

# COMPARATIVE PHYLOGEOGRAPHY OF THE OCEAN PLANET

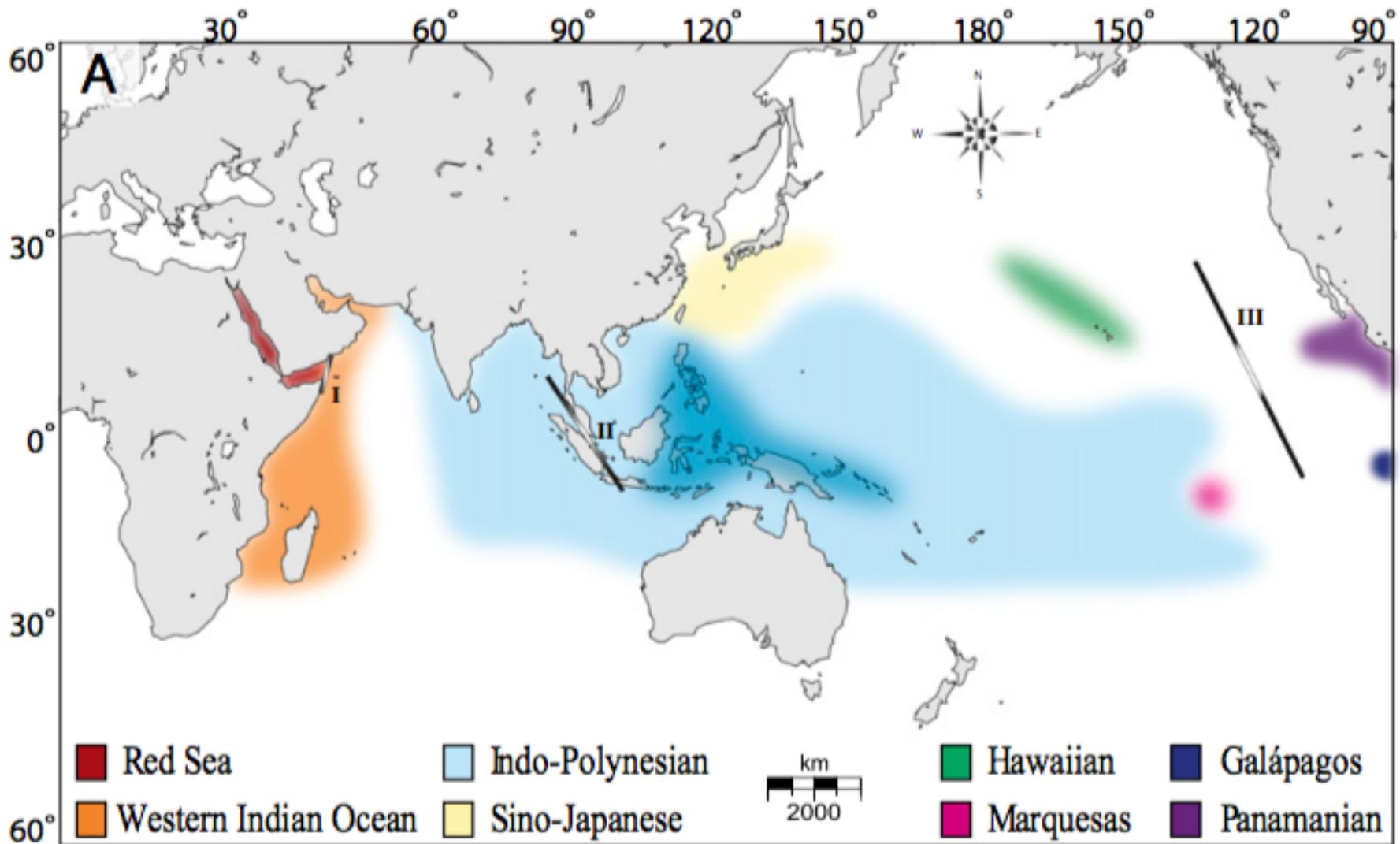
KALSI HEIMDAL

# PURPOSE OF THIS ARTICLE

- To understand how geography, oceanography, and climate have shaped marine biodiversity
- To give examples of comparative phylogeography from various provinces that show the origins of marine biodiversity
- Having an understand of where new species originate within endemism centers and biodiversity hotspots can aid in developing and prioritizing conservation efforts for the ocean

# THINGS TO KEEP IN MIND

- Phylogeography: the study of the historical processes that may be responsible for the geographical distributions of individuals
- Endemism: a species being unique to a defined geographical location
- Biogeographic provinces are identified by consistent shifts in species composition – each is a center of origin for new species



(A) Tropical biogeographic provinces of the Indo-Pacific (as defined by >10% endemism)

