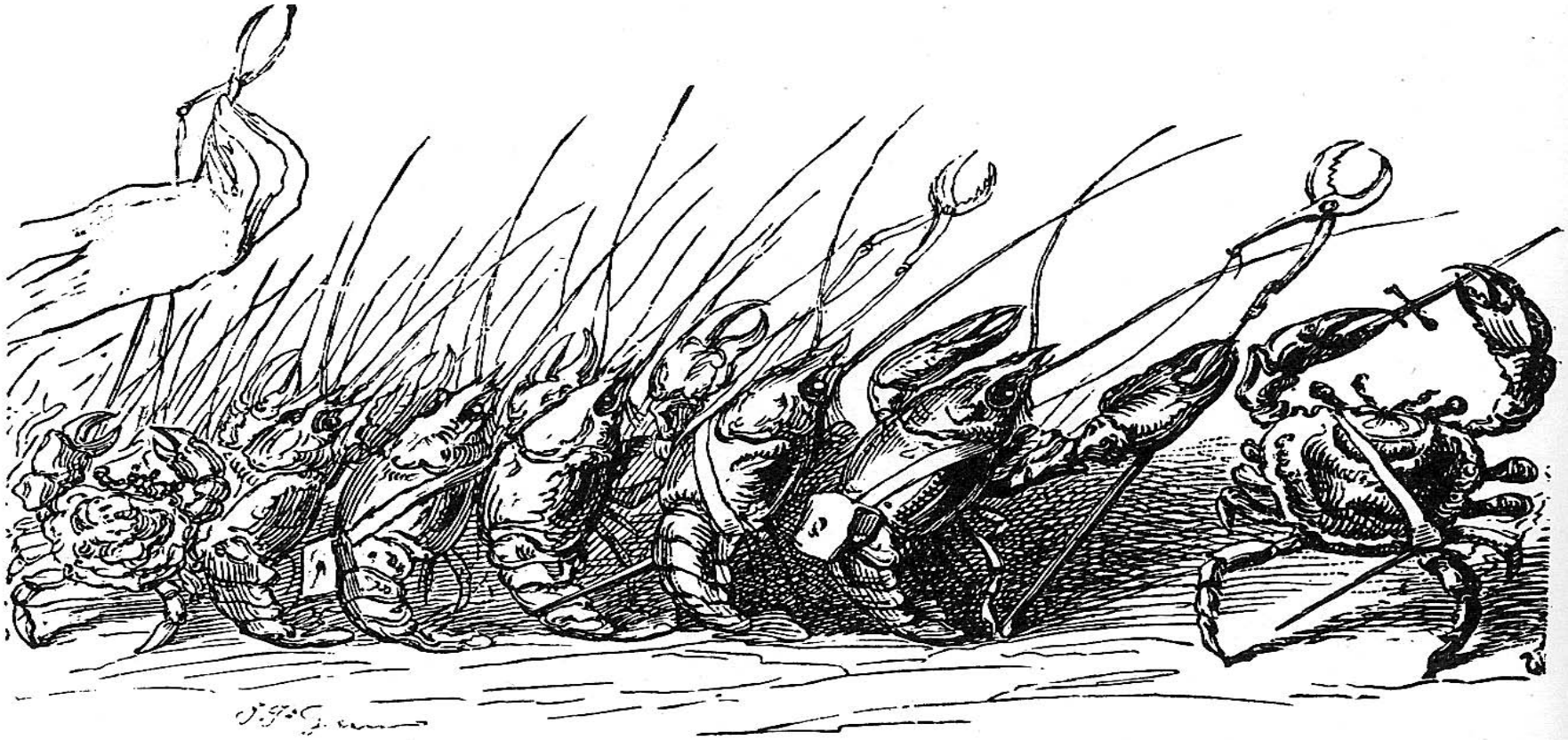
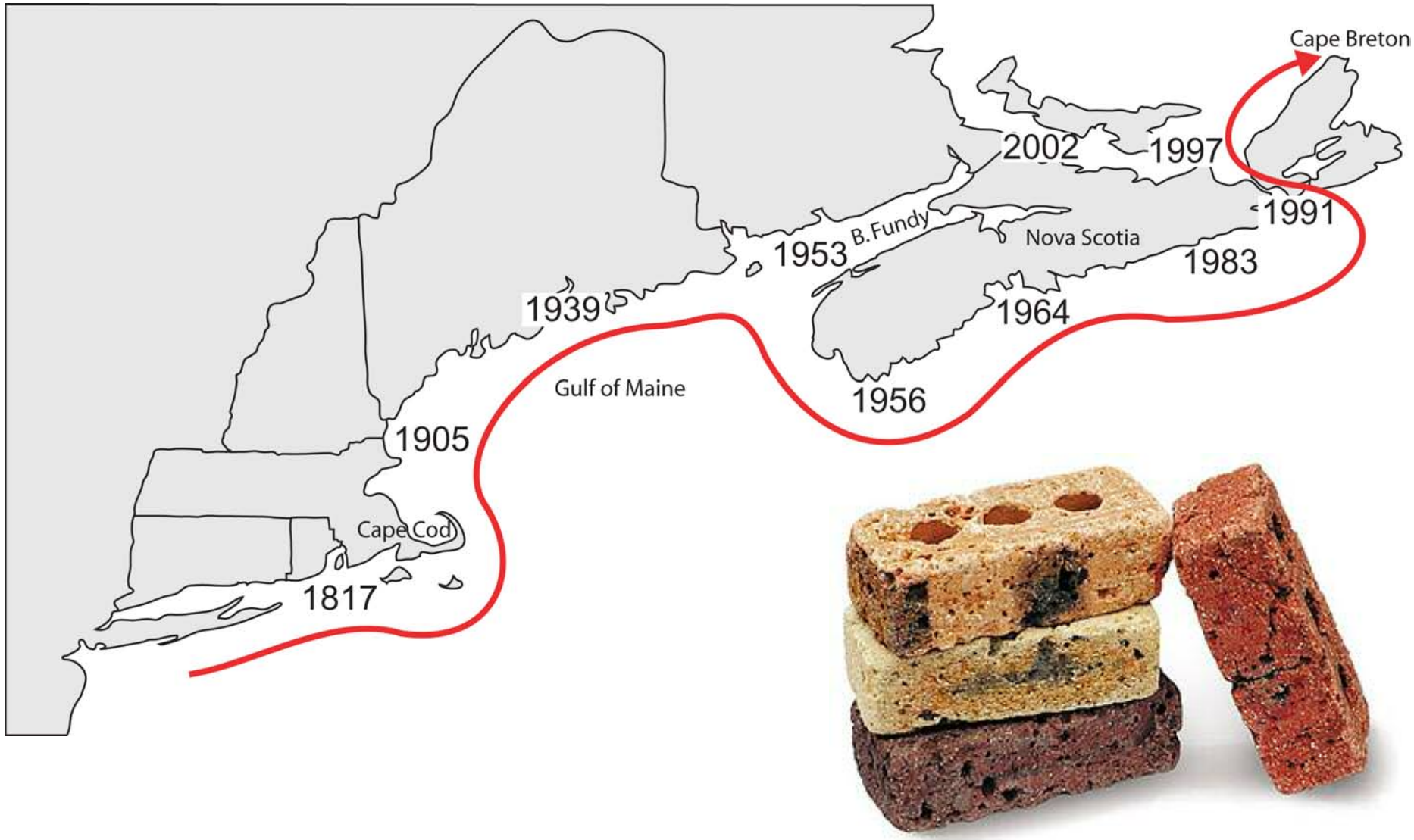




Green crab first recorded in Mid-Atlantic US in 1817

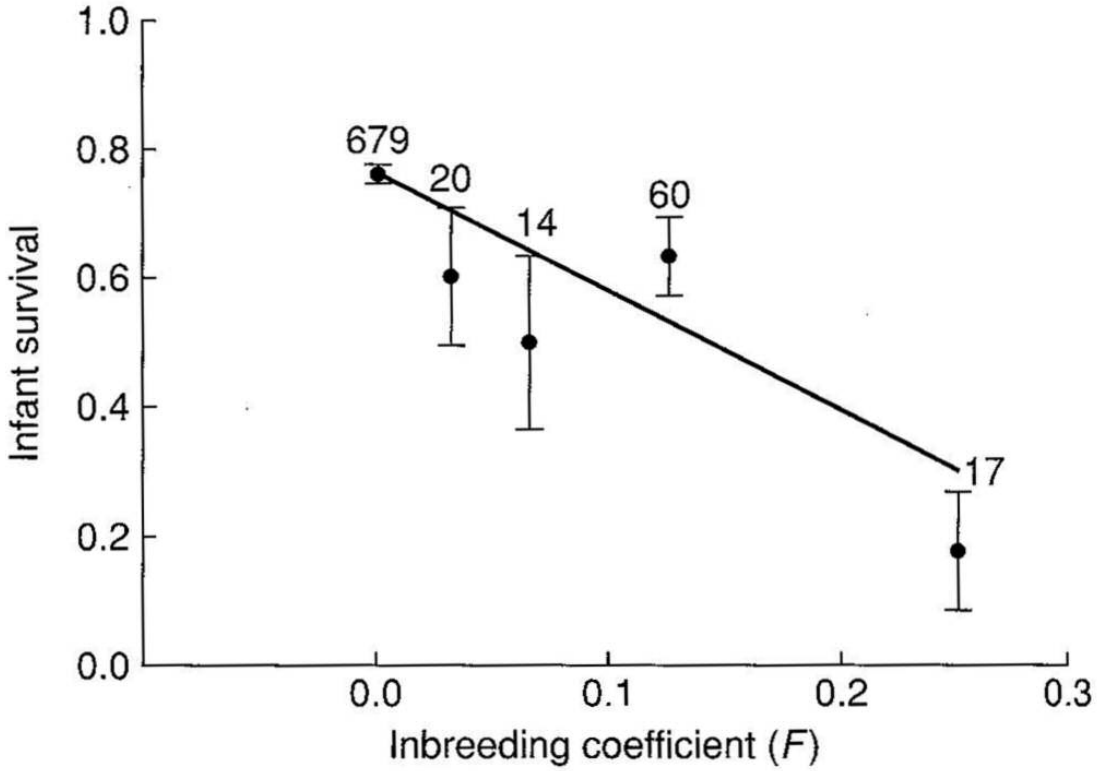
Most abundant crab in rocky intertidal zone

Until 1990s, rate of spread ~ 20 km/yr or that of walking adult crab

- Jamieson 2000

Crabs collected from 25 locations: Freeport, NY, to PEI

Genetic Paradox: Why So Successful?

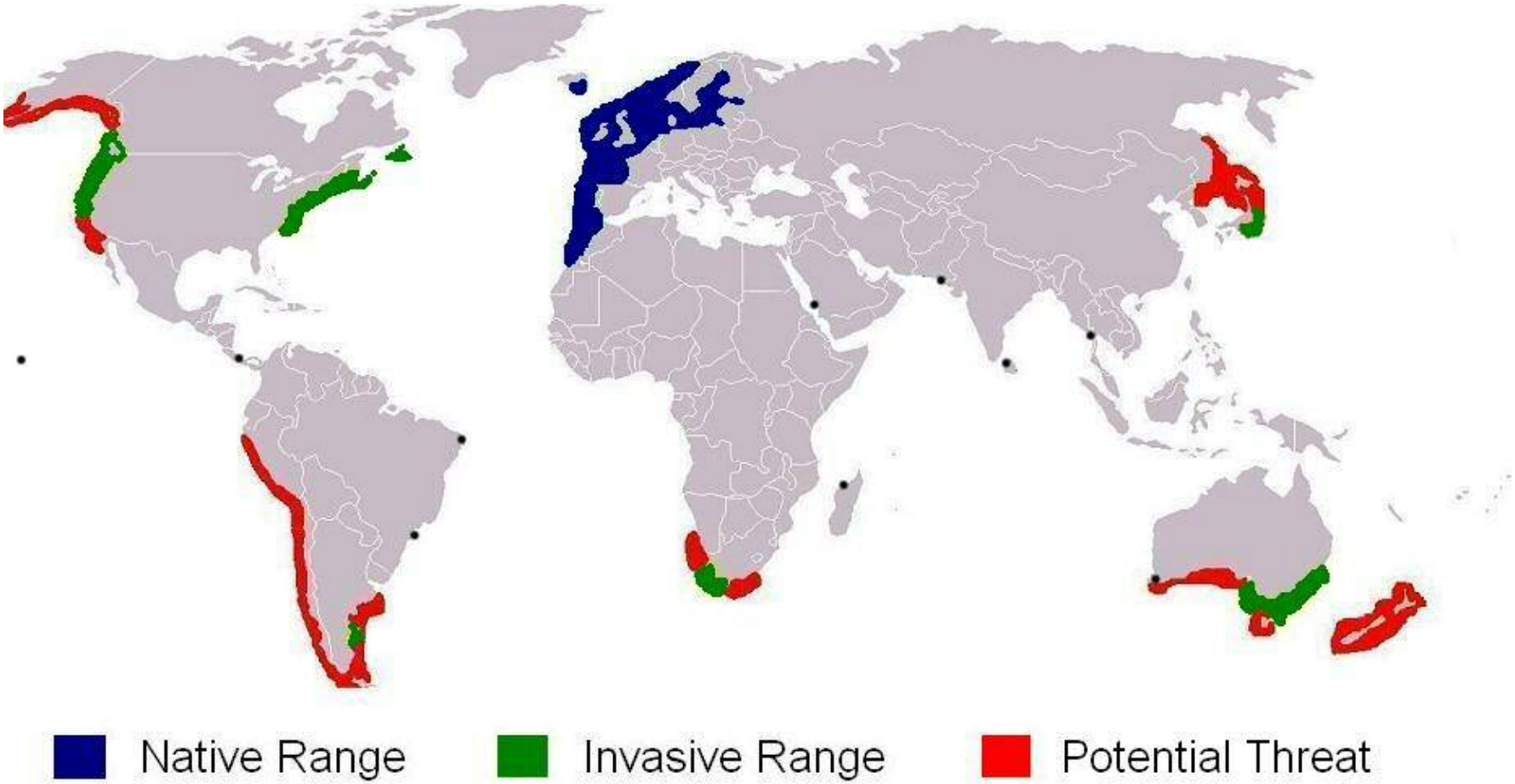


Small population size at higher risk of extinction

Founder effect: Genetic drift and inbreeding depression should reduce fitness and limit population's ability to adapt

