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STUDY ON THE BIG PURSE SEINERS FISHERY IN THE JAVA SEA

VI. Sampling Procedure. *

By

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ABSTRACT: With the fast development of the purse seine fishery of small pelagic fish in the Java Sea and its socio-economic impact on the coastal populations, a rational model for the management of the resources is required. A sampling survey method must be set up at landing points in the fishing harbours to determine the demographic structure and geographical distribution of the main species caught. This article proposes a method and discusses its advantages and constraints. Used very effectively at Tegal harbour, it is not working so well at Pekalongan, where the fishermen are opposed to the sampling on board or at the fish auction. This harbour is though the most representative one of all the Javanese purse seiner fleet and the survey must be performed as objectively as possible.

RESUME. Le rapide développement en mer de Java de la pêcherie de petits poissons pélagiques a la senne tournante et coulissante et son impact socio-économique sur les populations riveraines rendent nécessaire l'élaboration d'un modèle raisonné de gestion de la ressource. La mise en place d'une procédure d'échantillonnage sur les lieux de débarquements est indispensable pour connaitre la structure démographique et la répartition géographique des captures des principales éspeces. L'article présente la procédure retenue et discute de ses avantages et de ses contraintes. Efficace au port de Tegal, elle a été rendue caduque au port de Pekalongan du fait du désintérêt des pecheurs. Pourtant ce port le plus représentatif de la flottille des senneurs javanais doit absolument être echantillonne avec le moins de biais possible.

INTRODUCTION

In a recent document, BOELY *and al.*, (1987) compiled all the data existing on the encircling purse seiner fishery in the Java Sea. In preceding articles, (BOELY *and al.*, 1987; POTIER *and al.*, 1987; SUBHAT *and al.*, 1988) the statistical means available at each stage of the fishery were given in detail, their shortcomings analysed and futher improvements suggested.

A sampling survey on land is essential in order to obtain a coherent picture of the fish populations exploited, the distribution of species and the demographic structure. For the last few years, sampling operations have been undertaken in the fishing ports of Tegal and Pekalongan (Central Java) at the fish auction, immediately after the fish are landed. Some twenty individual fishes for each species are selected from a certain number of boxes and measured; sometimes biological observations are made at the same time. Before being put on sale however, the fish have already been sorted on board ship and placed in boxes according to size and commercial category.

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* This article is part of a series analysing in greater detail the global, problem of big purse seiners fishery in the Central Province of Java. It is founded on all the essential data available since 1976 on the activity of the fishing vessels based in this area (BOELY and al., 1987).

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To get a true picture of the catch landings, sampling must be repeated a great number of times, with at each stage, a risk of bias linked to the technicians and the way the fish are presented. Indeed inside each of the 40-kilo boxes the fish present a stratification, according to the density and size of each individual. Sampling is completed by an enquiry led among a selection of ships at Pekalongan, and on all the vessels in Tegal harbour. The number of days at sea and the fishing zones visited at each trip are recorded.

This procedure gives rise to many bias and that is why we propose here a new sampling survey method which, according to information available, takes into account the structure of the fishery, the manpower available and the mentality of the fishermen. It has been necessary to combine several sampling strategies, as each method of sampling corresponded to a different observation level.

THEORY

According to COLIN (1970) a sample is "un fragment d'un ensemble preleve pour juger de cet ensemble". It should provide a satisfactory representation of the whole entity to be studied and for this purpose various strategies can be employed. We shall recall briefly those most commonly used in fisheries biology.

1. Simple Random Sampling

This is based on the following mathematical hypotheses:

- Each element of a population has the same probability of belonging to the sample.
- Each sample of size n has the same probability of being chosen for the survey.
- There is entire independence between each element of the population.

2. Stratified Sampling

This technique consists in subdividing a heterogeneous population into subpopulations or homogeneous "strata", each one independent, thereby giving a complete picture of the population as a whole. We can for example subdivide the area exploited by a fishery into fishing zones equalling so many strata. It will likweise be possible to obtain a stratification according to commercial categories (fish grouped by their commercial value on landing) or by categories of boats. Within each stratum a precise sampling plan can then be considered.

3. Sampling By Degree

Here we have a ramified and hierarchic system of units. In fisheries sciences it is often used when the catches are not evaluated satisfactorily. If the fish are landed at various points, it is interesting to consider each port as one unit. A limited number of ports will then be selected.

