Overview of the North Pacific Albacore Management Strategy Evaluation

IATTC SAC Meeting - May 15, 2018 – La Jolla, USA

Desiree Tommasi

NOAA SWFSC– UCSC Cooperative Institute for Marine Ecosystem and Climate

With thanks to the ISC ALBWG, Juan Valero, Huihua Lee, and all the stakeholders that participated in the NPALB MSE workshops

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

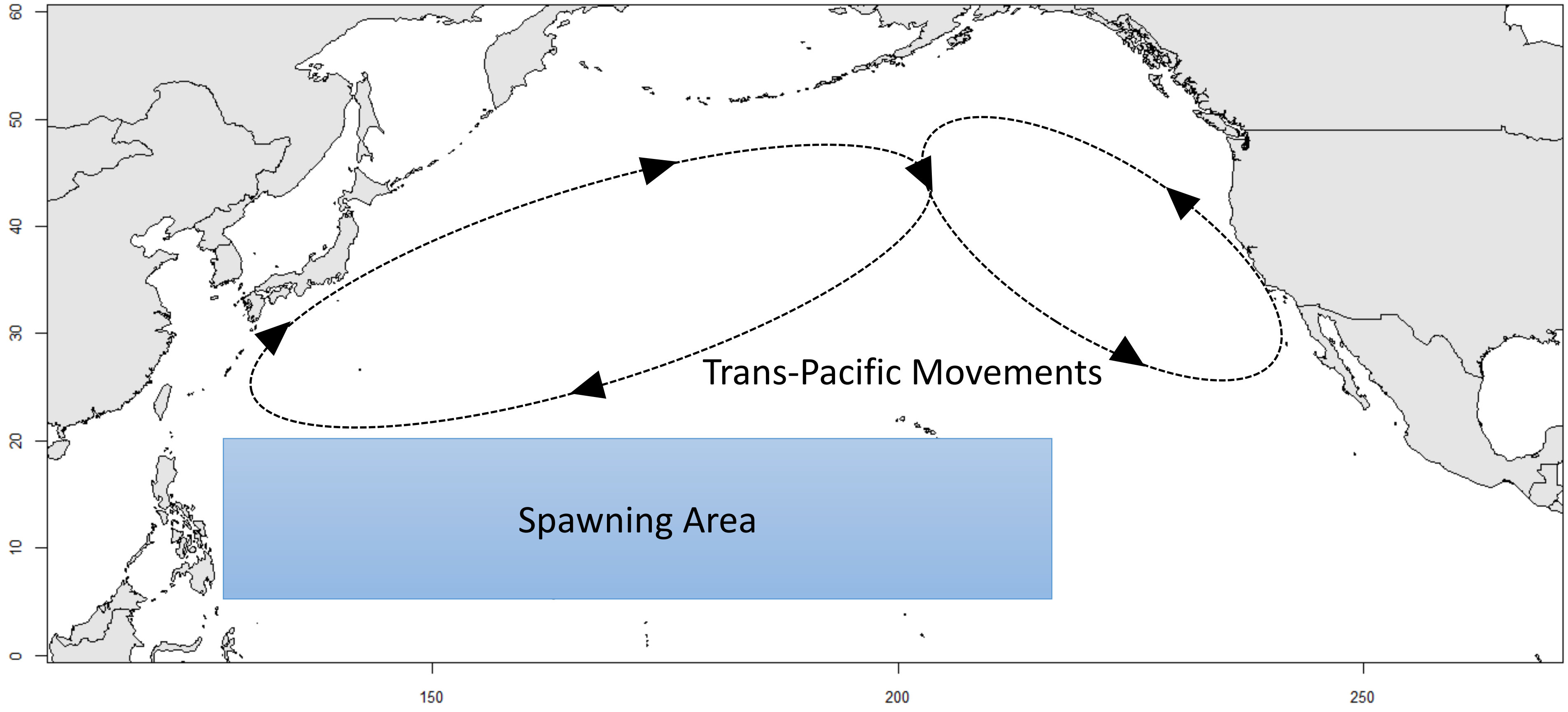
NOAA

UNIVERSITY OF CALIFORNIA SANTA CRUZ

CIMEC

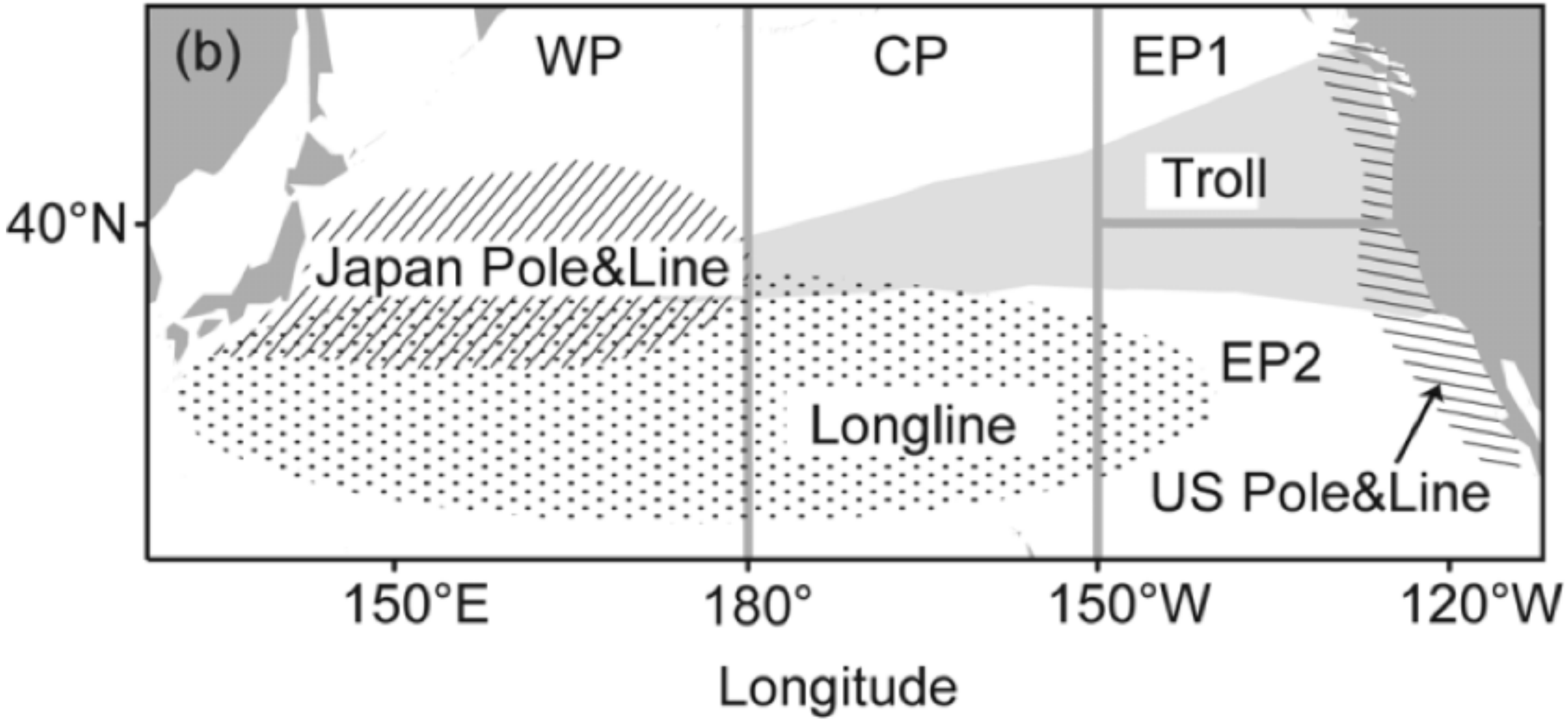
North Pacific Albacore

Highly migratory species whose habitat spans the entire North Pacific Ocean



North Pacific Albacore

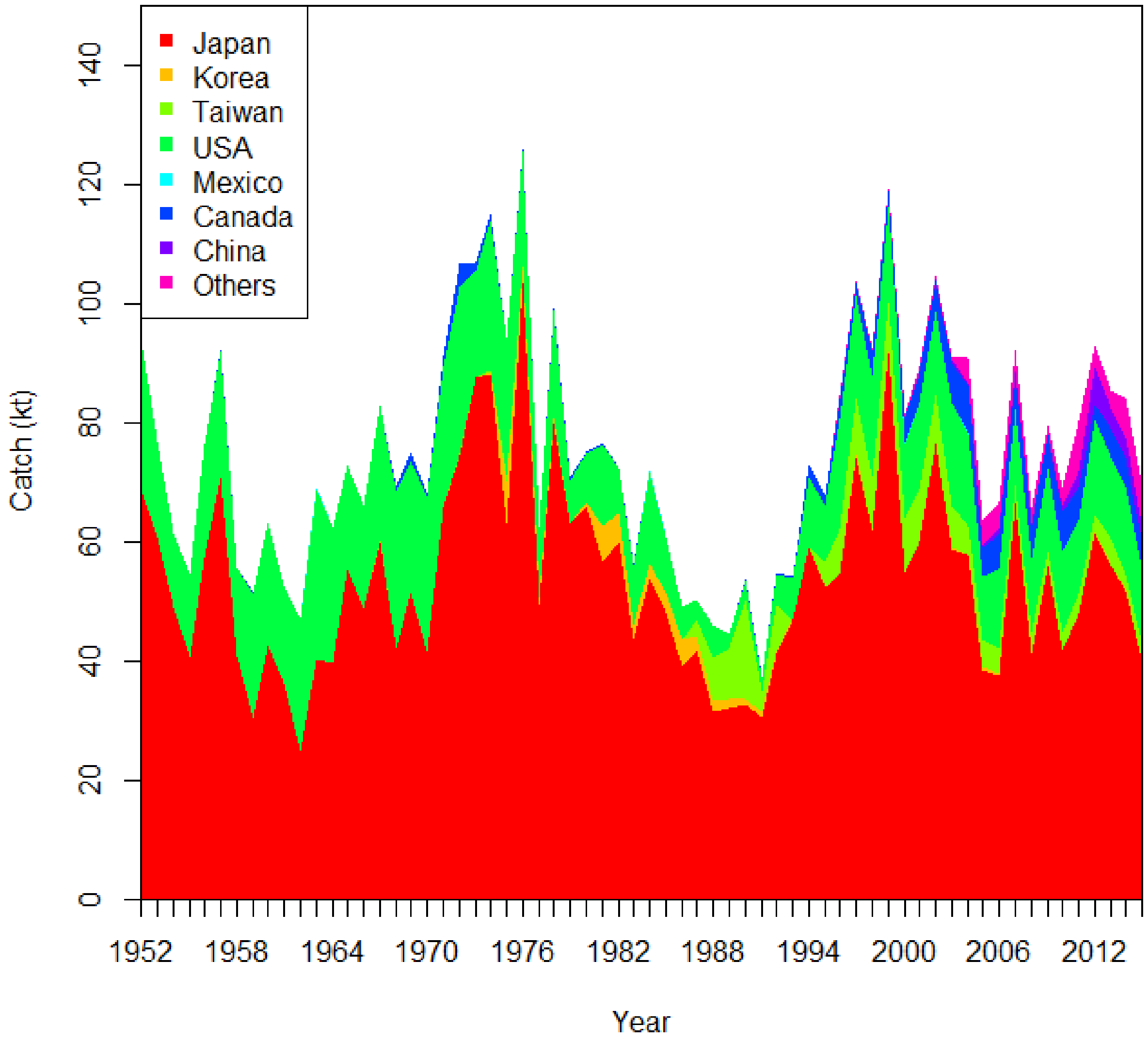
Fisheries include longline and surface gears



