

## WORKING GROUP TO REVIEW STOCK ASSESSMENTS

### 7<sup>TH</sup> MEETING

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## EVALUATION OF A MANAGEMENT MEASURE RESTRICTING CATCH BELOW 60 CM

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### 1. INTRODUCTION

[Resolution C-00-02](#) required that the purse-seine fishery using FADs be closed if the catch of bigeye tuna less than 60 cm in length (bigeye < 60 cm) reached the level achieved in 1999. This restriction is reevaluated as a possible candidate for future management measures for bigeye tuna.

### 2. METHODS

The amount of catch of bigeye < 60 cm over time calculated from the stock assessment was compared to the sampling model estimates. This was also compared to the “small” category (< 2.5 kg) in the observer data.

The amount of catch of bigeye < 60 cm over time (by quarter) was compared to many other indicators of the stock status:

- 1) Catch < 60 cm as a ratio of the total surface fleet catch
- 2) Catch < 60 cm as a ratio of the total catch
- 3) Spawning biomass ratio
- 4) The scaling parameter to scale the fishing mortality in that year to the level that would produce MSY
- 5) Average weight in the catch
- 6) The fishery impact
- 7) Recruitment
- 8) Exploitation rate on fish < 60 cm (ages 1-5 quarters)

Yield-per-recruit analysis was carried out for bigeye tuna to determine the impact on yield if the catch of fish less than 60 cm was reduced. The vectors of fishing mortality ( $F$ ), natural mortality ( $M$ ), and average weight at age were taken from the 2005 assessment (Maunder and Hoyle 2006). Fish below 60 cm were represented by fish aged 5 quarters and younger. Since the average length of bigeye ages 5 quarters was 64.1 cm, using the 5 quarters would eliminate some fish greater than 60 cm. The yield per recruit analysis was conducted under three scenarios: 1) no change in the relative age-specific fishing mortality; 2) 50% reduction in  $F$  for ages 5 quarters and younger; and 3)  $F = 0$  for ages 5 quarters and younger. First the analysis was carried out with the average fishing mortality equal to the average over 2002-2004, and then with the age-specific fishing mortality scaled to maximize the yield per recruit. Because the current assessment assumes that recruitment is independent of stock size, these yield-per-recruit analyses are also proportional to total yield estimates.

### 3. RESULTS

The amount of catch of bigeye < 60 cm over time calculated from the stock assessment was less than the sampling model estimates during 1995-1997 and 2003-2005 (Figure 1). However, the total catch estimated by the stock assessment was the same as the species composition estimate using the sampling model method (Figure 2). Therefore, the sampling model method had higher proportions of catch of bigeye < 60 cm during 1995-1997 and 2003-2005 (Figure 3).

The observers record data about tuna catch in three categories. The “small” category is all fish less than 2.5 kg, or about 3 quarters old in the case of bigeye. A 60 cm bigeye is about 4-5 quarters old. The proportion of bigeye tuna in the “small” category of the observer data is similar to that estimated by the stock assessment for fish 60 cm and smaller (Figure 3).

There has been substantial temporal variation in the amount of bigeye < 60 cm caught (Figure 4). Most of this catch is taken by the floating-object fisheries that have developed since 1993. The proportion of the catch that is less than 60 cm generally follows the total catch less than 60 cm (Figure 5). In the late 1990s and early 2000s there was a substantial drop in the catch that is less than 60 cm. This corresponded to a period of poor recruitment (Figure 6). However, the total catch of bigeye remained high (Figures 4 and 7), and therefore the ratio of catch that is less than 60 cm to total catch reduced during this period (Figures 5 and 8). This was because the large recruitments during 1995-1998 were still in the fishery (Figure 6) and also increased the average weight in the catch (Figure 9). This also caused the spawning biomass to be high (Figure 10). The increase in catch that is less than 60 cm beginning in 2002 was again due to increased levels of recruitment.

The expansion of the floating-object fisheries since 1993 greatly increased the fishing mortality of bigeye < 60 cm (Figure 11), which reduced the average weight in the catch (Figure 9). This caused the overall fishing mortality to be greater than that which would support MSY (Figure 12). It also greatly reduces the MSY (Figure 13).

The yield per recruit is increased if the fishing mortality of bigeye < 60 cm is reduced (Table 1). If the fishing mortality of bigeye < 60 cm is eliminated, the total catch can be greatly increased without changing the current fishing effort (Table 1). Under the current age-specific fishing mortality at age, fishing effort is too high (Figure 14) and needs to be reduced to maximize the yield per recruit. If small fish could be eliminated from the catch, under the current effort levels, the yield per recruit would be maximized if ages 10 quarters and younger were eliminated from the catch (Figure 15). If both the catch of small fish could be eliminated and the fishing effort could be controlled, the best yield per recruit would be obtained if all fish 13 quarters and younger were eliminated from the catch (Figure 14). Even if the fishing mortality of bigeye < 60 cm was halved, the current effort is still too high to maximize yield per recruit (Figure 16). If fishing mortality of bigeye < 60 cm was eliminated, the current effort is about the correct level to maximize yield per recruit (Figure 17).

### 4. CONCLUSIONS

The amount of bigeye < 60 cm caught is generally a function of the strength of the cohorts in the fishery. Therefore, annual variation in the amount of bigeye < 60 cm caught is expected, and any controls on the catch of bigeye < 60 cm would reduce fishing mortality rates on these fish in years of high abundance. Fishing mortality would not be reduced in years of low abundance when the reduction may be more beneficial.

