Preliminary Yield per Recruit Analysis of the Hawaiian Yellowfin Tuna Fishery

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Introduction

The yield per recruit (YPR) concept originates in work conducted in the 1950s as described by Beverton and Hold (1957). It is a relatively simple approach requiring estimates of fishing mortality (F), natural mortality (M), rate of growth in weight. YPR seems to have fallen into disuse because modern stock assessment methods provide more useful information for fisheries managers. Furthermore most presentations of YPR center around development of formulas for calculating YPR based on assumptions of constant F and M over the life of the exploited fish. Estimates of age-dependent F and M are often available from stock assessments or tagging experiments. These

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estimates can be easily applied to computing YPR with fewer assumptions. Sparre and Venema (1998) suggest on approach.

Estimates of F and M at age for Hawaiian yellowfin tuna are avaialble from two sources: the Hawaii Tuna Tagging Programme (HTTP) and the 2014 Western and Central Pacific Fisheries Commission (WCPFC) stock assessment.

WCPFC

The Main Hawaiian Islands (MHI) are split between two regions 2 and 4 in the MULTIFAN-CL (MFCL) analysis; Figure 1. The boundary between these two regions passes through the MHI. Region 4 extends from 10°S latitude to 20°N latitude and comprises the large-scale equatorial purse seine and longline fisheries and a portion of the small boat fishery in the MHI. Region 2 extends from 20°N latitude to 50°N latitude and comprises the Hawaii longline fishery and most of the small boat fisheries in the MHI. These small boat fisheries catch in aggregate more yellowfin than the longline fishery (Figure **??**), but are not included in the data on which the MFCL assessment is based.

The 2014 MFCL yellowfin assessment includes data from 1952 through 2012. The stock is assumed to consist of 28 quarterly age classes. The model output routinely includes estimate of natural mortality by age class, mean weight at age, and fishing mortality by year, age and region. For the purpose of YPR analysis, I average the natural mortality at age for each region from

2009 through 2014 (the last 5 years or 20 quarters).

The YPR analysis for regions 4 and 2 are presented in Figures 2 and 3 repectively. Each of this figures contains three panels. The top panel is the estimated fishing mortality at age plotted against mean weight at age. The red marks on the abscissa are placed at the current lower catch weight limit and at three other weight limits sometimes discussed; that is at 3, 10, 15, and 20 pounds.

The second panel show the change yield per recruit due to multiplying the fishing mortality at all ages by constant factor ranging from 0 to 10, that is from essential closing all fisheries to expanding all fisheries by a factor of 10. The dashed vertical red line is drawn at 1, the current fishing mortality.

The bottom panel shows the change in yield per recruit of increasing the minimum size limit in the fishery from 0kg to 70kg. The dashed vertical red line is drawn at the weight producing the highest yield per recruit.

In region 4, the purse seine and longline fisheries impose distinct fishing mortality patterns on the yellowfin stock resulting in two peaks in mortality, one near 5kg and another near 30kg. It would appear that increasing or decreasing the overall fishing mortality would cause a decrease in yield per recruit for all fisheries. *Or this may be an artifact of the math.* Increasing the size at first capture to around 10 kg appear to by about 25% to all fisheries.

In region 2, the situation is quite different. Since the catches from the small-boat fishery were excluded from the assessment, the fishing mortality is imposed by the longline fishery alone. There are not distinct peak. Increasing or decreasing the total fishing morality simply increases or decreases the yield. Similarly, increasing the weight at first capture merely decreases the yield.

HTTP

Working on it.

Discussion and Conclusions

Working on it.

Math Stuff

Working on it.

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References

Adam, M. S., J. Sibert, D. Itano and K. Holland. 2003. Dynamics of bigeye (Thunnus obesus) and yellowfin tuna (T. albacares) in Hawaii's pelagic fishery: analysis of tagging data with a bulk transfer model incorporating size specific attrition. Fishery Bulletin 101(2): 215-228.

Beverton, R. J. H. and S. J. Holt. 1957. On the Dynamics of Exploited Fish Populations. Fishery Investigations Series II Volume XIX, Ministry of Agriculture, Fisheries and Food. London: Her Majesty's Stationary Office.

