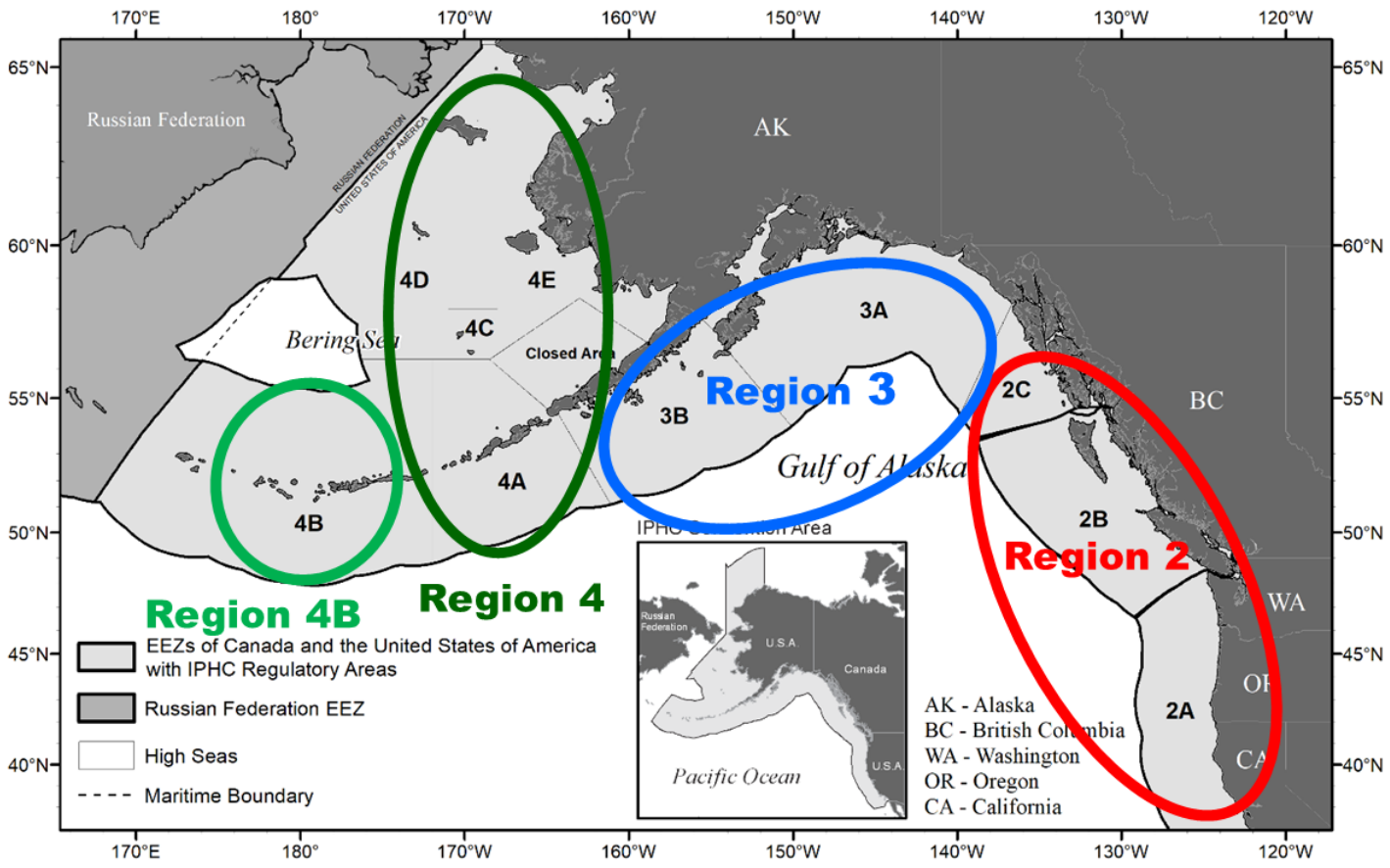
