Genetic Evidence for West to East Movement by Florida Manatees Through a South Florida Migration Corridor

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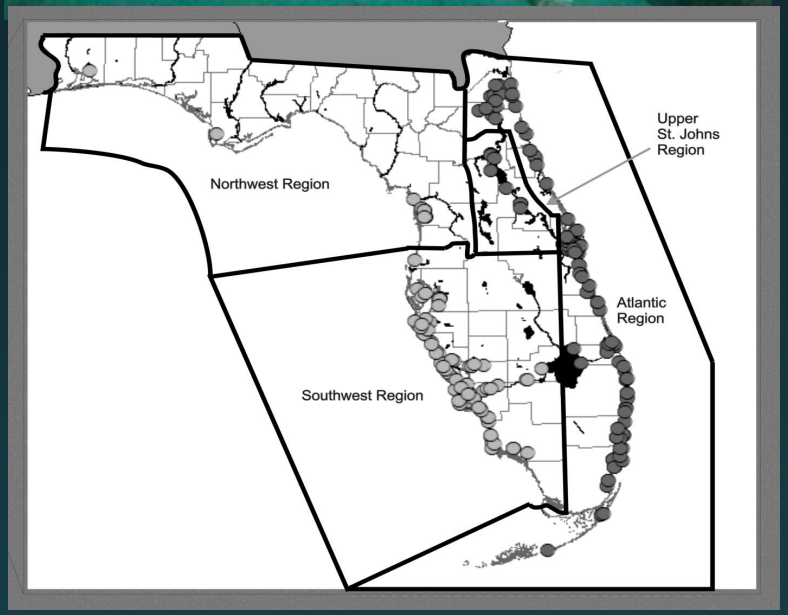
U.S. Department of the Interior
U.S. Geological Survey

Florida manatee

- Endangered
- Census size
  - 1200 (1991)
  - 4800 (2011)
- Threats
  - 25% deaths due to water craft (1970's-today)
  - Perinatal, Red tide, Cold stress
    - 2010: 766 deaths; 282 CS



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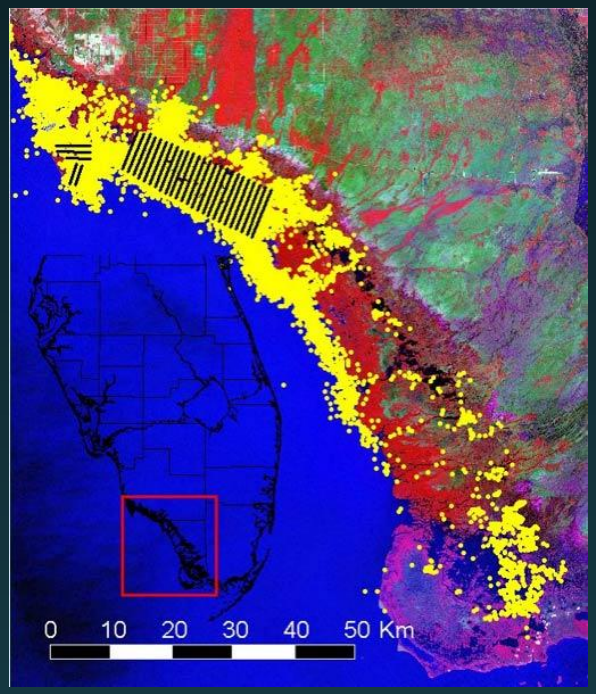
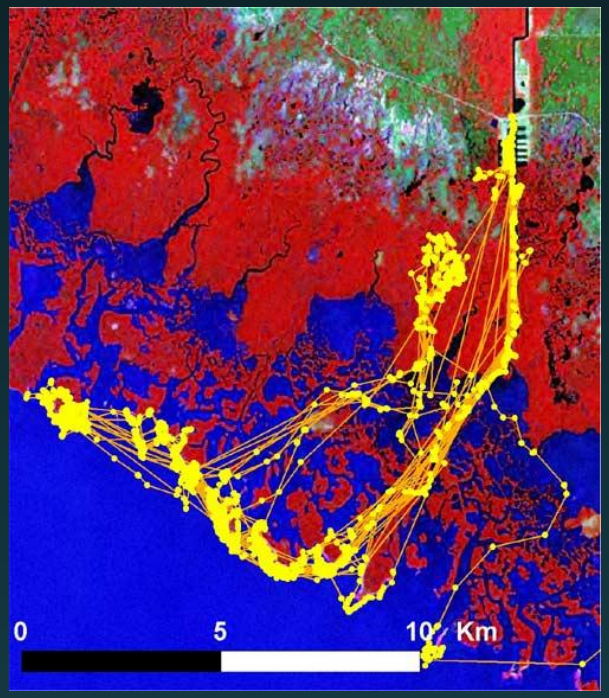
Southwest MU: Everglades region

- 10,000 Islands to Florida Bay
- Ocean, estuaries, and inland creeks





Modeling Manatee Response to Restoration in the Ten Thousand Islands and Everglades National Park. Bradley M. Stith, James P. Reid, and Susan M. Butler , First National Conference on Ecosystem Restoration (NCER), 2004, Orlando, Florida

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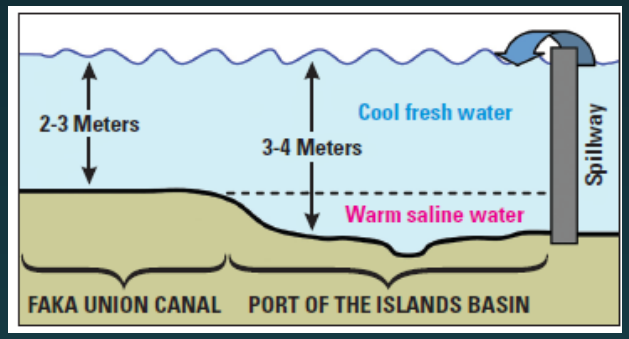
Southwest region

- Most difficult to quantify population size and estimate survival rates
  - Demographic data are lacking for the Everglades region
  - Population decline over time and 11.9% extinction probability within 100 years (Runge et al. 2007)
    - High mortality rate (Red tide)
    - Loss of warm water effluents



Langtimm, C.A., Swain, E.D., Stith, B.M., and others, 2009, Integrated Science: Florida Manatees and Everglades Hydrology: U.S. Geological Survey Fact Sheet 2009-3002

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Florida manatee conservation genetics tools

- Genetic diversity – bottlenecks and inbreeding
- Effective population size – the number of genetically effective breeders in a population
- Landscape genetics – determining genetic connectivity and dispersal

Genetic diversity

- Genetic diversity is the raw material of evolution
- Small, isolated populations have low diversity
- Threat to long-term population viability

