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PRELIMINARY ANALYSES FOR A CLOSE KIN MARK RECAPTURE FEASIBILITY STUDY IN WCPO

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M. Bravington[1], J. Farley[1], J. Hampton[2], S. Nicol[2]

[1] CSIRO
[2] Pacific Community (SPC), Ocean Fisheries Programme (OFP), Noumea, New Caledonia

Executive Summary

This Information Paper provides an initial examination of its suitability of CKMR for South Pacific albacore in the WCPO for estimation of population size, reproductive potential, mortalities, and connectivity.

Initial exploration indicates that a total of around 20-25,000 South Pacific albacore might need to be genetically sampled, in order to detect Pairs estimates from CKMR.

A description is included of the requirements for a follow-up detailed feasibility study, together with a proposed budget.

<u>Recommendation</u>

SC16 note the requirements for a feasibility for CKMR application to South Pacific Albacore and support of USD50,000 for its implementation

Introduction

Close-kin mark-recapture (CKMR) is a novel method recently developed by CSIRO which can provide absolute abundance estimates (i.e. numbers of living adults), age-specific reproductive potential, mortality rates, and connectivity, without relying on fishery-derived data such as CPUE (Bravington et al. 2016a, 2016b, Hillary et al 2018a) . SC15 recommended establishing “Project 100” to examine the feasibility and costs of applying the method to shark and tuna populations in the WCPO. In the end, Project 100 was not actually contracted during 2020 because Covid-19 prevented the necessary travel. However, the agreed objectives of Project 100 were:

1. To convene a small workshop of relevant experts to examine the feasibility and costs of applying the close-kin mark-recapture estimation of the population size to species caught within the WCPO.

2. To identify the scientific issues that conducting such a study would help address.

3. To identify those species in the WCPO for which it may be appropriate to conduct a close-kin mark-recapture study.

4. To outline the elements of a small project, identifying possible project investigators and associated costs, aimed at conducting a feasibility study in the WCPO.

This Information Paper contributes to Objectives 3 and 4 of Project 100 by undertaking an initial examination of its suitability for South Pacific albacore in the WCPO. The assessment of South Pacific albacore using conventional data is recognized as "challenging", with particular uncertainty about absolute abundance (e.g. p44 in Tremblay-Boyer et al. 2018). The initial examination provides approximate estimates of the likely quantity and breakdown of samples needed for CKMR to give useful results for this stock. As already noted, objectives 1 and 2 could not be addressed during 2020 because of Covid-19 travel restrictions, but could be followed up as part of a detailed feasibility study for South Pacific albacore.

Methods

CKMR, if implemented properly, should deliver unbiased estimates of demographic parameters. However, to be useful, the estimates also need to be reasonably precise— i.e. to have low CV. As with any mark-recapture method, precision in CKMR depends on how many "recaptures" are obtained. In CKMR, the "recaptures" are kin-pairs, and for teleost fish two different types of kin are normally needed: Parent-Offspring Pairs (POPs; one adult and its juvenile offspring), and cross-cohort Half-Sibling Pairs

(XHSPs; two juveniles born in different years that share either a mother or a father). On statistical grounds, at least 50 POPs and 50 XHSPs are required to have any chance of good precision, e.g. a CV of 15% on absolute abundance (see Bravington et al. 2016a, section 4). A preliminary scoping study like this one can be used to check what sample sizes might be needed to find that many pairs, provided that an existing stock assessment is available as a "working hypothesis".

For this paper, we used estimates from the Diagnostic Case model from the 2018 South Pacific albacore stock assessment (Tremblay-Boyer et al. 2018), including total average population number at age for 2014--2016, mean weight at age, proportion mature at age, and catch-at-age for the main longline and troll fisheries from which it was deemed feasible to obtain regular samples. We used an experimental R function `ckmr_laugh_test()` to explore different compositions (ratios) of younger (in practice, smaller) vs older (in practice, bigger) samples, different study durations, and different total sample sizes that might yield at least 50 POPs and 50 HSPs. The minimum total size appears to be around 20,000 albacore, spread out over 3–4 years of collection; see Table 1↓ for an example.

