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SITUATION OF THE STOCKS IN THE REGION (TOPICS AND ANALYSED DATA)

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SITUATION OF THE STOCKS IN THE REGION (TOPICS AND ANALYSED DATA)

THE STOCK STATUS OF *DECAPTERUS RUSSELLI*

1. Spawning Season

Investigating the relationship between the gonad stage and total length by month, *Decapterus russelli* was ripe over 160 – 170 mm in total length. As ripe individuals appeared in every month, it seemed that *D. russelli* spawned throughout the year. The main spawning season was not clearly, but the spawning group around September seemed to be especially large-scale. The spawning season as a parameter in the stock analysis was September.

2. Growth

The total length-weight relationship was determined by method of least squares using measured data of total length (mm) and weight (gr.). The results were as follows:

$$W = 6.87376 \times 10^{6} \times L^{3.07668}$$

$$W = 1.03236 \times 10^{5} \times L^{3}$$

Noticing the histograms of total length by month, polymodal distribution was decomposed into monomodal distribution by eyes. And, each mode of the monomodal distributions was read **(Figure 1)**. Considering the approximate growth with the results, the following data were got. The starting month of age was September which stated the above.

age 0.917	140 mm	(August)
age 1.917	230 mm	(August)
age 1.0	160 mm	(September)
age 2.0	240 mm	(September)
age 1.083	175 mm	(October)
age 2.083	230 mm	(October)
age 1.167	180 mm	(November)
age 2.167	235 mm	(November)
age 1.25	195 mm	(December)
age 1.417	185 mm	(February)
age 1.583	200 mm	(April)
age 1.75	215 mm	(June)

The following growth formula was got using a method of non-linear least squares (if the starting month of age is change, the parameter "t0" only change. The parameters "Loo" and "K" don't change).

$$Lt = 270.1\ [1 - \exp\{-1.0244\ (t - 0.13661)\}]$$

3. Maturity Rate

Since age 1 grew about 160 mm in total length and over 160 mm ripened, the changes of the maturity index of female as to over 160 mm were examined. The maturity index was different according as month, but all the individuals at October were ripened, Therefore, over age 1 seemed to ripen already. The maturity rate of over age 1 were hypothesized as 100%.

4. Longevity

The calculated total length at interval of a year by the growth formula were as follows:

age 1.0	158.6 mm
age 2.0	230.1 mm
age 3.0	255.7 mm
age 4.0	264.9 mm
age 5.0	268.3 mm

Investigating appeared ratio of individuals about over 260 mm from the size composition in catch, the ratio was 1.7% in 1993 and 0.1% in 1994. From this fact, it was able to consider that *D. russelli* between age 4 – 5 would die almost. Therefore the longevity was hypothesized as age 4.

A mode of the minimum size group on the size composition in catch had the range of 90 – 130 mm in total length. This group was below age 1. If the ratio of this group is high, the population analysis must be included this age group. Therefore, the ratio of below 130 mm was examined. The ratio accounted for 12% throughout from 1993 to 1994. Calculating the average total length as to below 130 mm and over 130 mm, it were 116 mm and 172 respectively. These weights were 16 gr. and 53 gr. respectively. The ratio of below age 1 in weight could calculate easily by the above ratio and weight. The result was only 4%. Therefore, the group below age 1 accounted for about 12% in number, but this group was only 4% in weight. From this results, the analysed unit was used a year excluding the group below age 1. The annual catch included the weight of below age 1, but the weight (4%) was ignored as tolerance.

5. Natural Mortality Coefficient M

The natural mortality coefficient M per year was estimated at 1.273 (survival ratio S = 0.28) by Biomass analysis. Therefore, 1.3 as M was used in the stock analysis.

6. Total Mortality Coefficient Z

Two normal distribution which are side by side usually differ with one years old for species which spawn at a specific month in a year. But, for species such as *D. russelli* which spawn throughout the year, the above distribution do not always differ with one years old. Therefore, if the modes between distribution of the oretical total length and normal distribution accord comparatively, these distribution can regard as spawning group at the same time. In case of the opposite, these distribution mean complex groups of different spawning time. Accordingly, the modes between the theoretical total length by the above growth formula and each monomodal distribution by normal distribution analyses were compared. From the results, modes accorded comparatively from May to November 1993. If two modes which are side by side have a gap of a year, the total number with the each distribution of these two modes can use calculation of total mortality coefficient (Z). Therefore, the gaps between each mode from May to November were examined, And, it became clear that the gaps at June and September accorded with a year. The other gaps showed below a year, and these distribution were interpreted as complex spawning groups.

