Hot Science Cool Talks

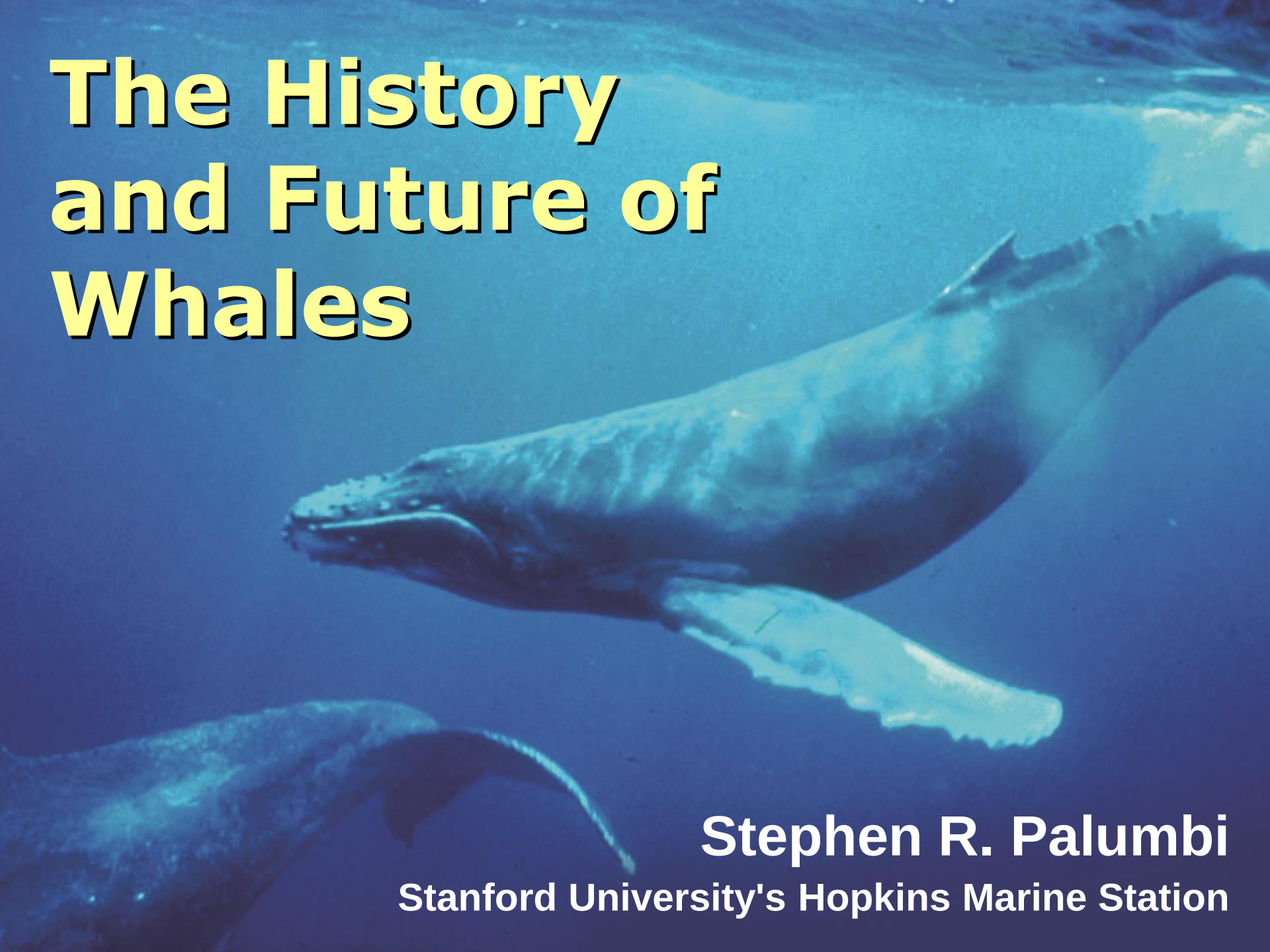
UT Environmental Science Institute

45

The History and Future of Whales

Dr. Stephen R. Palumbi

November 16, 2006

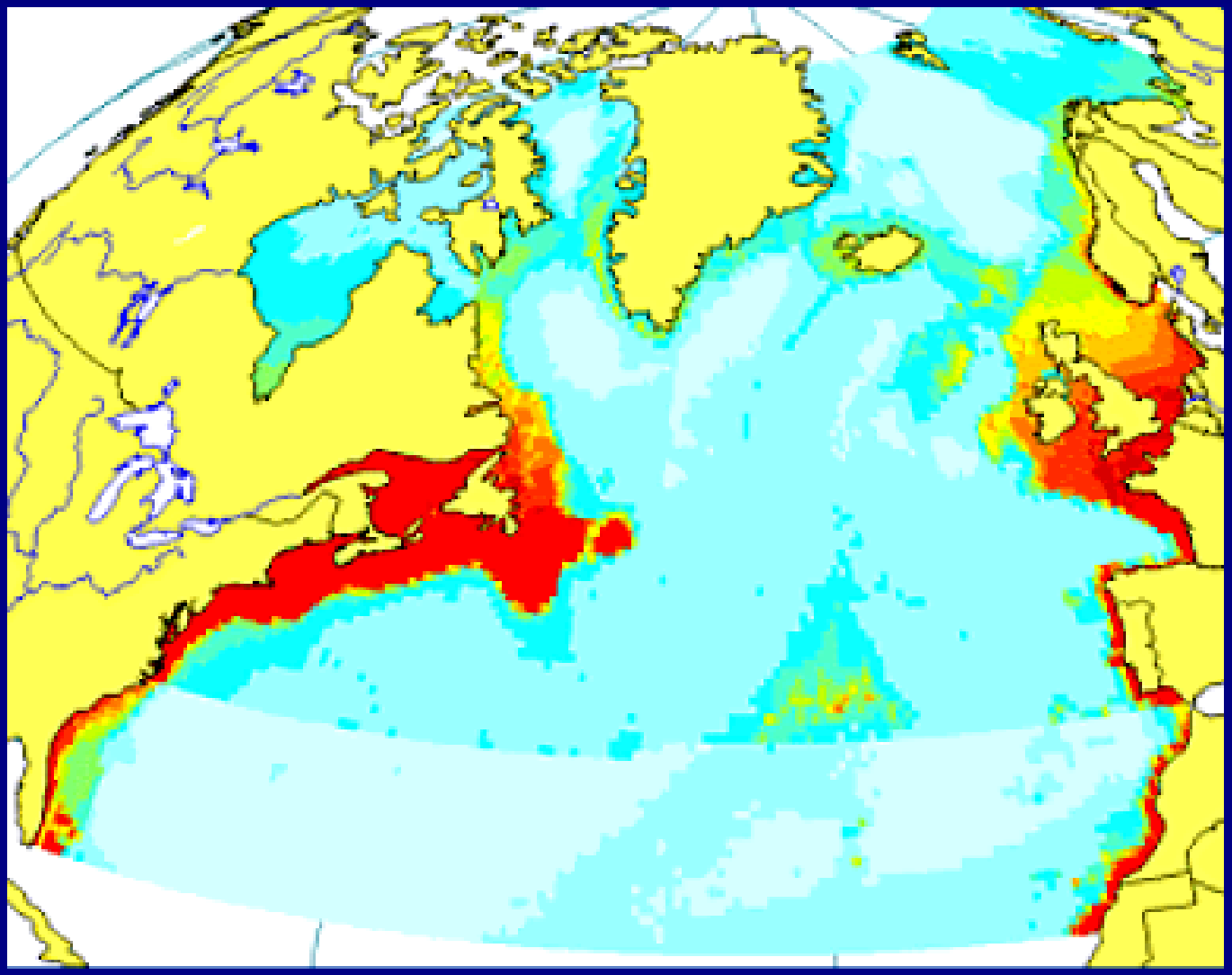


The History and Future of Whales

Stephen R. Palumbi

Stanford University's Hopkins Marine Station

Biomass distributions for high trophic-level fishes in the North Atlantic. 1900 - 2000



tons per sq km

- > 11
- < 11
- < 10
- < 9
- < 8
- < 7
- < 6
- < 5
- < 4
- < 3
- < 2
- < 1

1900 1950 1975 2000

Ocean neighborhoods have changed

The Sea Around Us Project:
D. Pauly and coworkers at UBC

Biomass distributions for high trophic-level fishes in the North Atlantic. 1900 - 2000

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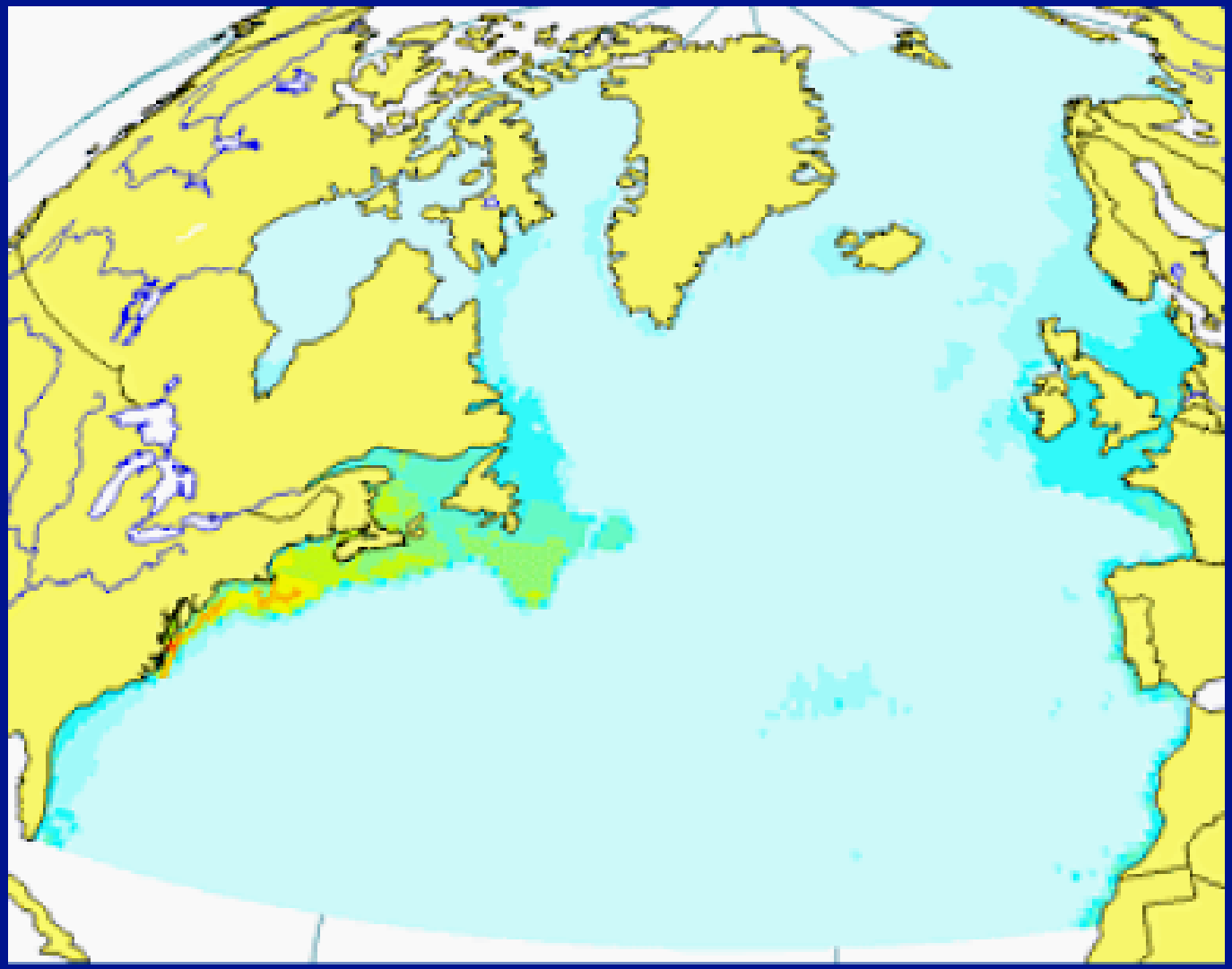

