Indian J. Fish., 59(1) : 15-22, 2012

Preliminary experiments on application of participatory GIS in trawl fisheries of Karnataka and its prospects in marine fisheries resource conservation and management

A. P. DINESHBABU, SUJITHA THOMAS, E. V. RADHAKRISHNAN* AND A. C. DINESH

Mangalore Research Centre of Central Marine Fisheries Research Institute, Mangalore - 575 001, Karnataka, India
**Central Marine Fisheries Research Institute, Kochi - 682 018, Kerala, India*
e-mail : dineshbabuap@yahoo.co.in

ABSTRACT

Geographic Information System (GIS) has become a part of our day today life in empowering institutions to formulate acceptable solutions in societal issues. 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. In fisheries, PGIS concept was first reported from Canada and on these lines pioneering efforts of involving concept of PGIS in fisheries is being attempted in Karnataka, where the geospatial data on fishing, catch and samples of fish caught by commercial fishing vessels were shared with the research organization and the data and samples thus shared were processed by fishery and GIS experts to come out with various tools for fishery management and resource conservation of the region. The study showed that the trawlers from Mangalore carried out trawling operations 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 was between 5 m and 167 m, which signify the importance of revalidation of state–wise policies in introduction of mechanized vessels based on the landing in the respective states. The study showed that during the period, 237 species / groups of marine fauna were discarded of which many were juveniles of commercial species and rest were of adult size fishes of low or no market value. Spatio-temportal distribution and abundance of commercially lesser known species, which was not reported earlier from the coast and which have high trophic importance like small crabs, *Charybdis hoplites* and shrimp species like *Metapenaeus andamanensis* were brought out as the results of the study. Study also provided information on a unique ecosystem off Karnataka coast and with reef species and there is an immediate need for conserving this ecosystem. Based on the results of distribution and abundance of marine resources, spatial and seasonal restrictions on fishing efforts can be advocated in areas and seasons during which high incidence of bycatch of juveniles and non-commercial biota is being caught. This will help in sustaining marine fisheries from Malabar and Konkan coasts.

Keywords: Conservation, Fishery management, Karnataka, Participatory GIS, Resource mapping

Introduction

Fishery science and fishery technology contributed immensely in augmenting fish production globally. Due to the extensive fishing near the coast, many of the commercial fish resources are reported to be overfished and there is an urgent need for regulation in fishing so that fishery production can be made sustainable (Devaraj and Vivekanandan (1999). Since the resources have wide spatial distribution, collection of information on the distribution by Institutional machineries is near impossible. Trawlers are the major mechanized fishing fleets which contribute to the fisheries production especially along the west coast of India. Analysis of Indian marine fisheries production trend showed that 80% of the marine fisheries catch was from trawlers (Srinath, 2003). During the last decade, trawlers were further equipped with modern gadgets and more engine capacity to fish more vigorously which led to increased contribution from these fleets.

The spatio-temporal information on catch from the trawlers are almost a replica of resource distribution in the commercial fishing grounds. This information can be developed as a database with the active participation of the fishermen which can be used in formulation of management measures. In the present fishery management options, qualitative and quantitative fish landing data from both commercial and experimental fishing are taken into consideration ignoring its spatial component (Booth, 2000). 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. It is a movement, aimed to develop

GIS adaptable to ordinary citizens and other non-official sources (Obermeyer, 1988). In fisheries, PGIS concept was first reported from Canada (Macnab, 1998), where resource mapping of Bonavista Bay, a strong fishing area of Newfoundland was carried out by geospatial data sharing 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 local environmental, fishery and socio-economic information that could be successfully utilized in various management measures (Hutchings and Ferguson, 2000; Maustard, 2000). Graham *et al.* (2002) stated that fishers' local knowledge is place bound and specific, and mapping makes this information tangible as well as appropriate for use in GIS.

During the present study (2007-2010), along Karnataka coast, fishermen shared the information collected in each cruise with the scientists involved in resource conservation and resource management. Strong database on resource distribution in different fishing grounds was illustrated with maps, time to time to the fishermen to make them aware about the importance of their contribution and also to ensure their involvement in the process. Database thus created can act as a handy tool for the policy makers for evolving participatory management policies. The spatio-temporal data on distribution and abundance based on Geographic Information will enable evolving policies for the improvement of the fishery in terms of restriction in fishing period, fishing pressure *etc.* (Caddy and Carocci, 1999). It will also help the policy makers to implement restrictions regarding fishing ground and fishing season on the basis of similar strong database of juvenile abundance in space and time. "No fishing zones" and "marine sanctuaries" can be marked on the basis of spatio-temporal data of fish distribution (Mansion and Die, 2001). The present study is only a preliminary attempt and since it needed time series data which is voluminous, very limited and reliable source of information was incorporated in this study to make it most reliable. The data out put from the study shows that immediate thrust has to be given for intensive studies with more number of fishermen participation to come out with spatio-temporal marine resource mapping of exploited marine fishes off Indian coast.