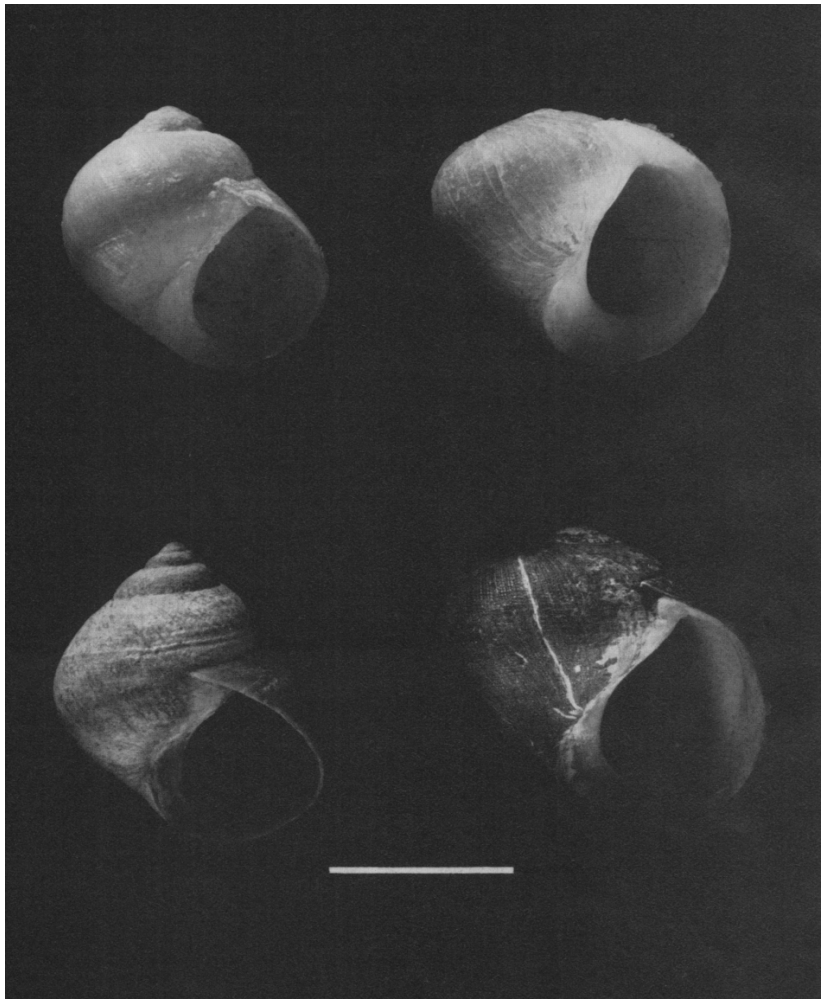
Carcinus maenas: Exemplary Invader

- High fecundity: 200,000 eggs/year
- Good dispersal potential: larval period up to 60 days
- Rapid growth: carapace width of 7 cm in 2 years
- Survives as carnivore, herbivore, or detritivore, but really likes mollusks
- Survives out of water > 10 days and short-term exposure to temperatures as low as 0° C and as high as 33° C



Carcinus has invaded five continents since 1817

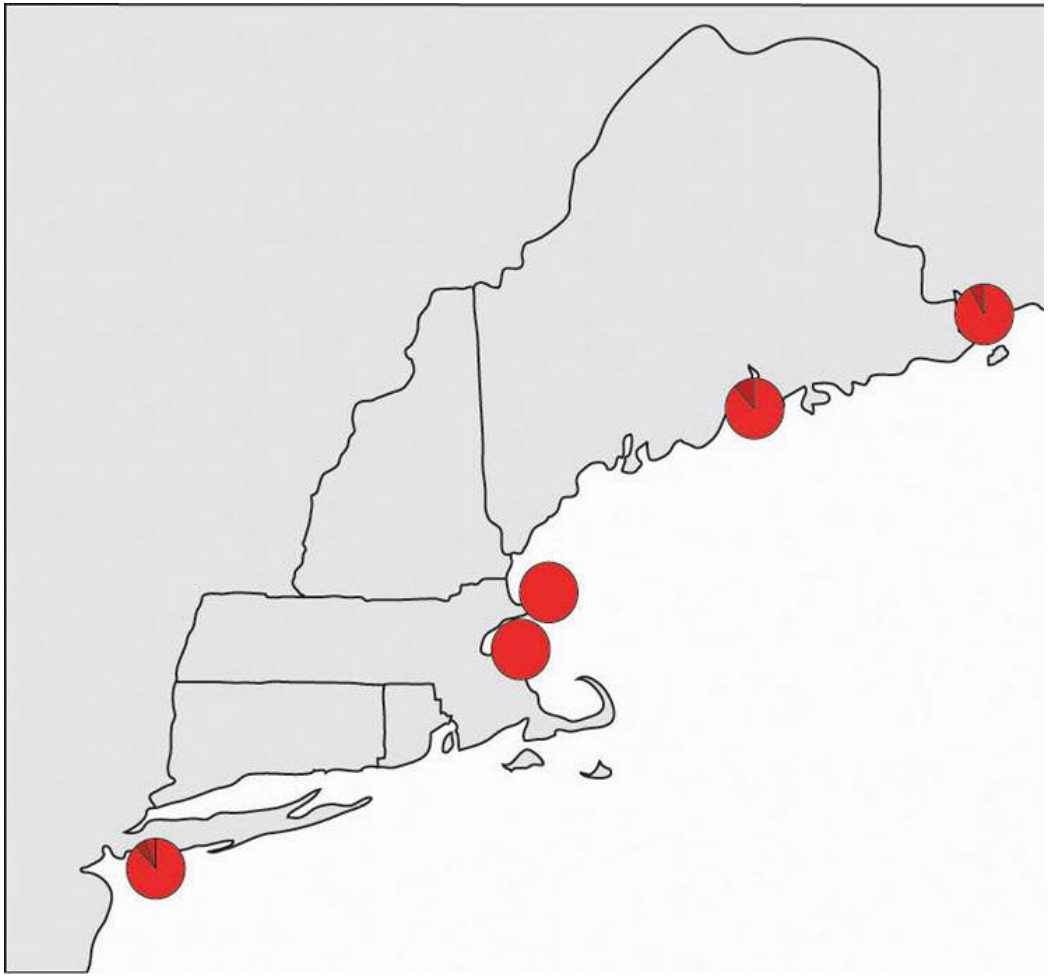
Notable impacts of green crab in Eastern NA



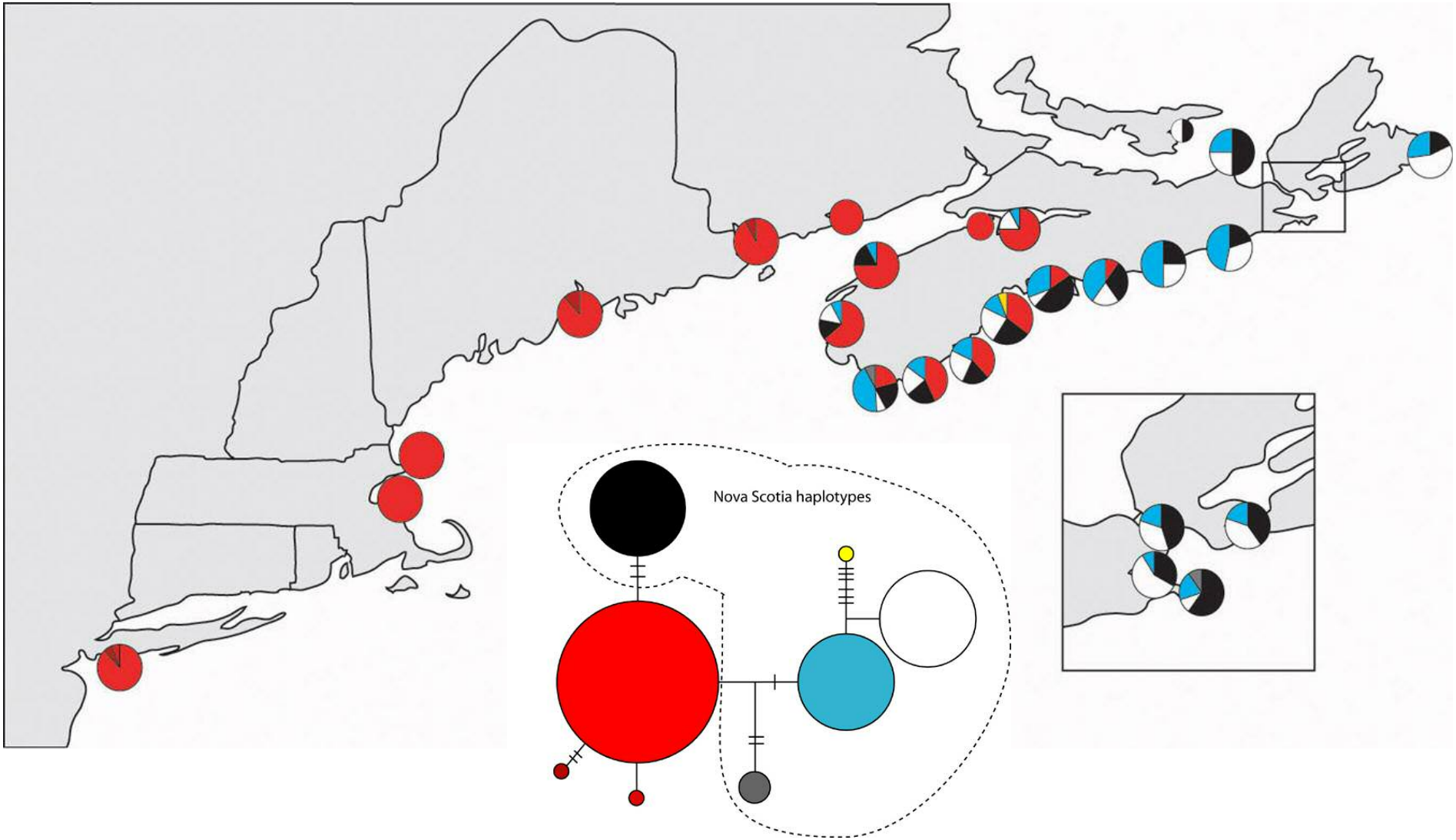
1900 1980s

Littorina obstusata

Seely 1986. *PNAS.*



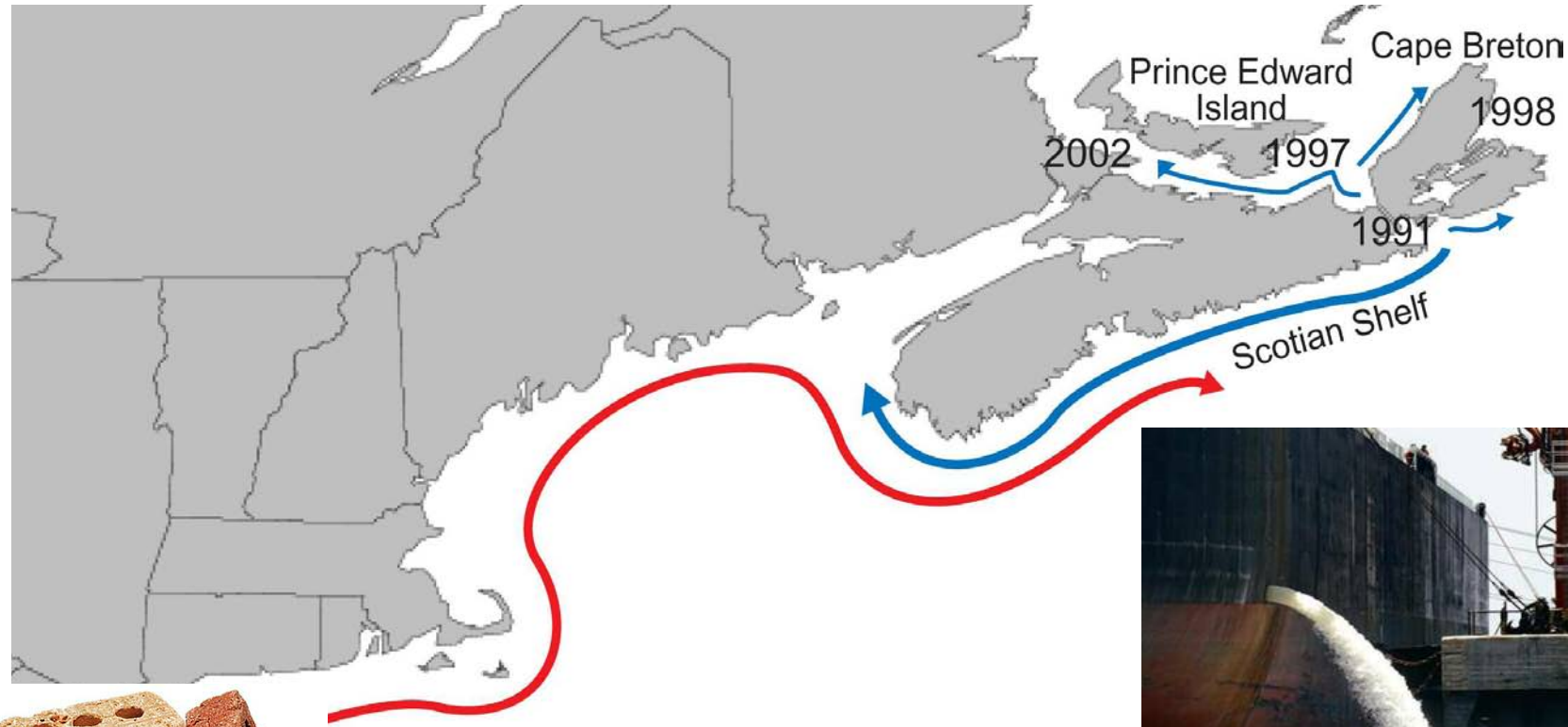
A single mitochondrial COI genotype dominates northeast US



