Center for the Advancement of Population Assessment Methodology

Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

CAPAM

NIWA
Taihoro Nukurangi

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INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

Tuna Stock Assessment Good Practices Workshop

Mark N Maunder and Simon D Hoyle

7-10 March, Wellington, New Zealand (IOTC-2023-WPTT25(DP)-14)

IATTC October Stock Assessment Workshop Series – First Workshop

- Recommended diagnostics for large statistical stock assessment models
- La Jolla, October 2 – 4. 2002
- Report: Shelton J Harley and Mark N Maunder

https://www.iattc.org/GetAttachment/fac01749-122c-46e7-a2e7-4aebb6dd7559/SAR-04_Recommended-diagnostics.pdf

IATTC October Stock Assessment Workshop Series – Topics

Topic	Year	Participants
Recommended diagnostics for large statistical stock assessment models	2002	10
Reference points for tunas and billfishes	2003	22
Developing indices of abundance from purse-seine catch and effort data	2004	27
Stock assessment methods	2005	36
Management strategies	2006	32
Using tagging data for fisheries stock assessment and management strategies	2007	41
Spatial analysis for stock assessment	2008	37
Modelling population processes	2009	43
Integrating movement information from tagging data into stock assessment models	2011	NA
Including Oceanography in Fisheries Stock Assessment and Management'	2011	NA

