M.K.

INDONESIAN-FRENCH JOINT COOPERATIVE RESEARCH ON OCEANOLOGY

OCCURENCE OF TAR POLLUTION ALONG SHORES IN INDONESIA

Preliminary report of CNEXO-LEMIGAS
FIELD SURVEY
May 1984

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INDONESIAN-FRENCH JOINT COOPERATIVE RESEARCH ON OCEANOLOGY
TAR BALL STUDY

Preliminary report of 1984 Field Survey

On the framework of the agreement between the French and Indonesian Governments a Cooperative Joint Research program on the chronic pollution on the beaches in the form of stranded tar balls has been carried out by CNEXO and LEMIGAS teams. A second field survey was conducted in May 1984 in continuation of a reconnaissance survey carried out in August 1982. [1]

This report is to give a picture, after the North Western monsoon period, of the tar accumulation on the four Indonesian test sites surveyed in 1982. The locations to be surveyed are beaches of islands in Kepulauan Seribu (Java Sea), Kepulauan Riau (Malacca Straits) as well as beaches of the Southern coast of Central Java (Krakal and Kukup near Jogyakarta) and Sulawesi (Langga).

These sampling areas were drawn from considerations relating to current features and operational factors as oil activities (refineries, loading ports, offshore production fields) and main shipping routes. It would be particularly interesting to compare the state of pollution along the Malacca and Makassar straits on account of differences in oil transportation. It may be pointed out that the route for extra large tankers does not go through the Malacca straits but through Lombok and Makassar straits when sailing to the East Asian countries and the United States.

Since more than 90% of the crude supply for the East Asian countries and the United States is shipped from the Middle East and some African countries through the Indonesian and South East Asian waters, monitoring of oil pollution phenomena, among others tar ball stranding should be initiated.

The implementation of survey in 1984 was carried out on May 3th to May 19th. During this times about 6650 m of coastline has been observed and 124 sampling stations have been set.

I - DESCRIPTION OF THE STUDIED TEST SITES

The four test sites studied along shores in Indonesia are shown on map 1. Some typical features of these sites are briefly indicated in order to give a better understanding of the data.

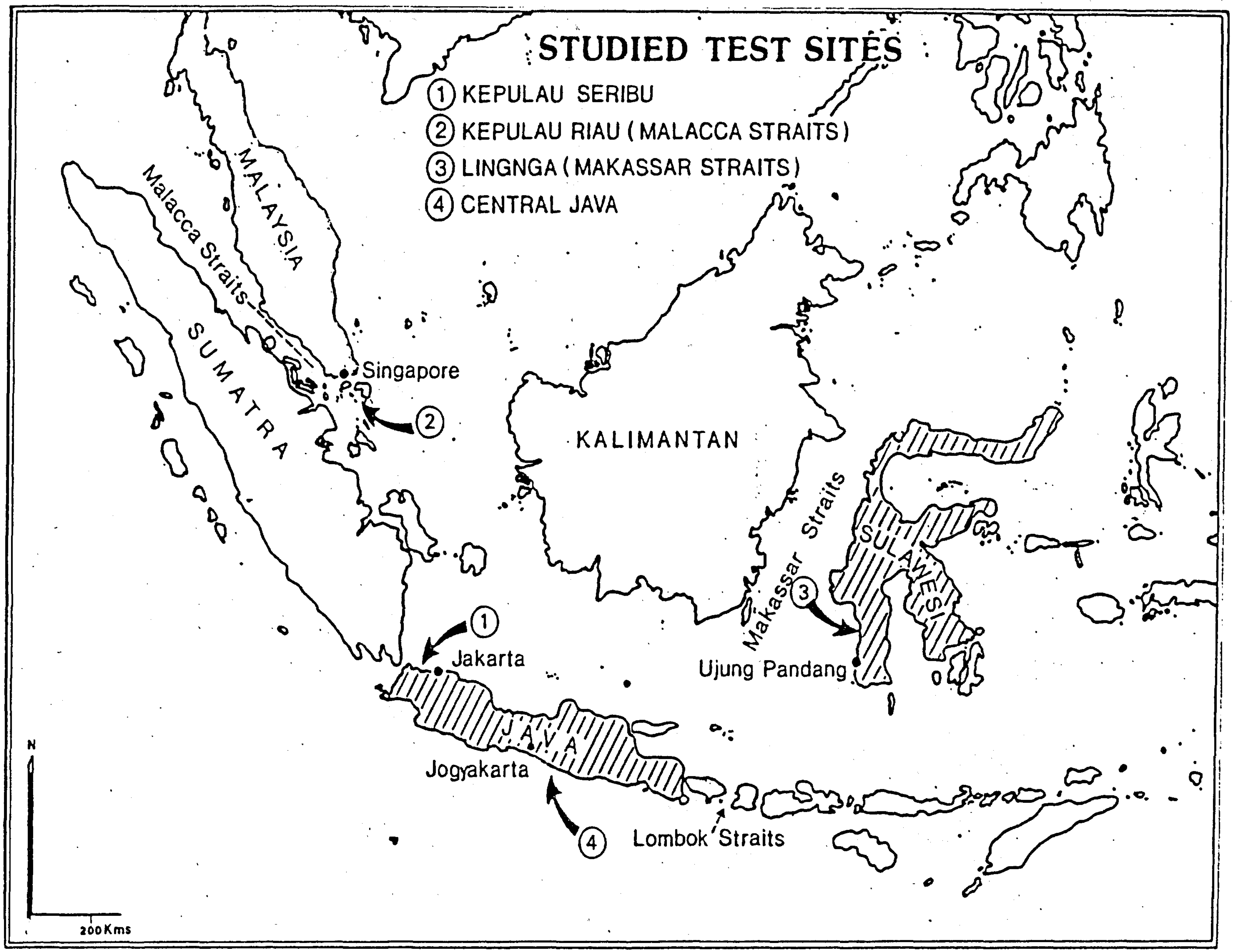
I.1 - KEPULAUAN SERIBU (PULAU PARI TEST SITES)

Kepulauan Seribu or Thousand Islands Archipelago is situated in the Java Sea at about 40km North-West of Jakarta. Composed of many small coral islands, it extends over 80km from North to South (see map 2). In the Indonesian planed development pattern, these islands are grouped for the purpose of industry (offshore activities), tourism, agriculture, and fisheries. In this archipelago there is a pseudo atoll composed of five islands (Pulau Pari, Pulau Tengah, Pulau Kongsi, Pulau Burung and Pulau Tikus) surrounded by a coral reef delimiting the internal lagoon (see map 3). The main shipping line to and from Jakarta harbour goes northwards in the vicinity of Pulau Pari. The North-Western part of the archipelago is occupied by offshore oil production. The surface currents in this region of the Java Sea are directed from East to West or North in August and from North-West to South-East, in March (i.e. North-West monsoon). The sampling on Pulau Pari (Northern and Southern coasts) has been done between May 3th to 5th 1984.

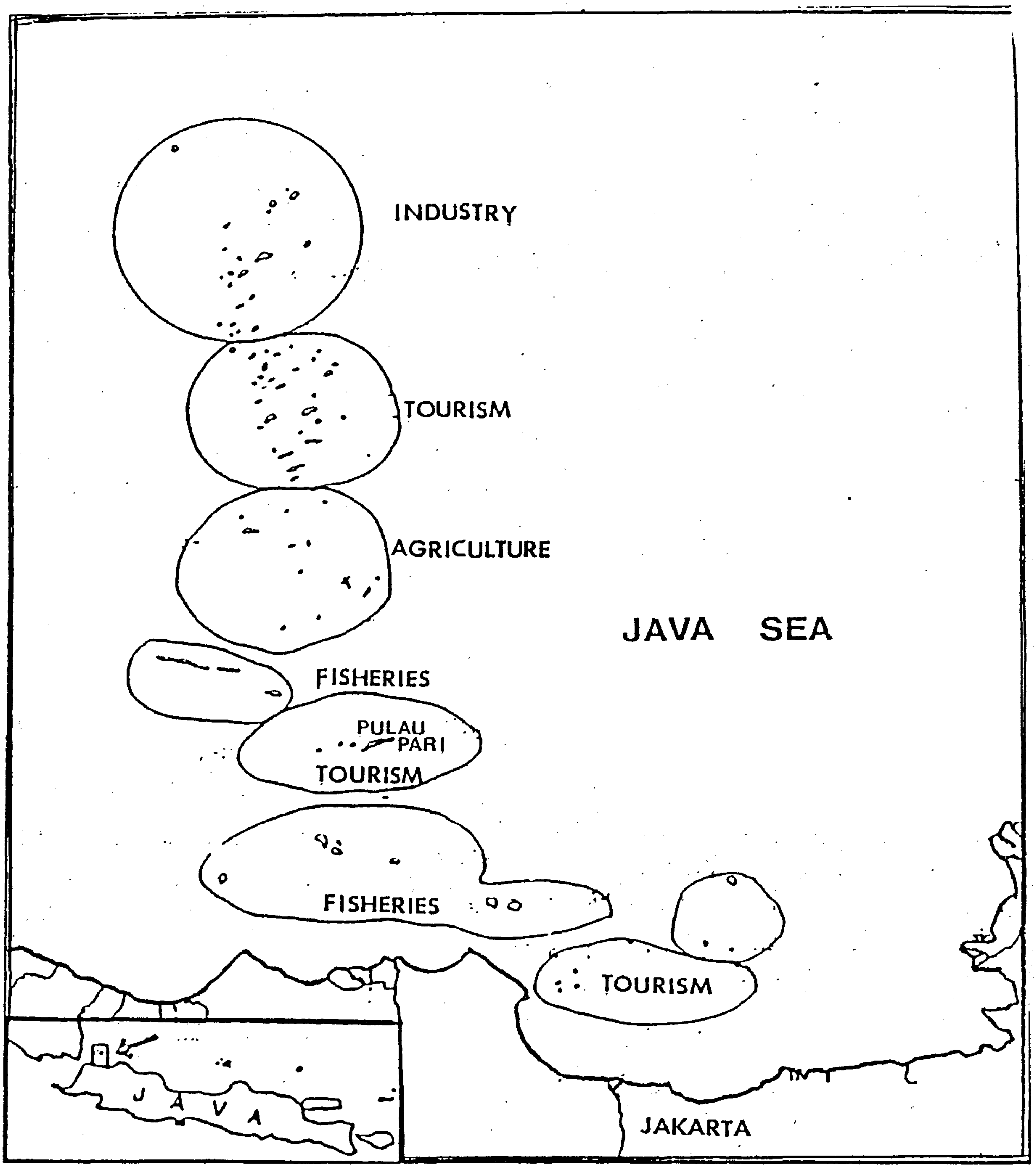
I.2 - KEPULAUN RIAU (MALACCA STRAITS)

Kepulauan Riau is an archipelago of more than 100 islands situated South of Singapore island. The studied area corresponds to the North-Western part of the archipelago and is composed of many small islands separated by narrow channels where tidal currents can be strong. The surface currents in this region are directed from South-East to North-West but strong tidal currents are locally preponderant. The tide may reach 3 m.