A single mitochondrial COI genotype dominates northeast US

High genetic diversity in the Maritimes

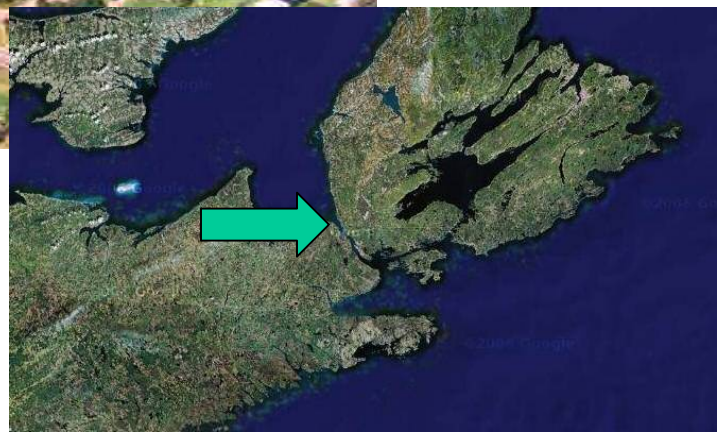
Roman Proc Roy Soc 2006



Until 1980s, *Carcinus* stalled along Scotian Shelf

Carcinus distribution is the result of multiple invasions

Northern invaders may have greater tolerance to cold

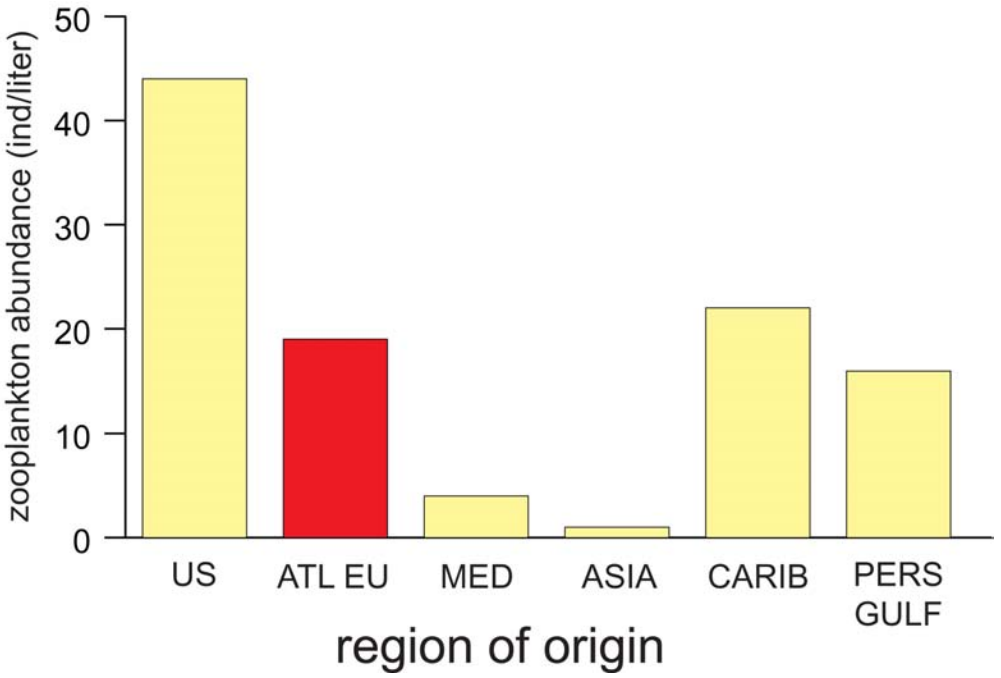


Canso Causeway

Constructed in 1953
Created largest ice-free harbor in eastern North America
and a retention zone, or nursery
First sighting of green crabs in 1991

High genetic diversity in Nova Scotia

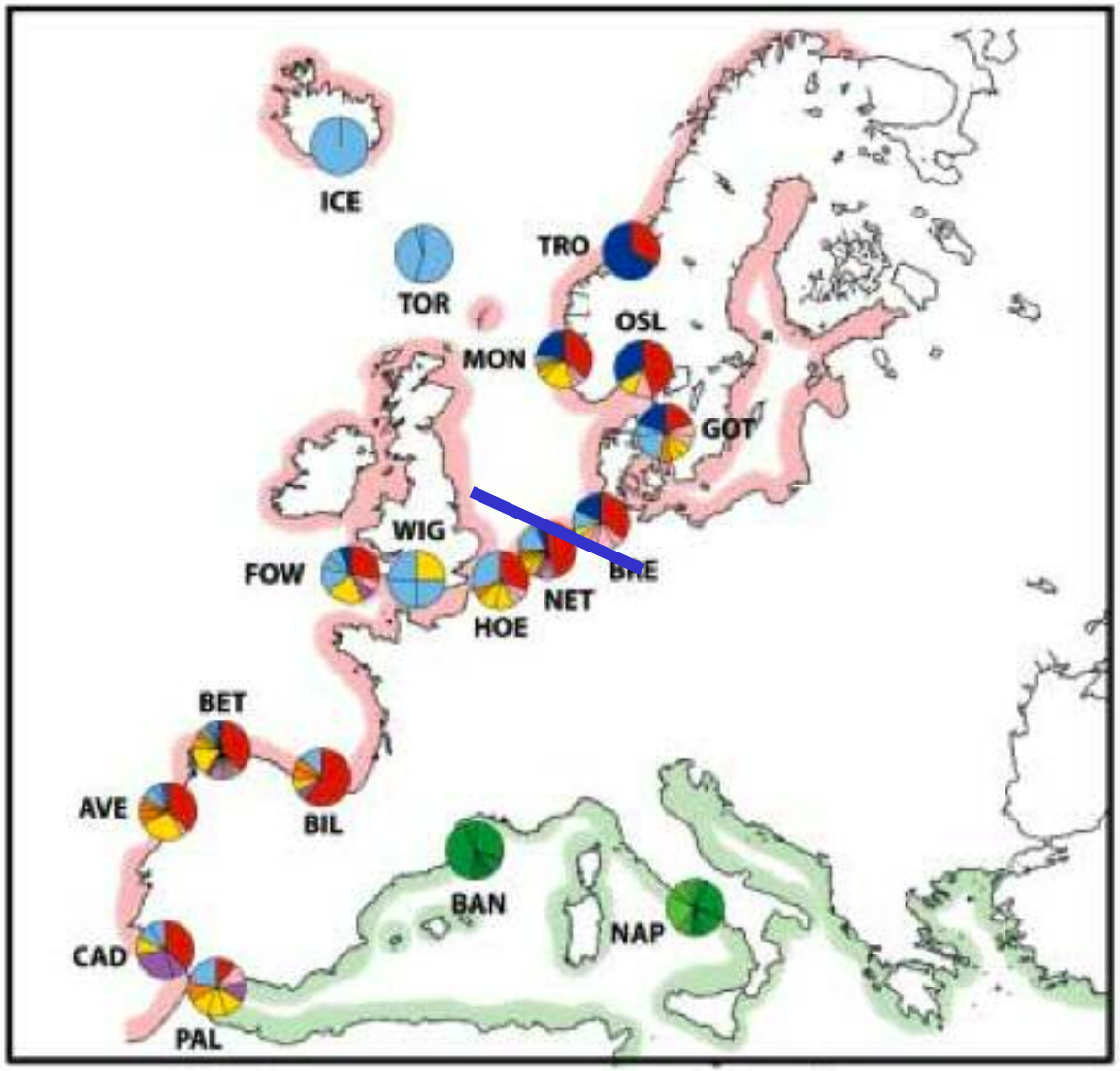
Population	**Haplotype diversity**	**Nucleotide diversity**
New England	0.06 ± 0.04	0.0001 ± 0.0004
Nova Scotia pre-1980	0.00 ± 0.00	0.0000 ± 0.0000
Nova Scotia 2000	0.77 ± 0.01	0.0048 ± 0.0029
Bilbao, Spain	0.65 ± 0.13	0.0029 ± 0.0021
Mongstadt, Norway	0.90 ± 0.05	0.0048 ± 0.0030



Carver and Mallet 2002

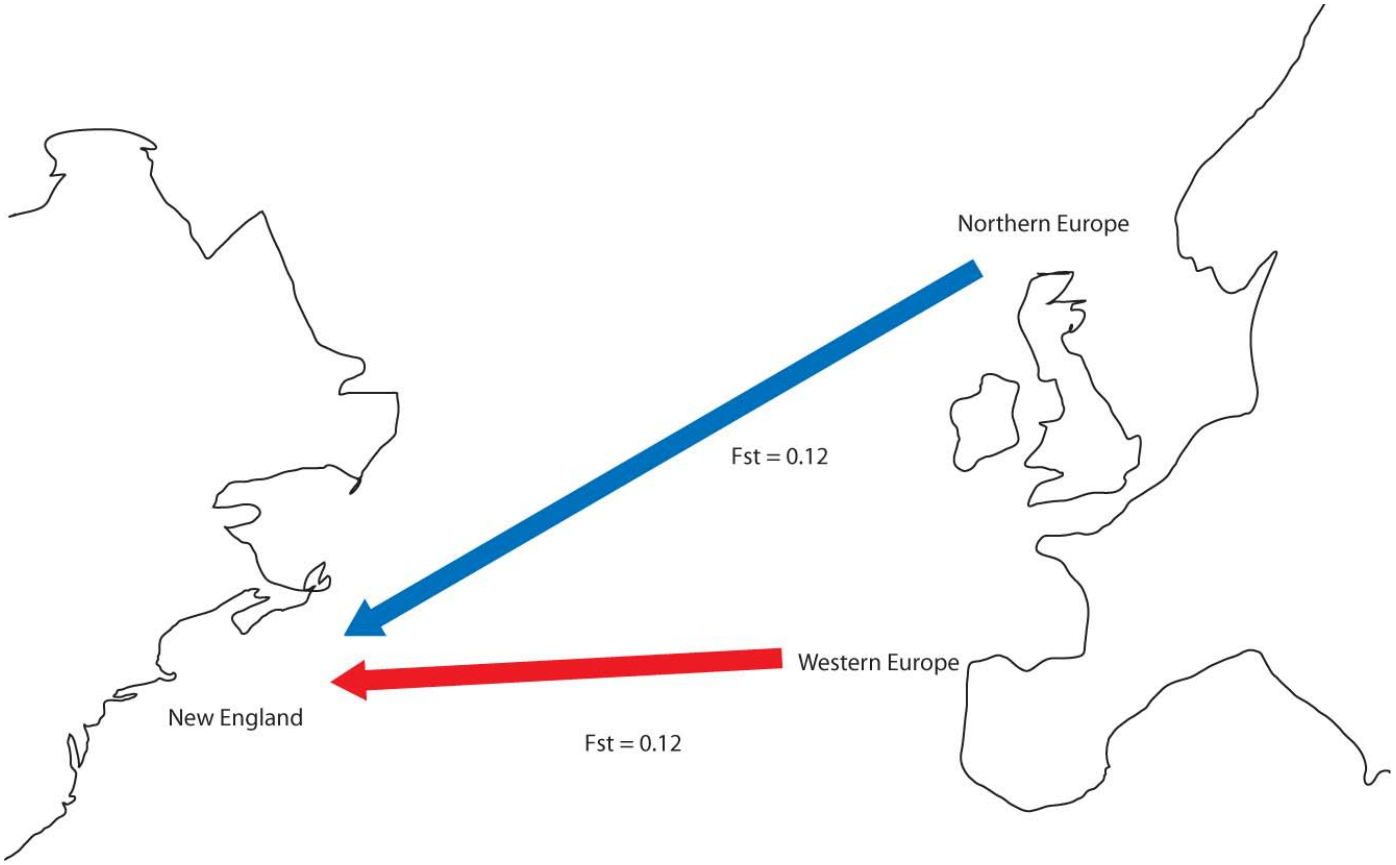
Average ship discharges 24 million liters ballast water

Large numbers of propagules and high genetic diversity, diluting founder effect and extending range



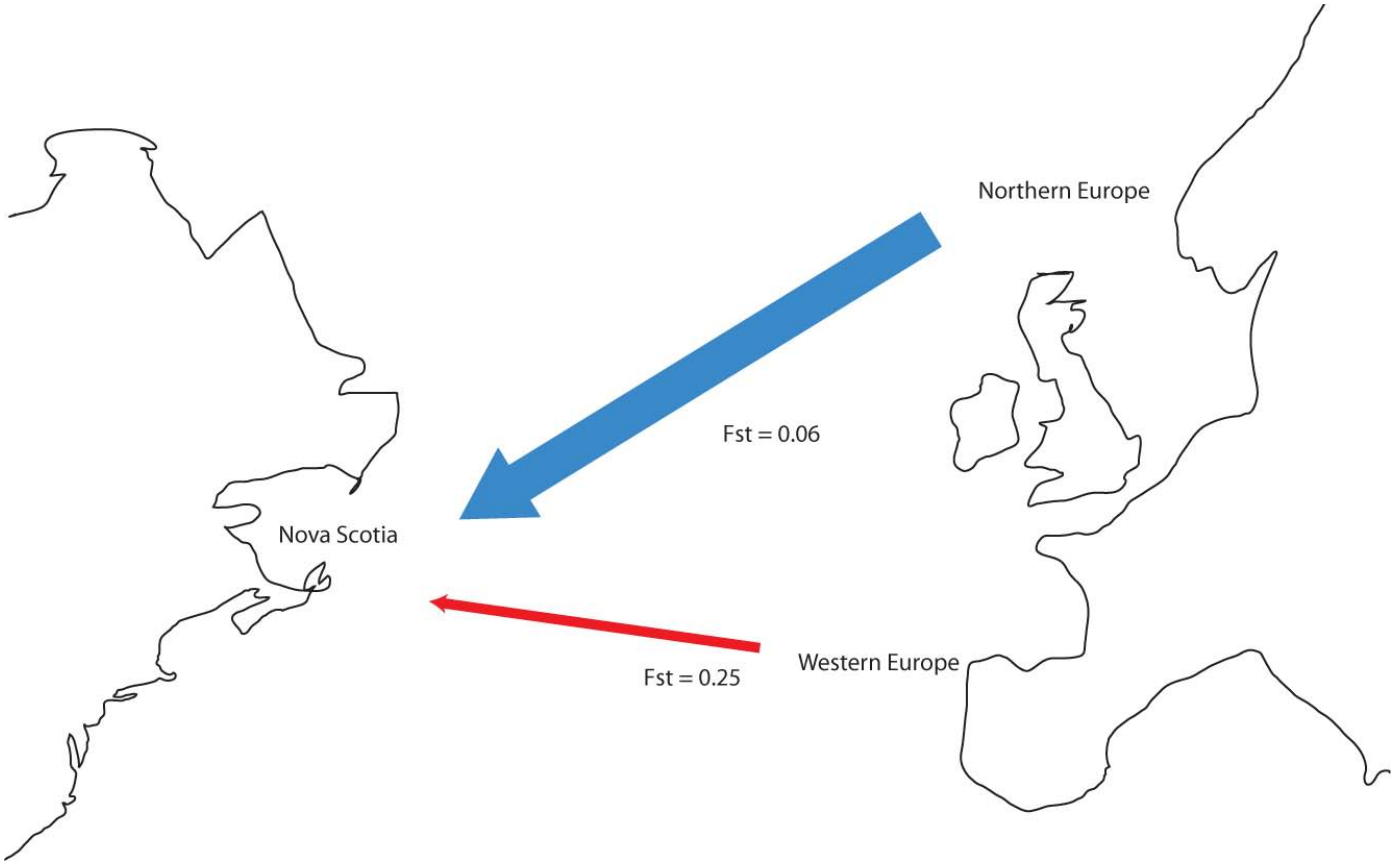
11% sequence divergence between Mediterranean and North Atlantic forms