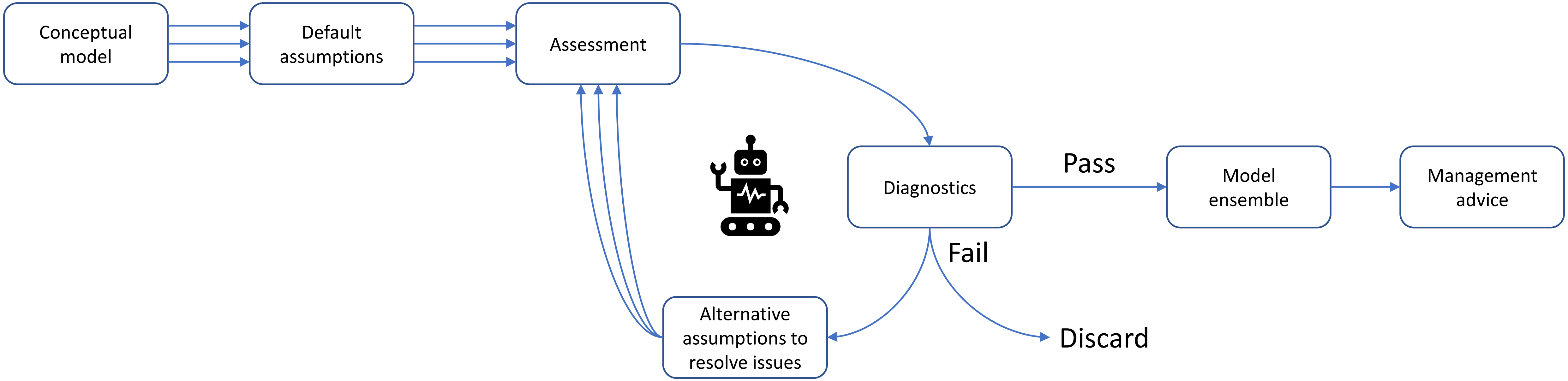
The founding of CAPAM: 2012

- Paul Crone, SWFSC
- Brice Semmens, SIO UCSD
- Mark Maunder, IATTC

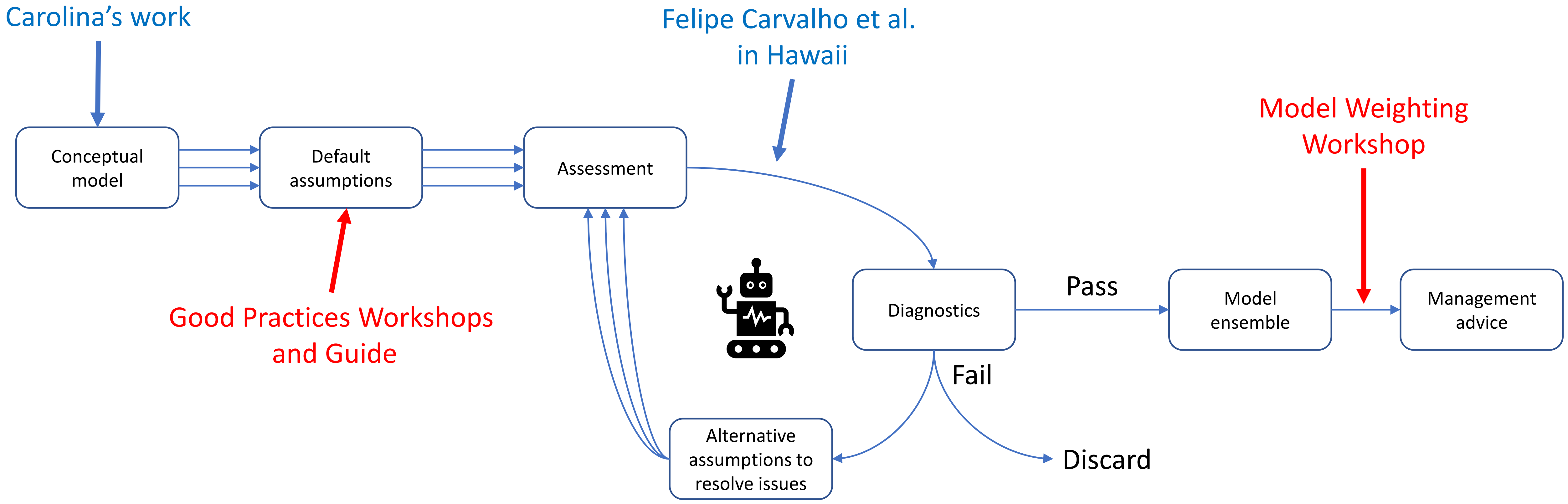
CAPAM workshops and special issues – Topics

Topic	Date	Location	Chair	In person participants	Special Issue
Selectivity	2013	San Diego	Maunder	65	Yes
Growth	2014	San Diego	Maunder	100	Yes
Data Weighting	2015	San Diego	Maunder	NA	Yes
Recruitment	2017	Miami	Sharma/Porch	95	Yes
Spatial stock assessment models	2018	San Diego	Maunder	NA	Yes
Spatio-temporal modelling	2018	San Diego	Maunder	NA	Yes
Next Generation Stock Assessment Models	2019	New Zealand	Hoyle	82	Yes
Natural Mortality	2021	Virtual	Hamel	Virtual	Yes
Diagnostics	2022	Virtual	Maunder	200+ Virtual	No
Good Practices	2022	Rome	Maunder		Yes
Model weighting	2022	Virtual	Maunder		No
Tuna Good Practices	2023	Hybrid	Maunder		No

Expert system to construct an ensemble of models for fisheries stock assessment



Expert system to construct an ensemble of models for fisheries stock assessment



Key concept

Key concept of CAPAM workshops

Discussion

Tuna Stock Assessment Good Practices Workshop

- CAPAM, NIWA, and ISSF
- Hybrid Meeting
- Wellington, New Zealand
- 7-10 March 2023

Speakers

Topic	Keynotes/commenters
Identifying stock structure	Carolina Minte-Vera + Brad Moore
	Steve Cadrin
Purse seine species comp and size data	Tom Peatman + Abascal, Kaplan, Duparc
	Cleridy Lennert-Cody
Longline size data	Simon Hoyle + Tom Peatman
	Kaisuke Satoh
Weight-length, maturity, conversion factors	Jed Macdonald + Simon Nicol
CPUE	Toshi Kitakado + Nicholas DB
	Laura Tremblay-Boyer
Tag data and modelling	Dan Goethel + Matt Vincent
	Rich Hillary
Recruitment	Andre Punt
	John Hampton
Natural mortality	Hoyle + Maunder + Williams + C M-V
	Kai Lorenzen
Growth	Lisa Ailloud
	Kai Lorenzen
Modeling selectivity/fishery structure	Maunder
	Dan Fu
Data weighting and process variation	Nicholas Fisch
Modelling stock structure	Aaron Berger
Model diagnostics	Felipe Carvalho
	Jim Ianelli
Model weighting	Max Cardinale
	Philipp Neubauer
	Nicholas DB
	Daithi Stone
Overview	Ray Hilborn

