

Methodology

We co-developed methodology in the initial stage of the project through a series of online workshops. Accounting for the heterogeneity in fisheries landscapes across project states, we developed a flexible framework and guidelines to generate information on common themes while factoring in the differences in fisheries of the project states (Fig 1).

We adopted a three-fold methodology consisting of profiling fish landing sites based on secondary literature, interviews, and biological characterisation. These methodological components ensured that the information gets well-triangulated. Considering the constraints of resources and the vast coastlines of the project states, we planned to execute the project in two stages – scoping and in-depth field data collection.

The scoping stage helped us prioritise and clarify the functioning of the fishing harbours and fish landing centres in the project states. It also helped in improving the understanding of the reduction fisheries industry in the region. We selected and prioritised the landing centres through harbour profiling and interviews with key informants. The key informants included scientists, fishmeal plant owners, heads of fishers' organisations, etc., who could provide us with an overview of reduction fisheries and the related social-ecological implications in the project states. We chose the key informants from Dakshin's and WWF-India's network with local communities and organisations and snowballed if required. These interviews were guided by a comprehensive questionnaire designed to cover information on all the major aspects of reduction fisheries.

In addition to prioritising sites, we also undertook reconnaissance surveys at these sites during the scoping stage to plan biological characterisation and in-depth actor interviews. In Odisha, we could not prioritise sites due to scattered reduction fisheries infrastructure along its coast and resource constraints. To overcome these limitations, we documented the reduction fisheries sector at sites from both north and south Odisha.

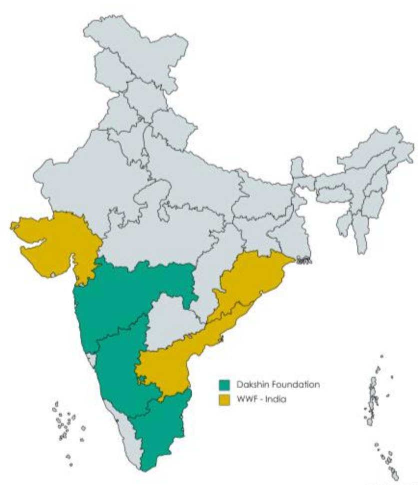

Figure 1: Map showing the project states (colour-coded)

During the second stage of the project, we documented the reduction fisheries supply chains and conducted in-depth interviews with actors across the supply chain to gain insights on aspects such as the demographic profile of actors and their issues and perspectives relating to the reduction fisheries. These interviews were conducted at the prioritised sites using a semi-structured questionnaire (Bernard, 2013) tailored to adapt to the site-specific requirements. Some of the questions were rephrased, as required, based on local language, ground situations, and type of respondent.

Interviews were conducted based on the standard ethics protocols. We sought verbal informed consent from the respondents. The respondents were given the option to opt out of the study at any time during the project. The interviewees' details were anonymised to protect their identities. While transcribing the interviews and analysing the transcript, systematic codes were assigned to each of the respondents.

Along with the interviews, we undertook biological sampling of the catch for reduction landings at landing centres selected during the scoping stage. The sampling strategy was kept flexible to suit the feasibility and variations encountered at each landing site while maintaining uniformity in data collection. The exercise was conducted following the steps below (Fig 2):

1. A representative sample was collected from the point of first sale to ensure maximum traceability of the catch. In the case of Gujarat, with certain traceability of catch to its origin (fishing vessel), samples were collected at FMFO plants.

2. The sample was weighed and sorted according to the taxonomic groups using visual inspection of their quality (intact, damaged, or rotten).

3. Specimens from each group were further measured and weighed along with photo documentation.

4. Specimens were identified to the lowest possible taxonomic level using FAO Species Identification Guide for Fishery Purposes and Murugan & Namboothri, 2012.

5. We also collected information on the fishing operation of the vessel the sample was collected from through on-field conversations. The information included fishing-trip duration, type of fishing gear, fishing region, depth of trawling, number of hauls, average soak time, high-value/target, low-value catch, etc.

6. The data collected was compiled and documented in spreadsheets to carry out an exploratory analysis.

Figure 2: Flowchart demonstrating the sampling process

Despite following uniform guidelines, biological characterisation was affected by many uncertainties, including bad weather and monsoon bans. The exercise could be carried out only in four (Gujarat, Karnataka, Tamil Nadu, and Andhra Pradesh) out of the six project states. We focused on site-level exploratory analysis rather than inter-site comparison as differences in sampling efforts and sampling season varied across states, making comparative analysis unreliable. Large-scale studies on bycatch monitoring must be designed to be long-term to normalise these variations and produce comparable results.

Gujarat

Veraval fish landing centre

State Profile

Gujarat with about 20% of the country's coastline, 33% of the continental shelf area (1,64,000 sq. km), and over 2,00,000 sq. km of EEZ (Exclusive Economic Zone) rank first among the maritime states in marine fish production in the year 2021-22 (Fisheries Statistics Division, 2023). The annual marine fish landings of Gujarat in 2021 were estimated at 6.88 lakh tonnes, which is about 16.7% of the all-India potential in the same year (Fisheries Statistics Division, 2023).

Site Profiles

Veraval is one of the largest fisheries harbours of Gujarat with a capacity of over 5000 boats. It is also known for its largest boat-making industry and the fishing activities take place almost throughout the year. Veraval is home to a large number of fish processing factories under the Gujarat Industrial Development Corporation (GIDC) which export prime-quality seafood to the USA, Japan, South East Asia, Gulf, and European Union Countries.

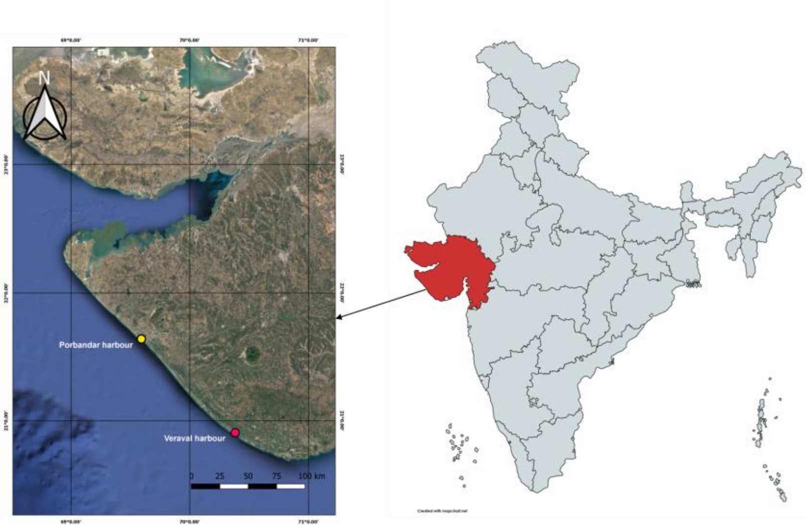

Figure 3: Map of the study sites along the Gujarat coast

The fishing gear was found to vary with the type of fishing operations. Trawlers, specifically, were recorded to have 30-35 tons of capacity with a size of 40-45ft (Hitanshi et al., 2021). The number of days per fishing trip varied with the type of vessel. The multi-day trawlers went fishing for 20-25 days whereas gillnets were observed to go fishing for 3-5 days per trip. At Porbandar, multi-day trawlers were observed to go fishing for about 15-18 days whereas gillnetters went for about 3-5 days per fishing trip. Certain boats were found to operate both gill nets and trawl nets.

Fisheries and species utilisation

Over 20 samples were collected from landing centres and fish meal plants located in both Veraval and Porbandar between August and September. While visually inspecting the specimens, we found that most of them were intact and measurable.

The maximum number of specimens observed was that of *Acetes indicus* (paste shrimp) belonging to the Sergestidae. Since the number of paste shrimp specimens couldn't be recorded due to their small sizes, we couldn't include them in the visualisation of the number of specimens recorded per group (Fig 4). Apart from Sergestidae, over 50% of the specimens were found to be belonging to Leiognathidae, Apogonidae, and Engraulidae families.

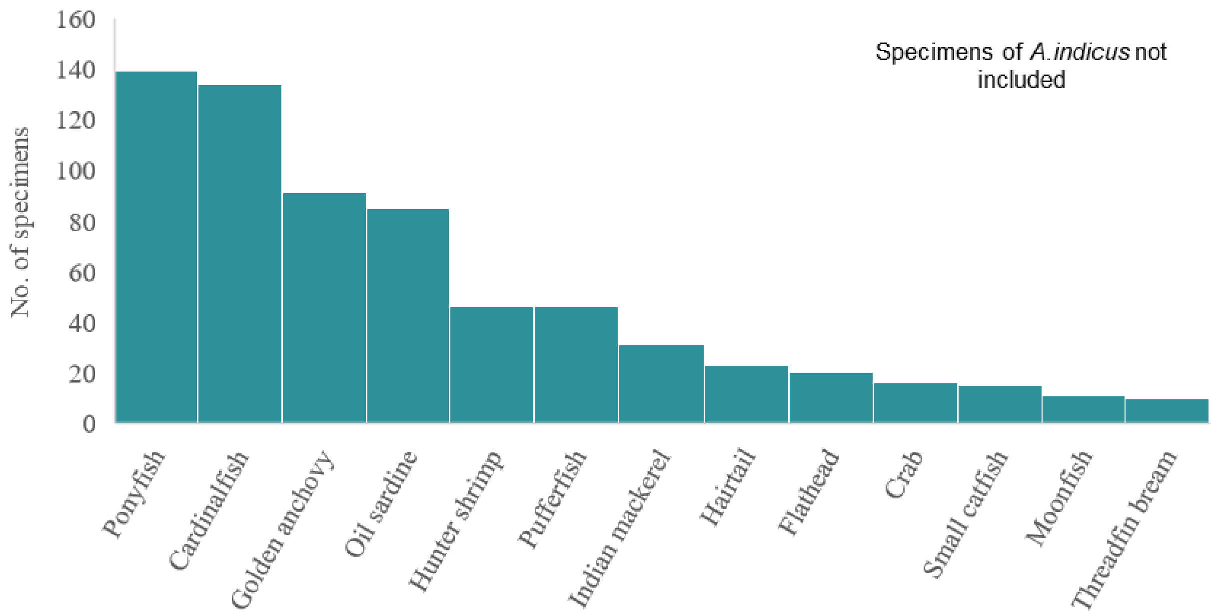

Figure 4. Graph representing the total number of specimens per faunal group observed in the samples (n=22) collected from both Veraval and Porbandar

Based on the observed trends of utilisation at Veraval and Porbandar, we found that 89% (17 groups) of organisms were preferred for both consumption and reduction fisheries whereas the remaining 11% (2 groups) were exclusively used for the production of fishmeal and fish oil, (Fig 5, Table 1).