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

North Pacific Albacore

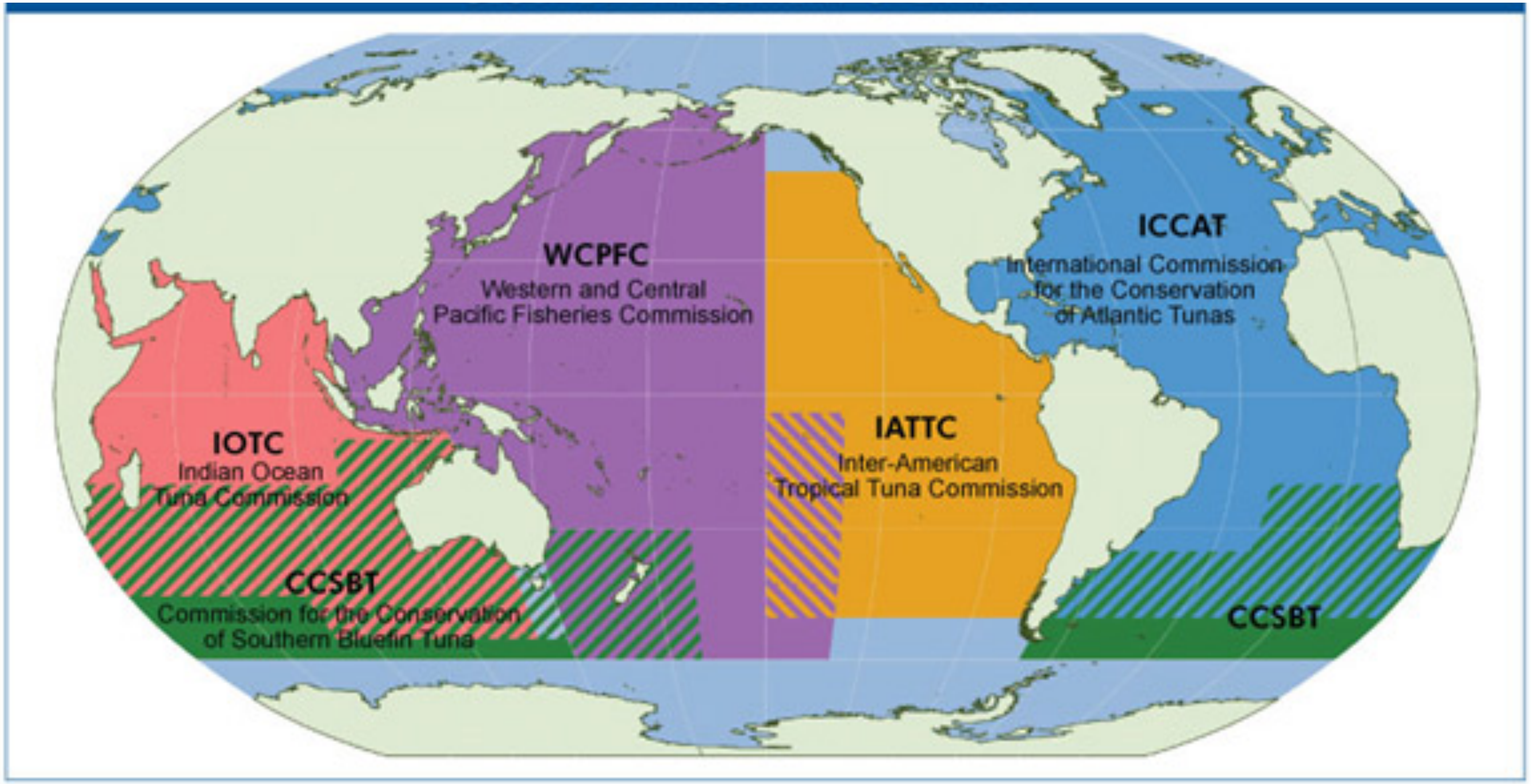
Majority of the catch occurs in the Western Pacific



ISC 2017 NPALB Stock Assessment

North Pacific Albacore

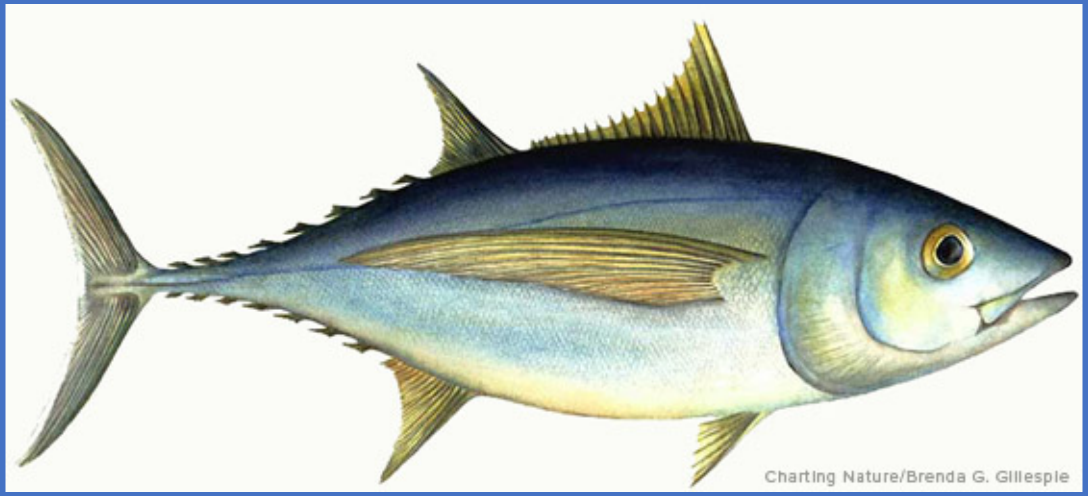
Managed by two Regional Fisheries Management Organizations, WCPFC and IATTC



http://www.pewtrusts.org

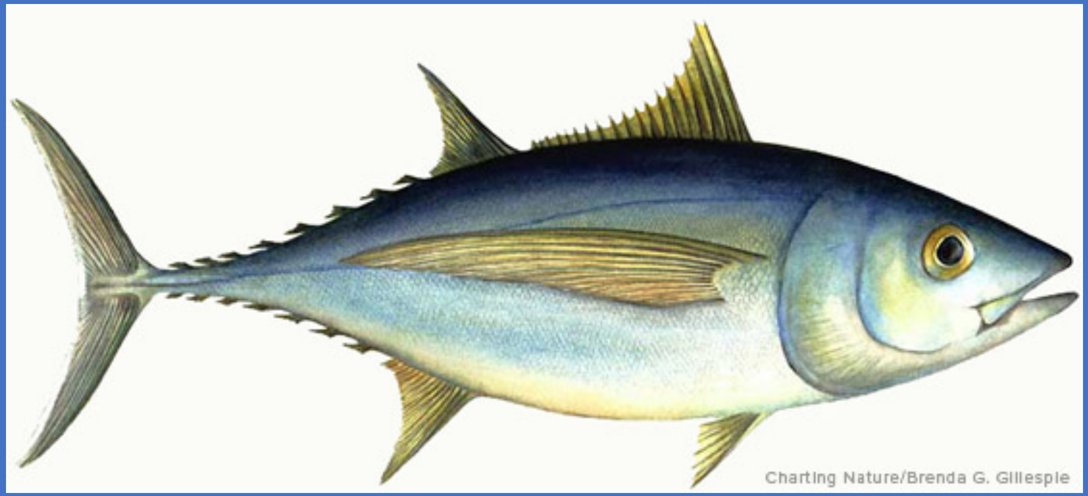
North Pacific Albacore MSE

International effort involving the Albacore Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), WCPFC, and IATTC



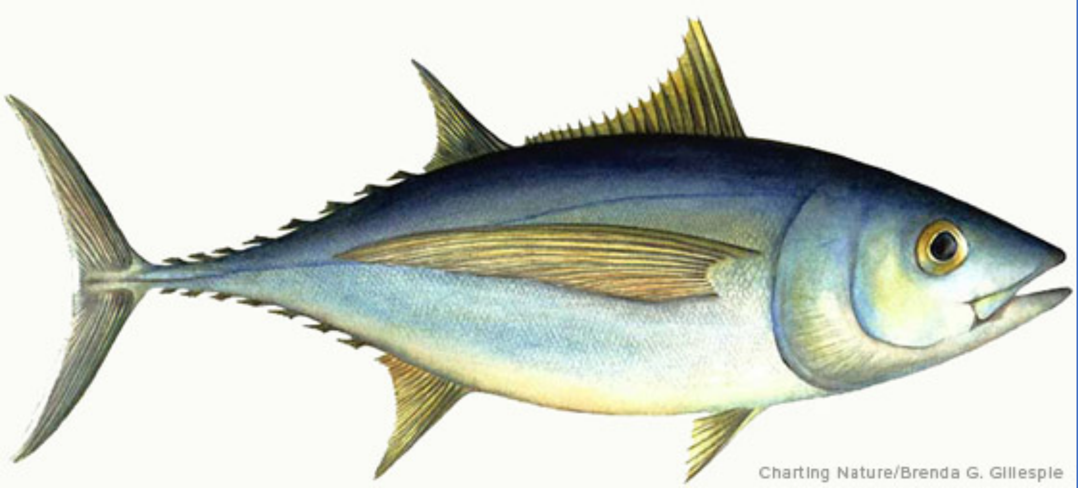
North Pacific Albacore MSE

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 target reference points for North Pacific albacore given uncertainty



Management strategies to be tested developed together with stakeholders

1st ISC MSE WS (16-17 April 2015 at Yokohama, JAPAN)

- **71 participants:** fishery managers, stakeholders, NGOs, and scientists
- **Purpose:** to learn about and understand the MSE process; review the objectives, benefits, and requirements to implement an MSE; as well as recent progress made by tuna RFMOs towards adopting and implementing the MSE process

2nd ISC MSE WS (24-25 May 2016 at Yokohama, JAPAN)

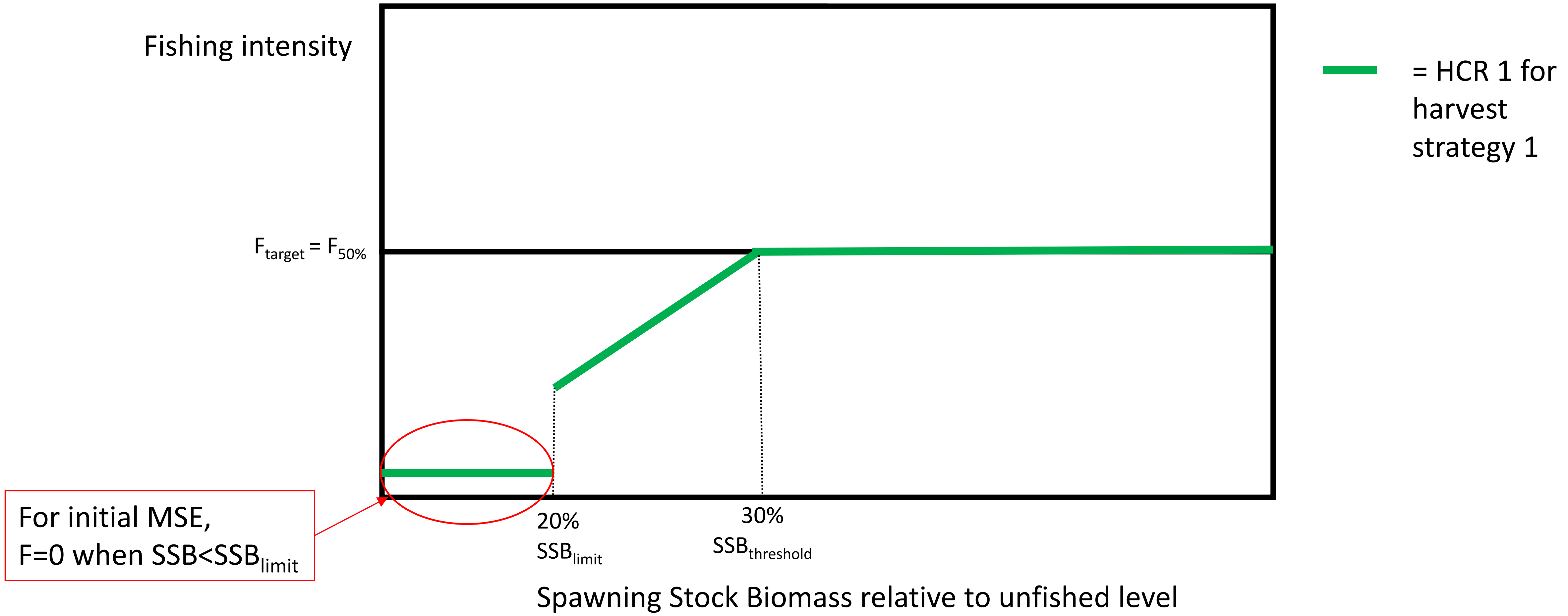
- **24 participants:** fishery managers, stakeholders, NGOs, and scientists
- **Purpose:** to develop management objectives and performance indicators, based on input from managers, stakeholders and scientists

3rd ISC MSE WS (17-19 October 2017 at Vancouver, CANADA)

- **23 participants:** fishery managers, stakeholders, NGOs, and scientists
- **Purpose:** to identify acceptable level of risk for each management objective; and develop candidate reference points and harvest control rules for testing

