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ON

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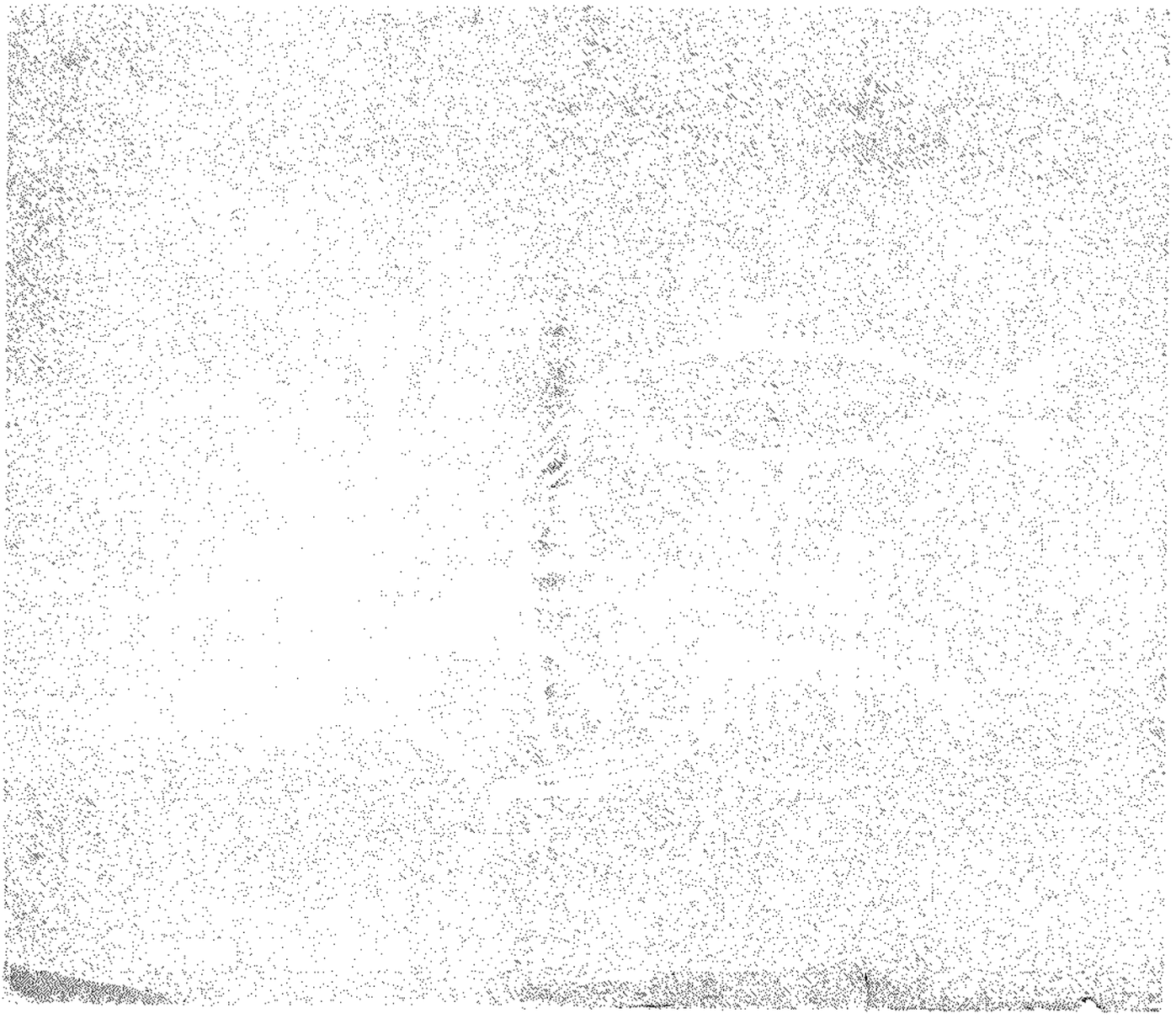

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ON THE ESTIMATION OF YIELD FROM EXPLOITED MARINE STOCKS WITH REFERENCE TO SOUTH-EAST ASIA

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ABSTRACT

Accurate estimates of yield and effort are necessary for a proper apraisal of exploited stocks. In the South-east Asian region where fishing is of a diffused nature and landings are by indigenous boats all along the coastline using various types of gear, complete record of catch and effort is impossible and a suitable sampling scheme for their estimation is the only logical alternative. The various factors influencing the choice of a sample design have been discussed in relation to the existing conditions in the region. The following points in particular have been dealt with in the paper: (*a*) the nature of stratification, (*b*) the choice of units, (*c*) intensity of sampling and (*d*) precision of estimate. The sampling design employed in India for the purpose of estimation of catch and effort has also been discussed in detail.

