

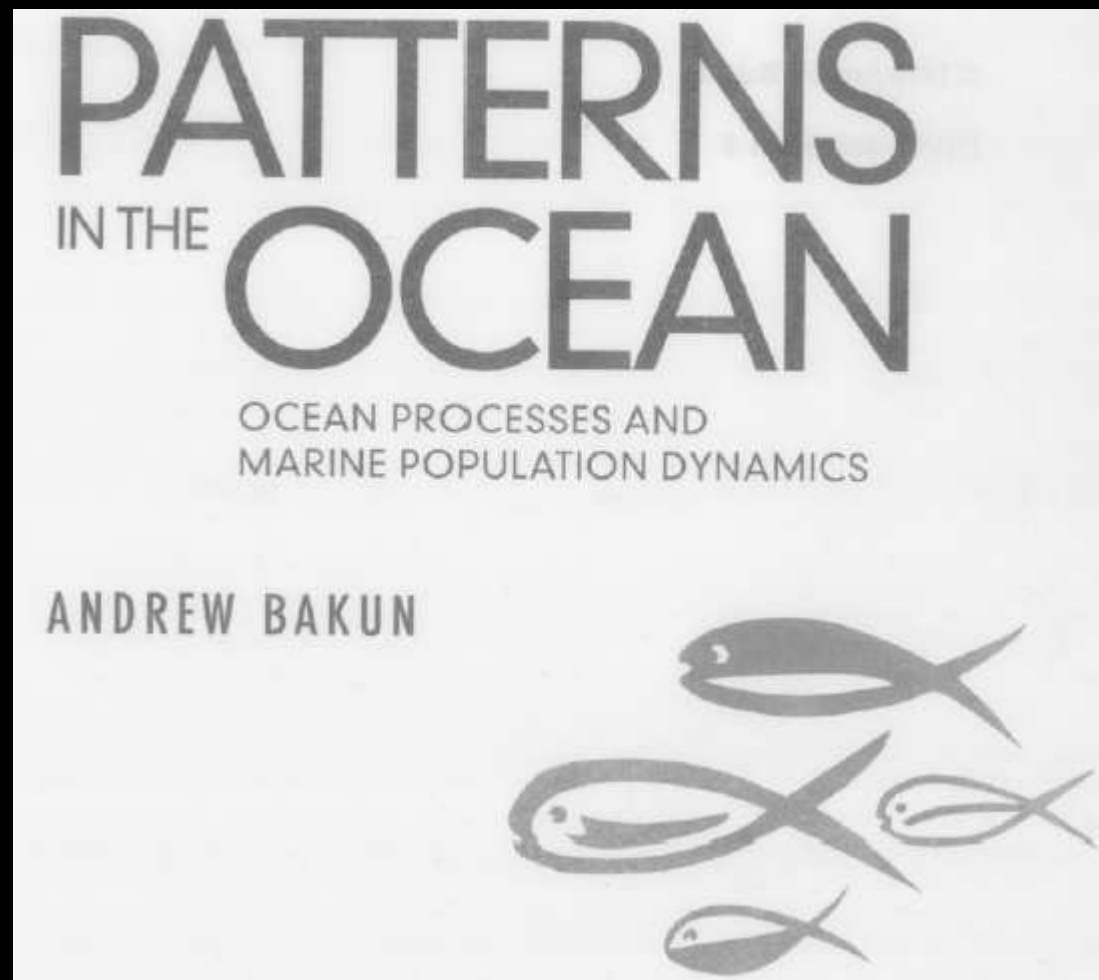


Towards landscape ecological modelling of marine reserves

Christophe Lett & David M. Kaplan

Conference on Integrative Landscape Modeling, Montpellier, 3-5 February 2010

Landscape ecology



Bakun (1996)

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Landscape ecology

- Applied to terrestrial and littoral systems
- Questions and concepts apply to oceanic systems too
- Connectivity via dispersal

Larval dispersal connects fish populations in a network of marine protected areas

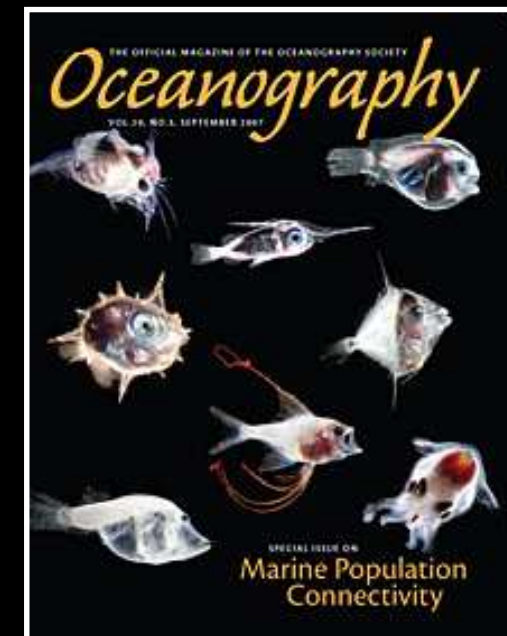
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Planes *et al.* (2009)