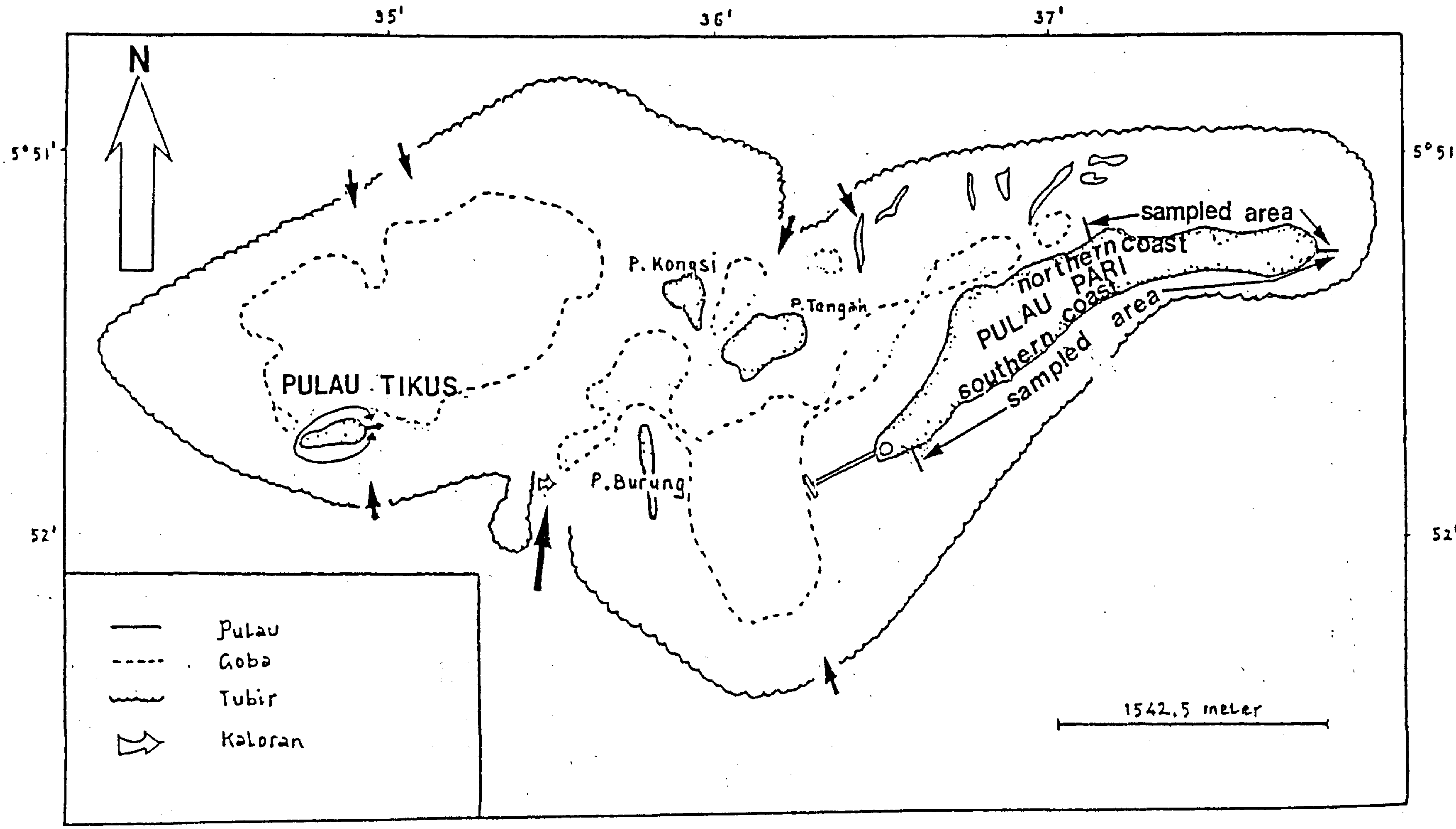
Main shipping route connecting both the Indian and Pacific Oceans lies between these islands and Singapore. Some of these islands (Pulau Pemping, Pulau Kasu, Kepala Jernuh) were polluted by the Showa Maru oil spill in 1975.



Map 1 - STUDIED TEST SITES ALONG SHORES IN INDONESIA



Map 2 - KEPULAU SERIBU (geographical location)



N
35'
36'
37'
5°51'
52'
sampled area
northern coast
PULAU PARI
southern coast
sampled area
P. Kongsi
P. Tengah
PULAU TIKUS
P. Burung
Pulau
Goba
Tubir
Kaloran
1542,5 meter

Map 3

The sampling was done between May 16th and 18th, 1984 on sandy areas on five islands (map 4).

- Pulau Takong Kecil }
- Pulau Pelampong } in the principal strait
- Pulau Nirup }
- Pulau Labon Kecil }
- Pulau Kapal Besar } on the South-Eastern part of the strait

Usually the sandy beaches in these islands are of small extent. The shores are mainly occupied by mangrove essentialy composed of sonneriata and rhizophora.

I.3 - SOUTH SULAWESI TEST SITES (Makassar straits)

The coastline on South Sulawesi is generally oriented South-North, except in the region of Madjene, with a succession of bays and estuaries and sometimes large sand accumulations as in Langga (map 5) The surface currents in this region are directed from North to South, tidal currents are generally unknown. The sampling was conducted on May 8th, 1984 on the sandy area of Langga beach.

I.4 - SOUTH JAVA TEST SITES

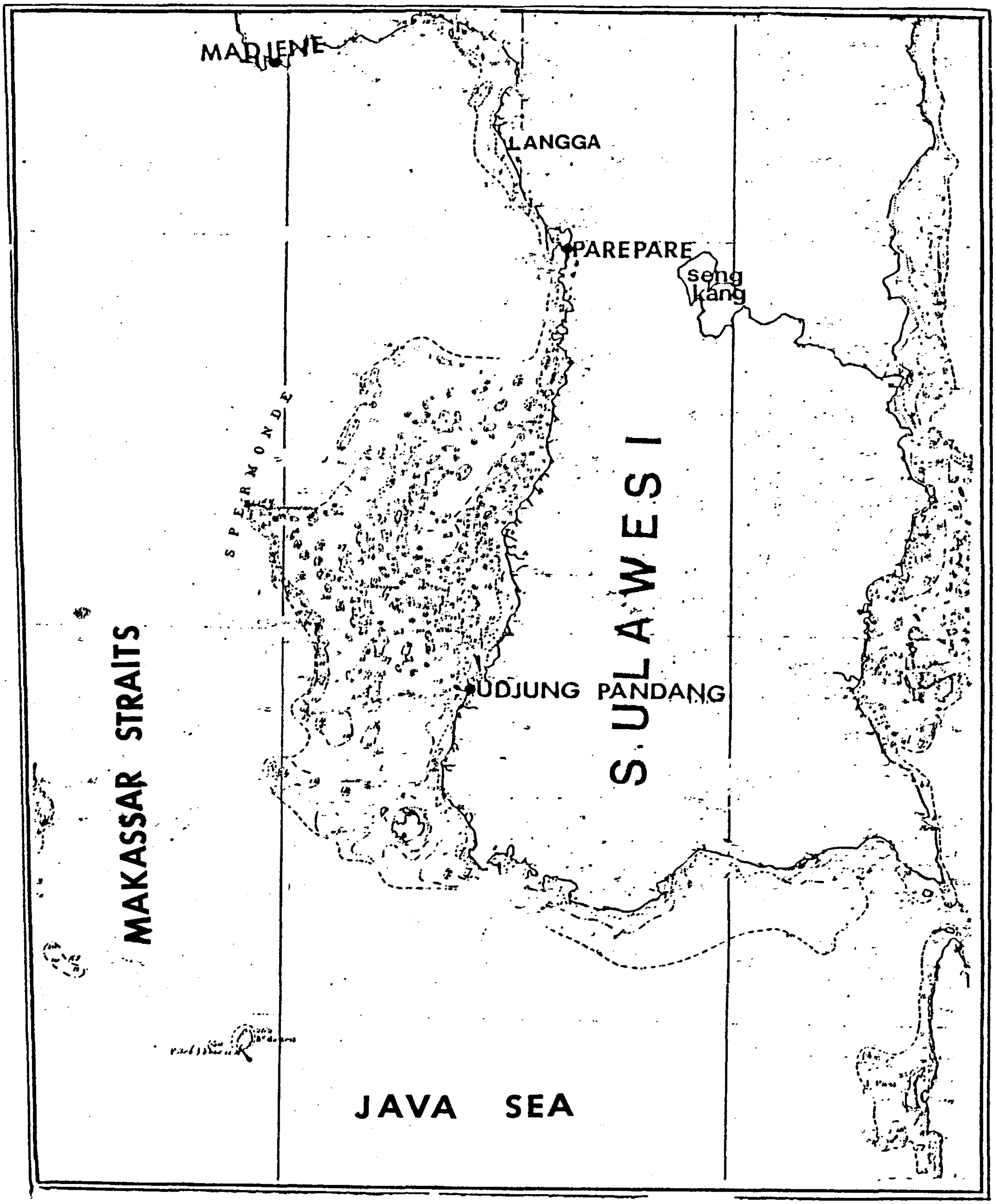
The studied area is situated in the central part of the Indian Ocean coast of Java. It is mainly composed of the beaches of Kukup and Krakal. These beaches are well exposed to the open ocean swell, the beach slope being very steep. They are composed of a sandy flat limited in their Eastern and Westhern parts by rocky points. These beaches were investigated on 11th of May.

