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Fish biomass estimation by calibrating the echointegrator deflection against catch data

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ABSTRACT

Acoustic survey for fish resources was conducted using echosounder (EK-400) with echointegrator (QD). The echointegrator coupled with echosounder sums-up the echo signal received. The sum of the echo signal received per nautical mile covered is an index of the quantum of fish recorded and therefore a measure of the relative density of fish in surveyed area. It is converted into absolute biomass using the calibration constant obtained by correlating the trawl catch data against the echointegrator reading corresponding to the opening of the net. The calibration constant thus arrived at was 1327 kg/n.mile^2 corresponding to 1 mm integrator deflection per nautical mile covered.

INTRODUCTION

The living resources of the sea though renewabie are subject to depletion due to continuous and over exploitation. Therefore the knowledge of stocks, their distribution in space and time, migration, fluctuations in their abundance, and annual recruitment levels and optimum level of harvesting of resources is absolutely essential for proper planning and management. In recent days hydro-acoustic instruments such as echosounder, sonar, echointegrator and trawl sonde are used to collect the required data in a systematic manner and for analysis of the same to provide reliable information on various aspects mentioned above for the effective management.

Fish resources survey using the acoustic equipments is generally termed as "acoustic survey" which is considered to be far superior to the conventional "spot fishing survey" technique for the following reasons.

— This methodology is infinitely faster, since survey is done at a normal speed of the vessel and or large area can be covered and sampled quickly.

- — Acoustic surveying is carried out to probe the entire column all along the track wherever the vessel moves, whereas a trawl survey is restricted only to trawlable ground corresponding to the depth interval swept by the gear.
- — Wear and tear of the gear and fishing time is reduced, as fishing is done occasionally for identification purpose only.

Considering its proven advantages as mentioned above the use of acoustic technology in modern fisheries research is becoming more relevant and important. In India erstwhile UNDP/FAO/Pelagic Fisheries Project carried out extensive acoustic surveys from 1971 to 1978 for the important fish resources of the southwest coast of India and estimated their biomass. Major fish resources responding to acoustic surveys by echosounder and echointegrator in Indian waters are the column fish such as whitebaits, catfish, ribbonfish and horse-mackerel etc, (Natarajan *et al.* 1980). In the case of surface schooling fish such as oil sardine and Indian mackerel, sonar survey has found to be more suitable acoustic technique for location and quantification. Acoustic surveys for fish resources are being conducted in Indian waters by *FORV Sagar Sampada* since 1985. Also using the same acoustic equipments investigations on the deep scattering layer (DSL) of the Indian EEZ was carried out, with special reference to euphausiids as a component (Mathew *et al.* 1990). The systematic collection of acoustic survey data during the cruises nos. 19, 20, 86, 116 of *FORV Sagar Sampada* were critically analysed and presented in this paper.

MATERIALS AND METHODS

Most modern acoustic equipments such as scientific echosounder (Simrad EK-400), echointegrator (Simrad QD), sonar (Simrad SM- 600), trawl eye (FR-500), hydrography echosounders (Simrad EA- 200), speed and distance log (Simrad NL) with electronic data processing facilities available on board *FORV Sagar Sampada* were used to locate fish schools quantitatively and qualitatively, plankton distribution in the deep scattering layer (DSL) and aimed trawling in the Exclusive Economic Zone (EEZ) of India.

The vessel, fitted with survey equipment is sailed on a predetermined parallel track keeping the instruments on. Setting of the instruments are power-high, beam width-wide, pulse width 3 m sec., band width-3 kHz, PD-5 (normalised to 1 n.mile) resetting - log '0', attenuation '0' dB, SL-137.6dB. VR-0, and TVG-20 log R. The integrator deflection for everyone nautical miles was noted. At the end of the cruise, the values obtained (mm per nautical mile) were plotted along the track on the chart and zero density line drawn, which forms fish special distribution chart (Figures 1-4) giving the synoptic picture of fish concentration with in the surveyed area. With the help of planimeter the area of concentration of fish ('A' in square nautical mile) was obtained. The average density in tonne/n mile^2 was obtained using the following relations (Forbes & Nakken, 1972,) $\bar{d} = c \times \bar{M}$ where $\bar{M}$ = average echointegrator output signal per elementary distance sampling unit (EDSU) referred to the distance unit being sailed (mm per n.mile), 'C'= proportionality coefficient, system constant or calibration constant which is the function of equipment parameters and the reflective

