Fisheries Management in an Uncertain Future: Using Management Strategy Evaluation to Assess Robustness of Harvest Guidelines to Changing North Pacific Albacore Tuna Productivity and Distribution

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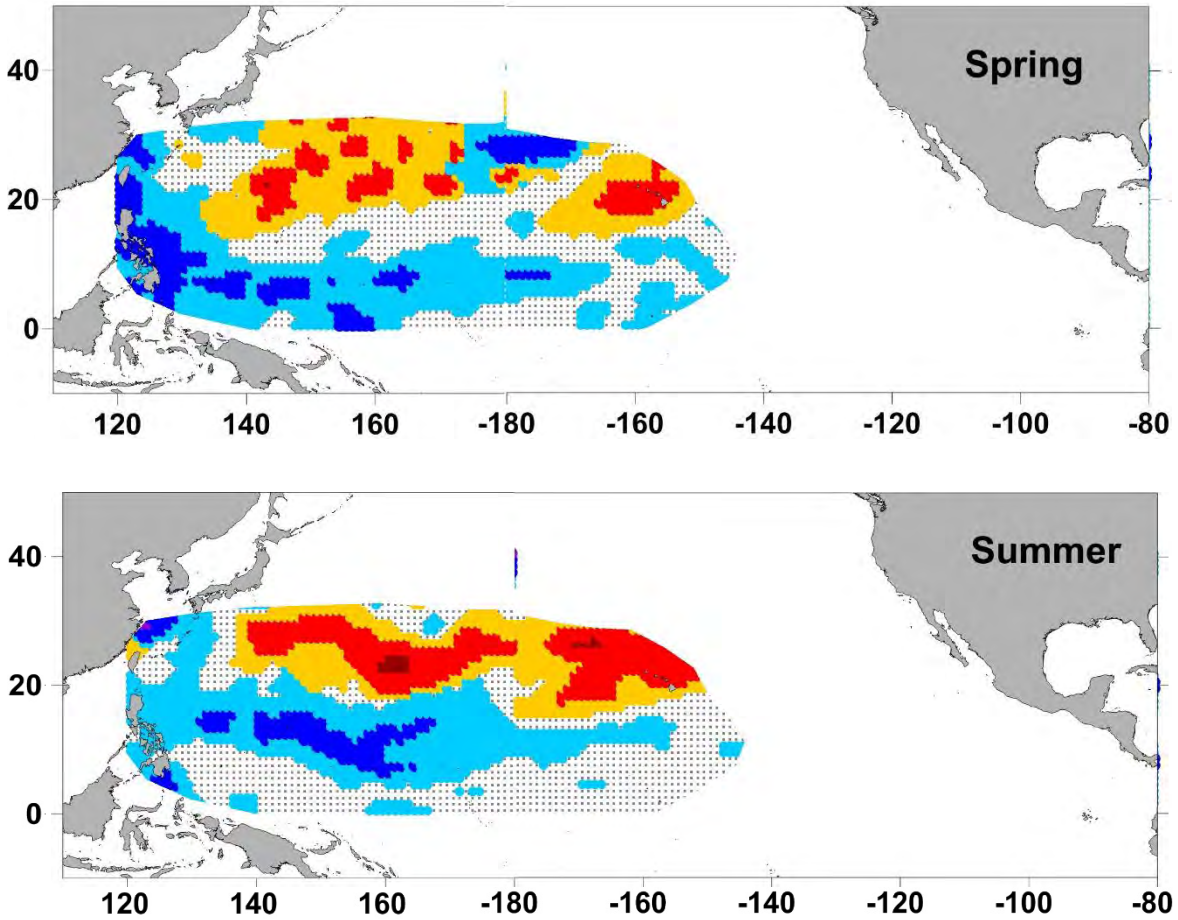
North Pacific Albacore Ecology

Highly migratory species whose habitat spans the entire North Pacific Ocean

Video from http://svs.gsfc.nasa.gov/3821, NASA/Goddard Space Flight Center Scientific Visualization Studio

Temperature and Recruitment

Spatial correlations between Reynolds SST and recruitment (1993-2012)

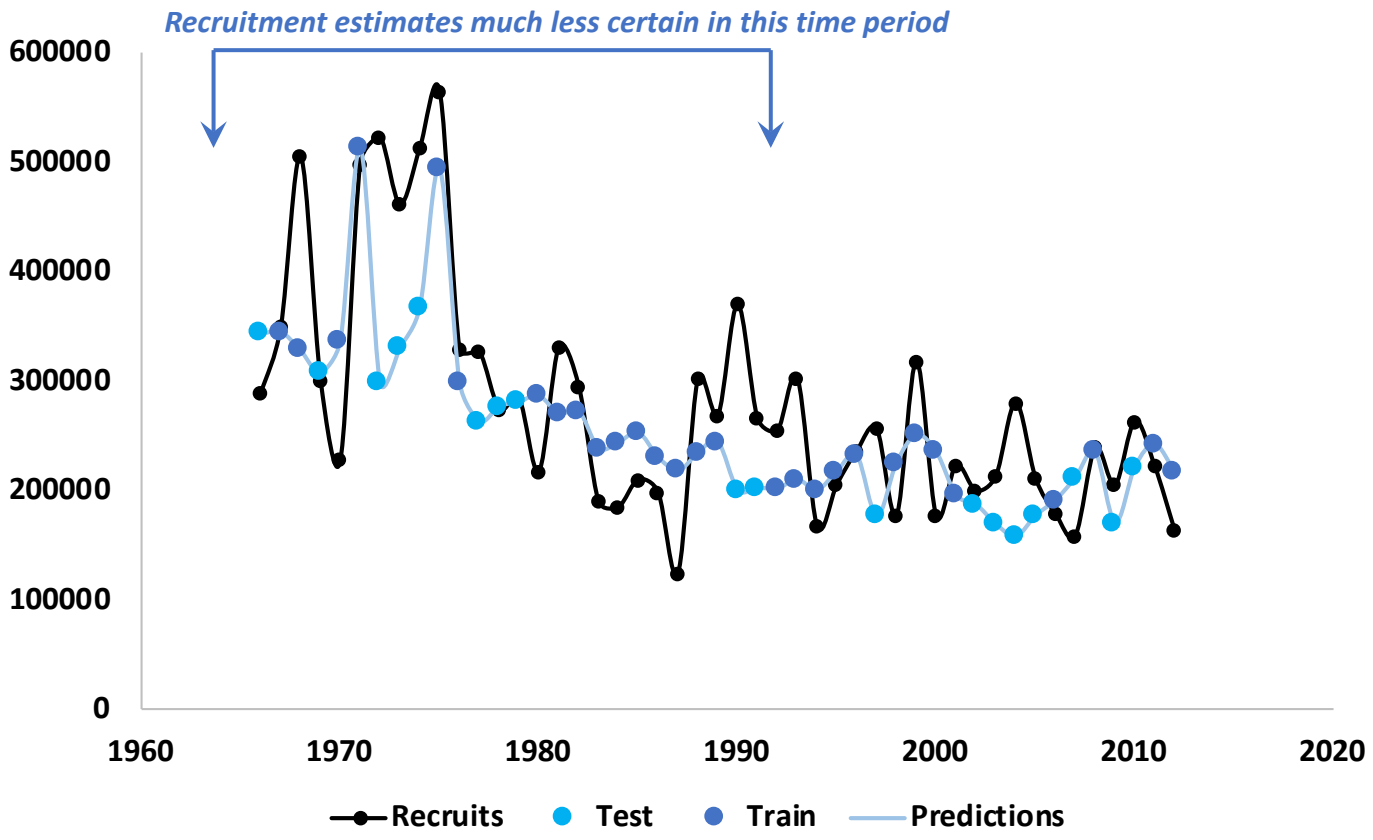


Cooler temperatures in subtropics and warmer temperatures in temperate latitudes associated with stronger recruitment

Muhling et al., in prep

Temperature and Recruitment

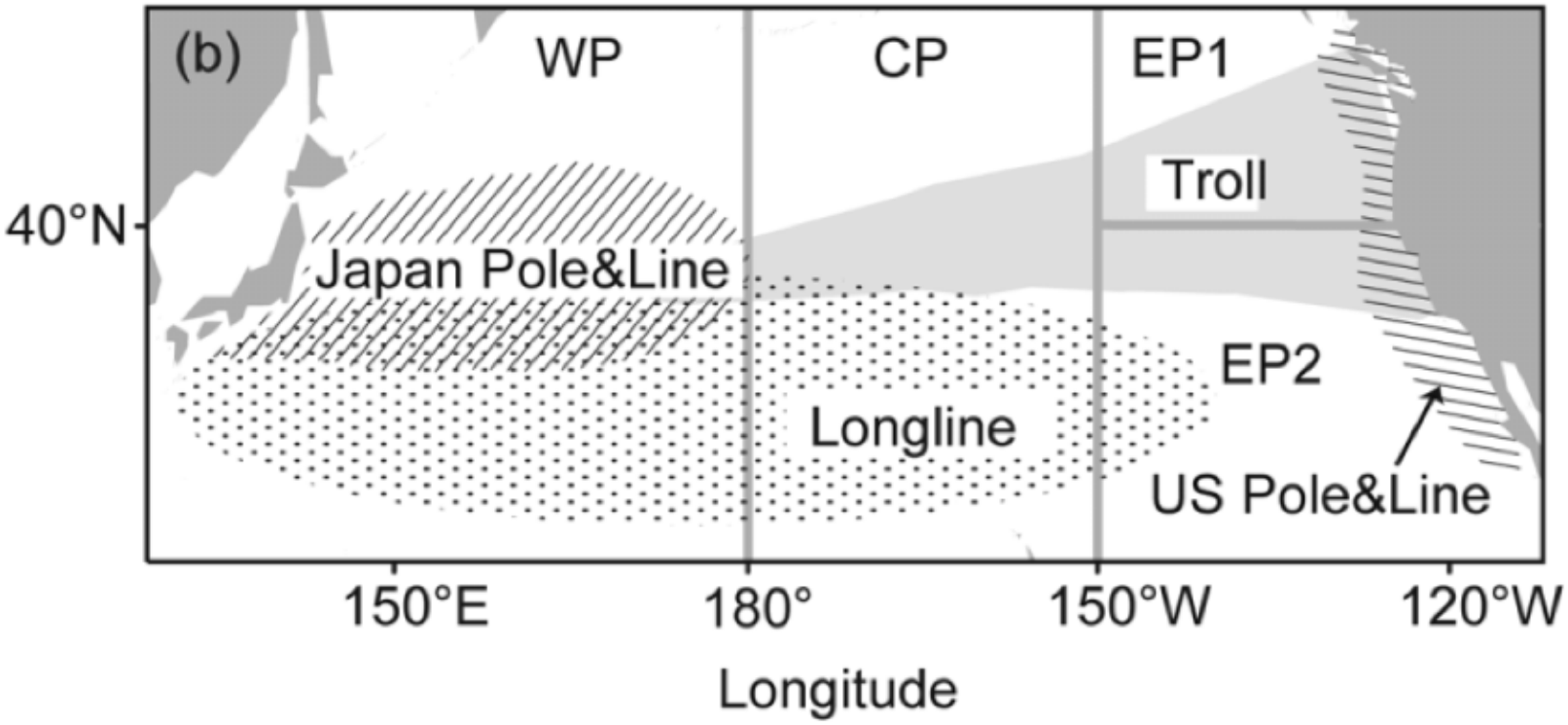
- Generalized Additive Model of recruitment from SSB, SST anomalies, PDO, ENSO
- Stronger recruitment at higher SSB / cooler SSTs but model skillful **only** when 1970s were included
- Random variability and decadal cycles in recruitment
- May be partially driven by temperature variability, but correlations are weak



