COMPOSITE MODEL ON SMALL PELAGIC RESOURCES

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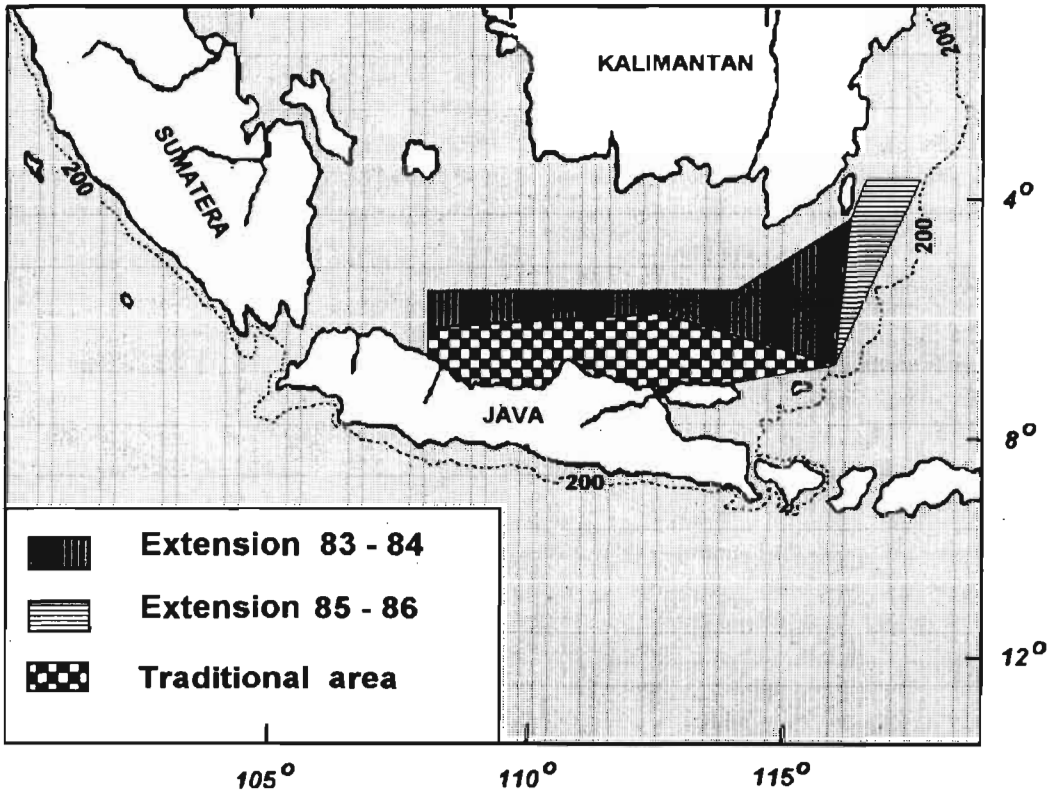

Figure 1

GEOGRAPHIC LOCATION OF THE MAIN FISHING AREAS OF THE SMALL PELAGIC RESOURCES IN THE JAVA SEA

LOKASI GEOGRAFIS DAERAH PENANGKAPAN UTAMA DARI SUMBER DAYA PELAGIS KECIL DI LAUT JAWA

ABSTRACT

This study is based on the catch and effort data, collected from different sources between 1976 and 1986. The composite model of Caddy and Garcia (1982), one of the models derived from the Schaefer and Fox model, was used to estimate the MSY (Maximum Sustainable Yield) and the optimum effort of the small pelagic resources in the Java Sea. It seems that the current status of exploitation is near its maximal level. The fisheries exploit a lot of species with various ecological behaviors. Some, such as the coastal species, are fully and heavily exploited while others, such as the oceanic ones, are partially exploited. Thus it is difficult to give an accurate assessment. Other approaches (analytical models) would allow more precise results. This is why the statistical data collection as well as the biological and behavior study must be continued. Since 1976 the catch of small pelagic increases continuously, in 1985 it reaches 150 000 tons. During this period the CPUE fluctuates a lot.

