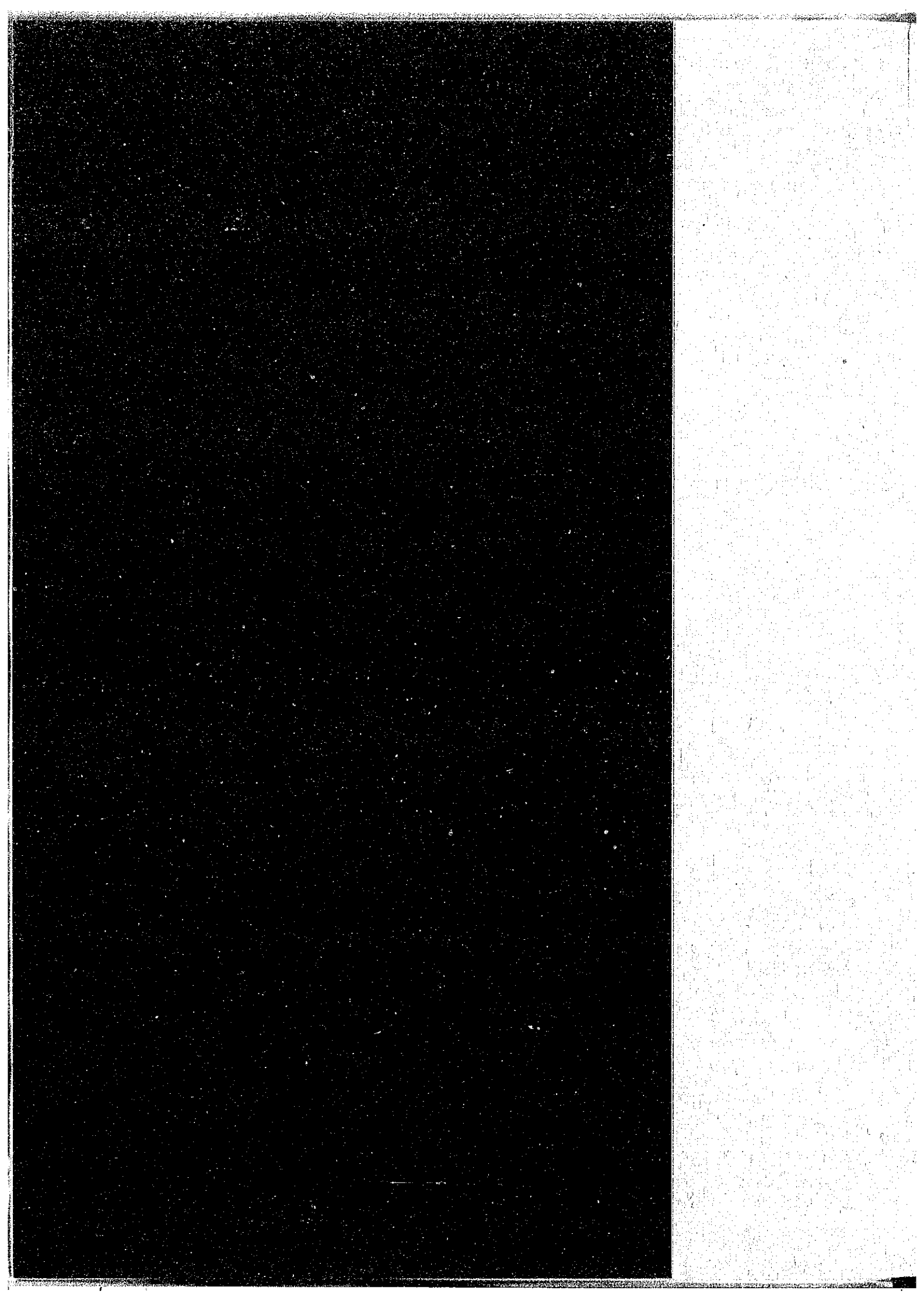


GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES  
STUDY MALAYSIA

REGIONAL REPORT



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**GOVERNMENT OF MALAYSIA**

**NATIONAL WATER RESOURCES  
STUDY, MALAYSIA**

**SECTORAL REPORT**

**VOL. 7**

**ECOLOGY**

**OCTOBER 1982**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

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COMPOSITION OF THIS VOLUME

This Volume consists of two parts: Part 1 deals with the subject matters of Peninsular Malaysia and Part 2 is devoted to the States of Sabah and Sarawak.





## ABBREVIATIONS

### (1) Plan

FMP	:	First Malaysia Plan
SMP	:	Second Malaysia Plan
TMP	:	Third Malaysia Plan
4MP	:	Fourth Malaysia Plan
5MP	:	Fifth Malaysia Plan
6MP	:	Sixth Malaysia Plan
7MP	:	Seventh Malaysia Plan
NEP	:	New Economic Policy
OPP	:	Outline Perspective Plan
RESP	:	Rural Environmental Sanitation Program

### (2) Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Division of Environment
DOF	:	Department of Forestry
DOFS	:	Department of Fishery
DOM	:	Department of Mines
DOS	:	Department of Statistics
EPU	:	Economic Planning Unit
FAMA	:	Federal Agricultural Marketing Authority
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
ICU	:	Implementation and Coordination Unit
MARDI	:	Malaysian Agricultural Research and Development Institute
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance

MOH : Ministry of Health  
 MOPI : Ministry of Primary Industries  
 MRRDB : Malaysia Rubber Research and Development Board  
 NDPC : National Development Planning Committee  
 NEB (LLN) : National Electricity Board  
 PORIM : Palm Oil Research Institute of Malaysia  
 PWD (JKR) : Public Works Department  
 RDA : Regional Development Authority  
 RISDA : Rubber Industry Small-holders Development Authority  
 RRIM : Rubber Research Institute of Malaysia  
 SEB : Sabah Electricity Board  
 SEBC : State Economic Development Corporation  
 S(E)PU : State (Economic) Planning Unit  
 SESCO : Sarawak Electricity Supply Corporation  
 UDA : Urban Development Authority

(3) International or Foreign Organization

ADAA : Australian Development Assistance Agency  
 ADB : Asian Development Bank  
 ASCE : American Society of Civil Engineers  
 FAO : Food and Agriculture Organization of the United Nations  
 IBRD : International Bank for Reconstruction and Development  
 ILO : International Labour Organization  
 IMF : International Monetary Fund  
 IRRI : International Rice Research Institute  
 JICA : Japan International Cooperation Agency  
 JSCE : Japan Society of Civil Engineers  
 MOC : Ministry of Construction, Japan  
 OECD : Organization for Economic Cooperation and Development  
 OECF : Overseas Economic Cooperation Fund, Japan  
 UK : United Kingdom  
 UNDP : United Nations Development Program

UNSF : United Nations Special Fund  
 US or USA: United States of America  
 US/AID : United States Agency for International  
 Development  
 USBR : United States Bureau of Reclamation  
 WHO : World Health Organization  
 WMO : World Meteorological Organization

(4) Others

B : Benefit  
 BOD : Biochemical Oxygen Demand  
 C : Cost  
 CIF : Cost, Insurance and Freight  
 COD : Chemical Oxygen Demand  
 D&I : Domestic and Industrial  
 dia : Diameter  
 EIRR : Economic Internal Rate of Return  
 El. : Elevation above mean sea level  
 Eq. : Equation  
 Fig. : Figure  
 FOB : Free on Board  
 FSL : Full Supply Level  
 GDP : Gross Domestic Product  
 GNP : Gross National Product  
 H : Height, or Water Head  
 HWL : Reservoir High Water Level  
 LWL : Reservoir Low Water Level  
 O&M : Operation and Maintenance  
 Q : Discharge  
 Ref. : Reference  
 SITC : Standard International Trade Classification  
 SS : Suspended Solid  
 V : Volume  
 W : Width

## ABBREVIATIONS OF MEASUREMENT

### Length

mm = millimeter  
cm = centimeter  
m = meter  
km = kilometer  
ft = foot  
yd = yard

