



UPDATED SCHEDULE FOR A CLOSE-KIN MARK-RECAPTURE STUDY ON INDIAN OCEAN YELLOWFIN TUNA

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Review and feedback

This paper is to request **feedback and support** from the Working Party on Tropical Tunas for the proposed updated schedule for a close-kin mark-recapture study on Indian Ocean yellowfin tuna. The paper summarises progress to date and provides an updated schedule for the implementation of a CKMR project for yellowfin tuna, building on the staged approach proposed in 2023.



Abstract

A close-kin mark-recapture (CKMR) design study completed in 2022 estimated that the collection of approximately 30,000 samples per year from Indian Ocean yellowfin tuna, over a five-year period, would provide an estimate of absolute abundance of spawning adults with an acceptable level of precision. In 2023, the Scientific Committee recommended that pursuing a CKMR project for yellowfin tuna should be a high priority for the Commission, and a staged approach for implementing the project was proposed. Since 2023, sampling activities have commenced through a pilot program in Pakistan, but broader implementation of the proposed staged approach has otherwise remained limited. This paper summarises progress to date and provides an updated schedule for the implementation of a CKMR project for yellowfin tuna, building on the staged approach proposed in 2023. The Working Party on Tropical Tunas is invited to provide feedback and support on the updated schedule.



Australia's National
Science Agency

Updated schedule for a close-kin mark- recapture study on Indian Ocean yellowfin tuna

IOTC Working Party on Tropical Tunas

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Contents

1	Summary	2
2	Introduction	2
3	Updated CKMR study proposal	3
3.1	Objectives.....	3
3.2	Schedule	4
3.3	Sampling considerations	5
3.4	Sample collection & processing	6
4	Sampling to date	7
5	Discussion.....	7
6	References.....	9

1 Summary

A close-kin mark-recapture (CKMR) design study completed in 2022 estimated that the collection of approximately 30,000 samples per year from Indian Ocean yellowfin tuna, over a five-year period, would provide an estimate of absolute abundance of spawning adults with an acceptable level of precision. In 2023, the Scientific Committee recommended that pursuing a CKMR project for yellowfin tuna should be a high priority for the Commission, and a staged approach for implementing the project was proposed. Since 2023, sampling activities have commenced through a pilot program in Pakistan, but broader implementation of the proposed staged approach has otherwise remained limited. This paper summarises progress to date and provides an updated schedule for the implementation of a CKMR project for yellowfin tuna, building on the staged approach proposed in 2023. The Working Party on Tropical Tunas is invited to provide feedback and support on the updated schedule.

2 Introduction

Yellowfin tuna is IOTC's second-largest fishery by catch, supporting substantial artisanal fisheries and underpinning food security and livelihoods across the Indian Ocean region. CPUE is currently the primary index of abundance used in the stock assessment, making its reliability critical to the quality of resulting management advice. However, CPUE indices are subject to a range of uncertainties that can affect their interpretation as indices of abundance. These include gaps and changes in the spatial and temporal coverage of fishing data, uncertainty in the quality of reported catch and effort data, changes in fishing practices and catchability, effort creep, environmental variability affecting the distribution and availability of tuna, and hyperstability in CPUE (Hoyle et al. 2024). These issues are particularly relevant to the Indian Ocean yellowfin tuna assessment, where there is uncertainty in CPUE standardisation, differences between alternative longline CPUE series, and uncertainty regarding the appropriate treatment of effort creep (Urtizberea et al. 2024; Hoyle 2024). More recent work has also highlighted differences between CPUE series used in recent yellowfin assessments and the need for further investigation of unusually low CPUE values in the southern Indian Ocean (Kitakado et al. 2025). These uncertainties are exacerbated by climate changes, which may also be affecting fish distribution and movement and changing spatial and temporal dynamics of fishing fleets.

