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Participatory GIS in trawl fisheries along Mumbai coast, Maharashtra

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An effort was made to prepare thematic maps of fisheries resources from trawlers along Mumbai coast, Maharashtra using Participatory GIS. Geospatial data on fishing, catch and samples of fish from commercial fishing vessels was collected and processed in Arc GIS 10.2 to develop tools for fishery management and resource conservation of the region. It emerged that the trawlers from Mumbai carried out trawling operations between $20^0$22'50"N to $18^0$12'20"N latitude and $72^0$21'50"E to $72^0$52'00"E longitude in depth range of 5 to 40 m. Catch percentage varied from 66% to 92% and 70% to 95% by multi-day and single-day trawlers respectively. Discard comprised juveniles of commercial species and adult fishes of low market value. In all, 121 species were caught by multi-day and single-day trawlers.

[**Keywords:** Fishery management, Participatory GIS, Resource mapping]

Introduction

Marine fisheries around the world remain seriously threatened from overfishing, over capacity and range of environmental problems[1]. As pressure on fisheries resource continues to increase, it has become evident that the data needed to make informed management decisions are either lacking or inaccessible[2]. Lack of proper resource database in Indian fisheries sector makes proper planning, execution and monitoring difficult[3]. The relevance of fisheries thematic mapping was emphasized in the general fisheries context and the current importance of resource mapping, particularly in the new Exclusive Economic Zones of developing countries[4]. In the present fishery management options, qualitative and quantitative fish landing data from both commercial and experimental fishing are taken into consideration while ignoring its spatial component[5]. Trawlers are the major mechanized fishing fleet which contribute significantly to the fisheries production especially along the west coast of India. Analysis of Indian marine fisheries production trend showed that 80% of the marine fish catch was contributed by trawlers[6]. Spatio-temporal information on catch from the trawlers is almost a replica of resource distribution in the commercial fishing grounds[7]. GIS technology has been affiliated to management and mapping of natural resources since the beginning of its use in 1960's. More recently, public participatory GIS (PPGIS) and participatory GIS (PGIS) are viewed as more efficient tools in solving social and resource conservation issues, which empower communities those who are often ignored in traditional GIS practices[8].

In fisheries, PGIS concept was first reported from Canada[9], where resource mapping of Bonavista Bay, a strong fishing area of Newfoundland was carried out by geospatial data shared between harvesters and government organizations. Most promising source of local information for GIS analysis is that which is available from fishers themselves. Many have noted this potential of fishers to share information on local environment, fishery and socio-economics that could be successfully utilized in various management measures[10,11]. Fishers' local knowledge is place-bound and specific, and mapping makes this information tangible as well as appropriate for use in GIS[12].

The present study was carried out during September 2013 – February 2014 along the Mumbai coast. Database created by this study can play an important role in policy making and fisheries management along the Mumbai coast.

Materials and Methods

Data for the study was collected from commercial multi-day and single-day trawlers

and *MFV Narmada*, Fisheries Training cum Research vessel of Central Institute of Fisheries Education, Mumbai. In order to get information from commercial fishing grounds, data was collected from a commercial trawler using their traditional technical knowhow for fishing operations. Multi-day trawler employed was a 15 m wooden boat with 120 hp engine capacity, engaged in multi-day trawling for a cruise period of 7 to 15 days per trip. Usually the trawler took one day break for unloading and ice-filling between the cruises. Single-day trawlers employed were 10 m wooden boat and 10 m FRP boat fitted with 83 hp and 86 hp engine capacities respectively.

Onboard information collected consisted of date, depth of shooting and hauling of net, geolocation of fishing operation, time of shooting and hauling of net, net type, mesh size (cod end), total catch (kg), total discard (kg) and number of hauls per day. Along with fishing information, an unsorted portion of discarded catch was collected as sample representing the haul. The spatial data thus collected was used as an input for the GIS study[12]. Samples were taken from unsorted trawl catch and preserved in ice and stored in fish-hold. During laboratory analysis, all fishes in the sample were identified up to species level and length-weight measurements of the same were taken. Base map of India with WGS coordinate reference system showing coastline was used for the study. Different types of spatial data overlay on the same to prepare various thematic maps. Personal geodatabase, feature datasets and feature classes were prepared in ArcCatalog 10.2. Thematic maps were prepared using ArcMap 10.2 visualization and interpretation capabilities.

Results and Discussion

The extent of fishing operations from Mumbai is given in Fig. 1. The database is strong enough to give the illustrative information regarding fishing ground on daily/monthly/seasonal basis with operational maps.