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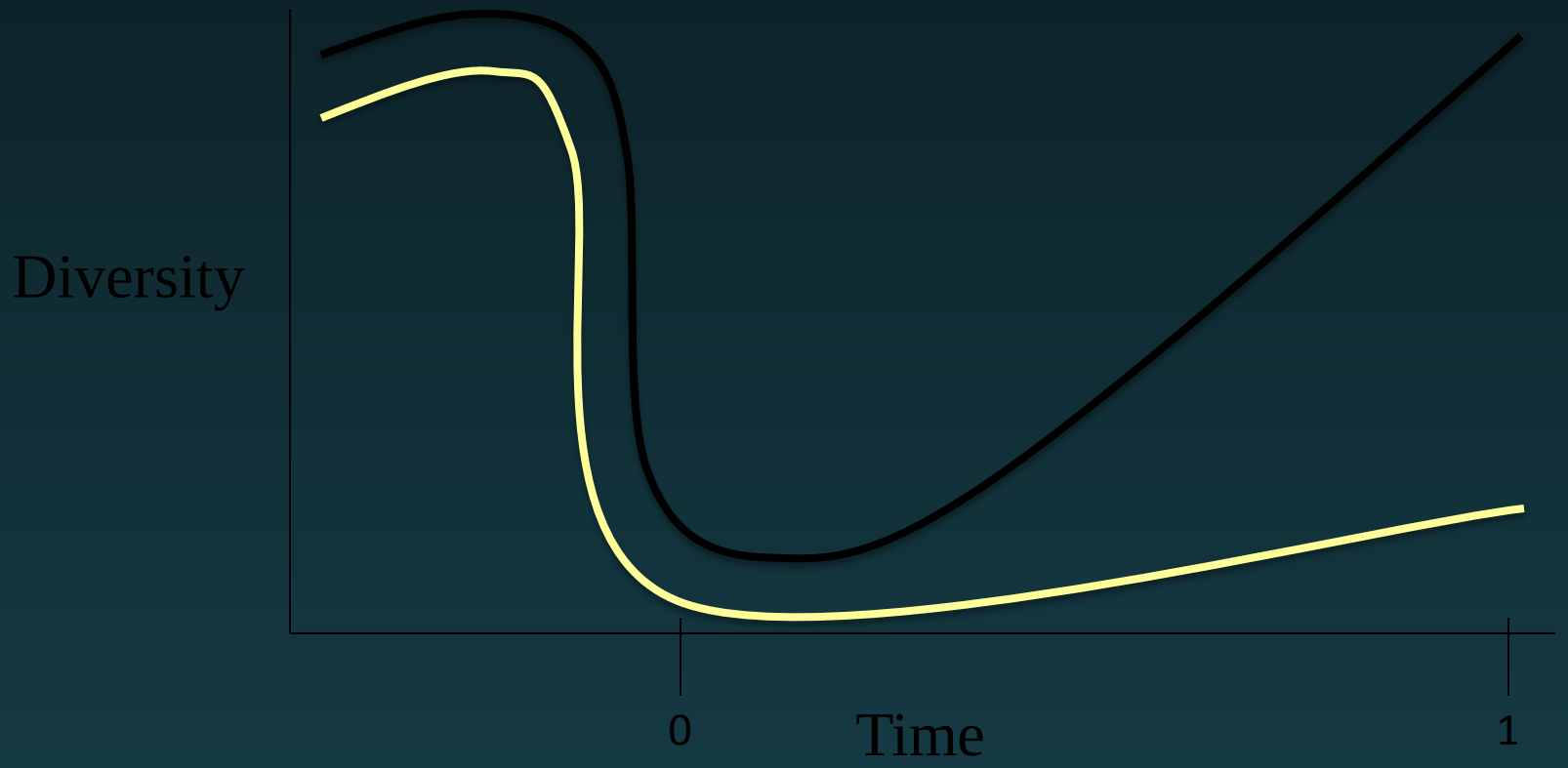
Population Size vs. Genetic Diversity



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Microsatellite genetic diversity

	Heterozygosity	Ave # of Alleles
Healthy mammalian*	0.6-0.7	8.8
Disturbed mammalian*	0.5-0.6	6.9
Florida[#]	0.480	4.8
Puerto Rico[$]	0.447	3.9
Belize[+]	0.455	3.4

*DiBattista, 2007; #Pause and Hunter et al. In Review; $Hunter et al. In Review; +Hunter et al. 2010

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Effective population size (N_e)

- Identify overall movement patterns
- N_e determines the rate at which genetic variability is lost in a population
- The average number of individuals in a population that actually contribute unique genes to succeeding generations

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Florida manatee population N_e

Population	Census size	Effective number	Ne/N ratio
Florida	EC 2430	429	17.6%
	WC 2400	197	8.2%

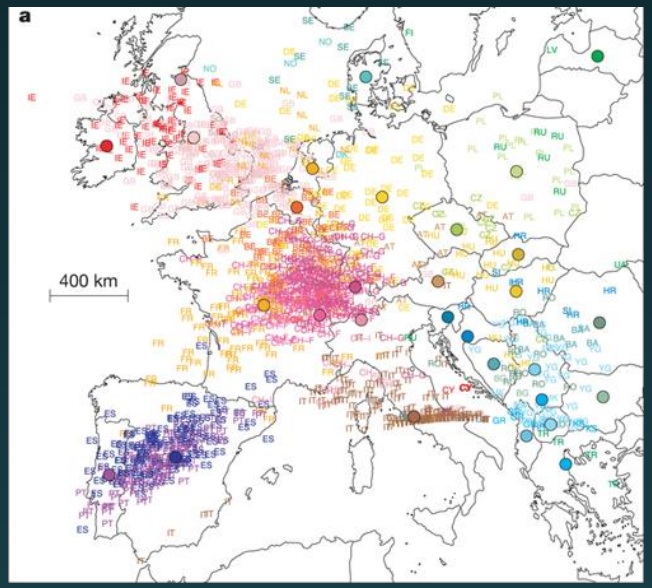
- **Ne /N <11% = Population contraction**
- **West Coast**
  - **F_{IS}= 0.046**
  - **Evidence for a bottleneck**

NE ESTIMATOR 1.3 SOFTWARE

MOLECULAR FISHERIES LABORATORY, QUEENSLAND, AUSTRALIA

Landscape genetics: movement corridors

- Genetically diverse groups
  - Increase genetic diversity through interbreeding
- Natural movement and adaptation to environmental conditions



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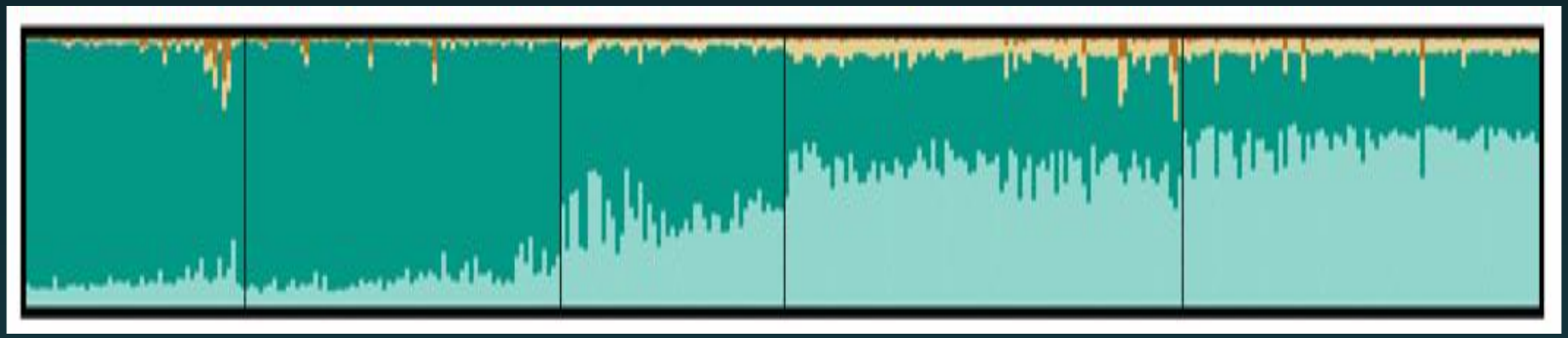
Bayesian population assignment

