



Changes in Latitude, Changes in Attitude – Emerging Biogeographic Patterns of Invasion in the Northeast Pacific

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OBJECTIVE:

Assess Macroscale Spatial Patterns of Nonindigenous Species (NIS) in the Northeast Pacific (NEP)

PATTERNS

Extent of invasion in estuaries & near-shore waters

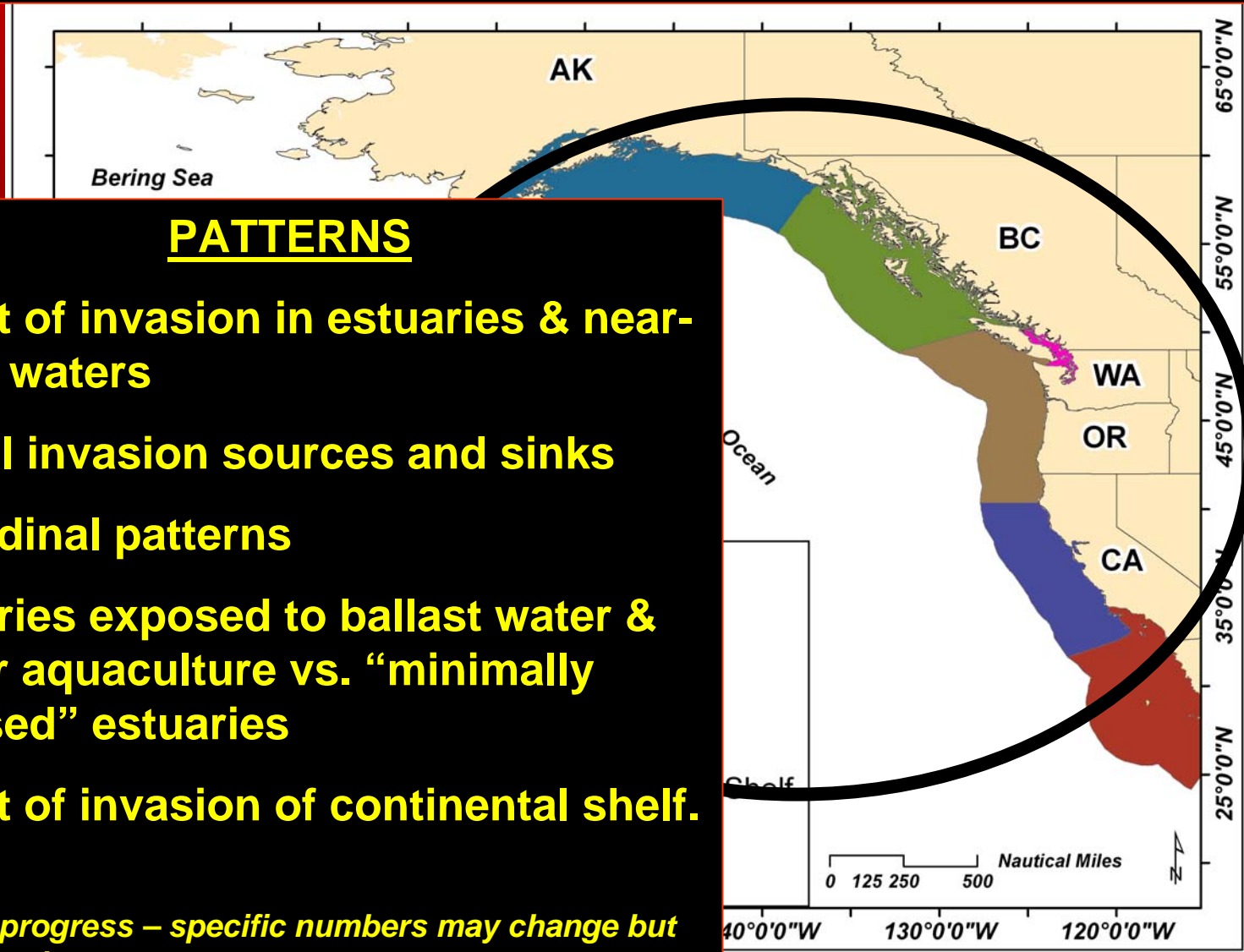
Global invasion sources and sinks

Latitudinal patterns

Estuaries exposed to ballast water & oyster aquaculture vs. “minimally exposed” estuaries

Extent of invasion of continental shelf.

Work in progress – specific numbers may change but patterns robust.



Assessing Environmental Condition From Tropical Beaches to Arctic Fjords: U.S. EPA's Western Coastal "Environmental Monitoring and Assessment Program" (EMAP)



Sampling Program:

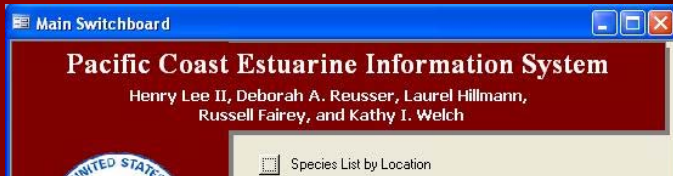
- 1999 Small estuaries of WA, OR, CA
- 2000 Large estuaries of WA, OR, CA
- 2001 Small estuaries of OR
- 2002 Coastal systems of HI, South Central AK
- 2002 Estuarine tidelands of WA, OR, CA
- 2003 Continental shelf of WA, OR, CA
- 2004 Estuaries of WA, OR, CA, HI, southeast AK, Guam pilot
- 2005 Estuaries of WA, OR, and CA (half of samples)
- 2006 Estuaries of WA, OR, and CA (half of samples)
- 2007 Aleutian Islands and southeast AK



RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Pacific Coast Estuarine Information System (PCEIS)



