Agenda Item G.2
Supplemental Attachment 4 (Electronic Only)
June 2018

Management Strategy Evaluation Listening Session

Summary Report

April 18, 2018

Hosted by:

NOAA Fisheries Southwest Fisheries Science Center
and
West Coast Region

NOAA FISHERIES
Sustainable Fisheries

Management Strategy Evaluation Listening Session

April 18, 2018
12:30-4:30pm

Background

A Management Strategy Evaluation (MSE) is a tool that scientists and managers can use to simulate the workings of a fisheries system and allow them to test whether potential harvest strategies—or management procedures—can achieve management objectives. MSEs are becoming an integral component of the fishery management process, helping to determine the harvest strategy likely to perform best, regardless of uncertainty, and balance trade-offs amongst competing management objectives.

The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) has been engaged in the development of an MSE for North Pacific albacore tuna since 2015 and plans to engage in the development of an MSE for Pacific bluefin tuna. Because the U.S. fishing industry targets both of these species, it is important that managers, scientists, industry, and other stakeholders understand the MSE process. The National Marine Fisheries Service West Coast Region and Southwest Fisheries Science Center are hosting a joint listening session to discuss the MSE process, provide updates on the ISC North Pacific albacore tuna MSE and plans for developing a Pacific bluefin tuna MSE.

Agenda

12:30 – 12:50	Welcome & Introductions • Around the Room at the SWFSC (La Jolla) • Around the Room at the WCR (Long Beach) • Who is on the Phone?	DiNardo, Taylor
12:50 – 1:00	Review of Agenda	Taylor
1:00 – 1:10	Goals and Objectives	Taylor, DiNardo
1:10 – 1:50	MSE 101: What is it? Why Implement? When do we Implement? How do we implement?	Tommasi
1:50 – 2:30	Overview of the ISC North Pacific Albacore MSE	Teo, Tommasi
2:30 – 2:45	Break	
2:45 – 3:05	Brief Overview of Recent Pacific Bluefin Tuna Stock Assessment	DiNardo
3:05 – 3:35	Review of ISC Pacific Bluefin Tuna MSE Activities and May Workshop Agenda	DiNardo
3:35 – 4:30	Open Discussion	DiNardo, Taylor

Summary of Listening Session

The following is a summary of the listening session compiled from notes taken by National Marine Fisheries Service (NMFS) West Coast Region (WCR):

The NMFS WCR and Southwest Fisheries Science Center (SWFSC) hosted a listening session regarding management strategy evaluation (MSE) on April 18, 2018. Stakeholders were invited to participate in person in either Long Beach or La Jolla, California, or remotely via webinar. The purpose of this listening session was to provide stakeholders with information about the MSE process and discuss ongoing MSE activities by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). Participants represented fishing industry, state and federal fisheries managers, fishery management council staff, scientists, and non-governmental organizations. The presentations are included in this summary report as Appendices.

North Pacific albacore MSE

Dr. Desiree Tomassi of the SWFSC gave an introduction to the MSE process and then provided an overview of the North Pacific albacore MSE (See Appendices I and II). The example results of the North Pacific albacore MSE were shown with spider plots, which provide a visual representation of trade-offs between management objectives. However, spider plots do not depict uncertainty.

A participant highlighted that there is uncertainty in percentage of the stock that migrates into the eastern Pacific Ocean (EPO). Dr. Tommasi pointed out that there are many unknowns, but that the operating model will try to address this uncertainty. When discussing the management objectives identified for North Pacific albacore, which is not overfished or subject to overfishing, [1] it was noted that these objectives may be different than those identified for a depleted stock. A participant expressed concern about fleets switching fishing pressure from South Pacific albacore to North Pacific albacore. This is an uncertainty that will be included in the MSE, but it is a scenario that does not seem likely to occur.

Lastly, participants raised questions about how catch may be allocated in the scenarios. Dr. Tomassi clarified that in scenarios with a total allowable catch, catch was allocated by country. Participants followed up by suggesting the MSE could examine economic objectives with different ways of allocating catch. Dr. DiNardo noted that it is very difficult to get countries to agree to allocations, which may stall the MSE process.

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[1] When compared to the biomass limit reference point adopted by the Western and Central Pacific Fisheries Commission and fishing mortality that corresponds to maximum sustainable yield.

Pacific bluefin tuna

Dr. Gerard DiNardo briefly discussed the 2018 Pacific bluefin tuna stock assessment. The Pacific bluefin tuna stock biomass continues to be at very low levels, although there has been a 0.6% increase in spawning stock biomass (SSB) since the 2016 stock assessment. Recruitment in 2016 that is higher than in the previous few years, which were at historic lows, and there are indications that recruitment may remain high in 2017 as well. As agreed to by the WCPFC, the ISC performed projections to determine if under a given set of assumptions (e.g., low recruitment until the initial rebuilding target is met, and then average recruitment) the initial and second rebuilding targets adopted by the WCPFC will be met[2]. Dr. DiNardo explained that the current recruitment index is derived from the stock assessment model and that efforts are underway to validate using small fish (age 0) caught in Japan's coastal troll fishery as a recruitment index in the future. Dr. DiNardo further explained that to assess the effectiveness of the recruitment increase in a single year, it is necessary to determine if that increase is observed in other fisheries in the subsequent years. The next stock assessment will be completed in 2020.

On the subject of survivability, Dr. DiNardo noted that most mortality is associated with larval stages, and once the fish migrate across the Pacific Ocean, survivability is good because fishing pressure in the EPO is relatively little. He added that recent diet studies have found more anchovy in the stomachs, which improves growth and survival---as compared to pelagic red crab, which has been observed in stomach contents from 2013-2016 and represented more than 50% of the diet in 2015 and 2016.

Dr. DiNardo provided an overview of the agenda for a Pacific bluefin tuna MSE workshop to be hosted by the ISC in Japan in May 2018 and potential candidate management objectives that stakeholders and managers may want to consider (see Appendix III). This workshop is organized as a result of a request from the WCPFC Northern Committee and Dr. DiNardo noted that ISC will begin work on the MSE in 2019 after the Northern Committee provides candidate reference points (target and limit) and harvest control rule, as well as funding to support hiring of staff to work on the MSE.

Dr. DiNardo presented a slide with potential candidate management objectives for the MSE (see Appendix III). In addition to those presented, below is a list of candidate objectives, concepts for objectives, or considerations for that resulted from the discussion at the listening session.

<u>Concepts and Considerations for Management Objectives</u>

- All fishing sectors should have access to catch. For example, different fishing sectors rely on Pacific bluefin tuna in different areas of the ocean and at different ages.

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[2] The Inter-American Tropical Tuna Commission adopted the initial rebuilding target in 2016 and is expected to adopt the second rebuilding target at its 2018 annual meeting.

- As fisheries improve, there may be new entrants or emerging fisheries to consider.
- Stability and continuity of market supply.
- Harvest Pacific bluefin tuna of certain sizes that would allow the greatest possibility of rebuilding.
- Maximize the economic value of the product.
- An objective that examines canning versus selling fish whole.
- An objective that supports historic participation in the Pacific bluefin tuna fishery.
- Maintain biomass.
- Utilize traceability to ensure catch from various fisheries are accounted, which could be incorporated into the model by testing whether there is uncertainty in the catch.
- Once the second rebuilding target is met:
    - maintain the stock above spawning stock biomass (SSB) expected to achieve maximum sustainable yield (MSY) and to maintain fishing mortality below the level that would achieve MSY (FMSY) with at least 75% probability;
    - if SSB has been assessed by the ISC as below SSB_{msy}, to rebuild SSB to or above SSBmsy, with at least a 75% probability, and within as short time as possible, but not longer than 1.5 generations;
    - limit changes in catch limits between management periods to no more than 10% upwards or downwards, unless the ISC has assessed that there is greater than a 50% chance the stock is below the SSBlimit, in which case more significant decreases in catch limits shall be approved;
    - maintain an equitable balance between the fisheries in the western and central Pacific Ocean and those in the EPO;
    - maximize the long-term yield and average annual catch from the fishery; and
    - maximize the productivity of the stock by managing the catch of the smallest fish.

‘

List of Participants

<u>Southwest Fisheries Science Center (La Jolla)</u>

Dale Sweetnam
David Rudie
Desiree Tommasi
Donna Seely
Elizabeth Hellmers
Gerard DiNardo
James Hilgar
James Smith
John Sweeny
Layna Siddall
Travis Buck

<u>Glenn M. Anderson Federal Building (Long Beach)</u>

Amber Rhodes
Anthony Vuoso
Celia Barroso
Corbin Hanson
Courtney Hahn
Daniel Studt
Heidi Taylor
Joey Ferrigno
John Zuanich
Mark Helvey
Michelle Horeczko
Mike Conroy
Mike Thompson
Nick Turbin Jurlin
Pete Ciaramitaro
Rachael Wadsworth
Rex Ito
Vince Torre
Will Stanke

<u>Via Webinar</u>

Alex Kahl
Andre Boustany

Bill Sardinha
Christa Svennson
Cyreis Schmidt
Deb Wilson-Vandenberg
Dianna Porzio
Dorothy Lowman
Douglas Fricke
Erik Kingma
Gerald Leape
James Gibbon
Josh Madeira
Kit Dahl
Josh Madeira
Karter Harman
Kit Dahl
Lynn Massey
Meggan Walline
Michael Brakke
Morgan Ivans-Duran
Natalie Webster
Rachel O'Malley
Steve Crooke
Taylor Debevec
Tonya Wick
Valerie Post
Wayne Heikkela

Appendix I

MSE 101: What, Why, and How

Desiree Tommasi
Southwest Fisheries Science Center - Cooperative Institute for Marine Ecosystem and Climate
MSE NMFS Listening Session
Southwest Fisheries Center, La Jolla, CA, USA
April 18,2018

Outline

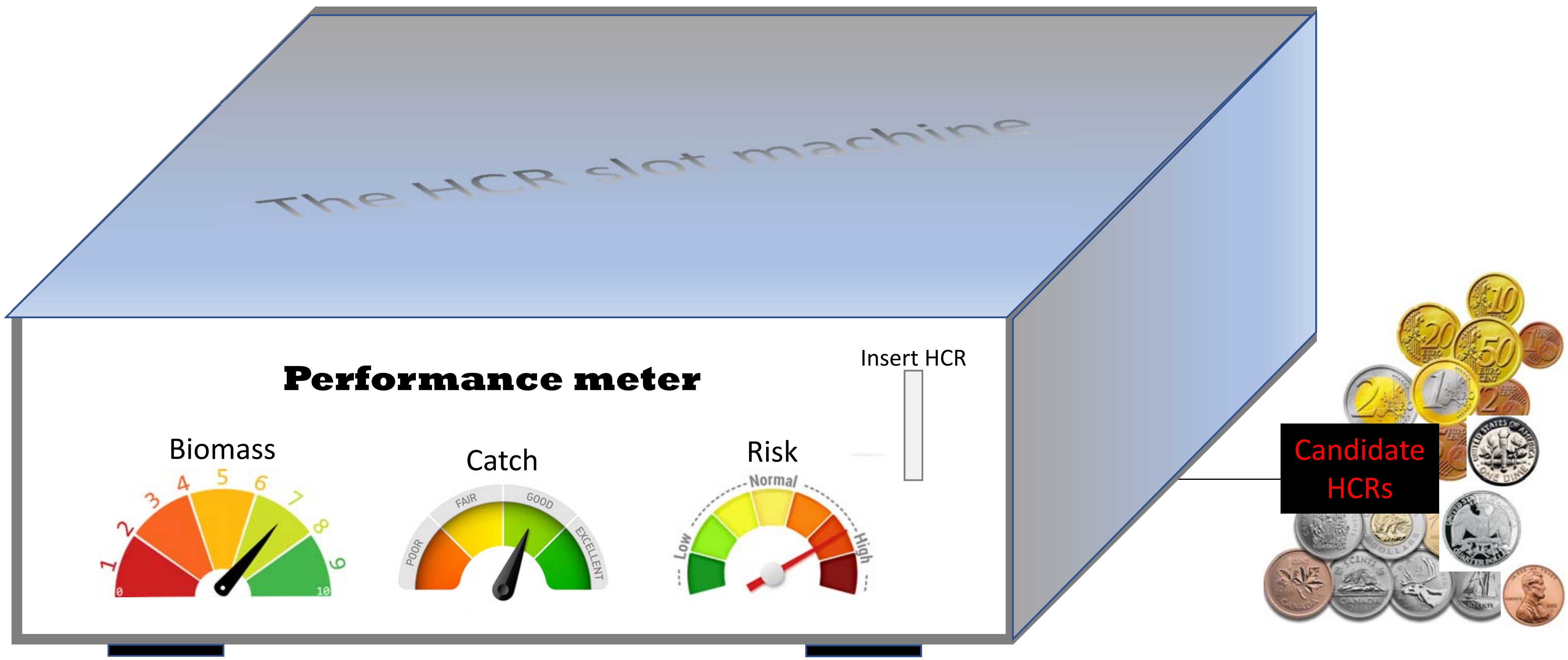
1. MSE Definition
2. Key ingredients
3. Examples

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

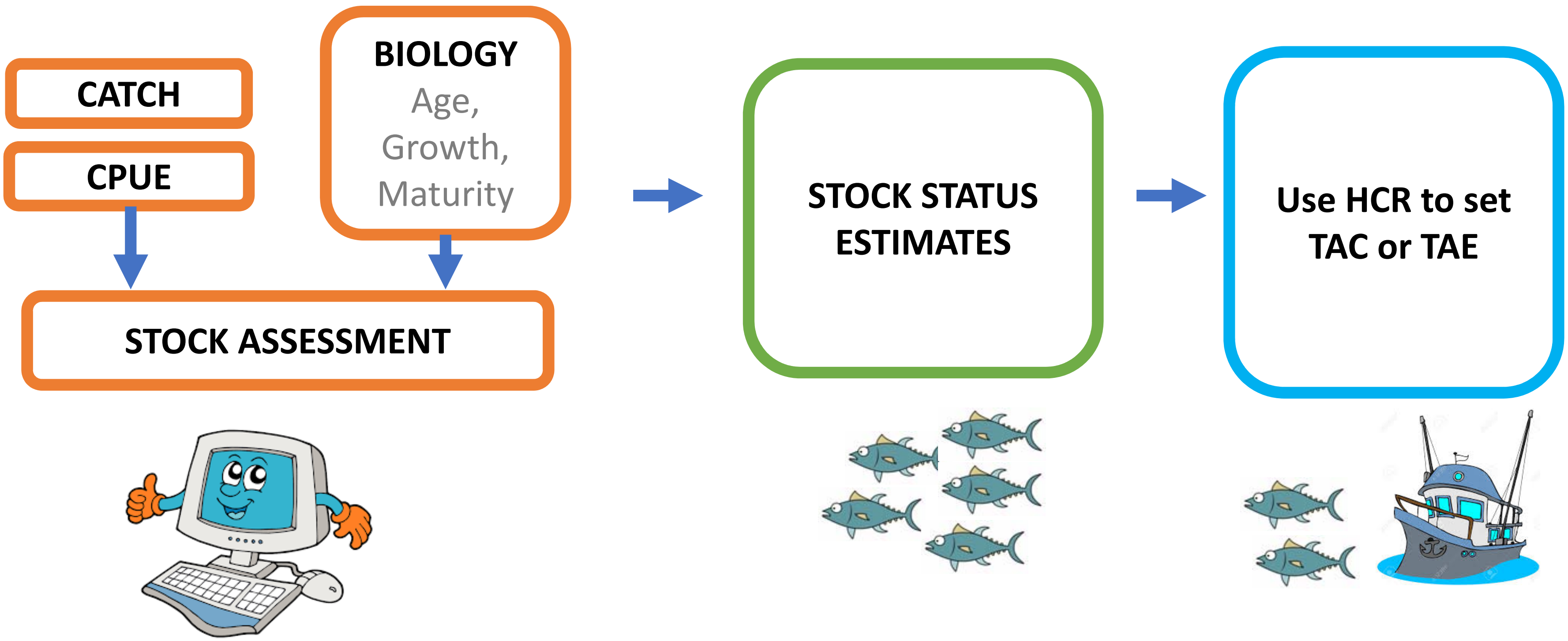
MSE = a harvest control rule (HCR) slot machine



