SCIENTIFIC COMMITTEE
FOURTH REGULAR SESSION

11-22 August 2008
Port Moresby, Papua New Guinea

ESTIMATION OF STRIPED MARLIN BIOMASS ABOVE 20°N IN THE CENTRAL AND WESTERN NORTH PACIFIC OCEAN

WCPFC-SC4-2008/GN-IP-9

ISC Billfish Working Group[1]

[1] International Scientific Committee for Tuna and Tuna-like Species in the North Pacific

ISC/08/BILLWG-2/01(Revised)

Estimation of Striped Marlin Biomass above 20°N in the Central and Western North Pacific Ocean

ISC Billfish Working Group

June 2008

Working document Billfish Working Group Workshop, 11-19 June 2008, Abashiri City, Hokkaido, Japan. Documents not be sited without permission of the authors.

Estimation of striped marlin biomass above 20^{o}N in the Central and Western North Pacific Ocean[1]

ISC Billfish WG

Abstract.
Results of the 2007 stock assessment of striped marlin from an assumed single stock in the North Pacific Ocean were used to estimate the percentage of age 1^+ biomass north of 20^{o}N latitude in the western and central regions. Assessment estimates of population number-at-age and selectivity patterns and CPUE catchability coefficients from the Japanese distant water longline fleet were used in the analysis. The Japanese distant water fleet was used because it was the most consistent data source that was spatially disaggregated and comparable by region. Results indicate that a majority (65-70%) of striped marlin in the western and central North Pacific Ocean occur north of 20^{o}N latitude. This conclusion is consistent with the distribution of fishery catches.

Introduction:

An assessment of striped marlin was completed by the International Scientific Committee (ISC) Billfish Working Group (WG) for the north Pacific (NPO) stock in 2007 (Annex 8). The assessment was completed using an age-structure assessment model without explicit regional dynamics. However regional effects were incorporated by defining fisheries (estimating selectivity patterns) and CPUE series (index of abundance) by gear and region (Figure 1). Spatial structure included a north-south break at 20^{o}N in the in the central and western Pacific (Figure 1). Two equally plausible assessment model scenarios were forwarded as representations of the range of possible stock dynamics. The scenarios differed only in that model 1 assumed a stock-recruitment (SR) steepness h=0.7 and model 2 assumed no SR relationship but instead a long term mean recruitment level (h=1.0). For a complete description of the stock assessment models and assessment process see Annex 8 and Piner (2007[a]: 2007[b]).

The most consistent data source across areas and time was the Japanese Distant Water Longline (JPDWLL) fleets. For this fleet, both size composition and CPUE data were available for all regions and over most years. Region-specific CPUE and proportional catch-at-length time series were constructed and used as separate likelihood series in the assessment model. Thus regional effects (dynamics) were captured as different regional index catchabilities (q) and selectivity patterns. The assessment model has two time blocks (initial year-1979 and 1980-terminal year) for both CPUE q and selectivity patterns for their respective fisheries. Thus both q and the selectivity-at-age changed in 1980. The analysis of CPUE and proportion-at-length data within each region were compiled using the same data and methods and were potentially additive to derive a single NPO series. If each region had the same selectivity pattern (captured the same size distribution) for the JPDWLL fleet, the ratios of CPUE would be a good proxy for the abundance by region. However the selectivity patterns were somewhat different and thus to determine the distribution of biomass by region requires accounting for these processes.

The objective of this paper is to characterize the distribution of biomass of striped marlin in the central and western Pacific Ocean relative to the 20^{o}N management line for regional areas 1-4. We do this using the estimated q's and selectivity patterns from the Japanese distant water longline fleet to estimate the proportion of biomass above the management line.

Methods:

We defined the Northern (above 20^{o}N) area to be regions 1 and 3 and the Southern area to be regions 2 and 4 (Figure 1). These were the same region specifications as used in the 2007 stock assessment. Region 5 was not used in the calculations except in the estimation of dynamics inside the stock assessment model. To estimate the fraction of the stock in the north, we used the estimates of JPNDWLL CPUE catchability (q) and the associated selectivity patterns. The estimates of q in the assessment model were treated as free parameters without priors, therefore the estimates of q can be thought of as a measure of the local density of the fully selected age/size classes in a particular area and for a specific gear. The associated selectivity pattern is an estimate of the relative availability of all age/size classes in that area and to that gear. The product of q and selectivity by age-class is the actual or effective catchability (q') of that age-class. Because the q are derived from a CPUE (not swept area biomass) the q themselves are not easily interpretable. However, the ratio of q' in the north to the south reflects the age/size-class specific proportion of fish found in each area. Therefore we can use this to describe the relative abundance of each age class above and below 20^{o}N as seen by the longline fleet.

