Current knowledge, key uncertainties and future research directions for defining the stock structure of skipjack, yellowfin, bigeye and South Pacific albacore tunas in the Pacific Ocean

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Identifying the Spatial Stock Structure of Tropical Pacific Tuna Stocks

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Executive Summary

A recent workshop organised by the Pacific Community has made significant progress in identifying the likelihood that each of the four tropical tuna species is comprised of separate stocks (self-replenishing populations). The workshop also identified the investments needed to identify the number, size, distribution and behaviour of all stocks comprising a tuna species in a Pacific Ocean context, and developed a strategic plan to implement this foundational research. Key findings from the workshop concluded that:

- the spatial structure of tropical Pacific tuna species is poorly understood but evidence is accumulating for the existence of multiple stocks for some species of tuna;
- a lack of knowledge about spatial stock structure has challenging implications for how the productivity of the four tropical tuna species (skipjack, yellowfin and bigeye tuna, and South Pacific albacore) is assessed and how harvests of each species are managed;
- building an accurate picture of the spatial structure of each tuna species is critical to managing the combined effects of fishing and climate change on tuna resources in a sustainable way;
- emerging technologies and multi-disciplinary science, in particular modern genetic approaches combined with traditional approaches, will prove useful for testing specific stock structure hypotheses;
- emerging technologies will help to address associated issues , such as determining provenance for chain of custody documentation; and
- a range of management strategy simulations assessing various hypothetical stock structure scenarios should be evaluated to improve the design of future stock structure research programmes.

The workshop and subsequent work identified a draft 'Strategic Plan to Identify the Stock Structure of Tropical Pacific Tuna'. The investments involved in the sampling and analyses required to identify the stock structure of each tuna species are considered to be an urgent priority, given the great significance of tuna to Pacific Island economies and the mobility of tuna species.

Introduction

The importance of fish to Pacific Islanders cannot be over-emphasised - 98% of the 27 million km^2 under the jurisdiction of Pacific Island countries and territories is ocean. The greatest resource for many of these large ocean states is tuna and it is in demand worldwide, with landings of four species from the Western and Central Pacific Ocean (WCPO) (skipjack, yellowfin and bigeye tuna and South Pacific albacore) making up around 60% of the global tuna catch.

Pacific Island countries and territories (PICTs) rely on tuna for economic development, food security and employment. Six PICTs derive at least 40% of all government revenue from tuna fishing licence fees; >25,000 full-time jobs have been created based on tuna; and across the region an additional 100,000 tonnes of fish will be needed for food security by 2030.

Recent assessments of the four tropical tuna species from the WCPO indicate that none of the species is overfished, and that overfishing is not occurring for any species. Yet important questions remain, including:

- what is the spatial structure of tuna stocks? and
- will knowledge of spatial structure enable further improvements to the management of tropical Pacific tuna resources?

The answers to these questions are important because if there are multiple stocks (i.e., self-replenishing populations) comprising each species, different approaches may be needed to assess and manage them. In the context of climate change, modelling the response of each species to climate change may also require each stock to be modelled separately to account for potentially varying responses by each stock to climate variables.

In short, establishing the number, distribution, size and behaviour of stocks for each tuna species will provide a stronger foundation for the stock assessments needed to set sustainable catch limits and harvest strategies, and for assessing the effects of climate change on tuna distribution and abundance.

Current knowledge, key uncertainties and future research directions for defining the stock structure of skipjack, yellowfin, bigeye and South Pacific albacore tunas in the Pacific Ocean[1] and the companion report on **The Impact of climate change on tropical tuna species and tuna fisheries in Pacific Island waters and high seas areas**[2] address these research needs.

[1] Moore, B., Hampton, J., Pilling, G., and Smith, N., et al. 2018. Current knowledge, key uncertainties and future research directions for defining the stock structure of skipjack, yellowfin, bigeye and South Pacific albacore tunas in the Pacific Ocean. Final Report (CI-3) for Conservation International project SAN 6004150.

[2] Senina, I., Lehodey, P., Smith, N., and Hampton, J., et al. 2018. Impact of climate change on tropical tuna species and tuna fisheries in Pacific Island waters and high seas areas. Final Report (CI-3) for Conservation International project SAN 6003922.

Current approaches and knowledge

Stock assessments for skipjack, yellowfin and bigeye tuna and South Pacific albacore across the Pacific Ocean assume eastern and western stocks. This split largely reflects the historical development of fishery management in the region rather than biological considerations.