From the above, Z was estimated using the data of June and September. Z of each month were 1.394 and 2.551 respectively. The average was 1.97. Accordingly, 2 as Z was used in the stock analysis.

7. Catch

The fisheries form on the east coast of Peninsular Malaysia had changed as a boundary at 1987. The catch trend of CPUE which was calculated by standardized effort was examined using the catch after 1987. The CPUE fluctuated on a large scale in the results. It seems that the CPUE was affected by the annual recruitment, the migration and the distribution. But, the cause was unknown. It was able to guess that the fluctuation of the stock was far larger than *Selar crumenophthalmus* and *Rastrelliger kanagurta*. However, the coefficient of variation which was calculated with the average and the standard error of the catch was about 20%. As the value was not regard extreme fluctuation, the catch of *D. russelli* in the stock analysis was used 28,720 ton of the annual average catch.

8. Full Available Age

As *D. russelli* also was caught by the same gears for *R. kanagurta*, the recruited information of *R. kanagurta* was used. As the full available age of *R. kanagurta* was about 125 mm (age 0.71), it seemed that *D. russelli* which is almost the same body type against *R. kanagurta* also recruited full about the same size. Therefore, the full available age in the stock analysis was used age 1.

9. Present Analysis

The following input parameters for the stock analysis were made from the above results.

Age	*TL (mm)*	*Weight (gr)*	*Maturity (%)*	*Age Composition*
1	158.57	41.16	100	1000
2	230.06	125.70	100	135.34
3	255.72	172.64	100	18.310
4	264.94	191.99	100	2.4788

M = 1.3, Catch = 28,720 ton, Full available age = 1

Using the above input data, the steady analysis model (Doi, 1982) was carried out. The results were as follows:

Age	*Total Stock*		*Available Stock*		*Catch*		*Adult*
	Number x 10^4	*Weight* ton	*Number* x 10^4	*Weight* ton	*Number* x 10^4	*Weight* ton	*Number* x 10^4
1	153526.0	63197.30	153526.0	63197.30	46461.7	19125.40	153526.0
2	20777.5	26118.40	20777.5	26118.40	6287.9	7904.27	20777.5
3	2811.9	4854.60	2811.9	4854.60	851.0	1469.16	2811.9
4	380.6	730.61	380.6	730.61	115.2	221.11	380.6
TOTAL	177496	94900.9	177496	94900.9	53716	28720.0	177496

It was clear that the main available age were age 1 and 2. The both are groups were occupied 67% and 28% in catch in weight respectively. As the exploitation rate was 30%, the nearly one thirds part of total stock in the sea was caught.

10. Reproduction and Sustainable Yield

Estimation of reproduction mechanism of *D. russelli* was used the same way which expressed on *R. kanagurta*. Hypothesizing the four relationships of Ricker type (**Figure 2**), the most suitable relationship (Case A) was estimated according to the examined method on *S. crumenophthalmus* and *R. kanagurta*. And, the following formula was hypothesized as the reproductive mechanism.

$$R = 1.02541A\exp(-9.39147 \times 10^7 A)$$

The answers which were estimated sustainable yield (SY) by the above formulas and KAFS model (Kinetic Analysis of Fisheries; Kimoto *et. al.*, 1988) were as follows:

F	*Catch* *x* 10^6	*Weight* *ton*
0.2	30341	18890
0.4	46218	26873
0.6	53361	29271
0.8	55351	28907
1.0	54417	27272
1.2	51934	25148
1.4	48742	22938
1.6	45344	20840
1.8	42028	18942
2.0	38952	17274

The fishing mortality coefficient (F) and the catch in weight at present were 0.7 and 28720 ton respectively. These values were not on the reproductive curve, but it was due to the reason which conformity between the present status and the used data on the above formula was imperfection. Judging the present status by the sustainable yield (SY), the stock status of *D. russelli* was nearby the maximum sustainable yield (MSY). And, possibility of overfishing was very low. As stated above,. the stock flúctuation of *D. russelli* was quite large. Therefore, the above reproductive mechanism should be considered with influence of the fluctuation. It was possibility that the potential productivity of *D. russelli* was far higher than *R. kanagurta* and *S. crumenophthalmus*.