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The Sea Around Us Project:
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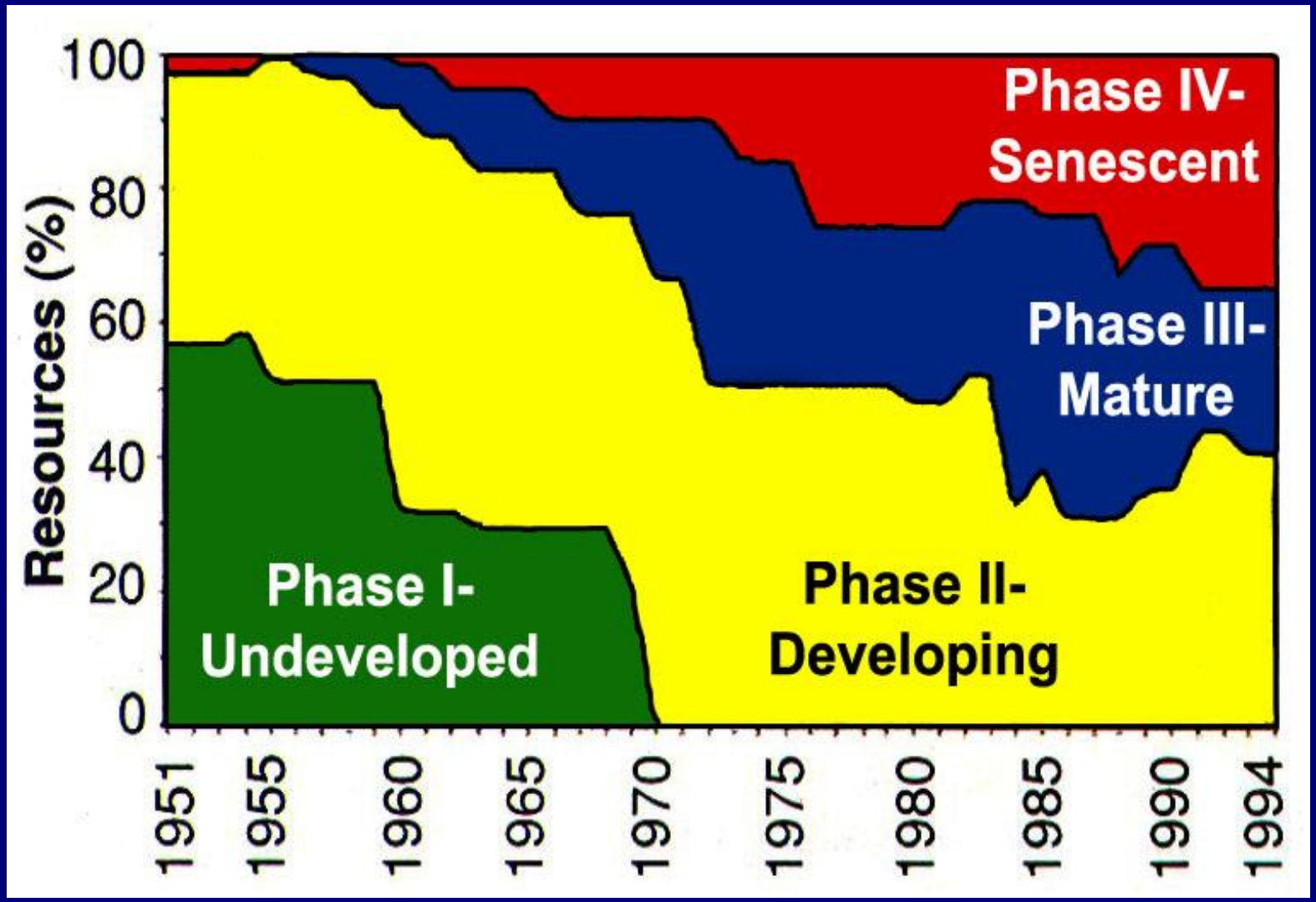
Decline in state of the World's fisheries



Vitousek et al. 1997

What fish is that on my plate?

Microdocs.org - Cooking with DNA - NPR's *Splendid Table*

Package of whale meat - what species is it?

What whale meat is legal?

- **International Whaling Commission (IWC)**

  Sets catch limits and manages population recovery

- **Convention on International Trade of Endangered Species (CITES)**

  Requires permits for international shipment

CITES

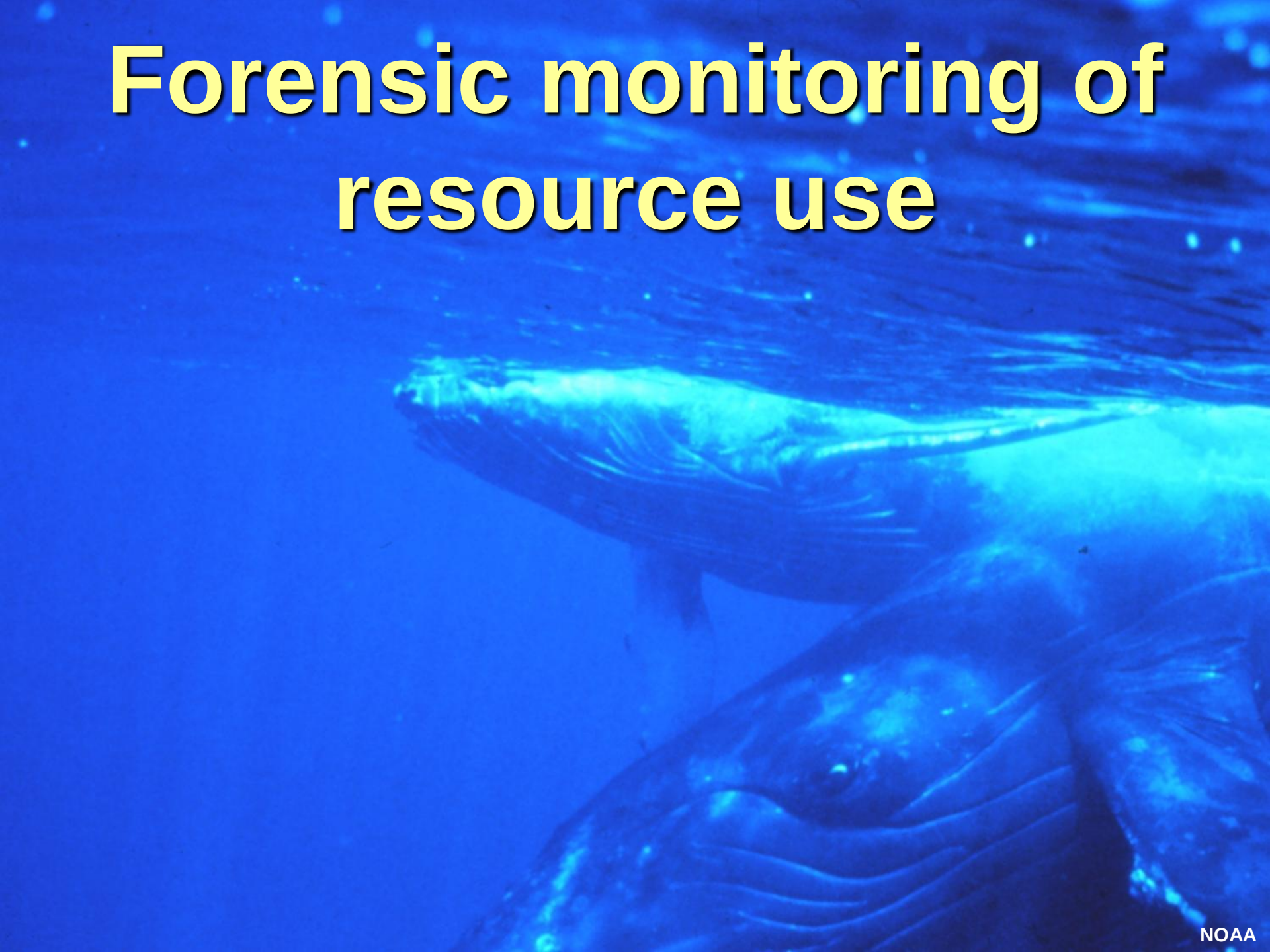
Convention for the International Trade of Endangered Species

- Regulates imports and exports of endangered species and derivatives of endangered species
- Distinguishes endangered and commercially threatened species
- Member nations follow strict import/export regulations

Scientific whaling

- IWC members issue themselves permits for scientific whaling.
- Review is necessary but approval is not.
- Commercial use of products is encouraged after research use.

