RITA CASTILHO

MARINE BIOGEOGRAPHY AND EVOLUTION

HISTORICAL BIOGEOGRAPHY

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HISTORICAL BIOGEOGRAPHY

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outline

HISTORICAL BIOGEOGRAPHY

DISPERSAL

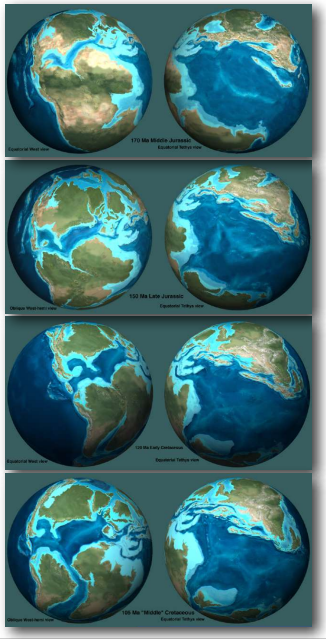
VICARIANCE

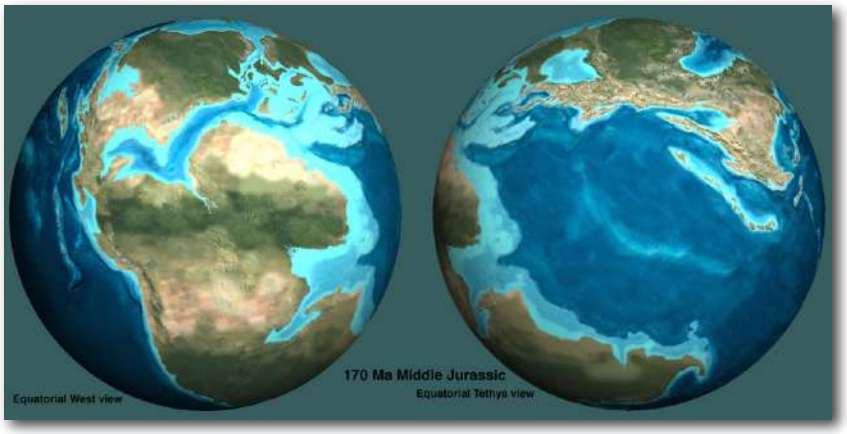
BARRIERS

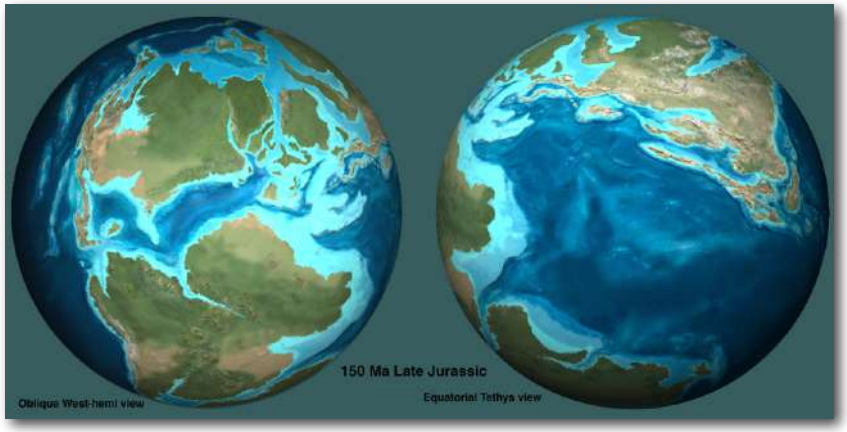
How historical events have affect the biology on the planet?

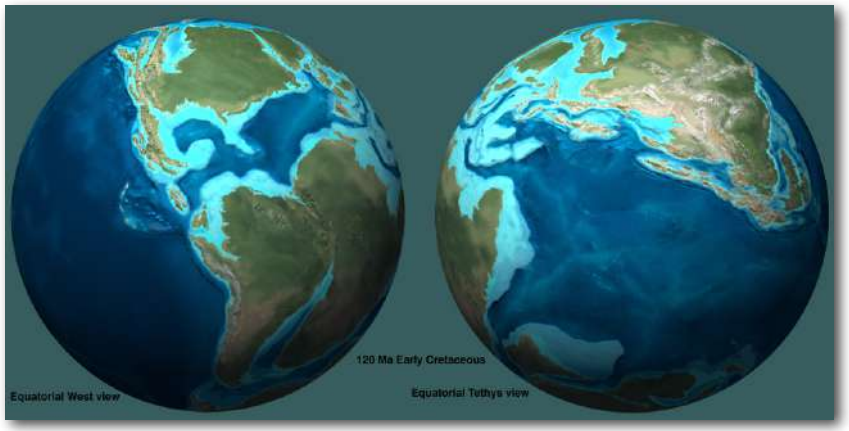
Changing climate and physical conditions

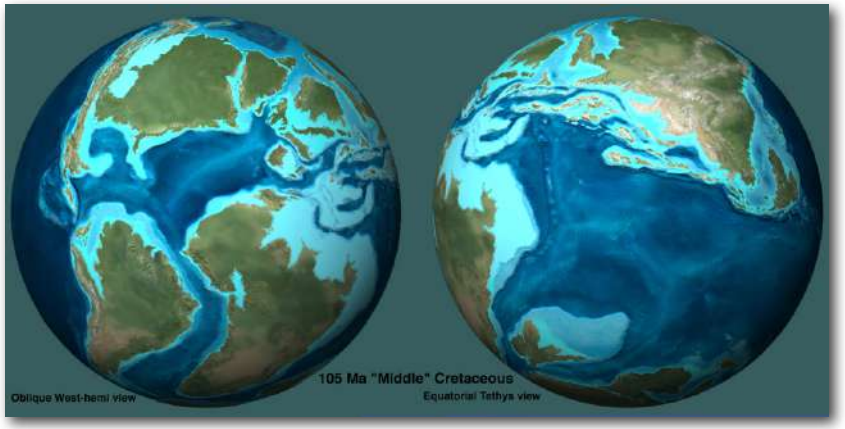
Rearrangements of the continents and ocean basins



