INTERNATIONAL PACIFIC HALIBUT COMMISSION

Considerations when integrating multiple stock assessment models

Allan Hicks & Ian Stewart

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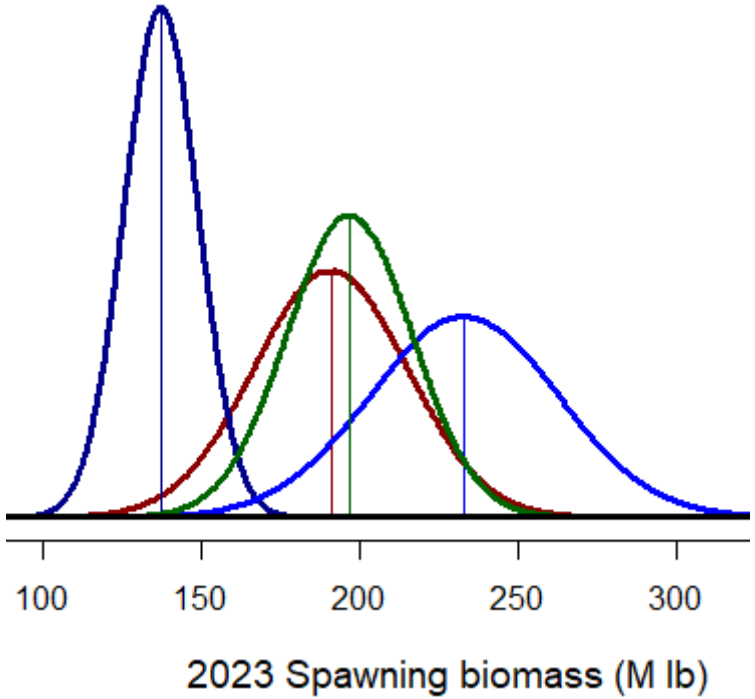
International Pacific Halibut Commission

- Formed in 1923
- Two parties (US & Canada)
- Many “ages” of stock assessment
  - Clark. 2003. Model for the world.
- New models often created to fix poor performance that appeared over time

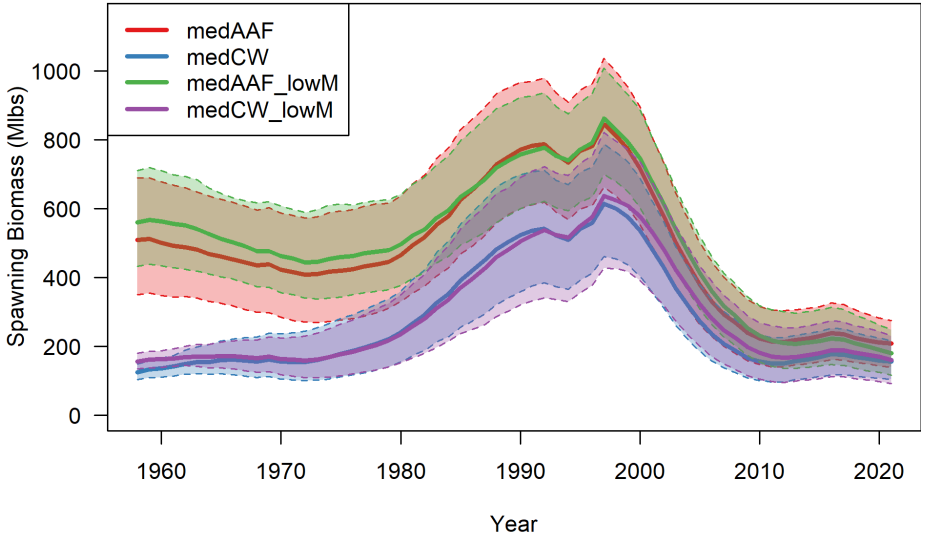
IPHC stock assessment

- Have used ensembles since 2012
- Current assessment is an ensemble of 4 SS models
  - 2 treatments of length of data
  - 2 treatments of fleet structure
- Weighted equally



IPHC MSE operating model

- Have used ensembles since 2019
- OM integrates 4 models
  - Multi-region model
  - 2 treatments of fleet structure
  - 2 treatments of M
- Weighted equally