THE data on catch and effort are the basic minimum requirements for the assessment of exploited stocks. In advanced countries of the world, statistics of fish landings are collected on a systematic basis and published regularly in great detail and they are often shown according to areas, seasons and gear of capture together with other important details like species composition. The method of collection of these statistics naturally varies a great deal from country to country. In advanced countries where fishing industry is well organised, the catch and effort statistics are obtained by complete enumeration from the logs kept by the skippers of the fishing vessels. In the developing countries of South-East Asia, where the fishing industry is still primitive and is in the hands of large number of illiterate fishermen and fishing is done by a large number of small indigenous boats and landings take place almost all along the long coastline throughout the day and even sometimes during the night, adoption of suitable sampling technique seems to be the only choice for the collection of such data. Currently in most of the countries of this region, marine fish landings are estimated by some sort of sampling method, though it is not known if the methods employed are based on objective statistical principles. While the estimates derived from subjective sample census may give some idea about the magnitude of the total landings, they cannot be properly used in the appraisal of fish populations. This necessitates adoption of suitable sampling designs. While evolving a suitable sampling design for the estimation of fish landings, it is necessary to take into consideration various factors like field conditions, availability of trained personnel to carry out the work and cost of the survey.

The earliest reference to estimates of marine fish catch in India is seen in the *Report on Marketing of Fish in the Indian Union* (1951) but "these data are not based on any scientifically planned surveys but mostly on trade enquiries and similar other evidences" (1961). The first attempt to build up a planned survey for the estimation of fish catch on an all-India basis was made by the Central Marine Fisheries Research Institute. Bal and Banerji (1951) gave an account of the efforts made by the Institute in developing such a survey and since then the method of survey has undergone a great deal of change based on the experience gained through years. Between 1950–51 and 1954–55 the Indian Council of Agricultural Research initiated a number of pilot surveys of various designs in different regions of the country with a view to evolving most suitable sampling designs for the estimation of fish landings in the country. Reference may also be made to the sample surveys carried out in U.A.R for the improvement of fisheries statistics in that country (1960). The pilot surveys and their results have influenced a great deal in

moulding the currently designed sample surveys undertaken by the Institute. A brief description of the main features of the pilot surveys along with pertinent results is given first. The currently employed sample designs adopted by the Institute are also described later. It is hoped that many countries of South-East Asia where the fishing conditions are similar to that of India will benefit from the sampling designs described in this paper.

Pilot Surveys

In 1950–51 a pilot survey was undertaken in Malabar coast for a coastline of hundred miles. A fixed number of boats was selected for each village. These were kept under observation over time for estimating (i) the percentage number of times they went out for fishing and (ii) average catch per boat on the basis of subsample of these boats. But in a village the number of boats is a highly variable factor, further boats of a village need not necessarily land in the same village. So the practice of selecting village was abandoned. In its place a landing centre was selected. In this method, over a period of time, the number of boats landing in the landing centre was determined and the average catch per boat is estimated on the basis of a subsample of boats landed. The product gave the total catch for the period. The design thus involved application of 4-stage stratified sampling. A group of continuous landing centres formed a stratum in space and a centre, week, day interval of time (20 mt) were the different stages of sampling. No stratification in time was used, observations on count and catch were not made in the same interval. The sampling error for the estimation of catch came to about 5%.

In 1953–54 an extension survey was carried out over a distance of 160 miles. Here the design involved two-fold stratification. In space stratification landing centres were grouped together in terms of total catch from these centres and months were the strata in time. The stages of sampling were centres, days and 2 hr period. Here also 2 days were kept for observation of count and two days for catch. The sampling error for estimation of catch by boat units came to 21%.

