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by

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Introduction

Yield per recruit (YPR) analysis is a commonly used and classic item in the arsenal of stock assessment scientists (Kleiber, 1994). For the Western Pacific yellowfin, the YPR analysis has been conducted by Suzuki (1986, 1988), Hampton (1992), Coan *et al.* (1993) and Kleiber (1994). One of the problems in the analysis mentioned by Hampton (1992) was that the catch of small size fish is likely to be overestimated, because of the assumption of constant fishing mortality with size. The fishing mortality for the small size fish should be less than constant amount assumed for all sizes in the analysis. Also, the assumption of constant natural mortality may affect the results of the analysis.

The objective of this study was to conduct a YPR analysis for the western Pacific yellowfin tuna caught by three main types of fishing gear: longline (LL), purse seine (PS) and local fishing gear used by Philippines/Indonesia fishermen (PH/ID). In the analysis the natural mortality rate is size specific and the fishing mortality rate is size and gear specific.

Method and Materials

In this study the growth equation and the length-weight relationship equation used were $L = 190(1 - e^{-0.33(t-0)})$ presented by Yabuta *et al.* (1960) and $W = 2.51 \times 10^{-5} L^{2.9395}$ presented by Morita (1973), respectively, where L is fork length in cm, t is age in year, and W is weight in kg. The annual instantaneous rates of natural mortality (M) and fishing mortality (F) by size class were provided by Dr. John Hampton, South Pacific Commission (SPC), New Caledonia. The rates were based on the SPC's tagging experiment, in which the rate of tag return was estimated to be 0.59 for all size classes. The F-value of each size class by type of gear was estimated by partitioning the total F-value of each size class into three types of gear, LL, PS and PH/ID, according to the catches of each size class by each type of gear.

The catches in number of fish by size class and by type of gear for 1995 were provided by Dr. Hampton. He estimated them from the total catch in weight reported in the SPC yearbook for 1995 to raise all length frequency sample data for 1990 to 1996 for LL, PS and PH/ID, using Morita's (1973) length-weight relationship equation. All the computation in this study was based on Ricker's (1958) model for the multigear fisheries.

Results and Discussion

M- and F-values by size

The M- and F-values by size class (10 cm) for the western Pacific yellowfin tuna fishery, when the three types of gear were combined, are shown in Figure 1. The M-value decreased from the maximum value of 6.36 for the size class of 20-30 cm to the lowest value of 0.396 for the size class of 60-70 cm. The value then increased to a high level of 2.4 for the size class of 90-100 cm, and decreased to 1.2 when the fish was larger than 100 cm.

The F-values ranged between 0.115 for the size class of 90-100 cm to 0.768 for the size class of 30-40 cm. The F-value was 0.156 when the fish was greater than 100 cm.

F-value by size and type of gear

The estimates of F-values by size and by type of gear are shown in Figure 2. The F-value of the PH/ID fishery for each size class was higher than those of the LL and PS fisheries when the fish was smaller than 50 cm, while the F-value of the PS fishery was much higher than those of LL and PH/ID fisheries when the fish was larger than 50 cm.

Estimates of YPR

The M-values shown in Figure 1 are particularly high for the size class of 20-30 cm (6.36) and the size class of 90-100 cm (2.4). For convenience, in this study three cases were discussed based on different M-values assumed; the M-values at the levels listed in Figure 1 (Case I), the M-value at a constant of 1.07 used by Hampton (1992) (Case II), and the M-values adjusted by 1.07/2.03 for each size class (Case III).

Case I -- The results of the YPR analysis for the western Pacific yellowfin entire fishery when the M-values are set at the levels in Figure 1 are shown in Figure 3. When the size at recruitment remains constant at 25 cm, the YPR is expected to increase with the increase in effort. Until the effort increases to 1.0 (multiplier = 1.0) or larger, the YPR then decreases gradually. If effort remains constant, the YPR increases and then decreases when size at recruitment increases. When the effort is doubled (multiplier = 2.0) and size at recruitment increases to 55 cm (3.3 kg), the YPR is 0.55 kg. The YPR would increase to 27% if size at recruitment is increased to 75 cm.