Penelitian ini berdasarkan data hasil tangkapan dan upaya penangkapan yang dikumpulkan dari berbagai macam sumber sejak 1976 sampai dengan 1986. Model komposit dari Caddy dan Garcia (1983), adalah model yang diturunkan dari model Schaefer dan Fox dan dicoba untuk menduga MSY dan upaya optimum dari sumberdaya pelagis kecil di Laut Jawa. Tampaknya situasi tingkat pengusahaan saat ini hampir mendekati tingkat maksimum Pengusahaan perikanan ditujukan terhadap ikan-ikan yang mempunyai sifat dan kebiasaan yang berbeda, ikan-ikan yang dekat pantai tampaknya telah mengalami tekanan penangkapan yang tinggi, sedangkan ikan-ikan yang bersifat oceanik belum seluruhnya diusahakan. Oleh sebab itu suatu kajian sumber daya yang tepat tidak mudah untuk dilaksanakan. Pendekatan lain (model analitik) diharapkan dapat memberikan hasil yang lebih baik, sehingga pengumpulan data statistik, biologi dan tingkah laku harus tetap terus dilaksanakan. Sejak tahun 1976 hasil tangkapan ikan pelagis kecil meningkat terus dan pada tahun 1985 mencapai 150 000 ton, selama ini hasil tangkapan per unit upaya mengalami peningkatan dan penurunan.

INTRODUCTION

The continuous increase of the fish catch in the Java Sea reflects the development that has taken place in the last decade. As fish resources are not unlimited intense fishing may greatly affect them. To assess the fishing effect on the resources there should be reliable information on the main parameters of the fisheries such as catch, effort and biology of the main species caught.

Stock assessment is one of the important component of the fisheries management. Although there has been an increasing number of assessment models in the recent years, they generally follow three major streams : (1) analytical models, (2) surplus production models, and (3) linear models.

The surplus production model allows to estimate the MSY (Maximum Sustainable Yield) and the optimal effort. Although the concept was initiated by Graham (1935), it was Schaefer (1954) who first described it as a mathematical function based on the logistic growth model of Velhurst-Pearl. The simplicity of the model, which only requires catch and effort data, is very attractive especially in a situation where biological data is lacking.

The catch and effort data of the small pelagic species caught between 1976 and 1986 in the Java Sea was collected from several sources by the project, while the data on mini purse and Danish seines was extracted from the national statistical data of the Directorate General of Fisheries.

In this paper we present the data used for the study and we apply the composite model of Caddy and Garcia (1982) one of the model derived from Schaefer and Fox models.

1. PRESENTATION OF THE MODEL USED

Schaefer (1954, 1957) supposed that the relationship between CPUE (**c/f**), catch (**c**) and effort (**f**) could be represented by :

$$c/f = a + bf \qquad (1)$$

then,

$$c = f(a + bf) \qquad (2)$$

Fox (1970) has substituted to the linear relationship of Schaefer an exponential relationship where the equations are :

$$c/f = a \cdot e^{-bf} \qquad (3)$$

then

$$c = f(a \cdot e^{-bf}) \qquad (4)$$

In this model any fish population is treated as a single unit without any consideration of the structure of the population ; thus, the dynamic of the population depends on the population itself. The model relies on a steady state condition where the yield balances the growth of the population.

Considering that the small pelagic biomass exploited in the Java Sea increases in relation with the extension of the fishing ground eastward, we apply the composite model of Caddy and Garcia, derived from Schaefer and Fox models. It is built by normalizing the catch and effort data in order to use the data which originates from different sizes of the stock in the same model.

This method is based on the relationship between CPUE and fishing intensity (effort divided by the surface of the exploited fishing area). The linear and exponential relationships are represented as follows :

$$c/f = a + b(f/A) \qquad (5)$$

$$c/f = a \cdot e^{-b(f/A)} \qquad (6)$$

where **A** = surface of the fishing area.

By multiplying the equations (5) and (6) by f/A, we obtain the following normalized production model :

$$c/A = (f/A)(a + bxf/A) \qquad (7)$$

$$c/A = (f/A)(a \cdot e^{-b(f/A)}) \qquad (8)$$

From the equations (7) and (8), we can rebuild the theoretical production model for each considered zone by multiplying the two axes of the model by the surface of the fishing area (A):

$$c = f\,(a + bf/A) \qquad (9)$$

$$c = f\,(a \cdot e^{-b(f/A)}) \qquad (10)$$

Since 1976 the large seiners fishery has extended twice its fishing areas (fig. 1). Three fishing areas can now be recognized :

- The North coast of Java, Karimunjava, Bawean (91 000 km^{-2}), since 1976.
- The Masalembo and Matasiri Islands (88 000 km^{-2}), since 1983.
- The Makassar Strait (23 000 km^{-2}), since 1985.

2. ESTIMATION OF CATCH AND EFFORT

2.1 Catch

The small pelagic species in the Java Sea are mostly caught by large purse seines. Only a small part is caught by mini purse seines and Danish seines, **"Payang"**. The annual catch for every fishing gear is given in table I from 1976 to 1986.