Table 1. Catch utilisation of different faunal groups observed during the study at Veraval and Porbandar

Utilisation	Faunal groups identified in the samples in Veraval & Porbandar
Consumption & reduction	Paste shrimp, threadfin bream, crab, ponyfish, flathead, solefish, squid, oil sardine, hairtail, anchovy, Indian mackerel, guitarfish, pufferfish, small catfish, octopus
Only reduction	Mantis shrimp, cardinal fish

A key informant highlighted the ‘sensitive nature’ of fishing for declining paste shrimp population. Based on complaints received from many fisherfolks, the trawl association are demanding strict actions against fishing *Acetes indicus* as it was observed locally as destructive to the commercial fisheries.

In the past 15 years, the fisherfolk have witnessed a significant increase in the low-value catch landings as compared to the high-value target fishes including the juveniles of various high-value species. They attributed this increase to the usage of the small and diamond-shaped mesh size. The increased landings had further accentuated the demand in the reduction fisheries sector, both domestic and international markets, thus, "dramatically changing" the fishing patterns over the last 5 years as quoted by one of our key informants.

While many of the interviewees agreed on the livelihood support achieved by the increase in the demand for the low-value catch, they also recognise its implications on the high-value catch landings and also on the overall health of the oceans over the long period. Some of them also suggested that if all the fisherfolk cooperate, they would like the state fisheries department to intervene and revise the regulations on fishing practices.

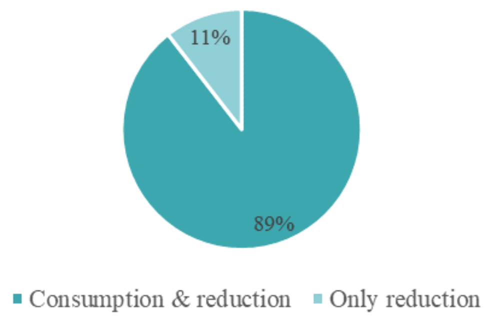

Figure 5: Catch utilisation (%) of the faunal groups observed during the study at Veraval and Porbandar

We found that in our study sites, during trawl fishing, almost every haul contributes to the low-value catch landings and about 90% of multi-day trawlers land catch for reduction along with high-value target catch. An estimated 2-3 tonnes of catch for reduction was landed per trawl boat in this region, especially from the bottom trawlers where the catch for reduction was found to be higher than that of target catch.

It was also observed that these landings contribute significantly to the overall profit margin of the trawl catch. During the time of the study, we were informed that over 20-30% of the total earnings are derived exclusively from low-value catch sold to fishmeal plants. We were also informed that the trends of exports of commodities like squids, cuttlefish, and ribbonfish have declined significantly thereby reducing the profit margins earned by the fisherfolk per fishing trip, incentivising higher landings of low-value bycatch.

"About 20-30% of the earnings of a fisherman is derived from the catch for reduction itself." - Trawl boat owner, Porbandar

Therefore, in order to sustain their businesses and bear any economic losses, the fisherfolk's reliance on the catch for reduction has increased and some have also started 'targeting' more species that are preferred by fish meal plants instead of targeting commercially important species used for direct human consumption.

Both Veraval and Porbandar are major suppliers of catch diverted as raw material to the FMFO plants in Gujarat. There are over 20-25 FMFO plants in this region which supply feed to aquaculture and poultry farms.

Figure 6: (clockwise from top) low-value bycatch segregated for reduction fisheries, Women worker sorting and salting of reduction catch, fish meal produced as a final product in FMFO processing plant.

Supply chain of reduction fisheries in Gujarat

At a broad level, we found a similar structure in the supply chain of Veraval and Porbandar. Trawlers contributed the maximum quantity to the low-value landings. Most of the auction of catch for reduction takes place at the time of landing itself wherein both the boat owners and traders were observed to negotiate the rates of reduction fish.

We found that rates were decided based on the quality of the catch along with the price of fresh fish in the local market (Fig 7). In Porbandar, the catch for reduction with a mixed composition of species was being sold at the rate of ₹17-18 per kg while the catch with paste shrimp was sold at around ₹8-10 per kg. We were informed that the price of the mixed catch for reduction could go up to ₹25-30/kg as well.

> ***"Increasing demand for the catch for reduction has dramatically changed the pattern of the fishing and entire market over the last five years." -Association head, Porbandar***

There was no significant difference in the rates between that of Veraval and Porbandar. We were informed that 20-25% of the low-value catch was sent to fish drying areas for human consumption whereas the remaining was diverted to FMFO plants (65-70%) and poultry farms.

Overall, we found 4 distribution pathways of fish trade in the sites we covered as illustrated in Fig 7. These channels are managed by traders, traders' associations, or fisheries cooperative societies.

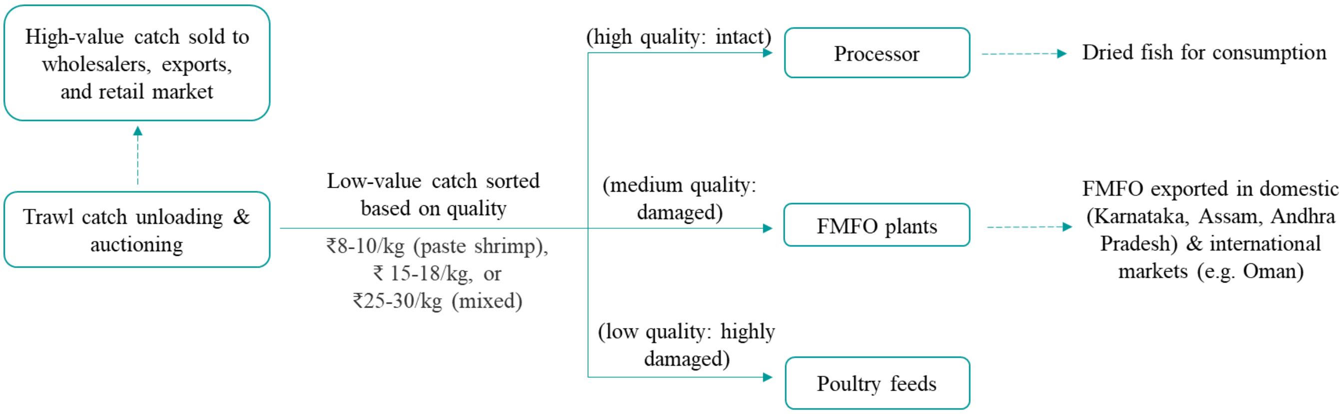

Figure 7: The supply chain of reduction fisheries in Veraval & Porbandar

Figure 8: Quality grades of low-value catch and its utilisation

Maharashtra

Bhaucha Dhakka (New Ferry Wharf), Mumbai

<u>State Profile</u>

Maharashtra has a coastline of about 720 km and a continental shelf of 1,12,512 sq. km. The annual marine fish landings of Maharashtra in the year 2020-2021 were 1.23 lakh tons (CMFRI, 2022). The state has 526 fishing villages and 3,64,899 fishers (Department of Fisheries, Government of Maharashtra, 2021). Based on the literature review, Mumbai stood out as a significant centre for the reduction fisheries. Hence, from the entire coastal belt of Maharashtra, Mumbai was prioritised for the study.

<u>Site Profile</u>

Mumbai has two major fishing harbours and one fish landing centre – *Bhaucha Dhakka* (also known as New Ferry Wharf), Sassoon Docks, and Versova respectively (Fig 9). Among these three, Bhaucha Dhakka is a major trawl catch landing site, therefore, an important place concerning fisheries catch going to reduction plants. In our on-field conversations, we were informed that several FMFO plants are located in Navi Mumbai (Taloja, Vashi, Belapur, etc.) (Fig 9).

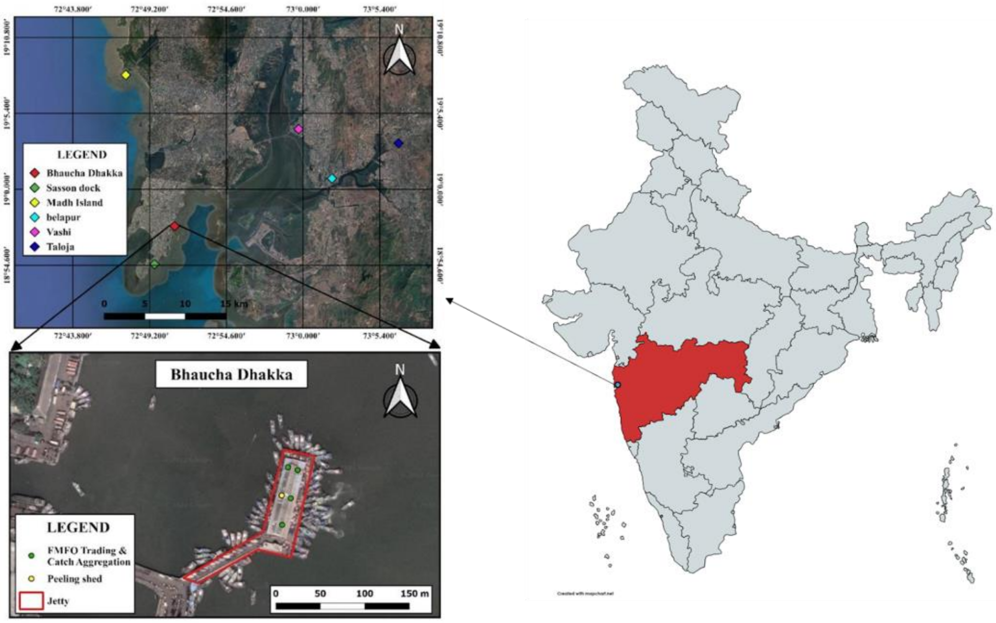

Figure 9: Map of the study sites along the Mumbai coast

Fisheries and species utilisation

Based on field observations, the target catch was dominated by ribbon fish (*Lepturus* sp.), croakers, Bombay duck, and shrimps. Apart from these, we also observed high-value commercial fish in the market, such as king mackerels, pomfrets, black pomfrets, Indian mackerel, sharks, lobsters, etc.

The low-value catch at Bhaucha Dhakka was sorted and aggregated in different piles of catch. These piles included a large number of species (Table 2), including juveniles of many commercially important fish like eels. We were informed that the catch composition varies according to season and other environmental factors. Based on interviews and observations, we found that 69% of the observed faunal groups were used for both direct consumption and reduction (Fig 10).