1. Spawning Season

Investigating the relationship between the gonad stage and total length by month, *Rastrelliger kanargurta* was ripe over 190 mm in total length. As ripe individuals appeared in every month, it seemed that *R. kanagurta* spawned throughout the year. The main spawning season was from July to December with September as the center. And, there was also a peak in about April. However, it was not clear because of shortage of data. The spawning season as a parameter in the stock analysis was September.

2. Growth

The total length-weight relationship was determined by method of least squares using measured data of total length (mm) and weight (gr.). The results were as follows:

$$W = 4.79906 \times 10^{6} \times L^{3.15526}$$

$$W = 1.11765 \times 10^{5} \times L^{3}$$

Noticing the histograms of total length from May to September in 1993, it seemed that the mode of the smallest group in May, July and August and the mode of the second group in September were the same spawning group. Therefore, the rough total length of those mode was read by eye. But, as the histogram in May was decomposed into normal distribution, the average total length was calculated using the results. On the other hand, since the group which had the mode of 11 cm. in May was felt to be September – born group of last year, the absolute age of the group was hypothesized as age 0.667 (=8/12). The absolute age of the other month groups were also calculated in a similar way. The following growth data were got from the results.

age 0.667	108 mm	(May)
age 0.833	165 mm	(July)
age 0.917	190 mm	(August)
age 1	205 mm	(September)

The following growth formula was got using a method of non-linear least squares.

$$LT = 287.1 \left[1 - \exp \{ - 2.375 (t - 0.4687) \} \right]$$

3. Maturity Rate

Since age 1 grow 200 mm in total length, age 1 was already adult. However, as *R. kanagurta* was ripe from about 190 mm, the gonad stage was examined by age 0.25. And, as the individual of age 0.75 was about 140 mm in total length, it was clear that this age group was not ripe yet (maturity rate = 0). Therefore, it was hypothesized that all the individuals was ripe over age 1.

4. Longevity

The calculated total length at interval of age 0.25 by the growth formula were as follows:

age 0.75	139.9 mm
age 1.00	205.8 mm
age 1.25	242.2 mm
age 1.50	262.3 mm
age 1.75	273.4 mm
age 2.00	279.5 mm
age 2.25	282.9 mm

Investigating the maximum size from the size composition in catch, a individual in 280 – 289 mm range at September 1993 was the maximum size. But, all the individuals of the other months were below 270 mm. From this fact, it was able to consider that *R. kanagurta* over age 2 would die almost. Therefore, the longevity was hypothesized as age 2.

R. kanagurta spawned throughout the year, but had the spawning peak. Accordingly, the group of the peak was expected to reflect in catch composition. As previously stated, the size compositions by month substantiated the expectation clearly, and it seemed that the compositions consisted of groups of some spawning peaks. Comparing each mode in the above histograms of total length to the calculated total length at interval of one month by the growth formula, spawning month of each mode was counted backward. From this results, it was ascertained that each group was the group which was born on the two spawning peaks. Therefore, as the analysis by a unit of year was rough, the stock analysis was carried out using the six age groups form age 0.75 as the minimum age to age 2 as the maximum age by interval of age 0.25.

5. Natural Mortality Coefficient M

The natural mortality coefficient M per 0.25 year was estimated at 0.916 (survival ratio S = 0.40) by Biomass analysis. This value is 3.665 (S = 0.0256) per annum. The value was used in the stock analysis.

6. Total Mortality Coefficient Z

The following groups were extracted from the previously stated histograms by month. And, reading the mode of each group, frequency of each group was calculated by separating each group at middle point in total length:

(*a*) to be side by side and to have a decreasing trend;

(*b*) furthermore, to seems that the groups are the same spawning season-born.

The groups of April, May, July and August 1993 could utilize for calculation of Z from the results. The results of age difference and survival ratio (S) of each month were as follows:

age difference and S at April ; age 0.17, S = 0.474;

age difference and S at May ; age 0.12, S = 0.288;

age difference and S at July ; age 0.21, S = 0.282;

age difference and S at August ; age 0.21, S = 0.316.