Davies, N., S. Harley, J. Hampton, S. McKechnie. 2014. Stock assessment of yellowfin tuna in the western and central pacific ocean. WCPFC-SC10-2014/SA-WP-04.

Itano, D., K. Holland. 2000. Movement and vulnerability of bigeye (Thunnus obesus) and yellowfin tuna (Thunnus albacares) in relation to FADs and natural aggregation points.Aquat. Living Resour. 13: 213-223.

Kleiber, P., J. Hampton, N. Davies, S. Hoyle, D. Fournier. 2014. MULTIFAN-CL Users Guide

Quinn, T. and R. Deriso. 1999. Quantitative fish dynamics. Oxford University Press, New York.

Sparre, P. and S. Venema.1998. Introduction to tropical fish stock assessment.

Part 1: Manual. Food and Agricultural Organization of the United Nations. Fisheries Technical Paper 306/1.

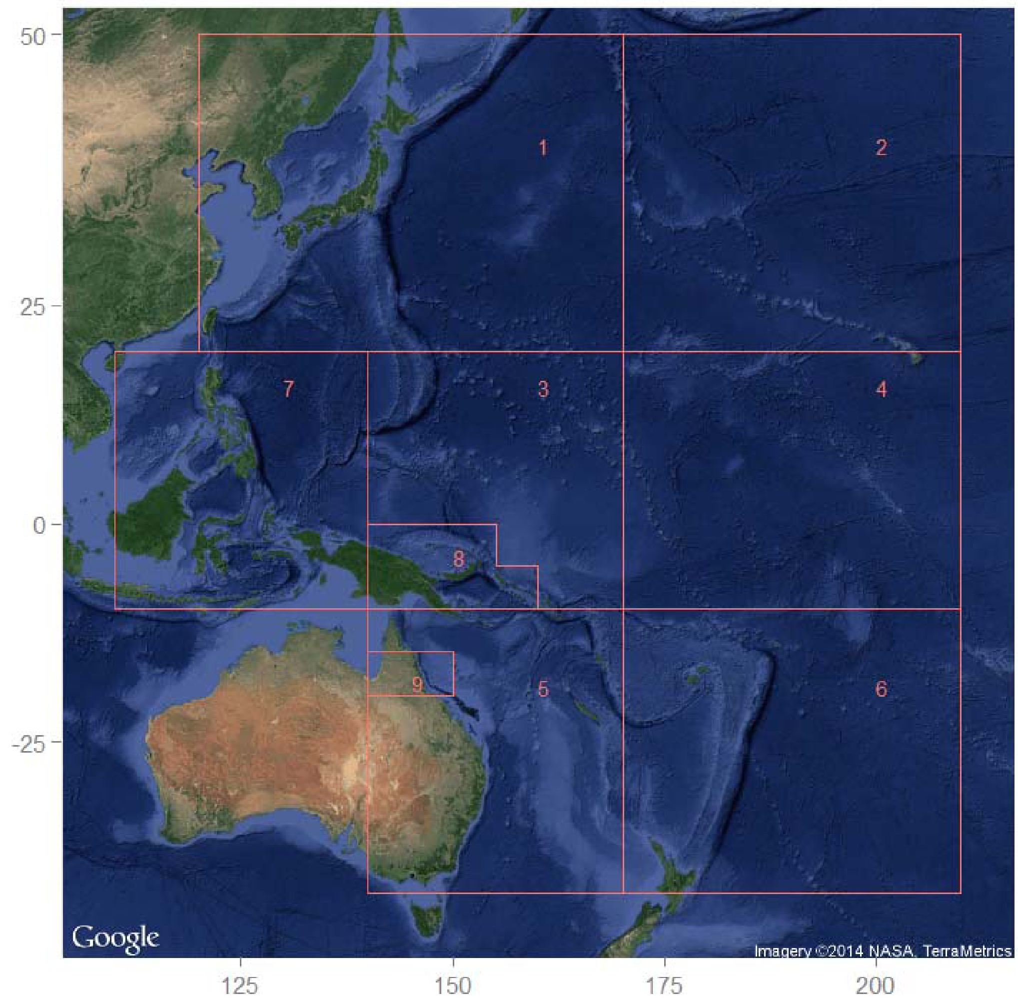

Figure 1: Regions used in the 2014 MFCL stock assessment; from Davies et al, 2014.