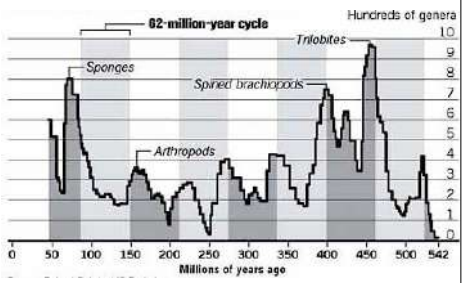

Equatorial West view
170 Ma Middle Jurassic
Equatorial Tethys view

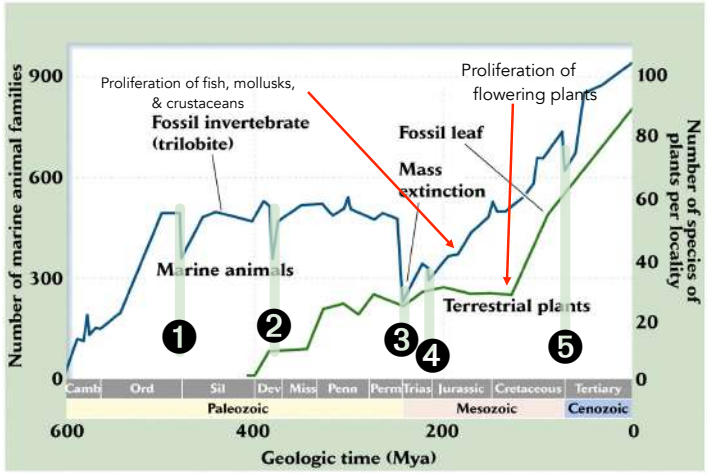

Oblique West-hemi view
150 Ma Late Jurassic
Equatorial Tethys view


Equatorial West view
120 Ma Early Cretaceous
Equatorial Tethys view


Oblique West-hemi view
105 Ma "Middle" Cretaceous
Equatorial Tethys view

Catastrophic collisions with asteroids





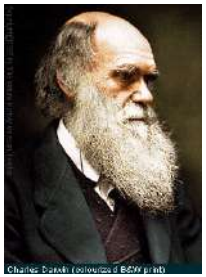
Diversity has generally increased over the past several hundred million years

An **exclusive** focus on local environmental conditions will yield an **incomplete** understanding of diversity

There are several fundamental processes in biogeography

The early "**dispersalists**"

Wallace

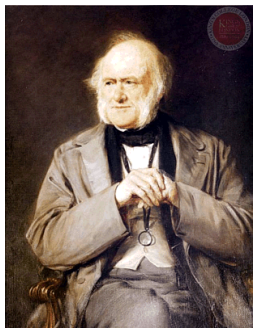


Darwin

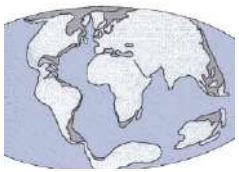
Gray

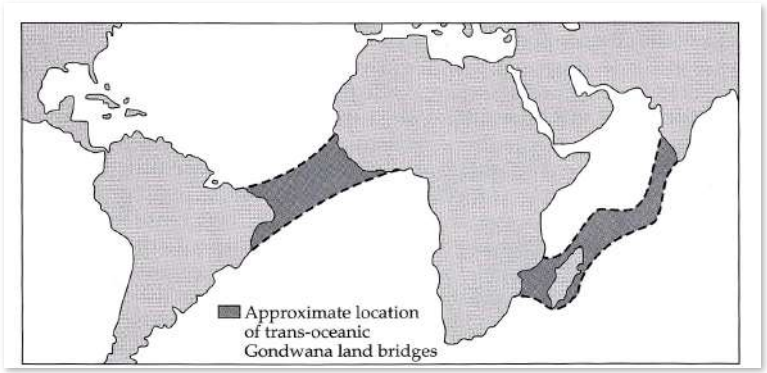
The "**extremists**"

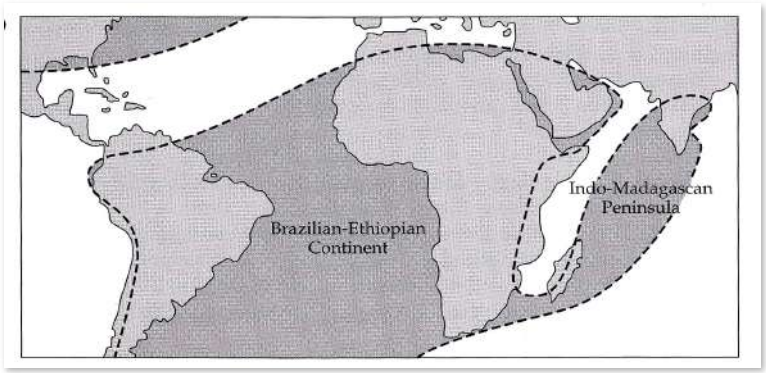
Lyell

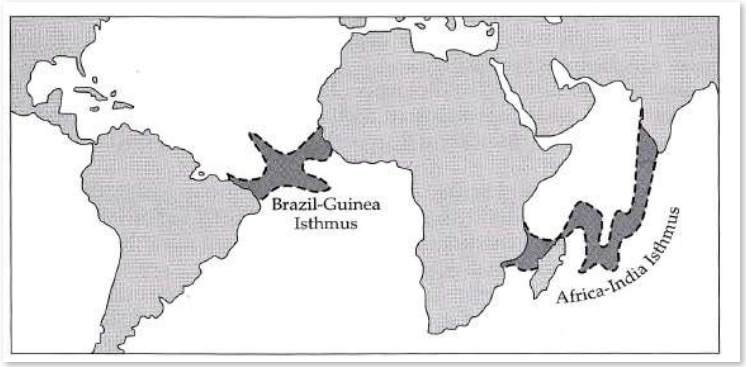


Hooker









"Other authors have thus hypothetically bridged over every ocean and united almost every island with some mainland. If indeed the arguments used by Forbes are to be trusted, it must be admitted that scarcely a single island exists which has not recently been united to some continent.

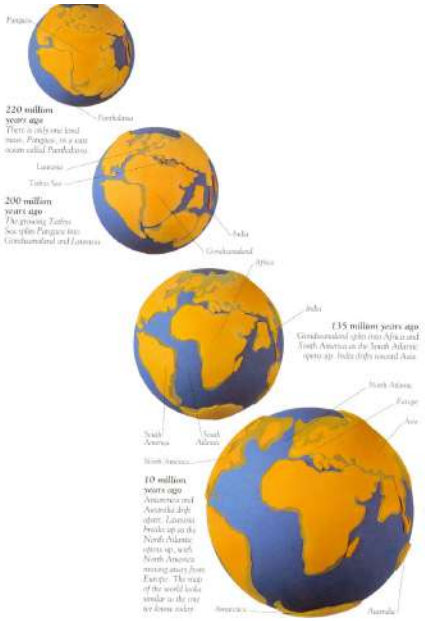
This view cuts the Gordian knot of the dispersal of the same species to the most distant points, and removes many a difficulty; but to the best of my judgement we are not authorized in admitting such enormous geographical changes within the period of existing species."

