Can temperature-dependent egg development affect connectivity between spawning areas and nursery grounds for arrowtooth flounder (*Atheresthes stomias*) in the Gulf of Alaska?

William Stockhausen
william.stockhausen@noaa.gov
Alaska Fisheries Science Center
NMFS/NOAA
Seattle, WA 98115-6349

Deborah Blood
debbie.blood@noaa.gov
Alaska Fisheries Science Center
NMFS/NOAA
Seattle, WA 98115-6349

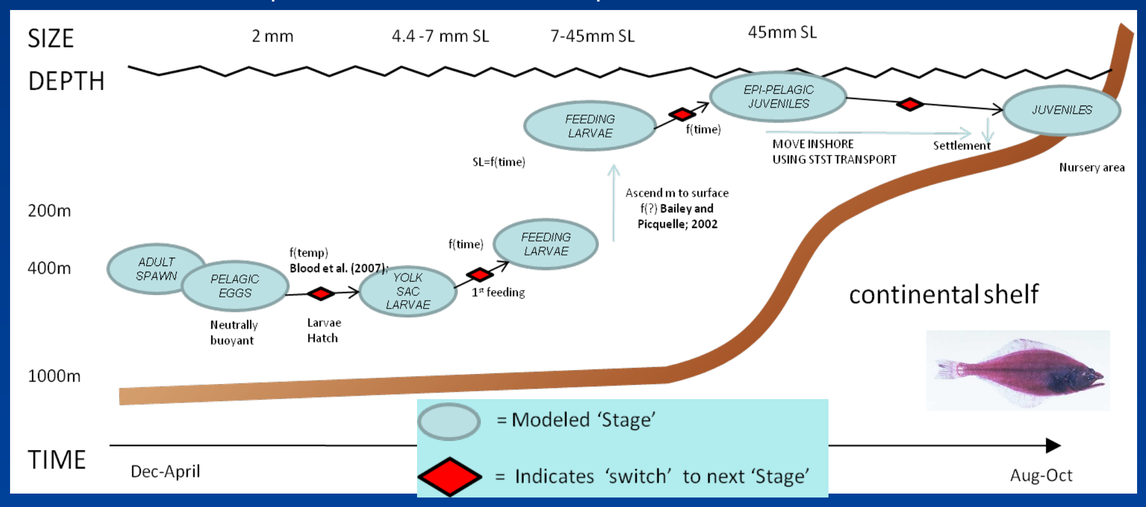
Kenneth Coyle
coyle@ims.alaska.edu
Institute of Marine Science
University of Alaska Fairbanks
Fairbanks , AK , 99775-7340

Introduction

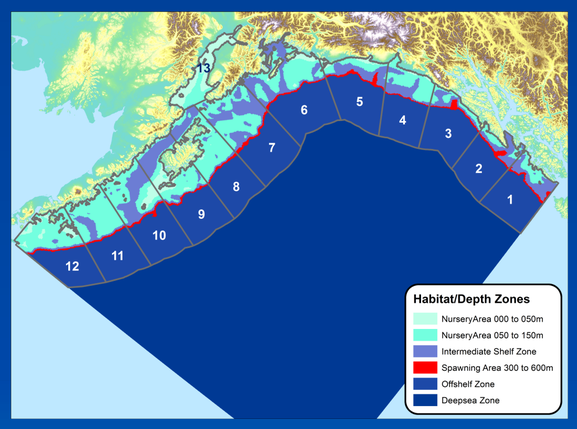
As part of the GOA-IERP Modeling Component, we hypothesize that fish recruitment is principally determined by processes acting on early life stages between offshore spawning sites and the end of the young of year stage, the "gauntlet". Among these processes, temperature-dependent egg development and/or larval growth rates may be important sources of variability. Here, we examined the potential importance of interannual and spatial variation in temperature experienced by arrowtooth flounder eggs on connectivity between the spawning areas and nursery grounds by developing a temperature-dependent egg development model, incorporating it within a coupled IBM/ biophysical model (DisMELS), and performing a set of numerical experiments.

Approach

We ran the arrowtooth flounder IBM (below) for 16 years (1996-2011) using daily output from the CGOA ROMS model to provide 3D current and temperature fields..