In a pilot survey in 1954–55 a fish curing yard itself was taken as stratum in space and month continued to be the stratum in time. Initially one single landing centre was selected at random. Four days were randomly chosen in a month and within a day the selected centre was kept under observation for 3 evenly spaced two hour intervals. In each interval one hour was meant for observing count of fishing units landed and the other for recording the catch of a few selected units. Here also the sampling error for boat units came to 9%

Next year some modification in the selection of centres was introduced. For a stratum, a fresh selection of centres was made for each of 4 days. Within a day the number of units landed were recorded in each of the 6 hours. The catch of the last boat completing operation in each hour and the same by shore seine in each two hour interval were recorded. This design involved three stages, centre-days, interval (2 hr period) and hours. It was observed that the variance component due to centre-day was less than intervals and hours, the last two were of the same order. The sampling error for boat unit did not improve and the same for shore seine came over 33%. The efficiency of overall stratification comes to 120 and 124 in respect of boat units and shore seine respectively.

In 1955, on the basis of the experience gained in pilot surveys, a full-fledged survey was launched in an area of 200 miles of Travancore Cochin coast with 123 landing centres. A group of continuous landing centres were taken as a stratum in space and week was taken as stratum in time. The primary unit of sampling was landing centre. In some stratum only one centre was selected and in some three. Each centre was kept under observation for two days selected at random out of the working days of the week. A day was divided into two clusters of 3 evenly spaced two hour intervals, The first comprises intervals 6–8 hrs., 10–12 hrs., 14–16 hrs.

and the second includes the intervals 8–10 hrs., 12–14 hrs. and 16–18 hrs. On each day one cluster was selected at random and one hour of each two-hour interval was used for counting the number of boats and another for recording the catch of some sample units landing during the period. The component of variation due to centres (the first stage unit) and hours (third stage unit) were very large. The percentage error came to about 6%. The efficiency of overall stratification works out to 169 and 164 for boat units and shore seine respectively.

In 1952–53 a pilot survey was conducted in Madras coast extending from Point Calimere to Kootapuly covering a distance of about 300 miles scattered with 112 landing centres. As before the stratification in space was a group of continuous landing centres and a month in time. There were 9 strata and in each stratum 3 centres were selected at random. Each landing centre was kept under observation for 8 days—4 days for count and 4 days for catch. The field work for each day lasted for 14 hrs. from 5 to 19 hrs. which was shared equally by two field staff. The percentage error for catch worked out to be about 9%.

In 1954–55 a pilot survey was undertaken in entire Madras coast comprising 210 landing centres grouped into 20 strata. For 12 strata one randomly selected centre was kept under observation each week and for the other 8 strata in addition to one centre selected at random, other two adjacent centres were observed for two days. Each day was divided into three clusters as (i) 6–8 hrs. and 12–14 hrs. (ii) 8–10 hrs. and 14–16 hrs. and (iii) 10–12 hrs. and 16–18 hrs. In a day two clusters were selected at random. In each two-hour interval one hour was used for observing the count and the other for the catch landed by the sampling boats. The percentage error was worked out as about 6%. The efficiency of overall stratification comes to 328 and 111 for boat units and shore seine respectively.

During 1954–55 Andhra coast comprising 246 landing centres was stratified into 12 strata. Every week one centre was selected at random from each stratum and was kept under observation for all the six working days of the week. As fishing was mostly confined to 10 to 16 hrs. this six-hour interval was divided into 3 intervals of 2 hrs. each. One hour was devoted to the count of fishing units landed and the other for recording the catch. Provision was also made to have a rough estimate of fish landed prior to and after the observation period 10 to 16 hrs. and also night catch. In this coast for boat units variation between centres (first stage unit) and days (second stage unit) were of same order. In the third stage (hour) variation was quite high. For shore seine units variation in the first stage (centres) was very high compared to that in second stage (days). The percentage error of estimate came to 14%. The efficiency of overall stratification in Visakhapatnam area came to 128 and 96 for boat units and shore seine respectively.

