

Oceanographic Connectivity and Population Modeling

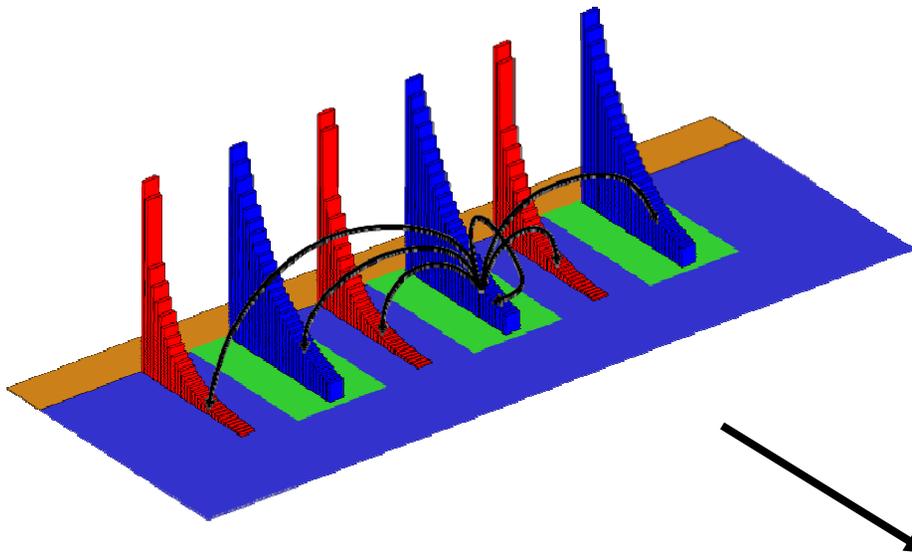
Matching Empirical Data to Predictive Needs

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El Segundo, CA

RESOURCES
LEGACY FUND
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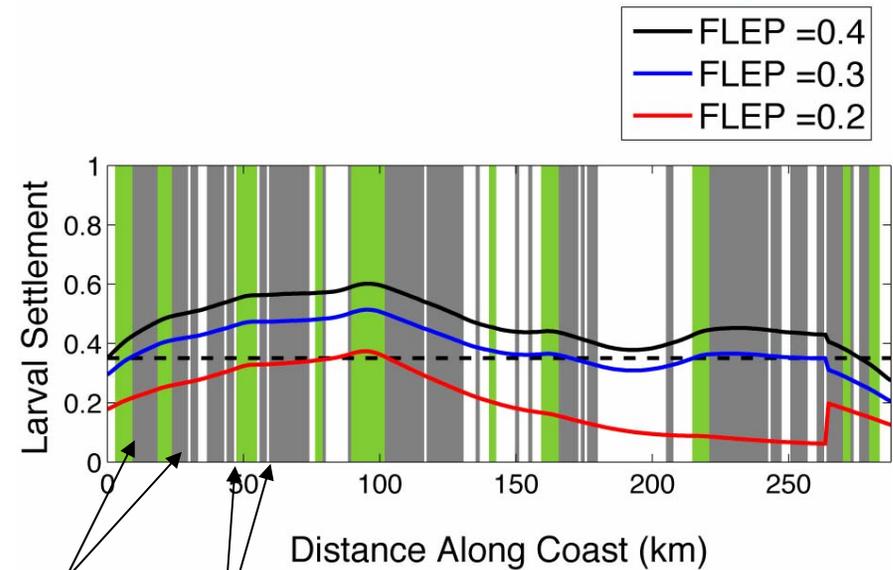
UC DAVIS
UNIVERSITY OF CALIFORNIA