Lenarz *et al.* (1974) states that if fishermen are unable to distinguish the size of fish before capturing them and a minimum size regulation prevents their landing, then the dumping (killing and discarding) of yellowfin will occur. Figure 4 present landings per recruit for the entire fishery when dumping of all yellowfin smaller than the size limit occurs. If the minimum size limit is 55 cm and effort remains the same, then a 16.7% decrease in landings per recruit will occur, and a 25.0% decrease in landing per recruit will occur if the minimum size is set at 75 cm. If the effort is doubled, and the minimum size is either 55 or 75 cm, there will be a great decrease in landings per recruit.

Case II -- The results of the YPR analysis for the entire fishery, when the M-value is set at 1.07, are shown in Figure 3. The YPR values are much higher than those found in Case I. If the size at recruitment remains constant at 25 cm, an increase in YPR is expected with the increase in effort until it reaches to 0.6 (multiplier = 0.6). When the effort increases beyond this level, the YPR will decrease gradually.

When the effort is doubled (multiplier = 2.0) and size at recruitment increases to 55 cm, the YPR value is 2.28 kg. The YPR would increase 18% when size at recruitment is increased to 75 cm.

Figure 4 show the landings per recruit. There will be a 16.7% decrease in landings per recruit when the minimum size limit is set at 55 cm and the effort remains the same, and a 26.7% decrease will occur if the minimum size is 75 cm. As Case 1, when the effort is doubled and the minimum size is either 55 or 75 cm, a great decrease in landings per recruit will occur.

Case III -- The results of the YPR analysis for the entire fishery, when the M-values are adjusted by 1.07/2.03 for each size class, are shown in Figure 3. When the size at recruitment remains constant at 25 cm, the YPR increases 11% when the effort increases from 0.2 to 0.4, then the YPR decreases with the increase in effort.

If the effort remains constant, the YPR increases and then decreases when size at recruitment increases. If the effort is doubled (multiplier = 2.0) and size at recruitment increases to 55 cm, the YPR value is 1.9 kg. The YPR would increase 51% when size at recruitment is increased to 75 cm.

Figure 4 show the landings per recruit. When the minimum size limit is set at 55 cm and effort remains the same, there will be a decrease of 17.4% in landings per recruit. The decrease will be 25.8% when the minimum size is set at 75 cm. As Cases I and II, when the effort is doubled and the minimum size is set at either 55 cm or 75 cm, there will be a great decrease in landing per recruit.

The values of YPR and landings per recruit in Cases II and III are much higher than those found in Case I.

Based on the results of the above three cases studied, it seems that the high M-values in Case I result in the low values of yield per recruit and landings per recruit (Figures 3 - 6). In Case II, the assumption of constant M is not valid because the M-value is usually size specific. In Case III, the M-value for each size class is adjusted by multiplying a ratio of 1.07 to 2.03, where 1.07 is the M-value for Case II and 2.03 is the average value by size specific in Case I. It seems that the M-values in Case III are more reasonable as compared to those of Cases I and II.

The results obtained in this study are preliminary, and a further analysis and evaluation is required before any attempt to establish the minimum size limit for the yellowfin tuna to regulate the fishery in the western Pacific.

Acknowledgements

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References cited

Coan, A.L., P. Kleiber, and D. Prescott, 1993. U.S. western Pacific purse seine fishery for tropical tunas. South Pacific Regional Tuna Treaty Meeting, Nadi, Fiji, April, 1993. SWFSC, LA Jolla, CA, 28 pp.

Hampton, J., 1992. Biological impact of catches of small skipjack and yellowfin in the western Pacific purse seine fishery. South Pacific Regional Tuna Treaty Meeting, Nadi, Fiji, Dec. 1992. TBAP, Noumea, New Caledonia, 3 pp.

Kleiber, P., 1994. Yield per recruit: Is there potential benefit from a size limit on skipjack and yellowfin catch. WPYRG 4/4, Koror, Palau, August 9-11, 1994. 5 pp.

Lenarz, W.H., W.W. Fox., G.T. Sakagawa, and B.J. Rothschild, 1974. An examination of the yield per recruit basis for a minimum size regulation for Atlantic yellowfin tuna, *Thunnus albacares*. Fish. Bull., 72(1): 37-61.

Morita, Y., 1973. Conversion factor for estimating live weight from gilled and gutted weight of bigeye and yellowfin tunas. Bull. Far. Seas Fish. Lab., 9: 109-122.

Ricker, W.E., 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada. Bull., 119: 300 pp.

Suzuki, Z., 1986. Interaction study on yellowfin stock between longline and purse seine fisheries in the western Pacific. IPTP collective Volume of working documents, p. 175-190.