Integration of models

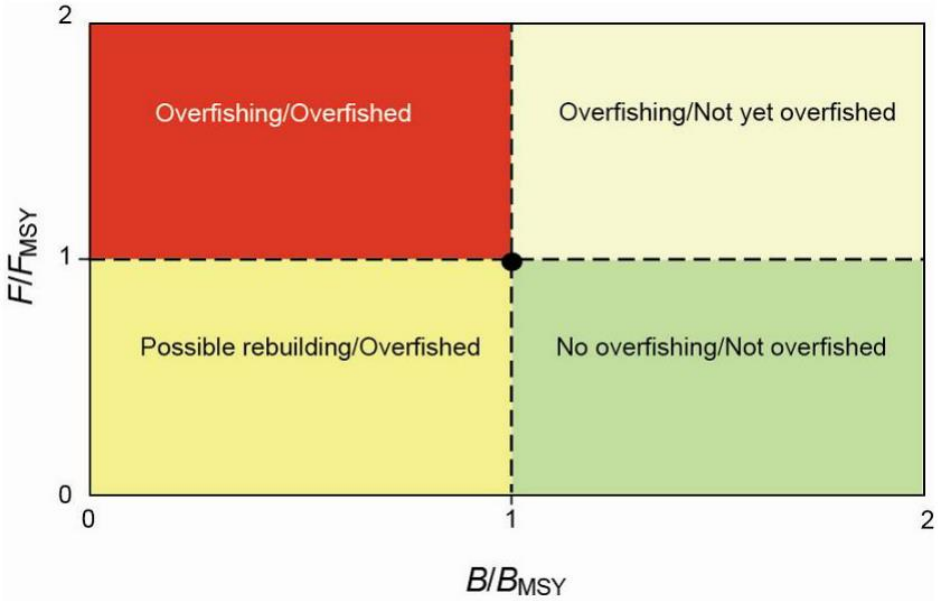
- Use the delta-MVN approach
  - Stock assessment
    - Estimated and derived parameters
    - Direct sampling, covariance not often needed
    - Many, many draws to provide precise quantiles
  - MSE
    - Sampling of parameters with covariance matrix
    - Create derived history from sampled parameters
    - Simulate multiple projected trajectories

Why do methods matter

- A method is used to supply certain quantities & metrics
  - Medians, means, etc
  - Appropriately characterize uncertainty
  - Various statistics may not need full distribution
  - Probabilities of exceeding a threshold require full distribution
- The method used may not match other methods
  - The ratio of medians is not the median of ratios
- A consistent approach for your needs is important

Hypothetical example: some background

- Overfished and overfishing are definitions of a harvest strategy
- Actions may occur when a stock is classified in either

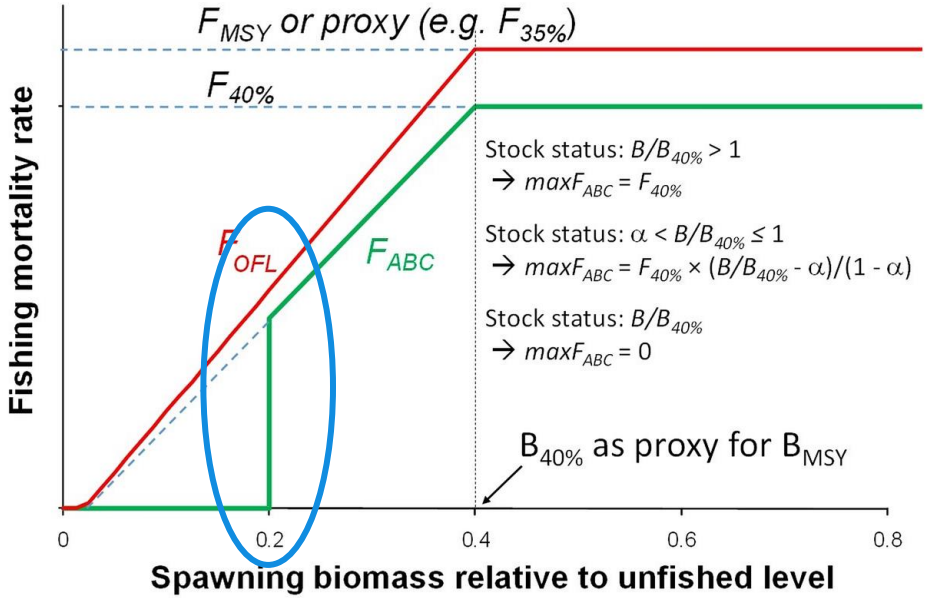


Kobe III, July 2011, Document K3-008
https://www.tuna-org.org/Documents/TRFMO3/K3-008%20ENG%20Addressing%20overfishing.pdf