METHOD

The method employed results from a compromise between a respect for the mathematical hypotheses, the conditions in which sampling is carried out in the ports concerned and the speed with which data is obtained. It is not known how many ships land each day in the harbour and besides they often arrive from different fishing zones. The various levels to be surveyed have not been chosen at random and a stratified sampling method was carried out systematically, so as to be as unbiased as possible. Indeed if the landings are chosen haphazardly their image may be distorted by overestimating certain fishing zones.

1. Landing Procedures

The fish are preserved in cooled sea water in a double row of fishholes, each containing several tons (POTIER and *al.*, 1987). Once at the guayside the fish are taken out of the fishholes with a scoop and spread out on the deck of the ship. They are then sorted by hand and regrouped into 40-kilo boxes, first according to their commercial category and then by size (small, medium, large). The boxes are then deposited on the guay and after being weighed are carried off three at a time to the fish auction.

At the fish market the boxes are always grouped by units of three or four, according to their commercial category. This is when the sampling described in the introduction occurs. The sale is soon over, the boxes usually being sold in lots which are at once carried away by the buyer.

2. A New Sampling Procedure

The purse seiners land in five ports of the Central Province of the Island of Java (Figure: 1), situated from west to east: Tegal, Pekalongan, Batang, Juwana and Rembang. The fish are caught in various fishing zones, but no more than three are visited at each trip (BOELY and *al.*, 1987). An examination of the fishing strategies and the representativity of the amounts landed led us to select the ports of Tegal and Pekalongan as the basis for our sampling procedure. In these ports two stratification levels were chosen, the ship and fishhole. At each of these levels another stratification was made for the fishing zones (Figure: 2).

The procedure employed in the port of Tegal is described below. This is where it was easiest to test out the method and then to apply it, as there were few boats, landings were slow, we were on good terms with the fishermen and shipowners there and competent technical assistance was available.

a. Choice of vessels

Two or three boats are sampled each day. Two hypotheses can be put forward:

- Boats come from the same fishing zone. The first, then the fifth boat to land will be sampled. If there are less than five, then only the first one will be sampled.
- Boats comme from different fishing zones. In this case the first ship to land will be sampled, then the first one to arrive from another zone. If a purse seiner appears from a third zone, it will also be sampled.

If this strategy is repeated day after day, then the fishing zones are well covered by respecting their representativity in the catches.

b. Choice of holes

Fish from each trip are usually divided into ten to fourteen fishholes which will up as the operation proceeds, starting with those at the centre. Two similar fishholes (i.e. each containing fish caught in the same zone) are selected according to the following process:

- When the whole catch of the ship has been taken in one single zone, then the first and the fifth fishholes will be sampled.
- When the catch comes from different fishing zones, the first fishhole homogeneous towards the first fishing zone defined will be sampled, then the first containing a catch homogeneous towards the second zone and so on with the following fishhole if there is a third fishing zone or more.

c. Sampling of boxes and operations performed

Two boxes of fish are sampled per fishhole. During this operation it is important to take into account the way the contents are presented in the fishhole. As the fish have been preserved in cold brine, it is likely that a stratification per weight (according to species and size-classes) has occured when filling up the fishhole. To prevent a biased picture, sampling is performed by filling scoops at different levels in the fishhole and the contents are then thrown on top of the two boxes. The contents of the first schoops are eliminated.

The contents of the boxes are then sorted per species directly on to the deck of the ship, the number of individuals of each species is recorded and the first fifty are measured (Figure: 3).

ADVANTAGES, CONSTRAINTS AND RESULTS

Thanks to this procedure most of the previous bias are avoided. Thus it is possible to determine the percentage of each species in the catches from each fishing zone and to have thereby a "true" idea of the structure of each species for each fishing zone and per size-class. Moreover, considerable time is gained in these operations.

However for sampling to be effective the technician must follow scrupulously the operational plan which has to be repeated in exactly the same way day after day. The human factor remains the principal constraint. Work on board ship must be carried out rapidly, without hindering the crew. An attempt has been made to extend this sampling procedure to the port of Pekalongan where there are many more landings (10 to 20 per day), so that there are more boats to sample.

The results obtained differ from one port to another.