Close-kin mark-recapture (CKMR) is a fisheries-independent method that uses genetically identified close relatives (e.g. parent–offspring and half-sibling pairs) among sampled fish to estimate absolute abundance of spawning adults (the quantity on which stock status and reference points are based) along with other key population metrics, including total mortality (Bravington et al. 2016a). Unlike CPUE, which provides an index of relative abundance, CKMR is independent of many of the data inputs and potential biases associated with conventional stock assessments. Because it does not rely on catch rates, CKMR also offers a means of monitoring abundance that is robust to changes in fleet structure and fishing practices, and to climate-driven shifts in the distribution of tuna and fishing effort. In addition, the spatial distribution of kin pairs detected across regions can provide direct information on contemporary connectivity, informing the movement and mixing assumptions in spatially structured assessments. CKMR has been

integrated into the stock assessment and management procedure (MP) for southern bluefin tuna, where it has considerably reduced the uncertainty in the stock assessments and is used directly in the decision rule of the MP that generates management advice for the stock (Bravington et al. 2016b, Hillary et al. 2019, 2020). CKMR is also being developed for other tuna species, including Atlantic bluefin tuna (Grewe et al. 2018) and South Pacific albacore (SPC and CSIRO 2023, 2025, 2026, CSIRO and SPC 2025, Lloyd-Jones et al. 2026).

A CKMR design study for Indian Ocean yellowfin tuna estimated that approximately 30,000 samples would need to be collected annually over five years to provide estimates of key population metrics with reasonable precision (Hillary et al. 2022). The study also indicated that precision could be improved by targeting a greater proportion of juveniles < 50 cm (approximately 70%) than adults > 75 cm (30%). At the time, collecting samples at this scale was recognised as a significant logistical challenge. Consequently, the WPM and WPTT supported a staged approach to implementation, beginning with an initial year of sampling to assess whether sufficient numbers and quality of samples could be obtained while maintaining acceptable levels of DNA contamination (IOTC 2022a, b).

CKMR has already delivered results for another species within the Indian Ocean. A study combining tissue samples from juvenile whale sharks at Ningaloo Reef, Western Australia, with further samples from Madagascar and Tanzania, used CKMR to estimate the adult breeding population and its decline between 2000 and 2019, demonstrating CKMR as a viable technique for monitoring shark species in the region (Patterson et al. 2025). Recent experience from the development of CKMR for South Pacific albacore provides further evidence that sample collection at a similar scale is achievable in a tuna fishery. Approximately 29,000 samples were collected between July 2025 and June 2026, bringing the total number of samples collected since 2024 to more than 75,500 (SPC and CSIRO 2026), of which over 24,000 have been sequenced to identify kin pairs. This demonstrates the capacity to collect large numbers of samples from commercial catches across the Pacific and provides a practical basis for revisiting the implementation schedule for Indian Ocean yellowfin tuna. Within the Indian Ocean itself, an initial CKMR pilot sampling program has now been completed in Pakistan (see Sampling to date, below), and two further projects are separately evaluating the feasibility of tissue sampling for other species in the IOTC area. This paper provides an updated schedule for implementing the staged CKMR approach proposed for Indian Ocean yellowfin tuna (Williams et al. 2023), building on this combined body of experience.

3 Updated CKMR study proposal

3.1 Objectives

The proposed CKMR study for Indian Ocean yellowfin tuna will be developed and implemented in collaboration with two existing projects evaluating the feasibility of tissue sampling for other species in the IOTC area. Collaboration with the existing projects, led respectively by the IOTC Secretariat and IFREMER, provides an opportunity to share experience to develop and expand sampling networks across a broader geographic area.

The main objectives of the CKMR study are to:

1. Develop and expand a network of suitable sampling areas and trained samplers to support a full-scale yellowfin tuna sampling program, including identifying training requirements and developing training materials for field staff.
2. Refine standard operating procedures for collecting, preserving, storing and transporting tissue samples, drawing on experience from existing sampling programs where appropriate.
3. Continue and progressively expand the collection of tissue samples from yellowfin tuna across the Indian Ocean, aiming for approximately 70% juvenile and 30% adult fish.
4. Conduct a review following the initial phase of sampling to evaluate the number and quality of samples collected, including DNA quality, the level of cross-contamination and the effectiveness of sample preservation methods, and revise sampling methods and targets as necessary.

