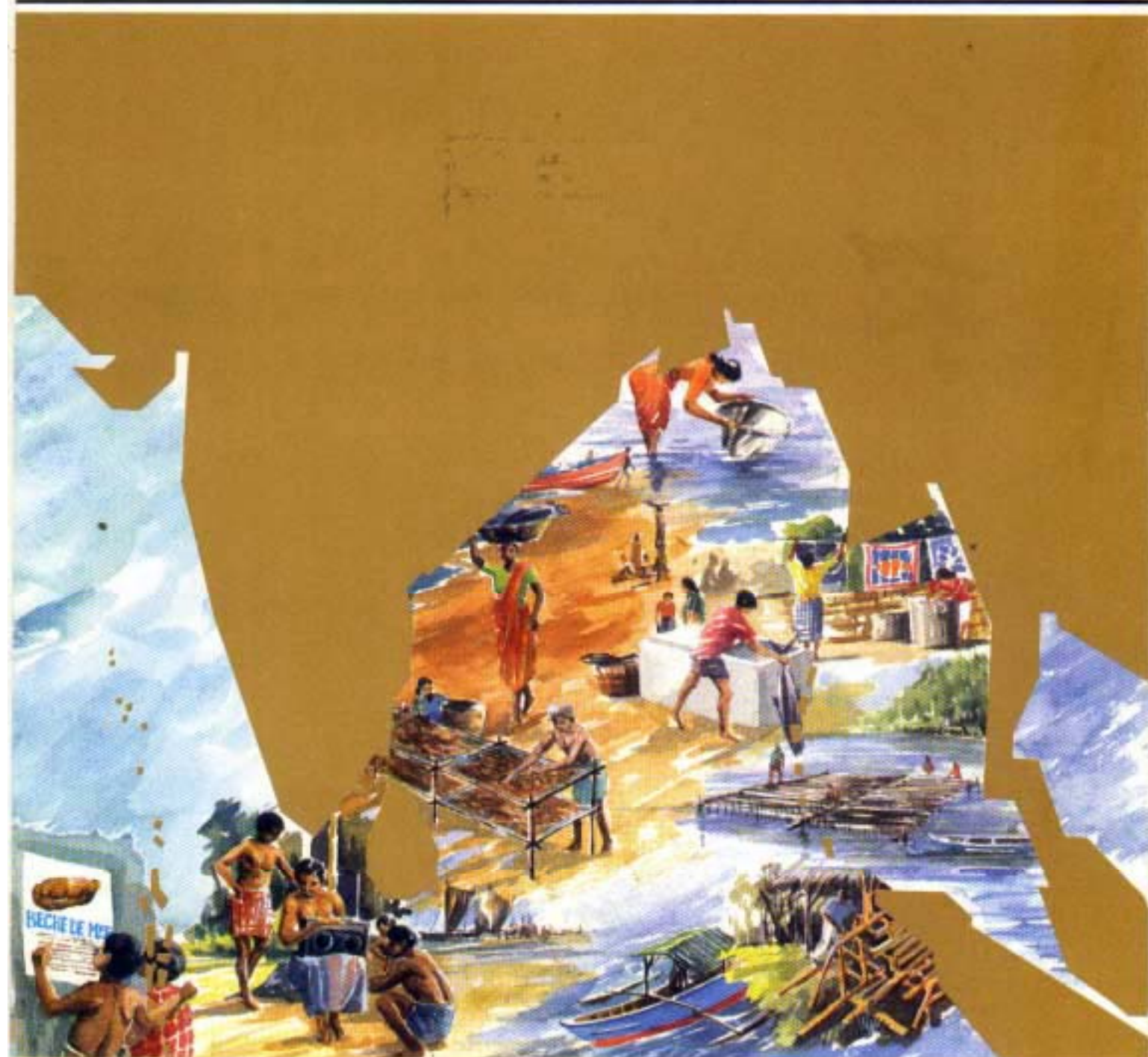


**BOBP/WP/99**



# **Biosocioeconomics of Fishing for Shrimp in the Langkat District, on the East Coast of North Sumatera, Indonesia**



**BOBP**

For Fisheries Development  
**BAY OF BENGAL PROGRAMME**

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BOBP/WP/99

Small-scale Fisherfolk Communities  
Bioeconomics of Small-scale Fisheries

GCPIRAS/1 18/MUL  
RAS/9 1/006

Biosocioeconomics of fishing for shrimp in the Langkat District,  
on the east coast of North Sumatera, Indonesia

by

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**BAY OF BENGAL PROGRAMME**

Madras, India  
**1994**

The North Sumatera Province of Sumatera, Indonesia, has access to marine resources on the east coast (Malacca Straits) as well as the west coast (Indian Ocean). A project to make a biosocioeconomic assessment of the methods being used to catch shrimp was undertaken by the Provincial Fishery Service (PFS) of North Sumatera with assistance from the Bay of Bengal Programme (BOBP).

Amongst other objectives, the project intended to examine management options to improve yield and revenue from shrimp resources, bearing in mind the effects of such measures on the community. The east coast is rich in shrimp resources. Langkat District, bordering the Malacca Strait, where small-scale fisheries, and particularly the production of shrimp, is an important feature, was selected as the area to be studied.

Based on the distribution of fishing villages spread out along the coast of Langkat District and the various fishing gear operated by fisherfolk to exploit the different shrimp resources in the area, a procedure of stratified random sampling was adopted for data-collection in five strata and at twelve sampling locations. Data were collected from April 1992 to March 1993 for five types of shrimp fishing gear and this was used to estimate biological and economic parameters of the shrimp fishery. A socio-economic survey of 112 villages was also conducted. The investigations were done under the Bay of Bengal Programme's (BOBP's) 'Small-scale Fisherfolk Communities' project funded by DANIDA and SIDA and the reporting under 'Bioeconomics of Small-scale Fisheries' funded by UNDP.

The Bay of Bengal Programme (BOBP) is a multiagency regional fisheries programme which covers seven countries around the Bay of Bengal — Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand. The Programme plays a catalytic and consultative role: it develops, demonstrates and promotes new technologies, methodologies and ideas to help improve the conditions of small-scale fisherfolk communities in member countries. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, and also by UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

This document is a working paper and has not been cleared by the Government concerned or the FAO.

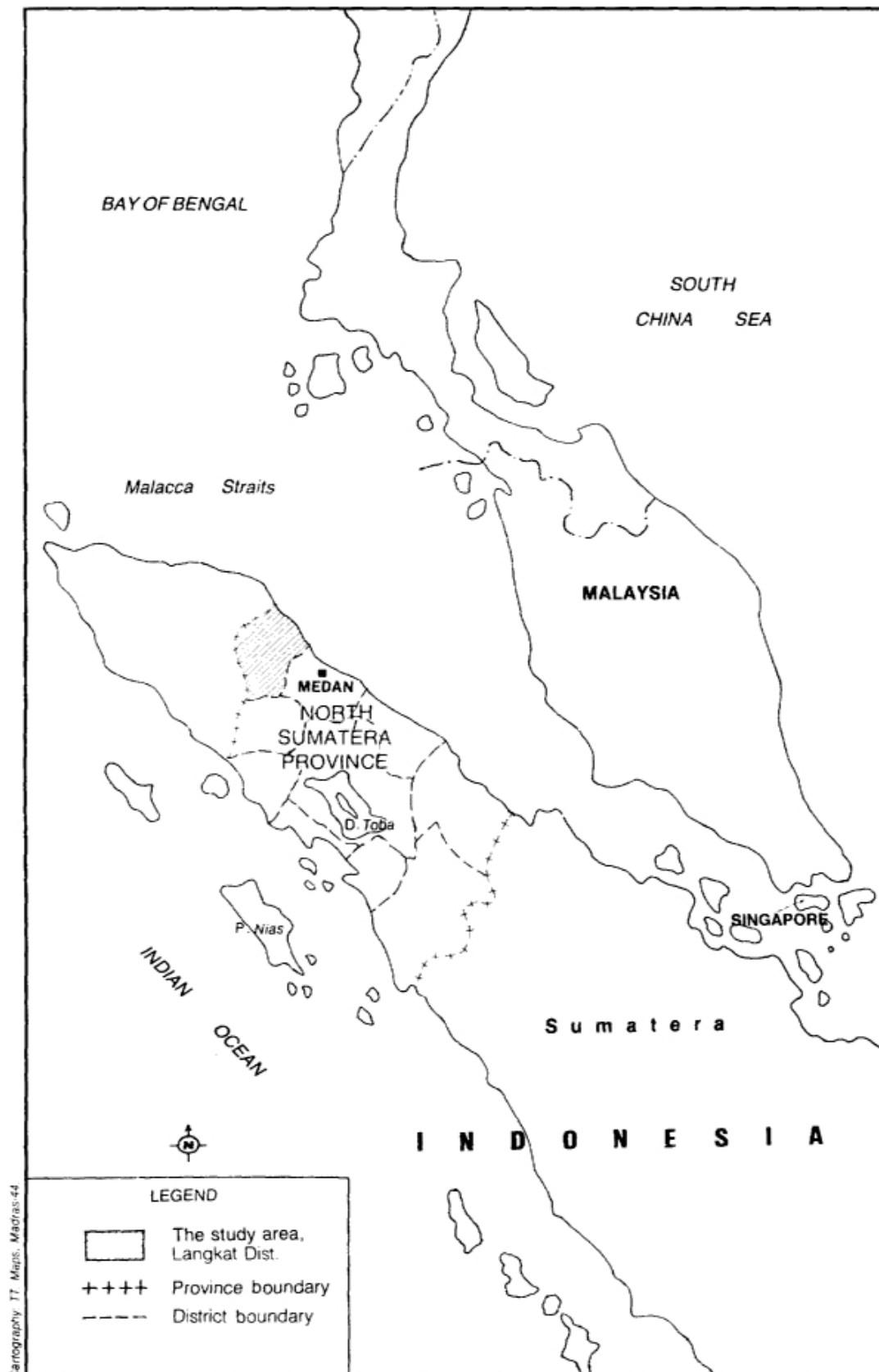
June 1994

Published by the Bay of Bengal Programme, 91 St. Mary's Road, Abhiramapuram, Madras 600 018, India, Designed and typeset for the BOBP by PACE Systems, Madras 600 028, and printed by MWN Press, Madras 600 005.

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Fig 1. Map of the Malacca Straits area showing the North Sumatera Province of Sumatera, Indonesia, both its coasts and the study area, Langkat District



# 1. INTRODUCTION

## 1.1 Fisheries in North Sumatera Province

The North Sumatera Province of Sumatera, Indonesia, has access to marine resources on the east coast (Malacca Straits) as well as the west coast (Indian Ocean) (see Figure 1 on facing page). It was estimated in 1980 that these two regions have Maximum Sustainable Yields (MSY) as shown in Table 1.

**Table 1: Maximum Sustainable Yield of the exploited resources of North Sumatera Province (in tonnes)**

| <i>Resource components</i> | <i>East coast region (Malacca Straits)</i> | <i>West coast region (Indian Ocean)</i> |
|----------------------------|--|---|
| Demersal fish              | 110,000                                    | 50,350                                  |
| Pelagic fish               | 126,500                                    | 226,110                                 |
| Coral fish                 | 6,802                                      | 12,638                                  |
| Shrimp                     | 20,000                                     | 850                                     |
| Total                      | 263,302                                    | 289,938                                 |

Under the 1986 Five-Year Development Plan, and the fisheries development strategy

*Source:* Directorate General of Fisheries, 1980

adopted in North Sumatera Province, six programmes have been initiated to ensure optimum utilization of these marine resources. They are:

- The Fisheries Enterprises and Agribusiness Sustainable Programme;
- The Fisheries Production Development Programme;
- The Post-harvest Technology and Marketing Programme;
- The Human Resources Quality Improvement Programme;
- The Fisheries Aquatic Resources and Environment Management Programme; and
- The Fisheries Extension Programme.

The impact of these programmes on fisheries production, per capita consumption and foreign exchange earnings from fisheries in North Sumatera Province between 1986 and 1990 is shown in Table 2.

**Table 2: Fisheries production, average consumption of fish and export value, in North Sumatera Province (1986 - 1990)**

| <i>Items</i>                | <i>1986</i> | <i>1987</i> | <i>1988</i> | <i>1989</i> | <i>1990</i> |
|-----------------------------|-------------|-------------|-------------|-------------|-------------|
| <b>Total production (t)</b> | 189,956.7   | 201,451.2   | 203,119.0   | 234,133.7   | 250,728.5   |
| MARINE FISHERIES (t)        |             |             |             |             |             |
| - Capture                   | 175,908.0   | 186,807.4   | 187,397.0   | 201,288.1   | 220,807.7   |
| - Mariculture               | —           | —           | —           | —           | 16.0        |
| INLAND FISHERIES (t)        |             |             |             |             |             |
| - Open water                | 5457.8      | 5847.3      | 6176.0      | 6279.9      | 6004.1      |
| - Capture                   | 2743.7      | 2816.9      | 3200.8      | 3274.1      | 3835.1      |
| - Cage culture              | 283.6       | 353.8       | 191.0       | 185.2       | 140.4       |
| - Floating net              | —           | —           | —           | —           | —           |
| - Brackishwater             | 1707.8      | 2591.0      | 2980.8      | 17,886.0    | 16,055.0    |
| - Ricefield culture         | 3649.8      | 2847.1      | 2996.5      | 3555.2      | 3695.2      |
| - Intensive culture         | 206.0       | 186.9       | 176.9       | 1665.2      | 175.0       |
| <b>Export</b>               |             |             |             |             |             |
| - Volume (t)                | 13,042.9    | 17,269.2    | 18,603.6    | 27,492.5    | 3695.7      |
| - Value (US\$ 1000)         | 48,596.9    | 66,052.5    | 87,140.5    | 138,658.2   | 175.0       |
| <b>Fish consumption</b>     |             |             |             |             |             |
| - Per capita per year (kg)  | 17.40       | 17.51       | 17.65       | 17.65       | 17.78       |

A project to make a biosocioeconomic assessment of the methods being used to catch shrimp was undertaken by the Provincial Fishery Service (PFS) of North Sumatera with assistance from the Bay of Bengal Programme (BOBP). The main objectives were to:

- Examine management options to improve yield and revenue from shrimp resources, bearing in mind the effects of such measures on the community;
- Assess the bioeconomics of fishing for shrimp by small-scale fisherfolk;
- Link the socioeconomics of the fisherfolk to the fishing activity; and
- Enable a better understanding of the interaction between different fishing methods and the different groups of fisherfolk who practise them.

The east coast (Malacca Straits) is rich in shrimp resources (refer Table 1). And these resources, together with demersal, pelagic and coral fish, are exploited in Langkat, Asahan, Deli Serdang, Medan, Tanjung Balai and Labuhan Batu Districts to meet the demands of domestic consumption and export.

Langkat District, bordering the Malacca Straits, where small-scale fisheries, and particularly the production of shrimp, is an important feature, was selected as the area to be studied. Total fisheries production had increased in Langkat District from 10,420 t in 1987 to 14,764 t in 1991. And shrimp production from 1,172 to 1,185 t.

The various fishing gear used to catch shrimp in North Sumatera include the set bagnet, liftnet, beach seine, Danish seine, gillnet and trammelnet. The dominant fishing gear in Langkat are

- trammelnet (TRN) (*Jaring Apollo and Jaring Taiwan*),
- shrimp gillnet (SGN) (*Pukat Udang and Jaring Planet*), and
- set bagnet (SBN) (*Ambai*).

