
L. Boitor

INTERNATIONAL PACIFIC HALIBUT COMMISSION

MSE update

Agenda Item 7

IPHC-2019-SRB015-09

IPHC-2019-SRB015-10 Rev_1

IPHC-2019-SRB015-11 Rev_1

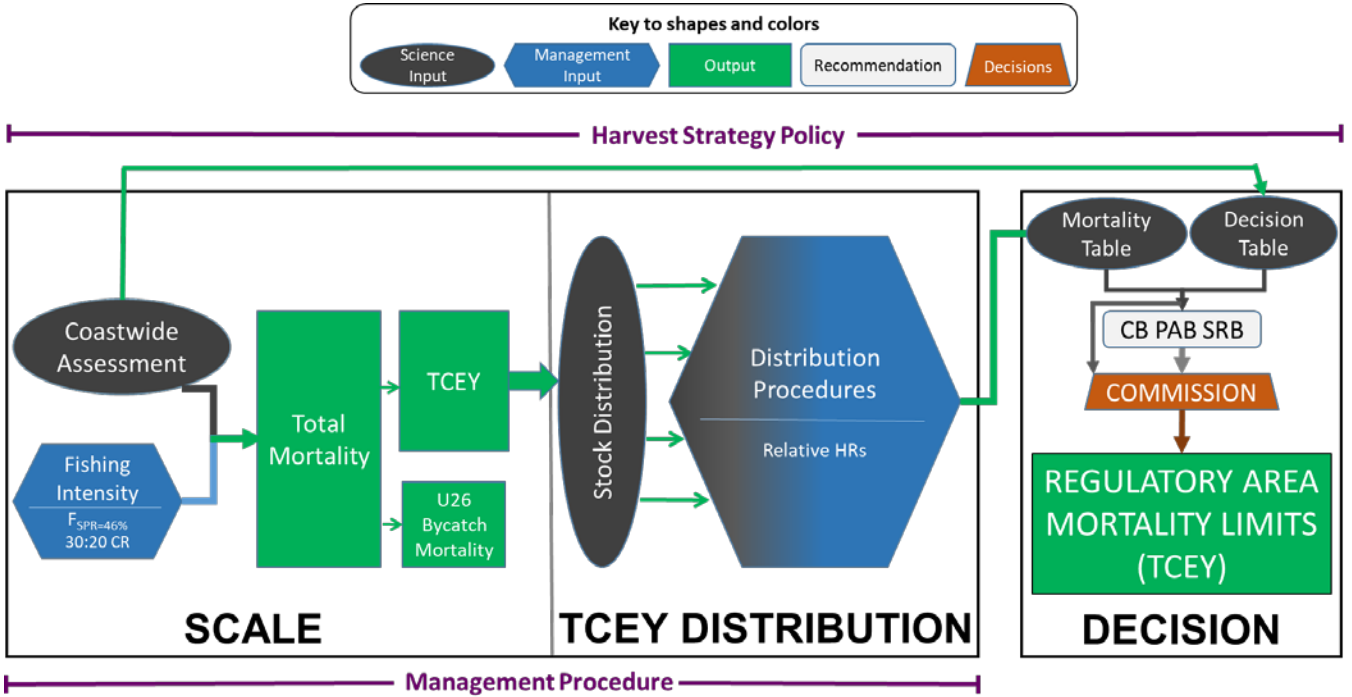
Outline

- Goals and objectives
  - Defining a target biomass objective
  - Objectives related to distributing the TCEY
- Distribution components of the MP
- Technical development
- Timeline

Goals & General Objectives

- Biological sustainability
  - Avoid critical stock sizes
- Optimize directed fishing opportunities
  - Maintain spawning biomass around a target level
  - Limit catch variability
  - Maximize directed fishing yield
- Minimize discard mortality
- Minimize bycatch and bycatch mortality

IPHC harvest strategy policy (current interim)



https://www.iphc.int/the-commission/harvest-strategy-policy

Commission directives and recommendations

AM095-R, para 59a. *The Commission **ENDORSED** the primary objectives and associated performance metrics used to evaluate management procedures in the MSE process (as detailed in paper IPHC-2019-AM095-12)*

AM095-R, para 59c. *The Commission **RECOMMENDED** the MSAB develop the following additional objective, as well as prioritize this objective in the evaluation of management procedures, for the Commission's consideration.*

i. A conservation objective that meets a spawning biomass target.

Biological sustainability (Coastwide)

General Objective	Measurable Objective	Measurable Outcome	Time-frame	Tolerance
1.1. Keep spawning biomass above a limit to avoid critical stock sizes	Maintain a female spawning stock biomass above a biomass limit reference point at least 95% of the time	SB < Spawning Biomass Limit (SB_{Lim}) SB_{Lim}=20% unfished spawning biomass	Long-term	0.05

Fishery coastwide objective: target biomass

General Objective	Measurable Objective	Measurable Outcome	Time-frame	Tolerance
2.1 Maintain spawning biomass around a level that optimises fishing activities	2.1A Spawning Biomass Threshold Maintain SB above a threshold reference point at least 80% of the time	SB<Spawning Biomass Threshold (SB_{Thres}) $SB_{Thres}=SB_{30\%}$	Long-term	0.20
	2.1B Spawning Biomass Target Maintain SB above a biomass target reference point at least 50% of the time	SB<Spawning Biomass Target (SB_{Targ}) $SB_{Targ}=SB_{??-??\%}$	Long-term	0.50

MSAB Request

MSAB013–Req.02 (para. 38) The MSAB REQUESTED that the Scientific Review Board (SRB) and the IPHC Secretariat consider the draft objectives contained within Table 1 and to provide advice to the MSAB on potential MSY and MEY proxy target reference points for objective 2.1B

Dynamic Reference Points

Purpose:

- to investigate variability in reference points given
  - changes in productivity and selectivity
  - different types of uncertainty
- provide a basis for defining a target reference point.

Reference points considered: SB_0, MSY, RSB_{MSY}, SPR_{MSY}

Methodology:

- Equilibrium model
- 2018 assessment model
- Coastwide MSE operating model

Main sources of variability considered:

- Environmental regimes (high or low unfished average recruitment)
- Weight at age
- Selectivity
- Steepness
- Natural mortality

See paper: IPHC-2019-SRB015-11 Rev_1

Dynamic Reference Point: methods (1)

Equilibrium model:

- 2 fleets (directed commercial and non-directed discard mortality)
- 2 sex
- Grid of scenarios across selectivity, weight at age, steepness, environmental regimes and M

Dynamic Reference Point: methods (2)

2018 Ensemble Assessment model:

- Each one of the 4 assessment models used retrospectively
- Weight-at-age and selectivity for the associated year
- R0 from the current regime
- No estimated uncertainty for each year

Dynamic Reference Point: methods (3)

MSE Operating Model:

- Short and long coastwide model from 2018 ensemble
- Reference point estimation for the last 50 years of the long term projection
- 500 simulations using final year (uncertainty)
- Low and high regime
- Weight-at-age modelled as a random walk & scenarios
- Selectivity modelled as a random walk, and changes in selectivity as a function of weight at age