Darwin, 1859

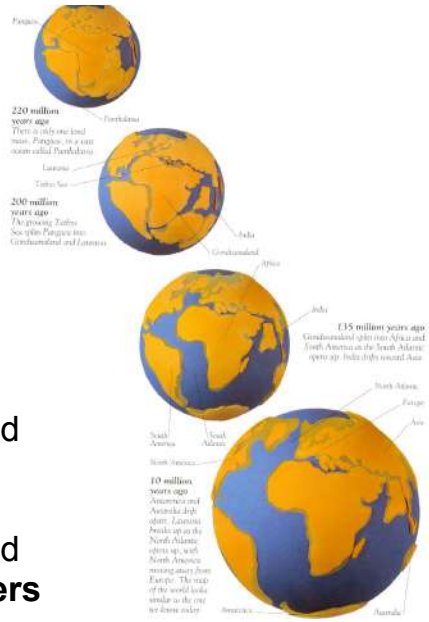
No evidence was ever discovered for the lost corridors proposed by the extensionists

However,

Continental drift theory made a lot of sense

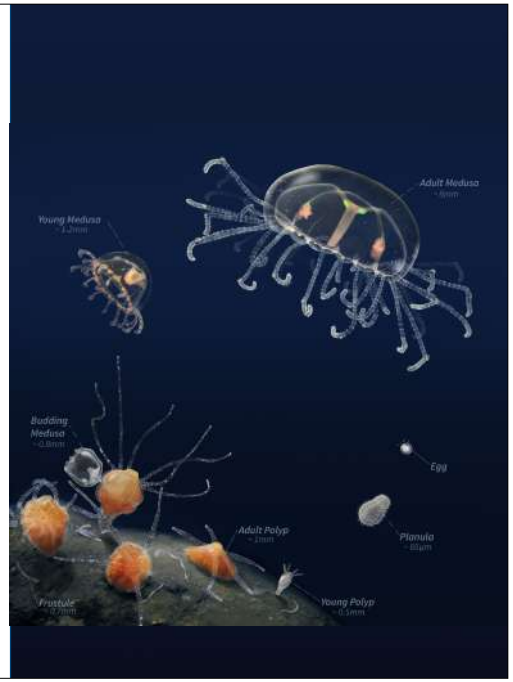


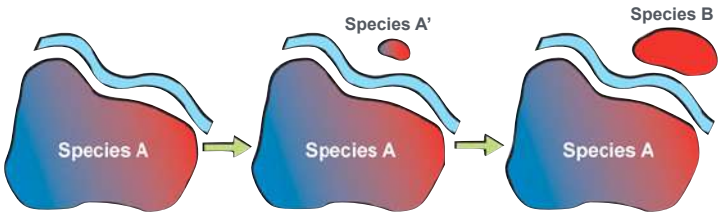
As a result, the debate between **dispersalists** and **extensionists** has been replaced by a debate between **dispersalists** and **vicariance biogeographers**



What is dispersal?

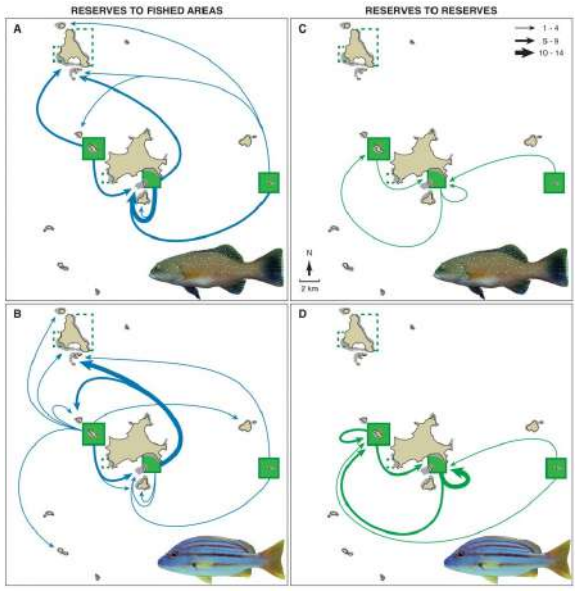
Simply, the movement of organisms away from their birthplace.

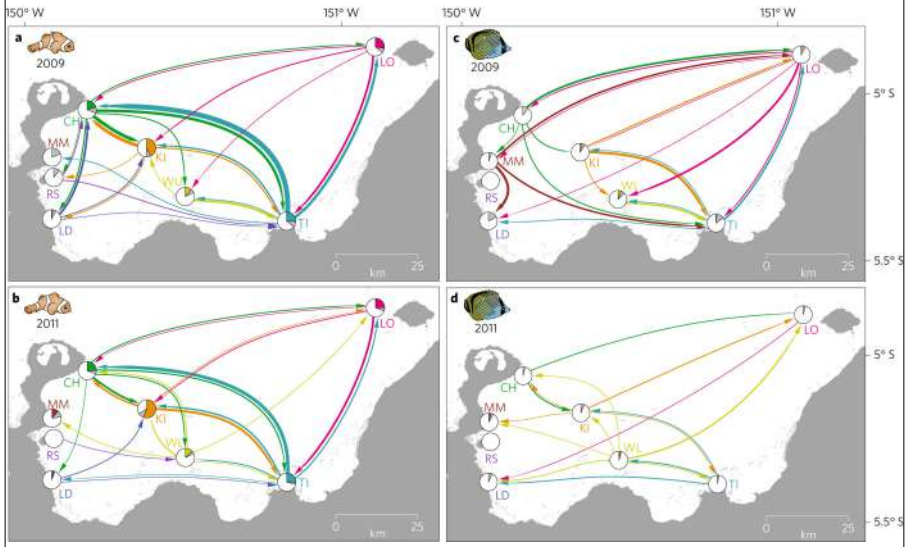




Ancestral population Geographic isolation Speciation

The role of **dispersal** in biogeography





Dispersal and Range Expansion

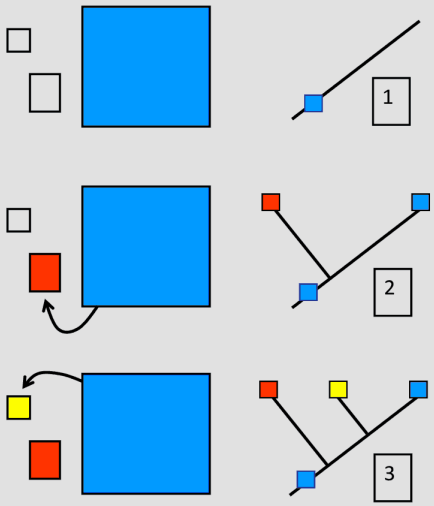
Jump dispersal

Definition:
Movement of individual organisms across large distances of inhospitable, followed by the successful establishment of a population of the original disperser's descendants at the destination.

This usually takes place over a time period less than the life span of the individual and often over inhospitable terrain.

Jump dispersal

A few individuals cross a preexisting barrier and start a new isolated population



From White 2008 Docsity.com

The sheepshead minnow (*Cyprinodon variegatus*)

Estuaries and mangrove swamps throughout the Caribbean

It has been able to colonize these habitats by **dispersing** many hundreds of miles **across ocean water**.

It's ability to tolerate wide ranges of salinity makes this possible.

We can see the same thing over **longer** distances and **greater** time periods for many other archipelagoes.

The Galapagos lie 800 km west of Ecuador in the Pacific Ocean.