To calculate the same ratio for biomass available to the JPNDWLL fleets in a specific year, we multiplied the age specific q' x population numbers-at-age (for a given year) x weight-at-age. Summing across the age-classes we wish to compare, we can add up the northern areas and southern areas separately and weight these by the region specific fraction of the total area (Table 1). The ratio of the north to south gives us the proportional difference in the biomass in the northern areas relative to the south. For a full description of the methods see Appendix 1.

Results and Discussion:

Our analysis indicates that the majority of the striped marlin biomass in the western and central NPO is found above 20^{o}N (Figure 2). Results do not differ significantly between assessment model scenarios (based upon the SR hypothesis). We estimate that q' is larger

for all age-classes in the north relative to the south due to the generally larger q estimates in those regions (initial CPUE was larger). We also note the northern ratio of q' increases with age-classes indicating that as fish age they are increasingly found northward of 20^{o}N. Because the age-specific q' are larger in the north for all age-classes, there are no possible population age distributions that would have a majority of the population in the southern areas. However, as the relative abundance of older age-classes declines, the proportion of biomass in the north will also decline somewhat (Figure 2).
We estimated the northern proportion of age1+ biomass for years 1964 -2004 (Figure 2 and Table 2) as these were the years with fully estimated population dynamics. Prior to 1964 dynamics in the model were controlled by an assumed SR function. The 1960's are more representative of the stock prior to the onset of major exploitation and thus reflect a more "virgin-like" condition. Further, the spatial extent of the JPNDWLL was broadest in the 1960's and this was before any potential fishing practice changes in the JPNDWLL fleets (e.g. deep setting for bigeye tuna). Therefore, the 1960's may be the most appropriate to represent a hypothetical distribution of striped marlin without significant fishing, or alterations in fishing practices.

We note that the area weightings used in this analysis include the East China Sea (ECS) as part of the southern area (Figure 1). The WG had postulated that the abundance of striped marlin in that area is lower than in the rest of region 2 and because of this it was not used to calculate CPUE for region 2. Thus the area weightings should be considered conservative with respect to the question of abundance distribution above 20^{o}N (gives more weight to the south than may be likely). Despite this conservative stance to the weightings, the majority of biomass is estimated to reside above 20^{o}N latitude.

One quick check of the validity of these results is to compare to the total catch of striped marlin by region with our estimates of biomass (Table 2). The results presented in this paper are consistent with the region catch statistics as roughly 60-90% of the total catch (by decade) was removed from above the 20^{o}N line which compares to the 60-70% of age1+ biomass we estimated in those areas. Comparisons to catch are a simple and robust check of our results as it is logical to assume that abundance is probably greater in the areas with the majority of the catch was taken. This is even more likely if the species is not generally targeted. We note that the catch proportions is in numbers and our estimation of abundance proportions was in weight, therefore a direct 1:1 comparison is problematic.

As an integral part of the stock assessment process, all of the JPNDWLL indices of abundance (used herein) were standardized using GLM methods to account for fishing power factors such as season, depth, sub-area within region, and a variety of interactions. This analysis assumes that after standardization, a single unit of effort (1000 hooks) is roughly equal across all regions and that only local area-specific, age-specific density affects the catch rates. However, if major targeting of striped marlin occurred in any region (beyond that which can be accounted for via GLM), it would call into question this assumption. The general consensus of the ISC Billfish WG is that striped marlin has not been targeted to any great extent by longline fishermen in the Central and Western North Pacific, occurring primarily as bycatch associated with the tuna-directed fisheries. Given this assumption, the JPNDWLL fleet is the best source of information to find regional density estimates.

Literature Cited

Annex 8. Report of the Marlin and Swordfish working group joint report. March, 2007.

