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Desiree Tommasi$^1$, Barbara Muhling$^1$, Steven Teo$^2$, and Gerard DiNardo$^2$

$^1$UC Cooperative Institute for Marine Ecosystem and Climate, $^2$NOAA Southwest Fisheries Science Center

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North Pacific Albacore Ecology

Highly migratory species whose habitat spans the entire North Pacific Ocean

Video from http://svs.gsfc.nasa.gov/3821, NASA/Goddard Space Flight Center Scientific Visualization Studio
Temperature and Recruitment

Spatial correlations between Reynolds SST and recruitment (1993-2012)

Cooler temperatures in subtropics and warmer temperatures in temperate latitudes associated with stronger recruitment

Muhling et al., in prep
Temperature and Recruitment

- Generalized Additive Model of recruitment from SSB, SST anomalies, PDO, ENSO
- Stronger recruitment at higher SSB / cooler SSTs but model skillful only when 1970s were included
- Random variability and decadal cycles in recruitment
- May be partially driven by temperature variability, but correlations are weak

Recruitment estimates much less certain in this time period

Muhling et al., in prep
North Pacific Albacore Fisheries

Fisheries include longline largely targeting adults and surface gears targeting juveniles

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

Majority of the catch occurs in the Western Pacific

ISC 2017 NPALB Stock Assessment
North Pacific Albacore Management

Managed by two Regional Fisheries Management Organizations, WCPFC and IATTC

http://www.pewtrusts.org
North Pacific Albacore Stock Status

Spawning biomass relative to unfished levels (%)

- Albacore: 50%
- Tropical Tunas: 10%
- North Pacific Bluefin: <5%
North Pacific Albacore Management Strategy Evaluation

Use MSE to 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 reference points for North Pacific albacore given uncertainty
North Pacific Albacore MSE

Example harvest control rule

For initial MSE, 
\( F = 0 \) when \( SSB < SSB_{\text{limit}} \)
North Pacific Albacore MSE

Example HCRs

Fishing intensity

\[ F_{\text{target}} = 30\% \]

14\% \( \text{SSB}_{\text{limit}} \)

20\% \( \text{SSB}_{\text{threshold}} \)

Spawning Stock Biomass relative to unfished level
Albacore MSE Framework

Catch is allocated to different fisheries using 1999-2015 catch ratios

Catch with implementation error

OPERATING MODEL
“True” Population dynamics

Data Generation

Age-structured population dynamics model using Stock Synthesis platform

MANAGEMENT MODEL
Harvest control rule Allocation

ASSESSMENT MODEL
Current Stock Synthesis assessment model

Estimation of stock status

Management Procedure
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

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

Fishing areas - ISC 2017 NPALB Stock Assessment
North Pacific Albacore Management Strategy Evaluation

Use MSE to examine performance of alternative management strategies and reference points for North Pacific Pacific Albacore given uncertainty.
Parameter Uncertainty – use an ensemble of operating models

Recruitment
Test a range of steepness values

Natural Mortality
• Age and sex specific
• Test a range of values

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<th>Option 1 Male</th>
<th>Option 1 Female</th>
<th>Option 2 Male</th>
<th>Option 2 Female</th>
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</table>

Growth
• Sex specific
• Test a range of values
Process Error

- Random recruitment variability with an autocorrelation of 0.42
- Random annual deviations in selectivity of eastern pacific surface fishery
Albacore MSE Framework

Catch is allocated to different fisheries using 1999-2015 catch ratios

Catch with implementation error

OPERATING MODELS
“True” Population dynamics

Data Generation

MANAGEMENT MODEL
Harvest control rule Allocation

ASSESSMENT MODEL
Current Stock Synthesis assessment model

Estimation of stock status

Management Procedure

Autocorrelated recruitment
Time-varying age selectivity
Different growth, mortality, steepness

Operational models

Catch with implementation error

Current Stock Synthesis assessment model

Management Procedure
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 – SSB is 46% of unfished SSB
Low productivity – SSB is 21% of unfished SSB
Ecosystems

Conservation Objectives

Socio-economics Objectives

Fishing Scenarios

Will current management frameworks be robust to such changes

Ecosystems
Uncertainty – Fishing Scenarios

• Movement of effort from South Pacific to North Pacific
Uncertainty – Climate Change

- Trend in recruitment?

South Pacific Albacore Biomass Projections

Lehodey et al., 2015
North Pacific Albacore MSE

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

- \( p(\text{no drastic mgmt action}) \) = Probability of SSB being > LRP
- \( p(\text{depletion}) \) = Probability of depletion being > minimum historical depletion
- TAC stability = 1 - % absolute difference in TAC between years
- \( p(\text{catch}) \) = Probability of catch being > average historical catch
Robustness to Climate Variability

- Trade-off between depletion and catch

- \( p(\text{no drastic management action}) = \text{Probability of SSB being } > \text{LRP} \)
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Robustness to Climate Variability

- **Trade-off between depletion and catch**

  - \( p(\text{no drastic management action}) = \) Probability of SSB being > LRP
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Base Case

- Radar chart showing:
  - \( p(\text{no drastic management action}) \)
  - \( p(\text{depletion}) \)
  - \( p(\text{catch}) \)
  - TAC stability

- Graphs showing:
  - Depletion vs. Catch (mt)
  - F50%-Base vs. F30%-Base

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Robustness to Parameter Uncertainty

- Increased risk of drastic management action with F30% at low productivity

- $p(\text{no drastic management action}) = \text{Probability of SSB being > LRP}$
- $p(\text{depletion}) = \text{Probability of depletion being > minimum historical depletion}$
- TAC stability = $1 - \%$ absolute difference in TAC between years
- $p(\text{catch}) = \text{Probability of catch being > average historical catch}$
Robustness to Future Change

• **p(no drastic management 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

- Patterns driven by increase in effort
- Lower catch because of increased management intervention
Conclusions

• Proposed HCRs generally robust to past range of climate variability
• Climate responsive rather than climate informed HCRs
• More work required to better understand drivers of North Pacific albacore productivity and movement
• Human dynamics important
• Parameter/model uncertainty needs to be considered
Future work

- Present results at stakeholders workshop in March 2019
- Develop economics informed performance metrics
- Refine recruitment analysis
- Investigate use of more mechanistic operating model (e.g. SEAPODYM)
- Assess climate change impacts on albacore distribution within California Current /US fishing communities with IBM and spatial distribution model as part of Future Seas Project (see Jacox et al. poster S12-P12)
Thank you!