Explaining the interpretation of the above results as an example for April, 0.474 means survival ratio (S) of time for age 0.17. S per annum was 0.01238, Z per annum was 4.39. Z of the other month were 10.37, 6.03, and 3.65 respectively. As there were very widely, it seemed that Z (or S) fluctuated considerably. Since the information about Z was nothing in Malaysia, 1.5 as Z by quarter was used in the stock analysis.

7. Catch

The fisheries form on the east coast of Peninsular Malaysia had changed as a boundary at 1987. The catch trend of CPUE which was calculated by standardized effort was examined using the catch after 1987. As the CPUE after 1987 was steady relatively, it seemed that the stock status was steady condition. Accordingly, the catch of *R. kanagurta* was used 2,300 ton which was a quarter of the annual average catch from 1987 to 1993 in the stock analysis.

8. Full Available Age

The full available age of *R. kanagurta* was about age 0.71 from the above mentioned Z. Therefore, the full available age in the stock analysis was used age 0.75 as the minimum age in the analysis.

9. Present Analysis

The following input parameters for the stock analysis were made from the above results.

Age	*TL (mm)*	*Weight (gr)*	*Maturity (%)*	*Age Composition*
0.75	139.91	30.61	0	1000
1.00	205.81	97.44	100	223.13
1.25	242.21	158.81	100	47.78
1.50	262.31	201.72	100	11.11
1.75	273.41	228.43	100	2.479
2.00	279.54	244.14	100	0.533
	M = 0.916,	Catch = 2,300 ton,	Full available age = 0.75	

Using the above input data, the steady analysis model (Doi, 1982) was carried out. The results were as follows:

Age	*Total Stock* *Number* x 10^4	*Total Stock* *Weight* *ton*	*Available Stock* *Number* x 10^4	*Available Stock* *Weight* *ton*	*Catch* *Number* x 10^4	*Catch* *Weight* *ton*	*Adult* *Number* x 10^4
0.75	12038.3	3684.82	12038.3	3684.82	3639.3	1113.97	0
1.00	2686.1	2617.23	2686.1	2617.23	812.0	791.22	2686.1
1.25	599.4	951.82	599.4	951.82	181.2	287.75	599.4
1.50	133.7	269.77	133.7	269.77	40.4	81.55	133.7
1.75	29.8	68.16	29.8	68.16	9.0	20.61	29.8
2.00	6.7	16.26	6.7	16.26	2.0	4.91	6.7
TOTAL	15494	7608.1	15494	7608.1	4684	2300.0	3459

It is clear that the catch were occupied around age 1 from the results. This status has to understand as a average result in quarter.

10. Reproduction and Sustainable Yield

The reproduction of *R. kanagurta* was studied with the relationship between recruitment stock and adult stock. Adult stock and recruitment stock mean number of adult and number of age 0.75 respectively. When X–axis and Y–axis are adult stock and recruitment stock respectively, one point can plot from the present status. If analysis of the past is carried out, the information of reproduction will increase, and reproductive mechanism can guess. However, as the past information was nothing, the analysia of the past could not carry out. Therefore, reproductive mechanism was studied with the point of the present results. The relationship between recruit and adult in nature never increase monotonously or exponentially. It is natural that the relationship will be saturated with density effect. Therefore, the four relationships of Ricker type which spawning quantity will decide mortality or recruit were hypothesized (**Figure 1**). Reading some values of adult and recruit on these the hypothesized curves, the following data were made. The eight data is the present value.

No.	*Case A* Adult	Recruit x 10^4	*Case B* Adult	Recruit x 10^4	*Case C* Adult	Recruit x 10^4	*Case D* Adult	Recruit x 10^4
1	500	6600	500	14000	2000	8100	2000	8100
2	1000	10200	1000	22200	4000	16200	2500	10150
3	1500	13200	1500	26600	6000	23500	4000	16000
4	2000	14900	2000	27600	8000	28200	6000	19900
5	2500	15300	2500	26000	9000	29000	6500	20000
6	3000	14900	3000	21000	10000	27800	7000	19700
7	4000	12400	4000	2000	12000	26700	7500	18900
8	3456	12038	3456	12038	3456	12038	3456	12038

Using the above data, the following formulas were got.