The craft using these fishing gear are nonmotorized boats, outboard motorized boats and inboard motorized boats. They generally fish 5-7 km from shore.

The major species of marine shrimp in Langkat that fishermen target are Banana shrimp (*P. merguensis*), Indian white shrimp (*P. indicus*), *Metapenaeus* sp. — primarily Yellow shrimp (*M. brevicornis*) and Speckled shrimp (*M. monoceros*) — Tiger shrimp (*P. monodon*) and Kiddi shrimp (*Parapenaeopsis styliifera*). The main demersal finfish captured are Croaker (*Scianidae*), Flatfish (*Psettodidae*), Ponyfish (*Leiognathidae*), Catfish (*Tachyurusidae*), Sweetlip (*Pomadasidae*) and Stingrays (*Dasyatidae*).

The study, and consequently the analysis, was restricted to the following species of shrimp,

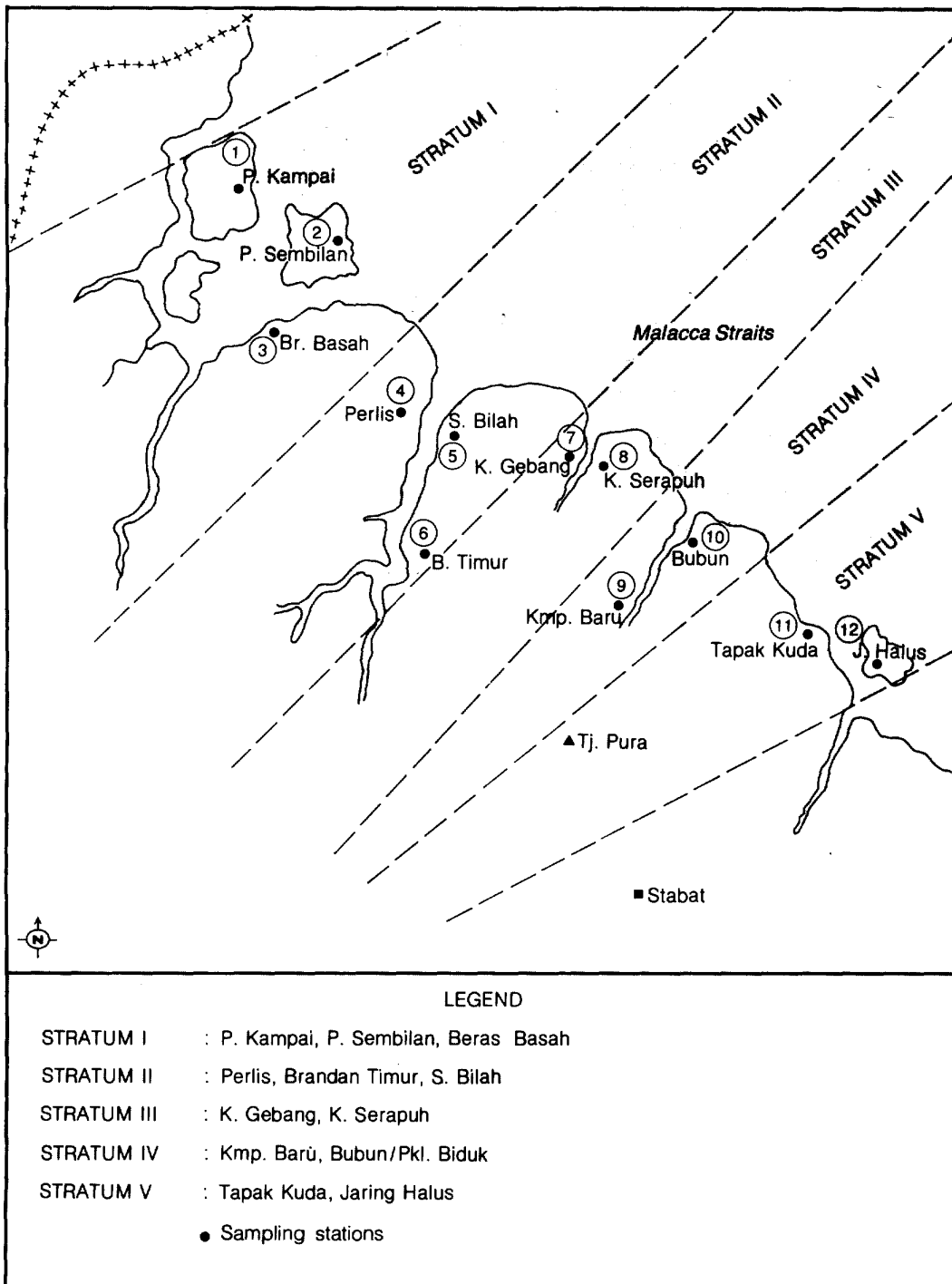
- Tiger shrimp,
- Banana shrimp,
- White shrimp, and
- Brown shrimp,

caught by trammelnets (TRN), shrimp gillnets (SGN) and set bagnets (SBN). As two different types of TRN and SON are used, they have been designated TRN1 and TRN2 and SGN1 and SGN2. Finfish catches with these gear have also been included in the catch, as their catch rates are significant when using SBN and SGN.

## 2. METHODOLOGY

Based on the distribution of fishing villages spread out along the coast of Langkat District and the various fishing gear operated by fisherfolk to exploit shrimp resources in the area, a procedure of stratified random sampling was adopted for data-collection. Figure 2 shows the five strata and twelve sampling locations, all major landing centres.

Fig 2. Map showing the five strata and 12 sampling stations in Langkat District, Sumatera, Indonesia





Stratum I has an open coast with moderate surf. The beach is sandy and wide. Stratum II has a shallow beach with mangroves along it. Stratum III is close to the major river, Sepung Besar. The remaining stretch of the coastline of the study area is the delta of the Sepung Besar. Mangroves grow along the beach discontinuously. The bottom sediment is usually muddy-sand and sandy upto about 10m depth, then rocky upto about 30 m depth.

For the socioeconomic study, eight villages were selected from among the sampling locations in the five strata, as shown in Table 3.

**Table 3: Distribution of survey locations/villages**

| <i>Strata No.</i> |    | <i>Main landing places/villages selected</i> | <i>Bioeconomic survey</i> | <i>Socioeconomic survey</i> |
|-------------------|----|--|---------------------------|-----------------------------|
| I                 | I  | Pulau Kampai                                 | v                         | -                           |
|                   | 2  | Pulau Sembilan                               | v                         | v                           |
|                   | 3  | Beras Basah                                  | v                         | -                           |
| II                | 4  | Perlis                                       | v                         | -                           |
|                   | 5  | Sungai Bilah                                 | v                         | v                           |
|                   | 6  | Brandan Timur                                | v                         | v                           |
| III               | 7  | Kuala Gebang                                 | v                         | v                           |
|                   | 8  | Kuala Serapuh                                | v                         | v                           |
| IV                | 9  | Kampung Baru                                 | v                         | v                           |
|                   | 10 | Pengkalan Biduk/Bubun                        | v                         | v                           |
| V                 | II | JaringHalus                                  | v                         | v                           |
|                   | 12 | Tapak Kuda Baru                              | v                         | v                           |

The distribution of fishing gear in the main landing centres is shown in Table 4.

**Table 4: Distribution of fishing gear by main landing places/villages in the five strata**

| <i>No.</i> | <i>Main landing places</i> | <i>Shrimp gillnet</i> |             | <i>Trammelnet</i> |             | <i>Set bagnet SBN</i> |
|------------|----------------------------|-----------------------|-------------|-------------------|-------------|-----------------------|
|            |                            | <i>SGN1</i>           | <i>SGN2</i> | <i>TRN1</i>       | <i>TRN2</i> |                       |
| I.         | Beras Basah                | 47                    | -           | 47                | -           | 15                    |
| 2.         | Pulau Kampai               | -                     | -           | 75                | -           |                       |
| 3.         | Pulau Sembilan             | -                     | -           | 28                | -           | 40                    |
| 4.         | Brandan Timur              | 28                    | -           | 30                | -           | 8                     |
| 5.         | Sungai Bilah               | 70                    | -           | 194               | -           | 81                    |
| 6.         | Perlis                     | 5                     | -           | 164               | -           | 15                    |
| 7.         | Kuala Serapuh              | -                     | 60          | 124               | -           | 16                    |
| 8.         | Kuala Gebang               | -                     | 15          | 25                | -           | 97                    |
| 9.         | Kampung Baru               | -                     | -           | -                 | 65          | -                     |
| 10.        | Pkl. Biduk/Bubun           | -                     | 373         | 102               | -           | 8                     |
| 11.        | Jaring Halus               | -                     | 9           | 250               | -           | 32                    |
| 12.        | Tapak Kuda Baru            | -                     | 69          | 40                | -           | 32                    |
|            | Total                      | 150                   | 506         | 1079              | 65          | 344                   |

## 2.1 Bioeconomics

Data were collected from April 1992 to March 1993 for the five types of shrimp fishing gear. This was used to estimate biological and economic parameters, viz, growth parameters, fishing and natural mortality, recruitment, species composition of shrimp, catch, fishing effort, as well as cost and earnings for different fishing gear operations.

Ten samples of each type of fishing gear, in each stratum, were selected for monthly observation.

The shrimp catch is, usually, commercially graded according to species and size and the different grades are placed in separate baskets. Sample length-frequencies (carapace-length) and price of each species according to commercial grade were recorded for each gear-craft combination. Besides this, catch records — maintained at the landing centres by the *towke* — of landings, number of trips and number of operations conducted each month, quantity landed by each craft and value of the catch, were also used.

From this data, the catch per operation and catch per day or catch per trip were estimated for each craft-gear combination. This was used to calculate the monthly production of each species by each fishing gear (Tables 6a-c on pages 7, 8 and 9). Average catch rates are shown in Tables 7a-c on pages 10, 11 and 12.

Production by each gear, per month and stratum were used to raise length-frequency data to the catch-at-length. The catch-at-length data from all five strata were pooled for each species for various population parameter estimations.

The average fishing mortality, natural mortality, recruitment pattern, lengths at 50 per cent and 75 per cent probability of capture were estimated by using the Compleat ELEFAN package (Gayanillo, Seriano and Pauly, 1989).

The ELEFAN package was used to carry out the Beverton and Holt yield per recruit and biomass per recruit analysis.

The length-cohort analysis programme, in the LFSA package (Sparre, 1987), was used to establish fishing mortality values for each length class caught and the  $F_{\max}$  values. These were used in a Thompson and Bell prediction analysis to obtain yields of each species as well as all species combined with each fishing gear.

## 2.2 Socioeconomics

A village profile and a frame survey were conducted in order to identify the general situation in a village, such as land use, population structure, physical and socioeconomic infrastructure and household data by type of household.

A baseline socioeconomic survey was, then, conducted by sampling 10-20 per cent of the households in the selected villages. Besides 22 fishing households sampled, 66 nonfishing households,

selected randomly, were sampled (Table 5). There were various difficulties in surveying a larger number of nonfishery households.

**Table 5: Villagewise household distribution and number sampled**

| <i>Main landing places</i> | <i>Household population</i> |               |              | <i>Household samples</i> |              |              | <i>%</i>   |
|----------------------------|-----------------------------|---------------|--------------|--------------------------|--------------|--------------|------------|
|                            | <i>FFH</i>                  | <i>NFHH</i>   | <i>Total</i> | <i>FHH</i>               | <i>NFHH</i>  | <i>Total</i> | <i>FHH</i> |
| Beras Basah                | 336                         | 1366          | 1704         | —                        | —            | —            | —          |
| Pulau Kampai               | 320                         | 337           | 657          | 64                       | 15           | 79           | 20.0       |
| Pulau Sembilan             | 178                         | 80            | 258          | —                        | —            | —            | —          |
| Brandan Timur              | 68                          | 1869          | 2135         | —                        | —            | —            | —          |
| Sungai Bilah               | 632                         | 1181          | 1813         | 119                      | 18           | 137          | 18.0       |
| Perlis                     | 881                         | 49            | 930          | 139                      | 5            | 144          | 15.8       |
| Kuala Serapuh              | 217                         | 195           | 412          | —                        | —            | —            | —          |
| Kuala Gebang               | 250                         | 43            | 293          | 50                       | 5            | 55           | 20.0       |
| Pkl.Biduk/Bubun            | 422                         | 29            | 451          | 86                       | -            | 86           | 20.4       |
| Kampung Baru               | 431                         | 1115          | 1546         | 51                       | 5            | 56           | 11.8       |
| Jaring Halus               | 360                         | 50            | 410          | 74                       | 13           | 87           | 20.8       |
| Tapak Kuda Baru            | 265                         | 36            | 292          | 39                       | 5            | 44           | 15.0       |
| Total                      | 4360<br>(40%)               | 6350<br>(60%) | 10,710       | 622<br>(90%)             | 66<br>(9.6%) | 688          | 14.3       |

Note: FHH: Fishing household (may also be engaged in other activities)  
 NFHH: Nonfishing household (Not involved in fishing activities)

The baseline socioeconomic survey compiled data on:

- Household members by sex, age, level of education, income activities.
- Living conditions of fisherfolk.
- Fishing, fishery-related and nonfishery activities and incomes.
- Ownership of fishing craft and gear.
- Sharing system.
- Indebtedness.
- Saving and investment.
- Household expenditure.

Due to limitations in the skill of the personnel assigned for sampling, data compilation and supervision, both bioeconomic and socioeconomic data collected suffered from errors in species separation, length-frequency sampling, separation of craft-gear combinations etc.

### 3. **BIOECONOMIC FINDINGS**

#### 3.1 *Species composition*

The analysis of the species caught by the different gear in the five strata is presented in the following pages. There are wide variations in catch composition among the gear as well as the strata.

# SHRIMP GILLNET (SON 1 and 2)

The catch by SGN 1 and 2 in the five strata indicated (Table 6a) that finfish dominated Stratum I with 95.2 per cent, were 36.7 per cent in Stratum II and 40.3 per cent in Stratum IV, but were below 10 per cent in Strata III and V. The species of finfish caught included Croaker (*Sciaenidae*), Goatfish (*Uppeneus* spp.), Stingrays (*Dasaytidae*), Catfish (*Arius* spp.), Bonyfish (*Leiognathidae*) etc.

Among the shrimp species, Tiger shrimp occurred in significant quantities in Stratum IV (12.4%), but were much less in other strata. Though the Banana shrimp and the Indian white shrimp are similar in their distribution, their compositions varied in the different strata. In Stratum III and Stratum V, Banana shrimp accounted for 70.5 per cent and 50.6 per cent of the catch respectively, whereas in Strata II and IV they were less and occurred in nearly equal proportions (20%).

Other species of shrimp caught were mainly Yellow shrimp, Speckled shrimp and Kiddi shrimp. These occurred in higher proportions in Stratum II (26.2%) and Stratum V (23.9%).