Forensic monitoring of resource use

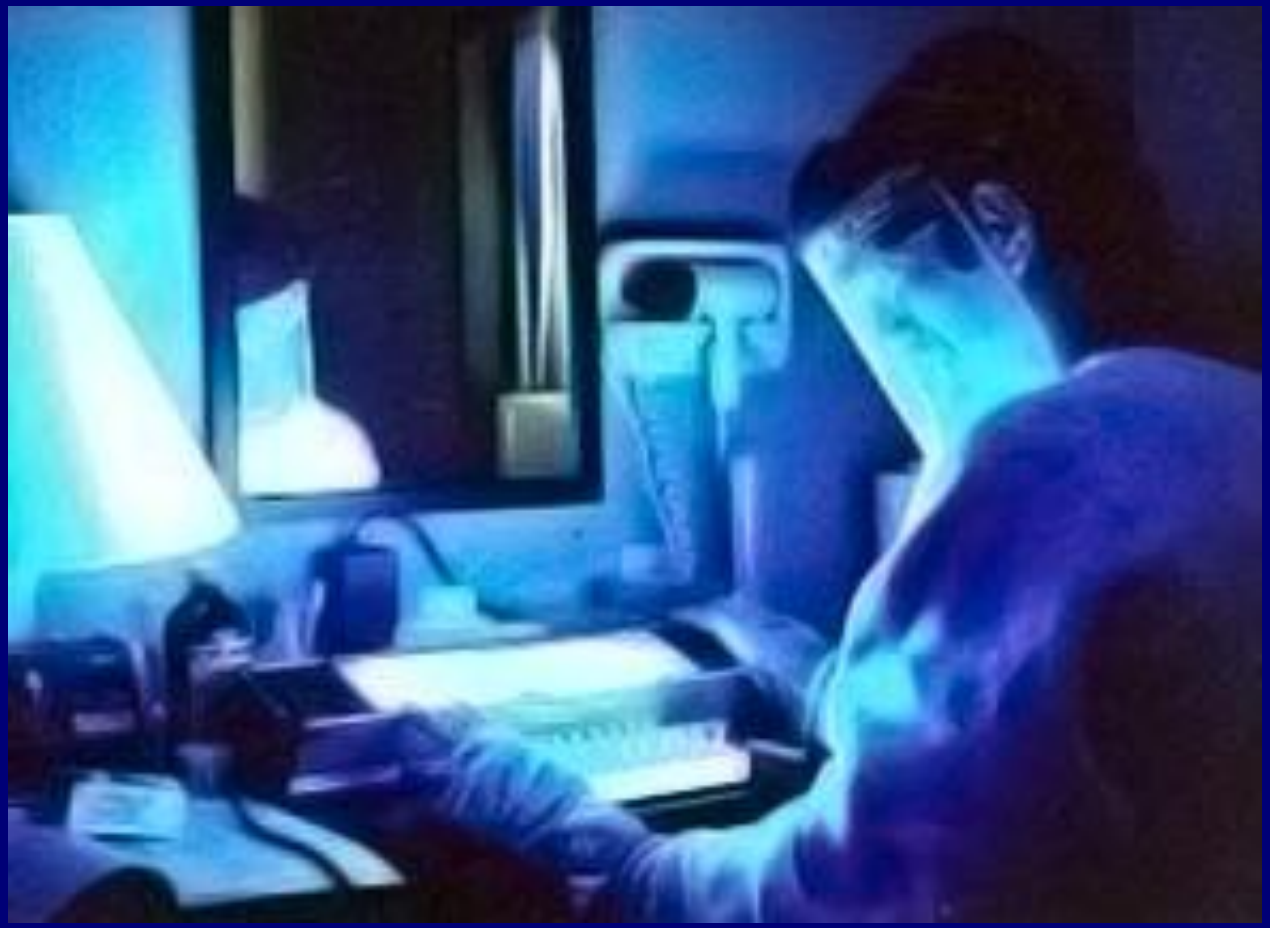


NOAA


Handi Wrap


MINI-BAR

Forensics and the future



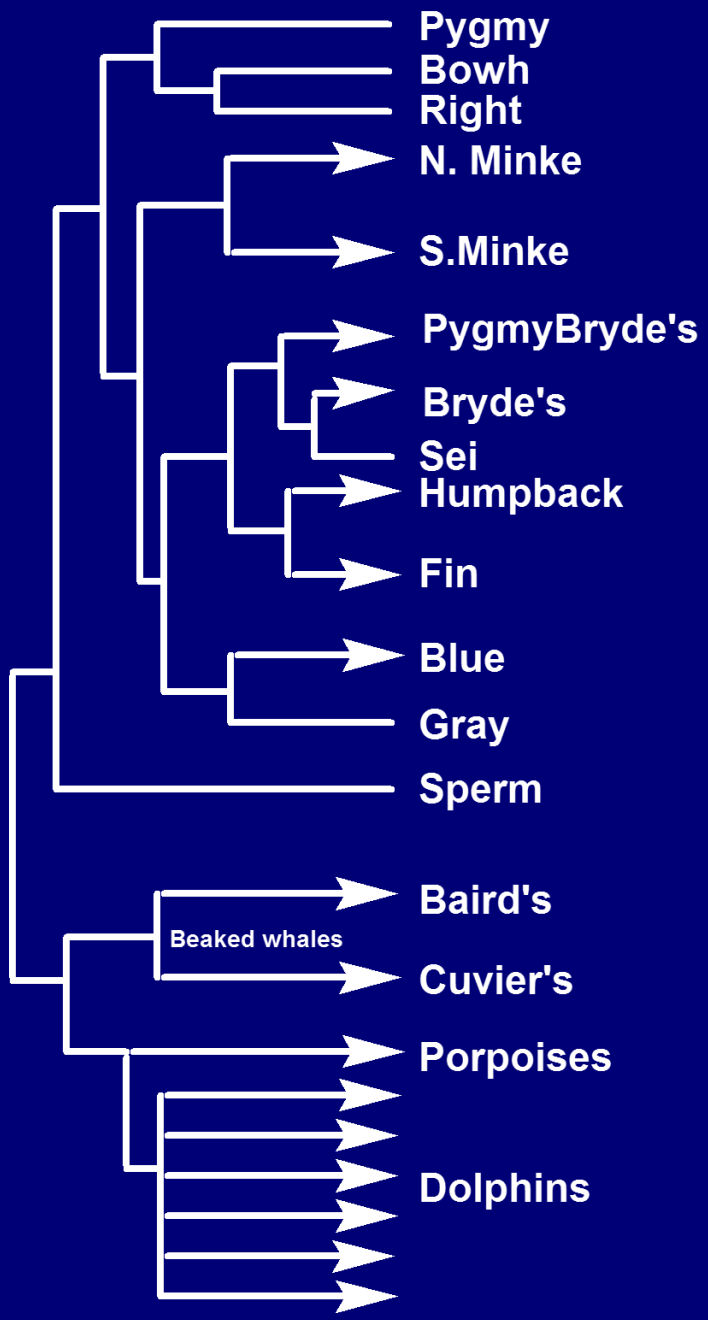
Scott Baker on first Tokyo meat mission (1993)

DNA testing of retail whale products examines relationship between policy and practice


Scott Baker
tries for a
GQ cover

Matt Hare on 1998 Tokyo mission

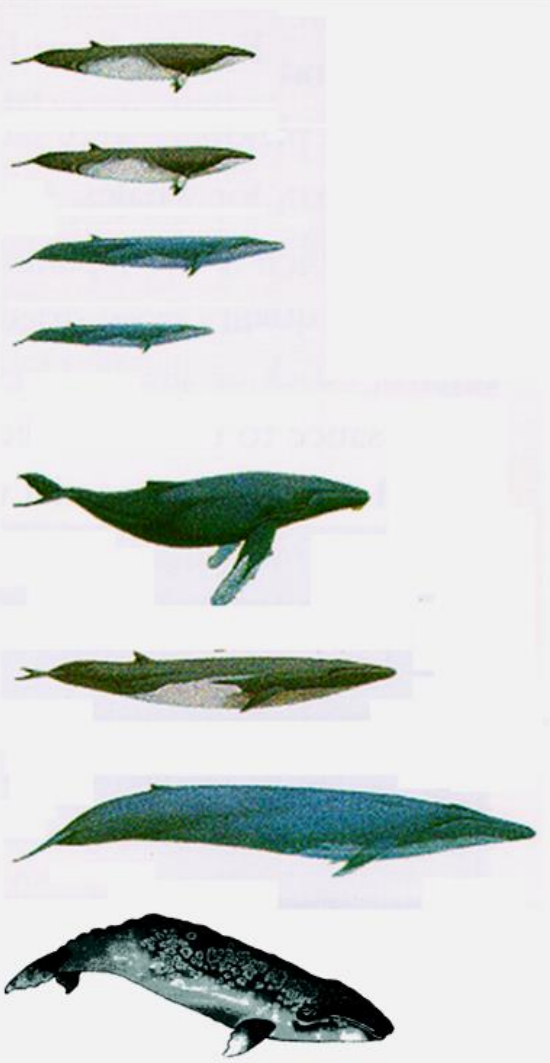
PCR copied whale genes are separated from native whale DNA in the field so we can strictly follow CITES regulations



Simplified phylogeny of whales used for assigning species names to meat samples

Molecular identification of baleen whale products

N. minke	339
S. minke	369
Brydes	10
Pygmy Brydes	2
Sci	9
Humpback	7
Fin	49
Blue	2
Grey	7



Data from Palumbi, Baker labs 1993-2000

Species other than baleen whales in retail markets

Sperm	5
Pygmy Sperm	1
Other Beaked Whales	5
Baird's	56
Cuvier's	6
Porpoise	19
Killer Whale	2
Dolphin	104
Non-Whale	7