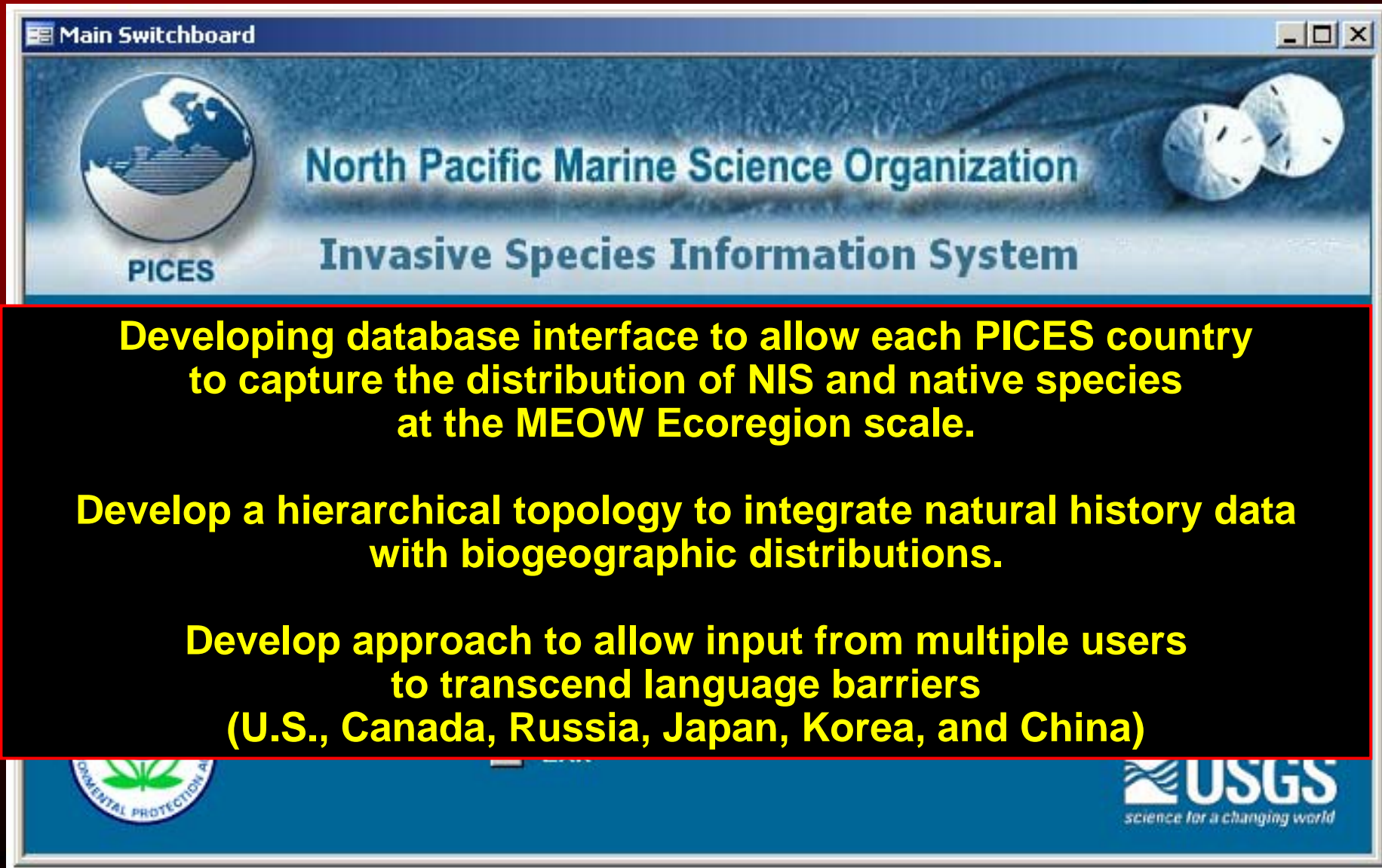
**Synthesizing spatial distributions of the
native & nonindigenous coastal and estuarine species
from Baja California (Mexico) to Alaska
at estuary to sub-estuary scale**

&

**Landscape characteristics of the estuaries & watersheds
of Oregon, Washington, and California**



U.S. EPA and USGS are developing a nonindigenous species database for the Pacific Rim countries for PICES.



Main Switchboard

North Pacific Marine Science Organization

Invasive Species Information System

PICES

- Developing database interface to allow each PICES country to capture the distribution of NIS and native species at the MEOW Ecoregion scale.**
- Develop a hierarchical topology to integrate natural history data with biogeographic distributions.**
- Develop approach to allow input from multiple users to transcend language barriers (U.S., Canada, Russia, Japan, Korea, and China)**

USGS
science for a changing world

Current Count of the Number of the Nonindigenous Species in the Northeast Pacific

Benthic & Pelagic Invertebrates:

NIS Invertebrates: 401 (ca. 4-5%?)

Native Invertebrates: >6000

NIS bivalves: 38 (6.5%)

Native bivalves: ca. 580

Fishes:

NIS fishes: 63 (4.3% - higher for estuarine)

Native estuarine & coastal fishes: >1450

Macroalgae

NIS macroalgal species: 28

Native macroalgal species: ?



ESTUARIES

NONINDIGENOUS SPECIES

= NIS reported
from estuary

Distribution of NIS across the estuaries of Oregon, Washington, and California

There are 219 outer coast
estuaries in California,
Oregon, and Washington
(exclusive of Puget Sound).

NIS have been reported from
71 of these estuaries.

All estuaries with ~>50
reported species contain at
least one nonindigenous
species.