We can see the same thing over **longer** distances and **greater** time periods for many other archipelagoes.

The Hawaiian Islands lie 4000 km west of Mexico.

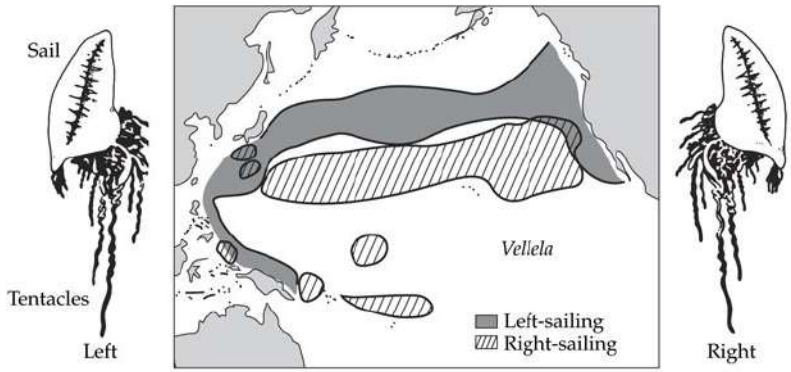
We can see the same thing over **longer** distances and **greater** time periods for many other archipelagoes.

An example can be seen in the rapid recolonisation of Krakatau after all life was wiped out by the volcanic explosion of 1883

Diffusion

Definition:
Diffusion is the gradual movement of populations across hospitable terrain for a period of many generations.
Species that steadily expand their ranges can be said to be diffusing.

Gradual spread of of individuals outward from the margins of a species' range.
It is a slower form of range expansion involving not just individuals, but **populations**.



Velella (by-the-wind sailors)

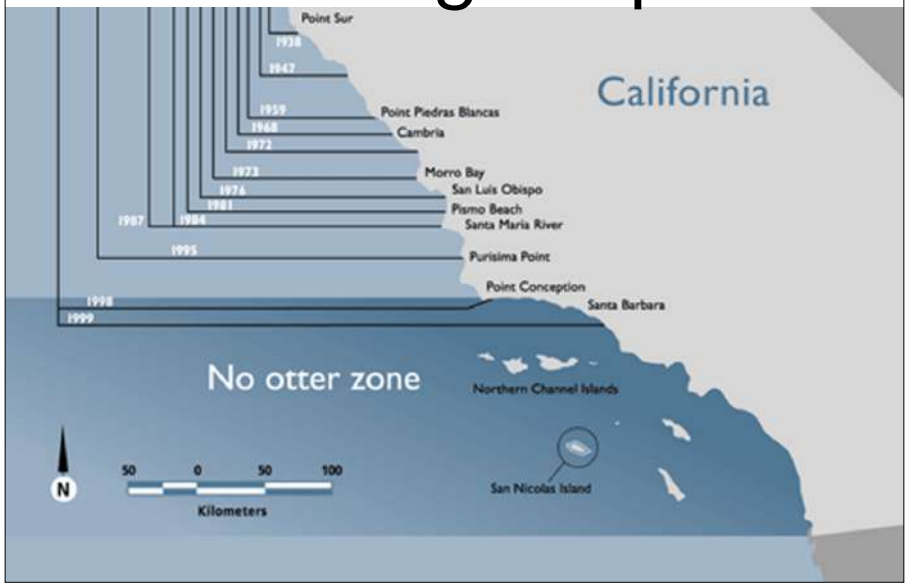
- The photo shows a lefty (backslash) →

LEFT
backslash: \

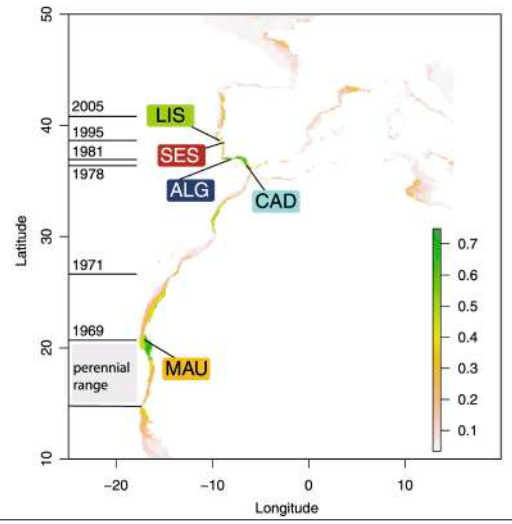
RIGHT
slash: /

Range expansion

Range expansion



Range expansion

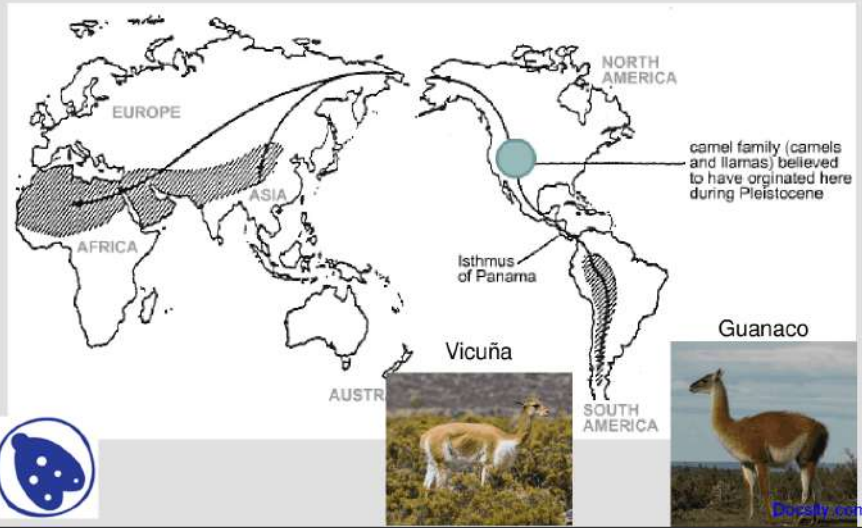


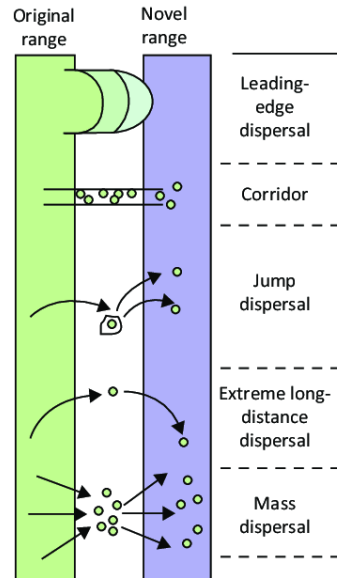
Secular migration

Definition:
Secular migration is diffusion taking place so slowly that the diffusing species undergoes appreciable evolutionary change during the process. The range of the species expands or shifts over long time intervals (thousands or millions of years). The environments themselves may change and natural selection acts on the descendant populations.

