Oceanographic Connectivity and Population Modeling

Matching Empirical Data to Predictive Needs

Will White and Loo Botsford

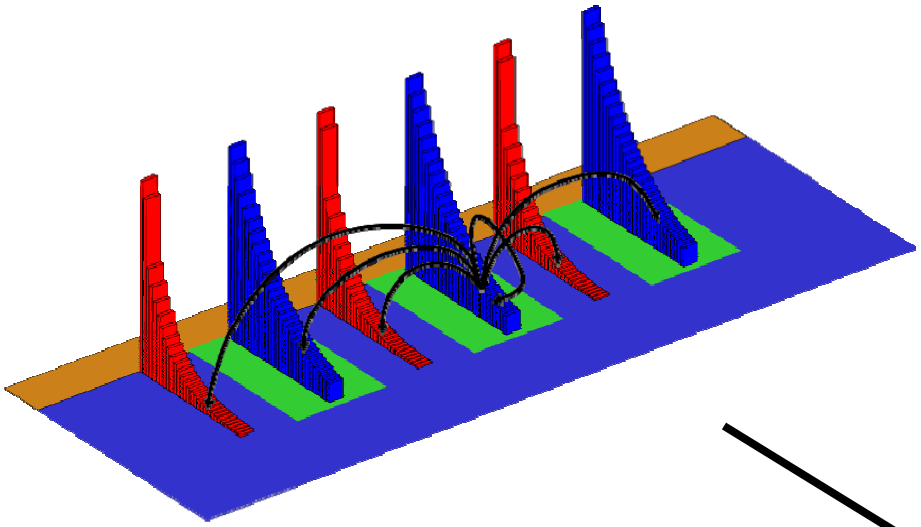
September 16, 2008

El Segundo, CA

RESOURCES LEGACY FUND FOUNDATION

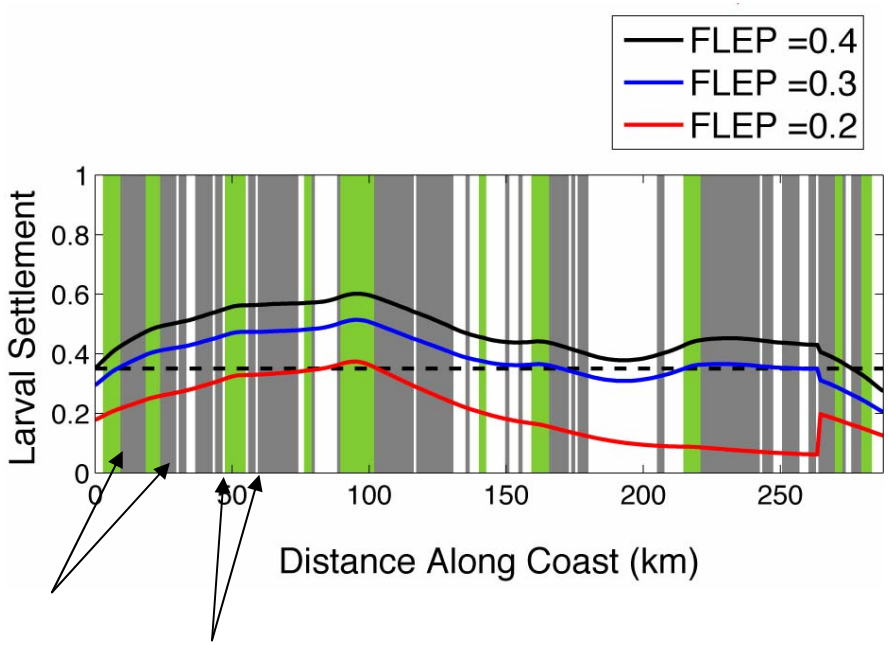
UC DAVIS
UNIVERSITY OF CALIFORNIA

Overview of basic modeling framework



Input:
Dispersal pattern
Distribution of
- habitat
- fishing

Results:
Distribution of
- larval settlement
- population persistence
- fishery yield