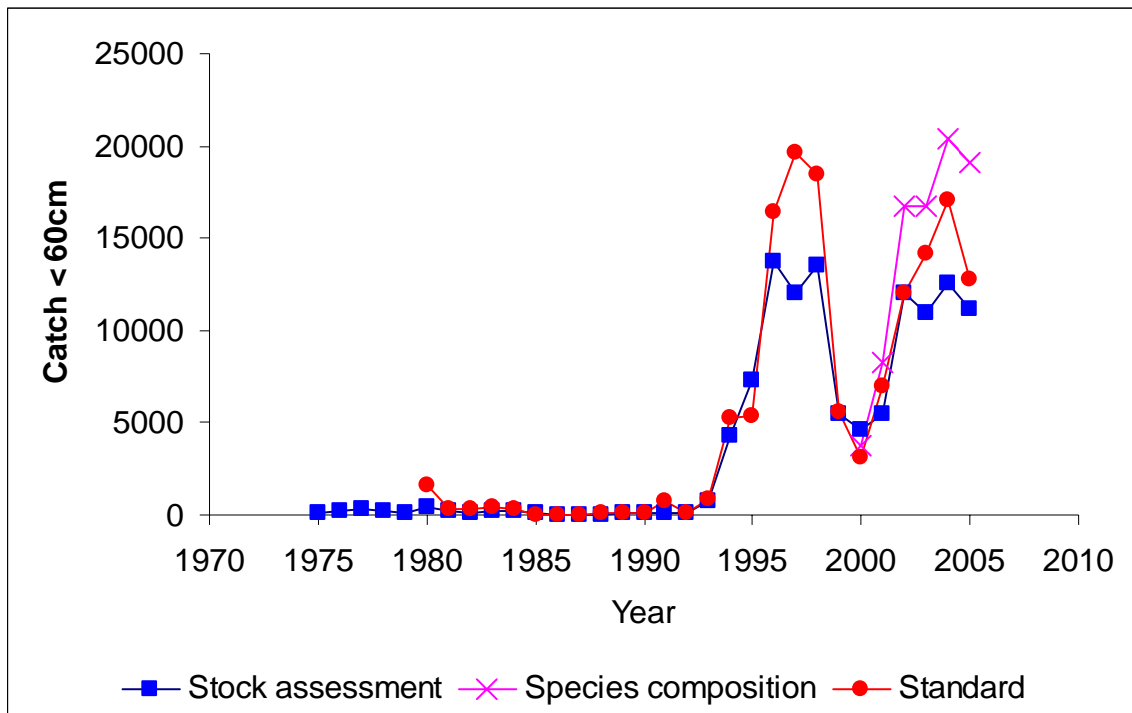
An indicator of problems in the fishery would be when the total catch of bigeye is low and the proportion of catch that is less than 60 cm to the total catch is also low. This would indicate that the adult population is low and that there is no recruitment to help sustain the fishery.

Reducing the fishing mortality on bigeye < 60 cm would greatly increase the yield per recruit and yield. However, even if the catch of bigeye < 60 cm could be eliminated, the current effort is still too high.

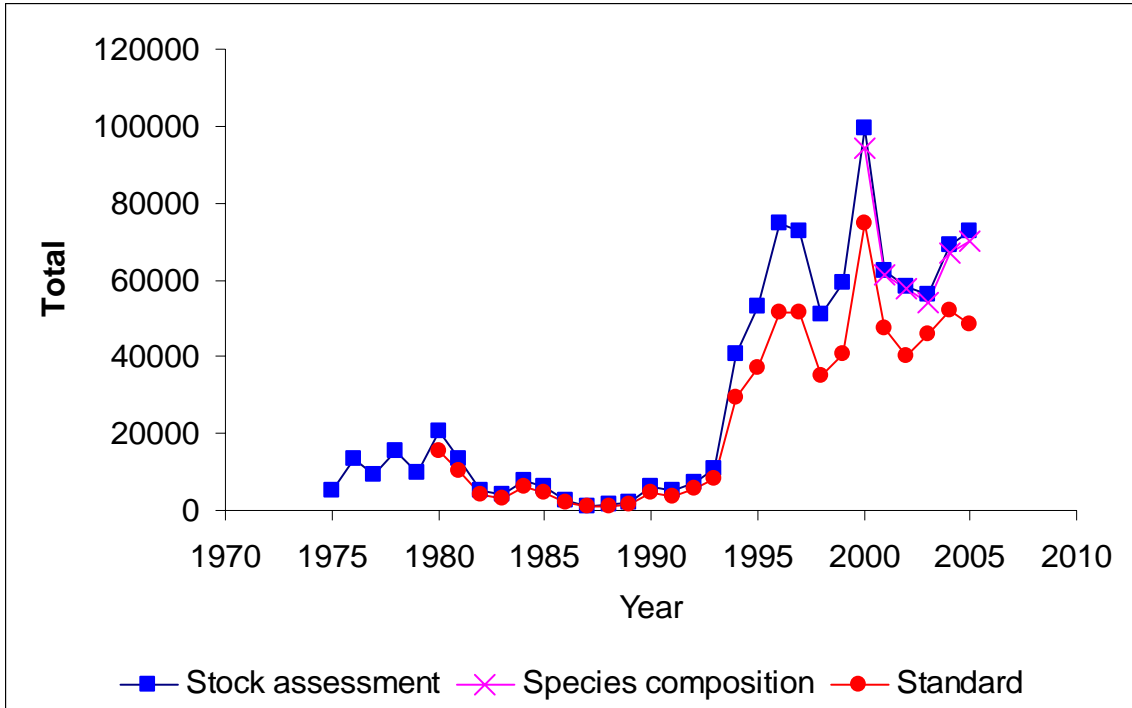
These results are conditioned on the assumed values for age-specific natural mortality. The rate of natural mortality is uncertain, particularly for the younger fish. Changes in yield per recruit would be reduced if the rate of natural mortality for young fish was higher than currently used in the model. Hampton (2000) estimates much higher rates of natural mortality than used in the EPO assessments, but this rate is confounded by possible high levels of tagging induced mortality.

Hampton J. 2000. Natural mortality rates in tropical tunas: size really does matter. *Can. J. Fish. Aquat. Sci.* 57: 1002-1010.