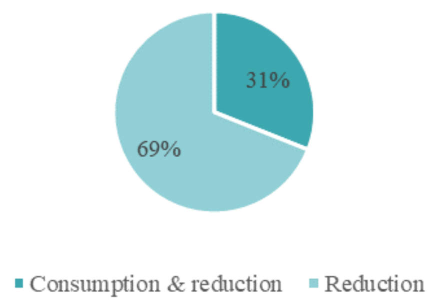

Figure 10: Catch utilisation (%) of the faunal groups observed during the study at Mumbai

Table 2 Catch utilisation of different faunal groups observed during the study at Mumbai

Utilisation	Faunal groups identified in the samples at Mumbai
Consumption & reduction	Anchovies (*Stolephorus spp.*), croakers, catfish, false trevally, snapper, Lunartail bigeye (*Priacanthus hamrur*), wolf herrings, paste shrimp, *Thryssa spp.*
Only reduction	*Nemipterus spp.*, ponyfish, moonfish, scad, horse mackerel, queenfish, pufferfish, porcupine fish, Indian oil sardine, lesser sardines, spiny-cheek grouper, crabs, grunter, triggerfish, Tardoore, mantis shrimp, tonguesoles, sharks, eels

Locals refer to the catch going for reduction as – *khad*, *khattar*, *khadar*, *khatti*, powder, fishmeal, etc. We observed two different grades in low-value bycatch going for reduction – one had fresh and sorted sardines, scads, etc., and one with damaged mixed fish. The rate at which traders valued the piles (mixed) was around ₹12-15, and sardines were around ₹12-17.

<u>Supply chain of reduction fisheries in Maharashtra</u>

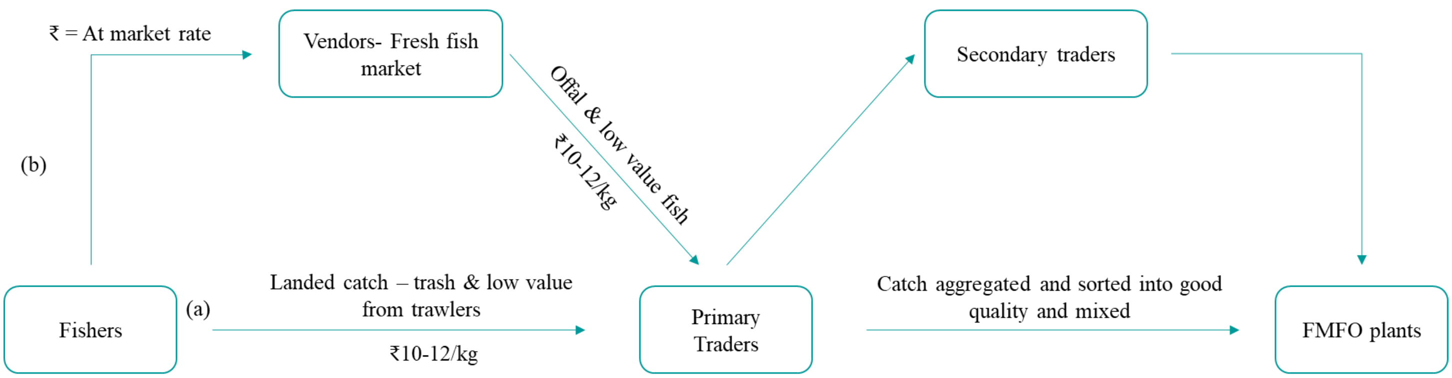

Figure 11: The supply chain of the reduction fisheries in Mumbai

In Mumbai, the fishmeal and fish oil plants use both freshly landed catch and offal for reduction. Based on different inputs – landed catch and offal from vendors – we observed two different pathways through which raw material was being majorly supplied to reduction plants in Mumbai (Fig 11). Dried fish is also a potential raw material in Mumbai; however, we need further study to explore that supply chain.

In Mumbai, the complexity of the supply chain increased with the presence of multiple intermediary nodes in comparison to other project sites. At Bhaucha Dhakka we observed more than 2-3 nodes of traders between fishermen and processors. According to our on-field conversations, many traders worked full-time under larger traders who supplied raw materials to FMFO plants. We were informed that multiple payment arrangements are possible between the reduction plants and traders – e.g., contracts, advance payments or full-time employment with FMFO processing companies.

Demographics of the reduction fisheries sector

Table 3. Demographics profile of actors involved in the reduction fisheries sector in Mumbai

Category	Actors	Gender Distribution	Remarks
Fishing	Owners	Mostly men	Locals, mostly from traditional fishing communities – *Koli, Nakhwa*. Many are not actively fishing anymore.
	Crew members	Men	Mostly from Uttar Pradesh, Bihar, Jharkhand, etc.
Trading	Primary and Secondary Traders	Men	All locals; employ workers to carry out the catch purchase.
	Workers - head loading, purchasing, sorting, aggregating	Men	Mostly from UP, Bihar, Jharkhand, etc.
Processing		Mostly men	Locals and migrants from north Indian states of the Hindi belt.
Retail – local consumption	Vendors	Dominated by women	Locals from traditional fishing communities.

Karnataka

Mangalore fishing harbour

State Profile

Karnataka has a coastline of about 313.02 sq km and a continental shelf of 27000 sq. km. The annual marine fish production from the state was estimated to be 5.89 lakh tonnes in the year 2021-22 (Fisheries Statistics Division, 2023). Out of 115 fish landing sites in the state, Mangalore is one of the largest, both in terms of trawl fisheries and the infrastructure for processing FMFO. The state has over 21 operational fishmeal plants, and 13 of them are in Mangalore (Department of Fisheries, Government of Karnataka, 2020).

Site profile

The fish is landed at Mangalore Old Port (Fig. 12), locally called '*dhakke*' (wharf). The catch is usually segregated on the boats before landing, into two broad categories: high-value and low-value catch. While the high-value catch is auctioned, the low-value catch is directly sold to traders after negotiations. The traders then further sell it to the FMFO plants. Besides designated docking space for the boats at the harbour, we observed sheds which were utilised for cutting, cleaning and temporary storage of the catch. The harbour is also equipped with two petrol pumps, general stores, a medical dispensary, and a hospital.

Mangalore, has 1301 mechanised vessels, 1467 motorised boats with outboard motor engines, and 545 traditional crafts (Department of Fisheries, Government of Karnataka, 2020). The fishing vessels are mostly owned by members of the local fishing community. The major fishing gears operational in this region include trawl nets (1392) and gillnets (1457) followed by purse seines, cast nets, ring nets, and other traditional nets (Department of Fisheries, Government of Karnataka, 2020). We observed that the trawlers here were registered with local associations and went for fishing trips lasting 8-15 days with vessel sizes ranging from 60 to 80 ft.

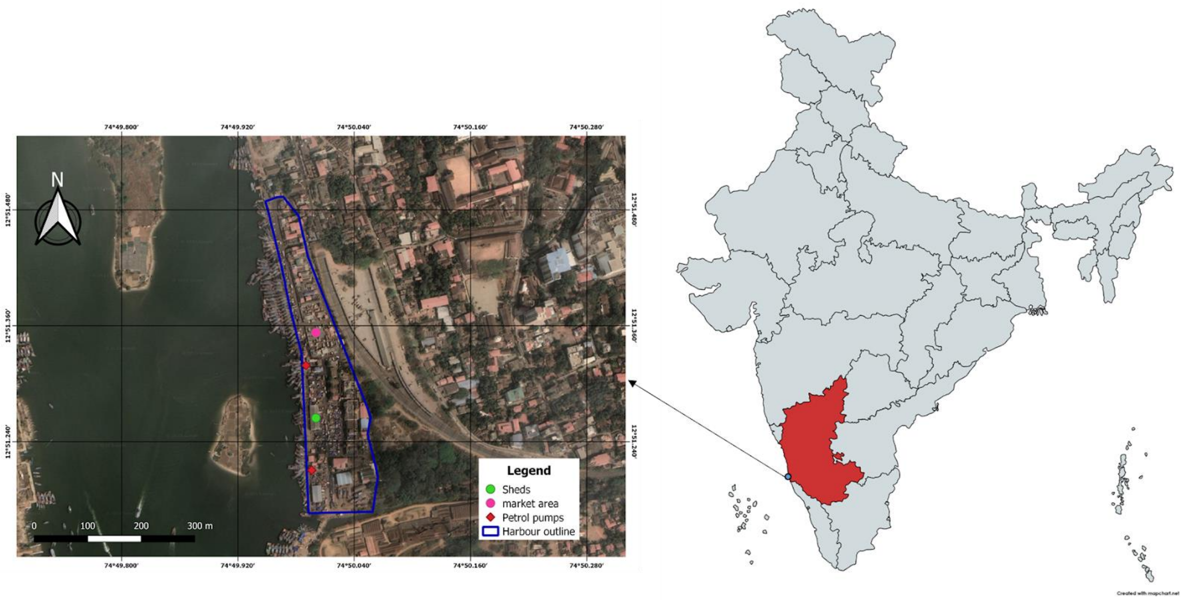

Figure 12: Map of the study area along the Mangalore coast, Karnataka

Fisheries and species utilisation

The majority of the high-value catch landings included kingfish, mackerel, squid, cuttlefish, octopus, sardines, ribbonfish, snappers, groupers, croakers, breams, etc. The quantity and the quality of the catch were said to vary significantly with seasons. The major groups recorded within these families included juveniles and damaged specimens of groups of flatheads, anchovies, shrimps, crabs, lizardfish, pufferfish, mantis shrimp, eels, etc. (Fig 13, Fig. 14).

Figure 13: Catch with mixed composition segregated for reduction at Mangalore harbour

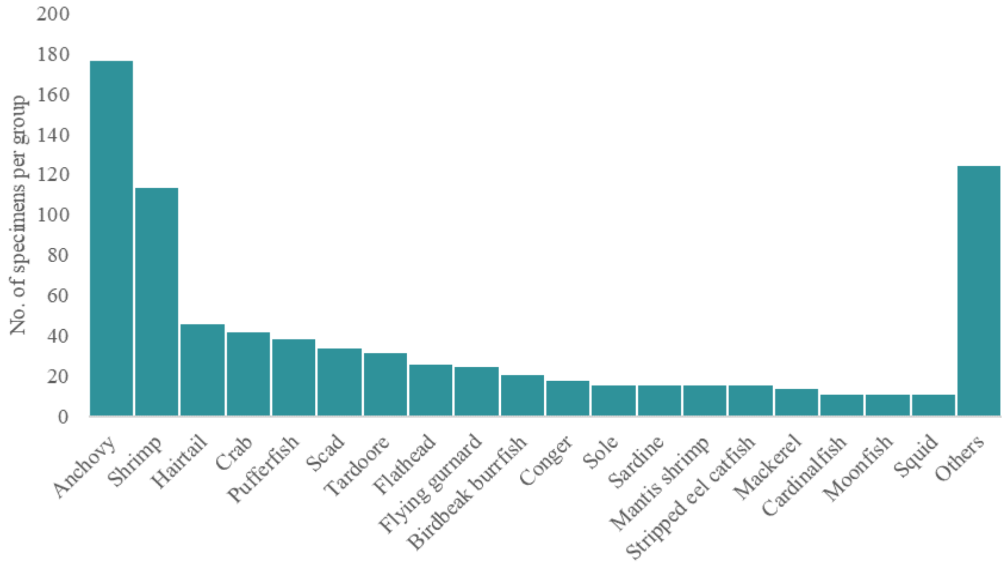

Figure 14: Graph representing the total number of specimens per faunal group observed in the samples (n=18) collected from Mangalore

Of all the observed groups, over 28% were not preferred for direct consumption and used for FMFO production, whereas the rest of the groups were found to be utilised for both consumption and as a low-value catch for reduction fisheries (Fig 15).