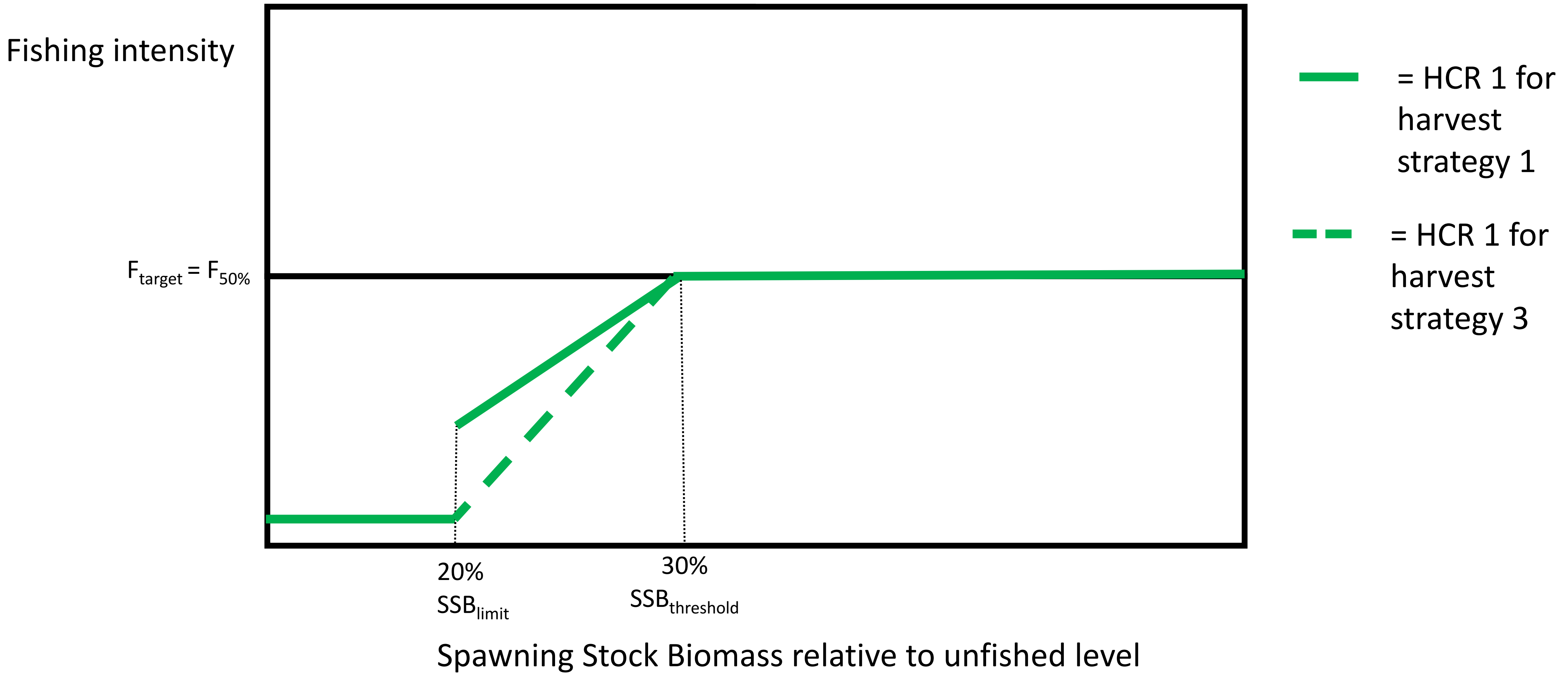
North Pacific Albacore MSE

Example harvest control rule (HCR) for Harvest Strategy (HS) 1



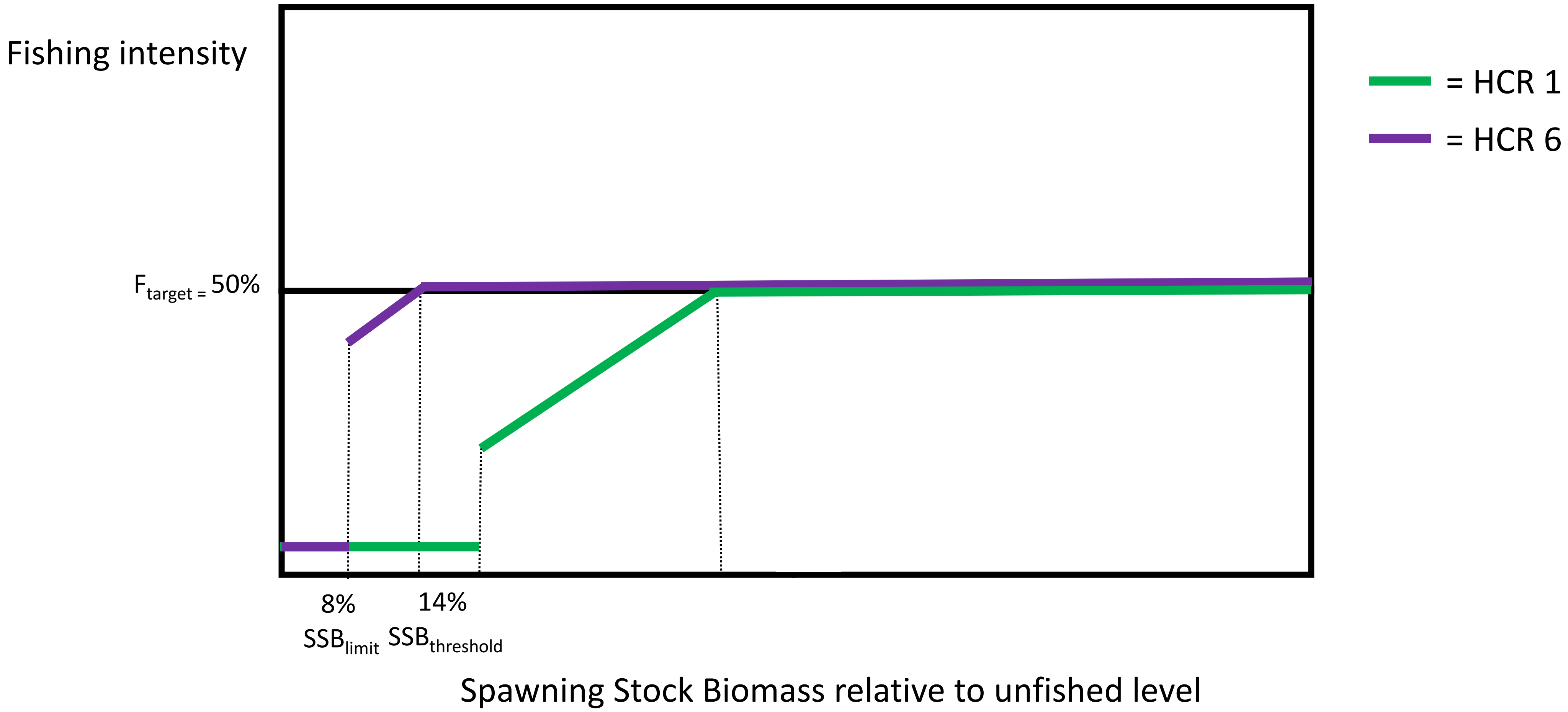
North Pacific Albacore MSE

Example HCR for HS3



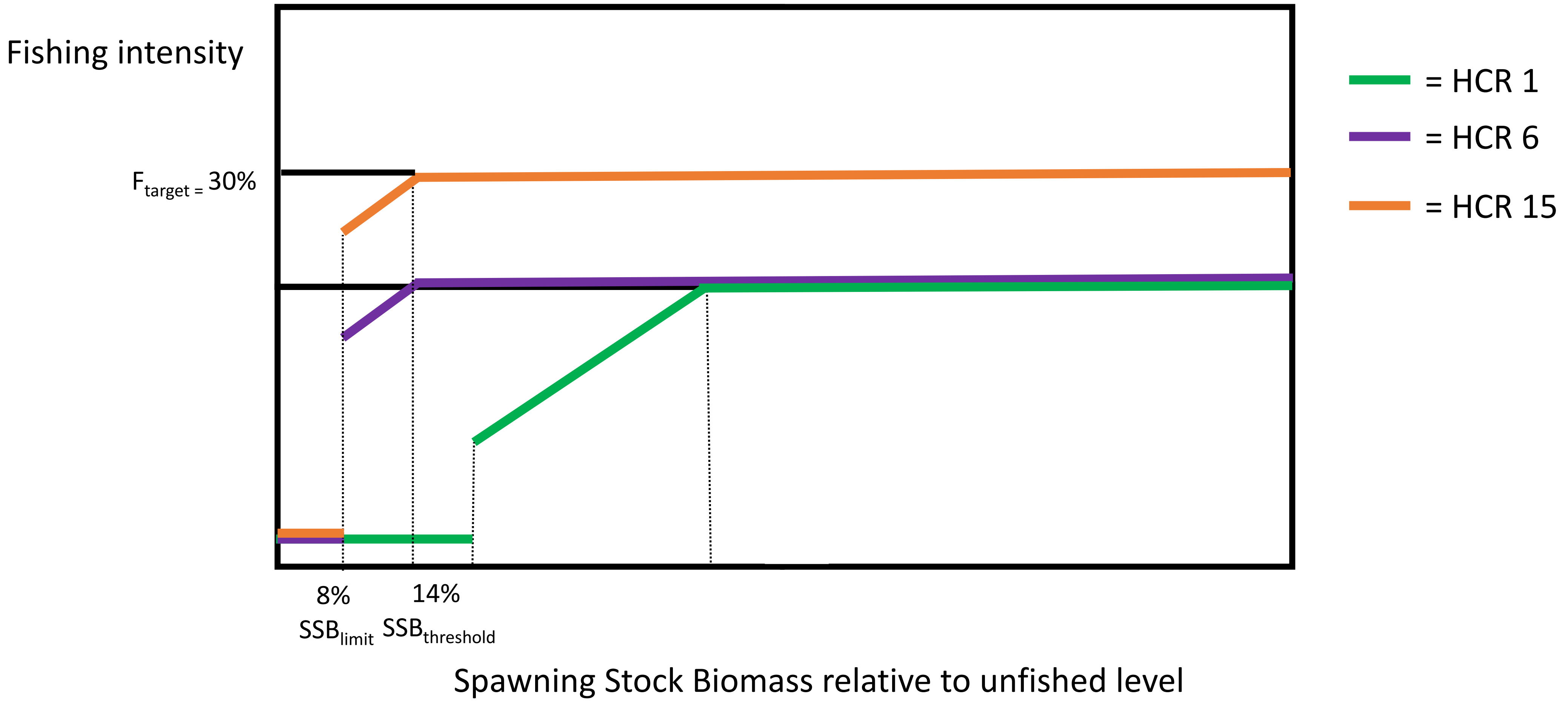
North Pacific Albacore MSE

Example HCRs for HS1



North Pacific Albacore MSE

Example HCRs for HS1



15 different Harvest Control Rules

Harvest strategy	Harvest control rule	Ftgt	SSBtgt	SSBthr	SSBlim
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1	13	30	30	20	14
1	14	30	30	20	8
1	15	30	30	14	8

North Pacific Albacore MSE

Harvest strategy 2 = IATTC tropical tuna rule

- If F exceeds F_{TARGET} (F_{msy}) with a 50% probability F = F_{msy}
- If the probability that F will exceed $F_{0.5r0}$ is greater than 10%, F=0 until the stock is rebuilt to SSB_{msy}, then F = F_{msy}
- If the probability that SSB is below $SSB_{0.5r0}$ is greater than 10%, F=0 until the stock is rebuilt to SSB_{msy}, then F = F_{msy}

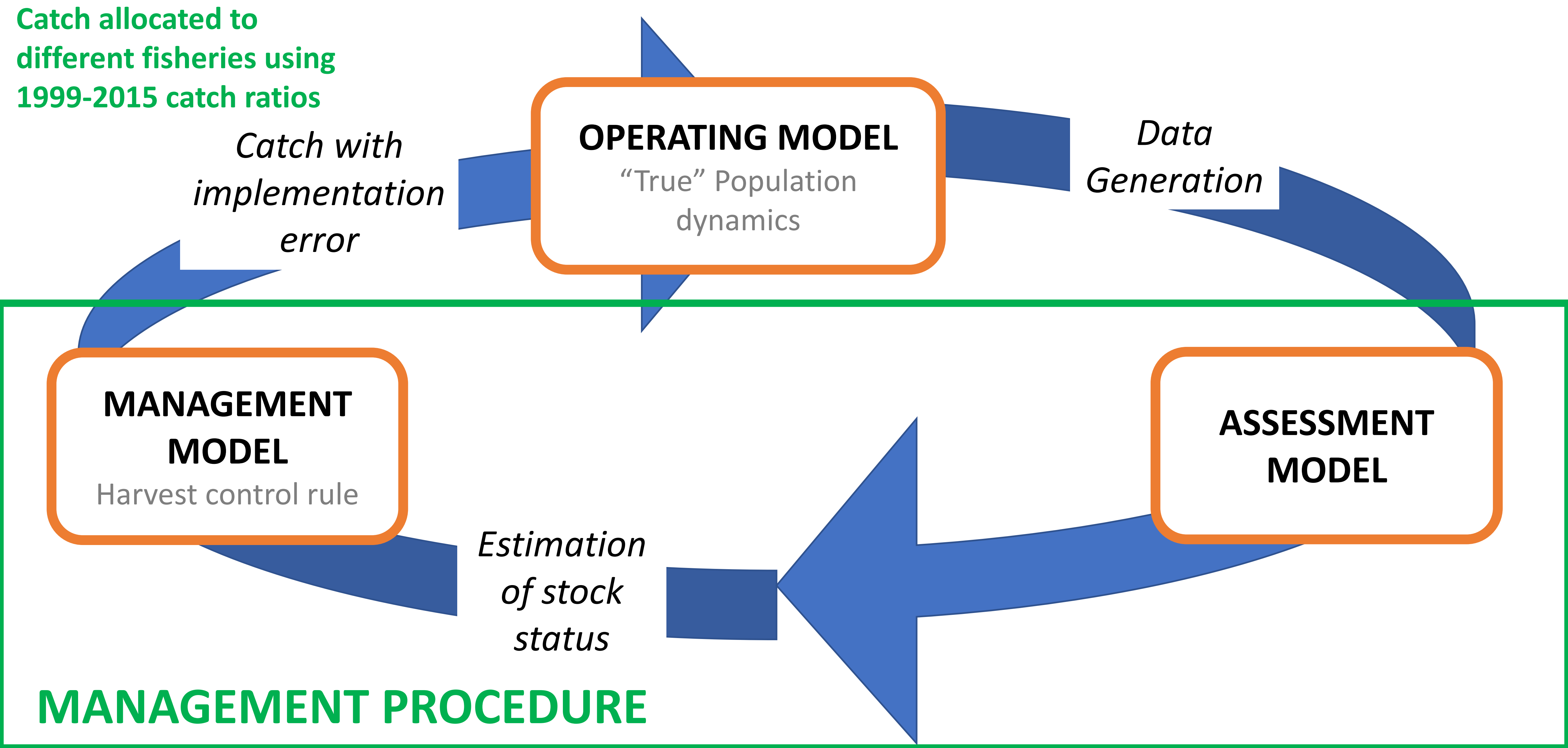
- $SSB_{0.5r0}$ and $F_{0.5r0}$ are the spawning biomass or fishing intensity corresponding to a spawning biomass that leads to a 50% reduction in the virgin recruitment level given a steepness value of 0.75. This corresponds to an SSB that is 7.7% of the unfished SSB