- In Tegal, sampling could be performed according to the procedure planned and the fact that the technician knew the captains well made operating easier. The system has been set up there since October 1986. The routine follow-up has allowed us to establish the structure of size frequency for each species and fishing zone, as well as the species distribution of catches within these zones. By associating this survey with enquiries, we were able to gain an overall view of the landings in this port.

- At Pekalongan, the attempt had to be abandoned rapidly, owing to the lack of cooperation afforded by the captains to the technicians on board, who were not themselves very competent anyway. Sorting operations and emptying the fishholes took place rapidly and the technician had to work fast. It seems essential then to have present a team of two qualified technicians, well integrated into the fishing community. For the time being, previous sampling procedures are employed.

CONCLUSION

At present a sampling method as reliable as possible is now in progress at Tegal. It simply must be used in Pekalongan harbour too, which reamins the most representative of the whole of the encircling purse seiner fishery. An understanding must be found with the shipowners and captains of the seiners, with the help of the Fisheries Service and the Port Administration.

The procedure used allows a stratified biological sampling survey to be set up (e.g. three individuals were sampled per size-class) and studies on the biometry, growth and reproduction of the main species caught can be undertaken, at any rate in Tegal harbour.

The results obtained at the harbour are then processed in the BPPL laboratory. Daily samples are regrouped by fortnight or by month according to species and zones. In the harbour, the quantities landed are not recorded per species, but per commercial category, which can include many species. A raising factor is indispensable, but in the present state of affairs it is possible to estimate it at Tegal harbour only.

For the moment, considering the means at the disposal of the BPPL, it is unnecessary to extend this type of sampling survey to the port of Batang, as its landings and fishing fleet are very similar to those at Pekalongan (POTIER and *al.*, 1988). However the eastward extension of the fishery and the increasing importance of Juwana raise a problem. Very soon a team of two should be established there to conduct enquiries and sample the landings according to this new procedure.

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ANNEX I

Mathematical review of the sampling procedures used in this paper. (Frontier, 1983).

I. Stratified sampling

Quantitative variables.

Data:

Stratum 1	Stratum 2	Stratum h	Stratum k
y_{11}	y_{21}	y_{h1}	y_{k1}
y_{12}	y_{22}	y_{h2}	y_{k2}
....	....	....	....
......	......	......	......
y_{1l}	y_{2l}	y_{kl}	y_{kl}
......	......	......	......
......	......	......	......
$y^{1n}{}_1$	$y^{2n}{}_2$	$y^{hn}{}_h$	$y^{kn}{}_k$

Preliminary results:

$$f_h = n_h/N_h \qquad W_h = N_h/N \text{ (weight of the stratum h).}$$

$$y_h = \sum_{i=1}^{N_h} y_{hi}/N_h \qquad s^2y = \sum_{h\ i=1}^{N_h} (Y_{hi} - Y_h)^2/N_{h-1}$$

Estimates:

$$y = \sum_{h=1}^{k} W_h\, y_h \qquad v(y) = \sum_{h=1}^{k} (W^2{}_h\ S^2{}_{yh}/n_h)\ (1 - f_h)$$

$$Y = N y \qquad v(Y) = N^2\ v(y)$$

$$\Pr (y - t\alpha/_2\ \sqrt{v(y)} < Y < y + t\alpha/_2\ \sqrt{v(y)}) = 1 - \alpha$$
$$\Pr (y - t\alpha/_2\ \sqrt{v(y)} < Y < y + t\alpha/_2\ \sqrt{v(y)}) = 1 - \alpha$$

Qualitative variables.

Data:

a_1 elements in n_1, a_2 in n_2, ..., a_h in n_h, ... a_k in n_k possess the character C in the strata 1, 2, ..., h, ..., k respectively.

Preliminary results:

$$p_h = a_h/n_h \qquad q_h = (n_h - a_h)/n_h$$

Estimates:

$$p = \sum_{h=1}^{k} W_h p_h \qquad v(p) = \sum_{h=1}^{k} (W^2{}_h p_h q_h / n_h)(1 - f_h)$$

$$\Pr(p - Z\alpha/2 \sqrt{v(p)} < p < p + Z\alpha/2 \sqrt{v(p)}) = 1 - \alpha$$

Optimization:

Optimal value of n and n_h for a total cost C given.

$$n = \frac{(C - C_o)\ (\Sigma N_h \sqrt{p_h q_h / C_h})}{\Sigma N_h \sqrt{p_h q_h c_h}} \qquad n_h = n. \frac{N_h \sqrt{p_h q_h / C_h}}{\Sigma N_h \sqrt{p_h q_h / c_h}}$$

II. Sampling by degree

We shall consider a sampling of first degree with equal clusters. The variants of this type of sampling being numerous we advise the reader to refer to the works of COCHRAN (1977) and FRONTIER (1983).