QUANTITATIVE ASSESSMENT OF TAR POLLUTION

II 1 - SAMPLING METHODOLOGY

The aim of the developed methodology is to obtain an estimation as precise as possible of the quantity of stranded tar over a determined test site in taking into account that the tar loading are not homogeneous (very high density variation may appear on the same beach). The stratified random sampling adopted in in this study has the advantage of giving a good precision of the estimated mean and of notablely minimizing the variance of this mean.

Map 4 - KEPULAU RIAU SURVEYED AREAS



Map 5 - SOUTH SULAWESI TEST AREAS

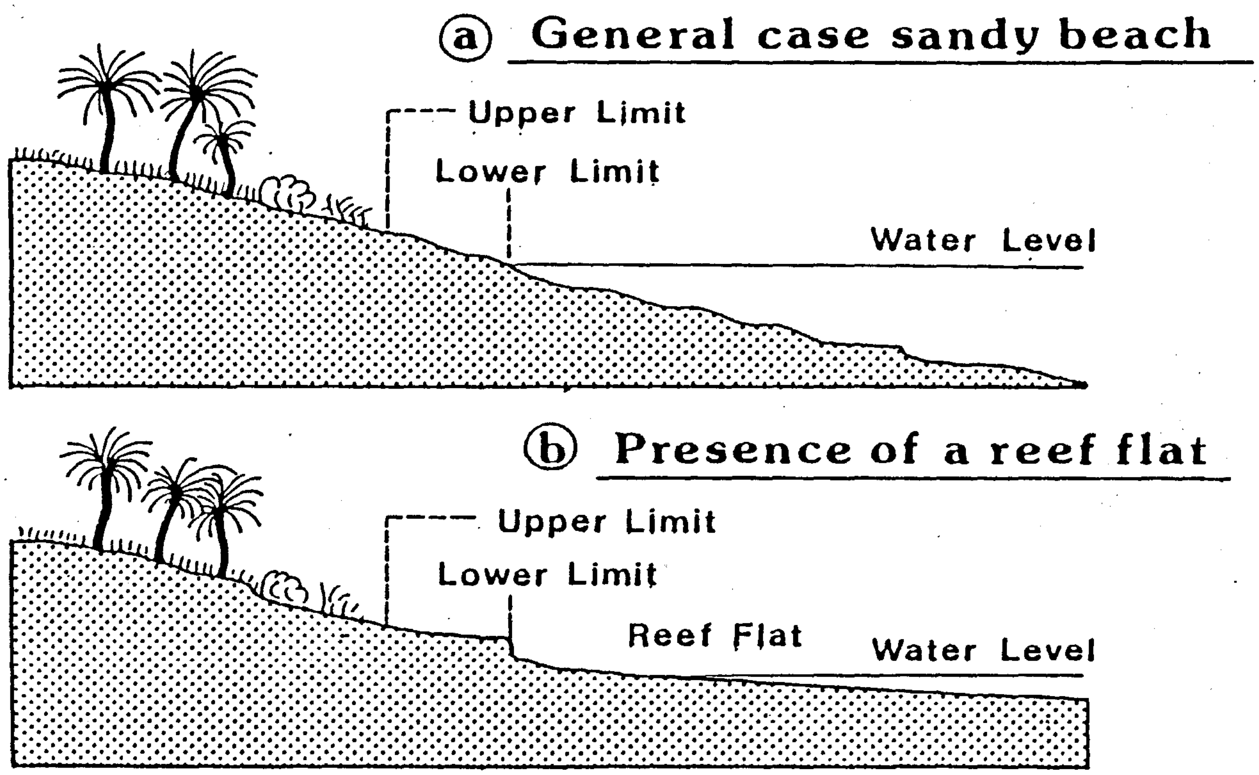
As the width of beaches varies, the reference unit adopted by CNEXO team was not gram per square meter (measurement of tar density) but gram per linear meter of beach. The results obtained through this unit have the advantage of being independent of the width of the beach and tide level. However as some data in the literature are expressed in gram per square meter (IGOSS method), the pollution level will be computed in this study in g/m and in g/m² of gross weight of stranded tar balls.

Briefly, this methodology could be divided into two steps:

The first step consist of making a rapid reconnaissance of the test area in order to divide it into strata representative of a type of accumulation (i.e. very high, medium, low...) each of which is internally homogeneous.

The second step consists in selecting, in each stratum, a random sampling composed of n samples of the total gross weight of tar collected in a transect of known width (generally 1 m.) perpendicular to the water line from the lower part of the investigated zone up to the upper part of the beach. Figure 1 gives an example of stratification and sampling. The values are expressed in gross weight of tar balls (oil, sand or other litter). By a further extraction in laboratory, it is possible to pass from the gross weight to net weight of hydrocarbons.

Each stratum is identified by a letter A, B, C ... The length of the stratum expressed in meters is defined by the letters N_A, N_B, N_C ... Each station randomly choosen into the transect is denoted by a number A1, A2, A3 ... So in the following tables of data, station 1 in stratum A is A1, station 2 in stratum B is B2 and soon. The number of stations into the transect A is nA. The total weight of tar collected into the transect is expressed in grams in gross weight. The lenght of the transect (polluted zone) is measured from the upper part of the beach to the water line (width in meters). So the quantity of tar could be expressed in grams per linear meter of transect (g/m) or in grams per square meter of transect (g/m²) in dividing the value in g/m by the width of the beach at the sampled station (IGOSS method).



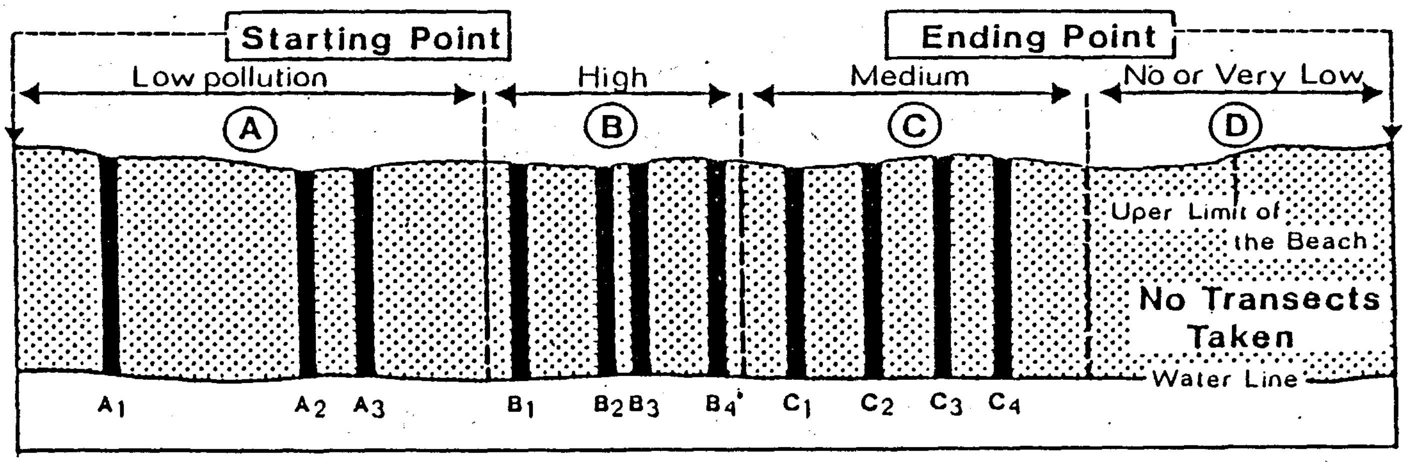


Figure 1 - EXAMPLE OF STRATIFICATION AND SAMPLING

Usually it is difficult to get, at a first survey, the best distribution of strata in order to reduce the variance of the estimated mean. However before going back to the field it is always possible to check whether the distribution of strata is optimal or not. So sometimes it may be necessary to redistribute the strata. For example it could be beneficial to regroup the strata which present equivalent means (Y_h) and standard deviation (S_h) or, to divide a stratum into new strata if the standard deviation is too high. The optimal allowance of stations (n opt) into each transect could be evaluated for a total number of stations (n) by the formula:

$$n\ opt = n \frac{N_h\ s_h}{\sum_{h=1}^{L} N_h\ s_h}$$

The program used for data processing and the results obtained during this survey are given at the end of this report.

II 2 - ANALYTICAL ASPECTS OF THE METHOD

Tar pollution on beaches are determined by the estimation of sample mean and confidence limits. The letters in the formulas used are defined as fol lowing.