It showed that the trawlers from Mumbai undertook trawling operations from $20^0$22'50"N to $18^0$12'20"N latitude and $72^0$21'50"E to $72^0$52'00"E longitude. Their depth of operation ranged from 5 to 40 m. Information on fishing operations and fishing grounds will enable sustainable exploitation for better management of fish resources.

Preliminary experiments on application of participatory GIS in trawl fisheries of Karnataka[7] and its prospects in marine fisheries resource conservation and management showed that the trawlers from Mangalore carried out trawling operations during 2007-10 from sea off Calicut in the south (75°E, 11°N) to off Ratnagiri in the north (73.5°E, 17°N). Their depth of operation varied between 5 m and 167 m.

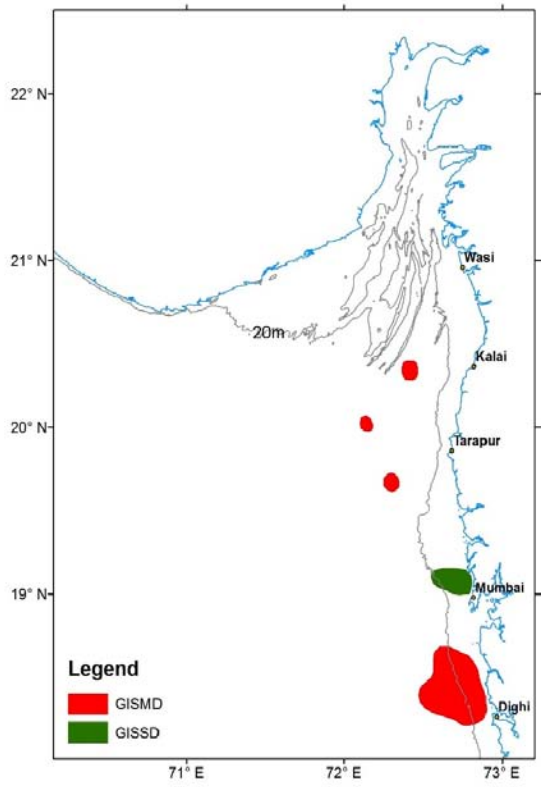

Fig. 1— Extent of fishing operations along Mumbai coast

The catch percentage by multi-day trawler varied from 66% to 92% (Fig. 2) while it varied from 70% to 95% in case of single-day trawler (Fig. 3). Discard percentage by multiday trawlers (7-33%) and single-day trawlers (4-30%) is shown in Fig. 4 and 5 respectively. The study indicated that discard was relatively less in single-day trawlers. Variation in catch per hour and discard per hour by multi-day and single-day trawler is given in Fig. 6 and Fig. 7. Catch per hour was maximum during

October for multi-day trawlers (73.27 kg) and during December for single-day trawlers (22.70 kg). Maximum discard per hour by multi-day trawlers i.e. 15.3 kg was during September, while it was October for single-day trawler (4.03 kg). Exploratory fishing operations carried out mainly by Government of India vessels enabled a general assessment of the productivity of different trawling grounds along the Indian coast. Catch per hour by otter trawling in the Arabian Sea was 198 kg/hour[13,14]. Annual trawl landings along the Eastern Arabian Sea showed an increasing trend over a period of time.

