



PRESENTER  
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## Problem

We are **required** by our national mandates to describe and map essential fish **habitat** (EFH) for our managed **fish stocks**. However, very **little** information exists to determine EFH for the **early life stages** of most stocks. This is due to variable sampling design, gear type, mesh size, timing, and survey objectives (Laman et al. 2022, NOAA Tech. Memo. NMFS-AFSC-459).

## Objective

We demonstrate a **novel** approach to raise the level of essential fish habitat information by using **biophysical** life-stage integrated individual based models (IBMs) that are post-processed to identify the spatial domain of early life stage **survivor trajectories**. We use two case studies of Pacific cod and sablefish in the Gulf of Alaska.

## Method

### Conceptual Model

- Multiple stages
- Time steps and rates
- Temperature ranges

### Biophysical Model

- Regional Ocean Modeling
- Nutrient Phytoplankton Zooplankton Model

### Essential Fish Habitat

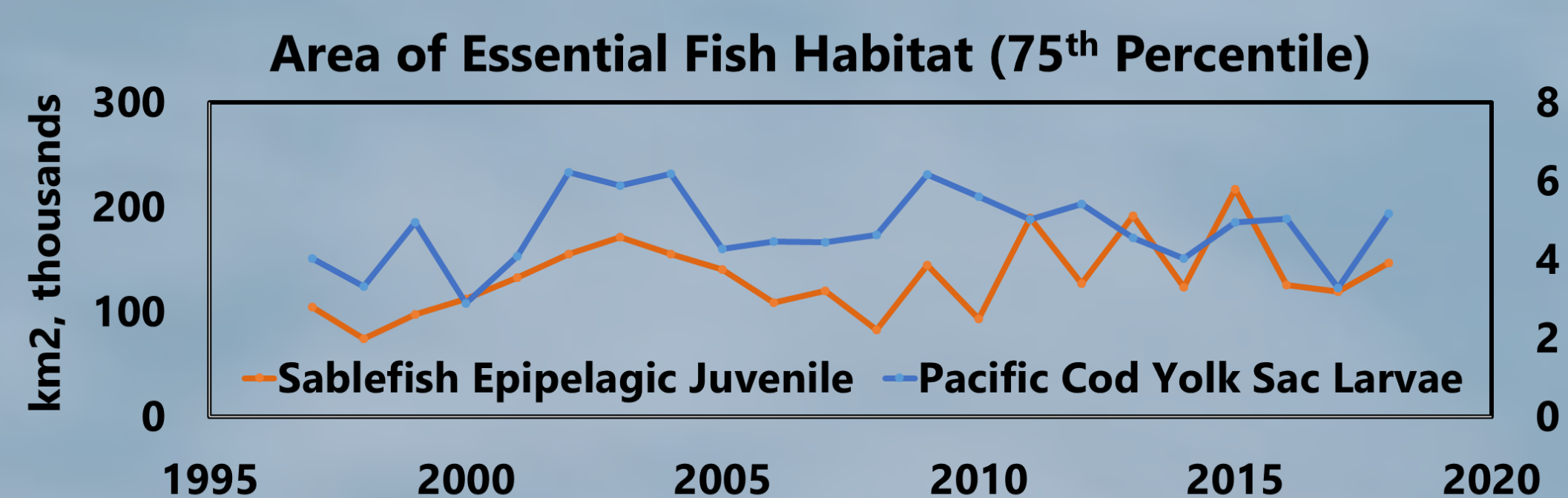
- Mean & annual percentiles
- EFH Level 2 and 3 maps
- Metrics for time series

### Individual Based Model

- Spawning & nursery sites
- Trajectory analysis
- Abundance, growth rate

## Management

Indicators can be derived from the early life EFH maps as seen below:



These indicators can be compared to stock assessment output (e.g., recruitment, growth) and used to inform management decisions.

Pirtle et al., 2020, EFH Discussion Paper, North Pacific Fishery Management Council (NPFMC), see Chapter 4, pg. 136.



Pirtle et al., 2023, Synthesis Report, NPFMC, C4 EFH, see Introduction, pg. 20.