Age	0	1	2	3	4	5	6	7	8	9	10	11+
Annual sample	0	2750	1350	150	150	150	700	700	300	300	250	250

Table 1. One possibility for an efficient annual sample composition for each year of a 3-year study (total 21,150 samples). Based on the current assessment, this particular configuration would on average be expected to yield 61 POPs and 51 XHSPs.

There is no implication that the scheme in Table 1↑ is the only possible sampling scheme; similar totals of POPs and XHSPs can be obtained by varying the composition and duration while increasing the total sample size somewhat, and such variations may in fact turn out preferable when detailed logistics are considered. Note also that 50 POPs and 50 XHSPs is a "necessary but not sufficient" condition for precise estimates. In practice, CVs will always be somewhat higher than the theoretical minimum, partly because of the need to estimate several parameters (not just "the abundance") and partly because some important covariates, in particular age, may not be known accurately for all samples. In addition, the "base case assessment" estimates on which those numbers are based, are unlikely to be exactly right. A more realistic and detailed feasibility study is required before proceeding to sample collection, partly to get a realistic idea of precision for assessment purposes, and also— crucially— to consider the logistic pros and cons of alternative sampling schemes.

Results & Requirements for a Feasibility Study

South Pacific albacore appear to satisfy the main qualitative requirements for CKMR on teleost fish: they are repeat-breeders that can be sampled both as immatures and also right through the age range of adults; lifetime spatial mixing is widespread over the range of the fishery (from tagging results); reliable ageing is possible (though otolith-derived age estimates are not usually necessary for all CKMR samples). Note that these requirements can differ slightly, depending on reproductive biology; for example, many sharks can be assessed just with data from immatures.

Our initial exploration of CKMR indicates that 20,000–25,000 south pacific albacore genetic samples might yield enough POPs and XHSPs for usefully-precise estimation of population size, turnover, etc. However, this exploration leaves open many questions, not least the exact design of a sampling scheme. Before implementing a full-scale program, a detailed feasibility study for south pacific albacore is required, which should include:

1. An evaluation of the fisheries and locations where useful quantities of samples can be collected, noting that samples must include approximate capture location information, and some information on fish age (ideally from otoliths, but possibly based just on length). This should include:
    a. Ensuring enough spatial coverage to detect spatial heterogeneity in population structuring, considering past observation of longitudinal trends in growth (Williams et al. 2012) and genetic structuring at adaptive loci (Anderson et al. 2019).
    b. The "population" representativeness of albacore unloaded in Pacific Island ports, and the practicality of sampling at these locations.
    c. Exploration of the WCPFC tissue bank to ascertain what existing samples could contribute to a CKMR study.

2. Realistic consideration of achievable precision in a stock assessment context:
    a. of key management parameters, such as Replacement Yield and Spawner-Per-Recruit-Ratio, besides abundance and natural mortality per se;
    b. given that any sampling scheme would be stratified by length rather than age;
    c. relationship to the accuracy of individual age estimates, e.g. what proportion of adult samples will be associated with otoliths, and how well the ages of 1–2yo juveniles can be inferred purely from length;
    d. implications if "base case" assessment results are inaccurate.
3. Develop the necessary collaborative and stakeholder consultation arrangements to move to full-scale implementation.

4. Use existing albacore samples to develop a panel of genetic markers that can be used for determining kinship and sex, incorporating any likely markers of population structure.

5. A costs and benefits comparison of adopting CKMR as a fishery monitoring tool for South Pacific albacore.

To assist SC16 a draft project description, including a budget request from WCPFC, is provided as Annex 1 to this Information Paper. The project also includes a workshop (to be held alongside other meetings) which, aside from albacore-specific issues, should help to progress the other objectives 1 and 2 of "Project 100".