In 1953–54 a pilot survey was conducted in South Canara coast where rampan nets are extensively used for catching shoaling fish. It was carried out on 80 miles of coastline. There were 40 fish landing centres which were grouped into 2 strata of continuous centres. Every week two centres were selected. The selection was made with probability proportional to approximate catch at each centre as maintained by the fish curing yards. Every day of six working days of the week, the number of rampan nets operating was counted. The catch of a few rampan nets was recorded on two specified days of the week. On the four days when the catch of the rampan nets was not to be recorded, fishing activity of other fishing units was observed. On each day 2 intervals of three hours, one in the forenoon and the other in the afternoon, were specified. During the interval, the total number of boats landed and catch from as many of them as possible were recorded. Next year the method was extended to North Canara district with 90 landing centres also. These centres were grouped into 5 strata. Every week one centre was selected from each stratum in North Canara and two centres from each stratum in South Canara. The sampling error worked out to be 16%. The components of relative variance due to rampan nets were much higher than the corresponding components in the case of boat units.

During 1954–55, a pilot investigation was done in North Bombay comprising 52 centres. Lunar month was the stratification in time. Lunar month was divided into three equal parts of

10 days each, the first 10 day period follows a full moon. Three centres were selected at random during each period of 10 days. Other three centres distinct from those selected earlier were kept under observation throughout the month. In a 10-day period observation was confined to first 9 days, the last being utilised for journey time. Nine days were grouped into three sets of three consecutive days. Each day was divided into three four hourly intervals; 6–10 hrs., 10–14 hrs., and 14–18 hrs. On a day observation on both count and catch were recorded every hour of a specific 4 hour interval. During the remaining two intervals observations on count and the same on catch were recorded on alternate hours. The sampling error came to 31%.

On the basis of the results obtained in the twelve pilot surveys described above the following broad conclusions can be drawn as to the different stages of design of large-scale sample survey for estimating fish production:—

Stratification

Space stratification is to be followed. It is to be examined if grouping of centres according to amount of catch in the centres will improve the design. Time stratification is also to be introduced.

Size of the primary unit

In the two-fold stratification over space and time the primary unit may be (i) a centre-day, (ii) a centre-group of days, (iii) cluster of centres-day, (iv) cluster of centres-group days. From the organisational point of view while a field staff is put in charge of a stratum over space, the cluster of centres-day may not be possible. Among the rest a centre-day or a centre-group of days may be used as primary unit depending on field conditions.

Size of the ultimate unit

It is seen that the ultimate unit would be an interval of time (one hr, two hrs etc.) in a day. The length of the interval has to be divided on the basis of statistical and field considerations. The sampling of interval within a day may however be done systematically.

Observation on count and catch

The pilot survey showed that observing count and catch in different time intervals entailed considerable loss of data (8–10%) whenever there was no boat to be observed in the subsequent time interval. It is therefore felt that count and catch are to be observed simultaneously in the same interval.

Currently Employed Sample Survey by C.M.F.R.I.

At present the C.M.F.R.I. is the organisation responsible for the collection and estimation of the marine fish landings for the country as a whole. The sampling design employed for the same is basically the same but it varies to some extent in details from region to region in view of the varying field conditions. The currently employed designs in different regions are described below:

Kerala

Kerala has got a coastal length of 560 Km. scattered with 213 landing centres. The entire coastline has been divided into 9 zones, each zone containing contiguous 18–28 landing centres. These zones have been further stratified into two strata on the basis of intensity of fishing in a

centre, taking into account the seasonal variation of the same. In a ten-day period of a month a group of six consecutive days is selected with a random start, other such groups being chosen systematically leaving a gap of 10 days between the starting points of two consecutive groups. From a stratum three landing centres are selected at random, the first one is observed on the first two days and the second on the next two days and the third on the last two days of thesix-day group. A day has been divided into four intervals of three hours each as: 6–9 hrs., 9–12 hrs., 12–15 hrs. and 15–18 hrs. On the first day in each centre observation is taken in two intervals: 9–12 hrs., and 15–18 hrs. Two other intervals are chosen on the next day. Provision has been made to collect data on landings from 18·00 hrs. of the first day to 6·00 hrs. of the second day which has been termed as night landings. The secondary sampling units within the primary sampling units have been divided into two categories, shore seine and other units comprising drift net, gill net, hooks and the lines etc. Data on these two categories are collected separately. On the allotted day a complete record of arrival time of all the units landed during the two specified intervals is taken. A predetermined fraction of total number of units landed is examined systematically with a random start for record of catch composition and other ancillary information. The primary sampling unit is a centre- two day group. The period of estimation is calendar month; the time stratification of 10 days period has been neglected for simplicity in computation and there was no appreciable loss of statistical efficiency in doing so. From the sample, estimates are made for centre-two day groups. The strata and zonal estimate of catch and effort for month are arrived from those of primary units. The annual estimates are obtained by pooling monthly estimates. The percentage error for these estimates is arrived at from the estimates of primary sampling units.