Propagule dispersal

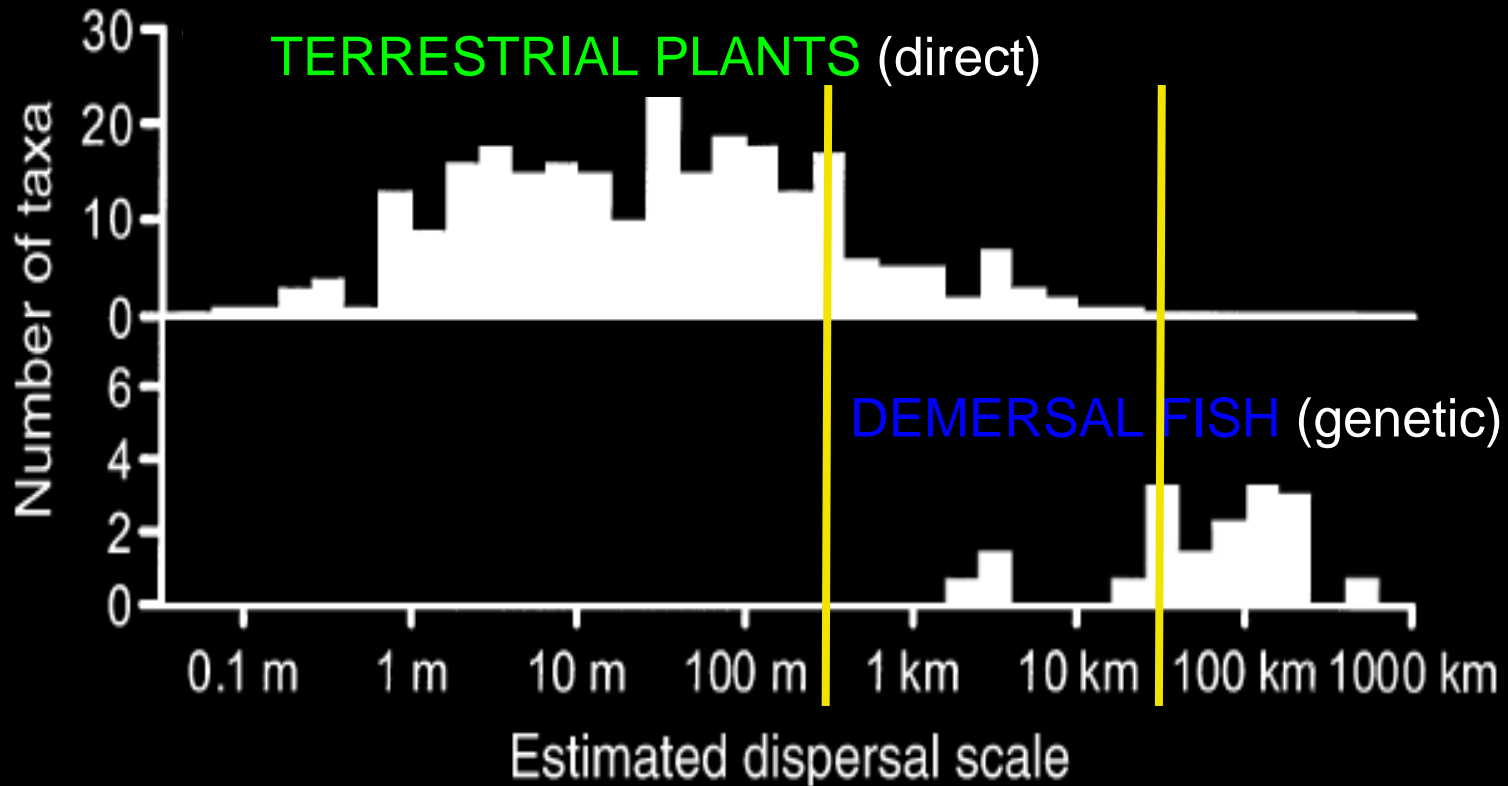


Terrestrial seed dispersal

Marine larval dispersal

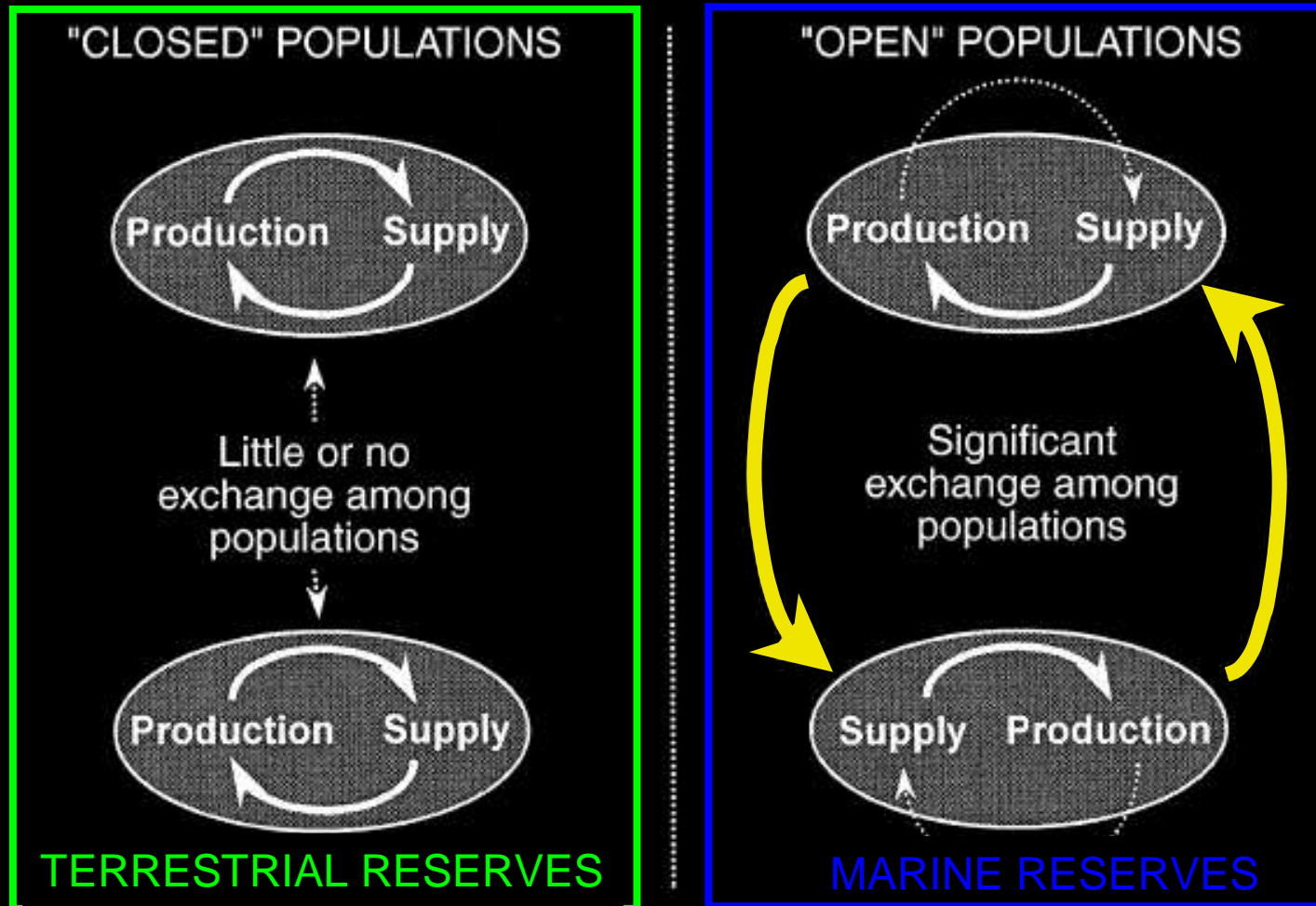


Dispersal scale



Kinlan and Gaines (2003)