Case A : $R = 16.3639A\exp(-4.1665 \times 10^4 A)$

Case B : $R = 71.9675A\exp(-9.7097 \times 10^4 A)$

Case C : $R = 4.75282A\exp(-5.1548 \times 10^5 A)$

Case D : $R = 4.91269A\exp(-7.7487 \times 10^5 A)$

The answers which were estimated sustainable yield (SY) by the above formulas and KAFS model (Kinetic Analysis of Fisheries; Kimoto *etal.*, 1988) were as follows:

F	*Case A* Catch x 10^4	Weight ton	*Case B* Catch x 10^4	Weight ton	*Case C* Catch x 10^4	Weight ton	*Case D* Catch x 10^4	Weight ton
0.2	1750	1063	1350	820	5978	3630	3158	1918
0.4	3447	1856	2797	1506	8911	4799	4879	2628
0.6	5063	2467	4359	2125	7912	3856	5585	2722
0.8	6537	2934	6043	2712	1667	748	5469	2454
1.0	7773	3259	7847	3289	−11644	−4881	4604	1930
1.2	8629	3420	9756	3866			2986	1183
1.4	8904	3370	11739	4442			558	211
1.6	8324	3032	13746	5008			−2787	−1015
1.8	6515	2300	15696	5542				
2.0	2978	1025	17470	6012				

The responses to fishing mortality coefficient (F) of Case C and D were sensitive. And, if the present is the saturated point, the maximum sustainable yield (MSY) in D is very small. Considering the catch and effort trend, the response to F was dull clearly. Therefore, it was hard to think the relationships such as Case C and D. On the other hand, the responses to F of Case A and B were dull. In especially Case B, the more cat' .n effort increase, the more catch increase. But, it is too extremely. It seemed that Case A was the most properness. As this was the limits of speculation because any information was nothing at present, Case A was hypothesized as the reproductive mechanism.

From the above, MSY of *R. kanagurta* was 3,400 ton (around 13,000 ton per annum). Diagnosis at the present status was under exploitation.

1. Spawning Season

Investigating the relationship between the gonad stage and total length by month, *Selar crumenophthalmus* was ripe over 180 – 190 mm in total length. As ripe individuals appeared in every month, it seemed that *S. crumenophthalmus* spawned throughout the year. The main spawning seasons were April – May and September – October. It seems that the former a bigger spawning recruitment and larger scale than the latter. The spawning season as a parameter in the stock analysis was April.

2. Growth

The total length-weight relationship was determined by method of least squares using measured data of total length (mm) and weight (gr.). The results were as follows:

$$W = 4.13369 \times 10^{6} \times L^{3.20569}$$

$$W = 1.27294 \times 10^{5} \times L^{3}$$

S. crumenophthalmus grows to about 20 cm a year after birth according to the reports from Manila Bay and Java Sea (Chullasorn, S. & P. Martosubroto, 1986). The information and the histograms of total length from every month were used as examined materials. And the following hypotheses were set.

(*a*) The growth of all the spawning month is the same.

(*b*) Polymodal distribution which overlaps too some monomodal distribution shows existence of different spawning groups of near spawning month.

From the above, finding out cases which each momomodal distribution separate clearly respectively, June 1993, April and October 1994 corresponded to such case. The mode of the smallest distribution at April could be read about 105 mm in total length. Considering the above information, the distribution was estimated at the birth in September – October of the last year. The mode at June was about 155 mm. From the estimation of April, the distribution of June was estimated at the birth in April – May of the last year. The distribution of October was also estimated at the birth in the same month of the last year. The following data were made from these estimation.

age 1.167	155 mm	(June)
age 2.167	235 mm	(June)
age 0.583	105 mm	(April)
age 1.583	215 mm	(April)
age 1.50	195 mm	(October)
age 2.50	255 mm	(October)

The following growth formula was got using a method of non-linear least squares.

$$LT = 338.9 [1 - \exp \{ - 0.5427 (t + 0.08076) \}]$$

3. Maturity Rate

Since age 1 grew over 200 mm and age 2 grew 229 mm in total length, age 1 started to recruit the adult group, and age 2 became adult. Calculating the maturity rate about over III from the maturity index of female between 150 – 229 mm in total length at April – May and September – October as the spawning peak, the maturity rate was 45%. The maturity rate of age 1 and over age 2 were hypothesized as 50% and 100% respectively.