Slide courtesy of Carsten Hvingel and Jacqueline Perry, Greenland Halibut MSE, NAFO RBMS Working Group

Key Ingredients of MSE

1. A set of Harvest Control Rules (HCRs)
    - Pre-agreed upon set of rules to specify a management action (e.g. setting the total allowable catch or location/timing of closures)



Key Ingredients of MSE

2. A set of Operating Models (OMs)
   - Plausible versions of true dynamics of the system
   - Conditioned on historical data
   - Represent the range of uncertainty in different factors

OMs

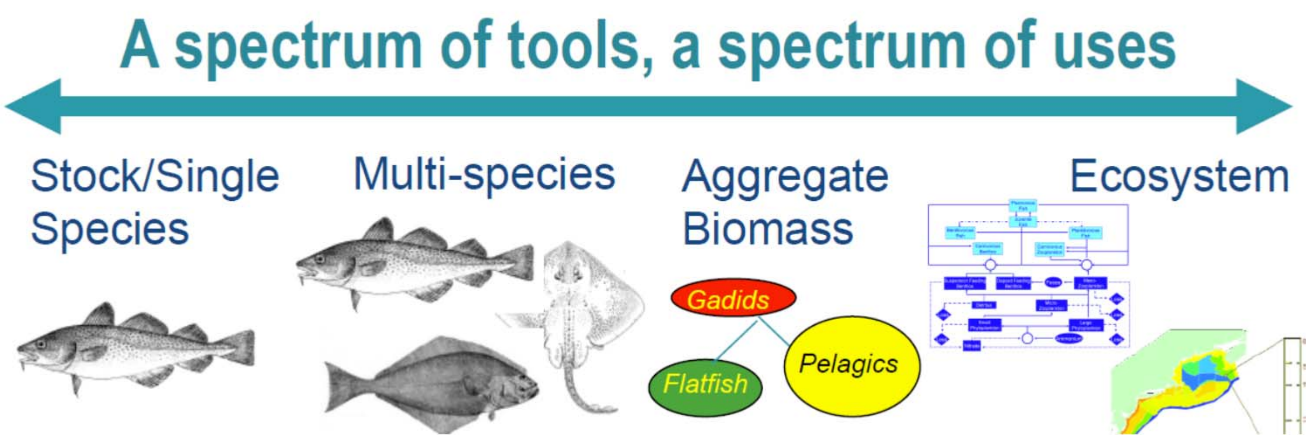
OPERATING MODEL 1
Natural Mortality = 0.45

OPERATING MODEL 2
Natural Mortality = 0.4

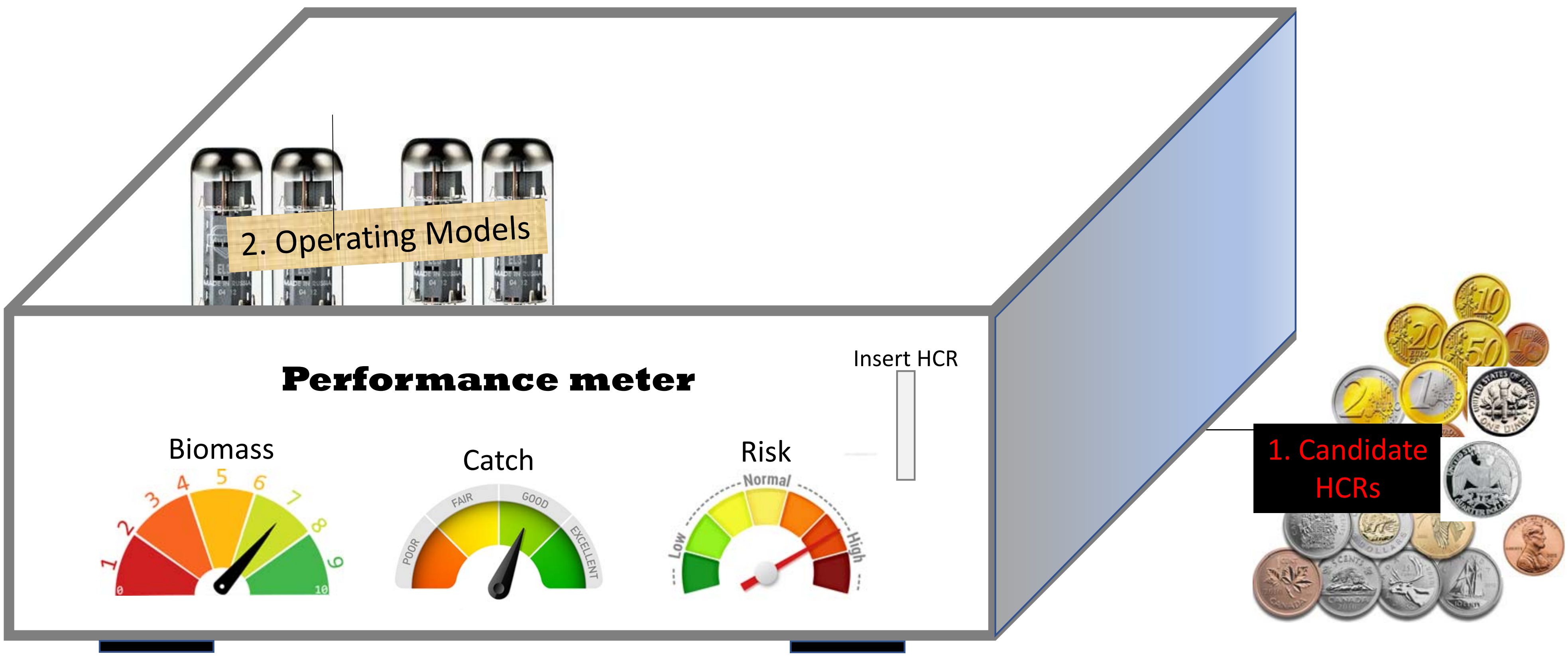
OPERATING MODEL 3
Natural Mortality = 0.35

Key Ingredients of MSE

2. A set of Operating Models (OMs)
   - Range in complexity depending on management objectives and management strategies of interest



Key Ingredients of MSE

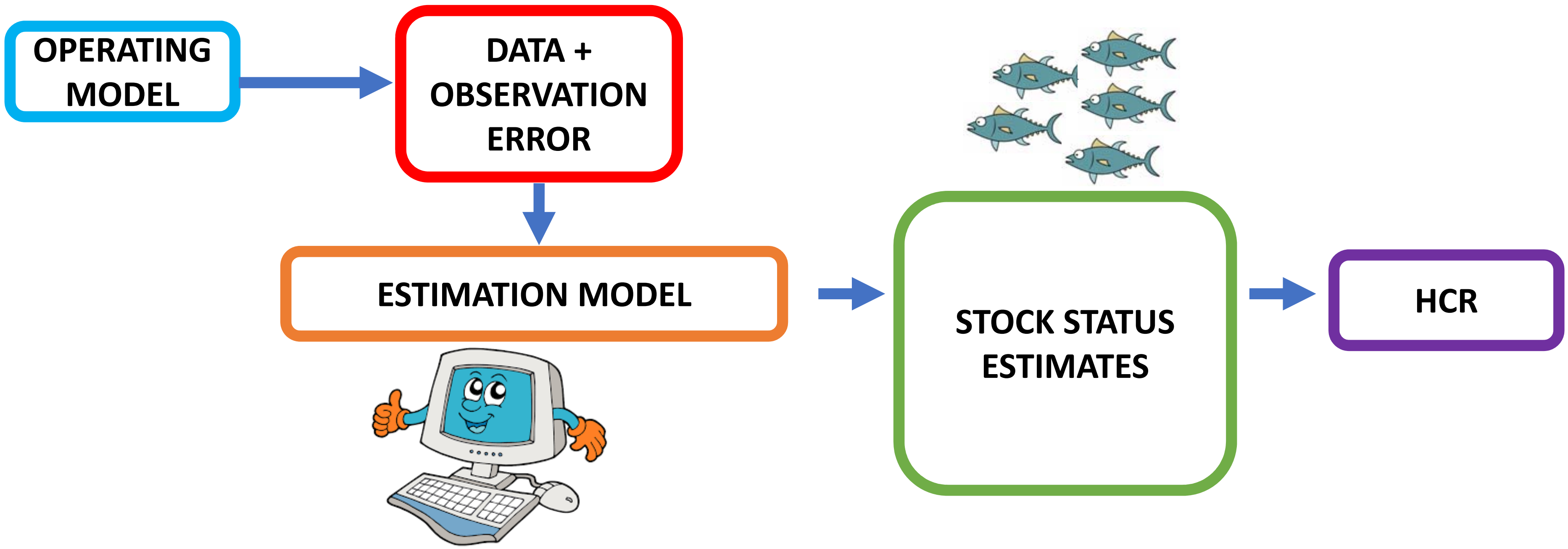


Modified from slide courtesy of Carsten Hvingel and Jacqueline Perry, Greenland Halibut MSE, NAFO RBMS Working Group

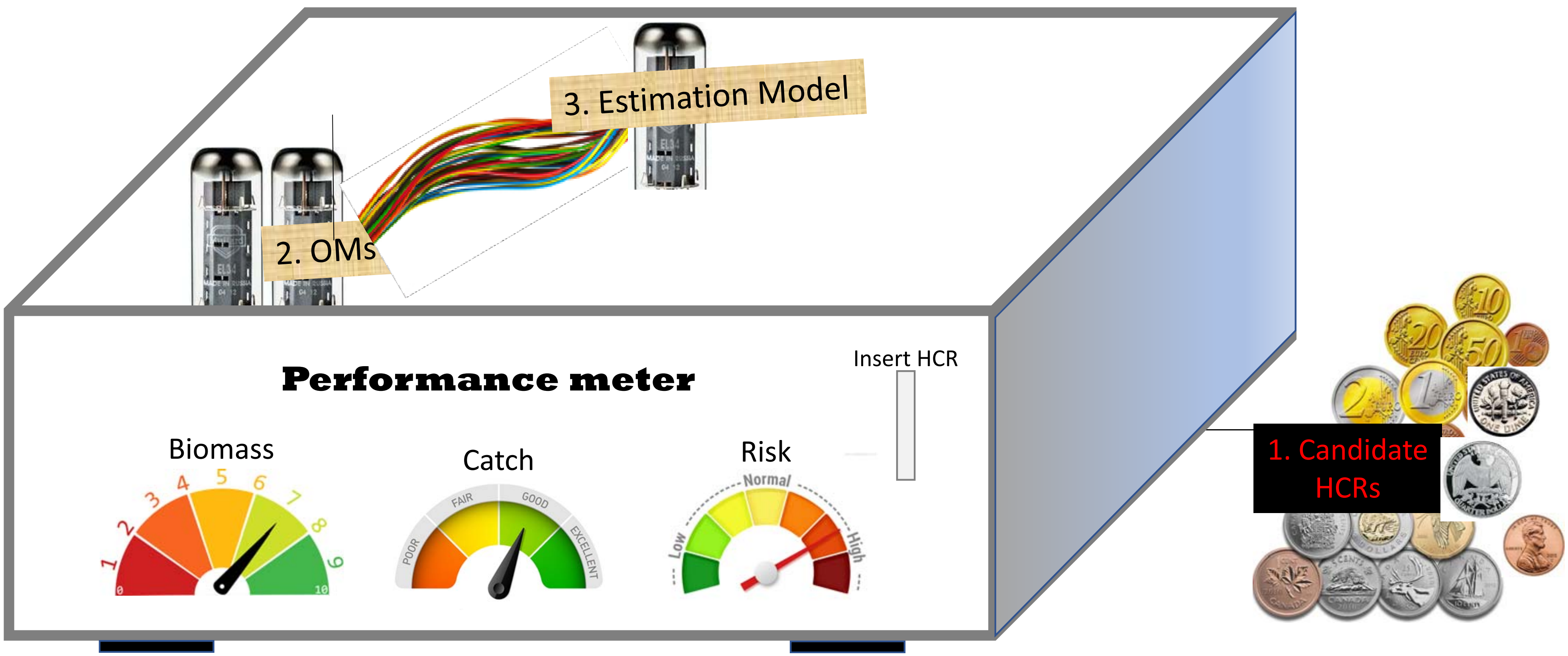
Key Ingredients of MSE

3. An Estimation Model

- Takes data generated with error by the OM (e.g. catch, abundance index) and produces an estimate of stock status