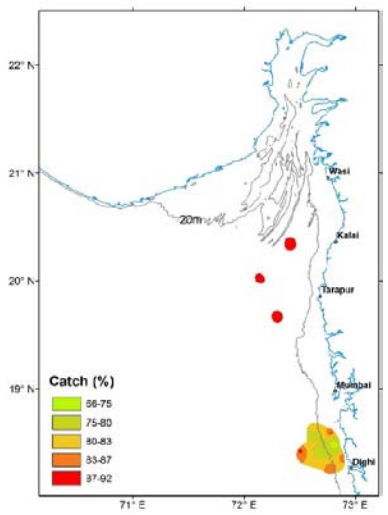

Fig. 2− Percentage of catch by multi-day trawlers

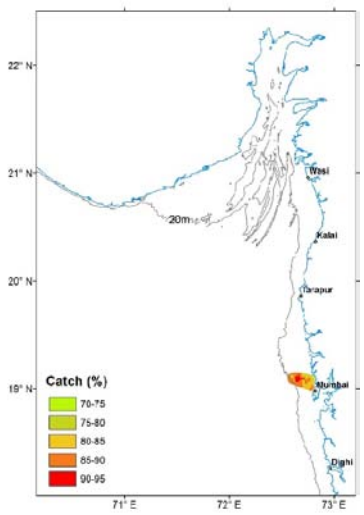

Fig. 3− Percentage of catch by single-day trawlers

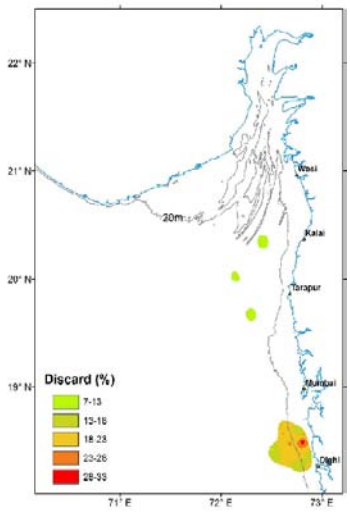

Fig. 4−Discard percentage by multi-day trawlers

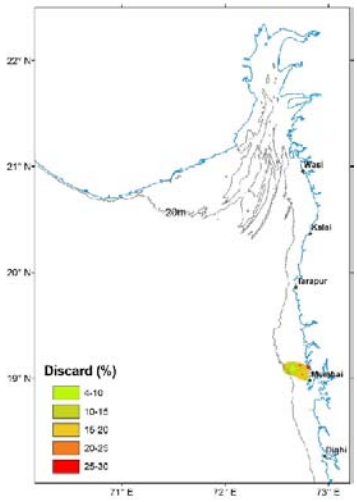

Fig. 5− Discard percentage by single - day trawlers

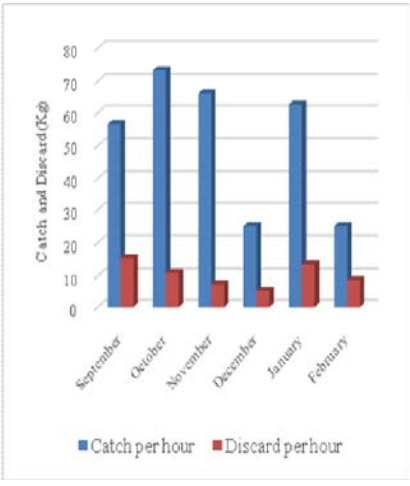

Fig. 6− Catch and Discard per hour from multi-day trawlers

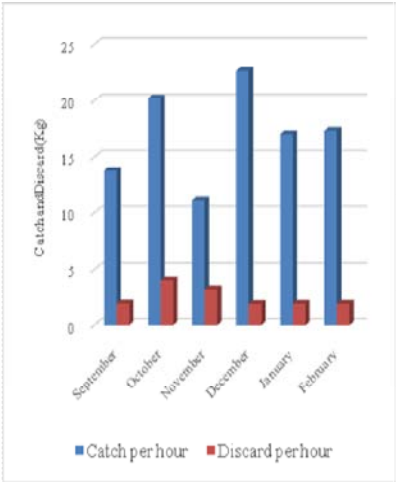

Fig. 7− Catch and Discard per hour from single-day trawlers

Table 1— List of species harvested by multi-day and single-day trawlers operating from Mumbai coast