Evolutionary divergence through range expansion.
Evolutionary time scale.

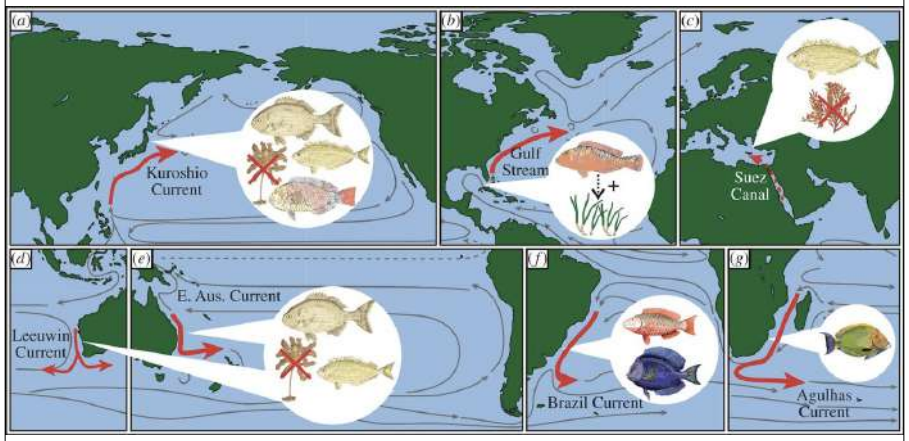
Secular migration - camels





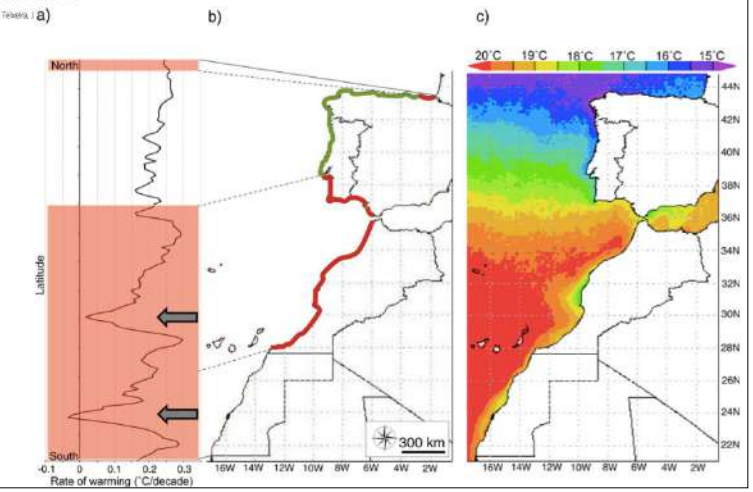
Measey et al (2017) African Biodiversity and Conservation

Range shift

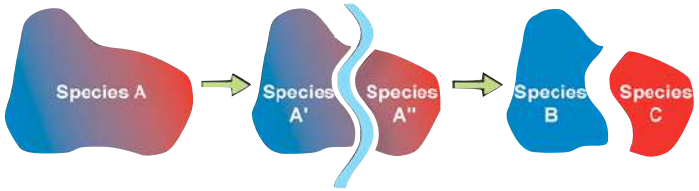


Shift happens

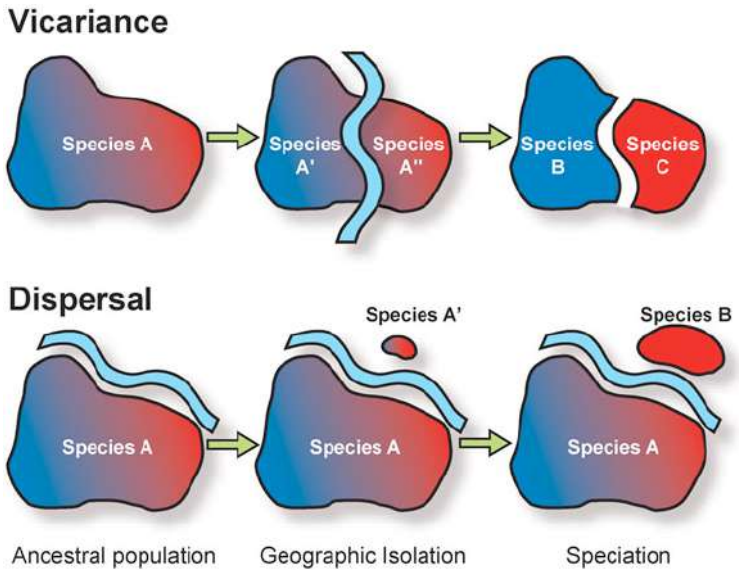
Shift happens: trailing edge contraction associated with recent warming trends threatens a distinct genetic lineage in the marine macroalga *Fucus vesiculosus*



Vicariance



Ancestral population Geographic isolation Speciation



BARRIERS

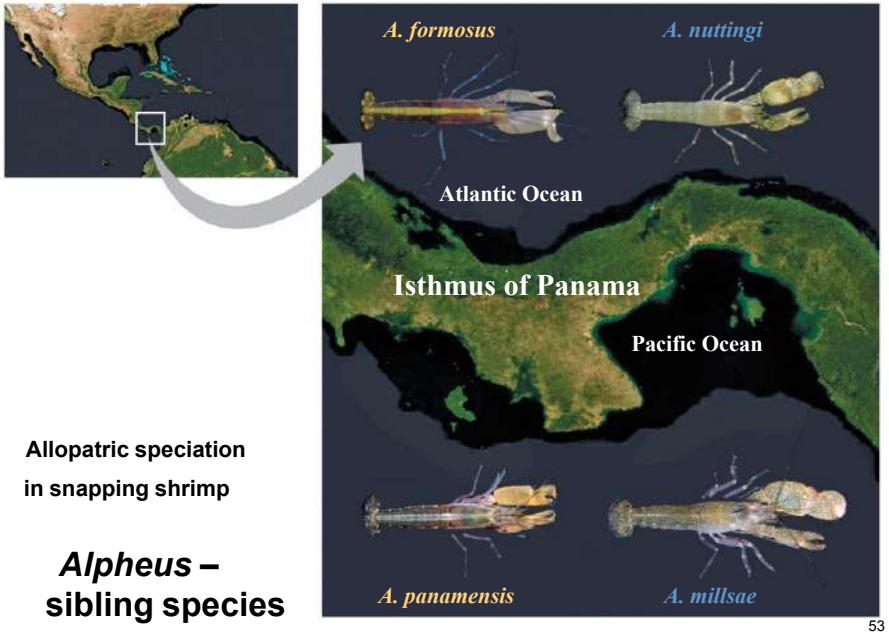
The nature of long-distance dispersal means that organisms often have to survive for periods of time in environments that are hostile to them.

These environments constitute physical and biological barriers to dispersal.

The effectiveness of such barriers in preventing dispersal depends not only on the nature of the barrier, but also on the organism dispersing.