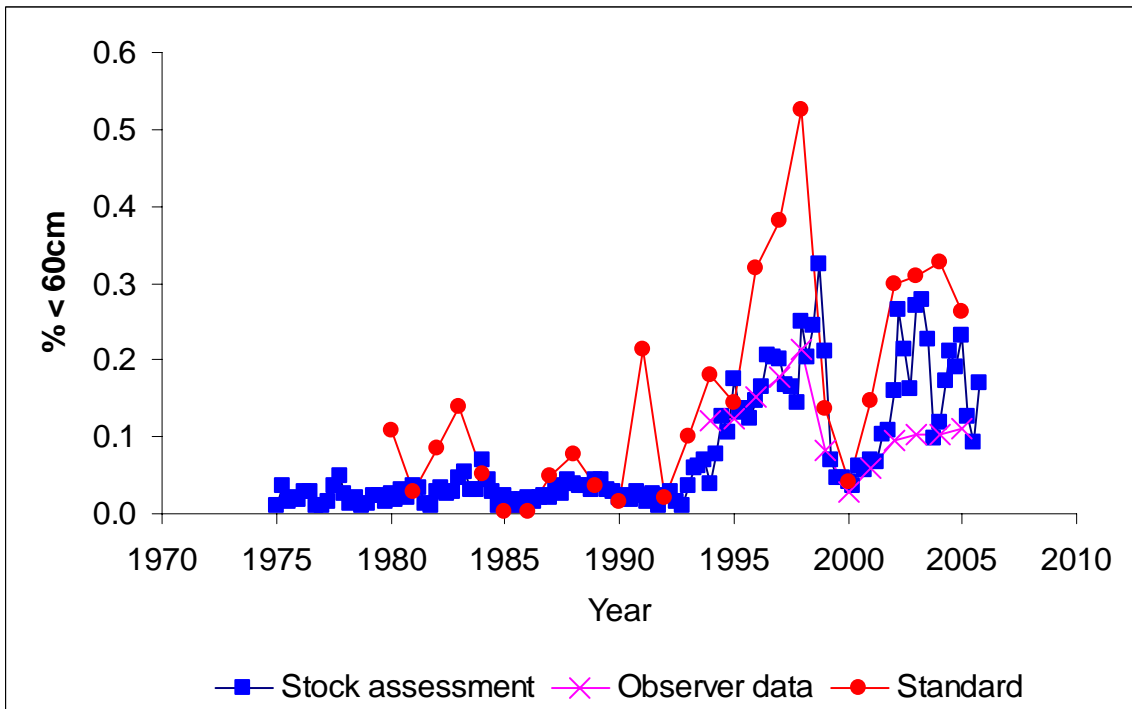
Maunder M.N. and S.D. Hoyle. 2006. Status of bigeye tuna in the eastern Pacific Ocean in 2004 and outlook for 2005. *Inter-Amer. Trop. Tuna Comm., Stock Asses. Rep.* 6: 103-206.



