Scoping the Next Generation of Tuna Stock Assessment Software

Progress Report (Project 123)

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Background

the need to migrate to new software

Progress against TOR items

evaluation of necessary software features, existing software, RTMB

likely next-gen software: IATTC designed tuna model

likely next-gen software: DTU spatio-temporal model (focusing on tags and movement)

less likely: FIMS tuna-specific modules

Planned activities 2025–2026

collaborate with IATTC and DTU on designing and developing models

funding required next year, software development project proposal at SC22

The need to to migrate to new software

MULTIFAN-CL (MFCL) has been used in SPC tuna assessments since 1990s

MFCL team (Dave Fournier, John Hampton, Nick Davies) retiring in the 2020s

Development of new features is slowing down

Resources are being allocated to succession plans

The overarching objective is to transition all assessments from MFCL

Project outline

This scoping project is scheduled from 1 Feb 2024 to 31 Dec 2026. It will:

Evaluate features and capabilities that will be important in future tuna assessments

Explore fitting models to tuna data using existing software platforms

Guide decisions on what kind of new software development will be required

Establish collaboration with tuna RFMOs and research labs to achieve these goals

TOR summary

Work areas from Aug 2024 to Aug 2025:

1. Evaluate necessary features for tuna assessment software and existing software

2. Conduct 2024 workshops

3. Evaluate RTMB programming environment

4. Explore feasibility of enhancing tagging module in Stock Synthesis

5. Support billfish assessments transitioning from MFCL to Stock Synthesis

6. Prepare a single-region YFT dataset for comparing and testing platforms

7. Prepare work plans and budget scenarios for upcoming development project

8. Communicate with tuna RFMOs and research labs to establish who will participate

9. Communicate with tuna RFMOs to evaluate FIMS development option

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Evaluation of necessary software features

A long wish list of next-generation software features was covered in the CAPAM 2019 review paper (Punt et al. 2020)

This year's P123 progress report to SC21 identifies features that are especially relevant for tuna assessments:

- ▶ Incorporate length comps, weight comps, tags, otoliths, close-kin mark-recapture data (!)

- ▶ Age-specific M, length-specific selectivity, sex-specific growth and M, region-specific growth

- ▶ Explicit regions with movement, time steps within a year, age and length structure (?)

- ▶ Multispecies interactions (?), climate change (?)

- ▶ Random effects (= state space), parallel computing, computation time

Evaluation of necessary software features

Three main criteria

1. *Scientific quality*: The software should have good statistical performance, make good use of available data, allow spatial and temporal variability, be computationally efficient, and provide scientific advice that matches the needs for the management of each stock.

2. *Beginner friendly*: The user interface and auxiliary tools should allow new scientific staff to have a good understanding of the configuration of model options and be able to work efficiently with the model.

3. *Widely used*: SPC does not want to use stock assessment software in isolation, the software should have a wider development team and user community beyond SPC, especially at tRFMOs, so new scientific staff can find expert help and technical advice outside of SPC.

Evaluation of existing software

Stock Synthesis

Used in tuna assessments by the IATTC, IOTC, and ICCAT, and in WCPFC billfish assessments

Two options for incorporate tagging data: (1) convert release lengths to age externally, or (2) analyze the tags externally and incorporate as abundance indices. Especially relevant for WCPO skipjack assessment

The SS3 development team does not plan to add new major features such as the ability to incorporate CKMR data, which is especially relevant for future South Pacific albacore assessment

The recent use of SS3 at SPC has had a positive impact on collaboration between the tRFMOs, relevant for the discussion, development, and tests of future software

Stock Synthesis scores particularly high in two key criteria: the ability of new staff scientists to use it effectively and the worldwide user community, including tuna RFMOs.