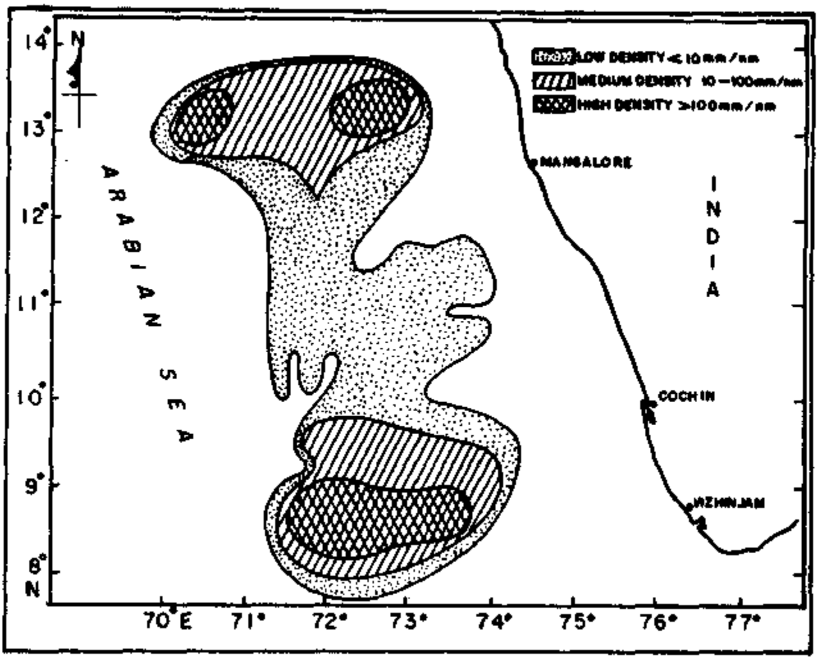

Fig.1 - Fish distribution chart (SS 19/86 23 July - 6 August 1986)

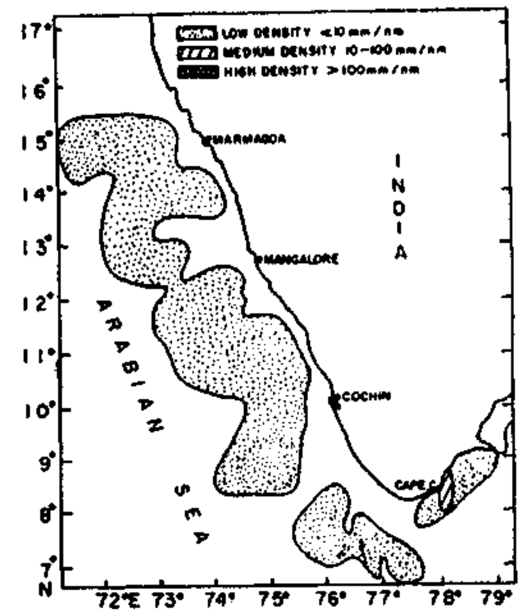

Fig.2 - Fish distribution chart (SS 20/86 19 August - 8 September 1986)

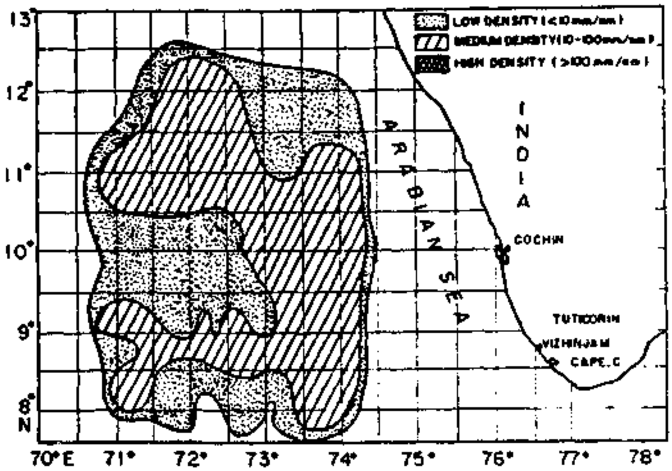

Fig.3 - Fish distribution chart (SS 86/91 2-9 March 1991)