Hypothetical example: more complexity

- The overfishing limit (F_{OFL}) may be defined by a sloping control rule
- When a stock is overfished, no directed fishery is allowed
  - Likely go into rebuilding

Example HCR for Bering Sea/Aleutian Islands
https://www.npfmc.org/wp-content/uploads/BSAIfmp.pdf



Kvamsdal et al 2016
https://doi.org/10.12952/journal.elementa.000114

Hypothetical example: When to apply averaging

	Model1	Model2	Ensemble
Status	15%	23%	19% Below limit
Option 1 F_{OFL} (average first)	0	0.02	0.01 Fishing allowed
Option 2 F_{OFL} (average ensemble outputs)	NA	NA	0 No fishing due to HCR

Apply HCR before averaging

Apply HCR to averaged quantities

Considerations: When to calculate

- Some quantities are dependent on the “stock assessment”
  - The status of the stock
  - The level of fishing mortality
  - Ensemble provides a median/mean and uncertainty
- Applying the HCR before integrating may produce inconsistencies
- However, each model in an MSE is a particular state

Considerations with stock assessment

- Incorporate within model variability, especially when distributions are different
  - However, models with fixed parameters may underestimate variability
- Appropriate metrics to characterize the ensemble distribution
  - For example, multi-modal ensemble
  - May be useful to characterize models at extremes
- Enough Monte Carlo draws to provide consistent metrics