Key Ingredients of MSE



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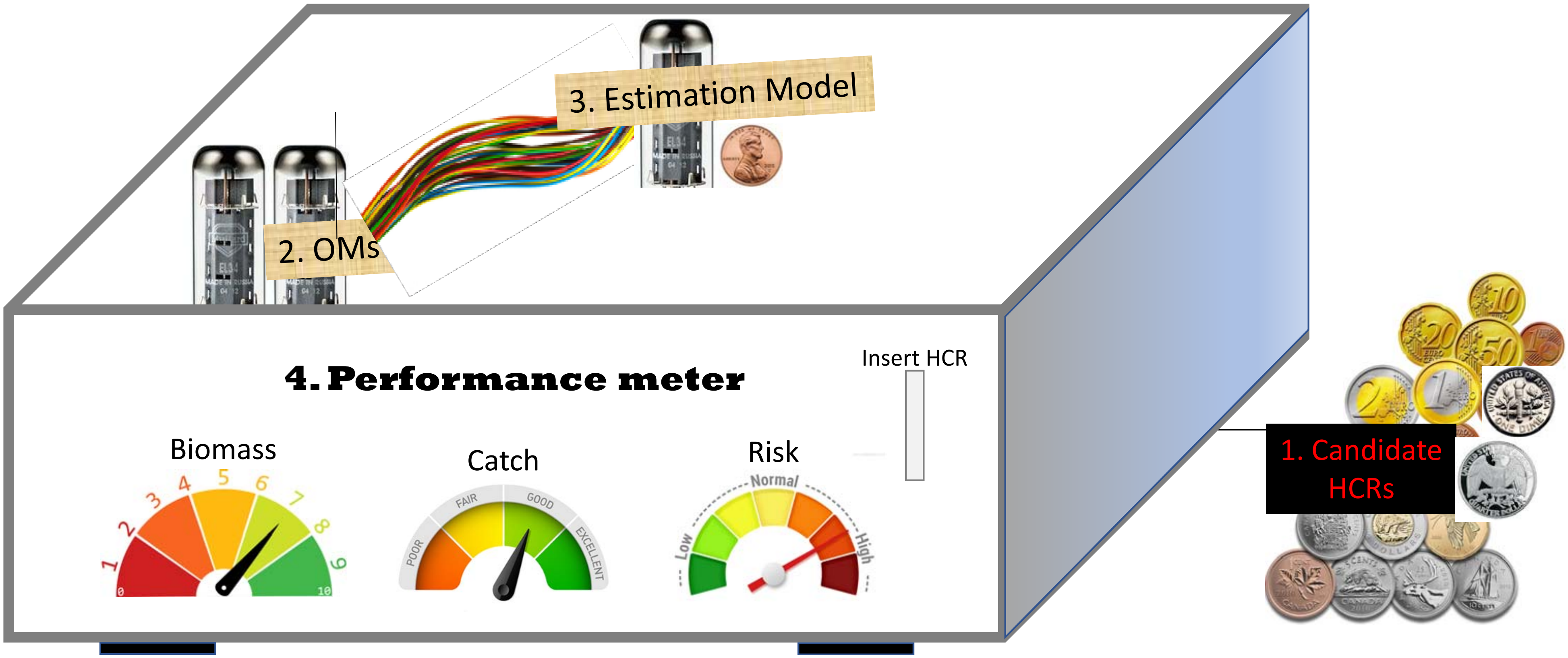
Key Ingredients of MSE



Modified from slide courtesy of Carsten Hvingel and Jacqueline Perry, Greenland Halibut MSE, NAFO RBMS Working Group

Key Ingredients of MSE

4. A set of performance metrics

- Quantitative indicators that are used to evaluate each HCR

Performance meter

Biomass

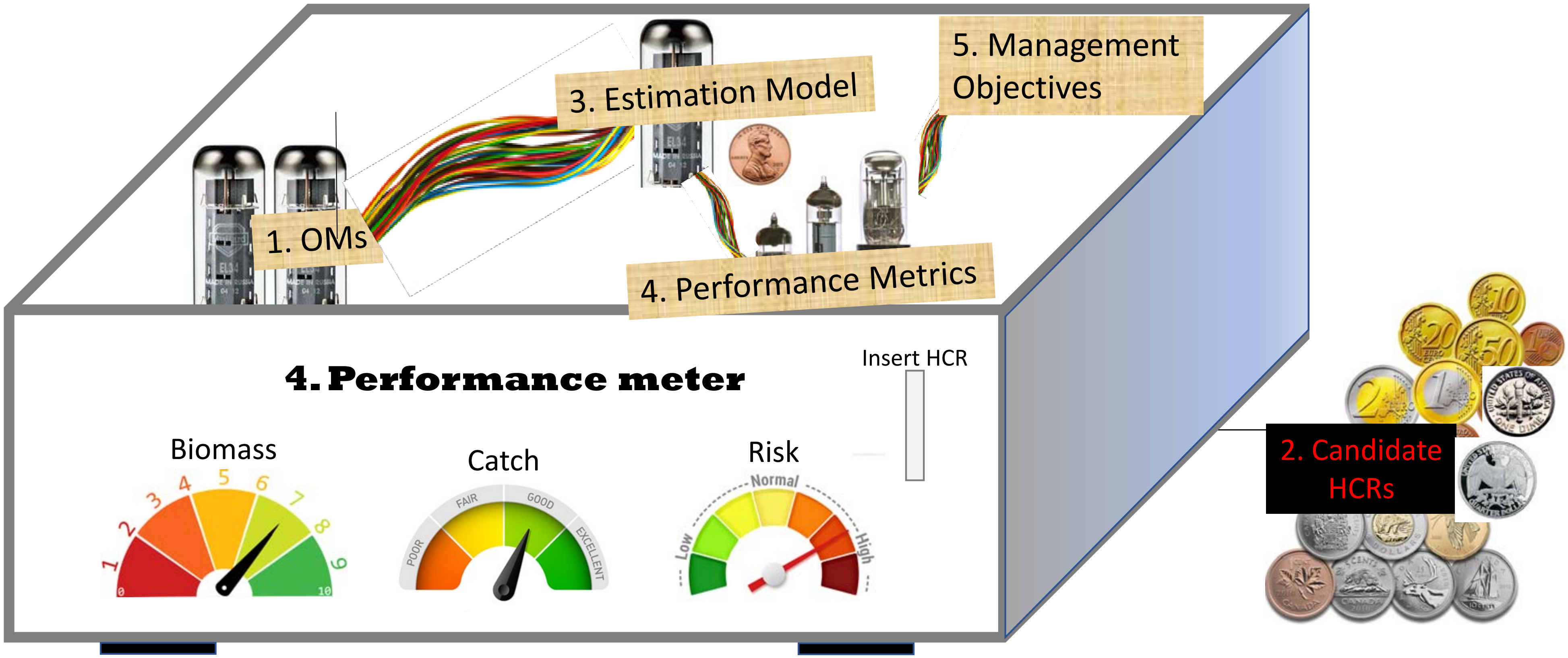
Catch

Risk

Key Ingredients of MSE

5. A set of management objectives
   - High level goals of a management plan
   - E.g. Prevent overfishing, Promote profitability of the fishery
   - There are often trade-offs among management objectives
   - Represented in MSE using performance metrics

Key Ingredients of MSE

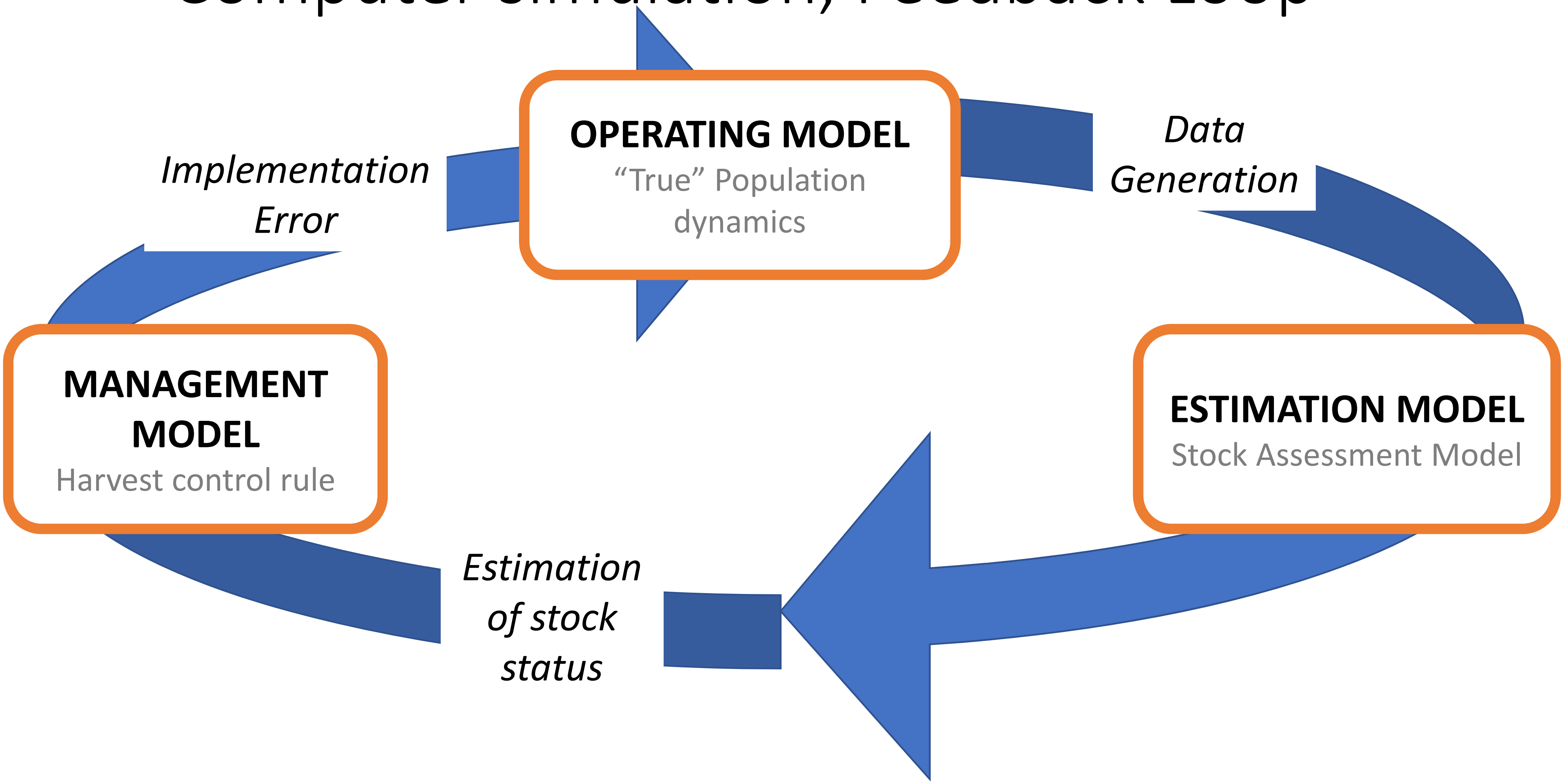


Modified from slide courtesy of Carsten Hvingel and Jacqueline Perry, Greenland Halibut MSE, NAFO RBMS Working Group

Why do an MSE

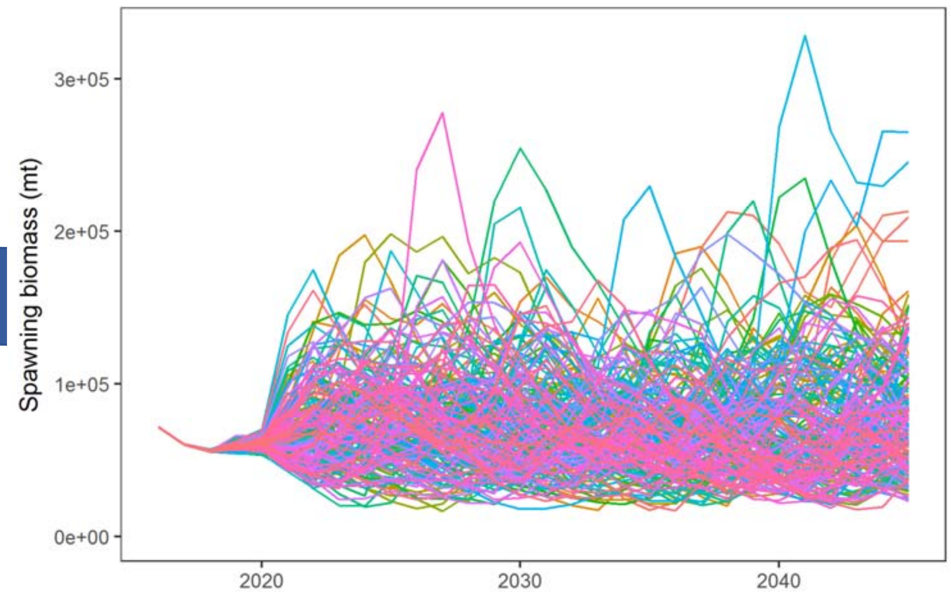
- How well can a management strategy achieve pre-agreed upon management objectives given uncertainty?
- How does a particular management strategy perform compared to alternative ones?
- Quantitatively and explicitly highlight trade-offs between different management objectives

How to do an MSE
Computer simulation, Feedback Loop

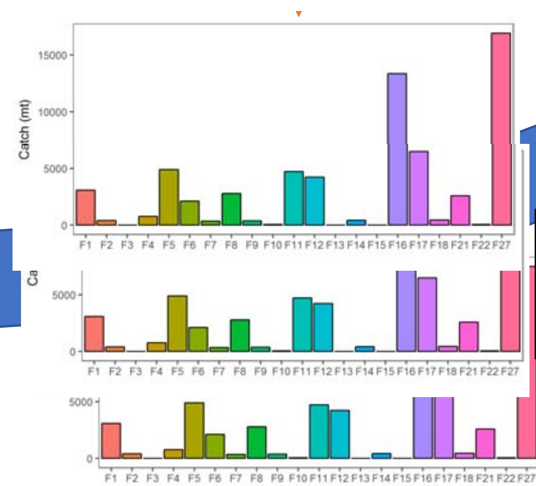


For each management strategy

1. Project (true) state given the catch



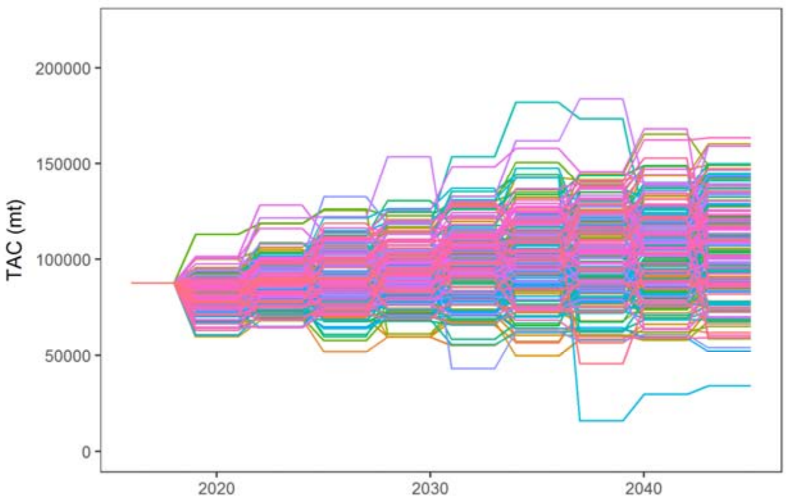
2. Generate data from true population



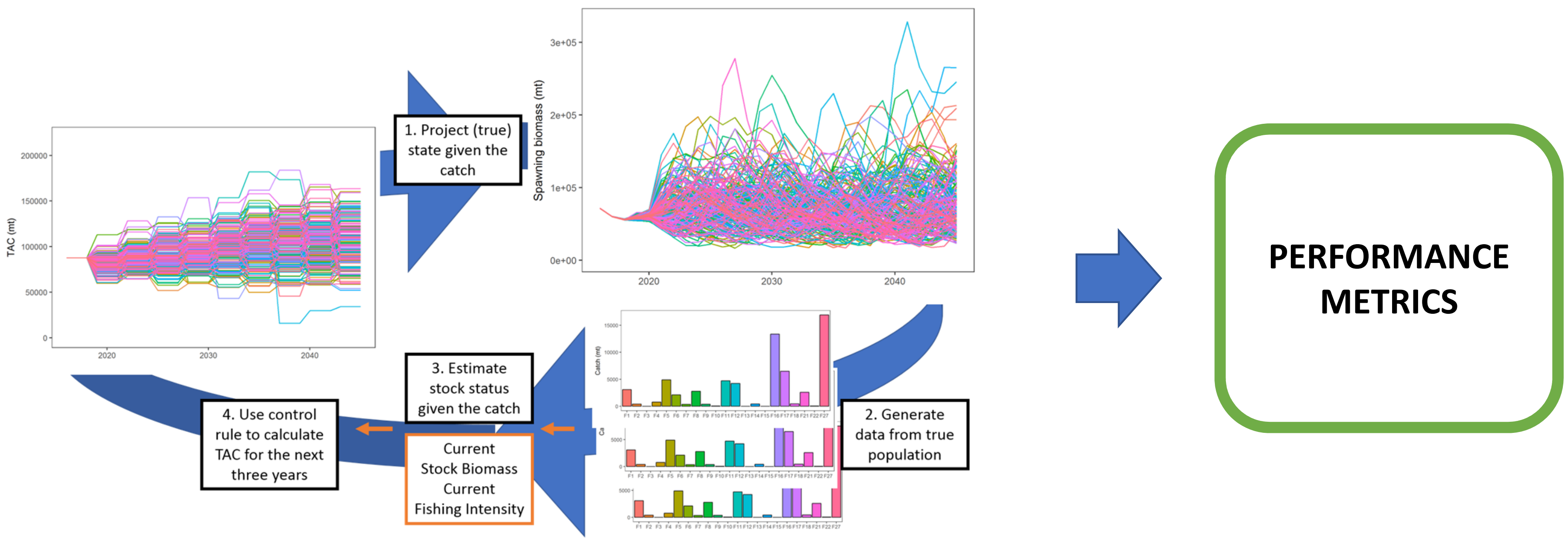
3. Estimate stock status given the catch