- The suffix h denotes the stratum.
- The suffix i denotes the unit in the stratum.
- N_h = total number of units in the stratum h = length of the stratum (sampling unit = meter).
- n_h = total number of sampling units taken in stratum h.
- y_{hi} = value of the i th unit in the stratum h.
- $w_h = \frac{N_h}{N}$ = stratum weight.
- $f_h = \frac{n_h}{N_h}$ = sampling fraction in the stratum.
- Sample mean : $\overline{y}_h = \sum_{i=1}^{n_h} . \frac{y_{hi}}{n_h}$
- $N = N_1 + N_2 + \ldots\ldots N_L$ = total number of units (L strata).

. Estimation of the standard deviation s_h in stratum h.

$$s_h = \sqrt{\frac{1}{n_h - 1} \sum_{i=1}^{n_h} (y_{hi} - \bar{y}_h)^2} \quad \text{or} \quad s_h = \sqrt{\frac{1}{n(n-1)} \quad n \Sigma y^2 - (\Sigma y)^2}$$

. Estimation of the whole population : $y_{st} = \sum_{h-1}^{L} N_h \bar{y}_h$

. Estimation of the mean per unit over the whole population

$$\bar{y}_{st} = \sum_{h=1}^{L} \frac{N_h \bar{y}_h}{N}$$

. Estimation of the variance of $\bar{y}_{st}$:

$$V(\bar{y}_{st}) = s^2(\bar{y}_{st}) = \sum_{h=1}^{L} W_h^2 \frac{s_h^2}{n_h} (1 - f_h)$$

. Estimation of the variance of the whole population :

$$V(y_{st}) = N^2 . V(\bar{y}_{st}).$$

. Approximation of the number of degrees of freedom of s $(\bar{y}_{st})$:

$$n_e = \frac{\left(\sum_{h=1}^{L} g_h s_h^2\right)^2}{\sum_{h=1}^{L} \frac{g_h^2 s_h^4}{n_h - 1}}$$

with : $g_h = N_h \frac{(N_h - n_h)}{n_h}$

Confidence limits :

. estimated mean : $\bar{y}_{st} \pm t_p \times s(\bar{y}_{st})$

with t_p obtained from Student's tables for the probability p and the number of degrees of freedom ne.

Optimal allocation :

In order to minimize the variance of $(\bar{y}_{st})$ for a total number of sampled units n, n_h must be :

$$n_h = n \frac{N_h S_h}{\sum_{h=1}^{L} N_h s_h}$$

Comparison of results :

. for $\bar{y}_{1st}$ and $\bar{y}_{2st}$, two means obtained upon two different sites or upon the same site at two different dates, the confidence limits of the different is given by :

$$\bar{y}_{1st} - \bar{y}_{2st} \pm t_p \sqrt{s^2 (\bar{y}_{1st}) + s^2 (\bar{y}_{2st})}$$

with t_p obtained from Student's table for the probability p and the number of degrees of freedom : $V = n_{e1} + n_{e2}$

If no stratification has been done the following equation has to be considered (simple random sampling).

. estimated mean :

$$\bar{y}_{st} = \sum_1^n \frac{y_i}{n} = \text{sample mean.}$$

. estimated standard deviation of the sample :

$$S = \sqrt{\frac{1}{n-1} \sum_1^n (y_i - \bar{y})^2}$$

. variance of the estimated mean :

$$V(\bar{y}_{st}) = \frac{s^2}{n}(1 - f) \quad \text{with } f = \frac{n}{N}$$

. degrees of freedom : $n - 1$;

. confidence limits of the mean :

$$\bar{y} \pm t_p \frac{s}{\sqrt{n}} \sqrt{1 - f}$$

with t_p obtained from Student tables.

II 3 - RESULTS

II 3 1 - Kepuluan Seribu

a) Pulau Pari southern coast.

The length of this test site is 2339 m.
Three strata have determined:

- stratum A: 682m long (NA) with 15 stations (nA)
- stratum B: 1595m long (NB) with 10 stations (nB)
- stratum C: 62m long (NC) with 3 stations (nC)

stratum	station	width [m]	weight [g/m]	weight [g/m²]
A	1	5,3	7000	1321
	2	5,3	7360	1389
	3	7,1	70	10
	4	8,2	110	13
	5	7,4	1160	157
	6	7,3	290	40
	7	8,5	3800	447
	8	8	100	12
	9	8	1200	150
	10	7,3	1700	233
	11	7,3	600	82
	12	6	700	117
	13	5,8	40	7
	14	8,5	25	3
	15	16	500	31
B	1	8,5	20	2
	2	7,1	40	6
	3	7,2	17	2
	4	8,2	113	13
	5	5,5	110	20
	6	8	20	7
	7	6	7	1
	8	7,6	375	49
	9	6,5	20	3
	10	6	105	18
C	1	6	295	48
	2	8	255	32
	3	6,7	240	36

* Sample means and standard deviations:

Y_A = 1644 g/m　　Y_B = 82,7　　Y_C = 263

S_A = 2449　　S_B = 111　　S_C = 28,4

* Number of degrees of freedom (estimated): n_e = 14

* Estimated mean per meter over all the sampled area: Y_{st} = 542 g/m

* Confidence limits of Y_{st}

tp obtained from the Student tables for n_e = 14 and p = 0,95 is 2,145

Y = 542 ± 394 g/m

The same computations could be done according to the listed formula with the data expressed in g/m².

* Sample means and standard deviations:

Y_A = 267,46 g/m²　　Y_B = 12 g/m²　　Y_C = 38,66 g/m²

S_A = 457,16　　S_B = 14,65　　S_C = 8,33

Y = 91,6 ± 78,4 g/m²

* The variance of the estimated mean could be reduce by a redistribution of the number of stations in each stratum according the optimal allowance: $n_A = 25$, $n_B = 3$, $n_C = 0$.

b) Pulau Pari northern coast

The length of this test site is 860 m.

3 strata have been determined:

- Stratum A 672 m long (N_A) with 10 stations (5376 m²)
- Stratum B 75 m long (N_B) with 3 stations (562 m²)
- Stratum C 113 m long (N_C) with 3 stations (817 m²)

stratum	station	width [m]	weight [g/m]	weight [g/m²]
A	1	8	100	12,5
	2	8	4250	531,2
	3	8,6	1700	197,7
	4	8,3	3700	445,8
	5	7	26700	3814
	6	8,1	14860	1834
	7	7,5	9000	1200
	8	8	11000	1375
	9	8,3	700	84,3
	10	8,5	1000	117,6
B	1	7,5	520	69,3
	2	7,4	5000	676
	3	7,6	8000	1053
C	1	6,5	35000	5385
	2	7	42500	6071
	3	8,2	1400	171

* Sample means and standard deviations:

$Y_A = 7301$ g/m $\quad Y_B = 4507$ g/m $\quad Y_C = 26300$ g/m

$S_A = 8425$ $\quad S_B = 3764$ $\quad S_C = 21885$

* Number of degrees of freedom (estimated) $n_e = 9$

* Estimated mean per meter with confidence limits (tp obtained from Student tables for $n_e = 9$ and $p = 0,95$ is 2,262)

$$Y = 9554 \pm 5979 \text{ g/m}$$

With the data expressed in g/m^2 the pollution level in this area could be estimated

* Sample means and standard deviations:

$Y_A = 961,2\ g/m^2$ $Y_B = 599,43\ g/m^2$ $Y_C = 3875,67\ g/m^2$

$S_A = 1180,5$ $S_B = 496,3$ $S_C = 3226,62$

* Estimated mean per square meter confidence limits: $n_e = 9$ (estimated)

$$Y = 1284 \pm 844\ g/m^2$$

* The optimal allowance (calculated) was $n_A = 11$, $n_B = 1$, $n_C = 5$

c) Pulau Tikus

The lenght of the test site is 681 m.

3 strata have been determined:

- stratum A 36 m long with 3 stations (191 m^2)
- stratum B 368 m long with 7 stations (2760 m^2)
- stratum C 277 m long with 3 stations (1662 m^2)

stratum	station	width [m]	weight [g/m]	weight [g/m²]
A	1	5,4	900	166,7
	2	5,5	750	136,4
	3	5	270	54
B	1	8,4	180	21,4
	2	9	65	7,2
	3	6,1	37	6,1
	4	6	90	15
	5	8,6	7	0,8
	6	7,1	45	6,3
	7	7,1	25	3,5
C	1	6	45	7,5
	2	6	70	11,7
	3	6,2	10	16

* Sample means and standard deviations:

$Y_A = 640\ g/m$ $Y_B = 64,1\ g/m$ $Y_C = 41,7\ g/m$

$S_A = 329$ $S_B = 57,7$ $S_C = 30,1$

* Estimated total pollution (including an isolated tar of 610 g) = 58790 g.
* Number of degrees of freedom (estimated) $n_e = 9$
* Estimated mean per meter with confidence limits ($tp = 2,262$ for $p = 0,95$)

$$Y = 86,3 \pm 37,8\ g/m$$

With the data expressed in g/m², the pollution level in Pulau Tikus area could be estimated.

* Sample means and standard deviations:

Y_A = 119,03 g/m² Y_B = 8,61 g/m² Y_C = 6,93 g/m²

S_A = 58,32 S_B = 7,13 S_C = 5,07

* Estimated mean per square meter with confidence limits: (n_e = 9)

Y = 12,6 ± 5,4 g/m²

* The optimal allowance was n_A = 4, n_B = 7, n_C = 3

d) General estimation of the pollution at Kepulauan Seribu

Considering the whole sampled area on Pulau Pari an Pulau Tikus, we can assess the general pollution of these islands.