Between 1976 and 1978 the catch slightly increased. It kept stable from 1979 until 1982, before increasing sharply in 1983. The stagnation of the large purse seines catch between 1976 and 1982 seems due to the heavy fishing pressure exerted on the traditional fishing ground. The extension of the fishing area to the East in 1983 led to an increase of the catch related to the beginning of the exploitation of new small pelagic resources or a larger part of the stocks already exploited. The mini purse seines catch increased regularly. In 1986 it was 4 times higher than in 1976 while during this period the Danish seines landing kept stable .

2.2 Fishing effort

Among many indexes, the fishing effort can be expressed in number of fishing vessels registered or in number of days at sea. If we had used the number of fishing vessels as a unit of fishing effort, the result would have been biased. It would have been over estimated since many vessels while not fishing anymore are still registered.

At this stage of the study, considering the available documents (based on the large purse seine data from the fishing port and harbor master of Pekalongan), the best estimation for fishing effort on small pelagic species in the Java Sea is the number of days at sea. Since every year the average horse power of seiners increases, a correction of the fishing effort was used in table II. Other parameters affecting the fishing power of the fishery such as the increase of the fishing vessels capacity, the net size or the changes in the fishing tactics are not taken into account in this study.

Concerning the days at sea, the corrected fishing effort of the large purse seines increases from 1976 to 1986 with a peak in 1985 (almost 20 times that of 1976). This sharp increase is due to the fast extension of the fishery since the trawl ban in the Java Sea in 1980 and 1981. Many trawlers were transformed into purse seines and widely modified the figure of the fishery.

Table I

SMALL PELAGIC SPECIES CAUGHT IN THE JAVA SEA FROM 1976 TO 1986 (IN TONS)

IKAN PELAGIS KECIL YANG TERTANGKAP DI LAUT JAWA DARI TAHUN 1976 SAMPAI DENGAN 1986 (DALAM TON)

YEAR	LARGE SEINERS	MINI SEINERS	DANISH SEINES	TOTAL
1976	22 000	7 184	17 796	46 980
1977	27 104	8 769	16 341	52 214
1978	33 842	9 473	18 149	61 464
1979	44 073	13 013	19 680	77 396
1980	46 126	20 039	19 040	85 205
1981	38 444	23 283	19 103	80 830
1982	49 898	22 701	17 301	89 900
1983	74 931	22 506	13 505	110 942
1984	80 314	28 245	14 300	122 859
1985	117 265	23 946	14 021	155 232
1986	106 097	31 864	17 788	157 749

Table II *(bottom)*

EFFECTIVE FISHING EFFORT (DAYS AT SEA) OF LARGE PURSE SEINERS FROM 1979 TO 1986 IN THE JAVA SEA.

UPAYA PENANGKAPAN EFEKTIF (HARI LAUT) DARI PURSE SEINERS BESAR DI LAUT JAWA DARI TAHUN 1979 SAMPAI DENGAN 1986

YEAR	NB.OF VESSELS	AVERAGE HP	TOTAL HP	CORRECTION FACTOR	NOMINAL EFFORT	EFFECTIVE EFFORT
1976	138	85	11 730	0.16	35 599	5 696
1977	155	90	13 950	0.19	42 350	8 047
1978	233	99	23 067	0.32	52 796	16 895
1979	329	104	34 216	0.47	75 316	35 399
1980	344	110	37 840	0.52	74 055	38 509
1981	398	115	45 770	0.63	78 282	49 318
1982	422	119	50 218	0.69	85 741	59 161
1983	422	113	47 686	0.66	91 414	60 333
1984	422	121	51 062	0.70	86 916	60 841
1985	520	130	67 600	0.93	85 257	79 289
1986	531	137	72 747	1.00	90 742	90 742

3. ESTIMATION OF TOTAL EFFORT AND FISHING INTENSITY ACCORDING TO FISHING AREA

Small pelagic species are caught either by large purse seines, mini purse seines or Danish seines (**"Payang"** and **"Lampara"**). The large purse seine is the most important fishing gear exploiting the small pelagic resources in the Java Sea. In 1983 and 1984 large purse seiners expanded their fishing area up to the Masalembo and Matasiri Islands (fig. 1). Around 63% of the effort of the large seiners was exerted in this area, and only 37% in the traditional area. In 1985 the eastern extension of the fishery continued, reaching the Makassar Strait. The fishing effort in the traditional fishing areas decreased and was about 25% of the total effort, while the rate of exploitation in Masalembo - Matasiri area increased to about 66% in 1985. Since 1985 the fishing effort of the large seiners is distributed among these three fishing areas.