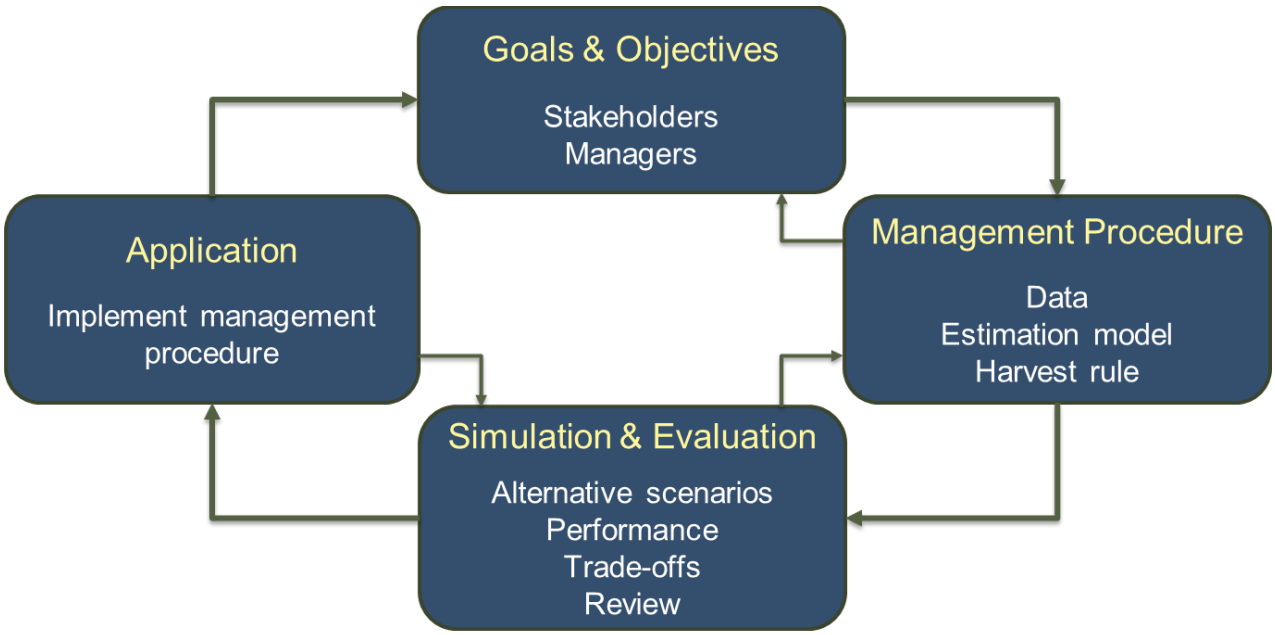


