

Empirical Dynamic Modeling for Short-Lived Penaeids



Drs. Michelle Masi, Stephan B Munch, Adam Pollack & Cheng-Han Tsai

Photo credit: <https://thefishsite.com/articles/gulf-of-mexico-shrimp-threatened-by-low-oxygen-forecast>



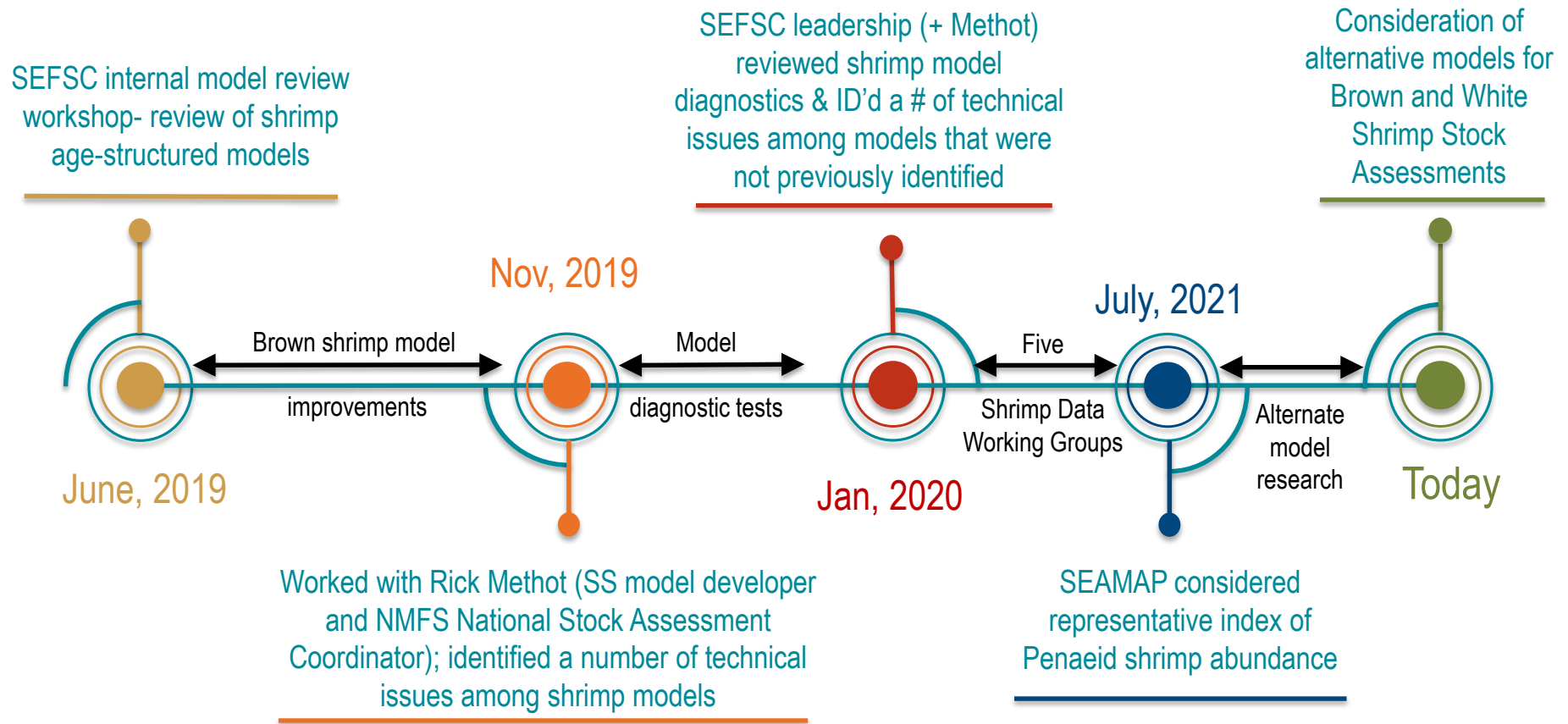
NOAA FISHERIES

In Today's Presentation



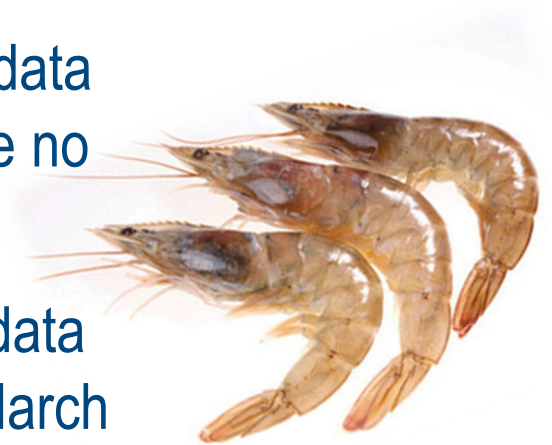
1. Overview of NMFS model review timeline, considerations for assessing Penaeids
2. Introduce a more responsive Penaeid modeling tool: Empirical dynamic modeling
3. Next steps in the Penaeid Research Track Process

Shrimp Research/Assessment Timeline



Considerations for Assessing Penaeids

- ❖ Penaeids are considered **annual crops** (high natural mortality \therefore mostly dead by ~1 year)
- ❖ We lack age-structured data; limited biology data (current based on studies from the 70s); have no recruitment or environmental signal
- ❖ NMFS receives 'last year's' fishery landings data (from state Trip Tickets) ~ mid-year (e.g. in March 2020, I reported on the 2018 stock status). These data lags mean NMFS can't provide timely stock status information for these annual crops



Current Gulf Shrimp Reporting Requirements

Shrimp AM 15

- Benchmarks were established using 2012 stock synthesis (SS) models
- If F_{msy} is exceeded for 2 consecutive years, action is considered by the Council
 - Given fishery data lags (~1.5 years), individuals are largely gone from the system when presented annually; add 2 more years of monitoring overfishing, now you are ~4 years out from taking action (i.e., not very responsive)

Shrimp AM 17B

- Aggregate maximum sustainable yield (MSY) = all managed shrimp species, & only uses offshore landings; species-specific MSY is inshore + offshore. Aggregate MSY is not comparable to the species-specific estimates coming from SS
- Aggregate MSY is used to estimate aggregate optimal yield (OY) - using a Schaeffer production model; totally separate from species-specific estimates in Shrimp AM 15

Shrimp Assessment Modeling Takeaways

- Preliminary findings of the research track process (shrimp data working groups) show data limitations make age-structured models like SS untenable (e.g. lack of recruitment information or environmental drivers)
- In 2021, the SEAMAP WG found this index to be representative of Penaeid abundance
- Considering the large # of technical concerns among the historic Penaeid assessment models, derived F_{msy} and B_{msy} values were inaccurate
- **So, do we really need a data rich SS model to provide relative SDC?**