Materials and methods

Data for the study was collected from commercial trawlers operated from Mangalore. In order to get information from commercial fishing grounds, data collection was done from a commercial trawler using their traditional technical know how for fishing operations. The trawler employed was a 52" wooden boat with 160 hp engine capacity, engaged in multi-day trawling for a cruise period of 8 to 13 days per trip. Usually the trawl took one day break for unloading and ice filling between the cruises. The trawler generally carried three types of trawl nets with about 10 different cod end pieces in order to change the cod end of the trawl net according to the availability of resource at space and time. Results presented in the present paper was based on the daily data obtained for 618 days of fishing from September, 2007 to April, 2010**.** Except the trawl ban periods (June-July) in 2008 and 2009, data collection was continuous. Daily hauling tracks (one of several hauls done on a particular day) from where the data was collected is shown in the Fig. 1. The cruise path traditionally followed by trawl fishermen of Karnataka was followed for data collection in the present study. To understand the fishing pressure in different fishing grounds, individual cruise line in particular fishing grounds were classified into low, moderate and high fishing intensity. Onboard information collected were date, geolocation of fishing operation, net type, mesh size, 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 with token number representing the haul. The spatial data thus collected were used as an input for the GIS study as described by Graham *et al.* (2002). The samples were preserved in ice and stored in fish-hold. All the species were identified up to species level.

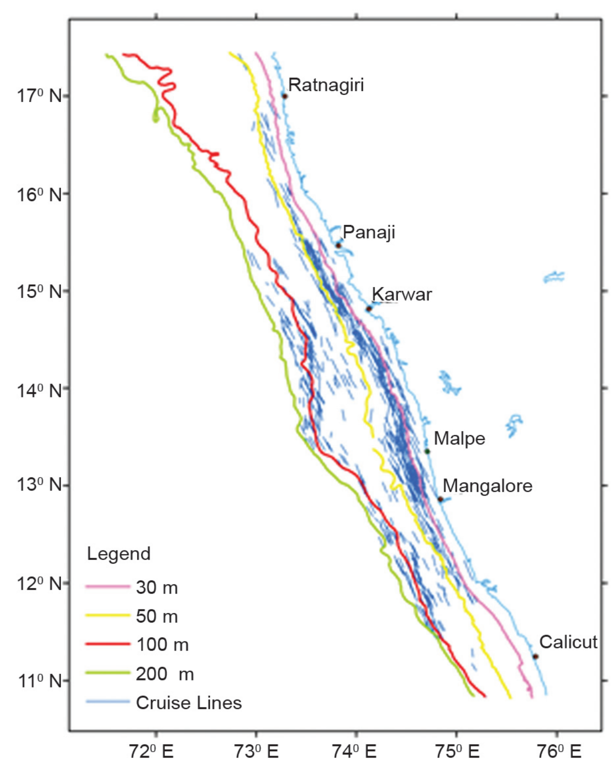

Fig. 1. Map showing the sampling area with cruise line of 618 days

Qualitative and quantitative analyses of the samples were carried out in the laboratory. Weight of samples were taken and the species present in the discard samples were sorted out. Number, length and weight of individual fishes in each group were recorded. The number was raised to number of fishes in each haul and then raised to day catch. Similar raising was also done for commercial fishes also. For the commercial species landed, the percentage by weight was taken as an indicator of abundance, whereas in the case of juveniles, since the sizes are small, weight percentage was giving an underestimation of resource abundance. For the present study, the percentage of numbers of juveniles in each haul is taken as an indicator of juvenile abundance in number percentage. These data were fed to MS Access files. Number, size and individual weight of the species in the sample were recorded to get a picture of life stages of the species, especially juveniles, subadults and adults of the species, which would enable the scientists to understand the spatio-temporal distribution of fishes as well as the distribution pattern of each species at different life stages.

For spatio-temporal distribution mapping and smooth handling of data, two softwares were used, ArcGIS and Visual Basic (VB) 6. VB is populated with data of commercial catch and discards, which comprises geographic coordinates, water depths, net types, commercial fish, discard species *etc*. Thematic shape files/ feature classes were prepared by sending queries into these tables. The cruises of each trawler are displayed as lines on the shape files/feature classes. ArcGIS is used as powerful map engines. The respective geo-database tables are mapped in ArcGIS. Apart from input for mapping, VB can handle analysis of the data as a very powerful query engine by incorporation of mathematical formulae, which can help in deriving very informative conclusions on topics like relationships and dependence of the species as well as in deriving indices for biodiversity and biological loss.

