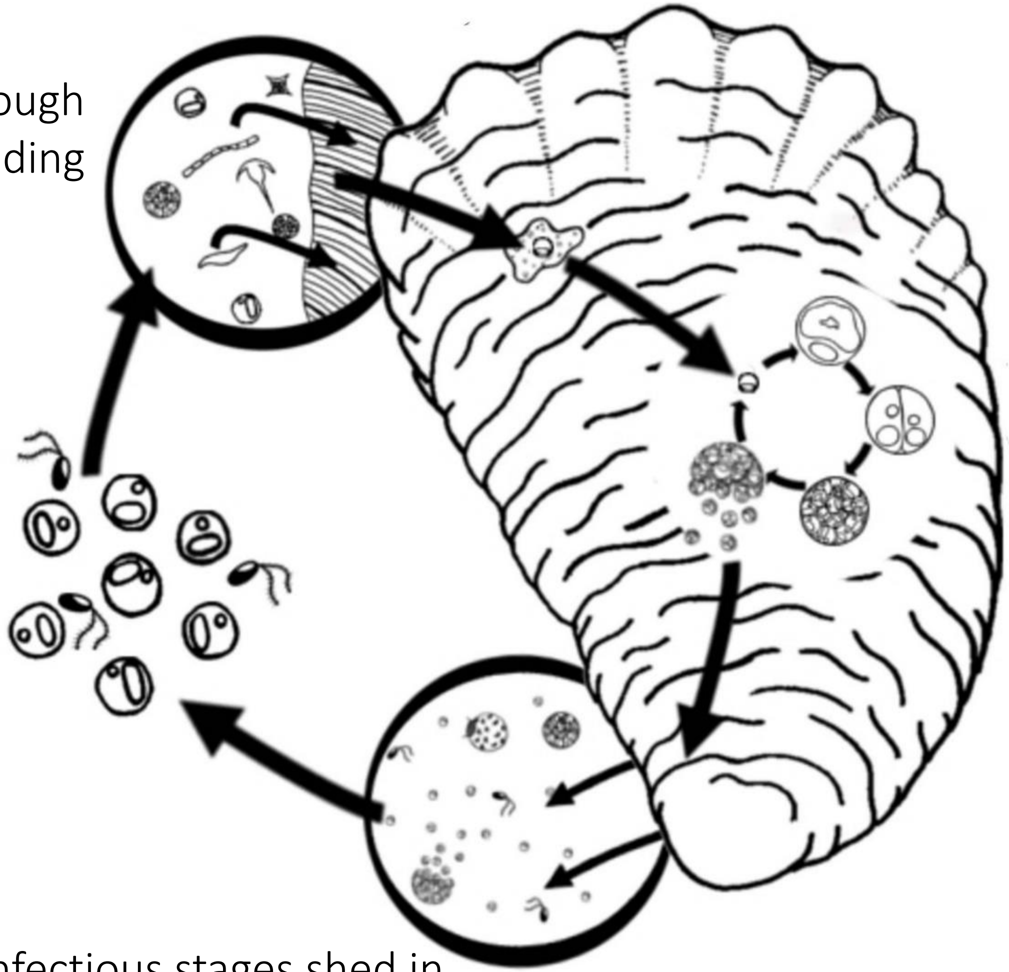
Pathogen dispersal in coastal marine ecosystems

