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

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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 due to the cross-jurisdictional nature of the stocks and associated management at domestic and regional scales. Current assessments conducted by the WCPFC assume that these species comprise single panmictic stock units present either throughout the WCPFC area or across the Southern Hemisphere portion of the region. 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 however, suggest that populations throughout the WCPFC region may be structured. Recent investigations into the stock structure of yellowfin tuna using next generation sequencing (NGS) methods have identified the presence of previously undescribed structure within populations across the Western and Central Pacific Ocean. These observations challenge current assumptions of stock structure and suggest that they may not accurately reflect the biology of commercially important tuna and billfish species throughout the region.

A three year project funded through the Fisheries Research Development Corporation on behalf of the Australian Government 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 targeted in the ETBF (albacore, bigeye and yellowfin tunas, broadbill swordfish and striped marlin) and examine their connectivity with the broader WCPFC region. This paper provides an update on progress on the first year of the project, including preliminary testing of historical samples held by CSIRO and the WCPFC Tuna Tissue Bank and collection of contemporary samples throughout the ETBF and western Pacific Ocean.

Background

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).

Although populations are assessed as single interconnected stocks, biological information on growth rates and reproduction, movement data derived from tagging studies and spatial and temporal variability in catches of these species suggest that there is likely to be some structure to stocks throughout the WCPFC region. 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.

The technical advances of DNA profiling used to investigate the population structure of yellowfin tuna now provide for high throughput sequencing platforms and improved power of population discrimination at much reduced cost. These methods have the potential to test the "single stock" paradigm for highly migratory stocks and provide the technical foundation for global chain of custody and provenance systems necessary to improve accuracy of catch reporting and curb Illegal, Unregulated, and Unreported (IUU) fishing (Grewe et al. 2016). Australia's national research agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), has invested in approximately a decade of work in developing these techniques and associated protocols for sample handling, quality control and processing in conjunction with a specialised processing laboratory based in Australia.

Using this technology, a three year project funded through the Fisheries Research Development Corporation on behalf of the Australian Government and the CSIRO (see Evans et al. 2016) aims to provide 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.

This project builds on previous studies conducted by the CSIRO that have documented genetic structure in yellowfin across three locations in the western and central Pacific Ocean and is part of a broader program of work being conducted by CSIRO on the stock structure of pelagic and neritic species across the Indian and Pacific Oceans (Grewe et al. 2016). Outputs from these projects are expected to provide essential information required for the assessment and management of marine species and in particular tuna and billfish species within the two ocean basins.

Progress to date

Muscle samples analysed by the project will comprise historical collections held by the CSIRO and the WCPFC Tuna Tissue Bank, and where samples from historical collections are inadequate, contemporary collection of muscle tissue will occur where feasible. The aim of the project is to be able to compare variability present at single nucleotide polymorphism (SNP) markers in the five species from three locations: the ETBF and two across the western and central Pacific Ocean (see Evans et al. 2016).

In order to determine the locations from which samples were to be compared a spatial assessment and inventory of tissue samples held by CSIRO and in the WCPFC Tuna Tissue Bank was completed for each of the five species. This survey has identified availability of tissues and their partitioning among key sampling sites as well as potential areas that sampling might be focused on for use in examining stock structure of each of the species. Initial planned spatial sampling structure for the project is provided in Table 1.

Discussions with staff from the Oceanic Fisheries Program (OFP) of the Pacific Community have focussed on facilitating access to samples currently held in the WCPFC Tuna Tissue Bank, with an

application submitted to the WCPFC Secretariat (currently under consideration) to access samples from albacore, bigeye and yellowfin tunas .

Table 1. Proposed sampling structure for investigating the population structure of five tuna and billfish species.

Albacore tuna	Bigeye tuna	Striped marlin	Swordfish	Yellowfin tuna
ETBF	ETBF	ETBF	ETBF	ETBF
Fiji	Fiji	New Zealand	Fiji	Fiji
Cook Islands/French Polynesia	Solomon Islands	Cook Islands/French Polynesia	Cook Islands/French Polynesia	Solomon Islands

Initial testing of historical samples

As a first step in investigating the viability of those historical samples identified and held by CSIRO and in the WCPFC Tuna Tissue Bank (provided by OFP staff), a quality control sequencing trial of samples was run in late 2016/early 2017. All samples from the WCPFC Tuna Tissue Bank passed quality control checks with both target quality control and single nucleotide polymorphism distance matrix results provided to OFP staff. Overall results from CSIRO collections were also positive, with the majority passing quality control checks.

Collection of contemporary tissue samples

Collection of contemporary samples from the ETBF was initiated in late 2016 with a first year of swordfish and bigeye tuna samples collected. Sampling of striped marlin within the ETBF via both commercial and recreational fishers has also commenced. Access to striped marlin samples from the New Zealand region is being facilitated through Blue Water Marine Research, with sampling planned to begin in September 2017.

A table of all samples currently held, those in the WCPFC Tuna Tissue Bank access has been applied for and those planned to be collected are provided in Table 2.

Next steps

Samples from albacore tuna, striped marlin and swordfish from the ETBF are currently being sequenced. Further collection of samples from bigeye tuna, striped marlin and swordfish are ongoing both in the ETBF and in New Zealand for striped marlin. As samples are collated, they will also be submitted for DNA sequencing. Initial runs of specialised models developed by CSIRO for discriminating stock structure will commence in the first half of 2018.

Discussions examining strategies for collecting samples from target areas for the project where there are currently not suitable numbers of samples in the WCPFC Tuna Tissue Bank (Solomon Islands, Fiji, Cook Island/French Polynesia) have been initiated with staff from the OFP. The authors would also like to use this meeting to extend these discussions to other relevant agencies across the WCPFC area on the feasibility of collecting samples from:

(i) bigeye tuna from the Solomon Islands region;
(ii) albacore and swordfish from the Fiji region;

(iii) albacore tuna, striped marlin and swordfish in the Cook Islands/French Polynesian region

Intended outcomes

The improved understanding of stock structure provided by this project will enable improved stock structure considerations used 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. In the Australian domestic context, this will allow for the updating of the harvest strategy currently used in the management of the ETBF with operating models that have increased accuracy and precision.

Table 2. Status of sampling from the five tuna and billfish species

Species	Location	Years	Status
Albacore tuna	ETBF	2	collection completed
	Fiji	1 (1)	WCPFC application submitted (planning underway)
	Cook Islands/French Polynesia		planning underway
Bigeye tuna	ETBF	2	collection underway
	Fiji	2	WCPFC application submitted
	Solomon Islands		planning underway
Striped marlin	ETBF	2	collection underway
	New Zealand	2	collection underway
	Cook Islands/French Polynesia		planning underway
Swordfish	ETBF	2	collection underway
	Fiji		planning underway
	Cook Islands/French Polynesia		planning underway
Yellowfin tuna	ETBF	2	collection complete
	Fiji	2	WCPFC application submitted
	Solomon Islands	2	WCPFC application submitted

Reporting

We anticipate providing updates on the project in the form of information papers to the WCPFC scientific committee at their meetings in 2017, 2018 and 2019, with further information on project progress provided to WCPFC if and when needed. A final report will be produced for submission to the Australian Government Fisheries Research Corporation in mid-2019 and a number of associated peer review publications produced, which will be forwarded on to the WCPFC.

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