**FIGURE 1.** Catch of bigeye tuna < 60 cm in metric tons.

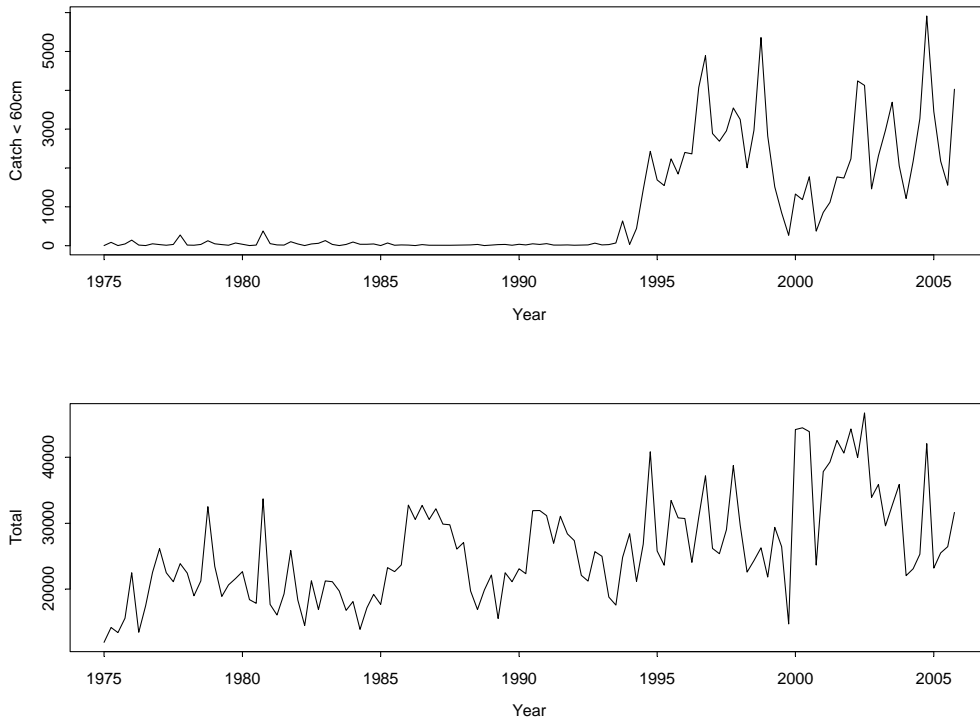


**FIGURE 2.** Total catch of bigeye tuna in metric tons.

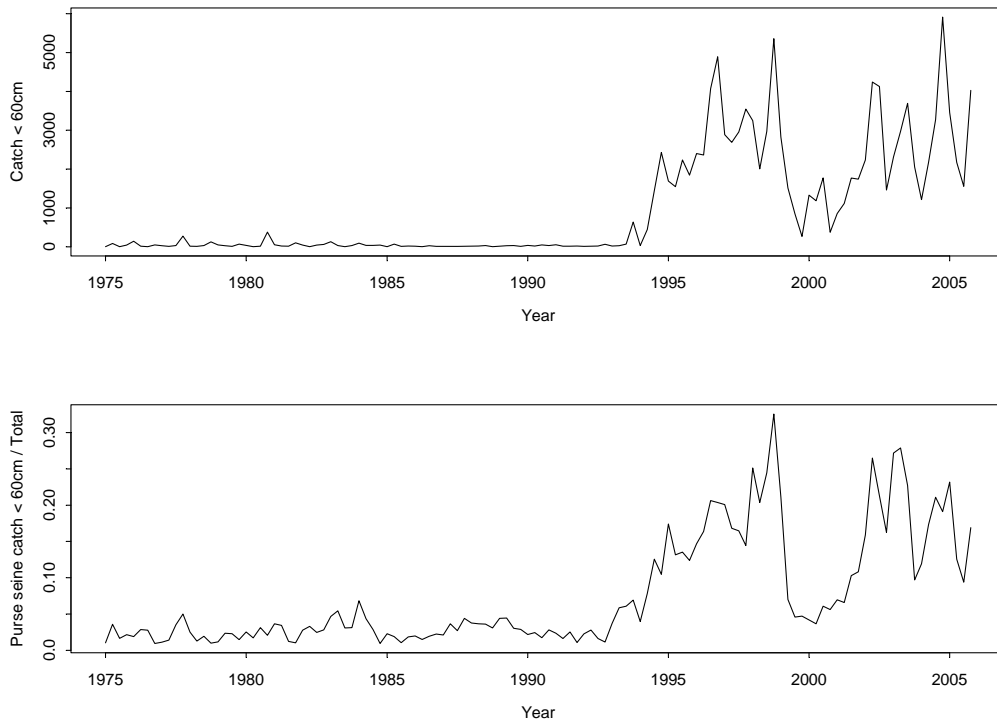


**FIGURE 3.** Proportion of catch of bigeye tuna < 60 cm.

SAR-7-12b Effect of catch length restriction

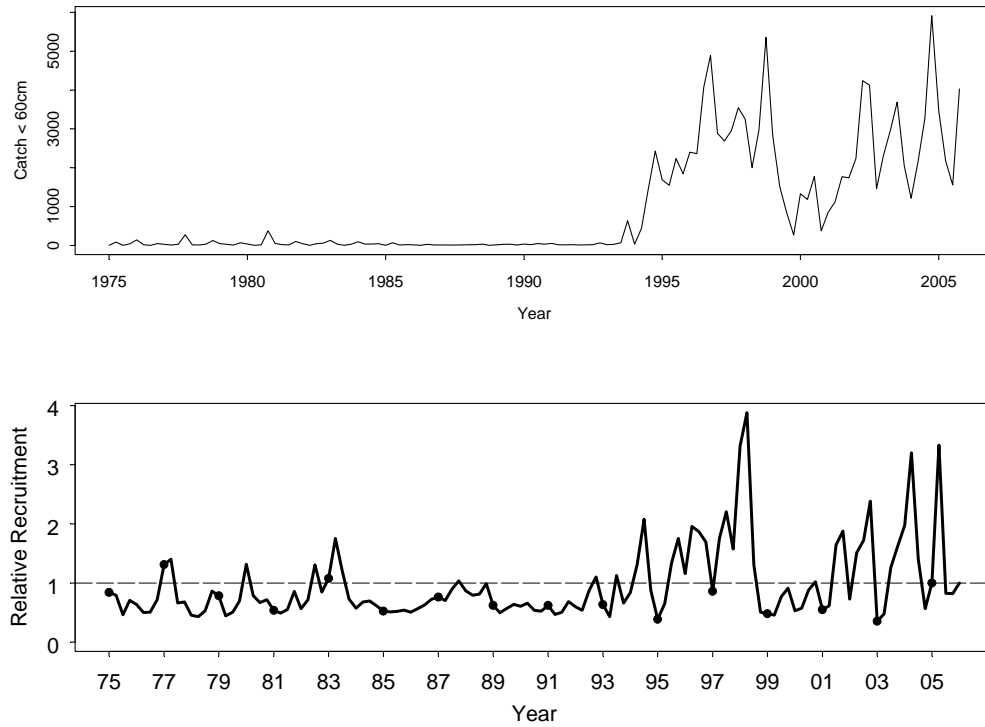


**FIGURE 4.** Catch of bigeye tuna < 60 cm (top panel) and the total catch of bigeye tuna (bottom panel) by quarter.

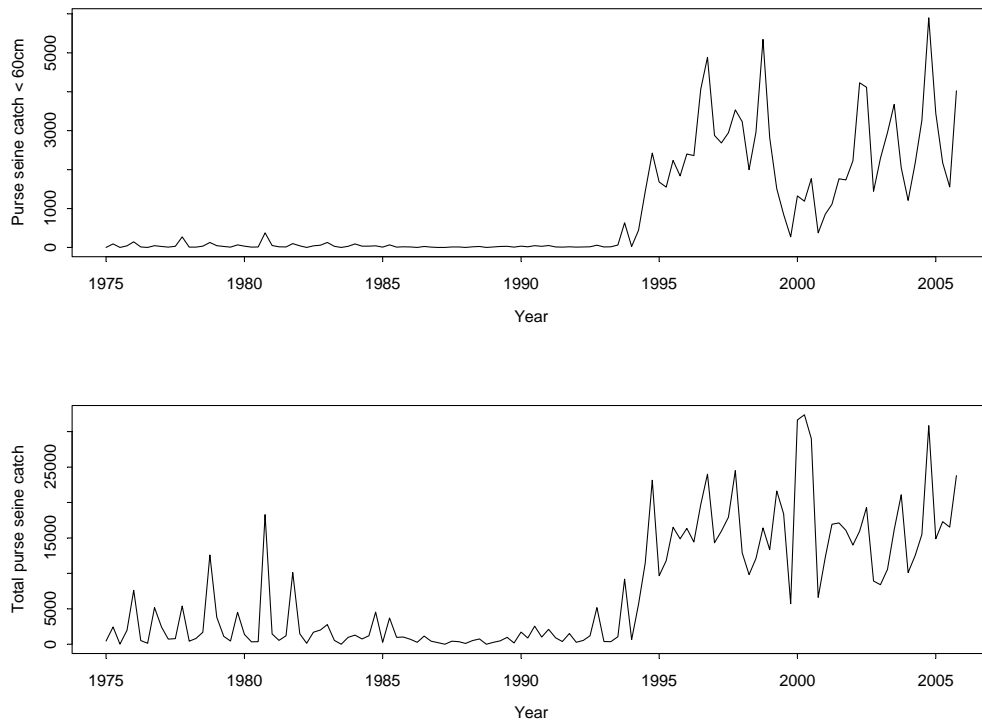