Distribution & Spread of *Grandidierella japonica*



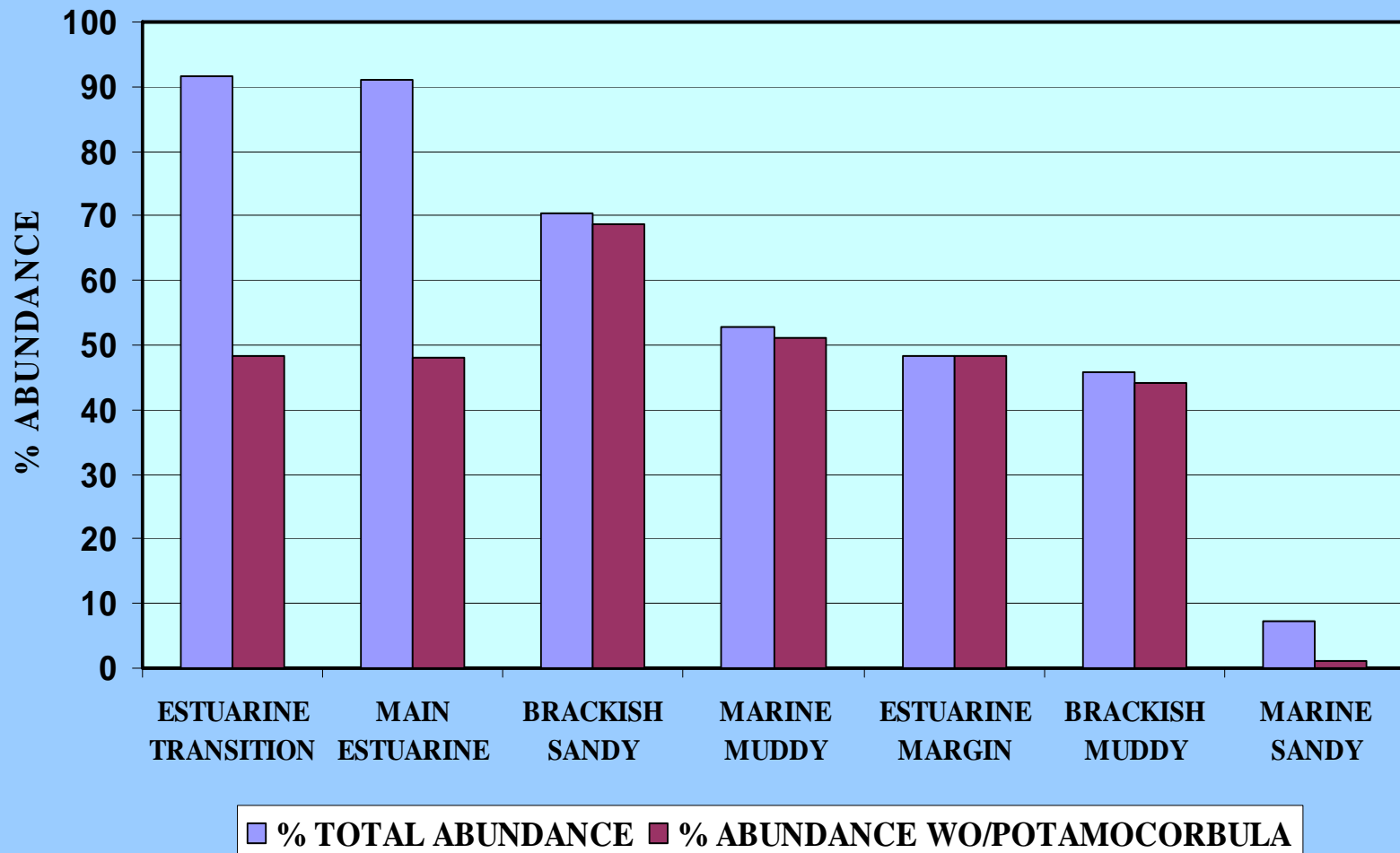
First found in San Francisco in 1966 and since invaded 46 estuaries on Pacific Coast.

First found in Yaquina Bay in 1994 and most abundant intertidal amphipod in Yaquina by 1996.