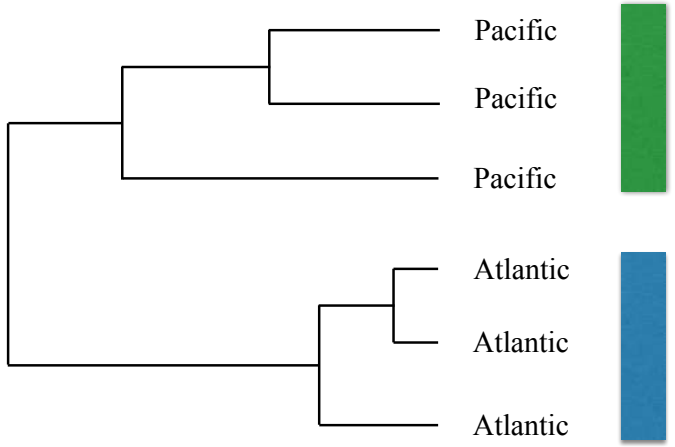
VICARIANCE

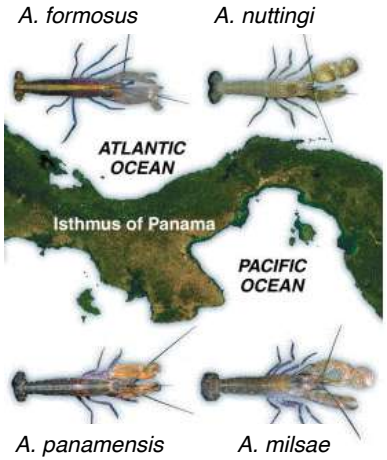
- Split ~150 "geminate" (twin) species

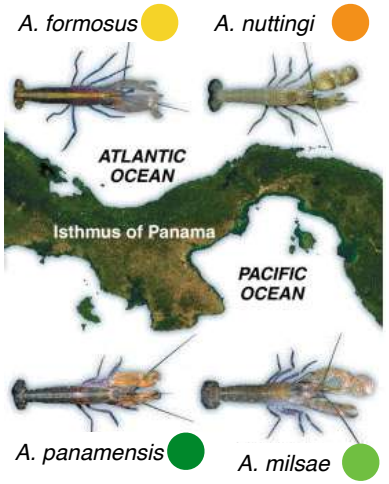


Allopatric speciation in snapping shrimp

***Alpheus* – sibling species**




A. formosus
A. nuttingi
ATLANTIC OCEAN
Isthmus of Panama
PACIFIC OCEAN
A. panamensis
A. milsae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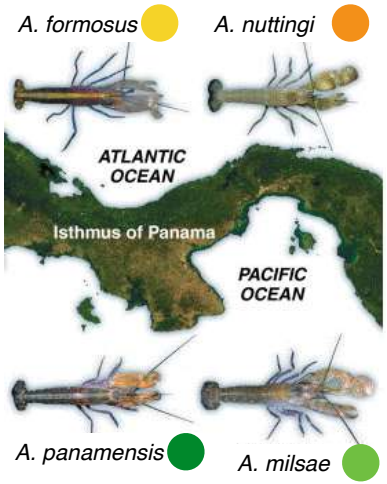
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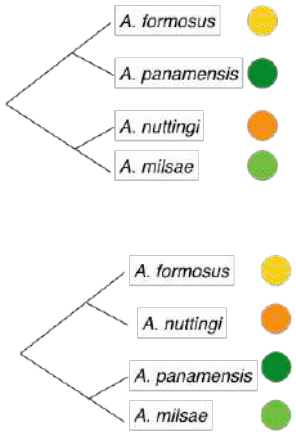
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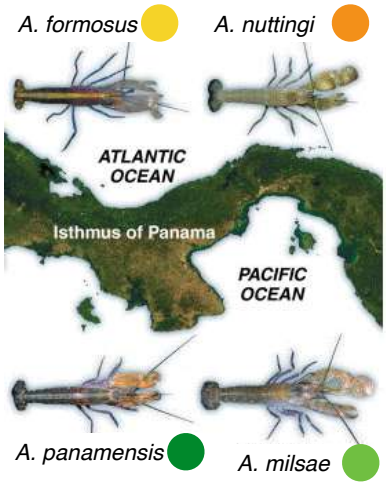
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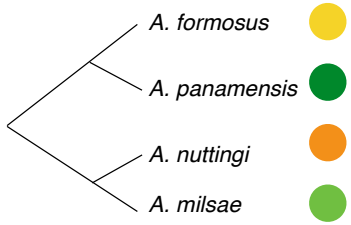
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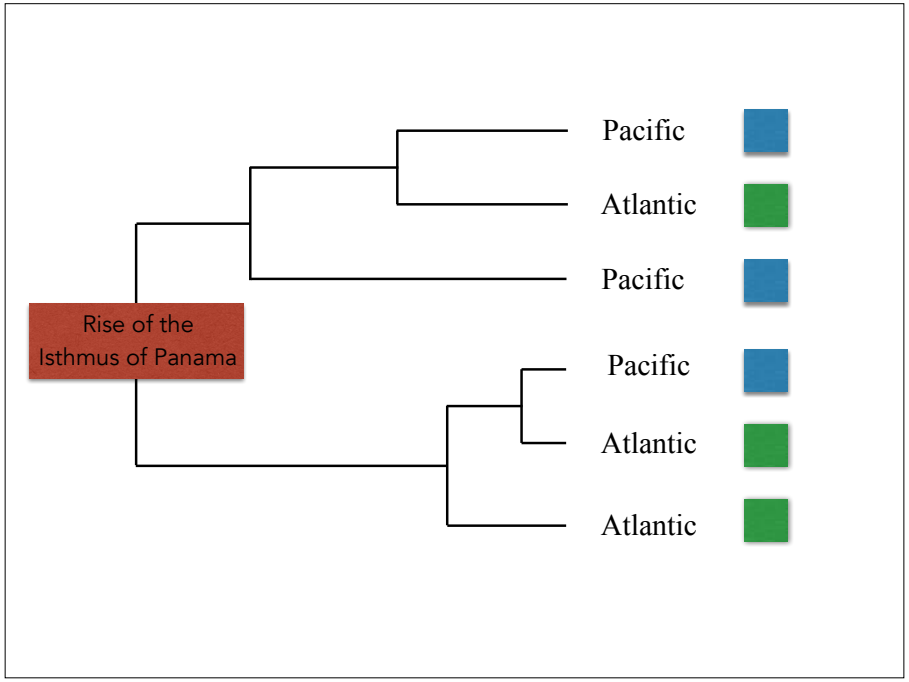
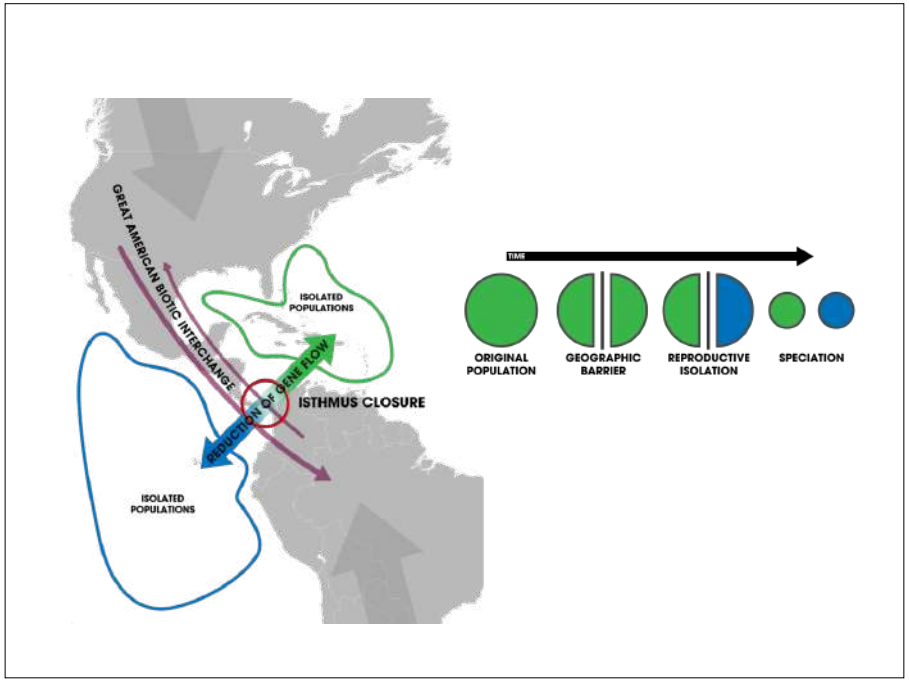