Management Strategy Evaluation (MSE)

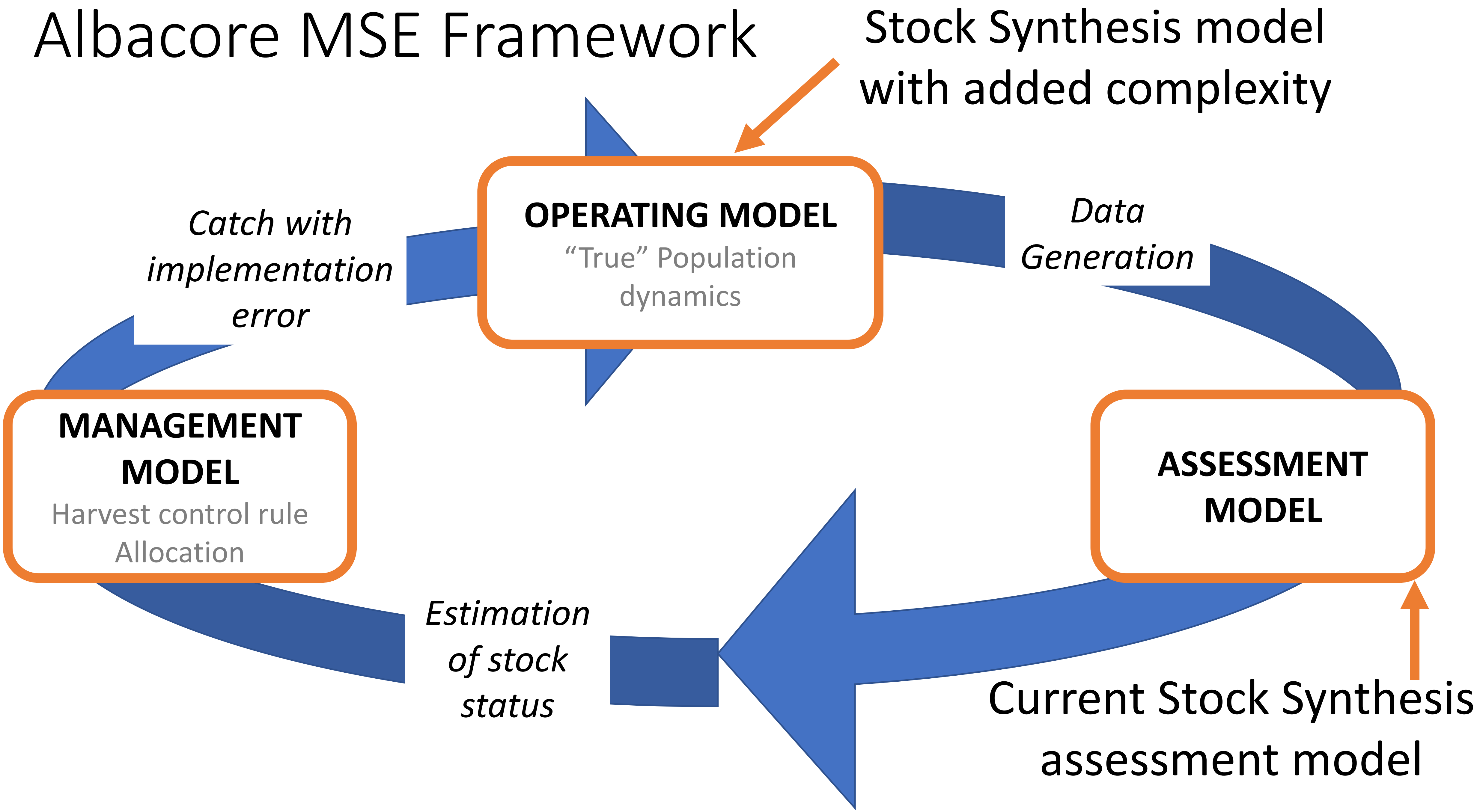
“Use of simulation to evaluate the trade-offs achieved by alternative management strategies and to assess the consequences of uncertainty in achieving management goals”