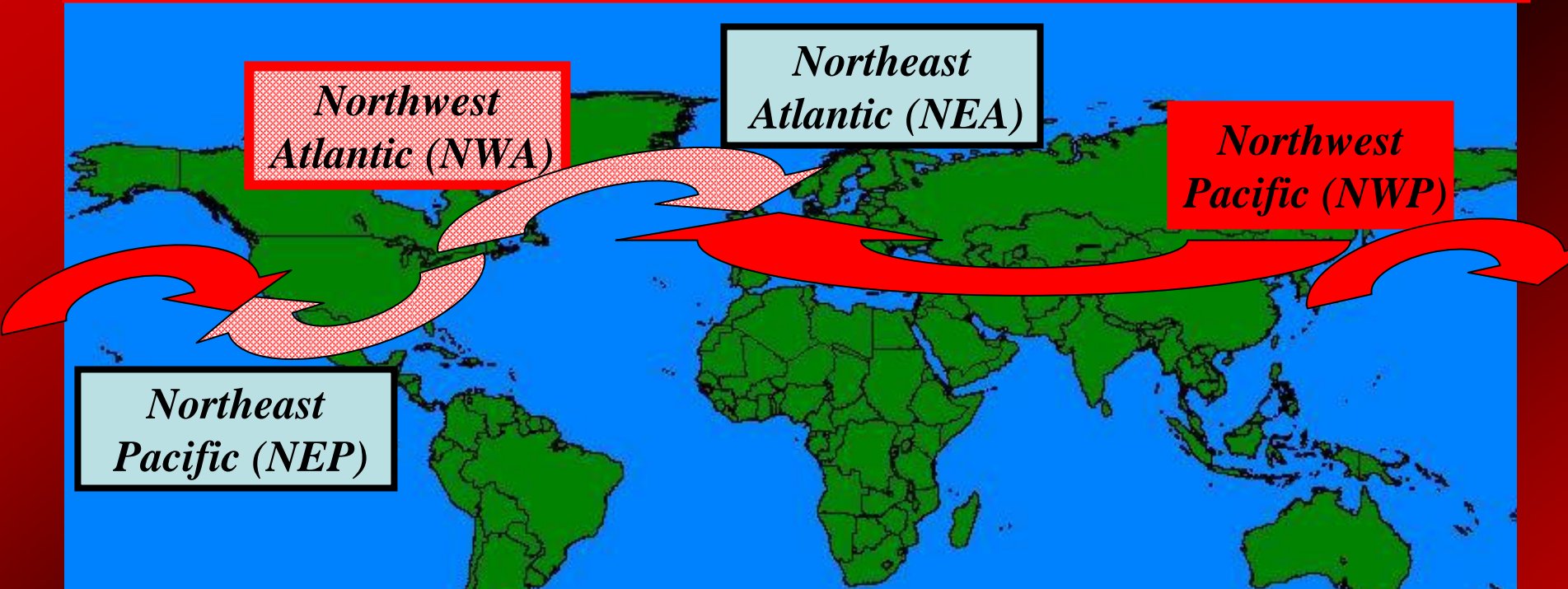


San Francisco Estuary Subtidal Benthic Assemblages are Dominated by Nonindigenous Species

NONINDIGENOUS SPECIES AS PERCENT
OF TOTAL ABUNDANCE



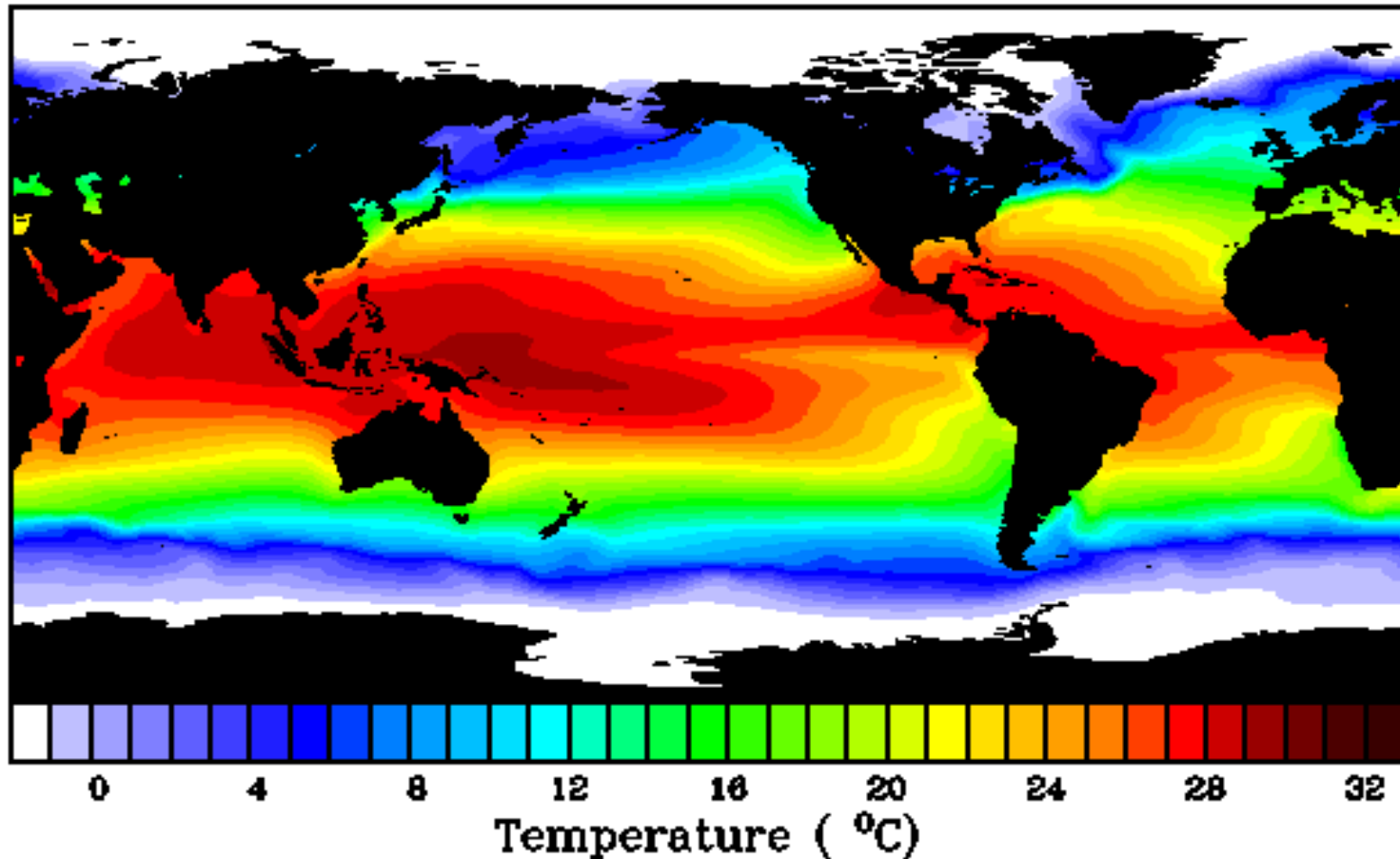
Global Patterns of Marine/Estuarine Invasions



- In the Northern Hemisphere, Western sides of oceans are donor regions while the Eastern sides are recipient regions (Chapman, 2000).
- NEP & NEA should contain more nonindigenous species than NWP & NWA.
- NEA, Baltic, & NEP should contain a high proportion of invaders from the NWA & NWP.