Suzuki, Z., 1988. Study of interaction between longline and purse seine fisheries on yellowfin tuna, *Thunnus albacares* (Bonnaterre). Bull. Far. Seas Fish. Lab., 25: 73-144.

Yabuta, Y., M. Yukinawa, and Y. Warashina, 1960. Growth and age of yellowfin tuna - II. Age determination (Scale method). Nankai Reg. Fish. Res. Lab. Rep. 12: 63-74.

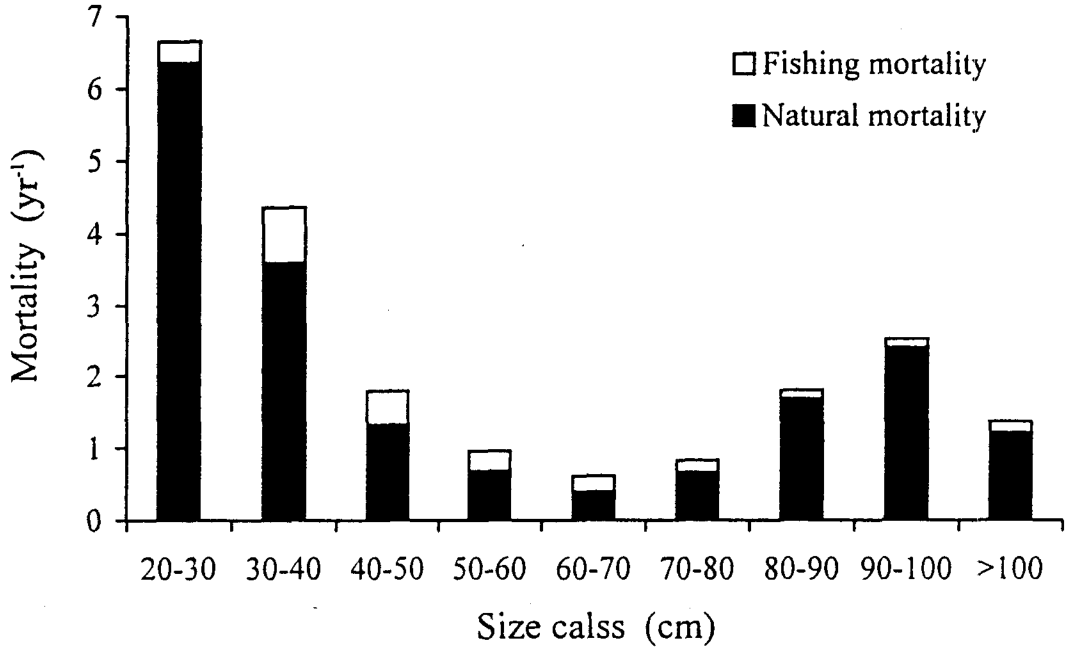

Fig. 1. Total mortality, natural mortality and fishing mortality of the Pacific yellowfin tuna by size class, estimated from RTTP tagging data. (Data provided by Dr. Hampton, SPC, 1997.)