Queries made on extend of fishing ground, temporal changes in fishing ground, spatial distribution of fishes, spatial distribution of species in different seasons, spatial congregation of adult and juveniles of particular species can be illustrated in ArcGIS as maps. Some of the GIS mapping made according to the queries given in VB from the data collected from commercial trawlers are given below to illustrate the utility of the data compilation in VB and GIS.

Results and discussion

Extent of fishing operation from Mangalore Fisheries Harbour

The extent of fishing operation from Mangalore Fisheries Harbor during 2007-2010 is given the Fig. 2. The illustration given incorporated all 618 days of fishing operation taken up during the study period and the database is strong enough to give the illustrative information on fishing ground on daily/monthly/seasonal and annual basis with operational maps. It shows the trawlers from Mangalore whcih undertook trawling operation from seas off Calicut in the south (75 °E, 11 °N) to off Ratnagiri in the north (73.5 °E to 17 °N). Their depth of operation was between 5 m and 167 m. While analyzing the fishing operation for 2007-2010, most intensive trawling operations were observed along the fishing ground at 30 m depth off Mangalore to Panaji, followed by fishing ground at 100 m depth off Malpe to Karwar. Fishing ground at 30 m depth off Ratnagiri was also found to be fished with moderate intensity. Present study reveals that most of the fishing operation are concentrated within the 150 m depth zone and extension was mainly parallel to the ground, towards south or north. The information on existing fishing pattern in traditional fishing grounds will enable policy making for the sustainable exploitation of resources from their jurisdiction more efficiently. These maps give a strong basis for participatory decision making on effort reduction in terms of months and seasons with stress on specific resources very effectively.

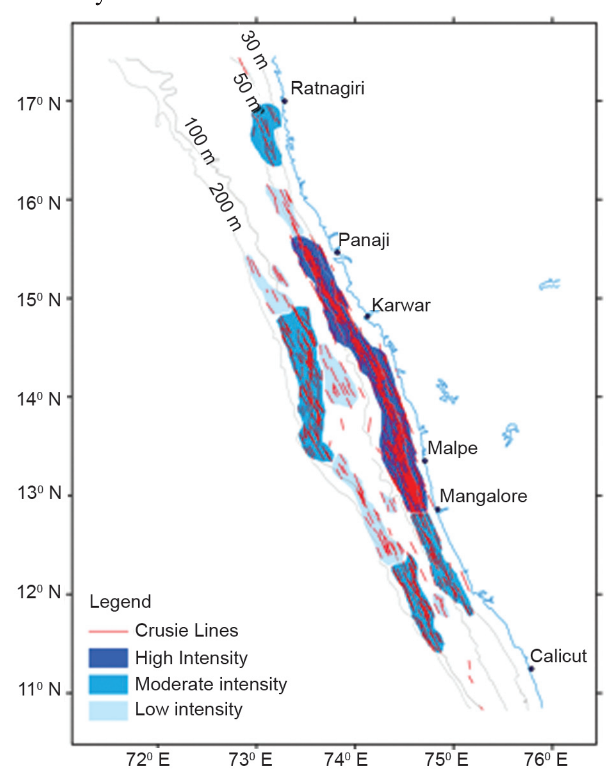

Fig. 2. Extent of fishing ground and intensity of fishing at different fishing grounds

From Fig. 1, it is observed that in this area no trawling operation has taken place in all the three years of fishing and by enquiry it was understood that these areas are spared because of the rocky nature of bottom topography. Even during intensive fishing season, such areas act as natural protected areas in the marine ecosystem, which may be helpful in replenishment of commercial resources, by giving protection to juveniles of many commercially important species. The non-fishing areas off the stretch between Maple and Karwar, coincides with the unique coral ecosystem reported by Zacharia *et al*. (2008). Fig. 3 gives the congregation and distribution of reef related species which prefer rocky substratum. For mapping this, distribution related species/groups were used and is listed in Table 1. The mapping of distribution of these resources will give an indication of presence of reefs/rocky bottom in the vicinity of trawling grounds which cannot be trawled due to the bottom conditions. Based on the results of the study on the diversity of fauna in this unique ecosystem, there should be effort to conserve this ecosystem.