Current Stock Biomass
Current Fishing Intensity

4. Use control rule to calculate TAC for the next three years



For each management strategy

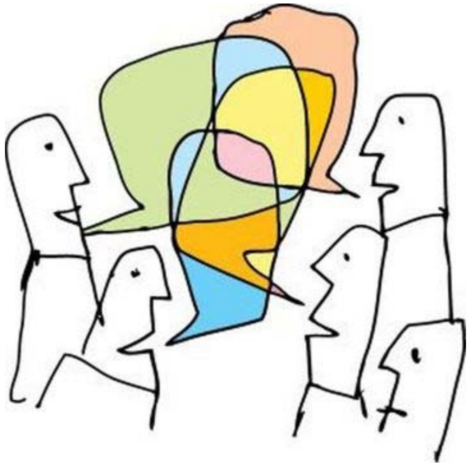


Stakeholders involvement is important for

1. Clearly specifying pre-agreed upon management objectives and performance metrics

2. Identifying candidate management strategies to be tested in MSE framework

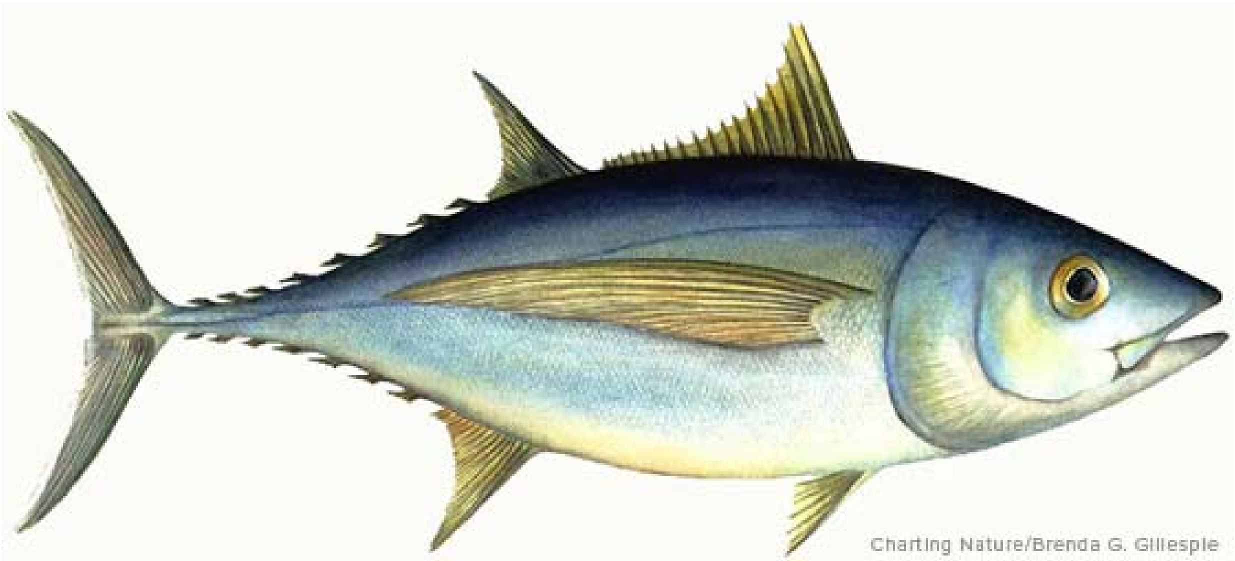
3. Review results



MSE Example – North Pacific Albacore

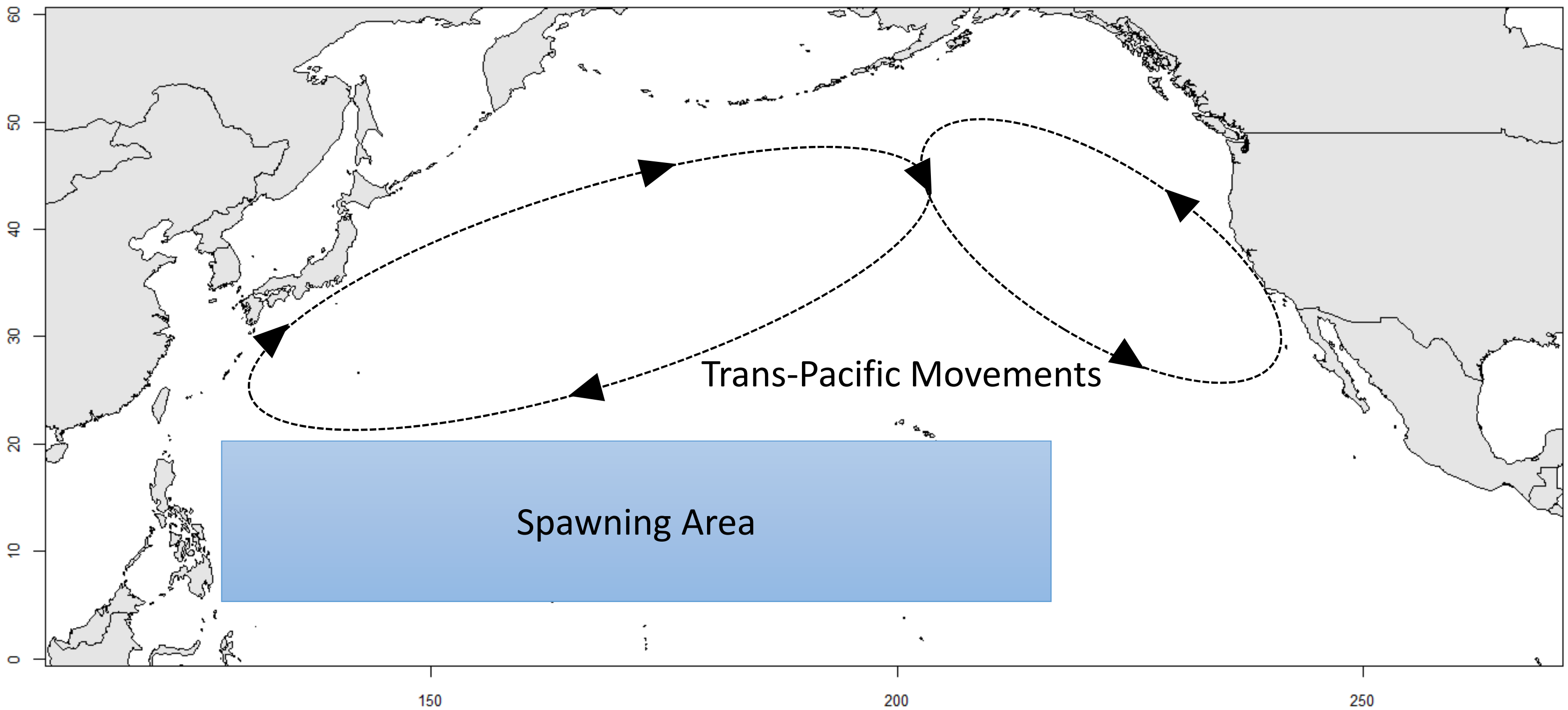
Background: see Steve Teo's talk

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



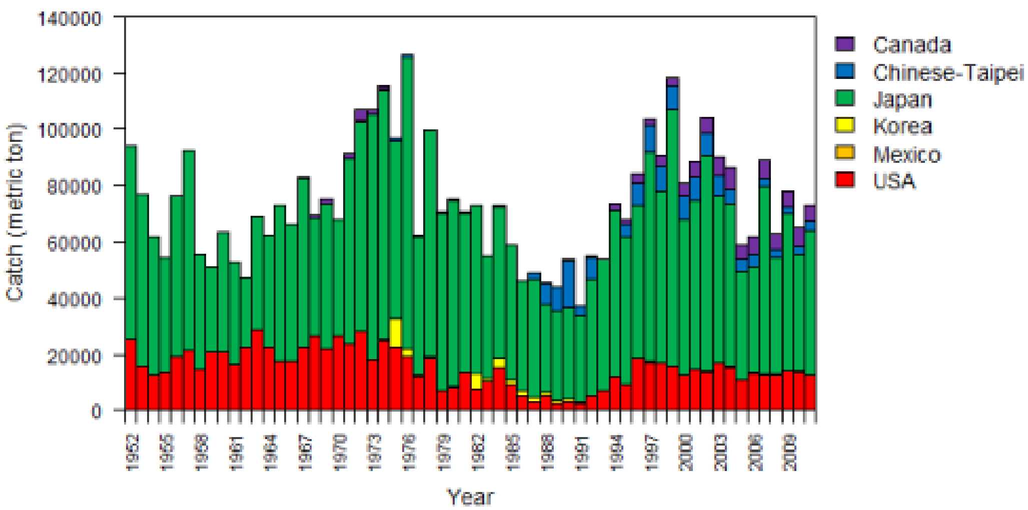
North Pacific Albacore

Highly migratory species whose habitat spans the entire North Pacific Ocean

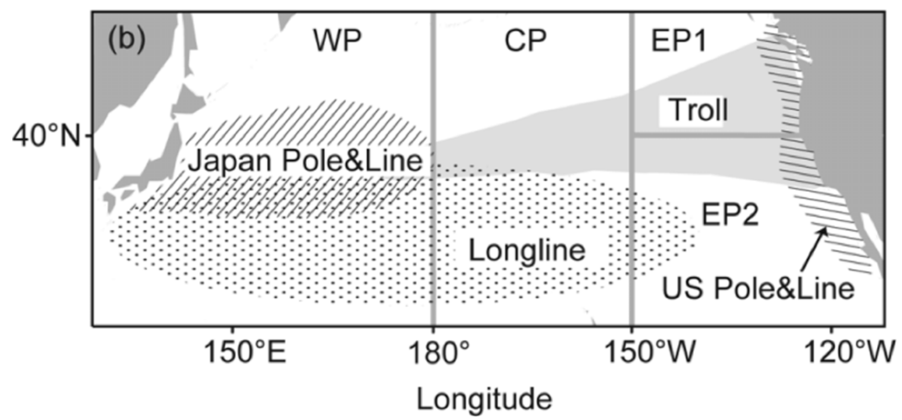


North Pacific Albacore

Majority of the catch occurs in the Western Pacific



ISC ALBWG,
http://isc.fra.go.jp/working_groups/albacore.html

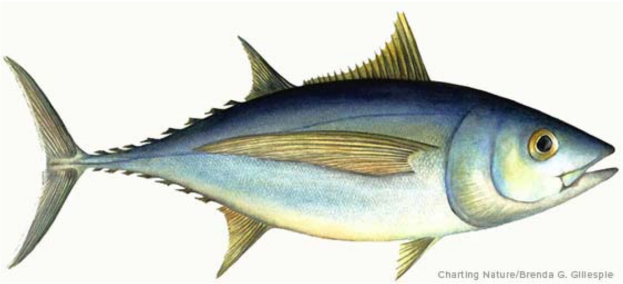


Ichinokawa et al. 2008, Canadian Journal of Fisheries and Aquatic Sciences

MSE Example – North Pacific Albacore

Management Objectives

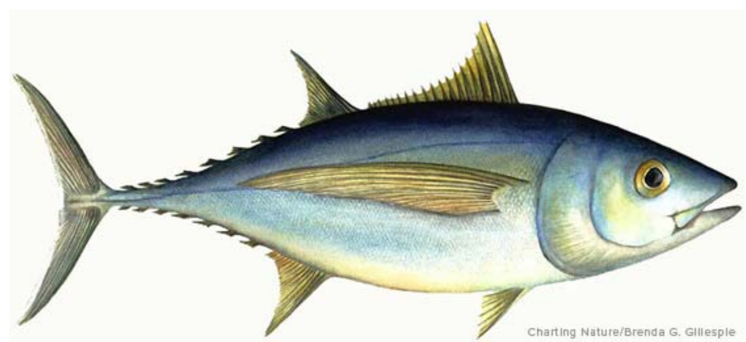
1. Maintain spawning biomass above the limit reference point
2. Maintain depletion (fished biomass/unfished biomass) around historical average depletion
3. Maintain fishing impact by fishery at historical average
4. Maintain catches by fishery above average historical catch
5. Change in total allowable catch between years should be relatively gradual
6. Maintain fishing mortality (F) at the target value