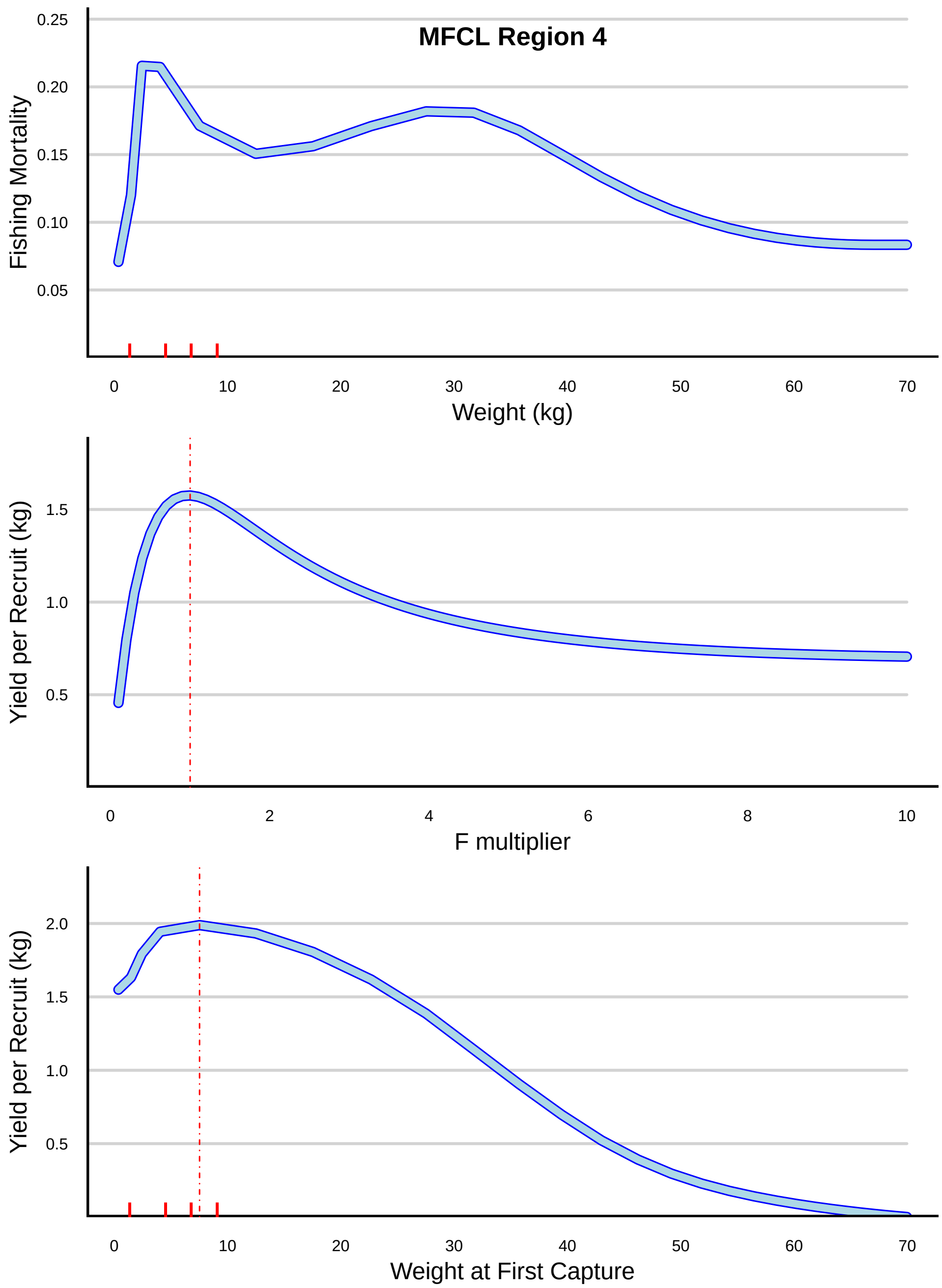

Figure 2: Fishing mortality and yield per recruit for MFCL region 4. See text page for explanation of panels.