# Early life stage essential fish habitat can be estimated through individual based models.



## Pacific Cod

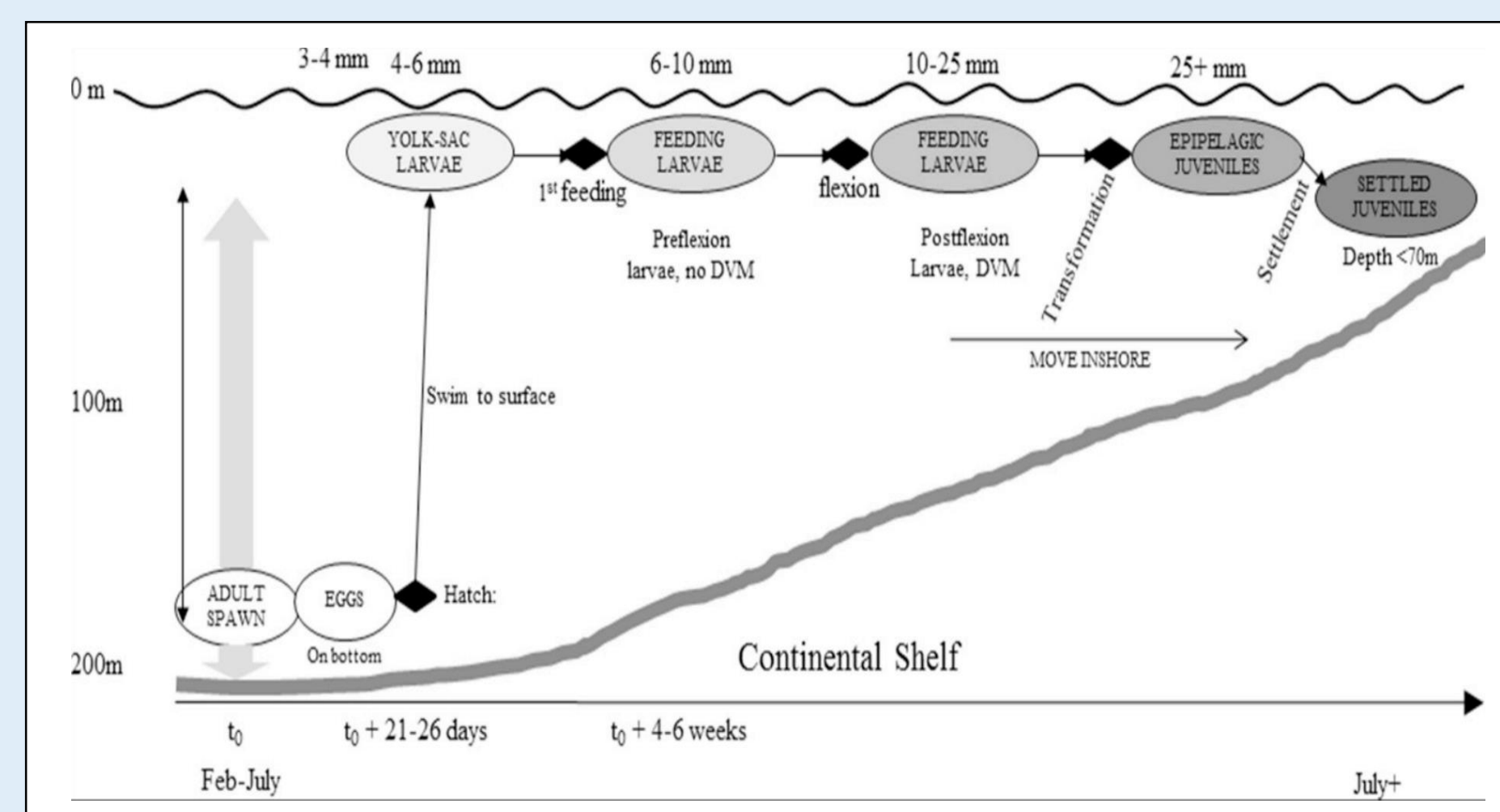


Figure 1: Conceptual model for Pacific cod early life history reproduced from Hinkley et al., 2019 (<https://doi.org/10.1016/j.dsr2.2019.05.007>)