Muhling et al., in prep

North Pacific Albacore Fisheries

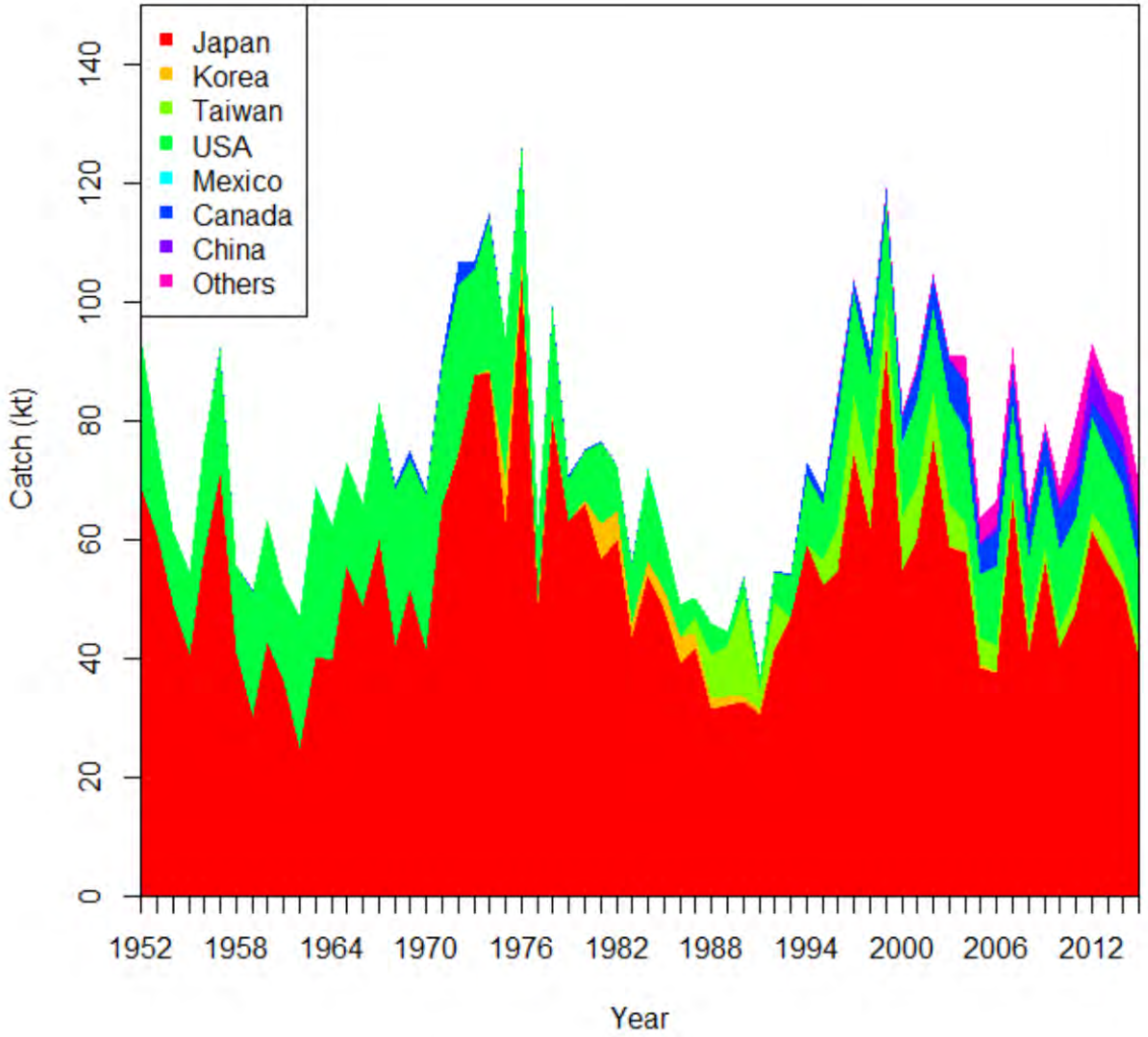
Fisheries include longline largely targeting adults and surface gears targeting juveniles



Ichinokawa et al. 2008, Canadian Journal of Fisheries and Aquatic Sciences

North Pacific Albacore Fisheries

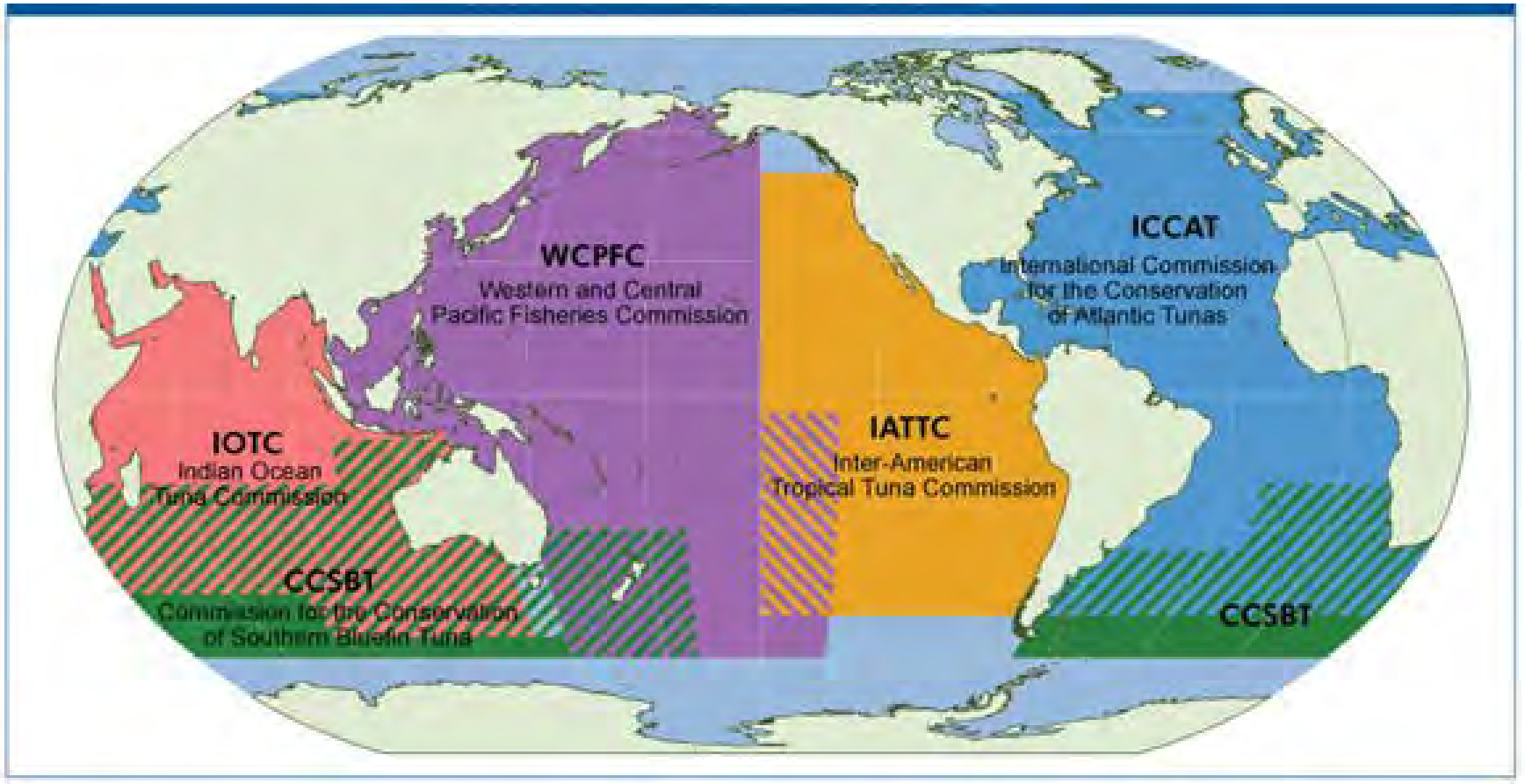
Majority of the catch occurs in the Western Pacific



