



# Trends and composition of trawl bycatch and its implications on tropical fishing grounds off Goa, India



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## HIGHLIGHTS

- 174 bycatch species out of 196 species account for significantly high biomass (68%).
- Discarded species comprised of trash species and juveniles of target species (89%).
- Species assemblages determined by recruitment patterns and ecological relationships.
- Temperature and salinity influenced seasonal trends of species abundance.
- Strong correlation between total catch and bycatch; bycatch and discarded.

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## ABSTRACT

Trawl bycatch is a globally recognized issue with intensified effects in tropical waters affecting both the ecosystem function and biodiversity, as well as causing physical damage and habitat loss. The present study envisages temporal variations of bycatch with regard to the species and their biological interactions based on data obtained from commercial single-day bottom trawlers operating off Goa, west coast of India. The data revealed that bycatch constituted about 68% of the trawl catch, the remaining being target species (shrimp, flat fishes, sciaenids, squids and crabs). Approximately 89% of the species discarded into the sea comprised of juveniles of target and trash species, suggesting a major share of non-target species, leading to species loss. Out of 196 taxa observed in the trawl catch, 174 constituted bycatch with a significantly high percentage of biomass. Abundance of discarded bycatch species (crustaceans, echinoderms, teleosts) displayed distinct peaks during pre-monsoon whereas molluscs, crustaceans and teleosts dominated during post-monsoon. A conspicuous increase in abundance of molluscs during post-monsoon (October, 2012) and echinoderms during pre-monsoon (April, 2011 and April, 2013) is largely attributed to the recruitment process. Cluster analysis identified different clusters during pre-monsoon and post-monsoon season corresponding to their recruitment patterns and diverse species assemblages. Principal Component Analysis performed using three environmental parameters accounted for 84% (five components) and 86% (four components) of variance during pre-monsoon and post-monsoon, respectively. Regression analysis indicated a significant linear relationship between total catch and bycatch ( $R^2 = 0.89$ ), and between bycatch and discarded catch ( $R^2 = 0.94$ ).

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## 1. Introduction

The exploitation of coastal demersal resources by trawl gear has led to indiscriminate removal of target as well as non-target species, affecting diversity (Davies et al., 2009; Thurston and Roberts, 2010). One of the most adverse problems faced is associated with shrimp bycatch (Clucas, 1997) affecting rare and endangered species (Wallace, 1996), habitat through hypoxia (Naqvi

et al., 2010) and food web through trophic displacement (Murawski, 1995). Published literature (Bijukumar and Deepthi, 2006; Davies et al., 2009) suggests that the bycatch is perceived contrarily in different parts of the world, and varies according to geographical region, fishing depth and fishing gear. This problem is more severe in tropical coastal waters where the shrimp trawlers arbitrarily target diverse faunal assemblages and eventually destroy vital benthic habitats (Rao et al., 2013).

Although it is well-accepted that bycatch is an unavoidable component of trawl net, increased utilization for economic purposes has led to reduction in discarded bycatch (Dineshbabu et al., 2013). The issue of discarded bycatch is particularly severe along

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the Indian coastal region due to multispecies fishery. Species composition of multispecies fishery trawl catch suggests that the enormity of bycatch resulting from such fishing operations is inevitable, causing loss of species and physical damage to the ecosystem (Bijukumar and Deepthi, 2006; Gibinkumar et al., 2012).

The concept of bycatch that has been put forth in the present paper, and the terminology used, follow Alverson et al. (1994), with minor modifications in view of species composition and its utilization from this region. The “Target catch” refers to the catch of a species or species assemblage that is primarily sought in a fishery (shrimp, soles, sciaenids, squids and crabs); “Incidental Catch” or “Commercial Bycatch”—Retained catch of non-target species; “Discarded bycatch” or “Trash fishes” is that portion of the catch that is returned to the sea as a result of economic, legal, or personal considerations; “Bycatch” or “Non-target catch” is the incidental, plus discarded catch.

In view of the above, the present study attempts to envisage seasonal changes in bycatch composition and species associations in respect of its application along the coast of Goa. Further, the occurrence of different groups of associated benthic fauna at different times has been assessed and discussed. The study also involves the assessment of species specific response to environmental parameters and the status of utility of bycatch along Goa coast.

## 2. Materials and methods

### 2.1. Study area

Goa, with a coastline of about 105 km along NW–SE (Lat: 14°53'54"N–15°48'00"N, Long: 73°40'33"E–74°20'13"E), facing the Arabian Sea, supports diversified ecological features and forms an integral part of the central west coast of India. It has a continental shelf of about 1 million hectares and active fishing area of 20,000 km<sup>2</sup> (Subramanian et al., 2014). The proposed study area (Fig. 1) covers the potential fishing grounds along the near-shore shelf waters off Goa coast. The near-shore waters are characterized by the presence of patchy reefs, submerged rocks, sandy silt substratum and an artificial habitat created by the sunken ship ‘River Princess’ (Ingole et al., 2006). The coastal waters are influenced by riverine discharge from the adjacent mangrove-fringed Mandovi–Zuari estuarine complex (Ansari et al., 1995).