MSE Example - North Pacific Albacore

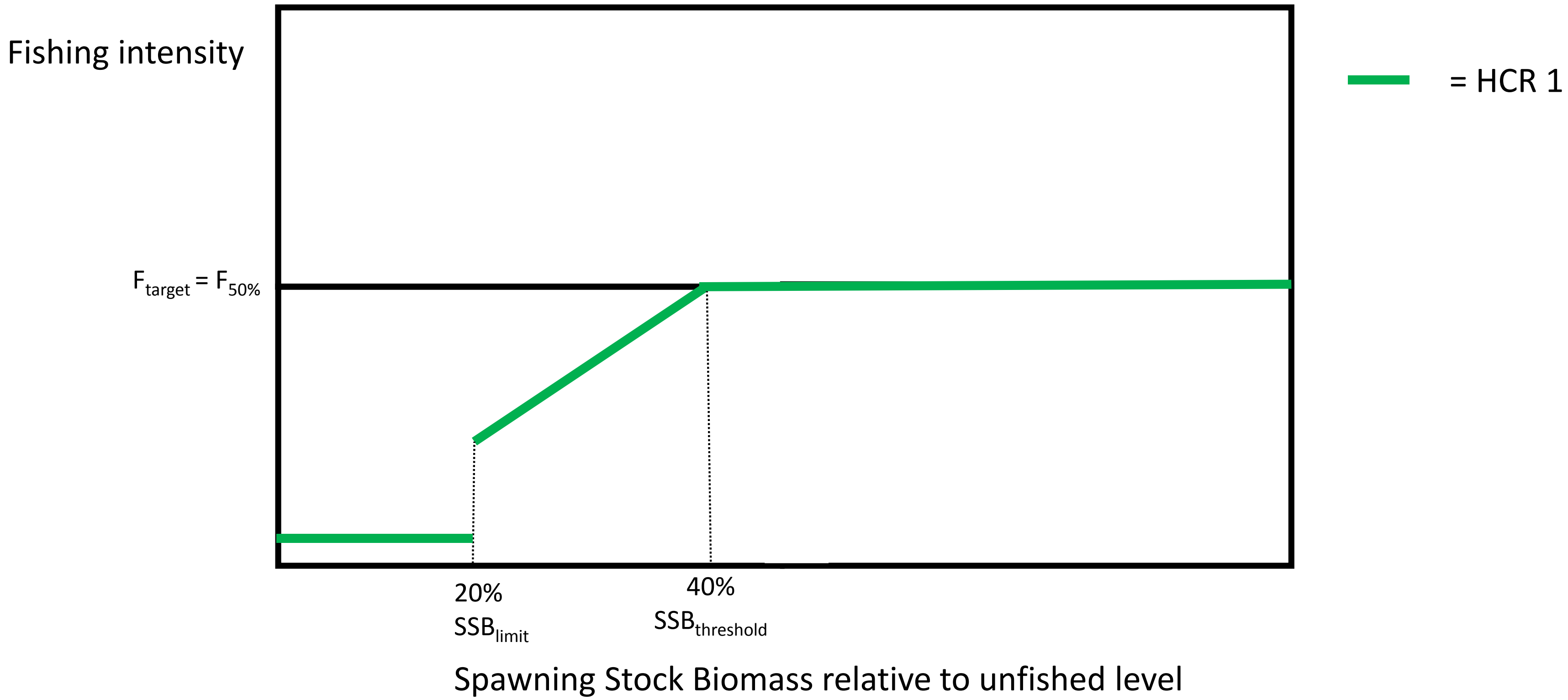
Performance Metrics

1. Spawning stock biomass (SSB)/SSB-based limit reference point (LRP)
2. Depletion/minimum historical depletion
3. Fishing impact by fishery/minimum historical fishing impact by fishery
4. Catch/average historical catch
5. % change in total allowable catch between years
6. F-based target reference point/F



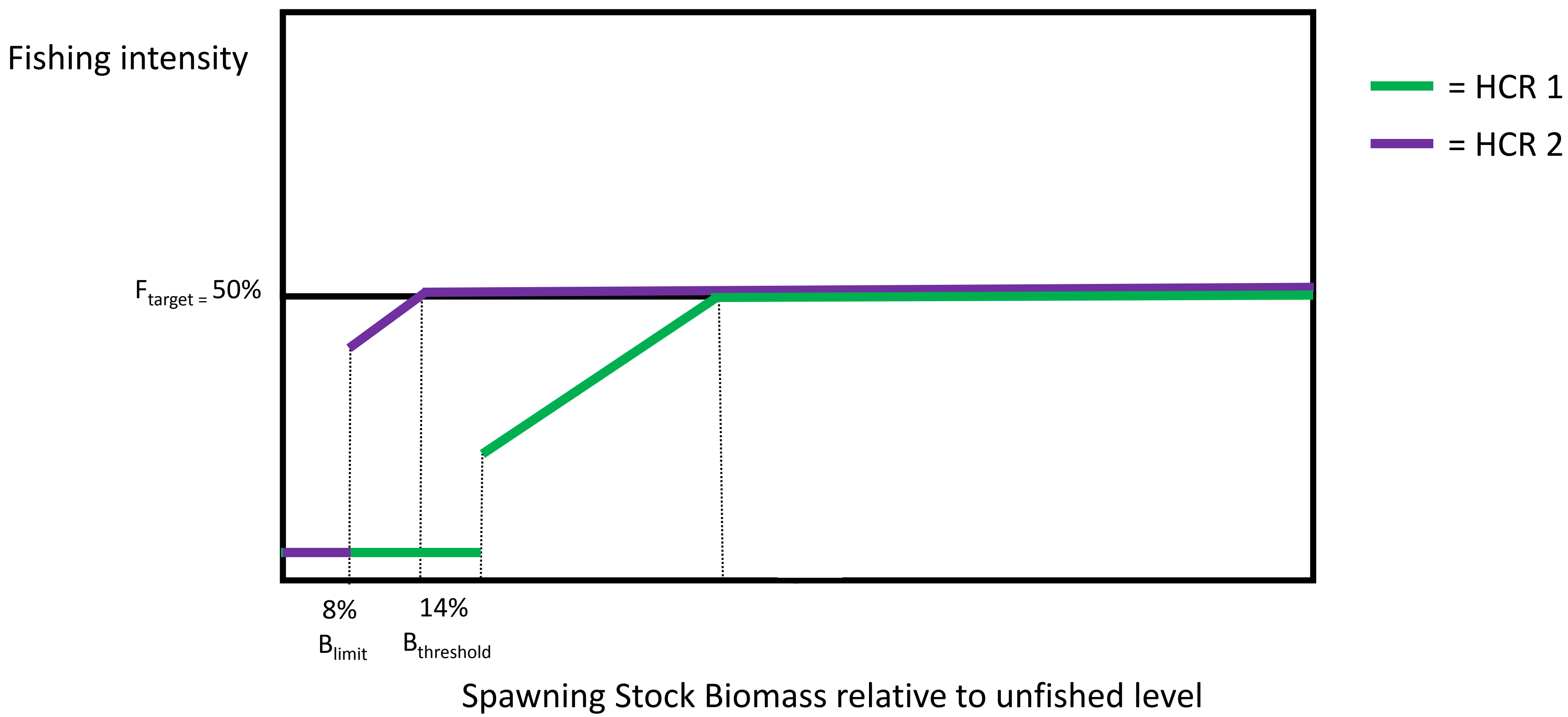
MSE Example – North Pacific Albacore

Harvest Control Rule (HCR)



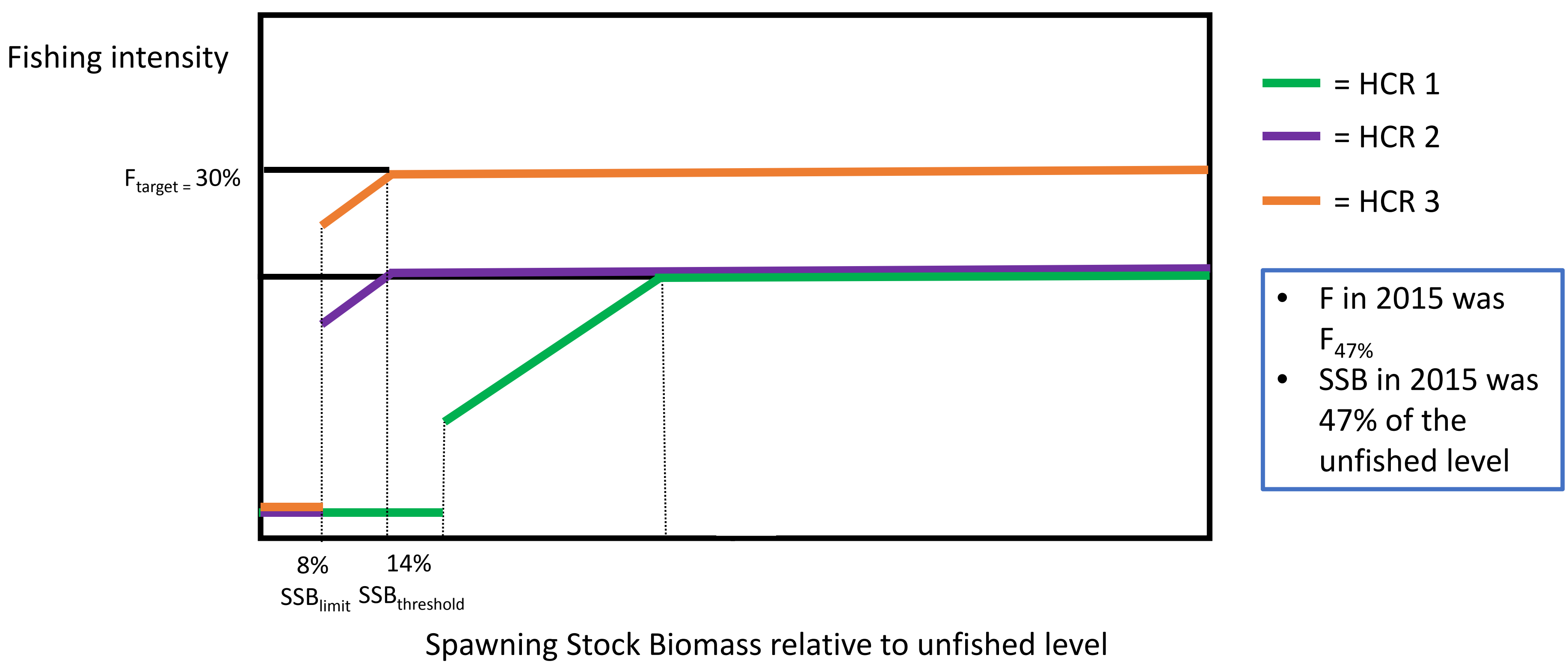
MSE Example – North Pacific Albacore

Strategies/HCRs



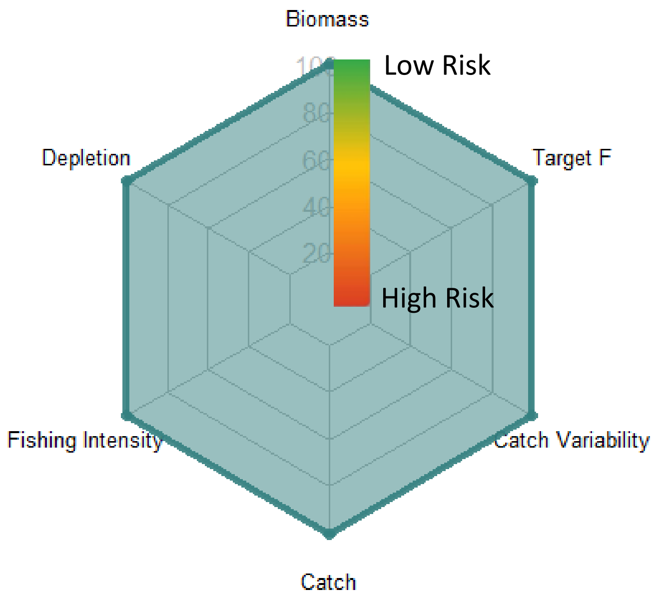
MSE Example – North Pacific Albacore

Strategies/HCRs



MSE Example - North Pacific Albacore

Performance Metrics Comparison

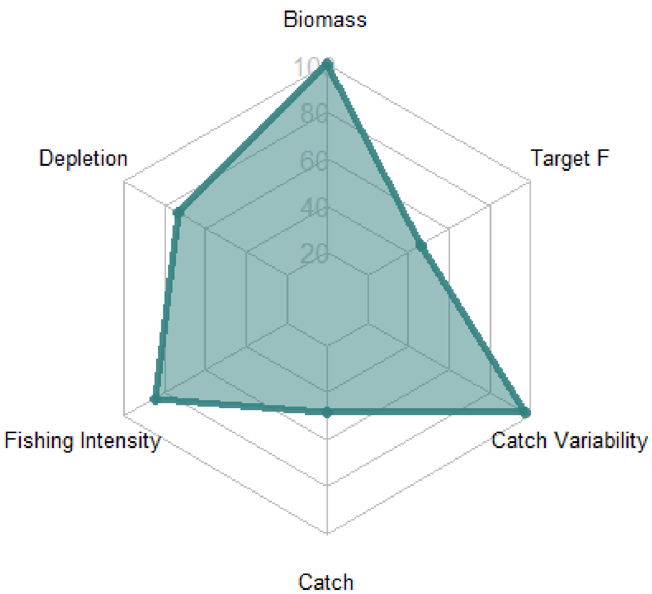


- *Biomass* - % SSB above limit reference point
- *Target F* - % F below target
- *Catch variability* - (100-average catch variability between years)
- *Catch* - % above historical catch
- *Fishing intensity* - % US fishing intensity above historical minimum fishing intensity
- *Depletion* - % above historical depletion

