MARINE RESEARCH

GLOBAL SPATIAL DYNAMIC PROJECT FOR JUVENILE SBT

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Abstract

This paper outlines a multi-year, large scale project that CSIRO has initiated to improve our understanding of the global spatial dynamics of juvenile southern bluefin tuna (SBT). The project plan is to archival tag 150 to 200 juvenile SBT per year for 3 years throughout the range of habitats in which they are exploited. The project aims to provide improved knowledge of, the basis for and an understanding of the implications of the incorporating spatial dynamics and habitat utilization information directly into the analyses of conventional tag return data, CPUE standardizations using habitat based approaches, the SBT stock assessments, and the management advice. The data collected in this spatial dynamics project will be useful in estimating mixing rates and should help to provide a robust basis for interpreting the conventional tagging results. The project is intended to be complementary to the current conventional tagging program under the CCSBT Scientific Research Program, and to take advantage of this program through recovery programs and deployment opportunities. This project also builds upon previous and concurrently running archival and conventional tagging projects. In this context, the project seeks and intends to collaborate with scientists from all CCSBT members in all of its phases including the deployment, sharing of movement information, development of appropriate spatial models and in the analyses of the results. Initial collaborative arrangements have met with positive responses, and further development of these and others are anticipated.

Introduction

Southern bluefin tuna (SBT) have an extensive spatial distribution covering entire southern ocean from with the exception of eastern Pacific. Given this large range, the spatial dynamics and habitat utilization can have large implications for the stock assessment and management advice. In addition, such information can be of critical importance for the estimation of mortality rates from conventional tag return and for the interpretation of CPUE indices. This paper outlines a multi-year, large scale project that CSIRO has initiated to improve our understanding of the global spatial dynamics of juvenile SBT. It is recognized that past and existing projects provide valuable information on the SBT spatial dynamics. The project is very much intended to be complementary and build upon previous and concurrently running archival and conventional tagging projects. The project intends to provide a comprehensive and integrated analysis and modeling approach building collaboratively on all available data. In this context, the project seeks the collaboration and intends to work with scientists from all CCSBT members in all of its phases, including the deployment, sharing of movement information, development of appropriate spatial models and in the analyses of the results.

Project Objectives

1. Tag 150-200 juvenile SBT per year for 3 years with archival tags throughout the full range of spatial habitats in order to provide a comprehensive understanding of their spatial dynamics;
2. For each tag returned (expected to be ~ 20-30%) estimate daily positions based on the stored light and temperature data and develop a database for the storage and analysis of all relevant location, temperature and depth data;

3. Contribute to the provision of statistically based estimates of mixing rates between the major SBT fishing grounds that can be used in conjunction with conventional tagging data to provide fishery independent estimates of fishing mortality rates for monitoring the SBT fishery;
4. Provide critical information and contribute to developing a framework for incorporating the archival tag and conventional tagging data within the SBT stock assessment model;
5. Integrate the position, temperature and depth data provided by the tags with oceanographic data to develop a seasonal model of residence times and habitat use;
6. Compare the CPUE indices abundance which use this seasonal habitat model as a basis for standardization with current standardized CPUE indices used in the SBT stock assessments;
7. Evaluate implications of the spatial dynamics of juvenile SBT for the management of the SBT resource (e.g. the potential consequences and benefits of either ignoring or using spatially explicit management actions).

Background

Fishery stock assessments have traditionally been based on assumptions of spatial homogeneity and spatial considerations have generally not been incorporated into management measures (e.g. quotas are mostly set at a global level). Nevertheless, spatial structure has long been recognized as a critical factor in a population's overall dynamics and should be accounted for within the stock assessments, management and the underlying inputs into both of these. The failure to incorporate spatial aspects stem largely from a lack of understanding and quantitative data about the underlying spatial dynamics of fish. This in turn largely reflects the absence of effective tools for actually measuring the fundamental elements of spatial dynamics (e.g. movement, migration, and residence time). For large pelagic resources, the problems of collecting data on spatial dynamics has been particularly challenging because of the wide range over which these resources occur and the inherent high cost associated with high seas research.