ISC 2017 NPALB Stock Assessment

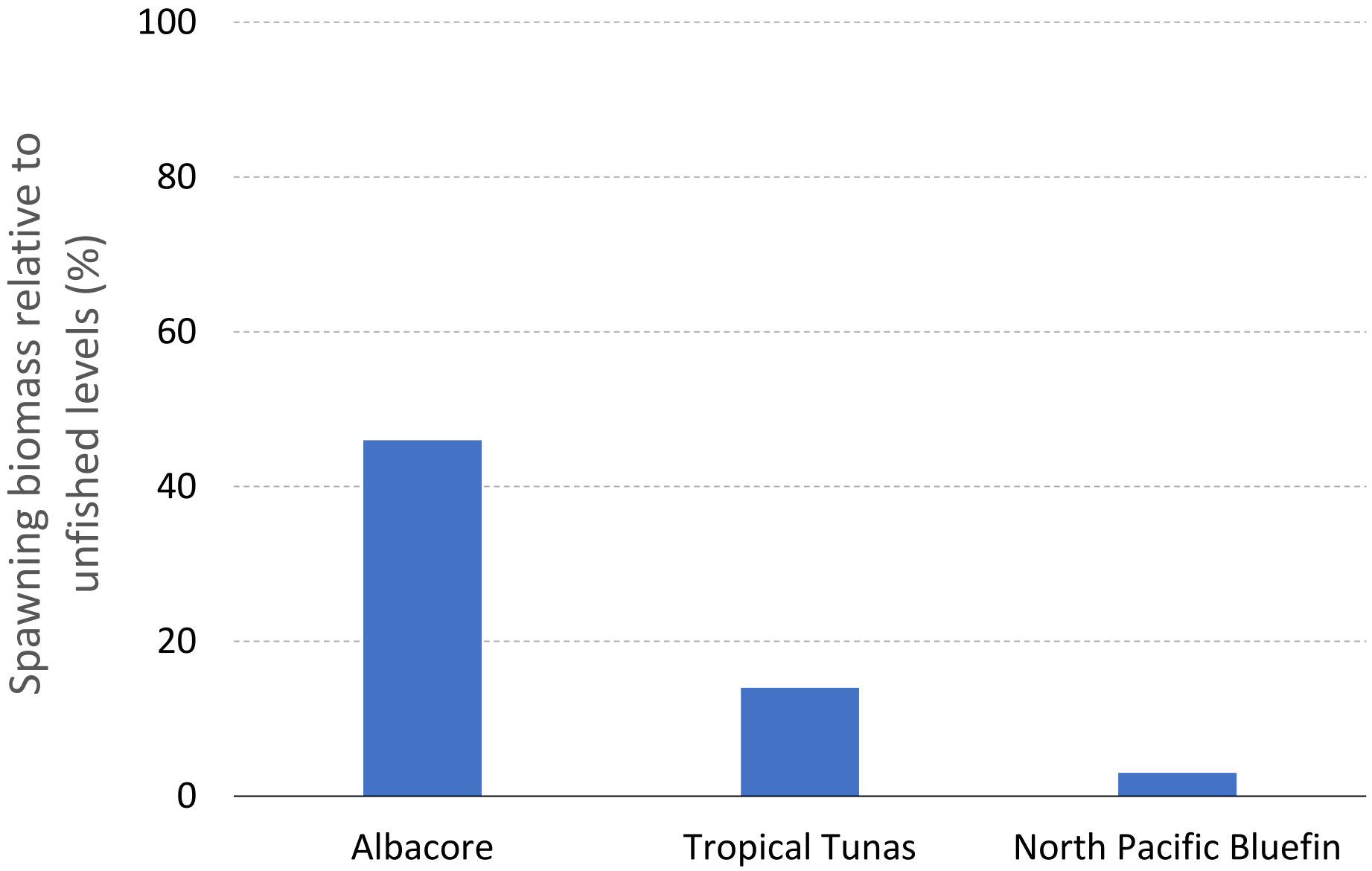
North Pacific Albacore Management

Managed by two Regional Fisheries Management Organizations, WCPFC and IATTC



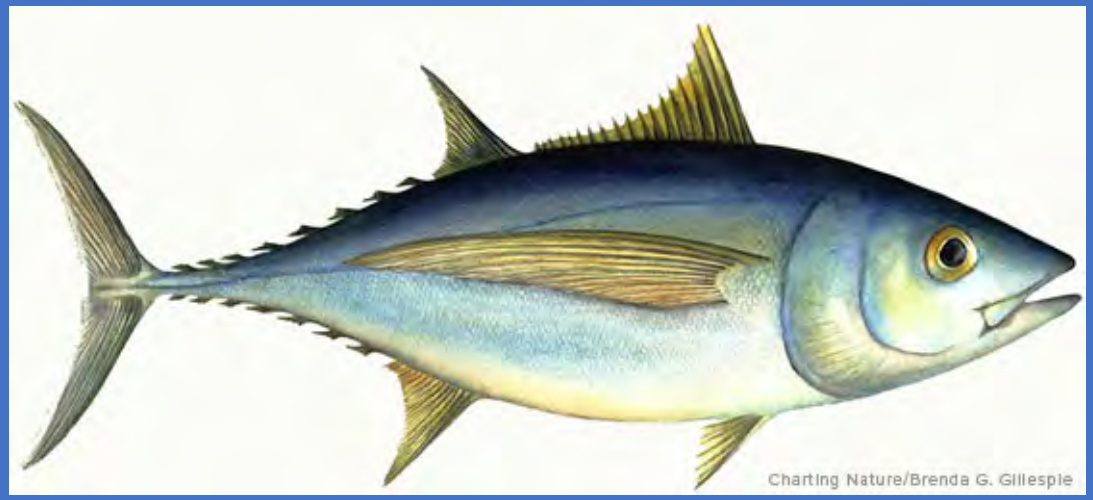
http://www.pewtrusts.org

North Pacific Albacore Stock Status



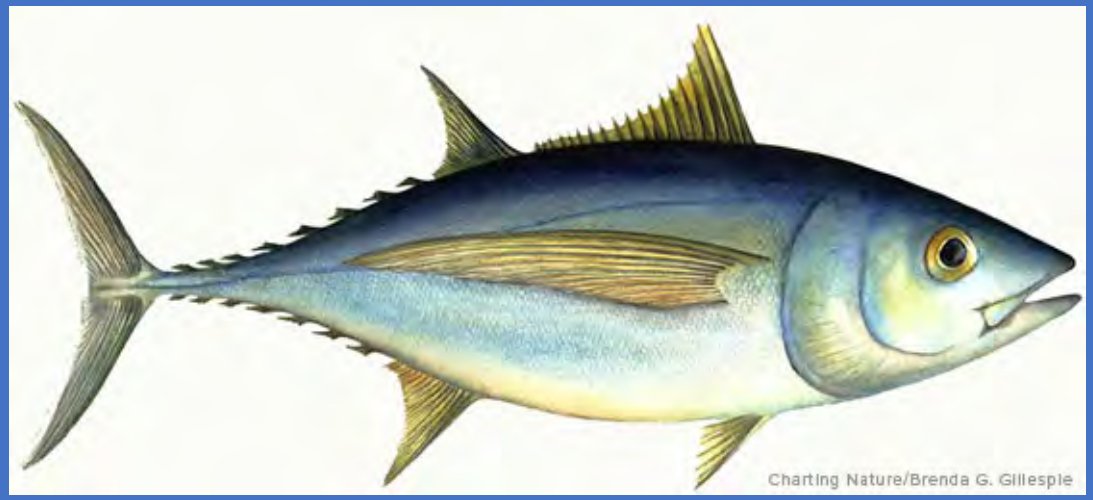
North Pacific Albacore Management Strategy Evaluation

Use MSE to examine performance of alternative management strategies and reference points for North Pacific albacore given uncertainty



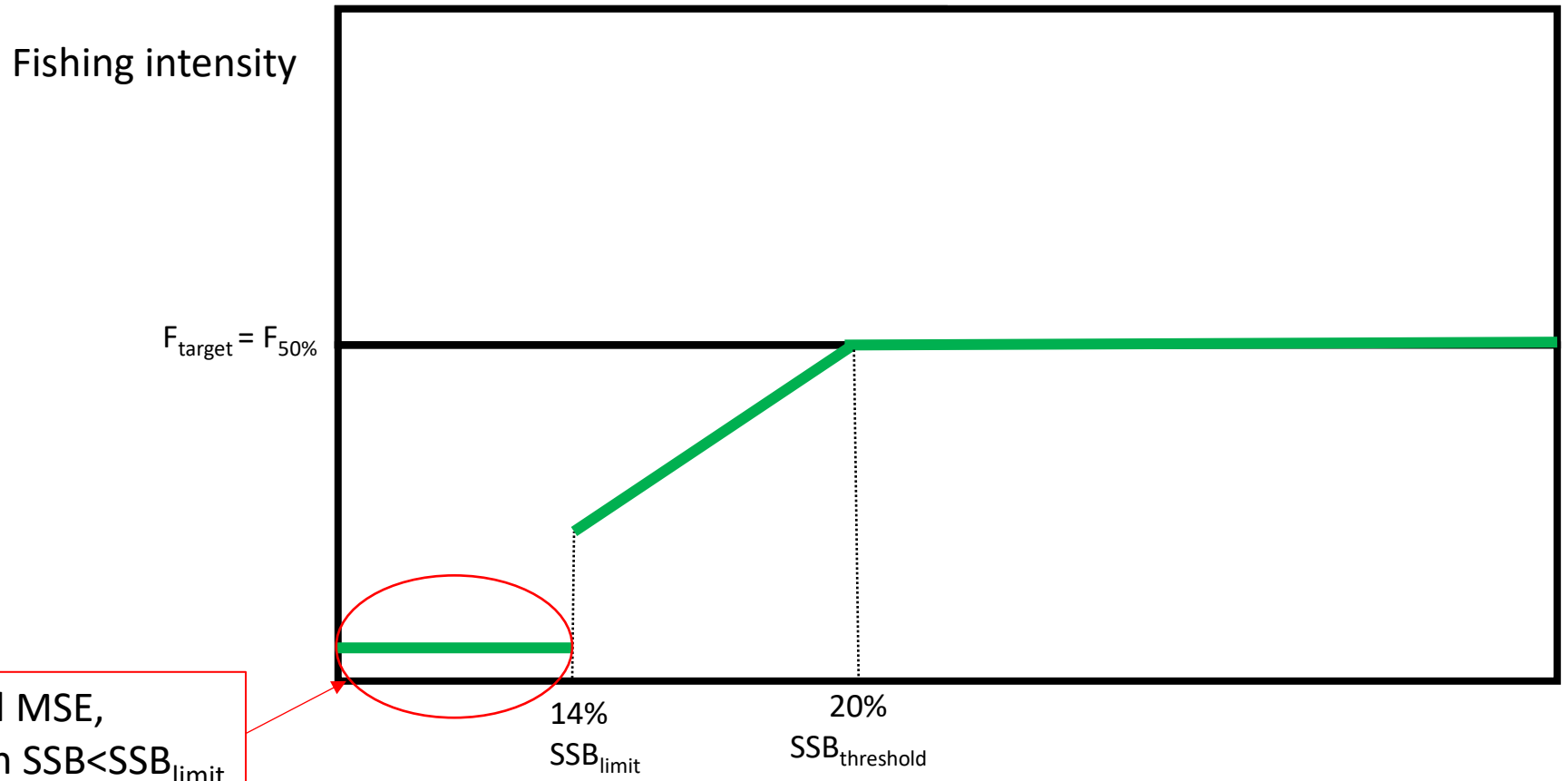
North Pacific Albacore MSE

Examine performance of alternative management strategies and reference points for North Pacific albacore given uncertainty