Dispersal scale

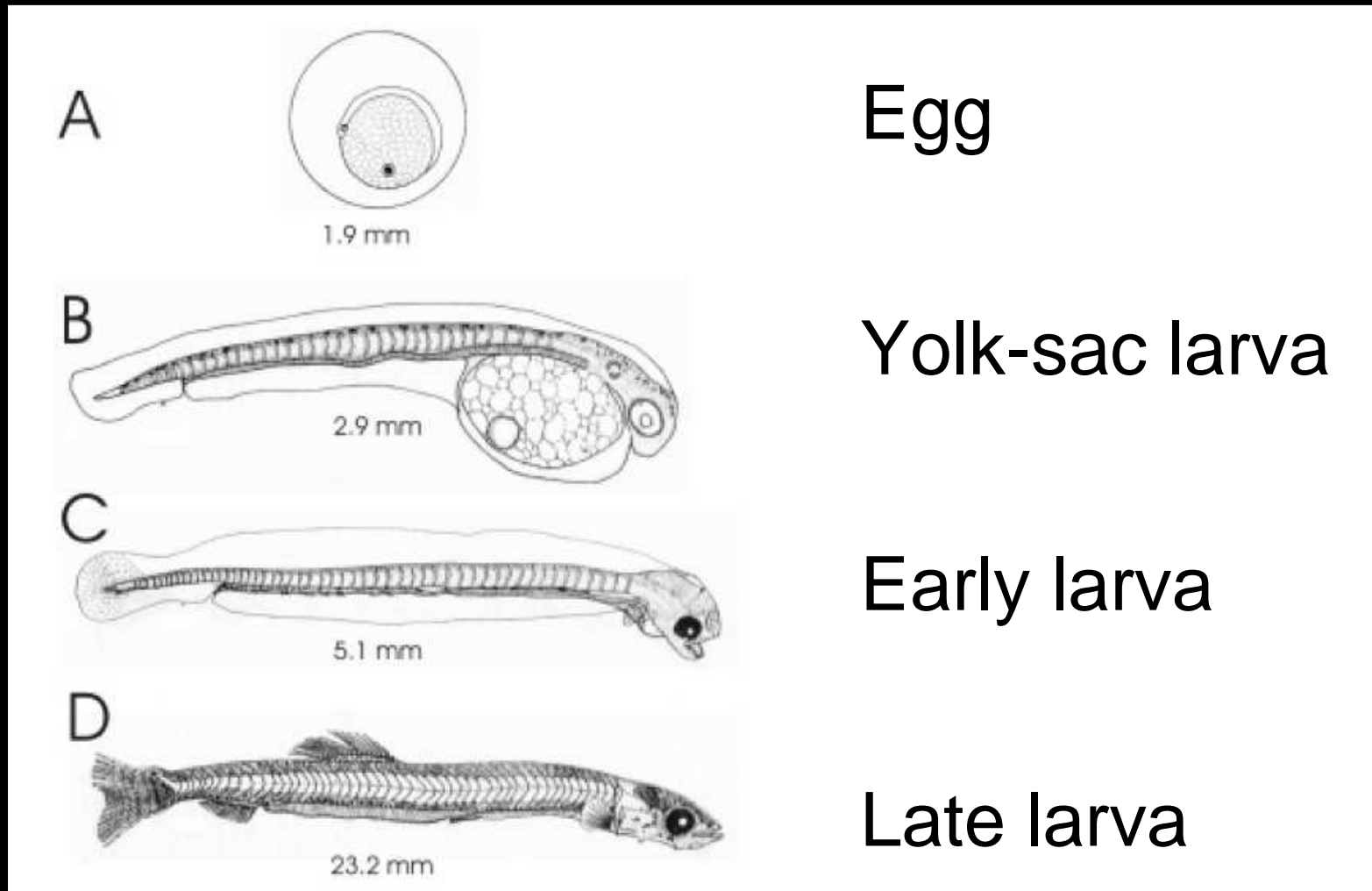


Carr *et al.* (2003)

Marine reserves models

- larval pool vs. explicit dispersal

Ichthyoplankton ontogeny



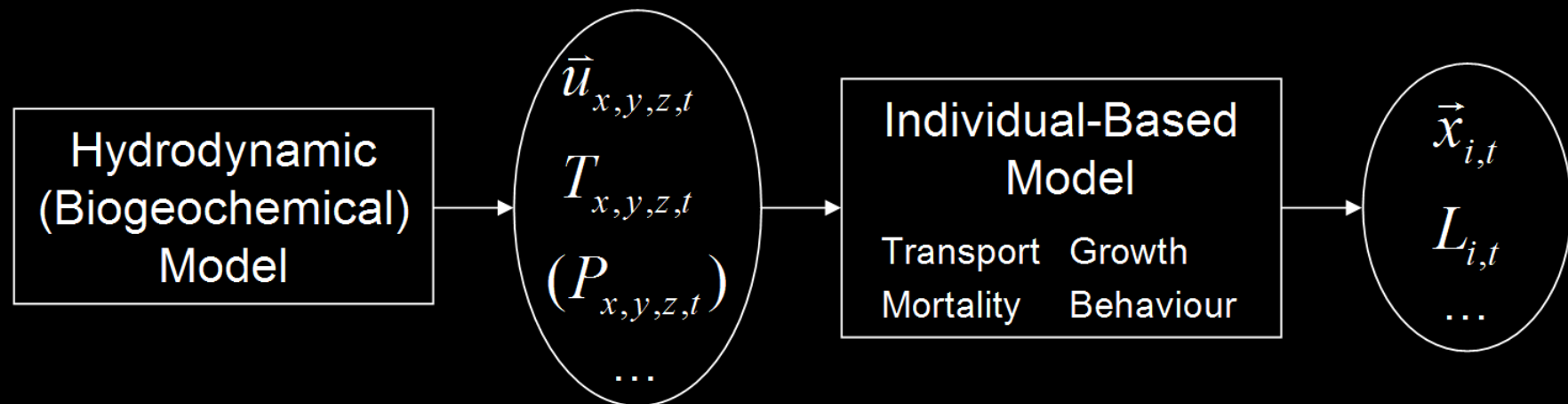
Sardine *Sardinops sagax* early life stages of development (Miller 2006)

Marine reserves models

- larval pool vs. explicit dispersal
- unstructured vs. size/age structured

Modelling larval dispersal

- **Physics: hydrodynamics model**
ROMS Regional Ocean Modeling System
MARS Model for Applications at Regional scale
- **Biology: individual-based model**