MSE Example - North Pacific Albacore

Performance Metrics Comparison

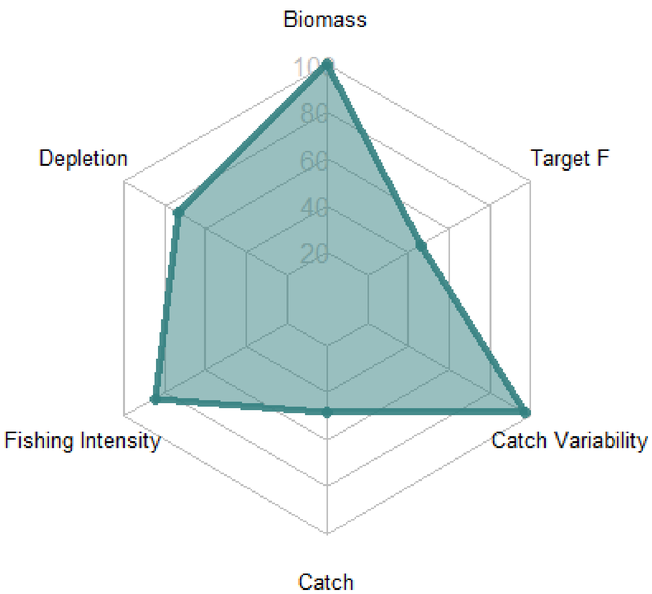
HCR 1



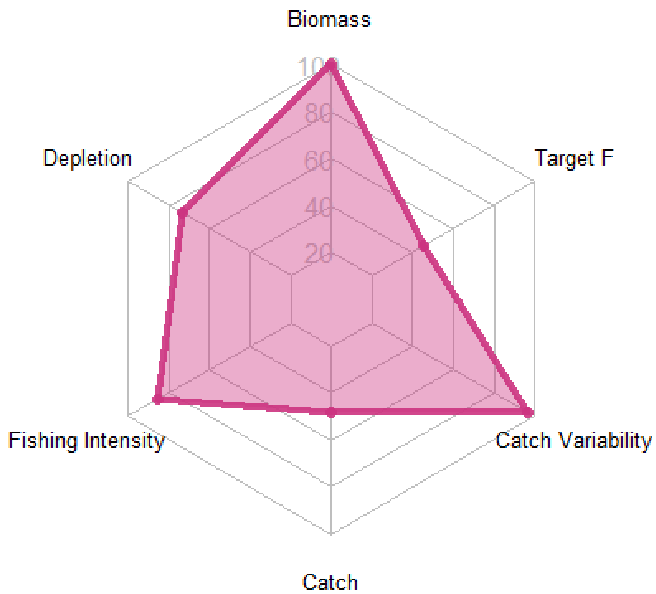
MSE Example - North Pacific Albacore

Performance Metrics Comparison

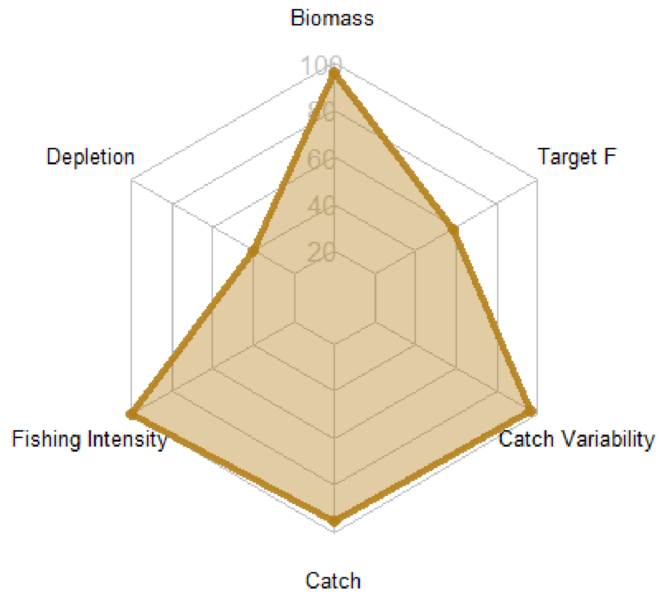
HCR 1



HCR 2



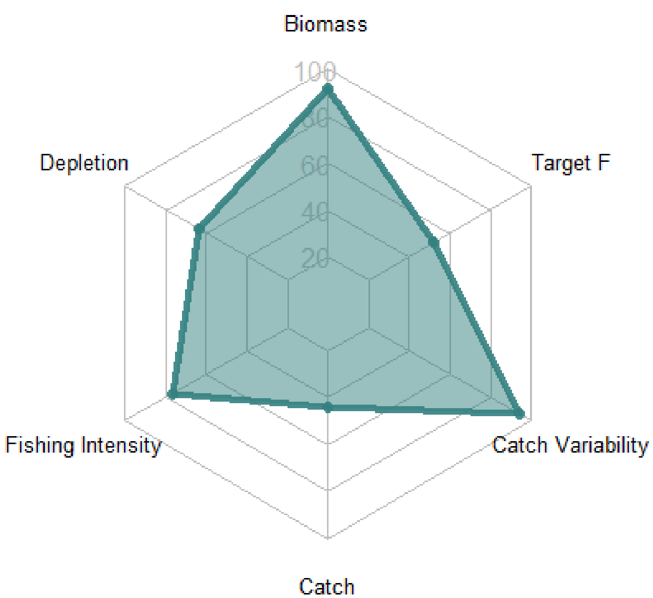
HCR 3



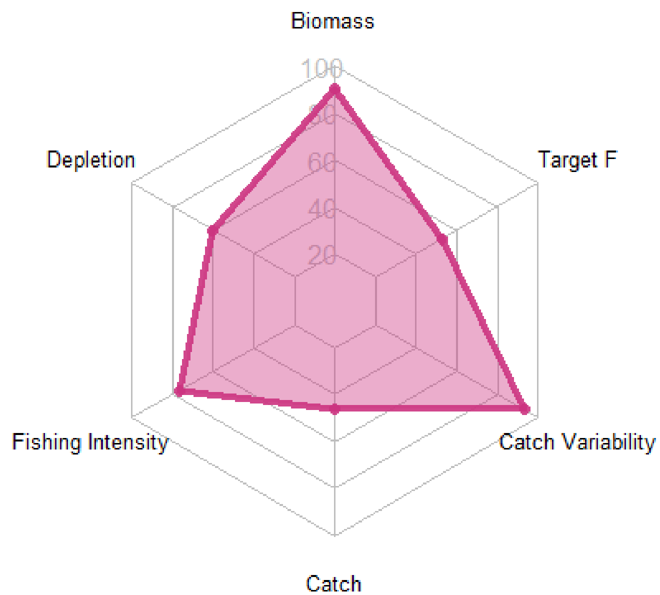
MSE Example - North Pacific Albacore

Performance Metrics Comparison – Scenario 2

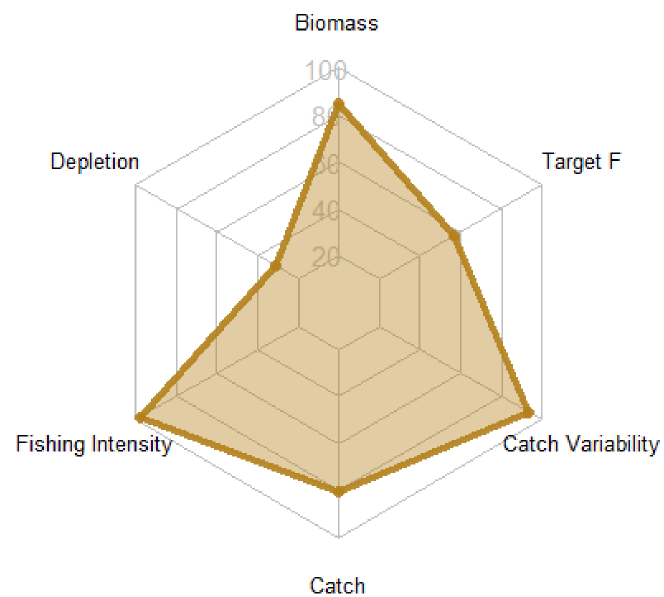
HCR 1



HCR 2



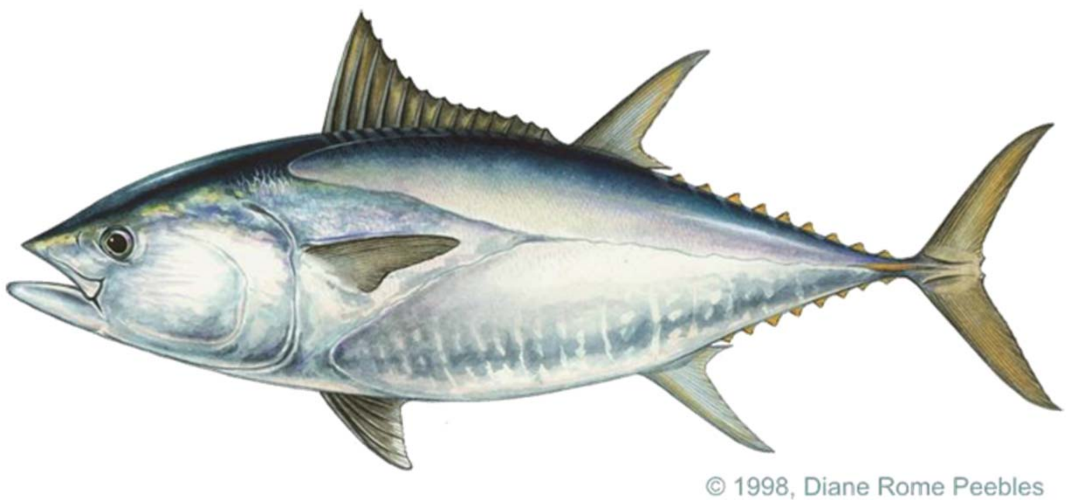
HCR 3



MSE Example – Southern Bluefin tuna

Background: high uncertainty in stock assessment results, for almost a decade managers struggled to reach agreement on TAC

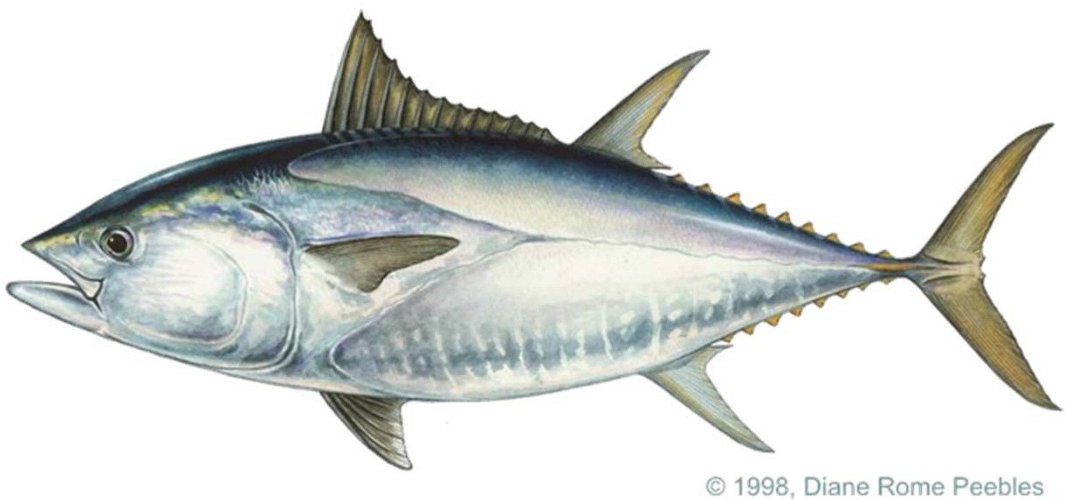
Goal: To evaluate the performance of pre-agreed upon management procedures



MSE Example – Southern Bluefin tuna

Management Objectives

1. Maximize catches
2. Avoid stock collapse
3. Minimize interannual catch variation

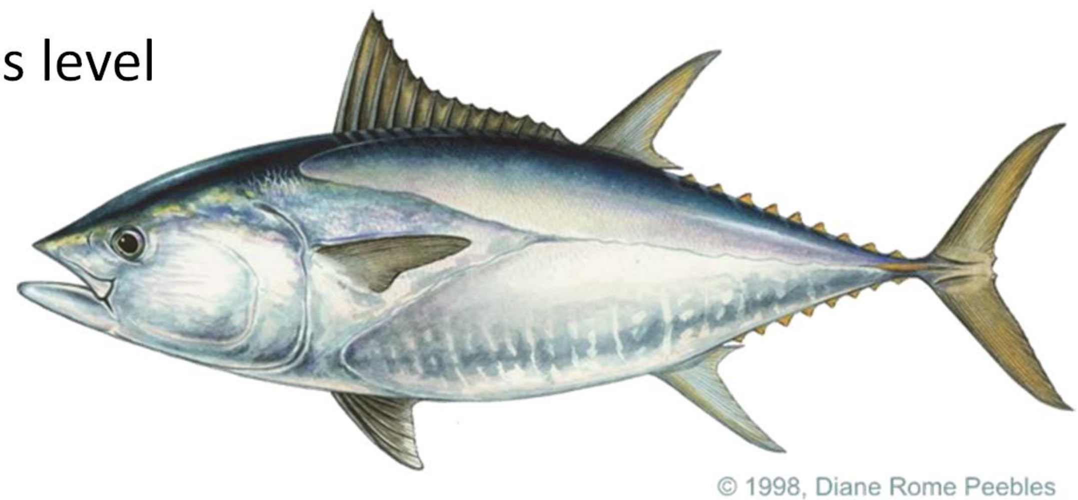


Kurota et al. 2010

MSE Example – Southern Bluefin tuna

Performance Metrics

1. Short and Long term mean catch
2. Catch variability
4. Maximum TAC decrease between years
5. Mean biomass
6. Risk of falling below low biomass level



Kurota et al. 2010

MSE Example – Southern Bluefin tuna

Development of MSE framework took longer than 10 years!

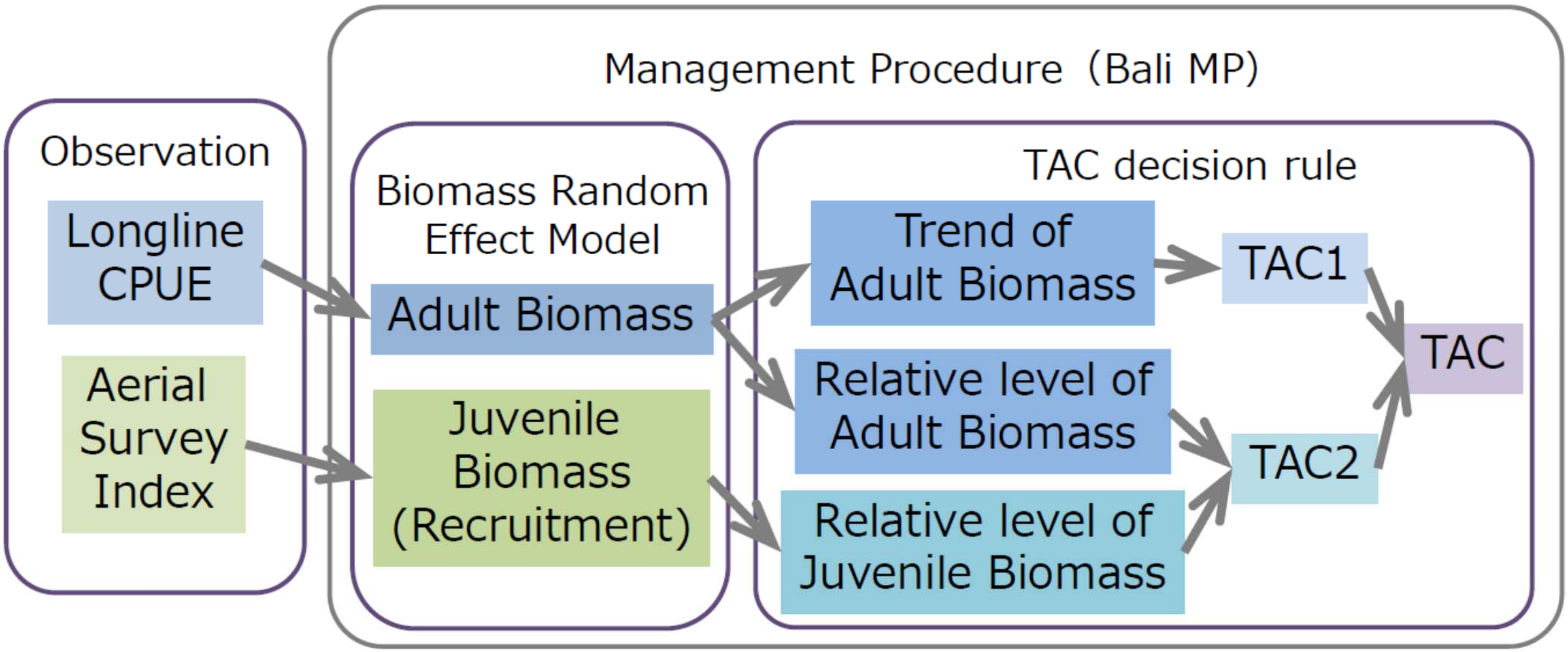


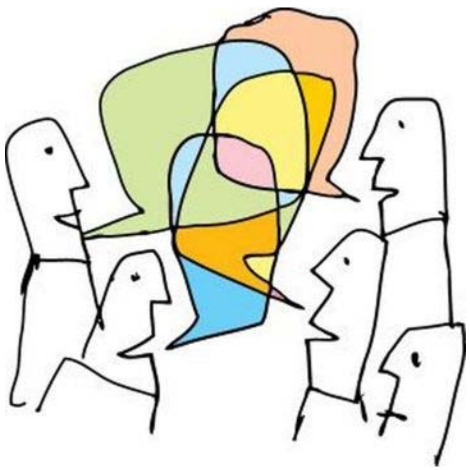
Figure from http://isc.fra.go.jp/pdf/2015_MSE/4-1c_Sakai_ISC_MSE_2015-0417.pdf