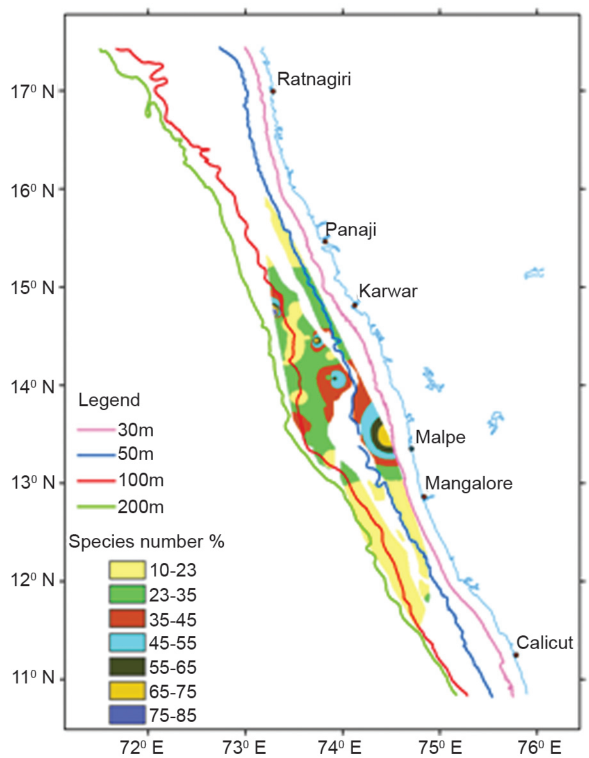

Fig. 3. Distribution of reef related species

Table 1. List of reef related species

Acanthurus sp.
Arothron sp.
Chaetodon sp.
Dendrochirus sp.
Odonus niger
Parrot fish
Pterois russelli
Pterois sp.
Pterois volitans
Sargocentron rubrum
Scarus sp.
Scorpaenodes sp.
Scorpion fish

Spatio-temporal distribution of fishes

Till early eighties, when the trawling was restricted to 30 to 40 m depth, the species distribution of marine fishes was well understood and documented. But when the fishing depth was extended to deeper waters and fishing operations were extended from single day to multiday, the fish landing data could not provide details of distribution of marine resources by depth. Even though experimental trawling provided some useful data, these data were not sufficient to conclude about distribution of fishes. Fishery researchers and managers who are involved in evolving management policies are left with no option other than assuming that the fishes landed were uniformly distributed in the fishing ground. The results of the present study can give the status of distribution and abundance of the resources which can give additional information for evolving successful management options for these resources.

Central Marine Fisheries Research Institute, Kochi has a comprehensive time series database on the species caught by trawlers from 1960 onwards, but the spatial distribution of the species are not clearly understood. One hundred twenty species/groups of species were observed from the commercial landing of trawlers from Mangalore Fisheries Harbor during 2007-2010 (Table 2). The study gives information on spatio-temporal distribution of different fishes in the fishing grounds off Mangalore. During the study period, 237 species/groups of marine fauna were discarded of which many were juveniles of commercial species and rest were adult size fishes of low or no market value.

Species based studies

To illustrate the utility of species based studies, the distribution of threadfin breams in commercial catch as well as in discarded juveniles are depicted in Fig. 4 and Fig. 5. The group included two major species (*Nemipterus randalli* and *Nemipterus japonicus*). When this distribution is drawn without giving query on the temporal distribution, the figure gives only a compiled annual pattern of species distribution. Most important utility is that monthly and seasonal queries can be answered on distribution and abundance of individual species or group of commercial species so that policy makers will have a handy tool in deciding the resource based, juvenile abundance based fishery restriction in different fishing grounds.

Trophic interactions

Based on this study, information on non-commercial species having importance from ecological point of view in these fishing grounds could be collected, which is not possible with existing method of landing based resource assessment. Many of these non-commercial species are less

Table 2. List of species caught by multiday trawlers operated from Mangalore Fisheries Harbour

