Using *in situ* Length Data to Determine Stock Status of Protected Aggregating Fish Species: A Case Study of Nassau grouper (*Epinephelus striatus*)

Utilizando Datos de Longitud *in situ* para Determinar el Estado del Stock de Especies de Peces Agregar Protegidos: Un Caso de Estudio del Mero de Nassau (*Epinephelus striatus*)

En Utilisant des Données de Longueur *in situ* Afin de Déterminer L'état des Stocks des Espèces de Poissons Agrégeants Protégées: Une Étude de Cas du Mérou de Nassau (*Epinephelus striatus*)

BRIAN C. STOCK*[1], LYNN WATERHOUSE[1], SCOTT HEPPELL[2], CHRISTY V. PATTENGILL-SEMMENS[3], BRICE X. SEMMENS[1], PHILLIPPE G. BUSH[4], CROY M. MCCOY[4], and BRADLEY C. JOHNSON[4]

[1]*Scripps Institution of Oceanography, University of California San Diego, 9500 Gilman Drive, La Jolla, California 92093-0202 USA. *b1stock@ucsd.edu.*

[2]*Oregon State University, Department of Fisheries and Wildlife, 104, Nash Hall, Corvallis, Oregon 97331 USA.*

[3]*Reef Environmental Education Foundation (REEF), PO Box 246, Key Largo, Florida 33037 USA.*

[4]*Department of Environment, Cayman Islands Government P.O. Box 486,GT Grand Cayman, Cayman Islands.*

KEY WORDS: stock assessment, data-limited, spawning aggregation

EXTENDED ABSTRACT

Managing data-limited fisheries can be challenging, particularly for species that form easily exploited spawning aggregations. Here we use *in situ* diver-generated length observations from a Nassau grouper (*Epinephelus striatus*) aggregation in the Cayman Islands to empirically test a new data-poor stock assessment method, the *length-based spawning potential ratio* (LB-SPR) model (Hordyk et al. 2014). Fish species that form spawning aggregations have several characteristics that, in theory, make them amenable to the LB-SPR assessment method:

i) The entire spawning stock is present,
ii) Selectivity is known (age/size at maturity), and
iii) Many non-lethal length observations can be efficiently gathered (hundreds over a few dives in one week).

The objective of our study was to evaluate the ability of the LB-SPR method to assess aggregating fish species, and identify shortcomings that could lead to model improvements. We demonstrate that the LB-SPR method can generate spurious results when applied to data from a non-equilibrium (rebuilding) population. We conclude that the LB-SPR method holds promise as an assessment technique when length-compositions are available, but caution that care must be exercised in applications when the population of interest is undergoing increasing pressure from harvest or ongoing recovery from conservation action.

The Cayman Islands, a UK Overseas Territory in the Caribbean Sea, historically hosted five known Nassau grouper spawning aggregation sites. Four of these sites were considered fished out by about the year 2000, but in 2001 local fishermen ''rediscovered'' an aggregation on Little Cayman that anecdotally had not been fished since the early 1970s. At the time of its rediscovery the aggregation was estimated to attract 7,000 - 8,000 fish (Whaylen et al. 2006). In 2003, after two years of intense fishing by local fisherman, the aggregation declined to approximately 2,000 - 2,500 fish and the Cayman Islands Marine Conservation Board banned fishing on all designated aggregation sites. Over the period 2004 - 2010, Heppell et al. (2012) collected *in situ* diver-generated length observations and documented that the mean length of fish at the aggregation decreased, while the range of lengths increased. Additionally, abundance estimates from mark-recapture work shows that the spawning population has increased from roughly 1,500 individuals in 2008, to 4,000 individuals by 2014 (Waterhouse et al. in prep).

Applying the LB-SPR assessment model to the 2004-2010 data pooled across years yielded both a good fit to the data (Figure 1a) and a reasonable SPR estimate of 0.67 (0.62, 0.73). However, fitting the model to each year individually resulted in a declining trend in SPR (Figure 1b).