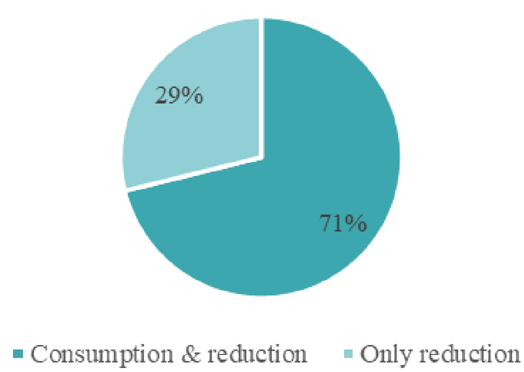

Figure 15: Catch utilisation (%) of the faunal groups observed during the study at Mangalore

Table 4. Catch utilisation of different faunal groups observed during the study at Mangalore

Utilisation	Faunal groups identified in the samples at Mangalore
Consumption & reduction	Conger eels, crab, flounder, bandfish, sole fish, octopus, haritails, shrimp, sardine, anchovy, Threadfin breams, Thryssa, smooth blassop, Indian threadfish, moonfish, scads, barracuda, Tardoore, mackerels, lizardfish, snakefish, Moontail bullseye, flathead, ponyfish, saddle grunt, leatherjacket, squid, cuttlefish, goatfish, false trevally, wolf herring, sharks, shads, cobia, grouper, *Alectis spp.*
Only Reduction	Birdbeak burrfish, red cornetfish, handfish, flying gurnard, stargazer, cardinalfish, moray eel, triggerfish, mantis shrimp, pufferfish, striped eel catfish, grunter, lionfish, anglerfish, trumpet-snout, sea robin, hermit crab

"Trawling is done at a very high-speed resulting in squishing of some portion of the catch and the additional time taken to pull the net out, sort and add ice to the catch makes it even more susceptible to rotting. So, nothing much can be done here" - Fisherman, Mangalore

<u>Supply Chain of reduction fisheries in Karnataka</u>

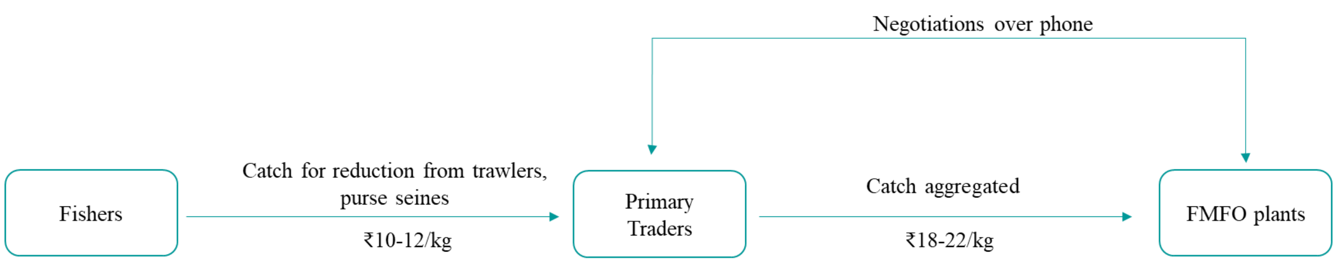

Figure 16: Supply chain of the reduction fisheries sector in Mangalore

The prices of the low-value catch going for FMFO plants vary with season. We were informed that the prices are lowest post-monsoon (August-December) due to the high abundance and superior quality of fish landings during this period. The prices are decided together by the traders union and the FMFO plants. The traders negotiate the prices with the boat owners before buying their catch. These traders receive a commission of 50 paise to ₹1 per /kg of the catch.

The prices are also influenced by the quality of the catch (i.e., the grades) along with the market rates. Boat owners informed us that even though they cross-check rates with other traders, they generally sell their low-value catch to the same traders. We also found that some of the traders in Mangalore give a credit amount to the boat owners as an assurance to sell their low-value catch only to them. The trucks for transportation are usually owned/rented by the traders. Larger trucks have a capacity of 150 crates with each crate having 50-55 kgs of catch.

Figure 17 Landing of low-value catch at Mangalore fishing harbour

The majority of the catch for reduction was transported to the Ullal region, where over 13 FMFO plants are located. The plants which used to operate at 30% capacity are now operating at over 60% of the maximum capacity. The common products produced by these factories included fishmeal, fish oil, and fish paste. With the growth of the pharmaceutical industry, we were informed that there was a rise in the demand for fish oil.

<u>Demographics of the reduction fisheries sector</u>

According to key informant interviews, 5000 to 7000 people work at the harbour. Amongst these, 3000 to 4000 people are seasonal immigrants from various states like Bihar, Jharkhand, Uttar Pradesh, Tamil Nadu, Andhra Pradesh, Gujarat, and Kerala (Table 5).

Table 5. Demographic profile of the actors involved in the reduction fisheries supply chain in Mangalore

Category	Actors	Gender	Remarks
Fishing	Owners	Men	Most fishers in Mangalore belong to the *Mogaveera* caste.
	Crew members including the boat captain	Men	Migrated mostly from coastal states like Tamil Nadu, Andhra Pradesh, Gujarat, and Kerala.
Trading-Reduction	Traders	Men	All of them are from local members.
	Workers- Head loggers, sorting and aggregating	Both men and women	Women were involved in the landing of low-value catch while men engaged in both landing and loading the catch in trucks.
Processing-Dried fish	Workers for drying	Both men and women	Mostly women engaged in drying fish in Thota Bengre
Processing-FMFO	Employees and workers at the factory level	Men	Migrated mostly from the north-Indian states.

Tamil Nadu

Landing site at Rameshwaram, Palk Bay

State profile

In 2021, total marine fish landings in Tamil Nadu was estimated to be 5.62 lakh tonnes, which is a marginal increase of 0.6% of landings as compared to 2020. Tamil Nadu state was recorded to be the second highest contributor to the landings, after Gujarat. Among 13 districts, the maximum contribution was from Ramanathapuram (33.7%) (CMFRI, 2022).

In 2021, Palk Bay alone accounted for 21.9% of the marine fish landings. Within Palk Bay, Pudukottai district, where we prioritised our study area, was estimated to contribute 9.7% to the total marine fish landings of Tamil Nadu (CMFRI, 2022).

Site profile

Palk Bay is a shallow stretch of sea between India and Sri Lanka and is known for rich seagrass meadows and biodiversity. Both mechanised and non-mechanised fishing crafts are operational in this region (Jagadis et al., 2004). There are only single-day trawlers operational in this region. It comprises 5 districts: Nagapattinam, Thiruvarur, Thanjavur, Pudukottai, and Ramanathapuram. Across the stretch, there are 6 major landing centres: Mallipattinam, Sethubavachatiram, Kottaipattinam, Jagathapattinam, Mandapam, and Rameshwaram. Palk Bay is also known for the geopolitical tensions along the international maritime boundary due to the increase in the density of trawl boats crossing the borders and fishing in Sri Lanka's under-fished grounds (Stephen et al., 2013).

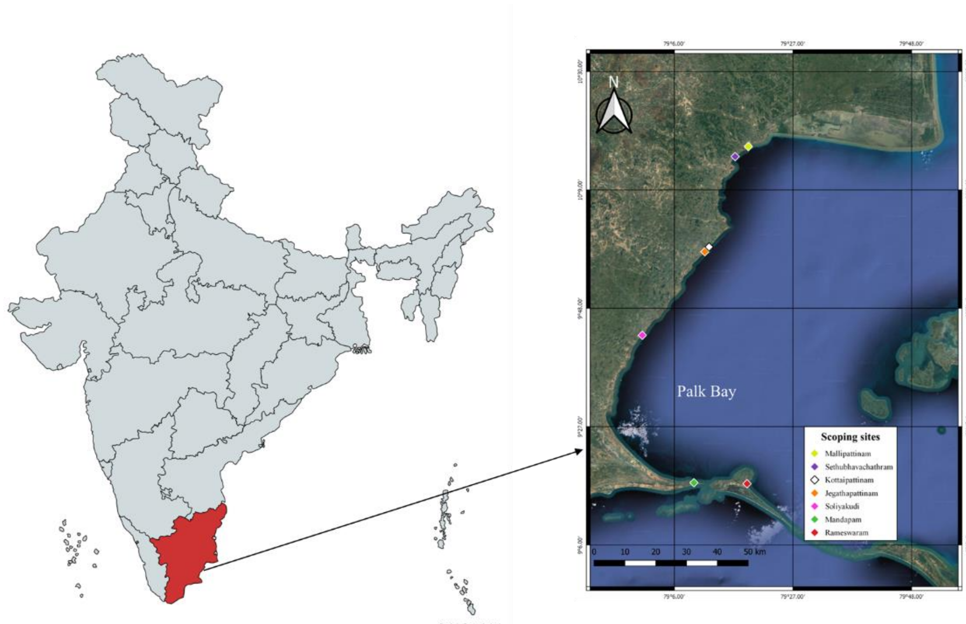

Figure 18: Map showing the sites chosen for scoping exercise at Palk Bay, Tamil Nadu. Kottaipattinam landing centre was prioritised for this study.

After scoping the entire stretch of Palk Bay, based on the scale of operations and availability of logistics, we prioritized Kottaipattinam for this study (Fig 18). Kottaipattinam is one of the largest harbours in the Pudukottai district. We observed both trawlers and country sailboat landings during our study period. The trawlers land their catch via country sailboats boats (called *vallam)* since the jetty is not large enough for all boats and the trawlers are docked quite distant from the jetty.