Recordings of the Tuna Good Practices Workshop

https://capamresearch.org/recordings-tuna-stock-assessment-good-practices-workshop

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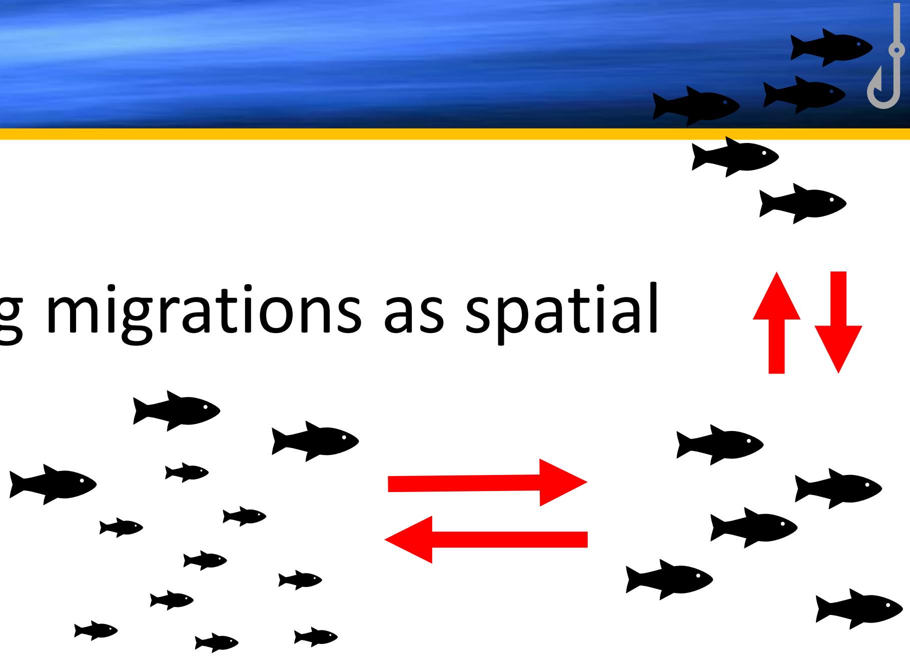
Chair’s Views on Tuna Good Practices

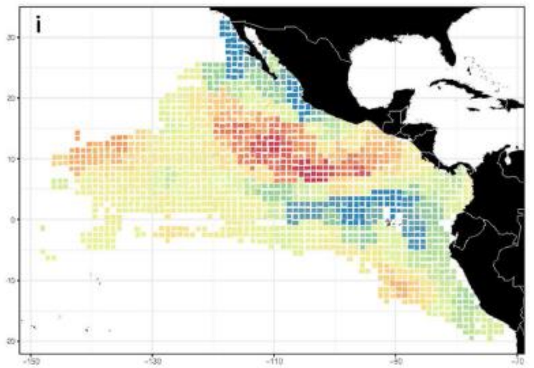
- Based on
  - Final summary and discussions at the Tuna GP Workshop
  - Rome Good Practices Workshop
  - Tuna Good Practices Workshop
  - Experience
  - Own opinions
- Will be more thoroughly investigated for final report
  - Presentations at Tuna Good Practices Workshop
  - Rome Good Practices Workshop
  - GP Special issue papers in Fisheries Research
  - Independent reviews of tuna assessments

Stock structure



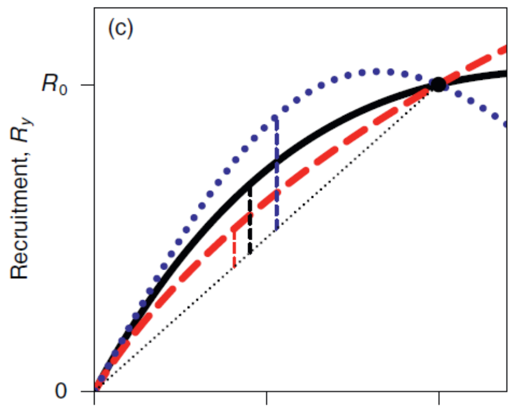
- Create a conceptual model
- Represent well documented spawning/feeding migrations as spatial models
- Either
    - Model isolated stocks (low interaction)
    - Using areas as fleets approach (high interaction)
- Tagging data is usually too problematic to use in integrated analyses and information on movement from length composition data is probably biased by spatial differences in growth rates
- Use analytical methods such as cluster analysis of the length composition data to identify potential fleets

