Oceanographic influences on the spawning and recruitment of Pacific bluefin tuna

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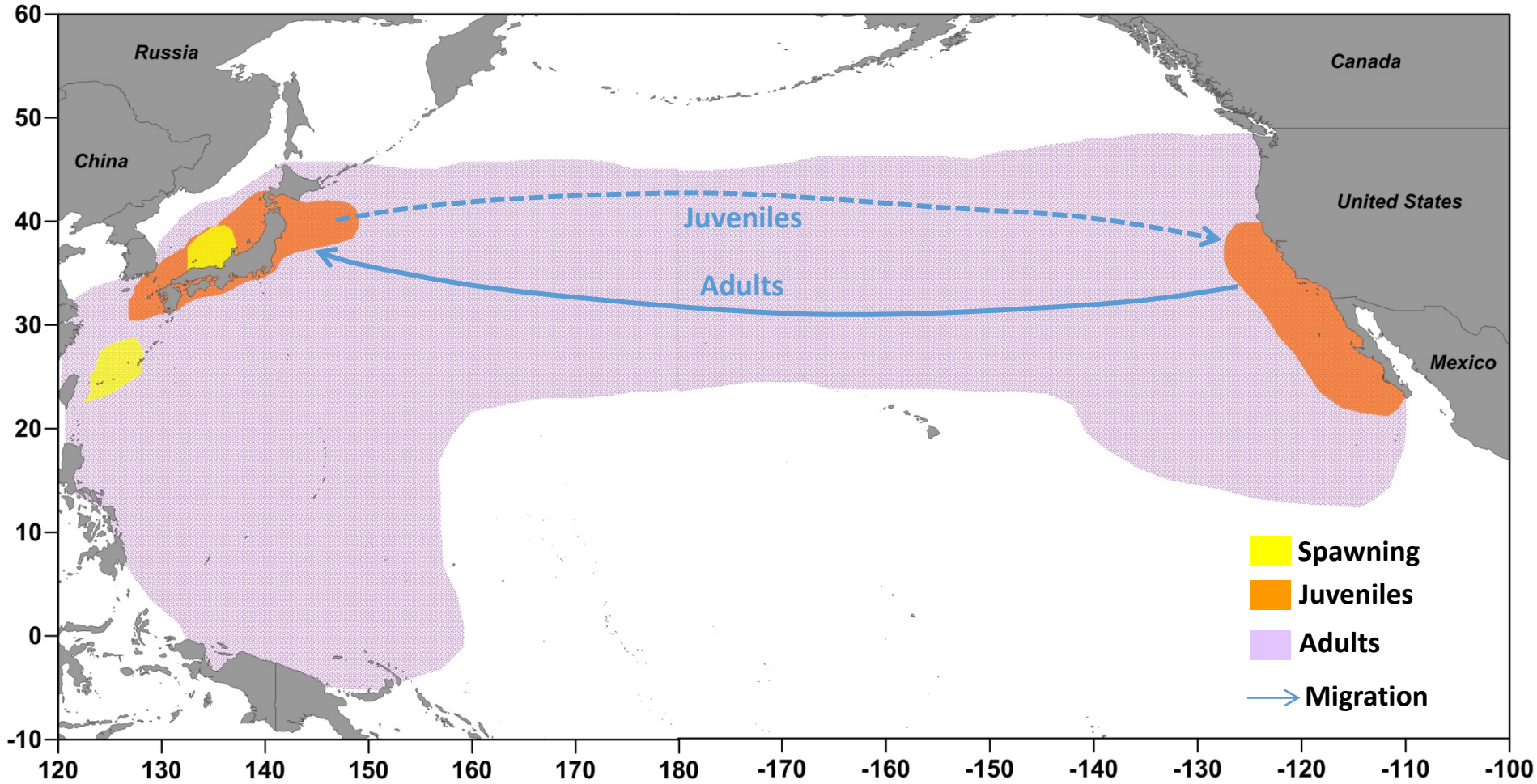
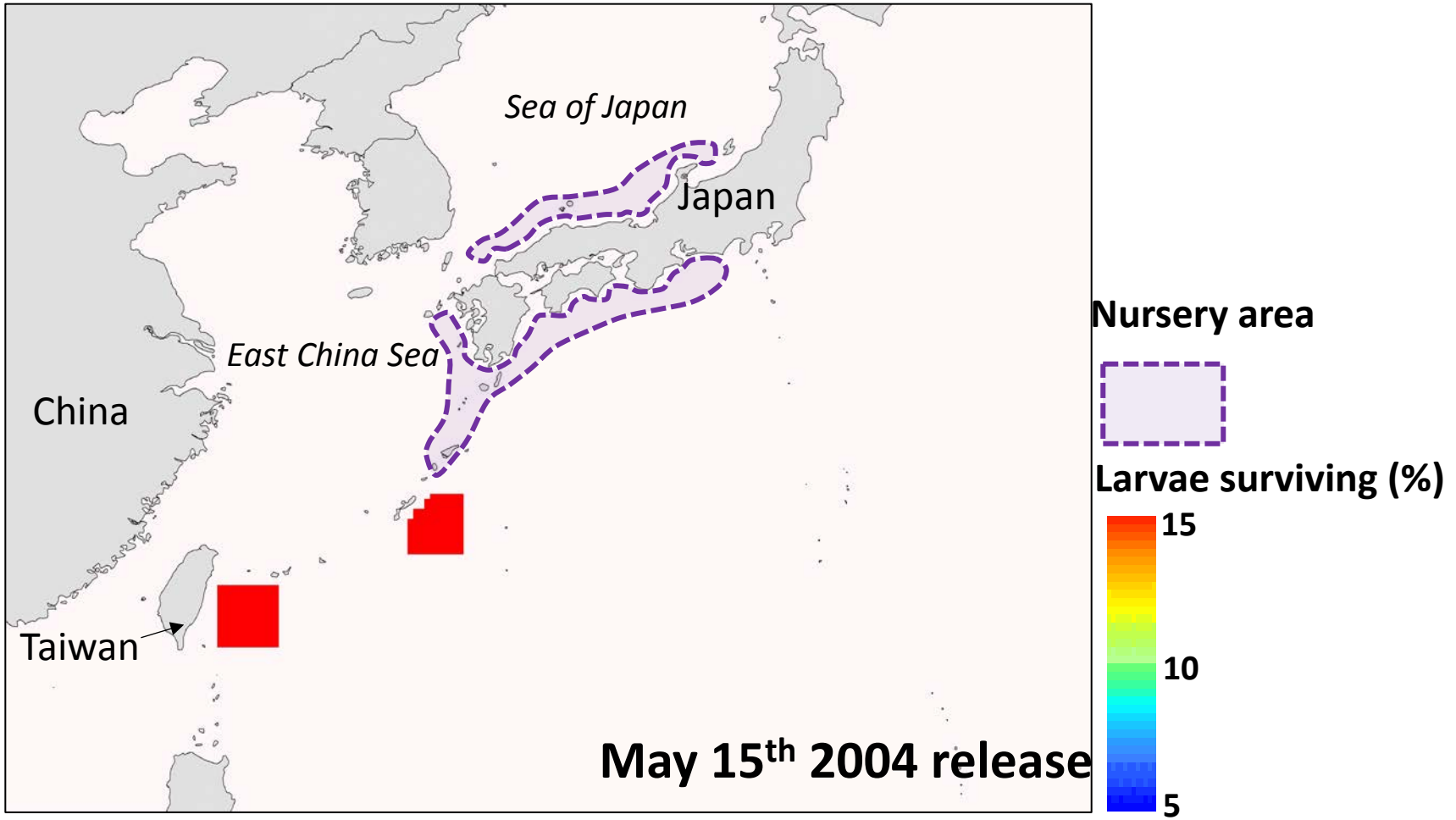
Pacific bluefin tuna