Overview of basic modeling framework



Input:
Dispersal pattern
Distribution of
- habitat
- fishing

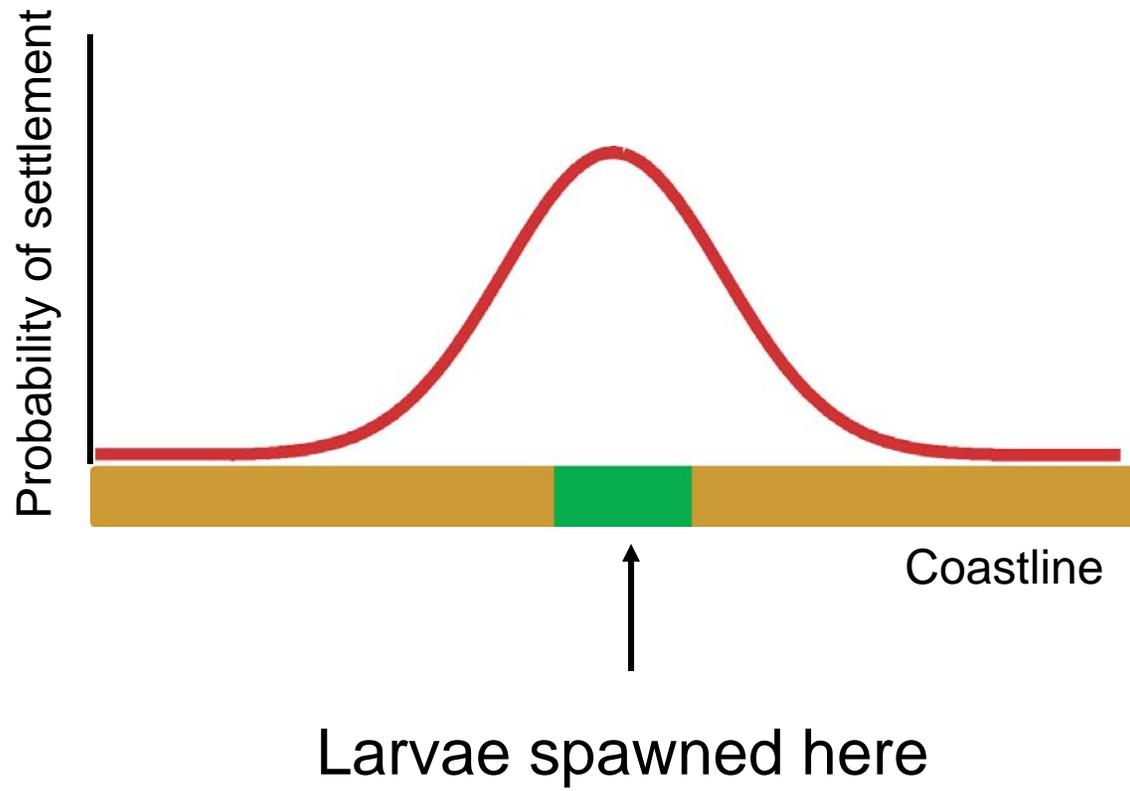
Results:
Distribution of
- larval settlement
- population persistence
- fishery yield