### Area

cm<sup>2</sup> = square centimeter  
m<sup>2</sup> = square meter  
ha = hectare  
km<sup>2</sup> = square kilometer

### Volume

cm<sup>3</sup> = cubic centimeter  
l = lit = liter  
kl = kiloliter  
m<sup>3</sup> = cubic meter  
gal. = gallon

### Weight

mg = milligram  
g = gram  
kg = kilogram  
ton = metric ton  
lb = pound

### Time

s = second  
min = minute  
h = hour  
d = day  
y = year

### Electrical Measures

V = Volt  
A = Ampere  
Hz = Hertz (cycle)  
W = Watt  
kW = Kilowatt  
MW = Megawatt  
GW = Gigawatt

### Other Measures

% = percent  
PS = horsepower  
° = degree  
' = minute  
" = second  
°C = degree in centigrade  
10<sup>3</sup> = thousand  
10<sup>6</sup> = million  
10<sup>9</sup> = billion (milliard)

### Derived Measures

m<sup>3</sup>/s = cubic meter per second  
cusec = cubic feet per second  
mgd = million gallon per day  
kWh = kilowatt hour  
MWh = Megawatt hour  
GWh = Gigawatt hour  
kWh/y = kilowatt hour per year  
kVA = kilovolt ampere  
BTU = British thermal unit  
psi = pound per square inch

### Money

M\$ = Malaysian ringgit  
US\$ = US dollar  
¥ = Japanese Yen

## CONVERSION FACTORS

	<u>From Metric System</u>	<u>To Metric System</u>
<u>Length</u>	1 cm = 0.394 inch 1 m = 3.28 ft = 1.094 yd 1 km = 0.621 mile	1 inch = 2.54 cm 1 ft = 30.48 cm 1 yd = 91.44 cm 1 mile = 1.609 km
<u>Area</u>	1 cm <sup>2</sup> = 0.155 sq.in 1 m <sup>2</sup> = 10.76 sq.ft 1 ha = 2.471 acres 1 km <sup>2</sup> = 0.386 sq.mile	1 sq.ft = 0.0929 m <sup>2</sup> 1 sq.yd = 0.835 m <sup>2</sup> 1 acre = 0.4047 ha 1 sq.mile = 2.59 km <sup>2</sup>
<u>Volume</u>	1 cm <sup>3</sup> = 0.0610 cu.in 1 lit = 0.220 gal.(imp.) 1 kl = 6.29 barrels 1 m <sup>3</sup> = 35.3 cu.ft 10 <sup>6</sup> m <sup>3</sup> = 811 acre-ft	1 cu.ft = 28.32 lit 1 cu.yd = 0.765 m <sup>3</sup> 1 gal.(imp.) = 4.55 lit 1 gal.(US) = 3.79 lit 1 acre-ft = 1,233.5 m <sup>2</sup>
<u>Weight</u>	1 g = 0.0353 ounce 1 kg = 2.20 lb 1 ton = 0.984 long ton = 1.102 short ton	1 ounce = 28.35 g 1 lb = 0.4536 kg 1 long ton = 1.016 ton 1 short ton = 0.907 ton
<u>Energy</u>	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
<u>Temperature</u>	°C = (°F - 32) · 5/9	°F = 1.8°C + 32
<u>Derived Measures</u>	1 m <sup>3</sup> /s = 35.3 cusec 1 kg/cm <sup>2</sup> = 14.2 psi 1 ton/ha = 891 lb/acre 10 <sup>6</sup> m <sup>3</sup> = 810.7 acre-ft 1 m <sup>3</sup> /s = 19.0 mgd	1 cusec = 0.0283 m <sup>3</sup> /s 1 psi = 0.703 kg/cm <sup>2</sup> 1 lb/acre = 1.12 kg/ha 1 acre-ft = 1,233.5 m <sup>3</sup> 1 mgd = 0.0526 m <sup>3</sup> /s
<u>Local Measures</u>	1 lit = 0.220 gantang 1 kg = 1.65 kati 1 ton = 16.5 pikul	1 gantang = 4.55 lit 1 kati = 0.606 kg 1 pikul = 60.6 kg

Exchange Rate  
(as average between July and December 1980)

\$1 = M\$2.22  
¥100 = M\$1.03



***PART 1***  
***PENINSULAR***  
***MALAYSIA***





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## 1. INTRODUCTION

The objective of this Study is to find out the possible influences of the various development activities on the environment from the viewpoint of aqua ecology of rivers.

A few ecological studies on this subject were carried out in Malaysia but the data and information obtainable from them are quite limited. Therefore, data and information for fish fauna were mainly obtained through interview surveys made for major rivers in Peninsular Malaysia.

Fourteen rivers out of 41 were selected for the interview surveys based on their geographical location and water quality conditions reported by DOE (Ref. 1) as shown in Fig. 1 and Tables 1 to 4, respectively. These rivers are Kedah, Muda, Kerian, Kurau, Perak, Melaka, Muar, Johor, Endau, Rompin, Pahang, Kuantan, Trengganu and Kelantan rivers. The total basin area is  $93.5 \times 10^3 \text{ km}^2$  which accounts for 72.4% of all the river basins in Peninsular Malaysia.

The interviews were carried out at 69 villages along the above-mentioned 14 rivers, names and locations of which are shown in Tables 3 to 5, and Fig. 1. Distances from river mouths are shown in Table 5, and zoning by longitudinal gradient are in Tables 6 to 7, respectively.

The Kelang river, which is passing through Kuala Lumpur and the most polluted river in the Peninsular, was not included because several ecological surveys were carried out since 1960 (Refs. 2 to 5).

In general, river basins in the west coast are well developed for the agricultural land use. Some of them, such as the Perak, Kelang and Johor rivers are under the influence of tin mining. River structures such as dams, weirs and tidal barrages were constructed in the main streams of the Kedah, Muda, Kerian, Kurau, Perak, Kelang and Melaka rivers. On the other hand, the rivers in the east coast are generally yet to be developed compared with those in the West Coast. But some upper reaches of the Endau, Rompin, Pahang and Kuantan rivers are already developed. All the rivers except the Trengganu and Kelantan rivers show abnormal values of water quality in some portions probably due to the processing factories for agricultural products.

## 2. PRESENT CONDITION OF AQUA ECOSYSTEM OF THE REPRESENTATIVE RIVERS

### 2.1 Fish Fauna

#### 2.1.1 Macro-characteristics

Tables 8 to 13 show local names of 143 types of fish. Out of them, 23 types could not be identified by scientific name. Other 4 types were not fish; shells, crabs and 2 types of shrimps. A total of 99 types were identified as freshwater or brackish water fishes. The remaining 17 types were identified as sea fishes.

Of them, 126 types are edible, 8 types are not edible and 9 types are eaten by some people. It means almost all listed fishes are the source of food for the people.

The qualitative potentiality of fish growth (fish fauna and other ecological factors) seems to have been kept its original characteristics in all the rivers, as far as the macroscopic conditions of fish fauna are concerned. It is evidenced by the common pattern of the basic fauna in all the rivers.

On the contrary, the microscopic conditions of fish fauna by location are sometimes quite different from each other even in the same river. For example, some faunas show seriously degraded conditions and others do not even in the same river. It is described in the Section 2.1.2.

Following facts on the fish fauna at each location of the rivers were obtained from the interview surveys:

- (1) Number of fish types of the rivers vary very much according to the river.

Kedah: 41, Muda: 54, Kerian: 47, Kurau: 46, Perak: 69,  
Melaka: 34, Muar: 60, Johor: 49, Endau: 65, Rompin: 55,  
Pahang: 94, Kuantan: 37, Trengganu: 63 and Kelantan: 56

The maximum was 94 of the Pahang river. The minimum was 34 of the Melaka river. Those faunas seem to have some positive correlation with the area of a river basin as shown in Fig. 2.