USING MANAGEMENT STRATEGY EVALUATION TO INVESTIGATE THE EFFECTS OF FISHING AND THE ENVIRONMENT ON PACIFIC HALIBUT



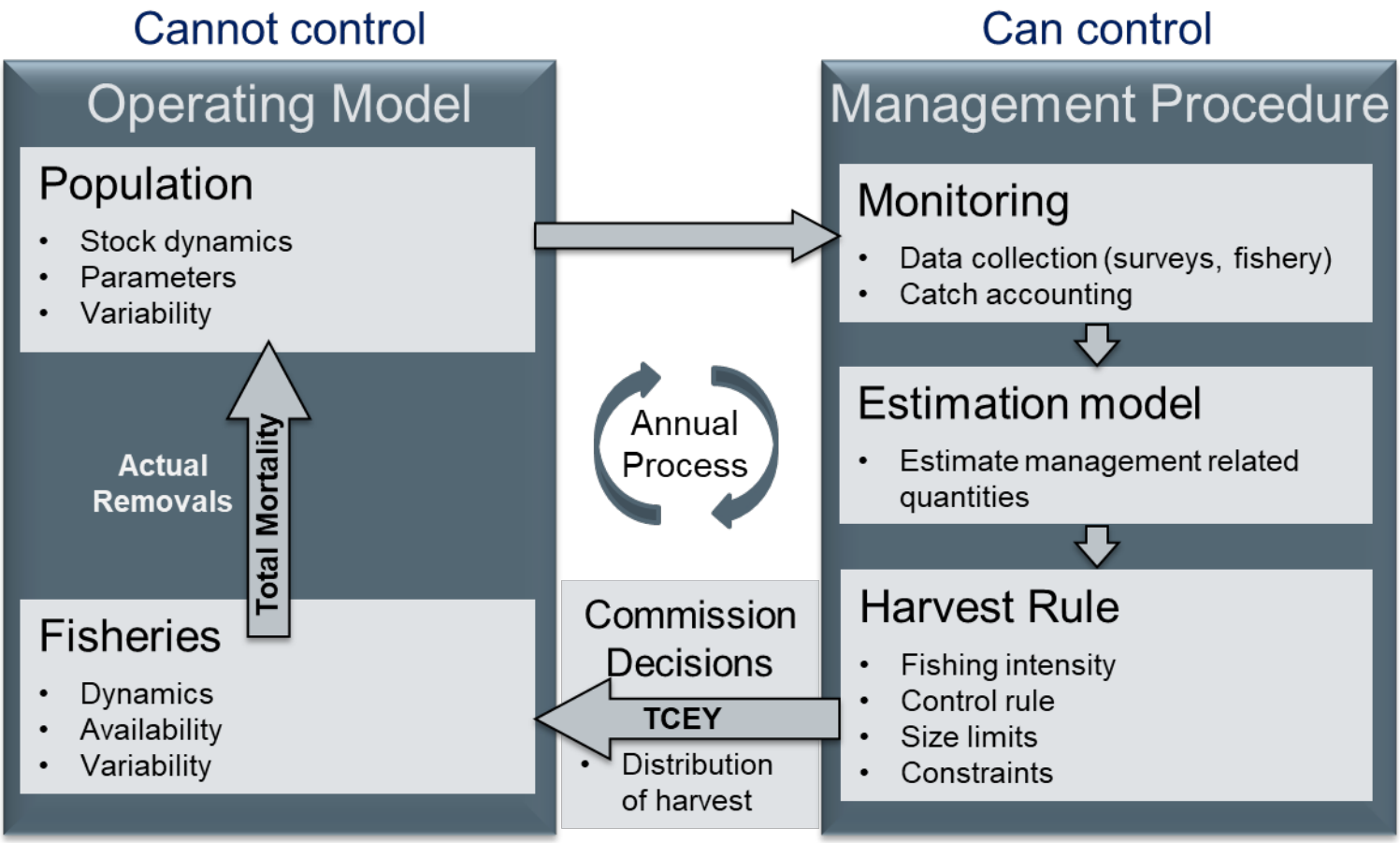
WHAT IS MSE?

Management Strategy Evaluation (MSE) is a process to evaluate the consequences of alternative management procedures. MSE uses a simulation tool to determine how alternative management procedures perform given a set of pre-defined fishery and conservation objectives, taking into account the uncertainties in the system.

MSE is a simulation technique based on modelling each part of a management cycle. The MSE uses an operating model to simulate the entire population and all fisheries, with potential environmental and/or ecosystem effects. The monitoring program, the estimation model, and management decisions (i.e. the management procedure) are factored in using closed-loop simulation. Processes that cannot be controlled, such as environmental effects, can be included as a source of variability, or by simulating specific scenarios to understand how different levels of the process affect the outcomes.

THE MSE PROCESS
DEFINE FISHERY & CONSERVATION OBJECTIVES
IDENTIFY MANAGEMENT PROCEDURES (MPS) TO EVALUATE
SIMULATE THE PACIFIC HALIBUT POPULATION USING THOSE MPS
EVALUATE RESULTS TO EXAMINE TRADE-OFFS
IMPLEMENT THE CHOSEN HARVST STRATEGY WITH THE TESTED MP

Undertaking an MSE requires scientists, managers, and stakeholders to be involved throughout the process. While the scientists do the modelling, managers must offer extensive input. Because of the many steps and the iterative process, communication among parties is critical for achieving buy-in on the results of the management strategy evaluation. The MSE is an essential part of the process of developing and agreeing to a harvest strategy policy.