Finfishes		
Cynoglossus macrostomus	*Alectis indicus*	*Naso annulatus*
Cynoglossus bilineatus	*Alectis ciliaris*	*Caesio striata*
Cynoglossus puncticeps	*Atropus atropos*	*Kyphosus cinerascens*
Psettodes erumei	*Caranx sexfasciatus*	*Amarsipus carlsbergi*
Pseudorhombus arsius	*Caranx ignobilis*	*Parambembras robinsoni*
Lactarius lactarius	*Elagatis bipinnulata*	*Acanthocepola limbata*
Rastrelliger kanagurta	*Uraspis helvola*	*Diodon holocanthus*
Scomberomorus commerson	*Epinephelus diacanthus*	*Pempheris adusta*
Nemipterus japonicus	*Epinephelus epistictus*	*Dendrochirus zebra*
Nemipterus mesoprion	*Epinephelus modestus*	*Neomerinthe procurva*
Parascolopsis aspinosa	*Epinephelus chlorostigma*	*Minous monodactylus*
Scolopsis vosmeri	*Priacanthus hamrur*	*Parapercis somaliensis*
Trichurus lepturus	*Heteropriacanthus cruentatus*	*Fistularia petimba*
Sardinella longiceps	*Pampus argenteus*	*Lagocephalus inermis*
Sardinella albella	*Sphyraena obtusata*	
Sardinella fimbriata	*Sphyraena jello*	Prawns
Sardinella gibbosa	*Chirocentrus dorab*	*Metapenaeus affinis*
Hilsa kelee	*Rachycentron canadum*	*Metapenaeus dobsoni*
Anodontostoma chacunda	*Congresox talabonoides*	*Fenneropenaeus indicus*
Opisthopterus tardoore	*Strongylura leiura*	*Fenneropenaeus merguiensis*
Dussumieria acuta	*Stolephorus insularis*	*Metapenaeus monoceros*
Thryssa mystax	*Stolephorus waitei*	*Melicertus canaliculatus*
Arius thalssinus	*Stolephorus commersonii*	*Penaeus monodon*
Arius dussumieri	*Encrasicholina punctifer*	*Penaeus semisulcatus*
Arius tenuispinis	*Terapon jarbua*	*Parapenaeopsis stylifera*
Johnius glaucus	*Mobula mobular*	*Trachysalambria spp.*
Johnius carouna	*Himantura gerrardi*	*Parapenaeus fissuroides*
Johnius dussumieri	*Grammoplites suppositus*	*Solenocera choprai*
Otolithus ruber	*Platycephalus indicus*	*Heterocarpus gibbosus*
Scoliodon laticaudus	*Leiognathus bindus*	
Saurida undosquamis	*Leiognathus splendens*	Stomatopods
Saurida tumbil	*Gazza minuta*	*Oratosquilla nepa*
Trachinocephalus myops	*Secutor insidator*	
Megalaspis cordyla	*Secutor ruconius*	Cephalopods
Decapterus russelli	*Sillago sihama*	*Loligo duvaucelli*
Decapterus macrosoma	*Sillago vincenti*	*Octopus membraneous*
Alepes klenii	*Gerres filamentosus*	*Sepeilla inermis*
Parastromateus niger	*Psenopsis cyanea*	*Sepia elliptica*
Selar crumenophthalmus	*Platax orbicularis*	*Sepia pharaonis*
Caranx sexfasciatis	*Parupeneus indicus*	*Sepia prasadi*
Scomberoides commersonnianus	*Echeneis naucrates*	*Loligo singhalensis*
Scomberoides tol	*Abalistes stellatus*	*Loligo edulis*

known but contribute in the food web of the ecosystem as a prey for most of the carnivorous and omnivorous resources, contributing substantially to the commercial fishery of the country in an indirect way. As an example, distribution and abundance of small crabs, *Charybdis hoplites* (Fig. 6), which was not reported earlier was taken for illustration. Study revealed that this species is distributed very widely and the examination of gut contents of *Epinephelus* spp. and *Nemipterus* spp. caught from these grounds, shows that large quantity of these crabs are consumed by these commercial species. Seasonal changes in distribution of this less known species can be correlated with the information from gut content studies and in many cases many species act as an indicator species of the presence of another species. Same is the case with shrimp species like *Metapenaeus andamanensis,* which is generally not a contributor to the shrimp fishery of Karnataka, even though it is landed as commercial catch in other parts of the country. The species have a wide distribution in the fishing grounds off Karnataka, beyond 40 m depth (Fig. 7). Most of the commercial fishes caught from these fishing grounds contained good amount of shrimps in their gut (Mohamed *et al.*, 2008) and this species may be a major contributor of food to these fishes.

