Oceanographic influences on the spawning and recruitment of Pacific bluefin tuna

Barbara Muhling
Desiree Tommasi
Seiji Ohshimo
Michael Alexander
Gerard DiNardo
Pacific bluefin tuna

- Fished throughout most of their range
- Spawn only in the western Pacific Ocean
- Some portion migrate to the California Current region as juveniles
Nansei Islands spawning ground

- Spawning near Taiwan and Nansei Islands April - June
- Larvae transported northwards in the Kuroshio Current
- Nursery grounds around southern coastal Japan
Sea of Japan spawning ground

- Spawning in the Sea of Japan July - September
- Larvae retained locally
- Nursery grounds around northern coastal Japan
Recruitment

- Historically variable
- Lower in the 1980s and 2010s, higher between
- Weak correlation with annual Pacific Decadal Oscillation (PDO)
Spatial characteristics of the PDO

- During positive phases of the PDO, California Current is warmer, Sea of Japan is cooler.
Methods and rationale

• Recruitment may be determined by larval survival (eg Watai et al. 2017)
• Does temperature variability in larval and juvenile habitats explain the effect of the PDO?
• We extracted SST at 1x1° resolution between Taiwan and the Sea of Japan (Reynolds OISST)
  • 1982 – 2014, April through November
• Where and when does temperature correlate with recruitment?
Temperature effects on recruitment

• Nearly always positive
• Summer and fall (not spring)
Areas of interest

• Temporal and spatial autocorrelation in SST datasets is high

• However, three distinct areas of interest were defined

• Warmer temperatures in these areas, at these times, associated with stronger recruitment
Areas of interest

- Relationships were strongest south of Shikoku in June and July
- A 2 degree increase in SST in this area could result in a four-fold increase in recruitment
- Temperature not strongly correlated among the selected areas of interest
- In particular, warm conditions south of Shikoku did not predict warm conditions in the Sea of Japan 1 – 4 months later
Different spawning grounds

- Juveniles south of Shikoku in June – July likely from southern spawning ground
- Larvae and juveniles in the Sea of Japan August – October likely from northern spawning ground
- Highest recruitment years when temperatures were warm in both areas
- Lowest recruitment years when both were cooler
Generalized Additive Models

- We used GAMs to look at the additive effects of temperature across the areas of interest
- 70.8% of deviance in annual recruitment explained
- A GAM using principal components of SST (reduces autocorrelation) explained 77.1%
- Spawning stock biomass significant to both models, but weak
Generalized Additive Models

- Decadal-scale and interannual variability captured well
- But over-prediction in most recent 2 – 3 years
Causes of temperature variability

• What causes the SST variability which then impacts recruitment?
  - Sea of Japan can vary by >4°C in August
• Air temperature explains SST variability better than Kuroshio Current flow
  - Atmospheric influences important?
• ENSO, PDO, Arctic Oscillation and summer monsoon also impact the area
Conclusions

• Warmer conditions near larval and small juvenile habitats correlates with stronger recruitment
• Highest recruitment years where conditions warm on both nursery grounds
• Temperature appears more important than spawning stock biomass in predicting recruitment
• Regional temperature variability associated with a range of climate modes
• Next: mechanisms...?