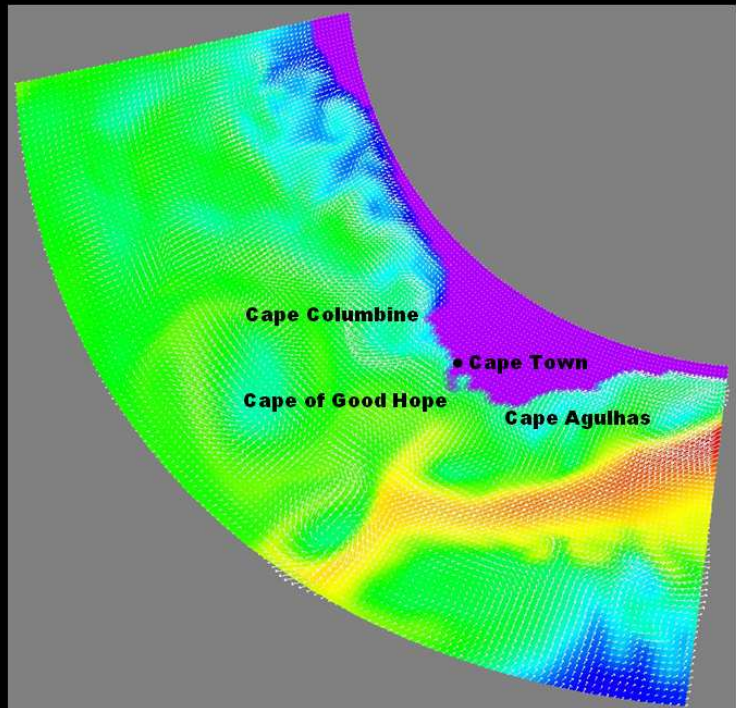


Modelling larval dispersal

- **Transport**
advection + stochastic term
- **Growth**
stage duration, size, or weight = $f(T)$, bioenergetics model
- **Mortality**
constant or function of stage, size, T , ...
- **Behaviour**
buoyancy of eggs, vertical (DVM, function of age, stage, size, ...) and horizontal movement of larvae