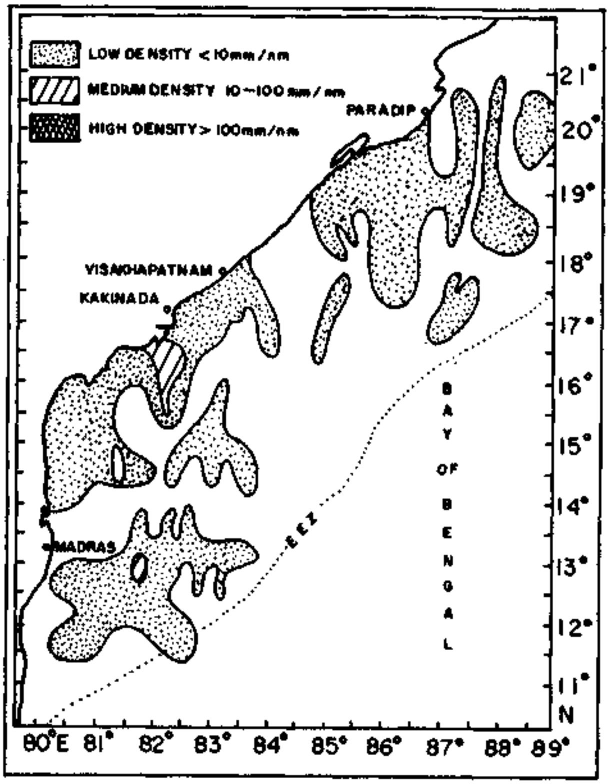

Fig.4 - Fish distribution chart (SS 116/93 22 December 93 - 1 January 1994)

properties of fish. (This assumes that the fish in the area are of the same species or of species with same acoustic properties). The total biomass W (in tonne) was arrived at by multiplying area and density, ($W = A \times \bar{d}$). Bottom trawling was carried out by *FORV Sagar Sampada* at lat. 09°41'N, long. 76°03' E in 45 m depth. Trawl sonde was used to find out the opening of the net. By calibrating the integrator reading corresponding to the opening of the trawl net against the fish catch (Anon, 1973) considering the volume of the water fished by the trawl and the volume sampled by the echosounder beam, assuming the catching coefficient is one i.e., that all fish in front of the trawl mouth are subsequently being caught, the average calibration constant value C was calculated as 1327 kg or 1.327 tonne/n. mile^2 corresponding to 1 mm integrator deflection per nautical mile covered. The basis for arriving at the calculated figure of C as 1.327 tonne/n. mile^2/mm deflection is elucidated below:

Length of head rope + foot rope, L_r	= 67.4 m
Vertical opening, H_v	= 2.5 m
Fish catch when dragged for 1 nmi, w	= 0.33 tonne
Deflection of echointegrator corresponding to opening of the net when covered for 1 nmi, d_n	= 5.48 m.m
Deflection of echointegrator corresponding to sea surface (transducer level) to bottom at 40 m depth when covered 1 nmile, d_t	= 18 m.m
The volume of the net swept along 1 nmi, v_n (assuming the cross- section of the net as circular with circumference equal to the length of foot rope + head rope)	= 668890.76 m^3
Volume of the net insonified by the beam corresponding to the opening of the net considering the beam angle and depth of operation, V_{nb}	= 25048.3 m^3
Total volume of the beam considering 40 m depth, 8° beam angle and conical shape of the beam (circular transducer), V_{tb}	= 206683.2 m^3
Fish catch reduced to the corresponding volume of net insonified by beam, w_b	$= \frac{w \times V_{nb}}{V_n} = 0.33 \times \frac{25048.3}{668890.76} = 0.012$ tonne
Fish catch reduced to 1mm deflection corresponding to the volume of net insonified by the beam, w/mm	$= \frac{w_b}{mm_n} = \frac{0.012}{5.48} = 0.002$
Fish catch raised to 1n. mile^2 considering the total volume of the beam (V_{tb}) and volume of water of 1n. mile^2 at 40 m depth, ($V_{1n.mile^2}$), C	$= w_b \times \frac{V_{1n.mile^2}}{V_{tb}} = 0.002 \times \frac{137196160}{206683.2} = 1.327$ tonne/n.mile^2/mm
Packing density in the area of calibration, d	$= C \times mm_t = 1.327 \times 18 = 23.88$ tonne/n.mile^2