**Table 6a: Monthly production by species in shrimp gillnet catch in Langkat District, and annual average species composition (%)**

| Species             | May<br>92 | Jun.<br>92 | Jul.<br>92 | Aug.<br>92 | Sep.<br>92 | Oct.<br>92 | Nov.<br>92 | Dec.<br>92 | Jan.<br>93 | Feb.<br>93 | Mar.<br>93 | Apr.<br>93 | Total    | %      |
|---------------------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|----------|--------|
| <b>Stratum I</b>    |           |            |            |            |            |            |            |            |            |            |            |            |          |        |
| Tiger shrimp        | 0.00      | 0.00       | 1.62       | 0.15       | 0.00       | 0.00       | 0.03       | 0.62       | 0.00       | 0.00       | 0.00       | 0.00       | 2.42     | 0.2    |
| Banana shrimp       | 0.00      | 0.00       | 1.50       | 11.26      | 1.22       | 1.46       | 0.70       | 2.30       | 1.12       | 1.01       | 3.52       | 1.00       | 25.09    | 2.3    |
| Indian white shrimp | 0.00      | 0.00       | 0.00       | 0.96       | 0.00       | 0.17       | 0.63       | 0.00       | 0.13       | 0.00       | 1.22       | 0.00       | 3.11     | 0.3    |
| Brown shrimp        | 0.00      | 0.00       | 0.00       | 3.44       | 1.88       | 1.64       | 4.88       | 3.79       | 2.73       | 2.84       | 3.24       | 0.00       | 24.44    | 2.0    |
| Finfish             | 0.00      | 0.00       | 98.40      | 1.75       | 217.72     | 26.78      | 80.40      | 136.25     | 37.96      | 97.91      | 332.84     | 63.26      | 1,093.27 | 95.2   |
| Total               | 0.00      | 0.00       | 101.52     | 17.56      | 220.82     | 30.05      | 86.64      | 142.96     | 41.94      | 101.76     | 340.82     | 64.26      | 1,148.33 | 100.00 |
| <b>Stratum II</b>   |           |            |            |            |            |            |            |            |            |            |            |            |          |        |
| Tiger shrimp        | 0.00      | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.06       | 0.02       | 0.08     | 0.01   |
| Banana shrimp       | 17.00     | 17.00      | 0.00       | 0.00       | 0.00       | 2.18       | 42.94      | 0.00       | 6.50       | 13.30      | 3.02       | 0.97       | 102.91   | 17.08  |
| Indian white shrimp | 0.00      | 0.00       | 0.00       | 0.00       | 2.75       | 3.53       | 0.00       | 3.54       | 12.48      | 91.23      | 2.62       | 4.33       | 120.48   | 20.00  |
| Brown shrimp        | 0.00      | 0.56       | 4.22       | 0.00       | 4.22       | 8.09       | 13.21      | 3.89       | 21.13      | 81.26      | 17.25      | 3.95       | 157.78   | 26.19  |
| Finfish             | 0.00      | 1.62       | 0.00       | 0.00       | 0.00       | 25.54      | 0.00       | 0.00       | 119.94     | 0.00       | 56.45      | 17.57      | 221.12   | 36.71  |
| Total               | 17.00     | 19.18      | 4.22       | 0.00       | 6.97       | 39.34      | 56.15      | 7.43       | 160.05     | 185.79     | 79.40      | 26.84      | 602.37   | 100.00 |
| <b>Stratum III</b>  |           |            |            |            |            |            |            |            |            |            |            |            |          |        |
| Tiger shrimp        | 4.85      | 0.18       | 0.17       | 0.00       | 0.62       | 1.35       | 0.03       | 0.13       | 0.49       | 0.10       | 0.17       | 0.03       | 8.12     | 7.09   |
| Banana shrimp       | 52.06     | 1.13       | 3.03       | 0.00       | 2.95       | 9.87       | 1.49       | 3.63       | 0.40       | 0.89       | 3.98       | 1.33       | 80.76    | 70.55  |
| Indian white shrimp | 0.00      | 0.00       | 0.00       | 0.00       | 0.21       | 0.00       | 0.00       | 0.19       | 0.00       | 0.00       | 1.75       | 0.14       | 2.29     | 2.00   |
| Brown shrimp        | 7.70      | 0.25       | 0.00       | 0.00       | 1.48       | 2.47       | 0.43       | 1.69       | 0.93       | 1.07       | 2.97       | 3.72       | 22.71    | 19.84  |
| Finfish             | 0.59      | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.00       | 0.59     | 0.52   |
| Total               | 65.20     | 1.56       | 3.20       | 0.00       | 5.26       | 13.69      | 1.95       | 5.64       | 1.82       | 2.06       | 8.87       | 5.22       | 114.47   | 100.00 |
| <b>Stratum IV</b>   |           |            |            |            |            |            |            |            |            |            |            |            |          |        |
| Tiger shrimp        | 0.00      | 0.00       | 0.00       | 0.00       | 2.11       | 2.77       | 0.81       | 0.00       | 0.00       | 0.00       | 0.00       | 5.69       | 11.38    | 12.36  |
| Banana shrimp       | 1.42      | 0.00       | 0.00       | 0.00       | 0.74       | 4.29       | 6.33       | 2.71       | 0.38       | 1.92       | 0.44       | 0.00       | 18.23    | 19.79  |
| Indian white shrimp | 0.00      | 0.00       | 0.00       | 0.00       | 0.64       | 4.57       | 1.10       | 6.92       | 1.73       | 2.20       | 1.81       | 0.00       | 18.97    | 20.60  |
| Brown shrimp        | 0.00      | 0.00       | 0.00       | 0.00       | 0.37       | 2.05       | 2.32       | 0.46       | 1.13       | 0.12       | 0.00       | 0.00       | 6.45     | 7.00   |
| Finfish             | 0.79      | 0.00       | 0.00       | 0.00       | 1.93       | 3.42       | 0.00       | 1.80       | 12.29      | 16.14      | 0.70       | 0.00       | 37.07    | 40.25  |
| Total               | 2.21      | 0.00       | 0.00       | 0.00       | 5.79       | 17.10      | 10.56      | 11.89      | 15.53      | 20.38      | 2.95       | 5.69       | 92.10    | 100.00 |
| <b>Stratum V</b>    |           |            |            |            |            |            |            |            |            |            |            |            |          |        |
| Tiger shrimp        | 0.00      | 0.64       | 0.00       | 0.00       | 0.00       | 0.13       | 0.27       | 0.00       | 0.00       | 0.00       | 0.47       | 0.00       | 1.51     | 2.14   |
| Banana shrimp       | 0.37      | 2.44       | 0.00       | 0.00       | 2.12       | 1.76       | 4.29       | 16.08      | 1.76       | 3.24       | 2.33       | 1.35       | 35.74    | 50.60  |
| Indian white shrimp | 0.09      | 1.08       | 0.00       | 0.00       | 0.51       | 1.54       | 1.01       | 1.19       | 0.89       | 0.00       | 0.49       | 1.79       | 8.59     | 9.33   |
| Brown shrimp        | 0.09      | 1.39       | 0.00       | 0.00       | 0.12       | 1.07       | 2.25       | 4.10       | 0.56       | 2.04       | 0.47       | 4.78       | 16.87    | 23.89  |
| Finfish             | 0.00      | 0.23       | 0.00       | 0.00       | 0.00       | 0.00       | 7.50       | 0.19       | 0.00       | 0.00       | 0.00       | 0.00       | 7.92     | 11.21  |
| Total               | 0.55      | 5.78       | 0.00       | 0.00       | 2.75       | 4.50       | 15.32      | 21.56      | 3.21       | 5.28       | 3.76       | 7.92       | 70.63    | 97.16  |

## SET BAGNET (SBN)

The catch by the SBN indicated (Table 6b) that finfish were dominant in Strata I, II and V, whereas in Stratum III shrimp were dominant. No SBN were operated in Stratum IV. Tiger shrimp catches with SBN were generally very low in all the strata, except III. Banana shrimp catches were greater in Strata III and V than in the other strata. The catch of White shrimp was very low in all strata, except II. Other shrimp (*Metapenaeus* spp.) accounted for nearly half the catch in Strata II and III, but in Strata I and V they were only about 10 per cent of the catch. Overall, the catch composition of SBN in all strata was dominated by finfish (47.3%), followed by other penaeid shrimp (*Metapenaeus* spp.) (28.8%), White shrimp (10%) and Banana shrimp (8.1%).

**Table 6b: Monthly production by species in set bagnet catch in Langkat District and annual average species composition (%)**

| <i>Species</i>      | <i>May</i><br><b>92</b> | <i>Jun.</i><br>92 | <i>Jul.</i><br>92 | <i>Aug.</i><br>92 | <i>Sep.</i><br>92 | <i>Oct.</i><br>92 | <i>Nov.</i><br>92 | <i>Dec.</i><br>92 | <i>Jan.</i><br>93 | <i>Feb.</i><br>93 | <i>Mar.</i><br>93 | <i>Apr.</i><br>93 | <i>Total</i>    | <i>%</i>      |
|---------------------|-------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-----------------|---------------|
| <b>Stratum I</b>    |                         |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                 |               |
| Tiger shrimp        | 0.06                    | 1.80              | 0.36              | 0.66              | 0.00              | 0.00              | 0.11              | 0.04              | 0.00              | 0.00              | 0.00              | 0.12              | 3.15            | 0.41          |
| Banana shrimp       | 6.02                    | 1.41              | 0.78              | 4.42              | 2.27              | 2.72              | 2.37              | 3.21              | 1.08              | 1.54              | 1.54              | 3.05              | 30.41           | 3.97          |
| Indian white shrimp | 0.00                    | 4.40              | 1.90              | 1.09              | 0.00              | 1.81              | 3.07              | 0.23              | 0.17              | 0.00              | 0.06              | 4.55              | 17.28           | 2.26          |
| Brown shrimp        | 3.97                    | 2.12              | 0.53              | 3.10              | 10.91             | 8.13              | 1.99              | 10.24             | 3.99              | 7.96              | 7.38              | 9.97              | 70.29           | 9.18          |
| Finfish             | 1.24                    | 22.48             | 42.73             | 1.66              | 107.81            | 70.16             | 54.90             | 71.20             | 73.21             | 85.38             | 49.70             | 64.00             | 644.47          | 84.18         |
| <b>Total</b>        | <b>11.29</b>            | <b>32.21</b>      | <b>46.30</b>      | <b>10.93</b>      | <b>120.99</b>     | <b>82.82</b>      | <b>62.44</b>      | <b>84.92</b>      | <b>78.45</b>      | <b>94.88</b>      | <b>58.68</b>      | <b>81.69</b>      | <b>765.60</b>   | <b>100.00</b> |
| <b>Stratum II</b>   |                         |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                 |               |
| Tiger shrimp        | 0.00                    | 0.19              | 6.32              | 0.00              | 0.00              | 0.00              | 0.00              | 0.04              | 0.00              | 0.00              | 0.01              | 0.30              | 6.86            | 0.37          |
| Banana shrimp       | 4.68                    | 3.90              | 11.37             | 0.00              | 1.36              | 2.07              | 21.53             | 1.08              | 112.05            | 2.61              | 0.97              | 11.61             | 173.23          | 9.41          |
| Indian white shrimp | 0.31                    | 0.00              | 12.00             | 0.00              | 1.88              | 5.80              | 21.90             | 4.08              | 203.04            | 3.53              | 4.39              | 3.03              | 259.96          | 14.12         |
| Brown shrimp        | 5.14                    | 1.33              | 2.45              | 0.00              | 1.86              | 3.99              | 27.86             | 3.82              | 190.26            | 490.71            | 6.50              | 4.46              | 738.38          | 40.11         |
| Finfish             | 3.77                    | 12.88             | 42.33             | 0.00              | 4.77              | 1.08              | 126.38            | 10.42             | 458.72            | 0.00              | 2.28              | 0.00              | 662.63          | 35.99         |
| <b>Total</b>        | <b>13.90</b>            | <b>18.30</b>      | <b>74.47</b>      | <b>0.00</b>       | <b>9.87</b>       | <b>12.94</b>      | <b>197.67</b>     | <b>19.44</b>      | <b>964.07</b>     | <b>496.85</b>     | <b>14.15</b>      | <b>19.40</b>      | <b>1,841.06</b> | <b>100.00</b> |
| <b>Stratum III</b>  |                         |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                 |               |
| Tiger shrimp        | 0.00                    | 0.33              | 0.07              | 0.00              | 0.26              | 0.46              | 0.02              | 0.30              | 0.17              | 0.54              | 29.12             | 0.69              | 31.96           | 15.96         |
| Banana shrimp       | 0.42                    | 3.77              | 1.61              | 0.00              | 2.16              | 4.17              | 1.75              | 4.22              | 1.14              | 5.32              | 4.34              | 2.71              | 31.61           | 15.79         |
| Indian white shrimp | 2.90                    | 3.09              | 1.13              | 0.00              | 0.00              | 1.16              | 3.63              | 0.80              | 0.00              | 2.47              | 4.63              | 3.32              | 23.13           | 11.55         |
| Brown shrimp        | 1.85                    | 6.71              | 1.42              | 0.00              | 6.82              | 8.19              | 4.12              | 9.82              | 6.77              | 7.39              | 21.31             | 16.68             | 91.78           | 45.84         |
| Finfish             | 0.91                    | 4.12              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 14.09             | 0.00              | 1.93              | 0.23              | 0.45              | 21.73           | 10.85         |
| <b>Total</b>        | <b>6.08</b>             | <b>18.02</b>      | <b>4.23</b>       | <b>0.00</b>       | <b>9.24</b>       | <b>14.68</b>      | <b>9.52</b>       | <b>29.23</b>      | <b>8.08</b>       | <b>17.65</b>      | <b>59.63</b>      | <b>23.85</b>      | <b>200.21</b>   | <b>100.00</b> |
| <b>Stratum V</b>    |                         |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                 |               |
| Tiger shrimp        | 0.01                    | 0.56              | 0.00              | 0.00              | 0.00              | 0.00              | 5.71              | 0.00              | 0.03              | 0.00              | 0.00              | 0.04              | 6.35            | 5.04          |
| Banana shrimp       | 3.01                    | 5.60              | 0.00              | 0.00              | 0.74              | 0.27              | 2.54              | 1.96              | 1.27              | 1.77              | 0.92              | 1.14              | 19.22           | 15.26         |
| Indian white shrimp | 0.68                    | 0.14              | 0.00              | 0.00              | 0.26              | 1.56              | 7.26              | 2.94              | 1.40              | 0.77              | 0.89              | 0.18              | 16.08           | 12.17         |
| Brown shrimp        | 1.65                    | 1.29              | 0.00              | 0.00              | 1.48              | 1.21              | 3.71              | 2.26              | 0.90              | 1.28              | 1.57              | 0.20              | 15.55           | 12.35         |
| Finfish             | 14.70                   | 7.56              | 0.00              | 0.00              | 2.48              | 3.04              | 16.61             | 7.16              | 3.60              | 3.81              | 8.19              | 1.56              | 68.71           | 54.57         |
| <b>Total</b>        | <b>20.05</b>            | <b>15.15</b>      | <b>0.00</b>       | <b>0.00</b>       | <b>4.96</b>       | <b>6.08</b>       | <b>35.83</b>      | <b>14.32</b>      | <b>7.20</b>       | <b>7.63</b>       | <b>11.57</b>      | <b>3.12</b>       | <b>125.91</b>   | <b>100.00</b> |

# TRAMMELNET (TRN 1 and 2)

The catch by TRN 1 and 2 indicated (Table 6c) that catches of finfish were 19-34 per cent in Strata I, II, IV and V, but were much lower in Strata III. The catch of Tiger shrimp was generally low (<9%), except in Strata IV (12.8%). Banana shrimp is the target species when using TRN and this is evident from catch data in all strata, which show catches of this species to be higher than others. White shrimp and other shrimp (*Metapenaeus* spp.) displayed large variations in the catch composition.