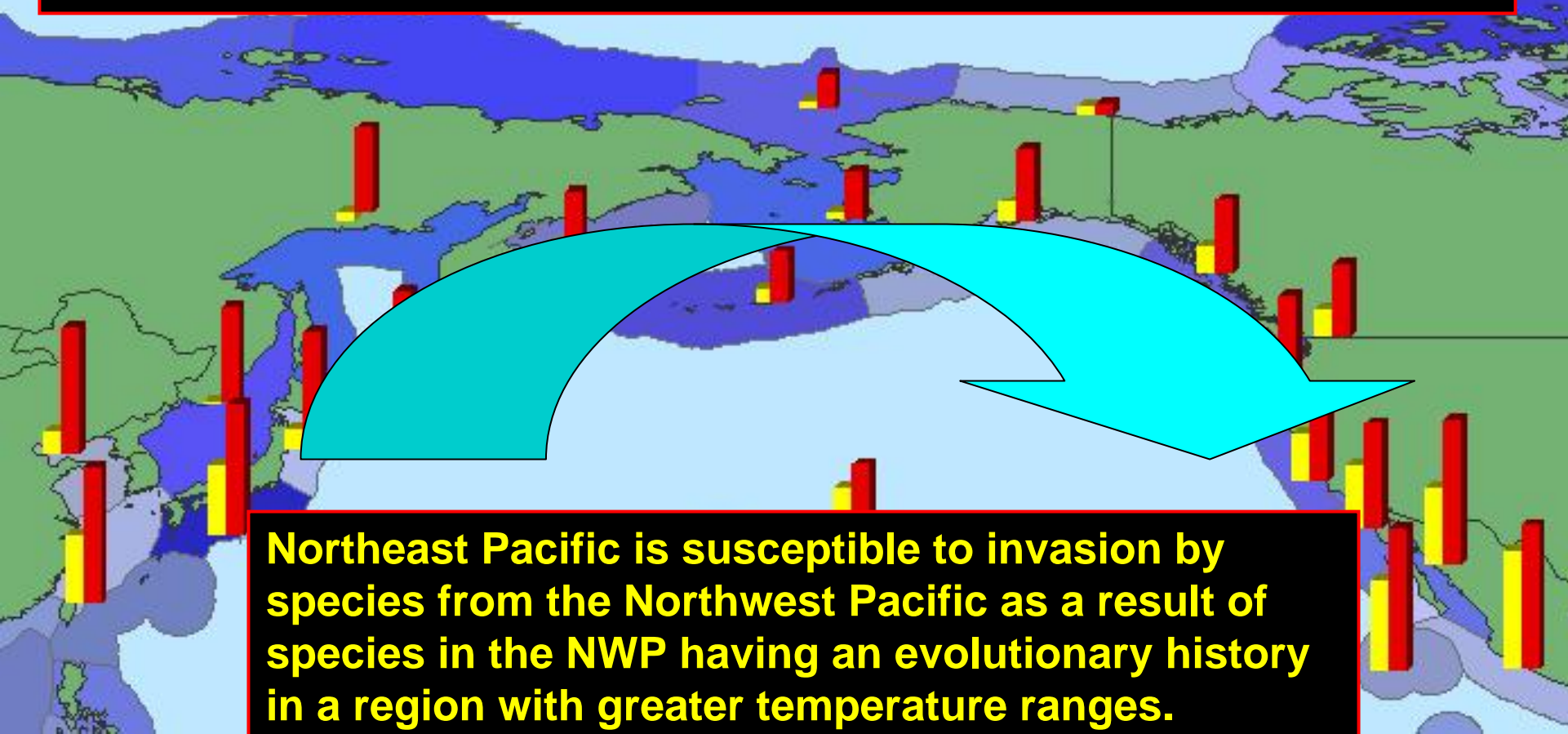
Eastern Sides of Oceans in Northern Hemisphere Have Greater Areas of Similar Temperatures