4. Longevity

The calculated total length at interval of age 0.5 by the growth formula were as follows:

age 1.0	150.4 mm
age 1.5	195.2 mm
age 2.0	229.3 mm
age 2.5	255.4 mm
age 3.0	275.2 mm
age 3.5	290.4 mm
age 4.0	301.9 mm

Investigating the maximum size from the size composition in catch, three individuals at April 1993 and a individual at July 1993 in 300 – 309 mm range were the maximum size. But, all the individuals of the other months were below 300 mm. From this fact, it was able to consider that *S. crumenophthalmus* between age 4 – 5 would die almost. Therefore, the longevity was hypothesized as age 4.

The minimum size group on the size composition in catch was about 100 mm in total length. This group was below age 1. If the ratio of this group is high, the population analysis must be included this age group. Therefore, the ratio of below 150 mm was examined. The ratio accounted for about 20% in the result. The central total length in catch was between 150 – 200 mm from the size composition. And many individuals over 200 mm also appeared. Accordingly, if the average total length over 150 mm in catch hypothesize as 200 mm, the weight will be about 100 grams. If the average length below 150 mm in catch also hypothesize as 125 mm, the weight will be about 25 grams. Therefore, the group below age 1 accounted for about 20% in number, but this group was only 4% in weight. From this results, the analyzed unit was used a year excluding the group below age 1.

5. Natural Mortality Coefficient M

The natural mortality coefficient M per year was estimated at 1.470 (survival ratio S = 0.23 by Biomass analysis. The value was used in the stock analysis.

6. Total Mortality Coefficient Z

The following groups were extracted from the previously stated histograms by month:

(*a*) to be side by side, and to have a decreasing trend;

(*b*) furthermore, to seems that the groups are the same spawning season–born.

The groups of June 1993, August, September and October 1994 could utilize for calculation of Z from the results. The histograms of these months were decomposed into normal distribution. From the results, total mortality coefficient (Z) were gained the values as 1.16, 2.41, 2.59 and 0.84. As there were very widely, it seems that fluctuation of natural mortality coefficient (M) or fishing mortality coefficient (F) contributed considerably. The sample number of these months were 282, 205, 1080 and 467 respectively. The number of August 1994 was the largest. Considering to grasp most the population, Z of August was used in the stock analysis.

7. Catch

The fisheries form on the east coast of Peninsular Malaysia had changed as a boundary at 1987. The catch trend of CPUE which was calculated by standardized effort was examined using the catch after 1987. As the CPUE after 1989 was steady relatively in the results, it seemed that the stock status was steady condition after 1989. Accordingly, the catch of *S. crumenophthalmus* was used in 18,451 ton which was the annual average catch from 1989 to 1993 in the stock analysis.

8. Full Available Age

As *S. crumenophthalmus* also was caught by the same gears for *R. kanagurta*, the recruited information of *R. kanagurta* was used. As the full available age of *R. kanagurta* was about 125 mm (age 0.71), it seemed that *S. crumenophthalmus* which is almost the same body type against *R. kanagurta* also recruited full about the same size. Therefore, the full available age in the stock analysia was used age 1.

9. Present Analysis

The following input parameters for the stock analysis were made from the above results.

Age	*TL (mm)*	*Weight (gr)*	*Maturity (%)*	*Age Composition*
1	150.39	43.29	50	10000
2	229.34	153.55	100	750.2
3	275.23	265.39	100	56.28
4	301.89	350.25	100	4.222

M = 1.5, Catch = 18,451 ton, Full available age = 1

Using the above input data, the steady analysis model (Doi, 1982) was carried out. The results were as follows:

	Total Stock		*Available Stock*		*Catch*		*Adult*
Age	*Number* x 10^4	*Weight* ton	*Number* x 10^4	*Weight* ton	*Number* x 10^4	*Weight* ton	*Number* x 10^4
1	84296.0	36499.20	84296.0	36499.20	32577.8	14405.80	421148.0
2	6398.5	9825.22	6398.5	9825.22	2472.8	3797.15	6398.5
3	485.7	1288.92	485.7	1299.92	187.7	498.13	485.7
4	36.9	129.12	36.9	129.12	14.3	49.90	36.9
TOTAL	91217	47742.5	91217	47742.5	35253	18451.0	49069

It was clear that the 78% in catch in weight were occupied age 1 from the results. Therefore, the main available stock was age 1. As the exploitation rate was 39%, the nearly half part of total stock in the sea was caught.