Results on dynamic reference points analysis

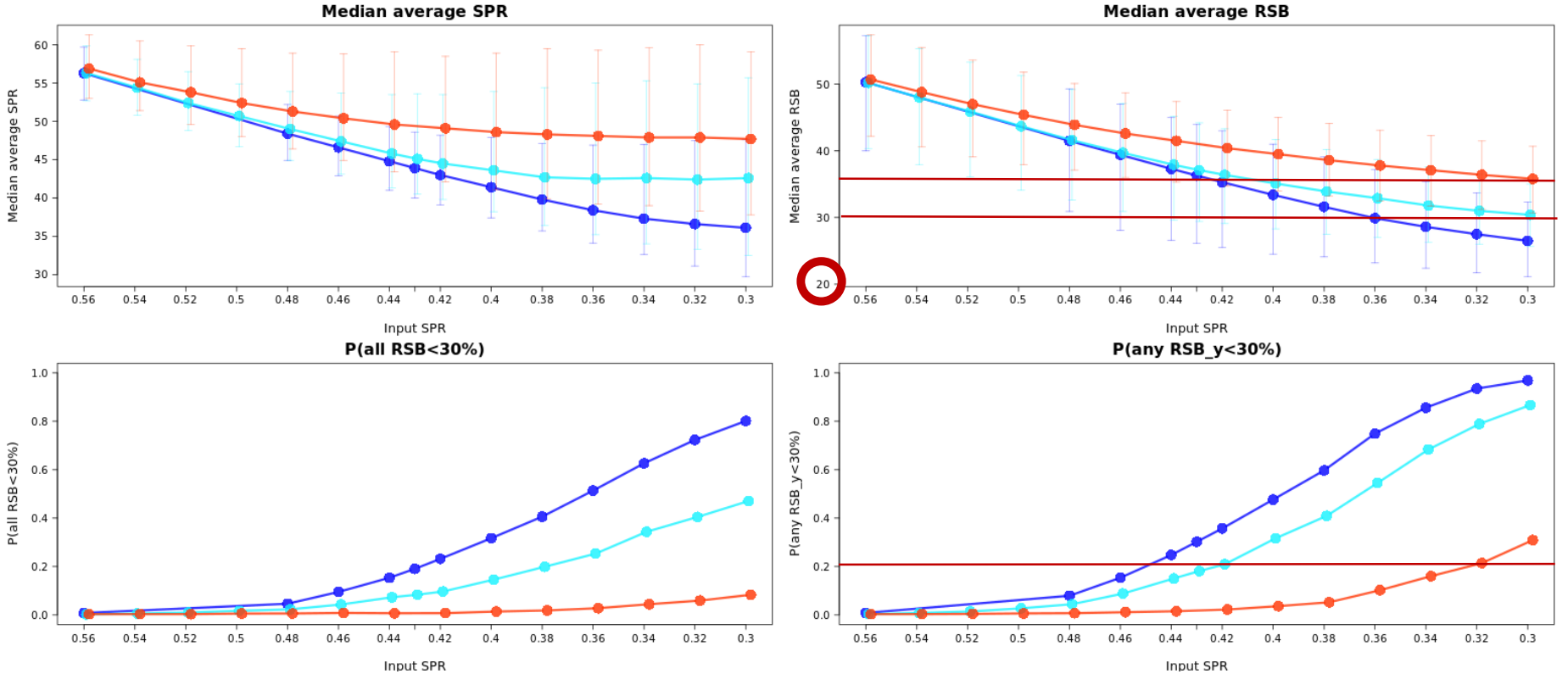
- SB_0 and MSY change depending on regime
- RSB_{MSY} and SPR_{MSY} are more consistent
  - RSB_{MSY} ~ 20-30%
  - SPR_{MSY} ~ 30-35%

- However, a target may be defined as MEY
  - Possibly 1.2× RSB_{MSY} (~36%)

Future research on dynamic reference points

- Presentations of this analysis at
  - PICES
  - CAPAM workshop “Next Generation Stock Assessment Models”
- Effect on reference points by fixing the shape of the stock recruitment curve at different weight-at-age scenarios
- Update analysis with 2019 ensemble assessment model
- Journal article

Coastwide simulation results



Catch variability and yield

General Objective	Measurable Objective	Measurable Outcome	Time-frame	Tolerance
2.2. Limit Catch Variability	Limit annual changes in the coastwide TCEY	Annual Change (AC) > 15% in any year	Short-term	0.25
2.3. Maximize Directed Fishing Yield	Maximize average TCEY coastwide	Median coastwide TCEY	Short-term	STATISTIC OF INTEREST

Note that Annual Change is used instead of Average Annual Variability (discussed at the Ad-Hoc WG, see IPHC-2019-SRB015-INF01)

Conservation Objectives - distributing the TCEY

General Objective	Measurable Objective	Measurable Outcome	Timeframe	Tolerance
1.1a Conserve spatial population structure	Maintain a defined minimum proportion of spawning biomass in each Biological Region	$p_{SB,R} < p_{SB,R,min}$	Long-term	
	Proportion of Pacific halibut spawning biomass in each Biological Region	Proportion of Pacific halibut spawning biomass in each Biological Region	Long-term	STATISTIC OF INTEREST

The minimum proportion should sum to <1, and may be based on

- Historical estimates from modelled FISS data
- Percentage of estimated unfished biomass
- Agreement

Fishery Objectives - distributing the TCEY (1)

General Objective	Measurable Objective	Measurable Outcome	Timeframe	Tolerance
2.1a Maintain biomass around a target that optimises fishing activities	Maintain a proportion of coastwide O26 Pacific halibut in each area, estimated from FISS data, greater than a threshold	$p_{B_{O26},A} > p_{B_{O26},A,min}$	Short-term Long-term	
	Proportion of O26 Pacific halibut biomass in each area	Proportion of O26 Pacific halibut biomass in each area	Short-term Long-term	STATISTIC OF INTEREST

Maintain exploitable biomass in each IPHC Regulatory Area

- O26 biomass (modelled survey results) as a proxy for exploitable biomass

Fishery Objectives - distributing the TCEY (2)

General Objective	Measurable Objective	Measurable Outcome	Timeframe	Tolerance
2.2a Limit Catch Variability	Limit annual changes in the TCEY for each Regulatory Area	Annual Change by Regulatory Area (AC_A) > 15%	Long-term Short-term	0.25
		Maximum AC by Regulatory Area (AC_A)	Long-term Short-term	STATISTIC OF INTEREST
		Average Annual Variability by Regulatory Area (AAV_A)	Long-term Short-term	STATISTIC OF INTEREST

Same as coastwide, except specific to IPHC Regulatory Area

- The ad hoc WG felt that coastwide and area objectives are useful
  - Coastwide: recognizing estimation error
  - Area: recognizing distribution uncertainty

Objectives related to distributing the TCEY

General Objective	Measurable Objective	Measurable Outcome	Timeframe	Tolerance
2.3A MAXIMIZE DIRECTED FISHING YIELD	Maximize average TCEY by Regulatory Area	Median Reg Area TCEY	Long-term Short-term	STATISTIC OF INTEREST
	Maintain TCEY above a minimum absolute level by Regulatory Area	$TCEY_A < TCEY_{A,min}$	Long-term Short-term	
	Maintain a percentage of the coastwide TCEY above a minimum level by Regulatory Area	$\%TCEY_A > \%TCEY_{A,min}$	Long-term Short-term	
	TCEY changes with local abundance	To be discussed at MSAB014		
	Present the range of TCEY by Regulatory Area that would be expected	Range of TCEY by Regulatory Area	Long-term Short-term	STATISTIC OF INTEREST