[a]Piner,K**.** Conser.R., DiNardo, G. and J. Brodziak. 2007. Evaluation of Model Performance from the 2007 ISC Striped Marlin Stock Assessment Meeting . Busan, Korea. ISC/07/SM-WG/04

[b]Piner,K. Conser.R., DiNardo, G. and J. Brodziak. 2007. Evaluation of Model Performance from the 2007 ISC Striped Marlin Stock Assessment Meeting . Busan, Korea. ISC/07/SM-WG/04

Table 1. The proportion of the combined area (Regions 1-4) within each of our geographic regions (Figure 1) and used in the analysis as area weights. Region 5 has been excluded.

Region 1	Region 2	Region 3	Region 4
0.21	0.32	0.22	0.25

Table 2. Estimates of the area-weighted (excluding Region 5) decadal average proportion of striped marlin in the central and western Pacific above 20^{o}N. Results are presented for both assessment model scenarios. This is the sum over the specified age range of age-specific q' * population numbers-at-age*weight at age. Some decades are not given (N/A) or are not complete because full dynamics are not estimated for all years in those periods. The average proportion of the total catch in numbers (Regions 1-4) coming from north of 20^{o}N (areas 1 and 3) by decade are given in the fourth column.

Decade	Model 1 (h=0.7)	Model 2 (h=1.0)	Catch
1952-1959	N/A	N/A	0.96
1964-1969	0.71	0.66	0.82
1970-1979	0.73	0.71	0.66
1980-1989	0.65	0.65	0.67
1990-1999	0.64	0.64	0.77
2000-2004	0.64	0.64	0.73

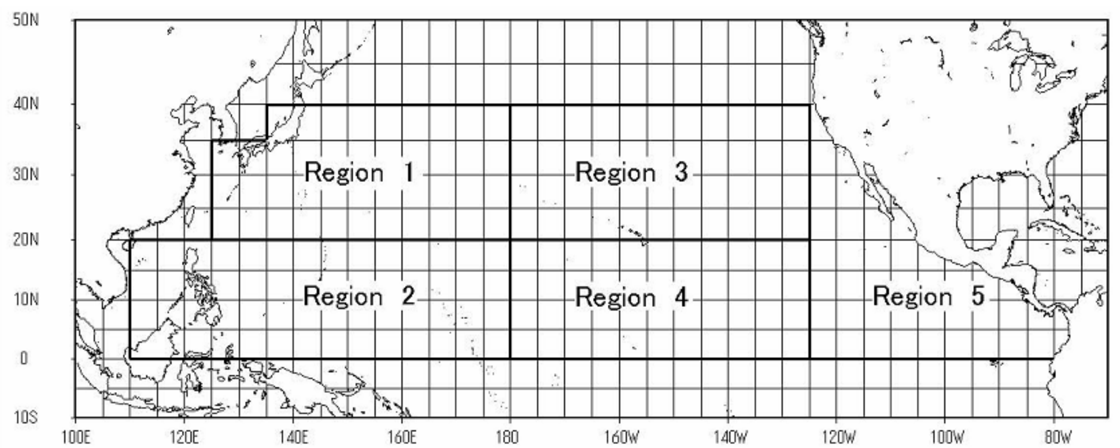

Figure 1. Map of the stock assessment areas. Region 1 and 3 correspond to the northern areas (above 20^oN) and regions 2 and 4 are the southern areas. In all calculations area 5 (EPO) has been excluded. Each regional proportion of the total (regions 1-4) is given in Table 1.

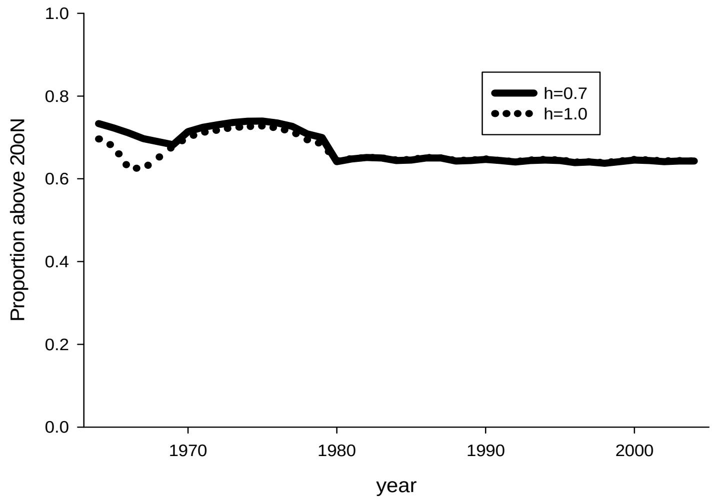

Figure 2. Yearly estimates of the proportion of striped marlin from the Western and Central North Pacific Ocean found above 20^{o}N. Estimates are given for both model scenarios (h=0.7 and no SR assumption).