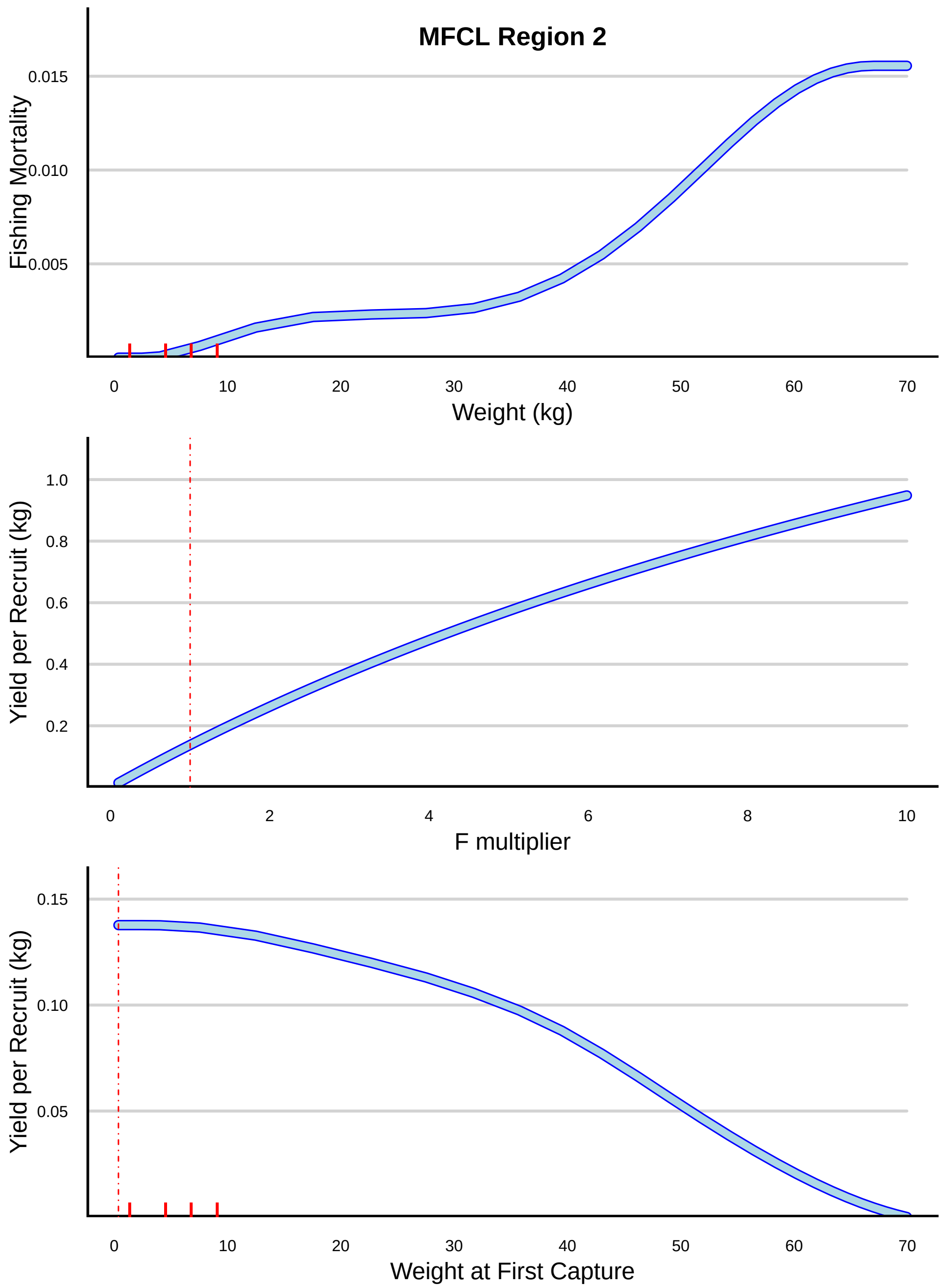

Figure 3: Fishing mortality and yield per recruit for MFCL region 2. See text page for explanation of panels.