SCIENTIFIC COMMITTEE
TWELFTH REGULAR SESSION

Bali, Indonesia
3-11 August 2016

Connectivity of tuna and billfish species targeted by the Australian Eastern Tuna and Billfish Fishery with the broader Western Pacific Ocean

WCPFC-SC12-2016/ SA-IP-15
Rev 1 (22 July 2016)

Karen Evans[1], Peter Grewe[1], Dale Kolody[1], Rich Hillary[1], Scott Foster[2], Trent Timmiss[3], Matt Lansdell[1], Peta Hill[1].

[1] CSIRO Oceans and Atmosphere, GPO Box 1538, Hobart Tasmania 7001, Australia
[2] CSIRO Data 61, GPO Box 1538, Hobart Tasmania 7001, Australia
[3] Australian Fisheries Management Authority, Box 7051, Canberra BC, Canberra ACT 2610, Australia

Connectivity of tuna and billfish species targeted by the Australian Eastern Tuna and Billfish Fishery with the broader Western Pacific Ocean.

Karen Evans[1], Peter Grewe[1], Dale Kolody[1], Rich Hillary[1], Scott Foster[2], Trent Timmiss[3], Matt Lansdell[1], Peta Hill[1].

[1]CSIRO Oceans and Atmosphere, GPO Box 1538, Hobart Tasmania 7001, Australia
[2]CSIRO Data 61, GPO Box 1538, Hobart Tasmania 7001, Australia
[3]Australian Fisheries Management Authority, Box 7051, Canberra BC, Canberra ACT 2610, Australia.

Abstract

Australia's Eastern Tuna and Billfish Fishery (ETBF) harvests stocks of tunas and billfish that are shared across a range of fisheries in the adjacent Pacific Ocean and are managed under the Western and Central Pacific Fisheries Commission (WCPFC). Management of these fisheries is complex because of the cross-jurisdictional nature of the stocks and governance through Australia's Harvest Strategy Policy and the WCPFC. Current assessments conducted by the WCPFC assume that these species comprise either single discrete stock units throughout the WCPFC area or across the Southern Hemisphere portion of the region. Genetic methods used in the past have been unable to refute such assumptions, however an investigation into the stock structure of yellowfin tuna using next generation sequencing (NGS) methods supports the presence of previously undescribed structure within populations across the Western and Central Pacific Ocean. Biological information on growth rates and reproduction, movement data derived from tagging studies and spatial and temporal variability in catches of other tuna and billfish species suggest that populations throughout the WCPFC region may also be structured. Consequently, current assumptions of single spawning populations may not be accurate. A three year project funded through the Fisheries Research Development Corporation and the CSIRO commenced in July 2016. The goal of this project is to use NGS technology to improve understanding of the population structure of five species caught in the ETBF (albacore, bigeye and yellowfin tunas, broadbill swordfish and striped marlin) and establish their connectivity with the broader WCPFC region. Results from this project will allow for a re-evaluation of the current paradigm in domestic and regional pelagic fisheries scientific advice and management. The project will provide key information for appropriate governance through the Commonwealth Harvest Strategy Policy domestically and the WCPFC regionally, to ensure any risks to regional stock biomass are minimised and to improve stakeholder concern over stock management.

Introduction

Australia's Eastern Tuna and Billfish Fishery (ETBF) operates in waters off on the east coast of Australia and catches a number of pelagic species including yellowfin, bigeye and albacore tuna, swordfish and striped marlin. Populations of these species are known to extend well beyond the Australian Exclusive Economic Zone (EEZ) and are considered to form part of at least a wider Western Pacific Ocean (WPO) population, although specifics on connectivity between various regions is still a major source of uncertainty. Populations are currently assessed as a single inter-connected stock distributed across the wider western and central Pacific Ocean or South Pacific Ocean and are managed at the international level under the auspices of the Western and Central Pacific Fisheries Commission (WCPFC).

Management of the ETBF is complex because of the cross-jurisdictional nature of the stocks and governance through the Australia's Harvest Strategy Policy and the WCPFC. Current assessments conducted by the WCPFC assume that these species comprise either single discrete stock units throughout the WCPFC area or across the Southern Hemisphere portion of the region and genetic methods used in the past have been unable to refute such assumptions. Biological information on growth rates and reproduction, movement data derived from tagging studies and spatial and temporal variability in catches of these species however, suggest that there is likely to be some structure to stocks throughout the WCPFC region and assumptions of single spawning populations may not be accurate.

More recently, traditional and next generation genomic methods have provided evidence of population structure in yellowfin tuna across the Pacific (e.g. Aguilar et al. 2015; Grewe et al. 2015) and provide some support to the hypothesis that yellowfin tuna fished by Australia's tuna fisheries may be a localised stock within the Coral and Tasman Sea region. If yellowfin tuna or the other principal species occurring in the ETBF do comprise localised stocks, this has obvious implications for the management both within national and regional contexts.

Here, we detail a three year project funded through the Fisheries Research Development Corporation and the CSIRO that commenced in July 2016. The primary aim of this project is an improved understanding of the population structure for five of the species caught in the ETBF (albacore, bigeye and yellowfin tunas, broadbill swordfish and striped marlin). The project also aims to establish the connectivity of the five species within the broader WCPFC region. Results from this project should permit a re-evaluation of the current paradigm in domestic and regional pelagic fisheries scientific advice and management. The project seeks to alleviate stakeholder concern over stock management by providing key information for appropriate governance through the Australia's Harvest Strategy Policy domestically and the WCPFC regionally, to ensure any risks to localised stock biomass are minimised.