**Table 6c: Monthly production by species in trammelnet catch in Langkat District and annual average species composition (%)**

| <i>Species</i>      | <i>May</i><br>92 | <i>Jun.</i><br>92 | <i>Jul.</i><br>92 | <i>Aug.</i><br>92 | <i>Sep.</i><br>92 | <i>Oct.</i><br>92 | <i>Nov.</i><br>92 | <i>Dec.</i><br>92 | <i>Jan.</i><br>93 | <i>Feb.</i><br>93 | <i>Mar.</i><br>93 | <i>Apr.</i><br>93 | <i>Total</i>  | <i>%</i>      |
|---------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---------------|---------------|
| <b>Stratum I</b>    |                  |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |               |               |
| Tiger shrimp        | 0.27             | 0.16              | 2.74              | 1.75              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 4.92          | 2.69          |
| Banana shrimp       | 12.11            | 19.70             | 3.53              | 4.61              | 10.68             | 9.85              | 19.67             | 14.37             | 0.00              | 1.72              | 0.00              | 11.37             | 107.61        | 58.17         |
| Indian white shrimp | 0.00             | 0.00              | 0.00              | 1.49              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 1.49          | 0.81          |
| Brown shrimp        | 0.10             | 0.00              | 0.00              | 5.29              | 0.00              | 0.00              | 14.78             | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 20.17         | 11.02         |
| Finfish             | 30.20            | 0.99              | 0.00              | 4.49              | 0.00              | 0.00              | 13.23             | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 48.91         | 26.71         |
| <b>Total</b>        | <b>42.68</b>     | <b>20.85</b>      | <b>6.27</b>       | <b>17.63</b>      | <b>10.68</b>      | <b>9.85</b>       | <b>47.68</b>      | <b>1437</b>       | <b>0.00</b>       | <b>1.72</b>       | <b>0.00</b>       | <b>1137</b>       | <b>183.10</b> | <b>100.00</b> |
| <b>Stratum II</b>   |                  |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |               |               |
| Tiger shrimp        | 0.00             | 0.00              | 7.59              | 0.00              | 0.13              | 0.00              | 0.92              | 0.12              | 0.01              | 3.11              | 0.77              | 3.53              | 16.18         | 5.65          |
| Banana shrimp       | 12.21            | 64.23             | 7.59              | 0.00              | 7.24              | 2.69              | 7.86              | 5.82              | 2.30              | 6.56              | 3.00              | 7.61              | 127.11        | 44.36         |
| Indian white shrimp | 0.00             | 0.00              | 0.00              | 0.00              | 8.70              | 0.73              | 0.81              | 4.11              | 0.09              | 0.00              | 13.31             | 1.23              | 28.98         | 10.11         |
| Brown shrimp        | 0.00             | 10.85             | 0.00              | 0.00              | 8.57              | 0.43              | 1.16              | 4.50              | 0.02              | 9.21              | 2.55              | 1.14              | 38.50         | 13.43         |
| Finfish             | 10.83            | 30.13             | 6.35              | 0.00              | 28.12             | 0.11              | 0.26              | 0.11              | 0.00              | 0.00              | 0.00              | 0.00              | 75.80         | 26.45         |
| <b>Total</b>        | <b>23.04</b>     | <b>105.21</b>     | <b>21.53</b>      | <b>0.00</b>       | <b>52.76</b>      | <b>3.85</b>       | <b>11.01</b>      | <b>14.66</b>      | <b>2.42</b>       | <b>18.95</b>      | <b>19.63</b>      | <b>13.51</b>      | <b>286.57</b> | <b>100.00</b> |
| <b>Stratum III</b>  |                  |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |               |               |
| Tiger shrimp        | 6.05             | 0.62              | 1.53              | 0.00              | 0.82              | 1.20              | 0.54              | 39.04             | 0.57              | 0.50              | 0.89              | 1.32              | 53.08         | 8.45          |
| Banana shrimp       | 52.39            | 9.18              | 4.23              | 0.00              | 3.86              | 5.74              | 7.42              | 281.48            | 2.88              | 3.05              | 3.95              | 4.09              | 378.27        | 60.20         |
| Indian white shrimp | 0.00             | 2.52              | 0.00              | 0.00              | 0.00              | 0.00              | 0.25              | 14.95             | 0.00              | 0.23              | 1.42              | 0.00              | 19.37         | 3.08          |
| Brown shrimp        | 9.03             | 1.44              | 1.97              | 0.00              | 0.60              | 0.60              | 4.07              | 94.94             | 0.49              | 0.94              | 1.44              | 12.47             | 127.99        | 20.37         |
| Finfish             | 13.71            | 2.01              | 0.00              | 0.00              | 0.00              | 0.00              | 0.00              | 31.52             | 0.00              | 0.00              | 0.00              | 2.42              | 49.66         | 7.90          |
| <b>Total</b>        | <b>81.18</b>     | <b>15.77</b>      | <b>7.73</b>       | <b>0.00</b>       | <b>5.28</b>       | <b>7.54</b>       | <b>12.28</b>      | <b>461.93</b>     | <b>3.94</b>       | <b>4.72</b>       | <b>7.70</b>       | <b>20.30</b>      | <b>62837</b>  | <b>100.00</b> |
| <b>Stratum IV</b>   |                  |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |               |               |
| Tiger shrimp        | 0.20             | 1.28              | 4.30              | 0.00              | 3.96              | 0.38              | 1.50              | 2.49              | 0.29              | 1.43              | 1.12              | 0.18              | 17.13         | 12.77         |
| Banana shrimp       | 0.45             | 1.01              | 6.02              | 0.00              | 4.34              | 0.56              | 8.26              | 5.67              | 1.14              | 2.80              | 4.38              | 2.49              | 37.12         | 21.66         |
| Indian white shrimp | 0.00             | 0.00              | 14.88             | 0.00              | 0.72              | 0.07              | 1.53              | 0.38              | 0.90              | 0.36              | 1.49              | 1.48              | 21.81         | 16.25         |
| Brown shrimp        | 1.15             | 0.00              | 1.63              | 0.00              | 0.30              | 0.02              | 2.99              | 5.22              | 0.00              | 0.00              | 0.16              | 1.61              | 13.08         | 9.75          |
| Finfish             | 2.15             | 0.00              | 17.03             | 0.00              | 1.12              | 0.11              | 0.02              | 1.74              | 0.01              | 3.50              | 1.94              | 17.43             | 45.05         | 33.57         |
| <b>Total</b>        | <b>3.95</b>      | <b>2.29</b>       | <b>43.86</b>      | <b>0.00</b>       | <b>10.44</b>      | <b>1.14</b>       | <b>1430</b>       | <b>15.50</b>      | <b>2.34</b>       | <b>8.09</b>       | <b>9.09</b>       | <b>23.16</b>      | <b>134.19</b> | <b>100.00</b> |
| <b>Stratum V</b>    |                  |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |               |               |
| Tiger shrimp        | 0.00             | 0.72              | 0.00              | 0.00              | 0.00              | 0.19              | 1.18              | 1.71              | 0.74              | 0.54              | 1.87              | 0.34              | 7.29          | 3.97          |
| Banana shrimp       | 20.60            | 11.86             | 0.00              | 0.00              | 4.76              | 5.92              | 10.50             | 11.77             | 9.01              | 5.25              | 2.83              | 1.90              | 84.40         | 45.93         |
| Indian white shrimp | 26.68            | 0.67              | 0.00              | 0.00              | 0.55              | 2.10              | 3.79              | 1.37              | 0.56              | 1.14              | 1.44              | 4.63              | 42.93         | 23.36         |
| Brown shrimp        | 0.00             | 3.10              | 0.00              | 0.00              | 0.00              | 1.59              | 4.15              | 0.00              | 2.47              | 0.51              | 1.15              | 0.98              | 13.95         | 7.59          |
| Finfish             | 0.01             | 13.49             | 0.00              | 0.00              | 0.00              | 0.00              | 21.65             | 0.00              | 0.02              | 0.00              | 0.00              | 0.00              | 35.17         | 19.14         |
| <b>Total</b>        | <b>47.29</b>     | <b>29.84</b>      | <b>0.00</b>       | <b>0.00</b>       | <b>5.31</b>       | <b>9.80</b>       | <b>41.27</b>      | <b>14.85</b>      | <b>12.80</b>      | <b>7.44</b>       | <b>7.29</b>       | <b>7.85</b>       | <b>183.74</b> | <b>100.00</b> |

### 3.2 Catch rates

Monthly average catch rates (Tables 7a, b, c,) displayed large variations among the different strata. Catch rates of different species using different gear also varied considerably from strata to strata.

It can, however, be generalized that catch rates for finfish were usually higher than for shrimp species in SBN and SGN, while the catch rate of Banana shrimp was high when using TRN, SBN and SGN also display a higher catch rate of other penaeid shrimps when compared to the three specified penaeid species.

Table 7a: Average catch rate by species in shrimp gillnet in Langkat District (kg/boat/day)

| Species             | May92 | Jun. 92 | Jul. 92 | Aug. 92 | Sep. 92 | Oct. 92 | Nov. 92 | Dec. 92 | Jan. 93 | Feb. 93 | Mar. 93 | Apr. 93 |
|---------------------|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>Stratum I</b>    |       |         |         |         |         |         |         |         |         |         |         |         |
| Tiger shrimp        | 0.00  | 0.00    | 1.35    | 0.12    | 0.00    | 0.00    | 0.02    | 0.54    | 0.00    | 0.00    | 0.00    | 0.00    |
| Banana shrimp       | 0.00  | 0.00    | 1.25    | 9.08    | 0.98    | 1.18    | 0.47    | 2.02    | 1.02    | 0.83    | 1.15    | 0.81    |
| Indian white shrimp | 0.00  | 0.00    | 0.00    | 0.77    | 1.52    | 0.14    | 0.43    | 0.00    | 0.12    | 0.00    | 0.40    | 0.00    |
| Brown shrimp        | 0.00  | 0.00    | 0.00    | 2.78    | 1.52    | 1.32    | 3.31    | 3.33    | 2.48    | 2.33    | 1.06    | 0.00    |
| Finfish             | 0.00  | 0.00    | 112.00  | 1.41    | 175.58  | 21.60   | 54.51   | 119.52  | 125.42  | 80.25   | 108.77  | 57.63   |
| Total               | 0.00  | 0.00    | 114.60  | 14.16   | 179.60  | 24.24   | 58.74   | 125.41  | 129.04  | 83.41   | 111.38  | 58.44   |
| <b>Stratum II</b>   |       |         |         |         |         |         |         |         |         |         |         |         |
| Tiger shrimp        | 0.00  | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.04    | 0.02    |
| Banana shrimp       | 0.00  | 15.18   | 0.00    | 0.00    | 0.00    | 1.91    | 39.00   | 0.00    | 3.46    | 12.31   | 2.04    | 0.86    |
| Indian white shrimp | 0.00  | 0.00    | 0.00    | 0.00    | 2.50    | 3.10    | 0.00    | 3.40    | 6.64    | 8.50    | 1.77    | 3.80    |
| Brown shrimp        | 0.00  | 0.50    | 15.17   | 0.00    | 3.83    | 7.10    | 12.00   | 3.73    | 11.24   | 7.50    | 11.66   | 3.46    |
| Finfish             | 0.00  | 1.45    | 0.00    | 0.00    | 0.00    | 22.75   | 0.00    | 0.00    | 63.80   | 0.00    | 38.14   | 15.42   |
| Total               | 0.00  | 17.13   | 15.17   | 0.00    | 6.33    | 34.86   | 51.00   | 7.13    | 85.14   | 28.31   | 53.65   | 23.56   |
| <b>Stratum III</b>  |       |         |         |         |         |         |         |         |         |         |         |         |
| Tiger shrimp        | 6.55  | 0.27    | 0.17    | 0.00    | 0.84    | 0.38    | 0.04    | 0.05    | 0.81    | 0.11    | 0.23    | 0.03    |
| Banana shrimp       | 7.14  | 1.53    | 2.93    | 0.00    | 3.98    | 2.75    | 2.01    | 1.46    | 0.67    | 1.02    | 5.34    | 11.41   |
| Indian white shrimp | 0.00  | 0.00    | 0.00    | 0.00    | 0.29    | 0.00    | 0.00    | 0.08    | 0.00    | 0.00    | 2.36    | 0.12    |
| Brown shrimp        | 10.40 | 0.33    | 0.00    | 0.00    | 2.00    | 0.69    | 0.58    | 0.68    | 1.55    | 1.23    | 4.00    | 3.19    |
| Finfish             | 0.80  | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.58    | 0.00    | 0.00    | 1.44    | 0.00    | 1.07    |
| Total               | 24.89 | 2.13    | 3.10    | 0.00    | 7.11    | 3.82    | 3.21    | 2.27    | 3.03    | 3.80    | 11.93   | 15.82   |
| <b>Stratum IV</b>   |       |         |         |         |         |         |         |         |         |         |         |         |
| Tiger shrimp        | 0.00  | 0.00    | 0.00    | 0.00    | 1.81    | 0.33    | 0.27    | 0.00    | 0.00    | 0.00    | 0.00    | 2.04    |
| Banana shrimp       | 1.22  | 0.00    | 0.00    | 0.00    | 0.64    | 0.51    | 2.83    | 0.73    | 0.08    | 0.28    | 0.22    | 0.00    |
| Indian white shrimp | 0.00  | 0.00    | 0.00    | 0.00    | 0.55    | 0.55    | 0.49    | 1.86    | 0.38    | 0.32    | 0.91    | 0.00    |
| Brown shrimp        | 0.00  | 0.00    | 0.00    | 0.00    | 0.32    | 0.25    | 1.04    | 0.12    | 0.25    | 0.02    | 0.00    | 0.00    |
| Finfish             | 0.00  | 0.00    | 0.00    | 0.00    | 0.97    | 0.41    | 0.00    | 0.48    | 2.70    | 2.33    | 0.35    | 0.00    |
| Total               | 1.22  | 0.00    | 0.00    | 0.00    | 4.29    | 2.05    | 4.63    | 3.19    | 3.41    | 2.95    | 1.48    | 2.04    |
| <b>Stratum V</b>    |       |         |         |         |         |         |         |         |         |         |         |         |
| Tiger shrimp        | 0.00  | 0.44    | 0.00    | 0.00    | 0.00    | 0.09    | 0.13    | 0.00    | 0.00    | 0.00    | 2.69    | 0.00    |
| Banana shrimp       | 0.03  | 1.69    | 0.00    | 0.00    | 1.45    | 0.21    | 2.08    | 13.78   | 1.38    | 0.37    | 13.39   | 0.94    |
| Indian white shrimp | 0.08  | 0.75    | 0.00    | 0.00    | 0.35    | 1.07    | 0.49    | 1.02    | 0.70    | 0.00    | 2.80    | 1.24    |
| Brown shrimp        | 0.08  | 0.96    | 0.00    | 0.00    | 0.08    | 0.74    | 1.09    | 3.52    | 0.44    | 0.23    | 2.69    | 3.32    |
| Finfish             | 0.00  | 0.19    | 0.00    | 0.00    | 0.00    | 0.00    | 3.62    | 1.85    | 0.00    | 0.00    | 0.00    | 0.00    |
| Total               | 0.19  | 4.03    | 0.00    | 0.00    | 1.88    | 3.11    | 7.41    | 20.17   | 2.52    | 0.60    | 21.57   | 5.50    |