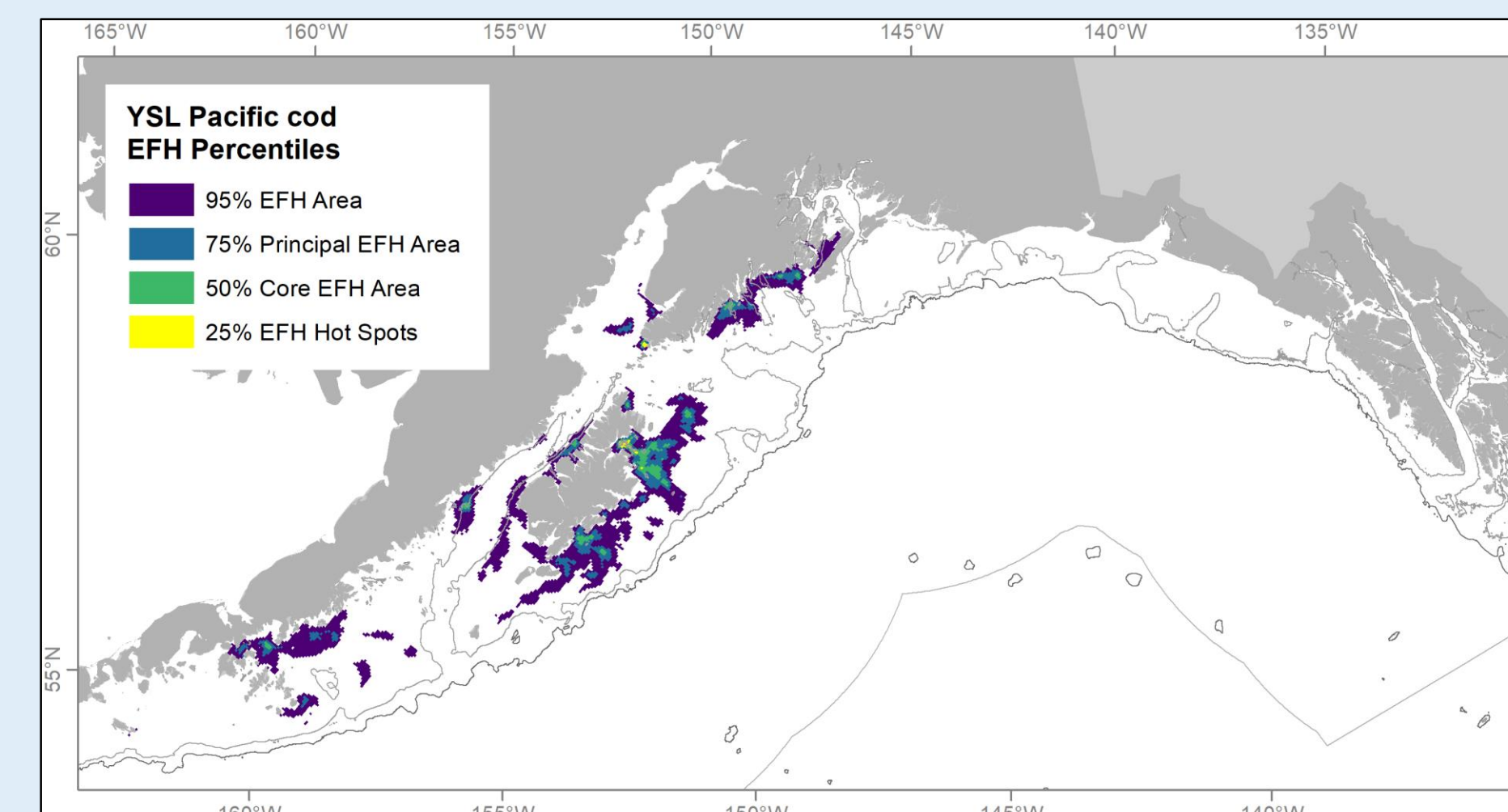


Figure 2: Abundance (EFH level 2) percentiles for yolk sac larval (YSL) stage of Pacific cod from observed spawning sites in the Gulf of Alaska