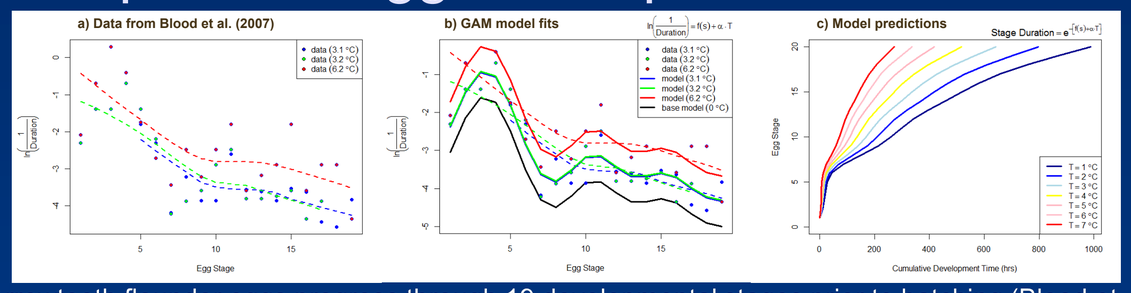


Each year, 1000's of simulated stage-1 eggs were released at 500 m depth along the shelf edge in 12 potential spawning areas (red zone on map at right) at bi-weekly intervals during January-March. Individuals were tracked in space for 200 days, and those that successfully settled in inshore nursery grounds prior to the end of each year were counted as "successful" recruits. Individuals that exited the model grid or failed to find suitable nursery habitat within the period during which they were competent to settle were regarded as "unsuccessful. For each model year, the fraction of "successful" individuals from each of the 12 potential spawning areas was quantified, as was the connectivity between the spawning areas and 26 potential nursery areas (12 alongshore zones + Prince William Sound x 2 depth zones).



To examine the potential importance of temperature-dependent egg development rates on connectivity between offshore spawning and inshore nursery grounds, we repeated the above numerical experiment above for 4 different temperature scenarios: 3 constant-temperature scenarios (1°C, 4.25°C, 7.5°C), and an *in situ* temperature scenario. In the constant temperature scenarios, all eggs experienced identical temperature regimes during development. For the *in situ* scenario, individual eggs developed according to the local (ROMS model) temperature, which varied temporally and spatially.

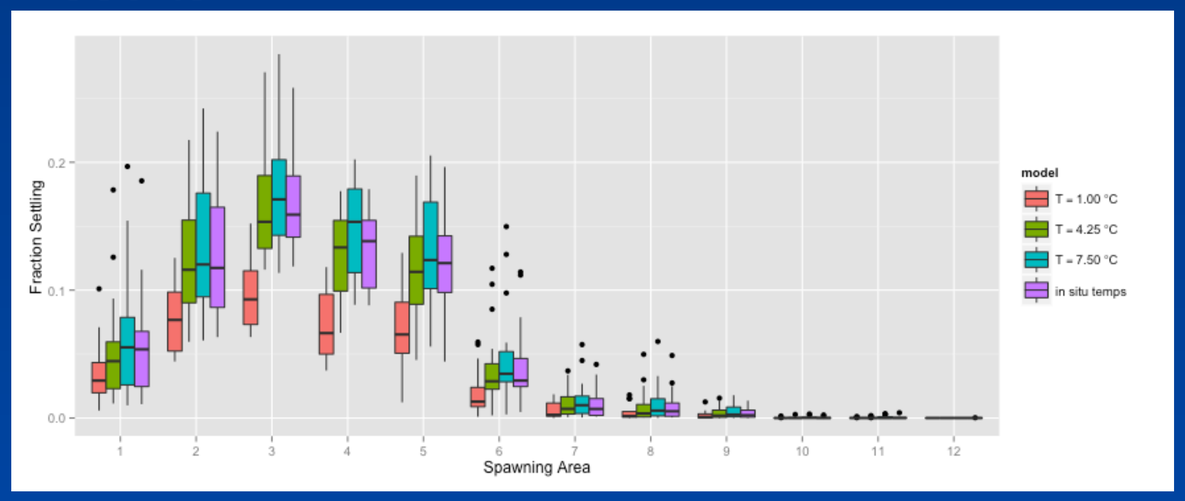
T-dependent egg development model



Arrowtooth flounder eggs progress through 19 developmental stages prior to hatching (Blood et al., 2007). The plots above illustrate:

a) In-scale mean egg stage durations, based on lab rearing experiments at different temperatures by Blood et al. (2007).Dashed lines are lowess fits to show general trends.
b) GAM fits to development rates (ln(1/duration)) assuming linear temperature dependence ($\alpha \cdot T$) across stage-specific base rates (f(s)).
c) Predicted cumulative durations (from egg stage 1) at various constant temperatures.

Results



The fraction of individuals spawned that successfully settled in juvenile nursery areas was consistently lower in the 1.0 °C constant temperature treatment than in the other treatments, all of which yielded similar results. The dependence on spawning area, however, was fairly similar across all treatments: spawning in areas 2-5 resulted in the highest fractions settling.

Conclusions

Higher temperatures (faster egg development rates) led to higher fractions of individuals recruiting to nursery grounds from individual spawning areas. With faster egg development rates, individuals were able to reach the life stage capable of settling in the nursery grounds in a shorter amount of time and were thus less likely to be transported westward out of the system by the Alaskan Stream. and Alaskan Coastal Current.

Acknowledgments

This study represents a contribution to NPRB's GOA IERP Modeling Component.

NOAA FISHERIES

UNIVERSITY OF ALASKA FAIRBANKS

The recommendations and general content presented in this poster do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

References

Blood, D. M., A. C. Matarese, And M. S. Busby. 2007. Spawning, egg development, and early life history dynamics of arrowtooth flounder (*Atheresthes stomias*) in the Gulf of Alaska. U.S. Dep. Commer., NOAA Prof. Pap. NMFS 7, 28 p.