**Table 7b: Average catch rate by species in set bagnet in Langkat District (kg/boat/day)**

| <i>Species</i>      | <i>May 92</i> | <i>Jun. 92</i> | <i>Jul. 92</i> | <i>Aug. 92</i> | <i>Sep. 92</i> | <i>Oct. 92</i> | <i>Nov. 92</i> | <i>Dec. 92</i> | <i>Jan. 93</i> | <i>Feb. 93</i> | <i>Mar. 93</i> | <i>Apr. 93</i> |
|---------------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>Stratum I</b>    |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.03          | 0.71           | 0.11           | 0.44           | 0.00           | 0.00           | 0.05           | 0.02           | 0.00           | 0.00           | 0.00           | 0.06           |
| Banana shrimp       | 3.26          | 0.55           | 0.24           | 2.94           | 0.88           | 1.23           | 1.16           | 1.72           | 0.81           | 1.34           | 1.11           | 1.46           |
| Indian white shrimp | 0.00          | 1.72           | 0.59           | 0.72           | 0.00           | 0.82           | 1.50           | 0.12           | 0.13           | 0.00           | 0.04           | 2.18           |
| Brown shrimp        | 2.15          | 0.83           | 0.16           | 2.06           | 4.21           | 3.66           | 0.97           | 5.51           | 3.00           | 4.64           | 5.30           | 4.78           |
| Finfish             | 0.67          | 8.80           | 13.27          | 1.10           | 41.63          | 31.59          | 17.00          | 38.32          | 55.29          | 49.82          | 35.65          | 30.68          |
| <b>Total</b>        | <b>6.11</b>   | <b>12.61</b>   | <b>14.37</b>   | <b>7.26</b>    | <b>46.72</b>   | <b>37.30</b>   | <b>20.68</b>   | <b>45.69</b>   | <b>59.23</b>   | <b>55.80</b>   | <b>42.10</b>   | <b>39.16</b>   |
| <b>Stratum II</b>   |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.00          | 0.17           | 2.47           | 0.00           | 0.00           | 0.00           | 0.00           | 0.04           | 0.00           | 0.00           | 0.01           | 0.35           |
| Banana shrimp       | 5.09          | 3.48           | 4.45           | 0.00           | 1.23           | 0.87           | 1.89           | 1.04           | 59.60          | 1.94           | 0.85           | 13.29          |
| Indian white shrimp | 0.33          | 0.00           | 0.47           | 0.00           | 1.71           | 1.92           | 1.92           | 3.93           | 10.80          | 2.62           | 3.85           | 3.46           |
| Brown shrimp        | 5.59          | 1.18           | 0.96           | 0.00           | 1.69           | 2.44           | 2.44           | 3.68           | 101.20         | 36.45          | 5.70           | 5.10           |
| Finfish             | 4.09          | 11.50          | 16.56          | 0.00           | 4.33           | 11.08          | 11.08          | 10.02          | 244.00         | 0.00           | 2.00           | 0.00           |
| <b>Total</b>        | <b>15.10</b>  | <b>16.33</b>   | 24.91          | 0.00           | 8.96           | 16.31          | 18.71          | 18.71          | 415.60         | 41.01          | 12.41          | 22.20          |
| <b>Stratum III</b>  |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.00          | 0.03           | 0.02           | 0.00           | 0.17           | 0.03           | 0.00           | 0.02           | 0.06           | 0.44           | 10.79          | 0.20           |
| Banana shrimp       | 0.01          | 0.29           | 0.42           | 0.00           | 1.42           | 0.27           | 0.11           | 0.28           | 0.42           | 4.29           | 1.61           | 0.79           |
| Indian white shrimp | 1.44          | 0.24           | 0.29           | 0.00           | 0.00           | 0.08           | 0.24           | 0.05           | 0.00           | 1.99           | 1.71           | 0.96           |
| Brown shrimp        | 0.92          | 0.52           | 0.37           | 0.00           | 4.49           | 0.58           | 0.27           | 0.64           | 2.49           | 5.96           | 7.89           | 4.83           |
| Finfish             | 0.45          | 0.32           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           | 0.92           | 0.00           | 1.56           | 0.09           | 1.09           |
| <b>Total</b>        | <b>2.82</b>   | <b>1.40</b>    | 1.10           | <b>0.00</b>    | <b>6.08</b>    | <b>0.96</b>    | <b>0.62</b>    | <b>1.91</b>    | <b>2.97</b>    | <b>14.24</b>   | <b>22.09</b>   | <b>7.87</b>    |
| <b>Stratum V</b>    |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.01          | 0.56           | 0.00           | 0.00           | 0.00           | 0.00           | 5.71           | 0.00           | 0.03           | 0.00           | 0.00           | 0.04           |
| Banana shrimp       | 2.95          | 5.60           | 0.00           | 0.00           | 0.74           | 0.27           | 2.54           | 1.96           | 1.27           | 1.77           | 0.92           | 1.14           |
| Indian white shrimp | 0.67          | 0.14           | 0.00           | 0.00           | 0.26           | 1.56           | 7.26           | 2.94           | 1.40           | 0.77           | 0.89           | 0.18           |
| Brown shrimp        | 1.62          | 1.29           | 0.00           | 0.00           | 1.48           | 1.21           | 3.71           | 2.26           | 0.90           | 1.28           | 1.57           | 0.20           |
| Finfish             | 14.41         | 7.56           | 0.00           | 0.00           | 2.48           | 3.04           | 16.61          | 7.16           | 3.60           | 3.81           | 8.19           | 1.56           |
| <b>Total</b>        | <b>19.66</b>  | <b>15.15</b>   | <b>0.00</b>    | <b>0.00</b>    | <b>4.96</b>    | <b>6.08</b>    | <b>35.83</b>   | <b>14.32</b>   | <b>7.20</b>    | <b>7.63</b>    | <b>11.57</b>   | <b>3.12</b>    |

**Table 7c: Average catch rate by species in trammelnet in Langkat District (kg/boat/day)**

| <i>Species</i>      | <i>May 92</i> | <i>Jun. 92</i> | <i>Jul. 92</i> | <i>Aug. 92</i> | <i>Sep. 92</i> | <i>Oct. 92</i> | <i>Nov. 92</i> | <i>Dec. 92</i> | <i>Jan. 93</i> | <i>Feb. 93</i> | <i>Mar. 93</i> | <i>Apr. 93</i> |
|---------------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>Stratum I</b>    |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.23          | 0.03           | 0.70           | 0.40           | 0.00           | 0.00           | 0.02           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           |
| Banana shrimp       | 3.92          | 4.21           | 0.90           | 1.06           | 2.70           | 2.50           | 4.86           | 4.06           | 0.00           | 2.00           | 0.00           | 1.70           |
| Indian white shrimp | 0.00          | 0.00           | 0.00           | 0.34           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           |
| Brown shrimp        | 0.03          | 0.00           | 0.00           | 1.22           | 0.00           | 0.00           | 3.65           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           |
| Finfish             | 9.43          | 0.00           | 0.00           | 0.76           | 0.00           | 0.00           | 3.25           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           |
| <b>Total</b>        | <b>13.61</b>  | <b>4.24</b>    | <b>1.60</b>    | <b>3.78</b>    | <b>2.70</b>    | <b>2.50</b>    | <b>11.78</b>   | <b>4.06</b>    | <b>0.00</b>    | <b>2.00</b>    | <b>0.00</b>    | <b>1.70</b>    |



**Table 7c contd.**

| <i>Species</i>      | <i>May 92</i> | <i>Jun. 92</i> | <i>Jul. 92</i> | <i>Aug. 92</i> | <i>Sep. 92</i> | <i>Oct. 92</i> | <i>Nov. 92</i> | <i>Dec. 92</i> | <i>Jan. 93</i> | <i>Feb. 93</i> | <i>Mar. 93</i> | <i>Apr. 93</i> |
|---------------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>Stratum II</b>   |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.00          | 0.00           | 1.53           | 0.00           | 0.03           | 0.00           | 0.22           | 0.02           | 0.01           | 0.04           | 0.06           | 0.63           |
| Banana shrimp       | 3.53          | 15.67          | 1.53           | 0.00           | 1.59           | 0.33           | 1.89           | 1.27           | 2.52           | 1.36           | 2.54           | 1.35           |
| Indian white shrimp | 0.00          | 0.00           | 0.00           | 0.00           | 1.90           | 0.09           | 0.19           | 0.90           | 0.01           | 0.00           | 1.13           | 0.22           |
| Brown shrimp        | 0.00          | 2.65           | 0.00           | 0.00           | 1.88           | 0.05           | 0.28           | 0.98           | 0.02           | 1.92           | 0.22           | 0.20           |
| Finfish             | 3.13          | 5.88           | 0.25           | 0.00           | 6.17           | 0.00           | 0.03           | 0.02           | 0.00           | 0.00           | 0.00           | 0.00           |
| <b>Total</b>        | <b>6.66</b>   | <b>24.20</b>   | <b>3.31</b>    | <b>0.00</b>    | <b>11.57</b>   | <b>0.47</b>    | <b>2.61</b>    | <b>3.19</b>    | <b>2.56</b>    | <b>3.32</b>    | <b>3.95</b>    | <b>2.40</b>    |
| <b>Stratum II</b>   |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 3.03          | 0.20           | 0.76           | 0.00           | 0.41           | 0.60           | 0.16           | 7.28           | 0.35           | 0.26           | 0.30           | 0.20           |
| Banana shrimp       | 26.19         | 3.02           | 2.11           | 0.00           | 1.93           | 2.87           | 2.25           | 52.54          | 1.77           | 1.59           | 1.32           | 0.62           |
| Indian white shrimp | 0.00          | 0.83           | 0.00           | 0.00           | 0.00           | 0.00           | 0.08           | 2.79           | 0.00           | 0.12           | 0.47           | 0.00           |
| Brown shrimp        | 4.52          | 0.47           | 0.99           | 0.00           | 0.30           | 0.06           | 1.23           | 17.71          | 0.30           | 0.49           | 0.48           | 1.90           |
| Finfish             | 5.69          | 0.55           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           | 5.87           | 0.00           | 0.00           | 0.00           | 0.06           |
| <b>Total</b>        | <b>39.43</b>  | <b>5.07</b>    | <b>3.86</b>    | <b>0.00</b>    | <b>2.64</b>    | <b>3.53</b>    | <b>3.72</b>    | <b>86.19</b>   | <b>2.42</b>    | <b>2.46</b>    | <b>2.54</b>    | <b>2.78</b>    |
| <b>Stratum IV</b>   |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.28          | 0.25           | 0.83           | 0.00           | 1.25           | 0.12           | 0.32           | 0.62           | 0.12           | 0.45           | 0.35           | 0.04           |
| Banana shrimp       | 0.64          | 2.10           | 1.17           | 0.00           | 1.37           | 0.18           | 1.77           | 1.42           | 0.46           | 0.89           | 1.39           | 0.60           |
| Indian white shrimp | 0.00          | 0.00           | 2.88           | 0.00           | 0.23           | 0.02           | 0.33           | 0.10           | 0.04           | 0.11           | 0.47           | 0.35           |
| Brown shrimp        | 1.65          | 0.00           | 0.32           | 0.00           | 0.10           | 0.01           | 0.64           | 1.30           | 0.00           | 0.00           | 0.05           | 0.39           |
| Finfish             | 2.87          | 0.00           | 3.17           | 0.00           | 0.20           | 0.02           | 0.01           | 0.43           | 0.25           | 0.54           | 0.42           | 2.55           |
| <b>Total</b>        | <b>5.44</b>   | <b>2.35</b>    | <b>8.37</b>    | <b>0.00</b>    | <b>3.15</b>    | <b>0.35</b>    | <b>3.07</b>    | <b>3.87</b>    | <b>0.87</b>    | <b>1.99</b>    | <b>2.68</b>    | <b>3.93</b>    |
| <b>Stratum V</b>    |               |                |                |                |                |                |                |                |                |                |                |                |
| Tiger shrimp        | 0.00          | 0.13           | 0.00           | 0.00           | 0.00           | 0.04           | 0.21           | 0.34           | 0.17           | 0.00           | 0.32           | 0.06           |
| Banana shrimp       | 4.31          | 2.20           | 0.00           | 0.00           | 0.86           | 1.09           | 1.90           | 2.33           | 2.04           | 1.00           | 0.49           | 0.35           |
| Indian white shrimp | 5.59          | 0.12           | 0.00           | 0.00           | 0.10           | 0.39           | 0.68           | 0.27           | 0.13           | 0.22           | 0.25           | 0.86           |
| Brown shrimp        | 0.00          | 0.58           | 0.00           | 0.00           | 0.00           | 0.29           | 0.75           | 0.00           | 0.56           | 0.10           | 0.20           | 0.18           |
| Finfish             | 0.00          | 0.35           | 0.00           | 0.00           | 0.00           | 0.00           | 0.17           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           |
| <b>Total</b>        | <b>9.90</b>   | <b>3.38</b>    | <b>0.00</b>    | <b>0.00</b>    | <b>0.96</b>    | <b>1.81</b>    | <b>3.71</b>    | <b>2.94</b>    | <b>2.90</b>    | <b>1.32</b>    | <b>1.26</b>    | <b>1.45</b>    |

### 3.3 Production and revenue

The production levels of all shrimp species and finfish are quite different for each strata. Production by each gear is also different. Table 8 (on facing page) indicates the production and revenue estimated for each species by fishing gear. The finfish production estimate is not accurate, because some of it is discarded at sea as trash and a portion of it is sometimes used for consumption by the fishing households.

The production trends of shrimp species, by gear, in the five strata during May 1992 - April 1993, were as follows:

The Tiger shrimp catch was 172,639 kg (TRN 57.4%, SGN 13.63% and SBN 28.9%) valued at Rp 1,975,599,000\* (TRN 68.5%, SGN 28.3% and SBN 3.21%). The revenue from the TRN was highest, probably because the size of shrimp caught was larger than those caught by other gear.

\* US \$ 1 = Ins Rp. 2100 (appx.)

**Table 8: Estimated production and revenue of selected species by gear type**

| <i>Species</i>                   | <i>Trammelnet</i> | <i>Shrimp gillnet</i> | <i>Set bagnet</i> |
|----------------------------------|-------------------|-----------------------|-------------------|
| <b>Banana shrimp</b>             |                   |                       |                   |
| — Production                     | 771,163           | 341,895               | 259,363           |
| — Number caught                  | 31,163,780        | 29,786,410            | 12,581,420        |
| — Revenue (x Rp. 1000)           | 7,794,659         | 1,367,840             | 546,240           |
| Indian white shrimp              |                   |                       |                   |
| — Production (Kg)                | 113,657           | 153,481               | 319,307           |
| — Number caught                  | 10,524,654        | 16,209,050            | 28,323,820        |
| — Revenue                        | 424,612           | 424,612               | 570,752           |
| <b>Tiger shrimp</b>              |                   |                       |                   |
| — Production (Kg)                | 99,112            | 23,526                | 49,997            |
| — Number caught                  | 1,694,598         | 1,906,206             | 2,239,197         |
| — Revenue (x Rp. 1000)           | 1,353,255         | 559,757               | 62,587            |
| Brown shrimp                     |                   |                       |                   |
| — Production (Kg)                | 213,193           | 228,258               | 919,054           |
| — Revenue (x Rp. 1000)           | 606,574           | 376,725               | 684,436           |
| <b>Finfish</b>                   |                   |                       |                   |
| — Production (Kg)                | 257.9             | 1509.2                | 1513.6            |
| — Revenue (x Rp. 1000)           | 184,430           | 349,162.4             | 430,640           |
| <b>Total</b>                     |                   |                       |                   |
| — Production (Kg)                | 1,197,382.9       | 748,669.2             | 1,549,234.6       |
| — Revenue (x Rp. 1000)           | 10,363,530        | 3,078,096.4           | 2,294,655         |
| — Effort (operation) (boat days) | 577,381           | 286,147               | 144,196           |

Banana shrimp production was 1,372,421 kg (TRN 56.2%, SGN 24.9% and SBN 18.9%). The revenue from this catch was Rp 9,708,739,000 (TRN 80.3% and SGN 5.6%). Again, the higher revenue from TRN is due to the larger size shrimp caught.