Quantitative variables.

System of notations:

N Size of the population (total number of primary units)

n number of primary units in the sample.

M_i number of secondary units in the i^{eme} primary unit.

Data:

Clusters	Observations
1	$y_{11}, y_{12}, \ldots\ldots y_{1j} \ldots\ldots\ldots\ldots y_{1M1}$
2	$y_{21}, y_{22}, \ldots\ldots y_{2j} \ldots\ldots\ldots\ldots y_{2M2}$
......	$y_{i1}, y_{i2}, \ldots\ldots y_{ij} \ldots\ldots\ldots\ldots y_{iMi}$
i	....
.....	....
n	$y_{n1}, y_{n2}, \ldots\ldots, y_{nj}, \ldots\ldots y_{nMn}$

$M_i = M = C^{te}$

Estimate of the mean by element (y) :

$$y = \sum_{i=1}^{n} y^1 / n \qquad v(y) = ((1 - f)/n).\ \sum_{i=1}^{n} (y_1 - y)^2 / n - 1$$

$$\text{with } y_1 = \sum_{i=1}^{n} y_{ij} / M \text{ let us denote } v(y_1) = 0 \text{ for } (1 - f_{2i}) = 0$$

Estimate of the total quantity (Y):

$$Y = NMy \qquad v(Y) = N^2 M^2 v(y)$$

$$\Pr(Y - t\alpha/2\ \sqrt{v(Y)} < Y < Y + t\alpha/2\ \sqrt{v(Y)}) = 1 - \alpha$$
$$\Pr(Y - t\alpha/2\ \sqrt{v(Y)} < Y < Y + t\alpha/2\ \sqrt{v(Y)}) = 1 - \alpha$$
$$\Pr(Y - t\alpha/2\ \sqrt{v(Y)} < Y < Y + t\alpha/2\ \sqrt{v(Y)}) = 1 - \alpha$$

Qualitative variables.

Data:

a_i elements in M_i possess the character C in the cluster i.

$M_i = M = C^{te}$

Estimate of the proportion (p):

$$p = \sum_{i=1}^{n} p_i / n \qquad v(p) = ((1-f)/n.\ \sum_{i=1}^{n} (p_i - p)^2/(n-1)$$

with $p_i = a_i / M$

Assumptions:

- Simple random sampling of the clusters.
- n must be large.
- p does not have to approach 0 or 1.

Estimate of the total quantity (A):

$$N = N.p \qquad v(A) = N^2 . v(p)$$

$$\Pr(p - Z\alpha/2\ \sqrt{v(p)} - 1/2n < P < p + z\alpha/2\ \sqrt{v(p)} + 1/2n) = 1 - \alpha$$
$$\Pr(Np - Z\alpha/2\ \sqrt{N^2 v(p)} - 1/2n < A < Np + Z\alpha/2\ \sqrt{N^2 v(p)} + 1/2n) = 1 - \alpha$$

ANNEX II

Calculation of the length distribution of the species A in the catch of the vessels which come from the same fishing zone.

Step I.

Let us denote P_E = weight of the sample.

$$P_E = \sum_{i=1}^{n} P_i$$

P_i = weight of the species i in the sample.

Raising factor of species A : $R_A = P_{Ae} / P_E$

where P_{Ae} = weight of the species A in the sample.

If T = Catch of the vessel sampled.

The catch of the species A will be: $P_{AT} = R_A * T$

If Q = Catch of the vessels coming from the same fishing zone.

The catch of the species A will be: $P_{AQ} = (P_{AT}/T) * Q$

Step II.

In the sample we know the length distribution for 50 individuals of the species A.
Let us denote Z_1 = Number of individuals of length 1 which are measured.
The number of individuals of length 1 in the sample will be:

$$n_1 = (z_1/50) * Z$$

where Z = Number of individuals of species A in the sample.