North Pacific Albacore MSE

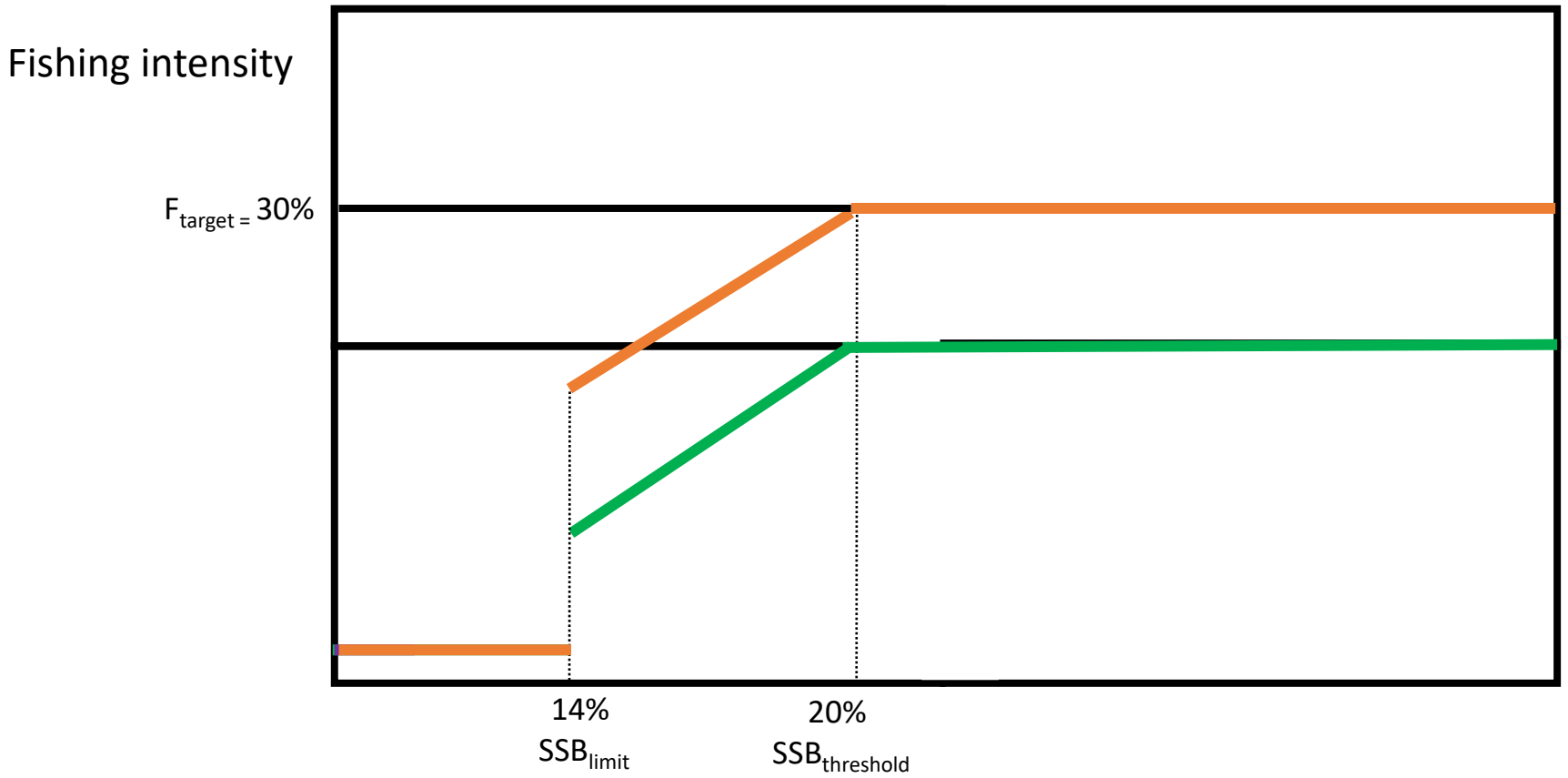
Example harvest control rule



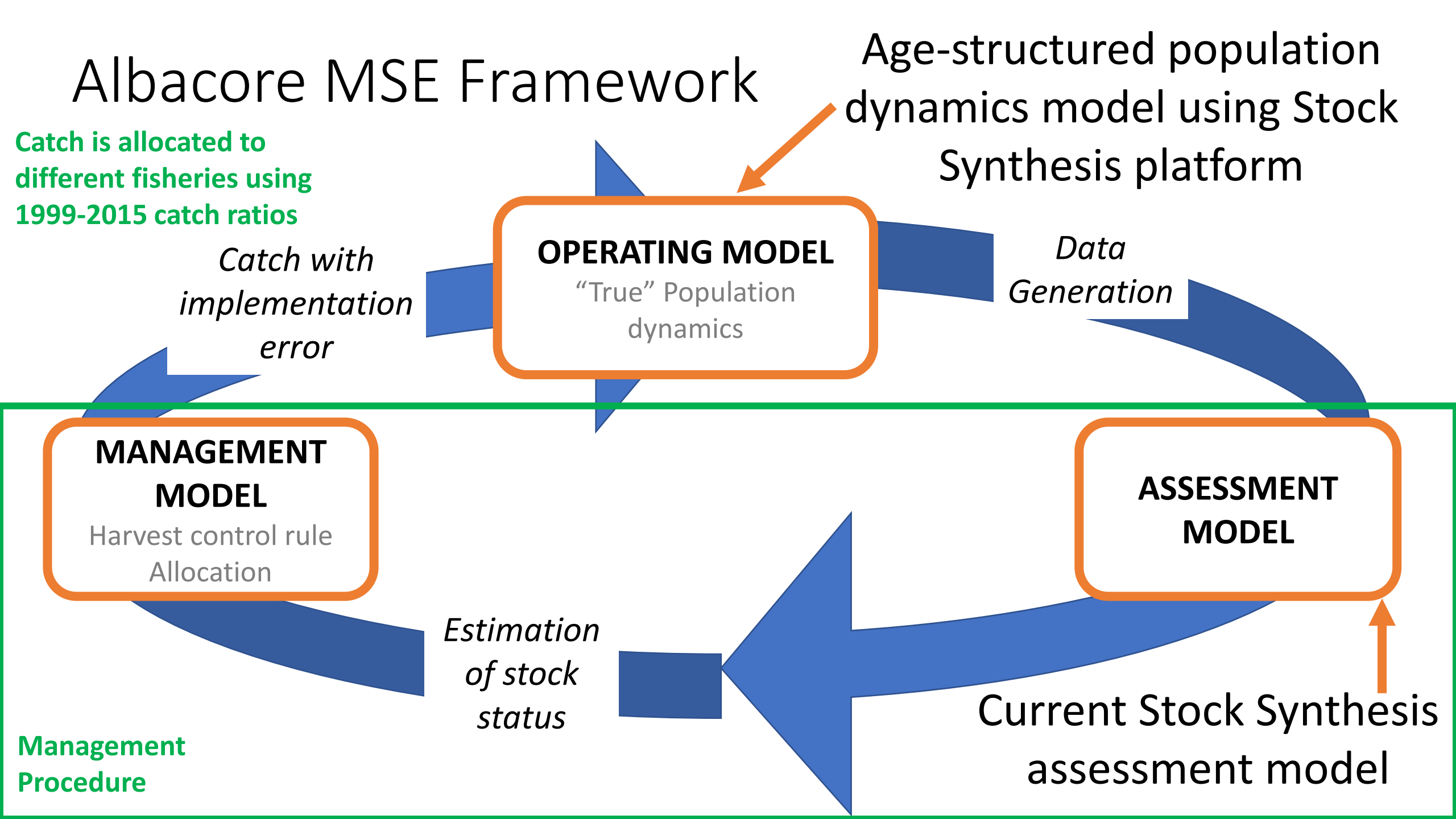
For initial MSE,
F=0 when SSB<SSB_{limit}