**FIGURE 5.** Catch of bigeye tuna < 60 cm (top panel) and the ratio of catch of bigeye tuna < 60 cm to

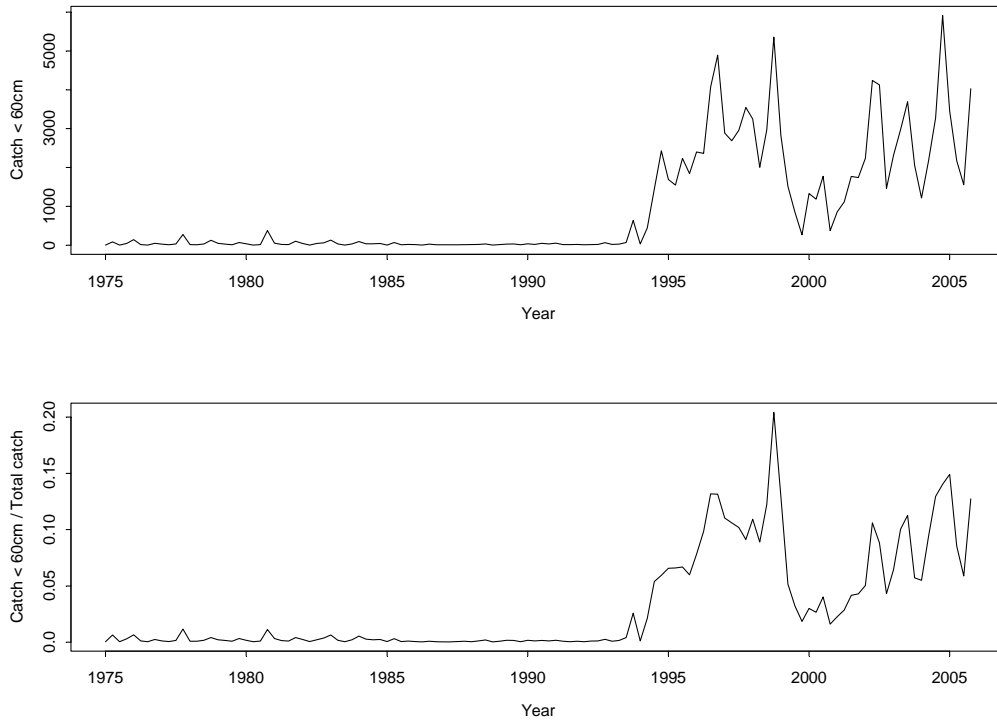
total catch of bigeye tuna in the surface fisheries (bottom panel) by quarter.



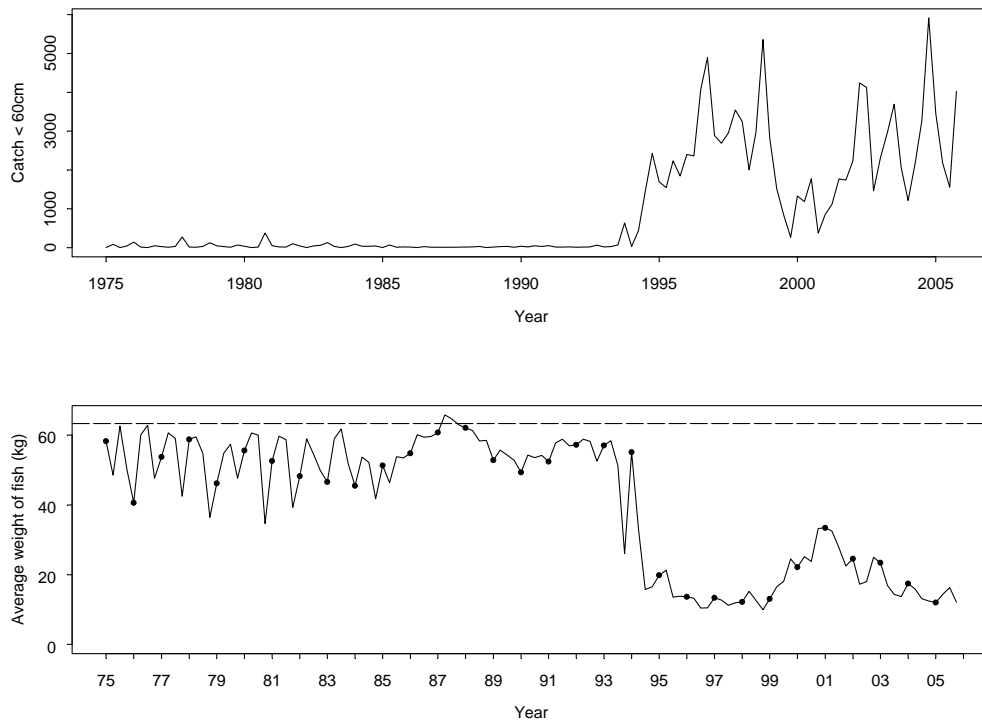
**FIGURE 6.** Catch of bigeye tuna < 60 cm (top panel) and the recruitment estimated in the stock assessment model (bottom panel) by quarter.



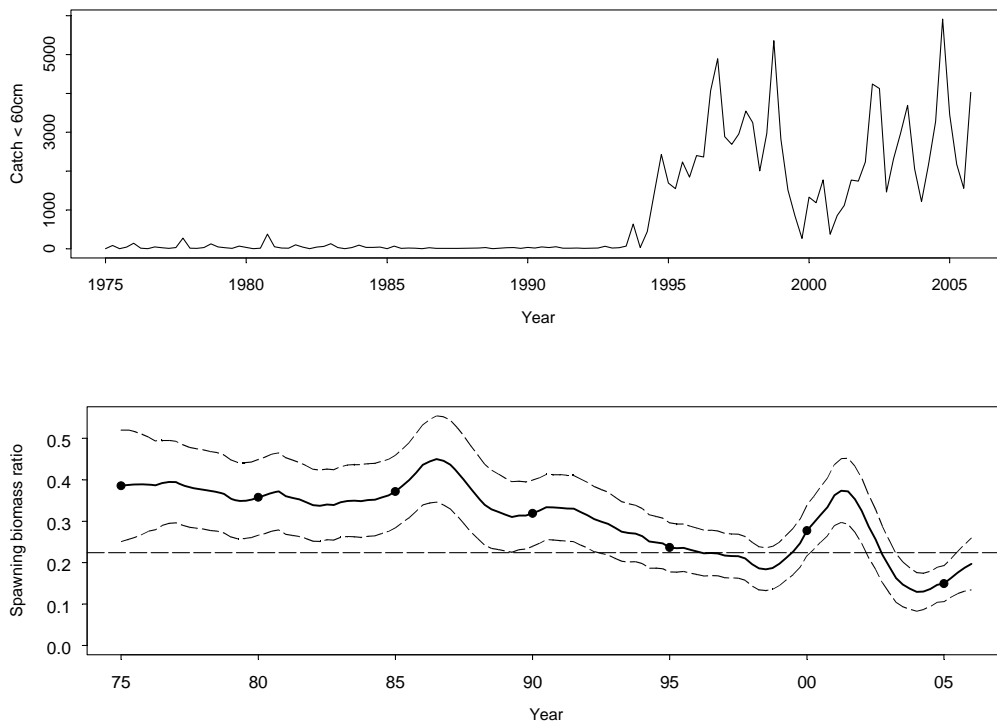
**FIGURE 7.** Catch of bigeye tuna < 60 cm in the purse seine fisheries (top panel) and the total catch of bigeye tuna in the surface fisheries (bottom panel).