3.2 Schedule

The updated schedule retains the staged structure proposed in 2023, with each stage designed to resolve practical uncertainties about sample collection, quality and cost before the next is undertaken.

2025-2026: Pilot sampling

1. A CKMR pilot sampling program was completed in Pakistan (Region 1), with DNA quality and contamination testing underway (see Sampling to date, below).
2. Discussions were held with the IOTC Secretariat and IFREMER project leaders on sampling networks across the Indian Ocean.

2027: Liaison with network of samplers, discussion of sampling protocols

Meetings will be held with interested parties and the IOTC Secretariat and IFREMER project leaders to discuss logistics and build the network of samplers, including training, tissue handling and preservation, data collection and management, and requirements to facilitate rapid DNA extraction for a range of key species, including yellowfin tuna for CKMR.

2028: Commence sampling program

Subject to confirmation of funding, an initial broader sampling program will commence in priority areas identified in the CKMR design study, drawing on the experience gained and the standard operating procedures developed for the project (see Sample collection & processing, below). A subset of samples will be genotyped ahead of the formal review to allow an initial assessment of kin-pair detection.

2029: Review progress

The broader sampling program will be regularly reviewed, and more formally reviewed after approximately 2 years, against four criteria: (i) whether sample numbers, size composition and rates of collection across the areas sampled indicate that CKMR-relevant sample sizes are

achievable at an acceptable cost and logistical effort, (ii) whether DNA quality and cross-contamination results confirm that samples are suitable for kinship analysis, (iii) whether sampler training, sample handling and transport workflows can be sustained reliably across sampling locations, and (iv) whether genotyping of samples confirms that kin pairs can be reliably identified, and whether early kin-pair detection rates are broadly consistent with expectations from the CKMR design study (Hillary et al. 2022). This review will be reported to the WPTT and SC in 2030, including any recommended adjustments to sampling or laboratory protocols. Where the formal review indicates sufficient progress against these criteria, sampling is expected to continue towards full implementation of CKMR for yellowfin tuna.

2030 onwards: Scaled up sampling

Sampling will continue and be scaled up as needed, with genotyping continuing to allow further assessment of kin-pair detection rates. Results will be reviewed and reported to the WPTT and SC to evaluate the feasibility of achieving the approximately 30,000 samples per year recommended by the CKMR design study (Hillary et al. 2022), and to inform a recommendation to the Commission on progressing to a full-scale, multi-year CKMR implementation for Indian Ocean yellowfin tuna. Given the scale and multi-jurisdictional nature of a full-scale program, appropriate governance arrangements would be developed in consultation with the WPTT, SC and participating CPCs. These could include a steering committee and a technical advisory group with representation from participating CPCs, the IOTC Secretariat and research partners, to oversee sampling coordination, data sharing and reporting.

3.3 Sampling considerations

Detailed consideration of sampling design for Indian Ocean yellowfin tuna CKMR, including spatial stratification, size-class targeting and an assessment of existing length-data collection programs as a basis for CKMR sampling, was presented in Williams et al. (2023). In summary, that paper used the four regional stock assessment areas from Fu et al. (2021) (Figure 1) to spatially stratify sampling. It identified Regions 1 and 4 as the primary source of juvenile (<50 cm) samples, with adult yellowfin tuna (>75 cm) more evenly available across all regions except Region 3, where fishing effort and available length data are comparatively sparse. We propose that sampling should be port-based and utilise existing length-data collection programs operated by the top catch reporting fleets (including Maldives, EU Spain, EU France, Seychelles, Indonesia, Sri Lanka, Iran, Japan and Taiwan, China). The sampling programs for these key fleets currently achieve a sampling intensity broadly consistent with CKMR requirements in most region and size-class combinations, providing a practical basis for building a CKMR sampling network. These findings will continue to inform the prioritisation of sampling areas and fleets under the present project, including the selection of Pakistan as an initial priority area.