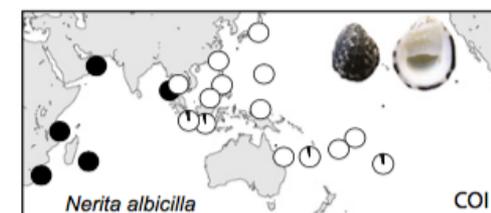
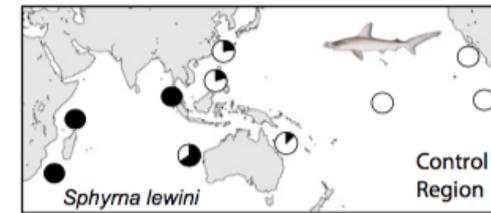
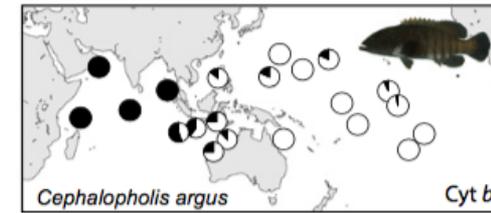
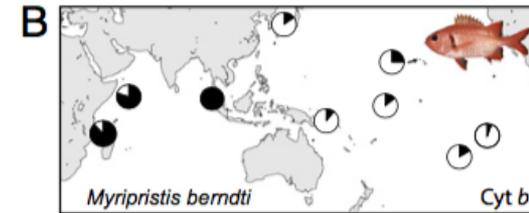
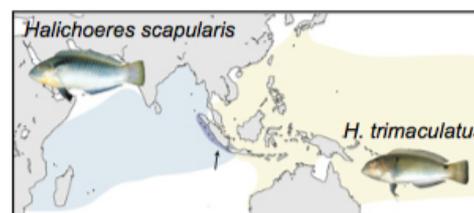
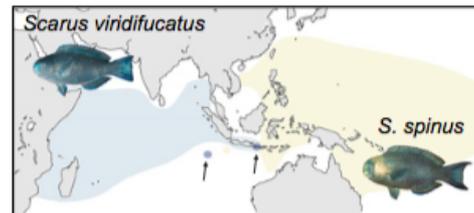
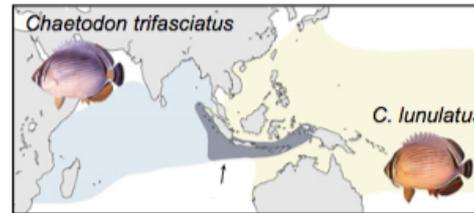
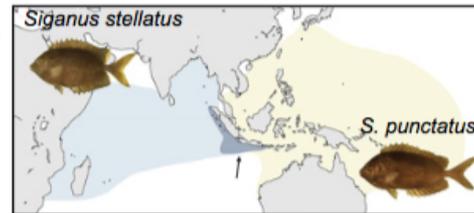
I: Red Sea Barrier

II: Indo-Pacific Barrier

III: East Pacific Barrier

# BIOGEOGRAPHIC PROVINCES - TROPICAL OCEANS

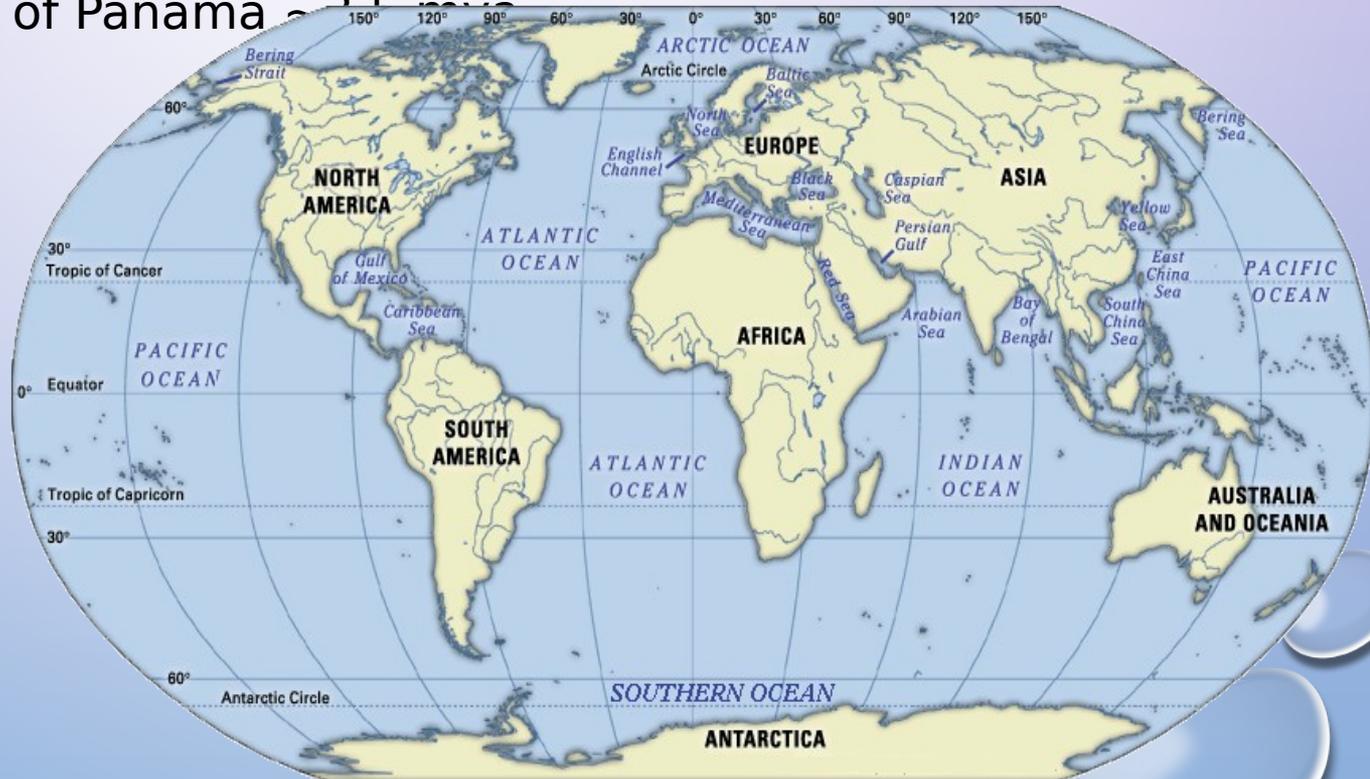
- Consists of the Caribbean, the Coral Triangle, Hawaii, and the Red Sea
- Coral triangle: has been a stable reef habitat for tens of millions of years
- Indo-Pacific Province (IPP): large, shallow habitat that spans about half the planet
  - Indo-Pacific Barrier
- Red Sea: many endemics of this area have sister species in the Western Indian Ocean, some of which have lineages older than those in the Indian Ocean