10. Reproduction and Sustainable Yield

Estimation of reproduction mechanism of *S. crumenophthalmus* was used the same way which expressed on *R. kanagurta*. Firstly, the five relationships of Ricker type which spawning quantity will decide mortality or recruit were hypothesized (**Figure 1**). Reading some values of adult and recruit on these the hypothesized curves, the following data were made. The seventh data is the present value.

No.	*Case A* A.	x 10^6 R.	*Case B* A.	x 10^6 R.	*Case C* A.	x 10^6 R.	*Case D* A.	x 10^6 R.	*Case E* A.	x 10^6 R.
1	100	540	50	970	150	320	200	350	200	350
2	200	820	100	1600	300	580	400	695	400	695
3	300	950	150	1950	400	730	600	1030	700	1215
4	350	960	250	2260	600	910	800	1280	1400	2360
5	400	940	350	2040	700	900	1000	1450	1600	2550
6	600	640	400	1740	800	810	1200	1520	1800	2670
7	491	843	491	843	491	843	491	843	491	843

Note: A : Adult, R : Recruit.

Using the above data, the following formulas were got.

Case A : $R = 7.89981A\exp(-3.17482 \times 10^5 A)$

Case B : $R = 27.9748A\exp(-5.04867 \times 10^5 A)$

Case C : $R = 2.92806A\exp(-1.0867 \times 10^5 A)$

Case D : $R = 1.99741A\exp(-3.23167 \times 10^6 A)$

Case E : $R = 1.80518A\exp(-8.30683 \times 10^7 A)$

The answers which were estimated sustainable yield (SY) by the above formulas and KAFS model (Kinetic Analysis of Fisheries; Kimoto *etal.*, 1988) were as follows:

F	*Case A* Catch x 10^6	Weight ton	*Case B* Catch x 10^6	Weight ton	*Case C* Catch x 10^6	Weight ton	*Case D* Catch x 10^6	Weight ton	*Case E* Catch x 10^6	Weight ton
0.2	89	6013	97	6528	112	7555	194	13074	519	34995
0.4	164	10259	181	11324	195	12204	304	18948	743	46379
0.6	228	13349	255	14949	258	15098	356	20823	771	45132
0.8	282	15670	320	17767	305	16926	370	20539	675	37472
1.0	329	17471	377	20018	341	18107	360	19152	506	26902
1.2	369	18911	427	21861	369	18893	337	17269	300	15377
1.4	404	20095	471	23405	391	19439	306	15233	80	3961
1.6	435	21093	510	24722	409	19843	273	13232	–140	–6793
1.8	462	21954	544	25866	424	20161	239	11364		
2.0	486	22711	575	26874	437	20431	207	9675		

The present status in Case E was overfishing. A temporary history which had appeared bigger catch effort and larger catch than the present was necessary to go through the process of overfishing. But, as such trend was not recognized in the transition of both factors after 1980, it was not reasonable that Case E counted as the reproductive mechanism.

The present status in Case A, B and C were under exploitation. And moreover, there are not shown in the table, but even if the fishing mortality coefficient (F) at present (about F = 1) was done twenty times, the catch did not reach MSY, and even if F became infinite, the stock was not extinction because adult survived. Therefore, it was hard to think the relationships such as Case A, B and C.

The last Case D was also overfishing as Case E, but the degree was barely. And, considering with accuracy of input data in the model, it did not declare that the present was overfishing clearly. The MSY was 20,823 ton against 18,451 ton at the present catch. Accordingly, it should regard as tolerance because the gap between the both values was only about 10% to the present catch.

From the above, it seems that the reproduction mechanism of *S. crumenophthalmus* approximated Case D. The extinction of the stock in Case D did not occur until about F = 6. As stated above, the fisheries form on the east coast of Peninsular Malaysia changed as a boundary at 1987. The change was the increase of F. However, as a drastic increased trend did not recognize, it seems that the present status was under exploitation near to MSY.