ANNUAL MEAN
GLOBAL SEA SURFACE TEMPERATURES



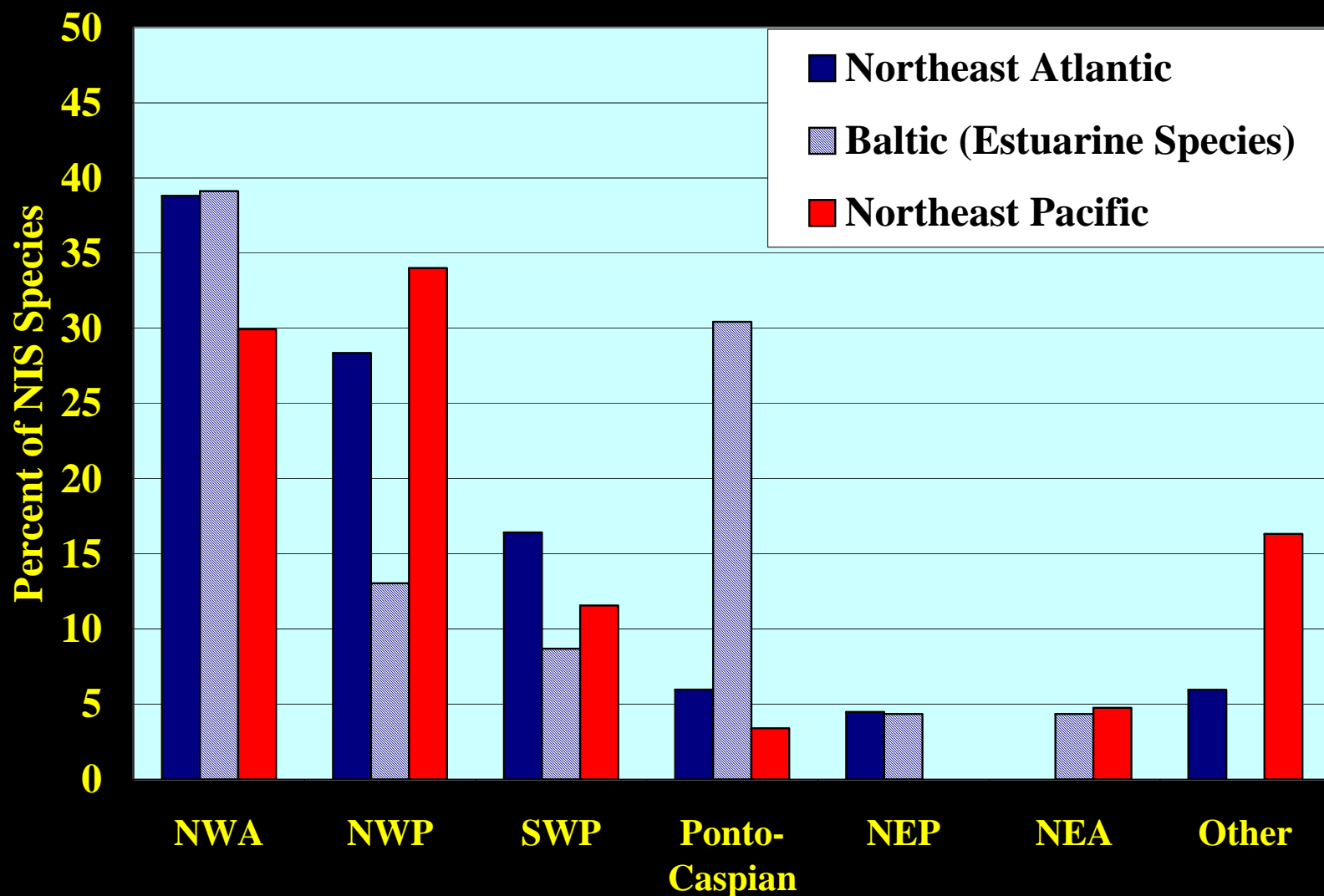
NEP Shows a Smaller Range in Near-Coastal Minimum and Maximum Temperatures Than the NWP

(By MEOW Ecoregion - one 0.5 degree grid per Ecoregion)



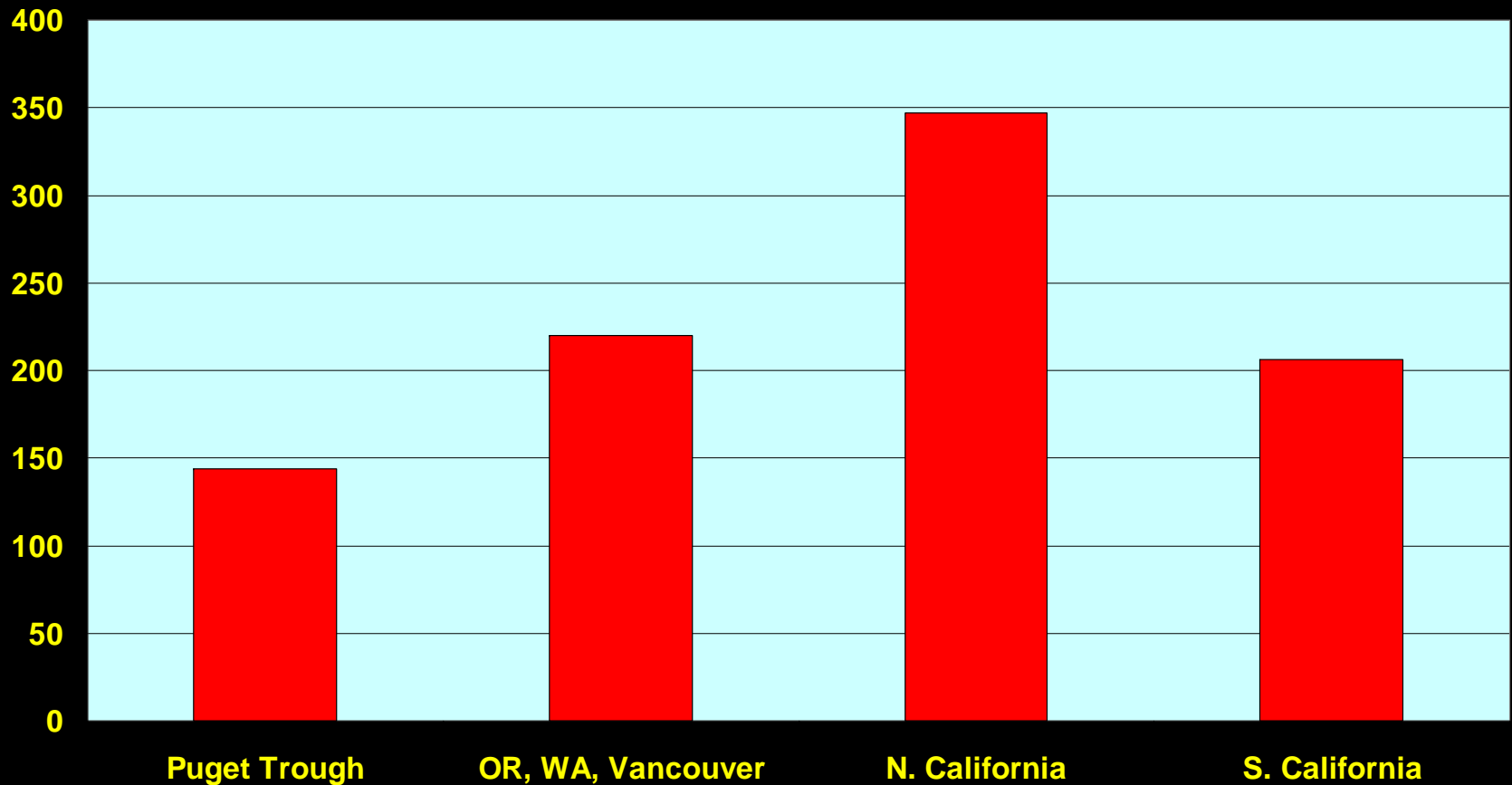
Northeast Pacific is susceptible to invasion by species from the Northwest Pacific as a result of species in the NWP having an evolutionary history in a region with greater temperature ranges.