Location	n_h	N_h [m]	Y_h [g/m]	S_h	Area [m²]	Y_h [g/m²]	S_h
	15	682	1644	2449	5251	267,5	457,16
Pulau Pari South	10	1595	82	111	11324	12,1	14,65
	3	62	263	28	428	38,7	8,33
	10	672	730	8425	5376	961,2	1180,5
Pulau Pari North	3	75	4507	3764	562	599,4	496,3
	6	113	26300	21888	817	3875,7	3226,6
	3	36	640	329	191	119,03	58,3
Pulau Tikus	7	368	64,1	57,7	2760	8,61	7,1
	3	277	41,7	30,1	1662	6,93	5,1

* Estimated mean with confidence limits considering n_e = 9 (estimated) and tp = 2,262 (Student tables) the general pollution in gross weight of tar was:

Y = 2460 ± 1349 g/m

Y = 362,6 ± 203,9 g/m²

II.3.2 Kepulauan Riau

a) Pulan Takong Kecil

§ On the southern part of this island (N_A = 79 m long and 6 m wide) the tar pollution level was very low and all visible tar balls were picked up and the total weight was 1270 g

$$Y = 16{,}1 \text{ g/m or } 2{,}7 \text{ g/m}^2$$

§ On the northern part the sampling area had 112 m long. Only one stratum has been determined with 5 stations:

stratum	station	width [m]	weight [g/m]	weight [g/m²]
	1	7	273	39
	2	9	20	2,2
A	3	7,5	53	7,1
	4	9	47	5,2
	5	8,5	7	1,2

* Sample means and standard deviation:

$$Y = 80 \text{ g/m with } s = 109$$

$$Y = 10{,}9 \text{ g/m}^2 \text{ with } s = 15{,}9$$

* Pollution level with confidence limits (n_e = 4 and tp = 2,776):

$$Y = 80 \pm 132 \text{ g/m}$$

The same calculation with data expressed in g/mm² gave the following result (n_e = 4, Area 918 m²):

$$Y = 10{,}9 \pm 19{,}7 \text{ g/m}^2$$

§ Estimated pollution on Pulau Takong Kecil:

$$Y = 53{,}6 \pm 77{,}6 \text{ g/m}$$

$$Y = 8{,}10 \pm 13 \text{ g/m}^2$$

b) Pulau Pelampong

Because of the low degree of pollution on this test site, all the visible tar were picked up along the sampled area (N = 271 m long).

* Total area: 3811 m²
* Total weight: 1780 g

* Mean per meter over all this test site:

$$Y = 6{,}57 \text{ g/m}$$

* Mean per square meter:

$$Y = 0{,}47 \ g/m^2$$

c) Pulau Nirup

Five separated beaches were sampled on this island. The tar pollution level was determined using two different methodologies. Along the beaches labelled I to IV the degree of pollution was very low and all the visible tar balls were picked up whereas the pollution on the last one (near a village) was more important and was estimated using a stratified random sampling method.

Beach Nb.	Lenght [m]	Width [m]	Total gross weight [g]
I	107	6	80
II	16	5	0
III	22	8	30
IV	24	9	170

- Total length: 169 m
- Total sampled area 1183 m² (estimated)

* Pollution level on the four beaches:

$$Y = 1{,}66 \ g/m \text{ or } 0{,}24 \ g/m^2$$

* Estimated pollution level on the beach N_V = 77 m long, 635 m² with four strata (simple random sampling)

Station	Weight [m]	Width [m]	Weight [g/m²]
1	0	6,5	0
2	42	8	5,2
3	10	9	1,1
4	0	9,5	0

* Sample means and standard deviations:

$Y = 13$ g/m $\qquad$ $Y = 1{,}57$ g/m²

$S = 19{,}9$ $\qquad$ $S = 2{,}47$

* Pollution level on the beach (no stratification) with confidence limits of the mean calculated by the formula:

$$\bar{y} \pm t_p \frac{s}{\sqrt{n}} \sqrt{1 - f} \quad \text{and } n_e = n - 1$$

$Y = 13 \pm 30{,}8$ g/m $\qquad$ or $\qquad$ $Y = 1{,}57 \pm 3{,}92$ g/m²

* Estimated pollution level on Pulau Nirup (N = 246 m):

$Y = 5{,}21 \pm 9{,}64$ g/m $Y = 0{,}70 \pm 1{,}37$ g/m²

d) Pulau Labon Kecil

The lenght of the test site is 350 m

Two strata have been determined with the following parameters:

- stratum A: 155 m long with 5 stations (729 m²)
- stratum B: 195 m long with 4 stations (926 m²)

stratum	station	width [m]	weight [g/m]	weight [g/m²]
A	1	7	2,7	0,38
	2	6	5	0,83
	3	3	0	0
	4	3,5	5,3	1,52
	5	4	9,3	2,3
B	1	3	1,7	0,55
	2	7	3,3	0,47
	3	6	1,3	0,22
	4	3	0	0

* Sample mean and standard deviation in g/m:

$Y_A = 4{,}46$ g/m $Y_B = 1{,}57$ g/m

$S_A = 3{,}44$ $S_B = 1{,}36$

* Sample mean and standard deviation in g/m²:

$Y_A = 1{,}01$ g/m² $Y_B = 0{,}31$ g/m²

$S_A = 0{,}92$ $S_B = 0{,}25$

* Estimated pollution level on Palau Labon Kecil with confidence limits (considering $n_e = 6$ and tp = 2,447 for the evaluated expressed in g/m and $n_e = 5$ and tp = 2,571 for the values in g/m²)

$Y = 2{,}85 \pm 1{,}88$ g/m $Y = 0{,}62 \pm 0{,}5$ g/m²

* The optimal allowance was $n_A = 6$ and $n_B = 3$.

e) Pulau Kapal Besar

The length of the test site is 106 m.

Two strata have been determined:

- stratum A: 56 m long with 5 stations (784 m²)
- stratum B: 50 m long with 3 stations (850 m²)

stratum	station	width [m]	weight [g/m]	weight [g/m²]
A	1	14	160	11,4
	2	14	55	3,93
	3	14	15	1,07
	4	14	12,5	0,89
	5	14	77,5	5,53
B	1	18	5	0,28
	2	16	1,7	0,11
	3	17	40	2,35

* Estimated mean and confidence limits (considering $n_e = 5$):

$Y = 41,2 \pm 37,8$ g/m **$Y = 2,66 \pm 2,55$ g/m²**

f) <u>General estimation of pollution in Kepulauan Riau</u>

The considerated data are grouped on the following table.

GENERAL ESTIMATION OF POLLUTION IN KEPULAUAN RIAU

Location	n_h	N_h [m]	Y_h [g/m]	S_h	Area [m²]	Y_h [g/m²]	S_h
Takong Kecil South		79	16,1		474	2,7	
Takong Kecil North	5	112	80	109	918	10,9	15,9
Pelampong		271	6,57		3811	0,47	
Nirup [I-IV]		169	1,66		1183	0,24	
Nirup [V]	4	77	13	19,9	635	1,57	2,47
Labon Kecil	5	155	4,46	3,44	729	1,01	0,92
	4	195	1,57	1,36	926	0,31	0,25
Kapal Besar	5	56	64	60,3	784	4,56	4,29
	3	30	15	21,2	850	0,91	1,25

* The number of degrees of freedom is $n_e = 5$ (estimated)
* The estimated mean and confidence limits expressed in gross weight:

$Y = 16,03 \pm 12,4$ g/m

$Y = 1,91 \pm 1,69$ g/m²

II.3.3. - South Sulawesi (Langga)

The length of this test site along Makassar Straits is 1000 m.

2 strata have been determined:

- stratum A: 350 m long with n_A = 5 stations (4956 m²)
- stratum B: 650 m long with n_B = 7 stations (8645 m²)

Data in gross weight:

stratum	station	width [m]	weight [g/m]	weight [g/m²]
	1	13,5	22	1,63
	2	14	22	1,57
A	3	15,3	30	1,96
	4	14	33	2,36
	5	14	33	2,36
	1	13,5	30	2,22
	2	12	50	4,17
	3	11,9	5	0,42
B	4	13,7	18	1,31
	5	17	15	0,88
	6	12,5	12	0,96
	7	12,5	7	0,56

* Sample means and standard deviation:

Y_A = 28 g/m Y_B = 19,6 g/m

S_A = 5,6 S_B = 15,7

* Estimated total pollution (including an isolated tar of 450 g): 22 990 g.

* Estimated mean with confidence limits considering n_e = 7 and tp = 2,365 for p = 0,95 .

Y = 22,54 ± 9,3 g/m

* The same calculation with the data expressed in g/m² gave the level of tar pollution:

Y = 1,68 ± 0,79 g/m²

The optimal allowance was n_A = 2 and N_B = 10

II.3.4 - South Java (Kukup)

In this area only two beaches: Krakal and Kukup, located near Jogyakarta in the central part of the Indian Ocean coast of Java were investigated.

Along Krakal beach only some dispersed small tar balls were found and the estimated pollution level was inferior to 1 g/m.