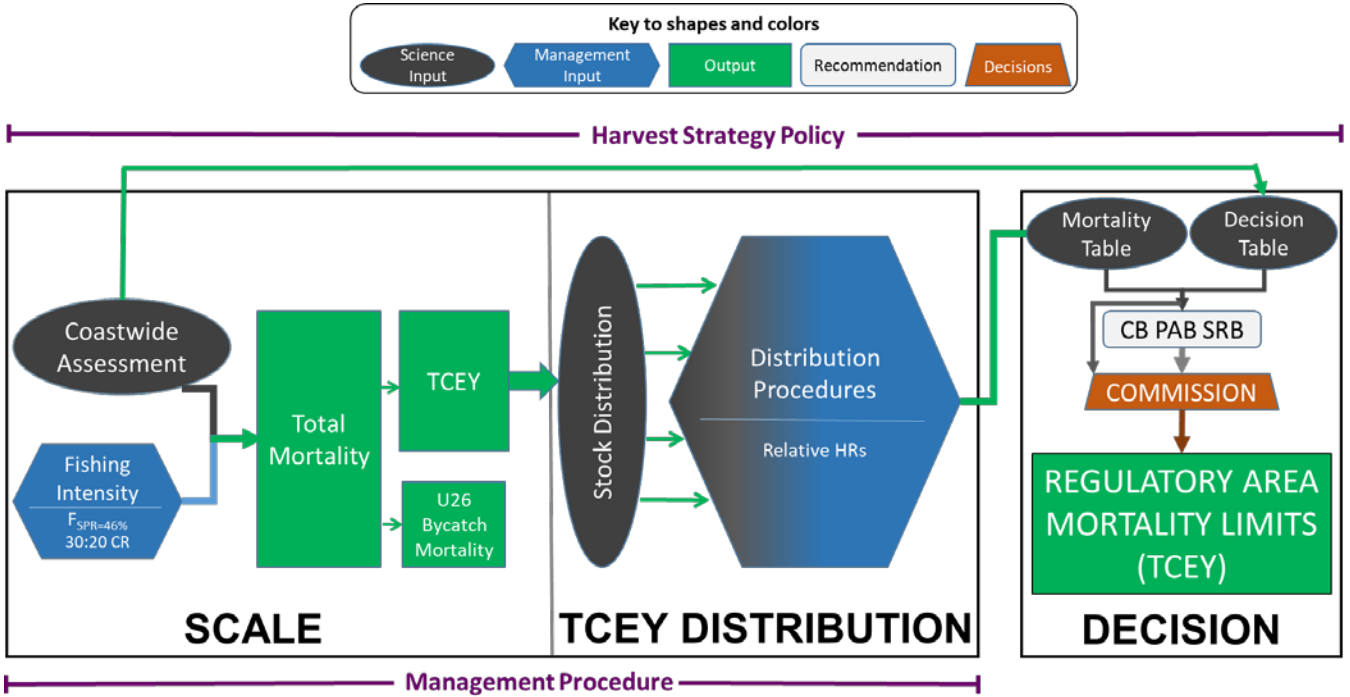
Objectives

- Coastwide
  - Biomass limit
  - Biomass target
  - Biomass threshold
  - Yield Variability
  - Maximize Yield

Obejectives

- Regions
  - Conserve spatial population structure
- IPHC Regulatory Areas
  - Maintain a proportion of coastwide O26 Pacific halibut
  - Limit annual changes in the TCEY
  - Maintain TCEY above a minimum absolute level
  - Maintain a percentage of the coastwide TCEY above a minimum level

Management Procedures



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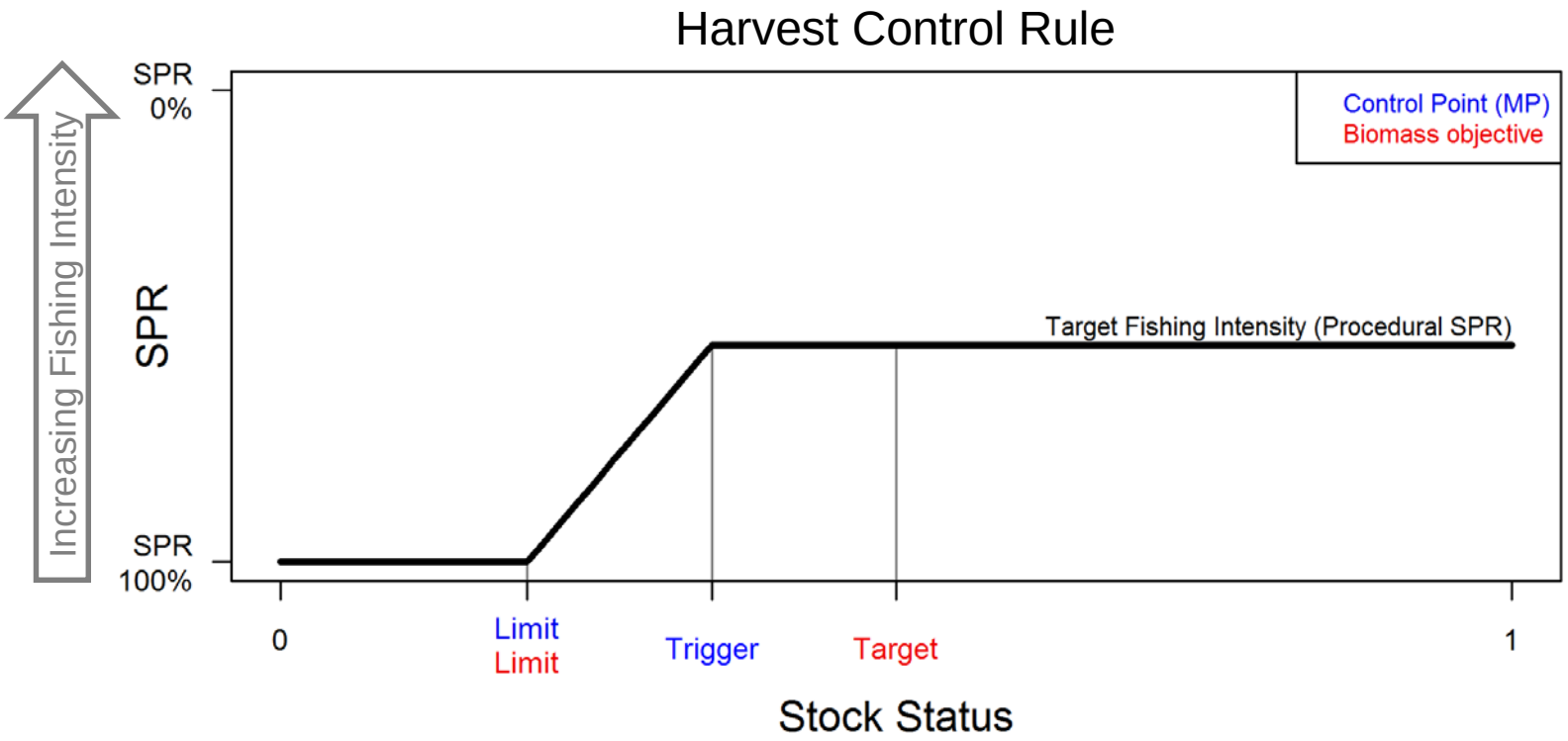
Reference Points and Control Points