Putative mixing zone

East Coast **West Coast**



St. John's | North Atlantic | South Atlantic | Southwest | Northwest

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Florida Gulf Stream

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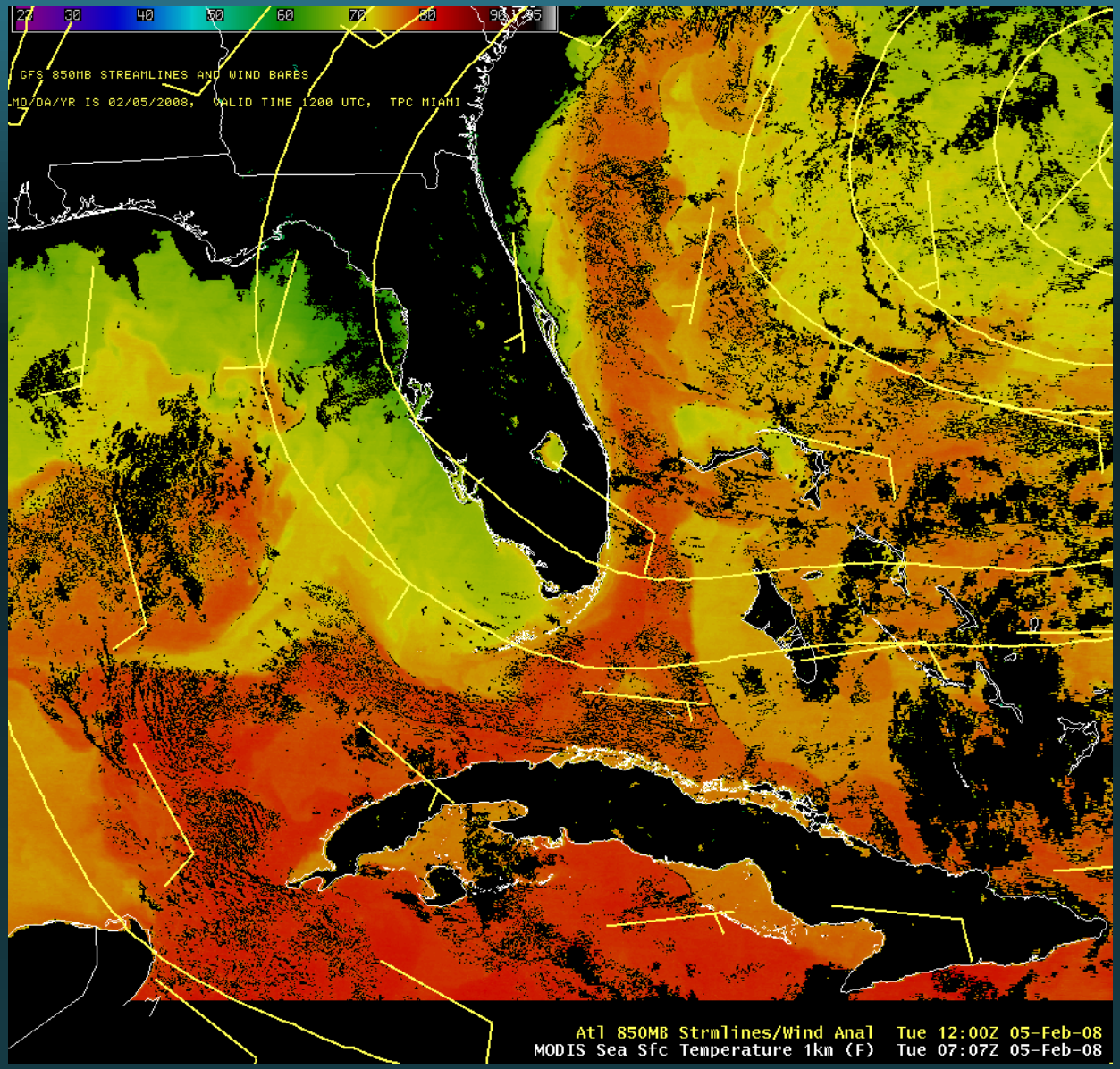

http://cimss.ssec.wisc.edu/goes/blog/archives/date/2008/02/05

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Florida manatee conservation genetic tools

- Low genetic diversity
  - Encourage migration and genetic mixing
  - Bottleneck on West Coast
- Effective population size
  - West Coast low effective population size
  - Supporting overall migration West to East
- Landscape genetics
  - East and West Coast genetically diverse
  - South Atlantic mixing zone
  - Gulf Stream

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Conclusions

- East coast may be gaining diversity and individuals through the South Atlantic mixing zone
- Everglades may be an important migration corridor to encourage genetic mixing

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Acknowledgments

- US Geological Survey, Sirenia Project, USFWS permit MA791721
- US Fish and Wildlife Service
- Florida Fish Research Institute
- University of Florida College of Veterinary Medicine
- University of Florida Aquatic Animal Health Program
- Caribbean Stranding Network, San Juan, Puerto Rico

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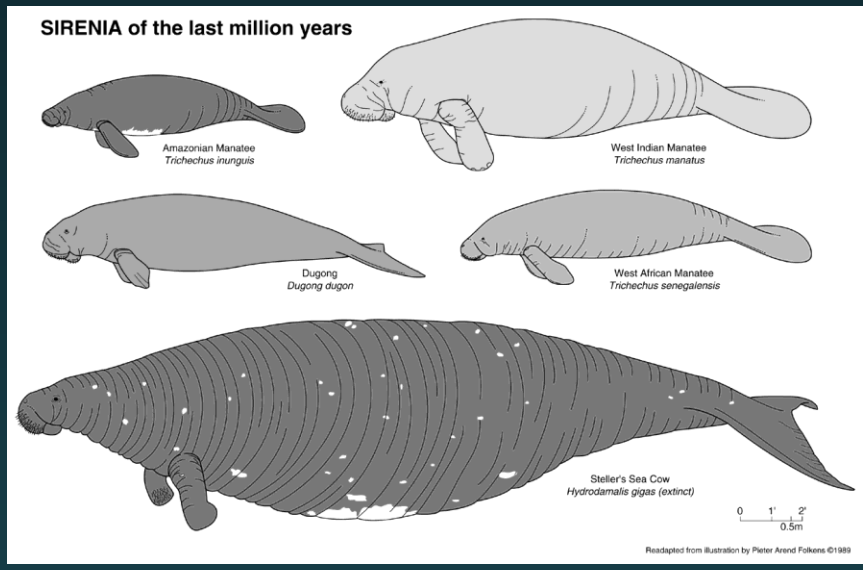
Demographic characteristics

- Long generation times
- Coastal habitat
- Small, isolated populations
  - Low genetic diversity



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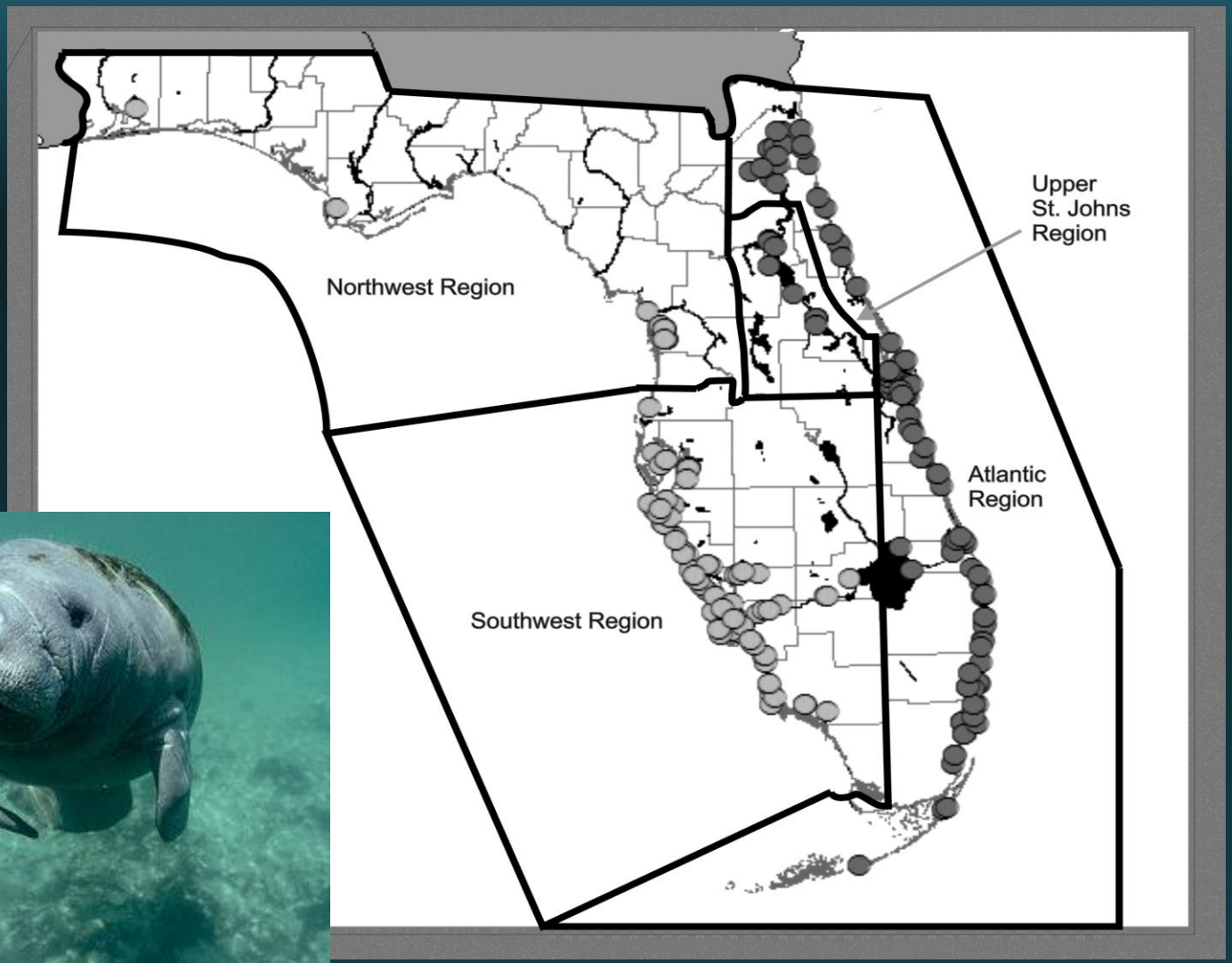
Florida manatee population genetics