CPUE Analysis



- CPUE standardization should be conducted over the area that is considered the whole stock (or sub-stock in a multi-area model)
  - Use a spatio-temporal model if the important covariates can be included.
  - Calculate the index by summing the product of the predicted CPUE and the size of the area for each spatial cell.
- Composition data for an index fishery should be generated by weighting by the cpue index and size of each spatial cell.
- An extraction fishery will have its own composition data, weighted by the catch.
- Index and fishery should have different selectivities
- The use of purse seine CPUE data for developing indices of abundance is questionable.

Recruitment



- Assume that recruitment is independent of stock size (i.e., h = 1)
- Put precaution in limit reference points
- Target reference points should not solely be related to YPR (i.e., MSY when h = 1) in cases where the fisheries select juveniles
- Autocorrelation should be ignored, the standard deviation fixed at a reasonable value, the bias correction ramp defined in Stock Synthesis applied.
- MSY calculations, projections, and other management quantity calculations should be based on average recruitment over a period where recruitment is estimated relatively precisely and is considered to represent the current or desired conditions.
    - Dynamic reference points that are based on the time series of estimated recruitments do not have this issue.

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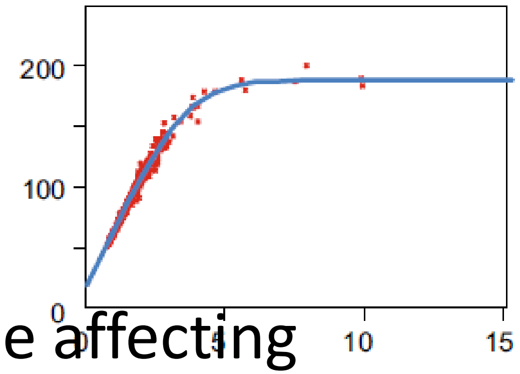
Natural Mortality

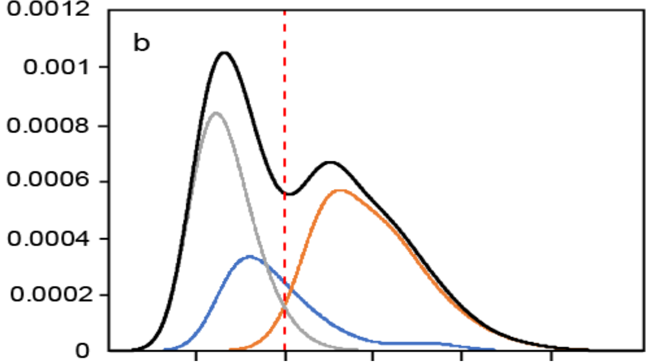
- Natural mortality should be modelled as a function of length using the Lorenzen relationship
- Estimate M for the old individuals using a prior based on maximum age
- Use maximum age from any stock of that species
- Consider using M estimated in spatio-temporal tagging models
- Until better information is available, assume M is the same for males and females (model growth as sex specific)

Growth

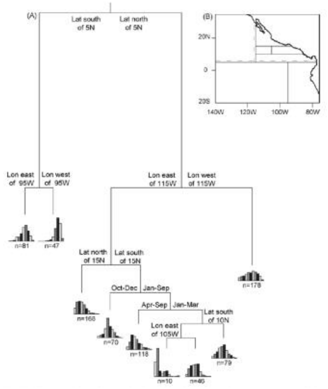
- Estimate growth inside the stock assessment model if you can
- Integrate age-length into the stock assessment as data conditional age-at-length to account for length-based sampling and length-based selectivity
- Length-increment data should be analyzed outside the model and the results used to create priors to include in the assessment model (until possible to include it in the model)
- Always analyze the data outside the model for comparison
- Use sex specific growth
- Need to consider spatial variation in growth and how it might be affecting the results.