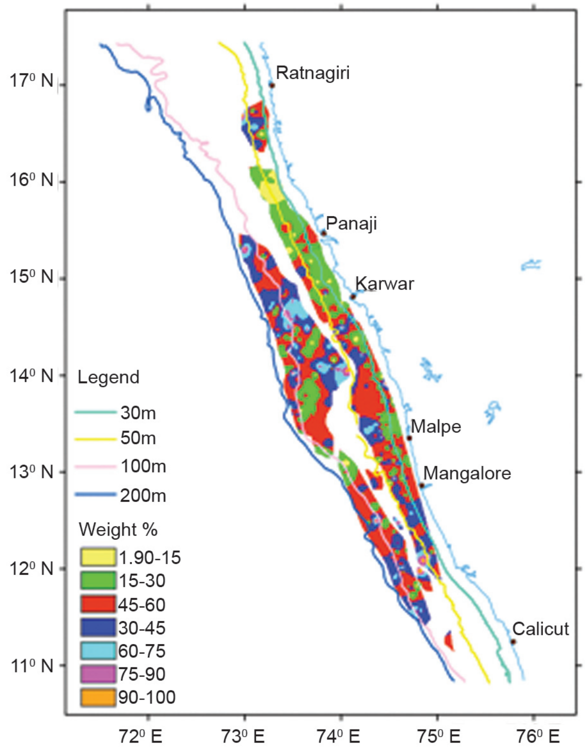

Fig. 4. Fishing ground from which commercial size threadfin breams are caught

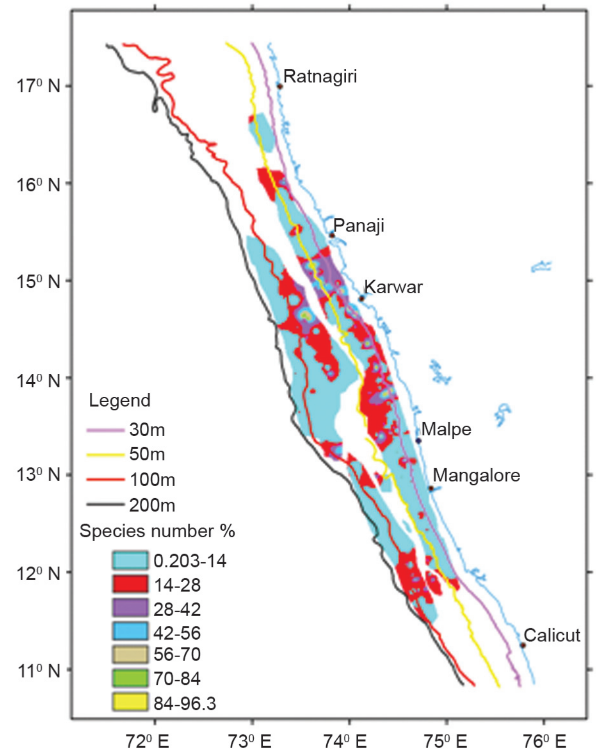

Fig. 5. Fishing ground from which juvenile threadfin breams were discarded

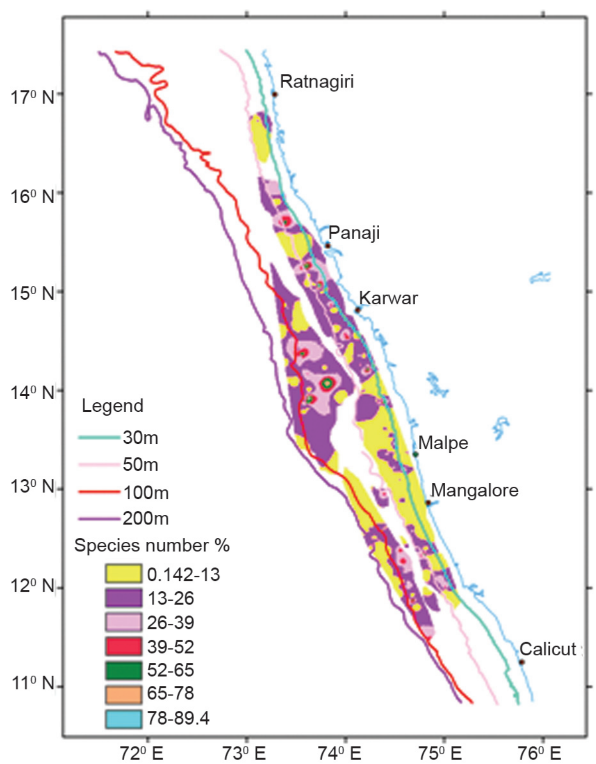

Fig. 6. Distribution of crab *Charybdis hoplites*

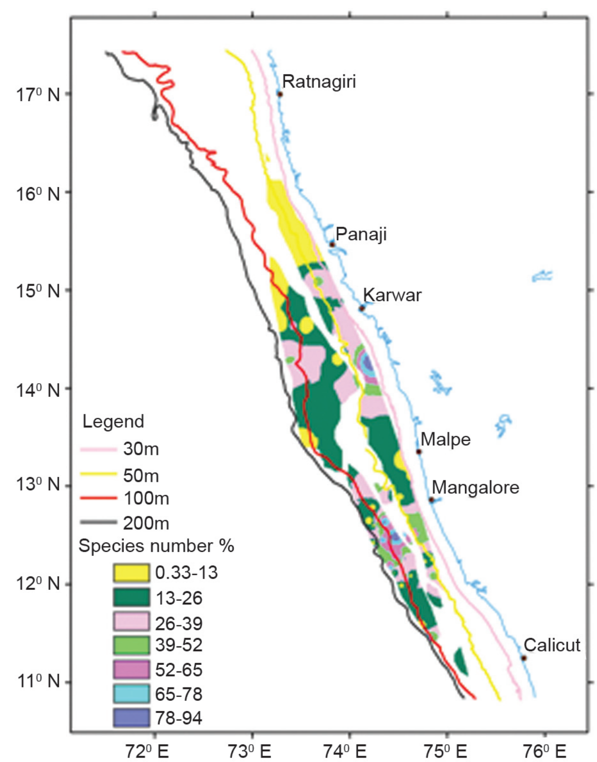

Fig. 7. Distribution of prawn, *Mateapenaeus andamanensis*

Utility in spatial restriction of fishing for fishery conservation

The map when drawn by pooling all data points collected irrespective of months/seasons may look less informative, probably giving a picture of overall distribution of species or area of fishing operation. Fig. 8 shows the result when temporal component alone are analysed in terms of monthly percentage of discards. Present data collection in participatory mode will help incorporating bycatch and discard components of fishery also in resource assessment studies and based on the qualitative and quantitative availability of all these components of the fishery, each fishing ground can be evaluated seasonally in terms of economic as well as in terms of biodiversity . Such overall information on fishing ground and resource mapping will enable demonstration of the impact of fisheries to the fishermen in visual format and would help the policy makers to evolve most appropriate policies with respect to restricting fishing in a particular fishing ground during a particular season. Spatio-temporal resource mapping on long term basis could also help in conservation of human and fuel resources which is spent in search of fishes.

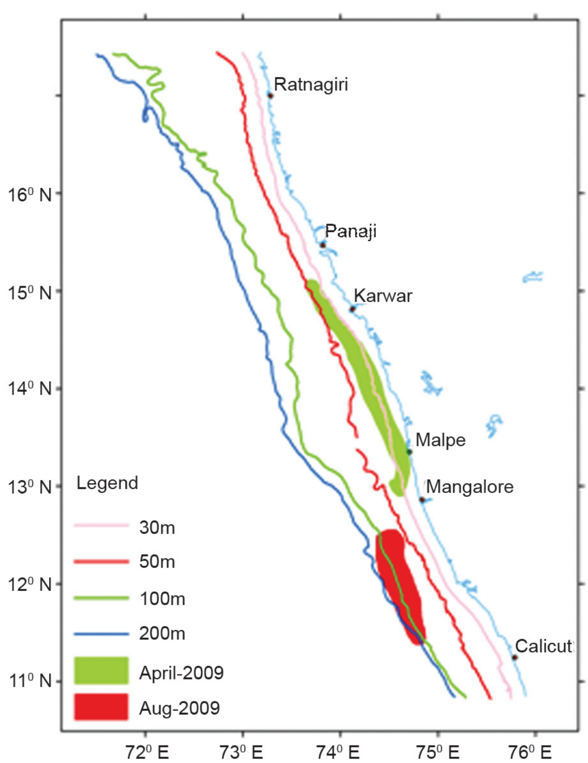

Fig. 8. Areas and months in which highest (August, 2009) and lowest (April, 2009) percentage of fishes were discarded

The results of the study shows that the fishing boats from Mangalore are operating throughout Malabar and Konkan coast, which is coming under the jurisdiction of four states, which necessitates a regional assessment of optimum fleet strength with co-operation of all the four states in order to sustain regional fishery. Based on the results of distribution and abundance of marine resources, spatial and seasonal restrictions on fishing effort can be advocated in areas and seasons of high incidence of juveniles and non-commercial biota.