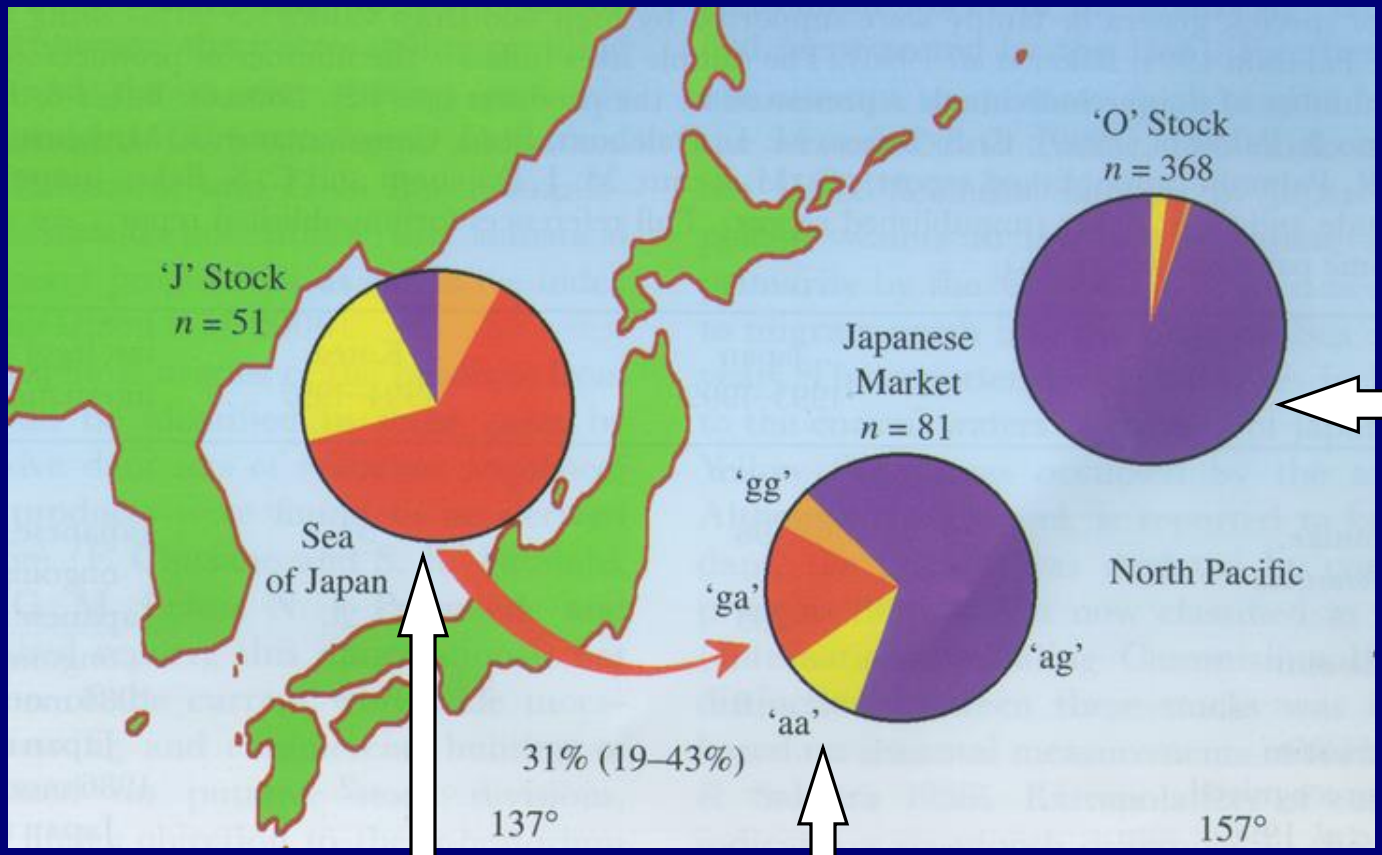
Data from Palumbi, Baker labs 1993-2000

Conclusion

- Many species of whales and dolphins are for sale in retail markets.
- Does this failure to protect put any whales at risk of extinction?

Consequences of selling the wrong whales

Threatened Sea of Japan minke meat masquerading as legal take from the North Pacific



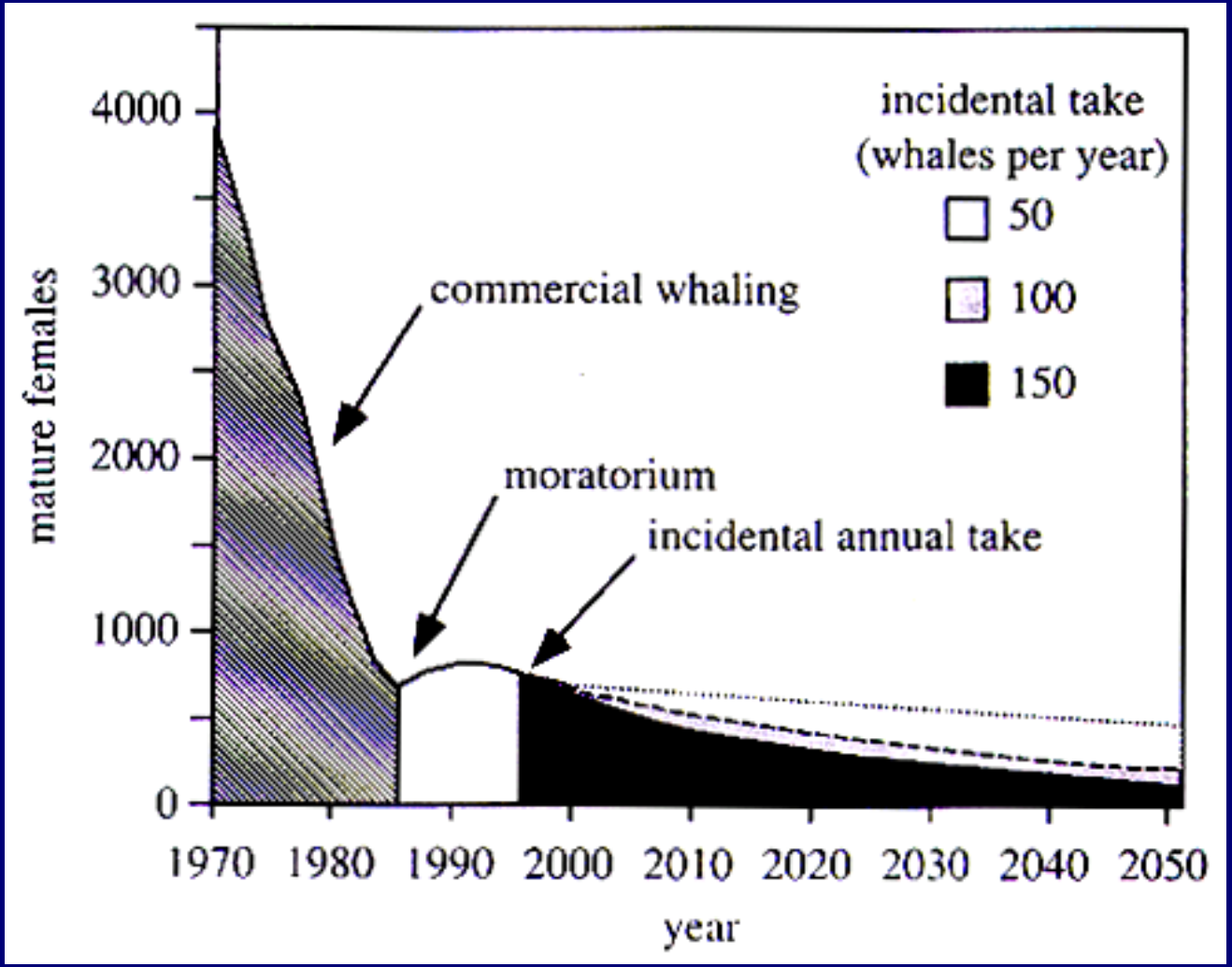
North Pacific genotypes

Sea of Japan genotypes

Genotypes from market Surveys show 1:2 mix of Sea of Japan and North Pacific animals

The consequence of scientific whaling

Predicted extinction of Sea of Japan minke whales



(Baker et al. 2000)

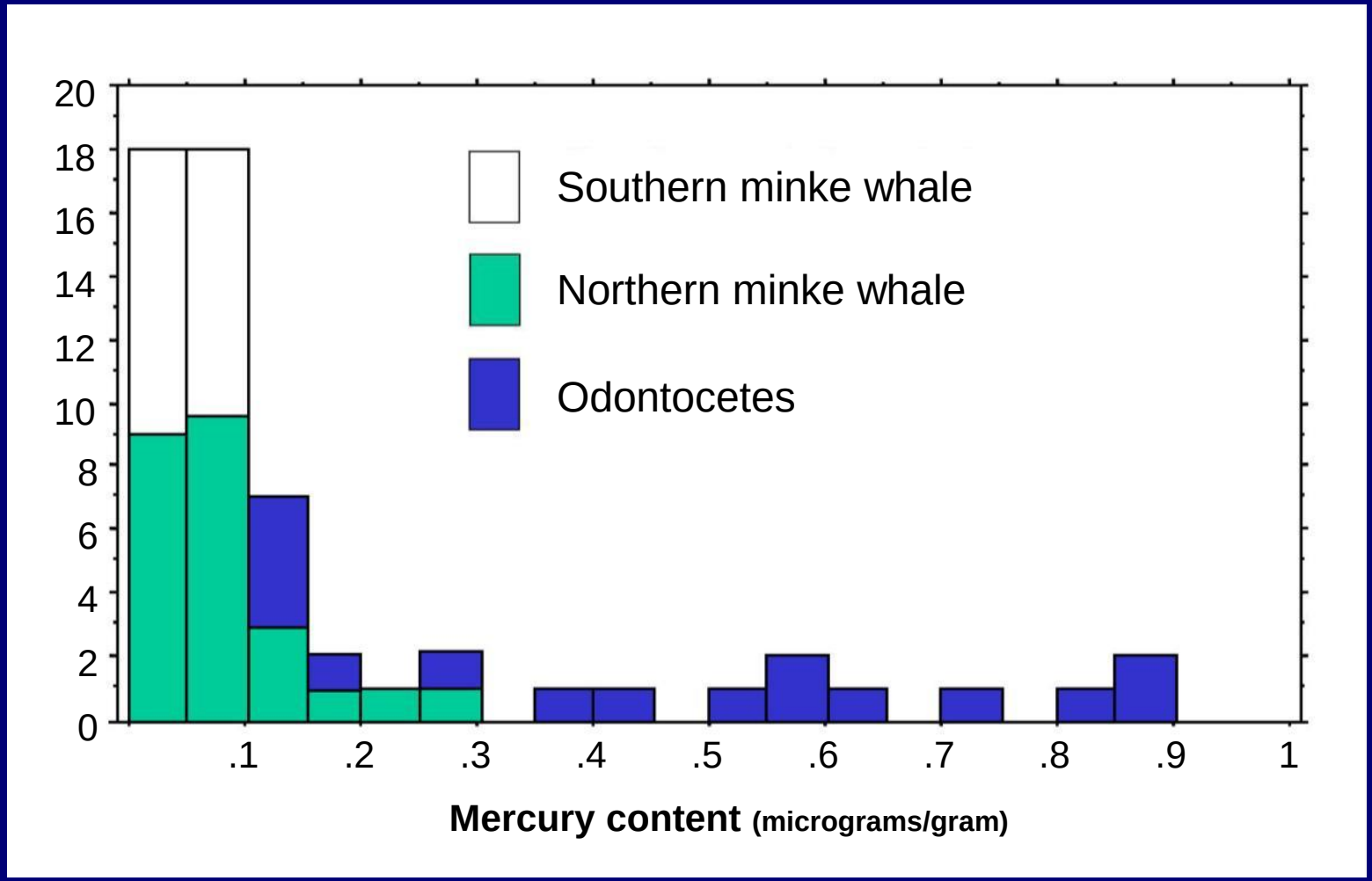
Dolphins and porpoises make up a major fraction of the whale meat market in Japan.