North Pacific Albacore MSE

Example HCRs

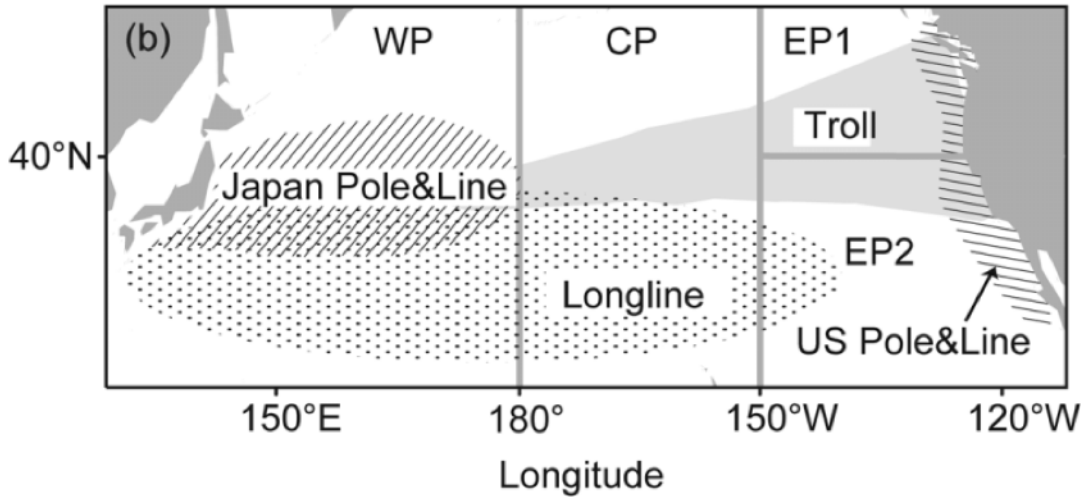


Albacore MSE Framework

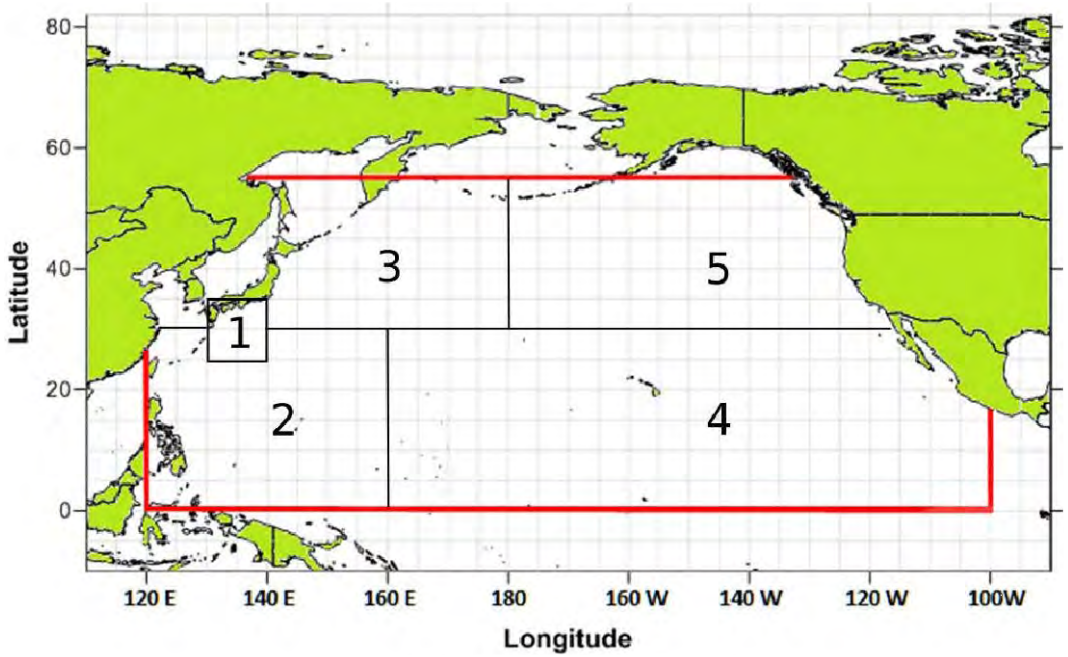


Fisheries

- Catch is dependent on population size as well as selectivity
- 29 fleets account for differences in selectivity by gear, area, and season
- EPO surface fleet has time varying age selectivity to account for random variability in juvenile migration



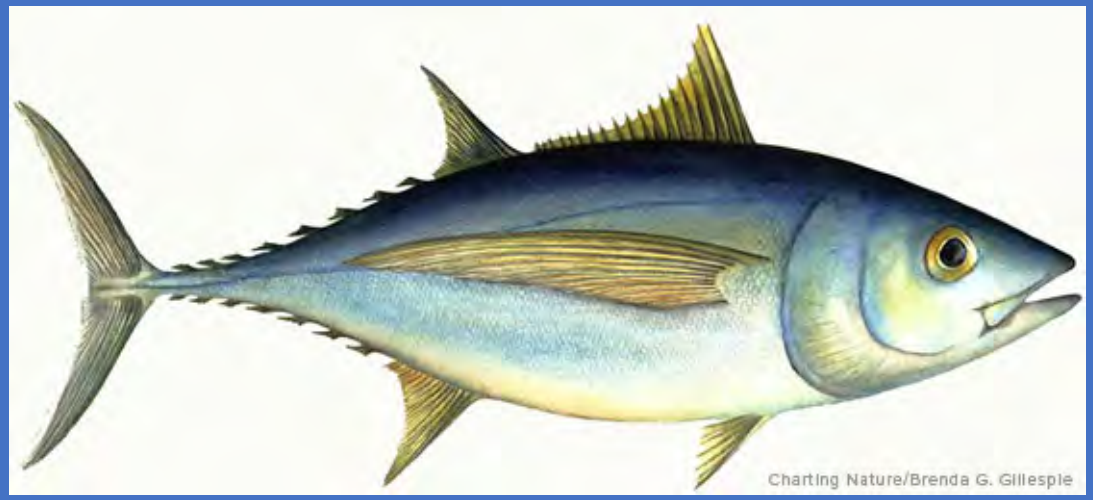
Ichinokawa et al. 2008, Canadian Journal of Fisheries and Aquatic Sciences



Fishing areas - ISC 2017 NPALB Stock Assessment

North Pacific Albacore Management Strategy Evaluation

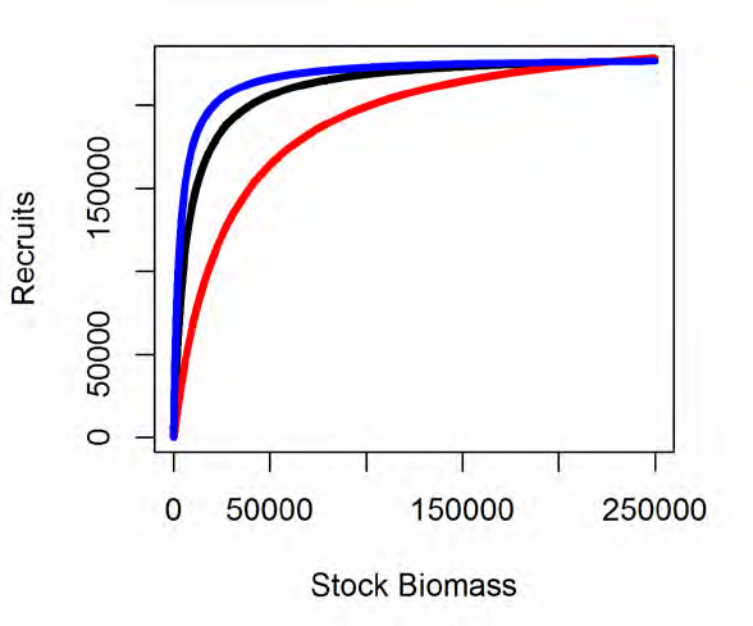
Use MSE to examine performance of alternative management strategies and reference points for North Pacific albacore given uncertainty



Parameter Uncertainty – use an ensemble of operating models

Recruitment

Test a range of steepness values



= 0.97
= 0.90
= 0.70

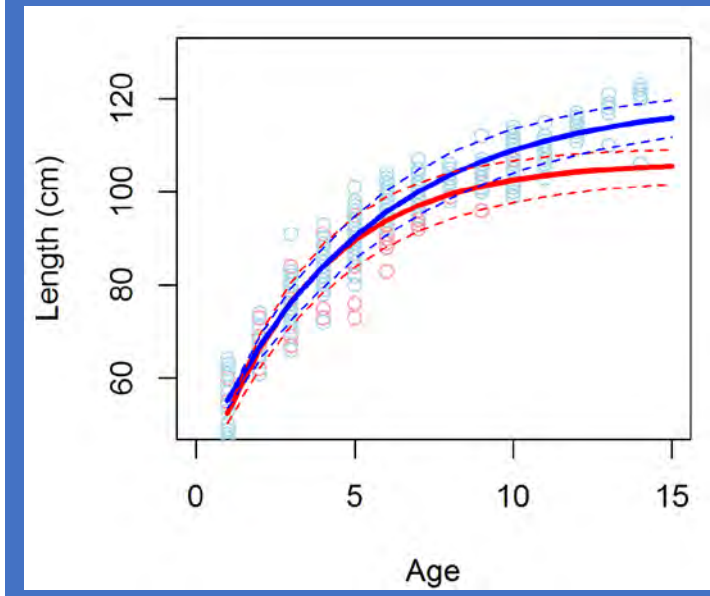
Natural Mortality

- Age and sex specific
- Test a range of values

	Option 1		Option 2		Option 3	
Age	Male	Female	Male	Female	Male	Female
0	1.01	1.01	1.84	1.84	1.36	1.36
1	0.42	0.42	0.76	0.76	0.56	0.56
2	0.33	0.33	0.61	0.61	0.45	0.45
3+	0.29	0.36	0.53	0.66	0.39	0.48