There is a difference between the MP and objectives



Interim MP: Stock Distribution

- Stock Distribution
  - Estimated from the space-time model mean O32 WPUE indices for each IPHC Regulatory Area
  - Linked to Biological Sustainability objectives
    - Specifically “Conserve Spatial Complexity”
- Changes for consistency
  - Use Biological Regions
  - Use All-sizes WPUE index (mostly O26)

Interim MP: Relative Harvest Rates

- Shift stock distribution from west to east
  - Past estimated productivity in each area
  - Past estimated biomass trends in each area
  - Differences in emigration and immigration
  - Presence of small fish
  - Uncertainty in past data and analyses
  - “Rates” of 16.125% in 3B, 4A, 4B, 4CDE and 21.5% 3A, 2A, 2B, 2C
- Using coastwide SPR, only relative harvest rates needed
  - The intensity of fishing in an area relative to other areas
  - Areas 3B, 4A, 4B, and 4CDE were 3/4 the target in other areas

Changes to Relative Harvest Rates

- Apply by Biological Region
- Separate into two components
  - Science-based and management-based
- Conduct research on productivity in each Region
- Enumerate uncertainty of data in each Region
- Consider other factors

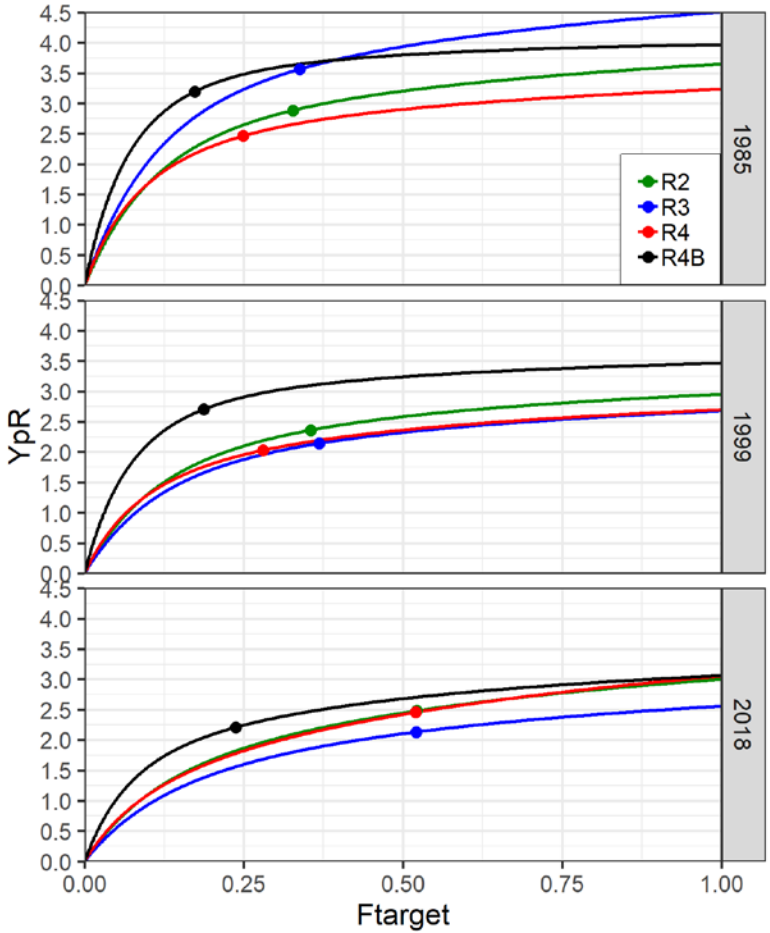
- Evaluate MPs against objectives with MSE

Productivity analysis by Biological Region

- Yield per Recruit (YpR) analysis
- Each region analysed separately (2,3,4,4B)
- Specifications: 1 fleet, 2 sexes
- Scenarios tested: weight-at-age and selectivity in 1985, 1999 and 2018.
- Sensitivity: shift selectivity curve to lower ages.
- Comparison of $F_{0.1}$ results relative to Region 3

Productivity by region

- Region 2 and 3
  - similar harvest rates for all scenarios.
- Region 4B
  - very different harvest rate for all scenarios.
- Region 4
  - in 2018 get harvest rate similar to region 3 and 2.



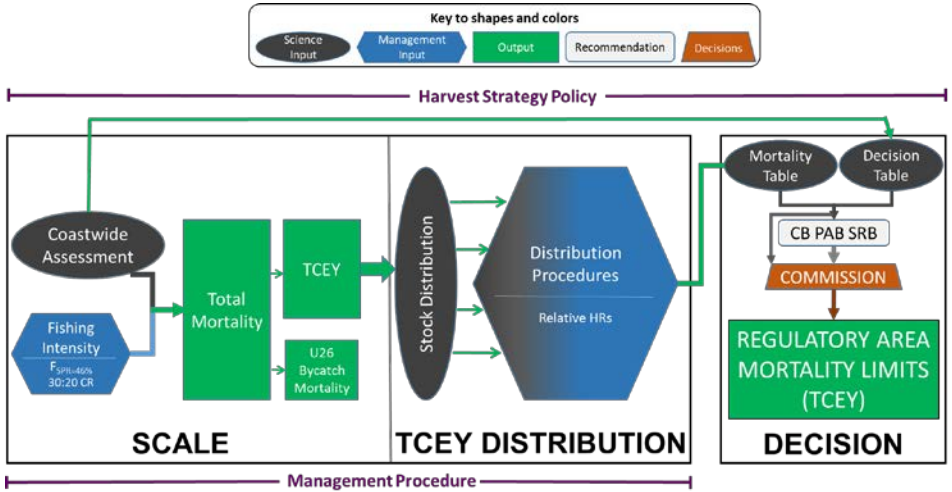
Relative productivity by region

		Biological Region			
Weight-at-age	**Selectivity**	**2**	**3**	**4**	**4B**
1985	1985	1.0	1.0	0.7	0.5
1999	1999	1.0	1.0	0.8	0.5
2018	2018	1.0	1.0	1.0	0.5
1985	Shift younger	0.8	1.0	0.8	0.5
1999	Shift younger	0.8	1.0	0.8	0.5
2018	Shift younger	0.9	1.0	1.1	0.5

- Supports lower relative HR in western areas in the past
- Changes in productivity over time may affect appropriate relative harvest rates