Evaluation of existing software

Gadget

Explicit age-length structured platform

Gadget 3 was recently implemented in TMB, resulting in substantial performance gains

Wide range of features relevant for tuna assessments and a plan is underway to test the use of Gadget on the single-region yellowfin tuna dataset

A useful reference for designing any future tuna assessment software

Gadget scores particularly high for representing state-of-the-art statistical methods of interest: explicit age-length structure and a TMB implementation that may allow the use of random effects to have processes vary with time and/or between regions

Evaluation of existing software

SBT

Used in the assessment of southern bluefin tuna by CCSBT

Implemented as an R package based on RTMB

Fitted to CKMR, a new and important data type in future South Pacific albacore assessments

The SBT package is designed for a single-region assessment and would require some additional development to be used for a multiregion assessment

The scoping project has reached out to the SBT team and will discuss further the possibility of using their model code as a starting point for developing new software for the South Pacific albacore assessment

SBT scores particularly high for incorporating CKMR data in a tuna stock assessment

Evaluation of existing software

FIMS

NOAA project developing a new framework of stock assessment models based on TMB

Initial development and case studies have focused on models fitting to age composition data, but the design includes the ability to fit to length composition data. Spatially explicit models and tagging data are currently not high priorities for the FIMS project

Might be possible to design and develop tuna-specific FIMS modules: basic model extensions and/or introducing underlying changes in the model structure.

The FIMS project might develop an overly complex framework architecture that results in slower progress and lower levels of code contributions than anticipated. A possible outcome could be that FIMS software cannot be used in future tuna assessments

Evaluation of existing software

Other

Casal 2 is the latest version of the Casal stock assessment platform, rewritten with an improved design and user interface

Wide range of features relevant for tuna assessments

However, its strengths and features fall slightly short of Gadget 3 for the purposes of this scoping project

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Upcoming development project

Development project proposal to be **submitted to SC22**, as a key outcome from the scoping project

As an initial estimate, the development project could be launched as a three-year project from 2027 to 2030, with an annual budget of $200,000. This would allow:

$50,000 per year for workshops and smaller development subprojects, in the same manner as the current scoping project; and

$150,000 per year to divide between the development options that will be prioritized.

A preliminary recommendation from the scoping project is to have the development project pursue primarily two work streams:

- ▶ DTU spatio-temporal model
- ▶ IATTC designed tuna model

DTU spatio-temporal model

New collaboration between SPC and statisticians at the Technical University of Denmark (DTU), Tobias Mildenberger and Anders Nielsen

A workshop was conducted in Copenhagen in May 2025, focusing on the fitting a spatio-temporal model for analyzing WCPO skipjack tagging data

Following a similar DTU spatio-temporal model that has been used to analyze EPO skipjack tags, producing abundance indices that were used in the 2024 EPO skipjack assessment

Upcoming development project

IATTC designed tuna model

Scoping project has reached out to IATTC regularly to discuss future software for tuna assessments

In the latest round of discussions in July 2025, Mark Maunder proposed an initial design of a platform that could be developed for tuna assessments:

- New codebase in RTMB that will be relatively small, easy to modify and extend

- Keeping it simple, just focusing on the priority needs of tuna assessments

- Random effects, useful for allowing processes to vary in time and possibly between regions

Online CAPAM workshop in December 2025 on the model design and a development plan

$\Rightarrow$ Small Informal Working Group discussion at SC21

General plan

1990s – 2024   *The past.* SPC uses MULTIFAN-CL for all tuna and billfish assessments

2025 – c2030   *The interim period.* SPC uses a combination of MULTIFAN-CL and Stock Synthesis for tuna and billfish assessments

c2030 – onward   *The future.* SPC starts replacing some of the MULTIFAN-CL and Stock Synthesis assessments with new software

The year 'c2030' is a placeholder; the exact year is not important

General plan

Year	Skipjack	Yellowfin	Bigeye	Albacore	Swordfish	Striped marlin
2025	MFCL				SS3	SS3
2026		MFCL	MFCL			
2027				MFCL/New[2]		
2028	MFCL/SS3/New[1]					
2029		MFCL/SS3/New	MFCL/SS3/New		SS3/New	SS3/New
2030				MFCL/New[2]		

1: Skipjack tags could be analyzed externally using the DTU spatio-temporal model before 2028, producing abundance indices for the MFCL/SS3/New stock assessment platform.

2: Albacore CKMR data could be incorporated in a New stock assessment platform, most likely in 2030.

https://github.com/PacificCommunity/ofp-sam-transition-plan