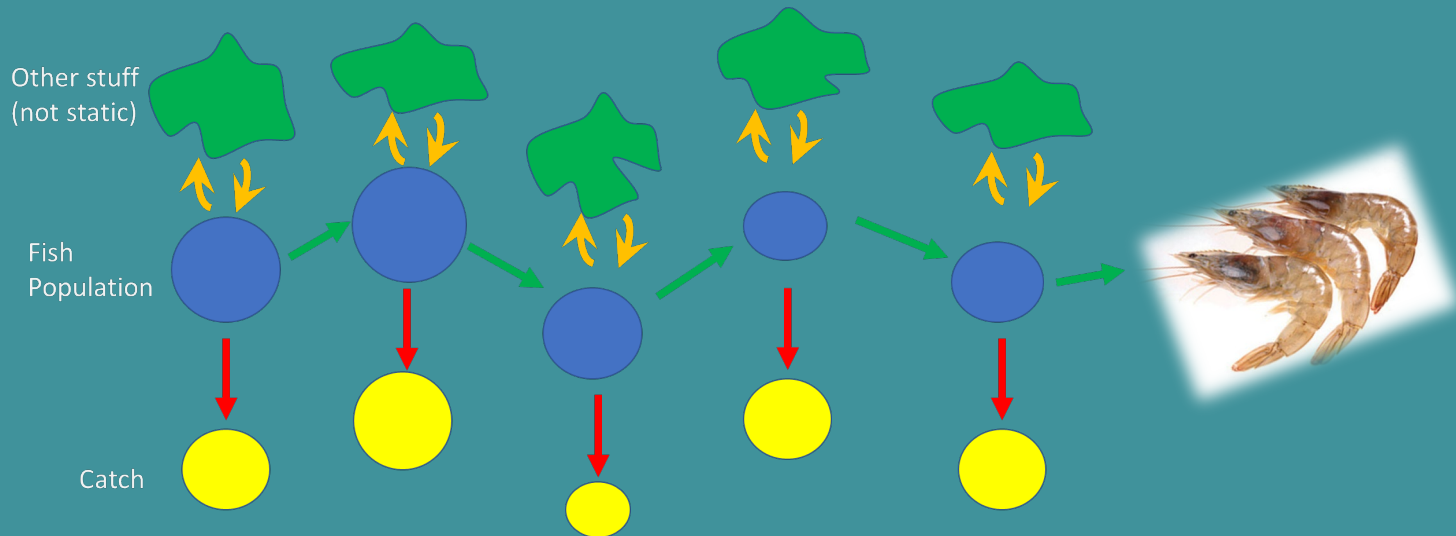
Model
Complexity &
Data Limitations



Derived Advice &
Responsiveness

Introducing a More Responsive Tool for Assessing Short-lived Penaeids (EDM)

- ❖ Empirical dynamic modeling (EDM) uses time delays of the observed variables (e.g. SEAMAP trawl survey data) to implicitly represent the nonlinear dynamics of the unobserved drivers of shrimp abundance (e.g. food or habitat availability, temperature tolerance).



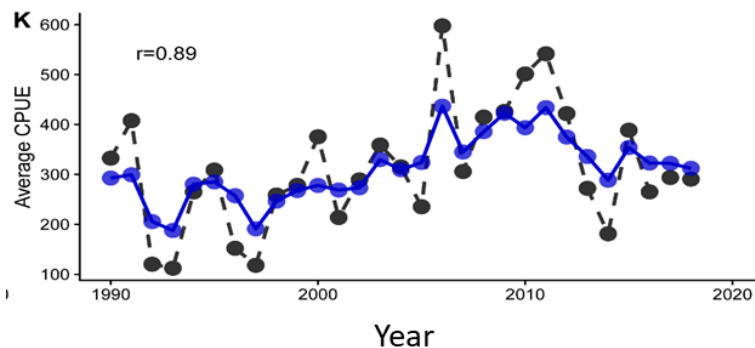
Why is EDM more responsive?

- ❖ EDM only requires representative index data
 - EDM can be updated quickly (just SEAMAP)
 - Historic SS models required annual fishery landings & fishery CPUE (& fixed biology inputs)
 - SEAMAP trawls annually and data is available internally; therefore, available to update empirical dynamic models by the end of the CURRENT year
 - EDM outputs can be ready by spring, providing more timely information for management advice (i.e., more responsive)
- ❖ EDM predictions respond (implicitly) to ecosystem drivers of shrimp abundance
 - Annual Penaeid shrimp abundance is highly variable, largely due to these ecosystem drivers

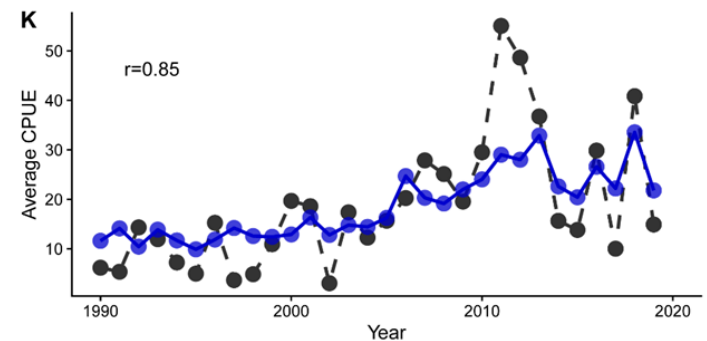
EDM of Brown and White Shrimp Abundance

- EDMs for Brown and White Shrimp predict abundance in each shrimp statistical zone
- Considering a suite of model variations, we found only temperature and time lags of abundance improved the model fit (i.e., increased the variance explained)
- Abundance across stat zones is averaged, to derive Gulf wide model predictions
- This year's EDM model prediction based on data from previous SEAMAP data years

Brown Shrimp EDM abundance predictions



White Shrimp EDM abundance predictions



Next Steps

- In 2022, use EDMs for Brown and White Shrimp to estimate annual stock status ($B_{\text{current}}/B_{\text{msy}}$)
- In 2023, rigorous peer-review of EDMs in SEDAR Research Track (consideration of EDM as an alternative modeling type)
- Assess potential to use EDM to forecast 1 year ahead – replace Galveston's annual brown shrimp forecast

Simulation example