Tucker et al., in review

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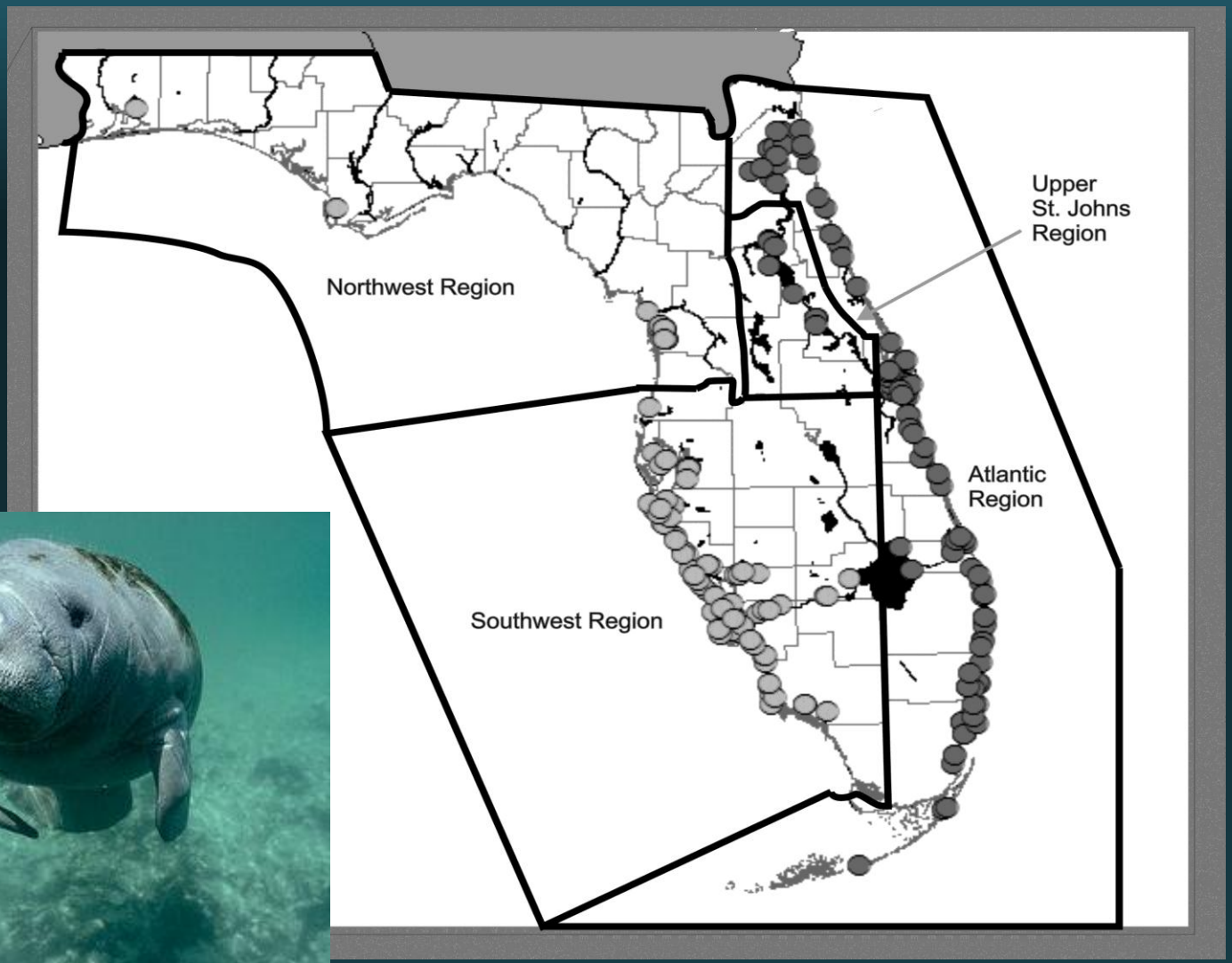
Florida manatee management units (MUs)



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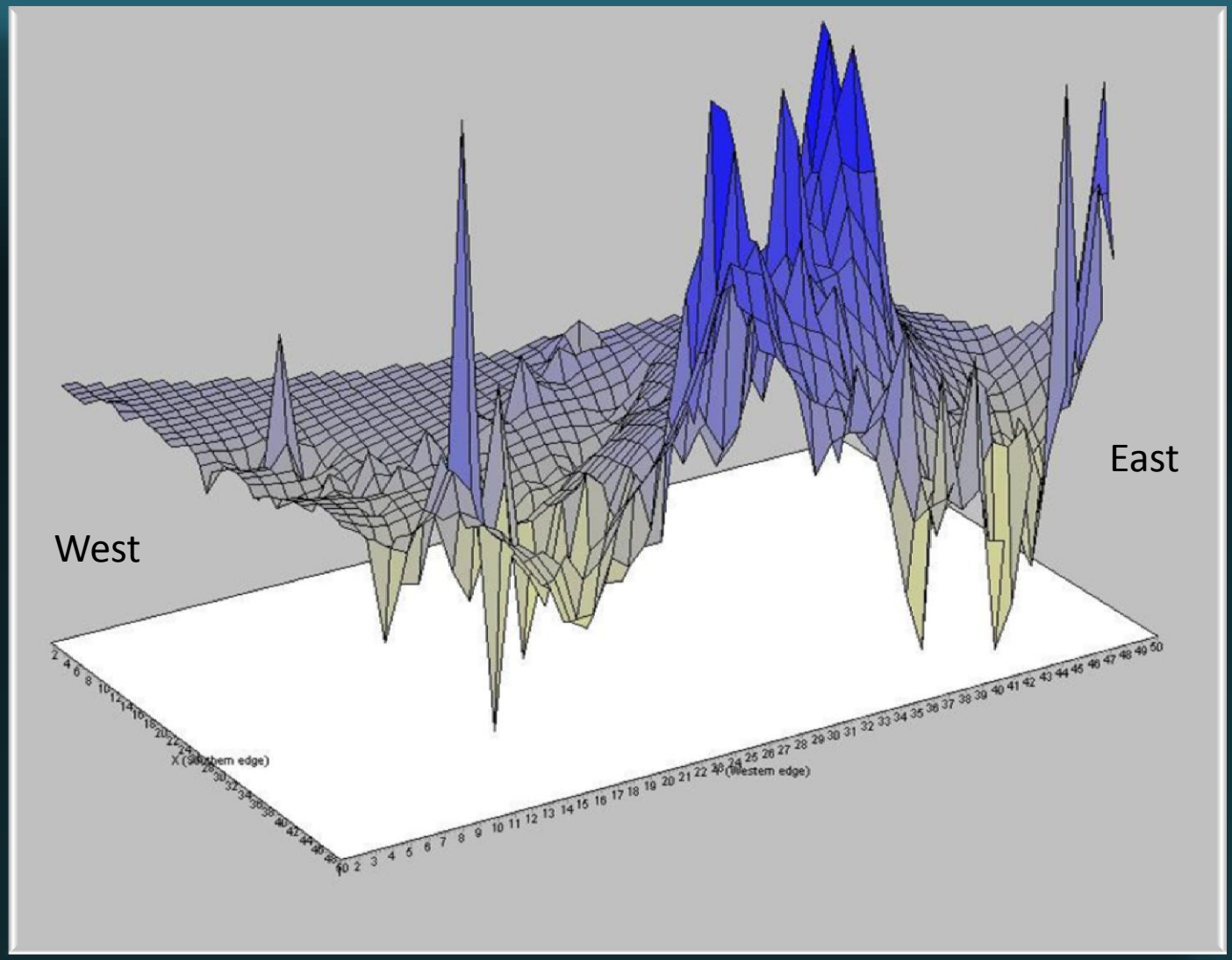
E and W genetic diversity