IPHC decision table

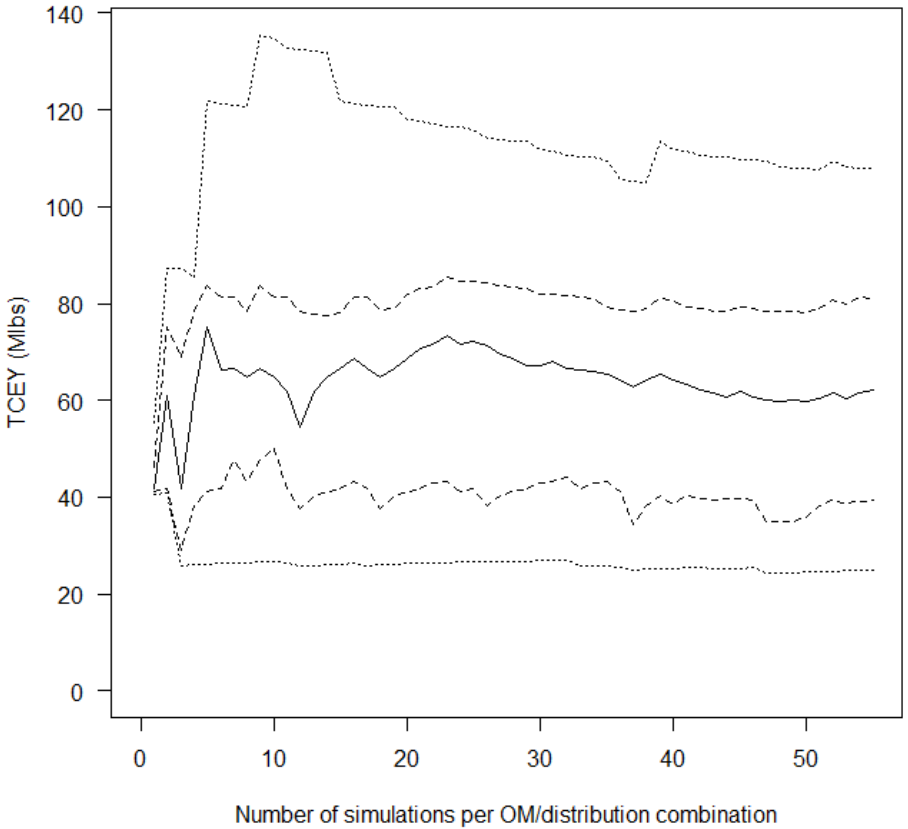
2023 Alternative					*Status quo*	3-Year Surplus				*Reference* $F_{43\%}$			
Total mortality (M lb)			0.0	31.3	42.5	44.3	48.1	49.8	51.5	52.3	55.1	57.1	59.1	61.3
TCEY (M lb)			0.0	30.0	41.2	43.0	46.8	48.4	50.2	52.0	53.8	55.8	57.8	60.0
2023 fishing intensity			$F_{100\%}$	$F_{59\%}$	$F_{50\%}$	$F_{48\%}$	$F_{46\%}$	$F_{45\%}$	$F_{44\%}$	$F_{43\%}$	$F_{42\%}$	$F_{41\%}$	$F_{40\%}$	$F_{39\%}$
Fishing intensity interval			--	37-71%	29-63%	28-62%	26-59%	25-59%	24-58%	24-57%	23-56%	22-55%	21-54%	21-53%
Stock Trend (spawning biomass)	In 2024	Is less than 2023	<1	20	49	53	63	67	71	75	79	83	86	89
		Is 5% less than 2023	<1	2	13	15	22	25	28	31	35	39	43	47
	In 2025	Is less than 2023	<1	18	46	50	60	64	68	72	76	80	83	87
		Is 5% less than 2023	<1	6	24	28	36	40	44	48	52	57	62	67
	In 2026	Is less than 2023	<1	20	46	50	60	63	67	71	75	79	82	85
		Is 5% less than 2023	<1	10	31	35	43	47	51	55	59	64	68	72
Stock Status (Spawning biomass)	In 2024	Is less than 30%	25	25	25	25	25	25	25	25	25	25	25	25
		Is less than 20%	<1	<1	1	1	1	1	2	2	2	2	3	3
	In 2025	Is less than 30%	18	25	25	25	25	25	25	25	25	25	25	25
		Is less than 20%	<1	<1	1	2	3	3	4	4	5	6	6	7
	In 2026	Is less than 30%	6	23	25	25	25	25	25	25	25	25	25	25
		Is less than 20%	<1	<1	2	3	4	5	6	6	7	9	10	11
Fishery Trend (TCEY)	In 2024	Is less than 2023	0	17	28	31	38	41	45	50	55	59	64	69
		Is 10% less than 2023	0	11	26	27	32	35	38	42	46	51	55	60
	In 2025	Is less than 2023	0	15	28	30	37	41	45	50	55	60	66	71
		Is 10% less than 2023	0	11	26	27	32	35	38	42	47	52	57	62
	In 2026	Is less than 2023	0	14	28	30	37	41	46	51	56	62	67	72
		Is 10% less than 2023	0	10	25	27	32	35	39	43	48	53	58	64
Fishery Status (Fishing intensity)	In 2023	Is above $F_{43\%}$	0	19	29	31	38	42	46	50	54	59	63	68

Considerations with MSE

- Individual trajectories for each model
  - Same projected random processes
    - Reduce possible random influence from a single model
  - Each model uses same random numbers in each projection
    - Have not had to integrate with unequal weights
- Effective sample size
  - A trajectory from a single model is not a single random sample
  - Variability in projected random quantities
- A large sample size would likely reduce any concerns
  - Characterize uncertainty in projections appropriately

Running quantiles

- IPHC MSE integrates
  - Four models
  - Five distribution procedures
- Therefore, 20 trajectories have same projected random processes
- Found out that 500 simulations was not enough

