



Pacific
Community
Communauté
du Pacifique

Scoping the next stock assessment platform

Stage I: Reaching out to tuna RFMOs and the scientific community

Arni Magnusson, Nick Davies

SPC Online Workshop

13–16 May 2024

Meeting Objectives

Communicate *project 123, explorations, decisions, development*

Discuss *succession plans, admb, multifan-cl, stock synthesis*

Seek Advice *insights, opinions, experiences, predictions, ideas*

Seek Collaboration *tuna RFMOs, research labs*

Meeting Schedule

- ⇒ 0:00–0:20 Introduction
- 0:20–0:30 **Platforms** currently used in tuna stock assessments (presentation, round table)
- 0:30–0:50 **Common challenges** for all tuna RFMOs, **longevity** of Stock Synthesis and MULTIFAN-CL, **succession plans** (round table)
- 0:50–1:00 SPC challenges and **project plan** (presentation)
- 1:00–1:10 **Features** of current and future platforms (presentation)
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Who Are Here Today?

People with expertise in

- ▶ Tuna
- ▶ Stock assessment
- ▶ Software development

What is your main line of work?

What part of your work is related to tuna/stock assessment/software development?

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Platforms currently used in tuna stock assessments

| | | |
|-------|----------------------------|--|
| ICCAT | Atlantic | Stock Synthesis , JABBA, one-off models |
| IOTC | Indian | Stock Synthesis for all stocks? |
| IATTC | Pacific, Eastern | Stock Synthesis for all stocks? |
| SPC | Pacific, Western & Central | MULTIFAN-CL for all stocks |
| CCSBT | Southern bluefin tuna | sbt , designed around CKMR |

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Round Table

- ▶ Common challenges for all tuna RFMOs
- ▶ Longevity of Stock Synthesis and MULTIFAN-CL
- ▶ Succession plans

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SPC Challenges

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

Quick turnover rate of stock assessment staff

Takes many years to become an expert in MFCL, John typically makes the main modeling decisions and guides new staff, with the help of Nick

We must prepare for an era where there might be no long-term staff, only short-term

Project P123

Scoping the next tuna stock assessment software

Project scheduled 1 Feb 2024 to 31 Dec 2026

This initial project 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 tRFMOs and research labs to achieve these goals

Additional projects can be launched in parallel to power up the model exploration and software development

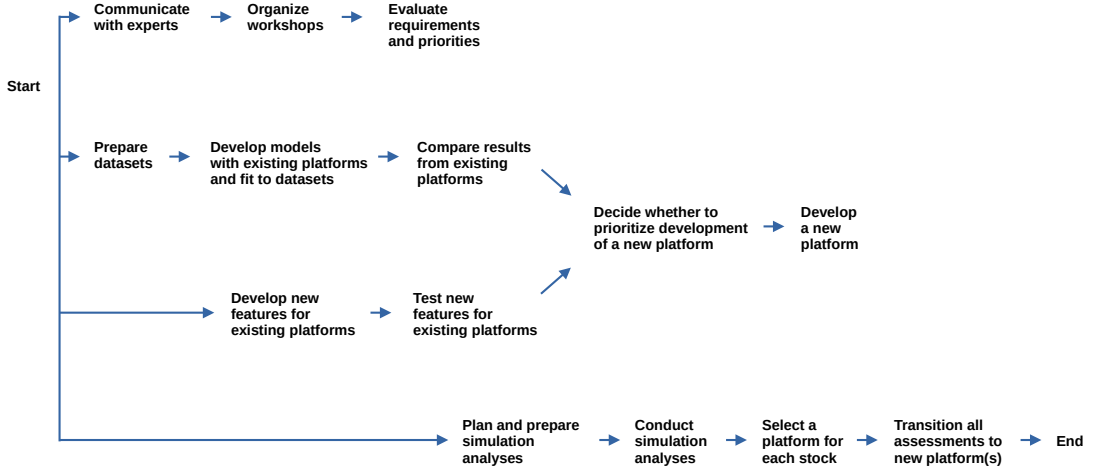
Project Plan

2024

1. Review and identify important model features for tuna assessments
2. Identify existing platforms that have these features or can be extended
3. Reach out to and initiate collaboration with model developers
4. Conduct two workshops in 2024, one online and one in person

2025–2026

5. Explore and compare existing platforms, fitting to SPC tuna data
6. Determine which platforms can be considered viable candidates
7. If a viable platform has been identified, plan transition
8. If no viable platform is identified, launch a development project to extend a platform or create a new one



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Tuna Models, Regions and Tags

Presentation by Nick Davies, SPC

Features of Current Platforms (CAPAM 2019)

| | Stock Synthesis | MULTIFAN | GADGET | SAM | Casal2 |
|---|------------------|------------------|------------------|------------------|------------------|
| <hr/> | | | | | |
| Issue is fairly well understand and best practices are understood | | | | | |
| Scalable from data-rich to data-poor | Yes | Yes | Yes | No | Yes |
| Age-length dynamics | No ¹ | No | Yes | No | No ¹ |
| Estimate data weights (index, composition and tagging) | Yes ² | Yes ³ | Yes ⁴ | Yes | Yes ⁵ |
| State-space formulation | No ⁶ | No | No | Yes | No ⁶ |
| Generate expected values of data | Yes | Yes | Yes ⁷ | Yes | Yes |
| Reference point calculation | Yes ⁸ | Yes ⁸ | Yes ⁷ | Yes ⁹ | No |
| Projections | Yes ⁸ | Yes ⁸ | Yes ⁷ | Yes | Yes |
| Several alternative models exist but the field has yet to identify best practices | | | | | |
| Spatial structure | Yes | Yes | Yes | No | Yes |
| New issue to most assessment analysts; methods under development | | | | | |
| Multiple stocks | No | Implicitly | Yes | No ¹⁰ | Yes |
| Close-kin genetics | No | No | No | No | No |
| Multispecies relationships | No | No | Yes | No | Yes |