Using the composite model of Caddy and Garcia, three fishing areas were taken into consideration. This model allows to use all the available series of data from 1976 to 1986 in a same model, although since 1982 the surface of fishing areas changed (tab. III). To obtain the fishing intensity, the corrected fishing effort was divided only by the surface of the traditional fishing area from 1976 to 1982, while since 1983 it was calculated for three fishing areas.

Table III

TOTAL CATCH, TOTAL EFFORT (IN DAYS AT SEA LARGE SEINERS STANDARD), CPUE AND TOTAL FISHING INTENSITY OF SMALL PELAGIC RESOURCES IN THE JAVA SEA THREE FISHING AREAS FROM 1976 TO 1986

TOTAL HASIL TANGKAPAN, TOTAL UPAYA PENANGKAPAN (DENGAN STANDAR HARI LAUT PURSE SEINE BESAR), HASIL TANGKAPAN PER UNIT UPAYA DAN TOTAL INTENSITAS PENANGKAPAN DARI SUMBERDAYA PELAGIS KECIL DI LAUT JAWA BERDASARKAN TIGA DAERAH PENANGKAPAN YANG BERBEDA DARI TAHUN 1976 SAMPAI DENGAN TAHUN 1986

FISHING AREA	YEARS	TOTAL CATCH (TONS)	CPUE LARGE SEINERS	TOTAL EFFORT AT SEA LARGE SEINERS	TOTAL FISHING (DAYS AT SEA/ km^{-2})
Traditional	1976	46 980	3 862	12 163	0.13
	1977	52 214	3 368	15 501	0.17
	1978	61 464	2 003	30 684	0.34
	1979	77 396	1 263	61 287	0.67
	1980	85 205	1 198	71 134	0.78
	1981	80 830	780	103 692	1.14
	1982	89 900	843	106 589	1.17
	1983	62 237	1 170	53 194	0.58
	1984	70 655	1 250	56 524	0.62
	1985	75 492	1 480	51 008	0.56
	1986	69 110	970	71 247	0.78
1st extension	1983	48 705	1 280	38 042	0.43
	1984	52 204	1 360	38 385	0.44
	1985	73 877	1 500	49 251	0.56
	1986	78 911	1 240	63 638	0.72
2nd extension	1985	5 863	1 230	4 767	0.21
	1986	9 728	1 340	7 259	0.32

4. MAXIMUM SUSTAINABLE YIELD AND OPTIMAL EFFORT

The relationship between the fishing intensity, CPUE and productivity (fig. 2) provides a normalized model (independent of the surface of the fishing area), which can be subdivided in three models ; fishing area 1976-1982 (91 000 km^{-2}), fishing area 1983 -1984 (179 000 km^{-2} and fishing area 1985 -1986 (202 000 km^{-2}), by multiplying the fishing intensity and the productivity by the respective surfaces (fig. 3).

The fishing intensity in the traditional fishing area increased between 1976 and 1982 and decreased in 1983 due to the eastward extension of fishing area which reduced the fishing pressure elsewhere. The fishing intensity was then transferred to the other fishing areas where it increased quickly (tab. III).

The decrease of the CPUE in the traditional area urged the large seiners to search for virgin fishing areas .

The results obtained by Caddy and Garcia models are given in table IV. The results achieved by the different models are very similar. The MSY is found between 175 000 and 180 000 tons with an optimal effort comprised between 138 000 and 187 000 days at sea.

Table IV

RESULTS OF MSY AND OPTIMAL EFFORT ACCORDING TO THE SCHAEFER AND FOX MODELS

NILAI HASIL TANGKAPAN LESTARI DAN UPAYA PENANGKAPAN OPTIMAL MENURUT MODEL SCHAEFER DAN FOX

	SCHAEFER	FOX
MSY (tons)		
Area 1976 - 1982	81 000	79 000
Area 1983 - 1984	159 000	155 000
Area 1985 - 1986	180 000	175 000
Optimal effort (days at sea)		
Area 1976 - 1982	62 000	84 000
Area 1983 - 1984	123 000	165 000
Area 1985 - 1986	138 000	187 000
Regression output		
a	2.620	2.60
b	-1.908	-1.09
r^2	0.470	0.62