Stakeholders involvement is important for

1. Clearly specifying pre-agreed upon management objectives and performance metrics

2. Identifying candidate management strategies to be tested in MSE framework

3. Review results



Appendix II

NOAA FISHERIES

SWFSC/FRD

Management strategy evaluation of albacore tuna in the North Pacific

Steven L. H. Teo & Desiree Tommasi
Southwest Fisheries Science Center
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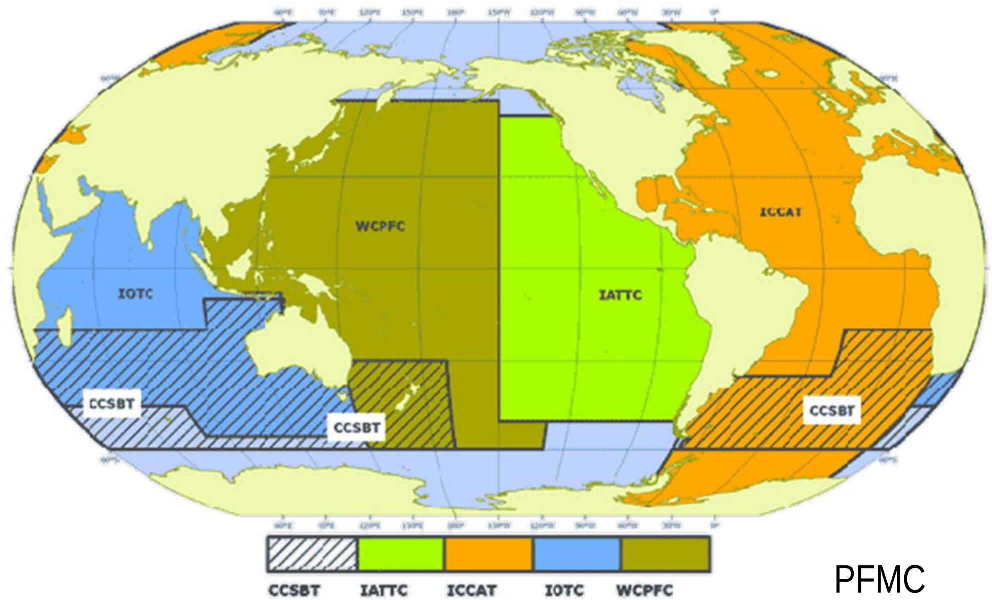
Management Strategy Evaluation
National Marine Fisheries Service Listening Sessions
Southwest Fisheries Science Center, La Jolla
April 18, 2018

Management of temperate tunas in the North Pacific

- 2 Regional Fisheries Management Organizations (RFMOs): IATTC & WCPFC Northern Committee (NC)
- Albacore & Pacific bluefin tunas travel between east & west Pacific
- Science & management of these 2 stocks must be coordinated between east & west Pacific
- International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) is the scientific body that assesses these 2 stocks (ALBWG & PBFWG)



PFMC

Brief history of the ISC Albacore Working Group

1975	Hawaii	1st North Pacific Albacore Population Dynamics Workshop
|		
1995		The Interim Scientific Committee for Tuna and Tuna-like-Species in the North Pacific Ocean
2004	Nanaimo	19th North Pacific Albacore Population Dynamics Workshop (last WS as NPALD WS)
2004		International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)
2005		NPALD WS was changed to ALBWG and continued to present
2011	Shimizu (JPN)	NPALB Stock Assessment (VPA and SS3)
2014	La Jolla	NPALB Stock Assessment (SS3)
2017	La Jolla	NPALB Stock Assessment (SS3)

NC management proposals for NP albacore

2012	NC requested advice from the ISC on reliability of steepness and M, maturity and selectivity estimates to determine the RPs (Attachment E - 8th NC report)
2013	USA concept paper on Precautionary management framework for NPALB (Attachment G – 9th NC report) MSE proposed
2014	Proposal by USA: Evaluation of candidate target and limit reference points and decision framework for NPALB (WCPFC-NC10-WP-01) Proposal by Canada: precautionary management framework for NPALB (WCPFC-NC10-2014/DP-08) **Adopted** limit reference point: $\mathbf{20\%SSB_{current,\ F=0}}$
2015	Proposal by USA: Evaluation of candidate HCR for NPALB (WCPFC-NC11-2015/DP-01)
2016	NC member's Response to: MSE Template: Information and Instructions (WCPFC-NC12-2016/WP-01)
2017	Proposal by USA and Canada : Interim harvest strategy for NPALB fishery

How does an MSE fit in or why do an MSE?

Because the managers wanted to …

- Evaluate candidate target reference points
- Associated harvest control rules

From the NC13 reports…

71. NC13 recommends that the Commission adopt the attached revision to the title of previously adopted precautionary management framework for North Pacific albacore (**Attachment H**), so that it may be recognized as a harvest strategy. In addition, NC13 recommends that the Commission direct the Secretariat to make this harvest strategy available, as a stand-alone harvest strategy document, on a web page dedicated to this and other harvest strategies, including interim harvest strategies, agreed to by the Commission.

Attachment H (Interim Harvest Strategy for NPALB Fishery)
4. Future work
This framework may be periodically reviewed and revised. To support such revisions, **NC endorses the ongoing development and implementation of an MSE for the stock and fishery**, which would yield new information that would enhance the robustness of this framework.

Attachment I (Work Programme for the NC)
NPALB:
(B) Implement the Interim Harvest Strategy, including: (1) monitor if LRP is breached; (2) continue to work to establish TRP and other elements of harvest strategies, if appropriate based on MSE; (3) recommend any changes to CMM 2005-03.

Timeline for NP albacore

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

Timeline for NP albacore

Dates	Task/Event
30 Apr – 5 May 2018	Completion of 1st round of MSE. ALBWG discuss and review preliminary results.
14-18 May 2018	Preliminary 1st round of MSE results presented to IATTC Science Advisory Committee
July 2018	ISC Plenary reviews 1st round of MSE results
August 2018	1st round of MSE results presented to WCPFC Scientific Committee
September 2018	1st round of MSE results presented to WCPFC NC (managers)
Late 2018 – early 2019	4th ISC MSE workshop (managers, stakeholder, NGOs & scientists) to: 1) Discuss MSE results in detail 2) Based on MSE results, propose RPs and HCRs to WCPFC NC and IATTC 3) Propose refinements to MSE

Management objectives for NP albacore MSE

Objective[A]	Quantity	Proposed Performance Indicators[B, C, D]	Example Output[B]
1. Maintain spawning biomass above the limit reference point	• 20%$SSB_{CURRENT, F=0}$ • 14%$SSB_{CURRENT, F=0}$ (calculated as (1-M)*SSB20%) • $SSB_{0.5R0}$, where h = 0.75 (IATTC SAC)	• SSB for each projected year / SSB-based LRP	• % of runs in which ratio ≥1 for 29/30, 27/30, 24/30; • Each run = 30 years
2. Maintain total biomass, with reasonable variability, around the historical average depletion of total biomass	• Historical depletion is estimated as the depletion level of total biomass for 2006-2015	• Depletion of projected total biomass over 30 yrs /minimum historical depletion of total biomass (minimum of 2006 - 2015)	• % of runs in which ratio ≥1 for 29/30, 27/30, 24/30; • Each run = 30 years
3. Maintain harvest ratios by fishery (fraction of fishing impact with respect to SSB) at historical average	• Historical harvest ratio by fishery estimated as the average of 2006 – 2015 • Historical variability in harvest ratio estimated from 2006 – 2015	• Harvest ratio (H) by fishery (i) for each year is calculated as $(1\text{-}SPR_i)/1\text{-}SPR_{total}$ • Projected harvest ratio by fishery over 30 yrs >= minimum historical harvest ratio by fishery (minimum of 2006 - 2015) and <= maximum historical harvest ratio by fishery (maximum of 2006 - 2015)	• % of runs within minimum and maximum for 29/30, 27/30, 24/30; • Each run = 30 years

Management objectives for NP albacore MSE

Objective[A]	Quantity	Proposed Performance Indicators[B, C, D]	Example Output[B]
4. Maintain catches by fishery above average historical catch	• Average catch by fishery over the 30 year period, 1981-2010.	• Total catch of each projected year / average total historical catch (1981 – 2010) • Catch by fishery of each projected year / average historical catch of the fishery (1981 – 2010) • Projected catch by fisheries over 30 yrs /lower 25% of historical catch (1981 - 2010) • Projected catch by fisheries over 30 yrs /upper 25% of historical catch (1981 - 2010)	• % of runs in which ratio ≥1 for 29/30, 27/30, 22/30, 15/30; • Each run = 30 years;
5. If a change in total allowable effort and/or total allowable catch occurs, the rate of change should be relatively gradual		• % change in TAE and/or TAC between years (separate increases vs decreases)	• Median ± 5 and 95% percentiles of maximum % change in TAE and/or TAC for all years over all runs • Median ± 5 and 95% percentiles of % of projected years where change (0-15%, 15-30%, >30%) in TAE and/or TAC for all years over all runs

Management objectives for NP albacore MSE

Objective[A]	Quantity	Proposed Performance Indicators[B, C, D]	Example Output[B]
6. Maintain F at the target value with reasonable variability	• Various potential target values previously suggested by NC	• F-ratio-target = F-based TRP/ F of each projected year	• Median ± 5 and 95% percentiles of median of F-ratio-target over all runs • Median ± 5 and 95% percentiles of 10%, 95% of F-ratio-target over all runs
7. Maximize economic returns of existing fisheries (**FUTURE WORK**)			
8. Maintain interests of artisanal, subsistence and small-scale fishers, including limiting the regulatory impact on these fisheries (**FUTURE WORK**)			

NOTES

A - Objectives 1-6 for the first round of MSE were reviewed and agreed upon by the 3rd MSE Workshop participants, October 17-19, 2017.

B - Performance indicators and example output proposed by the Albacore Working Group

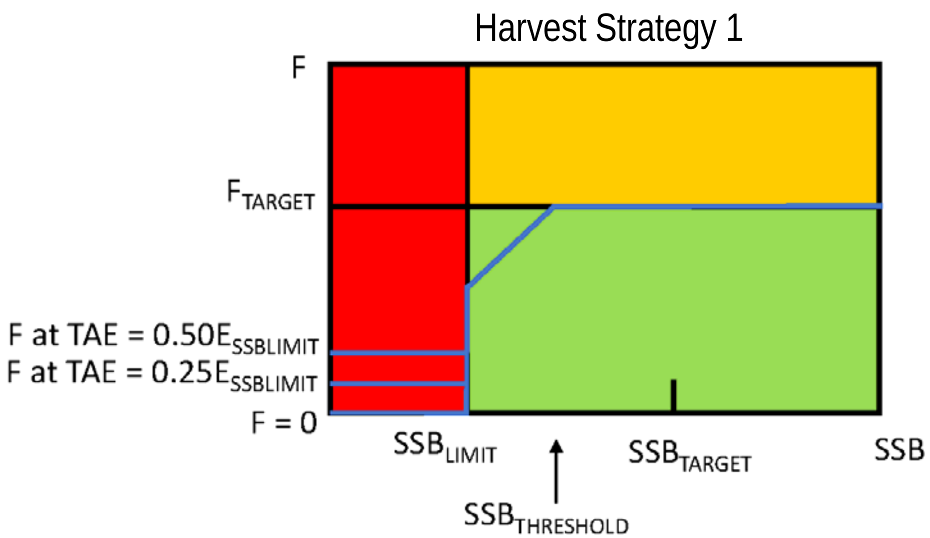
C - Performance indicators are configured so that higher estimated values mean better performance and lower estimated values means poorer performance, i.e., they have consistent directionality to reduce confusion in interpreting results. The exception to this practice is the first indicator (% change due to HCR between years) for objective 5 for which there is no directionality.

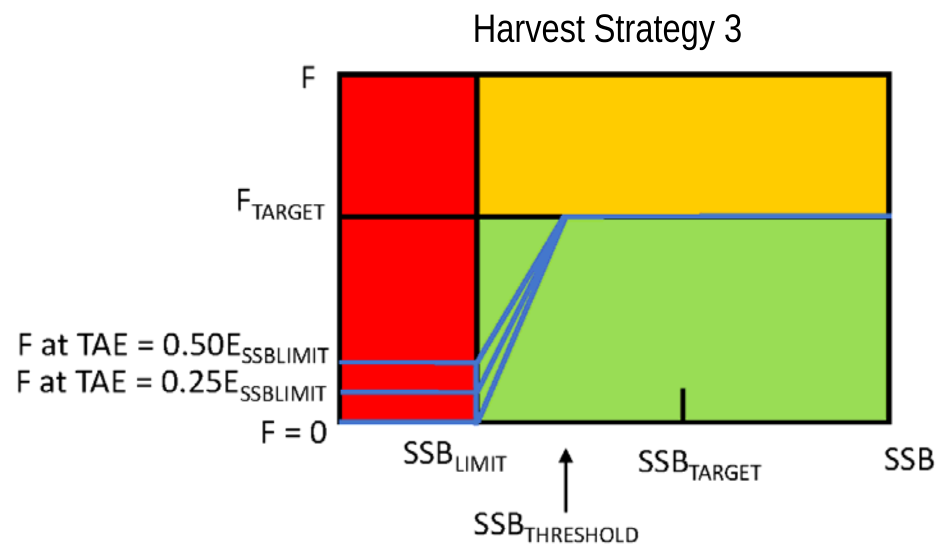
D - Definition of each fishery for fishery-specific performance indicators should be based on flag and gear.