### 2.2. Sampling

Sampling consisted of 100 trawl hauls on-board a 15 m long commercial shrimp trawler during day-time at fortnightly intervals. The sampling period extended from November 2010 to May 2013 with an exception of the monsoonal ban during June to September. Geographical position of sampling stations was recorded with 12-channel GPS and the corresponding depth was obtained from Naval Hydrographic Chart no. 2022. A trawl net with 20 m head and foot rope lengths and mesh sizes of 25 mm at mouth, 15 mm in the middle and 9 mm at cod end was towed at a speed of about 2–3 knots. Once the haul was taken on board, five random sub-samples of approximately 1 kg each were collected prior to sorting to assess total species composition. Subsequently, trash fauna were also sub-sampled after sorting. Quantitative assessment i.e. weight measurements of different target and commercial bycatch faunal groups and discarded bycatch (trash fauna) was done on-board the fishing trawler. All the samples were temporarily preserved in ice and brought to the laboratory. In the laboratory the abundance of representative species was quantified after sorting and identifying the mixed catch. The length of discarded species was obtained from discarded by-catch samples.

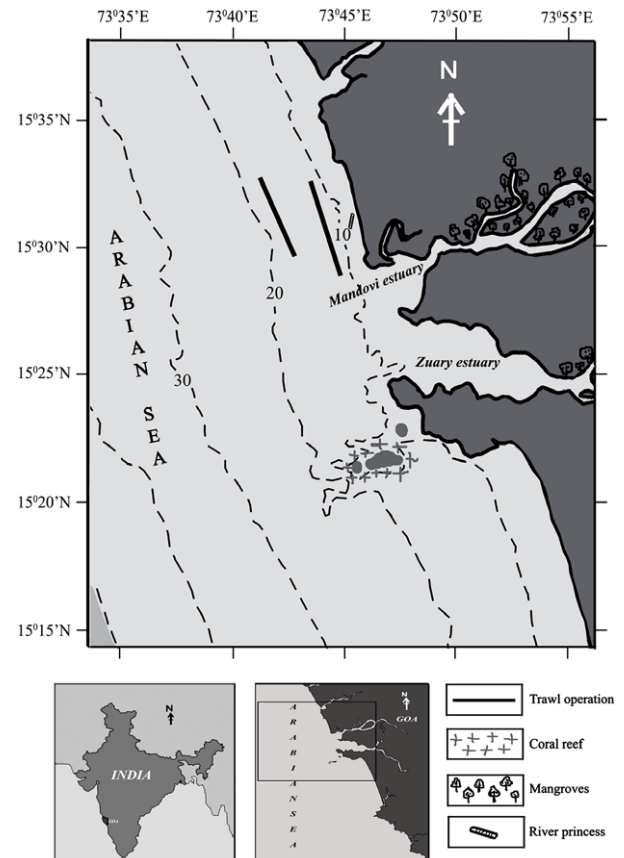


Fig. 1. Map showing study area.

In addition to these, water samples were collected to study environmental parameters (temperature, dissolved oxygen (D.O.) and salinity) at the start of trawl haul. The temperature was recorded on-board using mercury thermometer. Water samples for salinity were collected in 200 ml plastic bottles, and those for D.O. in 125 ml borosil glass stoppered bottles. Water samples for D.O. estimation were fixed on-board using Winkler's reagent and brought to the laboratory. In laboratory, salinity was estimated using Mohr–Knudsen titration method and D.O. using Winkler's method (Strickland and Parsons, 1968).

### 2.3. Species identification

Fauna were identified using conventional taxonomic methods involving phenotypic analysis and morphological measurements to the lowest possible taxonomic level aided by published taxonomic literature (Chhapgar, 1957; Froese and Pauly, 2014).

### 2.4. Data analysis

The total trawl catch was segregated into ‘target’ and ‘bycatch’ based on economic use. Further, the bycatch was grouped as ‘commercial’ and ‘discarded’. The discarded bycatch comprised mainly of juveniles of target species and a majority of non-edible fishes.

#### 2.4.1. Species abundance

Abundance data of discarded bycatch species from five sub-samples of each trawl haul was standardized to per hour (number h<sup>-1</sup>). Subsequently, standardized abundance data obtained from two fortnightly surveys was averaged to obtain

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