**FIGURE 8.** Catch of bigeye tuna < 60 cm (top panel) and the ratio of catch of bigeye tuna < 60 cm to total catch of bigeye tuna (bottom panel).



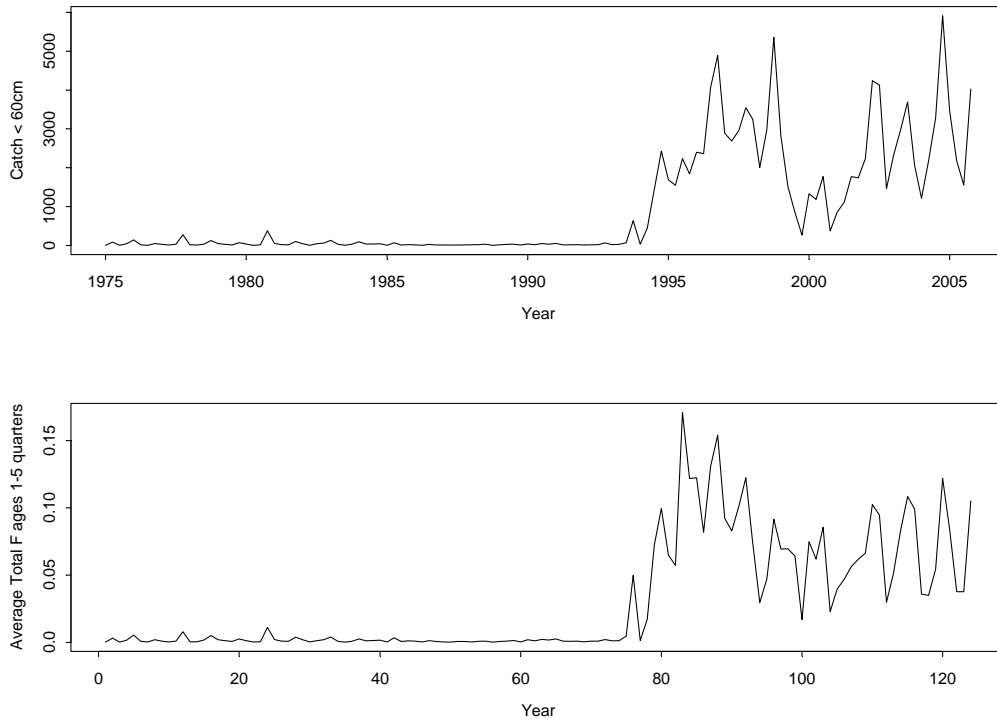
**FIGURE 9.** Catch of bigeye tuna < 60 cm (top panel) and the average weight of bigeye tuna in the catch (bottom panel) by quarter.



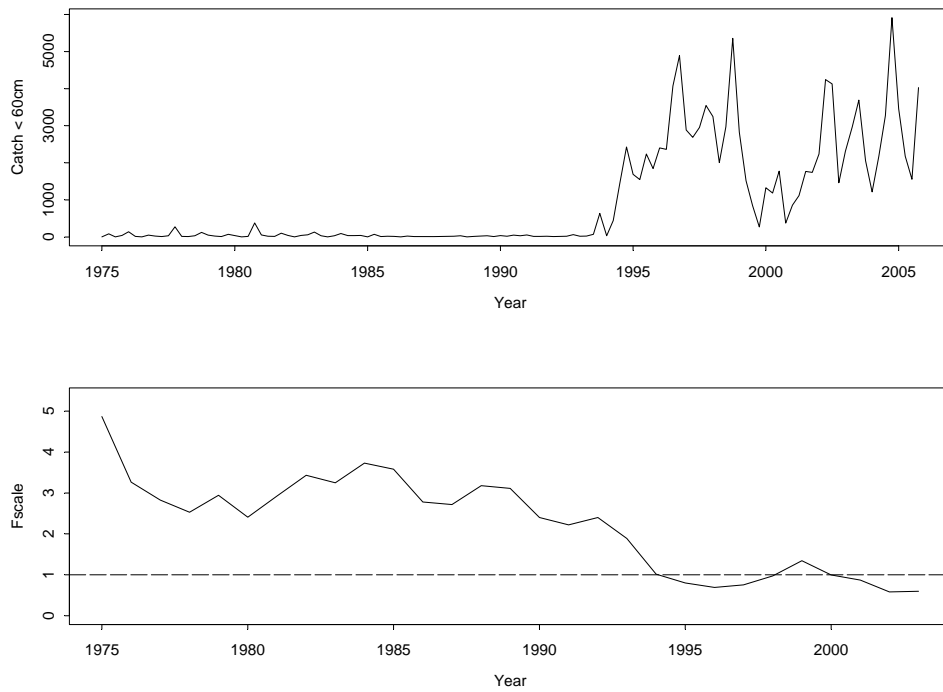
**FIGURE 10.** Catch of bigeye tuna < 60 cm (top panel) and spawning biomass ratio for bigeye tuna (bottom panel) by quarter.



estimated in the stock assessment (bottom panel) by quarter.