TAL BEN-HORIN, JENNA PEARSON, AND AAKASH SANE

BAYLOR FOX-KEMPER, SUSANNE MENDEN-DEUER, ERIC SCHNEIDER, ROXANNE SMOLOWITZ, AND MARTA GOMEZ-CHIARRI

Perkinsus marinus life cycle

1. Transmission through suspension feeding



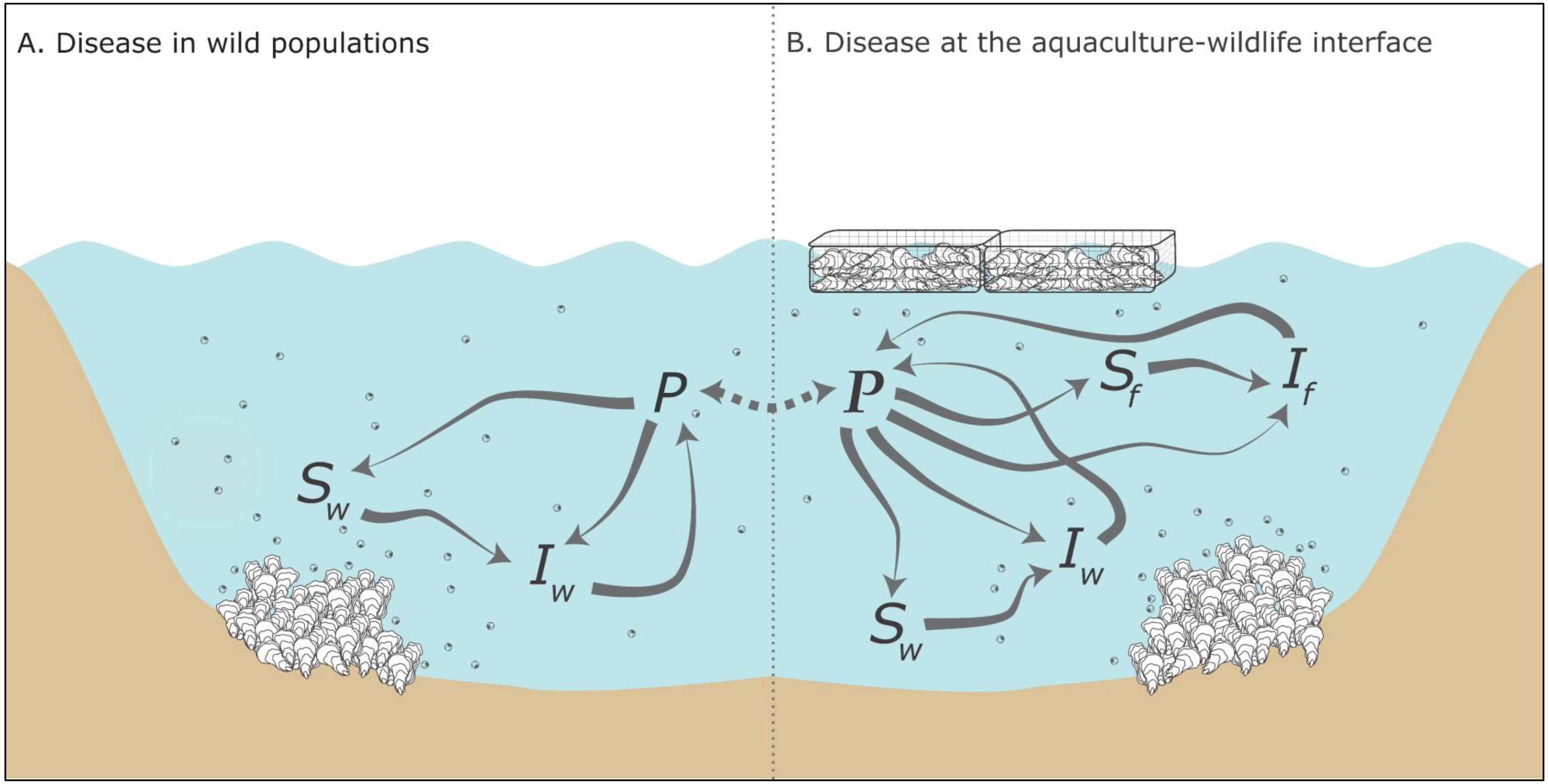
2. Schizogony within hosts

3. Infectious stages shed in feces and moribund hosts

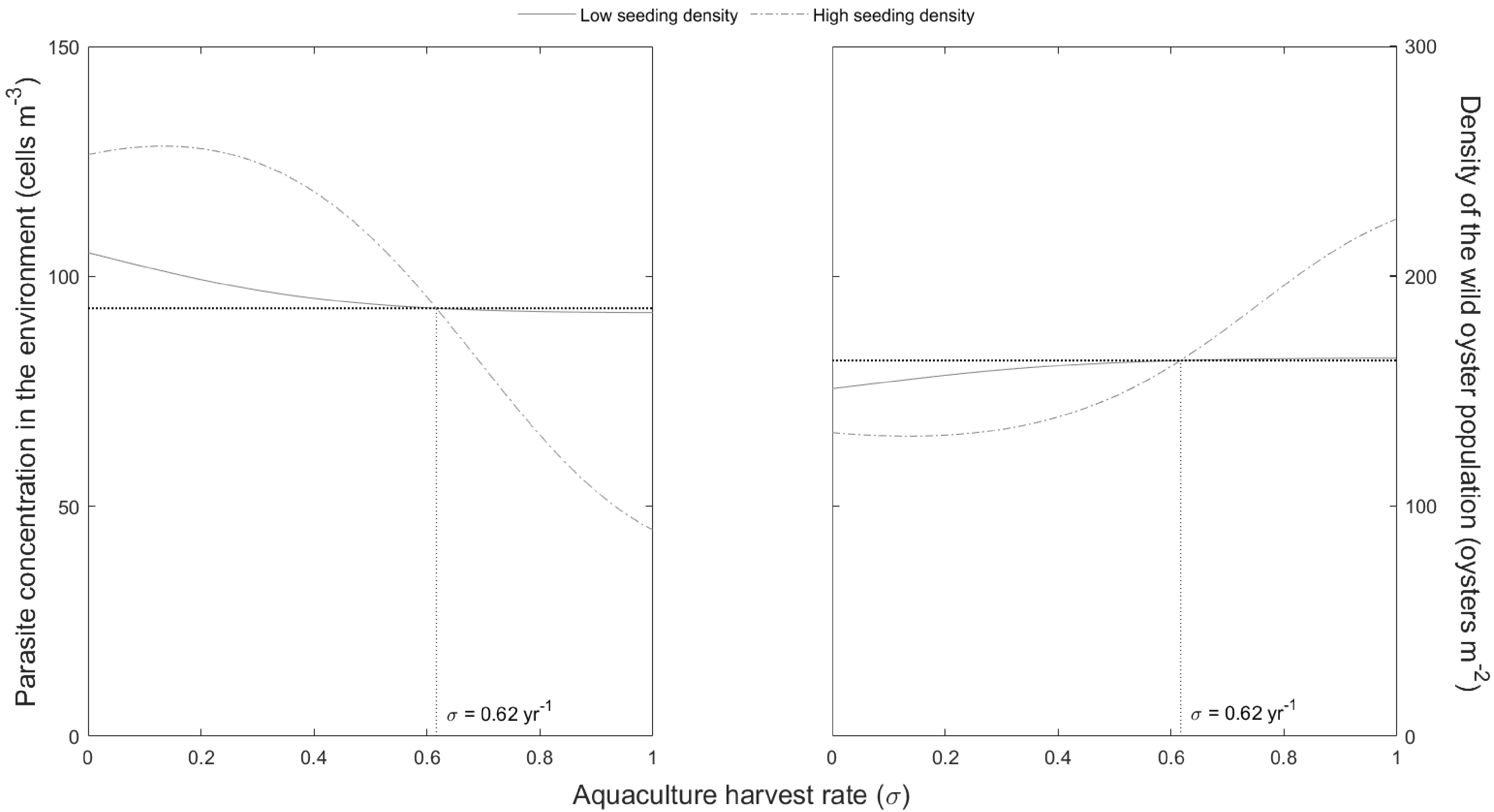
4. Environmental stages are well adapted for survival