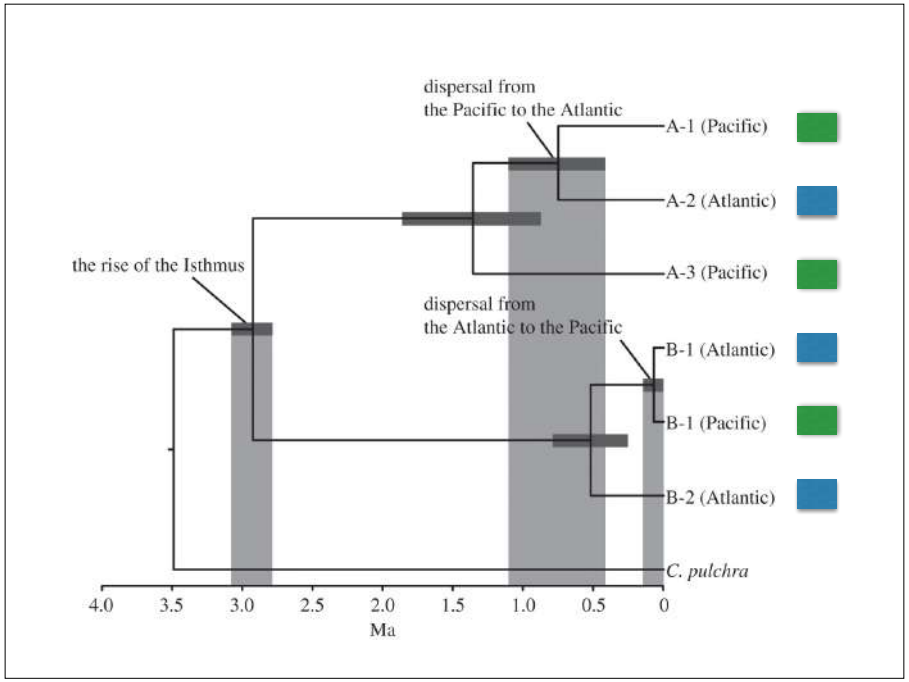


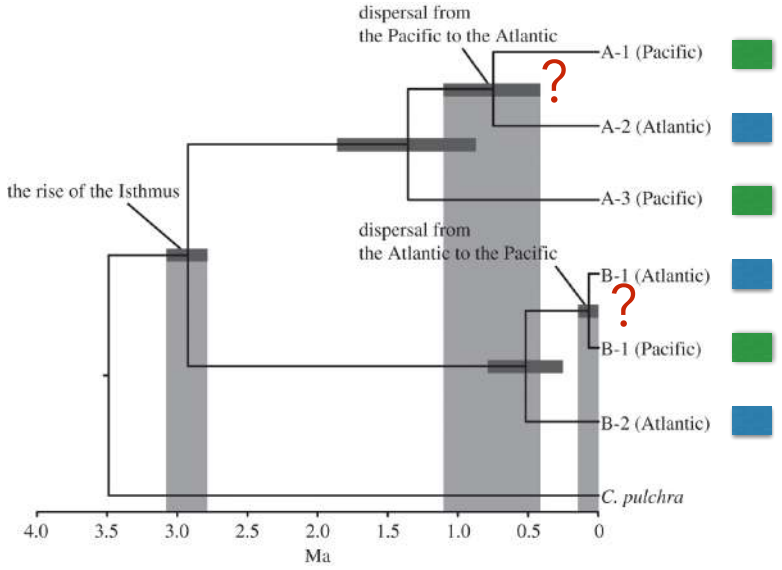
PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2012) **279**, 1061–1067
doi:10.1098/rspb.2011.1599
Published online 14 September 2011

Flying shells: historical dispersal of marine snails across Central America

Osamu Miura[1,2,*], Mark E. Torchin[1], Eldredge Bermingham[1], David K. Jacobs[3] and Ryan F. Hechinger[4]





Charles Darwin first postulated that invertebrates, including marine snails, could be dispersed long distances by birds. However, in contrast to terrestrial and fresh water invertebrates, there is little evidence for this for marine animals.

Our genetic evidence coupled with evidence from field studies provide a conservative estimate that marine snails crossed Central America on two separate occasions, established their alleles, which subsequently spread along both coasts.

This suggests that not only is such passive dispersal possible for marine organisms, but that it can occur across seemingly insurmountable barriers.

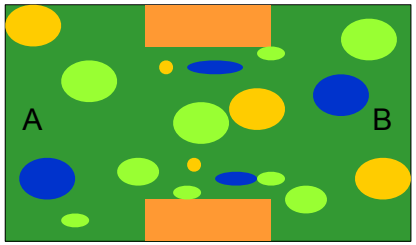
Biotic Exchange and Dispersal Routes

Biogeographers often distinguish three kinds of dispersal routes based on how they effect biotic interchange.

1. **Corridors**. Allow dispersal by permitting movement.
2. **Filters**. Conditions fall outside range of physiological tolerance. Restrictive dispersal pathway. Conditions restrictive to some species, not others. Can be biotic or abiotic.
3. **Sweepstakes routes.** Hazardous or accidental dispersal mechanisms by which animals move from place to place. The standard examples are island hopping and natural rafts.