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



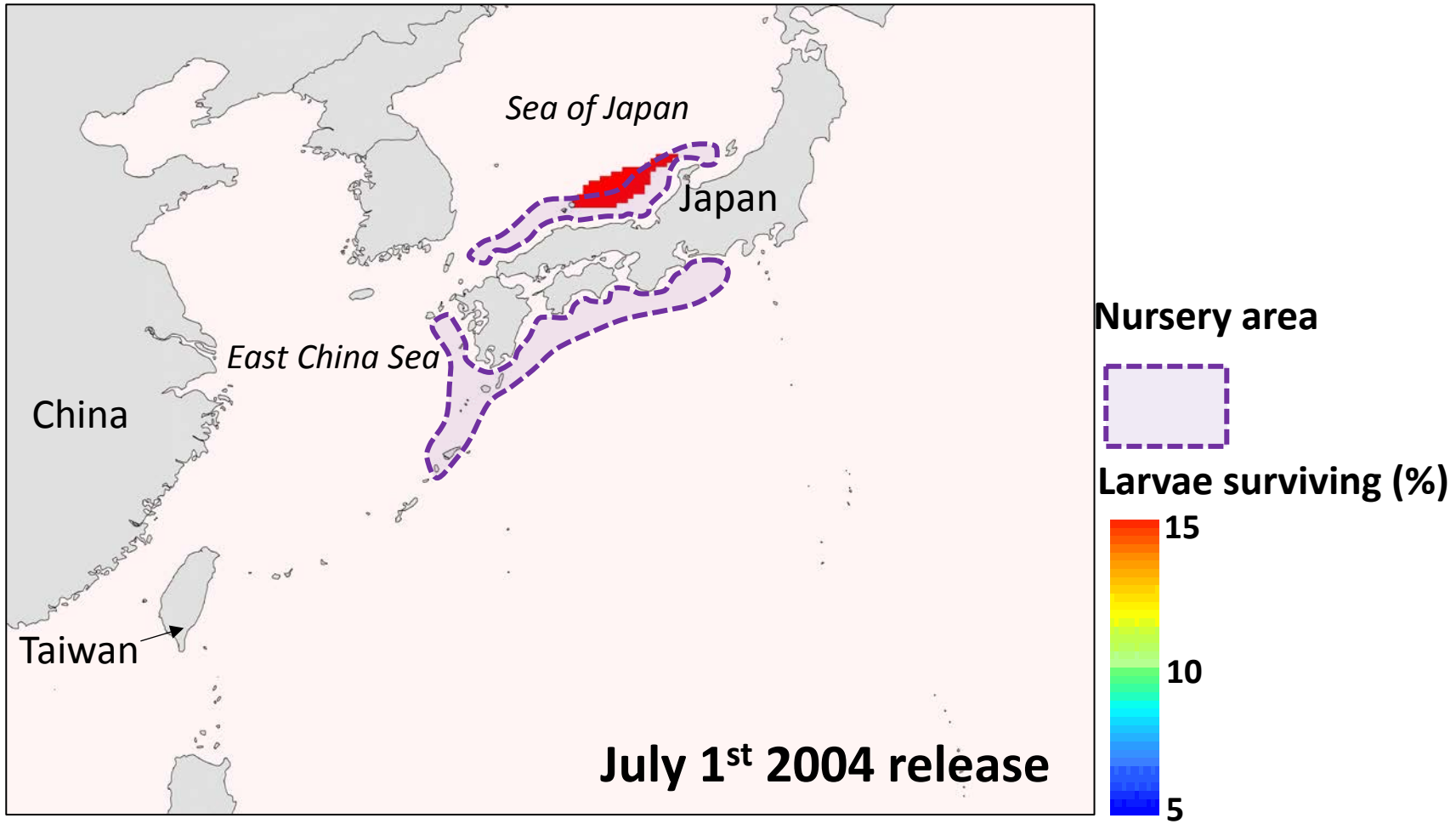
Nansei Islands spawning ground

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



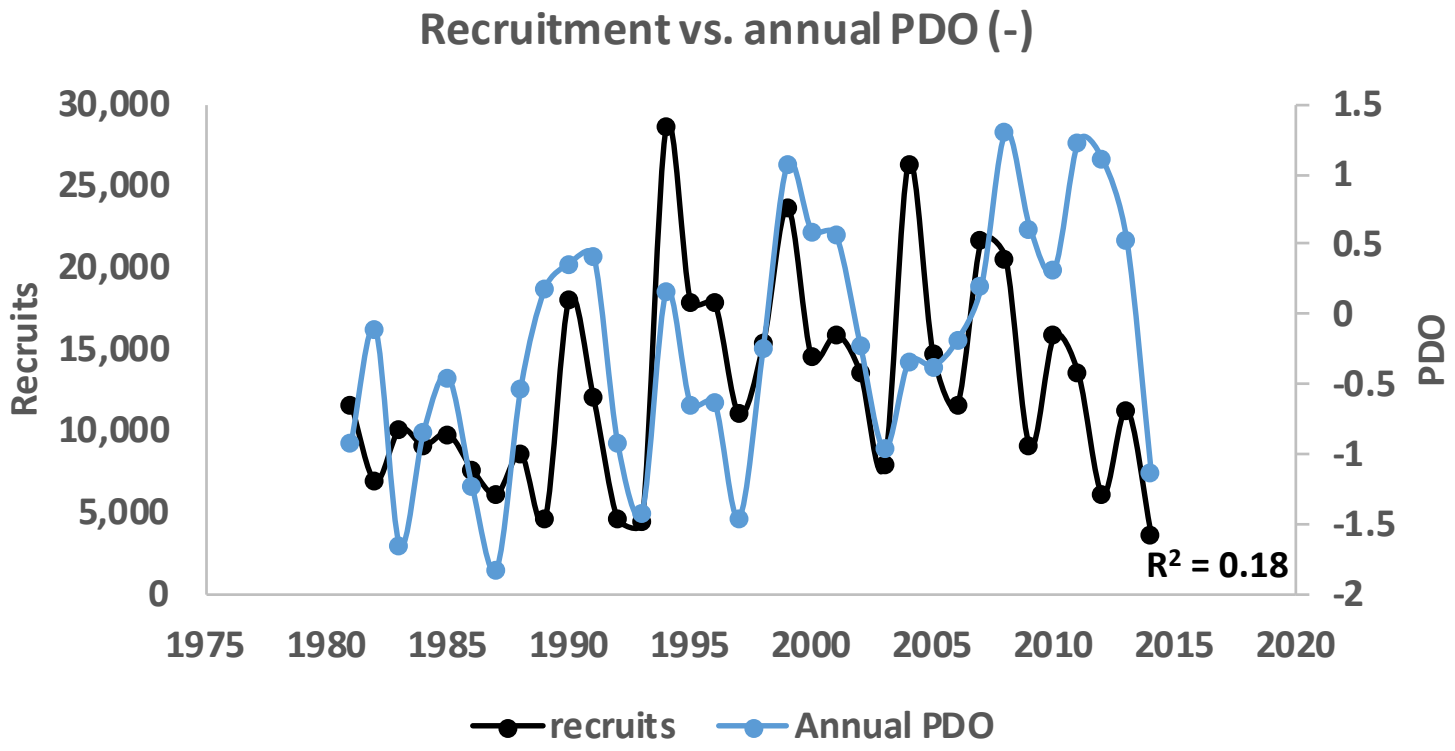
Sea of Japan spawning ground

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