Significant, though slight structure along Atlantic coast of Europe (F_{ST} = 0.015, p = 0.027)



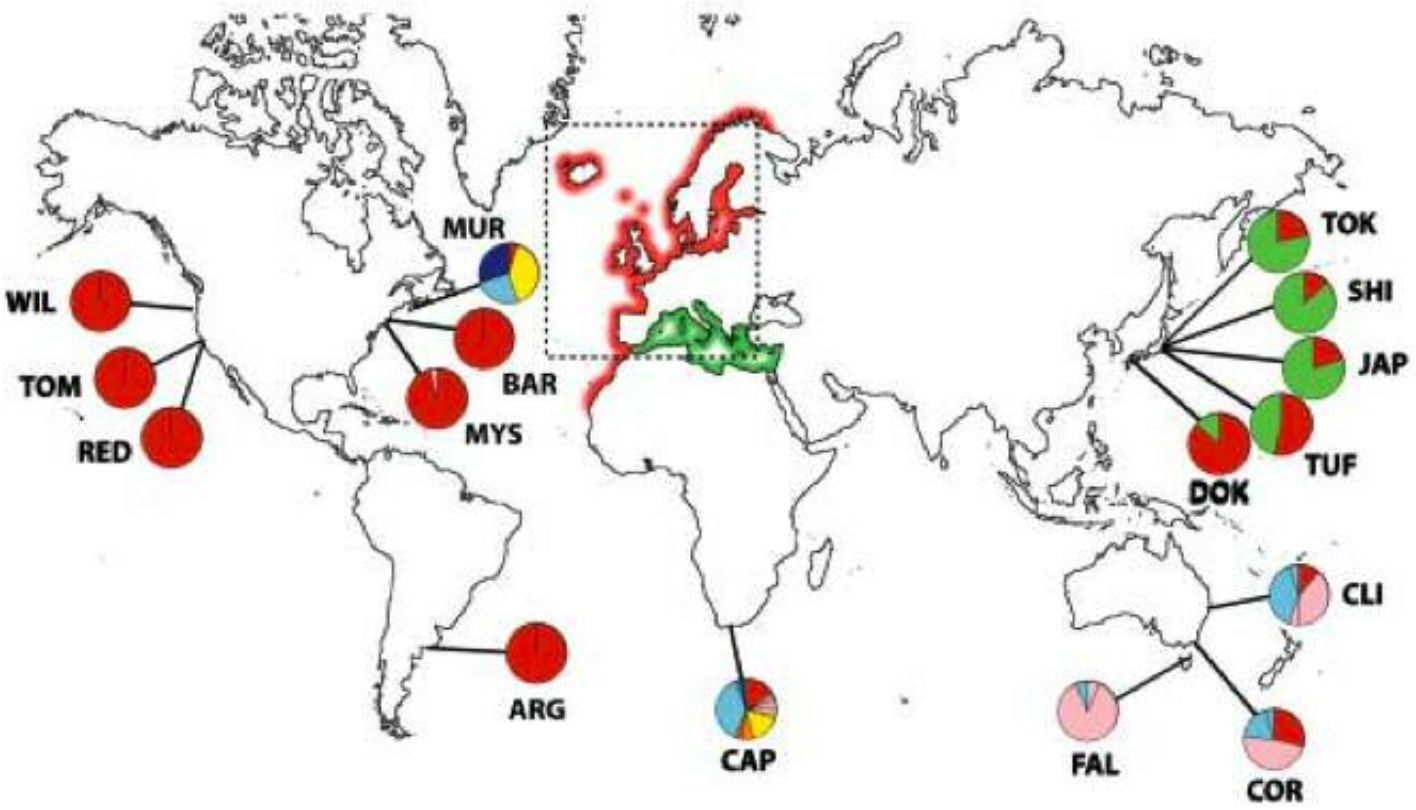
Early nineteenth-century invasion has same genetic distance to western and northern Europe

Roman Proc Royal Soc 2006



Late-20th-century invasion has much lower F_{ST} between Northern Europe and Nova Scotia

Carcinus Abroad



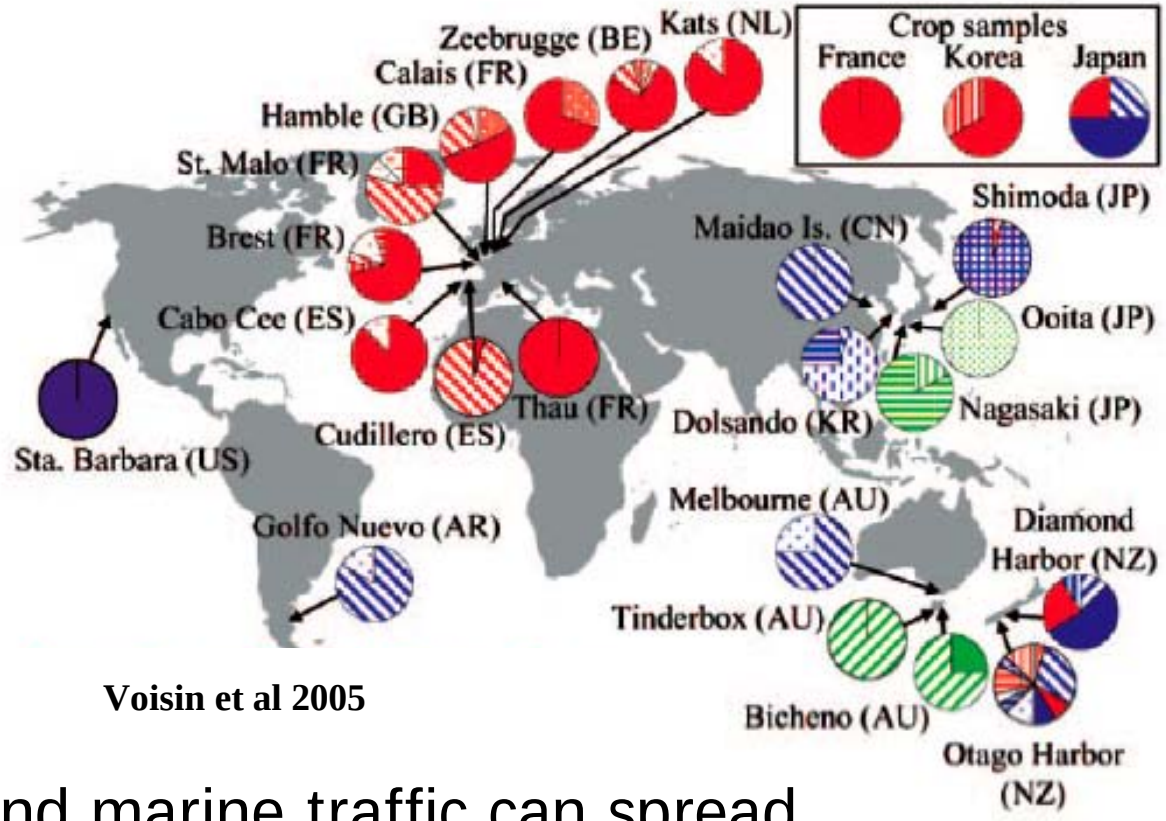
Darling et al Molecular Ecol. 2008

One global lineage

In New World, West Coast, NFLD, and Argentina are secondary invasions

Multiple invasions appear to be rule rather than exception

Undaria Abroad



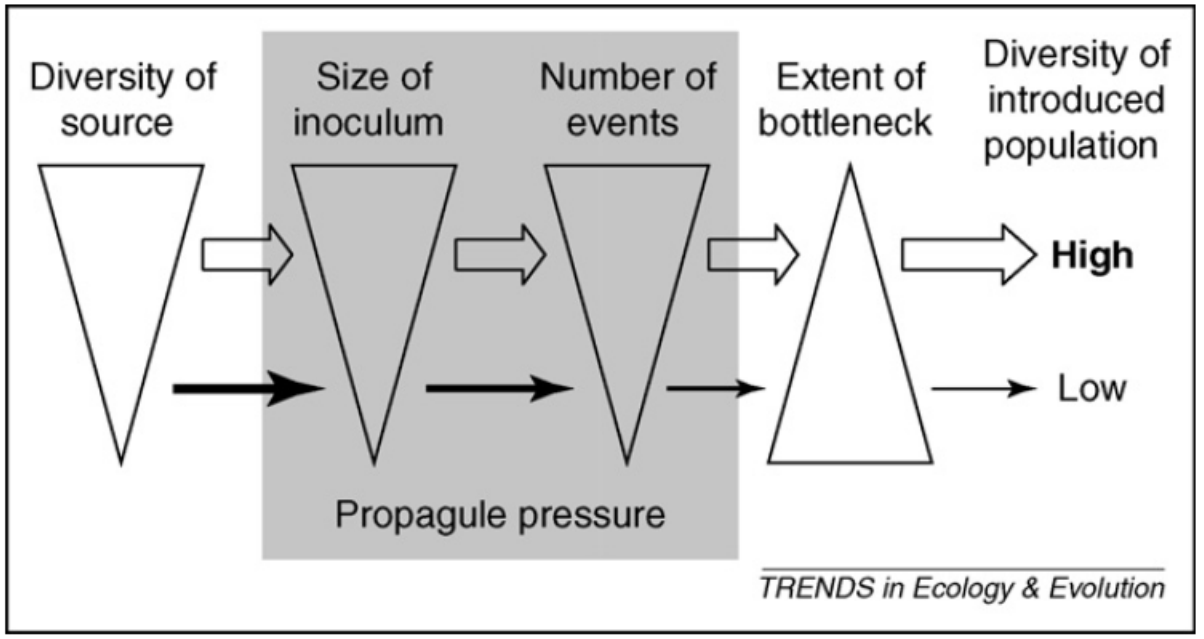
Voisin et al 2005

Both aquaculture and marine traffic can spread invasives, though different patterns emerge

European invasion likely through aquaculture

Australasian invasion probably through ballast transport

Paradox Lost



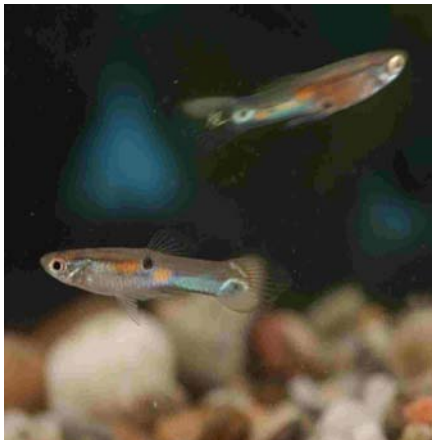
62% of aquatic invasions (n = 42) show increased or comparable levels of diversity as native populations, overwhelming founder effects

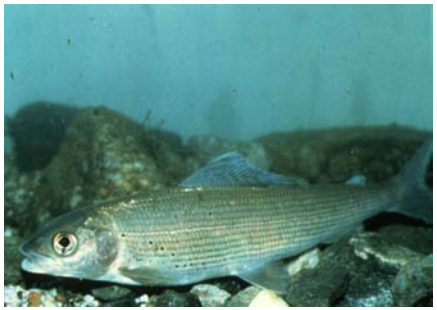
Ballast water and shellfish transplants convey most diverse populations

Multiple release events and postintroduction gene flow reduce variation between populations and increase within-population variation