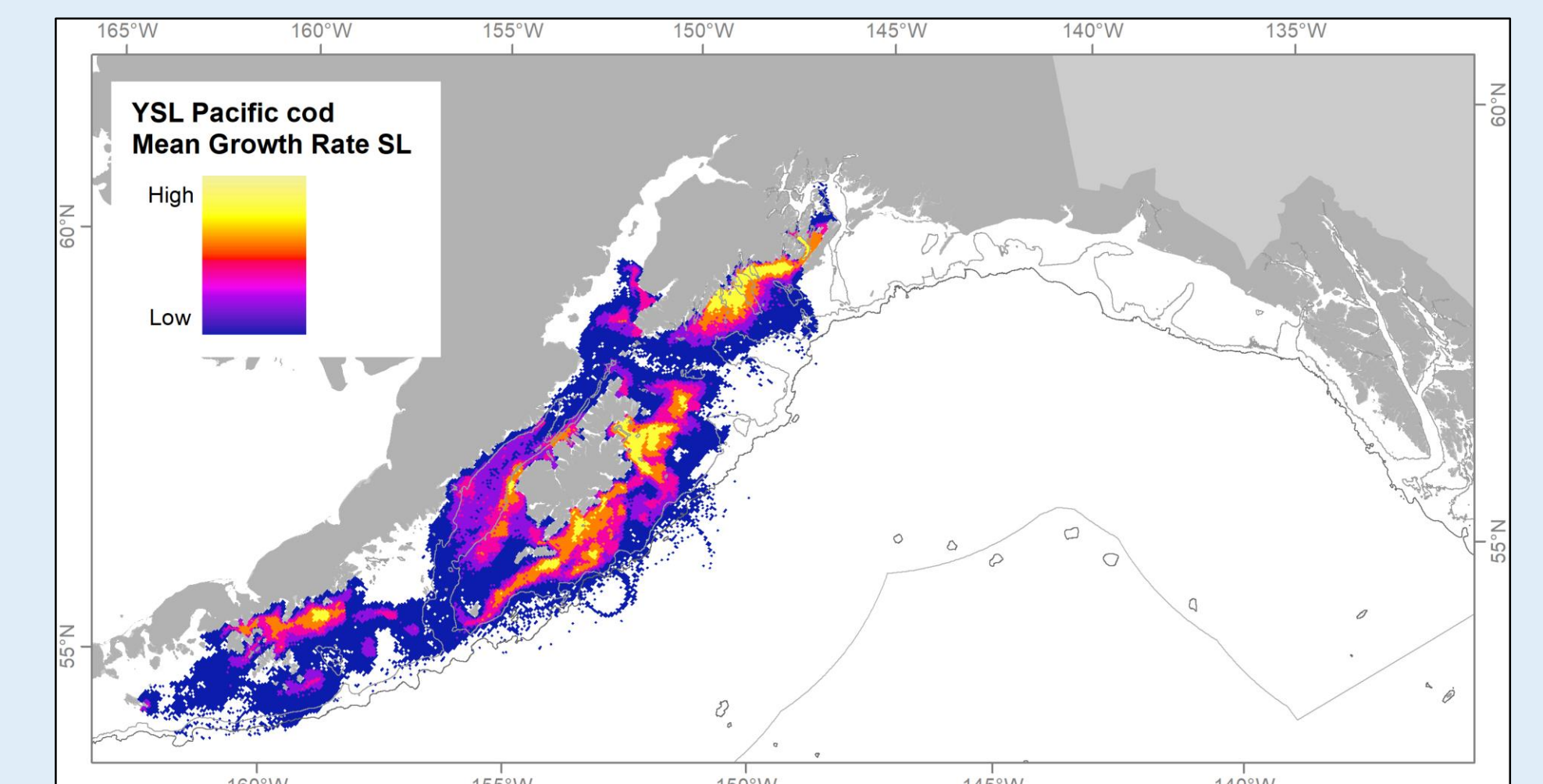


Figure 3: Average growth rate (EFH level 3) for yolk sac larval (YSL) stage of Pacific cod from observed spawning sites in the Gulf of Alaska