Finfish
Alepes djedaba
Ambassis ambassis
Anodontostoma chacunda
Antennarius striatus
Apogon sp.
Arius caelatus
Arius dussumieri
Arius maculatus
Arius tenuispinis
Bregmaceros mcclellandi
Coilia dussumieri
Cynoglossus arel
Cynoglossus macrostomus
Cynoglossus puncticeps
Dussumieria acuta
Eleutheronema tetradactylum
Epinephelus bleekeri
Epinephelus diacanthus
Escualosa thoracata
Eupleuroigrammus muticus
Gerres filamentosus
Glossogobius giuris
Grammoplites scaber
Harpadon nehereus
Ilisha filigera
Johnieops macrorhynus
Johnieops sina
Johnieops vogleri
Johnius belangerii
Johnius elongatus
Johnius glaucus
Lactarius lactarius
Lagocephalus lunaris
Leiognathus blochii
Leiognathus daura
Lepturacanthus savala
Megalaspis cordyla
Minous monodactylus
Muraenesox cinereus
Muraenesox talabonoides
Nemipterus japonicas
Nemipterus randalli
Odontamblyopus roseus
Opisthopterus tardoore
Osteogeniosus militaris
Ostorhinchus fasciatus
Otolithes cuveri
Otolithes ruber
Otolithoides biauritus
Pampus argenteus
Pampus chinensis
Parachaeturichthys polynema
Parastromateus niger
Pellona ditchela
Polynemus heptadactylus
Protonibea diacanthus
Sardinella fimbriata
Sardinella longiceps
Saurida tumbil
Saurida undosquamis
Scomberomorus guttatus
Sillago sihama
Stolephorus commersonii
Takifugu oblongus
Terapon jarbua
Terapon theraps
Thryssa dussumieri
Thryssa hamiltoni
Thryssa mystax
Thryssa setirostris
Trichiurus lepturus
Trypauchen vagina
Elasmobranch
Chiloscyllium arabicum
Himantura imbricata
Scoliodon lacticaudus
Sphyraena obtusata
Torpedo marmorata
Shrimps
Exhippolysmata ensirostris
Metapenaeopsis stridulans
Metapenaeus affinis
Metapenaeus brevicornis
Metapenaeus dobsoni
Metapenaeus monoceros
Nematopalaemon tenuipes
Parapenaeopsis hardwickii
Parapenaeopsis nana
Parapenaeopsis sculptilis
Parapenaeopsis stylifera
Sicyonia lancifer
Solenocera crassicornis
Lobster
Panulirus polyphagus
Crabs
Arcania septemspinosa
Charybdis annulata
Charybdis callianassa
Charybdis cruciata
Charybdis lucifera
Charybdis orientalis
Portunus pelagicus
Portunus sanguinolentus
Thalamita crenata
Cephalopods
Cistopus indicus
Loligo duvaucelii
Loliolus investigatoris
Onychoteuthis banksi
Sepiella inermis
Stomatopods
Harpiosquilla harpax
Harpiosquilla woodmasoni
Miyakea nepa
Oratosquillina interrupta
Other Shellfish
Arca bistrigata
Arca granosa
Babylonia spirata
Bursa spinosa
Bursa tuberculata
Cantharus spiralis
Ficus variegata
Murex tribulus
Natica picta
Surcula amicta
Surcula javana
Tibia curta

The catch trend was subjected to wide fluctuation in the earlier years but from 2009 onwards catch showed a steady increase and reached 1.18 m tonnes in 2012. Technological advancement in trawl fisheries could be attributed to this increase in production. Catch rate of trawlers fluctuated from 30 to 50 kg per hour during 1990- speed engines since 2010 may be one of the reasons for increase in catch rate[8].

List of species caught by multi-day and single-day trawlers operated from Mumbai coast is given in Table 1. Trawl surveys form an

important tool in assessing fish populations, their locations and habitat use[15]. One hundred twenty species/groups of species were observed from the commercial landing of trawlers from Mangalore Fisheries Harbour during 2007-2010[7].

Month-wise major contributors (species) by multi-day trawlers and single-day trawlers are given in Fig. 8 and Fig. 9 respectively. Bombay duck (*Harpadon nehereus*) landing by multi-day trawlers was betteras compared to single day trawlers during November. Peak landing of *Parapenaeopsis stylifera* by both multi-day and single-day trawler was observed during October.