Roman & Darling, TREE, 2007

Molecular diversity doesn't always predict invasion success



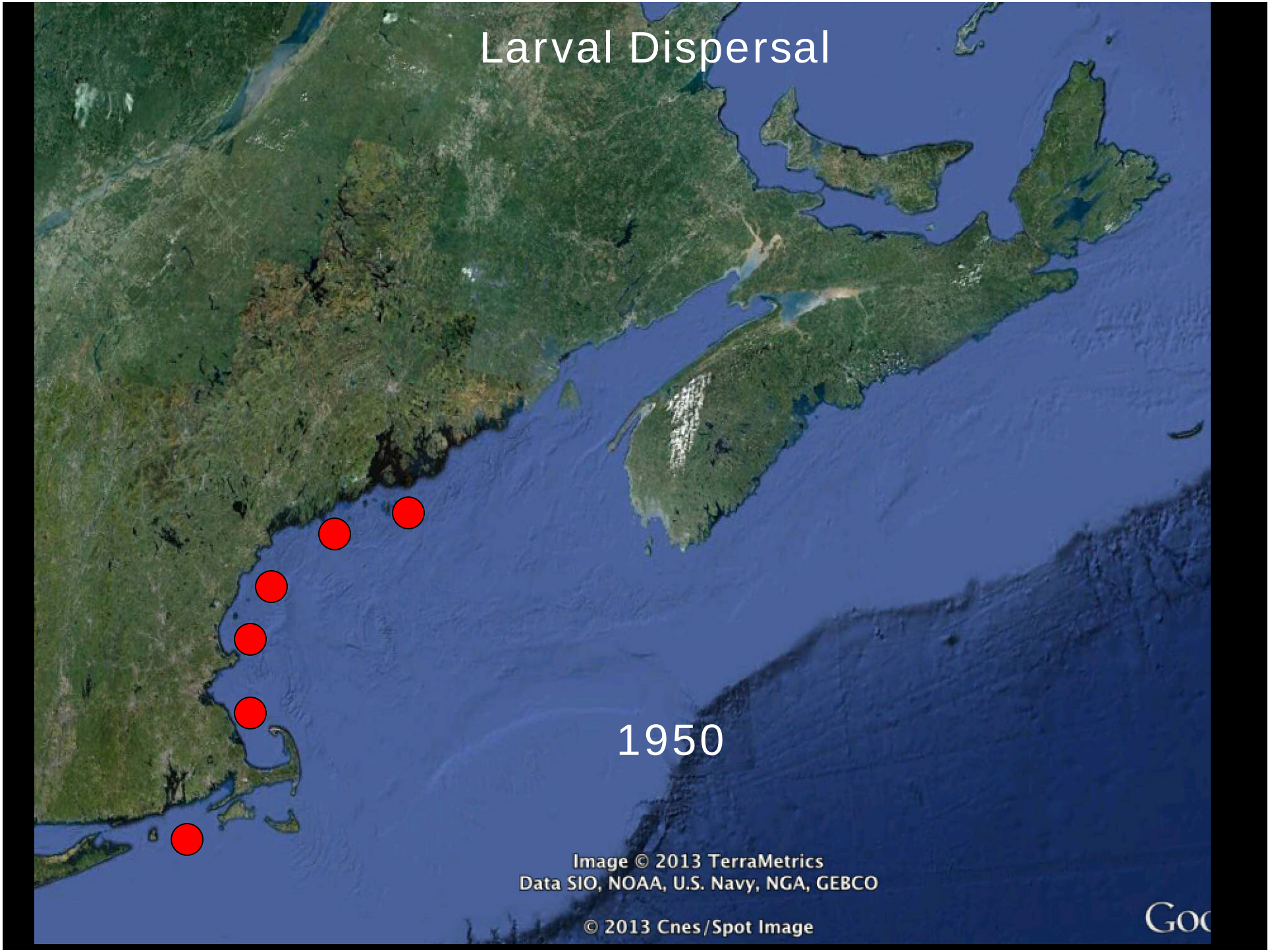


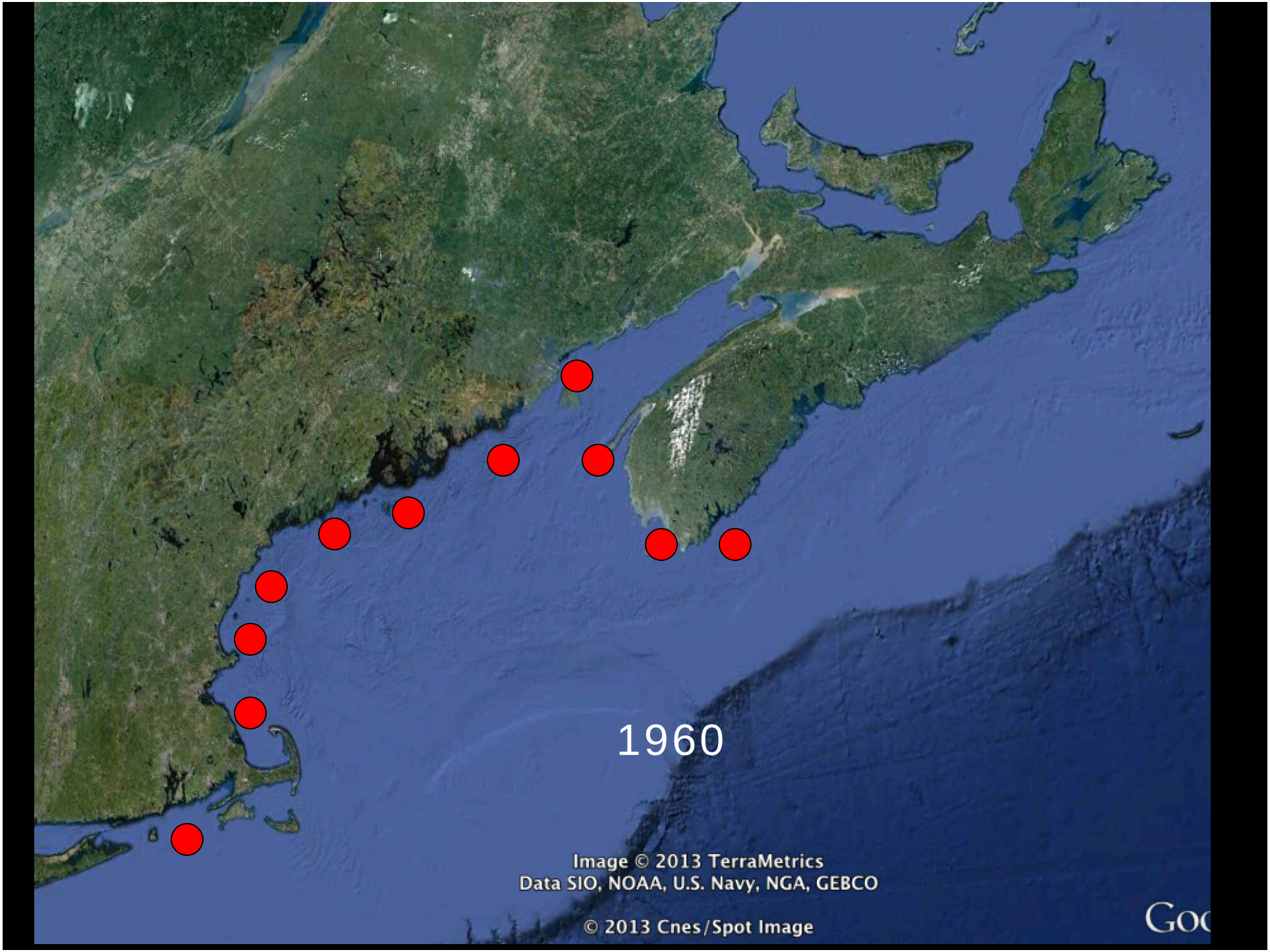
Highly invasive clonal haplotypes can invade with no genetic variation (eg. *Daphnia pulex* and *Caulerpa taxifolia*)

Some species exhibit ecological plasticity despite low diversity

Neutral markers do not always reflect genetic variation relevant to ecological success

Roman & Darling, TREE, 2007


Larval Dispersal
1950
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Cnes/Spot Image