## Sablefish

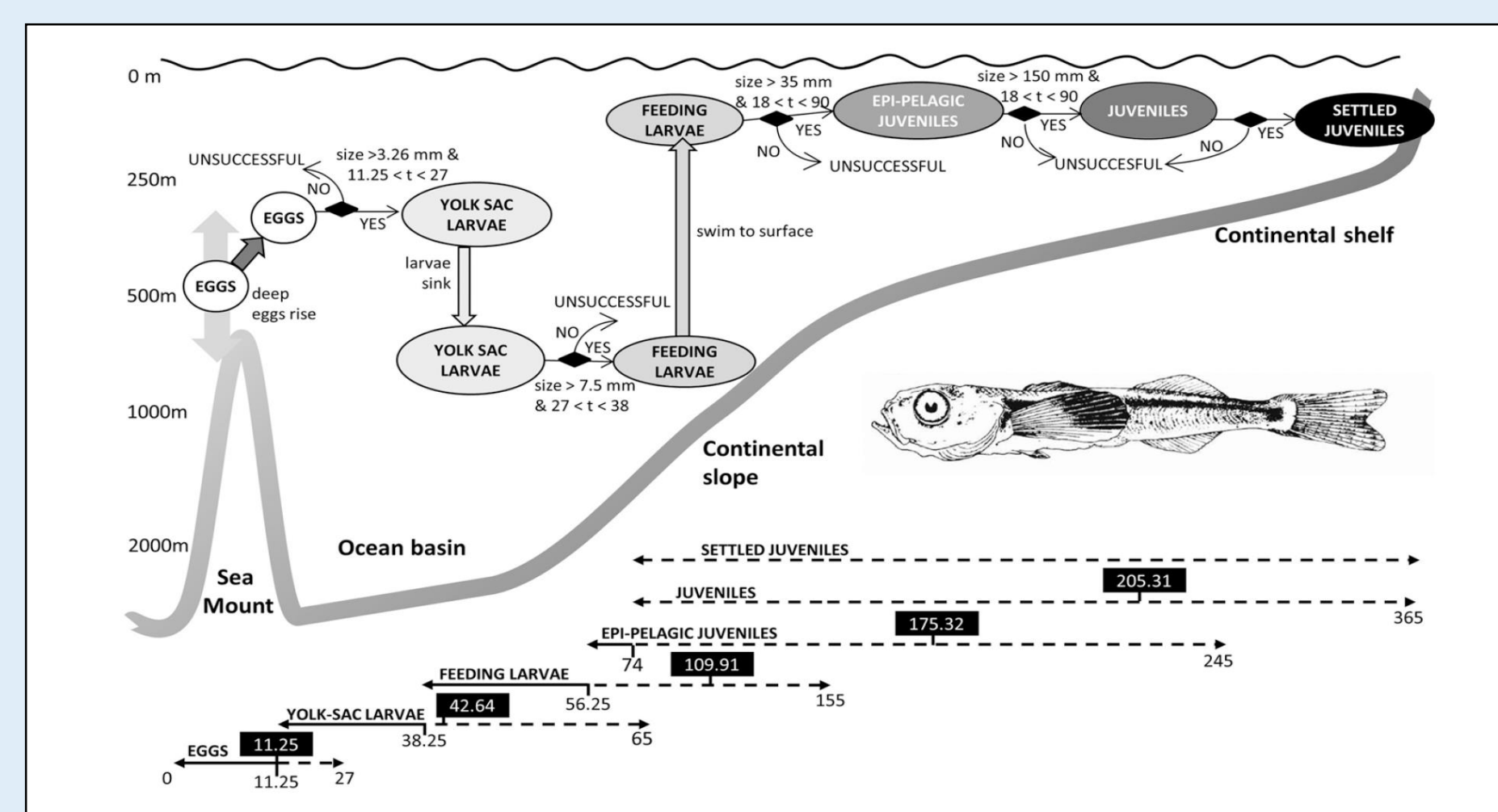


Figure 4: Conceptual model for sablefish early life history reproduced from Gibson et al., 2023 (<https://doi.org/10.1016/j.fishres.2023.106625>)