Ben-Horin et al (2015) *J Invert Pathol*

Pathogen transmission cycles in real ecosystems

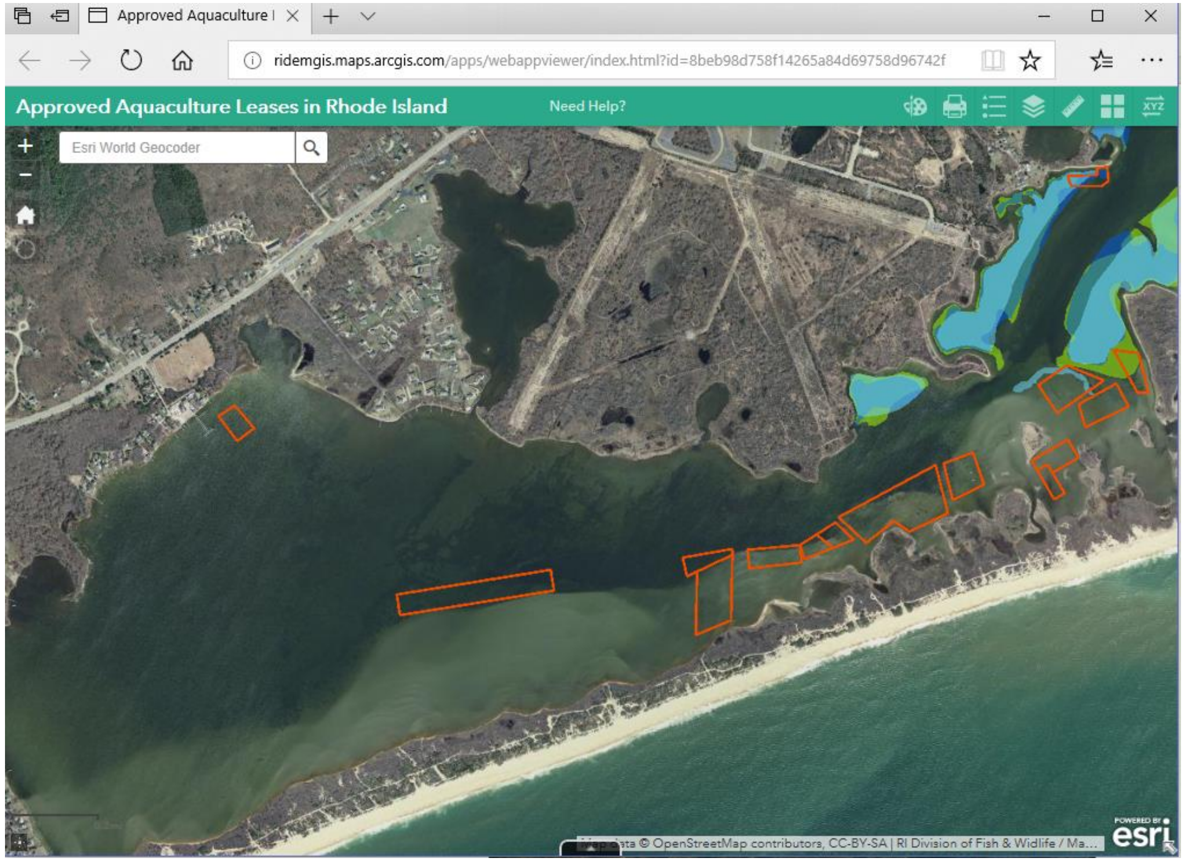


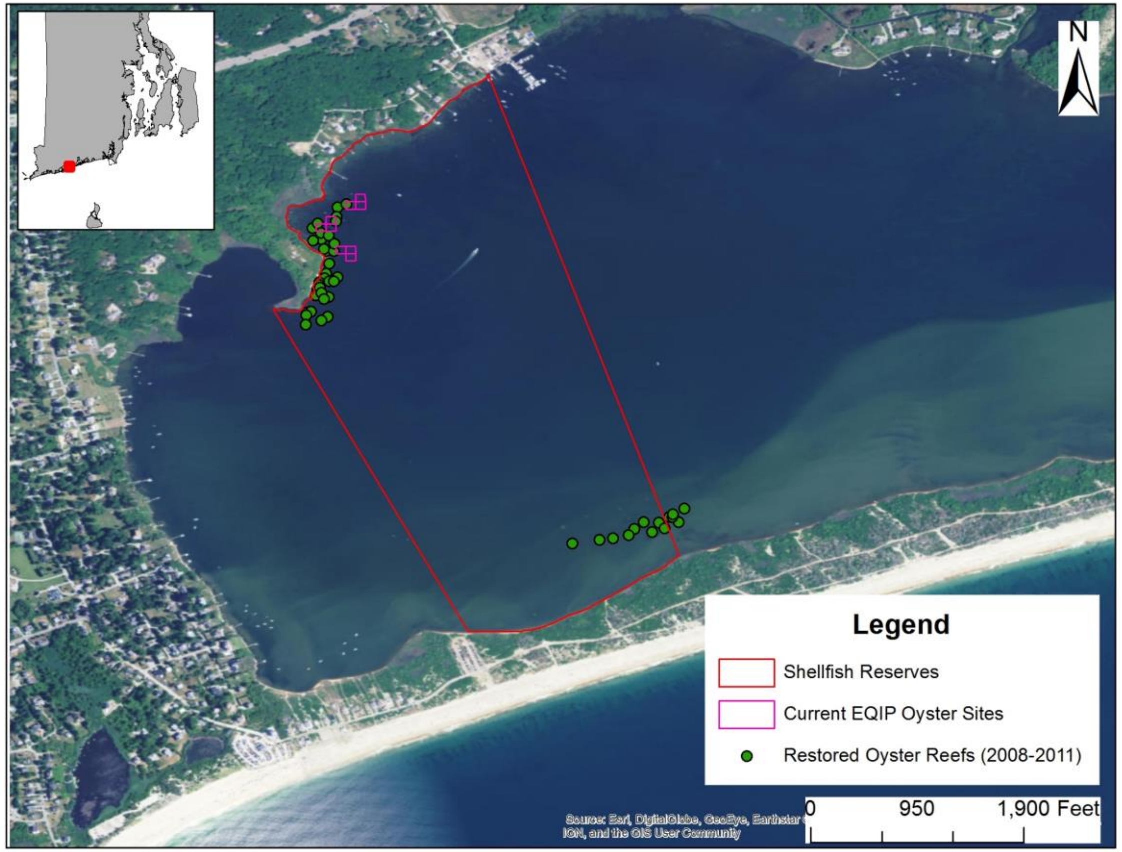
