Report on assessment and management advice for 2001 of the anchovy fishery in The Yellow Sea and The East Chin Sea

The Bei Dou Fisheries Management Project 2001-2005
Yellow Sea Fisheries Research Institute
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INTRODUCTION

According the Project Document for the "Bei Dou Fisheries Management Project 2001-2005" a small work shop was arranged 19-23 March 2001 at the Yellow Sea Fisheries Research Institute (YSFRI) in Qingdao. The work shop was arranged within the sub project "Fishery Management based on Scientific Investigations" to evaluate the present state of the anchovy stock and setting and advicing on a TAC for 2001. All the input data for the work shop were provided by YSFRI. However, the timing of the work shop was not the best due to other important tasks which were going on at YSFRI at the same time.

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DATA

Data on acoustic measurement of number and biomass by age of anchovy were available for the years 1985 - 2000, except for the years 1997-1998 (Table 1). The total catch by years are recorded (Table 1), but samples of the catches for converting the data to catches by age were not available. In addition reports on the general biology of the stock and the development of the fishery were used in the processing of the data and in the evaluation of the assessment results. The data were processed and the calculations were made on spread sheet (Excel).

Natural mortality.

The total mortality (Z) was estimated by comparing abundant estimates of year classes in subsequent years. Since there is a brake in the data series in 1997-98, only data from the years 1986-96 were used for the mortality estimate. The average natural mortality (M) in age group (t) was obtained by tuning back-calculated number of age groups (t) from age groups (t+1) against the corresponding acoustic measurements, using the solver function in Excel to identify the M-value giving the best fit. The catches were subtracted by converting the total catch to catch in number by age using the age composition in the stock from the survey data as basis for the calculation (Table 2). Since the catches prior to

1996 are rather small it is assumed that the possible error introduced by this approach is insignificant. The back calculation of cohorts by ages was done by Pope's approximation formula, and estimated number of age 3 was used as the terminal stock in the VPA run. The results are shown in Table 3.

The mortality from age 2 to age 3 in the years 1986 to 1995 was calculated by comparing the measured 2 years old to the back-calculated 2 years old derived from the measured 3 years old in the subsequent year. The differences in the estimates were squared and the M-value corresponding to the least sum of squares was selected as the average yearly M_2 for the period. The best fit was obtained when M_2 equalled 0.48 and the compared estimates are illustrated in Figure 1.

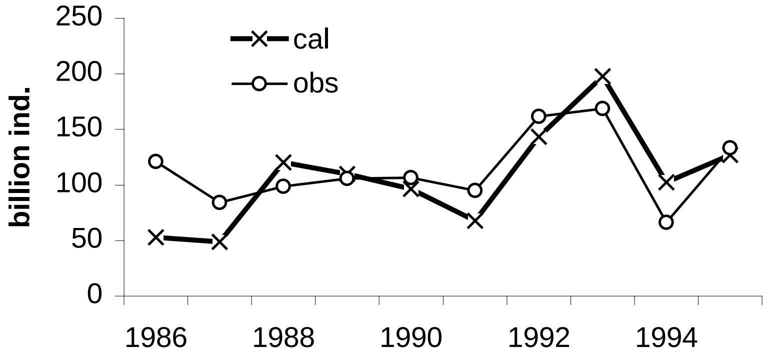

Figure 1. Number of 2 years old anchovies measured (obs), compared to back-calculated (cal) number from measured 3 years old the subsequent year. The 1991 figure is back-calculated from the corresponding 4 years old (see Table 4).

The Figure shows that the survey data for these two age groups are consistent and indicates that the estimated M_2 is fairly accurate.

Judging from Tables 2 and 3, the M-value of age group 3 (M_3) is probably higher than M_2, but due to the very low and fluctuating number left as four years old, the present method of estimating M_3 is not applicable. The M_3 and M_4 have therefore been set equal to M_2 in the assessment. The error introduced is however probably small, due to the low number left in the older age groups (Table 2).