Indian white shrimp catch was 586,444 kg (TRN 19.4%, SGN 26.2% and SBN **54.4%**). The revenue data for this species, unfortunately, contained several discrepancies, but it did indicate that TRN had the best overall gross revenue per unit effort in spite of the very low recorded catch.

Production of other penaeid species (primarily *Metapenaeus* spp.) was 1,360,505 kg. The catch of *Metapenaeus* species by SBN was four times that by TRN, but the revenue was nearly the same for both, probably because of the relatively higher price for the larger sizes caught by TRN.

### **3.4 Exploitation of penaeid shrimp**

Penaeid shrimp move from shallow waters into deeper waters as they grow older and larger. Consequently, their vulnerability to different fishing methods and fishing gear varies with the different stages of their lives and the different ecological conditions. This is reflected by the estimated number of individuals of each size group caught by each fishing gear.

Length-frequency data (Figures 3a-c) reveal that the three fishing gear exploit the same shrimp stocks at similar sizes, which is only to be expected with all of them being used in depths from 5-10 m. Only **TRN is sometimes used in deeper waters**. Large numbers of Banana shrimp between 30 and 40 mm in length are caught by all three fishing gear, though the length at first capture was between 12 and 16 mm.

In the case of White shrimp, the modal length at capture in all three fishing gear is about 20 mm, with similar sizes of entry for each gear. SBN accounts for the highest catch, **both by numbers and by weight**.

**The size range of Tiger shrimp** at capture is the largest for TRN. Catches of shrimp above 55 mm in length is the reason for the highest revenue it obtains among the three fishing gear.

### 3.5 Growth parameters of selected species of shrimp

Growth parameters were determined for the shrimp species, using pooled catch-at-length data for the three fishing gear, to ensure all modal groups are included for a good fit of the growth curve. Table 9 (on facing page) summarizes the growth parameters obtained. These parameters indicated that the entire fishing grounds off Langkat District contained single stocks of each species, since no significant differences were obtained.

### 3.6 Recruitment pattern and spawning seasons

The ELEFAN analysis showed two recruitments each year or two peak spawnings per year, which is common for most shrimp species in tropical waters. However, both spawnings are not of equal strength.

Fig 3a. Length-frequency of Banana shrimp caught in the shrimp fisheries

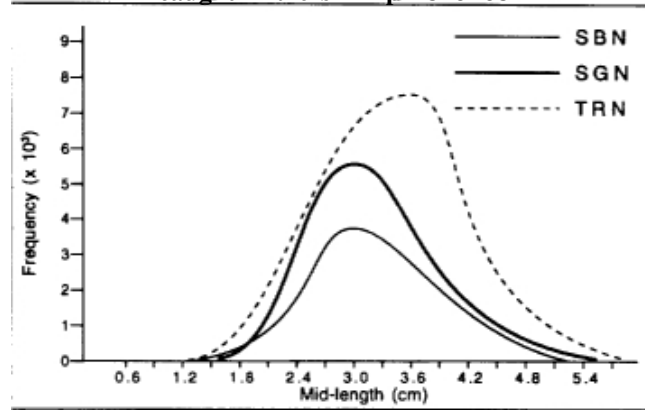


Fig 3b. Length-frequency of Indian white shrimp caught in the shrimp fisheries

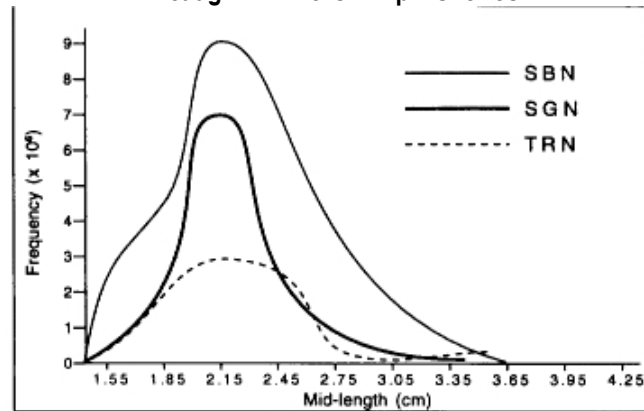
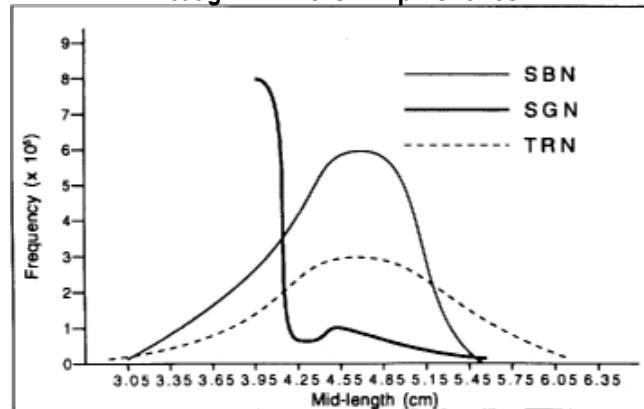


Fig 3c. Length-frequency of Tiger shrimp caught in the shrimp fisheries



**Table 9: Growth parameters of selected shrimp species in the Langkat District**

| <i>Species</i> | <i>Fisheries</i> | $L\alpha$ | $K$  | $F$  | $M$  | $E$  | $L_{50}$ | $L_{75}$ | $F_{max}$ |
|----------------|------------------|-----------|------|------|------|------|----------|----------|-----------|
| Banana Shrimp  | TRN              | -         | -    | 1.00 | 3.2  | 0.24 | 3.010    | 3.32     | 1.93      |
|                |                  | 5.60      | 1.20 |      |      |      |          |          |           |
|                | SBN              | -         |      | 1.5  | 3.2  | 0.32 | 2.68     | 2.97     | 3.44      |
|                | SON              | -         | -    | 2.90 | 3.2  | 0.48 | 3.032    | 3.347    | 3.57      |
| White Shrimp   | TRN              | -         | -    | 6.17 | 2.43 | 0.72 | 1.99     | 2.25     | 7.26      |
|                |                  | 5.05      | 0.75 |      |      |      |          |          |           |
|                | SBN              | -         | -    | 4.87 | -    | 0.67 | 1.956    | 2.21     | 6.42      |
|                | SON              | -         | -    | 5.07 | -    | 0.68 | 1.92     | 2.19     | 9.43      |
| Tiger shrimp   | TRN              | -         | -    | -    | -    | 0.22 | 4.53     | 4.54     | 2.99      |
|                |                  | 6.75      | 1.25 | 0.92 | 3.18 |      |          |          |           |
|                | SBN              | -         | -    | 0.61 | -    | 0.63 | 4.67     | 4.93     | 7.21      |
|                | SGN              | -         | -    | 5.31 | -    | 0.16 | 4.55     | 5.15     | 11.08     |

### 3.7 Cohort analysis

Jones' Length-Cohort Analysis was carried out using the LFSA package, to determine the fishing mortality ( $F$ ) for each length class,  $F_{max}$  value and the number of each species recruited to each fishery.

The estimated catch number of each species by all gear was 73 million for Banana shrimp, 55 million for White shrimp and 5.8 million for Tiger shrimp. The maximum fishing mortality observed ( $F_{max}$ ) using different fishing gear is presented in Table 9. Banana shrimp shows low  $F_{max}$  values for all gear compared to other shrimp species. TRN exhibited the lowest  $F_{max}$  (1.93), while the other two gear were almost equal at over 3.  $F_{max}$  for Tiger shrimp was the highest for all gear, but indicated a much lower value for TRN compared to SGN or SBN.  $F_{max}$  values for White shrimp caught by all three fishing gear are higher than those for Banana shrimp, but less than those for Tiger shrimp.

These trends may probably be explained by the fact that Banana shrimp is more abundant in the area than the other two species. Larger sizes of Tiger shrimp generally occur in depths much greater than those at which the adults of Banana shrimp occur. Trends of low catches and high  $F$  values of White shrimp may probably be due to low abundance of the species.

### 3.8 Thompson and Bell prediction analysis

The findings of the analysis for mixed species catch by individual fishing gear are discussed below.\*

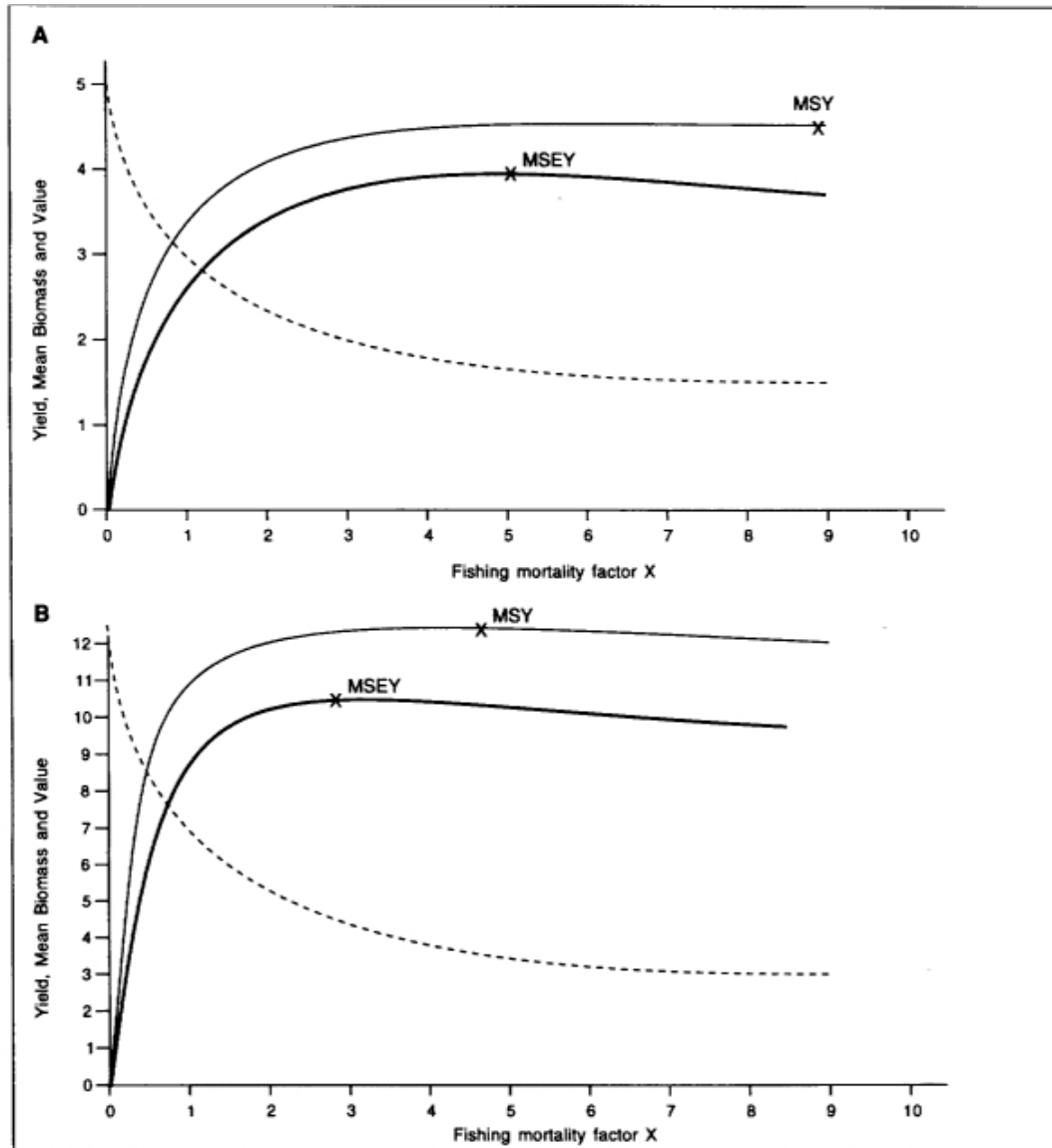
#### TRAMMELNET (TRN)

Using TRN for all three species specifically studied, the present level of fishing effort (the fishing mortality factor  $X$  is equal to 1.0), shows a yield less than the maximum sustainable yield (MSY).

\* Any discrepancies observed between the estimated level of yield and value from the Thompson and Bell analysis and the estimated production and value for the same fishery and species may be attributed to possible errors in the estimations of natural and fishing mortalities of the species concerned. Or due to the limitation in the estimation of production and value from the sampling carried out.

To attain MSY, the fishing effort has to increase nearly at least eightfold (Table 10 on facing page). The Maximum Sustainable Economic Yield (MSEY) will however result with a five-fold increase of fishing effort (see Figure 4A, and Table 10, Item 8).

Fig 4. Thompson and Bell long term prediction for (A) combined species, by trammelnet, with setbagnet and shrimp gillnet suppressed, and (B) selected shrimp species combined, by shrimp gillnet



For each of the three selected shrimp species exploited by TRN, the findings are:

- The present level of fishing effort for Banana shrimp results in yields below MSY and MSE, and could be increased by a factor  $X = 9.2$  and  $4.9$  respectively (Table 10, Item 2).
- The present level of fishing effort for Tiger shrimp results in yields far below MSY and MSE. Effort will have to be increased considerably to reach the optimum yield and revenue levels (Table 10, Item 1).
- The present level of fishing effort for White shrimp indicates a yield beyond MSY and should be reduced by about 20 per cent to maintain production at the MSY level. **It should, however, be reduced by 46 per cent to be at the MSE level.** This will ensure sufficient residual biomass, thereby avoiding recruitment overfishing (Table 10, Item 3).