Insights on biological characterisation & fisheries

Over 10 samples were collected during the study period including both bottom and mid-water trawling. Striking yet obvious differences were observed in the species caught in different gears. Besides, the samples collected from the mid-water trawling gear comprised more good quality fin-fishes whereas the demersal trawling landed more seagrasses, molluscs, and highly damaged fish (Table 6). We need more studies to explore this trend further.

Table 6. Commonly landed groups in mid-water trawling & bottom trawling in Palk Bay (based on observations)

Fishing gear	Prominent groups observed
Midwater trawling	goatfish, catfish, flathead, sardine, cardinalfish, ponyfish, scads, shads, conger, shrimp, mantis shrimp, Terapon, grunts
Bottom trawling	shads, ponyfish, catfish, Terapon, pufferfish, squid, anchovies, gobies, mantis shrimp, flathead, shrimp, crab, molluscs, jellyfish, stingrays, sea urchin, seagrass

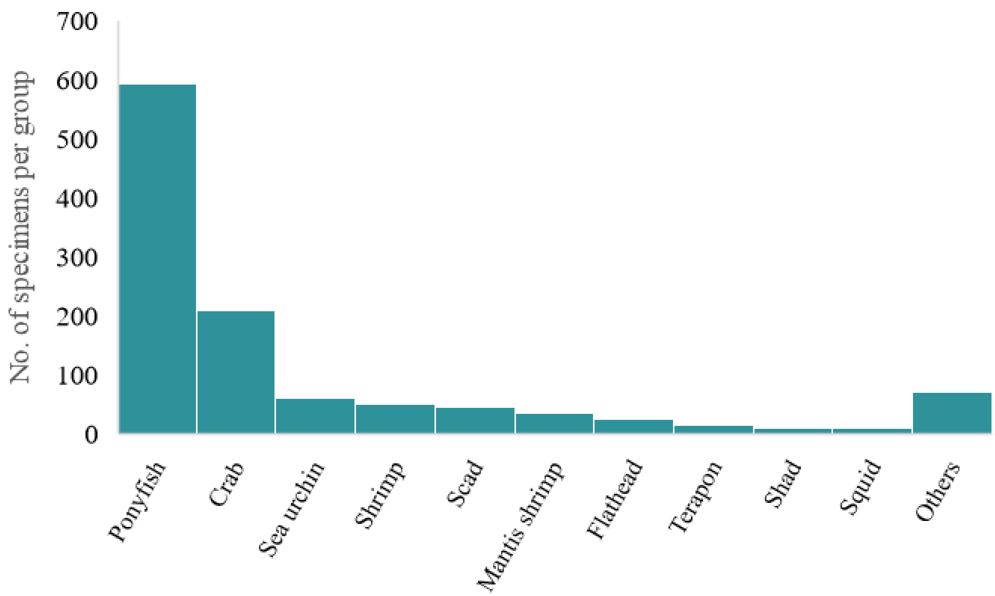

Figure 19. Graph representing the total number of specimens per faunal group observed in the samples (n=10) collected from Kottaipattinam, Tamil Nadu

Midwater trawling was being done using *meen valai* (nets used to catch finfish) whereas bottom trawling was done using *iral valai* (nets used for catching shrimps). In terms of the quality of low-value catch landings sold for reduction, midwater trawling was observed to land the fish which was preferred in FMFO plants whereas the low-value catch landed during bottom-trawling was diverted mostly to the poultry farms.

Ponyfishes (Leiognathidae) were highly abundant faunal groups observed in the samples during the study period (Fig. 19). More than 50% of the groups observed were observed to be utilised for both consumption and reduction fisheries (Fig. 20).

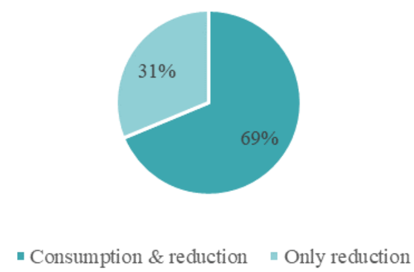

Figure 20. Catch utilisation (%) of the faunal groups observed during the study at Kottaipattinam

"When they [trawlers] go fishing with fishnets [midwater trawling], they may all get in total 500 to 700 kg. So 20 boats can make up for 10 tons of catch for reduction during a good season. But this quantity surely depends upon the quantity of the reduction catch." -Trader, Kottaipattinam

Table 7. Catch utilisation of different faunal groups observed during the study at Kottaipattinam

Utilisation	Faunal groups identified in the samples at Mangalore
Consumption & reduction	Shad, scad, ponyfish, Indian pellona, catfish, terapon, pufferfish, squid, flathead, shrimp, crab, octopus, sardine, sea urchin, anchovy, sea cucumber, goatfish, conger, solefish, stingray, triggerfish, saddle grunt,
Only reduction	Goby, mantis shrimp, mollusc, spotted scat, polychaetes, sea pen, cardinalfish, starfish, snakefish, bullseye, jellyfish

Supply chain of reduction fisheries in Tamil Nadu

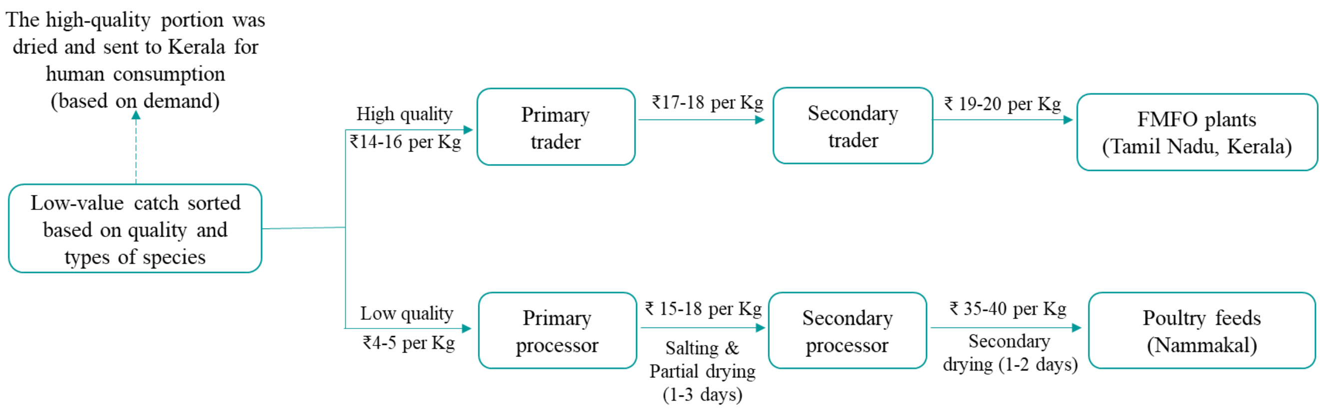

Figure 21. The supply chain of reduction fisheries in Kottaipattinam

There were a different set of traders for every category of catch-utilisation, i.e., exports, local consumption, reduction fisheries, and dried fish. In some cases, we observed the same traders dealing with bycatch which was diverted to FMFO plants and to poultry farms.

Here, the traders paid a token amount to the trawl boat owners to ensure the boats would sell a specific category of their catch only to them. As opposed to credit or advance in other project sites, this token amount was not deducted from the daily transactions but rather considered as insurance of trust between traders and trawl boat owners. In case of economic losses from fishing trips, boat owners take further debts from these traders which are to be returned back, unlike the advances.

In Kottaipattinam, there are over 25-30 primary traders who buy catch for reduction along with 7-8 secondary traders who deal with the dried fish that is diverted to poultry farms. Most of the poultry farms are located in the Namakkal district followed by the Salem district. FMFO plants are located in the Thondi, Vattanam, and Tuticorin districts of Tamil Nadu.

In the poultry sector, the secondary traders collect semi-dried catch from the primary traders and then further dry it for 1-2 days more at their facility before sending it to the poultry farms. One of the secondary traders was found to have contracts with over 10 primary traders for collecting the partially dried fish from Kottaipattinam. These secondary traders do not restrict their businesses to only Kottaipattinam but also deal with fish from locations like Jegathapattinam, and Soliyakudi, within Palk Bay.

Figure 22. (Clockwise from top) Woman worker drying catch for reduction, to be sent to poultry farms of Nammakkal; Weighing of the bycatch, to be sent to the FMFO processing plants; Drying of the catch for reduction, Mallipattinam, Thanjavur district, Palk Bay

Demographics of the reduction fisheries sector

Table 8. Demographic profile of the actors involved in the supply chain in Kottaipattinam

Category	Actors	Gender	Remarks
Fishing	Owners	Men	All of the owners belong to the Palk Bay region.
	Crew members including the captain	Men	All the crew members were native to districts within the Palk Bay region.
Trading-Reduction	Traders	Men	Belonging to Pudukkottai and Thanjavur districts.
	Workers-Head loggers, sorting and aggregating	Men & women	Both men & women handled the catch for reduction to FMFO and poultry feeds.
Processing-Dried fish	Workers for drying	Both men and women	Mostly women but some proportions of men were seen involved in drying the catch for poultry feed.

Andhra Pradesh

Kakinada fishing harbour

State profile

Andhra Pradesh has a long coastline of 974 km with a continental shelf of 33,227 sq km. The annual marine fish landing of Andhra Pradesh in the year 2020-2021 was 2.07 lakh tons (CMFRI, 2022). Andhra Pradesh diverted 0.22 lakh tons of catch for reduction fisheries in the year 2020 (CMFRI, 2022). There are 350 landing centres in the state out of which we selected Visakhapatnam and Kakinada for our study (Fig. 23).

Site Profile

Visakhapatnam

Visakhapatnam fishing harbour is the largest landing centre in Andhra Pradesh where the majority of the fish landings in the district take place from where the catch is exported. Over the last decade, there has been an increase in the number of trawlers – from 590 in 2010 to 700 in 2021. About 10% of the trawl boats are single-day trawlers while most others go for multi-day trips, ranging from 10 to 15 days. About only 30% of the boats were functional during our fieldwork due to a hike in fuel prices and losses in the industry.

To reduce the commodification of juvenile fish, since 2013, the utilisation of low-value catch for reduction was observed to be strictly prohibited by the boat owners associations of Visakhapatnam. We observed that although the ban was not fully effective, it did result in a decline in landings of low-value fish that were diverted to FMFO plants. Moreover, according to the key informants, a decrease in the cost of shrimp feed and soy reduced the demand for fishmeal, thus, contributing to a decline in catch landings for reduction.

Kakinada

Kakinada is located in the East Godavari district. It has three major landing centres – Yetimoga fish landing centre, Kumbhabhishekam landing centre, and Kakinada fishing harbour. While the majority of fish landing happens at Kakinada fishing harbour, other landing centres across the district also contribute to the overall catch landings. The catch was usually auctioned early in the morning from 4:30 am to 6:30 am. Trawl boats not only from Kakinada harbour but also from various other places of East Godavari district land at the harbour for sale and export.