(CAPAM 2019 paper)

Structural Features of Current Platforms

| Model | Random effects | Age | Length | Stock | Species | Sex | Area | Tag |
|-------------|----------------|-----|--|------------------------|------------------------|-----|------|-----------------------|
| Casal2 | N | Y | Platoons. Length-based in early development | Y | Y | Y | Y | Partly implemented |
| Gadget | N | Y | Y | Y | Y | Y | Y | Y |
| Multifan-CL | N | | N | Y | Y | Y | Y | Y |
| SAM | Y | Y | N | N | N | N | N | N |
| SS | N | Y | Platoons | As growth morph. | As growth morph. | Y | Y | Y |
| WHAM | Y | Y | N | N | N | N | N | N |

(CAPAM 2019 report)

Modifications Needed

Major modifications needed to turn existing general models into the NextGen SAM.

| Model | Changes | Practicality and potential |
|--------|---|--|
| SS | Recode in TMB to include random effects | Complete rewrite required |
| Casal2 | Implement Laplace approximation using the AD for higher level derivatives | Unclear, worth investigating |
| SAM | Increased functionality (e.g., length comp data, space) | Unclear, potential depends on application architecture |
| WHAM | Increased functionality | Unclear, potential depends on application architecture |
| Gadget | Recode in TMB | Complete rewrite required |

Features of Current and Future Platforms

Incorporating data

- ▶ Fit to length comps
- ▶ Fit to weight comps
- ▶ Fit to tagging data
- ▶ Fit to CKMR data
- ▶ Estimate growth curve using otolith data
- ▶ Utilize tag-recapture growth increment to estimate growth

Specifics

- ▶ Age-specific M
- ▶ Length-specific selectivity
- ▶ Sex-specific growth and M
- ▶ Region-specific growth

Dimensions

- ▶ Explicit regions with movement
- ▶ Tracking age and length in population
- ▶ Time steps within a year

Ecology

- ▶ Multispecies interactions
- ▶ Climate change

Implementation

- ▶ Random effects, state space
- ▶ Parallel computing
- ▶ Computation time

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State-Space Models

Deterministic

$$N_{t+1,a+1} = N_{t,a} \times e^{-(F_{t,a} + M_{t,a})}$$

State-space

$$N_{t+1,a+1} = N_{t,a} \times e^{-(F_{t,a} + M_{t,a} + \eta_{t,a})}$$

Recent and Ongoing Development

ALSCL state-space tracking age-length

Fan Zhang, Noel Cadigan

FIMS age-structured case studies

NOAA

Gadget3 ported to TMB, has CKMR

Jamie Lentin, Bjarki Elvarsson, Will Butler

sbt ported to TMB, has CKMR

D'Arcy Webber, Rich Hillary

SS+ckmr CKMR module for SS

André Punt, CSIRO

SS+tag tagging module for SS

Nicholas Ducharme-Barth, Arni Magnusson

SAM+length fitted to length comps

Colin Millar, Anders Nielsen

WHAM+length fitted to length comps

Giancarlo Correa, Tim Miller

Pathways to a State-Space Model for Tuna Assessments

| Starting point | Add features |
|----------------|---|
| ALSCL | catch data, tags, regions, CKMR |
| Casal2 | state space, CKMR |
| FIMS | state space, fit to length comps, regions, CKMR |
| Gadget3 | state space |
| sbt | regions |
| SS | state space, tags, CKMR |
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Possible Trajectories for SPC Assessments

If commitment and funding is limited, then the following unwanted outcome, characterized by a lack of progress, could well occur...

Upcoming assessments:

2024 MFCL with config changes, other platform(s) did not work well, workshop

2025 MFCL with config changes, other platform(s) did not work well, workshop

2026 MFCL without config changes, other platform(s) did not work well, workshop

2027 MFCL without config changes, other platform(s) did not work well, workshop

2028 MFCL without config changes, other platform(s) did not work well, workshop

2029 MFCL without config changes, other platform(s) did not work well, workshop

2030 MFCL without config changes, other platform(s) did not work well, workshop

Possible Trajectories for SPC Assessments

| 2024 | | Interim | | 2030s |
|------|---|---------|---|---------|
| MFCL | → | [none] | → | NextGen |
| MFCL | → | SS+tags | → | NextGen |
| MFCL | → | Gadget3 | → | NextGen |
| MFCL | → | Casal2 | → | NextGen |

Next Steps

SPC would like to move two projects forward in parallel:

Transition to interim platform *ideally around 3 years*

Collaborate with Stock Synthesis, Gadget3, and Casal2 experts

Produce a model from each platform to fit an example tuna dataset

Decide which platform would be the best interim model

Transition assessments to interim platform(s)

Development of next-generation platform *as long as it takes :)*

Collaborate with ALSCL, FIMS, sbt, SAM, and WHAM experts

Produce a model from each platform to fit an example tuna dataset

Evaluate which platform looks most promising for tuna assessments

Participate in the development to ensure a next-gen platform meets tuna requirements

Possible Outcomes

will depend on:

Level of funding

Level 0 – Annual workshops, coordination

Level 1 – Hire one person for 5 years

Level 2 – Hire two people for 5 years

Partnerships

Tuna RFMOs – funding and scientists' time

Domain experts in state-space model development – scientists' time

Other funding sources

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