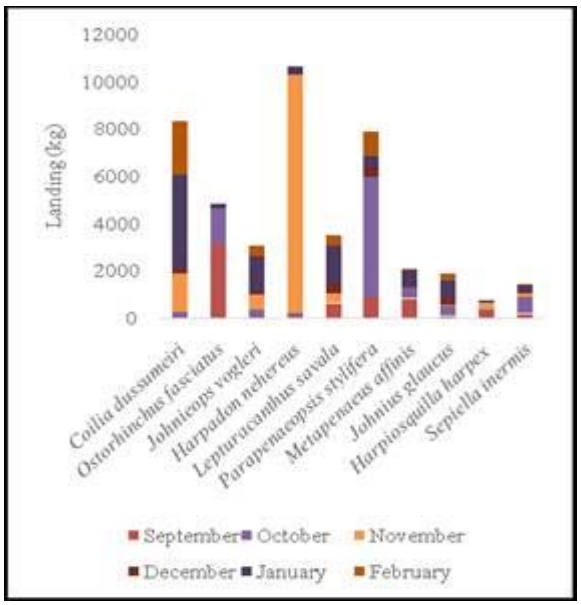

Fig. 8− Month-wise top landed species by multi-day trawlers

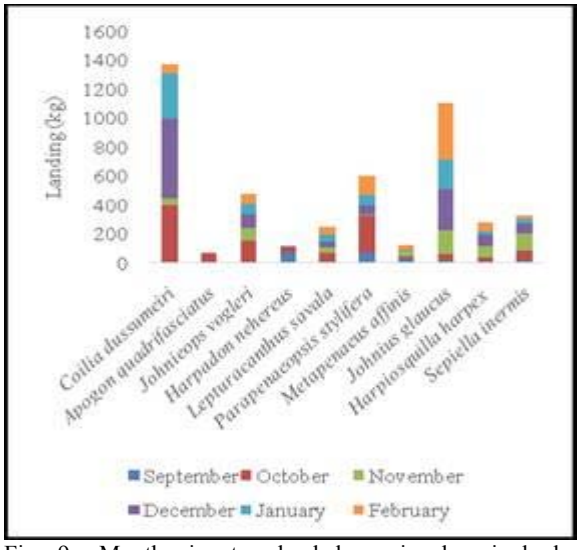

Fig. 9− Month-wise top landed species by single-day trawlers

The Fig. 10 gives an account of the percentage of juveniles of top landed species by multi-day trawler. There was 100% juvenile landing of *Harpadon nehereus* and *Johneiops vogleri* from September to February. Juveniles comprised almost all the landing of *Sepiella inermis*.

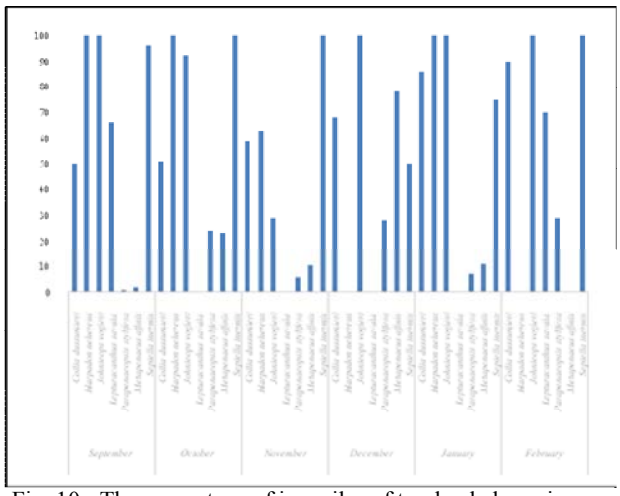

Fig. 10− The percentage of juveniles of top landed species by multi-day trawlers

The Fig. 11 highlights the percentage of juveniles of top landed species by single-day trawler. The juvenile landing of *Sepiella inermis* was almost similar in the case of multi-day trawler.

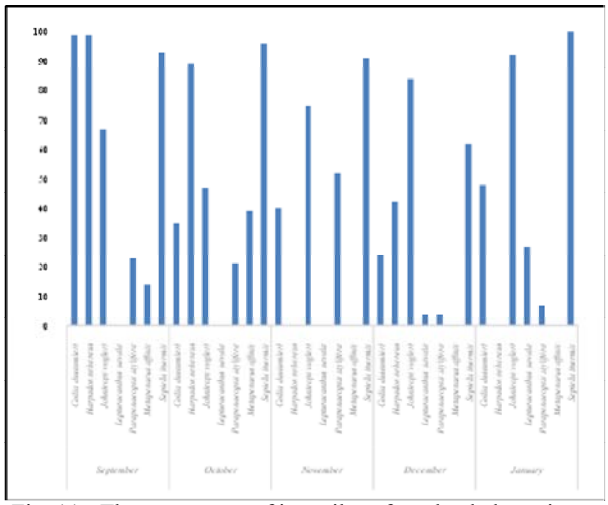

Fig. 11− The percentage of juveniles of top landed species by singleday trawlers

An estimated 6,200 t of juvenile fish and prawns were discarded back into the sea during 1980-84 along the south-west coast of India[16]. Quantitative estimation and seasonal variation in percentage of juveniles in the commercial trawl fishery of Mangalore and Malpe was done in

2006 and possible impacts of juvenile fishery on fish stock in terms of quantity and value were analysed[17]. Twenty finfishes and five shellfishes were identified in which considerable quantity of juveniles was caught and notable impact on adult fishery was observed.

Conclusion

Participatory GIS is viewed as an efficient tool in solving social and resource conservation issues. Spatio-temporal distribution and abundance of fishes and juveniles from commercial catches of trawlers along the coast was recorded. Database would help policy makers to implement restrictions regarding fishing ground and fishing season on the basis of juvenileabundance in space and time. Based on the results of distribution and abundance of marine fish resources, spatial and seasonal restrictions on fishing efforts can be advocated for maintaining sustainable production in areas and seasons during which high incidence of juveniles are recorded.

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