Sources of Benthic Nonindigenous Species in Northeast Atlantic, Baltic, & Northeast Pacific



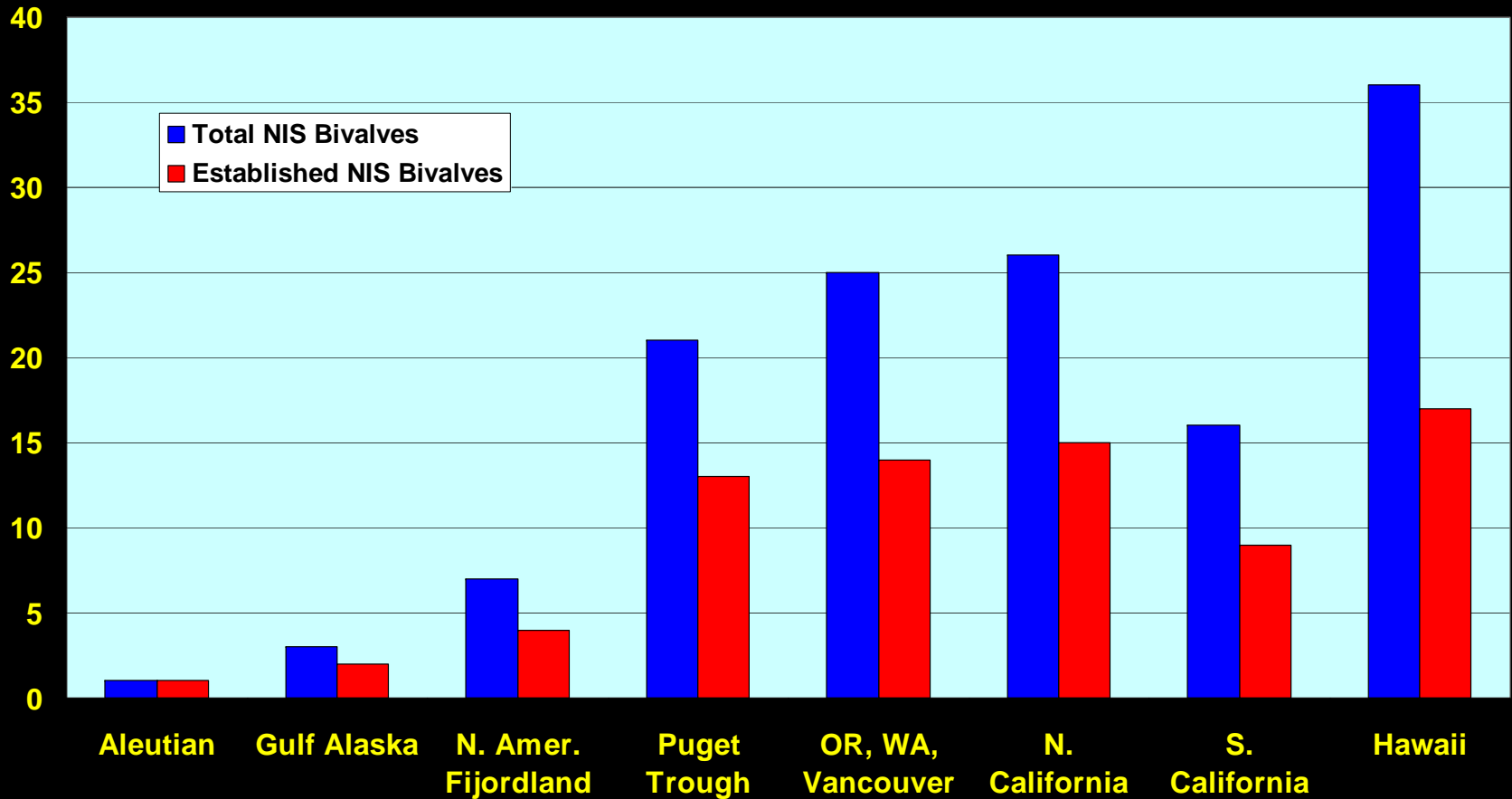
Latitudinal Patterns in NEP

Number of Nonnative Macroinvertebrate and Fish Species in the NEP by MEOW Ecoregions