Growth

- Sex specific
- Test a range of values



= male
= female

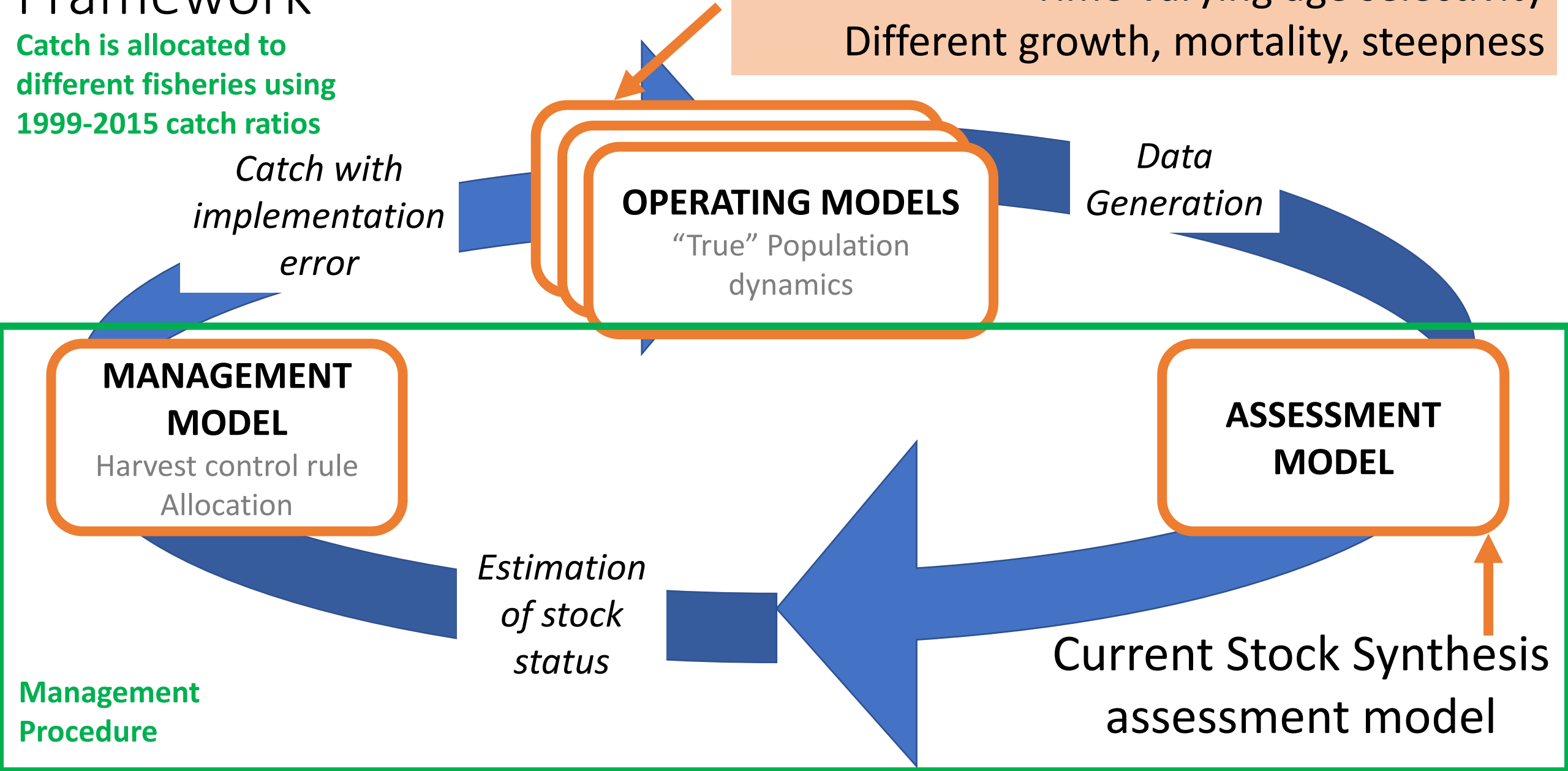
Process Error

- Random recruitment variability with an autocorrelation of 0.42
- Random annual deviations in selectivity of eastern pacific surface fishery

Albacore MSE Framework

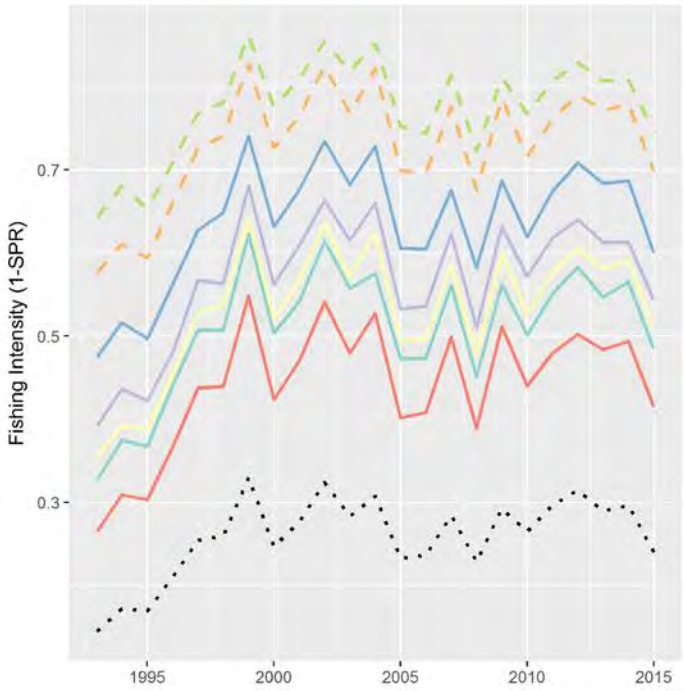
Catch is allocated to different fisheries using 1999-2015 catch ratios

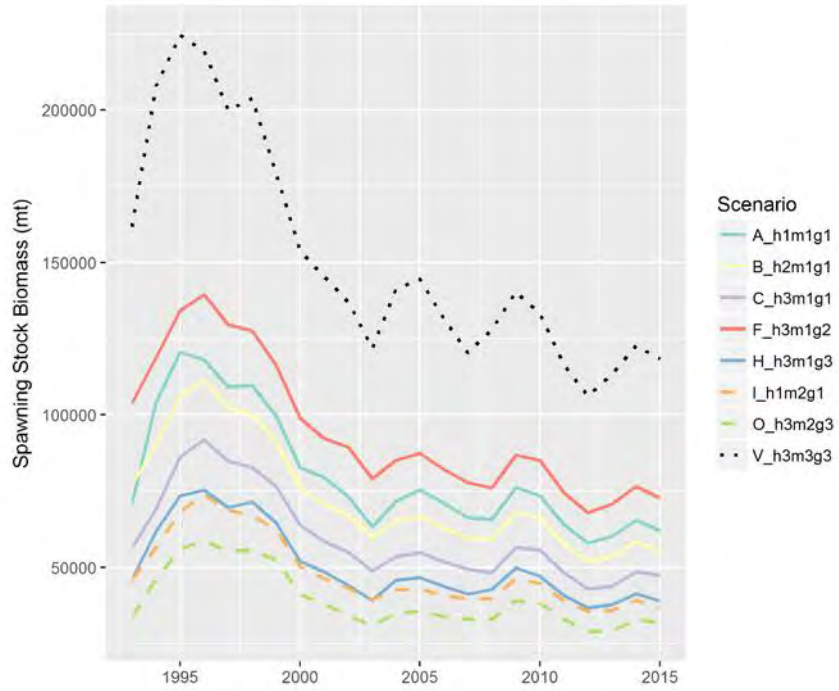
Autocorrelated recruitment
Time-varying age selectivity
Different growth, mortality, steepness



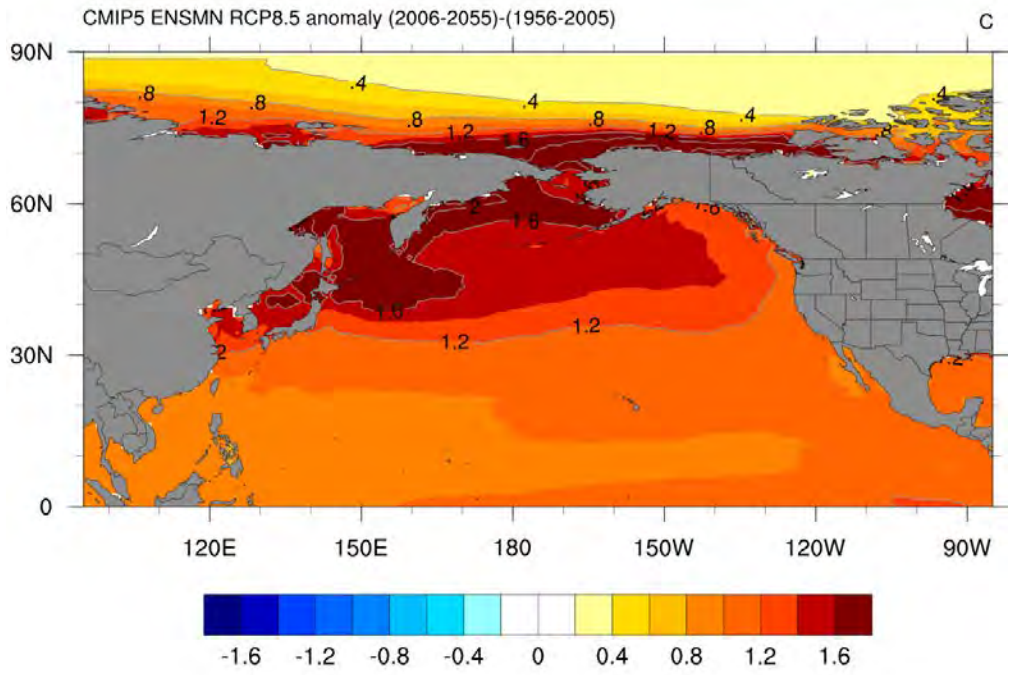
Conditioning on Historical Data (1993-2015)

- Fit using maximum likelihood given 2 CPUE indices, length composition data, and catch data
- Selected eight scenarios that avoid unrealistic biomass trends and duplication of similar trends





For start of projection:
Base case – SSB is 46% of unfished SSB
Low productivity – SSB is 21% of unfished SSB



Fishing Scenarios

Conservation Objectives

Will current management frameworks be robust to such changes

Socio-economics Objectives

Ecosystems

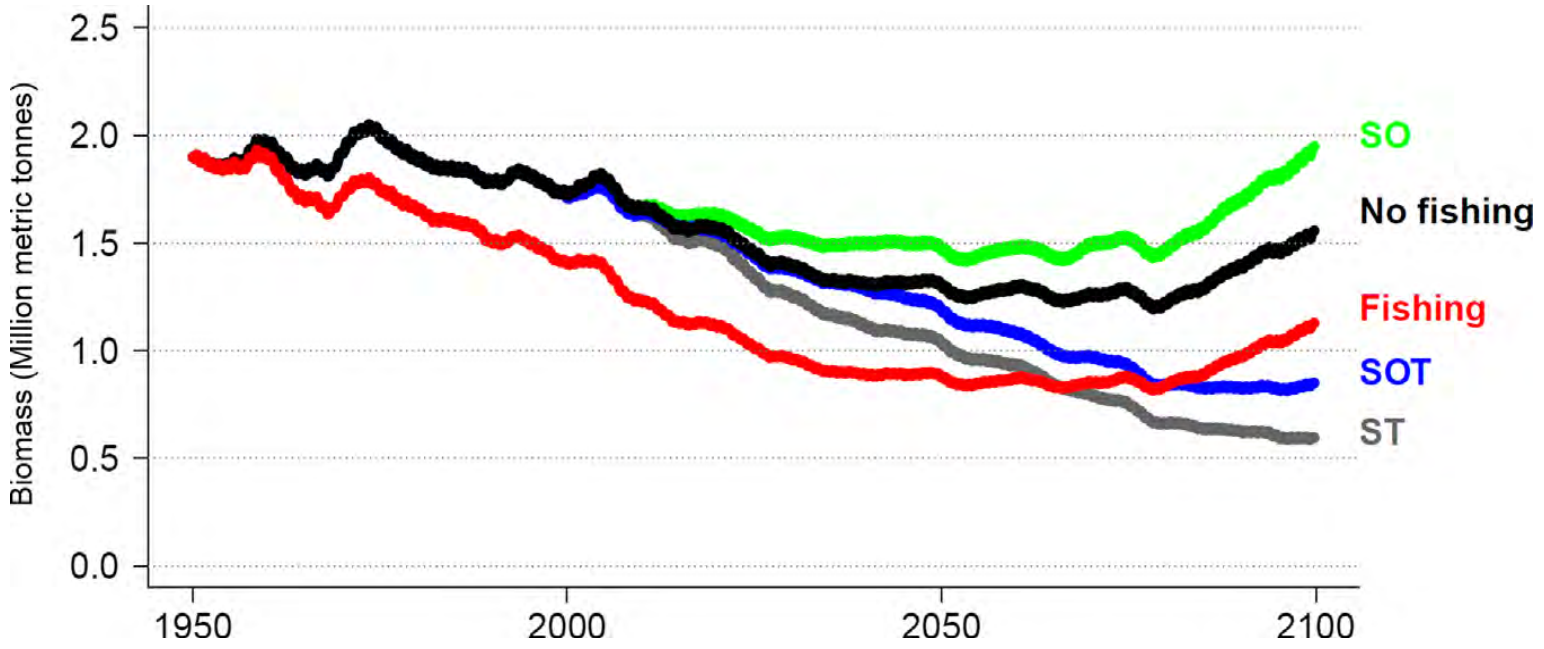
Uncertainty – Fishing Scenarios

- Movement of effort from South Pacific to North Pacific

Uncertainty – Climate Change

- Trend in recruitment?