	N	N_A	N_E	*PIC*	*Ho*	*He*	*F*
St. John's	48	3.27 ± 0.45	1.82 ± 0.15	0.71 ± 0.08	0.40 ± 0.04	0.42 ± 0.04	0.05 ± 0.03
Atlantic	118	3.18 ± 0.35	1.76 ± 0.10	0.69 ± 0.06	0.39 ± 0.03	0.41 ± 0.03	0.05 ± 0.03
Southwest	87	3.36 ± 0.47	1.82 ± 0.18	0.69 ± 0.10	0.39 ± 0.05	0.40 ± 0.06	0.01 ± 0.03
Northwest	78	3.36 ± 0.43	1.85 ± 0.20	0.68 ± 0.11	0.40 ± 0.06	0.40 ± 0.06	0.03 ± 0.05
East Coast	166	3.64 ± 0.49	1.79 ± 0.12	0.70 ± 0.06	0.40 ± 0.03	0.42 ± 0.04	0.05 ± 0.02
Gulf Coast	165	3.91 ± 0.51	1.86 ± 0.19	0.70 ± 0.11	0.39 ± 0.05	0.41 ± 0.06	0.03 ± 0.03
All	331	4.18 ± 0.57	1.82 ± 0.15	0.71 ± 0.08	0.39 ± 0.04	0.42 ± 0.05	0.05 ± 0.02

Landscape Genetics



Landscape Shape Interpolation

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Conserve genetic diversity

- Number of alleles (5.3)
- Effective population size N_e (???)
  - Demographic stochasticity can impact populations with N_e < 100
  - IUCN Vulnerable (Criterion D)
- Encourage genetic mixing
  - Corridors
  - Habitat protections

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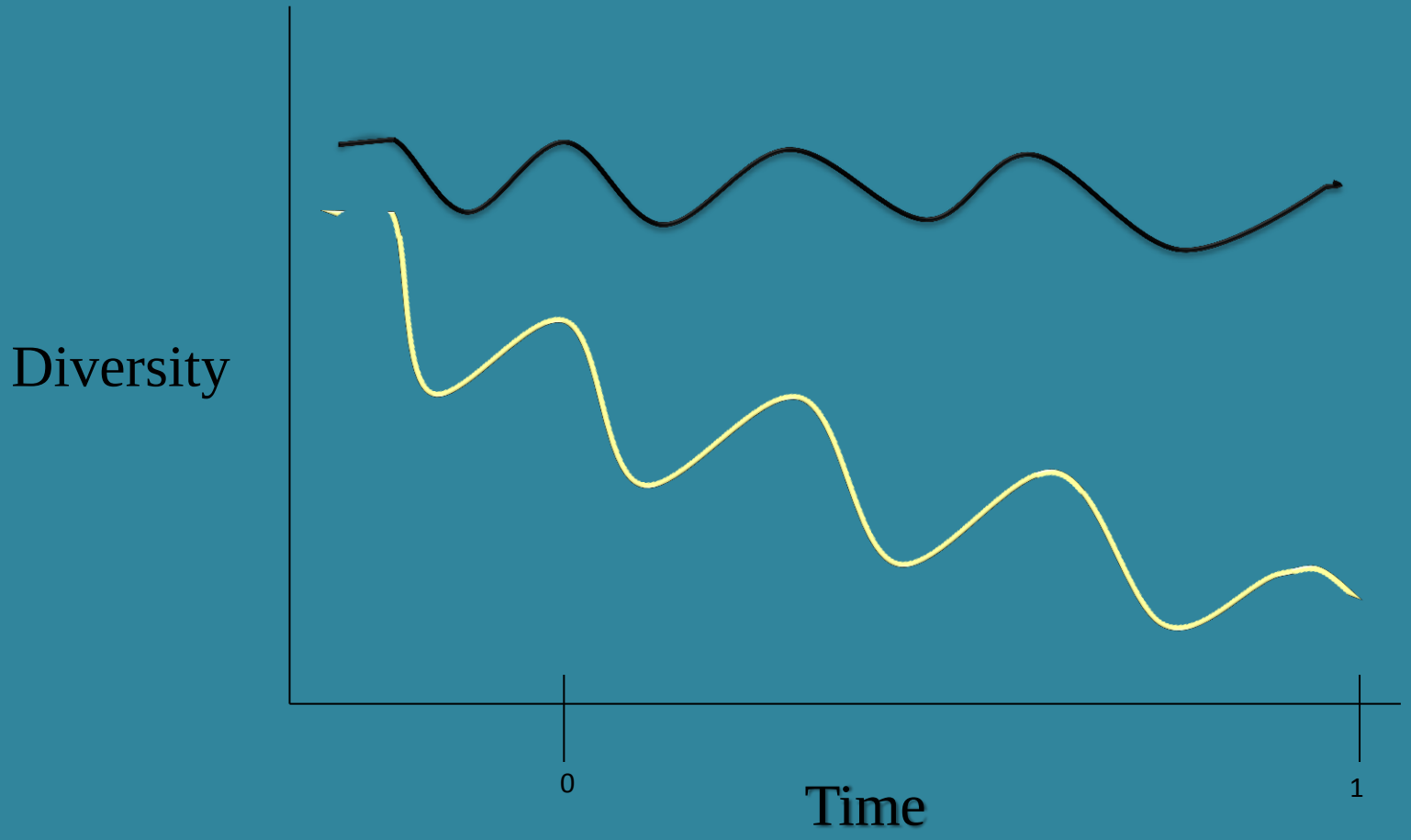
West Indian manatee mitochondrial DNA haplotype map

Population Size vs. Genetic Diversity



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N_e/N ratios

- N_e/N meta-analysis average is 11%
  - Low ratios indicate lack of genetic variation and potential demographic contraction

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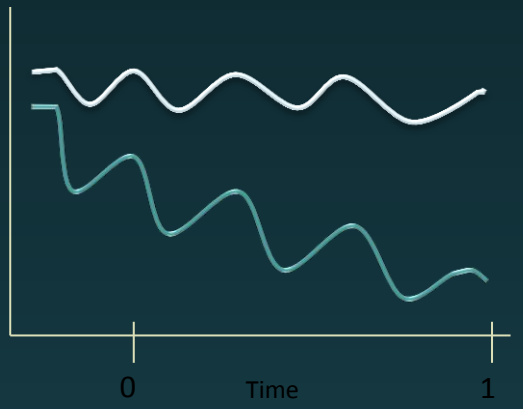
N_e is affected by

- Reproductive variance (total contribution of offspring per individual)
  - Wolf packs
- Unequal sex ratios
  - Elephant seal harems
- Fluctuations in population size



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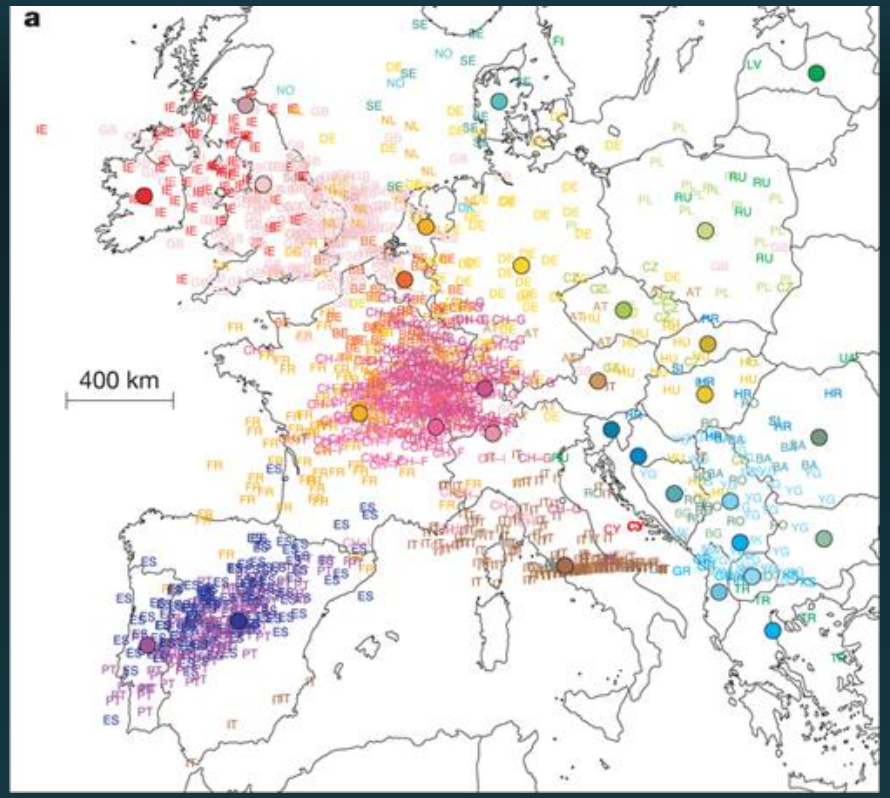
What influences genetic connectivity?