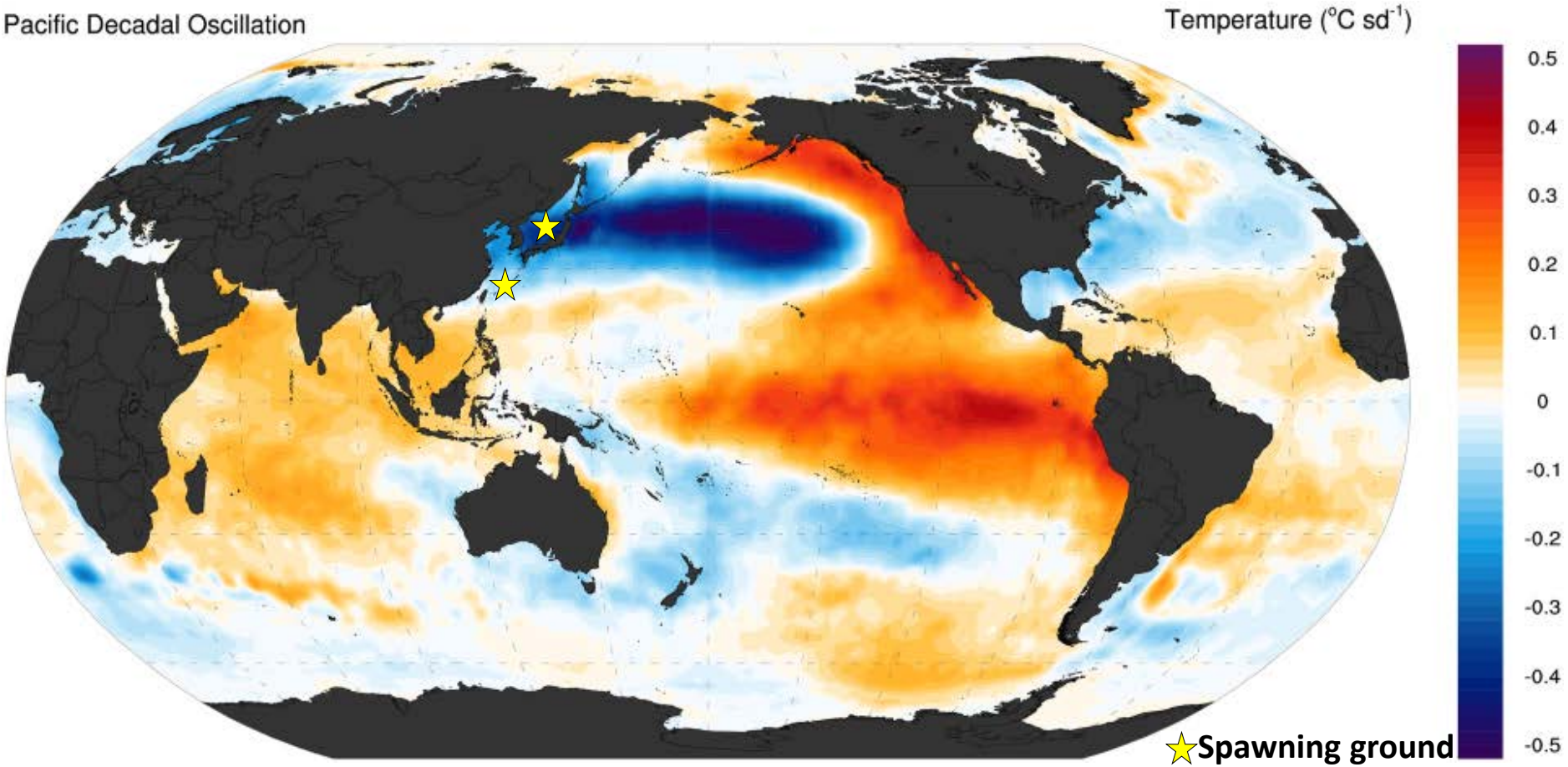
Recruitment

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



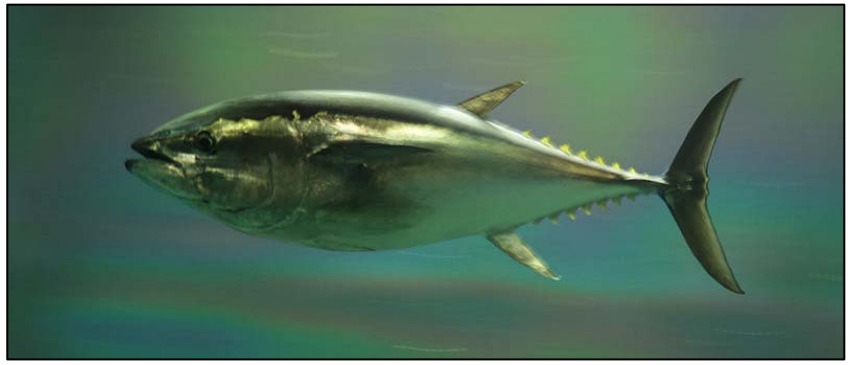
Spatial characteristics of the PDO

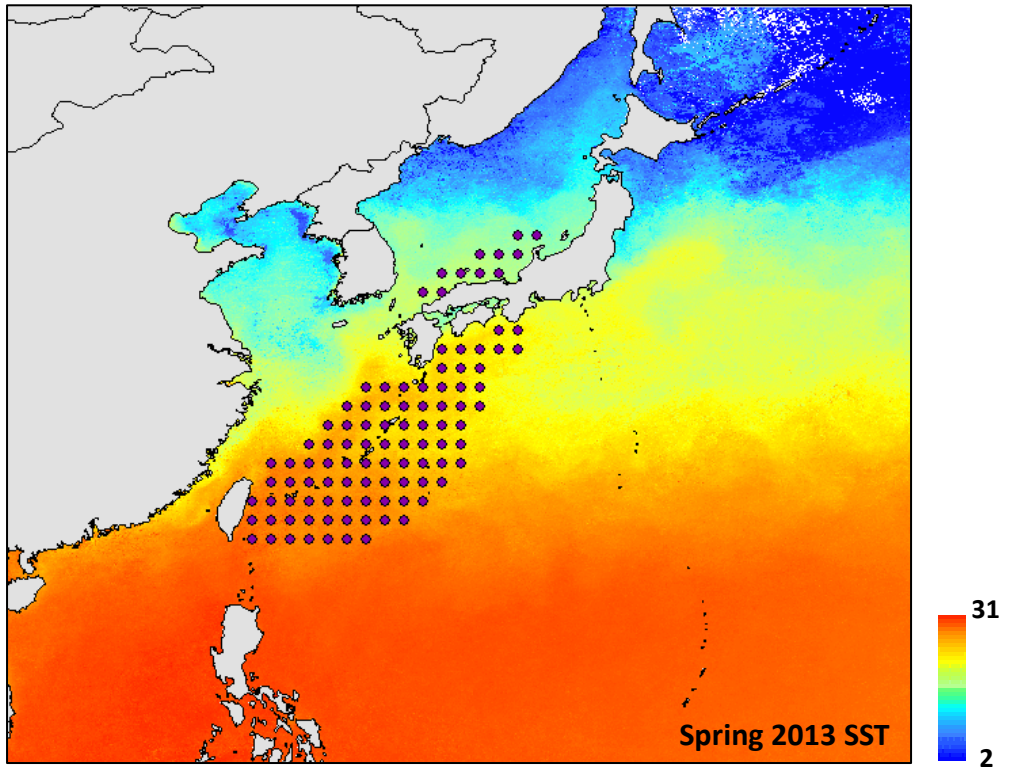
- During positive phases of the PDO, California Current is warmer, Sea of Japan is cooler