The current LB-SPR model does not accurately capture the recovering status of the Little Cayman Nassau grouper aggregation. This is not surprising because the model assumes the population is at equilibrium, which is clearly not the case in Little Cayman. Additionally, the LB-SPR model assumes that the length data constitute removals from the fishery, while in this case the sampling method is non-lethal and fish we measure are not removed from the population. Furthermore, fitting the LB-SPR model to each year individually does not allow the model to make SPR estimates dependent in time. Incorporating length distribution time-series and relaxing the equilibrium assumption are two active areas of future work that should improve the applicability of the LB-SPR method to the management of aggregating species.

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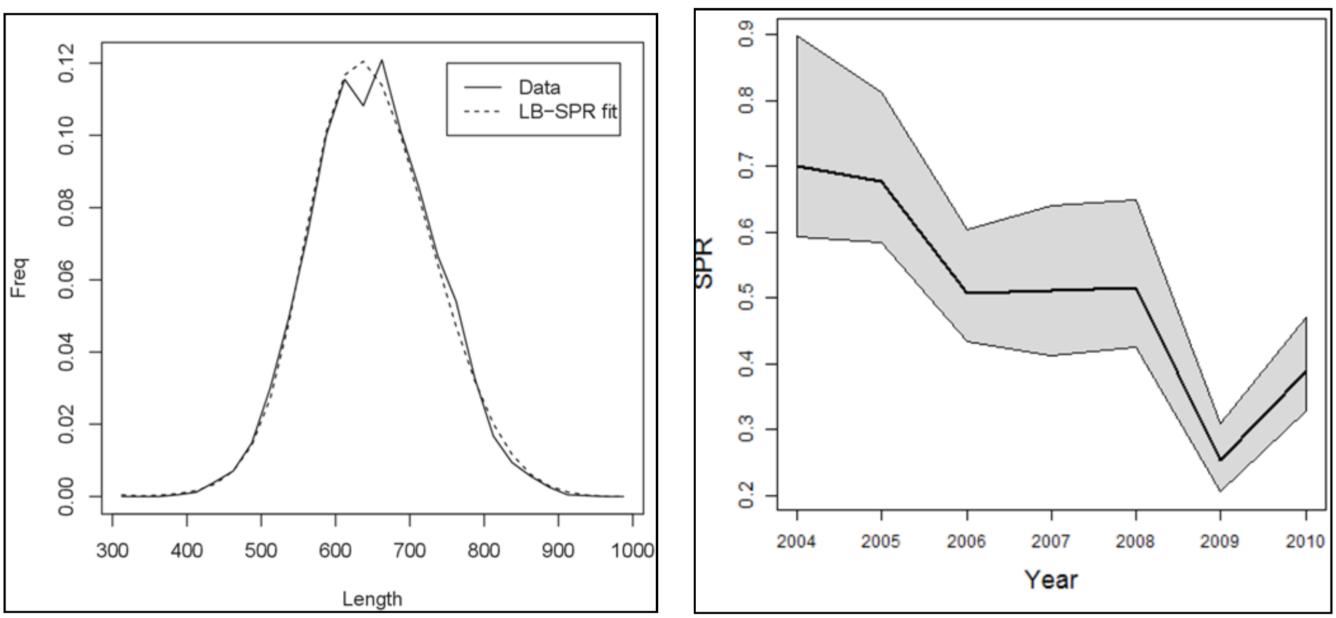

Figure 1. LB-SPR model output when fit to data a) pooled across years 2004-2010, and b) from each year individually. The LB-SPR model fit the pooled data well (a) and estimated a SPR = 0.67 (0.62, 0.73), which is reasonable given the population's recent history of exploitation. When fit to length distribution data from each year individually (b), the model estimated a declining trend in SPR (median = bold line, shading = 95% CI), in disagreement with evidence that the population is increasing.