Current knowledge of tuna movements has been built up mainly from information derived from tagging programmes, but also from biological and molecular data, studies of the chemical composition of fish hard parts, parasite load comparisons and simulation modelling. More recently, advances in molecular genetic technologies have indicated that yellowfin tuna at least is likely to be comprised of multiple (but as yet unquantified) stocks. This seminal finding has raised awareness that such techniques, combined with other biological markers (bio-tracers, parasites and otoliths), are likely to transform our knowledge of tuna stock structure, and improve management options for transboundary tuna stocks.

The report **Current knowledge, key uncertainties and future research directions for defining the stock structure of skipjack, yellowfin, bigeye and South Pacific albacore tunas in the Pacific Ocean**[1] provides a comprehensive technical review on a species by species basis of the methods applied to date, and our current knowledge of stock structure.

Recent progress

In October 2018, the Pacific Community (SPC) organized a workshop on 'Identifying the spatial structure of tropical Pacific tuna stocks' with assistance from Conservation International. The international experts who attended concluded that yellowfin and bigeye tuna are likely to be comprised of multiple stocks (i.e., self-replenishing populations) across the Pacific Ocean basin but that there is currently insufficient existing evidence to determine whether as much spatial structuring is also likely to occur for skipjack tuna and South Pacific albacore.

The workshop reinforced the need to consider self-replenishing populations as the basic units of fisheries management because such populations are unlikely to be replenished easily from neighbouring stocks if overfished.

The workshop also recognised that identifying the spatial structure of tuna stocks should enable:

- provenance to be attributed to stocks used by countries in initiatives designed to add value to tuna;

- models for assessing the impact of climate change on a tuna species to be applied at the appropriate scale, i.e., for each stock within the distribution of a species, rather than for all stocks comprising the species combined across the Pacific basin; and
- evaluation of the use of large-scale marine managed areas (LSMMA) to help manage tuna (as suggested by some NGOs), something that cannot begin to be robustly assessed until the distribution of the target stock is known.

The workshop considered which of the following forms of spatial structuring were most likely to occur for each of the four tuna species, based on existing observations of spawning and recruitment areas, and movements derived from tagging data:

- 'panmixia' across the entire Pacific basin;
- 'isolation by distance', i.e., a continuous stock with individuals exchanging genes with others from geographically close areas;
- 'metapopulation/islands', i.e., a series of small sub-stocks each largely isolated from other sub-stocks; and
- 'closed populations'.

Given the great mobility of tuna, it was acknowledged that homing to defined spawning areas could occur within stock structure types through isolation by distance, metapopulation/ islands and closed populations, and that mixing of stocks was likely. As a consequence of such mixing, individuals from several stocks could occur at some locations within the distribution of a tuna species.

Workshop participants also identified the sampling of genetic material and other biological markers needed to identify the stock structure for each tuna species, and movement of fish within each stock. A draft 'Strategic Plan to Identify the Stock Structure of Tropical Pacific Tuna' was subsequently incorporated into the report **Current knowledge, key uncertainties and future research directions for defining the stock structure of skipjack, yellowfin, bigeye and South Pacific albacore tunas in the Pacific Ocean**[1].

As described above, the mobility of tuna creates potential for separate stocks to have overlapping spawning and foraging areas, and for tuna sampled from a specific area to represent a mix of fish with different natal origins. To unravel the stock structure of such mobile species, three sets of information are needed:

- the conditions governing spawning (timing, location and behaviour);
- the extent of individual movement/mixing, including provenance (where the individual is sourced from); and
- the existence of natal homing (the tendency for individuals to return to their birth location to spawn).

The Strategic Plan, and the investments involved in the sampling and analyses required to identify the stock structure of each tuna species, are considered to be an urgent priority given the great significance of tuna to Pacific Island economies and the mobility of tuna species.

Benefits for management

Investments in the comprehensive research needed to identify the stock structure of the four tuna species are expected to put the management of tuna resources on a firmer footing. In particular, it should be possible to identify the stakeholders in each stock, and assist them to manage their shared stocks sustainably. Ultimately, this will allow individual stakeholders to map mutually beneficial partnerships that optimise the sustainable management of each tuna stock.

The investments will also set the stage for assessing the effects of climate change on the productivity of tuna fisheries, and implementing the necessary adaptations, with much greater confidence.

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