AN MSE FOR PACIFIC HALIBUT

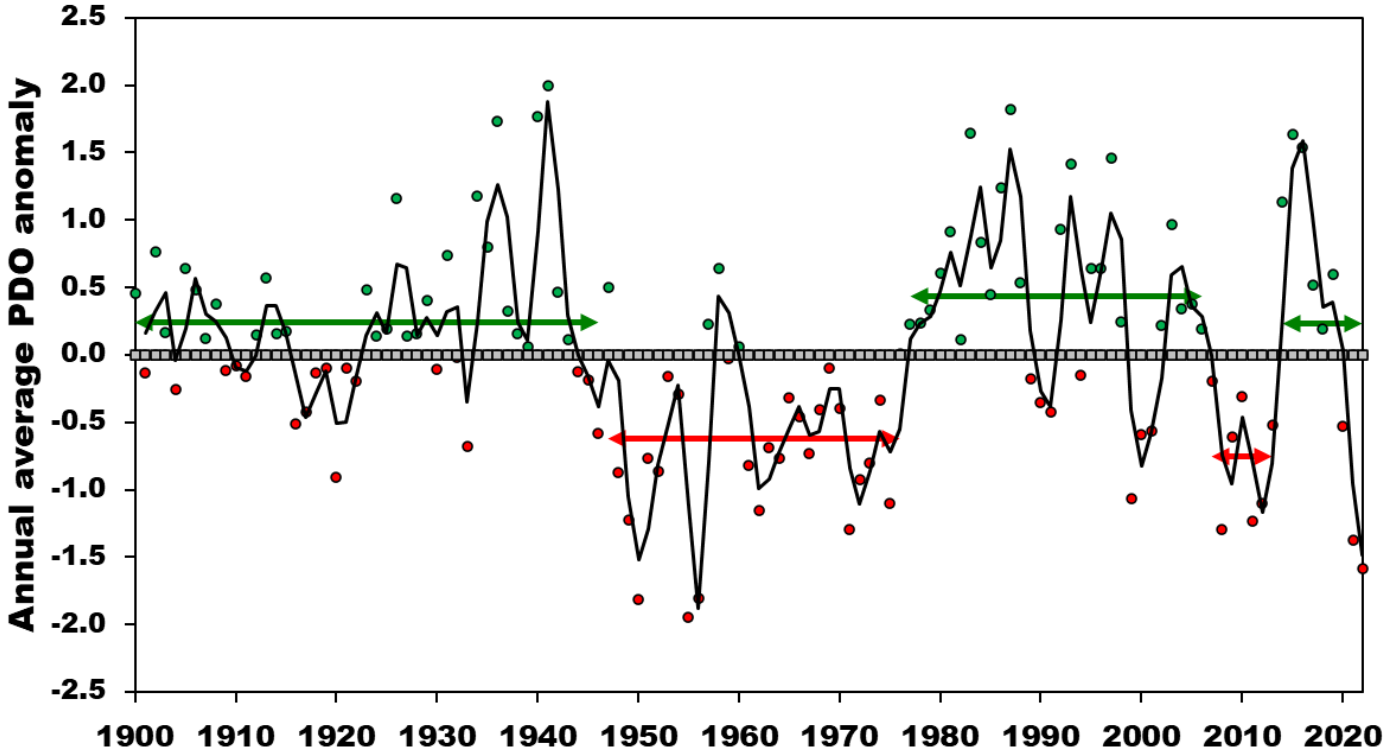
An operating model for Pacific halibut simulates the population dynamics within and between four regions across the Northeast Pacific Ocean. Fishing, movement, reproduction, and growth are modelled and simulation forward in time assuming a consistent harvest strategy. Variability in age-0 recruitment and growth are included. Outputs aggregated across all four regions (coastwide) include the future expected stock size, the expected fishery mortality limits (i.e. TCEY), and the interannual variability in the fishery mortality limits. These outputs are also available at the regional level. The IPHC Management Strategy Advisory Board (MSAB) provides input into the MSE process and the Commission uses the results in the development of a Harvest Strategy Policy.

