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Assessing billfish stocks: A review of current methods and some future directions

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ABSTRACT

Billfishes, excluding swordfish, are typically not the primary targets of large-scale fisheries, which has historically led to a lack of targeted monitoring efforts. The lack of data on age-composition, missing catch data and species identification problems for some species, lack of fishery-independent index data, as well as environmental influences on population dynamics is compounded by the international nature of how fisheries for billfishes are assessed and managed. This paper overviews the most recent assessments conducted for 20 stocks of billfishes in the Indian, Atlantic and Pacific Oceans, and how management advice is provided for these stocks. Assessments for billfishes are conducted using a wide range of techniques, ranging from catch-only methods which infer stock status based primarily on the prior distributions assumed for the parameters of a population dynamics model, to statistical catch-at-age analyses that integrate a wide range of data types. Key recommendations arising from this review include that age-structured stock assessments should be based on models that allow sex-structure to be represented, a full accounting for uncertainty requires adequately representing uncertainty regarding growth rates, natural mortality, the form and parameters of the stock–recruitment relationship, and how data are weighted, and that if biomass dynamics models are to be applied, they should be based on Bayesian state-space formulations rather than observation or process error estimators because such formulations are better able to represent uncertainty.

1. Introduction

Billfishes, which for the purposes of this paper, include marlins, spearfish, sailfish, and swordfish, are caught in all of the world's oceans, except the Arctic and Southern (Fig. 1). The fisheries which take these species are multinational, leading to the need for international management. Four Regional Fisheries Management Organizations, RFMOs (the International Commission for the Conservation of Atlantic Tunas, ICCAT, the Indian Ocean Tuna Commission, IOTC, the Inter-American Tropical Tuna Commission, IATTC; and the Western and Central Pacific Fisheries Commission, WCPFC) and the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) take the lead in terms of coordinating research and assessments for these species, as well as providing management advice. Assessment and management of billfishes is arguably more challenging than is the case for many fisheries of similar size (see Fig. 2 for the time-trajectories of catch since 1950) because (a) the fisheries are complex, multi-gear and multi-national, (b) the assessments tend to be based on a working group process rather than the more conventional single assessment group approach, and (c) apart from swordfish, these species are typically not the targets for large-scale fisheries, which means that they are seldom the primary focus for data collection efforts.

However, there is a still a need to conduct assessments for the stocks of these species, which are then used to provide estimates of their status relative to management reference points. Management reference points have not been formally selected by the relevant RFMOs for billfish stocks, but there is nevertheless is a remarkable degree of consistency regarding how the results of assessments of billfishes (and tunas) are reported to management agencies, with most assessments reporting estimates of time-trajectories of F/F_{MSY} and B/B_{MSY} (respectively, fishing mortality relative to the fishing mortality corresponding to MSY (maximum sustainable yield) and