A procedure for distributing the TCEY

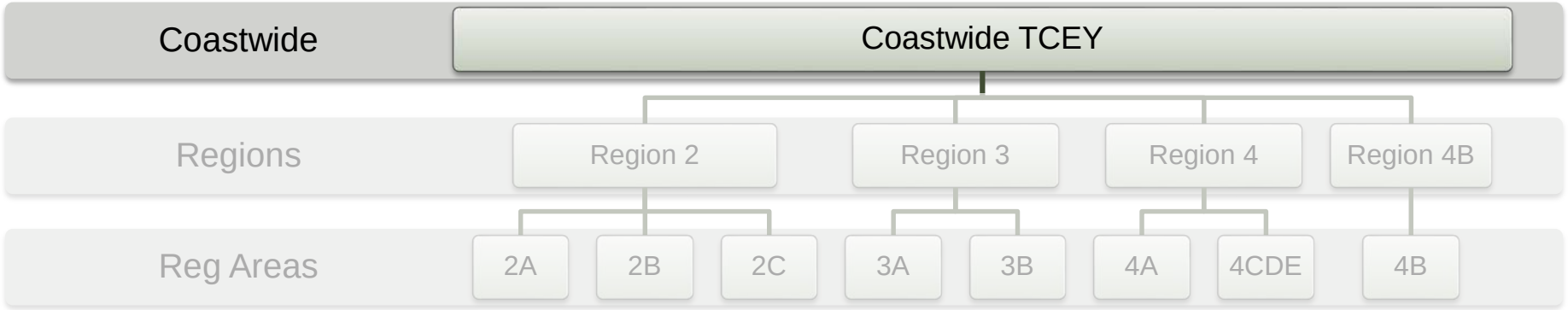
1. Coastwide target fishing intensity (science-based & management-derived)
2. Regional Stock Distribution (science-based)
3. Regional Fishing Intensity (science-based)
4. Regional Allocation Adjustment (management-derived)
5. Regulatory Area Allocation (management-derived)



A procedure for distributing the TCEY (1)

Coastwide Target Fishing Intensity

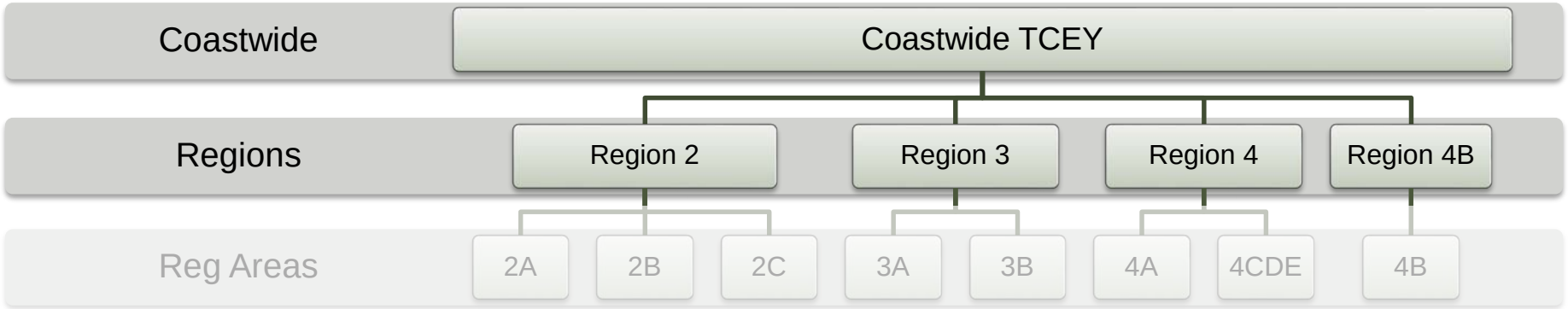
- Determine coastwide Total Mortality from Scale MP
- Separate TM into O26 (TCEY) and U26 components



A procedure for distributing the TCEY (2)

Regional Stock Distribution

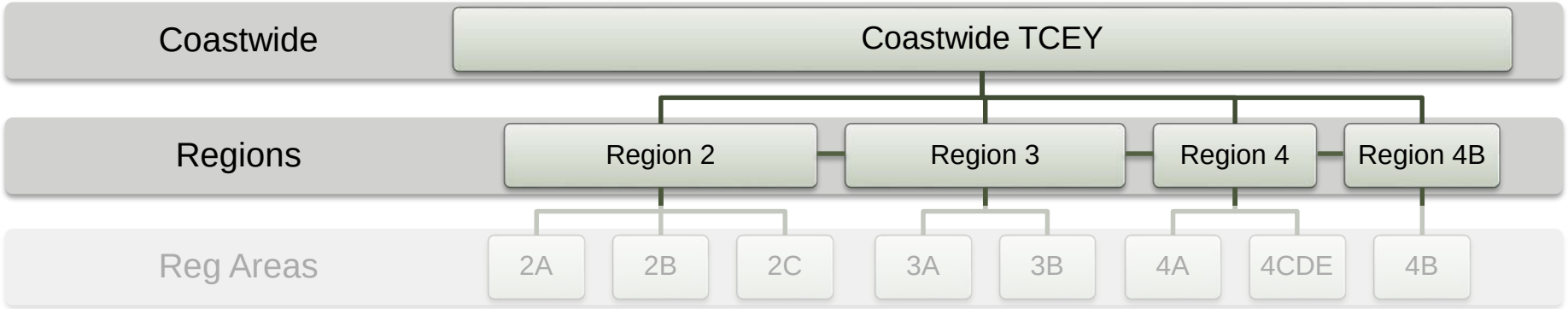
- Distribute the coastwide TCEY to biologically-based Regions
  - use proportion of the stock estimated from the “all sizes” WPUE index
- Biological Sustainability objectives



A procedure for distributing the TCEY (3)

Regional Relative Fishing Intensity

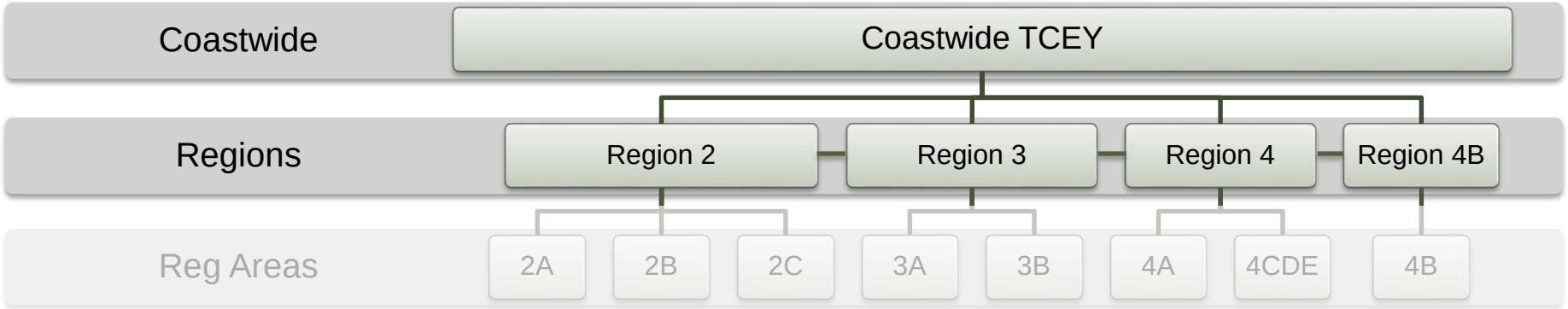
- Adjust the distribution of the TCEY among Regions
  - Relative target harvest rates by Region
  - Based on productivity, migration, other biological characteristics
- Biological Sustainability objectives