RESULTS AND DISCUSSION

The average packing densities of fish and total fish biomass estimation for the four cruises are given in Table 1. The packing density was maximum in the cruise no.86 comparing the other 3 cruises. This difference could be related to the time period of survey. Cruise nos. 19 and 116 were conducted during monsoon along the west coast and east coast of India respectively. Cruise no.20 corresponds to the transition period from monsoon to post-monsoon. Even then the packing density was less 2.59 tonne/n.mile^2. This may be due to the following reasons. Pelagic fish (sardine and mackerel) coming to the surface during post-monsoon period which has been confirmed earlier (Anon, 1974). The fish available up to 10 m from the surface is not covered by the integrator survey since the transducer is fixed at the hull about 5 m below the surface. The time varied gain (TVG) will not be effective in the beginning for 5 m from the surface of the transducers. Hence sonar survey was carried out for estimating fish biomass within 10 m from the surface (Krishna Rao *et al.* 1980). However, sonar survey could not be carried out on board *FORV Sagar Sampada* because of technical failure.

The estimation by this method will not be accurate and it is supposed to be less (Anon, 1973), since it is assumed that the fishing efficiency is 100% i.e. all the fish recorded in front of the trawl is being caught. But there will definitely be some small sized fish which escape from the net depending upon mesh size of the net. Secondly the efficiency of the fishing master also plays a role in the accuracy of the estimated calibration constant value, in turn the biomass estimation because the echosounder records the fish available just below the vessel. Whereas, the net is few hundred meters away from the vessel depending upon the depth of operation. It is presumed that the net is dragged exactly on line with path of the vessel and the fish as recorded in the echosounder is caught. But the position of the net may be deviated from the centre of the path of the vessel either port or star board side due to water current, wind velocity, etc. for which the fishing master must correct the course of the vessel accordingly, considering the hydrodynamics and gear behaviour. If the judgement by fishing master is wrong in manoeuvering the vessel while trawling, it may lead to under-estimation of fish biomass. Though the present estimated value of calibration constant is comparable with the findings of Pelagic Fisheries Project (Olsen *et al.* 1977), it need be confirmed by comparing with estimation arrived through other methods also in order to establish percentage of error or deviation. And also the live fish calibration for the commercially important species need by carried out as was done in the Pelagic Fisheries Project to overcome the inaccuracy in estimation caused by the erratic fishing, by considering the integrator deflection for the insonified fish of the known species and quantities (Vitullo *et al.* 1980).

The spatial distribution charts (Figs 1 - 4) give the area of concentration of fish with different density strata along the area of survey. This helps in locating the fishing ground easily. However, to understand the migratory pattern of the resources, regular survey with the definite short period interval is a must. Also the spatial distribution

Table 1 - Estimated fish biomass by acoustic surveys
(Calibration constant C in tonne/n.mile^2/mm is 1.327 tonne for all the cruises)

Cruise no.	Period	Survey area	Aver. packing densities (tonne/n.mile^2/mm) $\bar{d}$	Estimated biomass (tonne/n.mile^2) $W = \bar{d} \times A$	Major resources
19	22-27 July 86	8°30'N to 13°30'N 70°00'E to 74°00'E	8.04	434160 T	*Cubiceps natelensis* *Gempylus Serpens* *Kyphosis* sp.
20	19 Aug. - 9 Sept. 1986	6°30'N to 15°30'N 70°00'E to 79°00'E	2.73	172218 T	*Priacanthus* sp. *Nemipterus* sp. *Epinnala* sp.
86	28 Feb. - 10 March 1991	8°00'N to 12°00'N 71°00'E to 74°00'E	15.99	863460 T	Deep sea fishes, prawns and cephalopods
116	22 Dec.'93 - 10 January 94.	11°00'N to 21°00'N 80°00'E to 89°00'E	2.59	132867 T	Perches, microphils deep sea prawns

$\bar{d}$ = Average packing density in tonne/n.mile^2; W = total fish biomass in tonne; A = area of fish concentration in n.mile^2 (obtained from Figs 1 - 4, fish distribution chart using planimeter) maps could be drawn and the fish biomass could be estimated for the different species which will help in selective fishing.

Suitable computer software technology is needed so that spatial distribution chart could be drawn by the automatic plotter coupled with the computer. The biomass can be calculated with the help of the computer to provide the required information immediately after the survey is over. On the whole the systematic acoustic survey technique and technology has become a dependable tool to cover large part of commercial fish resources of Indian EEZ. Indigenous production of simple and cheap echosounders will go a long way in their increased use in efficient exploitation of fishery resources if encouraged.

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