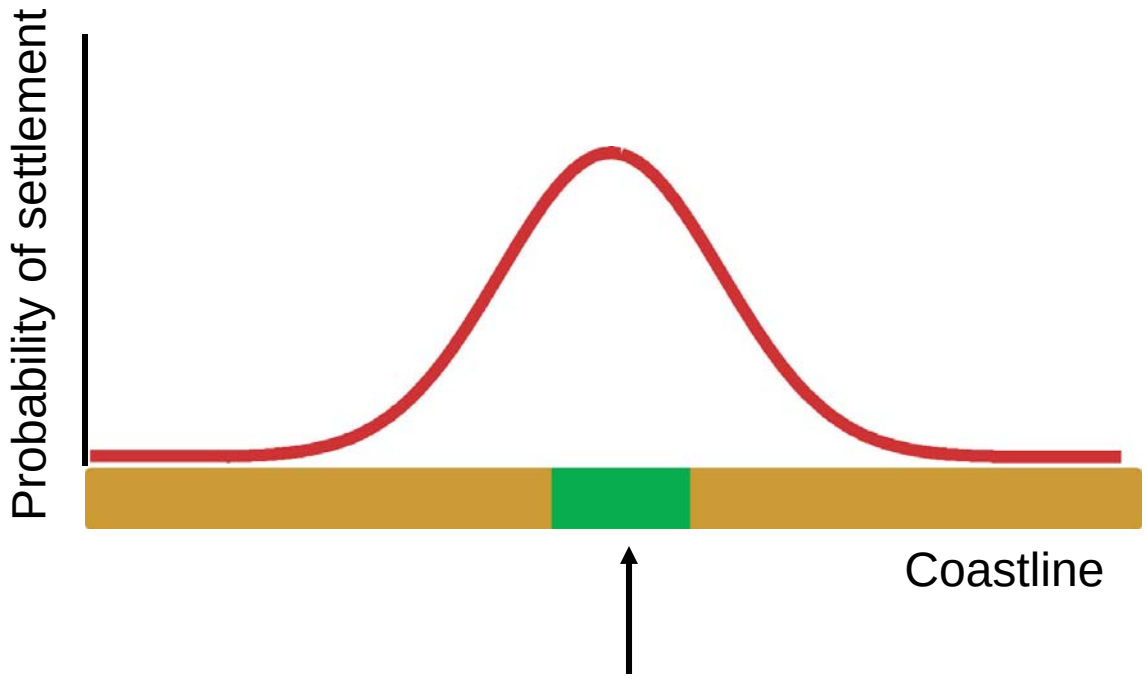


MPA

Habitat

Kaplan et al. (2006, 2008) *Ecol. Apps.*
White et al. (in prep)