Wide range of analyses are possible with fishery, geographic and environmental data collected from the participatory cruises. Some of the possible analyses are, composition of commercial catch with respect to fishing ground (GPS), percentage of discard/boat trip/month/year, composition of commercial catch and discards with respect to day/month/season, percentage of commercial fish juveniles in discards by weight and number. With little more information base, fisheries scientist can elucidate *in situ* growth and migration of fishes, dependencies of different group of fishes *etc*. Biological loss due to bycatch/discard, biodiversity index by ground, by season, biodiversity in relation to bottom/sediment structure, in relation to nearness to river, in relation to depth can also be evolved by incorporation of geo-referred information on topography, sediment character, vicinity of river mouth, port *etc.*

From the participatory trawling experiments in Gujarat conducted by national fisheries research Institutes *viz.*, Central Marine Fisheries Research Institute and Central Institute of Fisheries Technology with participation of fishermen of Gujarat, it was obvious that fishermen are more concerned about the sustainability of marine fish production and they are ready to cooperate with researchers and policy makers to make effective policies for conserving commercial species (Mohamed *et al*., 2010). Present study gives further encouragement for such ventures and with more and more involvements of the fishermen, a comprehensive picture of resource distribution along the coast, could be possible. More involvement of fishers will fill the lacuna in data source faced in the present study, by which multiple spatial data from different fishing grounds for a single day will be possible and the results would be more comprehensive. At present, mostly demersal fishes and the groups exploited by trawlers are taken into consideration and in future the data from purse seiners and gillnetters can also be incorporated to make the database exhaustive.