Punt et al. 2016, Fish and Fisheries

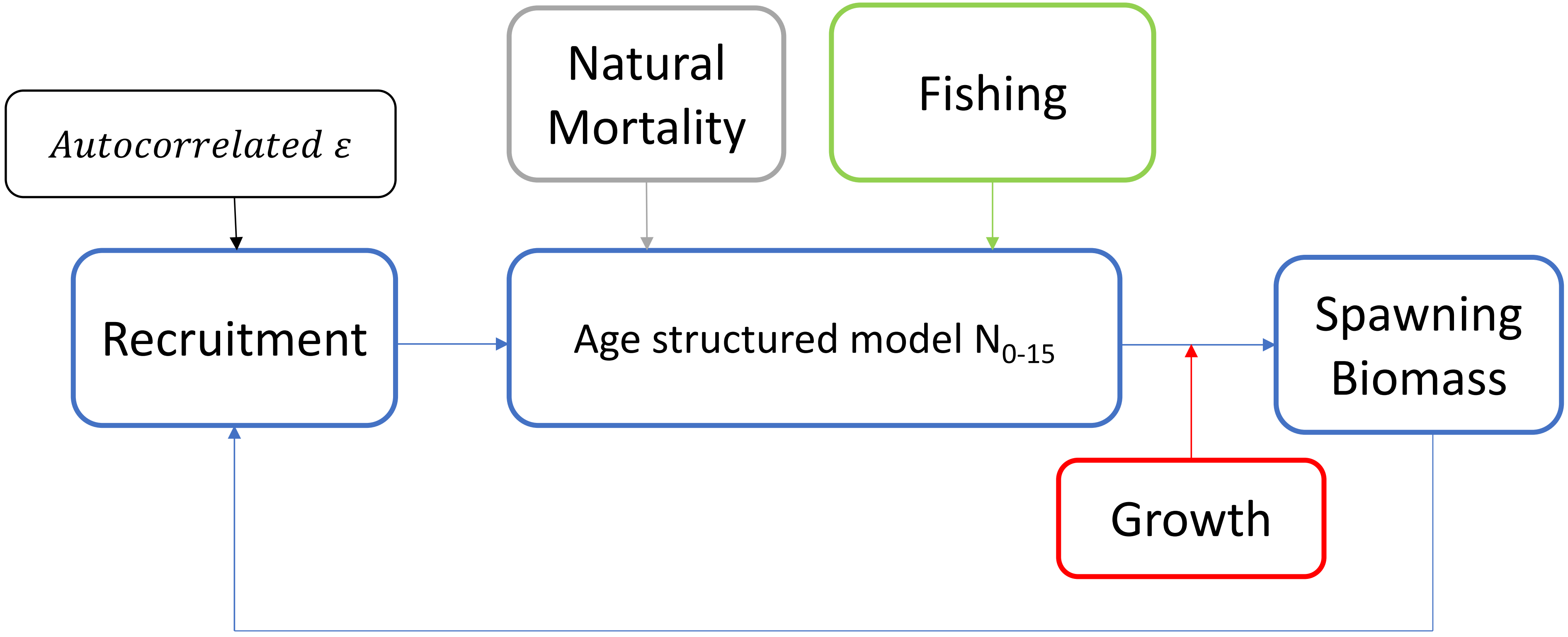
MSE Framework – Feedback Loop



Albacore MSE Framework

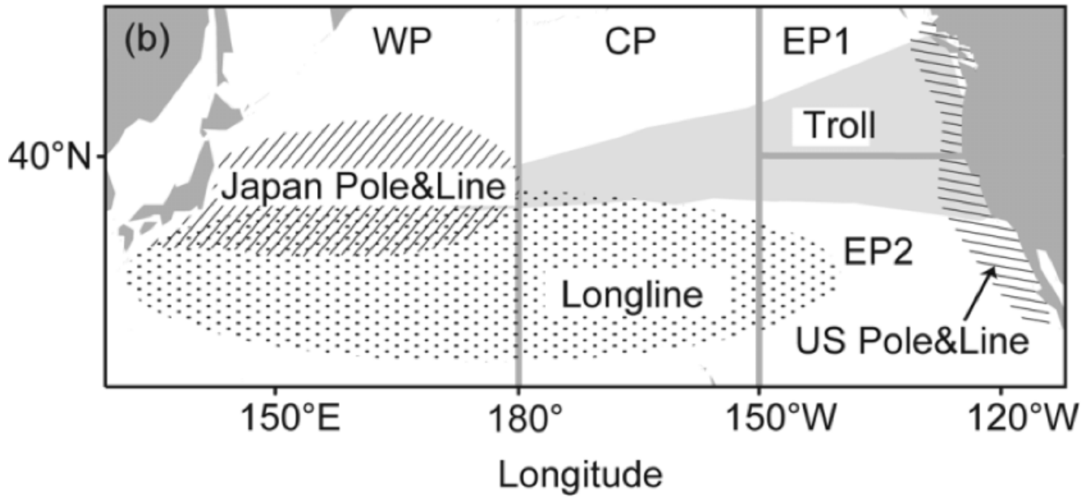


Operating Model



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



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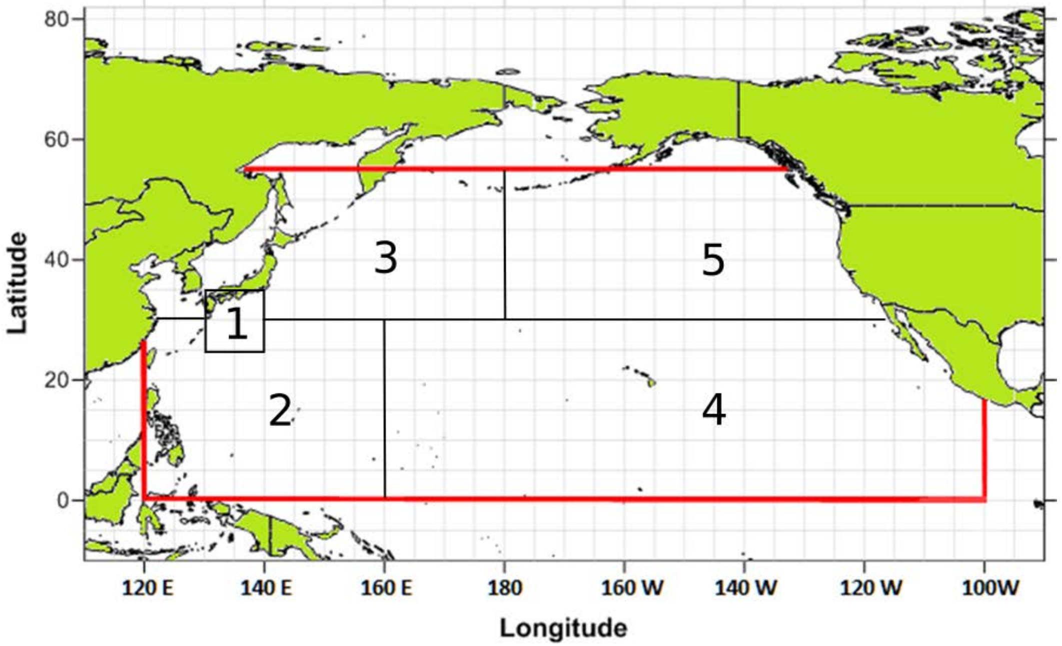
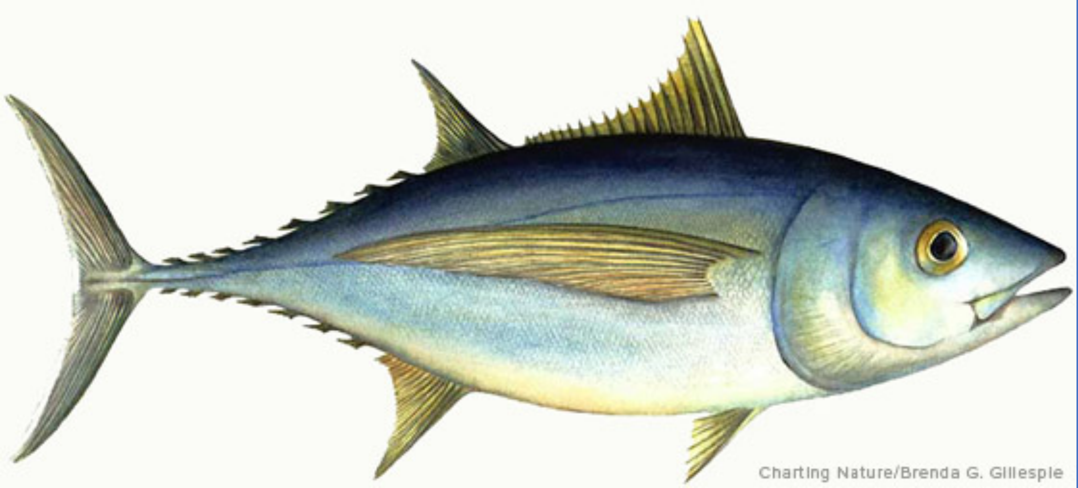


Fishing areas - ISC 2017 NPALB Stock Assessment

North Pacific Albacore MSE

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



Uncertainties to which management strategies should be robust to identified at ISC ALBWG Science Meeting in Vancouver, Canada, in October 2017

High priority

1) Recruitment – autocorrelation and various values of steepness
2) Natural mortality – various values of M
3) Growth – various values of growth parameters

Medium priority

1) Age selectivity – time-varying age selectivity
2) Recruitment – linked to environmental indices
3) Natural mortality – sex-specificity
4) Catchability – time varying implementation error

Low priority

1) Growth – time-varying growth
2) Catchability – time varying catchability of indices
3) Size selectivity – time varying selectivity

Uncertainties to which management strategies should be robust to identified at ISC ALBWG Science Meeting in Vancouver, Canada, in October 2017

High priority

✓ 1) Recruitment – autocorrelation and various values of steepness

✓ 2) Natural mortality – various values of M

✓ 3) Growth – various values of growth parameters

Medium priority

✓ 1) Age selectivity – time-varying age selectivity

2) Recruitment – linked to environmental indices

3) Natural mortality – sex-specificity

4) Catchability – time varying implementation error

Low priority

1) Growth – time-varying growth

2) Catchability – time varying catchability of indices

3) Size selectivity – time varying selectivity

Uncertainties most consequential to NPALB

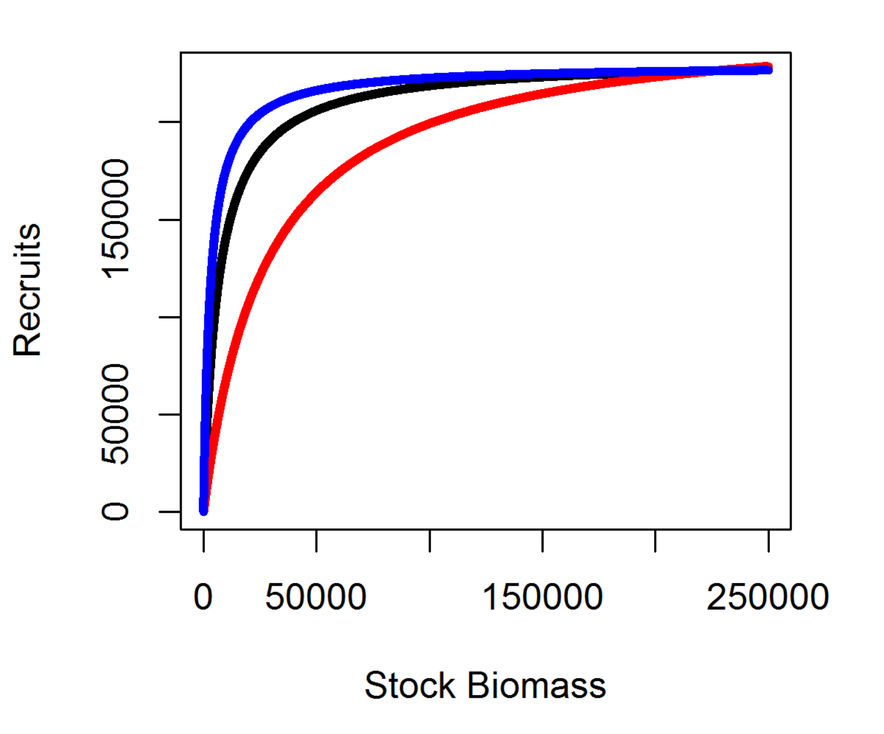
Recruitment Steepness

- Derived from Brodziak et al. 2011 - Probable values of stock-recruitment steepness for north Pacific albacore tuna, ISC/11/ALBWG/11 Working Paper
- Used Mangel's simulation method to estimate probable values of steepness given information on growth, maturity, weight at length, natural mortality, and reproductive ecology

Uncertainties most consequential to NPALB

Recruitment

Test a range of steepness values



= 0.97
= 0.90
= 0.70

From stock assessment

Uncertainties most consequential to NPALB

Natural Mortality

- age-specific M for ages 0 to 2 and sex-specific, constant M for ages 3+
- 25thquantile, 75th quantile, and the median of the age 3+ M distribution used in the assessment and calculated using the methodology described in Teo (2017) and Kinney and Teo (2016)
- M for ages 0 to 2 were calculated by assuming M for younger ages to be size dependent and using the Lorenzen method

Uncertainties most consequential to NPALB

Natural Mortality

	Option 1		Option 2		Option 3 (SAM)	
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

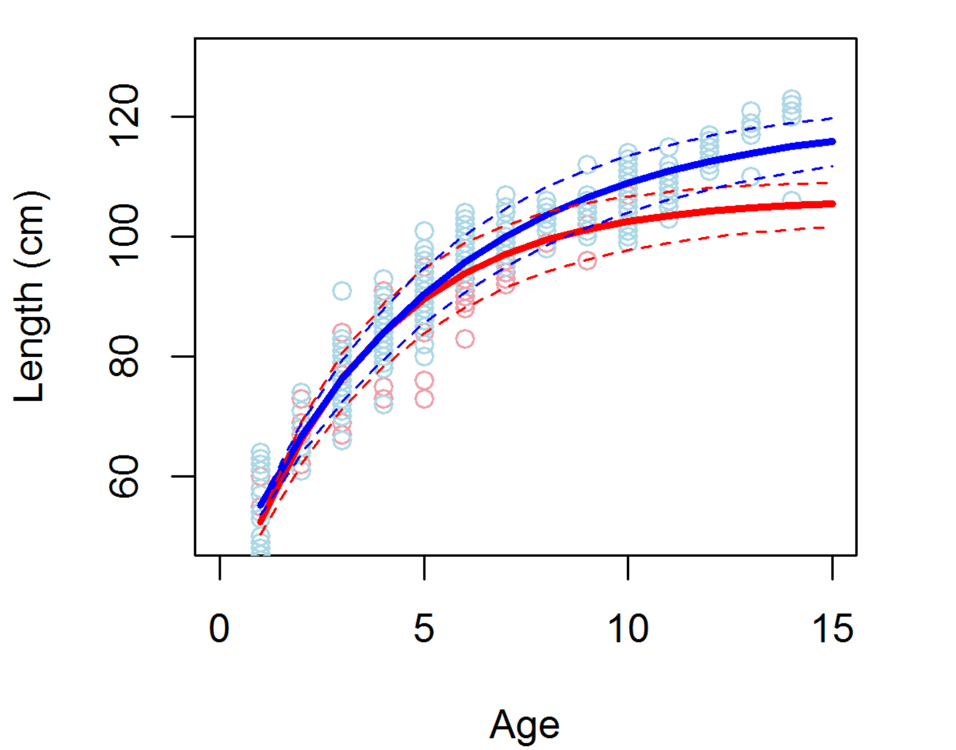
Uncertainties most consequential to NPALB

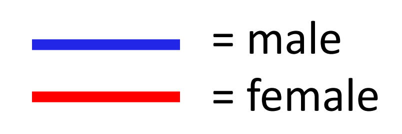
Growth

Test a range of K, L_{inf}

$$L_a = L_{inf}(1-e^{-K(a-ao)})$$

L_a = length at age
L_{inf} = asymptotic fork length
K = growth coefficient
a = age
a_o = age at length 0





Uncertainties most consequential to NPALB

Growth

- Sex specific growth parameters in SAM fixed to values from the Xu et al. 2014 working paper, which collated otolith data from the Chen at al. 2012 and the Wells et al. 2013 studies.
- For the OM, growth parameters initially estimated from within the stock assessment model by fitting to age-length data in addition to length composition data

Uncertainties most consequential to NPALB

Growth Estimation Workflow (for each steepness and mortality combination, total = 9)

1. Estimate growth given the age at length data with a weight of 0.6
2. Run the model with no age at length data and with the growth parameters fixed at what was estimated in step 1. These are the g1 cases.

Uncertainties most consequential to NPALB

Growth Estimation Workflow (for each steepness and mortality combination, total = 9)

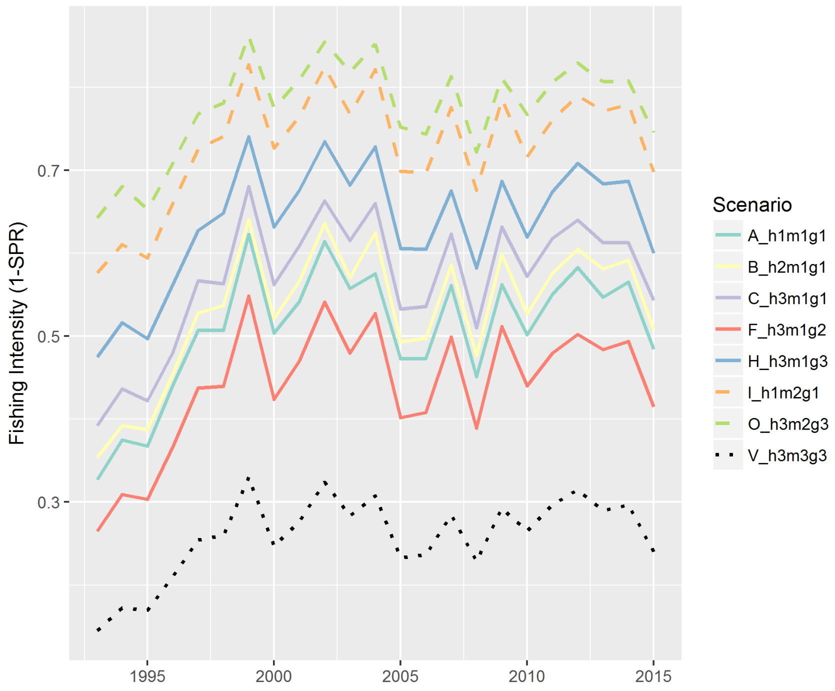
3. Take the 5% CI or 95% CI of Linf given the standard deviation of the Linf parameter in 1 and run the model again to estimate the other parameters using the age at length data
4. Run the model with no age at length data and with the growth parameters fixed at what was estimated in step 3. These are the g2 or g3 cases.