Methods and rationale

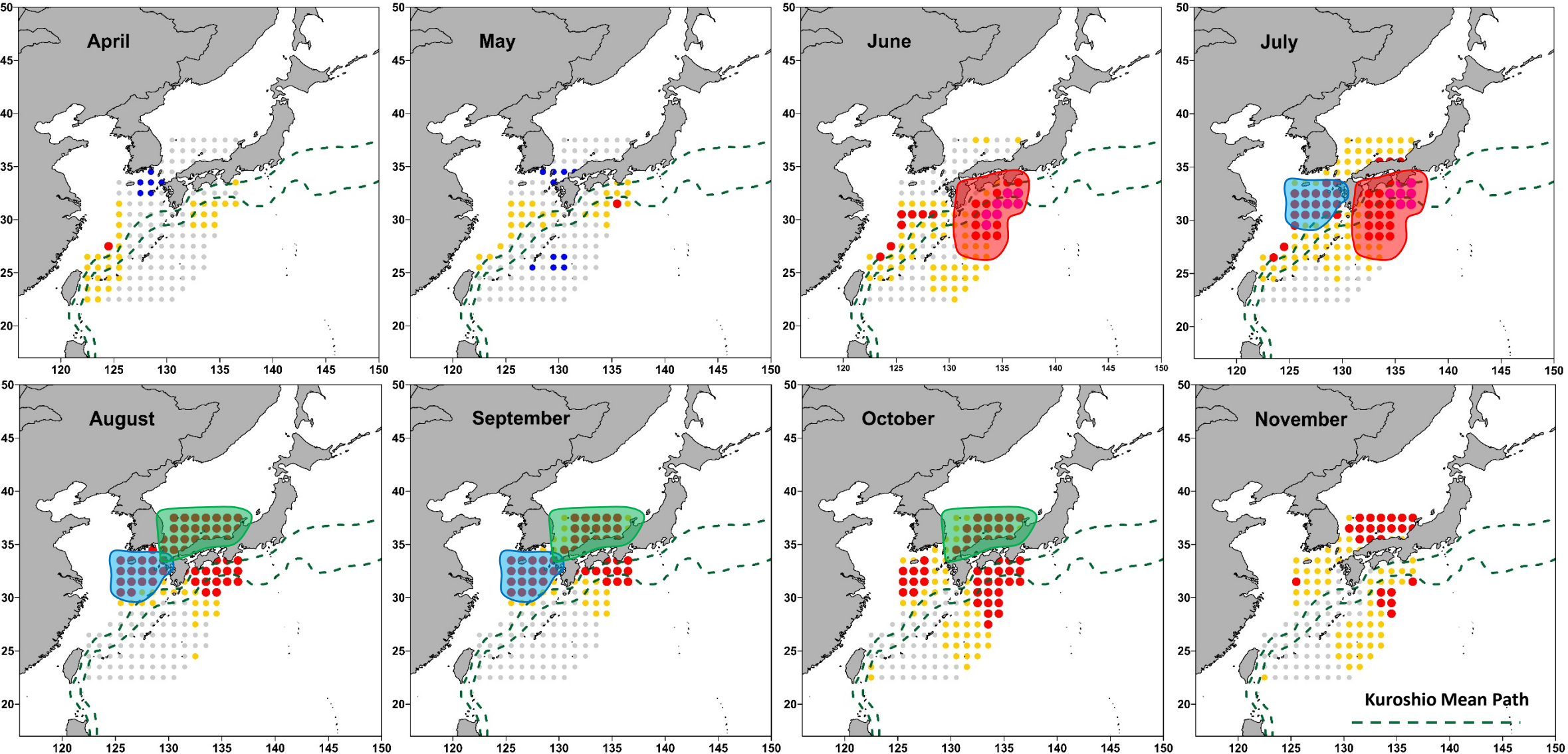
- Recruitment may be determined by larval survival (eg Watai et al. 2017)
- Does temperature variability in larval and juvenile habitats explain the effect of the PDO?
- We extracted SST at 1x1° resolution between Taiwan and the Sea of Japan (Reynolds OISST)
  - 1982 – 2014, April through November
-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