- (2) The longitudinal distributions of fishes are shown in Tables 14 to 17. Types of fishes are 60 in number which are mostly freshwater fishes distribute not only in the lower part of the rivers but also in the middle part gradients of which usually reach more or less 3%. Two of them are brackish Mugils (X1.1, X1.2). A total of 58 types which include 6 types of sea fishes distribute only in lower locations but they can reach more or less 300 km from river mouths. Up to 50 km from river mouths, 25 types which are mostly brackish or sea fishes distribute.



Some fishes such as D1.1, D1.2, D.2, D14.1 and D15 are said to stay usually in the upper locations (Ref. 6), but their distributions seem to be in wider range in some environmental conditions as shown in Table 14.

- (3) Identified fish faunas of the rivers are shown in Tables 18 to 20. The food habits of the identified fishes except sea fishes (99 types) are shown in Table 21.

Taxonomically, the 99 types of fishes are classified in the following three "basic faunas" as shown in Table 22, together with 12 types of food habit:

- (a) Cypriniforms (Carp form) - 5 types of food habits: herbivores (H), omnibores; herbivorous dominant (OH), omnibores; predator dominant (OP), carnivores; arthropods and invertebrales feeder (C); crustacea and fish feeder (CP)
- (b) Siluriforms (Catfish form) - 2 types: C and CP
- (c) Non-Ostaryophysii (Fishes which do not have Weberian Apparatus) - 5 types: H, OH, OP, C and CP

The compositions of the basic fauna and food habits in the 14 rivers were quite similar as shown in Figs. 3 to 5. Each composition of the basic fauna fluctuates as follows and illustrated in Fig. 6:

- (a) Cyp. : 39.0% (Johor river) - 56.9% (Muda river)
- (b) Sil. : 7.8% (Muda river) - 17.6% (Pahang river)
- (c) Non-Ost.: 48.8% (Johor river) - 34.0% (Kelantan river)

In case of the Kelang river, the composition of its fauna was reported as Cypriniforms 52.9%, Siluriforms 11.8% and Non-Ostaryophysii 35.3%, even though this river is severely polluted (Ref. 5). In addition, the fauna possesses 12 types of food habit mentioned above.

From these facts, it is reasonable to conclude that the basic fauna of the rivers in Peninsular Malaysia does not have much difference each other and it is still keeping such an original character which is composed of the predominant herbivores and omnivores of Cypriniforms, the carnivores of Siluriforms and the dominant herbivores and omnivores of Non-Ostaryophysii, even though each river is under the various kind of influences of river development.

(4) Following 14 types of fishes and 1 type of prawn, distribute commonly, at least, at one part of each river basin interviewed.

(a) Cyp. : 6 types - D4, D6, D12.1, D14.1, D18.2, D18.3

(b) Sil. : 2 types - H1.1, I1.1

(c) Non-Ost.: 6 types - C1, L1.1, L1.4, O1, O6, S1

(d) Prawn : 1 type - YY3

All the types are categorized in the group longitudinal distribution of which is from the lower to the middle part of the river as described in Section 2.1.1(2). Out of 15 types, 10 are carnivorous fishes. All the types of Siluriforms and Non-Ostaryophysi possess not only gills but also accessory air breathing organs so as to survive under very adverse conditions. D6 is reported to distribute even at the lower part of the Gombak river where water is seriously affected by the effluent from Kuala Lumpur city (Ref. 5). Ecological characteristics of the other types of Cypriniforms are not so clear but their food habits possess herbivores (D12.1), omnivores (D18.2 & D18.3) and carnivores (D4, D6 & D14.1). Accordingly, it means that there still exists ecologically suitable places for those cyprinids in some parts of each river concerned even at the present time.

#### 2.1.2 Micro-characteristics

The present conditions of fish fauna at each location in each river are shown in Tables 23 to 37. Their characteristics are classified by using the following 3 indices, which are summarized in Tables 38 to 40:

- (a) Occupation rate (%) of freshwater fish types at each location out of the total freshwater fish types in each river: (Of),
- (b) Occupation rate (%) of herbivorous and omnivorous fish types at each location out of the total of these types in each river: (Oh), and
- (c) The number of food habit types in the basic fauna: (Nh = 12).

##### (1) Kedah river

The following characteristics of fish fauna at each location are obtained as shown in Tables 23 and 38:

- (a) The fish fauna at Ked-3 is most balanced compared with those of other locations. Ked-3 is located at the midway between the river mouth and the Pedu Dam but is categorized in the lower part of the river. Just downstream of Ked-3, there is an irrigation weir. All types of food habits in the basic fauna still exist at Ked-3 but Oh value of 58% seems to be low. In other words, the role of carnivorous fish seems to be strong in the fish fauna at Ked-3;

- (b) The fish fauna to Ked-1 and Ked-2 which are located downstream of the tidal barrage at Alo Star shows the most deteriorated conditions in this river from the viewpoint of Of, Oh and Nh values. Their Of and Oh values are only half of the one at Ked-3. In addition, 3 to 4 types of food habit of fishes in the basic fauna (Cyp: H & OH and Sil: C, N-O & OH) do not exist in these locations;
- (c) Ked-4, Ked-5, Ked-6 and Ked-7 are located in the upstreams of the different tributaries. Ked-6 and Ked-7 are located near the irrigated area. Among them, the fish fauna of Ked-4 is comparatively well balanced. Those of Ked-5 and Ked-6 show slightly deteriorated condition. The fish fauna at Ked-7 shows the poorest condition. In all these locations, Oh values are below 50% and 1 to 2 types of food habit of the basic fauna are absent. It should be reminded that freshwater prawns (YY3) have recently disappeared from all these locations as shown in Table 23; and
- (d) The fish fauna of this river varies very much according to the locations. The variety of herbivorous fish seems to be poor.

(2) Muda river

The following characteristics of fish fauna at each location are obtained as shown in Tables 24 and 38:

- (a) The fish fauna at Mud-3 is most balanced compared with those of other locations. Mud-3 is located at midway between the river mouth and the Muda Dam and is situated in the lower part of the river. It shows high value of Of (78%) and Oh (73%) and Nh is 12;
- (b) On the contrary, the fish fauna of Mud-1 which is located downstream of the tidal barrage shows the most deteriorated condition and indicates it is somewhat under the influence of sea water (3 types of marine fish as shown in Table 24). Its Of and Oh values are only 18% and 23%, respectively. Five types of food habit in the basic fauna (Cyp: OH & CP, Sil: C and N-O: OH & C) are absent at this location;
- (c) Mud-4 is located upstream of Mud-3 and somewhat downstream of the Muda Dam. The fish fauna of this location is also heavily deteriorated. Of value is 38% which is only half of that at Mud-3. Oh value is 19% which is lower than that of Mud-1. Three types of food habit in the basic fauna (N-O: H, OH & OC) are absent;
- (d) Mud-5 is located downstream of the existing water supply dam which is located upstream of one of the tributaries. Its fauna is also much degraded (Of: 44%, Oh: 42% and Nh: 11%) but is still better than that of Mud-4. Freshwater prawn (YY3) has also recently disappeared from Mud-4 and Mud-5 which is also the case for Ked-4 to Ked-7; and

- (e) Mud-2 is located downstream of Mud-3 and just upstream of the tidal barrage. Its fauna is comparatively well balanced but deteriorated compared with that at Mud-3. Oh value of Mud-2 is only 54% compared with 73% of Mud-3.

(3) Kerian river

The following characteristics of fish fauna at each location are obtained as shown in Tables 25 and 38:

- (a) The fish fauna of Ker-2, Ker-3 and Ker-4 are comparatively well balanced. Among them, the fish fauna at Ker-3 which is located in the middle part of the river is most balanced with Of and Oh value of 71% each. Ker-2 is located just upstream of an irrigation weir situated in the lower part of the river and Ker-4 is located upstream of Bayor tributary. Fish faunas at these 2 locations show almost the same conditions and are more degraded than that of Ker-3 from the viewpoint of Of and Oh. These three locations possess all types of food habit in the basic fauna;
- (b) Like the case of Ker-4, Ker-5 is also located upstream of Ijok tributary. But its fauna is apparently poorer than that of Ker-4. Of and Oh values are low. Further, 2 types of Nh are absent at this location. Freshwater prawn has also disappeared from this location; and
- (c) Ker-1 is located downstream of the irrigation weir mentioned above. Its fauna shows the most deteriorated condition and is somewhat under the influence of sea water (1 type of marine fish as shown in Table 25). Of and Oh values are only 31% and 29%, respectively which are below half of these at Ker-3. In addition, 3 types of food habit are absent at this location.