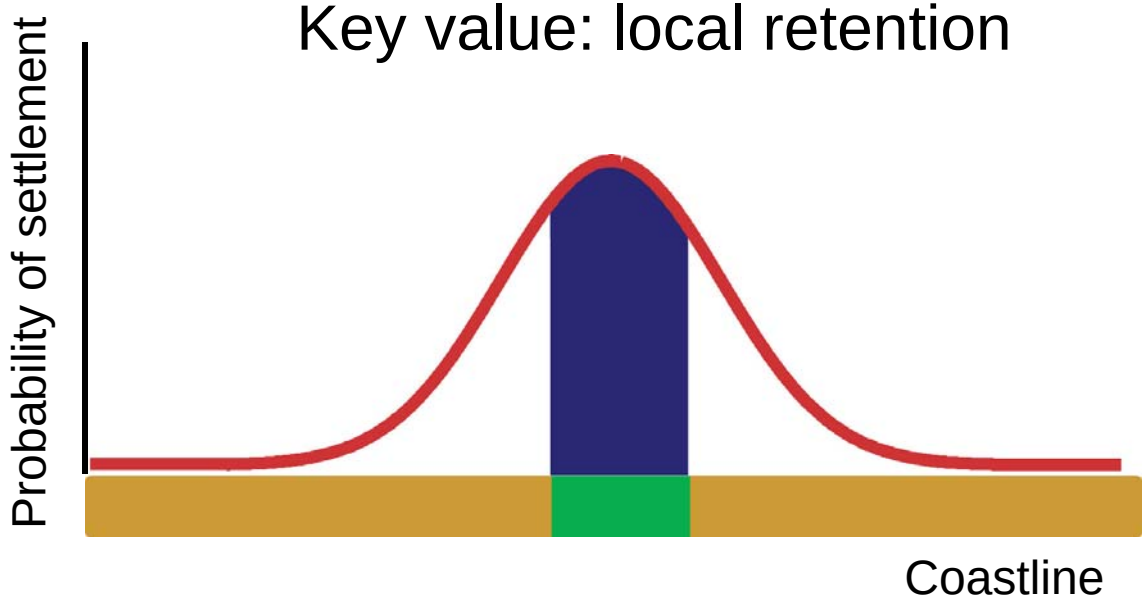
Dispersal Kernel



Larvae spawned here

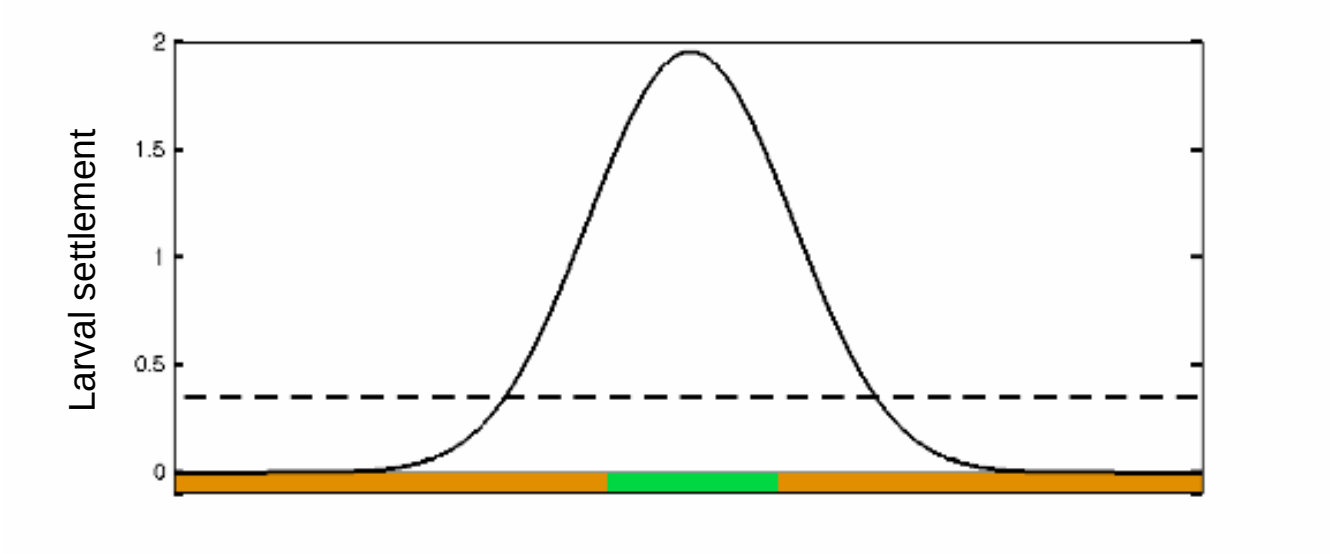
Dispersal Kernel

Key value: local retention



Local retention = probability of a larva returning to its natal population

If ***local retention*** is large enough, MPAs are ***self-persistent***



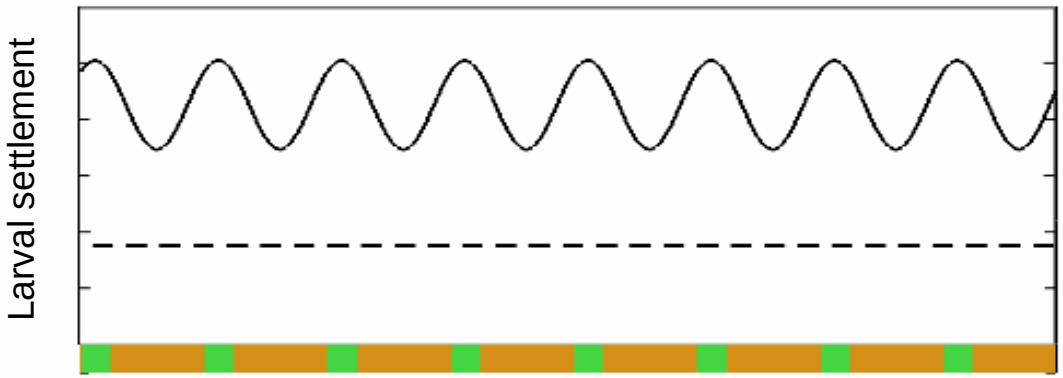
Threshold:

MPA width ≥ kernel width

Botsford et al. (2001) *Ecol. Letts.*
Hastings & Botsford (2006) *PNAS*

If MPAs are not wide enough for self-persistence,

Network persistence is possible



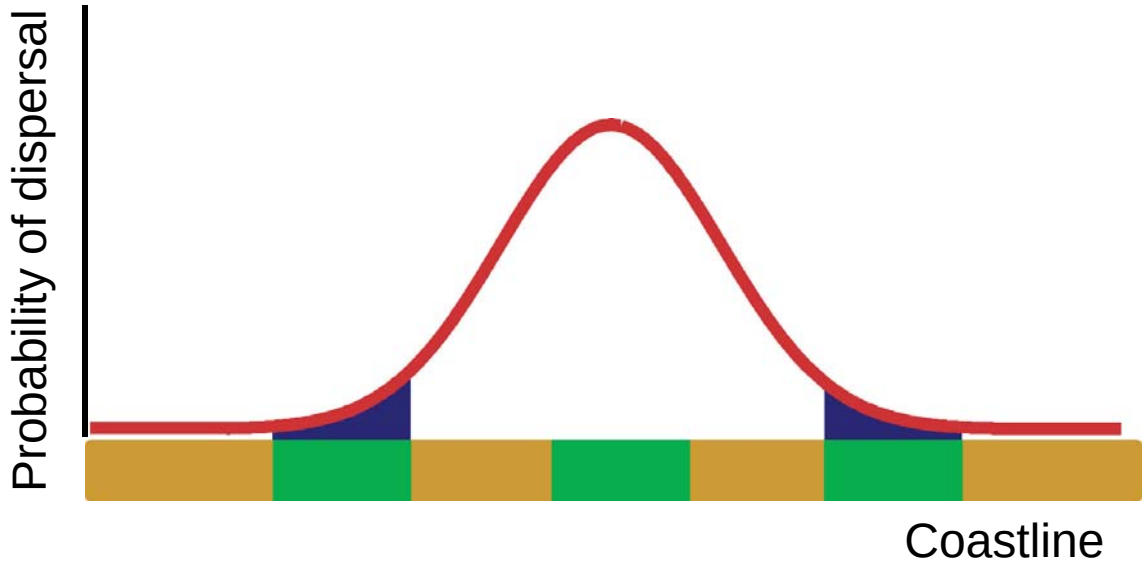
Threshold:

Total MPA area ≥ **X**% of coastline

(**X** determined by fishing rate outside MPAs)