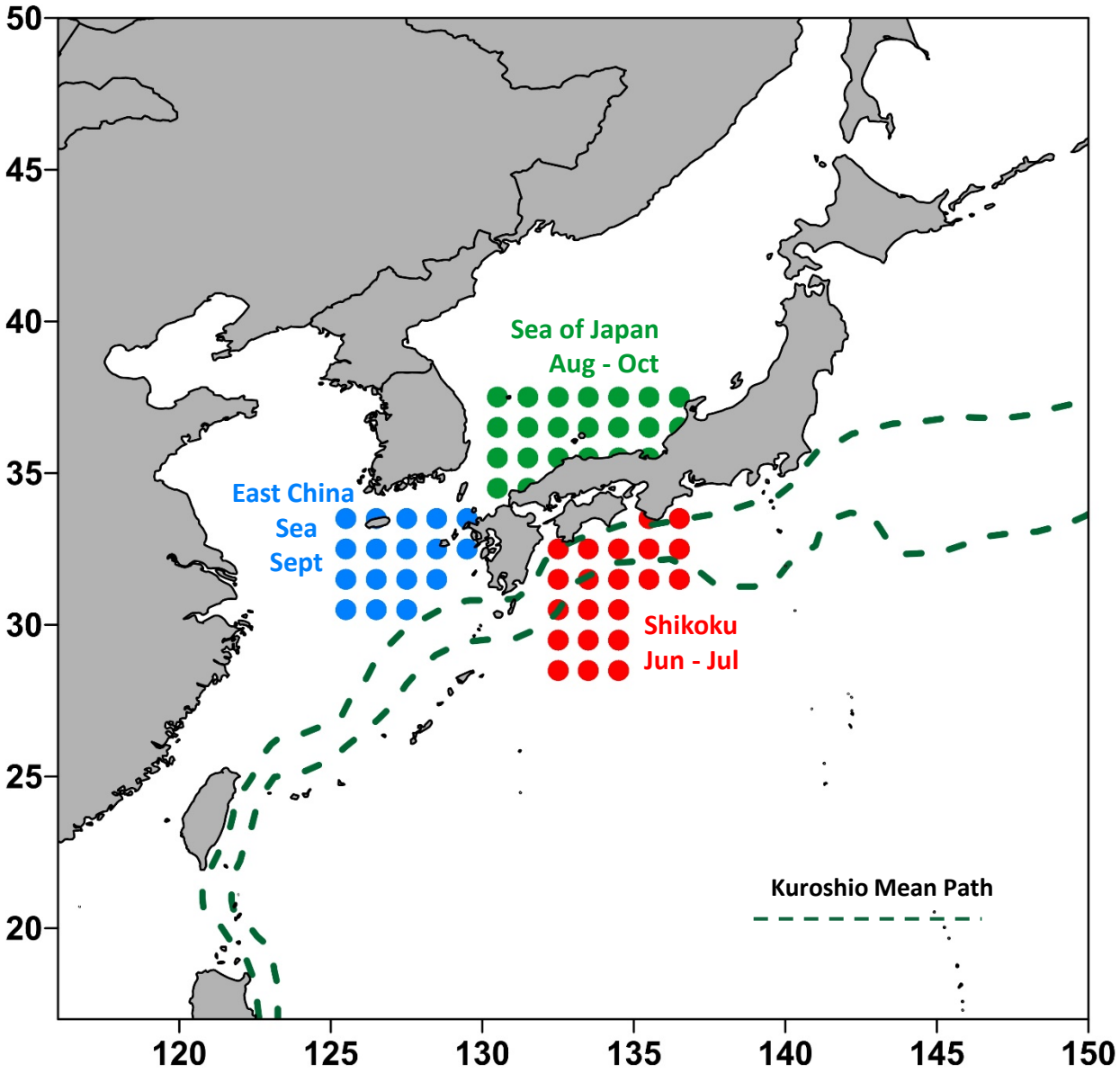


Temperature effects on recruitment

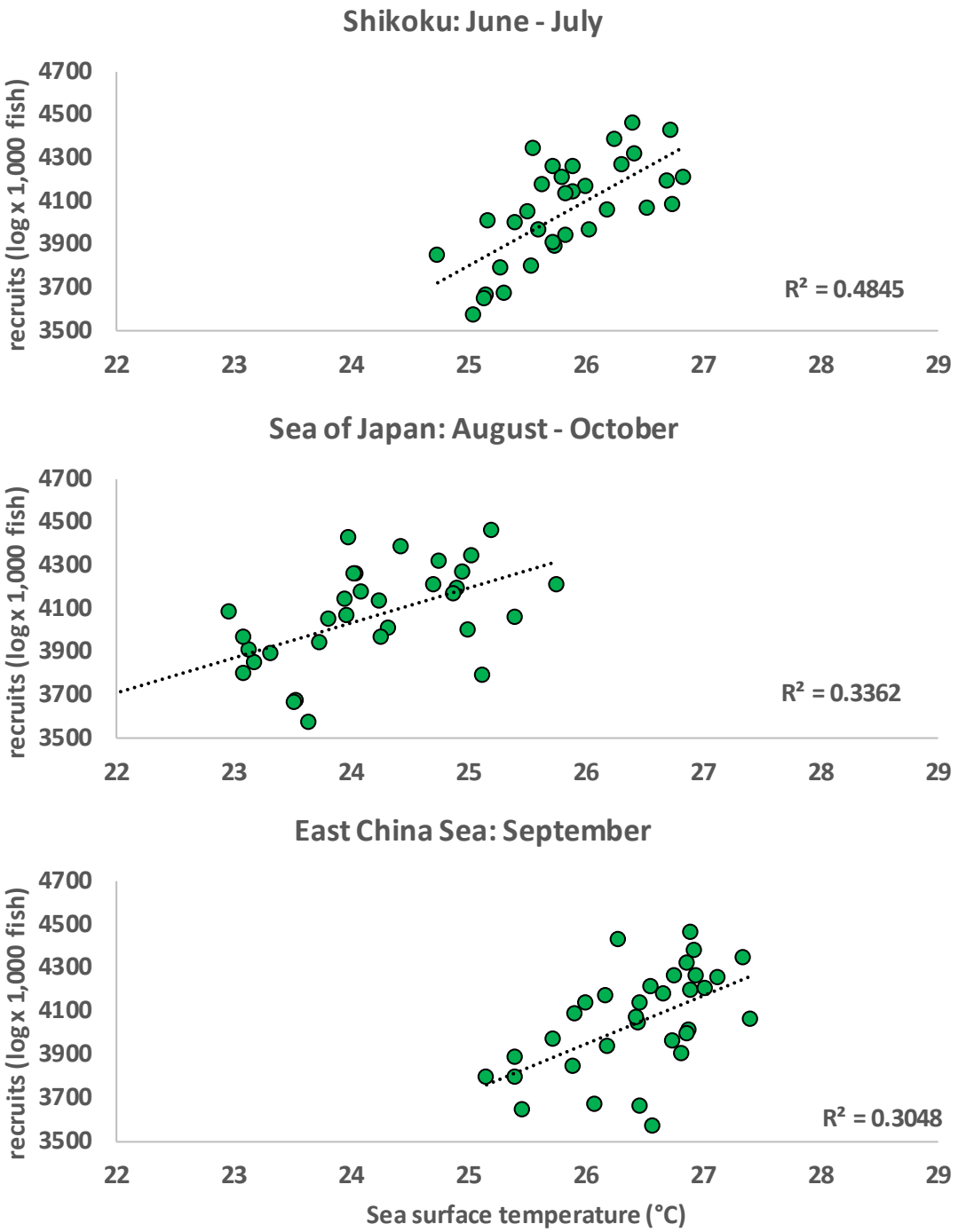
- Nearly always positive
- Summer and fall (not spring)



Areas of interest



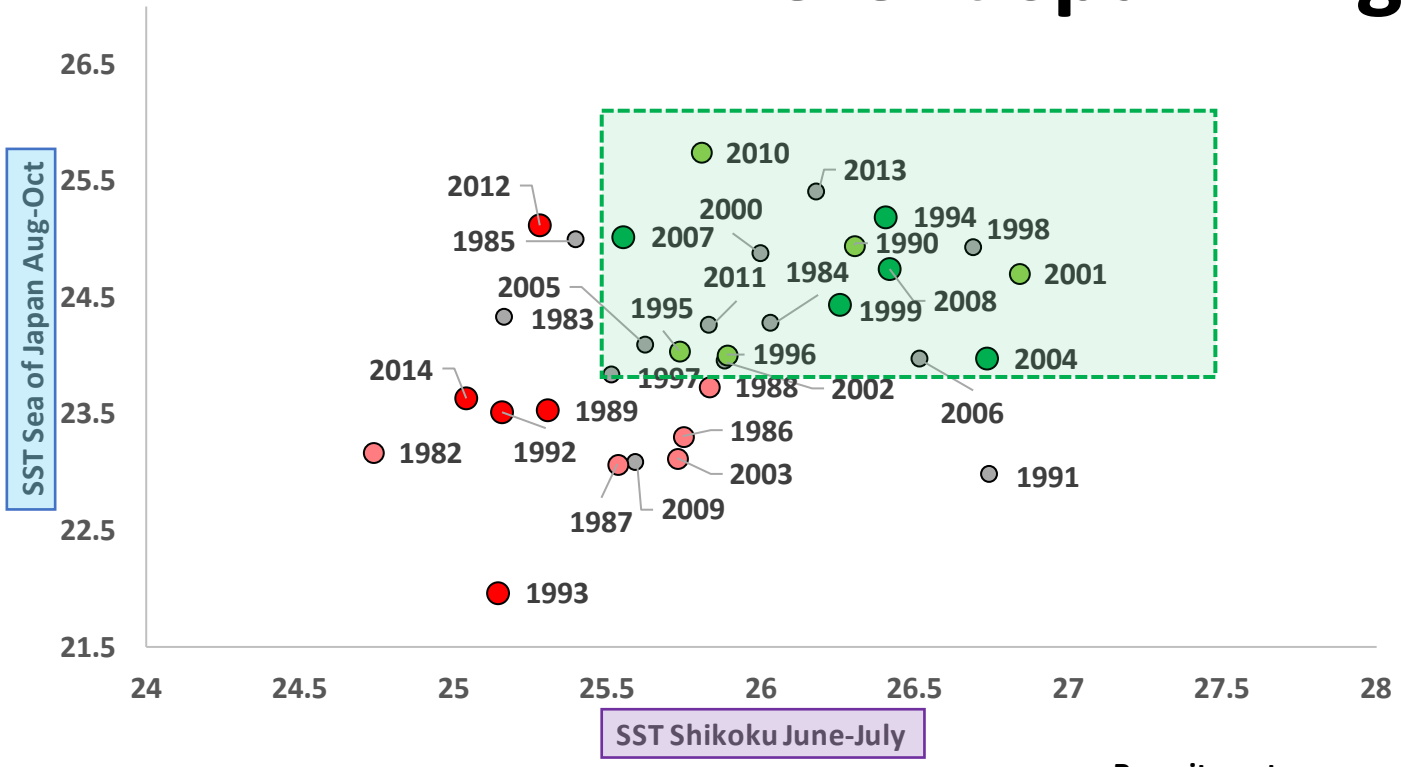
- Temporal and spatial autocorrelation in SST datasets is high
- However, three distinct areas of interest were defined
- Warmer temperatures in these areas, at these times, associated with stronger recruitment