Ben-Horin et al (2018) *Aq Env Interact*



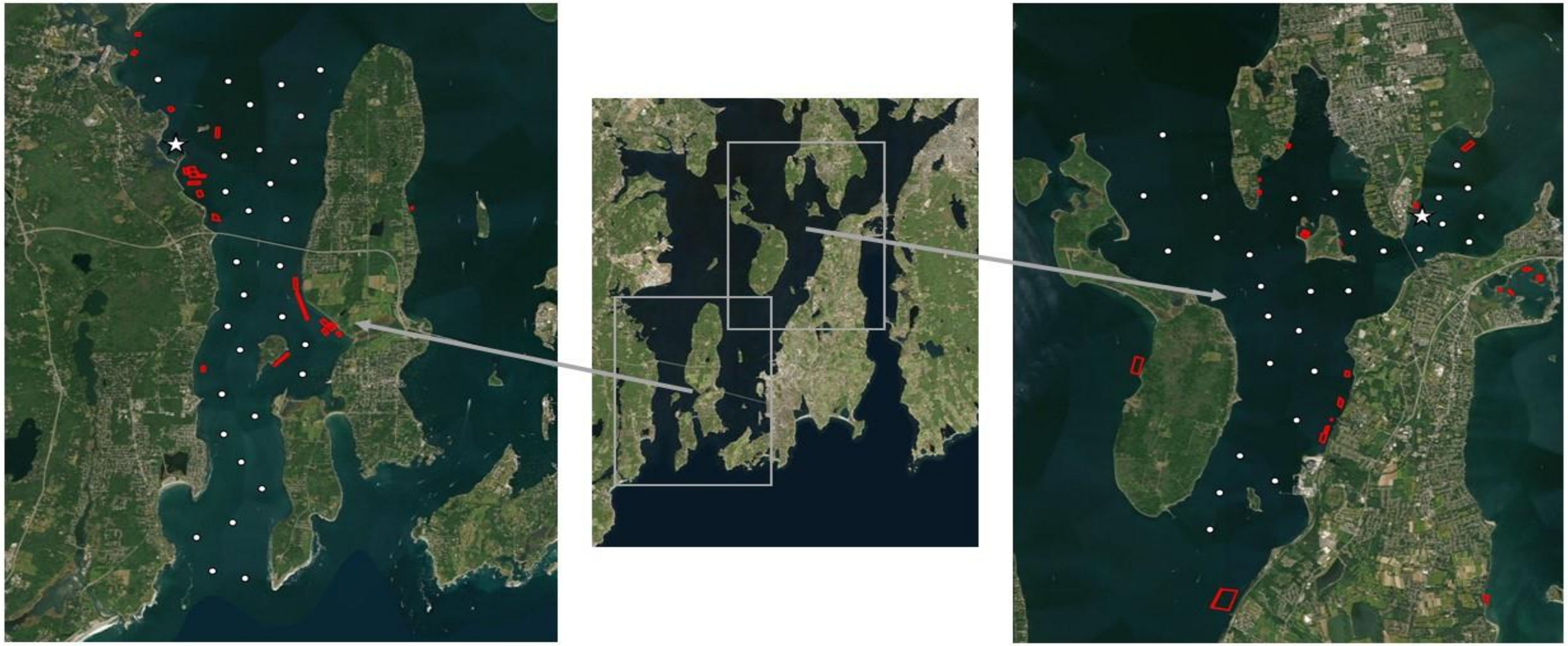
Ben-Horin et al. (2018) *Aq Env Interact*

What is going on in Ninigret?