1960
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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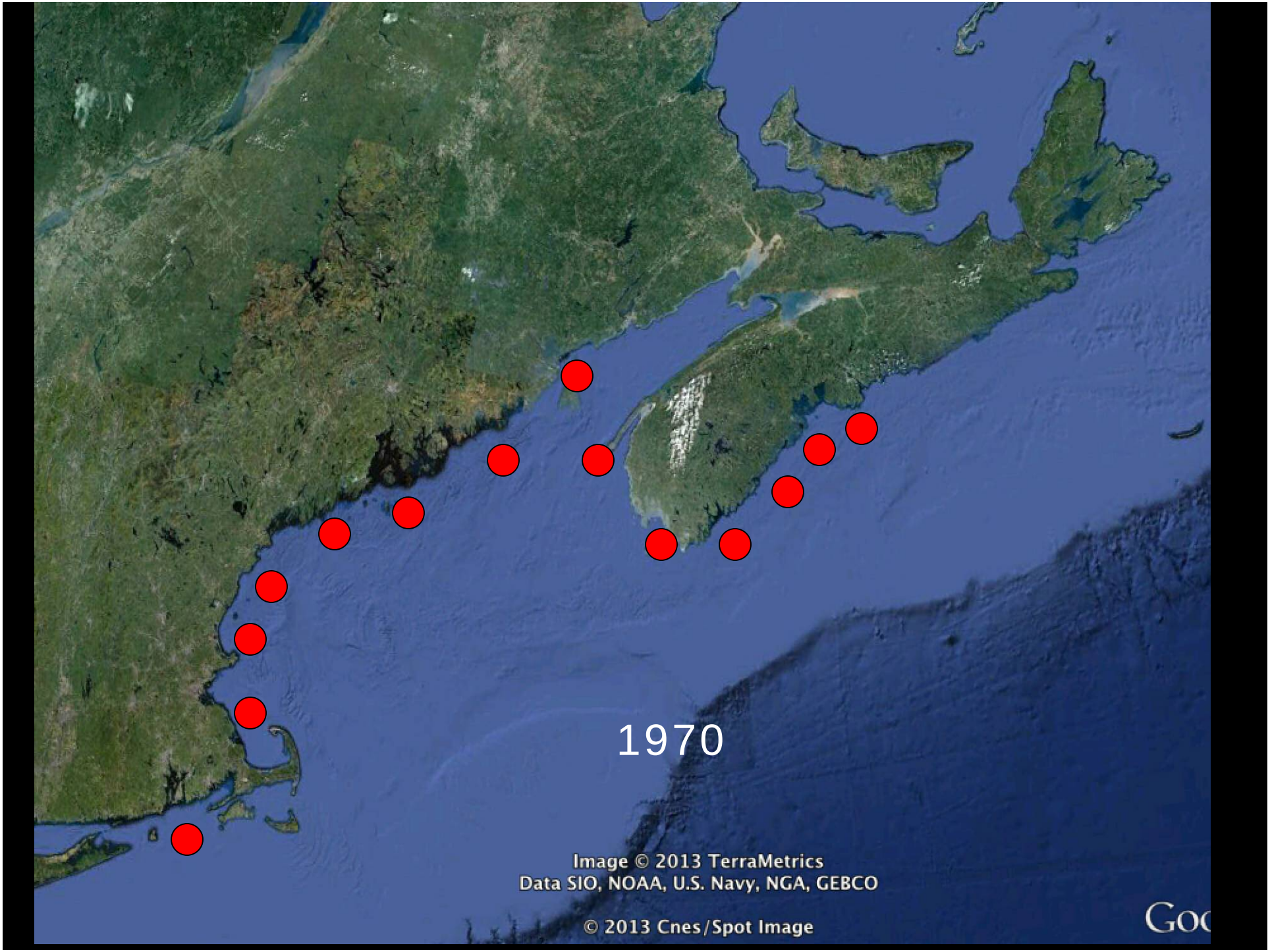
1970
Image © 2013 TerraMetrics
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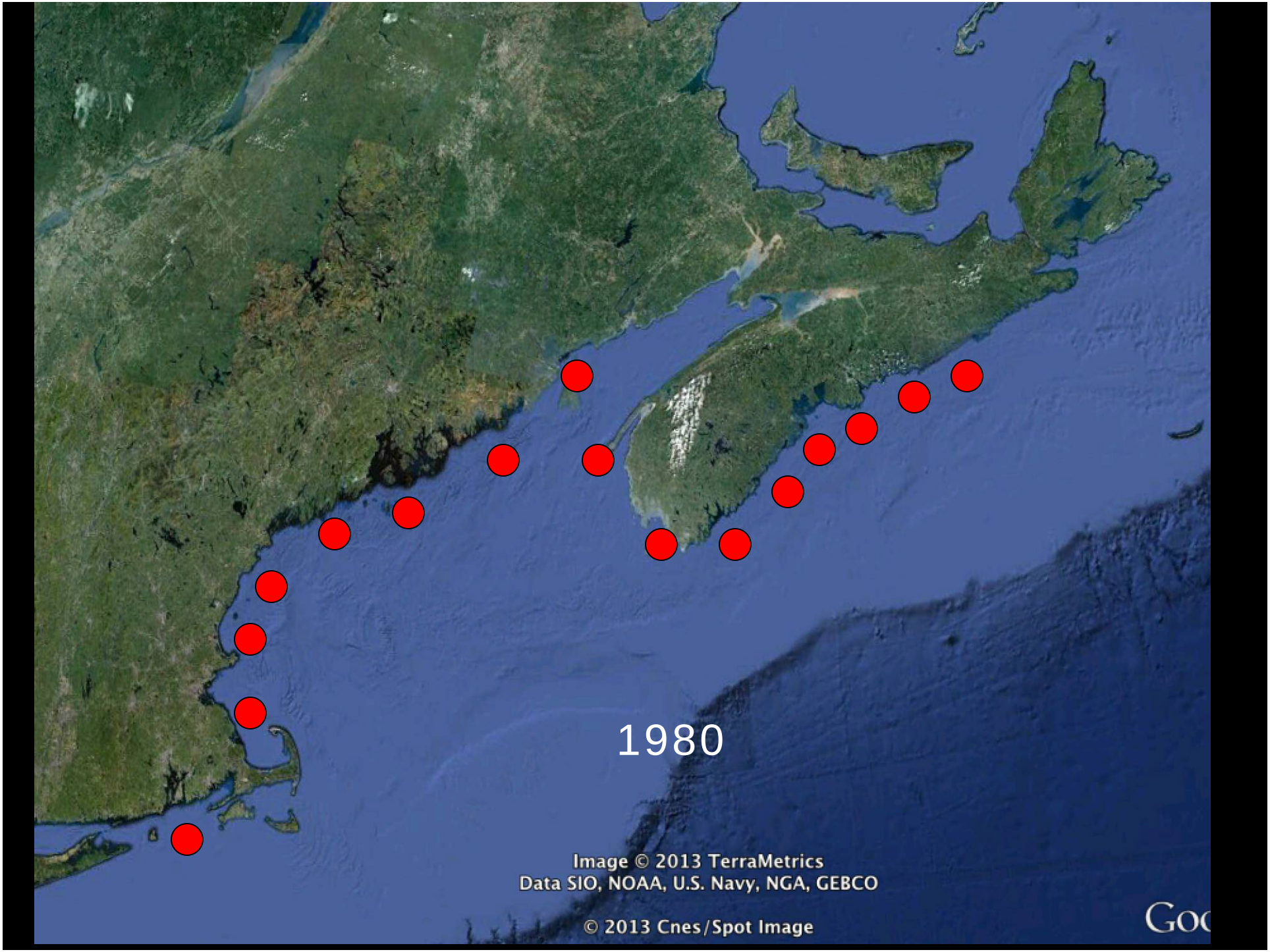
1980
Image © 2013 TerraMetrics
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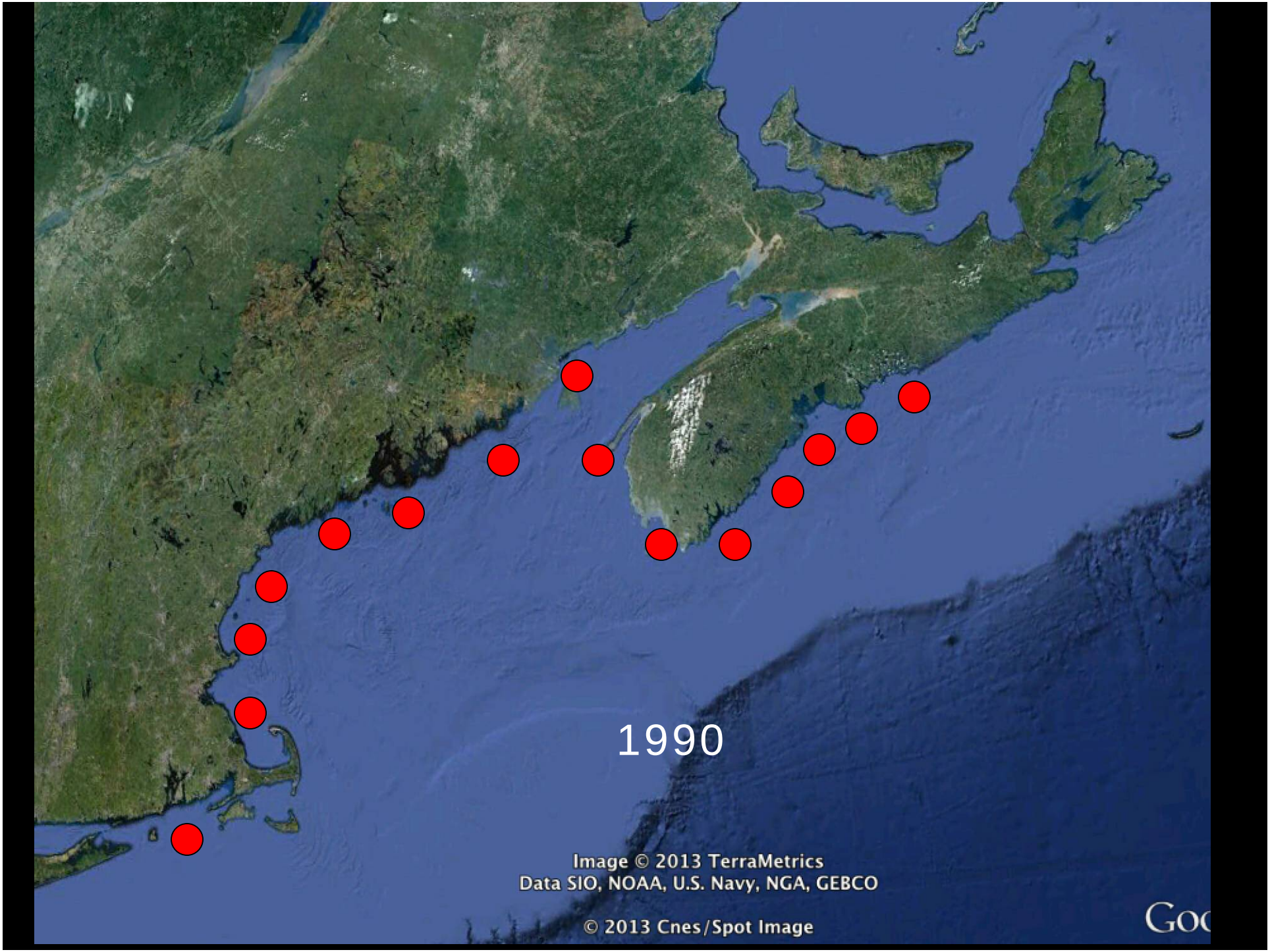
1990
Image © 2013 TerraMetrics
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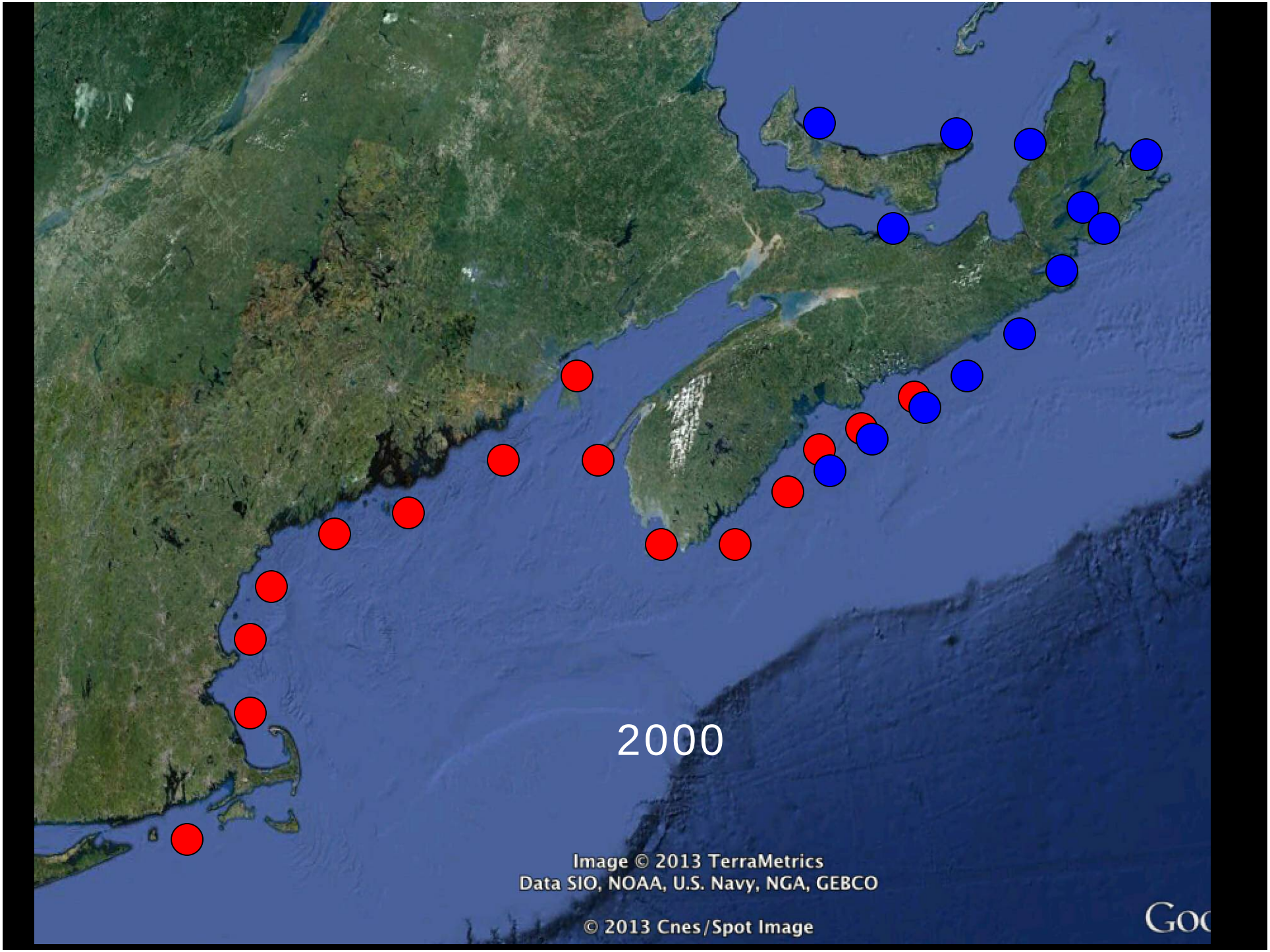
