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HABITAT MODELING OF ATLANTIC BLUE MARLIN WITH SEAPODYM AND SATELLITE TAGS

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SUMMARY

The use of habitat modeling is becoming a common approach for standardization of CPUE allowing one to incorporate environmental influences on the distribution of fishes (ICCAT 2004). We propose to model the habitat of Atlantic blue marlin using an approach developed for a Spatial Ecosystem and Populations Dynamics Model (SEAPODYM). The model will be calibrated and evaluated using fishing data and electronic tagging data. While the results will be useful for CPUE standardization, they will also provide the first step toward a full application of SEAPODYM to investigate spatial population dynamics of blue marlin and to develop stock assessment studies.

RÉSUMÉ

L'utilisation de la modélisation de l'habitat devient une approche commune à la standardisation de la CPUE, permettant d'incorporer les influences environnementales dans la distribution des poissons (ICCAT 2004). Nous proposons de modéliser l'habitat du makaire bleu de l'Atlantique en utilisant une approche développée pour un modèle d'écosystème spatial et de dynamique des populations (SEAPODYM). Le modèle sera calibré et évalué à l'aide des données de pêche et des données de marquage électronique. Tandis que les résultats seront utiles à la standardisation de la CPUE, ils constitueront aussi le premier pas vers une application intégrale de SEAPODYM afin de réaliser des recherches sur la dynamique spatiale des populations de makaire bleu et de mettre sur pied des études d'évaluation des stocks.

RESUMEN

La utilización de la modelización del hábitat se está convirtiendo en un enfoque común para la estandarización de la CPUE que permite incorporar influencias medioambientales en la distribución de los peces (ICCAT 2004). Proponemos una modelización del hábitat de la aguja azul del Atlántico utilizando un enfoque desarrollado para un modelo dinámico de población y ecosistema espacial (SEAPODYM). El modelo se calibrará y evaluará utilizando datos de pesca y datos de marcado electrónico. Los resultados además de ser útiles para la estandarización de la CPUE, proporcionarán también un primer paso hacia la plena aplicación del SEAPODYM para investigar la dinámica espacial de la población de aguja azul y para desarrollar estudios de evaluación de stock.

KEYWORDS

Habitat, blue marlin, population dynamics

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1. Background

Atlantic tuna and billfishes are managed by the International Commission for the Conservation of Atlantic Tuna (ICCAT). Stock assessments are carried out with standard approaches in fish population dynamics, i.e., VPA, stock-production models, or more recently, fully integrated models such as Multifan-CL or Stock Synthesis (SS) (Methot 2009). The choice of model and level of detail in the structure is generally dictated by the quality and quantity of data available on a particular species. Despite the fact that tuna and billfishes are well known to be distributed in time and space based on oceanographic conditions, none of the above mentioned modeling platforms (and consequently the resulting assessments) explicitly takes into account fish habitats and their variability.

Recently, a new modeling approach has been proposed that describe spatial population dynamics based on environmental relationships and the definition of species habitat (Lehodey et al. 2008). This model that also includes a parameter optimization framework based on likelihood approach (Senina et al., 2008) has been applied to four Pacific tuna species (Lehodey and Senina 2009, WCPFC). The model is driven by environmental variables (temperature, currents, primary production, and dissolved oxygen concentration) between surface and a depth of 1000 m. Predicted feeding and spawning habitats are used to model the movement of fish based on a system of advection-diffusion equations.

The last two decades have seen the increasing use of electronic tags to investigate the behavior and movements of many large marine species, including tuna and billfishes (Prince and Goodyear 2006; Prince et al. 2010). While much has been learned about the ecology of pelagic fishes through these modern tracking technologies, this knowledge has not been integrated into stock assessment science. In particular, these tagging data provide key information to evaluate and parameterize the 3D species habitats.