In the early 1990's, CSIRO Marine Research initiated extensive work into the development of archival tags that could provide quantitative data on how fish utilize their spatial environment (e.g. location, depth distribution, preferred water temperatures). This work, in conjunction with related research developments elsewhere, has resulted in the availability of highly efficient archival tags that can be deployed in tuna and other species. Extensive testing and targeted deployment of these tags has been conducted with juvenile southern bluefin tuna (SBT) within the Great Australian Bight (GAB). The results from this work have provided important insights into the SBT spatial behavior (particularly within the GAB) and have demonstrated the potential power of these tags to provide the data necessary to integrate the spatial dimension into the population ecology and assessment of pelagic resources (Gunn and Block, 2002)..

All current information suggests there is a single genetic SBT stock with only one spawning ground in tropical waters south of Indonesia. The species is distributed widely throughout most of the southern temperate oceans (30 - 50°S) except in the more easterly regions of the South Pacific. Large numbers of juveniles (ages one to five) are found in coastal waters of Australia, especially the GAB, where the majority

of the Australian quota is captured by Australian surface fisheries (currently almost exclusively by purse seining for farming purposes). However, juveniles are also found and captured by longline fisheries on the high seas in areas ranging from east of Tasmania to South Africa. Historically, catches of 3- and 4-year old fish with reasonable catch rates occurred during January, February and March in the South African fishing ground. More recently, there is significant evidence, based on information collected from Taiwan longline vessels, of aggregations of 2-3 year old SBT off southeast Africa during summer months (Gunn and Farley, 2000). In both cases, the occurrence of these juvenile SBT is at the same time as the majority of this age group has been assumed to be in southern Australia (principally in the GAB). The relationship between juveniles captured in these various areas is poorly understood. However, the existence of the large concentrations of juveniles off South Africa during these summer months has major implications for the analyses and interpretation of the results from the CSIRO/NRIFSF Collaborative Recruitment Monitoring Program (RMP) and the CCSBT conventional tagging program.

Analyses of Japanese longline catch rates for SBT have generally focused on generating aggregated indices covering the entire stock. Comparison of these aggregated indices with catch rate trends from the different summer grounds indicates a similar overall long-term trend (both for juveniles age 3-6 and the older components of the population). However, there have been substantive differences between the spatial regions over shorter time periods and particularly since the large reductions in catches beginning in the mid-to-late 1980's. This pattern suggests differential recruitment, exploitation and spatial structuring of the population among the spatially separated feeding grounds, with implications for developing strategies for rebuilding the stock and for setting appropriate catch levels.

It is known that juveniles conventionally tagged in southern Australian waters can move large distances and have been recaptured in all of the major longline fishing grounds. However, if one assumes complete mixing of tagged fish within the population, returns from the South Africa area have been proportionally too small compared to returns from the Tasman Sea and southeast Indian Ocean grounds. The extent to which this represents differential reporting rates or incomplete mixing cannot be determined with existing data. There are also some indications of differential returns from South Africa depending upon whether SBT were tagged in Western Australia or South Australia. Similarly, none of the archival tag returns from fish tagged in the GAB have shown movements to the South Africa fishing area. Most of the archival tags indicate 2 and 3 year old SBT have an annual migration between summer feeding grounds in GAB and winter feeding grounds in either the central and southeast Indian Ocean or the Tasman Sea area. For all the cohorts into which archival tags have been deployed (1990-1999), the majority of fish moved west into the eastern Indian Ocean during winter.