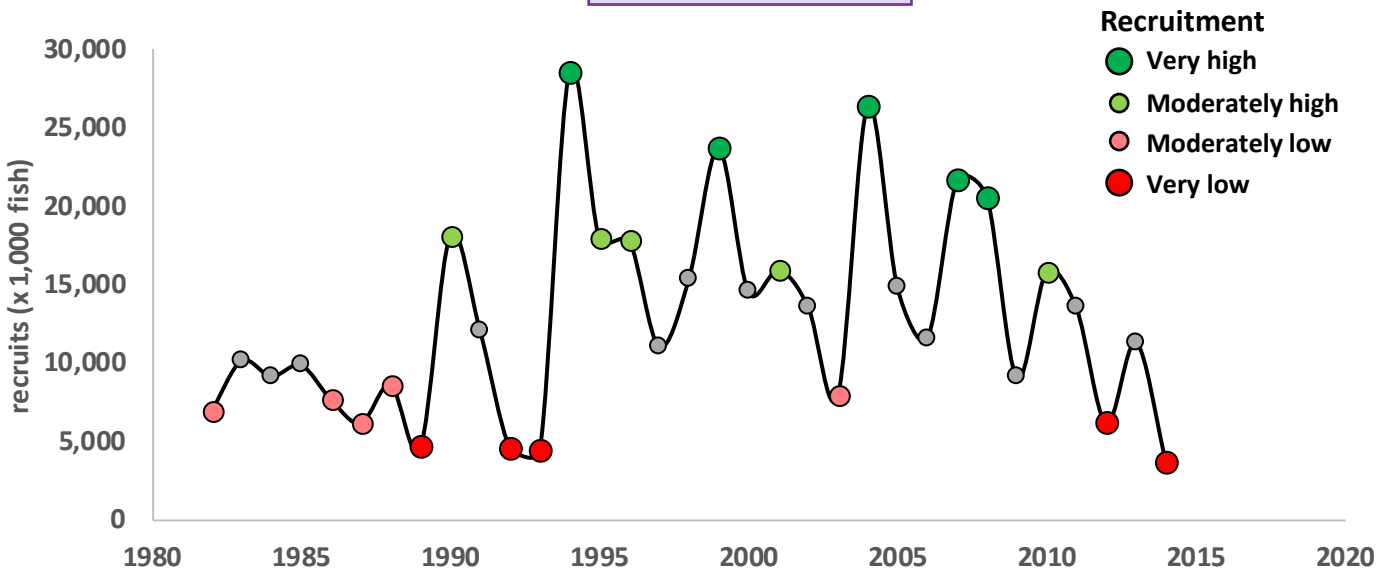


Areas of interest

- 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

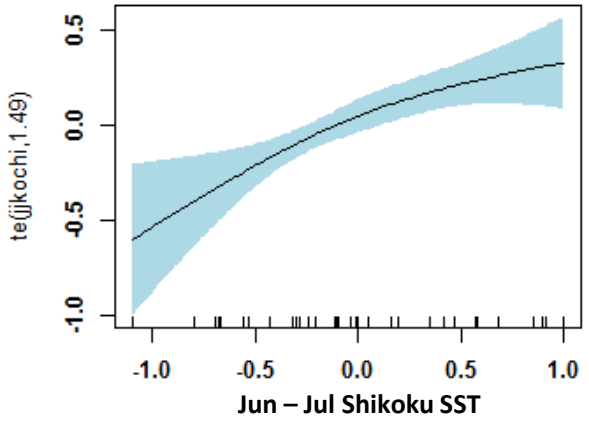


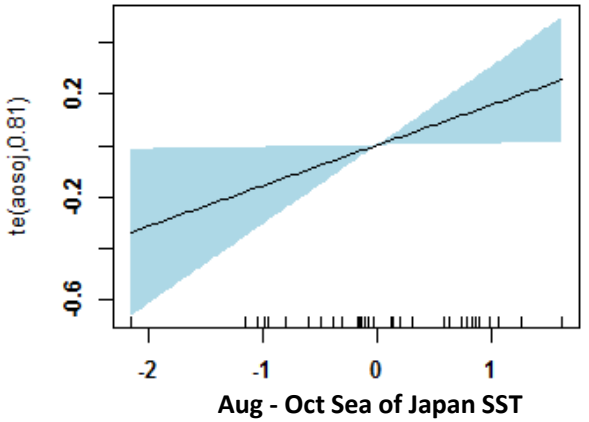


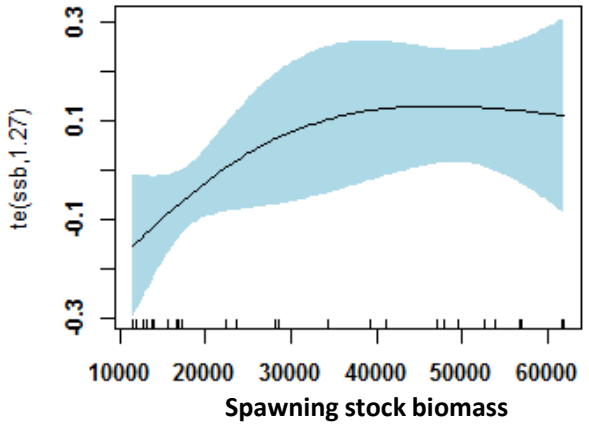
- Juveniles south of Shikoku in June – July likely from southern spawning ground
- Larvae and juveniles in the Sea of Japan August – October likely from northern spawning ground
- Highest recruitment years when temperatures were warm in both areas
- Lowest recruitment years when both were cooler