Maharashtra

Maharashtara has got a coastline of 600 Km. The number of landing centres is 179. The entire coast lin: has been divided into eight zones. Landing centres in each zone have been grouped into two strata on the basis of intensity of fishing. Separate estimate is arrived at for Sassoon Dock and Versova by sampling over time. Here the primary sampling unit is centre-day. The method of selection of centres and days are the same as in Kerala. But unlike in Kerala, a centre is kept under observation on the first day from 12–18 hrs. and on the 2nd day from 6–12 hrs. From the samples, estimates are made for center-day. The period of estimation is an calendar moth. Strata and zonal estimates of catch and effort for a month are arrived at from those of primary units. Annual estimates are arrived at by pooling the monthly estimates. Percentage error for the estimates of catch and effort is calculated on the basis of primary sampling units.

Madras including Pondicherry

The coastal length of Madras and Pondicherry comes to 960 Km. There are 35 landing centres in this coast. The coastal line of Madras has been divided into 17 zones. Zones have been further stratified into two to have separate estimate for Pondicherry territory. Here the design is more or less similar to that in Kerala but for the difference that in the group of six days only two centres are observed for two days, the first two days being allotted to the first centre, fourth and fifth days to the second centre. In view of difficulties in travel conditions from one centre to another, third and sixth days are meant for journey to the next centre or to the headquarters of the field staff. For sampling within a day in certain zones data are collected from 6–9 hrs. and 12–15 hrs. on the first day and 9–12 hrs. and 15–18 hrs. on the second day, while in other zones no sampling within day was found necessary. The primary sampling unit is a centre-two day group. From the sample the estimate for the primary sampling unit is made. On the basis of this the estimate of catch and effort for zone or a stratum and the percentage error of the estimates are arrived at for one calendar month which is the period of estimation for these States.

Gujarat

Gujarat has a coast line of about 1,500 Km. But the number of landing centres is only 79. The bulk of entire catch takes place in three major centres, Jafrabad, Rajpara and Navabander during October to April. The coastline has been divided into 4 zones. While three zones have been formed with contiguous landing centres, the other has been divided into two strata by taking landings in the three major centres of Jafrabad, Rajpara and Nava bander into consideration. The other details of design and method of estimation followed are the same as in Maharashtara.

Andhra

The coastal line of Andhra is about 970 Km. The number of landing centres in this State is 253. The entire coastline of this State has been divided into 9 zones. Out of these seven zones have been further stratified into two strata each, taking into consideration the intensity of landings in a centre. Catches by Hooks and Lines in Lowson's Bay is very important. These are treated separately from the other units. Nylon Gill nets also in certain zones are treated separately. The rest of the design and the method of estimation followed are the same as in Madras State.

Mysore

Mysore has got a coast line of about 270 Km. The number of landing centres in this coast is 98. The coast line has been divided into 5 zones. Each zone has been further stratified into two taking into consideration the operation of rampan nets. The other details of design and the method of estimation followed are the same as in Maharashtra.

West Bengal and Orissa

These two States account for about 680 Km. of Indian coastline. But in this survey, coastline of Midnapur district of West Bengal has only been covered. 20 centres in North Orissa and Midnapur district formed one zone, while South Orrisa with 25 landing centres was another zone. Each zone has been further stratified into two taking into consideration the intensity of landings in a centre, the rest of the design and the method of estimation are the same as in Andhra State.

Applying the methods described above the variety-wise landings and effort put in in different maritime States of India have been estimated from 1950 onwards. Some important facts of the design followed in different maritime States of India along with estimate of catch and percentage error for 1967 are given below.