(4) Kurau river

The following characteristics of fish fauna at each location are obtained as shown in Tables 26 and 38:

- (a) The fish faunas at Kra-3 and Kra-5 are comparatively balanced with Nh value of 12. But both faunas can not be considered as in good conditions. Because Of and Oh values show only 61 to 63% and 50 to 54%, respectively. The role of carnivorous fish seems to be strong in the fish fauna of these locations. The same tendency is observed in the Kedah river. Kra-3 is located just at the reservoir site at Merah Dam which is located in the middle part of this river. Kra-5 is located upstream of one of the tributaries. It is interesting that the fish faunas in these different environments possess the same characteristics;

- (b) On the other hand, Kra-4 is also located upstream of Kra-3, same as Kra-5 but in one of the different tributaries. Its fauna shows much degraded condition compared with that of Kra-5. Four types of fishes have recently disappeared from this location as shown in Table 26. Except the disappearance, the fish fauna at this location might have almost the same conditions as those of Kra-3 and Kra-5. Oh value of 54% at this location is the same as Kra-5;
- (c) Kra-2 is located somewhat downstream of the Merah Dam (Kra-3). Its fauna shows the same level of degraded condition as that of Kra-4. But it is more degraded from the point of the value of Oh (42%) compared with that of Kra-4 (54%);
- (d) The fish fauna of Kra-1 shows the most deteriorated condition. Its Of and Oh values are only 30% and 25%, respectively, which are half of Kra-3. Three types of food habit in the basic fauna (Cyp: CP and N-0: OH & CP) are absent; and
- (e) Freshwater prawn (YY3) has recently disappeared from all the locations in this river which did not happen in the other rivers.

(5) Perak river

The following characteristics of fish fauna at each location are obtained as shown in Tables 27, 28 and 39:

- (a) In the main stream (Per-1 to Per-10), the fish fauna at its middle part (Per-5, Per-6, Per-7) is most balanced even downstream (Per-5, Per-6) or upstream (Per-7) of the Chenderoh Dam. Comparatively, those at the downstream (Per-4 to Per-6) are better than those at the upstream (Per-7 to Per-10). Of and Oh values of Per-6 shows the highest values of 63% and 60%, respectively. However, these are not so high compared with those of Ked-3, Mud-3 and Ker-3. The values are about the same as those of Kra-3. In the lowest parts of the main stream (Per-1 to Per-3), the faunas are at deteriorated conditions from the viewpoint of the values of Of, Oh and Nh, and show some influence of the sea water (1 to 3 types of marine fishes as shown in Tables 27 & 28. Freshwater prawn seems to exist even at the upper part of the Chenderoh Dam; and
- (b) In the main tributaries (Kinta, Kampar, Batan Padang, Bidor and Sunkai rivers), the fish faunas seem to reflect the differences between the ecological conditions. The faunas at Per-11 and Per-12 which are located along the Kinta river show almost the same characteristics as these at Per-8 to Per-10, upstream of the Chenderoh Dam, but that at Per-12 shows a little bit better condition than that at Per-11 which is located downstream. The fish fauna at Per-13 and Per-14 which are located in the Kampar and Batan Padang rivers, respectively show most deteriorated conditions with Of of 32% to 34% and Oh of 29% to 31% which are only half of Per-6. The fauna upstream of Bidor river

(Per-16) shows the almost same condition of Per-8 to Per-10, but that of Per-15, located downstream of Per-16 at the confluence with Sungkai river, has recently lost 5 types of fishes as shown in Tables 27 & 28, the reason for which may be the same as for the worse condition of fish fauna at Per-17 upstream of Sungkai river.

(6) Kelang river

The following characteristics of fish fauna in the Kelang river are obtained as shown in Table 29 (Ref. 3 & 5):

- (a) At the upper part of the river (Gombak tributary), the fish fauna possesses 25 types which include all the types of food habit in the basic fauna; and
- (b) At the confluence of the Gombak and Kelang rivers which is located in the city of Kuala Lumpur, the fauna is completely deteriorated and only *Tilapia mossambica* is observed.

(7) Melaka river

The following characteristic of fish fauna at each location are obtained as shown in Tables 30 and 39:

- (a) The fish fauna of Mlk-2 which is located at the middle part of the river shows far better condition with Of of 82%, Oh of 80% and Nh of 12 than that of Mlk-1 with Of of 55%, Oh of 47 and Nh of 8. Mlk-1 has recently lost 8 types of fishes even though it is located in the upstream of the tidal barrage. It should be reminded that the fish faunas upstream of the tidal barrage in other rivers (Mud-2 and Ker-2) do not show such deteriorated condition as is the case for Mlk-1.

(8) Muar river

The following characteristics of fish fauna at each location are obtained as shown in Tables 31 and 39:

- (a) The fish faunas of this river except Mua-1 and Mua-6 are basically kept in similar conditions. Among them, the fauna of Mua-3 which is located in the middle part of the river is most balanced with Of of 73%, Oh of 65% and Nh of 12. The fish fauna of Mua-2 shows poor conditions. Its Of of 69% is second to the highest but Oh of 54% is the lowest among the locations. On the contrary, the fish fauna of Mua-5 shows reverse condition. Its Of of 60% is the lowest but Oh of 65% is the highest with Mua-3. The fish fauna of Mua-4 and Mua-7 show the same values of Of (64%), Oh (62%) and Nh (12), even though geographical location is quite different each other. Mua-4 is located in the middle part of the main stream and Mua-7 is located in the upperstream of one of the tributaries;

- (b) At the most upper part (Mua-6), the fish fauna shows the lowest value of Of, 45%. Freshwater prawn has recently disappeared from this location; and
- (c) At the river mouth (Mua-1), the fish fauna shows more degraded condition than these upper locations except Mua-6. Only this location, Mua-1, does not possess all the types of food habit in the basic fauna.

(9) Johor river

The following characteristics of fish fauna at each location are obtained as shown in Tables 32 and 40:

- (a) At the middle part of the river (Joh-2), the fish fauna is most balanced with Of of 71%, Oh of 61% and Nh of 12;
- (b) At the upper part of the river (Joh-3), the fish fauna is much degraded with Of of 50% and Oh of 50%, but is still possessed all the types of food habit in the basic fauna;
- (c) The fauna of the river mouth (Joh-1) shows the most deteriorated condition with Of of 32%, Oh of 28% and Nh of 8 and strong influences of the sea water (6 types of marine fishes as shown in Table 32; and
- (d) Freshwater prawn has not disappeared even though the conditions of the fish fauna at each location are quite different each other.

(10) Endau and Rompin rivers

The following characteristics of fish fauna at each location are obtained as shown in Tables 33 and 40:

- (a) The fish faunas at both river mouths (End-1 and Rom-1) show well balanced condition and strong influence of the sea water (5 types of marine fish as shown in Table 33). Those possess all the types of Nh in the basic fauna and shows high value of Of (88% to 89%) and Oh (78% to 82%); and
- (b) On the contrary, the fauna in the middle part of the river (End-2) shows much deteriorated conditions with Of of 59%, Oh of 56% and Nh of 11.