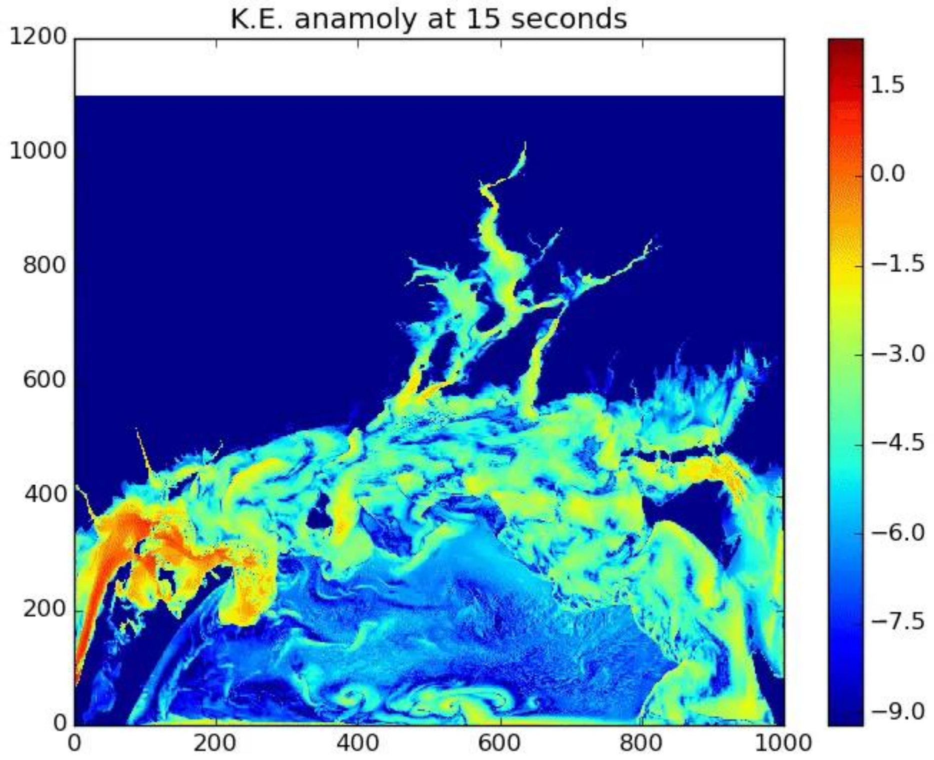


Step 1 – inferring ecological interactions outside hosts

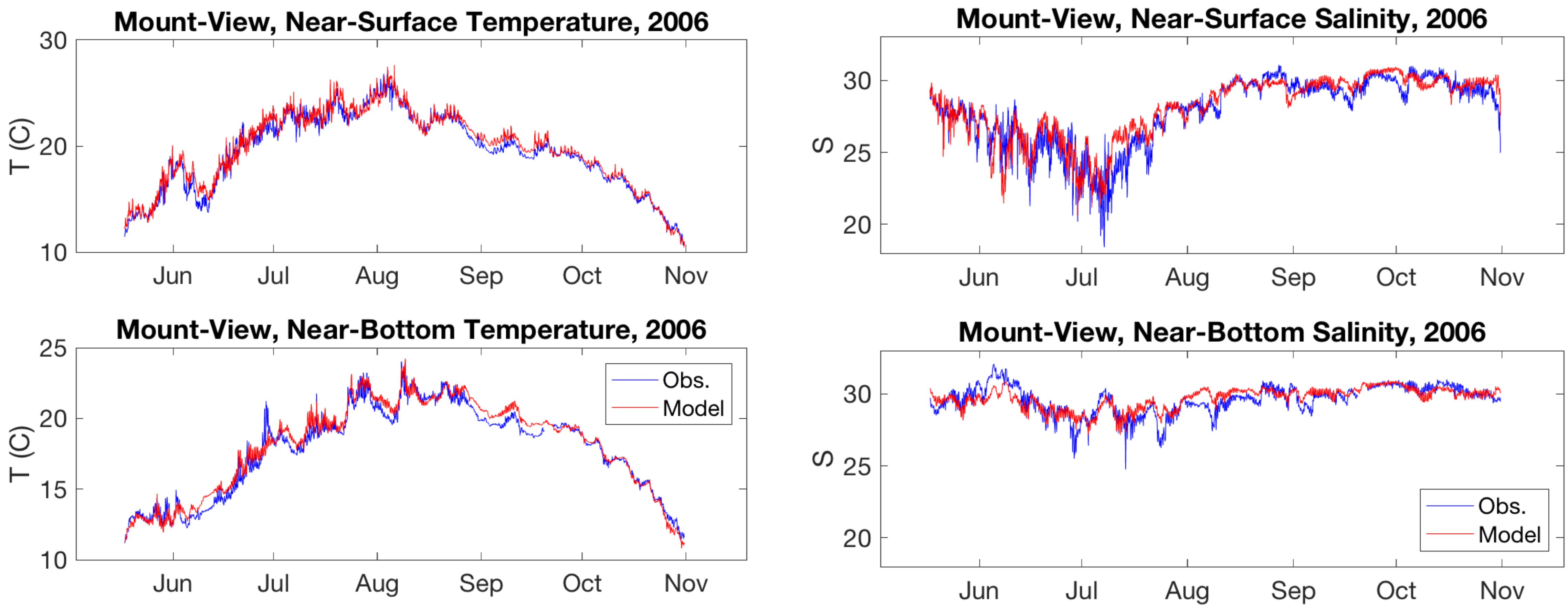


ROMS-OSOM: Computational hydrodynamic model simulating the bay

Well-validated field variables such as Velocity w.r.t (x,y,z,t)