TABLE I

Name of the State	Approximate length of coast line in km	No. of landing centres	No. of space strata	Estimated landings during 1967 in tonnes	Percentage error
West Bengal and Orissa ..	680	45	2	18,953	N.A.
Andhra ..	970	253	9	76,054	8·90
Madras including Pondicherry ..	960	359	17	132,505	4·90
Kerala ..	560	213	9	364,129	9·58
Mysore including Goa ..	380	98*	6	61,645	27·12
Maharashtra ..	600	179	8	133,302	13·12
Gujarat ..	1,500	79	4	75,633	23·50
Others ..	..	..	...	410	..
All India ..	5,650	1,226	..	862,631	5·64

* No of landing centres in Goa not included,

Discussion

The results of the investigations presented above demonstrated that the stratification over space and time removed a considerable portion of total variation. The table shows that with the adoption of space and time stratification the figure for the total marine fish landings in India has been estimated in 1967 with the percentage error of 5·6. The percentage error in different States varies a great deal. The figures are quite high in Mysore, Maharashtra and Gujarat. In Mysore, the bulk of the catch is accounted for by rampan nets. It has been found that the component of relative variance due to rampon nets were much higher than the corresponding components in the case of boat units. Taking this into account the extent of sampling for rampan nets were kept higher than that for the boats. But the sampling error is still high. It indicates that the intensity of sampling in this area should be increased. At present the sampling fraction at the primary stage of sampling is about 2%. This has to be raised. The further stratification in space promises better result. Similarly the overall sampling fraction at the primary stage in Maharashtra and Gujarat area is slightly more than 1%. Steps have already been taken to introduce further stratification in space and thereby to increase the overall sampling fraction. Space stratification was followed in all surveys. It may be argued if it may be done with group of contiguous landing centres or it should be on the basis of intensity of landings in a centre. From organisational point of view, the geographical stratification has got certain advantages, but it cannot be universally used. Though catch over time does not remain constant, yet the grouping of landing centres on the basis of catch promises more efficiency. As for example, the quantity of landing in certain centres like Sassoon Dock and Versova in Maharashtra and Jafrabad, Rajpara and Navabander in Gujarat is so high, that quantity of catch should be taken into account in deciding space stratification or such places should be made in separate strata by themselves. Similarly landings in rampan operating centres in Mysore should be grouped together though these may not be geographically contiguous. The difficulties may be greatly reduced if a stratum contains a few landing centres of a small coastal length. This will ensure higher sampling fraction also. Stratification over time does not pose much problem. It may be a week, month or a quarter of a year. But fishing conditions over longer period of time may not be the same, so a shorter interval like week or month may be preferable. In a country like India where monsoons greatly affect the fishing conditions, further stratification of the quarters of the year covering monsoon period will greatly reduce the percentage error. The stratification in final enumeration unit may also prove useful. In India the secondary sampling units within the primary sampling units have been divided into two categories: shore seine (rampan) and other units (gill nets, drift nets, hooks and line, etc.), For the former boats are not used whereas for others boats are used. The latter may be called boat units. In Lawson Bay area the catches by hooks and lines are treated separately. This ensures greater accuracy in the estimates of primary sampling units.

Another important factor requires proper consideration in planning a large-scale sample survey: the control of bias and non-sampling error. The field staff is to undergo intensive field training in the methods of collection of data. The data should be collected following objective methods. Unless the precautions to eschew non-sampling errors and bias are taken, the more error will creep in with increase in sampling. Steps to tackle bias and non-sampling error should be initiated at the planning stage of the survey. Some experiments on investigators' bias on different survey items may be helpful.

Summary

The most of the south-east countries where marine fishing industry is carried on with the help of a large number of small indigenous boats landing their catches almost all along the shore, suitable sampling scheme seems to be the only choice for a proper estimation of the fish landings. Several pilot surveys employing varied designs were tried in different regions with a view to evolving most suitable design or designs for estimation of marine fish landings. These surveys

along with pertinent results have been described in the paper. Currently employed sampling designs in India for the purpose of estimation of fish landings are also described. It has been shown that along with space-stratification with or without reference to the importance of landing centres, time stratification is necessary. In this space time stratum, the choice of a primary sampling unit lies between a centre-day or a centre-group of days, the criterion of choice being dependent on the field conditions of the survey. The second stage of ultimate sampling units will be time intervals in a day, the length of the time interval being dependent on the field conditions again. The number of fishing units landing within a timei nterval forms the count and the catch can be obtained by examining subsample of the units landed. The precision of estimate will primarily depend on the sample size of the primary units, and if proper stratification for the first stage units can be arranged, the sample-size of the primary units can be kept small.

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