Selectivity



- Different gear types or purse seine set types should be different fisheries
- Define areas as fleets by applying an analytical method such as clustering of length composition data to determine spatial or season structure

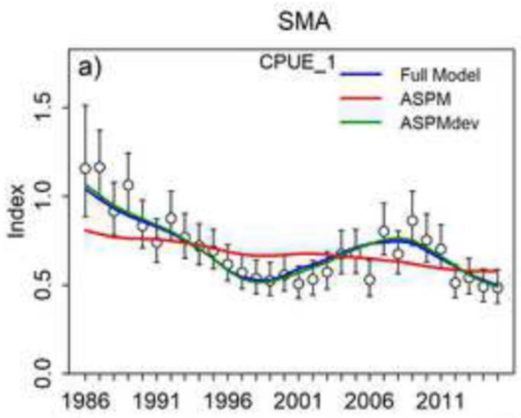


- Any deviation from a double normal shape, such as multiple modes, shoulders, long tails, implies further splitting is needed
- The model should be fit using double normal selectivity curves
- The empirical selectivity diagnostic should be applied.
- Time varying selectivity for fisheries should be considered.
- In the real world, selectivity almost always varies through time, and is non-asymptotic.

Model weighting

- Start with the conceptual model and create a set of hypotheses about the population and the general structure of the model.
- Use the good practices to turn the hypotheses into alternative stock assessment models.
- Use diagnostics to either reject or fix the models.
- Equal weight should be the default, but if model weighting is desired, then hindcasting a reliable index of abundance that is related to the management objectives (i.e., spawning biomass) could be used.
- The approach to diagnostics and model weighting should be set in advance and made transparent to ensure that subjective judgements are not used, including listing hypotheses that were not included because it was not practical to implement and test them (e.g., fine scale spatial models).
- Most model weighting is based on the hypotheses you choose to include, not what the diagnostics eliminate. Be realistic about the true uncertainty by including sufficient hypotheses. Use statistical methods (confounding) to run an efficient grid.

Data weighting



- **ASPM-Rdev for Index CV**: estimated additive component
- **Comp N from sampling design:** Estimate the sample size outside the model based on the sampling design and fix all model mis-specification and explicitly model the process variation.
- **Compare to multinomial:**
  - Compared input N with multinomial and the Francis approach.
  - If input N differs from multinomial and/or if multinomial differs from the Francis then the model is probably mis-specified or there is some unmodelled process variation and the model should be further investigated
  - If the model can't be improved then use the Francis method for fisheries with lots of data and the McAllister and Ianelli approach for the other fisheries
- **Down weight or drop bad data:** Down weight or remove the composition data and share selectivity
- **Remove outliers:** Remove few small (or large) fish

Process variation

- **Use random effects:** estimate variance
- **Fix variance:** Not all general models can implement random effects, so need to fix variance
- **Model correct process:** Care needs to taken to ensure that temporal variation is modelled in the correct process
- **Model time varying selectivity:** If temporal variation is modelled in natural mortality, it should also be modelled in fishery selectivity

- **Recruitment** – Yes
- **Fishery selectivity** –Probably (possibly time blocks)
- **Growth** – If have data
- **Natural mortality** – Maybe
- **Movement** - Rarely