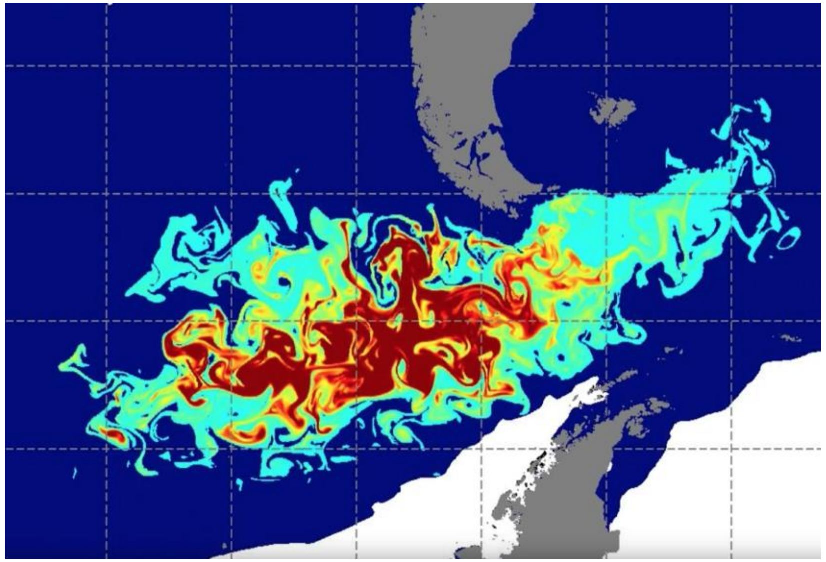


ROMS-OSOM exhibits high skill (from NSF visit for RI C-AIM)



Tracers

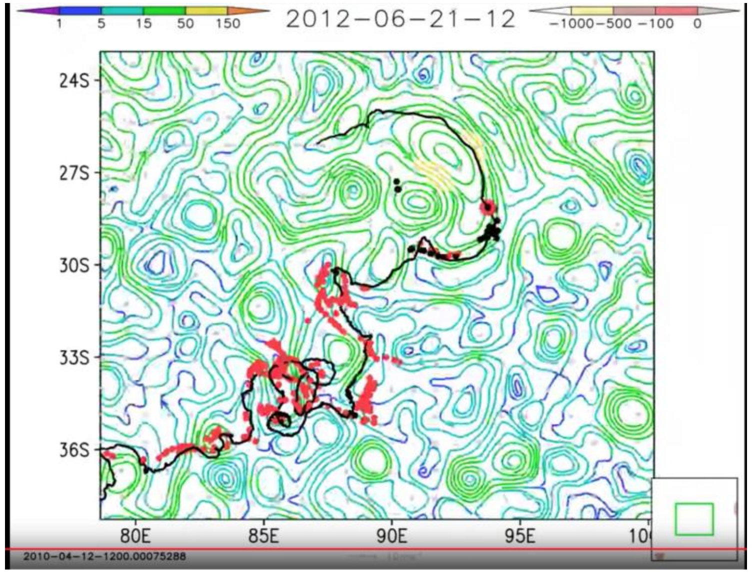
Source with impulsive ejection of tracer. The concentration advects and diffuses with the flow.