MPA

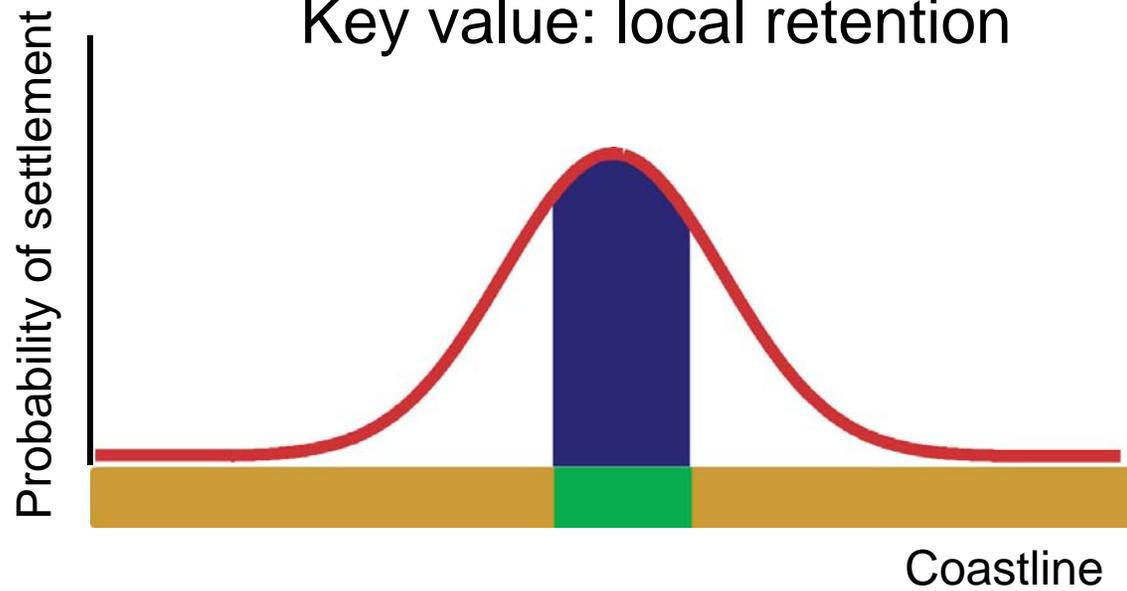
Habitat

Dispersal Kernel



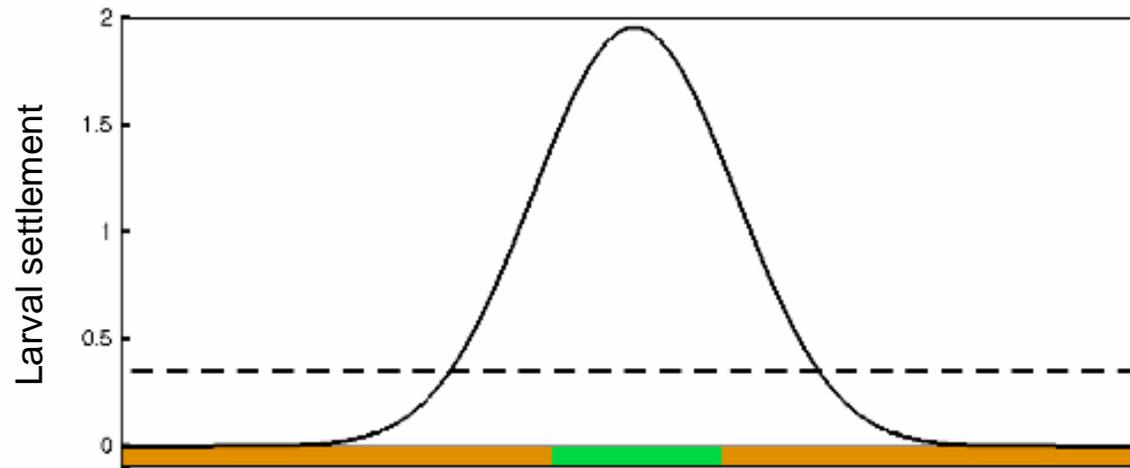
Dispersal Kernel

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**

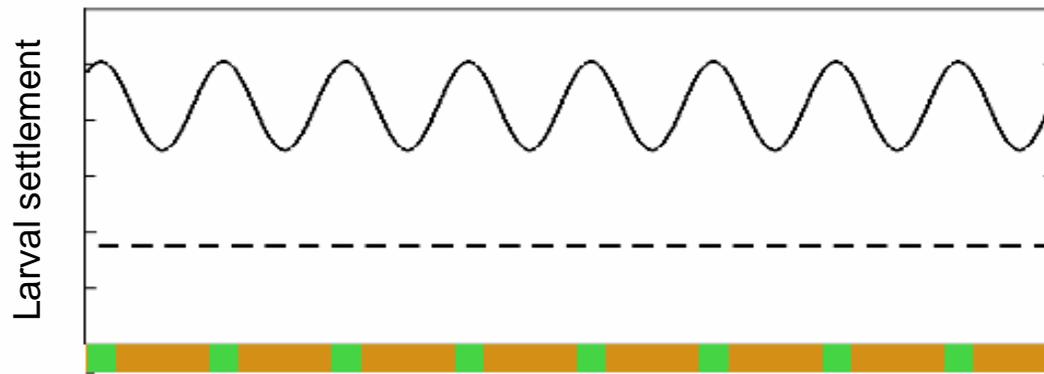


Threshold:

MPA width \geq kernel width

If MPAs are not wide enough for self-persistence,

Network persistence is possible

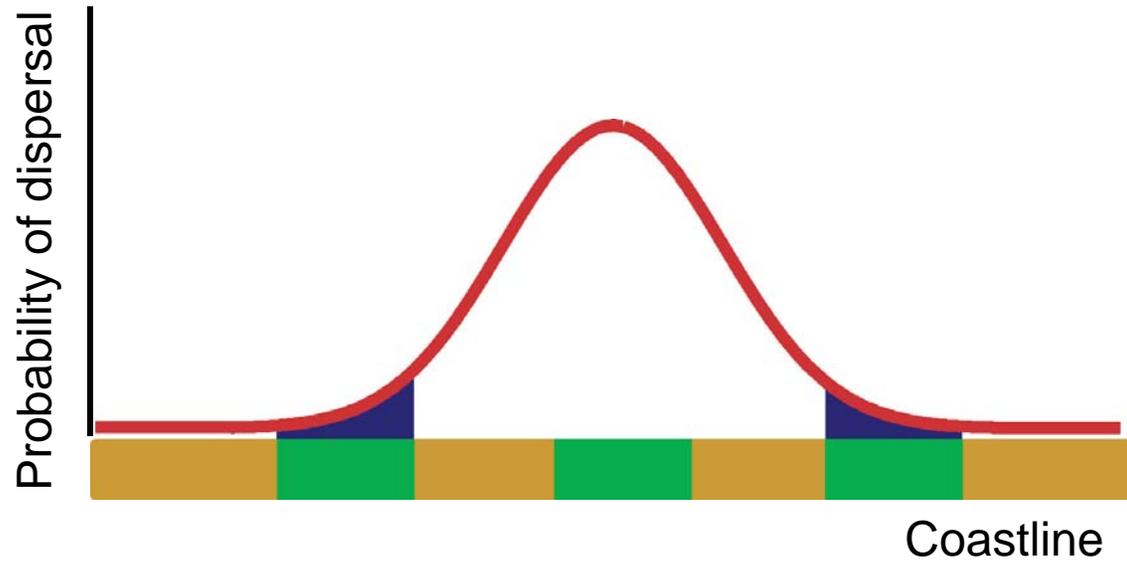


Threshold:

Total MPA area \geq **X**% of coastline

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

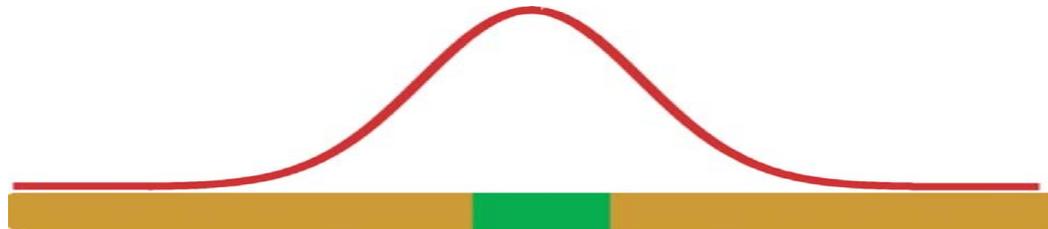
Dispersal Kernel



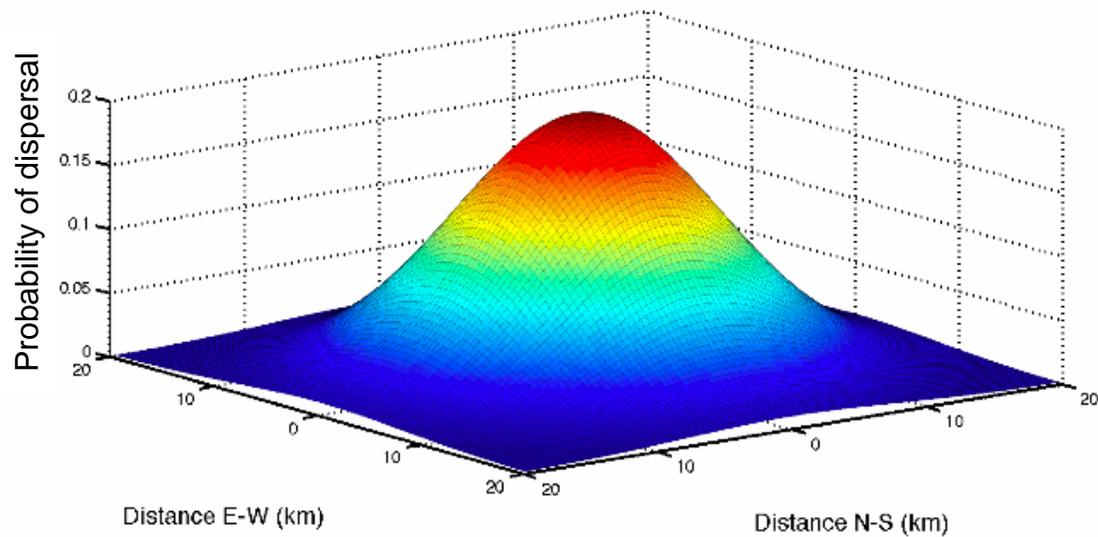
What about the tails of the dispersal kernel?