**Table 10: Thomson and Bell production analysis**

| <i>Shrimp species</i> | <i>Gear</i>          | <i>MSY<br/>(tonnes)</i> | <i>F<br/>(Factor)</i> | <i>MSEY*<br/>(Rp.1000)</i> | <i>F<br/>(Factor)</i> | <i>Biomass<br/>(%)</i> |
|-----------------------|----------------------|-------------------------|-----------------------|----------------------------|-----------------------|------------------------|
| Tiger shrimp          | SBN                  | -                       | <b>&gt;50</b>         | 413,587                    | 36.3                  | >35                    |
|                       | SON                  | -                       | >50                   |                            | >50                   |                        |
|                       | TRN                  | -                       | >50                   | 429,604                    | 32.55                 | >30                    |
| Banana shrimp         | SBN                  | 309.33                  | 0.84                  | 1,334,320                  | 0.54                  | -                      |
|                       | SGN                  | 966.18                  | 5.0                   | 8,093,420                  | 2.80                  | 47                     |
|                       | TRN                  | 1970.77                 | 9.2                   | 15,382,180                 | 4.88                  | 29                     |
| White shrimp          | SBN                  | 309.33                  | 0.84                  | 1,334,320                  | 0.54                  | 33                     |
|                       | SGN                  | 141.35                  | 0.56                  | 603,980                    | 0.38                  | 35                     |
|                       | TRN                  | 94.76                   | 0.8                   | 408,060                    | 0.54                  | 29                     |
| All three species     | SBN                  | 1064.33                 | 3.00                  | 8,490,080                  | 2.38                  | 25                     |
|                       | SON                  | 1223.99                 | 4.80                  | 10,342,870                 | 2.98                  | 28                     |
|                       | TRN                  | 2360.04                 | >9                    | 19,598,510                 | 5.64                  | 35                     |
| Tiger shrimp only     | only<br>trammelnet,  | >593.71                 | >50                   | 8,007,460                  | 32.5                  | >20                    |
| White shrimp only     | others<br>suppressed | 548.67                  | 0.80                  | 2,362,080                  | 0.54                  | 23                     |
| Banana shrimp only    |                      | 3649.54                 | 9.17                  | 30,518,920                 | 5.10                  | 29                     |
| <b>Total</b>          |                      | <b>4659.60</b>          | <b>8.7</b>            | <b>39,454,190</b>          | <b>5.53</b>           | <b>27</b>              |

\* Here too, MSEY data showed inconsistencies.

### **SHRIMP GILLNET (SGN)**

Using SGN to catch all three species of shrimp, the present level of fishing effort is still below that necessary to attain MSY and MSE. Therefore it is possible to increase the present fishing effort five times for MSY or three times for MSE without risk of recruitment overfishing,

The present level of fishing effort for Banana shrimp results in yields below MSY and MSE, which occur at  $X = 5.04$  and  $X = 2.8$  respectively (see Table 10, Item 2).

However, the present level of fishing effort for White shrimp indicates a yield beyond MSY and MSE. Hence, the fishing effort must be reduced by around 50 per cent to attain MSY and MSE of this species.

### **SET BAGNET (SBN)**

The yield from SBN for all three species combined is below MSY and MSE at the present fishing effort and could be increased three times (see Table 10, Items 1-4). However, the present level of fishing effort for Banana shrimp has resulted in a yield exceeding MSY and MSE. Reduction of effort for this species is recommended. The same is the case for White shrimp. On the other hand, the yield of Tiger shrimp is far below MSY and MSE.

All three gear do not appear to catch Tiger shrimp effectively. For instance, even if fishing effort by TRN is increased fifty times, the residual biomass would still be acceptable. It must be noted, however, that yields may not improve unless these gear are operated in deeper waters. This is not possible with SBN. TRN could be operated in deeper waters more effectively to catch the larger sizes.

All three gear indicate that the present level of effort targeting White shrimp is greater than the effort required for MSY and MSE. But even at the present level of effort, the residual biomass is between 19-25 per cent, which is just adequate to avoid recruitment overfishing. Further increase in effort may damage the spawning stock. It appears that resources of White shrimp are relatively poor compared to Banana shrimp.

The relative yield of Banana shrimp from all three gear shows that it is the most abundant *Penaeus* species in the Langkat District, but, according to the analysis, appears to be underexploited. Fishing effort could, therefore, be considerably increased to attain MSY and MSE. At the MSY level, the residual biomass is nearly 30 per cent when using SGN and TRN, but slightly lower (24%) for SBN. However, any significant increase in fishing effort will adversely affect the stock of White shrimp.

The analysis for all three species combined indicates that the relatively large stock of Banana shrimp influences the shrimp fishery the most. Shrimp of *Metapenaeus* spp. comprise of at least four different species of smaller-sized animals, but the yield from these is not comparable to that of Banana shrimp. Normally, such species are caught by trawling and in the absence of such a fishing method, adaptation of TRN or SGN to exploit these resources will result in significant increases to yield and revenue.

Considering these results and the suitability of TRN as a shrimp-catching gear in the entire fishing ground, a Thompson and Bell production analysis was carried out to predict effects on yield and value when both SBN and SGN were not operated, assuming that recruitment to these fishing gear would be available to TRN (see Figure 3A). The results show that the MSY and MSE for the three shrimp species combined, could increase from 2,360,040 kg to 4,659,600 kg and Rp 1.9 x 10<sup>6</sup> to Rp 3.9 x 10<sup>10</sup> (100%). Though the gain from operating only TRN is negligible compared to the total yield and value from the catches when operating all three gear (Table 10, Item 4), the gain from operating only the TRN can be expected to be higher if the operation is in greater depths and the soaking time of the gear is increased considerably from the 15 minutes at present. Catches of live and ripe females for aquaculture purposes will also fetch a larger revenue.

### 3.9 Costs and earnings

Table 11: Characteristics and costs of the small motorized craft used in the shrimp fisheries in Langkat District

| Size, horsepower, crew numbers, average life and cost of popular craft for shrimp fisheries are presented in Table 11. | Item                               | TRN  | SGN  | SBN  |
|--|------------------------------------|------|------|------|
|  | Length (m)                         | 5-7  | 3-6  | 5-7  |
|  | Avg. hp of engine                  | 5    | 5    | 5    |
|  | Avg. no. of crew members           | 2    | 2    | 2    |
|  | Avg. life of hull (yrs)            | 5    | 5    | 5    |
|  | Avg. life of engine (yrs)          | 5    | 5    | 5    |
|  | Avg. original cost (x Rp. 1000)    | 1000 | 800  | 1000 |
|  | Avg. replacement cost (x Rp. 1000) | 1500 | 1200 | 1000 |
|  | Avg. repair cost/year (x Rp. 1000) | 300  | 240  | 300  |

Due to the difficulties in separating gear-craft combinations data during the bioeconomic survey, the economic analysis was carried out for the most popular type of fishing boat in Langkat District — the small motorized fishing boat with inboard engine, using either TRN, SGN or SBN.

The fishing gear with their variations, basic characteristics, average life and cost are presented in Table 12.

**Table 12: Shrimp fishing gear, their specifications and costs**

| <i>Items</i>                                | <i>TRN-I</i> | <i>TRN-II</i> | <i>SGN-I</i> | <i>SGN-II</i> | <i>SBN</i>            |
|---|--------------|---------------|--------------|---------------|-----------------------|
| No. of panels                               | 3            | 10-15         | 10-15        | 10-15         | 2-5                   |
| Avg. no. of panels                          | 3            | 12            | 12           | 12            | 1                     |
| Size of panel or set (m)                    | 20-25 x 4    | 20 x 2        | 15-20 x 2    | 20-25 x 2     | 23/12-14<br>3-4/12-14 |
| Avg. no. of crew                            | 2            | 2             | 2            | 2             | 2                     |
| Avg. life of gear (yr)                      | 2            | 1             | 1            | 1             | 2                     |
| Original cost (x Rp 1000)*                  | 225          | 180           | 480          | 900           | 150                   |
| Replacement cost (xRp 1000)**               | 375          | 240           | 780          | 1125          | 200                   |
| Avg. repair cost per***<br>month (xRp 1000) | 300          | 180           | 480          | 900           | 120                   |

\* at time bought, \*\* at today's prices, \*\*\* based on total repairs during life of gear.

TRN1 (*faring Apollo*) is operated in Strata I, II, III and IV, TRN2 (*faring Taiwan*) in Stratum IV, SGN1 (*Pukat Udang*) in Strata I and II and SGN2 (*faring Planet*) in Strata III, IV and V. SBN is operated in all strata except Strata IV.

The system of sharing the earnings with the crew is similar in the case of all three craft-gear combinations. The crew get 50 per cent after deducting variable costs. The economic performance of each craft-gear combination in each station is presented in Table 13 on the facing page. The cost and earnings analysis shows that almost all the shrimp fishing activities are profitable, except SGN Stratum I. Due to much higher investment costs for TRN in Stratum IV, because prices of materials are higher there, the net revenue is low.

**Table 13: Economic performance of fishing with different gear at different stations**

| <i>Item</i>                      | <i>Station</i> |           |            |           |          |
|----------------------------------|----------------|-----------|------------|-----------|----------|
|                                  | <i>I</i>       | <i>II</i> | <i>III</i> | <i>IV</i> | <i>V</i> |
| <b>Trammelnet (TRN)</b>          |                |           |            |           |          |
| 1. Investment (xRp 1000)*        | 1480           | 1480      | 1480       | 1900      | 1480     |
| 2. Gross revenue (xRp 1000)      | 5129           | 5294      | 4924       | 5738      | 4378     |
| 3. Fixed cost (xRp 1000)         | 1460           | 1460      | 1460       | 2300      | 1460     |
| 4. Variable cost (xRp 1000)      | 828            | 1149      | 919        | 858       | 620      |
| 5. Crew share (xRp 1000)         | 2151           | 2073      | 2003       | 2440      | 1879     |
| 6. Owner net earnings (xRp 1000) | 690            | 612       | 542        | 140       | 419      |
| 7. Return on investment (%)      | 46.6           | 41.3      | 36.6       | 7.4       | 28.3     |
| <b>Shrimp Gillnet (SGN)</b>      |                |           |            |           |          |
| 1. Investment (xRp 1000)*        | 1025           | 1025      | 980        | 980       | 980      |
| 2. Gross revenue (xRp 1000)      | 2160           | 5154      | 4981       | 2165      | 3264     |
| 3. Fixed cost (xRp 1000)         | 813            | 813       | 760        | 760       | 760      |
| 4. Variable cost (xRp 1000)      | 900            | 636       | 625        | 221       | 691      |
| 5. Crew share (xRp 1000)         | 630            | 2259      | 2178       | 972       | 1286     |
| 6. Owner net earnings (xRp 1000) | -180           | 1446      | 1418       | 212       | 527      |
| 7. Return on investment (%)      | -              | 141.5     | 144.7      | 21.6      | 53.8     |
| <b>Set Bagnet (SBN)</b>          |                |           |            |           |          |
| 1. Investment (xRp 1000)*        | 1200           | 1200      | 1200       | -         | 1200     |
| 2. Gross revenue (xRp 1000)      | 4634           | 6698      | 3988       | -         | 3097     |
| 3. Fixed cost (xRp 1000)         | 695            | 695       | 695        | -         | 695      |
| 4. Variable cost (xRp 1000)      | 643            | 776       | 415        | -         | 710      |
| 5. Crew share (xRp 1000)         | 1995           | 2961      | 1786       | -         | 1194     |
| 6. Owner net earnings (xRp 1000) | 1301           | 2266      | 1092       | -         | 498      |
| 7. Return on investment (%)      | 108.4          | 188.8     | 91.0       | -         | 41.5     |

\* Boat + net



## 4. SOCIOECONOMIC FINDINGS

### 4.1 Village profile

The coastal villages of Langkat District have a multi-ethnic population. In the twelve villages surveyed, nearly half the households are involved with fishing or fishery-related activities (Table 14).

Table 14: Major economic activities of households (HH)

| Stratum |     | Fishing | Brackish water culture | Processing | Fish trade | Other trade | Agriculture | Livestock | Poultry | Labourer | Trader | Civil servant | Dukun | Other  | Total |
|---------|-----|---------|------------------------|------------|------------|-------------|-------------|-----------|---------|----------|--------|---------------|-------|--------|-------|
| I       | No. | 834     | 47                     | 4          | 22         | 10          | 266         | 87        | 64      | 263      | 94     | 657           | 0     | 269    | 2617  |
|         | %   | (31.8)  | (1.7)                  | (0.1)      | (0.8)      | (0.4)       | (10.2)      | (3.4)     | (2.4)   | (10.1)   | (3.6)  | (25.2)        |       | (10.3) | (100) |
| II      | No. | 1581    | 5                      | 202        | 177        | 650         | 167         | 47        | 66      | 1326     | 0      | 450           | 0     | 7      | 4678  |
|         | %   | (33.8)  | (0.1)                  | (4.4)      | (3.7)      | (13.8)      | (3.6)       | (1.1)     | (1.4)   | (28.4)   |        | (9.6)         |       | (0.1)  | (100) |
| III     | No. | 467     | 11                     | 14         | 14         | 0           | 129         | 5         | 10      | 24       | 0      | 0             | 0     | 31     | 705   |
|         | %   | (66.3)  | (1.6)                  | (1.9)      | (1.9)      |             | (18.3)      | (0.7)     | (1.5)   | (3.4)    |        |               |       | (4.4)  | (100) |
| IV      | No. | 853     | 11                     | 12         | 28         | 0           | 5           | 0         | 0       | 17       | 0      | 0             | 0     | 8      | 934   |
|         | %   | (91.4)  | (1.2)                  | (1.3)      | (2.9)      |             | (0.6)       |           |         | (1.8)    |        |               |       | (0.8)  | (100) |
| V       | No. | 625     | 1                      | 4          | 21         | 0           | 834         | 0         | 0       | 98       | 37     | 58            | 73    | 25     | 1776  |
|         | %   | (35.1)  | (0.0)                  | (0.2)      | (1.2)      |             | (46.9)      |           |         | (5.6)    | (2.1)  | (3.3)         | (4.2) | (1.4)  | (100) |
| Total   | No. | 4360    | 75                     | 236        | 262        | 660         | 1401        | 139       | 140     | 1728     | 131    | 1165          | 73    | 340    | 10710 |
|         | %   | (407)   | (0.7)                  | (2.2)      | (2.4)      | (6.2)       | (13.2)      | (1.2)     | (1.3)   | (16.2)   | (1.3)  | (10.8)        | (0.6) | (3.2)  | (100) |

Close to 80 per cent of the fisherfolk population is Malay. Chinese are not usually active fisherfolk, but they act as agents for the shrimp trade and are locally called *towke*. They often provide credit to fisherfolk. They purchase nearly all the shrimp catch.

The average family size of fishing households is five persons. Children below 14 years make up 43 per cent of the fisherfolk population and those aged above 60 two per cent.

Most of the population (70%) in fishing households have had a basic education upto primary school.

All villages have basic civic amenities, such as primary schools, hospitals, markets and places of worship.

### 4.2 Household income and expenditure

It is evident from Table 15 (facing page) that most of the fishing households in the district are dependent on fishing as the sole source of income. Strata III and IV have a greater percentage of fishing households than the other strata (Table 14). Fishery-related activities, such as aquaculture, processing and fish trade are undertaken by a very small percentage (0.7-2.4%) of the households. Agriculture is a relatively important activity in Stratum V.

About a quarter of the fishing households have an annual income of Rp. 3,000,000-3,500,000 and another quarter have incomes over that, while 4.3 per cent are below the poverty line of 1,000,000 Rp/year. Income from other sources does not significantly increase annual incomes.