Diagnostics

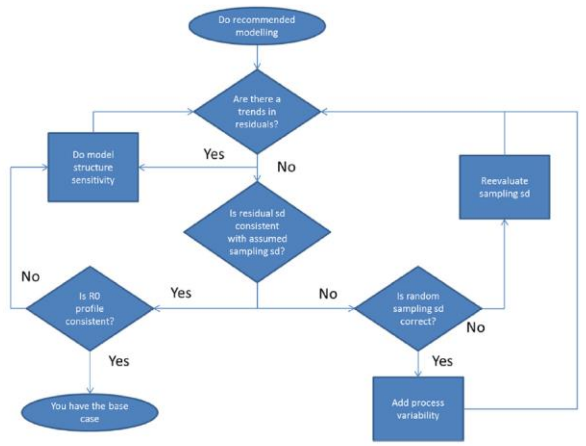
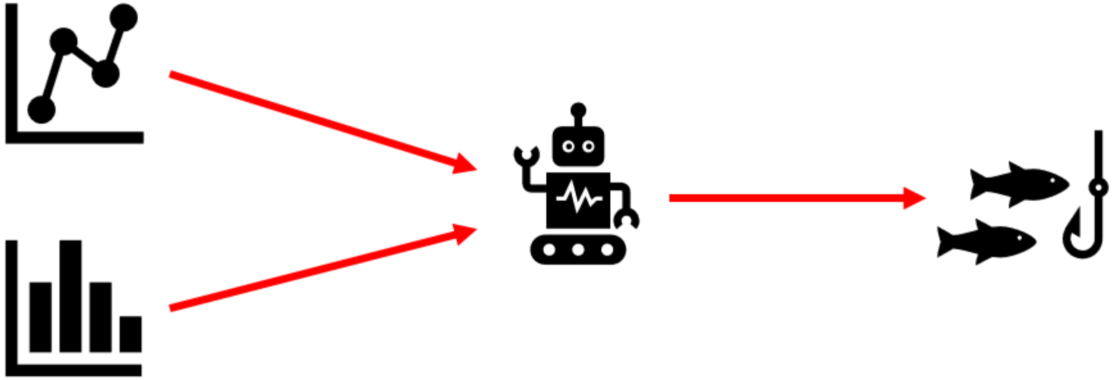


Fig. 5. Flow chart depiction of a simplification of the recommended modelling approach.

- Currently it is unclear
  - Which diagnostics are useful for evaluating models
  - What criteria should be used for each diagnostic
  - Which results from each diagnostic provide information about what is mis-specified.
- More research is needed



Tagging

- Tag mixing is an issue for most tuna stocks
- It is not advisable to integrate the tagging data into the stock assessment model
- Some form of fine scale spatio-temporal model is need to deal with non-mixing and make most use of the information contained in the data.
- Tag reporting, tag loss, and tagging mortality
  - Tagging programs should both minimize these or have experiments to estimate these quantities
- Research should be conducted to see how applicable CKMR is for tunas

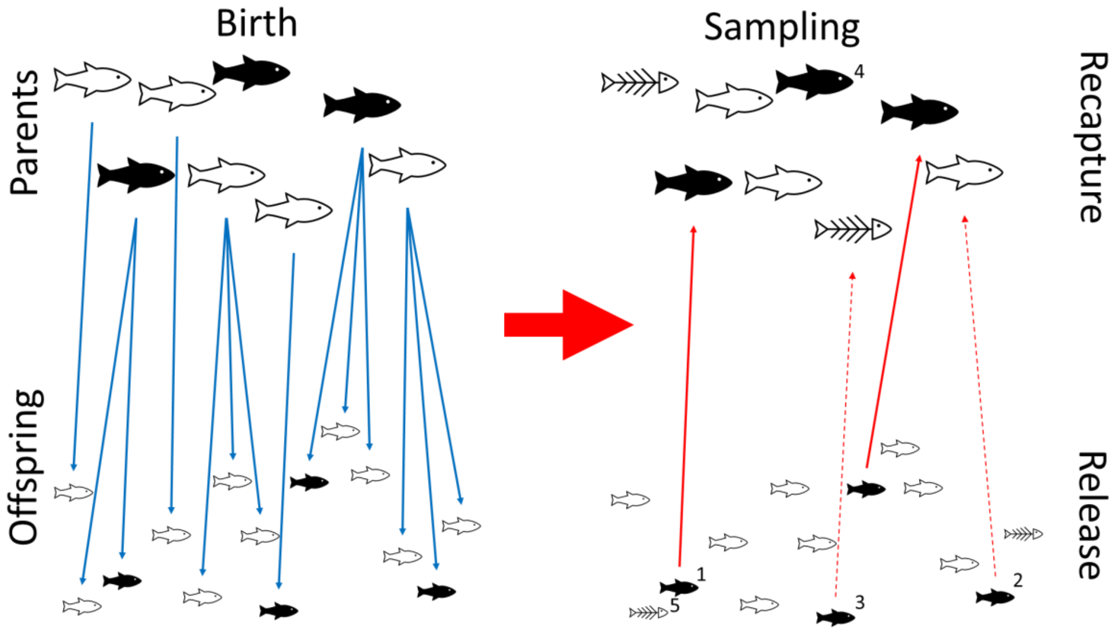
Size data, weight-length, conversion factors, …