2000
Image © 2013 TerraMetrics
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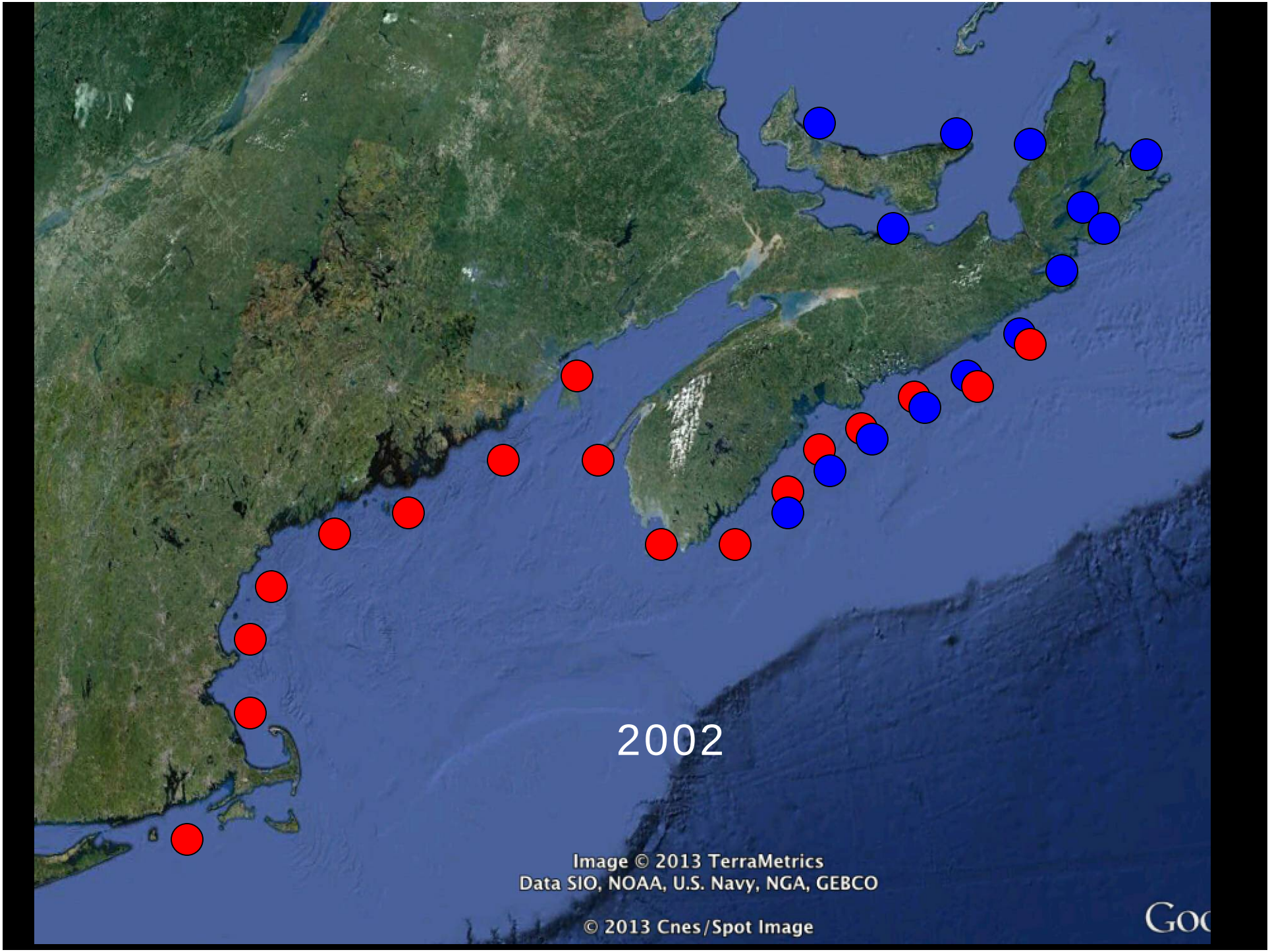
2002
Image © 2013 TerraMetrics
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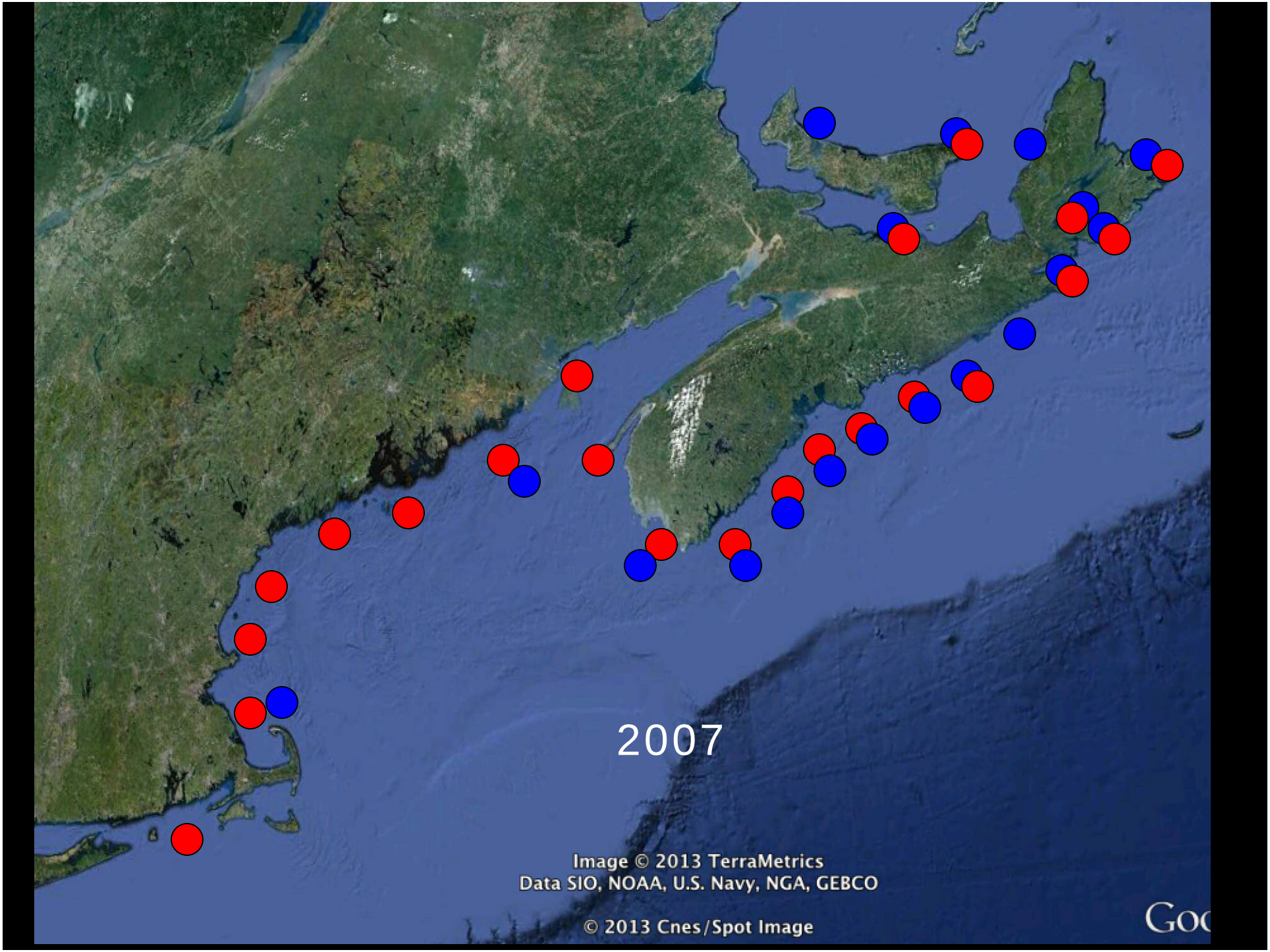
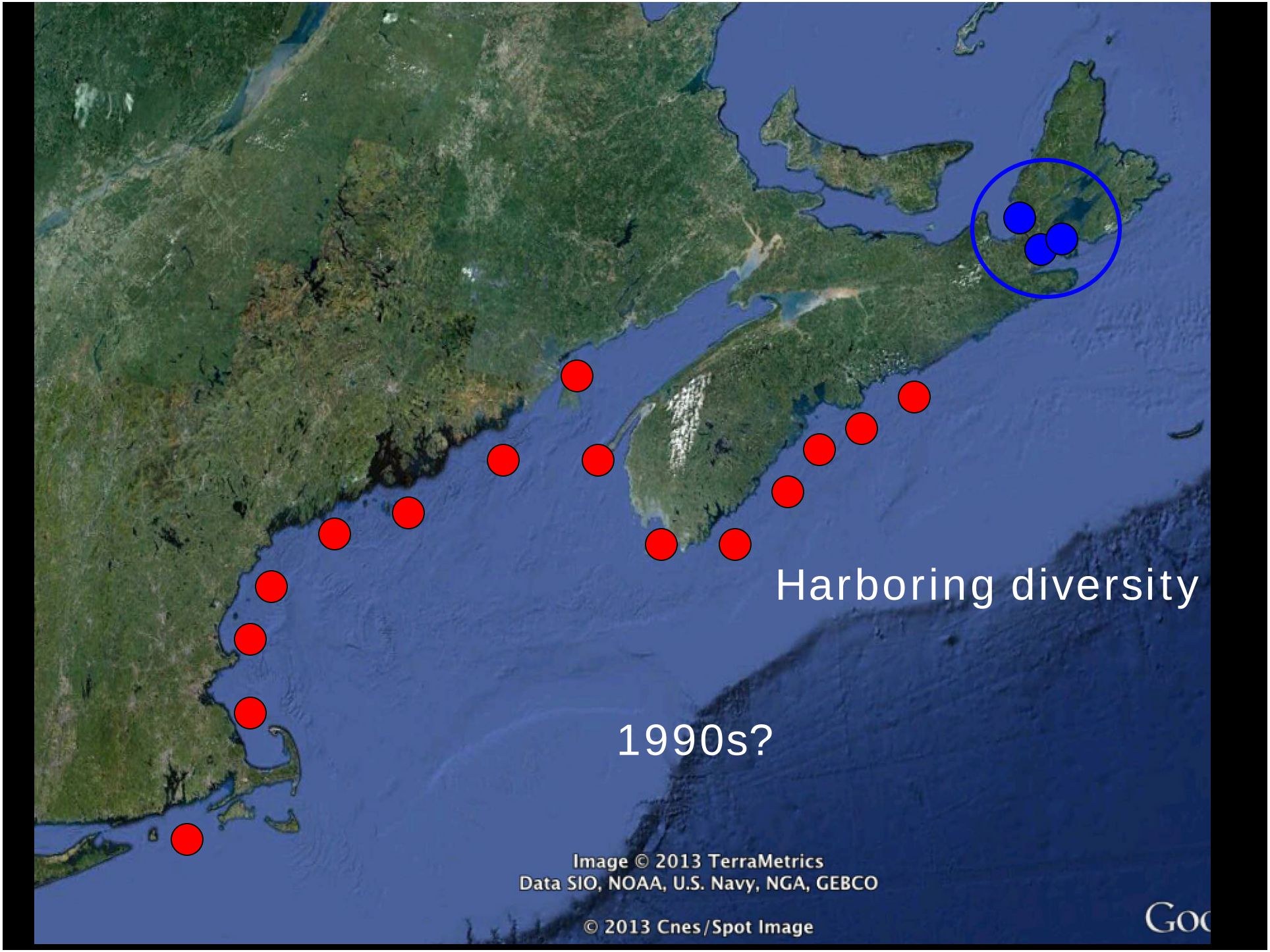
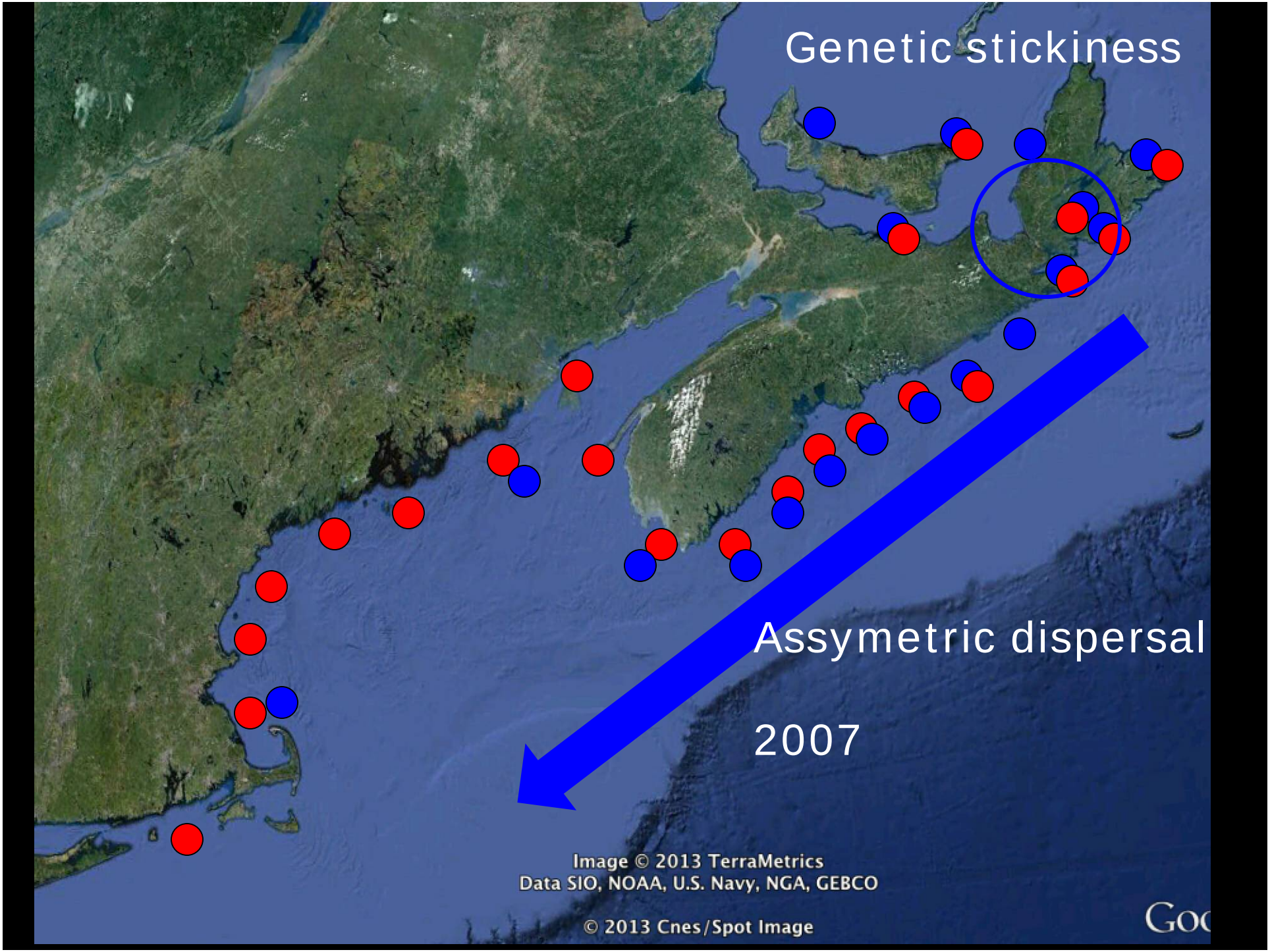
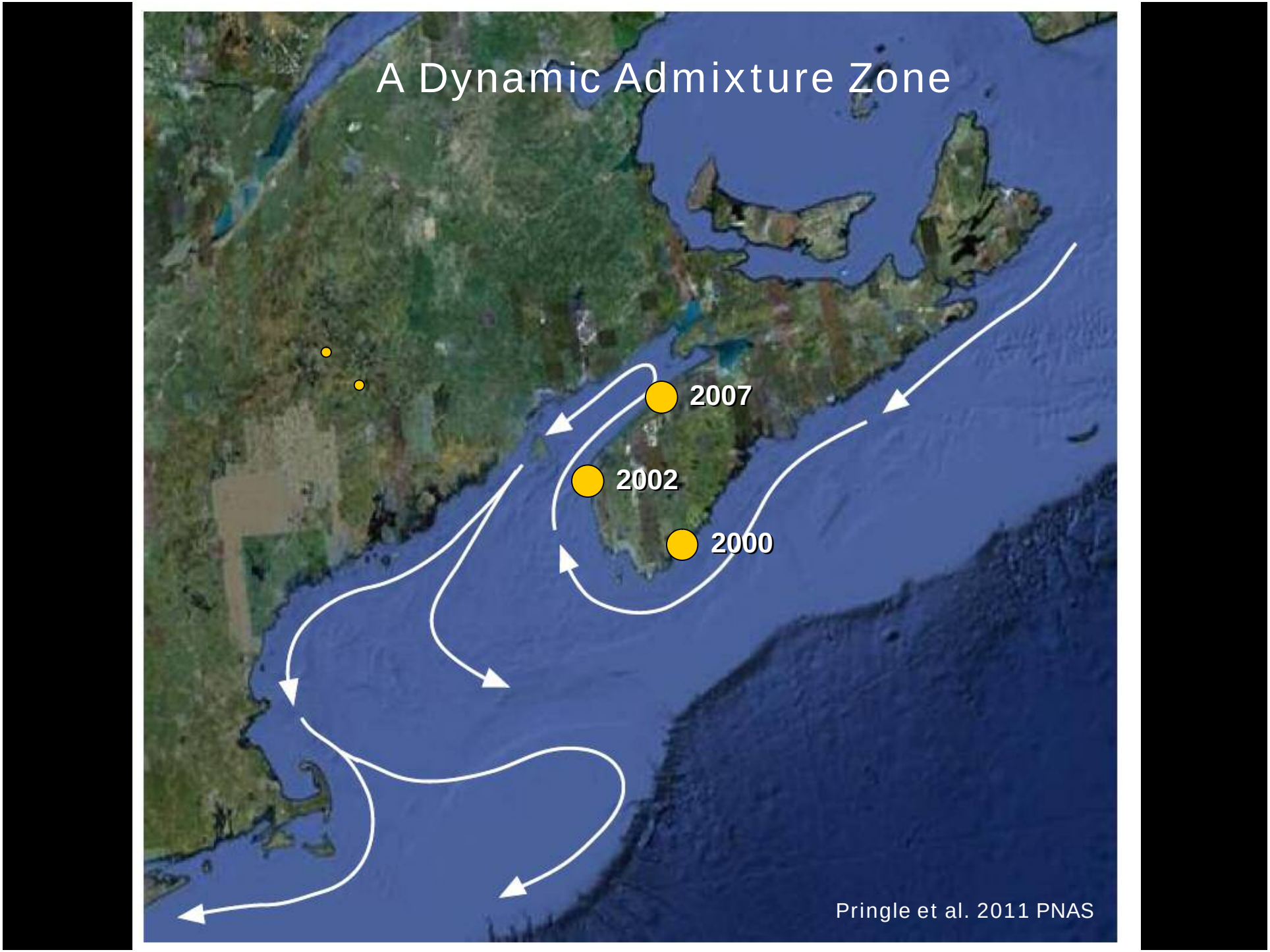
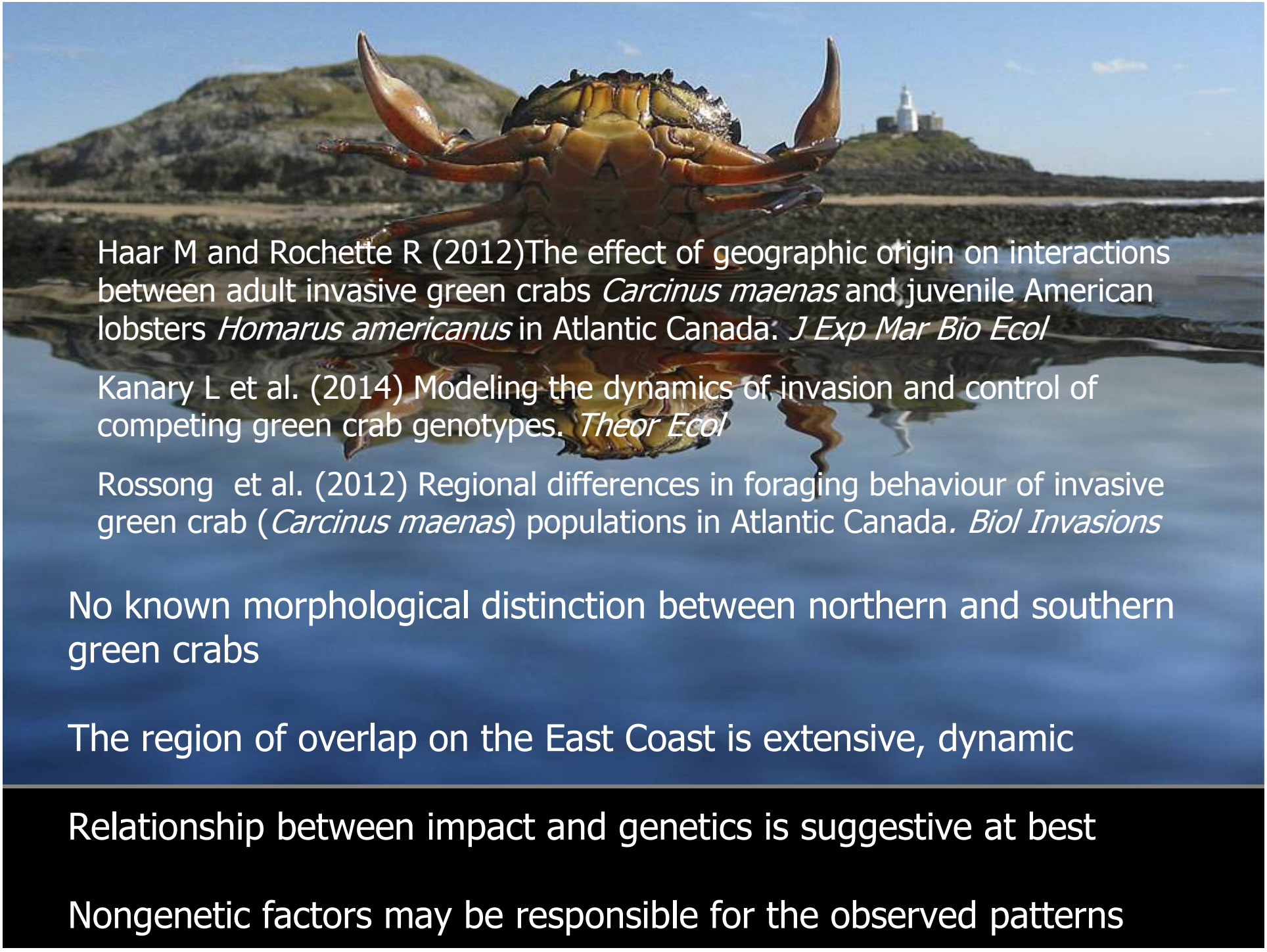
© 2013 Cnes/Spot Image