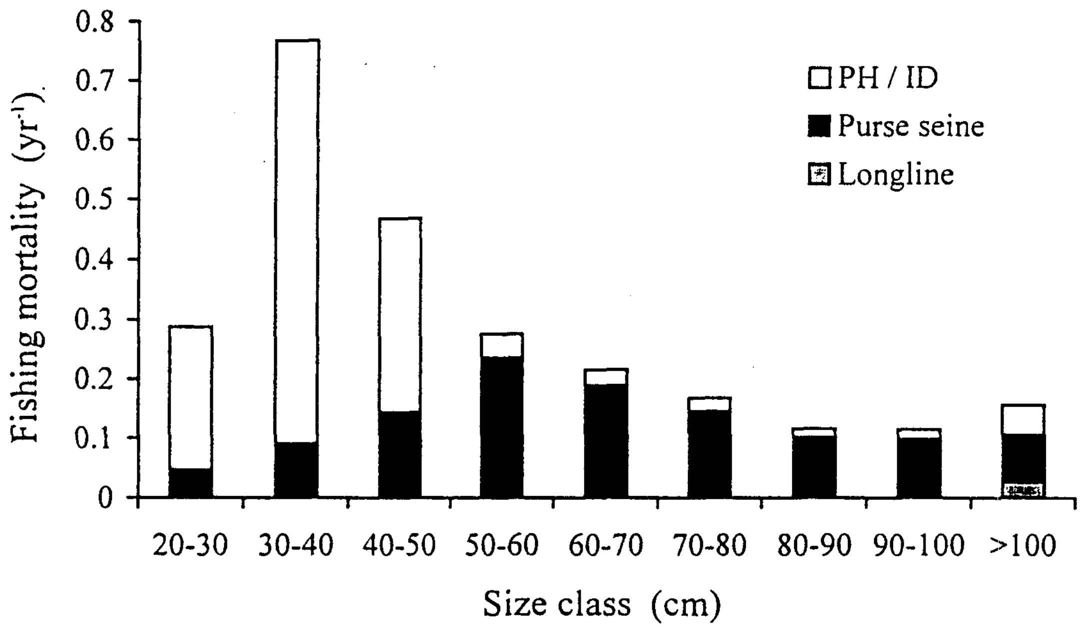

Fig. 2. Fishing mortality of the western Pacific yellowfin tuna by size class and by type of gear.