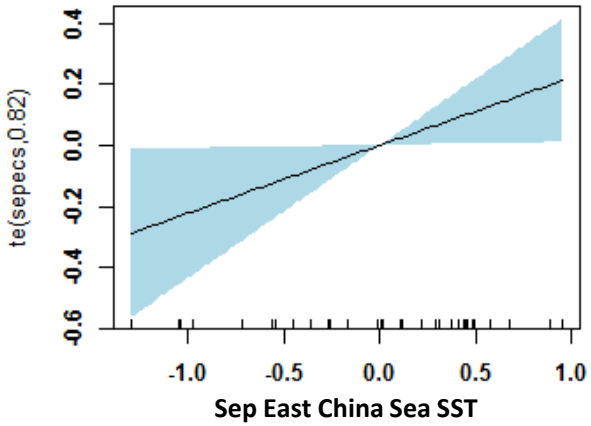
Generalized Additive Models

- 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



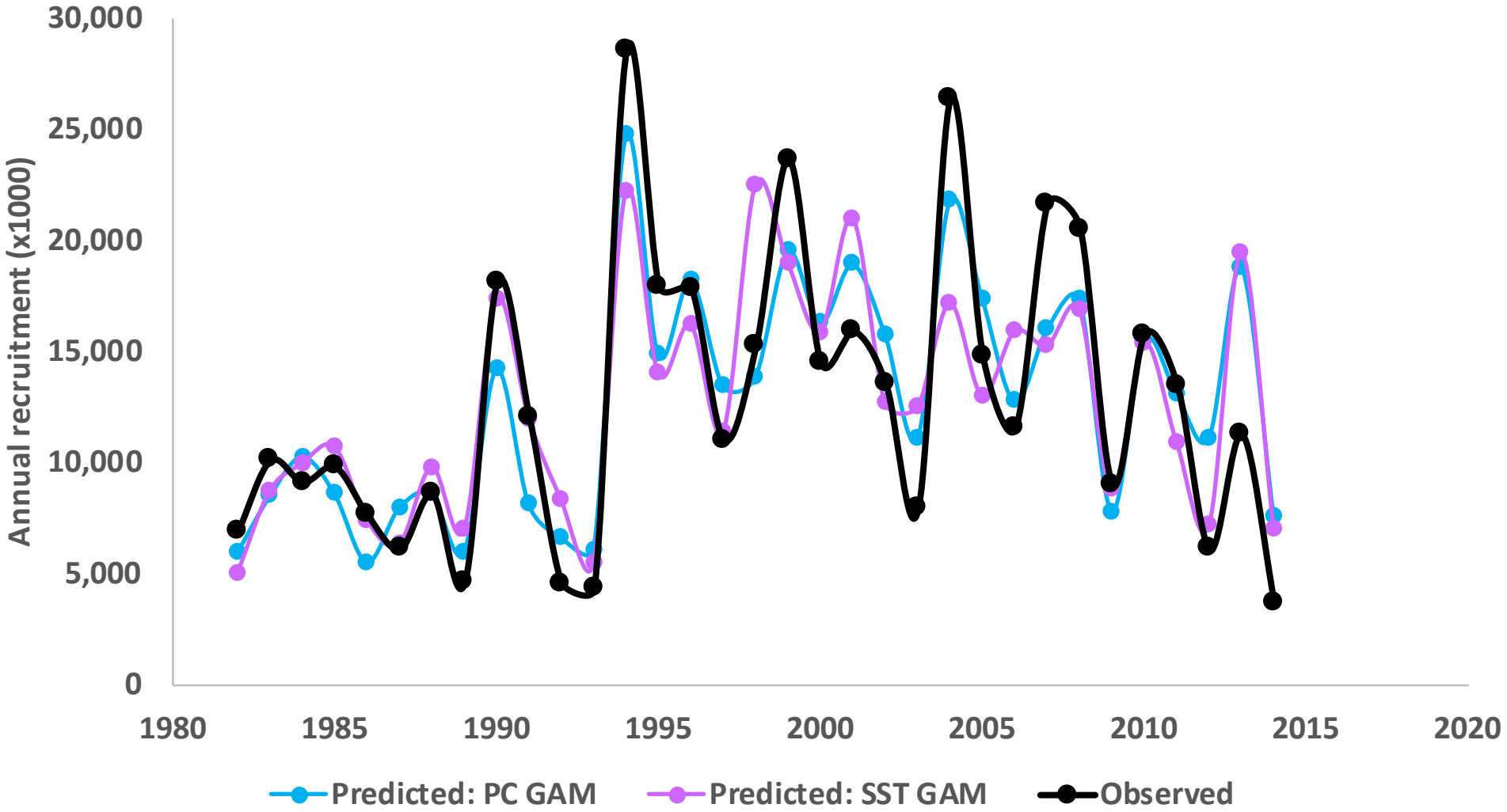






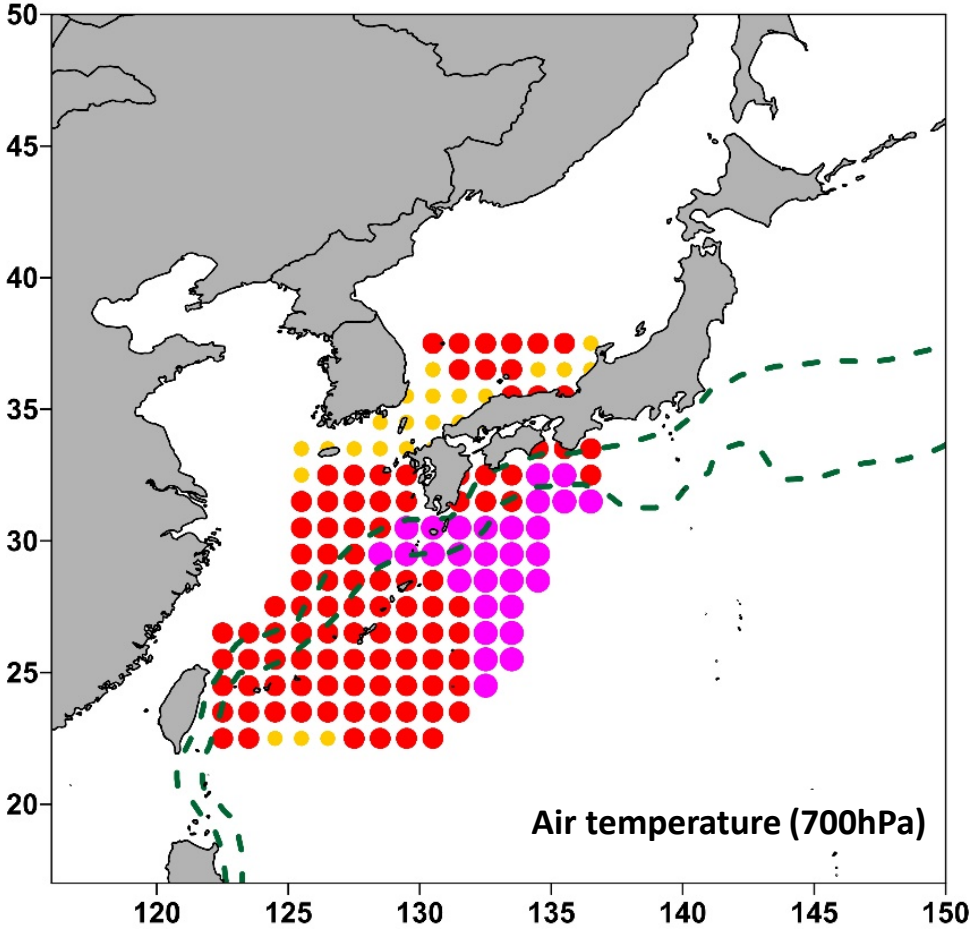
Generalized Additive Models

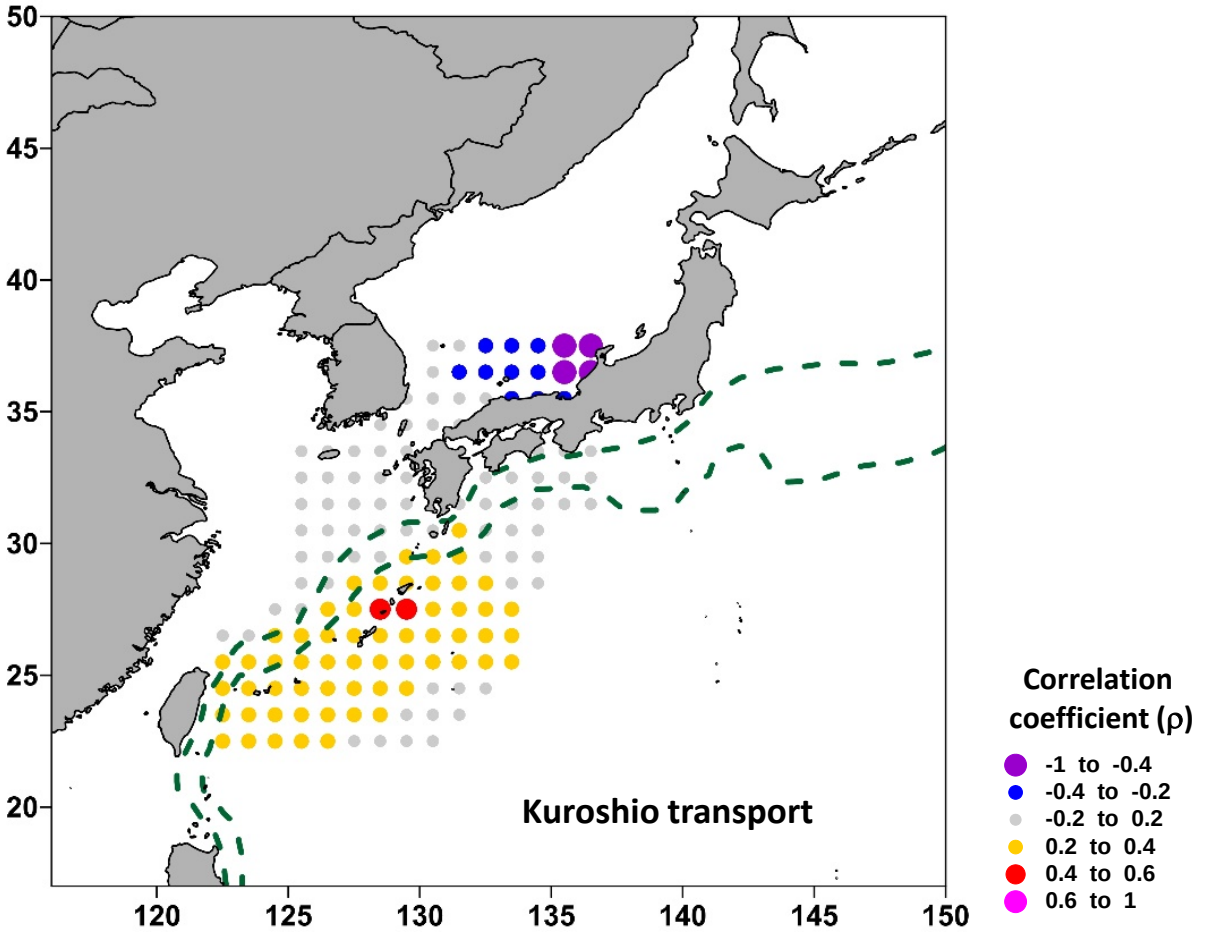
- Decadal-scale and interannual variability captured well
- But over-prediction in most recent 2 – 3 years



Causes of temperature variability

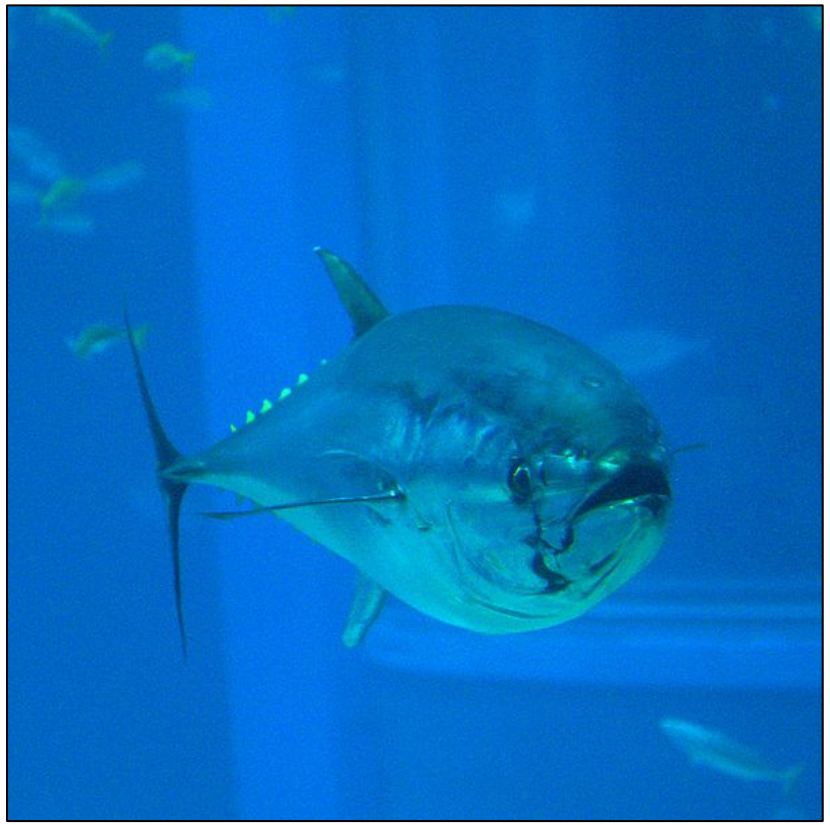