Probability of a larvae dispersing to a neighboring population

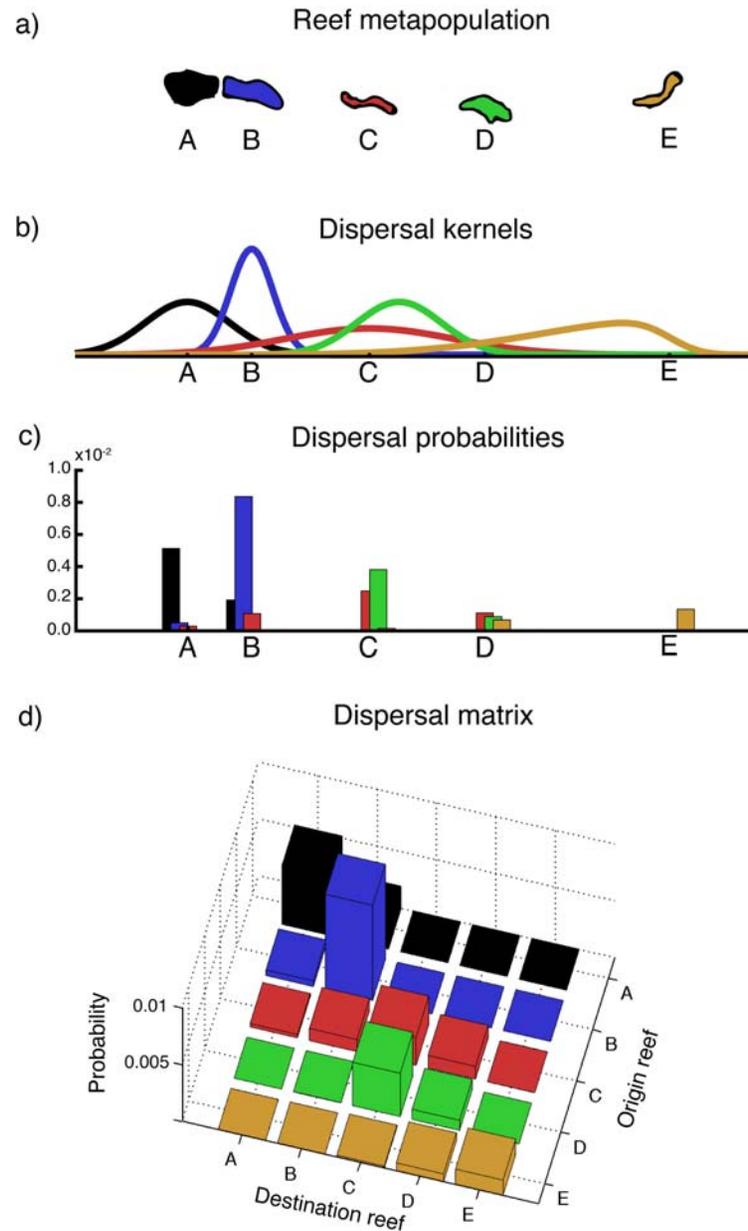
Previous models were 1-dimensional



But same principles apply in 2-D



Dispersal Matrix = Dispersal Kernels for all locations



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



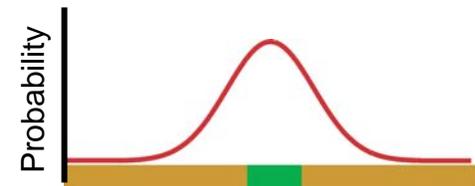
Pitfalls:



- 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)