During our study, the number of trawlers in Kakinada was approximately 600. Unlike Visakhapatnam, most of the trawl boats are single-day trawlers while others go for multi-day trips, ranging from 10 to 15 days. There are no restrictions imposed on the landing or sale of catch for the reduction in the harbour.

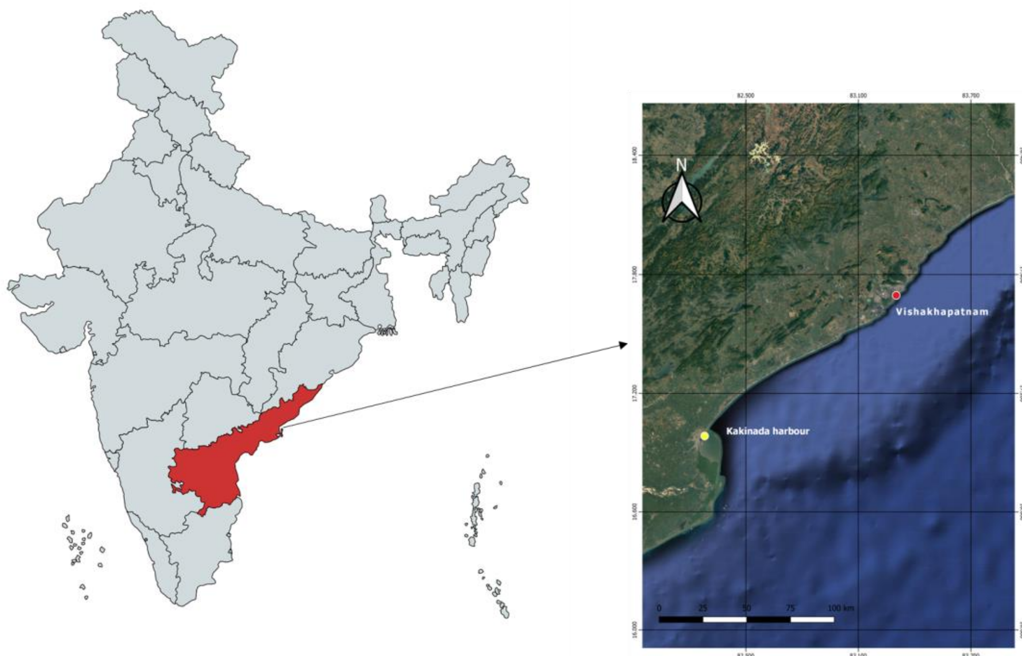

Figure 23. Map of the study sites along the Andhra Pradesh coast

Fisheries and species utilisation

We were informed that despite the ban on catching low-value fish for reduction, 20-30 trawlers still sold their catch to FMFO plants. The quantity varied from 5-10 baskets per boat and could contribute to 40-90% of the entire catch by volume. In Kakinada, we observed that the speed of some trawler boats can be unregulated. These trawlers were locally called 'speed boats' and landed higher quantities of catch for reduction.

At Visakhapatnam, the biological characterisation of the catch for reduction indicated major proportions of faunal groups like mantis shrimp, shrimps, crabs, tongue soles, ribbonfish, squids, etc. Additionally, according to our key informant interviews, shrimp heads from the low-value catch were sold to chitin factories for pharmaceutical purposes.

Figure 24. Low-value catch landings- to be utilised for reduction fisheries

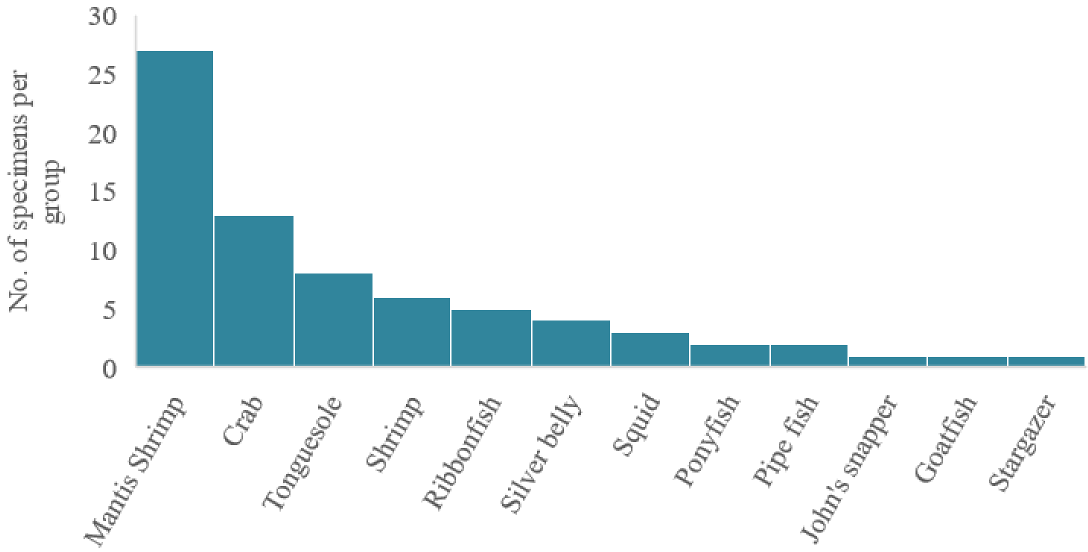

Figure 25. Graph representing the total number of specimens per faunal group observed in the samples (n=6) collected from Visakhapatnam

Around 36% of the sample from the catch for reduction consisted of groups which were also commercially important and preferred for consumption as well (Fig. 26). These groups include ponyfish and tonguesoles, usually consumed by the local people after drying (Table 9). Other groups like squids, ribbonfish, and prawns were generally preferred by export markets. Apart from the sampling data, our on-field observations and interviews indicated that other commercially important groups like anchovies, Indian oil sardines, and Bombay duck were also often observed in the catch sold for reduction.

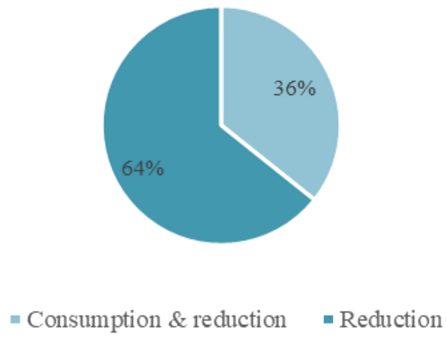

Figure 26. Catch utilisation (%) of the faunal groups observed during the study in Visakhapatnam

Table 9. Catch utilisation of different faunal groups observed during the study at Visakhapatnam

Utilisation	Faunal groups identified in the samples, Vishakhapatnam
Consumption & reduction	Ponyfish, tonguesoles, squid, shrimp, ribbonfish, shrimp
Only reduction	Mantis shrimp, crab, pipefish, silver-bellies, snapper, goatfish, stargazer

Supply chain of reduction fisheries in Andhra Pradesh

At Visakhapatnam, the catch is segregated on the boats into categories like high-value fish, catch for drying, and catch for reduction. The catch for reduction is either dried and sold locally in small quantities to poultry farms, or it is supplied in large quantities to poultry-feed manufacturers through traders in East Godavari and West Godavari districts of Andhra Pradesh (Fig 27).

When the catch for reduction is sold directly, the primary traders soak the fish in a brine solution for 3-5 days before drying. The dried fish is further sold to secondary traders at ₹25-40 per kg. We found that the secondary processors pay advance to primary processors and purchase in bulk quantity.

The fish workers earn 10 – 12% of the revenue primarily from the sales of the high-value catch. They also earn an additional income from the sale of crabs, dry fish, and catch going for reduction. This additional income is not usually shared with the boat owners. During our visit, the catch for reduction was being sold for ₹40 to 50 per basket, weighing ~8kg, to traders by the fish workers.

> ***"Prices [of fish] have increased, the catch has decreased, and rates of dry fish have also increased. Leftover is used for the fish meal"- women vendor, Visakhapatnam***

In Kakinada, however, the catch for reduction is only sold directly to the traders who themselves dry and sell the dried catch to the secondary traders. The secondary traders ultimately sell the processed fish to the poultry farms, either directly or through poultry feed manufacturers (Fig 27).

In Kakinada, the crew earn 10% of the income from the high-value catch. Unlike Visakhapatnam, the boat owners in Kakinada were observed to have an equal share in sales of low-value catch going to FMFO plants. During our field visits, we observed the boat owners selling the reduction catch to the processors for ₹40 per basket, with each basket weighing ~8kg. Similar to Visakhapatnam, the processors dry the low-value catch and sell it to traders for ₹18 - 38 per kg. Over 20 traders were observed dealing with the catch for reduction at Kakinada, with each of them dealing with 5-50 tonnes of low-value catch a month. Due to insufficient high-quality (high-protein) FMFO plants in the state, catch for reduction was utilised more for manufacturing poultry feeds rather than high-protein aquafeed for the aquaculture sector.

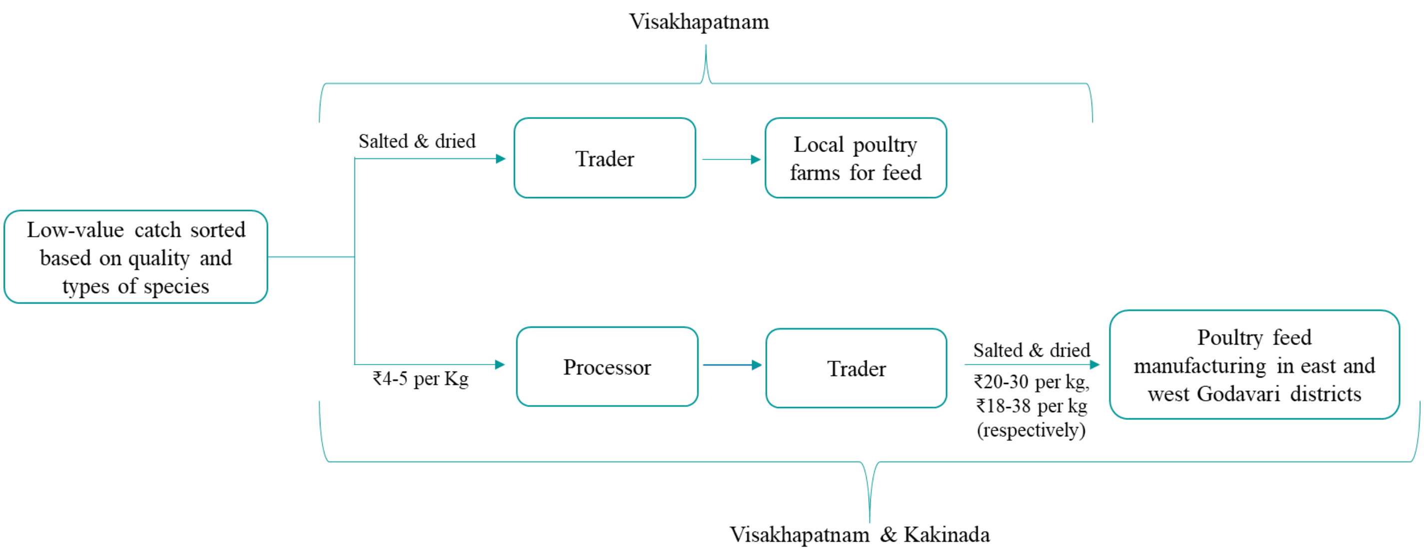

Figure 27. The supply chain of reduction fisheries in Visakhapatnam & Kakinada

Figure 28. (left to right) Low-value catch being transported for drying; Still of the drying area at trader's location

Odisha

Sorting of catch at fish landing centre, Odisha

State Profile

Odisha has a coastline of 480 km along the Bay of Bengal with a diverse coastal ecosystem. The coastal zone of Odisha is shared by six districts, namely Balasore, Bhadrak, Ganjam, Jagatsinghpur, Kendrapara, and Puri, which contribute significantly to the State Fisheries Revenue.