- What causes the SST variability which then impacts recruitment?
  - Sea of Japan can vary by >4°C in August
- Air temperature explains SST variability better than Kuroshio Current flow
  - Atmospheric influences important?
- ENSO, PDO, Arctic Oscillation and summer monsoon also impact the area

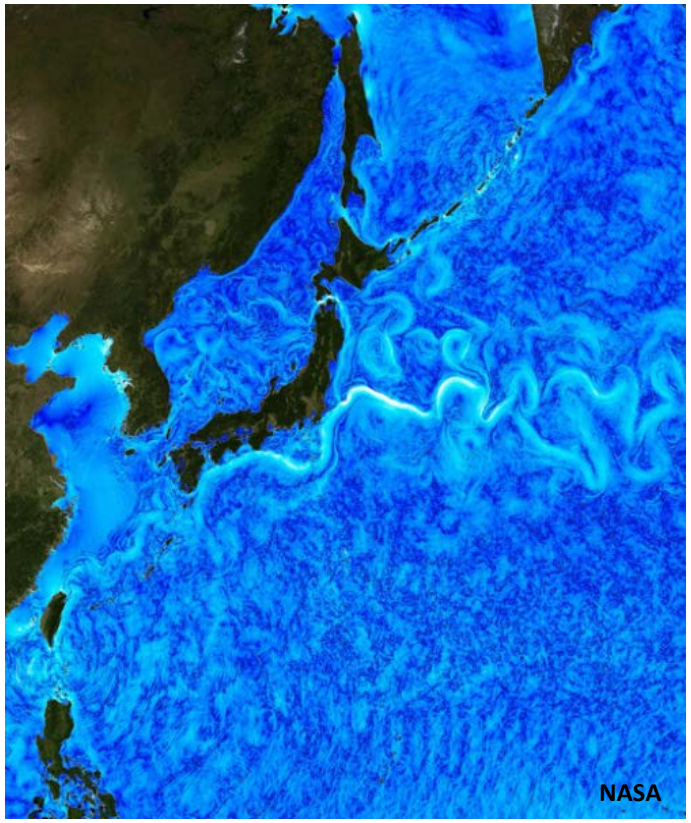


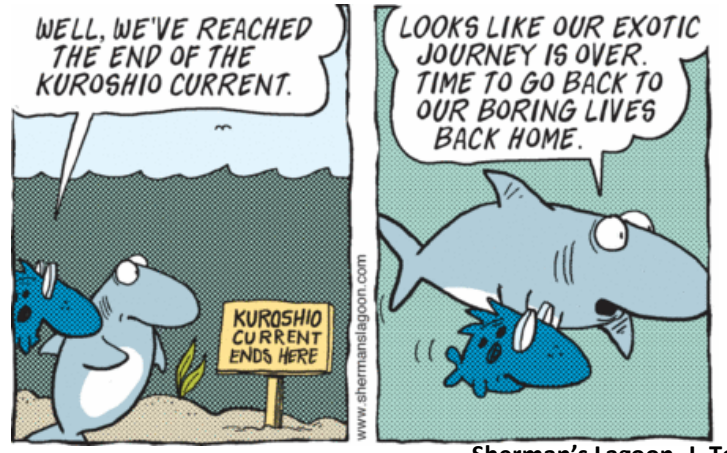


Conclusions

- 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…?







Sherman's Lagoon, J. Toomey