2007
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Cnes/Spot Image


Harboring diversity
1990s?
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Cnes/Spot Image


Genetic stickiness
Assymetric dispersal
2007
Image © 2013 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Cnes/Spot Image


A Dynamic Admixture Zone
2007
2002
2000
Pringle et al. 2011 PNAS



Haar M and Rochette R (2012)The effect of geographic origin on interactions between adult invasive green crabs *Carcinus maenas* and juvenile American lobsters *Homarus americanus* in Atlantic Canada. *J Exp Mar Bio Ecol*

Kanary L et al. (2014) Modeling the dynamics of invasion and control of competing green crab genotypes. *Theor Ecol*

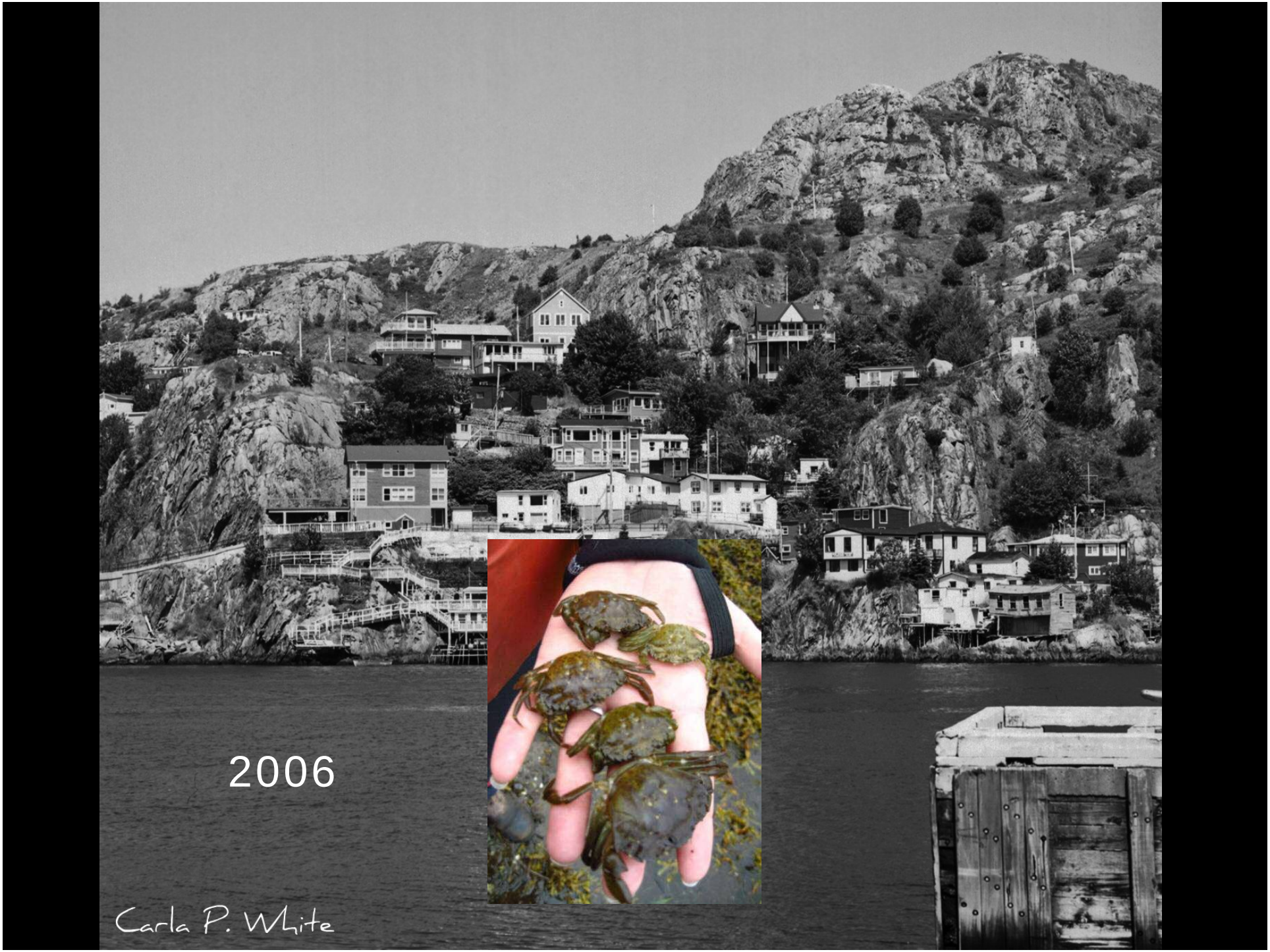
Rossong et al. (2012) Regional differences in foraging behaviour of invasive green crab (*Carcinus maenas*) populations in Atlantic Canada. *Biol Invasions*

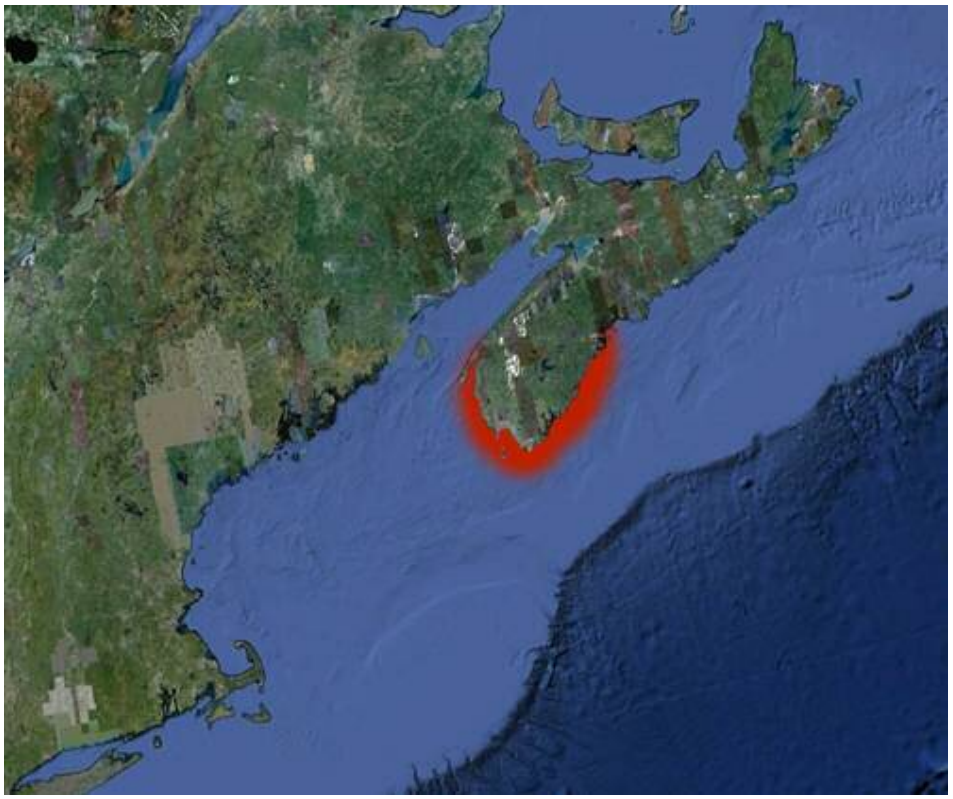
No known morphological distinction between northern and southern green crabs

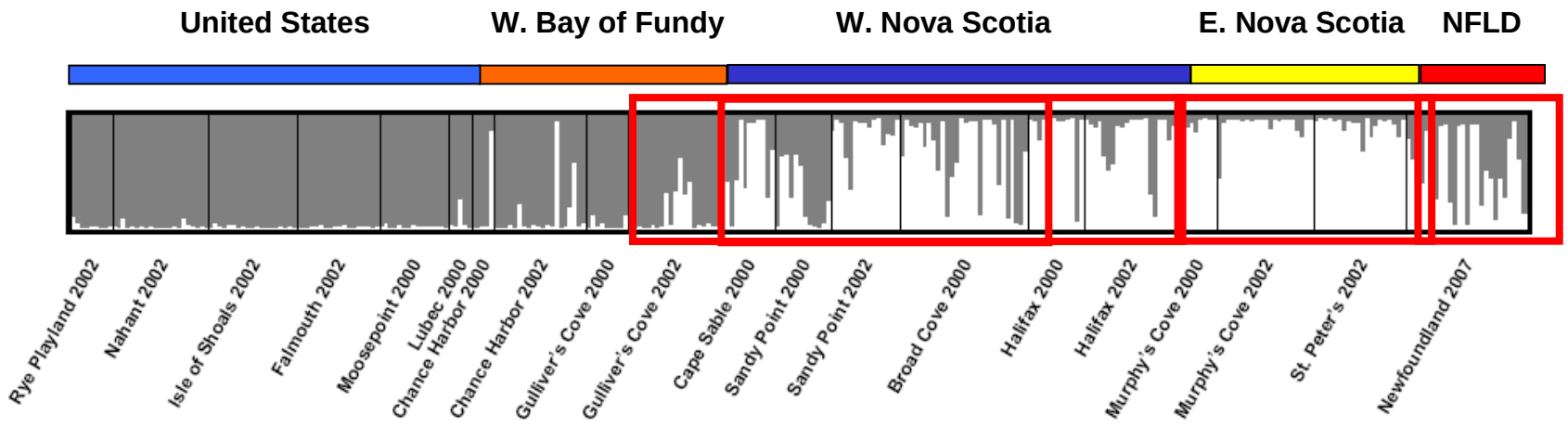
The region of overlap on the East Coast is extensive, dynamic

Relationship between impact and genetics is suggestive at best

Nongenetic factors may be responsible for the observed patterns


2006
Carla P. White





Blakeslee et al Diversity Distrib. 2010

Lagoon of Venice

Soft-shelled crabs in spring: *molecche*

Females with ripe ovaries in fall: *masanette*

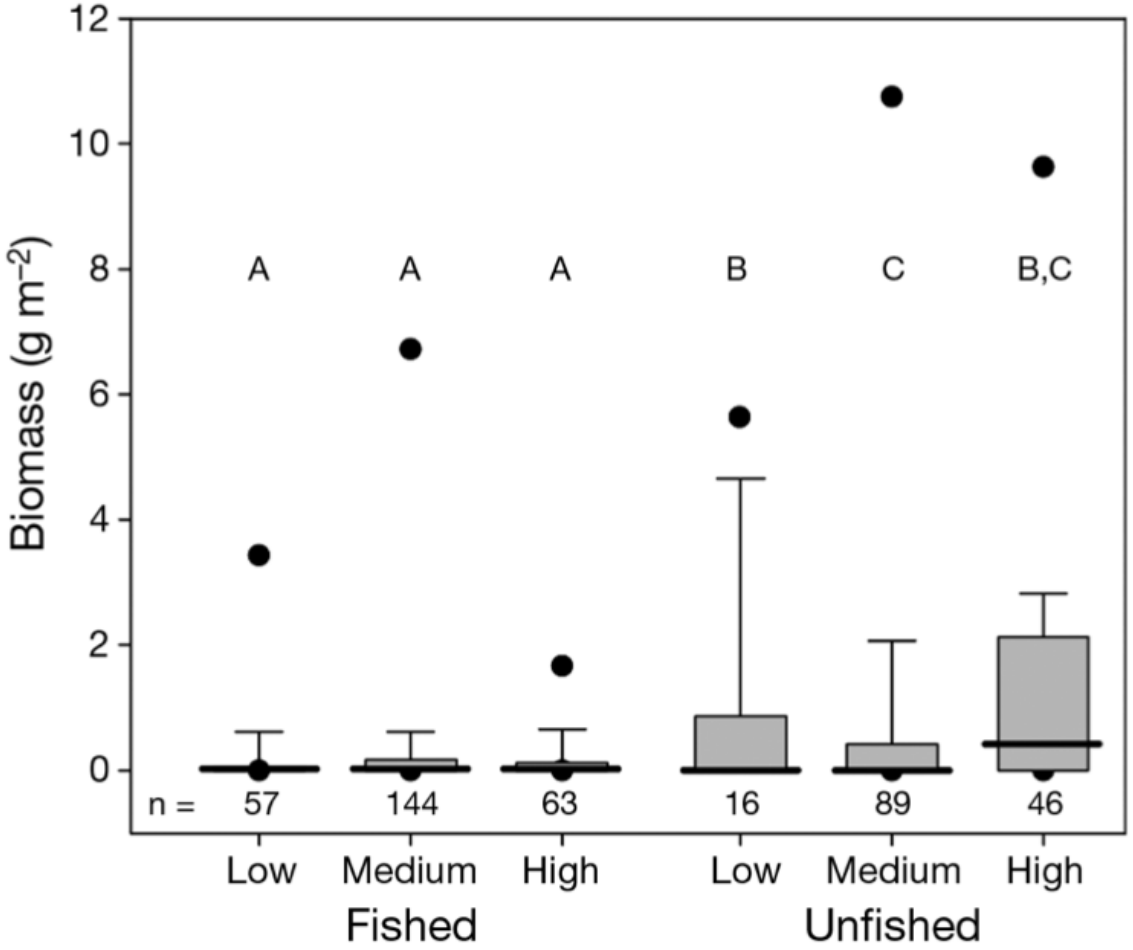
EAT THE INVADERS

FIGHTING INVASIVE SPECIES, ONE BITE AT A TIME

Blue Plate Special: Asian Shore Crab

Last month, we got together with New Haven sushi chef Bun Lai to discuss eating invaders at Williams College. Read about the Asian shore crab and find out how to ...

eattheinvaders.org



Lionfish biomass in fished locations on Bonaire was 2.76-fold lower than in unfished areas and 4.14-fold lower than on unfished Curaçao

Acknowledgments

Blakeslee, J. Byers, J. Carlton, C. Cunningham, J. Darling, L. Farrell, L. Johnson A. Locke, H. Overhill, N. Overhill-Rosenthal, S. Palumbi, J. Pringle, G. Ruiz, E. Sotka, M. Torchin, B. Von Holle, J. Wares, and S. Yamada

Census of Marine Life, EPA, NSF