Accounting for temporal variability in productivity of Pacific halibut

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Pacific halibut (*Hippoglossus stenolepis*)

- Range from CA through BC, AK, and the western Pacific Ocean
- Live to greater than 30 years
- Grow to greater than 400 pounds
- Highly variable weight-at-age across years
- Have been observed to migrate very long distances
Pacific halibut fishing mortality

Discard mortality (nontargeted/nondirected)
Subsistence
Recreational
Discard mortality (targeted/directed)
Commercial landings

Mortality (Thousand mt net)
Mortality (Million lb net)

Pacific halibut weight-at-age
Recruitment Regimes

- Average age-0 recruitment is linked to environmental conditions
  - Pacific Decadal Oscillation (PDO)
  - ~1.5 to 3.2 times greater in good conditions
Productivity of Pacific halibut
Biological reference points

• Values that are useful for managing fish stocks
  – $SB_0$: Unfished spawning biomass
  – MSY: Maximum Sustainable Yield
  – RSB: Relative spawning biomass (relative to $SB_0$)
  – SPR: Spawning Potential Ratio

• These may change with changes in productivity
Equilibrium yield curve

- With no fishing
  - Yield is zero
  - Unfished biomass

- With extremely high F
  - Yield is zero
  - No biomass
Equilibrium yield curve

- **MSY**
  - Maximum Sustainable Yield
  - The maximum of the yield curve

- **F_{MSY}**
  - The fishing mortality rate that would result in MSY

- **Productivity regimes**
  - Change the shape of the equilibrium yield curve
Dynamic Reference Points

Purpose:
• to investigate variability in reference points given
  – changes in productivity and selectivity
  – different types of uncertainty

Reference points considered:
• SB0: Unfished biomass given the current regime
• MSY: Maximum Sustainable Yield
• RSB_{MSY}: Relative spawning biomass at MSY
• SPR_{MSY}: Spawning Potential Ratio at MSY
Use of models for fisheries management

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FAO 2008. Technical guidelines for responsible fisheries. 4, Suppl. 2, Add. 1
Dynamic Reference Points

Methodology:
• Conceptual: Equilibrium model
• Tactical: 2018 stock assessment model
• Strategic: Coastwide MSE operating model

Main sources of variability considered:
• Environmental regimes
• Weight at age
• Selectivity
• Steepness
• Natural mortality
Equilibrium model
Results from stock assessment models

[Graphs showing trends in MSY, SSB, RSB_MSY, and SPR_MSY over time]
Results from MSE operating model

- **SB₀** (Mlbs)
  - Low Regime
  - High Regime
  - Simulation Year

- **MSY** (Million lbs)
  - Simulation Year

- **RSB烜**
  - Simulation Year

- **SPR烜**
  - Simulation Year
Conclusions

- $SB_0$ and MSY vary depending on regime
- $RSB_{MSY}$ and $SPR_{MSY}$ are more stable
  - $RSB_{MSY} \sim 20\text{-}30\%$
  - $SPR_{MSY} \sim 30\text{-}35\%$
Development of a harvest strategy

Management Strategy Evaluation (MSE)

Goals & objectives

- Stakeholders
- Managers

Application

- Implement management procedure

Communication is a key part of every component

Management procedure

- Data
- Estimation model
- Harvest rule

Simulation & Evaluation

- Alternative scenarios
- Performance
- Trade-offs
- Review
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