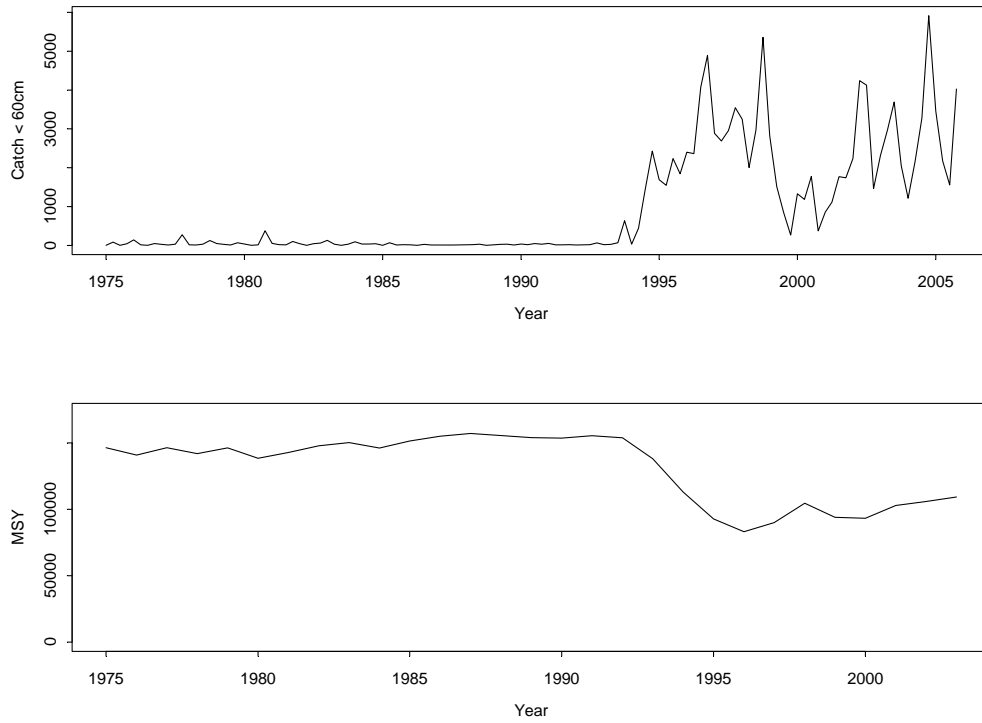


**FIGURE 11.** Catch of bigeye tuna < 60 cm (top panel) and the exploitation rate on bigeye tuna less than 60 cm (ages 1-5 quarters) estimated by the stock assessment model (bottom panel) by quarter.

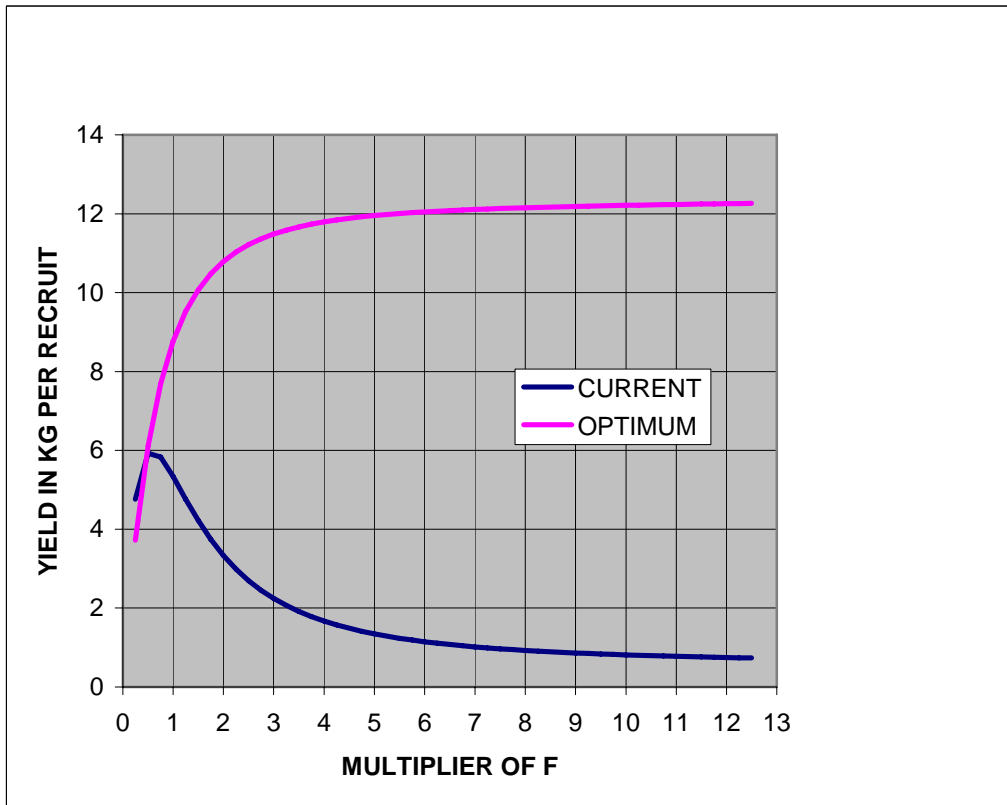


**FIGURE 12.** Catch of bigeye tuna < 60 cm (top panel) and the fishing mortality scalar that would be applied to convert the fishing mortality in that quarter to the fishing mortality that would support MSY

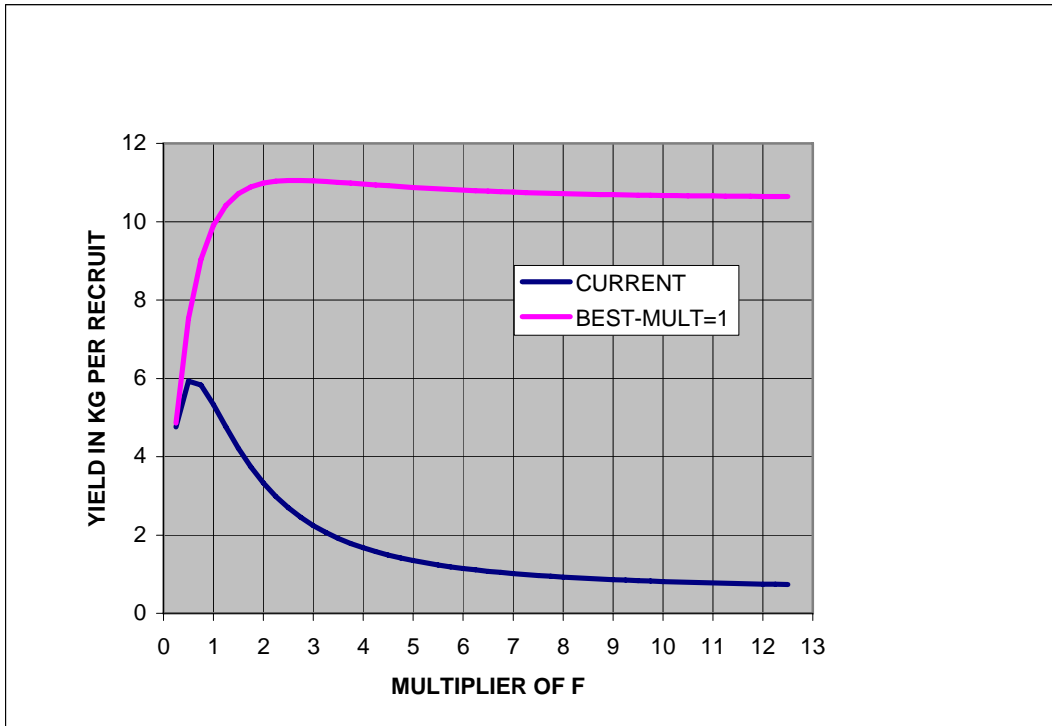
(bottom panel).