Comparing the measured number of the 1-groups to the back-calculated number from the 2-groups in the subsequent years (Table 3), it is seen that the sum of the former figures is about 20 % lower then that of the latter ones. This indicate that M_1 is smaller then M_2. However, if the 1-group fish is not fully recruited to the measurable stock, the difference may also be explained as a measure of incomplete recruitment . Judging from the general knowledge of biology and distribution of the smallest fish, the latter is a more likely explanation to the difference in the two estimates, and M_1 is therefore set equal to M_2 assuming that some 80% of the 1- group is recruited to the measurable stock at the 1^{st}. of January each year.

Stock - recruitment relationship.

In the stock- recruitment plot shown in Figure 2, the back-calculated number of 1-group fish (Table 3) is regarded as recruits (R_1) and the measurable stock as spawning stock biomass SSB (Iversen et.al. 1993)

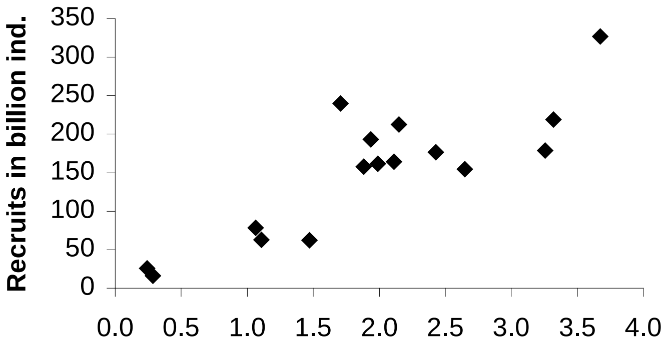

Figure 2. Recruits R_1 (back-calculated) versus calculated stock size in million tonnes.

The plots fall within two groups, one for stock sizes above 1.5 mill tonnes and one for stocks below. The latter group has low reliability because they represent the period after 1995 when the age composition of the catches (judge from survey data), to a large extent determines R_1.The former group is less dependent on the catches and indicate that the recruitment is randomly distributed in a range of 150 to 350 billion individuals when the stock is above 1.5 mill tonnes. The average R_1 in this group is estimated at 180 billion fish.

Sustainable yield.

Based on the parameter estimates given above, sustainable yield (Y) and corresponding stock biomass (BS) versus fishing mortality (F) has been calculated and shown in Figure 3. In this calculation the catchability of the 1-group is set to 0.8 when the two years old and older fish is 1. This is considered as the best choice of fishing pattern as long as catch by age data is lacking. The calculation is based on an average R_1 of 180 billion fish, M = 0.48 and on weight by age obtained from the survey data.

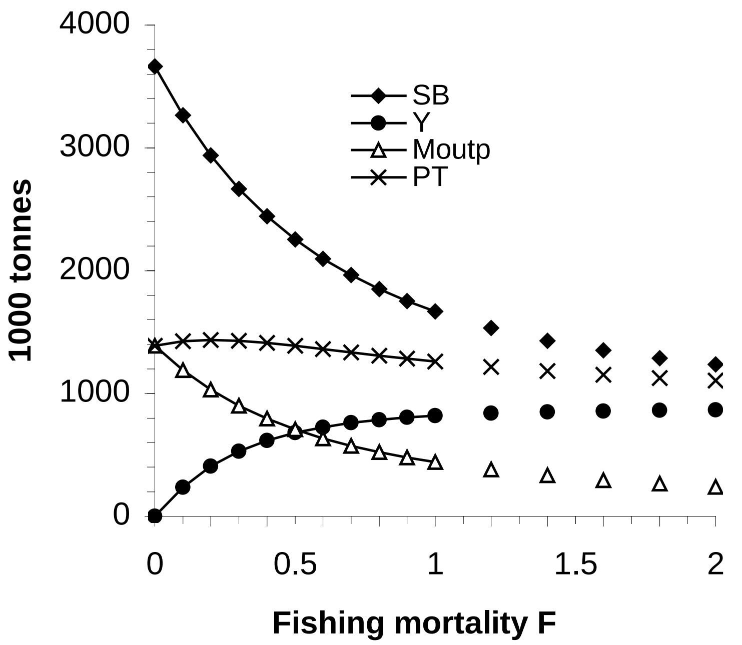

Figure 3. Stock biomass (SB), Sustainable yield (Y), M-output (M_{outp}) and total biomass production (PT) of anchovy versus fishing mortality.