Potential Model Scenarios

	h	G	M	Selectivity	Recruitment	Convergence
Base	1	1	1	Time varying Age selectivity	Autocorrelation	
2	1	1	2	Base	Base	
3	1	1	3	Base	Base	
4	1	2	1	Base	Base	
5	1	2	2	Base	Base	
6	1	2	3	Base	Base	
7	1	3	1	Base	Base	
8	1	3	2	Base	Base	
9	1	3	3	Base	Base	
10	2	1	1	Base	Base	
11	2	1	2	Base	Base	
12	2	1	3	Base	Base	
13	2	2	1	Base	Base	
14	2	2	2	Base	Base	
15	2	2	3	Base	Base	
16	2	3	1	Base	Base	
17	2	3	2	Base	Base	
18	2	3	3	Base	Base	
19	3	1	1	Base	Base	
20	3	1	2	Base	Base	
21	3	1	3	Base	Base	
22	3	2	1	Base	Base	
23	3	2	2	Base	Base	
24	3	2	3	Base	Base	
25	3	3	1	Base	Base	
26	3	3	2	Base	Base	
27	3	3	3	Base	Base	

Conditioning on Historical Data (1993-2015)

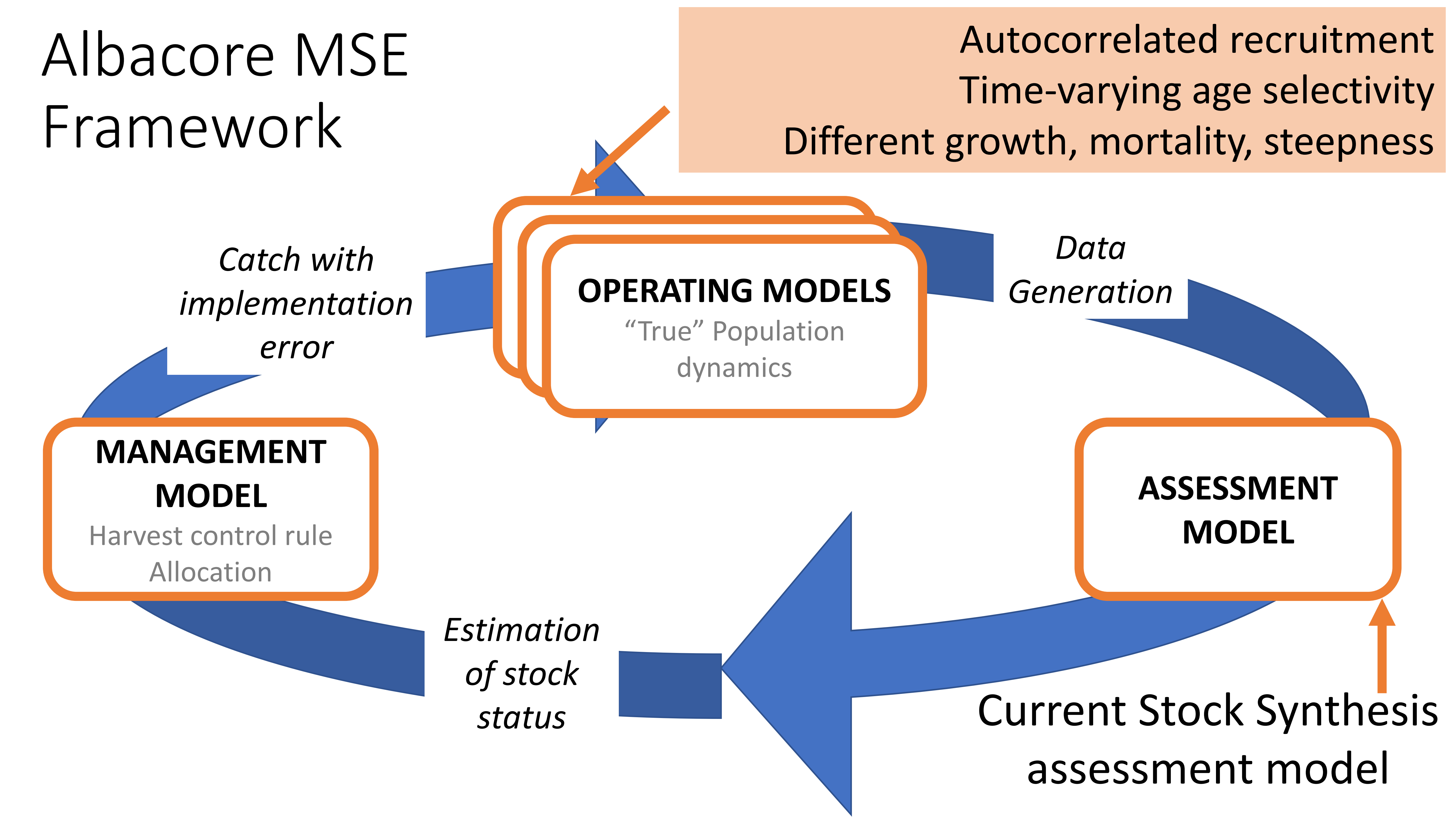
- Fit using maximum likelihood given 2 CPUE indices, length composition data, and catch data
- Selected eight scenarios that avoid unrealistic biomass trends and duplication of similar trends



For start of projection:

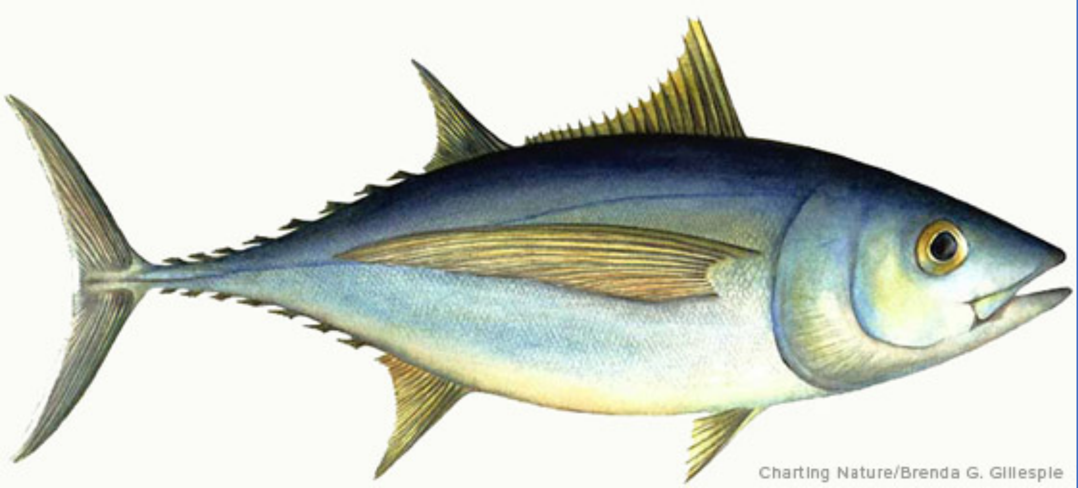
Base case – Depletion = 0.63 Fished total biomass is 63% of unfished
SSB is 46% of unfished SSB

Low productivity – Depletion = 0.43 Fished total biomass is 43% of unfished
SSB is 21% of unfished SSB


Albacore MSE Framework
Autocorrelated recruitment
Time-varying age selectivity
Different growth, mortality, steepness
OPERATING MODELS
"True" Population dynamics
Catch with implementation error
Data Generation
MANAGEMENT MODEL
Harvest control rule
Allocation
ASSESSMENT MODEL
Estimation of stock status
Current Stock Synthesis assessment model

North Pacific Albacore MSE

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



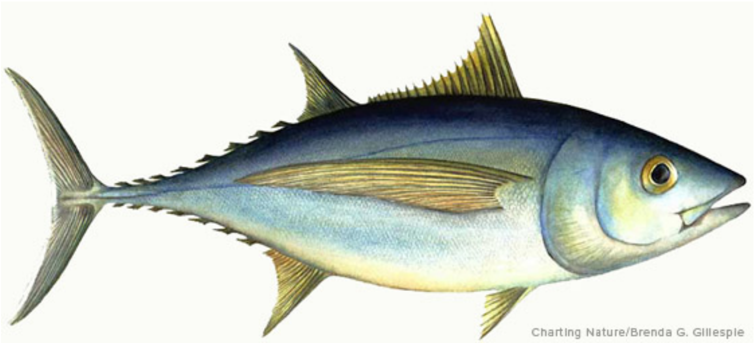
North Pacific Albacore MSE

Management Objective

Maintain spawning biomass above the limit reference point

Performance Metric

p(no drastic management action) = Probability spawning biomass in any given year is above the LRP



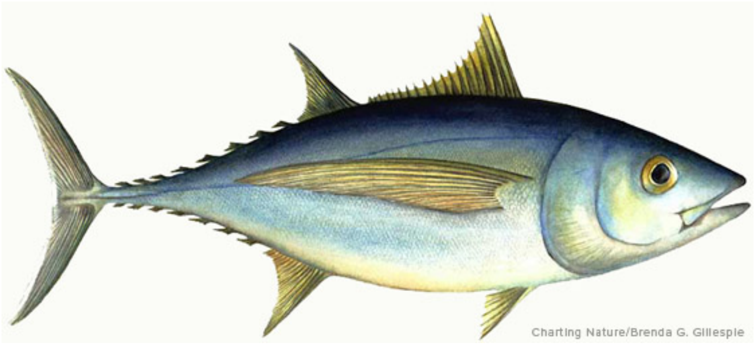
North Pacific Albacore MSE

Management Objective

Maintain depletion (fished total biomass/unfished total biomass) around historical average depletion

Performance Metric

p(depletion) = Probability depletion in any given year is above minimum historical (2006-2015) depletion



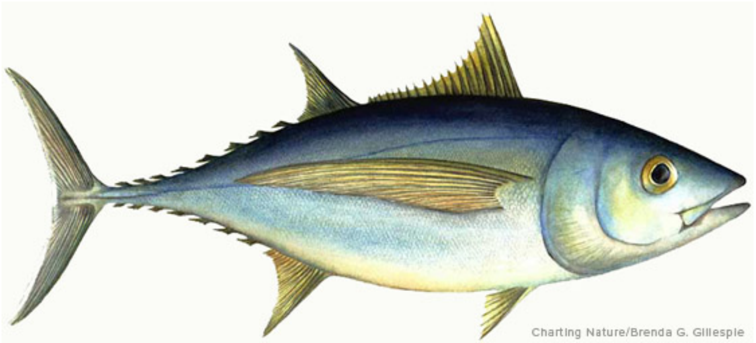
North Pacific Albacore MSE

Management Objective

Maintain catches by fishery above average historical catch

Performance Metric

p(catch) = Probability catch in any given year is above historical (1981-2010) catch



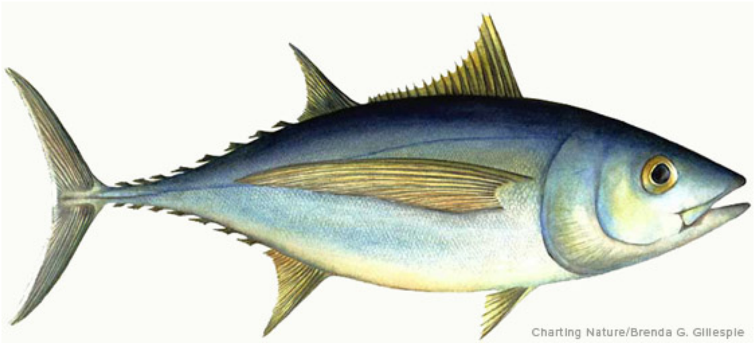
North Pacific Albacore MSE

Management Objective

Change in total allowable catch between years should be relatively gradual

Performance Metric

TAC stability = 1 - % absolute change in TAC between years
Calculated excluding years TAC = 0