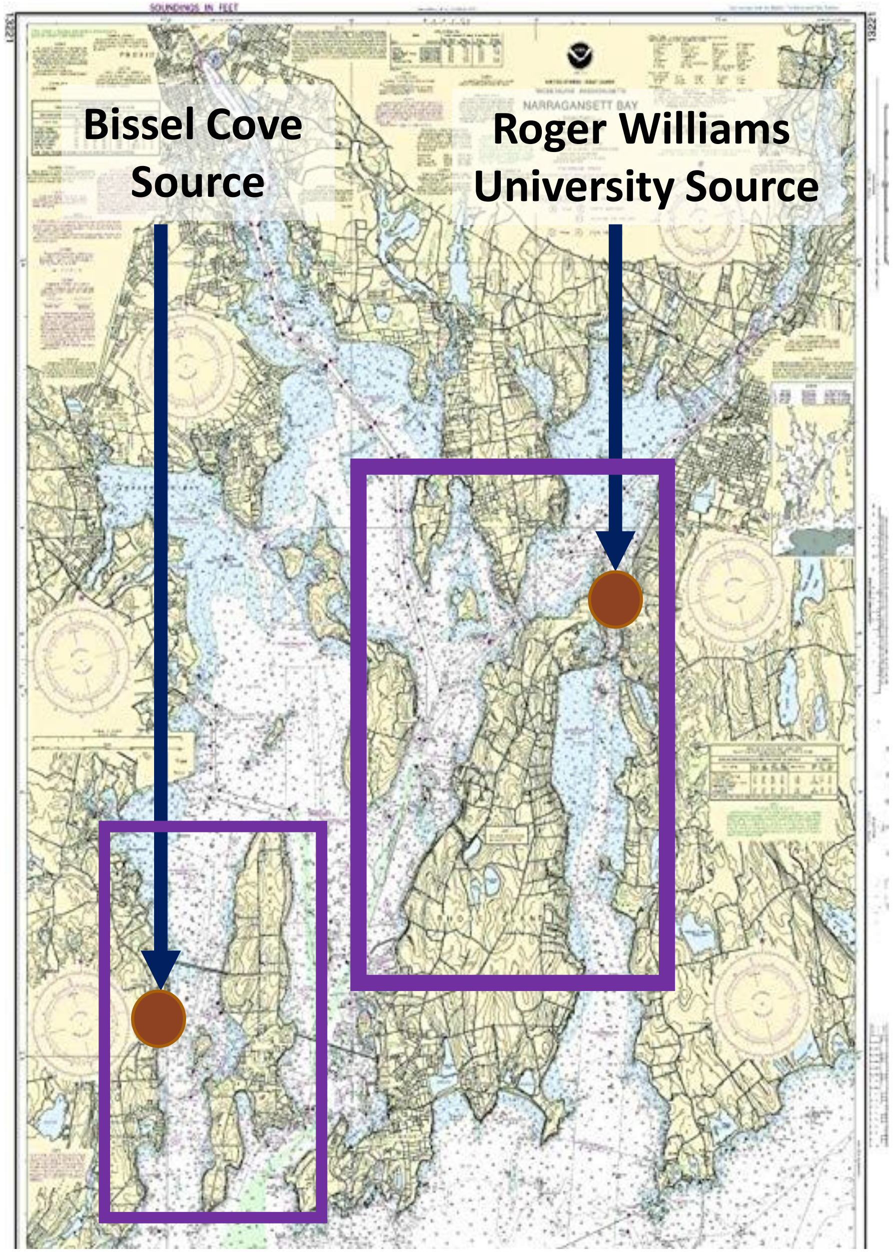
Passive tracer released in Southern Ocean
Source: https://www.youtube.com/watch?v=Fcpaucqtn6s

Drifters

Source with particles released as point particles. Individual drifters advect with the flow. Point particles hence no diffusion with the back ground flow.



Passive drifter released in a box model. Green and blue represent the background flow.
Source: https://www.youtube.com/watch?v=jqg6kmEnOOw



Solution to Tracer Equation

Both advection and diffusion are linear operators with respect to c and can be collectively denoted by $\mathcal{L}$

$$\frac{\partial C}{\partial t} + u \cdot \nabla C = \kappa \nabla^2 C + Q = (\partial_t + \mathcal{L})C(\boldsymbol{x}, t) = Q(\boldsymbol{x}, t)$$

Consider a tracer injected at $(\boldsymbol{x_0}, t_0)$ denoted by
and moved to any point $(\boldsymbol{x}, t)$ under the flow operator $\mathcal{L}$ in the sample area denoted by

For a steady state ocean the solution of this equation that transports the parcel under the prescribed flow and initial and boundary conditions is given by a *Greens Function:*

$$G(\boldsymbol{x}, t | \boldsymbol{x_0}, t_0)$$

Transit time distributions

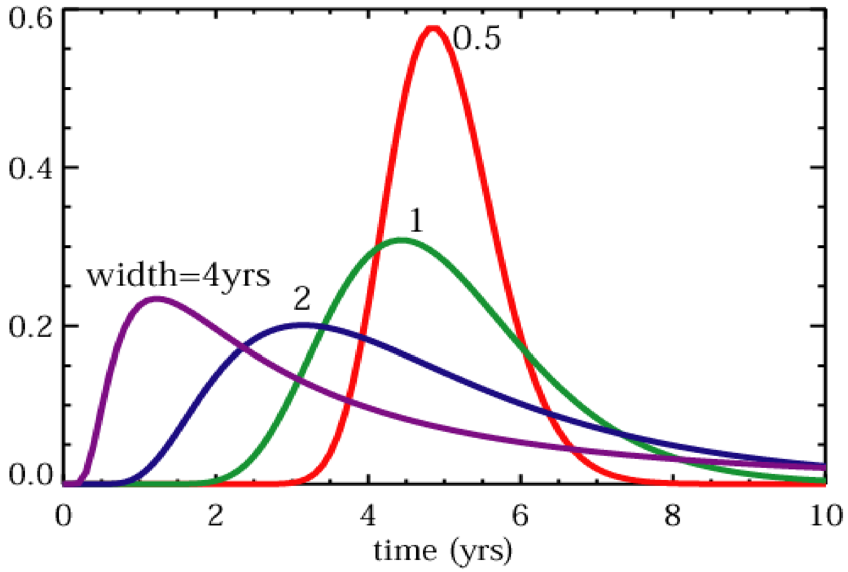
The integral of this source propagator over interior sources is the PDF of $\boldsymbol{x_0}$-to-$\boldsymbol{x}$ transit times