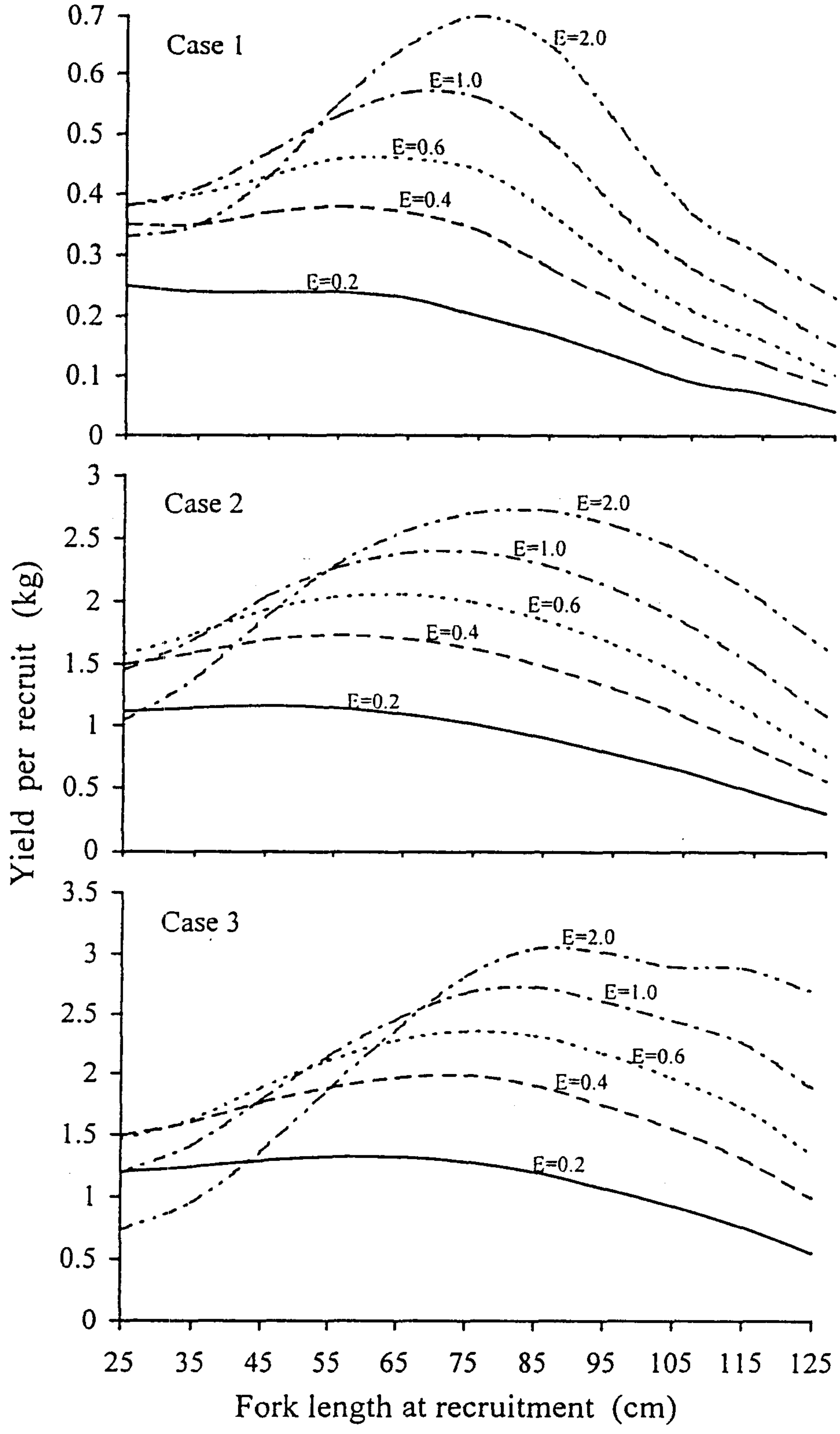

Fig. 3. Yield-per-recruit (kg) analyses for the entire western Pacific yellowfin tuna fishery for the three cases (E: multiplier of effort).

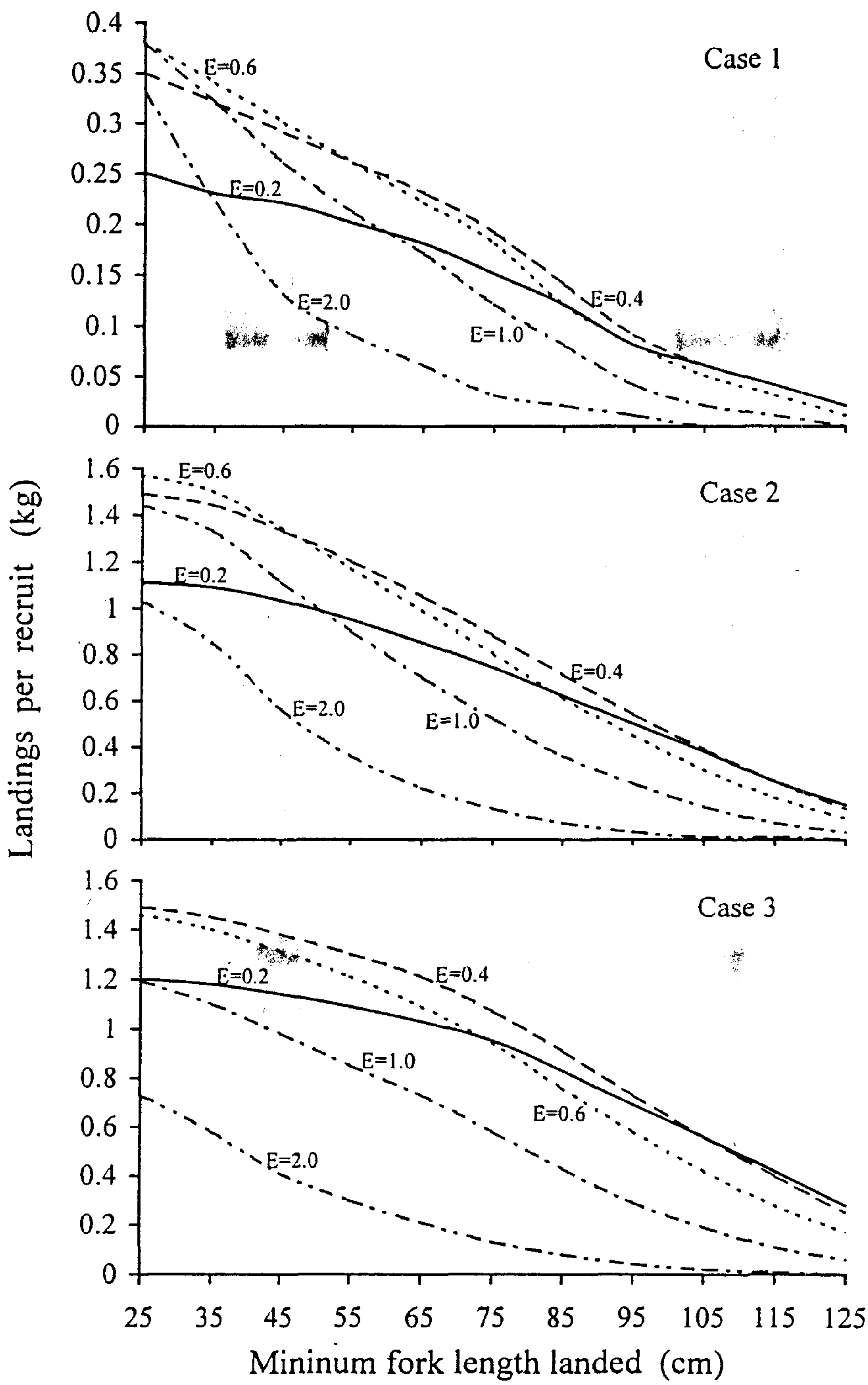

Fig. 4. Landings-per-recruit (kg) analyses for the entire western Pacific yellowfin tuna fishery for the three cases (E: multiplier of effort).