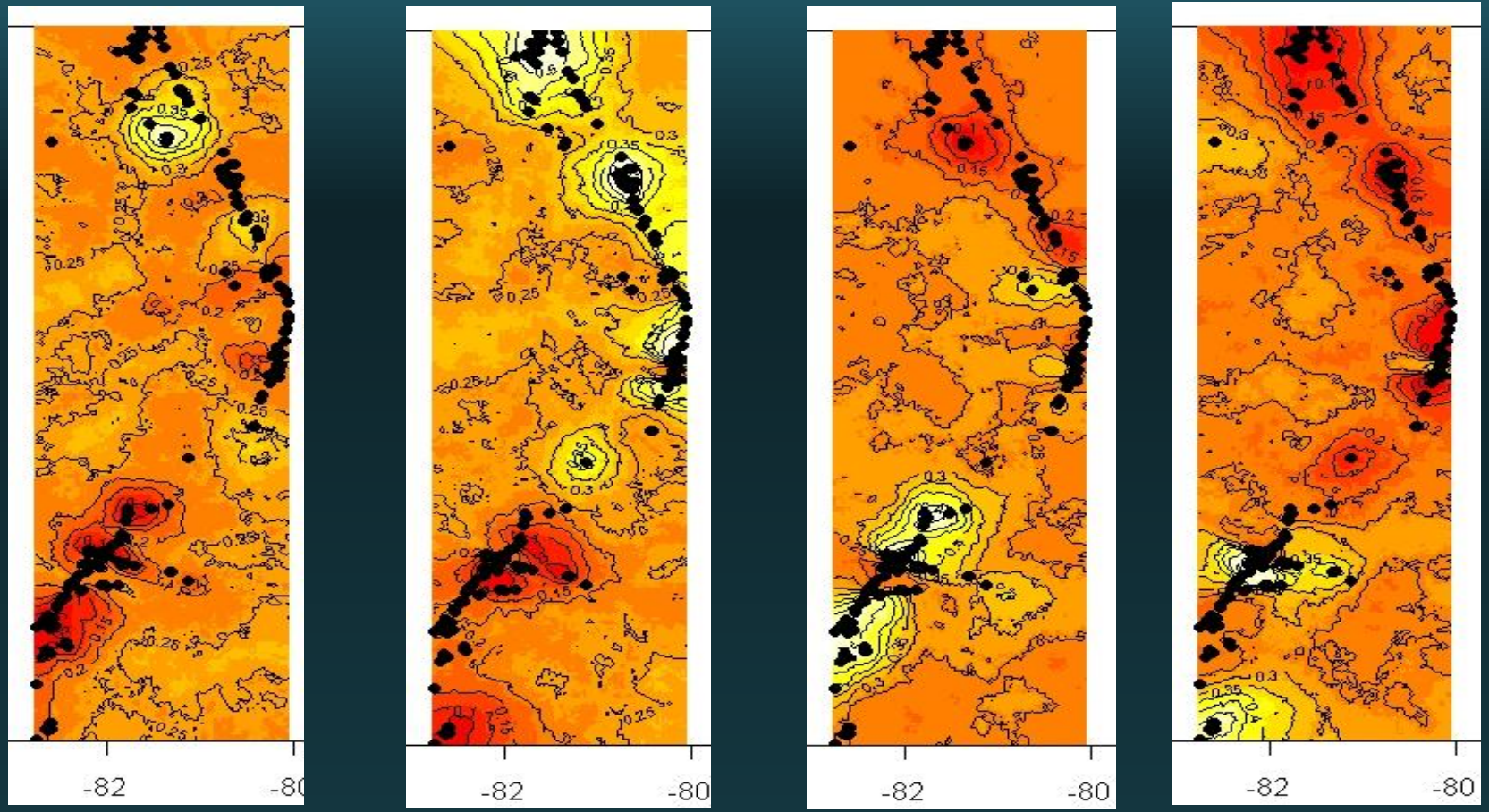
- Evolutionary distance/time
- Landscape
- Distance
- Population size
  - Removal



Landscape genetics: Spatially explicit model

East Coast

Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4



Upper St. John | Atlantic coast | Southwest | Northwest

West Coast

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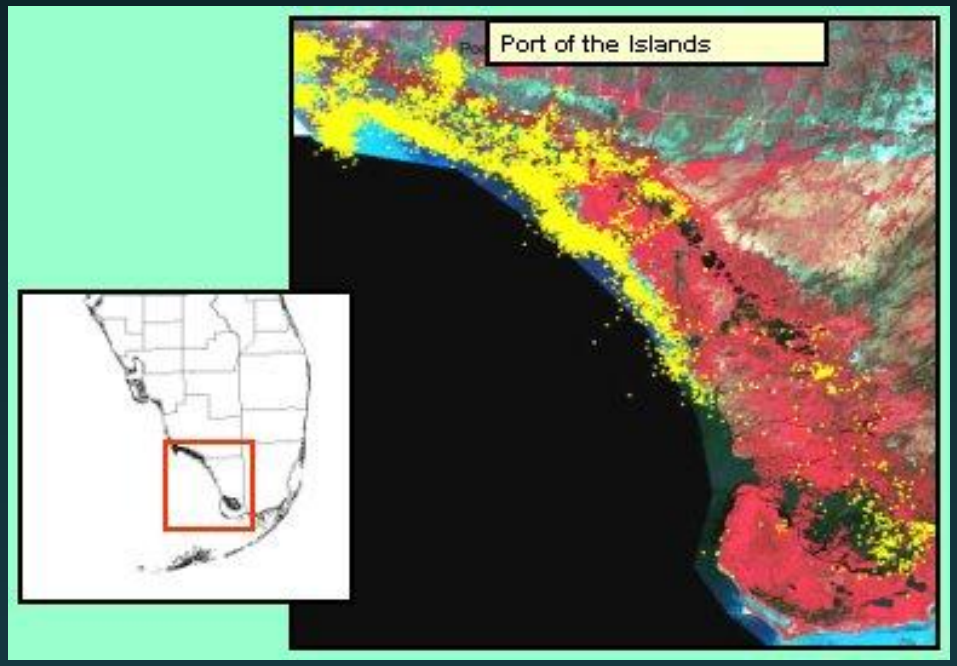
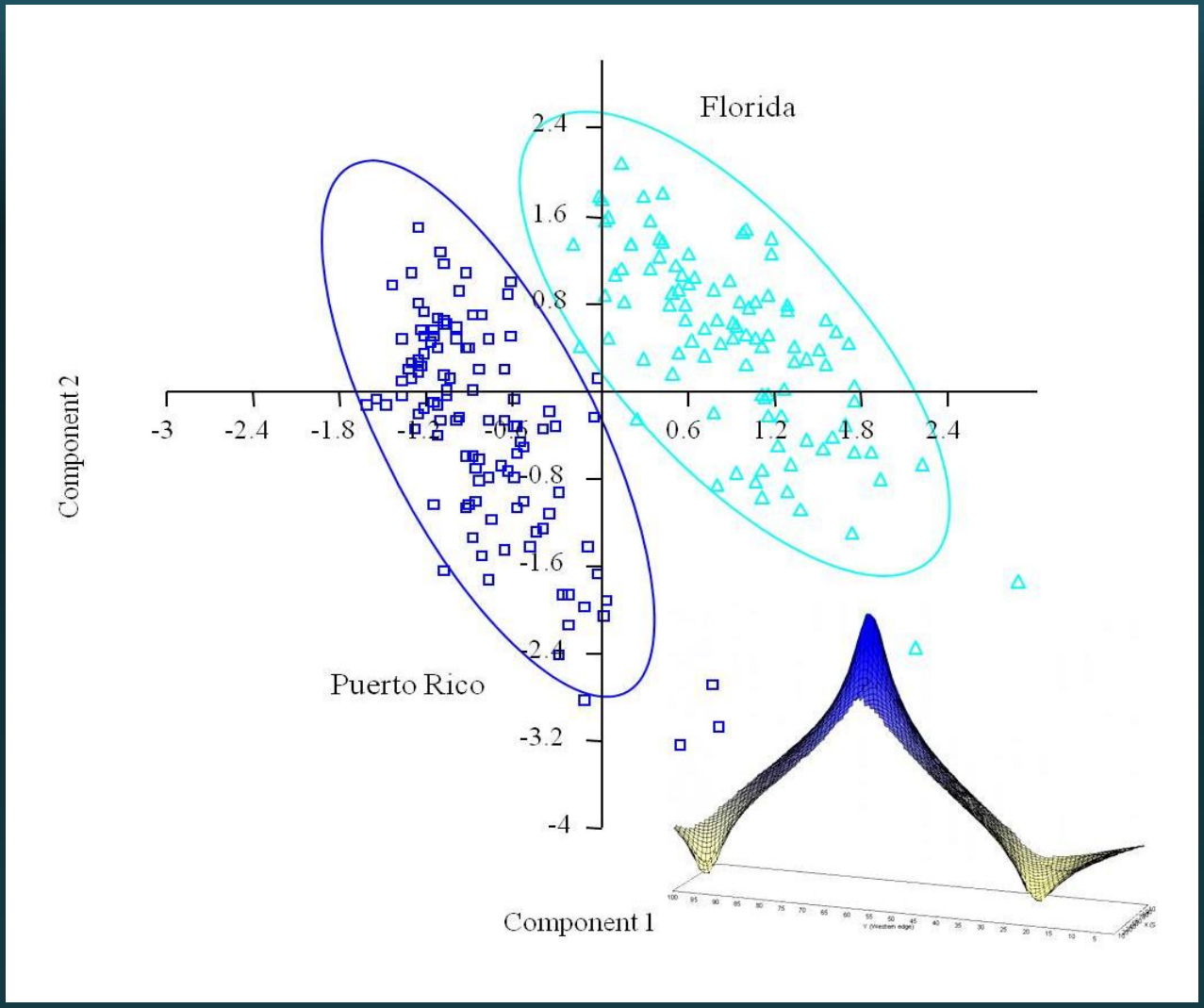