The CCSBT has initiated a large scale Scientific Research Program (SRP) for improving the information required to assess the state of the SBT resource. One of the primary components of the SRP is a conventional tagging project to estimate fishing mortality rates and thereby current stock sizes. This tagging program was seen as the key element in reducing the uncertainty in the stock assessment. The implementation of this program was seen as a matter of urgency and tagging commenced in southern

Australia 2002. The Scientific Committee, in recommending a tagging program, recognized that a key uncertainty in the interpretation and analyses of the data would be modeling the mixing of tag animals within the full population. It recommended that data be collected (including archival tagging data) that would useful in estimating mixing rates and provide a robust basis for interpreting the conventional tagging results.

The CCSBT SRP conventional tagging program is intended to provide direct estimates of juvenile fishing mortality rates and recent recruitment. It is intended to provide a basis for reducing uncertainty in the stock assessments and to allow more reliable, short-term information for evaluating the sustainability of recent catch levels. However, the robustness and uncertainty associated with estimates of fishing mortality rates will depend upon the extent to which non-mixing can be ignored or to the extent that it can be accounted for within the analyses. The information provided by the conventional tagging program on mixing and spatial structuring will be limited by two factors: (1) conventional tagging cannot provide information on the movements of fish among areas where there is no fishing activity, and (2) mixing rates are highly confounded with the estimation of reporting rates. For the longline fisheries, conventional tag reporting rates are likely to be poorly estimated. As such, independent information on SBT movements will be critically important for the interpretation of the results. Because archival tags provide information on the daily position of individual fish, they are highly informative about movement and mixing rates. This contrasts with information from conventional tags, which only provide information on release and recapture location but no information on where the fish has been in the interim. In addition, although the recovery of archival tags is dependent upon a fish being recaptured in a commercial fishery, the tags provide information on mixing and movements in regions not covered by the fleets.

The large amount of “fishery-independent” movement information available through the use of archival tags would complement and greatly improve the information content and interpretation of the conventional tagging data, and vice versa. The effectiveness of this archival tagging project will be greatly enhanced because it will be run at the same time as the large scale CCSBT conventional tagging program. This would ensure that differences among years in factors affecting movements (e.g. water temperatures) are not confounded.

Implementation and Methods

This project aims to build upon and supplement the existing data on SBT to ensure that a spatially comprehensive and temporally comparable data set is available over the entire range where juvenile SBT are commercially harvested. The collection of new data is intended to complement previous and other on-going efforts to provide a data set with sufficient sample sizes and spatial coverage to allow for reliable analysis and modeling. The project seeks the collaboration and intends to work with scientists from all CCSBT members in all of its phases, including the deployment, sharing of position data, development of appropriate spatial models and in the analyses of the results.

There are three major regions where the high-seas long line fisheries catch juvenile SBT. These are below South Africa, the mid-Indian Ocean and in the Tasman Sea. The project will deploy ~120-150 archival tags in each of these major SBT longline fishing grounds in three successive years (beginning in the 2004 longline fishing season

Archival tagging will be done primarily by trained observers aboard commercial longline vessels. The techniques for this procedure have already been developed and the reliability of the method has been shown. As part of the deployment process each archival tag will be tested and calibrated prior to release. The data collected from each archival tag will be downloaded into a central computing system. Daily estimates of the position will be calculated using the existing geo-location methods and software. These position estimates, along with the depth, temperature and light data will be entered into a database for access and analysis. These data will be linked with data from previous SBT archival tags, conventional tagging and on oceanographic conditions (e.g. surface temperatures, mixed layer depths, surface productivity, etc) to provide a comprehensive data set for the analysis component of this project.

A variety of analytical approaches will be employed to complete the objectives of this project. Statistical likelihood estimators for tag recapture data will be used in the analyses and interpretation of mixing rates and mortality rates from integration of the archival and conventional tagging data sets. Statistical and process based models will be developed for characterizing the SBT habitat and the integration of these into CPUE abundance indices.

The first three years of this project will focus on tag deployment into the various spatial regions. The third year will also focus on tag recoveries and initial data processing. The fourth and fifth year will focus on tag recovery, data processing, analyses, model building and preparation of the final report.

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