A procedure for distributing the TCEY (4)

Regional Allocation Adjustment

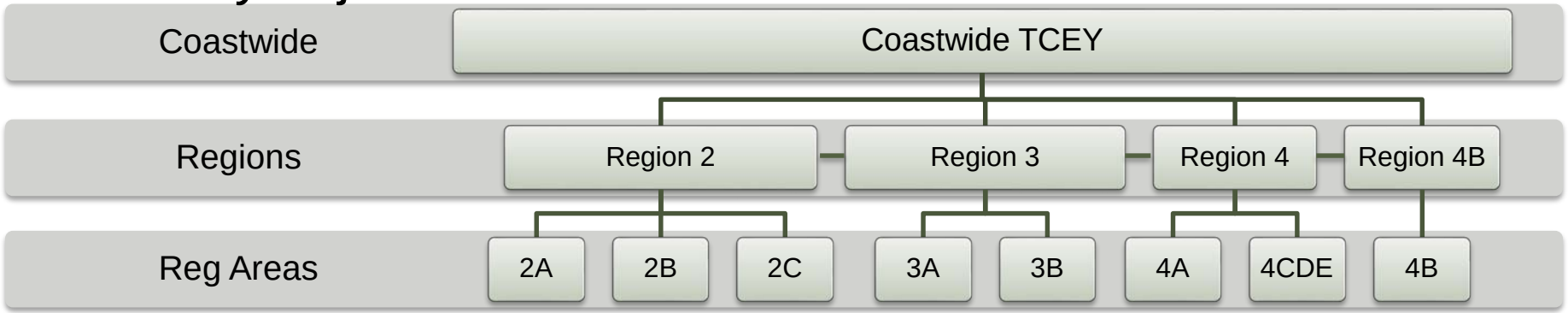
- Adjust the distribution of the TCEY among Regions
  - Management/policy based
  - Trends in data, historical observations, agreements
- Fishery objectives



A procedure for distributing the TCEY (5)

Regulatory Area Allocation

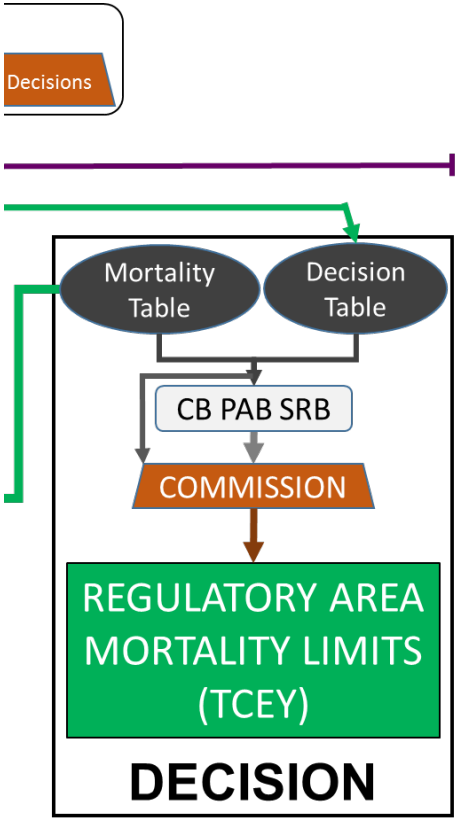
- Apply allocation percentages for each Regulatory Area within a Region
- Based on policy, data, observations, or agreement
- Fishery objectives



Decision-Making

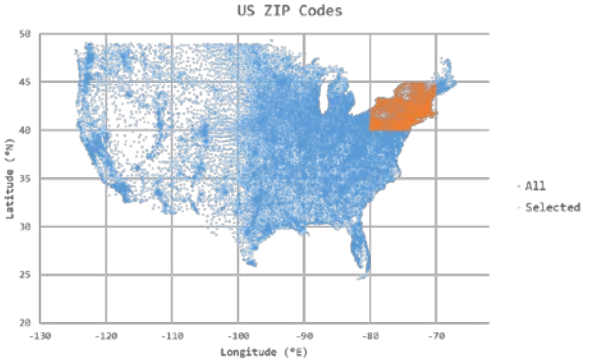
Annual Regulatory Area Adjustment

- Adjust Regulatory Area TCEY's to account for other factors as needed
- May deviate from the management procedure
  - Will have unpredictable consequences



Technical Development (Current)

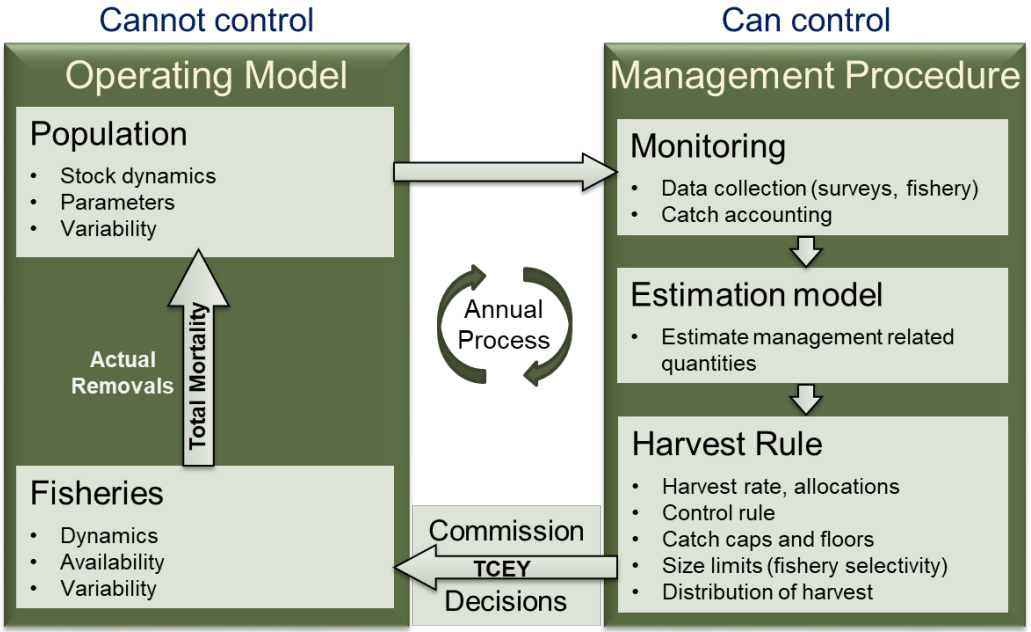
- Stock operating model (C++)
  - Simulate stock processes & dynamics on annual timestep and with (configurable) spatial extent (Regulatory Area, Biological Region)
  - Apply fishing mortality per sector
  - Standardize output to compare w/ stock assessment data
  - Validation w/ in-house R, Stock Synthesis
- Conditioning toolset (AD Model Builder)
- Large data set management
  - Dense or sparse arrays that may not fit in memory
  - Fast reads/writes through multithreading & parallelization
  - Ad hoc partition slices using ‘query’-style tooling



A few lines of C++, Python, or R can slice your data at will – here, gridded zip code data