Site Profile

During the scoping study we learned the reduction fisheries sector is diverse and scattered. Therefore, instead of prioritising one landing site, multiple sites from northern and southern Odisha were selected (Fig. 29). The details of the selected landing centres are as follows.

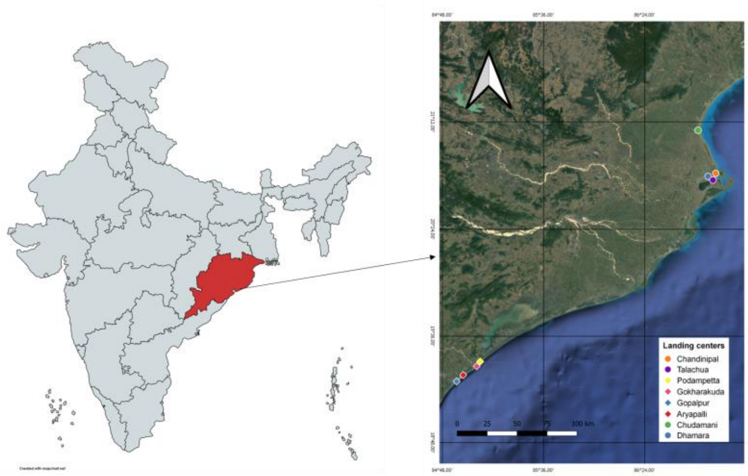

Figure 29. Map of the study area along the coast of Odisha

Northern Odisha- Bhadrak & Kendrapara districts: Dhamra, Chandinipal, Chudamani, Talachua

Dhamra fishing harbour in Bhadrak district is located on the northern bank of Dhamra river close to the confluence zone where the river meets the Bay of Bengal. The commercial catch from this landing centre is mostly exported to agents/companies abroad. The Chandinipal landing centre is located in proximity to the Dhamra landing centre. Unlike Dhamra, this landing centre caters mostly to the local market.

Chudamani is located along a minor but dynamic river mouth called Gamei which branches out from the Salandi River. It is a minor landing site with only 45 registered mechanised gillnetters owned by the locals belonging to the Odia fishing community. Talachua is a seasonal landing centre which is located in proximity to the Bhitarkanika mangrove forest in the Kedrapara district. It operates during the post-monsoon season.

Southern Odisha- Ganjam district: Aryapalli, Gopalpur, Gokharkuda, Podampetta

Aryapalli is the largest landing centre in the Ganjam district of Odisha. This landing site is active throughout the year with approximately 250 registered motorised fishing vessels. The motorised fishing vessels in Aryapalli make approximately 1- 3 trips a day to meet the demands of buyers and FMFO manufacturing units across the country. Gopalpur operates throughout the year. Most of the target catch from this place was observed to be exported to Digha, Kerala, Andhra Pradesh, and Tamil Nadu, while some are sent abroad to countries like Singapore, China, Japan, and European Countries. Fishing gears like hook and line, *kabala jaal*, *chandi jaal*, *bada jaal*, and ring nets are widely used in this region.

Gokharkuda in the Ganjam district is a fishing village having a landing site exclusively for the local villagers. It is located near the Rushikulya river mouth and is renowned for its Olive ridley turtle nesting beach. Podampetta, adjacent to Gokharkuda is also noteworthy for its Olive ridley nesting site. Like Gokharkuda, the catch is landed on the village landing jetty. The fishers from Podampetta also use ring nets for fishing.

Both in northern and southern Odisha, women fish workers were observed to work in local dry fish processing units.

Fisheries and species utilisation

Odisha has a variety of fishing gear and craft across the coast, including trawlers, mechanised gillnetter, and other motorised and artisanal fishing vessels.

Our field observations showed a significant overlap between the species found in low-value catch and that of fish diverted to markets for human consumption.

Table 10. Catch utilisation of different faunal groups observed during the study at Odisha

Northern Odisha	Juveniles of *Sardinella longiceps* (Indian oil sardine), *Rastrelliger kanagurta* (Indian mackerel), eels, crabs, mantis shrimp, shrimps (damaged), ponyfish, ribbonfish, *Takifugu oblongus* (Lattice blassop), *Lagocephalus spadiceus* (half-smooth golden pufferfish), stingrays, squids
Southern Odisha	*Sardinella longiceps* (Indian oil sardine), silver bellies (*Gerres spp.*), ponyfish, *Rastrelliger kanagurta* (Indian mackerel), anchovies

Figure 30. (left to right) (a) Catch landed for reduction awaited for the respective traders (b) Low-value damaged catch diverted to the Poultry farms

<u>Supply chain of reduction fisheries in Odisha</u>

Northern Odisha:

In the Dhamra district, crew members were observed to take ownership of the catch for reduction. They sell it individually for an extra source of income. They generally sell it to the dry fish processors who further dry it and sell it to traders (Fig 25). In Chudamani, FMFO and poultry plants offer an advance amount to the traders in exchange for an assurance to supply dried fish only to them. During our study period, the rates of dried fish were noted to be around ₹40/kg while the freshly landed reduction fish was being sold at ₹10-20/kg.

Southern Odisha:

In Aryapalli, we were informed that around 10-15 tons of catch were being landed for reduction on a daily basis. This quantity varies with the season. The rates during our study were, ₹200-500/crate (each crate could hold 25-50 kg) whereas, in Gopalpur, the rates were ₹300-400/crate and dried fish was being sold at ₹50/kg.

Similarly, in Gokharkuda, the catch to FMFO plants was sold for ₹800-1000/crate (each crate could hold 50 kg). This village has about 5 middlemen who collect the catch from the boat owners to supply them to the local dry fish unit, the local market, and the local agents (Fig. 25). The catch for reduction at Podampetta was being sold at ₹200-700/crate.

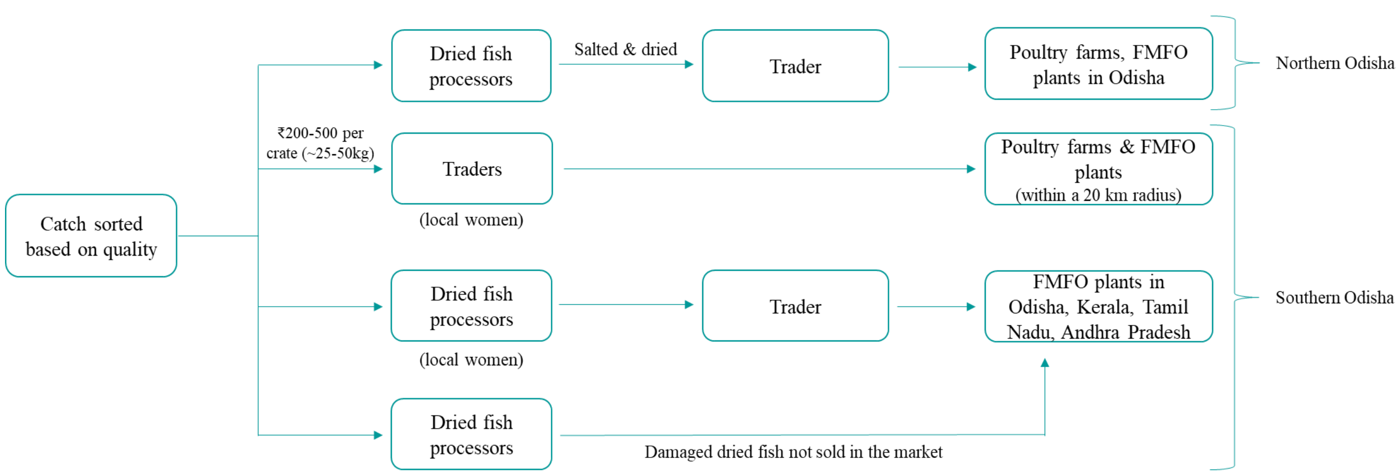

Figure 31. The supply chain of reduction fisheries observed in Odisha

Major Insights and Discussion

Diversity begets diversity

Indian fisheries sector as discussed earlier is a highly diverse system – in terms of scale, capital, fishing practices, and demographic profile. Consequently, we observed that the fishmeal and fish oil industry's supply chain is a reflection of fisheries and pre-existing infrastructure of a region. In six project states, we observed differences in the supply chains of reduction fisheries with respect to both structure and functioning.

Quantity and quality (condition of catch) are some of the important factors in shaping the structure of the reduction fisheries supply chain. Regional availability of oil-rich fish species was found to influence the reduction fisheries landscape of a region. For example, the availability of oil-rich species such as sardines and anchovies has encouraged the emergence of the FMFO industry in the Mangalore region.

In addition to the scale of fisheries, the presence of reduction plants and processing infrastructure like poultry farms shape the reduction fisheries supply chain of a region. The presence of FMFO plants in the vicinity of Mangalore fishing harbour allows easier transport of catch from the fisheries harbour to reduction plants, resulting in a relatively shorter supply chain. With just one intermediary (trader), Mangalore had the least complex supply chain of all study sites in project states. Similarly, in Veraval and Porbandar, the scale of operations and presence of FMFO and poultry feed manufacturing plants near the landing centres ensures a shorter supply chain.