Latitudinal Patterns in NEP

Number of Nonnative Bivalves in the NEP and Hawaii by MEOW Ecoregions

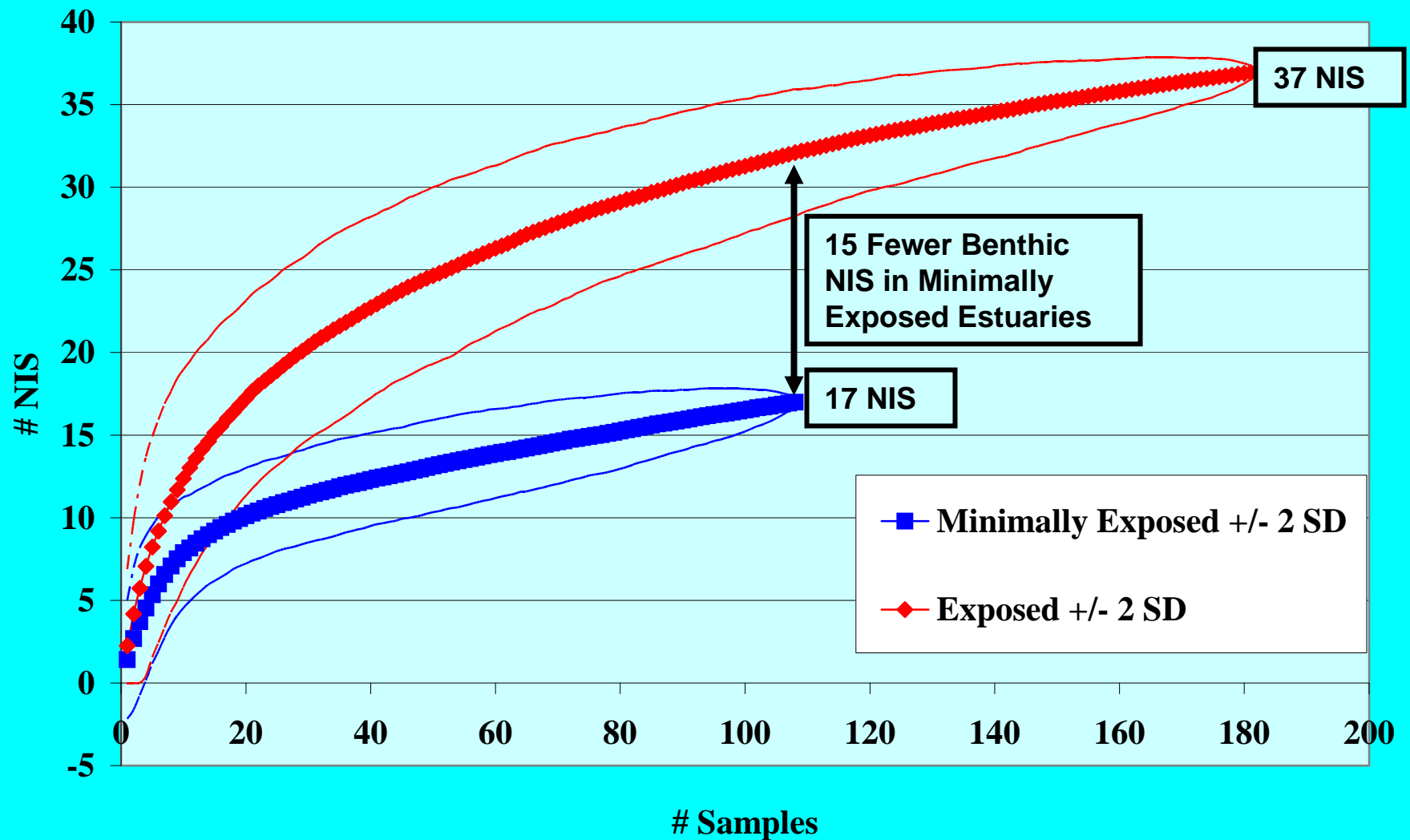


“SMALL ESTUARY” PROJECT

How invaded are estuaries with no or minimal exposure to ballast water discharges or oyster aquaculture?

- Conducted extensive surveys (3 grabs/estuary) in 14 “minimally exposed” estuaries in Oregon, Washington, and California in 2002.
- Intensive benthic survey (30 grabs) in the Siletz Estuary in Oregon in 2003.
- Collated benthic data from “minimally exposed” and “exposed” estuaries from EMAP surveys

Species-Area Curves for Nonindigenous Benthic Species in Minimally Exposed vs. Exposed Estuaries



Estimated Number of Nonindigenous Benthic Species in Minimally Exposed Estuaries vs. Exposed Estuaries Based on Five “Species Estimators”

	<u>Observed</u>	<u>Predicted</u>
Minimally Exposed Estuaries	17	18 - 27
Exposed Estuaries	37	41 - 50

*Predicted numbers are for amusement purposes only
and no warranty is expressed or implied.*

How Do Minimally Exposed Estuaries Get Invaded? Potential Secondary Vectors



**Longshore Drift
(flotsam and jetsam)**



Migratory Birds & Wildlife



Recreational Boats



**Fishing Boats in
Shallow Draft Estuaries**

Extent of Invasion in Benthic Assemblages from EMAP 2003 Survey of the Continental Shelves of Oregon, Washington, and California

- **Only 13 nonindigenous species found out of 1107 taxa identified to species (1.2% or 1.7% of natives only).**
- **No nonindigenous species included among the 50 most abundant benthic species.**
- **Nonindigenous species constituted only 0.4% of the total abundance.**
- **121 of the species found are currently classified as cryptogenic. However, further taxonomic studies may show that many of these are unrecognized sibling species rather than actual introductions.**

Spatial Patterns of Invasion in the Northeast Pacific

- **The estuarine and near-coastal assemblages of the Northeast Pacific are highly invaded.**
- **This invasion is not limited to estuaries with ports or aquaculture, and even “pristine” estuaries are moderately to highly invaded.**
- **Continental shelf benthic assemblages are much less invaded than the NEP estuaries and near-coastal assemblages.**
- **The Northern California ecoregion is the most heavily invaded, and the extent of invasion appears to decline dramatically in the Gulf of Alaska and Aleutian ecoregions.**
- **The Northwest Pacific (Asia) and Northwest Atlantic (East coast of United States) are the major sources of the nonindigenous species in the Northeast Pacific.**

QUESTIONS?