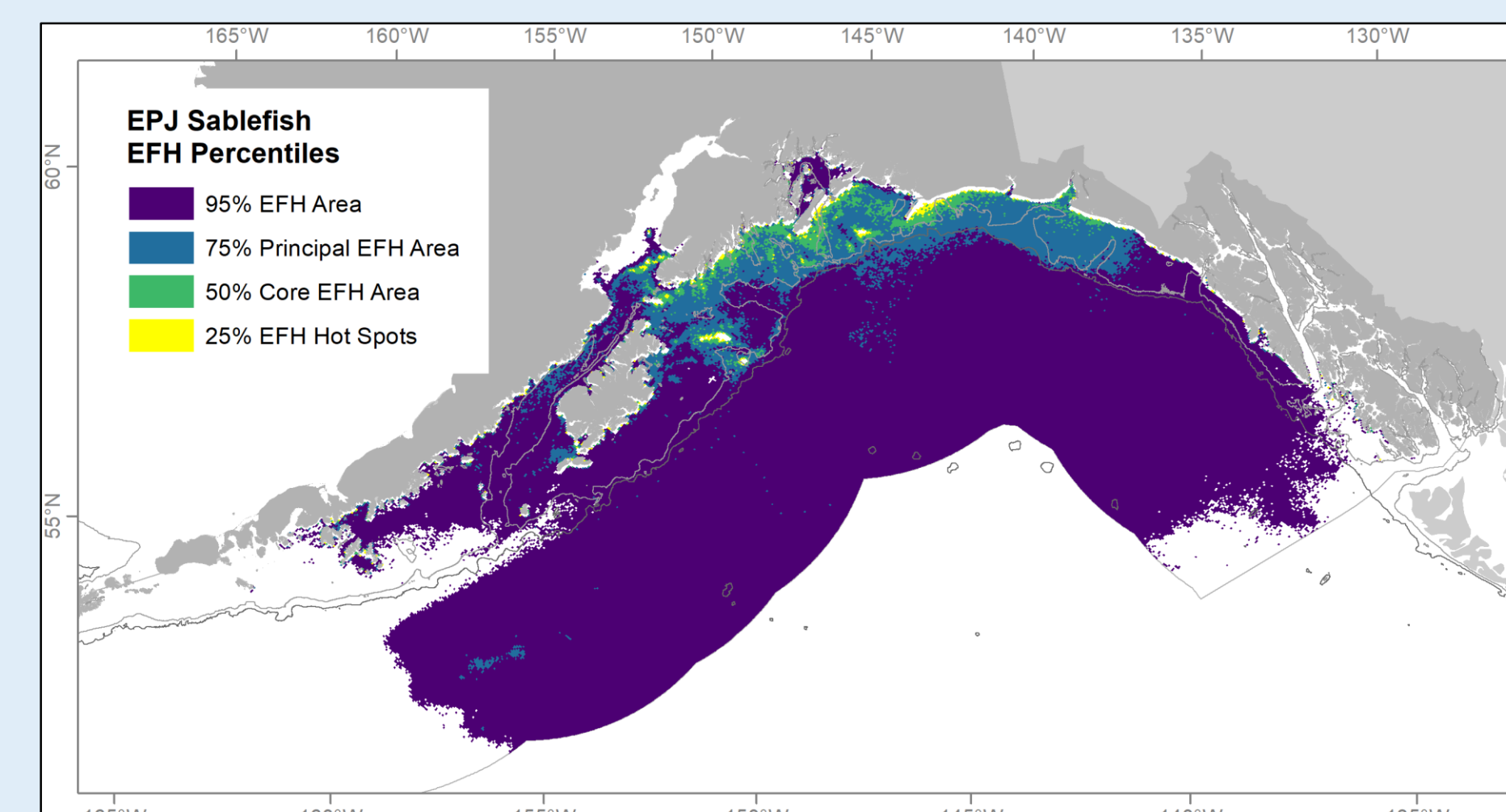


Figure 5: Abundance (EFH level 2) percentiles for epipelagic juvenile (EPJ) stage of sablefish from uniformly spaced spawning sites across the Gulf of Alaska