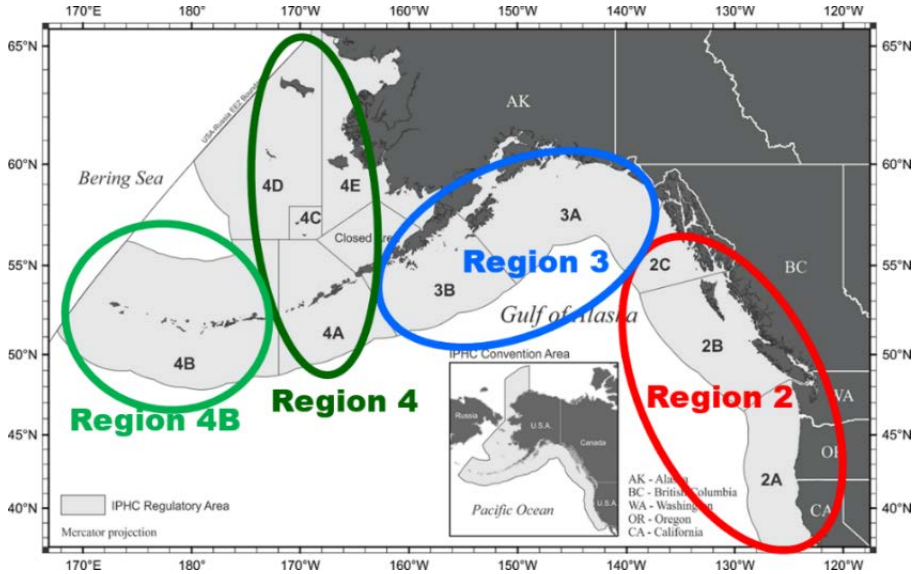
Technical Development (Upcoming Work)

- Add templates for management procedures
- Revise simulation tools (workflow management)
- Fully integrate tooling to close simulation-MP loop



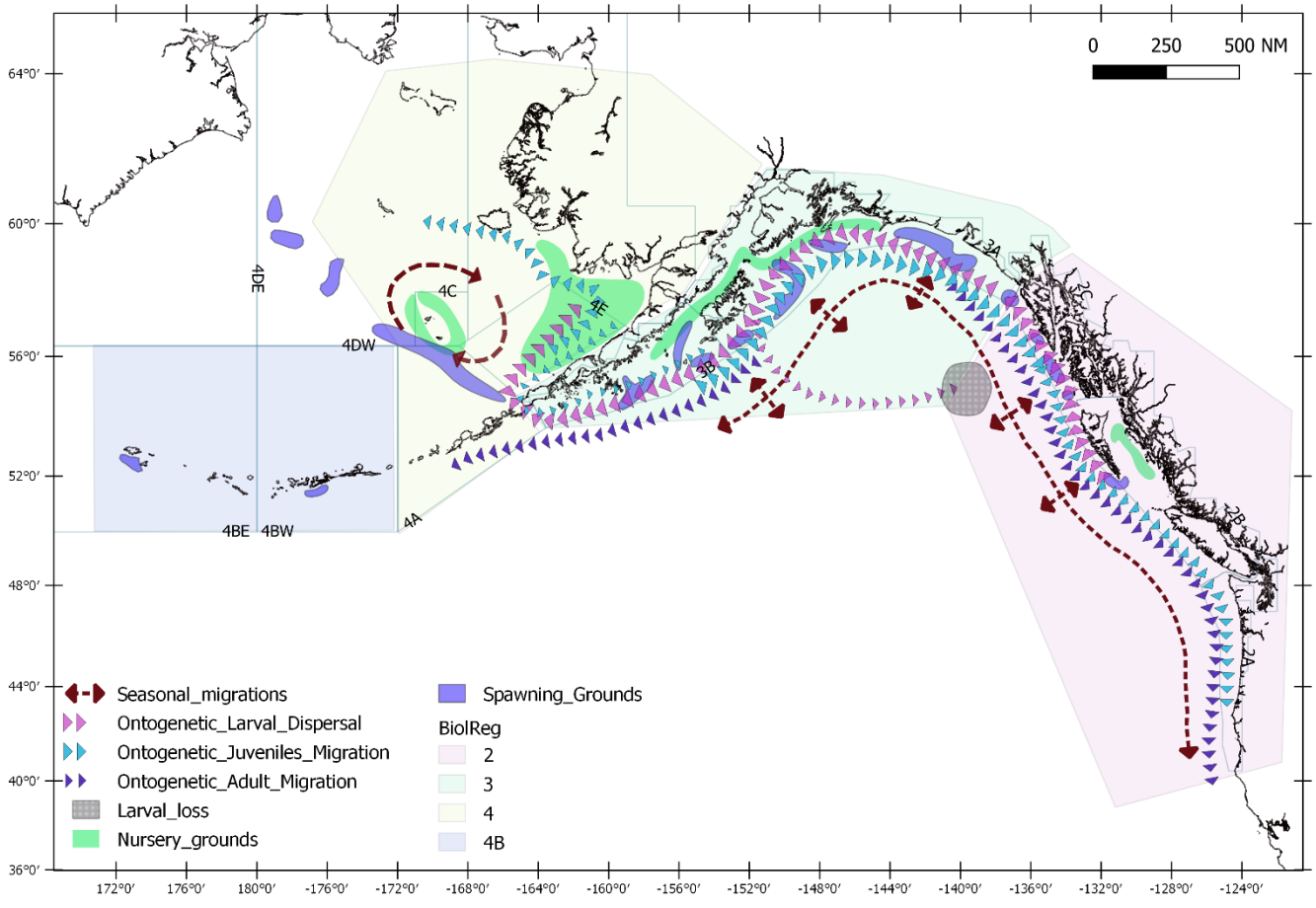
Modelling Regions and Areas

- Biological Regions
  - Population dynamics
  - Movement matrix
- IPHC Regulatory Areas
  - Fisheries
  - Within Biological Regions
  - Distribution or proportion of abundance