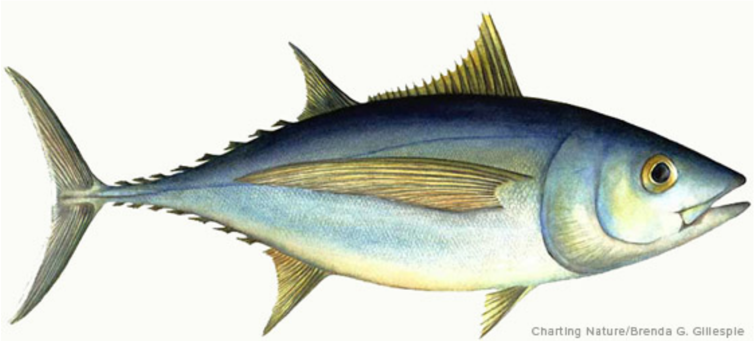
North Pacific Albacore MSE

Management Objective

Maintain fishing intensity (F) at the target value with reasonable variability

Performance Metric

F_{TARGET}/F



15 different Harvest Control Rules

Harvest strategy	Harvest control rule	Ftgt	Btgt	Bthr	Blim
1	1	50	50	30	20
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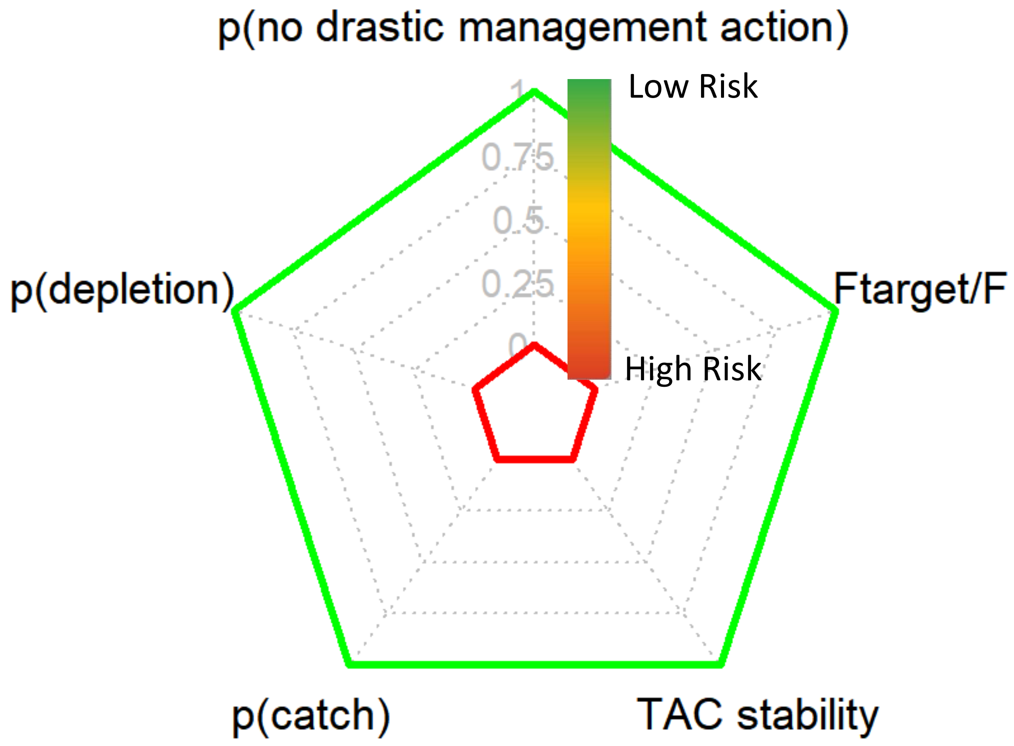
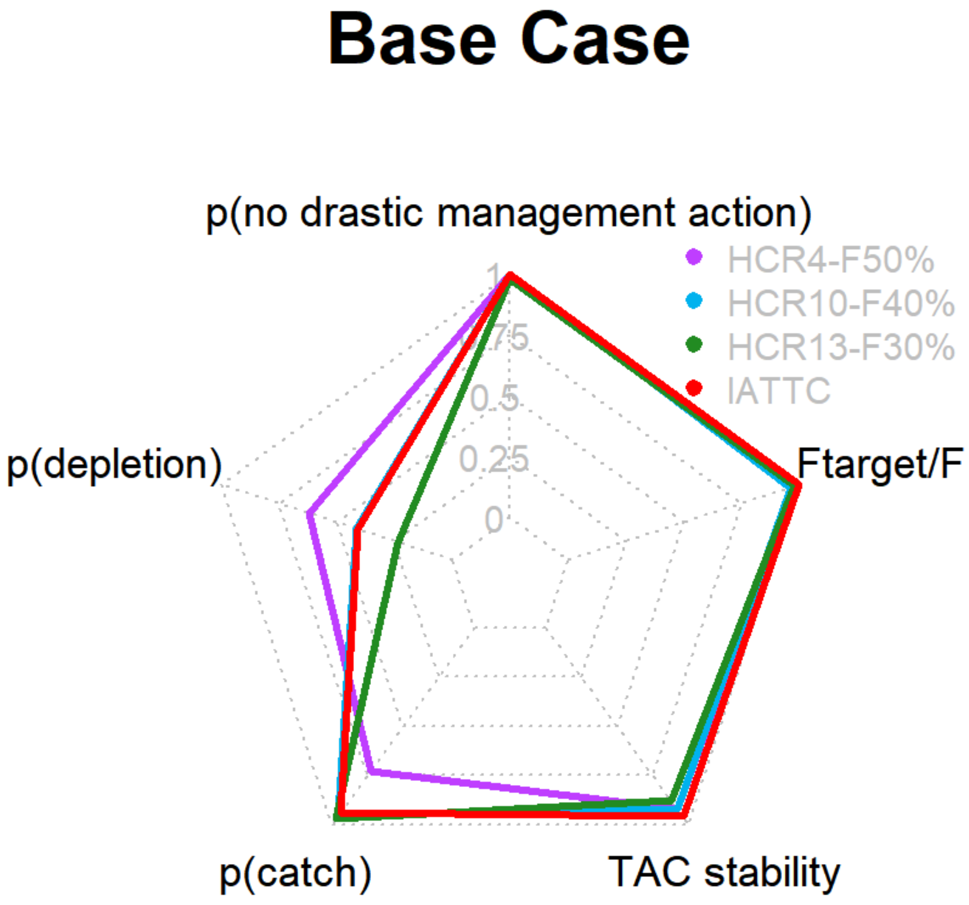
Performance Metrics Comparison



- 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

Impact of F_{target} on performance metrics



- Trade-off between depletion and catch

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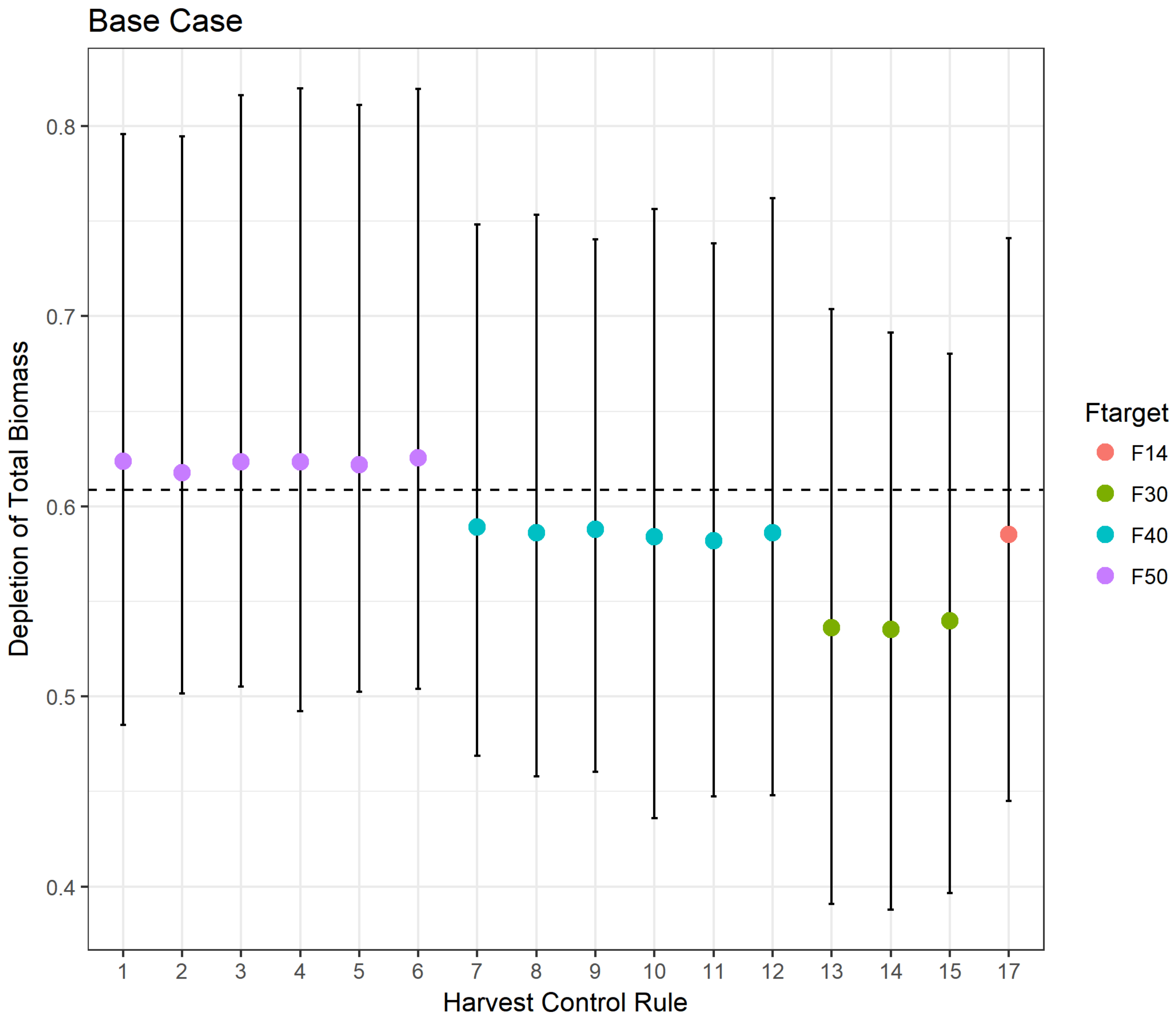
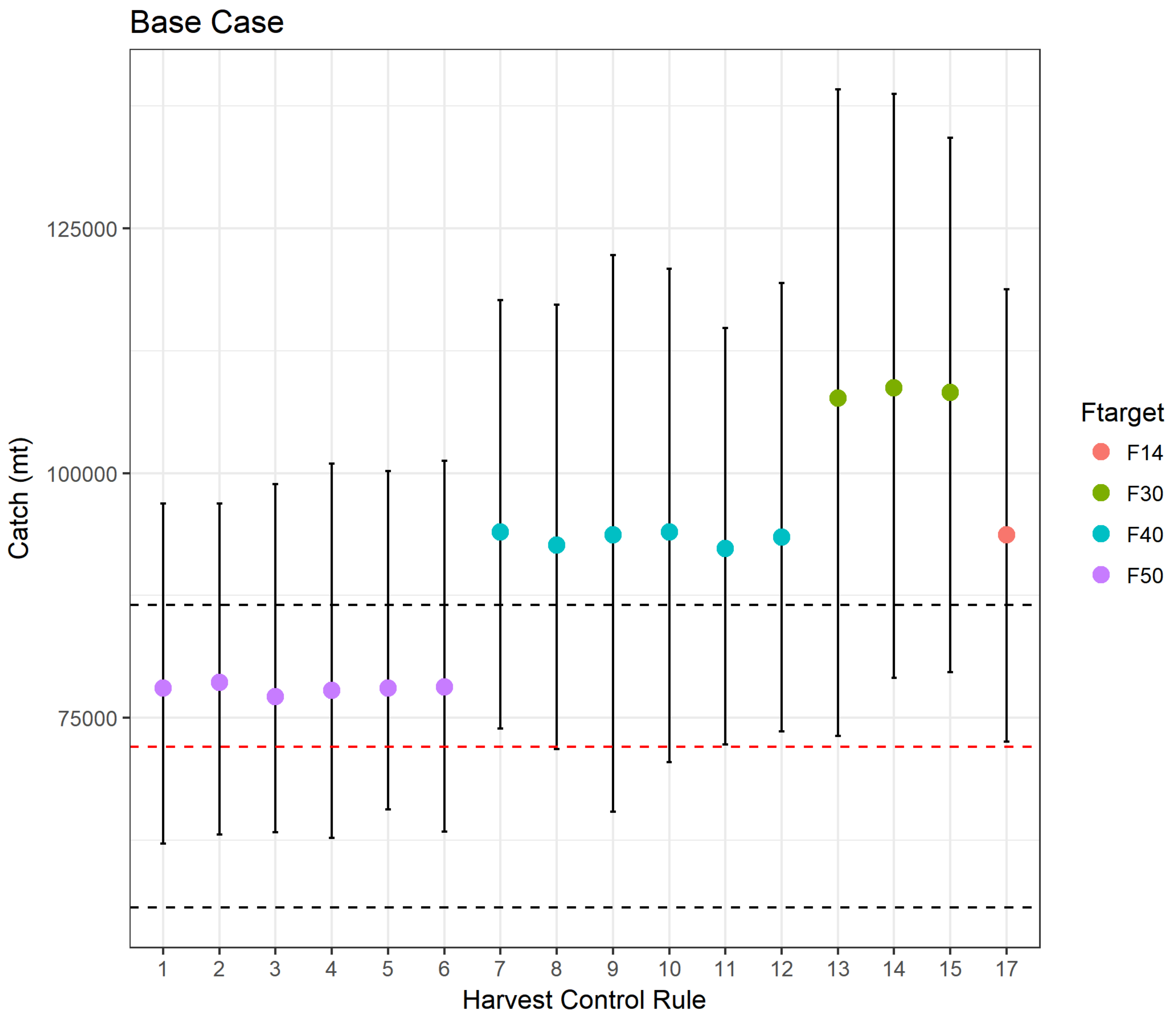
Impact of F_{target} on depletion