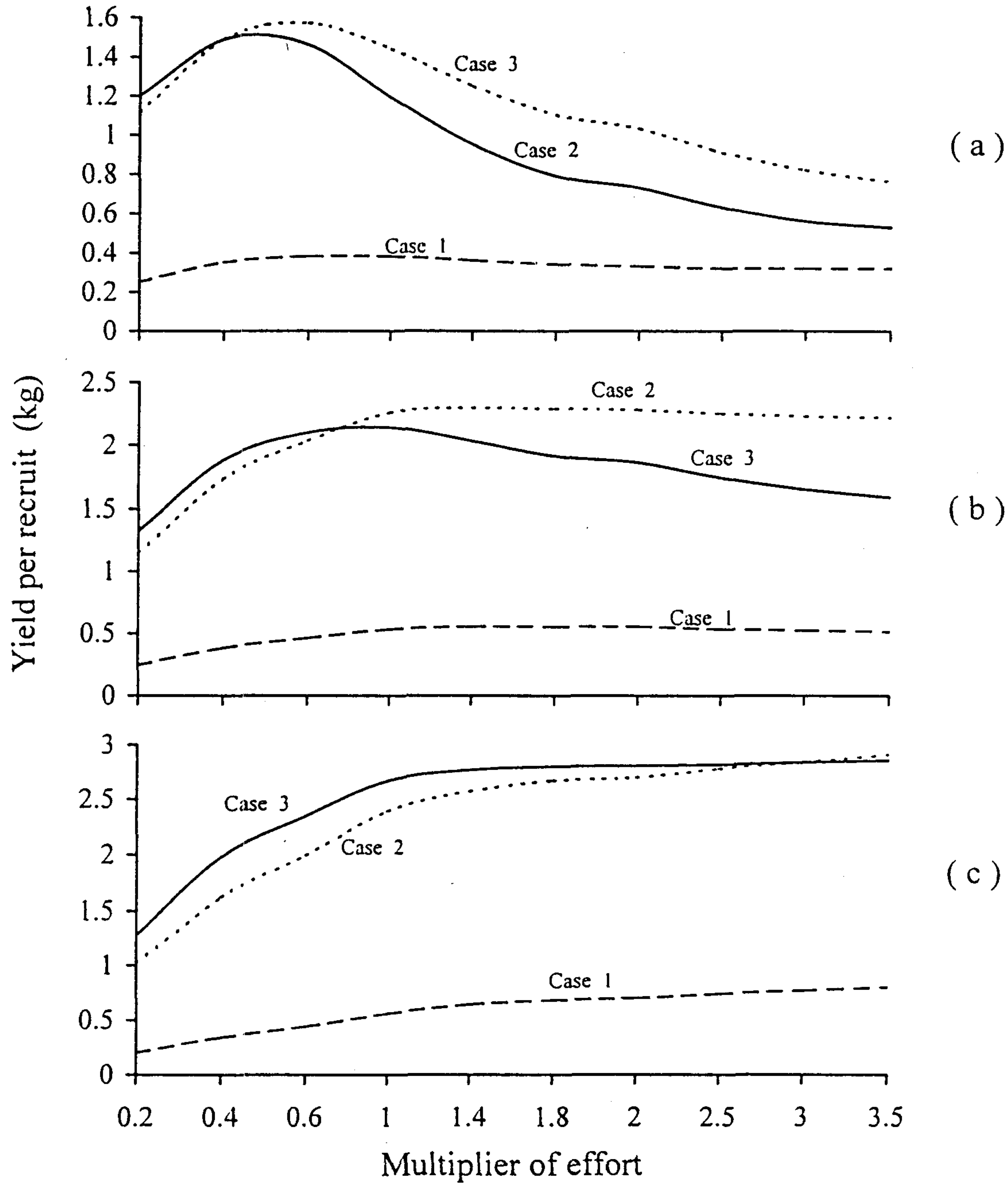

Fig. 5. Estimates of yield per recruit (kg) for the three cases, when (a) size at recruitment (l_r) is 25 cm (b) l_r = 55 cm (c) l_r = 75 cm, as a function of multiplier of fishing effort for the entire western Pacific yellowfin tuna fishery.