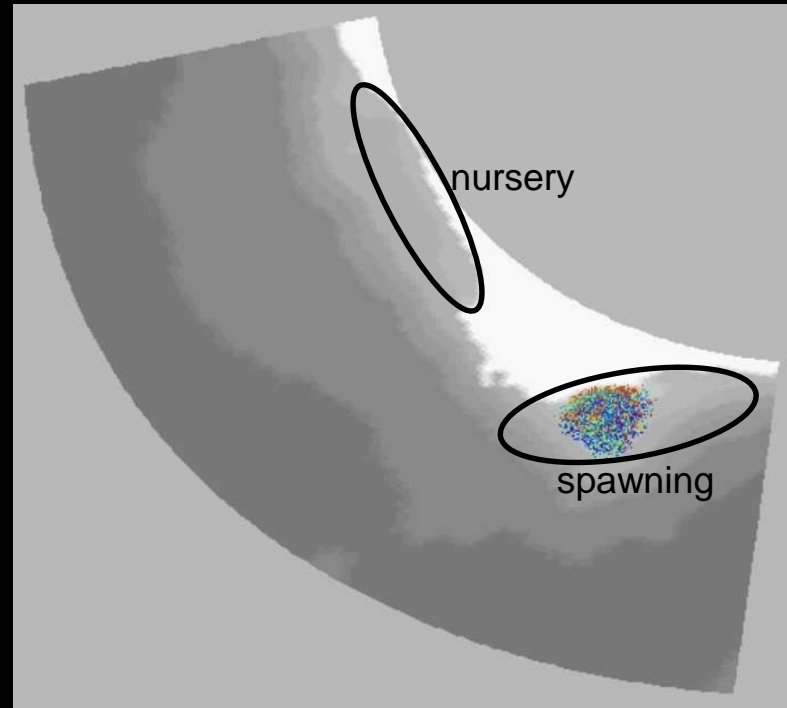
Simulating larval dispersal

Physics Benguela

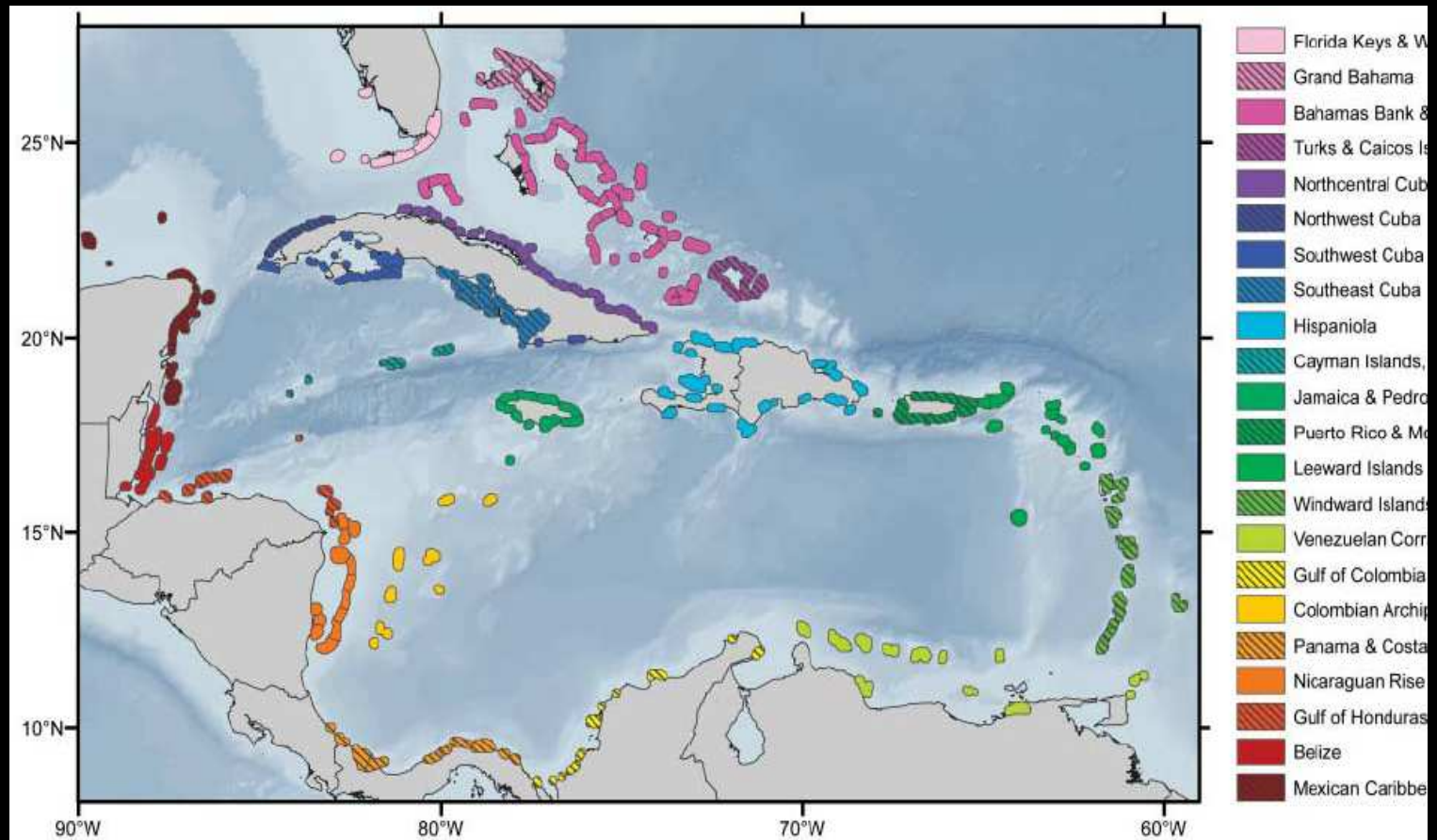


12°C SEA SURFACE TEMPERATURE 22°C