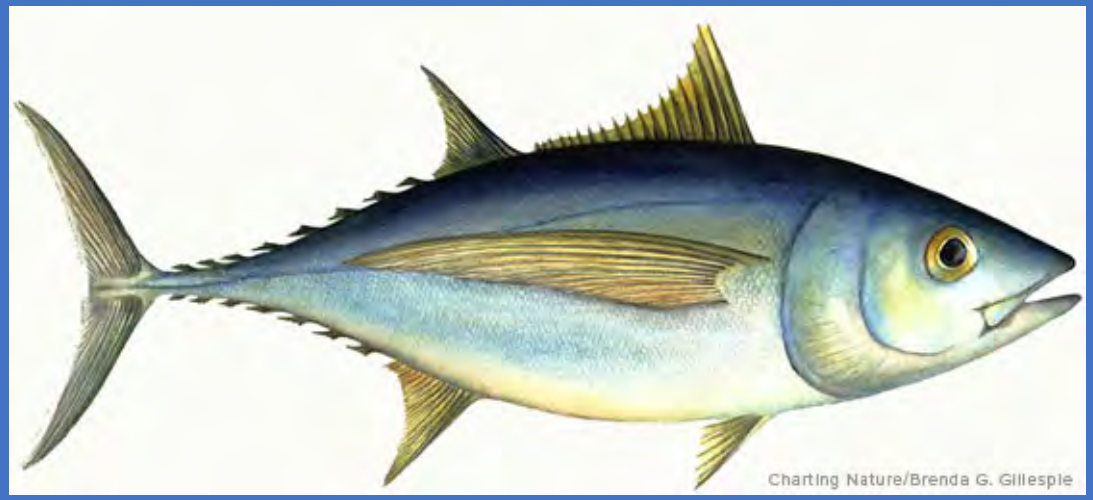
South Pacific Albacore Biomass Projections



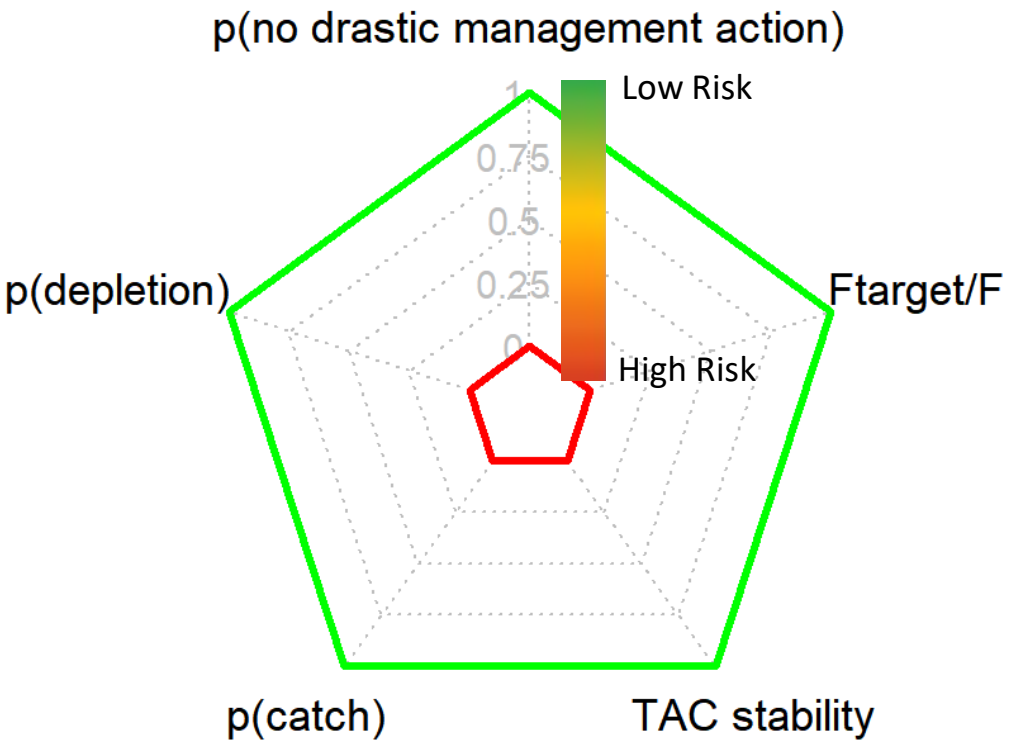
Lehodey et al., 2015

North Pacific Albacore MSE

Examine performance of alternative management strategies and target reference points for North Pacific albacore given uncertainty



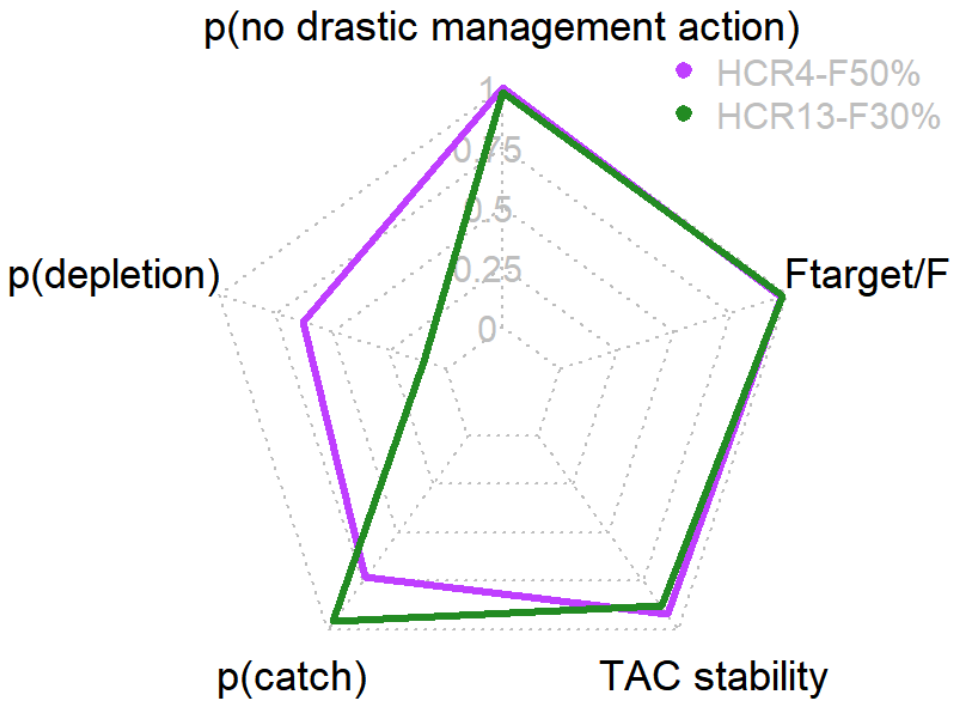
Performance Metrics Comparison



- p(no drastic mgmt action) = Probability of SSB being > LRP
- p(depletion) = Probability of depletion being > minimum historical depletion
- TAC stability = 1 - % absolute difference in TAC between years
- p(catch) = Probability of catch being > average historical catch

Robustness to Climate Variability

Base Case



- Trade-off between depletion and catch

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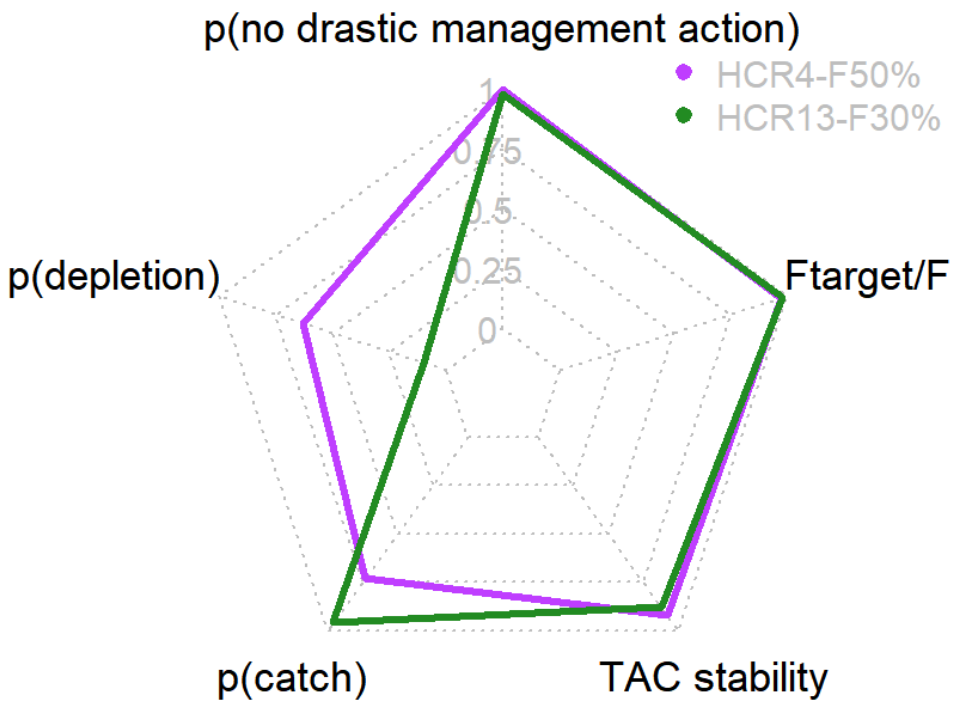