Kukup beach (166 m long) was divided into two separated sandy beaches by small rocky points. The southern part (97 m long) looked very clean and was used as a recreative area. The northern part (69 m long) was very well exposed to the open ocean swell and and looked more polluted. Along a lenght of 29 m (estimated area 376 m²) all the visible tar balls were picked up (total gross weight 95 g) whereas on the remaining part (40 m long) the pollution level was determined using the random sampling methodology. On this zone, oil contimanation was in form of small oily deposits looking very fresh and seemed homogeneously distributed on the upper tidal area. So only one stratum with 3 stations has been determined:

station	width	weight [g/m]	weight [g/m²]
1	17,8	8,3	0,47
2	10,2	11,7	1,15
3	10,9	11,7	1,07

* Sample means and standard deviations:

$Y = 10,6$ g/m $\qquad$ $Y = 0,89$ g/m²

$s = 1,96$ $\qquad$ $s = 0,37$

* Estimated total pollution on the southern part of Kukup beach (69 m long): 519 g (including 95 g)

* Estimated mean per meter over all the sampled area ($n_e = 2$ and tp = 4,303):

$$Y = 7,5 \pm 2,7 \text{ g/m}$$

* Estimated mean per square meter (estimated total area 895 m²):

$$Y = 0;58 \pm 0,5 \text{ g/m}^2$$

General estimation of the pollution on the studied area in may 1984

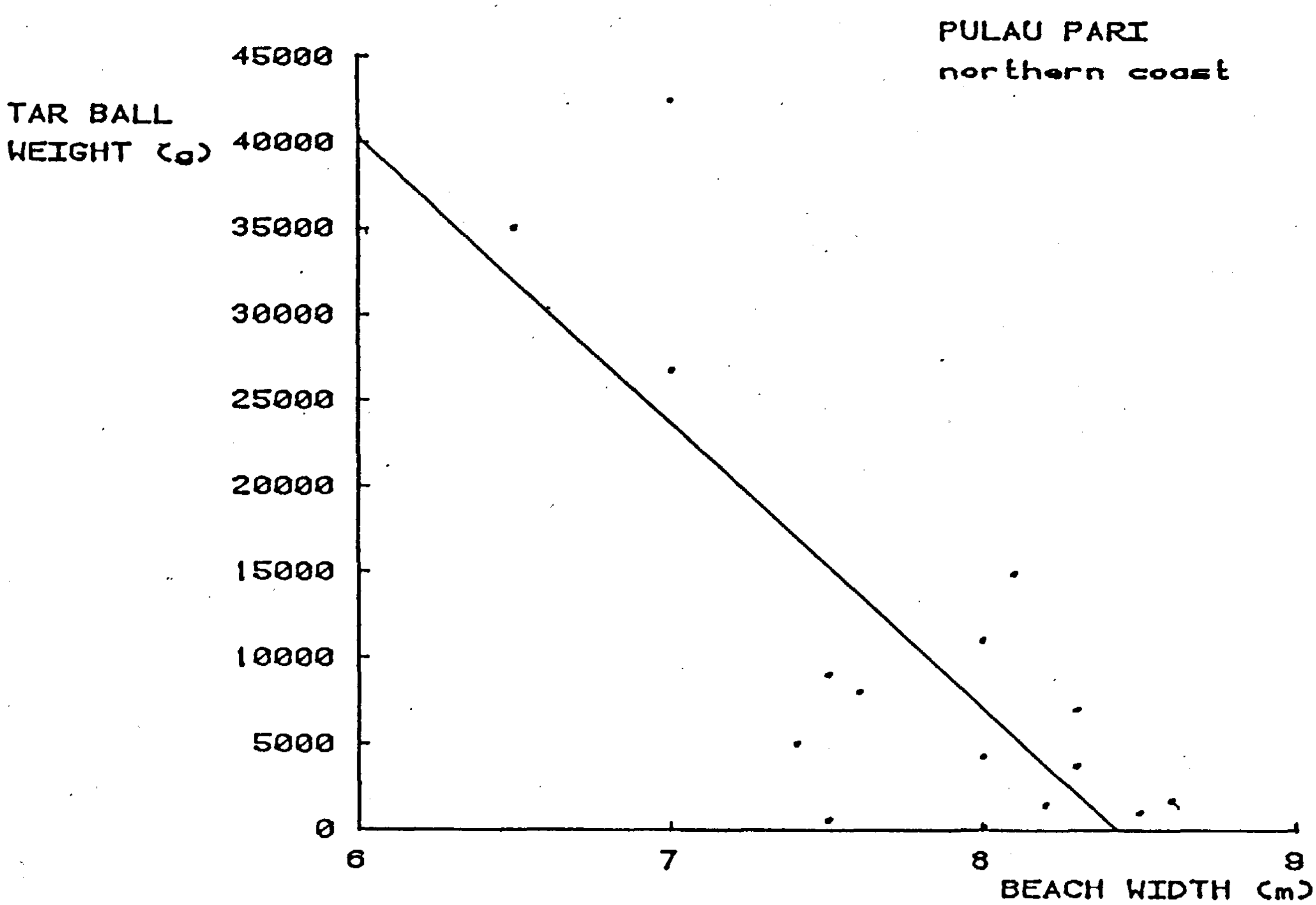
(data expressed in gross weight)

Geographical site	mean weight [g/m]	mean weight [g/m²]	mean weight [g/m] / mean weight [g/m²]
Pulau Pari [southern coast]	542 ± 394	91,6 ± 78,4	5,9
Pulau Pari [northern coast]	9554 ± 5979	1284 ± 844	7,4
Pulau Tikus	86 ± 37,8	12,6 ± 5,4	6,8
Average value in Kepulauan Seribu	2460 ± 1349	362,6 ± 203,9	
Takong Kecil	53,6 ± 77,6	8,10 ± 13	6,6
Nirup	5,21 ± 9,64	0,70 ± 1,37	7,4
Labon Kecil	2,85 ± 1,88	0,62 ± 0,50	4,6
Pelampong	6,57	0,47	
Kapal Besar	41,2 ± 37,8	2,66 ± 2,55	15,5
Average value in Kepulau Riau	16,03 ± 12,4	1,91 ± 1,69	
Langga beach	22,6 ± 9,3	1,68 ± 0,79	13,4
Kukup beach	7,5 ± 2,7	0,58 ± 0,51	12,9

III - DISCUSSIONS

II.1 - Comparison of the results according to the unit used

As seen previously, the tar pollution level could be expressed in two different units: gram per linear meter (g/m) and gram per square meter (g/m^2). The first unit is independent of the beach width and the tide level whereas the second one involved that all sampling was accomplished within 3 hours of low tide. Is there some evident correlation between the data expressed in g/m and in g/m^2 ? The values of pollution degree collected in the last table show that the ratio of results expressed in g/m and in g/m^2 is not fixed and fluctuates between 4,6 and 15,5. In fact the deposition of tar balls on the beach is not uniform. Usually there was heavy deposition at mid and high tide marks. At some places, parts of beaches between the two levels of tar deposition were completely free of tar. So the amount of tar balls is not related to the width of the beach. This particularly noticeable for Pulau Pari northern coast.



The weight of tar balls collected decreases as width of beach increases, as seen on the graph representing the weight of tar collected at a station versus the beach width. Everywhere else is the same behaviour on a less extent and with a higher dispersion (lower correlation coefficient). However the results expressed in g/m or in g/m², the estimted means are comparable but the confidence limits of the results in g/m are considerably better than in the g/m² results. In case of data in g/m², one should also say a particular attention to survey all the sampled areas at the same tidal conditions.

III.2 - Comparision of pollution level in the studied sites

III.2.1 - KEPULAUAN SERIBU

Kepulauan Seribu in Jakarta Bay appeared in May 1984 to be about two hundred times more polluted than the other studied sites. At the sampling times, the two islands, Pulau Pari and Pulau Tikus, surveyed in this area were characterized by a great difference in stranded tar ball accumulation. The raison why more tar was deposited on Pulau Pari than on Pulau Tikus is not clear until one examines possible internal current circulation inside the lagoon, local geographical features of the site and preferential wind direction. The northern coast of Pulau Pari is situated near the main shipping lines to and from Jakarta harbour and is directly exposed to the tar pollution coming from the oil wastes ans ship spillage discharged at sea. On this area, pollution appears in the form of large agglomerated oily patches several cm deep (see photographs at the end of the report) coninuously distributed at the upper tidal zone. On account of the homogeneity of the pollution and the importance of oil penetration into the sand, the contamination seemed to result from the same oil slick. The deposits are usually in an uninterrupted longitudinal line.

The southern coast of Pulau Pari showed an aspect of tar pollution different as on the northern coast. Accumulations on the beach are very often dispersed at random. Usually oily residues were composed of small tar balss and oil patches often lying on the sea bottom at low tidal zone. Some samples were relatively soft whereas others were as hard as bituminous coal. On this side, we observed also a lot of plastic and rubber wastes probably coming from industrial discharges in Jakarta bay. So oil pollution in this area seemed to be linked more likely to local shipping activities (fishing and local transportation) and petroleum discharges (industrial and oil terminal activities) in Jakarta bay.

The pollution level was about twenty times less than on the northern coast; however the estimated mean (542 g/m) measured on this area was characteristic of a polluted zone. In contrary, the degree of tar contamination on Pulau Tikus (85,4 g/m) was low although the two islands are located in the same lagoon and were separated by less than 3 km length.

III.2.2 - COMPARISON SERIBU - RIAU

The general results for Kepulaun Seribu is: 2460 ± 1349 g/m whereas the value for Kepulauan Riau is: 16,03 ± 1,4 g/m. As the confidence limits do not overlap, it is obvious that the degree of tar pollution (in gross weight) of Kepulauan Seribu is much higher than the North-Western part of Kepulauan Riau in the Malacca straits. It could be very surprising to find so little pollution in front of Singapore Harbour and in a region of such dense a marine traffic. The reason for this could be explained by the presence of strong tide currents. In fact, it seems that the small visited islands observed in the region do not act, as Pulau Pari does, as a trap for hydrocarbons. There are no accumulations of tar but only transit. The general pollution in the Straits is going elsewhere and should be located southward along the coasts of Sumatra and Bangka or northward along the Sumatra and Malaysia coasts.