Methods

Biological sampling

Sampling protocols developed as part of a previous joint Pacific Community (SPC)-CSIRO project have been incorporated into the regional observer program for the WCPFC and a collaborative arrangement between SPC, the Fisheries Forum Agency (FFA), WCPFC and CSIRO and other laboratories across the Western and Central Pacific Ocean is providing for the collection and archiving of biological samples of tropical tuna, billfish and other species across the western Pacific (Nicol et al., 2015).

A spatial assessment of tissue samples for tropical tunas and billfish species held in the WCPFC Tissue Bank and historical samples held by CSIRO has identified key areas where samples are available for stock structure analyses on the five principal species are distributed. Initial discussions with SPC in facilitating access to currently held samples and strategies for collecting samples not currently held in the WCPFC Tissue Bank occurred in early July 2016. Further discussions on the feasibility of extension of current sampling to resolve spatial distribution and species gaps in the Tissue Bank are planned. The CSIRO currently holds an extensive collection of tissue samples from the five species and where there are spatial distribution and species gaps in tissues currently held, we will undertake collection of samples for each of the five species via sampling of fish during onshore processing. Where relevant, we will also negotiate with recreational fishers for further collection of samples.

Samples derived from three sites will be collated for each of the five species in each of two years (100 per site per year to derive provenance and 50 per site per year to derive mixing). Samples during the first year of sampling will comprise running ripe gonads from spawning fish and will provide for the determination of provenance of spawning. Samples collected in the second year of sampling will comprise a mixture of cohorts and will establish the degree of mixing of fish across the three areas. Specific sample sites for each of the five species will be chosen based on current understanding of spatial structure in populations and availability of samples for analyses. As a result, sites are unlikely to be completely consistent between species.

Genomics and analyses

Variation present at single nucleotide polymorphism (SNP) markers extracted from samples collated from the three sites will be examined using next generation sequencing techniques. This sequencing technology facilitates high throughput/low cost genotyping, allowing firstly verification of species identification, secondly investigation of stock structure/identification of ocean of origin and thirdly, provision of markers useful for close kin approaches to estimating spawning stock biomass (e.g. Bravington et al. In Press). These techniques are currently being used by CSIRO in investigations of the population structure in skipjack, yellowfin, and bigeye tuna throughout the Indonesian archipelago, have provided preliminary evidence of population structure in yellowfin tuna across the Pacific Ocean and form the basis of a broad collaborative project under development for the whole Indian Ocean (see also working paper SA-WP-01). The techniques are proving capable of discriminating population structure where other techniques have failed and are therefore the most suitable technologies for investigating population structure in pelagic species available.

Genomic information from additional outlier sites required for establishing provenance will be derived from other existing genomic projects being conducted by CSIRO across the Indian Ocean. The genomic information derived from the samples analysed under this project and data from the outlier samples derived from other projects will be input into statistical models currently being developed by CSIRO for use in the projects listed above. These models will then be applied to investigate the presence and level of stock structure across the five species.

Outputs and outcomes

The project will provide a comprehensive evaluation of the population structure and connectivity of the five principle species targeted in the ETBF. Working papers and presentations will be provided to national and regional fisheries management agencies and papers for publication in peer-review journals will be developed.

The improved understanding of stock structure will enable a re-evaluation of the current paradigm in domestic and regional pelagic fisheries scientific advice and management. Conducting stock assessments and implementing management on spatial units that reflect the underlying biology of the population structure should reduce the risk of over-fishing smaller and less productive stocks, while potentially enabling higher exploitation of larger and more productive stocks. Furthermore, understanding of the spatial dynamics of each species will allow Australia (and neighbouring coastal states) to understand and assert their property rights within the WCPFC management framework. In the Australian domestic context, this will allow for the updating of the harvest strategy current used in the management of the ETBF with operating models that have increased accuracy and precision. If a revised and more detailed population structure emerges from the genomic work conducted under this project, close-kin mark-recapture estimators and feasible sampling regimes can be developed. Once implemented, these estimators should reduce uncertainty in spawning stock size, and could potentially provide an abundance index for use in harvest strategies.

References

Aguilar RD, Perez SKL, Catacutan BJN, Lopez GV, Barut NC, Santos MD. 2015. Distinct yellowfin tuna (Thunnus albacares) stocks detected in Western and Central Pacific Ocean (WCPO) using DNA microsatellites. Paper WCPFC-SC11/SA-IP-11a presented to the Western and Central Pacific Fisheries Commission Scientific Committee eleventh regular session, Pohnpei, Federated States of Micronesia, 5-13 August 2015.

Bravington MV, Skaug HJ, Anderson EC. In Press. Close-kin mark-recapture methods. Statistical Science.

Grewe PM, Feutry P, Hill PL, Gunasekera RM, Schaefer KM, Itano DG, Fuller DW, Foster SD, Davies CR. 2015. Evidence of discrete yellowfin tuna (Thunnus albacares) populations demands rethink of management for this globally important resource. Nature Scientific Reports 5: 16916.

Nicol S, Farley J, Muller B, Sanchez C, Roupsard F, Tavaga N, Phillips B, Usu T, Sisor K. 2015. Project 35: Bigeye biology and WCPFC tuna tissue bank. Paper SA-WP-01 presented to the Western and Central Pacific Fisheries Commission Scientific Committee eleventh regular session, Pohnpei, Federated States of Micronesia, 5-13 August 2015.