In Odisha, intermediaries such as dry fish processors, traders and aggregators are important nodes in the reduction fisheries supply chain. We were informed that reduction plants need bulk quantities for their plants to operate. Salting and drying fish is an easy method to preserve and aggregate a highly perishable resource like fish in bulk, especially in regions with less access to FMFO or poultry farms. As opposed to Odisha, the presence of a small-scale poultry industry near Palk Bay was the reason for dry fish processors as intermediaries in the supply chain.

In our study, we also found multiple interlinkages with other sectors, such as the pharmaceutical, health care and cosmetic industry. We observed interstate flows of raw material – such as plants in Maharashtra and Karnataka procuring fresh fish catch from Odisha, Andhra Pradesh, and Gujarat; and export linkages to countries in Southeast Asia, Africa, and South America. These linkages give us an idea of the scale of the Indian reduction fisheries industry.

The reduction industry, even if developed as a function of the pre-existing natural and built environment, it is also actively shaping it. We need to investigate these linkages in detail to have a better understanding of the sector and how their operations are driving the fisheries and seafood trade in India and the world.

Reduction fisheries and species utilisation

Our study presents a broad snapshot of the current species utilisation and fisheries associated with the reduction industry at project sites. The most common faunal groups utilised for reduction, as observed in biological characterization and field observations are presented in (Fig. 26)

Earlier studies have reported range extensions of sardines and anchovies due to rising sea surface temperature and climate change (Vivekanandan et al., 2010). These newly available resources to fisheries may not have a strong preference in the local markets, which leaves FMFO and poultry farms as their prime markets. This in turn increases the demand for such resources and creates a vicious cycle. We were informed that in recent years in Odisha, the rising demand for the manufacturing of poultry feed motivates even small-scale fishers to target juvenile sardines.

In addition, we also observed a huge variation in the trawl fishing operations across study sites, with respect to trip duration, engine capacity, etc. The fisherfolk in Gujarat witnessed a significant increase in the reduction fish landings as compared to the target fishes. These included juveniles of commercially important species caught in small and diamond-shaped mesh sizes. The increased supply has further accentuated the demand for raw material in the reduction fisheries sector thus "*dramatically changing*" the fishing patterns over the last 5 years as quoted by one of our key informants. We were informed by respondents in many of our sites that a large proportion of trawl catch is composed of bycatch (60-87%). This corresponds to studies conducted on trawl catch utilisation (Dineshbabu et al., 2014). These figures are concerning; there is an urgent need to monitor the bycatch and utilisation for a longer term to figure out and underscore the implication of biomass fishing on the ecosystem.

In Karnataka, respondents informed us about changes due to engine capacity allowing higher towing speed which inevitably leads to the crushing of a portion of the catch – leaving it more prone to damage. This makes it all the more likely to land up as reduction fish rather than being sold for direct human consumption.

Even though trawling is closely associated with reduction fisheries, our study clearly shows that fish for reduction is not limited to trawl fisheries but other fishing practices as well, including artisanal methods practices, such as bag-net or dol fishing in Maharashtra and Gujarat. Small-scale gillnetting in Tamil Nadu and Odisha also diverts quantities of their catch for reduction. In addition to this, other large-scale fishing practices such as purse-seining are also involved in the reduction fisheries.

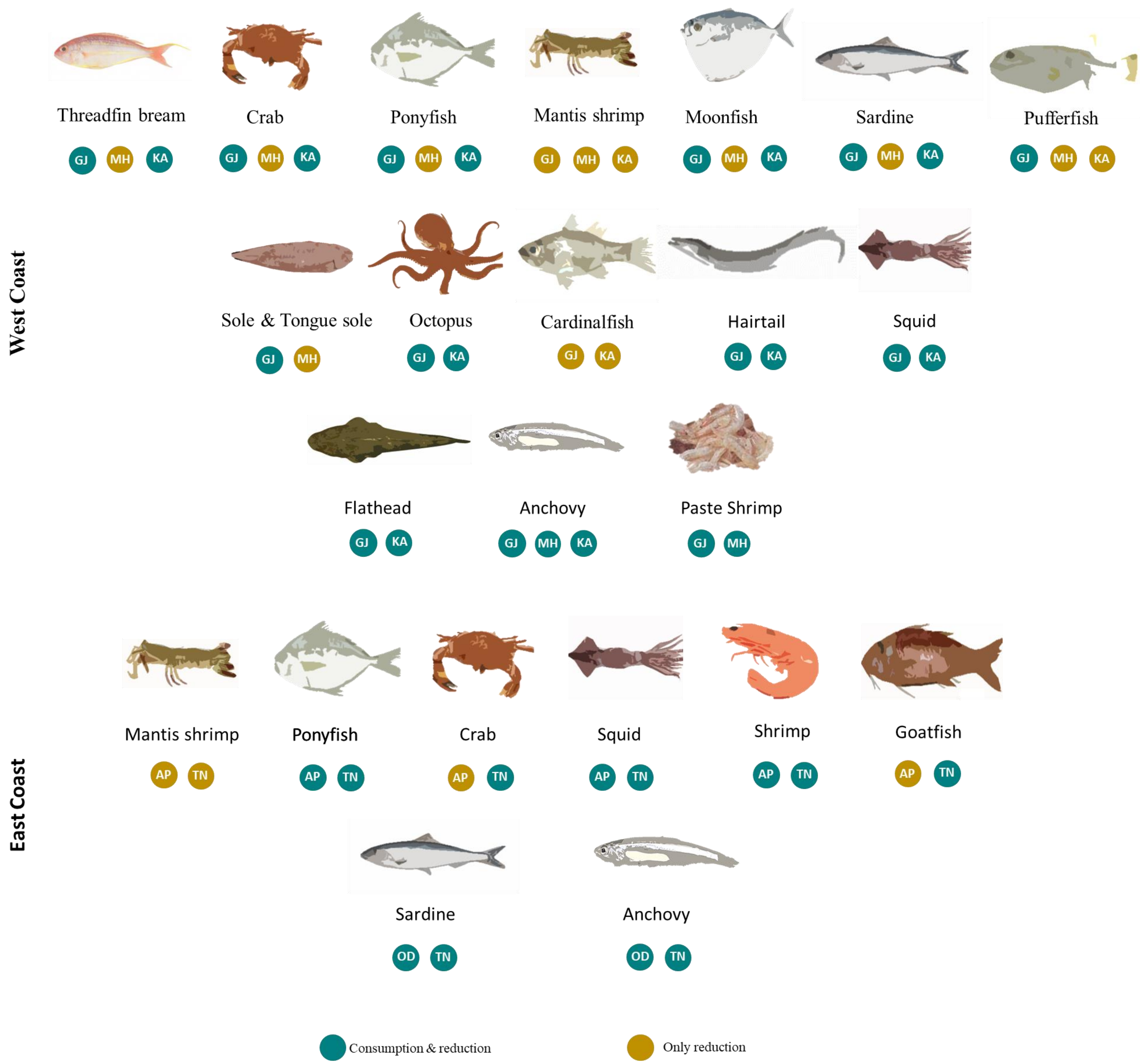

Figure 32. Utilisation of the faunal groups commonly observed in two or more states during the study

Overlap between consumption for food and utilisation for feed

In all our project sites we observed a huge overlap (64-89%) between the fish consumed for food and also used for manufacturing aquaculture and poultry feed. Socio-economically, the reasons for multiple utilization of fish can be attributed to many inter-dependent factors including quantity, quality, local preference, price fluctuation in local markets and access to logistics and large buyers including processing factories and export companies.

Understanding these reasons is crucial to check the diversion of essential micronutrients from the fishing community. We need more studies to point towards the particular causes and to quantify the diversion towards reduction rather than securing food for local fishing communities. However, irrespective of the reason the overlap of utilisation categories is a potential indicator of the diversion of crucial micronutrients from dependent fishing communities.

Socioeconomic dependencies and drivers in reduction fisheries

The reduction fisheries sector has gradually become a major part of the fisheries economy. It supports thousands of livelihoods across the supply chains from fishing and trading. We found that in all the project states multiple types of actors are involved across all nodes of the supply chain – from local fishers to migrant crew and fish workers, from big processors to women drying fish at small scales, and from head-loaders to fish-lorry drivers.

At the same time, we cannot ignore that reduction fisheries incentivise and sustains intensive, non-selective, and economically unviable fishing practices like trawling. Selling fish for reduction supported up to one-third of trawl fishers' income in Gujarat. Respondents from other states also highlighted the importance of selling low-value trawl bycatch to FMFO plants in supplementing their income. For example, in Visakhapatnam (Andhra Pradesh) and Dhamra (Odisha), low-value bycatch is an extra source of income for the crew members. In times of frequently fluctuating prices in local markets, reduction plants offer certainty, and this can become an incentive for fishers to land bycatch for reduction.

Although we need strong measures to mitigate the implications of reduction fisheries, it is imperative to consider the complex interdependencies present. These dependencies often involve dynamics that can create resistance to direct or top-down interventions. Further, the consequences can create ripple effects throughout the food system, affecting each and every stakeholder – affecting the poor and marginalised sections the most.

Way Forward

This current study has illuminated many knowledge gaps and opened many avenues for further research and possible policy and management interventions. Going forward we believe that the following three broad points should be considered.

1. **Long-term studies on bycatch and reduction fisheries catch**

   This was a relatively shorter study aimed at gaining a broad understanding of the reduction fisheries sector. Differences in sampling efforts and intensity created a barrier in producing inter-state level comparable data. Although the study was able to highlight the range of major faunal groups utilised for reduction, the taxonomic resolution was low which made it difficult to identify the impact of trawling and FMFO on juveniles – an important measure to check growth overfishing. We suggest building on the information from this study to initiate longer-term studies on bycatch and reduction fisheries. This will help build strong quantifiable evidence on the implications of this sector.

2. **Exploration of the supply chain linkages further**

   The overlap between the reduction fisheries sector and other sectors provides some interesting insight into complexities in the reduction fisheries sector. It is important to study the linkages between the reduction fisheries sector and other industries like aquaculture, poultry, pet food, pharmaceutical, and cosmetic industries. This will help in better understanding the drivers of the demand for FMFO.

3. **Holistic policy actions informed by bottom-up processes**

   During our study we came across many instances where actors along the supply chain expressed their inability to adhere to regulations, such as fish size regulation, mesh size, area limits, and bans on landing bycatch – often pushing smaller actors (like fish workers and crew) to tread the fine line between legal and illegal fishing. Taking the actors' perspectives into account is crucial to understand the dependencies and drivers. Interventions/policy actions informed by ground socioeconomic realities (bottom-up process) are more likely to be adhered to, making Indian fisheries more sustainable.

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