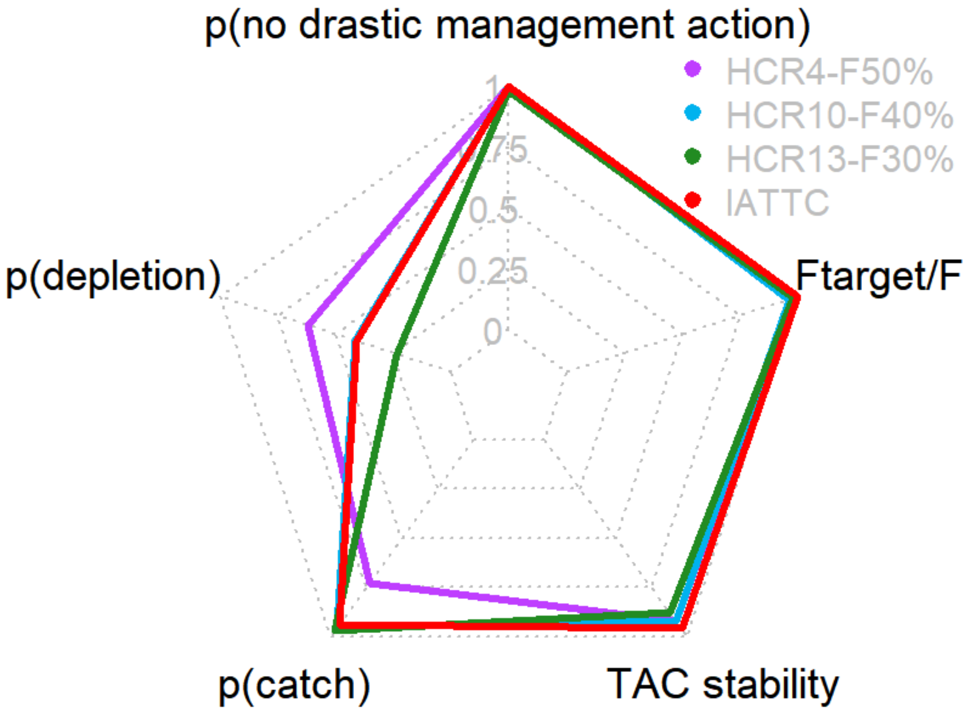


Impact of F_{target} on catch

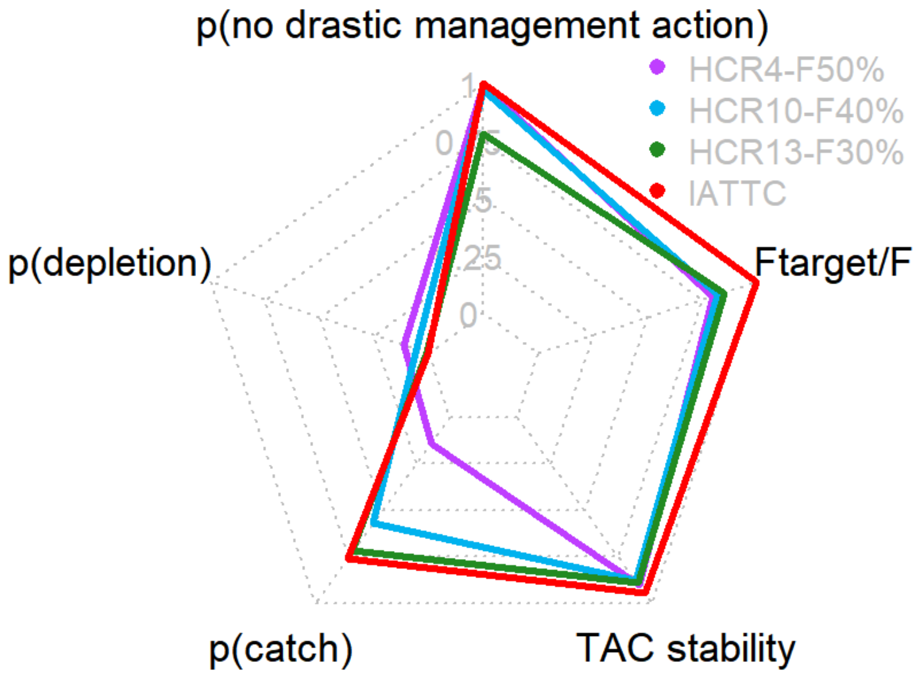


Impact of F_{target} on performance metrics

Base Case



Low Productivity Scenario



- Increased risk of drastic management action with HCR13 at low productivity

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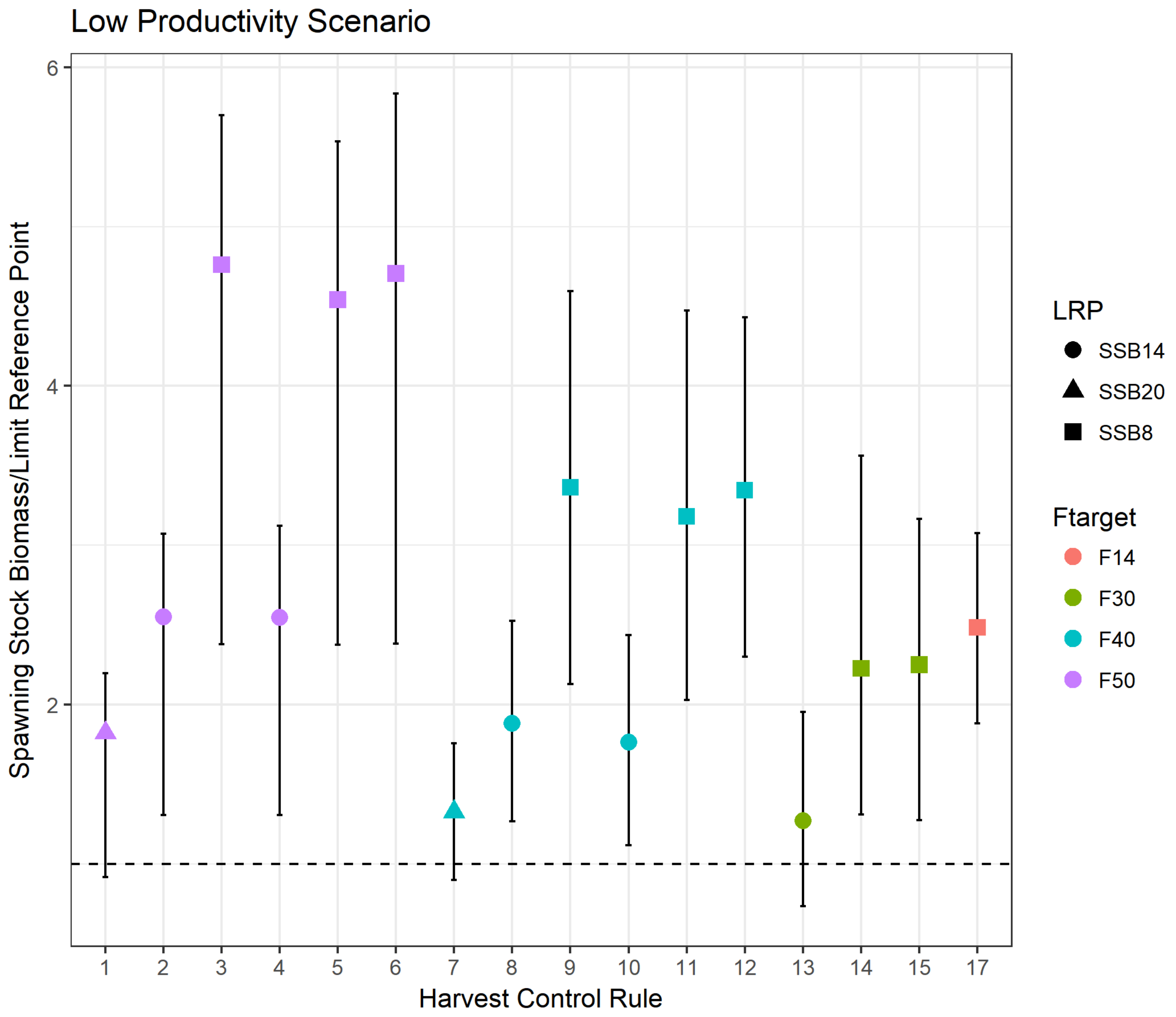
Impact of F_{target} and LRP on p(drastic mgmt action)



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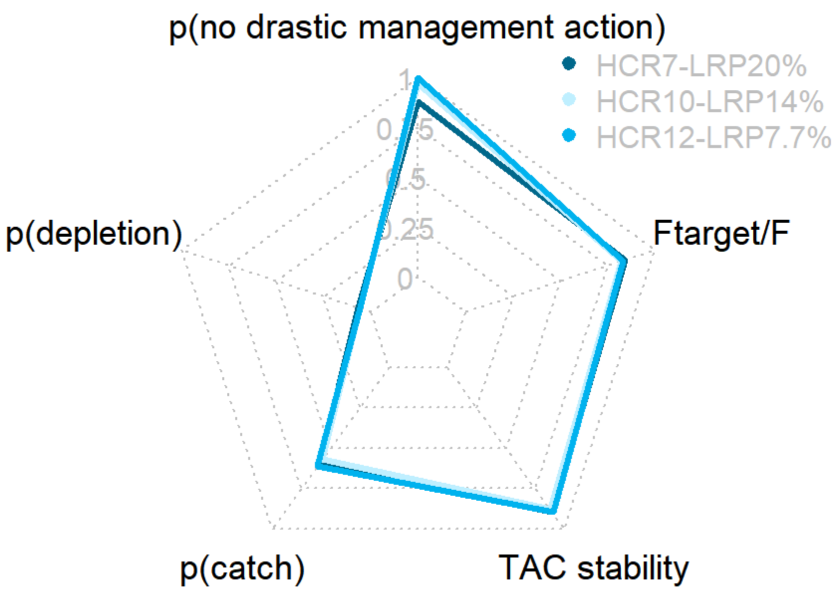
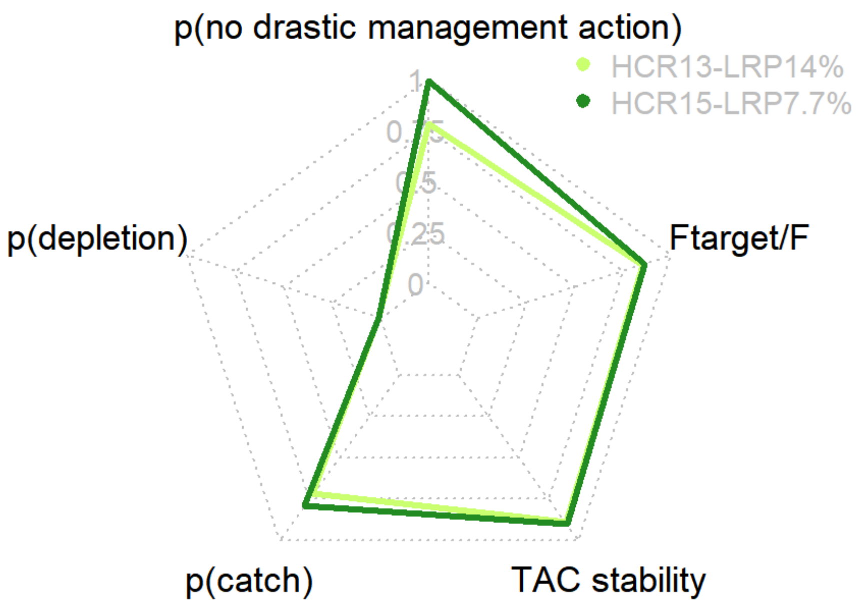
1	9	40	40	30	0.5r0
1	10	40	40	20	14
1	11	40	40	20	0.5r0
1	12	40	40	14	0.5r0
1	13	30	30	20	14
1	14	30	30	20	0.5r0
1	15	30	30	14	0.5r0

Impact of LRP on performance metrics

Low Productivity Scenario - F40%



Low Productivity Scenario - F30%



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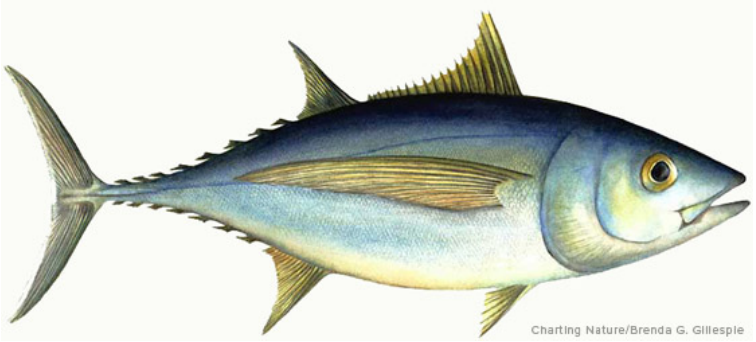
- p(depletion) = Probability of depletion being > minimum historical depletion
- TAC stability = 1 - % absolute difference in TAC between years
- p(catch) = Probability of catch being > average historical catch

Higher LRP, higher probability of drastic management action

Future work

- Finish first round of results by stakeholders meeting in early spring 2019
- Explore methods to reduce run time (analyze trends in estimation error, explore use of ASPM as assessment model)
- Test robustness to decadal recruitment cycles
- Develop economics informed performance metrics



Thank you