Common language and values for acceptable risk categories in an MSE proposed by the ISC NPALB WG

Term	Median	Quantiles
Almost Certain	95	90-<100
Highly Likely	85	80-90
Likely	75	70-80
Better than Even	65	60-70
Even	50	40-60
Less than Even	35	30-40
Unlikely	25	20-30
Highly Unlikely	15	10-20
Almost Never	5	>0-10

Three candidate harvest strategies proposed



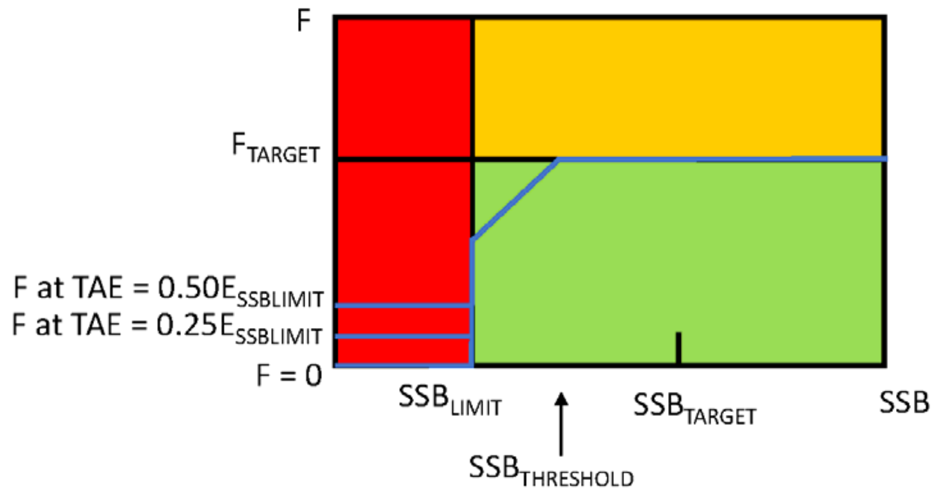


Harvest Strategy 2 (based on IATTC-Resolution C-16-02)
Harvest strategy 2 is based on the IATTC HCR for tropical tunas.

Changes in management actions occur when there is a risk that SSB drops below a biomass-based LRP or fishing intensity is higher than an F-based LRP

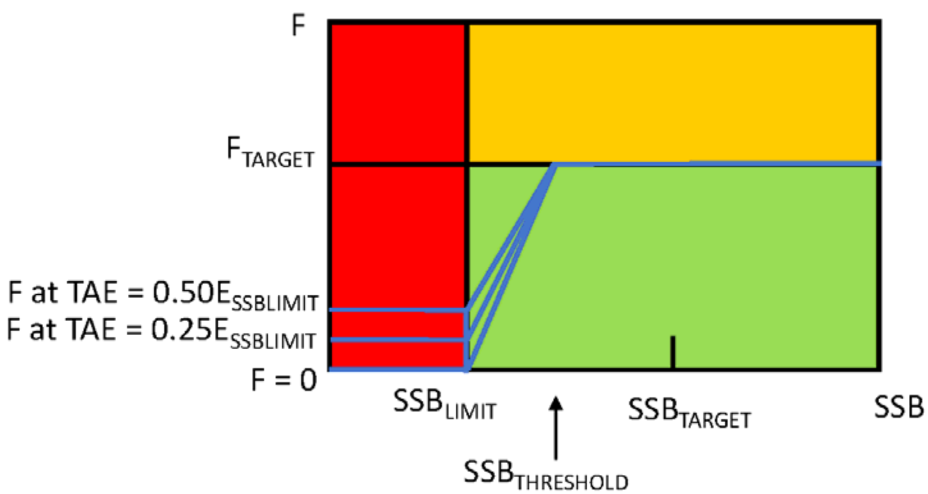
Candidate Harvest Strategy 1

- For stocks at or above $SSB_{THRESHOLD}$ an annual Total Allowable Catch (TAC) or Total Allowable Effort (TAE) is set to allow the stock biomass to fluctuate around SSB_{TARGET} and the fishery to have a fishing impact around F_{TARGET}.
- For stocks below $SSB_{THRESHOLD}$ with a given probability (see Table 4 for the range of probabilities to be tested) but above SSB_{LIMIT}, an annual TAC or TAE is set based on a proportional reduction from F_{TARGET}, using the fraction SSB_{LATEST} / $SSB_{THRESHOLD}$
- For stocks below SSB_{LIMIT}, a stock rebuilding plan is implemented such that SSB will be rebuilt to SSB_{TARGET} within 2 generations. More specifically, if the spawning biomass is below the limit reference point (SSB_{LIMIT}) with a given probability, management measures are established to ensure a probability of at least 50% of restoring SSB to the target level (SSB_{TARGET}).



Candidate Harvest Strategy 3

- For stocks at or above $SSB_{THRESHOLD}$, the HCRs are the same as Harvest Strategy 1.
- For stocks below $SSB_{THRESHOLD}$, the annual TAC or TAE decreases linearly until the TAC_{LIM} or TAE_{LIM} is reached. The TAC_{LIM} or TAE_{LIM} are the TAC and TAE when SSB < SSB_{LIMIT}, and a stock rebuilding plan is not implemented.
- For stocks below SSB_{LIMIT}, the stock rebuilding plan is the same as harvest strategy 1 but alternative actions only include constant TAE or TACs



Candidate Harvest Strategy 2

Harvest strategy 2 is based on the IATTC HCR for tropical tunas. In summary, changes in management actions occur when SSB drops below a biomass-based LRP or fishing intensity is higher than an F-based LRP.

- If the probability that F will exceed F_{LIMIT} is greater than 10%, management measures shall be established that have a probability of at least 50% of reducing F to F_{TARGET} or less, and a probability of less than 10% that F will exceed F_{LIMIT}.
- If the probability that SSB is below SSB_{LIMIT} is greater than 10%, management measures shall be established that have a probability of at least 50% of restoring SSB to SSB_{TARGET} or greater, and a probability of less than 10% that SSB will descend to below SSB_{LIMIT} in a period of two generations of the stock or five years, whichever is greater.

Reference points

- SSB_{LIMIT} is $SSB_{0.5r0}$ and F_{LIMIT} is $F_{0.5r0}$. This is 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.
- SSB_{TARGET} is SSB_{MSY} and F_{TARGET} is F_{MSY}. These refer to the spawning biomass or fishing mortality corresponding to the maximum sustainable yield (MSY). For North Pacific albacore, SSB_{MSY} corresponds to approximately 14% of the virgin spawning biomass in the latest stock assessment but is considered difficult to estimate reliably for this stock.

Candidate Reference Points

	Harvest Strategy 1	Harvest Strategy 2	Harvest Strategy 3
Reference Points			
B_{TARGET}	$50\%SSB_{CURRENT, F=0}$ $40\%SSB_{CURRENT, F=0}$ $30\%SSB_{CURRENT, F=0}$	$14\%SSB_{CURRENT, F=0}$	$50\%SSB_{CURRENT, F=0}$ $40\%SSB_{CURRENT, F=0}$ $30\%SSB_{CURRENT, F=0}$
$B_{THRESHOLD}$	$30\%SSB_{CURRENT, F=0}$ $20\%SSB_{CURRENT, F=0}$ $14\%SSB_{CURRENT, F=0}$		$30\%SSB_{CURRENT, F=0}$ $20\%SSB_{CURRENT, F=0}$ $14\%SSB_{CURRENT, F=0}$
B_{LIMIT}	$20\%SSB_{CURRENT, F=0}$ $14\%SSB_{CURRENT, F=0}$ $SSB_{0.5r0}$	$SSB_{0.5r0}$	$20\%SSB_{CURRENT, F=0}$ $14\%SSB_{CURRENT, F=0}$ $SSB_{0.5r0}$
F_{TARGET}	$F_{50\%}$ $F_{40\%}$ $F_{30\%}$ $0.75F_{14\%}$	$F_{14\%}$	$F_{50\%}$ $F_{40\%}$ $F_{30\%}$ $0.75F_{14\%}$
F_{LIMIT}		$F_{0.5r0}$	

Candidate Harvest Control Rules

	Harvest Strategy 1	Harvest Strategy 2	Harvest Strategy 3
Harvest Control Rules 1			
$SSB \geq SSB_{TARGET}$	$TAE = E_{2002\text{-}2004}$ $TAE = E(F_{TARGET})$ $TAC = B_{LATEST} * F_{TARGET}$		$TAE = E_{2002\text{-}2004}$ $TAE = E(F_{TARGET})$ $TAC = B_{LATEST} * F_{TARGET}$
$SSB \geq SSB_{THRESHOLD}$	$TAE = E_{2002\text{-}2004}$ $TAE = E(F_{TARGET})$ $TAC = B_{LATEST} * F_{TARGET}$		$TAE = E_{2002\text{-}2004}$ $TAE = E(F_{TARGET})$ $TAC = B_{LATEST} * F_{TARGET}$
$SSB < SSB_{THRESHOLD}$, $> SSB_{LIMIT}$	$TAE = E(F_{TARGET}) * SSB / SSB_{THRESHOLD}$ $TAC = B_{LATEST} * F_{TARGET} * SSB / SSB_{THRESHOLD}$		$TAE = TAE_{MIN} + [E(F_{TARGET}) - TAE_{MIN}] * (SSB - SSB_{LIMIT}) / (SSB_{THRESHOLD} - SSB_{LIMIT})$, or TAE_{MIN}, whichever is greater $TAC = TAC_{MIN} + [(B_{LATEST} * F_{TARGET}) - TAC_{MIN}] * (SSB - SSB_{LIMIT}) / (SSB_{THRESHOLD} - SSB_{LIMIT})$, or TAC_{MIN}, whichever is greater TAE_{MIN} and TAC_{MIN} are the TAEs and TACs when $SSB \leq SSB_{LIMIT}$, without the rebuilding plan (see below)

Candidate Harvest Control Rules

	Harvest Strategy 1	Harvest Strategy 2	Harvest Strategy 3
Harvest Control Rules 1			
$SSB \le SSB_{LIMIT}$	Trigger rebuilding plan TAE = 0 $TAE = 0.25 * E_{SSBLIM}$ $TAE = 0.5 * E_{SSBLIM}$ $TAE = E(F_{TARGET}) * SSB / SSB_{THRESHOLD}$ TAC = 0 $TAC = 0.25 * C_{SSBLIM}$ $TAC = 0.5 * C_{SSBLIM}$ $TAC = B_{LATEST} * F_{TARGET} * SSB / SSB_{THRESHOLD}$ $E_{SSBLIM} = E(F_{TARGET}) * SSB_{LIMIT} / SSB_{THRESHOLD}$ $C_{SSBLIM} = B_{LATEST} * F_{TARGET} * SSB_{LIMIT} / SSB_{THRESHOLD}$	Trigger rebuilding plan	Trigger rebuilding plan TAE = 0 $TAE = 0.25 * E_{SSBLIM}$ $TAE = 0.5 * E_{SSBLIM}$ TAC = 0 $TAC = 0.25 * C_{SSBLIM}$ $TAC = 0.5 * C_{SSBLIM}$ E_{SSBLIM} and C_{SSBLIM} for this harvest strategy are the same as the E_{SSBLIM} and C_{SSBLIM} for harvest strategy 1 $E_{SSBLIM} = E(F_{TARGET}) * SSB_{LIMIT} / SSB_{THRESHOLD}$ $C_{SSBLIM} = B_{LATEST} * F_{TARGET} * SSB_{LIMIT} / SSB_{THRESHOLD}$
$F > F_{LIMIT}$		$TAE = E(F(Prob. (F < F_{TARGET}) > 50\%)$ & $Prob. (F > F_{LIMIT}) < 10\%))$	
F > Ftarget		$TAE = E(F_{TARGET})$	

Candidate Harvest Control Rules

	Harvest Strategy 1	Harvest Strategy 2	Harvest Strategy 3
Harvest Control Rules 2			
Prob(SSB > SSB_{LIMIT})	90%, 75%, 50%	90%	90%, 75%, 50%
Prob(SSB > $SSB_{THRESHOLD}$)	75%, 50%		75%, 50%
Prob(F < F_{LIMIT})		90%	
Rebuilding plan	TAE = E(F(Prob. (SSB > SSB_{TARGET}) > 50%)) in 2 generations TAC = B * F(Prob. (SSB > SSB_{TARGET}) > 50%) in 2 generations	TAE = E(F(Prob. (SSB > SSB_{TARGET}) > 50%) & Prob. (SSB < SSB_{LIMIT}) < 10%))) in 2 generations TAC = B * F(Prob. (SSB > SSB_{TARGET}) > 50%) & Prob. (SSB < SSB_{LIMIT}) < 10%)) in 2 generations	TAE = E(F(Prob. (SSB > SSB_{TARGET}) > 50%)) in 2 generations TAC = B * F(Prob. (SSB > SSB_{TARGET}) > 50%) in 2 generations
Additional Assumptions			
Allocation	Average of 1999-2015	Average of 1999-2015	Average of 1999-2015
HCRs controls on albacore targeting and/or non-targeting	Both targeting and non-targeting Targeting only	Both targeting and non-targeting Targeting only	Both targeting and non-targeting Targeting only
Assessment periodicity	Once every 3 years	Once every 3 years	Once every 3 years
Comments			

Lessons learnt

- Takes longer than expected to find and hire an MSE analyst
- Progress is slow because WG has to squeeze this into the assessment schedule
- Important to have stakeholders at the MSE workshops
- Having clear management objectives from the start will help
- Technical terms and acronyms can be overwhelming to non-scientists but taking the time to explain things in different ways (e.g., graphical) is worth the effort

Questions?

Appendix III

PACIFIC BLUEFIN TUNA
Management Strategy Evaluation Workshop

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

Background

How we Decided on an MSE?

Is ISC Going to Complete the MSE?

What is the Time Frame?

What is Process?

Pacific Bluefin Tuna
Management Strategy Evaluation Workshop

Queens Forum, Queens Tower B 7th Floor (in Queen's Square)
Yokohama, Japan
May 30-31, 2018

May 30, 2018

1. Welcome-Japan

2. Opening Remarks

3. Review and Adoption of Agenda

4. MSE Presentations

- **a. Management Strategy Evaluation – Realizing its Full Potential**
- **b. MSE Application Case Studies – G. DiNardo (60 minutes) – 1:30-2:30**
- **c. MSE Application to Pacific Bluefin Tuna: Requirements for Implementation**

5. Towards Development of a Pacific Bluefin Tuna MSE - Open Discussion

May 31, 2018

5. Towards Development of a Pacific Bluefin Tuna MSE - Open Discussion

6. Future Work Plan and Expectations

7. Open Discussion

8. Other matters: latest information about Pacific Bluefin Tuna

9. Closing remarks

Example Candidate Objectives and Indicators for Pacific Bluefin Tuna

Type	Objective	Indicator
Economic	Rebuild and Stabilize Catches Stability and continuity of market supply	Biomass depletion Levels Market throughput of tuna products
Biological	Maintain biomass at levels that provide stock sustainability Rebuild population to target reference point within 10 years	Estimated biomass or CPUE as proxy Estimated biomass or CPUE as proxy
Social	Maintain equitable allocation among fishing sectors	Landings by sector; number of fisherman
Ecosystem	Minimize catch of non-target species Restore ecosystem function (full size structure)	Logbooks or reporting mechanisms Recruitment monitoring and small juvenile monitoring

NOAA FISHERIES

Other Objectives?