CLOSED-LOOP FEEDBACK

AN OPERATING MODEL SIMULATES THE HALIBUT POPULATION INTO THE FUTURE

A MANAGEMENT PROCEDURE DETERMINES THE FISHING MORTALITY LIMITS AND FEEDS BACK INTO THE OPERATING MODEL

See https://www.iphc.int/research/management-strategy-evaluation/

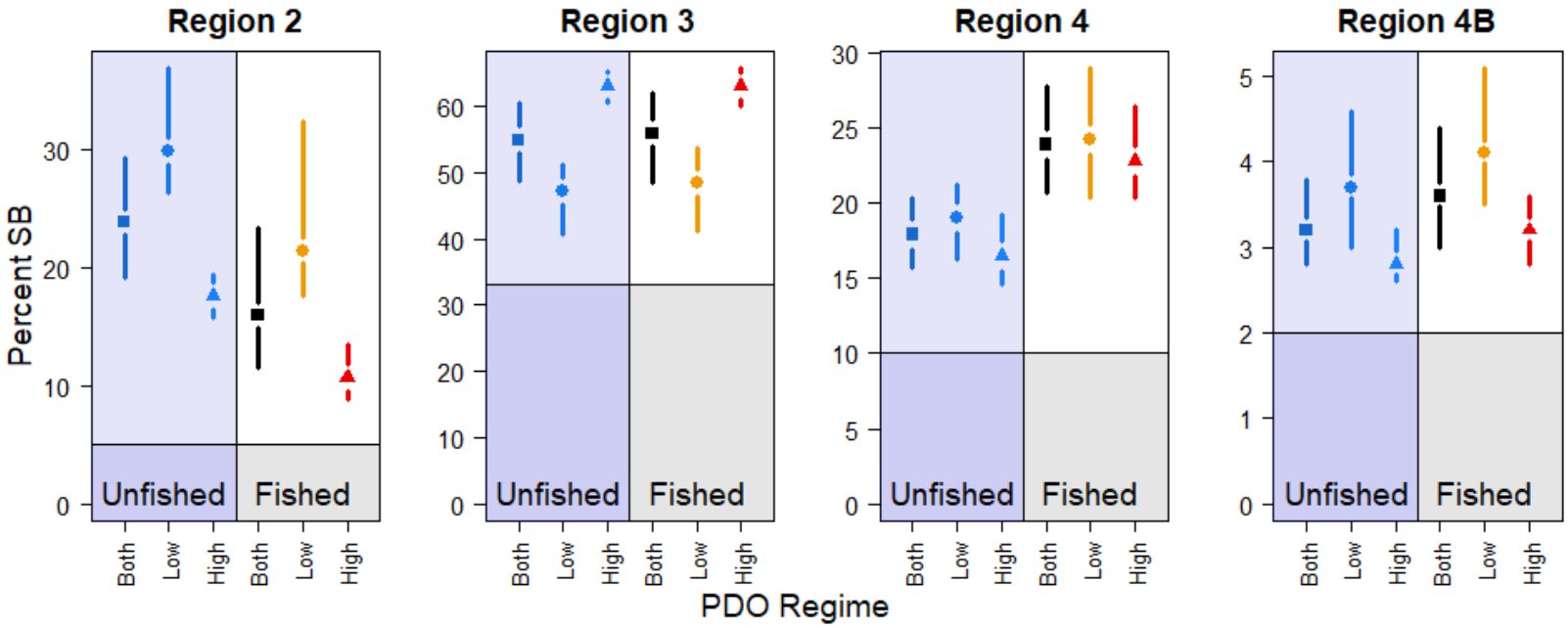


THE EFFECTS OF THE ENVIRONMENT ON PACIFIC HALIBUT

A strong correlation between the environmental conditions in the northeast Pacific Ocean, specifically the Pacific Decadal Oscillation (PDO), and recruitment of Pacific halibut to the commercial fishery during the 1900s has been identified. For Pacific halibut, the positive 'phase' of the PDO (years up to and including 1947, 1977-2006, and 2014-19) appears to have resulted in typically higher average recruitment. Additional work suggests that movement and the distribution of age-0 Pacific halibut are also different depending on the phase of the PDO.

The PDO indicates warm and cool surface waters in the Pacific Ocean and has oscillated at a decadal time scale. It has been correlated with salmon productivity as well. Since the late 1800's the PDO has oscillated between warm and cold phases at least 4 times. Recent research, however, shows many other environmental indicators were highly anomalous in recent years, and it is unclear whether these years represent comparable conditions to previous PDO observations.