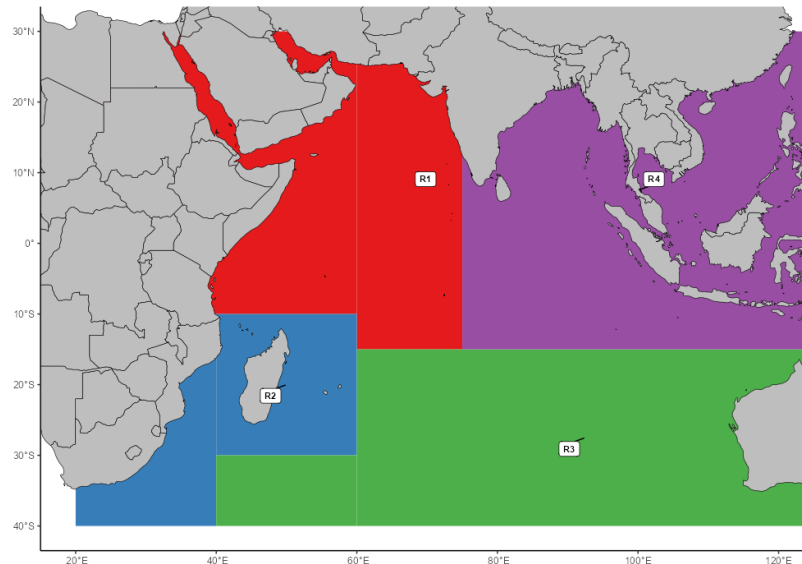


Figure 1. Four-region spatial stratification of the Indian Ocean for the basic yellowfin tuna assessment model (Fu et al. 2021).

3.4 Sample collection & processing

Tissue sampling protocols for this project will draw on well-established procedures already used extensively in the Southern Bluefin Tuna (SBT) gene-tagging program (Preece et al. 2015, 2026), in tuna fisheries observer and port sampling programs in the Pacific Ocean (e.g. Sanchez et al. 2023), and in equivalent programs in the Indian Ocean (Anon. 2018). These existing protocols may need to be adapted and combined to be suitable for application within the IOTC context, including meeting the contamination control and sample volume requirements specific to CKMR for yellowfin tuna and making tissue handling cost-effective, given the large sample sizes involved.

We propose collecting muscle tissue samples using a spring-loaded biopsy ('widget') gene-tagging tool (Bradford et al. 2016) fitted with a single-use tip. The widget tool is designed to minimise DNA contamination risks and fish handling time. It collects a tiny (size of a grain of rice) tissue sample, and facilitates very high-throughput processing for DNA extraction. This is preferred over the scalpel- or knife-based methods used in earlier Indian Ocean biological sampling programs for tuna, billfish and sharks (Davies et al. 2019, 2020), which are better suited to programs with small sample sizes (approximately 50–100 samples per species, per location) and requiring larger tissue volumes.

Strict hygiene protocols will be followed between sampling each fish, including clean, dry hands, single-use tips and wipes, and cleaning of any reusable tools and surfaces with ethanol or clean water between samples to avoid cross-contamination. Tissue samples will be transferred directly into individually labelled vials and frozen as soon as practicable after collection, ensuring no contact between the sample and any other surface. For each sampled fish, ancillary data will be recorded for as many fields as possible; including species, fork length (measured following IOTC conventions), weight, sex and maturity stage (assessed macroscopically from the gonads if possible), landing location and date. A unique identifying code will be used to link all samples and data to an individual fish. Otoliths will also be retained where feasible to support complementary ageing studies.