The virgin stock (F=0) is estimated at about 3.5 mill. tonnes, which is in accordance with the survey measurements. The sustainable yield (Y) is approaching 850 000 tonnes (Y_{max}) which may reduce the stock to 1.5 mill. tonnes. This is the stock level where the recruitment is supposed to be affected (Figure 2). This means that fishing more then 850 000 tonnes a year for several years, as has been the case in this fishery, the stock is bound for a collapse according to this assessment. The optimum sustainable yield (Y_{opt}) is estimated at 775 000 tonnes, corresponding to F_{opt} or $F_{.1}$ of 0.7. The corresponding stock biomass is estimated at 2.0 mill. tonnes.

Anchovy is important as prey species for other fish stocks in this area. Therefore when managing the anchovy stock, multispecies aspects also have to be taken into consideration (YSFRI, 1999). In order to quantify this statement the biomass production corresponding to the natural mortality, the M-output (Hamre and Tjelmeland 1982), was calculated and is shown in Figure 3. The M-output is considered as the food potential for the predators, and is estimated at 1.4 mill. tonnes in the virgin state (F=0). The M-output is reduced to 0.6 mill. tonnes when the stock is exploited at the optimal level ($F_{.1}$) and below 0.3 mill. tonnes if F is increased above F_{max}. These findings clearly demonstrate that anchovy is a very important prey species in the area and that a stock collapse will have serious impact on the food supply for other important commercial stocks in this ecosystem.

State of stock and fishery.

The development of stock and fishery is shown in Figure 4.

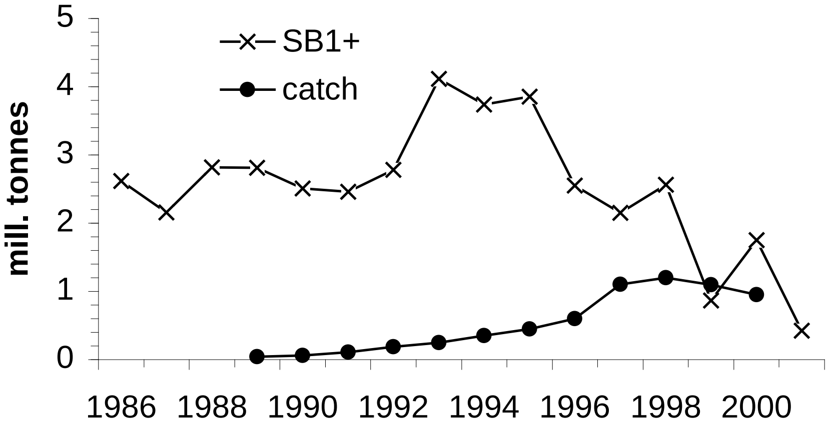

Figure 4. Measured stock biomass of 1-group and older anchovies (SB_{1+}) and yearly catches. For the years 1997-98 the stock biomass is back-calculated from the 1999-2001 stock measurements and 1997-2000 catches.

The abundance of anchovy has been measured annually since 1986, except for the years 1997- 1998. The surveys have been carried out in the winter season, November- March, with R/V "Bei Dou, applying acoustic method. Stock measurement done in November-December one year is considered as stock estimate at 1. January the following year. For the years 1997-98, Figure 4 shows the VPA-calculated stock sizes.

The catches prior to 1989 were low and anchovy was only taken as by-catch in the trawl fisheries. From 1990 onwards the catches increased to 0.45 mill. tonnes in 1995 and to a record catch of 1.2 mill. tonnes in 1998. The catch in 2000 is estimated at about 0.95 mill. tonnes.