Recommendations

SC16 note the sampling requirements for implementing CKMR for South Pacific albacore.

SC16 note the requirements for a feasibility study for implementing CKMR for South Pacific albacore.

SC16 consider supporting the implementation of the feasibility study with a budget contribution of USD50,000.

References

Anderson, G., et al. (2019) Indications of strong adaptive population genetic structure in albacore tuna (*Thunnus alalunga*) in the southwest and central Pacific Ocean. Ecology and Evolution 9, 10354-10364. doi.org/10.1002/ece3.5554

Bravington, M.V., Skaug, H.J., Anderson, E.C. (2016a) Close-kin mark-recapture. Statistical Science, 31 (2) 259-274.

Bravington, M.V, Grewe, P., Davies, C.R. (2016b) Absolute abundance of southern bluefin tuna estimated by close-kin mark-recapture. Nature Communication, DOI: 10.1038/ncomms1316.

Hillary, R, et. al. (2018) Genetic relatedness reveals total population size of white sharks in eastern Australia and New Zealand. Scientific Reports, 8:2661, DOI:10.1038/s41598-018-20593.

Tremblay-Boyer, L. et al. (2018) Stock assessment of South Pacific albacore tuna. WCPFC-SC14-2018/ SA-WP-05 Rev. 2

Williams, A. J., et al. (2012) Spatial and Sex-Specific Variation in Growth of Albacore Tuna (*Thunnus alalunga*) across the South Pacific Ocean. PLoS One. 2012; 7(6): e39318. doi: 10.1371/journal.pone.0039318

Annex 1

Project proposal, with budget overleaf

Project XXX	Feasibility of Close-Kin Mark-Recapture assessment for South Pacific albacore in the WCPO
Rationale	Initial explorations suggest that a total of around 20–25,000 south pacific albacore, spread over a few years, might need to be sampled in order to reliably estimate population size and other management parameters via CKMR. Such a quantity seems broadly achievable, but a detailed analysis is required to develop an appropriate sampling strategy, and an evaluation of benefits and costs so the Scientific Committee can determine if CKMR is warranted for this stock.
Objectives	See WCPFC-SC16-2020/SA-IP-15 for more detail. 1. An evaluation of the fisheries and locations where useful quantities of samples can be collected, noting that samples must include approximate capture location information, and some information on fish age or at least length. This should address overall spatial coverage, likely population composition of Pacific Island landings, and potential use of samples already in the WCPFC tissue bank. 2. Detailed design of stratified sampling schemes, including realistic consideration of achievable precision in a stock assessment context 3. Develop the necessary collaborative and stakeholder consultation arrangements to move to full-scale implementation. 4. Use existing albacore samples to develop a panel of genetic markers that can be used for determining kinship and sex, incorporating likely markers of population structure; 5. A costs and benefits comparison of adopting CKMR as a fishery monitoring tool for South Pacific albacore.

Budget	A total budget contribution from WCPFC of USD50,000 is requested for the above work. The SPC and CSIRO columns show additional in-kind contributions of expert time.			
	Activity	WCPFC	SPC	CSIRO
	Logistic Evaluation and Detailed Design	USD15,000 [A]	USD25,000 [B]	USD10,000 [C]
	Consultation (workshop)	USD15,000 [D]	USD5,000 [E]	
	Marker Development	USD10,000 [F]	USD10,000 [G]	
	Costs-Benefits Comparison	USD10,000 [H]	USD5,000 [I]	USD5,000[C]

[A] CSIRO expertise in CKMR design and use in stock assessment

[B] SPC Sampling expert

[C] Additional CKMR modelling support

[D] Support workshop costs and CSIRO travel, assuming workshop can be held in the margins of existing meetings

[E] SPC Sampling and Assessment experts

[F] CSIRO expertise in locus selection for CKMR

[G] SPC Molecular Geneticist

[H] CSIRO expertise in CKMR for design and use in stock assessment

[I] SPC Assessment Scientist