Botsford et al. (2001) *Ecol. Letts.*
Hastings & Botsford (2006) *PNAS*

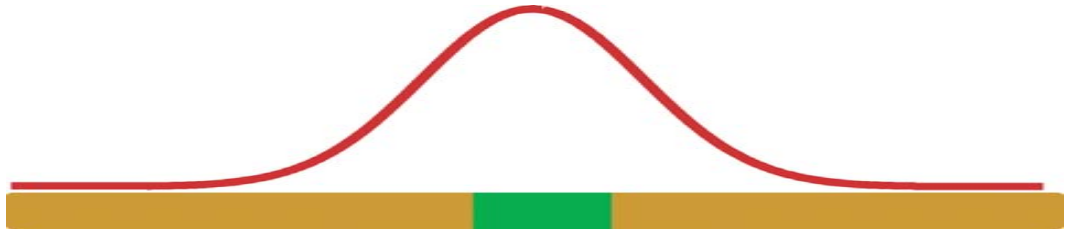
Dispersal Kernel



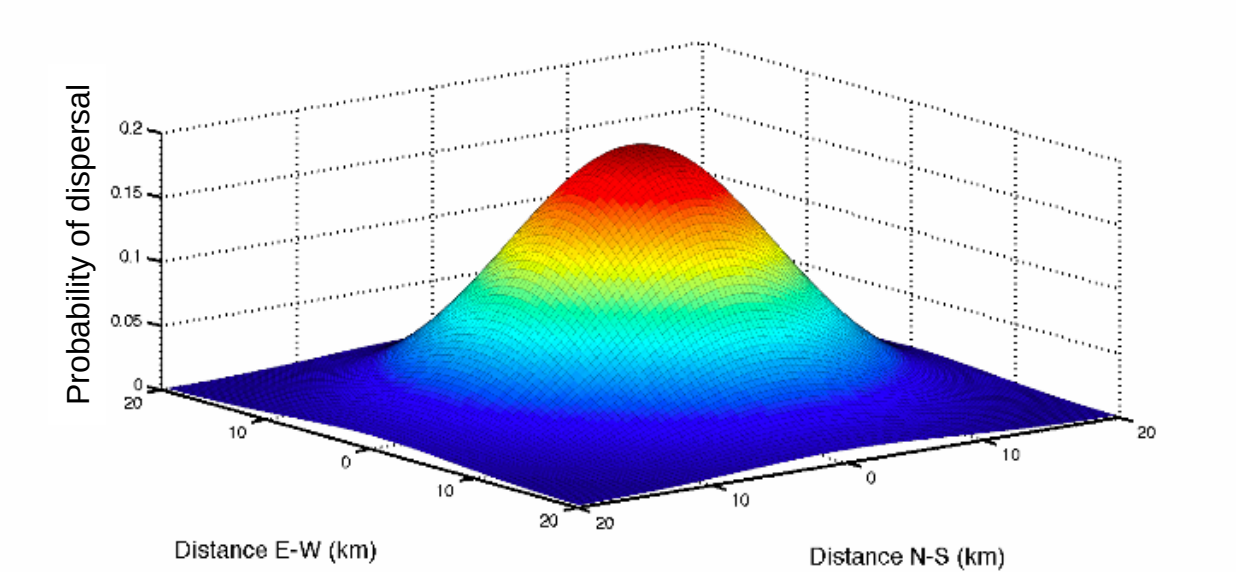
What about the tails of the dispersal kernel?

