Oceanographic Connectivity and Population Modeling

Matching Empirical Data to Predictive Needs

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RESOURCES LEGACY FUND FOUNDATION

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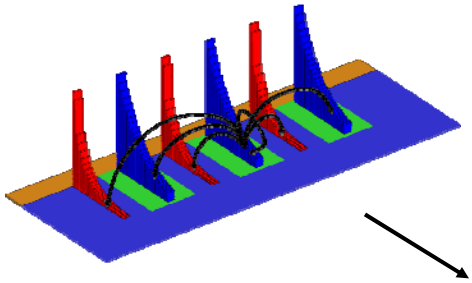
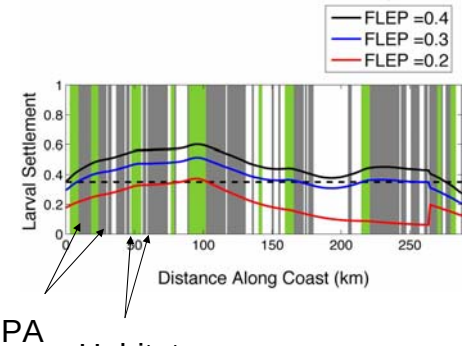
Overview of basic modeling framework



Input:
Dispersal pattern
Distribution of
- habitat
- fishing

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

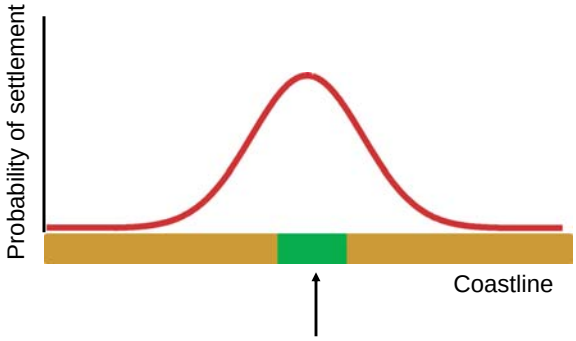


MPA

Habitat

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

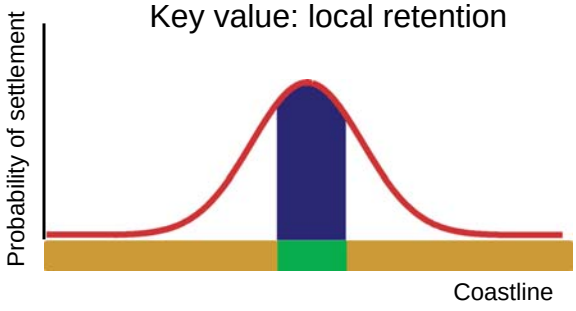
Dispersal Kernel



Larvae spawned here

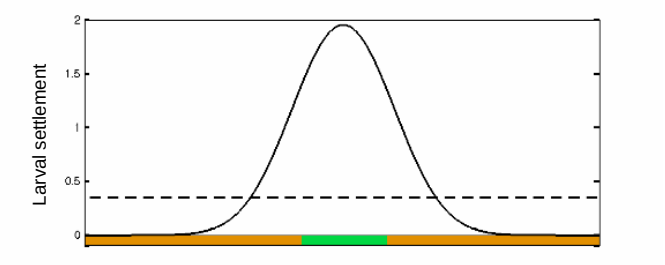
Dispersal Kernel

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***



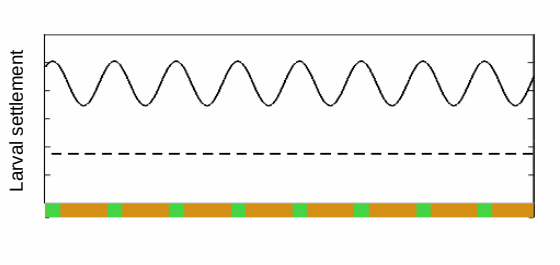
Threshold:

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



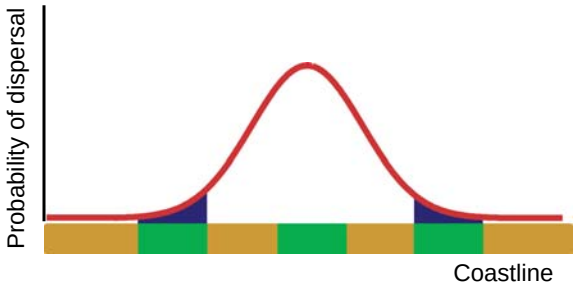
Threshold:

Total MPA area ≥ **X**% of coastline

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

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

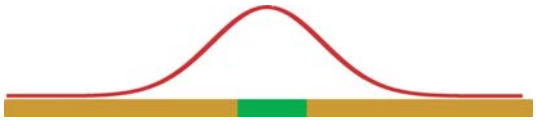
Dispersal Kernel



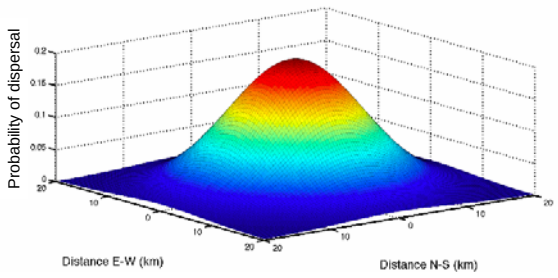
What about the tails of the dispersal kernel?

Probability of a larvae dispersing to a neighboring population

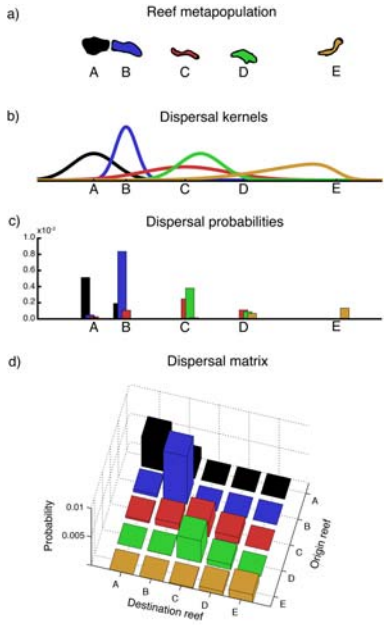
Previous models were 1-dimensional



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

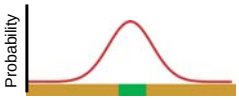
Advantage:
Estimate number of migrants (larvae) exchanged between populations each generation

Pitfalls:

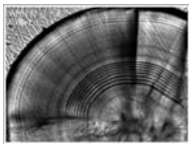
-Traditional F_{ST} measures:
integrates over time, not necessarily contemporary connectivity patterns (microsats > mtDNA)
- Newer Bayesian assignment tests are better
- Best at finding **breaks** in connectivity

- Estimates total number of migrants (*Nm*)

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



Otolith / Statolith geochemistry



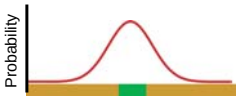
Advantage:
Estimates contemporary connectivity patterns

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*)

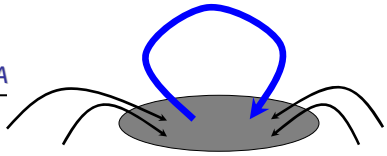


Otolith / Statolith geochemistry

Pitfalls:

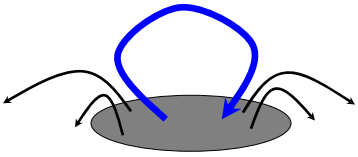
Self-recruitment estimates:

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



Contrast to local retention:

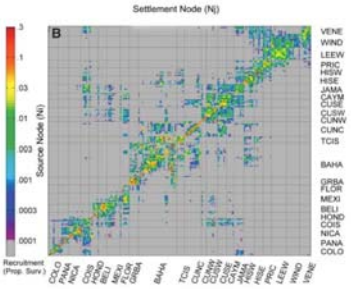
$$\frac{\text{\# locally produced larvae settling at } A}{\text{total \# larvae produced at } A}$$



Biophysical circulation models

Advantages:

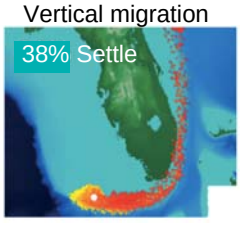
Can estimate full dispersal matrix



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)