2. Approach

We propose a study aimed at identifying the main sources of variability of Atlantic blue marlin habitats and spatial dynamics, through the combined use of a state of the art ecosystem model and movement data from electronic tags. The increased availability of recent data on the ocean scale movements for blue marlin using electronic tags (Prince and Goodyear 2006; Goodyear et al. 2008; and Prince et al., 2010) facilitated our species selection process. SEAPODYM will be the main tool to achieve the goals of this project. This model was developed to simulate the spatial dynamics of tuna populations in the pelagic ecosystem. It uses bio-physical environmental fields to simulate the upper trophic levels of marine ecosystem organized in two groups: the tunas or associated species and their prey species of the mid-trophic levels (i.e. micronekton). Modeling the habitat and vertical structure of micronekton distribution, as well as the age-structured spatial dynamics of tuna (through an advection-diffusion framework) is based on first biological principles, such as thermal habitat, oxygen tolerance, prey and predator interactions. The parameterization of these components defines a movement index with seasonal switching between feeding and spawning habitats, defining in turn the spatial dynamics of the target species. The emphasis of this one-year project will be put on defining the feeding habitat, based on mechanisms developed in the model for other tuna species, in order to recreate the key movement patterns of individuals, as described by archival tags. A review covering biology, ecology, fisheries and population structure of Atlantic blue marlin will be conducted to gather all the necessary information needed to parameterize the model SEAPODYM for a second phase study. Finally, a statistical analysis will help to investigate the link between CPUE and predicted habitat.

One key issue for these modeling studies is to obtain high resolution-3D environmental data covering the entire habitat of the species considered. Unfortunately there is no observation database providing such information. Only ocean reanalyses based on ocean circulation model can provide this type of dataset. Thus, we will use the physical reanalysis GLORYS (GLobal Ocean ReanalYsis and Simulations) that is provided by the French Groupe Mission Mercator Coriolis, at a resolution of ¼ deg x 6 days, and using data assimilation to provide higher realistic prediction. We will use satellite derived primary production at the same resolution to run a simulation with the micronekton model (Lehodey et al., 2010), for the period 2002-2008 (2009?).

3. Benefit

SEAPODYM model will provide an estimate of the spatial distribution of blue marlin habitat. This estimated distribution will be a new piece of information not currently available to ICCAT. This study is also a preparatory phase to investigate in more detail the spatial population dynamics of blue marlin and to develop stock assessments studies with a new generation of model not yet used by ICCAT, and that can be compared to other stock assessment models estimates.

4. Deliverables

This project will deliver i) predicted habitat of Atlantic blue marlin with optimized parameterization based on archival tagging data and fishing data, ii) a review on Atlantic blue marlin to prepare the second-phase study with a complete application of the model SEAPODYM to the population dynamics of Atlantic blue marlin. The results of these simulations will be presented to the ICCAT as part of their regularly scheduled i) BUM assessment meetings, ii) their Ecosystems Subcommittee, and iii) Species Group Meeting / Standing Committee on Research and Statistics.

5. References:

Lehodey, P., Senina, I., Murtugudde, R., 2008, A spatial ecosystem and population dynamics model (SEAPODYM) - Modeling of tuna and tuna-like populations. *Progress in Oceanography* 78 (4), 304-318.

Lehodey, P., Murtugudde, R., Senina, I. 2010, Bridging the gap from ocean models to population dynamics of large marine predators: a model of mid-trophic functional groups. *Progress in Oceanography*, 84: 69-84

Lehodey, P., Senina, I. 2009, An update of recent developments and applications of the SEAPODYM model. Fifth regular session of the Scientific Committee of the Western and Central Pacific Fisheries Commission, 10-21 August 2009, Port Vila, Vanuatu, WCPFC-SC5-2009/EB-WP-10, 44 pp. http://www.wcpfc.int/meetings/2009/5th-regular-session-scientific-committee

Methot, R.D. 2009, Stock assessment: operational models in support of fisheries management. In: The Future of Fishery Science in North America, pp. 137-165. Ed. by R.J. Beamish, and B.J. Rothschild. Fish and Fisheries Series, 31. 736 pp

Prince, E.D. and Goodyear, C.P. 2006, Hypoxia-based habitat compression of tropical pelagic fishes. *Fisheries Oceanography.* 15(6): 451-464.

Prince, E.D., Lou, J., Goodyear, C.P., Hoolihan, J.P., Snodgrass, D., Orbesen, E.S., Serafy, J.E.., Ortiz, M. and Schirripa, M.J. 2010, Ocean scale hypoxia-based habitat compression of Atlantic istiophorid billfishes. *Fisheries Oceanography*. 19(6): 448-462.

Senina, I., Sibert, J., Lehodey, P. 2008, Parameter estimation for basin-scale ecosystem-linked population models of large pelagic predators: application to skipjack tuna. *Progress in Oceanography* 78 (4), 319-335.