Scoping the next stock assessment platform

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

Arni Magnusson, Nick Davies

SPC international expert meeting (online)
13 May and 18 June 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)
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Who Are Here Today?

People with expertise in

- Tuna
- Stock assessment
- Software development

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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

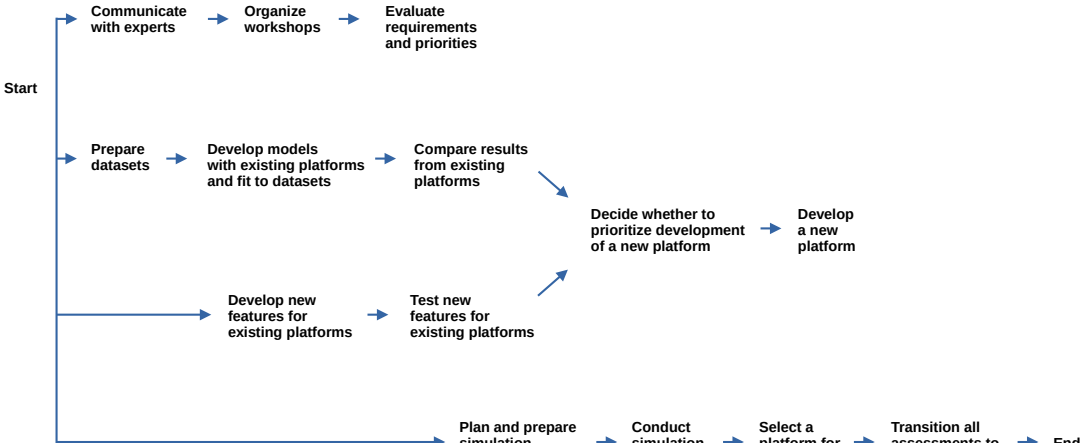
Project Plan

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 software development project to extend a platform or create a new one


Start
Communicate with experts
Organize workshops
Evaluate requirements and priorities
Prepare datasets
Develop models with existing platforms and fit to datasets
Compare results from existing platforms
Decide whether to prioritize development of a new platform
Develop a new platform
Develop new features for existing platforms
Test new features for existing platforms
Plan and prepare simulation analyses
Conduct simulation analyses
Select a platform for each stock
Transition all assessments to new platform(s)
End

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Tuna Models, Regions and Tags

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Presentation by Nick Davies, SPC

Features of Current Platforms (CAPAM 2019)

	Stock Synthesis	MULTIFAN	GADGET	SAM	Casal2
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

(CAPAM 2019 report)

Features of Current and Future Platforms

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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

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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	enhanced tag 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
SAM	fit to length comps, regions, CKMR
WHAM	fit to length comps, regions, 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	$\rightarrow$	[none]	$\rightarrow$	NextGen
MFCL	$\rightarrow$	SS+tags	$\rightarrow$	NextGen
MFCL	$\rightarrow$	Gadget3	$\rightarrow$	NextGen
MFCL	$\rightarrow$	Casal2	$\rightarrow$	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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