A: gray area shows areas of sister species overlap  
 B: black and white circles show distribution of mtDNA mutations (difference of at least 3 mutations)

# BIOGEOGRAPHICAL PROVINCES - ATLANTIC & INDO-PACIFIC CONNECTIONS

- Two geological events isolated the tropical Atlantic from the Indo-Pacific
  - Closure of the Tethys Sea ~13 mya
  - Rise of Isthmus of Panama ~2.5 mya
- Infrequent dispersal around southern Africa is the main route for colonization between the Indo-Pacific and Atlantic Oceans



# BIOGEOGRAPHICAL PROVINCES – TEMPERATE AND POLAR SEAS

- Glacial cycles have repeatedly disrupted the fauna of the sub-Arctic shelf
- The North Pacific and North Atlantic waters create barriers
  - North Pacific taxa at higher latitudes (NW and NE) vs mid-latitudes (only one side)
  - Populations on either side of the North Atlantic were isolated during glacial episodes, so a range of genetic divergences are present
- The Arctic biogeographic province (~2.5 myo) provides a route for genetic exchange between the N. Atlantic and N. Pacific
- The Antarctic biogeographic (~25 myo) province has high endemism

# PATTERNS WITHIN BIOGEOGRAPHICAL PROVINCES

- More population structure is shown between endemic species in a confined province than in a widespread species
- Pelagic species have less predictable genetic structure compared to the strong genetic structure in species that lack pelagic development
- Within shallow water provinces, species commonly share genetic breaks at geological features or geographical regions
- Genetic breaks are often seen in species that show genetic structure

# TAXON SPECIFIC PATTERNS

- Antitropic taxa: sister species separated by the tropics
  - Some of these cold-adapted species can cross the tropics, even though the waters should be lethal to them
- Cetaceans: because of their wide variety of life history traits, their gene flow patterns vary greatly
- Sea turtles: population structure within ocean basins is due to natal homing
- Pelagic fishes: have strong genetic structure between the Atlantic and Indo-Pacific, but little to none between ocean basins
- Plankton: in the pelagic zone, habitat selection may be a primary force driving speciation instead of physical barriers

# TERRESTRIAL VS MARINE PHYLOGEOGRAPHY

- There are fewer barriers in the ocean, so there is more potential for dispersal
- Evolutionarily, terrestrial organisms have more chance of speciation, while marine species remain more conserved
- Both use the same processes (isolation, selection, adaptation, speciation), but they have different outcomes

# CRITIQUES AND CONCLUSIONS

- They did not research the Atlantic, Caribbean, or Mediterranean
- Biodiversity hotspots and endemism centers produce and export evolutionary lineages
- Species distributions are shaped by factors such as temperature tolerances, glaciation, and physical barriers
- More confined, shallow provinces have higher endemism
- The age of a province can influence the amount of biodiversity and endemism

# BIBLIOGRAPHY

- [HTTP://WWW.GLOBALCITYMAP.COM/WORLD/IMAGES/WORLD-OCEAN-MAP.GIF](http://www.globalcitymap.com/world/images/world-ocean-map.gif)
- Bowen, B. et al (2016). Comparative phylogeography of the ocean planet. *PNAS*, 113(29): 7962-7969.