Appendix 1. Equations for regional biomass estimates.

Define terms as follows:

a	age in years (a=1,2,…,15^{+})
y	year (y=1964….2004)
r	region of the WCPO (r=1,2,3,4) as defined in the striped marlin assessment
JLL	Japanese distant-water longline fishery
C_{ayr}	predicted JLL catch in number of age a fish during year y in region r (from SS2 output)
N_{ay}	mean number of age a fish during year y in the total population. Approximated by the SS2 estimate of the number of age a fish in the population on July 1st (i.e. beginning of Quarter 3).
W_{ar}	weight-at-age of fish in region r on July 1st (kg)
q_r	catchability of JLL in region r (from SS2 output), i.e. the proportion of N_y caught in region r within the area covered by 1000 longline hooks (unitless)
A_q	area covered by 1000 JLL longline hooks (km^2), i.e. the area associated with q_r.
A_r	area of the entire region r (km^2).
η_{yr}	number of fish "vulnerable" to the JLL fishery in region r during year y (from SS2 output)

Then the JLL fishing mortality rate (yr^{-1}) on age a fish during year y in region r is:

$$F_{ayr} = C_{ayr} / N_{ay} \tag{1}$$

Define the average "fully-recruited" JLL F in region r as:

$$F_{yr} = Max_a \left\{ F_{ayr} \right\} \tag{2}$$

The age-specific JLL selectivity in region r is:

$$S'_{ar} = F_{ayr} / F_{yr} \tag{3}$$

Note that S'_{ar} is an age-based selectivity and from Equation (3), at least one age must be fully-selected. However, the striped marlin stock assessment was carried out (in SS2) assuming length-based selectivity. When the underlying selectivity is length-based, it is possible that age-based selectivity may be less than one for all ages, e.g. if only part of the length range associated with an age is fully selected. Define the appropriate age-based JLL selectivity by region as:

$$S_{ar} = \omega_r S'_{ar} \tag{4}$$

where ω_r corrects the nominal age-based selectivity (S'_{ar}) to be consistent with true age-based selectivity when the underlying selection model is length-based. The correction factor is:

$$\omega_r = \frac{\eta_{yr}}{\sum_a S'_{ar} N_{ay}} \tag{5}$$

Then the mean number of age a fish during year y in region r is:

$$N_{ayr} = \frac{A_r q_r S_{ar} N_{ay}}{A_q} \tag{6}$$

The total biomass on July 1st of year y in region r is:

$$B_{yr} = \sum_{a=1}^{15} W_{ar} N_{ayr} \tag{7}$$

The spawning stock biomass on July 1st of year y in region r is:

$$SSB_{yr} = \sum_{a=5}^{15} W_{ar} N_{ayr} \tag{8}$$

The area covered by 1000 JLL longline hooks (A_q) is conceptually straightforward, i.e. the product of (i) the distance along the great circle arc covered by the part of the main line supporting 1000 hooks and (ii) the width of the band (orthogonal to the main line) from which fish will be attracted to the baited hooks. In practice, however, these components may be difficult to quantify – especially (ii).

But as long as A_q is constant over regions, a relative measure of N_{ayr} is:

$$N'_{ayr} = A_q N_{ayr} = A_r q_r S_{ar} N_{ay} \tag{9}$$

Analogously, relative measures of total biomass and SSB are:

$$B'_{yr} = \sum_{a=1}^{15} W_{ar} N'_{ayr} \tag{10}$$

$$SSB'_{yr} = \sum_{a=5}^{15} W_{ar} N'_{ayr} \tag{11}$$

Then the proportion of total biomass north of 20° N latitude is:

$$_N B'_y = \frac{B'_{y1} + B'_{y3}}{\sum_{r=1}^{4} B'_{yr}} \quad (12)$$

and similarly, the proportion of SSB north of 20° N latitude is:

$$_N SSB'_y = \frac{SSB'_{y1} + SSB'_{y3}}{\sum_{r=1}^{4} SSB'_{yr}} \quad (13)$$