Anchovy dispersal

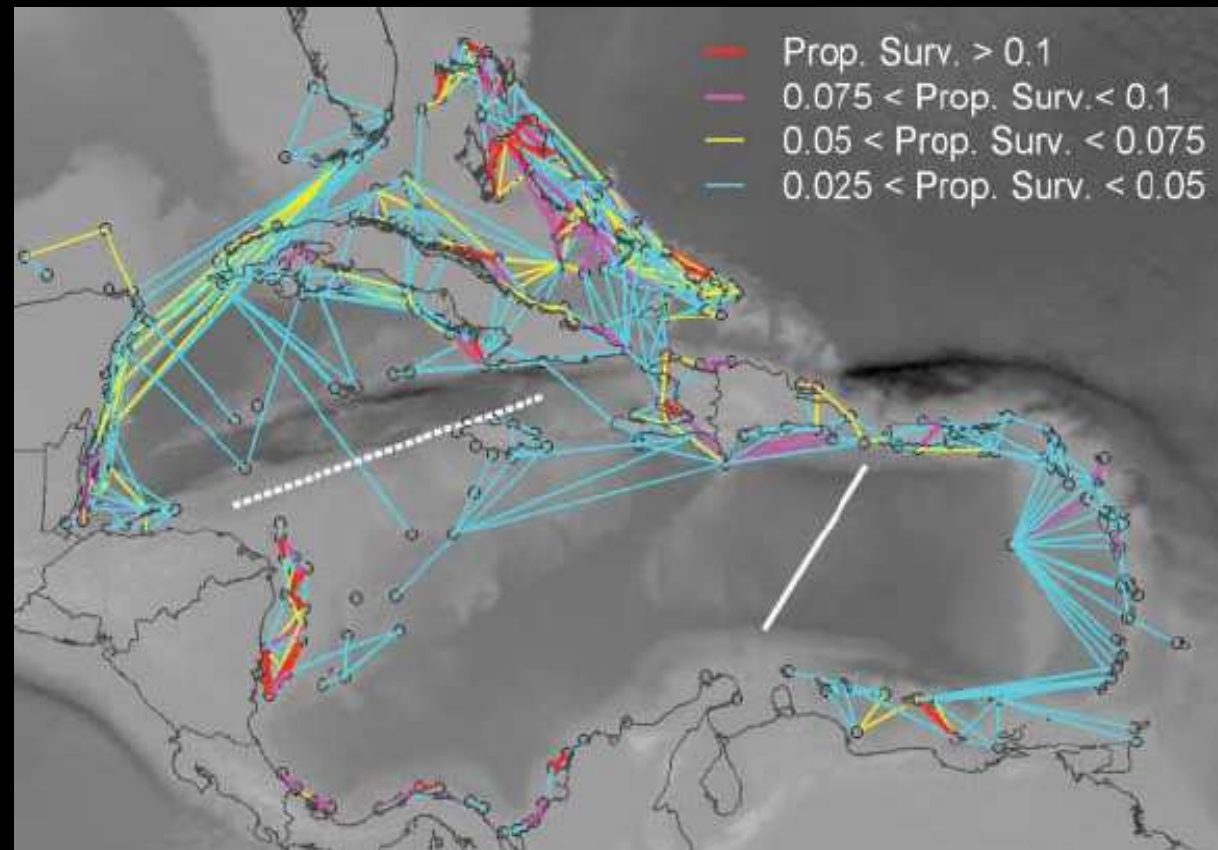


Larval connectivity models



Connectivity of reef fish populations in Caribbean (Cowen *et al.* 2006)