We've known for a while that unsafe toxin loads (heavy metals, PCBs, Dioxins) are found most commonly in dolphin and porpoise products.

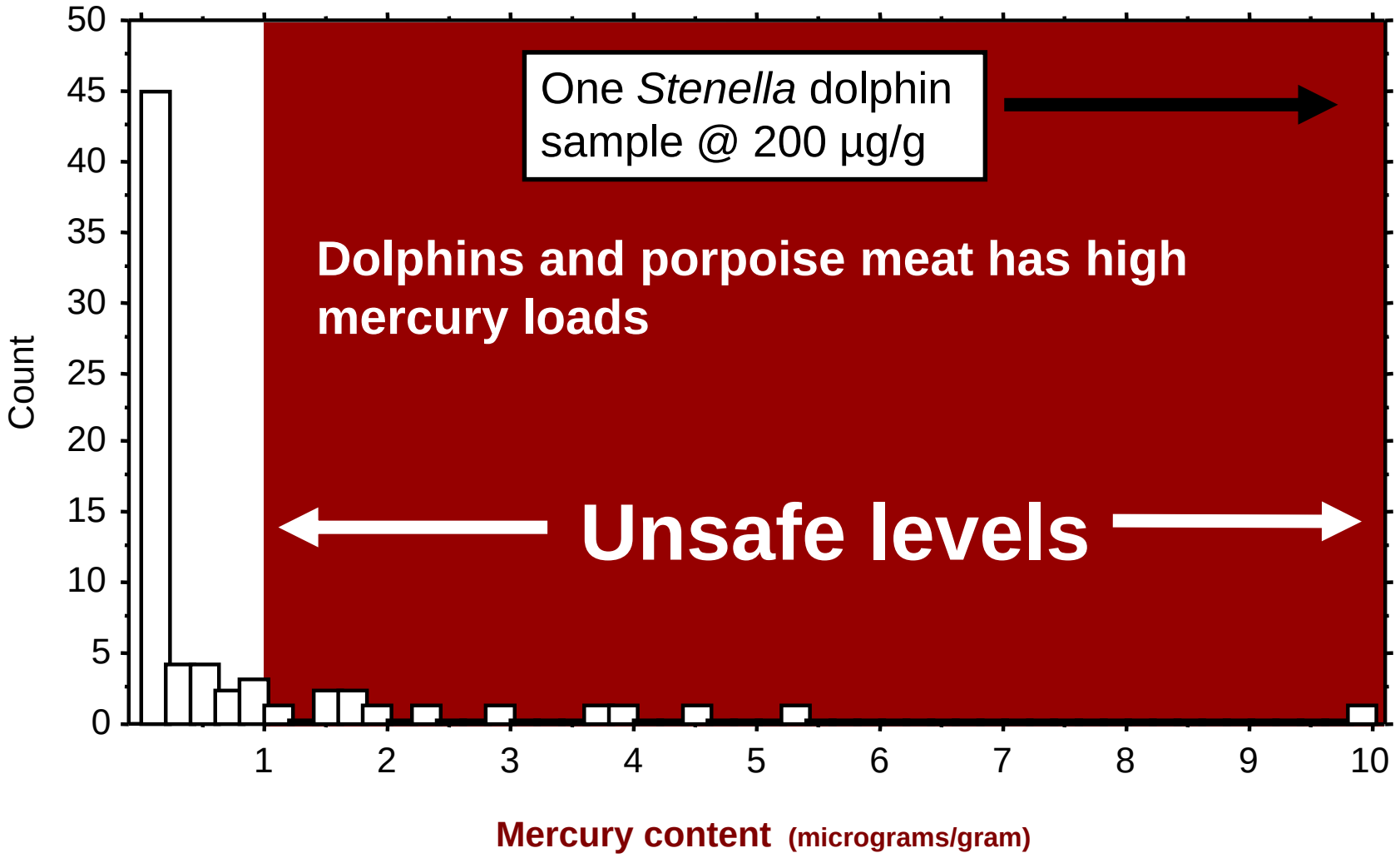
So, is dolphin meat labeled as whale meat unsafe?

Yes, dolphin meat is often toxic

How bad? Dolphins > Pacific minke whales> southern minkes

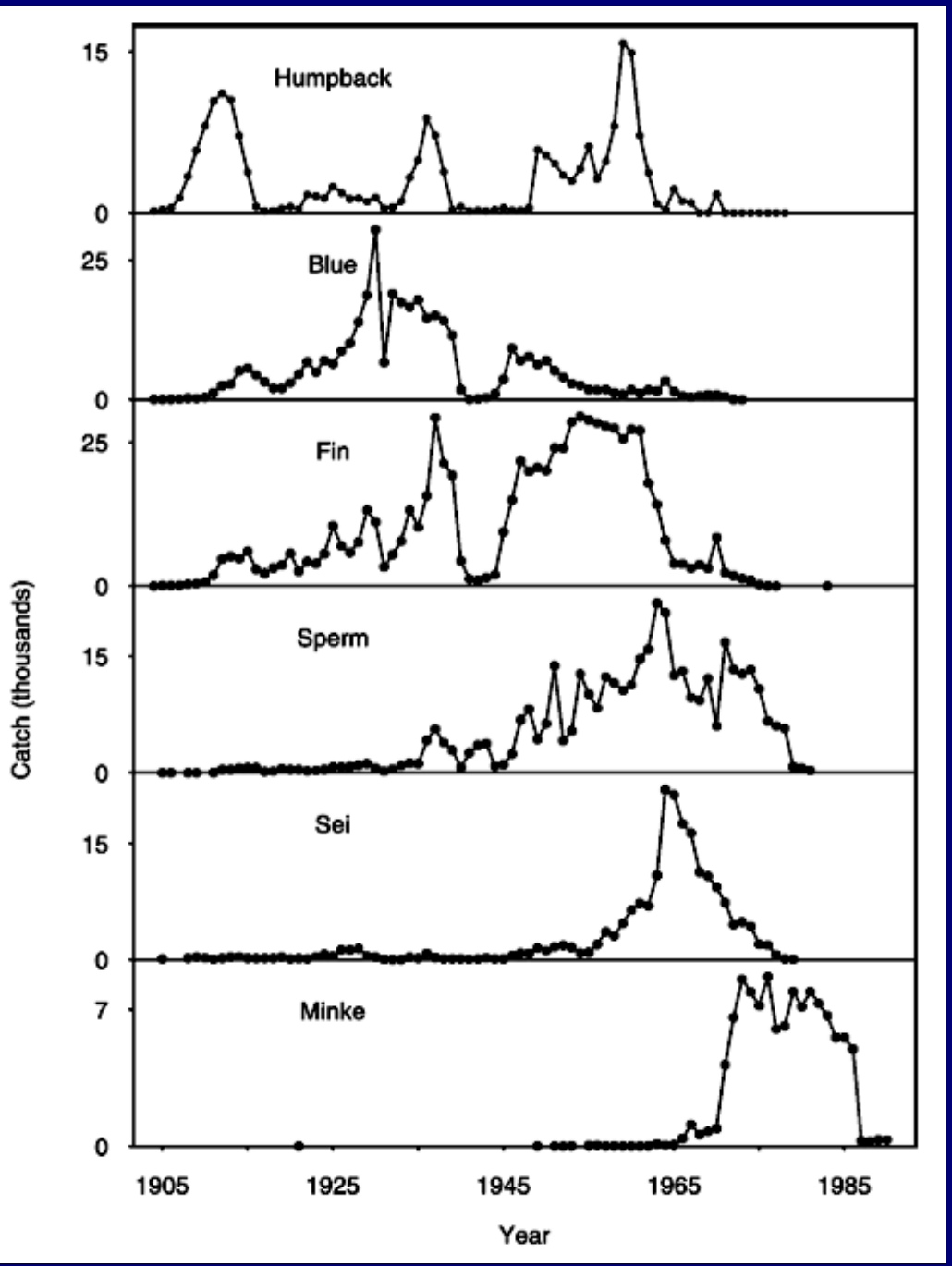


Mercury in Whale Meat
(samples from 1999)



The history of whales revealed by genetics

How many whales were there before hunting?



Catch records for Antarctic whales are well known.

From Hilborn et al. 2004

Where History Comes From

- Written records
- Oral records
- Fossils
- Tree rings
- Ice cores
- Reef cores

Climate History

Tree rings and ice cores record climate

Family history

My Great Aunts


What do we know
about the histories
of whale
populations?

“It is impossible to describe either the number of whales or their familiarity,” with breath that “caused a most annoying stench”

Jean Francoise de La Perouse, 1786

Trouble with conventional wisdom about whale history

(e.g. Atlantic fin whales)

Current estimate:

47,300

Fin Whales North Atlantic 1969-89

Mean: 47,300 Range: 27,700 - 82,000

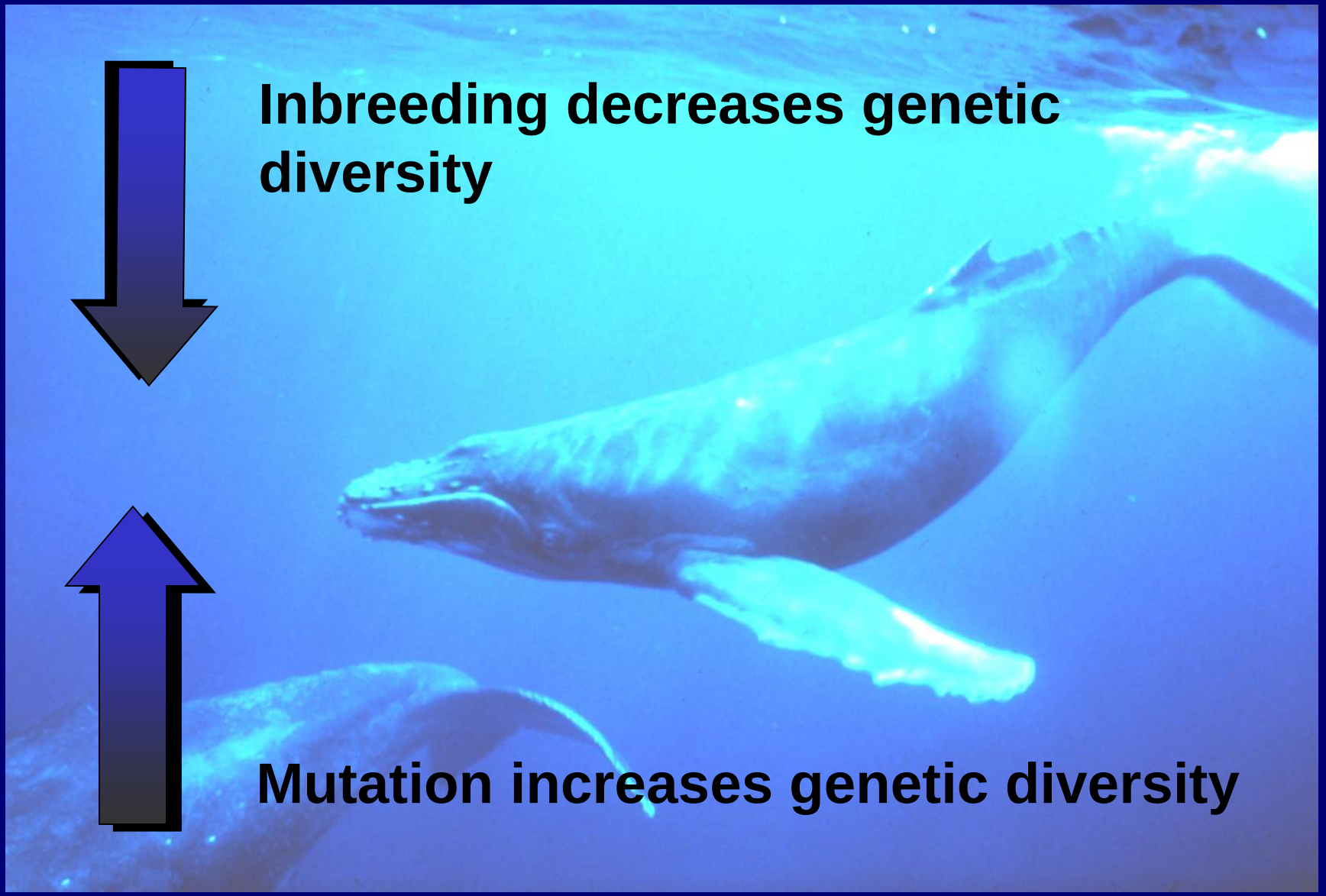
www.iwcoffice.org/conservation/estimate.htm

Past estimate:

30-50,000

(Sargeant 1977)

Genetic estimates of population size



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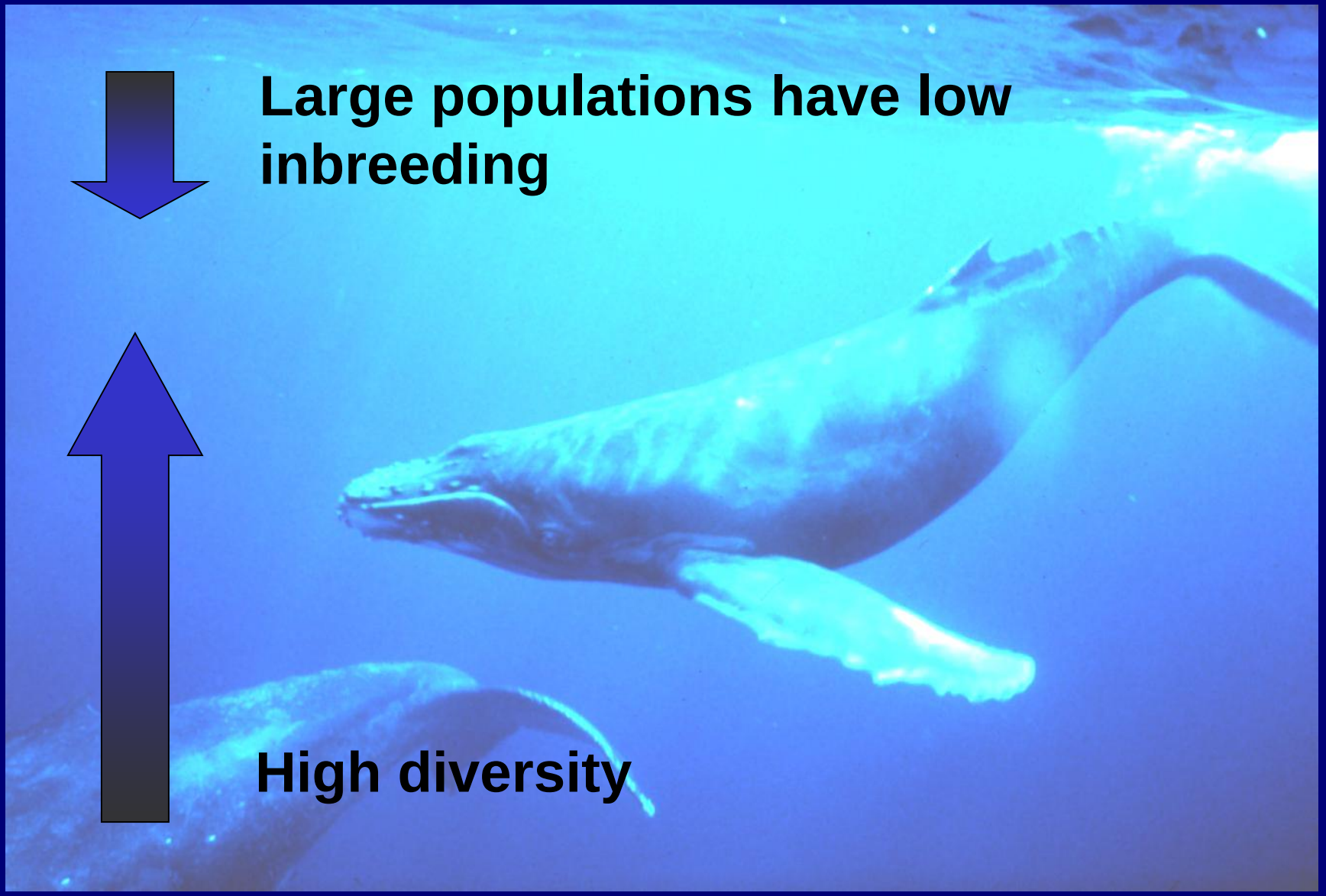
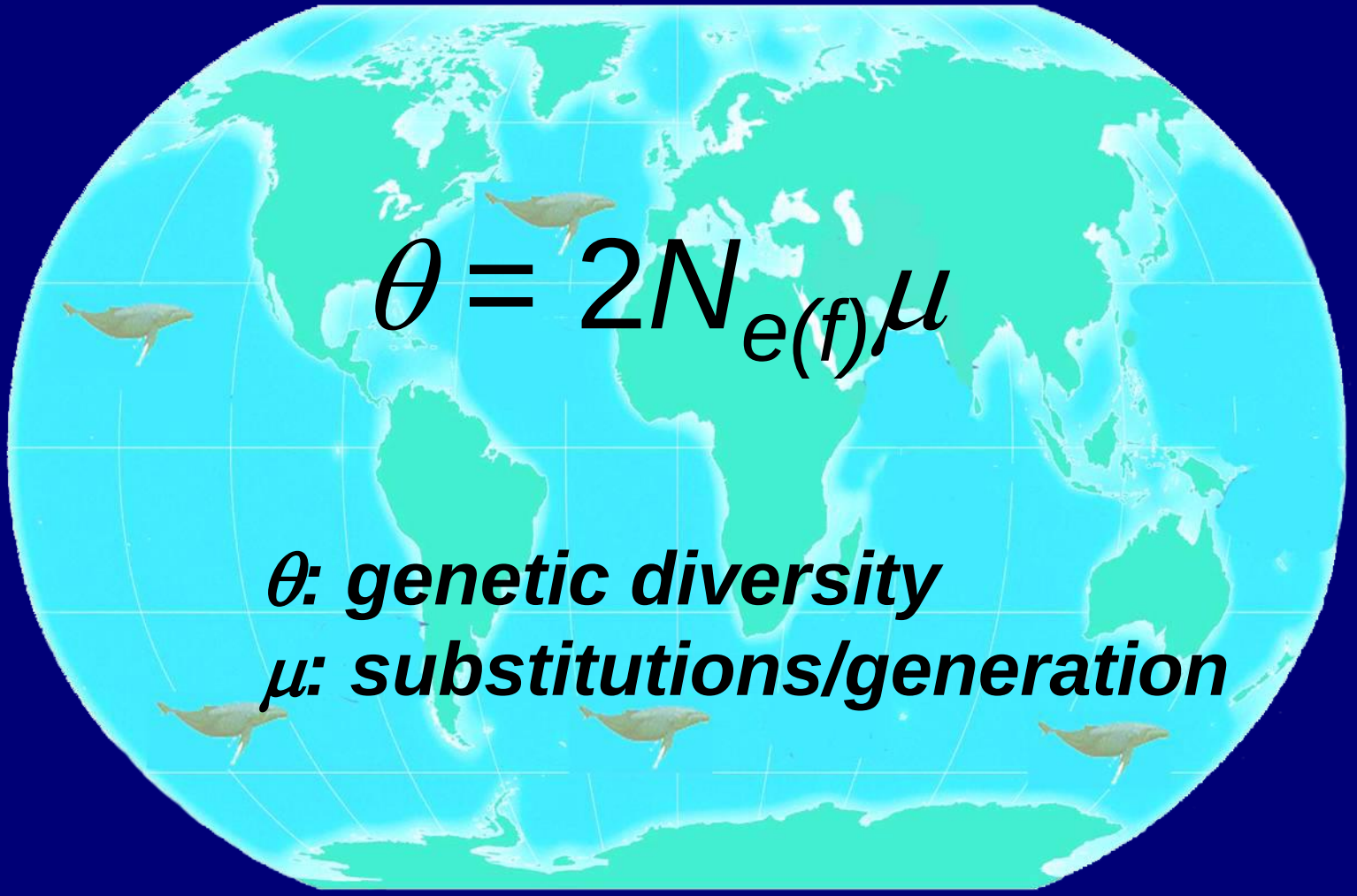


Genetic estimates of population size

For stable, single populations and neutral mtDNA variation:



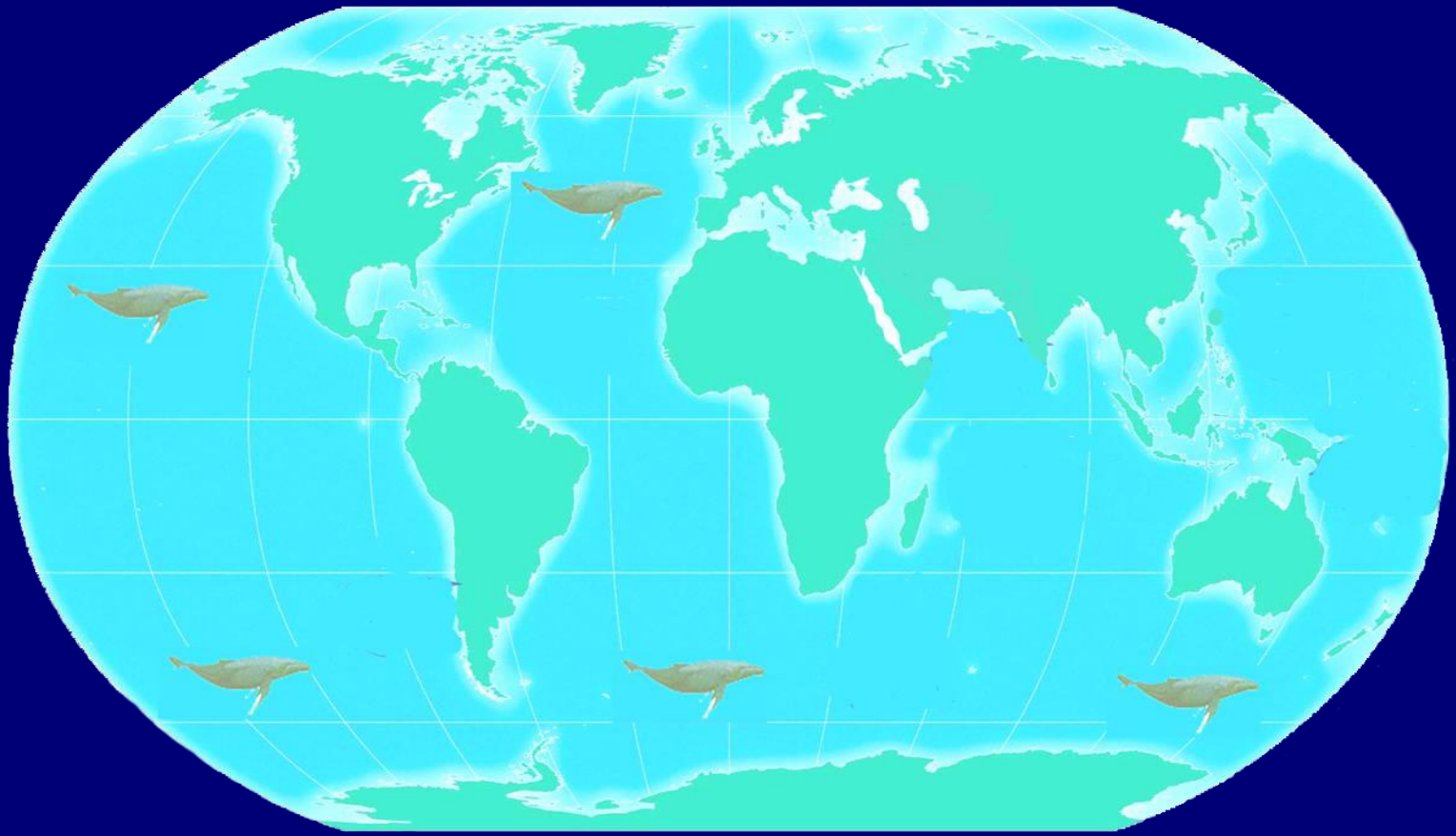
$$\theta = 2N_{e(f)}\mu$$

θ: genetic diversity

μ: substitutions/generation

Atlantic collaborator Joe Roman at Harvard University

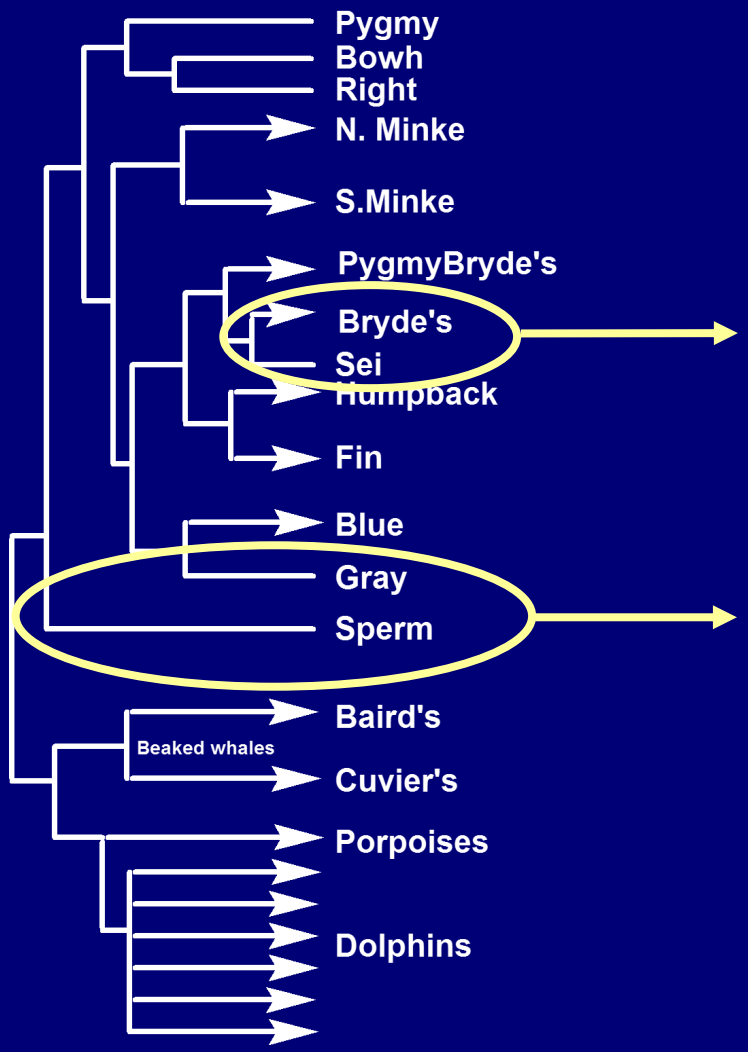
World-wide sample of humpback whales from biopsies