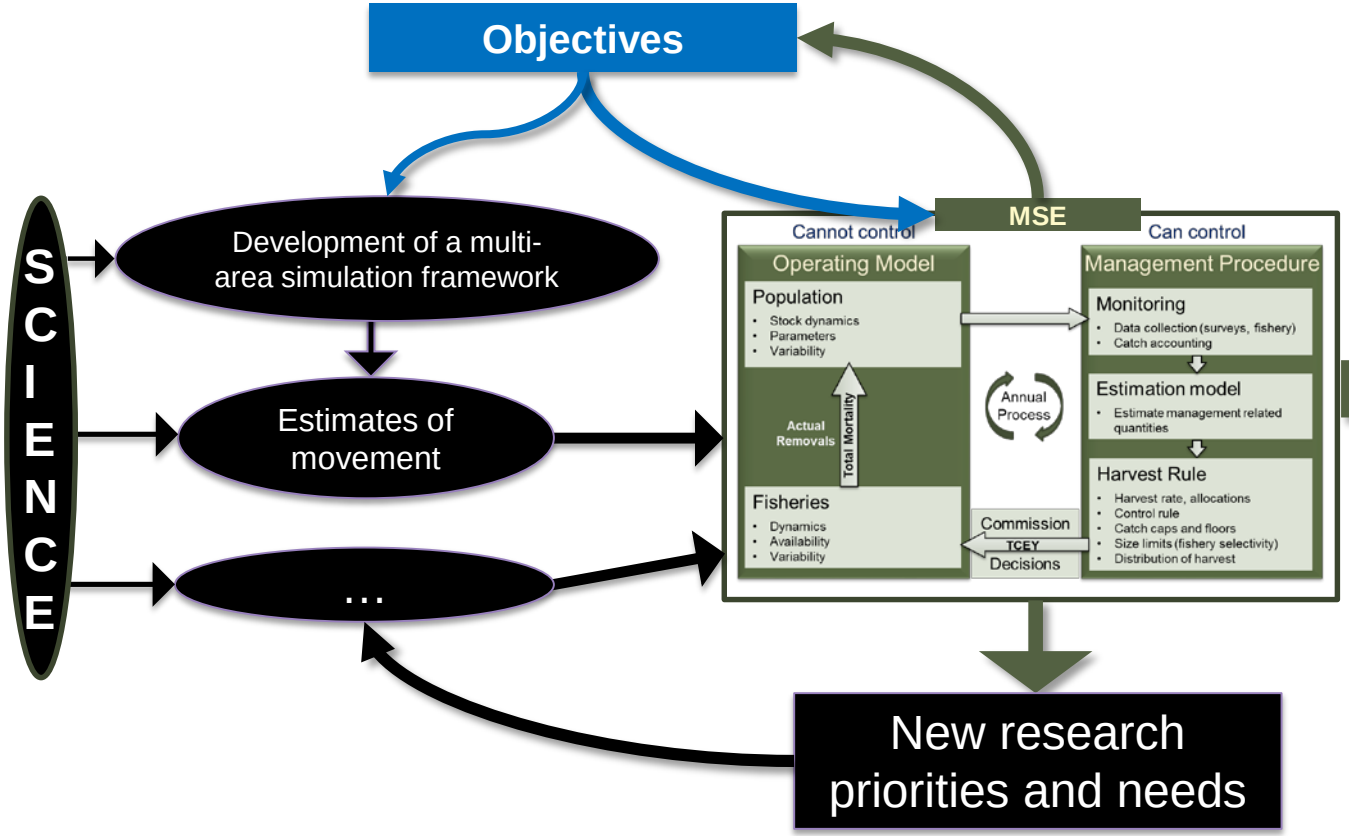


Movement

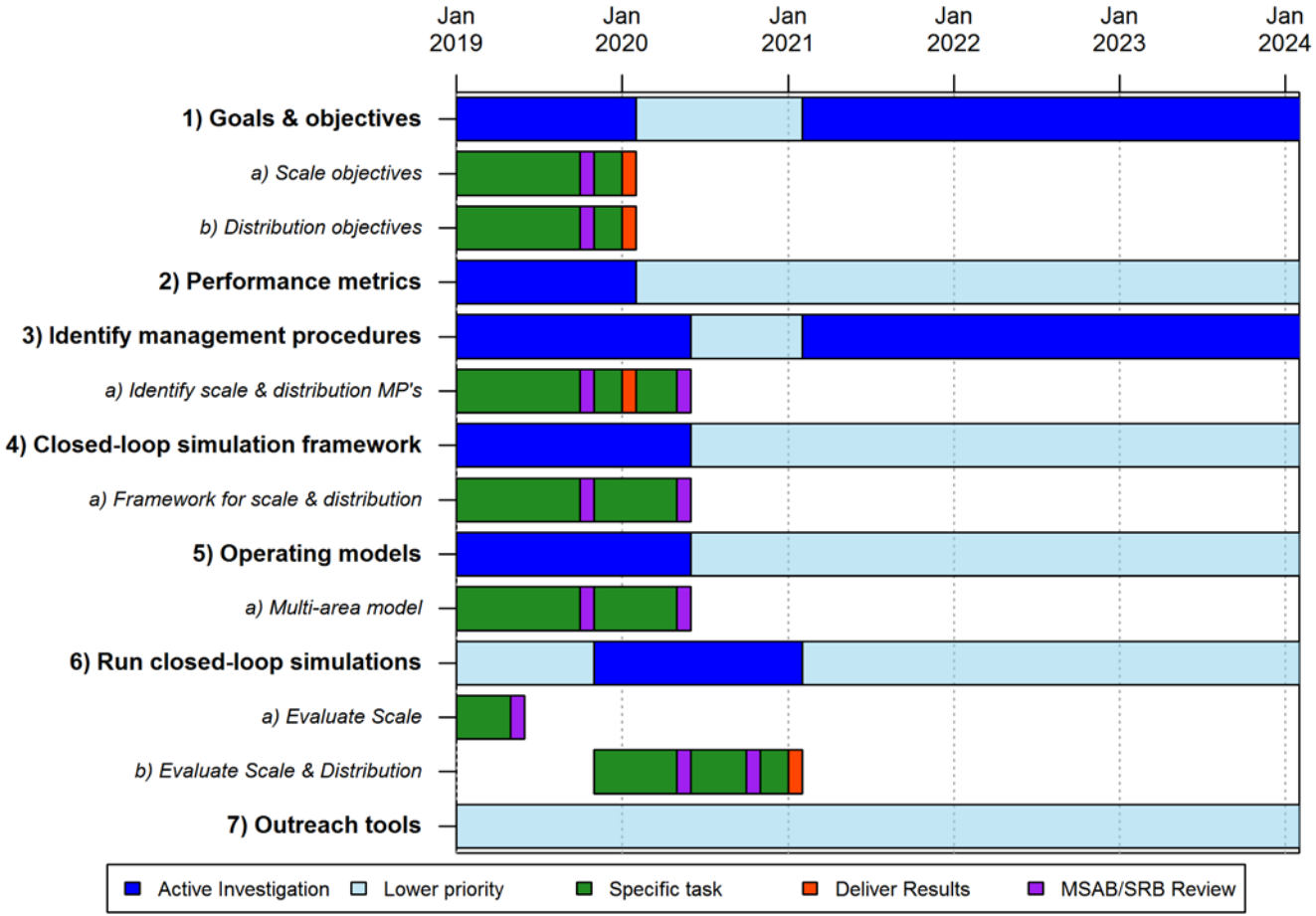
Conceptual model of main ontogenetic and seasonal migrations



Research priorities



Program of Work



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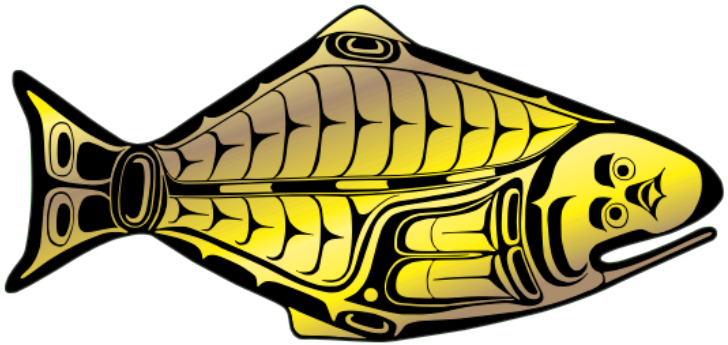

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