(11) Pahang river

The following characteristics of fish fauna at each location are obtained as shown in Tables 34 and 40:

- (a) The fauna at Pah-4 which is located in the middle part of the main stream shows the most balanced conditions with Of of 78% and Oh of 74% but it does not possess 1 type of food habit (N-0: H) in the basic fauna. At Pah-5, Of is 69% and Oh, 74%. One type of Nh (N-0: H) is absent;

- (b) The fauna of Pah-3 which is located somewhat downstream of the confluence of the Bera tributary shows the most deteriorated condition with Of of 38% and Oh of 31% which are below half of these of Pah-4. One type of Nh (N-O: H) is also absent; and
- (c) The fish faunas of Pah-1 and Pah-2 are comparatively well balanced from the viewpoint of Nh but the values of Of (53% to 62%) and Oh (51% to 54%) are quite low compared with those of Pah-4 (Of: 78% and Oh: 74%).

(12) Kuantan river

The following characteristics of fish fauna at each location are obtained as shown in Tables 35 and 40:

- (a) Kuant-1 is located in the middle part of the river. Its fauna is much more balanced with Of of 92%, Oh of 80 and Nh of 12 compared with that of Kuant-2;
- (b) Kuant-2 is located in the upstream of Lembing tributary where longitudinal gradient become more or less 2%. There is an active mining area just downstream of Kuant-2. Its fauna shows comparatively low values of Oh (62%) and Oh (73%) and one type of Nf (N-O: H) is absent. But the value of Oh 73% is quite high compared with those of other rivers; and
- (c) Freshwater prawn still exists at both locations of the river.

(13) Trengganu river

The following characteristics of fish fauna at each location are obtained as shown in Tables 36 and 40:

- (a) The fish fauna of Trng-2 and Trng-3 shows almost the same conditions and are comparatively well balanced, Of of both locations are same with 74% and Oh lies in the range of 62% to 66%. Nh values of both are 12. Trng-2 is located in the middle part of the main stream and just downstream of hydro-electric power dam site (under construction), Trng-3 is located upstream of the Ulu Brang tributary. It is interesting that the fish faunas in the different environmental conditions show the similar characteristics; and
- (b) On the contrary, the fauna at Trng-1 is much degraded and shows the influence of the sea water (3 types of marine fish as shown in Table 36). Of and Oh values are 50% and 45%, respectively. In addition, 2 types of food habit do not exist in Trng-1 (Cyp: C and N-O: H).



#### (14) Kelantan river

The following characteristics of fish fauna at each location are obtained as shown in Tables 37 and 40:

- (a) The fish faunas of this river do not have clear tendency compared with other rivers. Klnt-1 and Klnt-2 are located in the lower part of the main stream. Of value of Klnt-2 is 70% which is the highest among all locations. But its Oh value is 57% which is higher than that of Klnt-1 (54%) but lower than those of Klnt-3 (61%) and Klnt-6 (68%). Only at Klnt-2, the fish fauna possesses all the types of the food habit in the basic fauna. Klnt-3 is located at the confluence with the Lebir tributary in the middle part of the river. The fish fauna of Klnt-3 shows the same value of Oh (63%) with that at Klnt-1 but its (61%) is higher than those of Klnt-1 (54%) and Klnt-2 (57%). Accordingly, the fish faunas in the lower-middle part are not so much different each other but have some tendencies that the upper stream possess more preferable conditions for the herbivorous or omnivorous fishes in this river; and
- (b) Klnt-4 and Klnt-5 are located in the middle-upper part of the Pergau tributary. The fish fauna at Klnt-4 is poorest (Of: 59% and Oh: 54%) among all the locations but that of Klnt-5, which is located upstream of Klnt-4 shows well balanced condition (Oh: 67% and Oh: 68%). There may be some environmental differences between these locations;

## 2.2 Other Ecological Conditions

### 2.2.1 Macro-characteristics

Interviews on the following ecological conditions of the 14 rivers were carried out during the interview surveys:

- (1) Recent change of river flow pattern, for which answers are summarized in Tables 41 to 43; and
- (2) Trend of fish catch from the river during last 10 years, for which answers are summarized in Tables 44 to 46.

Generally, all the aqua ecosystems of the rivers in Peninsular Malaysia are more or less under the negative influences of the following two patterns of the river flow:

- (1) The river flow during rainy season has been controlled and stabilized. Accordingly, the flood does not occur regularly, compared with the case of the previous time.

This pattern occurs in some parts of the rivers in the west coast, such as the lower and middle locations of the Kedah river, whole of the Muda river, the upper location of the Kerian and Kurau rivers, most part of the Perak river, whole of the Melaka river and the upper and middle locations of the Johor river.

- (2) The river flow during rainy season has increased recently. The water level goes up and down more quickly than the previous time. Flooding occurs in all the rivers in the east coast such as the Endau, Rompin, Pahang, Kuantan, Trengganu and Kelantan rivers. In the west coast, it occurs in the remaining parts of the rivers mentioned above and the whole of the Muar river.

Under both patterns of the river flow, the productivity of fish of the rivers have been recently reduced. This is evidenced by the recent decrease of fish catch in all the rivers interviewed.

### 2.2.2 Micro-characteristics

Rough profiles of the ecological conditions other than fish fauna of the 14 rivers are as follows:

#### (1) Kedah river

The river flow during rainy season has recently stabilized in the lower and middle locations (Ked-2, Ked-3, Ked-6 and Ked-7). On the other hand, at the river mouth (Ked-1) and at the most upper location (Ked-4), the river flow during the rainy season increased these years. But in the upper location of the Tekai tributary (Ked-5), such tendency was not observed.

Fish catch has recently decreased at all the locations. Generally, this decrease is common to almost all types of fishes except D14.7 (*Puntius gonionotus*) which is strong against turbid condition and has recently increased at the various locations (Ked-2, Ked-3, Ked-4, Ked-6 and Ked-7) as shown in Table 23.

On the other hand, YY3 (*Macrobrachium rosenbergii*: freshwater prawns) does not exist at Ked-4 and has recently disappeared at Ked-5, Ked-6 and Ked-7. It means the distribution of this prawn has been restricted only to the location in lower part (Ked-1, Ked-2 and Ked-3).

#### (2) Muda river

The river flow during rainy season has recently been stabilized in all the locations (Mud-1, Mud-2, Mud-3, Mud-4 and Mud-5). In addition, the river flow during dry season has also decreased compared with that of the previous time in Mud-2 and Mud-3.

Fish catch has recently decreased at all the locations. Generally, this decrease is common to almost all types of fishes. As it is the case for the Kedah river, the distribution of YY3 is limited to the lower locations (Mud-1, Mud-2 and Mud-3), and has recently disappeared at Mud-5. At Mud-4 and Mud-5, 4 types of Cypriniforms (D1.1, D1.2, D15 & D23) have also disappeared. D14.17 and D23 (Grass carp) seem to have increased mainly at Mud-3.

(3) Kerian river

The river flow during rainy season has become unstable in the lower and middle locations (Ker-1, Ker-2 and Ker-3), but those of the upper locations (Ker-4 and Ker-5) become more stable.

Fish catch has recently decreased at all the locations. Generally, this decrease is common to all types of fishes. YY3 distributes only at Ker-1, Ker-2 and Ker-3. It has recently disappeared at Ker-5. It was reported that D12.1 and D4 in Ker-1 and Ker-2 types of Cypriniforms (D1.2 & D15) in Ker-3 have recently disappeared.

(4) Kurau river

The river flow in lower (Kra-1 and Kra-2) and upper (Kra-4) locations has a tendency to show increase during rainy season than that of the previous time. But, at Kra-3, no change has been indicated. On the contrary, in the upper locations (Kra-4 and Kra-5), the river flow during dry season shows decrease compared with the previous time.

Fish catch has recently decreased in almost all the locations (Kra-1, Kra-3, Kra-4 and Kra-5) except Kra-2 where the fish catch has recently increased. Formerly, only at Kra-2, YY3 existed, but it has recently disappeared from this location. As a result, YY3 has completely disappeared from this river, as far as the interview surveys are concerned. It should be reminded that 4 types of fishes have recently disappeared from Kra-4.