The weight of the size-class 1 in the sample will be:

$$x_1 = \sum_{i=1}^{n} n_i * p$$

where $n_1 = n_i$ .... n_n number of individuals of length 1
p = weight of one individual of length 1

In the catch of species A the weight of the size-class 1 will be: $X_1 = (X_1/P_{Ae}) * P_{AQ}$

The number of individuals of length 1 in the catch of the species A will be: $N_1 = X_1 / p$

This operation renewed for each size-class will give the length distribution of the species A in the catch.

$$D = \sum_{i=1}^{n} N_i \qquad N_i = \text{Number of individuals of the size-class } i$$

This procedure renewed for each fishing zone and each species will give the length distribution of the species by fishing zone and their proportions in the landings.

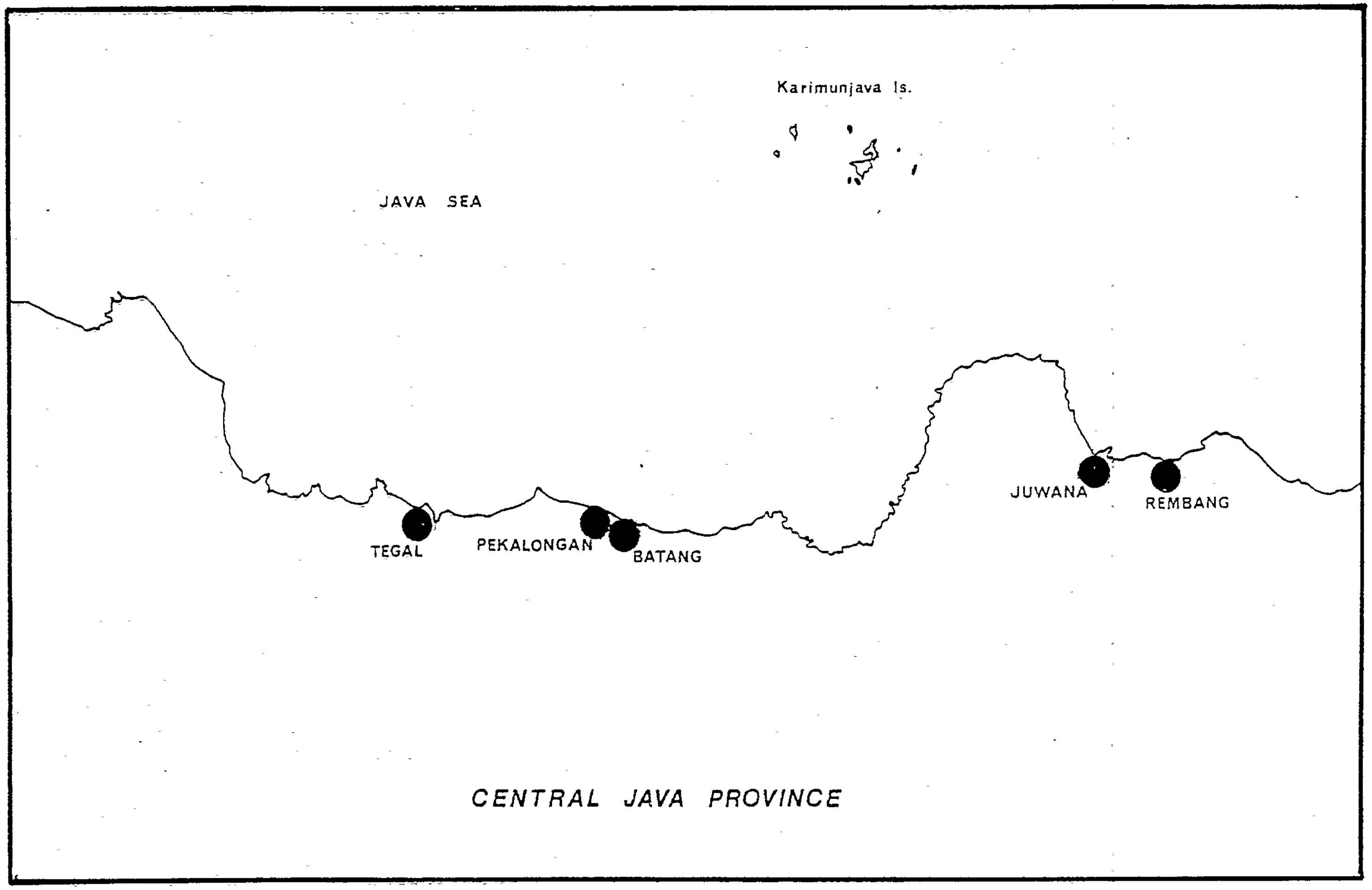

Figure 1: Location of the harbours where land the Javanese purse seiners.
Localisation des port où débarquent les senneurs javanais.