III.2.3 - COMPARISON RIAU - LANGGA

The general results at these two areas are respectively 16,03 ± 12,4 g/m (Riau) and 22,6 ± 9,3 g/m (Langga). As the confidence limits are overlapping we must use a statistical test to compare the level of pollution. We could use the WELCH test [3] and compare the value of R calculated from the expression:

$$R = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

and from the Welch's table determined with the value of:

$$B = \frac{\frac{s_1^2}{n_1}}{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

With B = 0,678, R 0,975 = 2,14 whereas the calculated R value = - 2,49.

So with a probability P = 0,975 we could conclude that the tar pollution (in gross weight) at Langga in the southern part of Makassar straits was heavier than in Kepulauan Riau (Malacca straits). However, looking only on the data expressed in gross weight may lead to incorrect evaluation and comparison between the pollution level on two sites when the values are very close from one another. So in this case, it is necessary to express the degree of tar contamination in net weight.

III.2.4 - COMPARISON RIAU - KUKUP

The general results at these two areas are respectively 16,03 $\pm$ 12,4 g/m and 7,5 $\pm$ 2,7 g/m. Here too, the confidence limits are overlapping and we must apply the WELCH test.

R = 3,87 (calculated)

B = 0,96 and p = 0,975 R = 2,31 (table)

So we could conclude that Kukup on the southern Java coast was, at the time of the sampling, the less polluted zone among the four studied test sites. It seems that because of the very strong action of the Indian ocean swell, the pollution cannot stay on the beaches. On the other hand, this region is certainly not subjected to chronic pollution but occasional one.

III - 3 - Evolution of coastal pollution between 1982 and 1984

The four test areas studied on the Indonesian coasts has been surveyed in August 1982 and in May 1984 to determine the variability of the tar pollution level according to the time of observation, the geographical location, currents systems, meteorology, oil and shipping activities. Oil dispersion and accumulation of tar balls is also very dependent on wind actions, and tidal movements. Generally the sea currents are ruled by the monsoon. The monsoon changes the direction of the currents twice a year and is practically reversed in large areas at the time when the influence is strongest. So our field survey was carried out in August and after the northwestern monsoon in May. The general estimation of coastal pollution determined during our study are gathered on the following table. The values are expressed in gram per meter of beach (g/m) of collected tar balls (in gross weight).

Location	August 1982 survey	May 1984 survey
Kepulauan Seribu	811,6	2460
Kepulauan Riau	15,44	16
Makassar Straits (Langga)	56,8	23
South Java coast (Kukup)	1	7,5

We observe an increase of the tar pollution level in Kepulauan Seribu area by a factor of about three times between August 1982 and May 1984. On the other sites no characteristic fluctuations in tar loading are noted when compared to the two surveys. To summarize this part of the discussion, Pulau Pari in Kepulauan Seribu area, acting as a trap of all wastes discharged at sea, could be considered as a good test site for further investigations. The increase of deposition in May could be due to changes in coastal circulations pattern and wind direction during the northwestern monsoon.

It is possible with the approach of monsoon conditions, that the oil wastes and ship spillage floating at sea for sometimes are washing ashore in a great deal during this time. The pollution on Pulau Pari seems to be linked to the general traffic in the region transportation of oil from the northern offshore fields to Jakarta for example. In particular on the northern coast, the oil depositions were found in soft or melted conditions due to heat and get mixed with sand to form large lumps continuously distributed along the beach. So it could be interesting to test the gradient of pollution from South (Bay of Jakarta) to North (Northern islands) in Kepulauan Seribu.

III.4 - Comparison with some reference data

The general estimation of tar pollution on some Indonesian beaches are compared with data found in the literature. We could note that the level of tar deposition was among the less polluted zones for the Indonesian test sites of Malacca ans Makassar straits whereas Kepulauan Seribu was more polluted than Kowait for example.

III.5 - Comparison of tar pollution in gross weight and in net weight

The presence of non-petroleum inclusions in the tar samples (shell, sand, water, seaweeds ...) inflated the weight of stranded tar so that the actual petroleum weight represents sometimes a low percent of the reported weights.

During our 1982 field survey we collected about 55 tar samples for determining by chemical analysis the oil content (soxhlet extraction). The percent of oil in the sample collected at a given station was calculated and used to determine the result in net weight. In this preliminary report, we have gathered in the table only the results obtained during our 1982 survey in order to compare the values in gross weight and in net weight. The average oil content in tar balls collected in the studied sites varied between 6,6 and 72,2 % (average value 36,5 ± 21,3 %). So the data expressed in net weight represents about 36 % of the reported values in gross weight. However in this study this result do not change the order in the pollution level of the studied sites. Kepulauan Seribu remains the most polluted zone. A more complete discussion will be done after receiving the results of the chemical analyses carried out in 1984.

Comparison of tar pollution levels in gross weight and in net weight in August 1982

Location	mean in gross weight [g/m]	mean in net weight [g/m]	mean in gross weight / mean in net weight
Pulau Pari southern coast	102 ± 45	25,9 ± 11,4	25,4
Pulau Pari northern coast	2867 ± 840	189 ± 55	6,6
Pulau Tikus	61,1 ± 49,4	18,1 ± 10,8	29,6
General estimation at Kepulauan Seribu	812,7 ± 219,3	67 ± 15,3	8,2
Pulau Takong	29,8 ± 18,2	8,14 ± 7	27,3
Pulau Pelampong	15,2 ± 16,5	7,6 ± 8,2	50
Pulau Nirup	11,3 ± 13,1	8,5 ± 9,9	75,2
Pulau Labon Kecil	9,6 ± 13,7	5,5 ± 7,9	57,3
Pulau Kapal Besar	24,1 ± 20,7	11,3 ± 10,1	46,9
General estimation at Kepulauan Riau	15,4 ± 5,4	7,8 ± 3,4	50,6
Makassar Straits (Langga)	56,8 ± 36,5	30,7 ± 21,2	54,1

Estimation of stranded tar ball pollution on some geographical areas

Location	date	mean weight [g/m²]	max. weight [g/m²]	mean weight [g/m]	max. weight [g/m]	References
Cap Cod (USA)	1958				45	[4] Dennis J.V. 1959
Malacca Straits (Indonesia)	1982	1,9		16		[1] CNEXO-LEMIGAS report
Trinidad and Tobago	1980			54	3000	[5] Georges et al. 1983
Gujarat (India)	1974	500	2375			[5] Georges et al. 1983
Makassar Straits (Indonesia)	1984	1,7		23		this study
North Brittany (France)	1982			190	5800	[6] CNEXO report 1983
West Brittany (France)	1984	7,1		260	540	[6] CNEXO report 1983
Bermuda	1973			700		[7] Butler et al. 1973
Kepulauan Seribu (Indonesia)	1982			812	29000	[1] CNEXO-LEMIGAS report
South California	1978				4700	[8] Straughan 1979
Kuwait	1977	200	6290	1280		[9] Oostdam et al. 1978
Kepulauan Seribu (Indonesia)	1984	363		2460		this study
Mediterranean coast (Israël)	1977			3625		[10] Wahly 1978
Gulf of Guinea	1980			9100	40000	

Pulau Pari (Northern coast)
Tar deposition at different tide levels during May 1984

Pulau Pari (Southern coast)
Tar balls deposition during May 1984

Tar deposition along the beaches on the Northern coast of Pulau Pari during May 1984

Typical oily patch found on Keplauan Seribu area (Pulau Pari northern coast) during May 1984

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Computerized calculations program

```
100 INIT
110 DIM N1(15),T(15),W(15),F(15),Y(15),S1(15),G(15),G2(15),V1(15)
120 N1=0
130 T=0
140 W=0
150 F=0
160 Y=0
170 V1=0
180 A$=""
190 PRINT "nom du site ?";
200 INPUT A$
210 PRINT "Nombre de strates ?";
220 INPUT H
230 FOR I=1 TO H
240 PRINT "longueur de la strate ";I;" ?";
250 INPUT N1(I)
260 PRINT "nombre de transect de la strate ";I;" ?";
270 INPUT T(I)
280 PRINT "moyenne de la strate ";I;" ?";
290 INPUT Y(I)
300 PRINT "ecart-type de la strate ";I;" ?";
310 INPUT S1(I)
320 NEXT I
330 N=SUM(N1)
340 A=0
350 B=0
360 C=0
370 D=0
380 FOR I=1 TO H
390 W(I)=N1(I)/N
400 F(I)=T(I)/N1(I)
410 G(I)=N1(I)↑2*(1-F(I))/T(I)
420 G2(I)=G(I)*S1(I)↑2
430 A=A+G2(I)
440 B=B+G2(I)↑2/(T(I)-1)
450 V1(I)=W(I)↑2*S1(I)↑2*(1-F(I))/T(I)
460 C=C+Y(I)*N1(I)
470 D=D+N1(I)*S1(I)
480 NEXT I
490 S=SQR(SUM(V1))
500 N2=A↑2/B
510 PRINT "le nombre de degre de liberte est :";N2;" ."
520 PRINT "quel est le t de Student ?"
530 INPUT T1
540 PRINT "l'intervalle de confiance est :"
550 PRINT USING 560:C/N;"+ou- ";T1*S
560 IMAGE 5x, 5d.2d, 2x, 5x, 3d.2d
570 PRINT "IMPRESSION ? (OUI=1, NON=0)";
580 INPUT Z
590 IF Z=0 THEN 760
600 PRINT @41:A$
610 PRINT @41:"J_J_"
620 PRINT @41:"           nh      Nh        Yh       sh      n opt"
630 PRINT @41:"J_"
640 FOR I=1 TO H
650 X=SUM(T)*N1(I)*S1(I)/D
660 PRINT @41: USING 670:I,T(I),N1(I),Y(I),S1(I),X
670 IMAGE "Strate ",2d,2x,2d,2x,7d,2x,5d.2d,5d.2d,4x,2d
680 NEXT I
690 PRINT @41:"J_"
700 PRINT @41: USING 710:N,N2,T1
710 IMAGE "N=",7d,5x,"Ne=",2d,5x,"tp=",2d.3d
720 PRINT @41:"J_"
730 PRINT @41: USING 740:C/N,T1*S
740 IMAGE "Yst = ",4d.2d," + ou - ",4d.2d
750 PRINT @41:"J_J_J_J_J_"
760 END
```