(5) Perak river

It is reminded that at almost all the locations along the main stream, the river flow was reported to have been stabilized recently. Same tendency is reported for Per-14 in the Batang Padang tributary, Per-16 in the Bidor tributary and Per-17 in the Sungkai tributary. No remarkable change was reported for Per-15, the confluence of the Bidor and Sungkai rivers. On the contrary, the river flow during rainy season at Per-11, Per-12 and Per-13 has a tendency to show increase than that of the previous time.

Fish catch has recently decreased in all the location of the river. Generally this decrease is common to almost all types of fishes. YY3 still exists even upstream of the Chenderoh dam (Per-7 and Per-10), but it was reported to have disappeared at one part of the upper locations (Per-8) and in 3 tributaries (Per-13, Per-14 and Per-17).

Other kind of fishes are reported to have disappeared mainly in the tributaries (Per-13, Per-14, Per-15 and Per-17). At Per-3 and Per-5 in the main stream, some fishes have also recently disappeared.

(6) Melaka river

The river flow during rainy season has been recently controlled and stabilized at both locations, Mlk-1 and Mlk-2.

Fish catch has recently decreased. Especially at Mlk-1, 8 types of fishes including YY3 have disappeared. But at Mlk-2, some sails and 2 types of fishes (B1.1 & O3.1) have recently appeared due to some change of ecological condition caused by the deepening of the river.

(7) Muar river

The river flow during rainy season has recently unstabilized at almost all the locations except Mua-2. The water level after raining goes up faster than the previous time but the water level during dry season has become lower.

Fish catch has recently decreased at all the locations. Generally, this decrease is common to all types of fishes. At the uppermost location (Mua-6), YY3 has recently disappeared. At the middle locations (Mua-2, Mua-3 and Mua-4), some types of fishes have disappeared (L1.3, F1, D14.2 and D9) and recently O3.2, D14.7, D21.2, U1 and G3.1 have disappeared.

(8) Johor river

The river flow during rainy season have recently decreased at the middle (Joh-2) and the upper (Joh-3) locations, but it was reported to have increased at the lowest location (Joh-1).

Only at Joh-2, fish catch has been kept at the same level as the previous time. At the other locations, it has decreased compared with the previous time. Especially, at Joh-1, 4 types of fishes have recently disappeared.

(9) Endau and Rompin rivers

The river flow during rainy season was reported to have gone up more quickly than before at the middle location of the Endau river (End-2) and the lower location of the Rompin river (Rom-1), but no change happened at the lower location of the Endau river (End-1).

Fish catch has recently increased at End-1. But at End-2 and Rom-1, it has decreased.

(10) Pahang river

The river flow during rainy season at all the locations goes up more quickly compared with the previous time. On the contrary, the flow during dry season has become less.

Fish catch has recently decreased at all the locations. Generally, this decrease is common to all types of fishes. But YY3 still exists even at the uppermost location (Pah-5).

It is reported that G3.1 has disappeared at Pah-3. At Pah-5, D12.1 and D19 are reported to have disappeared.

(11) Kuantan river

The river flow during rainy season at all the locations goes up more quickly compared with the previous time. On the contrary, the flow during dry season has become less.

Fish catch has recently decreased at all the locations. Generally, this decrease is common to all types of fishes. But YY3 still exists at the uppermost location (Kua-2).

(12) Trengganu river

The river flow during rainy season at all the locations goes up more quickly compared with the previous time. On the contrary, the flow during dry season has become less.

Fish catch has recently decreased at all the locations. But YY3 still exists at the uppermost location (Trng-3).

(13) Kelantan river

The river flow during rainy season at all the locations goes up more quickly compared with the previous time. On the contrary, the flow during dry season has become less.

Fish catch have recently increased at the lower-middle location of the main stream (Klnt-2) and the Lebir tributary (Klnt-3). But in the other locations, fish catch has recently decreased. Especially at the upper location of the Perugan tributary, the decrease is common to all the types of fishes. On the other hand, some fishes have increased at Klnt-1, even though the total fish catch has decreased. It is reminded that YY3 still exists at the uppermost location, Klnt-5 and has recently increased at the lower location (Klnt-1, Klnt-2 and Klnt3).

### 3. RELATIONS BETWEEN AQUA ECOSYSTEM AND DEVELOPMENT ACTIVITIES

#### 3.1 General

The influences of various kinds of development activities including dam, barrage, irrigation, plantation, logging, mining, processing factories for agricultural products and road construction on the aqua ecosystem in each river are analyzed based on the following information:

- (a) Condition of fish fauna at each location as shown in Tables 38 to 40;
- (b) Development activities along the river as shown in Tables 47 to 49 and 56;
- (c) Present condition of water quality as shown in Tables 50 to 52;
- (d) Probable causes of the recent change of river flow pattern as shown in Tables 41 to 43;
- (e) Probable causes of the recent decrease of fish catch as shown in Tables 44 to 46; and
- (f) Complaints of present river conditions as shown in Tables 53 to 55.

Relation among these information in each river are summarized in Table 56 to 68.

The characteristics of the relation between various development activities and aqua ecosystem are described in the following sections.

#### 3.2 Macro-characteristics

Relation between various development activities and aqua ecology observed through the analysis of the results of the interview survey are described from macro-scopic viewpoint as follows:

- (1) The downstreams of tidal barrages always show deteriorated fish faunas, such as the cases of Ked-1, Ked-2, Mud-1 and Ker-1. On the other hand, the fish faunas in the upstreams of tidal barrages are not deteriorated in some conditions such as the cases of Mud-2 and Ker-2 but, in other conditions, it shows deteriorated fauna such as the case of Mlk-1.
- (2) In case of the dams which are located in the middle part of the river such as the Merah dam (Kra-3) and the Chenderoh dam (Per-7), the fish faunas both in downstream and upstream do not show conspicuous differences each other.

On the other hand, when the dam is located at the upper part of the river such as in the Muda river and most tributaries of the Perak river, the fish fauna shows poor conditions which is the case for Mud-4, Mud-5, Per-11, Per-13, Per-14, Per-15 and Per-17.

- (3) The large-scale irrigation areas exist in the lower and the middle part of the Kedah, Kerian and Kurau rivers. Their influences should be analyzed from three viewpoints, that is, the effect of water diversion to paddy field, the effect of the effluent from paddy fields which might contain much agricultural chemicals and the effect of the existence of water intakes. But, in this study, these effects could not be clarified so well, because the conditions of fish fauna did not agree with the negative influences of irrigation development obtained by interview survey. For example, in case of the agricultural chemicals it was reasoned for the decrease of fish catch at Mud-2, Ker-1, Ker-4, Ker-5, Kra-1 to Kra-5, Per-1 and Per-4. But the faunas of these locations do not give any indications as are shown in Tables 57 to 60. Only the following fact should be reminded that in the Kurau river freshwater prawn (YY3) has recently disappeared. The application of agricultural chemicals was said to be responsible for it.

The influence on the fish faunas of water intakes for irrigation seems to be observed at Ked-6, Mud-4, Ker-5, and Kra-5, which show relatively deteriorated fauna.

- (4) The influence of tin mining discharge is clearly observed in the Kinta river (Per-11), Kampar river (Per-13) and Batang Padang river (Per-14). But the upper Kinta (Per-12) and Bidor river (Per-16) show comparatively well balanced fish fauna.

Accordingly, the influence of tin mining discharge to the fauna might be dependent upon the intensity of the activities of the tin mines and the size of the rivers,

- (5) The combined influence of the tin mining discharge, industrial effluent and city sewage is clearly observed at the middle stream of the Kelang river. The fauna includes only 4 species compared with 14 species at the upstream of Kuala Lumpur.
- (6) It is concluded that the comparatively well developed rivers basins are concentrated in the west coast. Those are the Kedah, Muda, Kerian, Kurau, Perak and Melaka rivers. The river flow of them have recently been stabilized.
- (7) In case of the rivers except those mentioned above, the relationship between the fish fauna and development activities seems to be not so clear. But the river flow of these rivers has more or less the same pattern, namely, the flow has recently changed and the water level after raining goes up faster than the previous time but it becomes lower during dry season. Under these conditions, fish catch has recently decreased in all the rivers,

even though those rivers have not been developed so much yet. Accordingly, it is natural to consider that the fish catch decrease may have some relation with this river flow pattern. This point is also supported from the biological viewpoint.