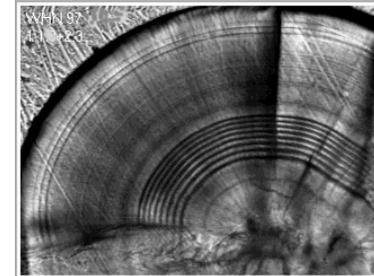
- need to know local production to get dispersal rate per larvae (m)



Otolith / Statolith geochemistry

Advantage:

Estimates contemporary connectivity patterns

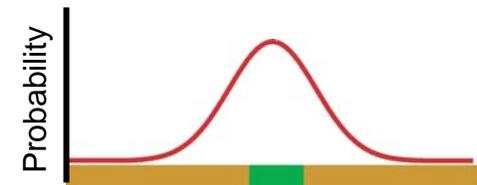


Pitfalls:

- 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)



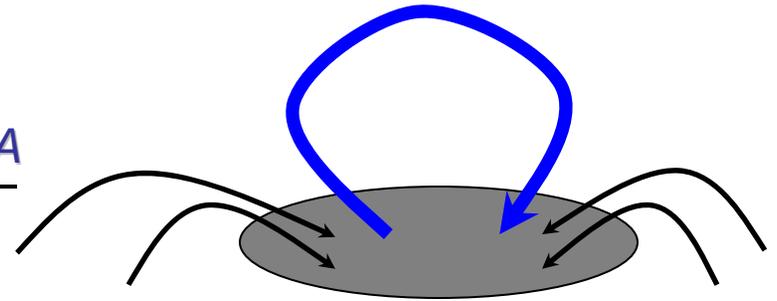
Otolith / Statolith geochemistry



Pitfalls:

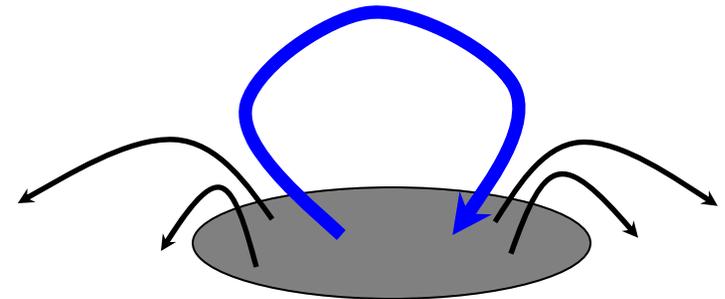
Self-recruitment estimates:

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



Contrast to local retention:

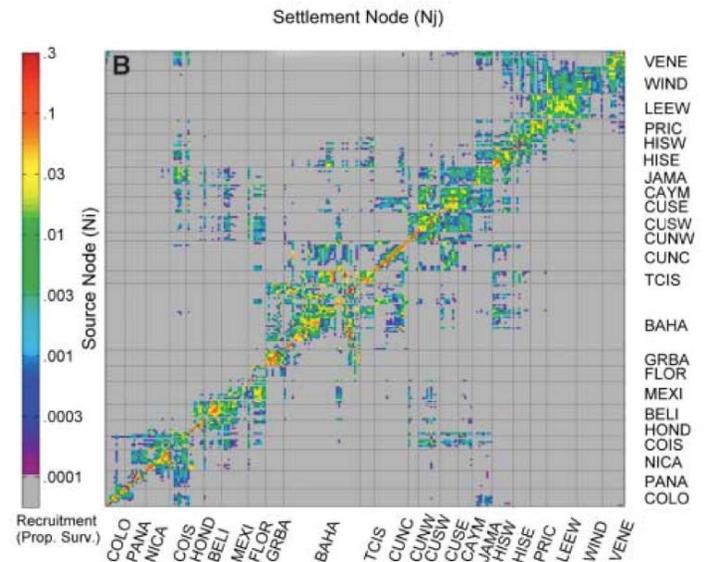
$$\frac{\# \text{ locally produced larvae settling at } A}{\text{total \# larvae produced at } A}$$



Biophysical circulation models

Advantages:

Can estimate full dispersal matrix

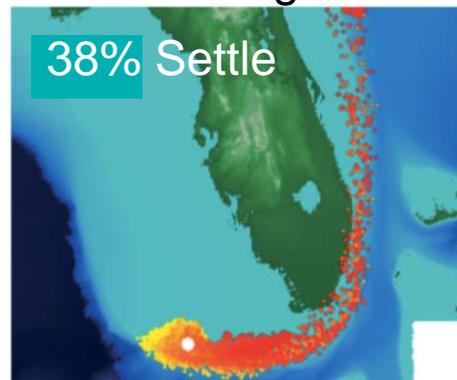


Cowen et al. (2006) *Science*

No behavior



Vertical migration

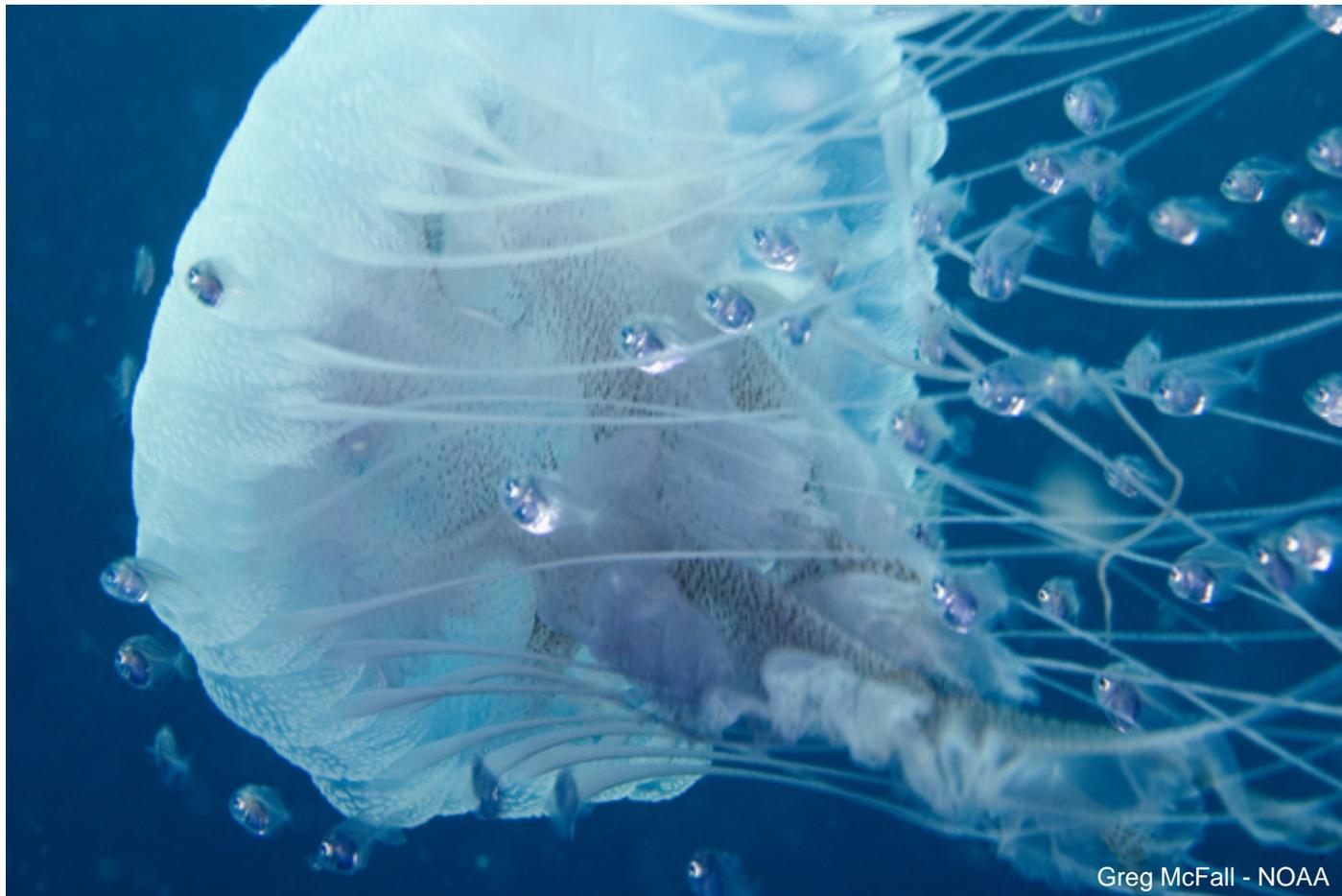


Paris et al. (2007) *MEPS*

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)



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