Low PDO	High PDO
Low average recruitment	High average recruitment
Typically, less recruitment in Region 4	Typically, more recruitment in Region 4
Less movement from Region 4 to 3	More movement from Region 4 to 3
More movement from Region 3 to 2	Less movement from Region 3 to 2



What Would a Changing Environment Mean for the Management of Pacific Halibut

Using MSE, the Pacific halibut population was simulated forward in time, with fishing mortality similar to what has occurred recently, assuming that the PDO was either always low or always high. This allows for the separation of the effects of fishing and the effects of the environment. These results, however, would likely differ with a different harvest strategy.

The environment has a modest effect on the coastwide fishing mortality limits with the expected TCEY being 1.6 times greater in a high PDO regime when compared to a low PDO regime, although the interannual variability is the same. This is because the population size is smaller, thus fewer fish can be harvested in a persistent low PDO regime. Fishing and the environment affect the proportion of spawning biomass in each Biological Region in different ways. Region 2 (CA, OR, WA, BC, and SE AK) is affected by both the PDO and fishing. Region 3 (central Gulf of Alaska) is mostly affected by the PDO regime and fishing has little effect on the proportion of spawning biomass because fish move into this region at different rates depending on the PDO regime. Region 4 (western Gulf of Alaska and the Bering Sea) is mainly affected by fishing as fish generally move out of this region. Region 4B (Aleutian Islands) is affected by both fishing and the PDO regime because few fish move in or out of this region, but recruitment of age-0 Pacific halibut is dependent on the PDO regime.

EFFECTS OF THE ENVIRONMENT AND FISHING

THE TCEY IS 1.6 TIMES GREATER, ON AVERAGE, WITH A PERSISTENT HIGH PDO

AREAS ARE AFFECTED DIFFERENTLY BY FISHING AND BY THE ENVIRONMENT

Long-Term Performance Metrics			
PDO	Both	Low	High
Median RSB	38.8%	37.6%	39.2%
P(RSB<20%)	<0.001	<0.001	<0.001
P(RSB<36%)	0.238	0.329	0.157
Median TCEY (Mlbs)	65.6	51.4	83.0
Median AAV of TCEY	5.2%	4.5%	4.5%
Median TCEY Region 2 (Mlbs)	20.5	19.1	21.2
Median TCEY Region 3 (Mlbs)	33.7	23.0	48.7
Median TCEY Region 4 (Mlbs)	8.1	6.6	9.4
Median TCEY Region 4B (Mlbs)	2.4	2.2	2.6

IMPORTANCE TO DECISION MAKING

Even though we cannot "manage" the PDO regime, it is useful to understand the effects of the PDO regime on the Pacific halibut population and fisheries, separating the effect of fishing from the effects of the environment. In some cases, the environment may have a bigger effect on yield and the distribution of spawning biomass than fishing at a specific rate does. The environment is certainly influential on management outcomes and investigating the effects of a single regime on the management of Pacific halibut helps to understand the variability and uncertainty in the potential management outcomes.

In reality though, the environment is variable and often unpredictable. Therefore, the MSE simulations informing Commissioners, and the development of a Harvest Strategy Policy, oscillate randomly between PDO regimes and integrate the uncertainty of the environmental regime into the results. Including this variability provides the assurance that a chosen harvest strategy meets management objectives and is robust to uncertainty in the environment.

UNDERSTANDING THE EFFECTS OF THE ENVIRONEMNT

THE ENVIRONMENT IS VARIABLE AND OFTEN UNPREDICTABLE

UNDERSTANDING THE EFFECTS OF THE ENVIRONMENT IS USEFUL, BUT THE GOAL IS TO FIND A MANAGEMENT PROCEDURE THAT IS ROBUST TO THE VARIABILITY IN THE ENVIRONMENT

FOR MORE INFORMATION

QR code to https://www.iphc.int/research/management-strategy-evaluation/

References

Mantua et al. 1997

Clark and Hare 2002; Clark et al. 1999

Litzow et al. 2020

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