Port of the Islands

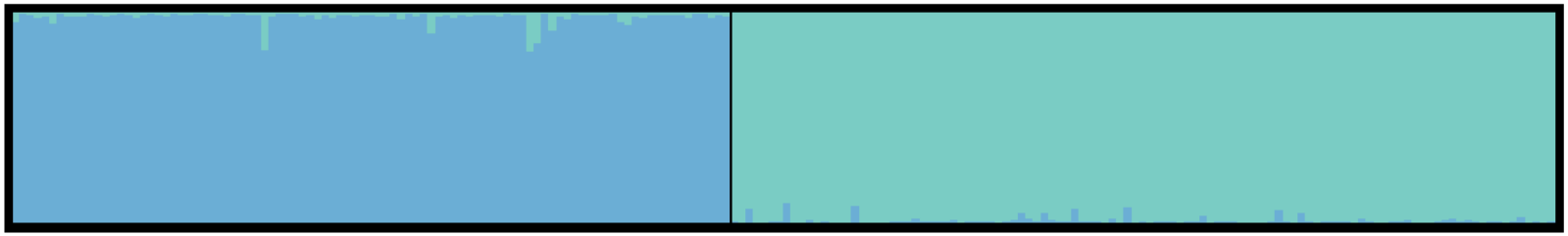
Landscape genetics



Hunter et al., In Review

Bayesian population assignment

a.

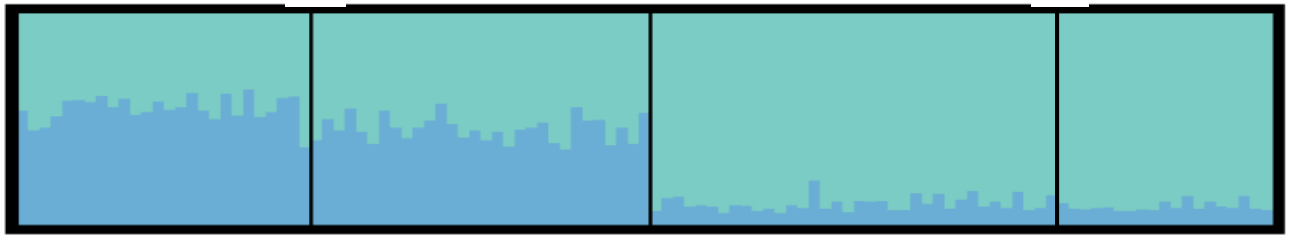


Florida Puerto Rico

b.

Puerto Rico Subclusters

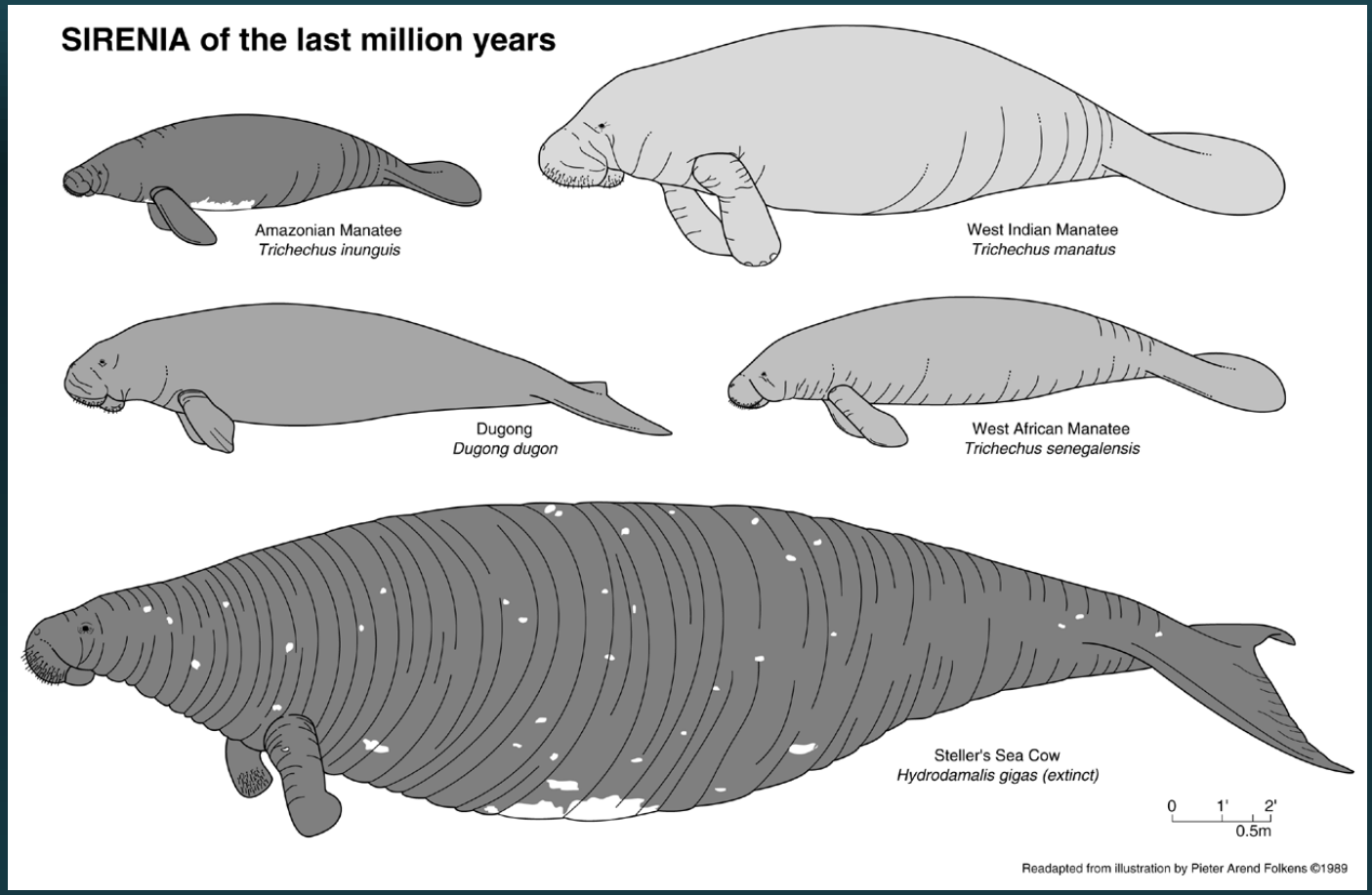
[A] [B]