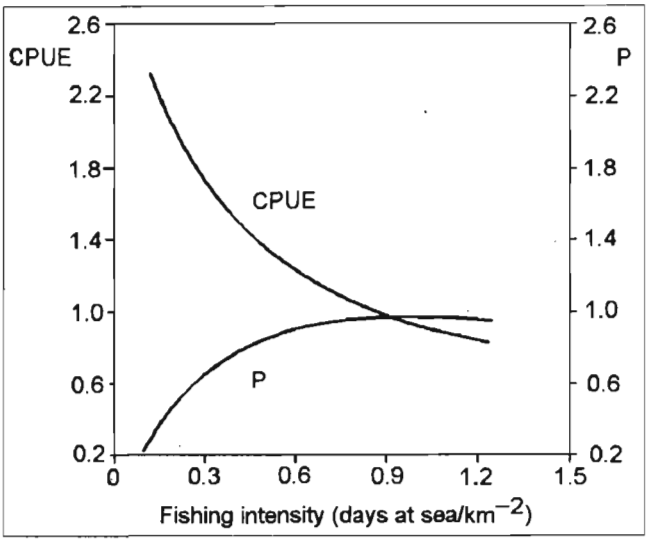

Figure 2

RELATIONSHIP BETWEEN FISHING INTENSITY, CPUE(TONS/DAYS AT SEA) AND THE PRODUCTIVITY (TONS/KM^{-2}) OF SMALL PELAGIC RESOURCES IN THE JAVA SEA

HUBUNGAN ANTARA INTENSITAS PENANGKAPAN, HASIL TANGKAPAN PER UNIT UPAYA (TONS/HARI DI LAUT) DAN PRODUKTIVITAS (TONS/KM^{-2}) SUMBER DAYA PELAGIS KECIL DI LAUT JAWA

The catch and effort registered in 1980 exceeded the MSY and the optimal effort for the traditional area. Although the effort increased in 1981 in this area, the CPUE decreased and the traditional fishing area seemed fully exploited. In 1983 the large seiners began to fish around the Masalembo - Matasiri Islands. In this area, the increase of the effort is related to the increase of CPUE. The same trend is observed in the Makassar strait since 1985. In 1986, the catch of small pelagic and the effort exerted on the resources in the Java Sea are close to the MSY and optimal effort values. It could mean that in 1986 the small pelagic stock in the Java Sea was nearly fully exploited.

Applying the composite model, we suppose that the considered stocks only differ in their size (then in their biomass) and that the other sources of variations can be neglected (Garcia, 1984). The pelagic species with high migratory behavior do not fully comply with this hypothesis. The migration of the pelagic species is not taken into account by this model, and it is known that in the Java Sea the fish availability according to the years is highly related to this behavior.

CONCLUSION

All fisheries exploiting pelagic resources of the Java Sea tend to extend their fishing areas and improve the fishing efficiency. Size and vessels number increase. Thus the fishing pressure on the stock is higher. As the small pelagic are highly variable resources, it is necessary to remain cautious about this trend. The number of days at sea would be one of the effort estimation, but corrections have to be done to improve the quality of the effort estimation.

The results given by this type of model depend on the accuracy of collected data statistics, and the knowledge we have of the fisheries. Regarding the catch and effort data between 1987 and 1991 concern, it seems that the data do not fit well with the model used, as some important changes in the fishing strategy and tactics occurred and are not taken into account by the model. However all pieces of information cannot be taken into account. Those are only tools allowing to give a first approximation of the exploited stage. Among the management measures, allocation of the effort on the different fishing areas or freezing of the effort at the current level can be considered. Although fishery resources are limited the improvement of the resource management entirely depends upon a good communication among scientists, administrators, fishermen and others involved parties.

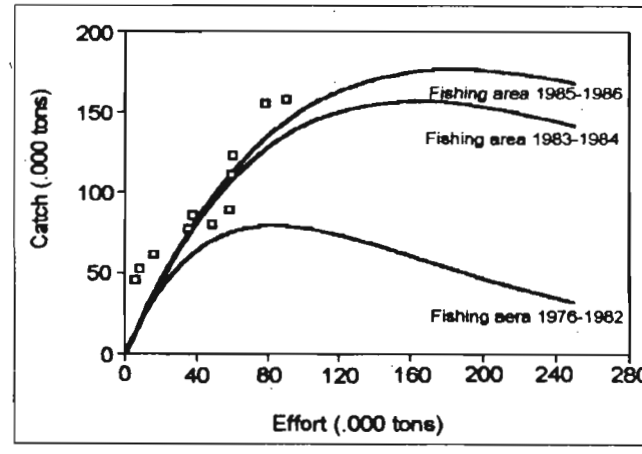

Figure 3

PRODUCTION MODEL OF THE SMALL PELAGIC RESOURCES FOR VARIOUS FISHING AREAS IN THE JAVA SEA

MODEL PRODUKSI DARI SUMBER DAYA PELAGIS KECIL DARI BEBERAPA DAERAH PENANGKAPAN DI LAUT JAWA

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