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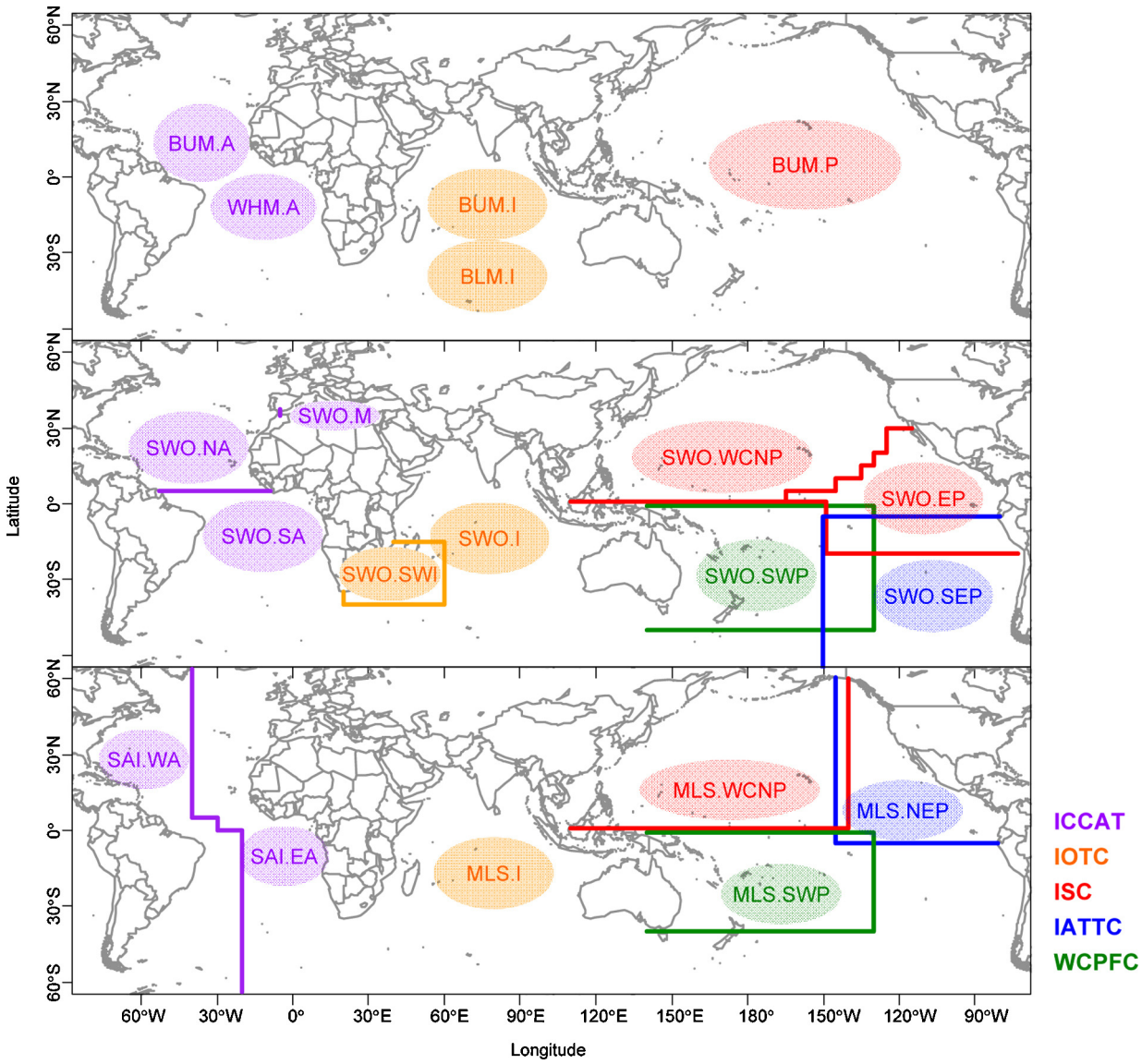

Fig. 1. Management stocks for the billfish species considered in this paper (see Table 1 for the acronyms for the various species and management areas).

the biomass (or spawning stock biomass, S/S_{MSY}) relative to that corresponding to MSY) in the form of a 'Kobe plot' (Fig. 3; ISC, 2013). Thus, F/F_{MSY} and B/B_{MSY} are the 'default' management reference points for billfish stocks. Assessments tend to quantify uncertainty, particularly in relation to the status of the stock in recent years relative to reference points. The assessments are also often used to form the basis for projections under different assumptions regarding future management actions.

Notwithstanding the general standardization of assessment outputs for management purposes, stocks of billfish differ markedly in terms of the types of data available for assessment purposes, and the methods used to conduct assessments and quantify uncertainty. This paper provides a global overview of the types of data available for conducting assessments of billfishes, how those data are used to provide estimates of current biomass, and biomass relative to management reference points, and how uncertainty is quantified.

Fig. 4 summarizes the stocks considered in this paper (see Table 1) in terms of current F/F_{MSY} versus current B/B_{MSY} (note that 'current' differs among stocks even for the same species), or versus S/S_{MSY} depending on how assessment outputs are presented. Although the world status of billfish stocks is not the primary focus of this paper, it is clear that stocks range from under-exploited relative to the expectations of a MSY-based harvest strategy (e.g. swordfish in the southeast Pacific) to subject to both overfishing ($F > F_{MSY}$) and being in an depleted state ($B < B_{MSY}$) (e.g. sailfish and blue marlin in the Atlantic).

Tables 2 and 3 summarize various aspects of the 20 assessments on which this review is based[1]. Assessments are not available for some stocks of sailfish and black marlin, nor for any of the spearfish stocks. Table 2 lists the specifications for the assessments on which management advice was based while Table 3 summarizes how uncertainty was quantified and provides additional information for some of the stocks.

The review is based on recent assessments of billfish stocks, even though most stocks have been assessed using several methods over the years. The focus of the paper is on identifying data gaps and limitations, as well as determining the state of the art in

[1] These tables also include results from Eastern Pacific Ocean sailfish, but the authors of the assessment did not consider the results to be useful for management purposes because "the results do not provide reliable information on stock productivity and the biomass level corresponding to MSY".