Data from Palumbi, Baker, Palsbol, Rosenbaum

Phylogenetic Trees

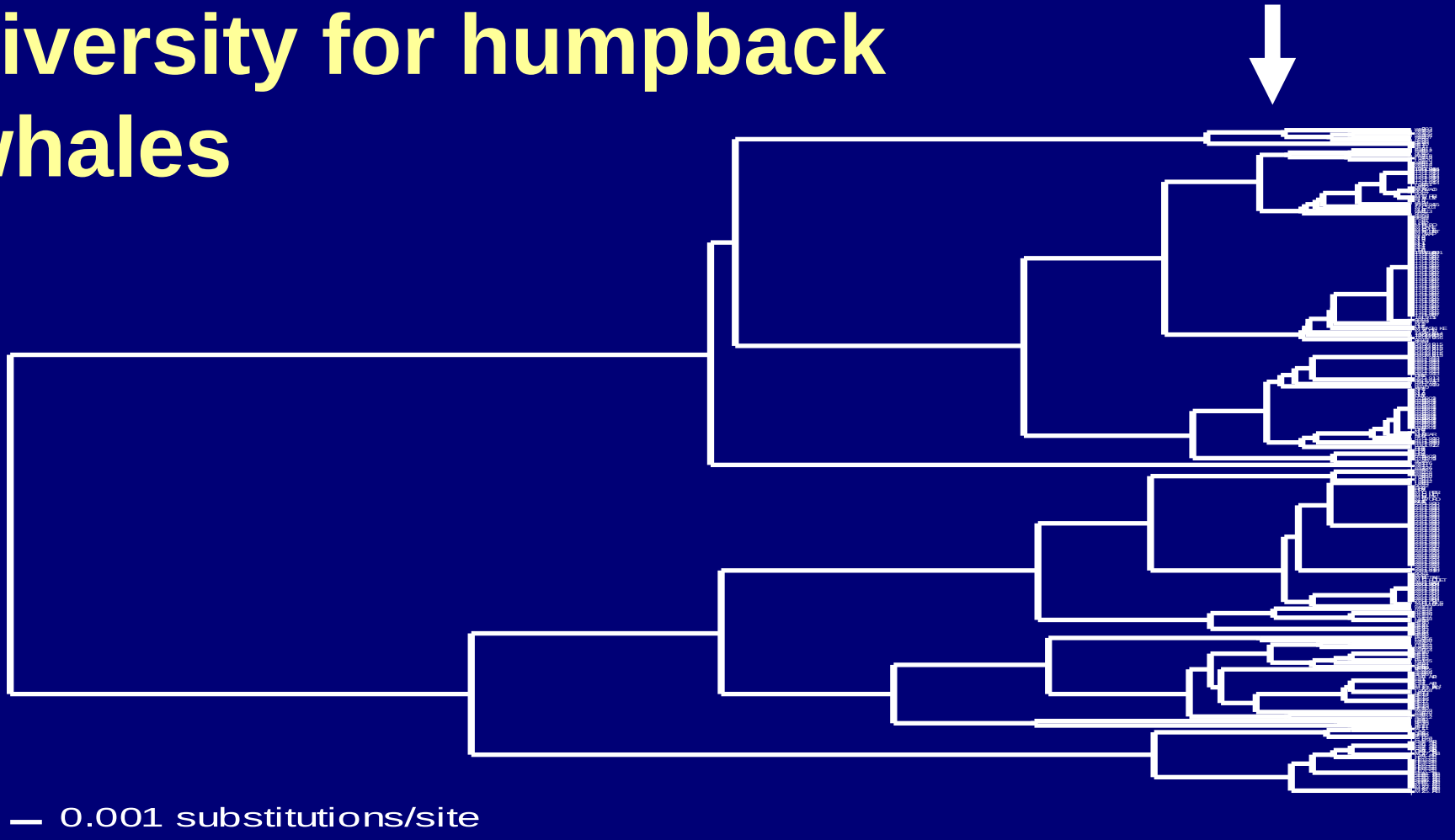
Branch Length and Genetic Diversity



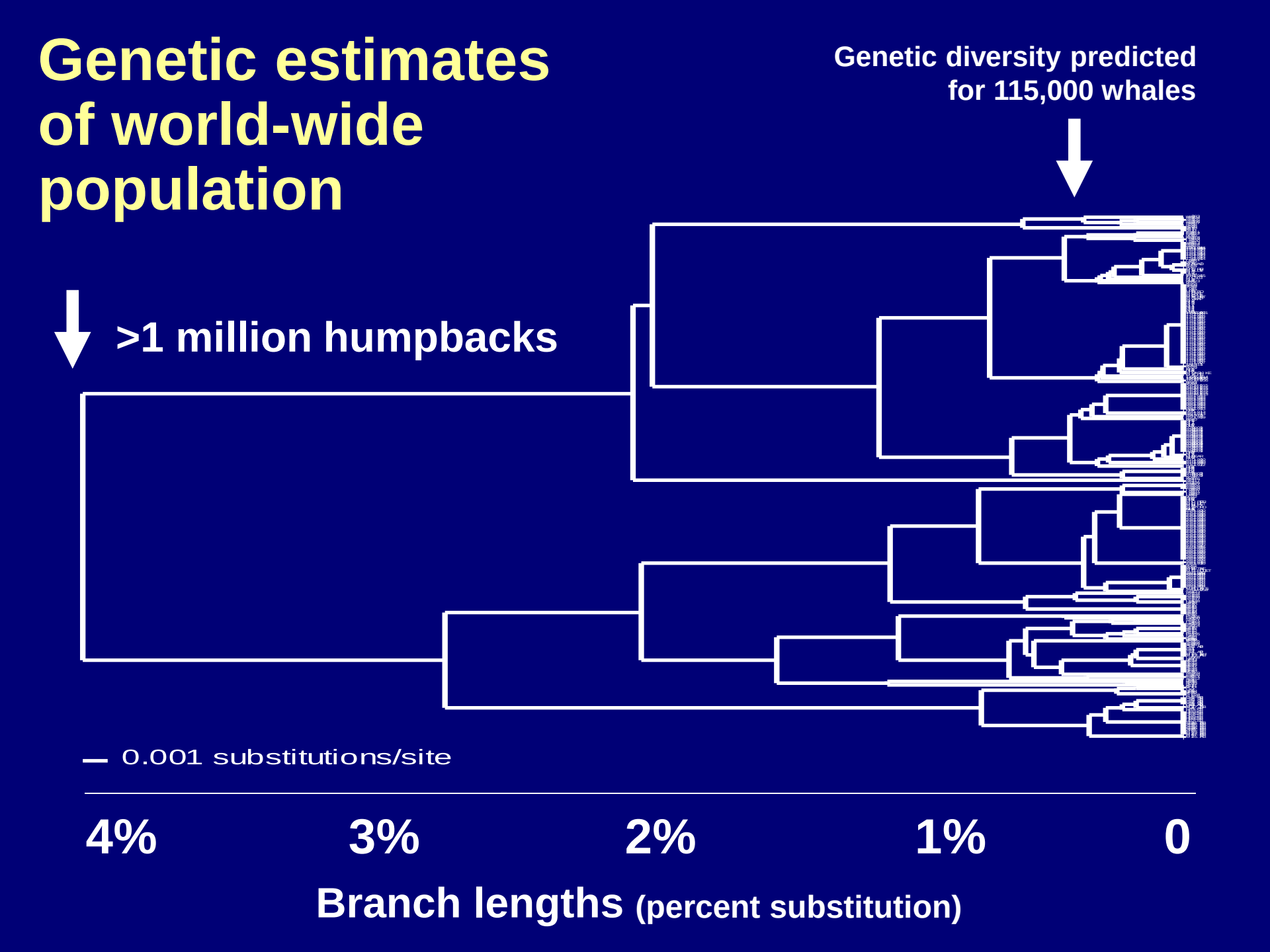
Shared recent ancestors (similarity of DNA signified by shorter branch length)

Shared ancient ancestors (greater differences in DNA signified by longer branch length)

High global mtDNA diversity for humpback whales



Genetic estimates of world-wide population



North Atlantic humpback mtDNA diversity

= 2.2% (n = 188)

= 2*(# breeding females) * (mutation/generation)

==> female size = 68,000

==> population size = 240,000

Current view of the history of humpback whales

Original population - 115,000

North Atlantic original - 30,000

North Atlantic current - 10,000

MSY North Atlantic - 16,000

Nearly ready for harvest

Genetic view of the history of humpback whales

Original population - 1,500,000

North Atlantic original - 314,000

North Atlantic current - 10,000

MSY North Atlantic - 170,000

Ready for harvest in 150 years

Antarctic whales existed in huge numbers

What does DNA tell us about their past?

Frank goes back to Japan for Antarctic samples

$\theta = 2N_e$ (μ/year)((years/generation)

θ = 0.02 for cyt b
μ/year = 0.34%
permillion years (cyt b)

Generation time
= 15 yr

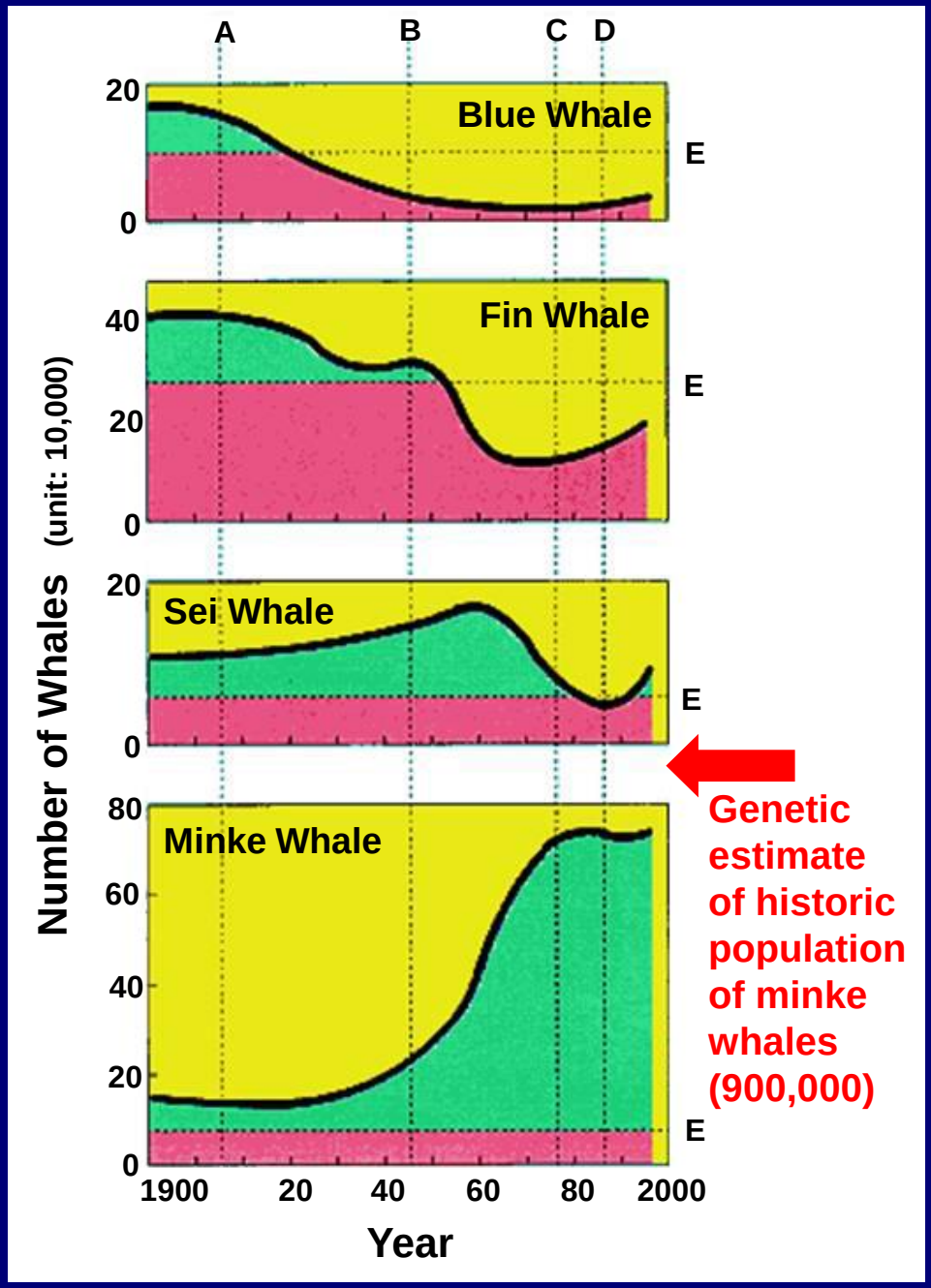
*θ/2 * 5.1% per million generations =>*
195,000 females => 1,150,000 population size

$\theta = 2\ N_e$ (μ/year)(years/generation)

θ = 0.09 for entire HVI of control region
μ/year = 2.0% per million years (CR)

Generation time = 15 yr

*θ/2 * 30% per million generations => 150,000 females => 900,000 population size*



No evidence that minke whales prevent recovery of cousins in the Antarctic

Data: Dr. Seiji Ohsumi

Genetic surveys to date that show large historic population sizes

2004 IWC recommendation for continuing genetic estimates

- Verify substitution rate
- Analyze multiple loci
- Measure population dynamics
- Measure variance
- Evaluate ghost populations
- Get better measures for log records
- Estimate food levels needed

Summary

- The past history of whales is a very important part of our view of what the future should be.
- Estimates based on whaling ship log books appear to underestimate populations. The genetics of whale populations suggest that they were much more numerous than we believed.
- Genetic techniques are useful tools for understanding population levels, species diversity, and human exploitation of whale resources.
- Knowledge of the history of whale populations and resource use are essential components of whale conservation efforts.

Dr. Stephen R. Palumbi

Professor of Biological Sciences, Stanford University's Hopkin Marine Station

Stephen R. Palumbi is a professor of Biological Sciences at Stanford University's Hopkin Marine Station. He and other research scientists in the Palumbi Lab study genetics, evolution, conservation, population biology, and systematics of a diverse array of marine organisms. He uses molecular genetic techniques in conservation-related research, including the identification of whale and dolphin products available in commercial markets and the genetics of marine reserves designed for conservation and fisheries enhancement. His 2003 publication in the journal Science on Whales before Whaling in the North Atlantic suggests that whale populations were 10 times larger than historical records indicate, which has critical implications for the future of whaling and whale conservation.

Dr. Palumbi received his Ph.D. from University of Washington in marine ecology in 1984. In 1996, he received a Pew Fellowship for Marine Conservation Research. He has published on the genetics and evolution of butterflyfishes, bryozoans, cone snails, corals, sea urchins, sharks, spiders, shrimps, and whales. His recent books include The Evolution Explosion: How humans cause rapid evolutionary change and Marine Reserves: An Ecosystem Tool for Marine Management and Conservation.