Because in the tropical countries, most fishes spawn eggs at the beginning of the rainy season in the flooded area and those fry will stay and grow in those flooded area until the water return to the river. This flooding period is considered to be important for fish growth.

It is apparent that the present river flow has recently been losing its original character which should show a slow increase and decrease of its water level during rainy season. At present, information is not adequate for determining the cause for the recent change of river flow. But it is suggested that the development of large-scaled agricultural plantation in those river basins might have some relations with this change of river flow pattern.

### 3.3 Micro-characteristics

The following characteristics were observed for the relation between various development activities and the fish fauna at each location:

#### (1) Kedah river

Following characteristics were obtained as shown in Table 56:

- (a) This river has been well developed. Main structures and development activities are Pedu irrigation dam upstream of Ked-3, a tidal barrage just upstream of Ked-2, irrigation weirs in Ked-3 and Ked-6 and river improvement by dredging and widening at Ked-6 and Ked-7. Accordingly, the river flow seems to have become stable in most locations except Ked-4 which is located at the upper part of one of the tributaries. The decrease of flood may have caused the decrease of productivity of fishes. Other activities are factories and logging. Factory discharge seems to have caused in various locations not only decrease of fish catch but also disturbance of domestic water use. The BOD values of Ked-2 and Ked-3 may be the evidence. No clear relations between logging and fish fauna were obtained in this river;
- (b) The tidal barrage located upstream of Ked-2 may be the cause of severe deterioration of the fish fauna at Ked-1 and Ked-2;
- (c) After the construction of the Pedu Dam, the river flow has decreased during dry season and was polluted by the discharge of a sugar factory located upstream. This is the reason why the people made complaints to the Government against the Dam and a factory, even though the fish fauna of Ked-3 shows most balanced condition out of all the locations; and



- (d) No clear influences of irrigation discharge on fish fauna were observed in this river.

(2) Muda river

Following characteristics were obtained as shown in Table 57:

- (a) This river also has been developed. Main structures and development activities are Muda irrigation dam just upstream of Mud-4, an irrigation intake and canal in Mud-1 to Mud-4, a tidal barrage downstream of Mud-2 and a water supply dam upstream of Mud-5. Accordingly the river flow seems to have become stable in all the locations. The decrease of flood may have caused the decrease of productivity of fish. Other activities are factories and logging. Factory discharge seems to have caused in wide areas not only decrease of fish catch but also disturbance of domestic water use. The BOD values of Mud-2 and Mud-4 may be the evidence. As in the case of Ked-3, complaint was made to the Government about the present deteriorated condition of Mud-3 because of the dam construction and factory discharge even though the fauna is most balanced at this location in this river. Accordingly the poor condition of fish fauna at Mud-4 which is located upstream of Mud-3 and somewhat downstream of the Muda Dam may have strong relation with this dam construction;
- (b) The tidal barrage located upstream of Mud-1 may be the cause of severe deterioration of fish fauna at Mud-1. But this deterioration may have been enforced by the decrease of river flow because of the Muda Dam; and
- (c) The influence of the agricultural chemicals discharged from the irrigated areas on fish may be suggested for the lower part of the river (Mud-2) but it is not so clear.

(3) Kerian river

Following characteristics were obtained in Table 58:

- (a) This river has been developed mainly for securing irrigation water. Major structures and development activities are the tidal barrage which is located just downstream of Ker-2, an irrigation dam which is located upstream of Ker-4 and river improvement by dredging and widening at Ker-4 and Ker-5. Accordingly, the river flow seems to have become stable in almost all locations. The decrease of flooding may be one of the causes of fish decrease in this river. Other activities are tin mining, factories and logging. As it is the case for Ked-3 and Mud-3, the fish fauna of Ker-3 located in the middle part of the river shows the most balanced condition but complaints were made to the Government against mining discharge. The fish fauna of Ker-2 which is located downstream of Ker-3 shows poorer conditions. Complaints were also made against the heavy siltations due to mining operation and blocking of the water stream by the tidal barrage.

The condition of this fauna is still far better than that of Ker-1 which is located downstream of the tidal barrage. Accordingly, it is reasonable to consider that the poorness of fish fauna at Ker-1 is basically caused by the tidal barrage. Other factors such as factory discharge, mining discharge or agricultural chemicals may be worsening the condition of fish fauna;

- (b) The poor condition of the fauna at Ker-5 may have some relation with the irrigation activities, especially relating the management of agricultural chemicals such as fertilizers and pesticide which could be easily used for catching fish; and
- (c) The pH value of this river water is quite low regardless the location. The reason is not clear. But it may not be the main cause of the various conditions of fish fauna in this river.

(4) Kurau river

Following characteristics were obtained in Table 59:

- (a) Major structures and development activities are the Merah irrigation which is located in the middle part of the river (Kra-3), an irrigation weir at Kra-4 and a water supply dam and an irrigation intake at Kra-5. Irrigation activities at this river is intensive. The fish faunas at the downstream and upstream of the Merah Dam do not show much difference each other;
- (b) The fish fauna at Kra-4 shows poorer conditions than that of Kra-5. Both are located upstream of different tributaries but they join together at the confluence. Accordingly, it is reasonable to consider that the fish fauna at Kra-4 is affected by some environmental impact. According to Table 26, 5 types of fishes have recently disappeared from this location. Such drastic change may be induced by factory discharge or agricultural chemicals;
- (c) People at all the locations in this river have some negative impressions against agricultural chemicals, irrigation, factory discharge and poison application for fishing. There is big possibility that irrigation discharge containing agricultural chemicals or fishing using agricultural chemicals or poison has affected the fish fauna of this river. Especially as shown in Table 26, freshwater prawn has recently disappeared from all the locations in this river; and
- (d) The fish fauna at Kra-1 is most deteriorated. It is difficult to find relation between the fauna at this location and river development activities from Table 59. But it is suggested that this deteriorated condition has some relations with the abnormally high value of suspended solid (2,040 mg/lit) at Kra-1.

(5) Perak river

Following characteristics were obtained in Table 60 to 62:

- (a) Major structures and development activities are the Chenderoh Dam and the Temenggor Dam. By these dams, the flow of the mainstream seems to have become stable. The decrease of flooding may have caused the decrease of productivity of fish. The fish faunas at the downstream (Per-4 to Per-6) and at the reservoir (Per-7) of the Chenderoh Dam do not show much difference each other. On the other hand the fish faunas of upperstream of the reservoir (Per-8 to Per-10) show a little poorer conditions. Accordingly, it is supposed that the fish fauna of the main stream is affected by the Chenderoh Dam, But its degradation is not serious because the fauna of the reservoir is kept in the same condition as that of the downstreams. The relation between the fish fauna and the Temenggor Dam is not clear because the location of the dam is far from Per-9 which is the nearest location and is affected by the influence of other tributaries;
- (b) The fish faunas below Per-4 show poor conditions. Some factories are located along the river. The river water is highly turbid. Sea water may be intruding up to Per-3. But information is not adequate to find the cause of the poor conditions; and
- (c) Major structures relating to river development in the main tributaries are several dams. These are located upstream of Per-12 in the Kinta river, upstream of Per-13 in the Kampar river, upstream of Per-14 in the Batang Padang river and upstream of Per-17 in the Sungkai river. The fish fauna of the Kinta river in its upstream (Per-12) is in similar condition to those at Per-8 to Per-10 but shows a little degraded condition in its downstream (Per-11), which may be influenced by the high level of SS (395 to 2,005 mg/lit) due to tin mining discharge. The fish fauna at Per-12 may not be affected by the mining discharge but by the siltation which covers the spawning place and at the same time by slightly polluted river water. The fish fauna at Per-13 and Per-14 shows the most degraded conditions of all the locations except the tidal area (Per-1 to Per-3). Both locations have dams in their upstreams, and river flow is stable at these locations. The fish fauna at Per-13 may be under the influence not only of the dam but also of highly turbid water of the mining discharge (20 to 2,690 mg/lit). On the other hand, the fish fauna at Per-14 may be only under the influence of 2 dams. From these information, it can be said that the fish fauna of both locations are basically affected by the existence of the dams and the mining discharge gives the additional negative influence on the fish fauna. Per-15 is located at the confluence of the Bidor and Sungkai tributaries which is located somewhat upstream of Per-3. Per-16 and Per-17 are located upstream of the Bidor and Sungkai tributaries, respectively. The former does not have any dams in its vicinity but the latter has a dam.