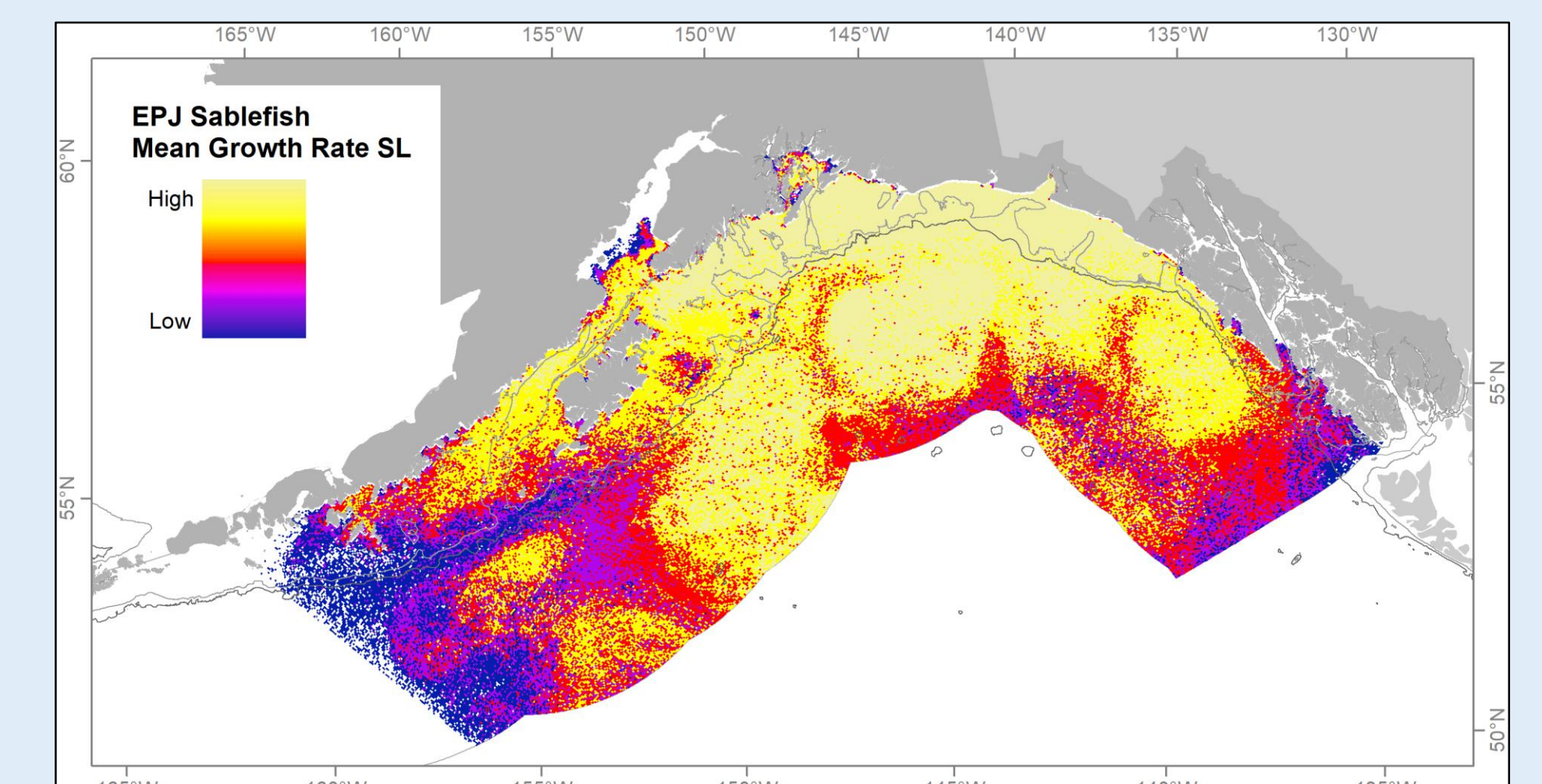


Figure 6: Average growth rate (EFH level 3) for epipelagic juvenile (EPJ) stage of sablefish from uniformly spaced spawning sites across the Gulf of Alaska

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