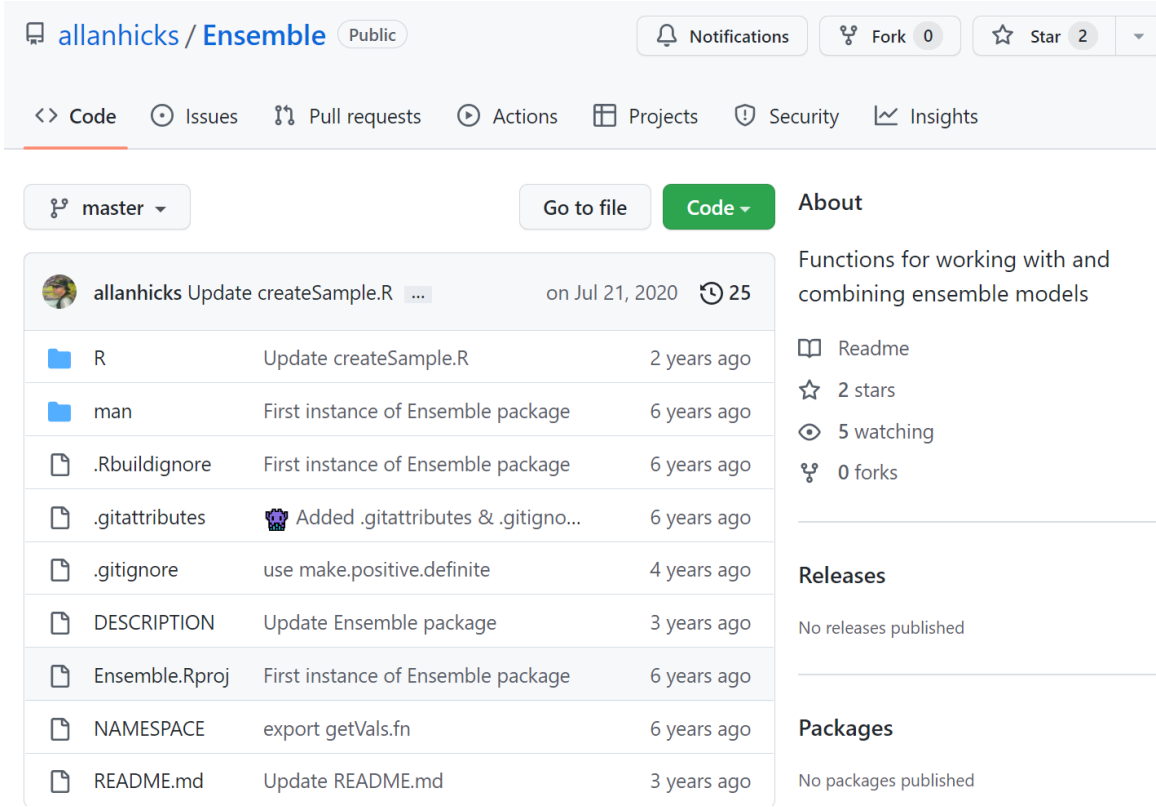


Ensemble R package

- Similar to the delta-MVLN method
  - Uses normal (asymptotic) distributions for each parameter
- Can integrate subsets of parameters over multiple SS models
- Can sample from truncated distributions
- Can sample with or without covariances
- Will attempt to make covariance matrix positive definite
- Hope is to generalize it for any ADMB model

Ensemble R package on GitHub

- GitHub repository
- Example
  - Read in SS models
  - Combine with Ensemble
  - Calculate metrics



devtools::install_github("allanhicks/Ensemble")

Future of the ensemble R package

- Could use improvement and development
- Has been useful at IPHC
  - Would this be useful to others?
- Collaboration is welcomed
  - Could incorporate ideas used by others

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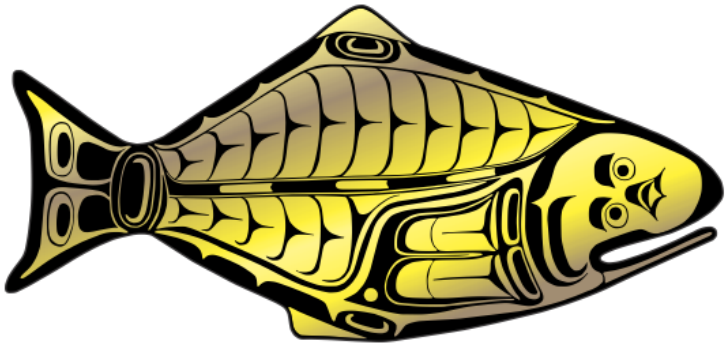

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