North East South West

Hunter et al., In Review

Order: Sirenia



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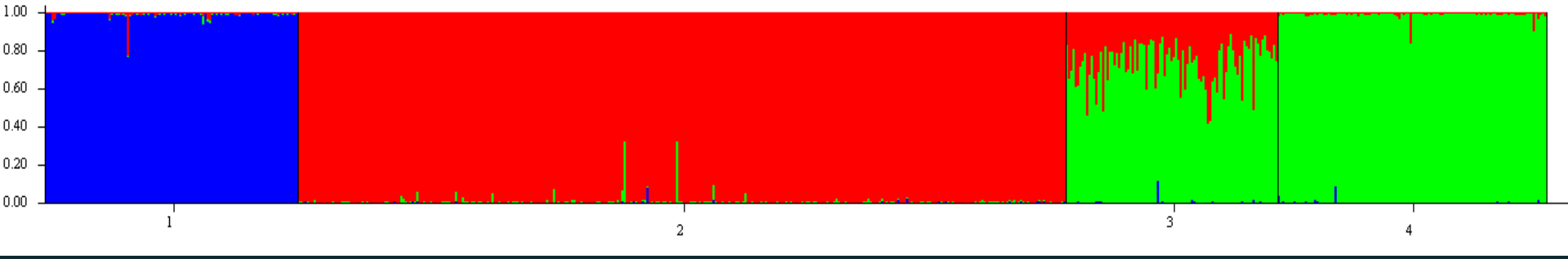
Mark-Recapture using photo and genetic identification

- Manatee Individual Photo-Identification System (MIPS), Cathy Beck
- 25% mortality from watercraft
- Majority of adults scarred

Caribbean population assignment



Puerto Rico Florida Mexico Belize

Gene analysrs – q-PCR or Microarrays

- Gene pathways involved in:
  - Red tide adaptation
  - Cold stress responses
    - Natural Springs vs. Power plant
  - Captive vs. wild
  - Immune state, Disease outbreaks
  - Capture stress
  - East vs. West Coast, Florida vs. Puerto Rico

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Genetics: Blood and tissue

IUCN Red List Criterion

- Therefore $N < 1000$ considered ‘Vulnerable’ (Criterion D)
  - Demographic stochasticity can impact populations with $N_e < 100$.
- If the data is available, N_e could provide a more accurate representation of the genetic status

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Florida manatee threats

- 25% mortality from watercraft
- 85% of all manatees have boat-strike scars

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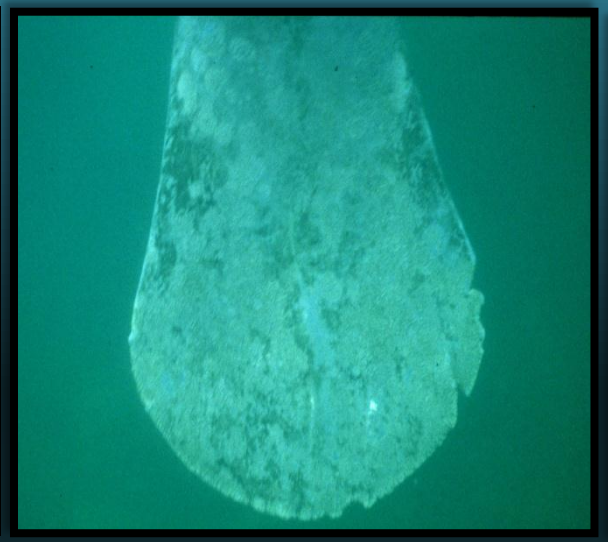
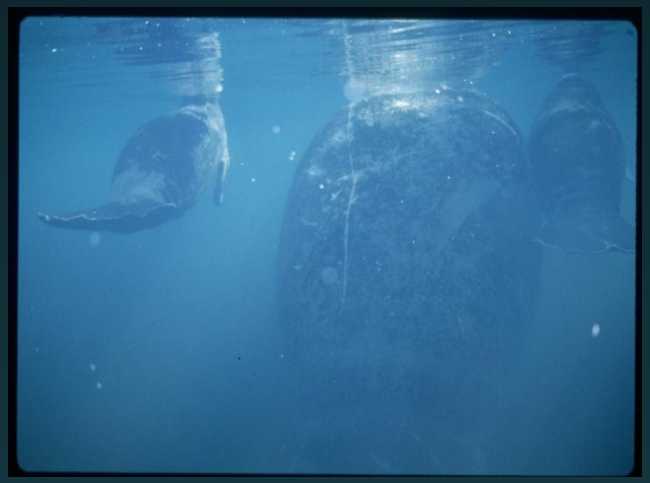
Brazil mtDNA

Sample category	N	HT	h	π
Stranded live calves*	47	M01,M03, M04	0.043	0.00021
Carcasses and live adults	17	M01, M04	0.221	0.00054
Captive-born calves	9	M01	0	0
Total	**73**	**-**	**0.08**	**0.00262**




Manatee Core Biological Model: Detects trends in demography and population size

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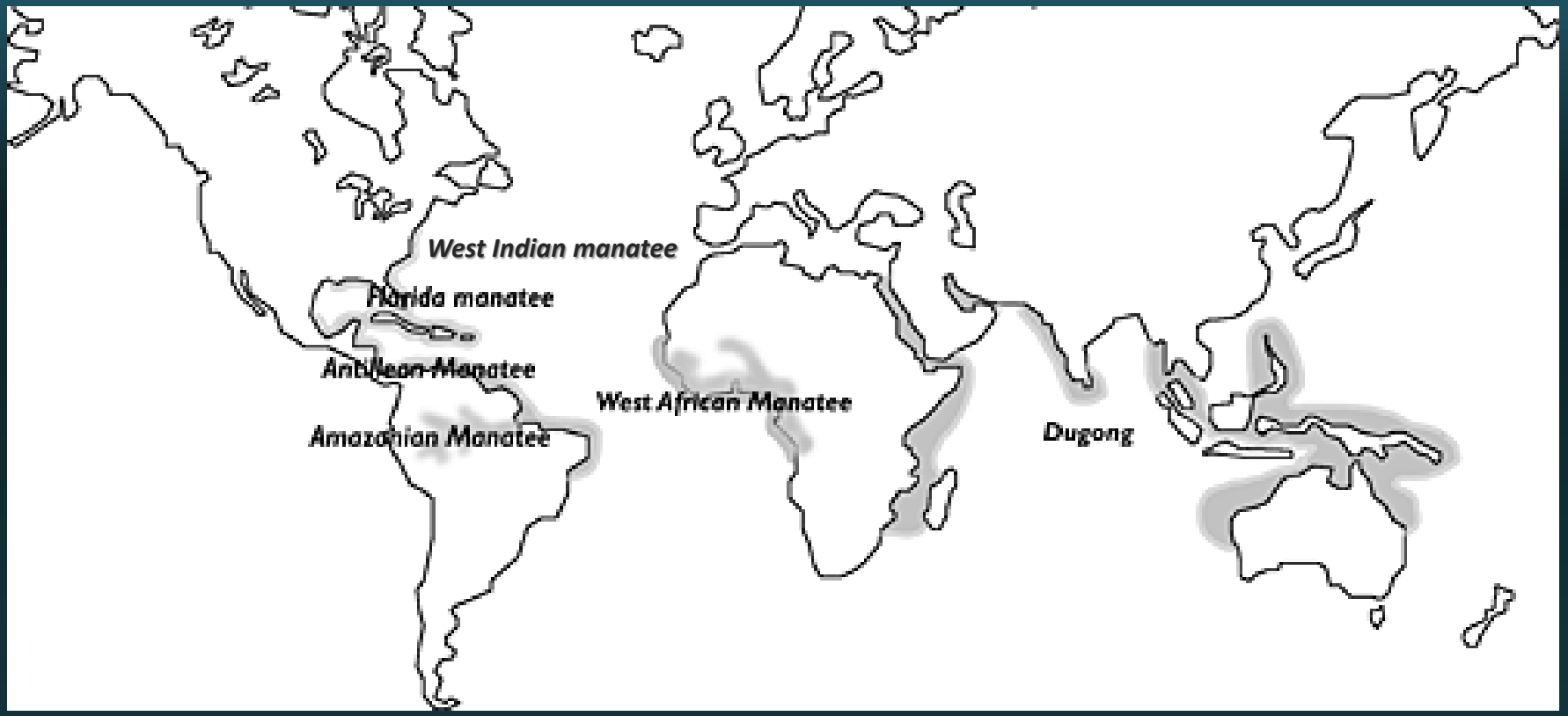
Sirenian Distribution



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