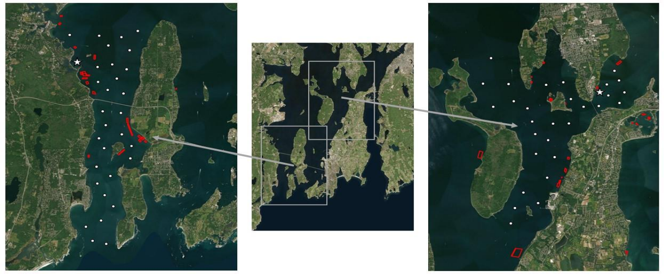
$$\mathcal{G}(\boldsymbol{x}, t, Q, t_0) = \iiint_V d^3\boldsymbol{x_o} G(\boldsymbol{x}, t | \boldsymbol{x_0}, t_0)$$

$$G(z,t) = \frac{\Gamma}{2\Delta\sqrt{\pi t^{*3}}} \exp\left[\frac{-\Gamma^2(t^*-1)^2}{4\Delta^2 t^*}\right]$$

$\mathcal{G}$ is the ***transit time distribution*** or ***age spectrum:***

- The probability that a given interior water parcel was at a source a given time ago
- The first raw moment of the TTD is the mean age or transit time (Γ)
- The second central moment is a measure of the distribution’s width (Δ)





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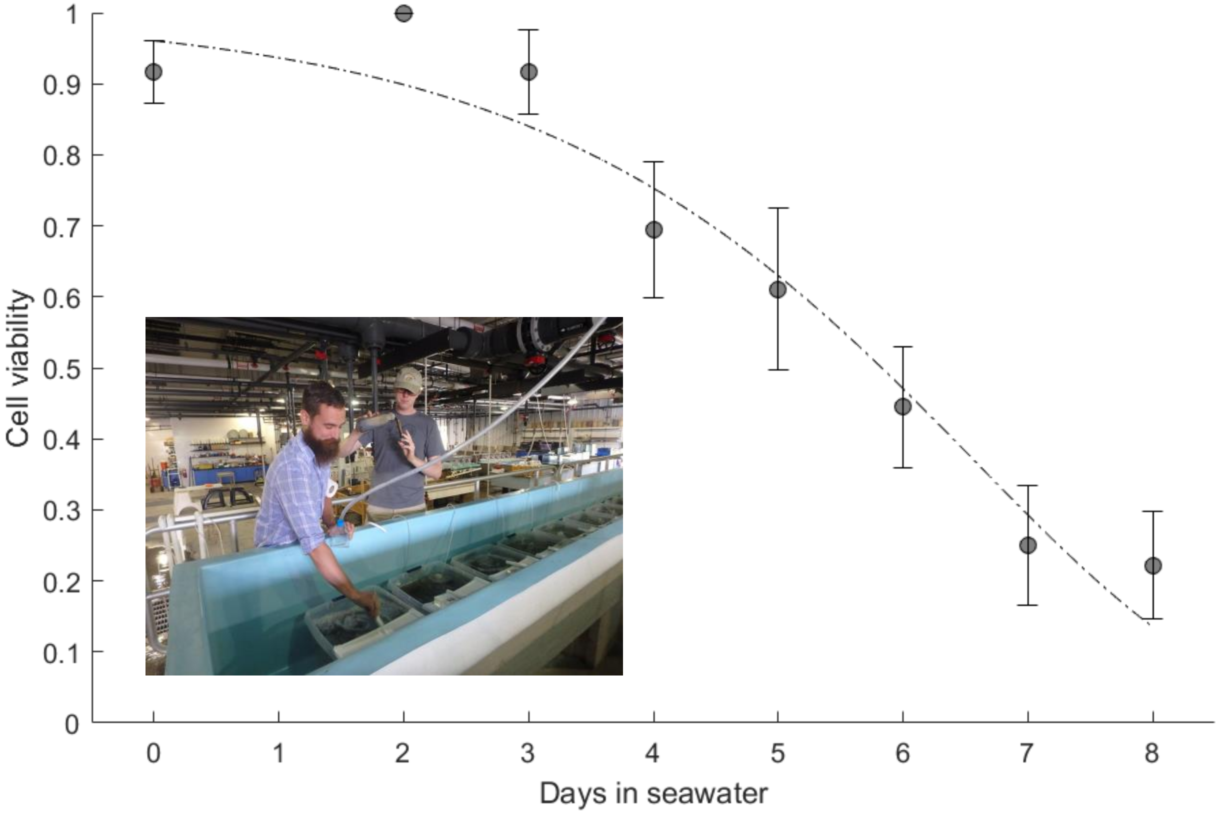

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Bayesian integration of TTDs and ecological data

$$P_i = KDE_{G(z,t)} P_s e^{-\gamma G(z,t) - \frac{\alpha}{\beta}\left(e^{\beta G(z,t)} - 1\right)}$$