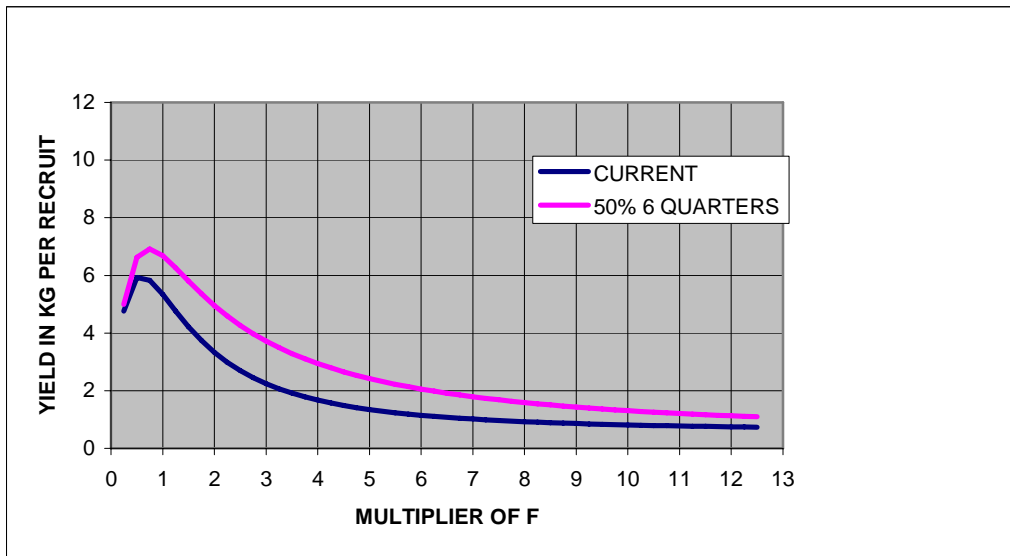
**FIGURE 13.** Catch of bigeye tuna < 60 cm (top panel) and the MSY calculated using the age-specific fishing mortality in that quarter (bottom panel).



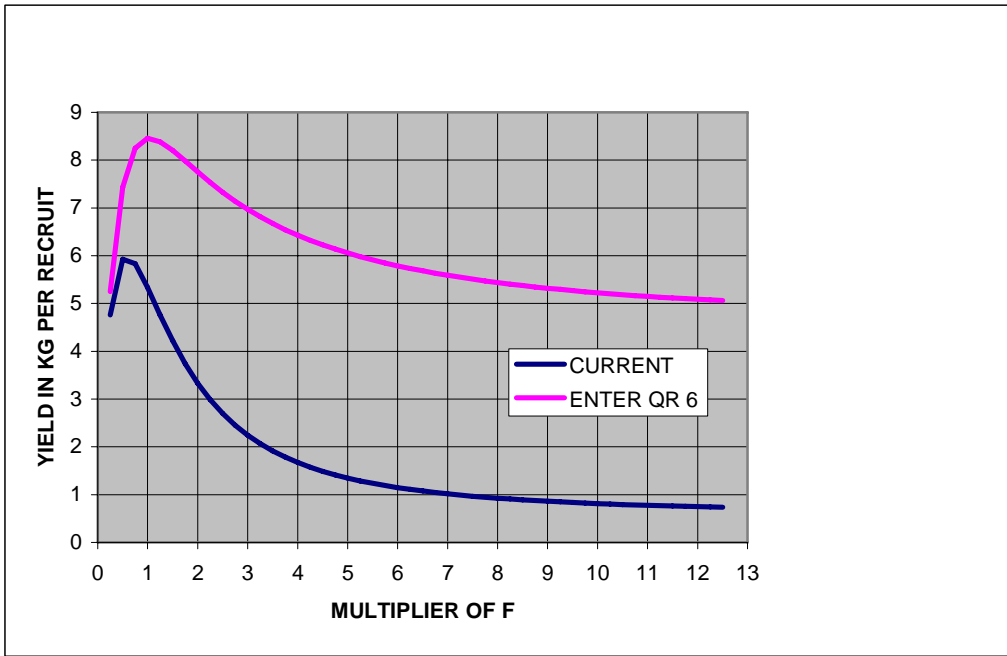
**FIGURE 14.** Yield per recruit under different scaling factors for the current age-specific fishing mortality and when the age-at-entry into the fishery is controlled (Optimum).



**FIGURE 15.** Yield per recruit under different scaling factors for the current age-specific fishing mortality and when the age-at-entry (age 11 quarters) into the fishery is set to maximize the yield per recruit under current effort levels (BEST-MULT=1).



**FIGURE 16.** Yield per recruit under different scaling factors for the current age-specific fishing mortality and when the fishing mortality for ages 5 quarters and less is set to 50% of the current value (ENTER QR 6).



**FIGURE 17.** Yield per recruit under different scaling factors for the current age-specific fishing mortality and when the fishing mortality for ages 5 quarters and less is set to zero (ENTER QR 6).

**TABLE 1.** Yield per recruit (Y/R) in kg per recruit and associated quantities for the three scenarios described in the text where average fishing mortality is equal to the average over 2002-2004.

Scenario	Y/R < 60 cm	Y/R all sizes	% small	% increase
1	0.7562	5.3363	14.2	0%
2	0.4614	6.6741	6.9	25%
3	0.0000	8.4546	0.0	58%