Probability of a larvae dispersing to a neighboring population

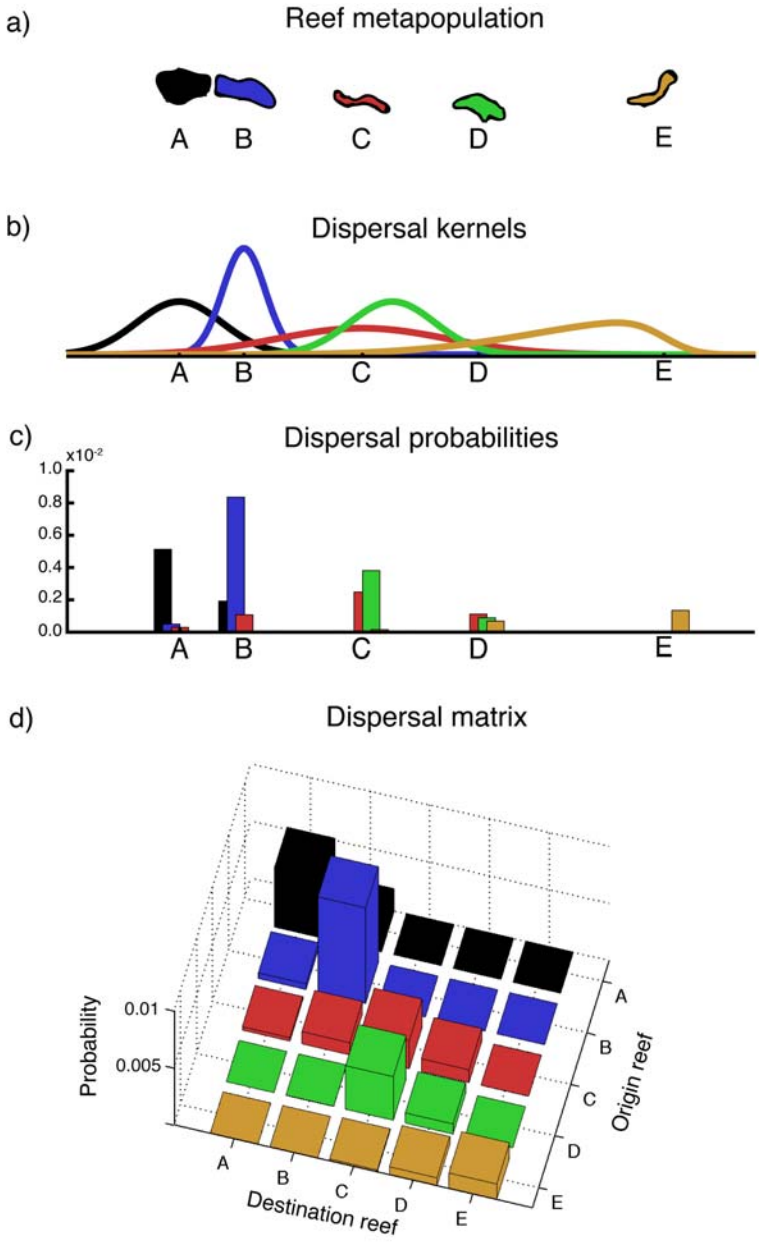
Previous models were 1-dimensional



But same principles apply in 2-D



Dispersal Matrix = Dispersal Kernels for all locations

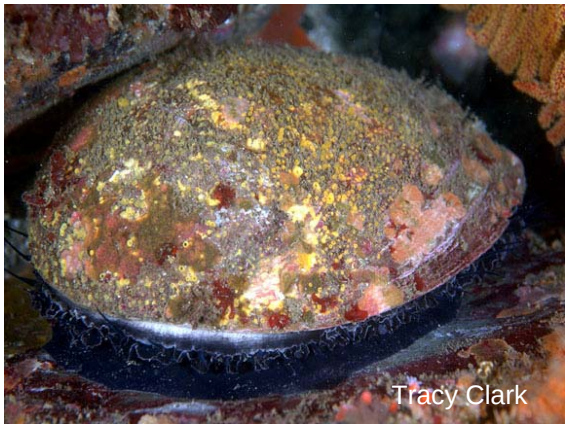


Botsford, White, Coffroth, Paris, Planes, Shearer, Thorrold, & Jones (in review) *Coral Reefs*

Empirical estimates of

- local retention

- long-distance dispersal



Techniques:

- Population genetics

- Geochemical tags

- Circulation models

Population Genetics

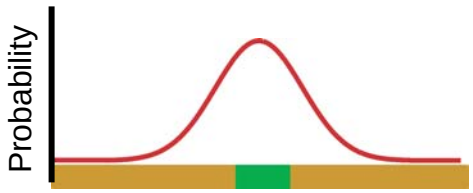
Advantage:
Estimate number of migrants (larvae) exchanged between populations each generation

Pitfalls:

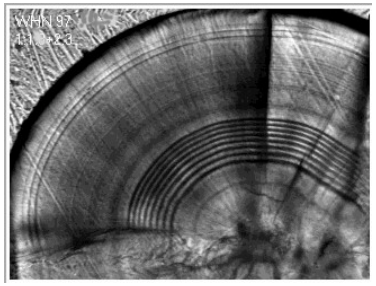
-Traditional F_{ST} measures:
integrates over time, not necessarily contemporary connectivity patterns (microsats > mtDNA)
- Newer Bayesian assignment tests are better
- Best at finding **breaks** in connectivity

- Estimates total number of migrants (*Nm*)

- need to know local production to get dispersal rate per larvae (*m*)



Otolith / Statolith geochemistry



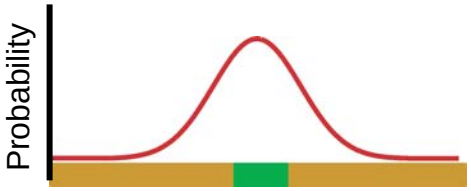
Advantage:
Estimates contemporary connectivity patterns

Pitfalls:

- Does geochemistry vary at the appropriate spatial scale?

- Estimates total number of migrants (*Nm*)

- need to know local production to get dispersal rate per larvae (*m*)

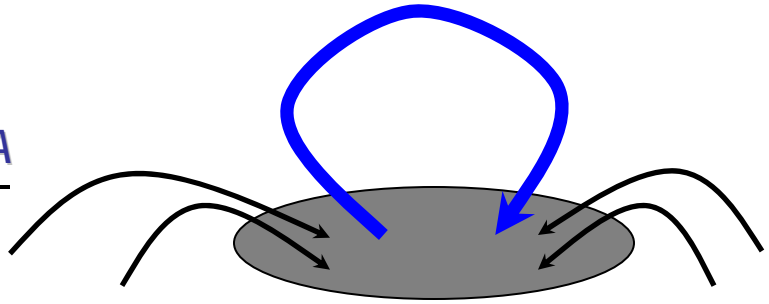


Otolith / Statolith geochemistry

Pitfalls:

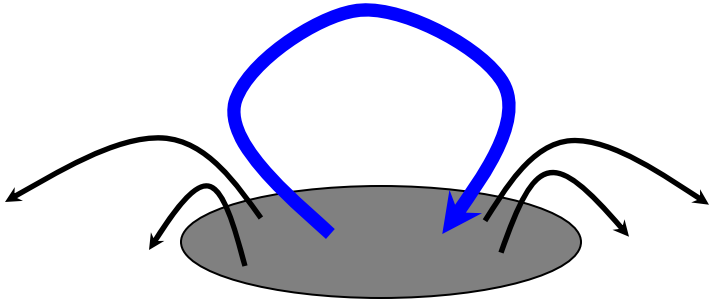
Self-recruitment estimates:

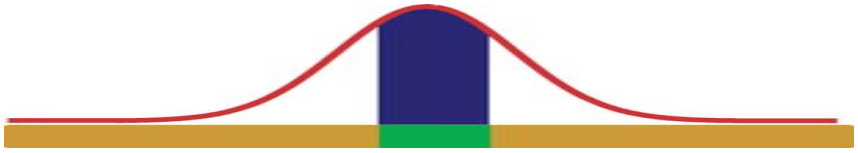
$$\frac{\text{\# locally produced larvae settling at } A}{\text{total \# settlers at } A}$$



Contrast to local retention:

$$\frac{\text{\# locally produced larvae settling at } A}{\text{total \# larvae produced at } A}$$

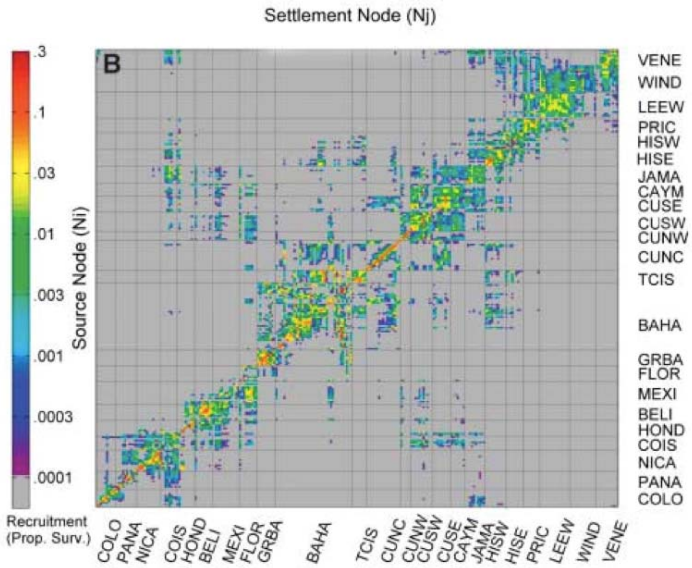




Biophysical circulation models

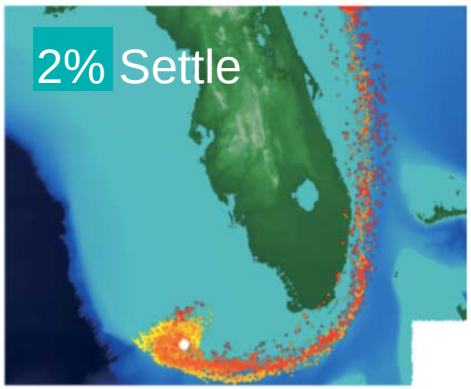
Advantages:

Can estimate full dispersal matrix

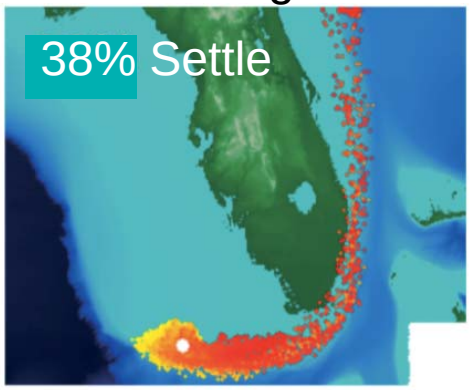


Cowen et al. (2006) *Science*

No behavior



Vertical migration



Paris et al. (2007) *MEPS*

Pitfalls:

need to be sure of boundary conditions, environmental forcing, etc. and *larval behavior*

Uncertainty in dispersal patterns comparable to uncertainty in fishery stock status (FLEP, CRT)