Larval connectivity models

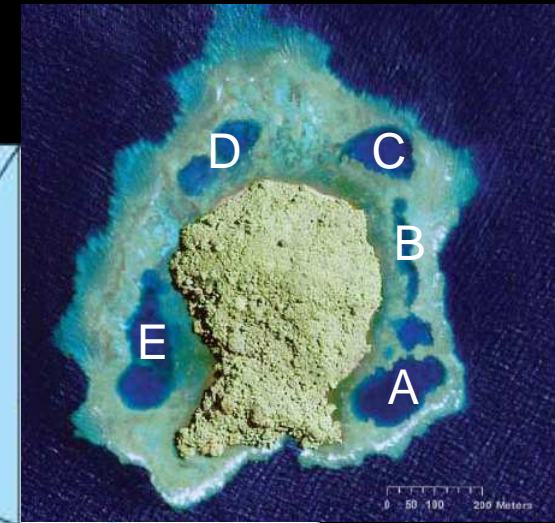
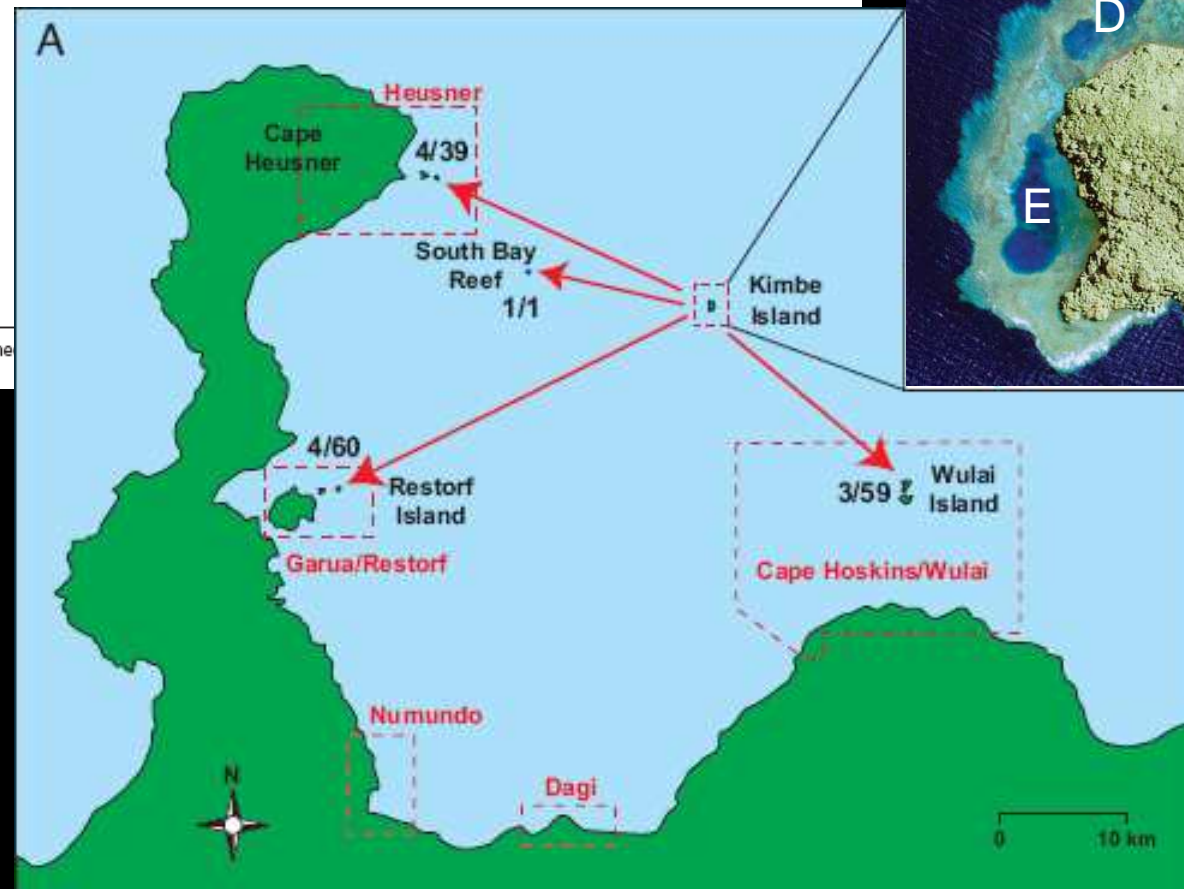


Connectivity of reef fish populations in Caribbean (Cowen *et al.* 2006)

Larval connectivity measures

Settlement lagoon, December 2004 collection					
	A (n = 32)	B (n = 20)	C (n = 11)	D (n = 32)	E (n = 38)
Natal lagoon					
A	12	3	1	1	1
B	3				
C	0				
D	2				
E	0				
	A (n = 29)				
Natal lagoon					
A	5				
B	4				
C	2				
D	3				
E	5				

Lagoon A, 69 anemones (n_{ane}), 125 adults screened
 E, $n_{ane} = 75$, $n_{scr} = 145$.



