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THE APPLICATION OF GENETICS AND GENOMICS TO PACIFIC FISHERIES BY SPC AND IMPLICATIONS FOR THE WCPFC TUNA TISSUE BANK

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Executive Summary

1. SPC, in collaboration with interested research partners, has commenced a genetics and genomics research program in the Pacific region to address key knowledge gaps that impact the region's capacity to manage its fisheries.
2. The current focus of this work for tuna fisheries is an improved understanding of connectivity and stock structure to better parameterise the models SPC currently uses for stock assessment and climate change projections.
3. The initial phase of this tuna work is two-fold:
    a. a detailed design study to determine the sorts of questions that the research program can/should consider, and the feasibility and costs associated with differing levels of investment.
    b. an evaluation of the requirements any genetic/genomic program may add to WCPFC's biological sampling activities.
4. SPC is establishing an advisory committee to provide it with technical assistance and advice on genetic and genomic applications. The membership of this advisory group is expected to include technical experts from within and outside the region.

Recommendations

1. SC16 is invited to note SPC's commencement of genetic and genomic applications in the Pacific region.
2. CCMs are invited to recommend to SPC suitable experts to participate in its genetics advisory committee.
3. SC16 may wish to establish a new project number for genetic applications in WCPFC so that SPC and other CCMs can regularly advise the SC on their activities that apply genetic and genomic methodologies.

Introduction

The information derived from genetic and genomic analyses is becoming increasingly useful in natural resource management. In particular, next generation sequencing allows easy access to high-resolution genomic assessments at continuously reducing per-unit costs. Routine applications in marine fisheries research and management are now affordable. However, genetic assessment methods are only effective if applied accurately and with appropriate expectations to answer specific questions. SPC is currently undertaking scoping analyses to identify how a range of molecular genetics tools can address key knowledge gaps that at present limit the resolution and precision of scientific advice provided to its members. The types of proposed applications are summarised in Table 1.

Table 1. Knowledge gaps and genetics tools to address them.

Gap	Molecular genetics tools and applications	Related management issues
Stock and population structure	A diverse suite of analyses provides direct measurement of population differentiation at multiple generation time-scales; further inference about population dynamics, e.g. occurrence of discrete populations; isolation by distance; metapopulations; panmixia; spawning fidelity; etc.	- The potential for local depletion, including local recruitment overfishing - The degree to which regions of zero or low exploitation provide stock-wide protection against overfishing
Connectivity	Relatedness/migrant analyses provide individual-scale information that underpins spatial structures within a generation and test mixing assumptions within population dynamics models and interpretation of CPUE data.	- The impact of fishing in one area on the abundance and fishery performance in other areas (spatial interaction)
Absolute abundance and fishing mortality estimates	Close-Kin Mark-Recapture methods provide quantitative estimation of the number of adults contributing to spawning biomass and current fishing mortality.	- Potentially reducing uncertainty in assessments and MSE, with impacts on associated risk analysis
Species and provenance identification	Barcoding adds value to trade certification; verifies traceability and substitution.	- Potentially providing greater market certainty around fish origins - Potential MCS applications

Ecosystem Indicators	Metagenomics (eDNA in particular) provides a rapid and cost-effective measure of marine biodiversity; Micro-organism diversity provides an immediate measure of ecosystem condition.	- Monitoring the ecosystem effects of fishing, or demonstrating lack thereof
Impacts of fishing and fishery rebuilding	Genetic diversity can be used to identify abrupt reductions in population size (bottleneck events), extrapolated to infer intensity of the loss, time since the event, and extent of the population's recovery.	- Potentially providing a direct measure of management performance - Detection of unexpected events before they are apparent in routine fisheries data and assessments
Adaptive capacity	Genetic diversity translates to the latent ability of a population to survive changes in the environment; e.g., as water temperature and oxygen content change, or prey compositions shift, gene variants (alleles) that previously provided no particular advantage can start out-performing other variants and allow at least a portion of the population to flourish (or survive) in the new conditions.	- Potentially important in evaluating resilience to climate change

Stock Structures of WCPO Tropical Tunas

SPC hosted a workshop in October 2018, attended by experts and SPC members, to identify pressing knowledge gaps pertaining to the stock structure of tropical tunas. The workshop outcomes are summarised in SC15-SA-IP-03 (Macdonald et al. 2019), and arising from them are two research papers now published in the journal *Fisheries Research* (Moore et al. 2020a, b). These papers include a review of genetic analyses undertaken in the WCPO to inform decisions on stock structure. Two features of the preliminary work conducted to date are: (1) that detectable differences in genetic composition exist between samples collected from the eastern and western boundaries of the Pacific, suggesting that neither south Pacific albacore, bigeye, skipjack or yellowfin are likely to be truly panmictic Pacific populations; and (2) the spatial scale and population processes behind any genetic structuring remain uncertain (Grewe et al. 2019).

The workshop concluded that, to reduce this uncertainty, any future biological sampling program should include: (1) broadscale sampling in space, ideally covering each species' distribution, targeting adults in spawning condition; (2) temporally-repeated sampling of the same geographical areas to assess stability in observed patterns over time and influences of oceanography; (3) collection of all biological material that can be used to delineate stock boundaries (tissue and organs, hard-parts, parasites); and (4) careful planning of logistics and coordination of sampling efforts across agencies to ensure no contamination or deterioration of sample quality.

WCPFC tissue bank

Collection strategies for the WCPFC tissue bank have not previously been designed with the above-listed criteria. Analyses of the current holdings in the tissue bank have identified several gaps in species-time-area strata indicating that questions on stock structure would be difficult to answer without additional sampling. SPC and research partners has commenced a design study to identify the sampling coverage and protocol needed to address questions associated with the stock structures of tropical tunas, what logistics such designs may impose on existing approaches for sample collections (e.g. scientific cruises, observer and port sampling), and what limits may exist on answering these questions given the suite of potential hypotheses.

To assist with the design study, SPC has also initiated the establishment of an informal advisory panel. While the initial role of this panel is to advise on the question of tuna stock structures, it is expected to evolve in scope to further advise on the implementation of molecular genetics studies undertaken by SPC. Panel participants include specific experts in the application of molecular genetics and sample collection in the Pacific region, and it is anticipated that several of these experts will be drawn from the national pool of interested CCMs. While the advisory panel is informal, SPC will utilise this panel as a first step in ensuring science quality and appropriate peer-review for molecular genetics applications in the region.

SPC-WCPFC Linkages

The WCPFC tissue bank and the WCPFC Scientific Committee provide additional peer-review opportunities for molecular genetics applications undertaken by SPC. The processes of the tissue bank include review by the WCPFC Research Sub-Committee to ensure the maximum efficiency in the sequence of techniques applied to samples (i.e. non-destructive uses are applied before

destructive uses) and that samples are used for priority analyses. The WCPFC Scientific Committee also provides oversight on research priorities for WCPFC.

Similarly, the work program SPC implements for its members in oceanic fisheries and the research needs of WCPFC have historically been well aligned and synergistic. Noting that this is unlikely to change in the foreseeable future, it may assist WCPFC in its work planning and prioritisation if SPC provides an annual update on its activities associated with molecular genetics. The SPC genetics advisory panel may also provide WCPFC with an additional independent source of information and advice on applications in molecular genetics.

References

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