- It's important that data that are reliable and match the assumptions in the model. If you don't understand or have confidence in a dataset, don't allow it to affect the model.
- The way selectivity is modeled in a fleet will affect the way you prepare size data.
- More important for size data to be reliable than to include data for the whole time series of a fleet.
- Weight-length relationships and conversion factors should be based on large collections from multiple fleets, periods, and locations.
- More research and data collection are needed.

The solution: Close-Kin Mark-Recapture

1. Stock structure
2. Adult natural mortality (survival)
3. Absolute spawner biomass estimates

- Still need to estimate
  - Juvenile abundance
  - Juvenile natural mortality
  - Stock-recruitment relationship
- Benefits
  - Can use dead fish so wider sampling coverage
  - No tag induced mortality
  - No tag loss
  - No misreporting
  - Larval and juvenile dispersal distributes the tags spatially



Bravington, Mark V., Peter M. Grewe, and Campbell R. Davies (2016). "Absolute abundance of southern bluefin tuna estimated by close-kin mark-recapture". In: Nature Communications 7.

Skaug 2001. Allele-sharing methods for estimation of population size. Biometrics 57, 750-756.

Hillary et al. 2018. Genetic relatedness reveals total population size of white sharks in eastern Australia and New Zealand. Scientific reports 8, 2661-2661.

Bravington et al. 2016. Close-Kin Mark-Recapture. Statistical Science 31, 259-274.

Summary: No BS GPG
https://www.youtube.com/watch?v=-58BuJVU5B4

- Fisheries
  - Separate by gear
  - Define fisheries based on regression tree analysis of composition data using area, season, and possibly year
- CPUE
  - Standardize CPUE and composition data using spatio-temporal models
  - Create index and composition data using area weighting
  - Weight index composition data using CPUE not catch
  - Treat index and catch composition separately in the assessment model
- Growth
  - Estimate growth within the stock assessment model
  - Use a flexible growth curve   Sex specific
  - Model time varying growth if there is adequate data
  - Deal with spatial variation by modeling separate populations (or in specific cases using age specific selectivity) until spatial structure and movement is understood.
- Selectivity
  - Fisheries
    - Remove fish at the right age/size
    - Use dome shape selectivities
    - ~~Use flexible selectivity curves (e.g. spline, random walk)~~
    - Use time varying selectivities for fisheries
    - Refine fisheries to remove weird selectivities (e.g. bimodal)
  - Index
    - Standardize CPUE and associated composition data using spatio-temporal models
    - Use asymptotic time-invariant functional forms if possible
- Natural mortality   Lorenzen
  - Use age and ~~sex-specific~~ natural mortality
  - Estimate inside the stock assessment model
  - Use the proxies as priors with prediction uncertainty

Max age

- Recruitment
  - Assume recruitment is independent of stock size except in specific situations (e.g. low fecund species, very low population size)
  - Use random effects if feasible
  - Otherwise
    - Fix Rsd at a reasonable value and use penalized likelihood
    - Adjust the bias correction appropriately
    - Average the over the desired years for management quantities
- Data weighting
  - Assign effective sample size and CVs based on sampling error
    - Bootstrap compositions
    - Fit ASPM-Rdev for index
    - Include correlations with a multivariate (log-)normal if needed
  - Model process variation and fix model misspecification
- Process variation
  - Which processes
    - Recruitment
    - Selectivity (fisheries)
    - Natural mortality (possibly)
    - Growth (time series of age-length data)
  - Use random effects/state-space models if practical otherwise use penalized likelihood and fix sd
  - Only model autocorrelation if you need it for prediction/projection (e.g. catch quotas in short lived species)
- Diagnostics
  - Start with good practices model
  - Use algorithm to eliminate model misspecification   Needs research
  - All models must pass diagnostics
- Data limited
  - Use integrated model (unless MSE shows otherwise)
- Close-Kin Mark-Recapture
  - Implement ASAP

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