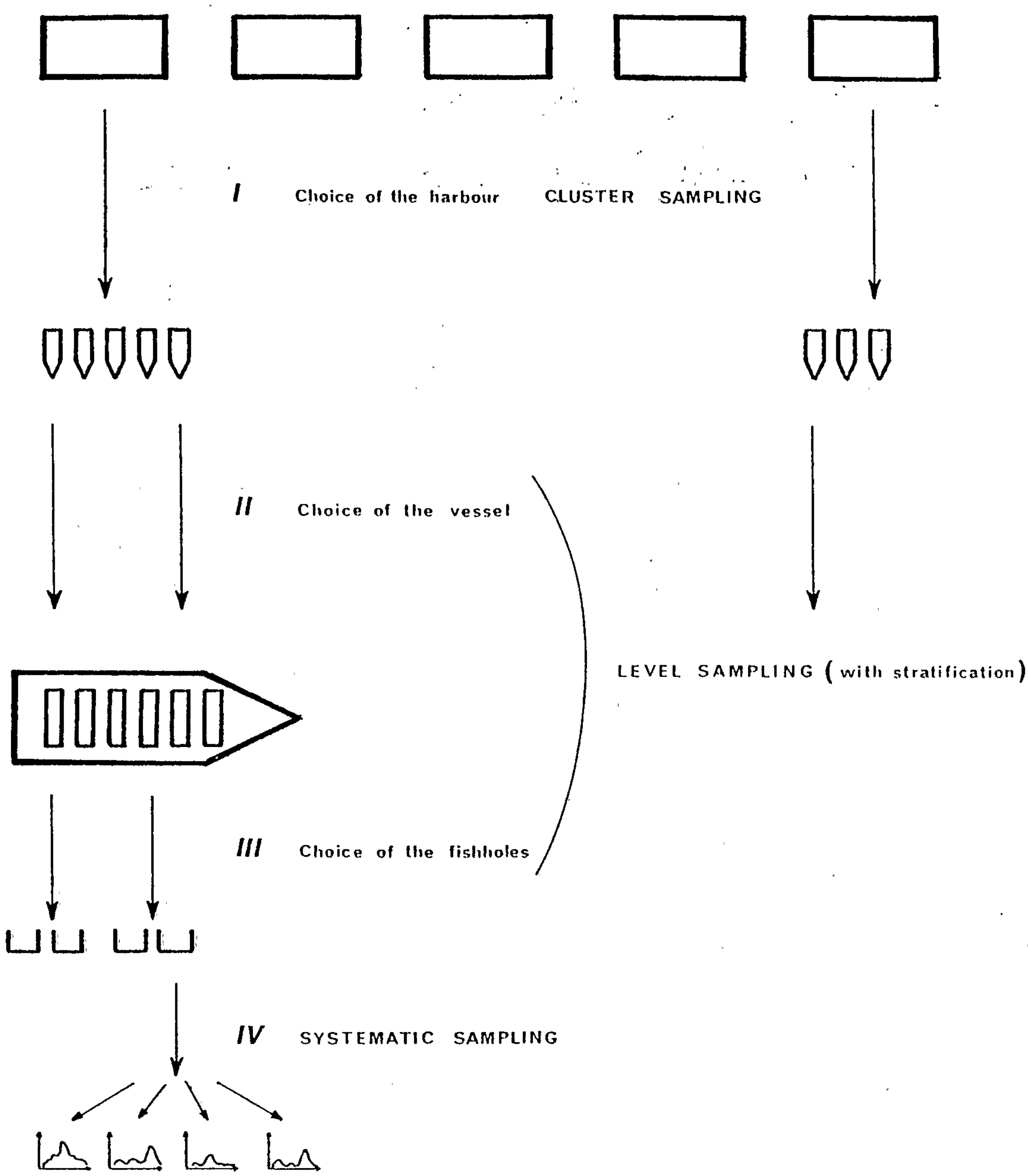

Figure 2: General scheme of the sampling survey considered for the study of the catch of the Javanese purse seiners fleet.