Acknowledgements

The authors are thankful to Dr. G. Syda Rao, Director, CMFRI, Cochin for his constant encouragement, support and valuable suggestions. The co-operation and help provided by the fishing community of Mangalore, especially the owner and crew of trawler group “Harikripa” from Mangalore Fisheries Harbor is acknowledged with gratitude. The technical assistance provided by Shri. B. Sridhar, Shri. Kemparaju, Shri. G. Nataraj and Shri. Y. Muniyappa of Mangalore Research Centre of CMFRI and software support provided by Medu Computers, Padil, Mangalore, Karnataka are also thankfully acknowledged.

References

Aarts, G. and Poos, J. J. 2009. Comprehensive discard reconstruction and abundance estimation using flexible selectivity functions. *ICES J. Mar. Sci.*, 66: 763–771.

Booth Anthony, J. 2000. Incorporating the spatial component of fisheries data into stock assessment models. *ICES J. Mar. Sci.,* 57: 858-865.

Caddy, J. F. and Carocci, F. 1999. The spatial allocation of fishing intensity by port-based inshore fleets: a GIS application. *ICES J. Mar. Sci.,* 56(3): 388-403.

Devaraj, M and Vivekanandan, E. 1999. Marine capture fisheries of India: Challenges and opportunities, *Curr. Sci.*, 76 (3): 314-332.

Graham, J., Engle, S. and Recchia, M. 2002. *Local knowledge and local stocks: an atlas of groundfish spawning in the Bay of Fundy*. Antigonish, Nova Scotia: The Centre for Community-based Management, Extension Department, St. Francis Xavier University.

Hutchings, J. A., and Ferguson, M. 2000. Links between fishers' knowledge, fisheries science, and management: Newfoundland's inshore fishery for northern Atlantic cod, *Gadus Morhua*. In: Neis, B. and Felt, L. (Eds.), *Finding our sea legs: linking fishery people and their knowledge with science and management*, ISER Books, St. John's, NF, p. 82-110

Kyem, P. A. K. 2002. Promoting local community participation in forest management through a PPGIS application in Southern Ghana. In: Craig, W. J., Harris, T. M. and Weiner, D. (Eds.), *Community participation and geographic information systems,* Taylor & Francis, London, p. 218–231.

Macnab, P. 2002. There must be a catch: participatory GIS in a Newfoundland fishing community. Craig, W. J., Harris, T. M., Weiner, D. (Eds.), *Community participation and geographical information systems,* p. 173-191.

Maurstad Anita 2000. Trapped in biology: an interdisciplinary attempt to integrate fish harvesters' knowledge in to Norwegian fisheries management. In: Barbara Neis and Lawrence Felt (Eds.), *Finding our sea legs: linking fishery people and their knowledge with science and management*, St. John's Newfoundland: ISER Press, p. 135-152

Meaden Geoff, J. 1999. Applications of GIS to fisheries management. In: Dawn Wright and Darius Bartlett (Eds.), *Marine and coastal Geographical Information Systems*, London: Taylor and Francis, p. 205-226.

Mohamed, K. S., Prvin, P., Asokan, P. K., Madhu, V. R., Ghosh, S., Vivekanandan, E. and Meenakumari, B. 2010. Assessment of economic loss due to use of legal cod end mesh in multi-day trawlers in Gujarat. In: Meenakumari, B., Boopendranath, M. R., Edwin Leela and Sankar, T. V., Gopal Nikita and Ninan, G. (Eds.), *Coastal fishery resources of India; conservation and sustainable utilization*. Society of Fisheries Technologists, Cochin, p. 370 – 377.

Srinath, M. 2003. *An appraisal of the exploited marine fishery resources of India.* In: Mohan Joseph, M. and Jayaprakash, A. A., (Eds.), *Status of exploited marine fishery resources of India*. Central Marine Fisheries Research Institute, Cochin, p. 1-17.

Zacharia P. U, Krishnakumar, P. K. Dineshbabu, A. P. Vijayakumaran, K., Pratibha Rohit, Sujitha Thomas, Geetha Sasikumar, Kaladharan, P., Durgekar, R. N. and Mohamed, K.S. 2008. Species assemblage in the coral reef ecosystem of Netrani Island off Karnataka along the south-west coast of India *J. Mar. Biol. Ass. India*, 50 (1): 87-97.

Date of Receipt : 27.12.2011
Date of Acceptance : 26.03.2012