DISPERSAL: OVERCOMING BARRIERS

Dispersal corridor



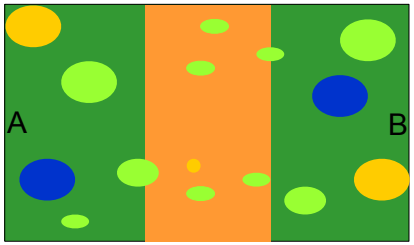
wide variety of corridor habitats

dispersal from A to B easy

Allow dispersal by permitting movement

DISPERSAL: OVERCOMING BARRIERS

Dispersal filter



Limited array of corridor habitats

dispersal from A to B difficult, only certain species

Conditions fall outside range of physiological tolerance.

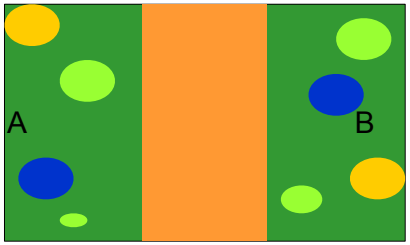
Restrictive dispersal pathway.

Conditions restrictive to some species, not others.

Can be biotic or abiotic.

DISPERSAL: OVERCOMING BARRIERS

Sweepstakes dispersal



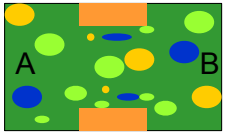
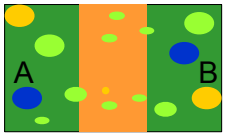
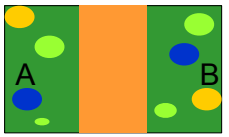
No corridor habitats

Very occasional migrants

Hazardous or accidental dispersal mechanisms by which animals move from place to place.

The standard examples are **island hopping** and **natural rafts**.

DISPERSAL: OVERCOMING BARRIERS

		corridor habitats	A to B dispersal
dispersal corridor		**wide variety**	**easy**
dispersal filter		**limited array (oases)**	**difficult; only certain organisms make it**
sweepstakes dispersal		**none**	**occasional migrants**

outline

HISTORICAL BIOGEOGRAPHY

DISPERSAL

VICARIANCE

BARRIERS

DISPERSAL VS MIGRATION

DISPERSAL VS MIGRATION

Dispersal: *unintended/rarer* movements

Dispersal vs Migration

Dispersal: *unintended/rarer* movements

Migration: *periodic* movements

Migration

Feeding Migration

Spawning Migration

Recruitment/Juvenile Migration

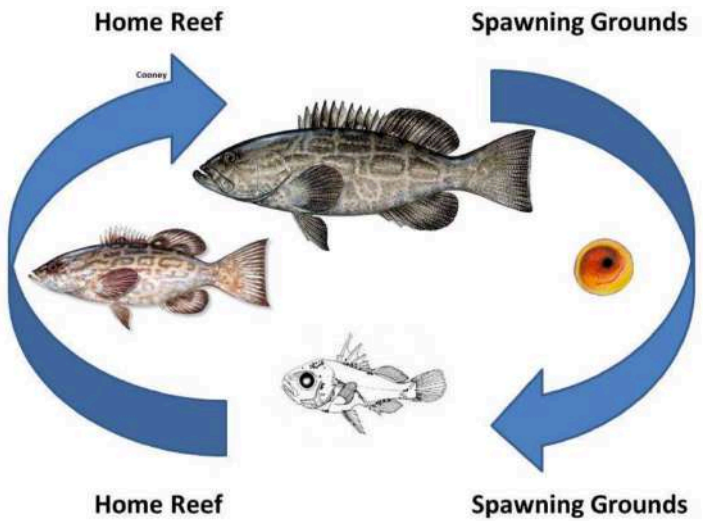
Seasonal Migration

Migration

Many types of fish migrate on a regular basis, on time scale ranging from daily to annually or longer

Travel over distances ranging from a few meters to thousands of km.

Oceanodromous



OCEANODROMOUS

Truly migratory marine fish.

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Travel long distances with in sea to spawn & return to the feeding areas.

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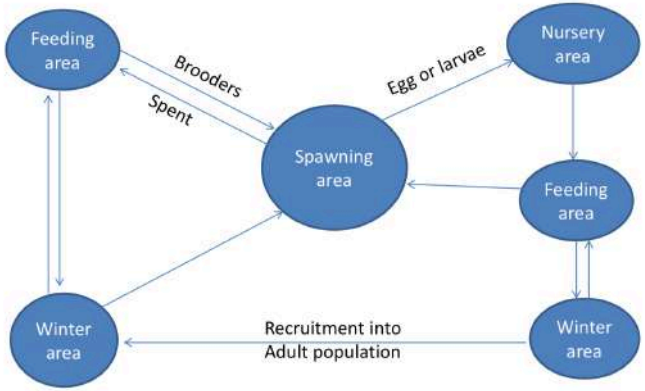
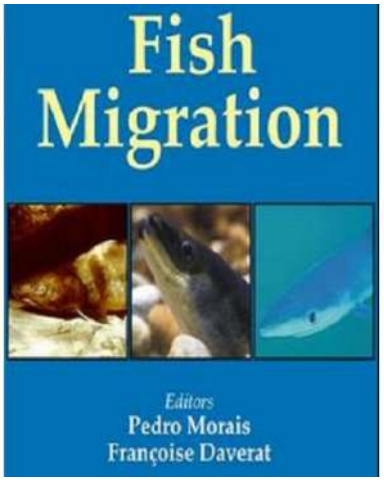
OCEANODROMOUS

Showing pattern of movements in Oceanodromous fish migration



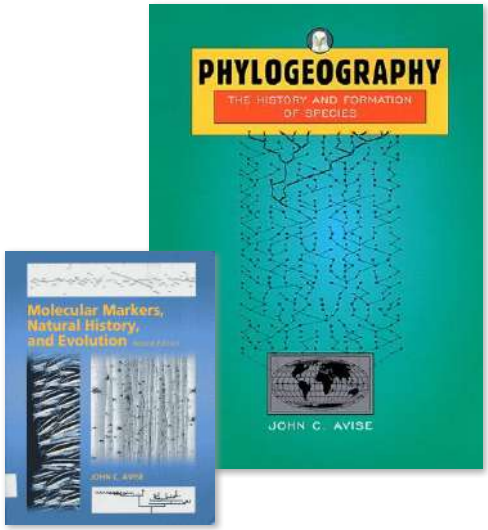


Phylogeography or historical biogeography

Phylogeography

Avise coined the term in 1987.

"Study of the principles and processes governing the geographic distributions of genealogical lineages, including those at the intraspecific level, on the basis of molecular data."



outline

HISTORICAL BIOGEOGRAPHY

DISPERSAL

VICARIANCE

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