Schéma général de la procédure d'échantillonnage retenue pour l'étude des captures de la flottille des senneurs javanais.

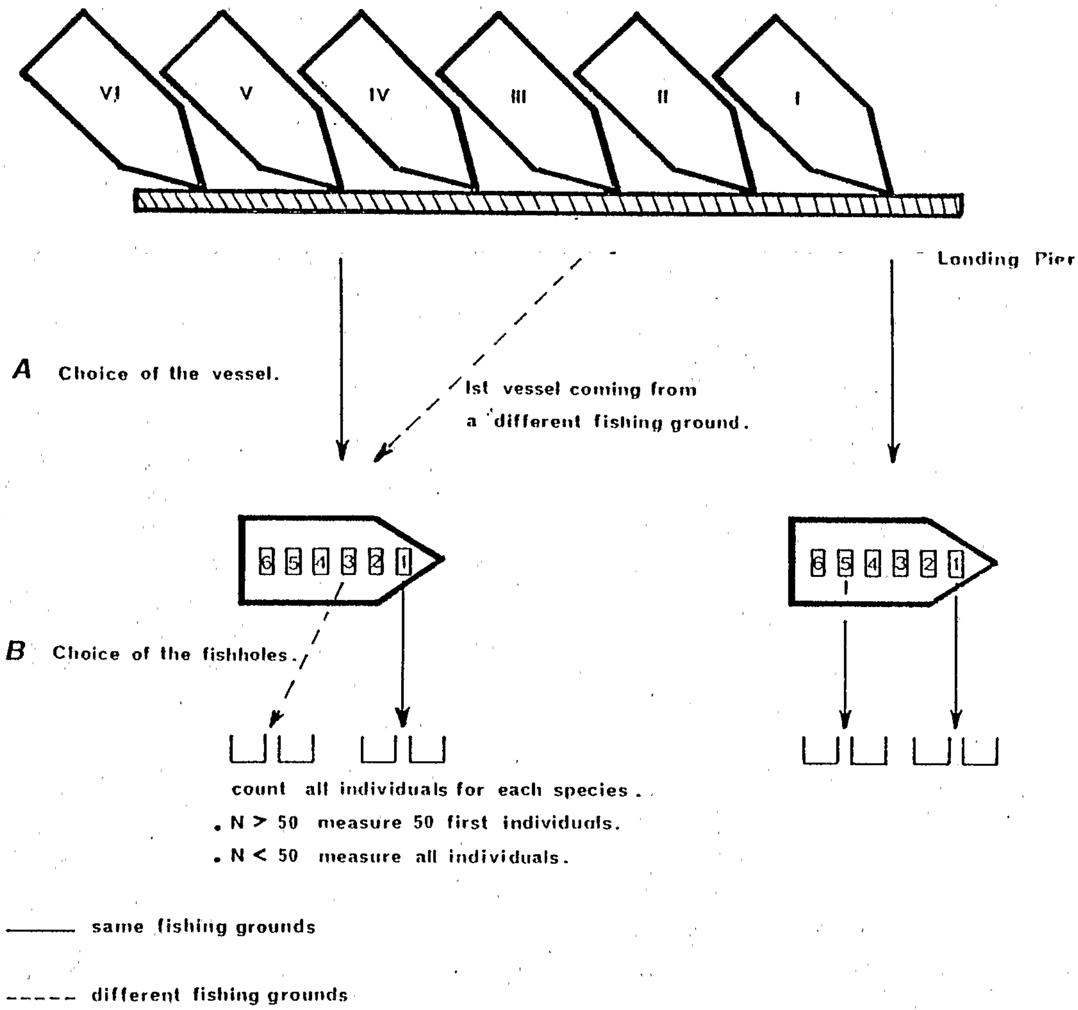

Figure 3: Particular scheme for the choice of the vessels and fishholes in the sampling survey of the Javanese purse seiners fleet.

Schéma particulaier du choix des navires et des cales dans la procédure d'échantillonnage mise en place sur la flottille des senneurs javanais.