**Table 15: Distribution of fisheries household by income level and type of economic activities in Langkat District**

| income level (Rp)     | Type of households |                                   |                                      |  |                          |  | Total       |
|-----------------------|--------------------|-----------------------------------|--------------------------------------|--|--------------------------|--|-------------|
|                       | Fishing only (A)   | Fishing and fishery-related (A+B) | Fishing and nonfishery related (A+C) | Fishing, fishery-related and non fishery related (A + B + C) | Fishery-related only (B) | Fishery-related and nonfishery related (B+C) |             |
| <1.000.000            | 21 (4.3%)          | —                                 | —                                    | —  | —                        | —  | 21 (3.4%)   |
| 1,000,001 - 1,500,000 | 41 (8.5%)          | 3 (5.5%)                          | 4 (5.5%)                             | —  | 1 (20%)                  | —  | 49 (7.9%)   |
| 1,500,000 - 2,000,000 | 39 (8.1%)          | 2 (3.8%)                          | 11 (15.1%)                           | —  | —                        | —  | 52 (8.4%)   |
| 2,000,001 - 2,500,000 | 43 (8.9%)          | 3 (5.7%)                          | 3 (4.1%)                             | —  | 1 (20%)                  | —  | 50 (8.0%)   |
| 2,500,001 - 3,000,000 | 89 (18.4%)         | 14 (26.4%)                        | 6 (8.2%)                             | —  | 1 (20%)                  | 1 (33.3%)                                    | 111 (17.8%) |
| 3,000,001 - 3,500,000 | 120 (24.7%)        | 15 (28.2%)                        | 7 (9.6%)                             | —  | 1 (20%)                  | —  | 143 (23.0%) |
| 3,500,001 - 4,000,000 | 48 (9.9%)          | 4 (7.5%)                          | 10 (13.7%)                           | 1 (25%)  | —                        | 1 (33.3%)                                    | 64 (10.3%)  |
| 4,000,001 - 4,500,000 | 30 (6.2%)          | 1 (1.9%)                          | 18 (24.6%)                           | —  | —                        | 1 (33.3%)                                    | 50 (8.0%)   |
| 4,500,001 - 5,000,000 | 12 (2.5%)          | 2 (3.8%)                          | 3 (4.1%)                             | —  | —                        | —  | 17 (2.7%)   |
| >5,000,000            | 41 (8.5%)          | 9 (17.0%)                         | 11 (15.1%)                           | 3 (75%)  | 1 (20%)                  | —  | 65 (10.5%)  |
| Total                 | 484(100%)          | 53(100%)                          | 73 (100%)                            | 4(100%)  | 5(100%)                  | 3(100%)                                      | 622(100%)   |

Most fisherfolk have used their own funds to acquire fishing assets. Those who needed loans, relied on local money-lenders and *towkes*, rather than banks.

Almost every household has a radio, 57 per cent have television sets, 29 per cent have motorcycles, 13 per cent own bicycles and some own commercial transport vehicles.

Monthly household expenditure varied from Rp. 75,000-300,000, depending on the household's affluence. Food ranked as the item of highest expenditure.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The possibility of erroneous data with limited sampling, due to constraints of inexperienced data-collectors and remoteness of some villages, does not permit any firm conclusions and recommendations. However, the study did result in a general understanding of the shrimp fishery and the fisherfolk involved in it in Langkat District. Some of the main points to note are:

- Shrimp fishing in Langkat District is artisanal and, at present, conducted in shallow waters, mostly 5-10 m deep.
- The three important fishing gear, SBN, SGN and TRN, are highly interactive, harvesting the same stock and at similar sizes.
- In the absence of trawlers, shrimp resources in deeper waters — particularly Tiger shrimp — are not being exploited.
- SBN cannot be operated in deeper waters. TRN is a better option for operating in deeper waters to catch larger shrimp and finfish.
- It is possible that other shrimp (*Metapenaeus* spp. and *Parapaneopsis* spp.) may be more abundant in these waters than penaeid shrimp, as in the case of the Malaysian coast bordering the Malacca Straits.

- While reducing mesh size may result in higher catches of *Metapenaeus* spp., operation of these nets should be carefully monitored, and the season limited, if necessary, to ensure that they do not exploit juveniles of penaeid shrimp.
- Since fishing seems to be the main source of income in the coastal belt of Langkat District and options to increase income from other sources are limited, some thought must be given to increasing yield and value without drastic increases in fishing effort. This may be possible only by encouraging more fisherfolk to use TRN and fish in deeper waters.

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## PUBLICATIONS OF THE BAY OF BENGAL PROGRAMME (BOBP)

*The BOBP brings out the following types of publications:*

Reports (BOBP/REP/...) which describe and analyze completed activities such as seminars, annual meetings of BOBP's Advisory Committee, and subprojects in member-countries for which BOBP inputs have ended.

Working Papers (BOBP/WP/...) which are progress reports that discuss the findings of ongoing work.

**Manuals and Guides (BOBP/MAG/...) which** are instructional documents for specific audiences.

**Information Documents (BOBP/INF/...) which** are bibliographies and descriptive documents on the fisheries of member-countries in the region.

Newsletters (*Bay of Bengal News*) which are issued quarterly and which contain illustrated articles and features in nontechnical style on BOBP work and related subjects.

**Other publications which include books and other miscellaneous reports.**

Those marked with an asterisk (\*) are out of stock but photocopies can be supplied.

### **Reports (BOBP/REP/...)**

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33. *Nonformal Primary Education for Children of Marine Fisherfolk in Orissa, India.* U. Tietze, N. Ray. (Madras, 1987.)
34. *The Coastal Set Bagnet Fishery of Bangladesh — Fishing Trials and Investigations.* S. E. Akerman. (Madras, 1986.)
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37. *High-Opening Bottom Trawling in Tamil Nadu, Gujarat and Orissa, India : A Summary of Effort and Impact.* (Madras, 1987.)
38. *Report of the Eleventh Meeting of the Advisory Committee, Bangkok, Thailand, 26-28 March 1987.* (Madras, 1987.)
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40. *Tuna in the Andaman Sea.* (Colombo, 1987.)
41. *Studies of the Tuna Resource in the EEZs of Sri Lanka and Maldives.* (Colombo, 1988.)
42. *Report of the Twelfth Meeting of the Advisory Committee.* Bhubaneswar, India, 12-15 January 1988. (Madras, 1988.)
43. *Report of the Thirteenth Meeting of the Advisory Committee.* Penang, Malaysia, 26-28 January 1988. (Madras, 1989.)
44. *Report of the Fourteenth Meeting of the Advisory Committee.* Medan, Indonesia, 22-25 January, 1990. (Madras, 1990.)
45. *Gracilaria Production and Utilization in the Bay of Bengal Region: Report of a seminar held in Songkhla, Thailand, 23-27 October 1989.* (Madras, 1990.)
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47. *Exploratory Fishing for Large Pelagic Species in Sri Lanka.* R. Maldeniya, S. L. Suraweera. (Madras, 1991.)
48. *Report of the Fifteenth Meeting of the Advisory Committee.* Colombo, Sri Lanka, 28-30 January 1991. (Madras, 1991.)
49. *Introduction of New Small Fishing Craft in Kerala, India.* O. Gulbrandsen and M. R. Anderson. (Madras, 1992.)
50. *Report of the Sixteenth Meeting of the Advisory Committee.* Phuket, Thailand, 20-23 January 1992. (Madras, 1992.)
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52. *Feeds for Artisanal Shrimp Culture in India — Their development and evaluation.* J. F. Wood et al. (Madras, 1992.)
53. *A Radio Programme for Fisherfolk in Sri Lanka.* R. N. Roy. (Madras, 1992.)
54. *Developing and Introducing a Beachlanding Craft on the East Coast of India.* V. L. C. Pietersz. (Madras, 1993.)
55. *A Shri Lanka Credit Project to Provide Banking Services to Fisherfolk.* C. Fernando, D. Attanayake. (Madras, 1992.)
56. *A Study on Dolphin Catches in Shri Lanka.* L. Joseph. (Madras, 1993.)
57. *Introduction of New Outrigger Canoes in Indonesia.* G. Pajot, O. Gulbrandsen. (Madras, 1993.)
58. *Report of the Seventeenth Meeting of the Advisory Committee.* Dhaka, Bangladesh, 6-8 April 1993. (Madras, 1993.)
59. *Report on Development of Canoes in Shri Lanka.* G. Pajot, O. Gulbrandsen. (Madras, 1993.)
60. *Improving Fisherfolk Incomes through Group Formation and Enterprise Development in Indonesia.* R. N. Roy. (Madras, 1993.)
61. *Small Offshore Fishing Boats in Shri Lanka.* G. Pajot. (Madras, 1993.)
62. *Fisheries Extension in the Maldives.* A. M. H. Heelas. (Madras, 1994.)
63. *Small-scale Oyster Culture on the West Coast of Peninsular Malaysia.* D. Nair, R. Hall, C. Angell. (Madras, 1993.)
64. *Chandi Boat Motorization Projects and Their Impacts.* R. Hall, A. Kashem. (Madras, 1994.)
65. *Learning by Doing in Bangladesh: Extension systems development for coastal and estuarine fisherfolk communities.* R. N. Roy. (Madras, 1994.)
66. *Promotion of Small-scale Shrimp and Prawn Hatcheries in India and Bangladesh.* C. Angell. (Madras, 1994.)

67. *The Impact of the Environment on the Fisheries of the Bay of Bengal*. Ed. by S Holmgren. Swedish Centre for Coastal Development and Management of Aquatic Resources. SWEDMARIBOBP. (Madras, 1994.)
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69. *Report of the Eighteenth Meeting of the Advisory Committee*. Furana Fushi, Maldives, 16-19 April, 1994. (Madras, 1994.)

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50. *Experiences with a Manually Operated Net-Braiding Machine in Bangladesh*. B.C. Gillgren, A. Kashem. (Madras, 1986.)
51. *Hauling Devices for Beachlanding Craft*. A. Overa. P.A. Hemminghyth. (Madras, 1986.)
52. *Experimental Culture of Seaweeds (Gracilaria Sp.) in Penang, Malaysia*. (Based on a report by M. Doty and J. Fisher). (Madras, 1987.)
53. *Atlas of Deep Water Demersal Fishery Resources in the Bay of Bengal*. T. Nishida, K. Sivasubramaniam. (Colombo, 1986.)
54. *Experiences with Fish Aggregating Devices in Sri Lanka*. K.T. Weerasooriya. (Madras, 1987.)
55. *Study of income. Indebtedness and Savings among Fisherfolk of Orissa, India*. T. Mammo. (Madras, 1987.)
56. *Fishing Trials with Beachlanding Craft at Uppada, Andhra Pradesh, India*. L. Nyberg. (Madras, 1987.)
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59. *Fishery Statistics in the Bay of Bengal*. T. Nishida. (Madras, 1988.)
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66. *Improving Marketing Conditions for Women Fish Vendors in Besant Nagar, Madras*. K. Menezes. (Madras, 1991.)
67. *Design and Trial of Ice Boxes for Use on Fishing Boats in Kakinada, India*. I.J. Clucas. (Madras, 1991.)
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69. *Agar and Alginate Production from Seaweed in India*. J. J. W. Coopen, P. Nambiar. (Madras, 1991.)
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80. *Reef Fish Resources Survey in the Maldives — Phase Two*. R. C. Anderson, Z. Waheed, A. Arif. (Madras, 1992.)
81. *Exploratory Fishing for Large Pelagic Species in South Indian Water*. J. Gallene, R. Hall. (Madras, 1992.)
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83. *Survey of Fish Consumption in Madras*. Marketing and Research Group, Madras, India. (Madras, 1992.)
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90. *Socioeconomic Conditions of Estuarine Set Bagnet Fisherfolk in Bangladesh.* K.T. Thomson, Sk Md Dilbar Jahan. Md Syed Hussain. (Madras, 1993.)
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92. *Cage Nursery Rearing of Shrimp and Prawn Fry in Bangladesh.* C. Angell. (Madras, 1994.)
93. *Dealing with Fishery Harbour Pollution — The Phuket Experience.* R. Ravikumar. (Madras. 1994.)
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95. *Biosocioeconomic Assessment of the Effects of Fish Aggregating Devices in the Tuna Fishery in the Maldives.* A Naeem, A Latheefa, Ministry of Fisheries and Agriculture, Male, Maldives. (Madras, 1994.)
96. *Biosocioeconomics of Fishing for Small Pelagics along the Southwest Coast of Sri Lanka.* P. Dayaratne, K.P. Sivakumaran. (Madras, 1994.)
97. *The Effect of Artificial Reef Installation on the Biosocioeconomics of Small-scale Fisheries in Ranong Province, Thailand.* Hansa et al. (Madras, 1994.)
98. *Biosocioeconomics of Fishing for Shrimp in Kuala Sepetang, Malaysia.* A.A. Nuruddin, Lim Chai Fong. (Madras, 1994.)
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### *Manuals and Guides (BOBP/MAG/...)*

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2. *Towards Shared Learning : Non-formal Adult Education for Marine Fisherfolk. Animators' Guide.* (Madras, June 1985.)
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4. *Separating Mixtures of Normal Distributions : Basic programs for Bhattacharya's Method and Their Application for Fish Population Analysis.* H. Goonetilleke, K. Sivasubramaniam. (Madras, 1987.)
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6. *A Manual on Rapid Appraisal Methods for Coastal Communities* P. Townsley. (Madras, 1993.)
7. *Guidelines for Extension Workers in Group Management, Savings Promotion and Selection of Enterprise.* H. Setyawati, P. Limawan, Directorate General of Fisheries, Ministry of Agriculture, Government of Indonesia, Jakarta and Bay of Bengal Programme. (In Indonesian). (Madras, 1992.)
8. *Extension Approaches to Coastal Fisherfolk Development in Bangladesh: Guidelines for Trainers and Field Level Fishery Extension Workers* Department of Fisheries, Ministry of Fisheries and Livestock, Government of Bangladesh and Bay of Bengal Programme. (In Bangla). (Bangladesh, 1992.)
9. *Guidelines on Fisheries Extension in the Bay of Bengal Region.* I Jungeling. (Madras, 1993.)
10. *Our Fish, Our Wealth.* A guide to fisherfolk on resources management — In 'comic book' style (English/Tamil/Telugu). K. Chandrakanth with K. Sivasubramaniam, R. Roy. (Madras, 1991.)
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18. *A Handbook of Oyster Culture.* H. Nawawi. (In English and Malay). (Madras, 1993.)
19. *Management of Fisherfolk Microenterprises - A manual for training of trainers.* V. Muthu, P.S.A. Kunchitha Padam, Bhatnagar. (Madras, 1993.)
20. *Life on Our Reefs - A colouring book.* Ministry of Fisheries and Agriculture, Male, Republic of Maldives and the Bay of Bengal Programme. (Madras, 1993.)

### **Information Documents (BOBP/INF/...)**

10. *Bibliography on Gracilaria — Production and Utilization in the Bay of Bengal.* (Madras, 1990.)
11. *Marine Small-Scale Fisheries of West Bengal : An Introduction.* (Madras, 1990.)
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13. *Bibliography on the Mud Crab Culture and Trade in the Bay of Bengal Region.* (Madras, 1992.)

### **Newsletters (Bay of Bengal News)**

Quarterly, from 1981

### **Other Publications**

1. *Helping Fisherfolk to Help Themselves : A Study in People's Participation,* (Madras, 1990.).
2. *The Shark Fisheries of the Maldives.* **R C Andersen, H Ahmed.** Ministry of Fisheries and Agriculture, Maldives. (Madras, 1993).

**NOTE:** Apart from these publications, the BOBP has brought out several folders, leaflets, posters etc., as part of its extension activities. These include Post-harvest Fisheries folders in English and in some South Indian languages on anchovy drying, insulated fish boxes, fish containers, ice boxes, the use of ice etc. Several unpublished reports connected with BOBP's activities over the years are also available in its Library.

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