Jones *et al.* (2005)

Almany *et al.* (2007)

Planes *et al.* (2009)

Need for integrative studies

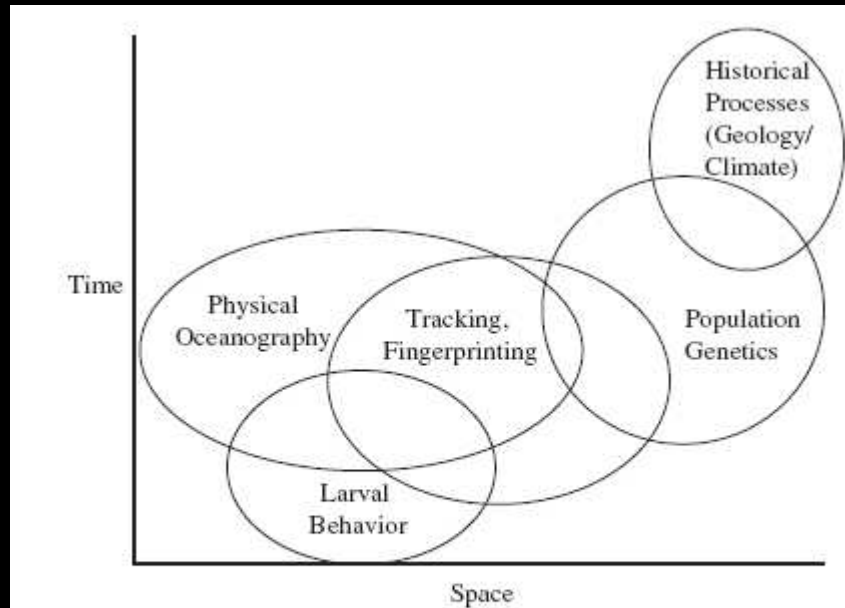


Fig. 3 Time and space scales relevant to different approaches to the study of larval dispersal. A challenge for the future is to integrate these methods.

Levin (2006)

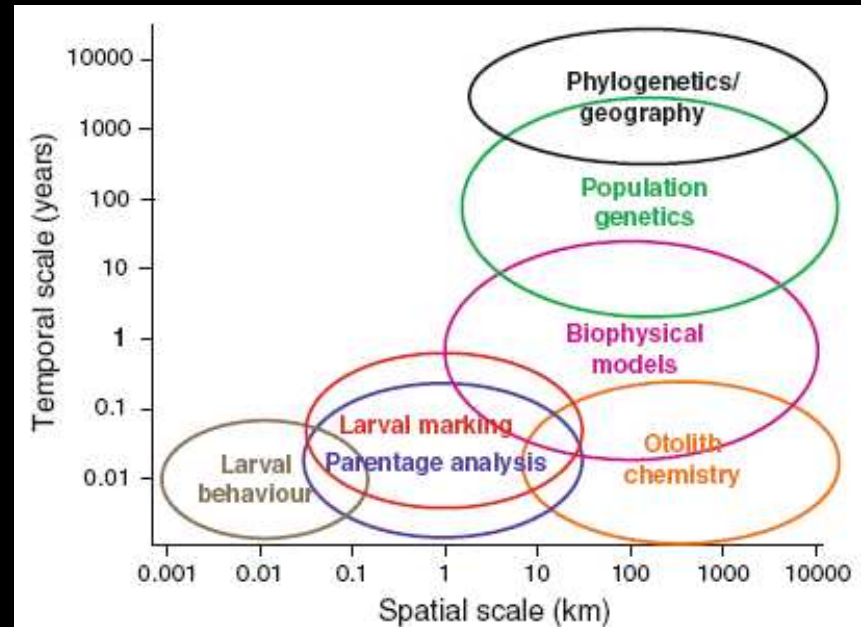


Fig. 3 Schematic view of the spatial and temporal scales over which different approaches and techniques can provide information on larval retention and dispersal in coral reef organisms with pelagic larvae

Jones *et al.* (2009)

Marine reserves models

- larval pool vs. explicit dispersal
- unstructured vs. age/size structured

Terrestrial vs. marine systems

- Main human threat is ...
habitat degradation fishing pressure
- Main goal of reserves is to maintain ...
biodiversity fish biomass

Marine reserves models

- larval pool vs. explicit dispersal
- unstructured vs. age/size structured
- single vs. multi-species
- strategic vs. tactical



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