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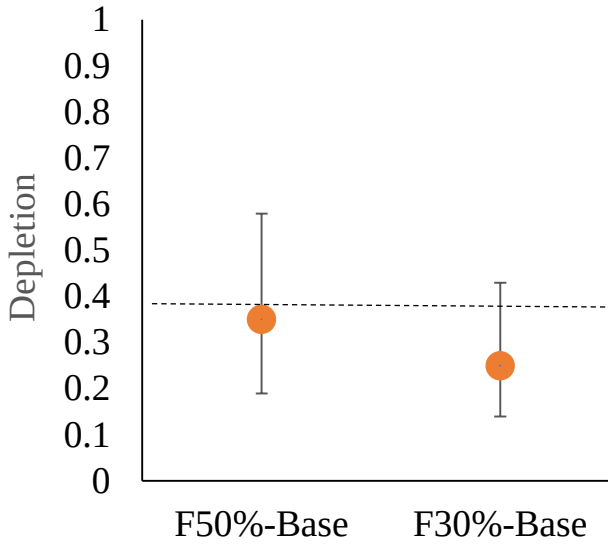

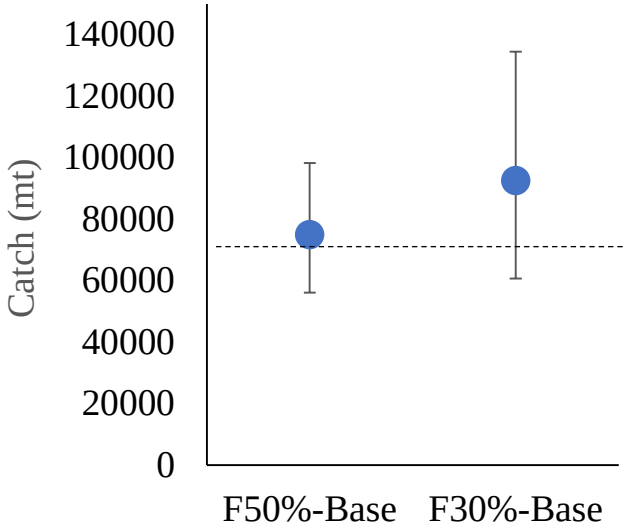

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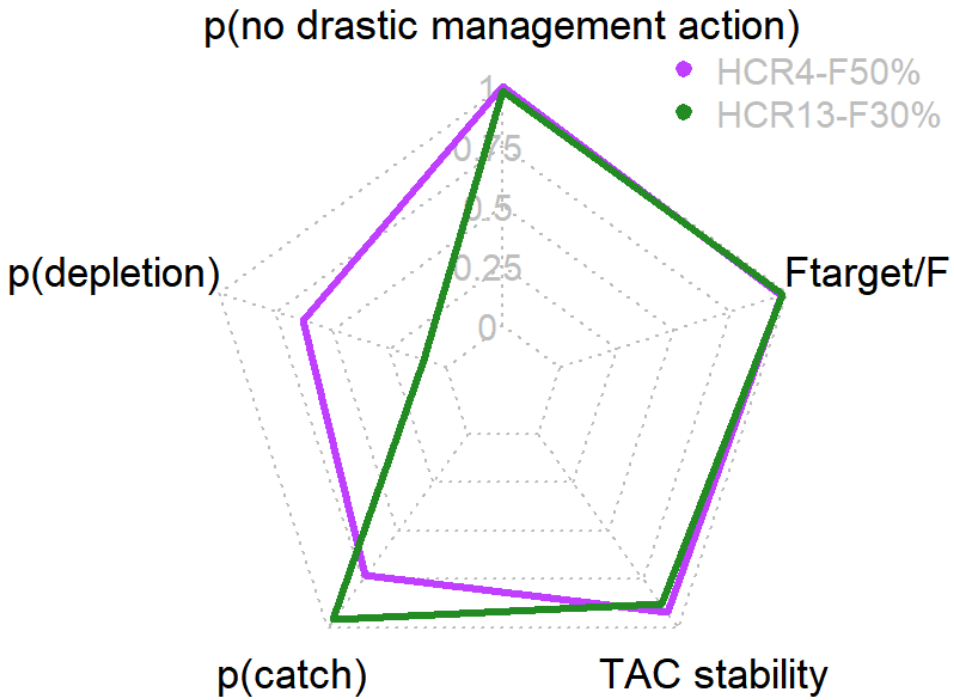
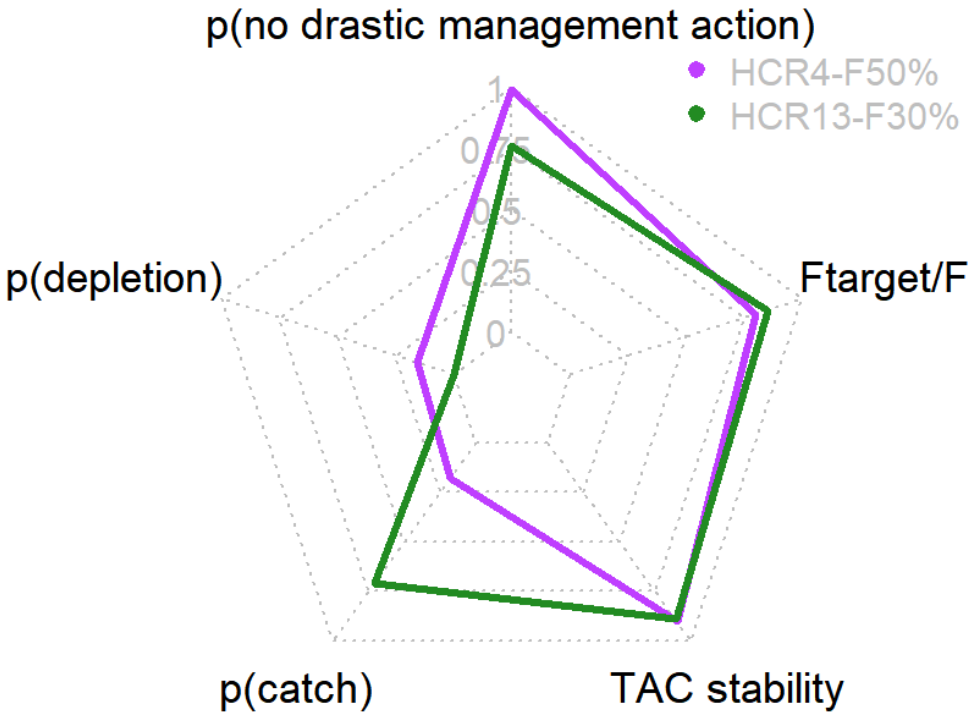
Robustness to Parameter Uncertainty

Base Case



Low Productivity



- Increased risk of drastic management action with F30% at low productivity

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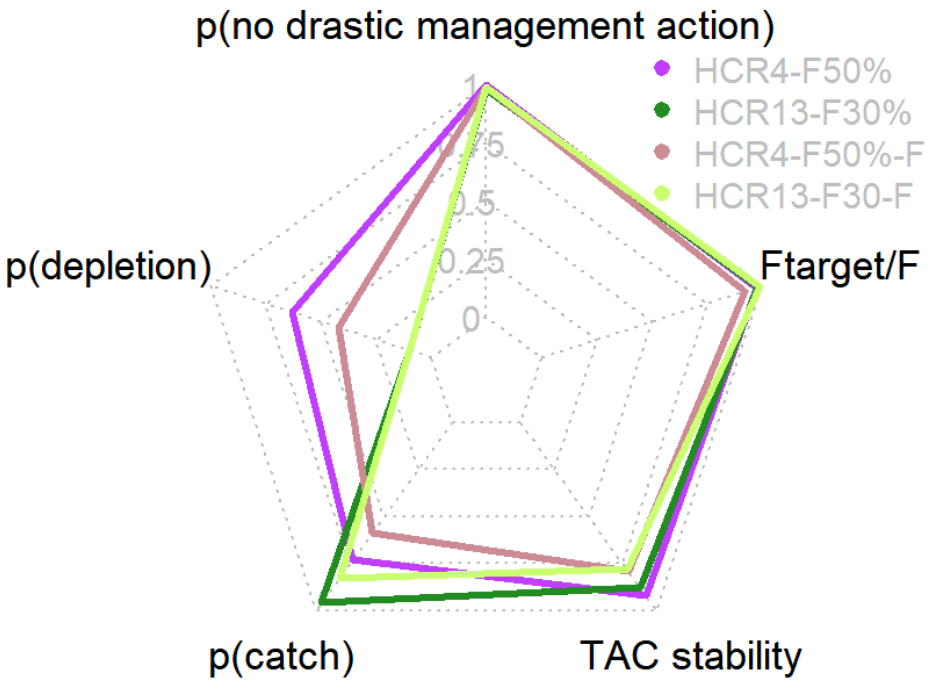
Robustness to Future Change

Base Case



- Patterns driven by increase in effort
- Lower catch because of increased management intervention

- p(no drastic management action) = Probability of SSB being > LRP
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- TAC stability = 1 - % absolute difference in TAC between years
- p(catch) = Probability of catch being > average historical catch

Conclusions

- Proposed HCRs generally robust to past range of climate variability
- Climate responsive rather than climate informed HCRs
- More work required to better understand drivers of North Pacific albacore productivity and movement
- Human dynamics important
- Parameter/model uncertainty needs to be considered

Future work

- Present results at stakeholders workshop in March 2019
- Develop economics informed performance metrics
- Refine recruitment analysis
- Investigate use of more mechanistic operating model (e.g. SEAPODYM)
- Assess climate change impacts on albacore distribution within California Current /US fishing communities with IBM and spatial distribution model as part of Future Seas Project (see Jacox et al. poster S12-P12)

Thank you!