The fish fauna at Per-17 has recently lost 4 types of fishes and shows the poorest condition among the locations of Per-15, Per-16 and Per-17, which may be due to the construction of the dam. The fish fauna of Per-16 shows the best condition among the locations located in the tributaries and in the same condition as in Per-10 which is located upper part of the main stream. There may be an irrigation weir or intake, because irrigation activities and its impact are reported as described in Table 62. The fish fauna at Per-15 has recently lost 5 types of fish. The same phenomenon occurred in Per-17. The fauna at Per-15 shows intermediate condition between those of Per-16 and Per-17. No constructions relating to river development exists near this location. Accordingly, there are three possibilities of the relation between this fauna and development activities. One is that the fauna of Per-15 has been affected by the dam upstream of Per-17 though it is located far away from Per-15. Second is that the fauna is affected by the factory discharge as shown in Table 62. Third is that the fauna was affected by both impacts mentioned above.

(6) Melaka river

Following characteristics were obtained as shown in Table 63:

- (a) Major structures relating to development activities are a water supply dam, which is located upstream of Mlk-2, an irrigation weir which is located just downstream of Mlk-2 and a tidal barrage which is located just downstream of Mlk-1. By these structures river flow has become stable. The decrease of flooding may induce the decrease of the productivity of fish. The fish fauna of Mlk-1 shows severely deteriorated condition. Seven types of freshwater fish and 1 type of sea fish have recently disappeared as shown in Table 30. This drastic decrease may be affected by the factory discharge which stays for long time upstream of the tidal barrage and kill particular fishes;
- (b) Tidal barrage may not allow sea fishes to migrate to the river.

(7) Muar river

Following characteristics were obtained as shown in Table 64:

- (a) No large-scaled constructions have yet been carried out in this river. Plantation of oil-palm and rubber trees is very popular in this river basin. Processing factories are located at almost all the locations except Mua-6. Accordingly, in many locations, BOD shows comparatively high value. Mua-2 shows BOD of 1 to 9 mg/lit. People there have strong dissatisfaction against the factory discharge. Oh value of this location is quite low compared with Of value. The fish faunas at most locations in this river are basically similar each other. No conspicuous relation between factory discharge and fish fauna was observed;

- (b) The river flow pattern may have been changing in recent years. At almost all the locations, people answered "Nowadays, flooding occurs more often. Flood comes quickly after the rain in the mountain. But, after the flood, water level of the river become shallower than in the previous time." This river flow pattern may be one of the causes of the decrease of fish catch.

(8) Johor river

Following characteristics were obtained as shown in Table 63:

- (a) No large-scaled constructions have been carried out yet in this river. Other development activities are tin mining and processing factories of rubber, palm oil and sugar. Almost all the areas in this basin have been developed for the plantation of these agro-products mentioned above. The fish fauna of Joh-1 shows severely deteriorated condition. Five types of freshwater fishes have recently disappeared from this location. Factory discharge may be one of the causes of the deterioration. As shown in Table 32, 6 types of sea fishes are included in this fauna. It indicates this location is under brackish water condition. According to the information of a full-time fisherman at this location, fish production at present is only one-fourth of the previous time. If this is the case, there is another possibility of explain the cause of the deteriorated fish fauna of Joh-1, that is, the possibility of environmental change which have strengthened the brackish condition of this location;
- (b) The fish fauna of Joh-2 shows the most balanced condition. There are tin mines and factories upstream of Joh-2. But fish catch has not decreased these days, according to a full-time fisherman; and
- (c) Joh-3 is located in the upper part of the river. The river is running along low hills which are all used for plantations of rubber or oil palm trees. Processing factories are located near the river and discharge effluent. The fish fauna of Joh-3 shows degraded condition compared with that of Joh-2. BOD of the river water shows 0 to 14 mg/lit. It can be said the fauna is affected not only by the factory discharge but also by those simplified environmental condition. But it should be reminded that all types of the basic fauna are still existent in the fauna.

(9) Endau and Rompin rivers

Following characteristics were obtained as shown in Table 65:

- (a) Major agricultural activities including plantation and logging are concentrated in the middle and upper part of the Endau river and in the upper part of the Rompin river. In addition, new highway was constructed crossing the upper part of the Rompin river. Several large-scaled factories are also located at the upper part of the Endau river;

- (b) The fauna at End-1 near the river mouth shows rich condition, even though the BOD shows values of 1.8 to 5.1 mg/lit. The fauna at End-2 which is located in the middle part of the river shows much poorer condition which may be affected by the discharge of the factories. On the other hand, the river flow has changed its pattern as is the case for the Muar river;
- (c) The fauna at Rom-1 shows almost the same condition as that at End-1. It is reported that the fish catch has recently decreased and the river flow has changed its pattern. It is considered that the fish faunas of End-1 and Rom-1 have not been affected so much by the development being performed in their upstream reaches; and
- (d) It is reported that from both rivers plenty of fishes were killed 1 to 3 times a year when the factories upstream discharged their effluent. It is not cleared yet what kind and degree of damages were given to the fish fauna by these effluents.

(10) Pahang river

Following characteristics were obtained as shown in Table 66:

- (a) No large-scaled constructions relating to river development have started yet. Only agricultural developments along the middle to upperstreams are on-going. No clear relation are obtained between the agricultural activities including processing factories and characteristics of the fish fauna at each location; and
- (b) On the other hand, it is clarified that the river flow at all the locations has recently changed its pattern as described in the case of the Muar river. This change may give serious influence to the habitant and spawning place of fish.

(11) Kuantan river

Following characteristics were obtained as shown in Table 67:

- (a) No large-scaled constructions relating to river development have started yet. A tin mine is located in the upper part of the Lembing tributary. Other activities are only agricultural development in the middle part of the river. Kuant-2 is located just upstream of the tin mine. The fish fauna shows a little poorer condition than that of Kuant-1. The fauna may be affected by this mining effluent because the fish may not be able to migrate through the point where the mine discharges its effluent; and
- (b) It is clarified that the river flow at these locations has recently changed its pattern as described for the case of the Muar river.

(12) Trengganu river

Following characteristics were obtained as shown in Table 67:

- (a) Hydroelectric power dam is under construction in the middle part of the river. Others are all agricultural development activities along the river course. The upper part of the river basin still remains virgin. Trng-2 is located just downstream of the dam site. The fish fauna shows comparatively well balanced and similar to that of Trng-3. It means, at this stage the fauna was not affected by the dam construction. Trng-1 is located near the river mouth and its fauna shows the most deteriorated condition. It may be caused by the influence of sea water intrusion; and
- (b) The river flow pattern shows the same tendency as the case of Muar river and other eastern rivers. Fish catch has recently decreased in this river. This may have some relation with the change of river flow pattern.

(13) Kelantan river

Following characteristics were obtained as shown in Table 68:

- (a) Highway which will run along the Pergau tributary is under construction. No other construction activities have started yet. Other are all agricultural development in the lower to middle part of the river. Almost all the upper areas still remain virgin. The fish fauna of Klnt-4 shows the poorest condition, which may have some relation with the influence of the highway construction. Because it was reported that the river bed has recently been covered with silt. No probable relations are available between the agricultural development and fish fauna; and
- (b) The river flow pattern shows the same tendency as the case of Muar river and other eastern rivers. Fish catch has recently decreased in this river except Klant-2. This may have same relation with the change of river flow pattern.

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