PULAU PARI (southern coast)

		nh	Nh	Yh	sh	n opt
Strate	1	15	682	1644.00	2449.00	25
Strate	2	10	1595	82.40	111.00	3
Strate	3	3	62	263.00	28.40	0

N= 2339 Ne=14 tp= 2.145

Yst = 542.51 + ou - 394.44

PULAU PARI (northern coast)

		nh	Nh	Yh	sh	n opt
Strate	1	10	672	7301.00	8425.00	11
Strate	2	3	75	4507.00	3764.00	1
Strate	3	3	113	26300.00	21888.00	5

N= 860 Ne= 9 tp= 2.262

Yst = 9553.72 + ou - 5979.47

PULAU TIKUS

		nh	Nh	Yh	sh	n opt
Strate	1	3	36	640.00	329.00	4
Strate	2	7	368	64.10	57.70	7
Strate	3	3	277	41.70	30.10	3

N= 681 Ne= 9 tp= 2.262

Yst = 85.43 + ou - 37.72

KEPULAUAN SERIBU **1984** **g/m**

		nh	Nh	Yh	sh	n opt
Strate	1	15	682	1644.00	2449.00	0
Strate	2	10	1595	82.40	111.00	1
Strate	3	3	62	263.00	28.40	0
Strate	4	10	672	7301.00	0425.00	31
Strate	5	3	75	4507.00	3764.00	2
Strate	6	3	113	26300.00	21888.00	14
Strate	7	3	36	640.00	329.00	0
Strate	8	7	368	64.10	57.70	0
Strate	9	3	277	41.70	30.10	0

N= 3880 Ne= 9 tp= 2.262

Yst = 2459.62 + ou - 1240.00

PULAU PARI (southern coast)

		nh	Nh	Yh	sh	n opt
Strata	1	15	5251	267.46	457.16	26
Strata	2	10	11324	12.10	14.65	2
Strata	3	3	428	38.66	8.33	0

N= 17003 Ne=14 tp= 2.145

Yst = 91.63 + ou - 78.36

PULAU PARI (northern coast)

		nh	Nh	Yh	sh	n opt
Strata	1	10	5376	961.20	1180.50	11
Strata	2	3	562	599.43	496.30	0
Strata	3	3	817	3875.70	3226.60	5

N= 6755 Ne= 9 tp= 2.262

Yst = 1283.60 + ou - 844.08

PULAU TIKUS

		nh	Nh	Yh	sh	n opt
Strata	1	3	191	119.03	58.32	4
Strata	2	7	2760	8.61	7.13	7
Strata	3	3	1662	6.93	5.87	3

N= 4613 Ne= 9 tp= 2.262

Yst = 12.57 + ou - 5.36

KEPULAUAN SERIBU **1984** **g/m²**

		nh	Nh	Yh	sh	n opt
Strata	1	15	5251	267.46	457.16	12
Strata	2	10	11324	12.10	14.65	1
Strata	3	3	428	38.66	8.33	0
Strata	4	10	5376	961.20	1180.50	30
Strata	5	3	562	599.43	496.30	1
Strata	6	3	817	3875.70	3226.60	13
Strata	7	3	191	119.03	58.32	0
Strata	8	7	2760	8.61	7.13	0
Strata	9	3	1662	6.93	5.87	0

N= 28371 Ne=10 tp= 2.228

Yst = 362.50 + ou - 283.87

TAKONG KECIL (northern coast, s/m)

		nh	Nh	Yh	sh	n opt
Strate	1	5	112	80.00	109.00	5

N= 112 Ne= 4 tp= 2.776

Yst = 80.00 + ou - 132.26

NIRUP 5 (s/m)

		nh	Nh	Yh	sh	n opt
Strate	1	4	77	13.00	19.90	4

N= 77 Ne= 3 tp= 3.182

Yst = 13.00 + ou - 30.83

LABON KECIL (s/m)

		nh	Nh	Yh	sh	n opt
Strate	1	5	155	4.46	3.44	6
Strate	2	4	195	1.57	1.36	3

N= 350 Ne= 6 tp= 2.447

Yst = 2.85 + ou - 1.88

KAPAL BESAR (s/m)

		nh	Nh	Yh	sh	n opt
Strate	1	5	56	64.00	60.30	6
Strate	2	3	50	15.60	21.20	2

N= 106 Ne= 5 tp= 2.571

Yst = 41.17 + ou - 37.80

KEPULAUAN RIAU (s/m) **1984**

		nh	Nh	Yh	sh	n opt
Strate	1	5	112	80.00	109.00	17
Strate	2	4	77	13.00	19.90	2
Strate	3	5	155	4.46	3.44	1
Strate	4	4	195	1.57	1.36	0
Strate	5	5	56	64.00	60.30	5
Strate	6	3	50	15.60	21.20	1

N= 645 Ne= 5 tp= 2.571

Yst = 23.76 + ou - 22.38

TAKONG KECIL (northern coast, g/m2)

		nh	Nh	Yh	sh	n opt
Strate	1	5	918	10.90	15.90	5

N= 918 Ne= 4 tp= 2.776

Yst = 10.90 + ou - 19.69

NIRUP 5 (g/m2)

		nh	Nh	Yh	sh	n opt
Strate	1	4	635	1.57	2.47	4

N= 635 Ne= 3 tp= 3.182

Yst = 1.57 + ou - 3.92

LABON KECIL (g/m2)

		nh	Nh	Yh	sh	n opt
Strate	1	5	729	1.01	0.92	7
Strate	2	4	926	0.31	0.25	2

N= 1655 Ne= 5 tp= 2.571

Yst = 0.62 + ou - 0.50

KAPAL BESAR (g/m2)

		nh	Nh	Yh	sh	n opt
Strate	1	5	784	4.56	4.29	6
Strate	2	3	850	0.91	1.25	2

N= 1634 Ne= 5 tp= 2.571

Yst = 2.66 + ou - 2.55

KEPULAUAN RIAU (g/m2) **1984**

		nh	Nh	Yh	sh	n opt
Strate	1	5	918	10.90	15.90	10
Strate	2	4	635	1.57	2.47	2
Strate	3	5	729	1.01	0.92	1
Strate	4	4	926	0.31	0.25	0
Strate	5	5	784	4.56	4.29	4
Strate	6	3	850	0.91	1.25	1

N= 4842 Ne= 5 tp= 2.571

Yst = 3.38 + ou - 3.59

LANGGA BEACH (g/m)

		nh	Nh	Yh	sh	n opt
Strate	1	5	350	28.00	5.60	2
Strate	2	7	650	19.60	15.70	10

N= 1000 Ne= 7 tp= 2.365

Yst = 22.54 + ou - 9.30

LANGGA BEACH (g/m2)

		nh	Nh	Yh	sh	n opt
Strate	1	5	4956	1.98	0.38	2
Strate	2	7	8645	1.50	1.32	10

N= 13601 Ne= 6 tp= 2.447

Yst = 1.68 + ou - 0.79

SERIBU 82 nw

		nh	Nh	Yh	sh	n opt
Strate	1	10	375	80.40	84.10	9
Strate	2	15	2260	16.90	18.30	12
Strate	3	2	820	3.10	0.09	0
Strate	4	11	258	623.00	315.00	23
Strate	5	3	51	70.40	15.20	0
Strate	6	3	46	1205.60	649.90	9
Strate	7	5	330	5.25	5.79	1
Strate	8	4	380	23.60	13.33	1
Strate	9	3	17	144.40	132.00	1

N= 4537 Ne=16 tp= 2.120

Yst = 66.97 + ou - 15.30

SERIBU 82 sw

		nh	Nh	Yh	sh	n opt
Strate	1	10	375	316.50	331.05	3
Strate	2	15	2260	66.40	72.23	5
Strate	3	2	820	47.00	1.41	0
Strate	4	11	258	9440.90	4773.20	34
Strate	5	3	51	1166.70	230.90	0
Strate	6	3	46	18266.70	9847.50	13
Strate	7	5	330	78.30	86.40	1
Strate	8	4	380	26.25	14.00	0
Strate	9	3	17	505.00	464.20	0

N= 4537 Ne=11 tp= 2.220

Yst = 812.70 + ou - 219.30

LANGGA 82 nw

		nh	Nh	Yh	sh	n opt
Strate	1	4	200	52.00	39.10	3
Strate	2	5	711	24.70	21.80	6

N= 911 Ne= 6 tp= 2.447

Yst = 30.69 + ou - 21.27

TAKONG 82 nw

	nh	Nh	Yh	sh	n opt
Strate 1	5	79	10.00	4.90	2
Strate 2	4	128	7.00	7.90	7

N= 207 Ne= 4 tp= 2.776

Yst = 8.14 + ou - 7.04

RIAU 82 nw

	nh	Nh	Yh	sh	n opt
Strate 1	7	175	0.97	0.86	1
Strate 2	4	261	3.46	4.75	5
Strate 3	3	48	63.70	51.40	10
Strate 4	5	79	10.10	4.90	2
Strate 5	4	128	7.00	7.90	4
Strate 6	8	271	7.60	10.90	11
Strate 7	4	190	1.85	1.35	1
Strate 8	4	126	10.90	12.40	7
Strate 9	7	108	11.30	10.00	5

N= 1206 Ne= 9 tp= 2.262

Yst = 7.82 + ou - 3.26