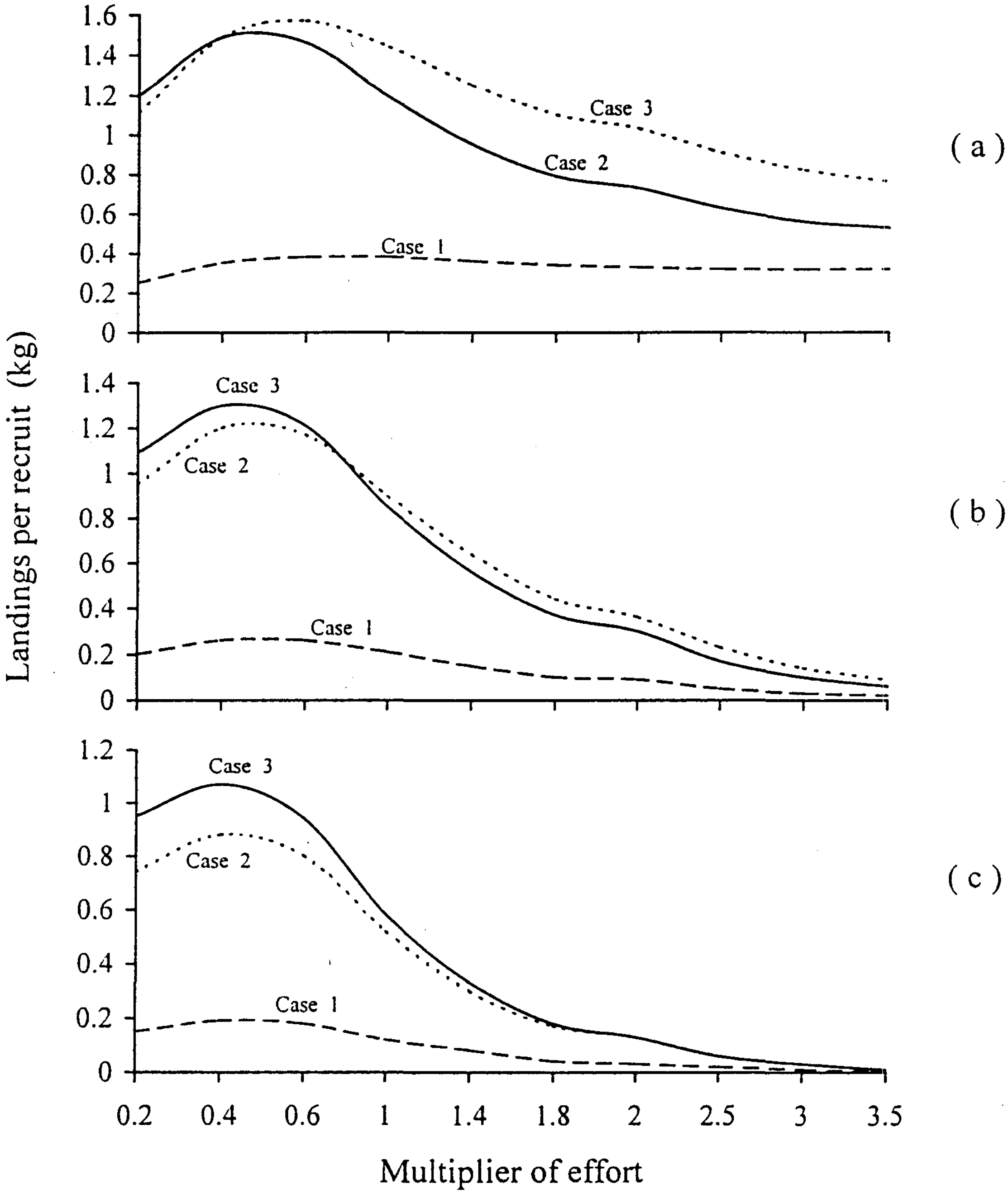

Fig. 6. Estimates of landings per recruit (kg) for the three cases, when (a) size at recruitment (l_r) is 25 cm (b) l_r = 55 cm (c) l_r = 75 cm, as a function of multiplier of fishing effort for the entire western Pacific yellowfin tuna fishery.