The catch-stock development in1995-2001 confirms the conclusion drawn from the sustainable yield estimates based on the 1986-1995 data (Figure 3). When the catches approach the $F_{.1}$ level (0.7 mill. tonnes), the stock is reduced to about 2 mill. tonnes, and is depleted when the yearly catches result in F-values above F_{max} (catches > 0.85 mill. tonnes). The stock is at present reduced to some 400 000 tonnes.

The conclusion which must be drawn from this analysis is that this anchovy stock is grossly overexploited, and may soon collapse if not immediate management action is taken to reduce the fishing mortality below $F_{.1}$. In the present state of the stock, $F_{.1}$ may correspond to a sustainable catch of less then 100 000 tonnes.

Fishery management and prediction.

A work shop for giving scientific management advice for 2000 (YSFRI, 1999) valued the average potential yield of anchovy in the Yellow Sea and East China Sea at 500 000 tons a year (Iversen et al.1993). The estimate was considered conservative and regarded as a precautionary catch level. The work shop concluded that since 1996 the catches had been far above the 500 000 tonnes level and warned that if the present fishing effort was carried on in the coming years the risk for stock collapse would be high.

The catch in 2000 is estimated at 950 000 tonnes and far above the recommended precautionary catch level. The stock in 2001 is reduced to some 400 000 tonnes and is now on the point of collapsing. Reliable estimates of catch and corresponding stock development (prediction) for 2001 could however not be made because data on the age composition of the catches are lacking. Such data are needed to determine the fishing pattern and the recruitment curve, which are essential input parameters in forecasting stock development as a function of the catch. Immediate management action should however be taken to reduce the fishing mortality below $F_{.1}$ in order to avoid a stock collapse. This corresponds to a TAC for 2001 of less then 100 000 tonnes.

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Tables

Table 1. Stock size and yearly catches in mill.tonnes in 1986-2001.

	Stock	Catch
1986	2.62	
1987	2.16	
1988	2.82	
1989	2.82	0.04
1990	2.51	0.06
1991	2.46	0.11
1992	2.78	0.19
1993	4.12	0.25
1994	3.74	0.35
1995	3.85	0.45
1996	2.55	0.6
1997		1.1
1998		1.2
1999	0.79	1.10
2000	1.75	0.95
2001	0.42	

Table 2. Stock measurements in number and weight by age.

	Stock in number (billion ind.)				Mean weight in gram			
age:	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1986	139	121.2	34.7	0.3	6.0	10.8	13.5	15.7
1987	102	84.1	32.8	1.4	6.8	12.0	13.0	16.4
1988	210.1	98.9	30.3	0.1	6.8	10.1	12.9	15.7
1989	136.5	105.9	74.6	8.5	3.3	11.1	14.2	15.3
1990	72.9	106.6	67	4.4	5.3	11.0	13.2	15.7
1991	163	94.9	58	17.3	4.8	8.3	11.2	13.5
1992	104.2	161.6	19.9	2.2	6.1	11.3	14.4	15.9
1993	185.6	168.7	80.4	24.1	5.0	10.1	14.1	14.6
1994	122.8	66.4	114.7	43	6.8	11.4	13.0	15.2
1995	198	133.3	58.6	0.6	6.6	12.7	14.6	15.7
1996	113.3	69.1	66.5	5.7	7.3	10.1	13.8	18.8
1997								
1998								
1999	30.1	38.4	14	0.9	5.9	10.8	13.4	15.7
2000								
2001	18.733	23.238	4.413	0.134	5.9	10.8	13.4	15.7

Table 3. Back calculated stock in number (billion ind.) by age from age 3 (terminal stock)

age:	**0**	**1**	**2**	**3**
1986	312	79	53	35
1987	285	194	49	33
1988	255	177	120	30
1989	180	158	110	75
1990	387	111	97	67
1991	528	240	68	58
1992	289	328	143	39
1993	353	179	198	80
1994	250	219	102	115
1995	265	155	127	59
1996	343	165	78	67