Tissue samples and associated biological data collected for CKMR will also have value beyond abundance estimation. Archived samples could support complementary research on yellowfin tuna population structure and connectivity, while otoliths and biological data can inform studies of age, growth and reproductive biology. Coordinating sampling and protocols with the parallel IOTC Secretariat and IFREMER projects on other species provides further opportunity for a shared, multi-species sampling network that maximises the scientific return from sample collection across the Indian Ocean.

Detailed standard operating procedures, including equipment specifications, step-by-step sampling instructions and data recording templates, will be presented in a working paper to the IOTC Working Party on Data Collection and Statistics (WPDCS).

4 Sampling to date

In 2025, WWF-Pakistan initiated a CKMR pilot sampling program targeting yellowfin tuna landed by the artisanal tuna gillnet fishery in the North Arabian Sea (Region 1) (WWF-Pakistan 2025). This pilot addressed a priority spatial and life-stage sampling gap identified in the CKMR design study (Hillary et al. 2022), where juvenile yellowfin tuna from the northern Indian Ocean were poorly represented in existing biological sampling programs.

Weekly port-based sampling was conducted at Karachi Fish Harbour from August 2025 to mid-2026, through participating fishers to provide consistent access to landed yellowfin tuna across the seasons (WWF-Pakistan 2025). A trained sampling team collected tissue and ancillary biological data from each fish.

A total of 1,898 yellowfin tuna were sampled during the pilot, in a size distribution broadly consistent with the CKMR design study's target proportions of approximately 70% juveniles and 30% adults. Although collected from a single location, this represents a substantial contribution towards the annual sampling target for Region 1, and indicates that the regional target is achievable if similar sampling can be established at other locations within the region. It also demonstrates the feasibility of sustained, CKMR-compatible sampling from an artisanal gillnet fishery.

A subsample of 100 tissue samples was provided to CSIRO to evaluate DNA quality and the level of cross-contamination among samples, an important step in confirming that the remaining samples are suitable for CKMR kinship analysis. DNA has been extracted from this subsample and sent for sequencing, but results were not available at the time of writing.

5 Discussion

This paper provides an update on progress towards implementing a staged approach to CKMR for Indian Ocean yellowfin tuna, building on the pilot study proposed in 2023 (Williams et al. 2023). The collection of close to 1,900 samples from a single location in Pakistan, in a size composition broadly consistent with the target proportions of juveniles and adults, demonstrates that sustained sampling following CKMR protocols can be delivered from an artisanal fishery in a

priority sampling area identified in the CKMR design study. If similar rates of collection can be achieved at other locations, sampling targets appear achievable.

Confirmation of acceptable DNA quality and low cross-contamination in the subsample sent to CSIRO will be an important next step in validating the broader sample collection for CKMR analysis. Pending these results, and building on the parallel feasibility projects being progressed by the IOTC Secretariat and IFREMER, the updated schedule proposed in this paper sets out a pathway for expanding sampling to additional priority areas, with a view to informing a recommendation to the Commission on progressing to a full-scale, multi-year CKMR implementation for Indian Ocean yellowfin tuna.

The staged approach is intended to reduce the risk of committing to a large, complex, multi-jurisdictional program before its practical requirements are well understood and suitable implementing arrangements developed. The experience of CSIRO and partners in developing CKMR for southern bluefin tuna and other species is that investment in careful design and testing of sampling and laboratory workflows, before scaling up, substantially improves both the immediate outcomes and the longer-term value of such programs. Each stage of the updated schedule is therefore intended to generate the evidence needed to refine sampling design and protocols, and to provide the WPTT, SC and Commission with a sound basis for deciding whether to progress to full-scale implementation.

The authors seek feedback from the WPTT on the updated schedule presented in this paper, including the proposed expansion of sampling activities, and welcome expressions of interest from CPCs, research partners and other stakeholders in contributing to or supporting the ongoing development of CKMR for yellowfin tuna in the Indian Ocean.

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