Ecosystem typologies in the North Pacific: a useful concept for ecosystem-based management?

R. Ian Perry

Fisheries & Oceans Canada, Pacific Biological Station,

Nanaimo, B.C., Canada

E-mail: perryi@pac.dfo-mpo.gc.ca

Acknowledgements:

Wolf Carolsfeld

Ian Murfitt

Yukimasa Ishida

Tatsu Kishida

Chris Harvey

Vladimir Sviridov

Jae-Bong Lee

Issues:

How to identify the spatial extent of ecosystems in order to define “ecosystem-based management areas”?

How to apply these ‘ecosystems’ in practice, in particular among many jurisdictions (Nations)?

Ecosystem:

- a dynamic complex of plants, animals, microbes and physical environmental features that interact with one another. (McLeod et al. 2005)
- “fuzzy” concept
- may be species-centered (i.e. species dependent)
- fixed (geographic) *versus* spatially-variable attributes which may vary over time
    - pelagic – may vary seasonally or on longer scales
    - demersal – may be less spatially-variable due to relationships with fixed habitat features

Practical approach:

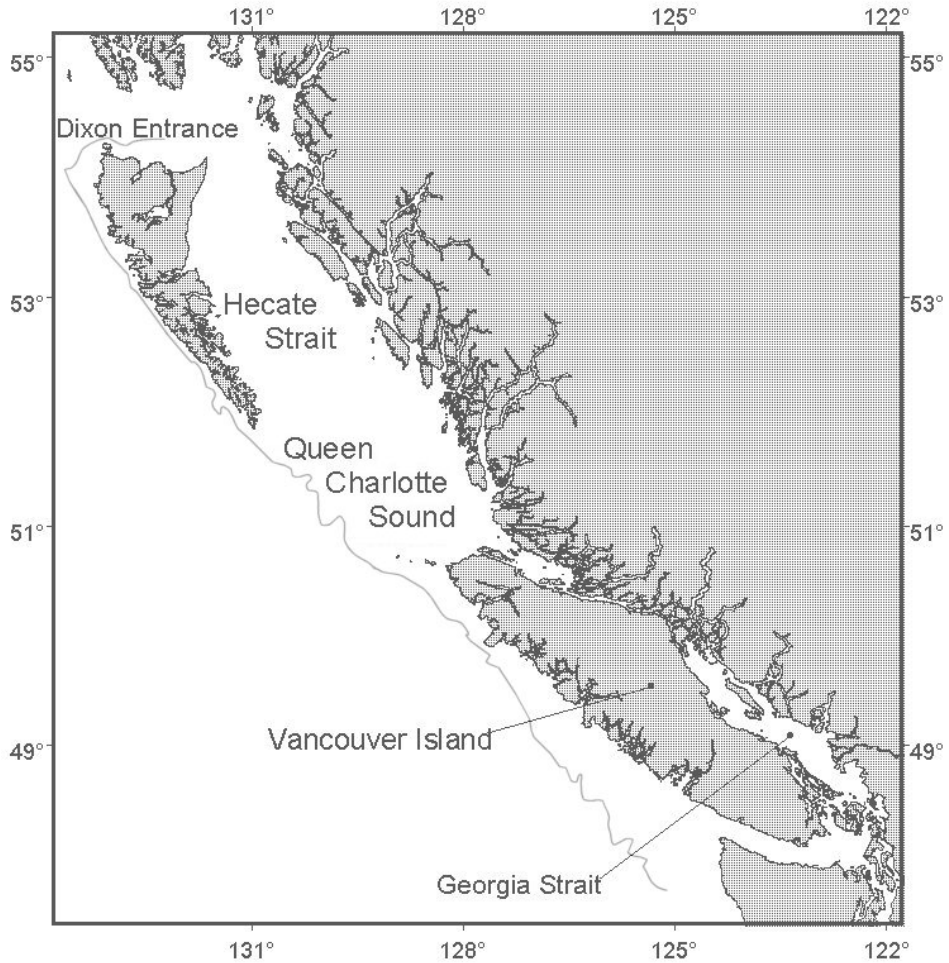
Define “ecoregions”:

- “part of a larger marine area (ecoprovince) characterised by continental shelf-scale regions that reflect regional variations in salinity, marine flora and fauna, and productivity” (Harper et al. 1993; see also Loveland and Merchant. 2004. Environmental Management 34, Supplement 1, pp. S1-S13)
- in practice (at least in Canada) strongly based on existing political and marine management boundaries

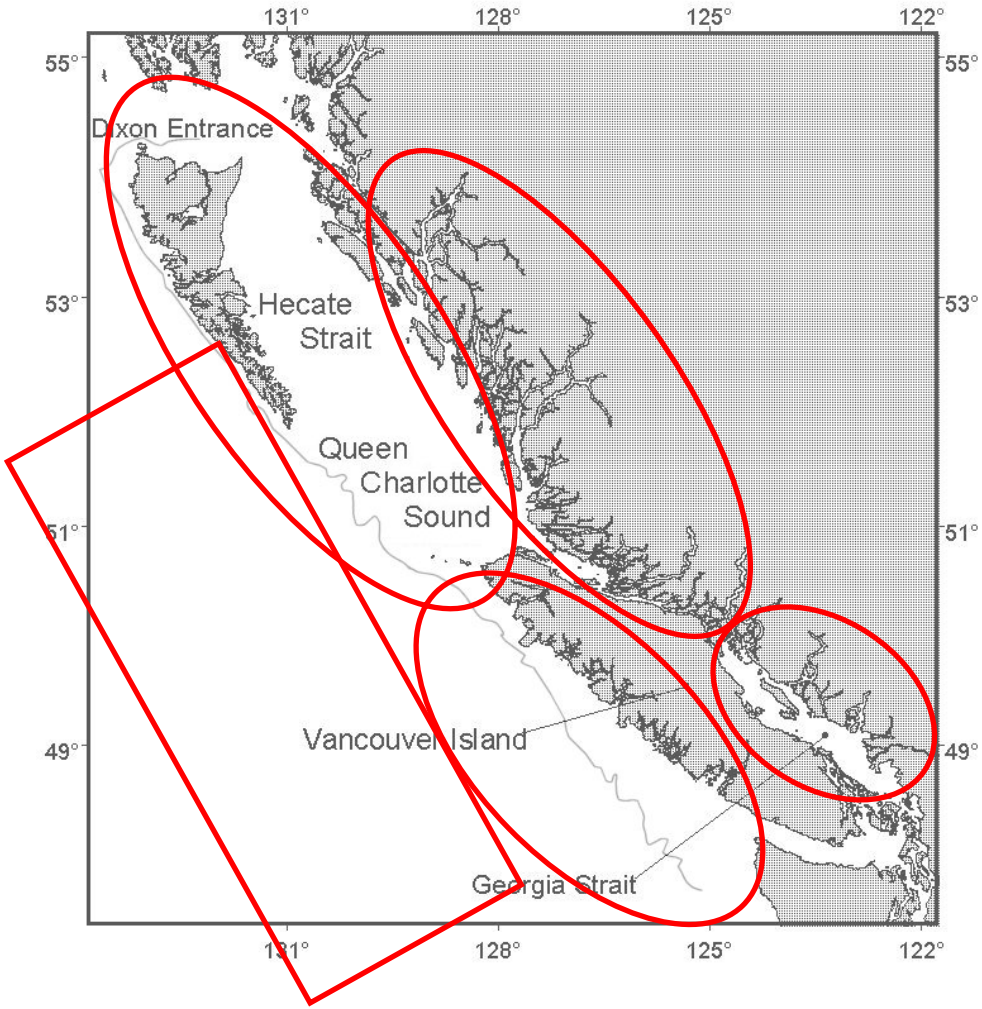
Objective:

To assess the extent to which existing marine management and statistical areas in the North Pacific correspond to (large-scale) ecosystems/ecoregions (ecosystem typologies) defined for the North Pacific

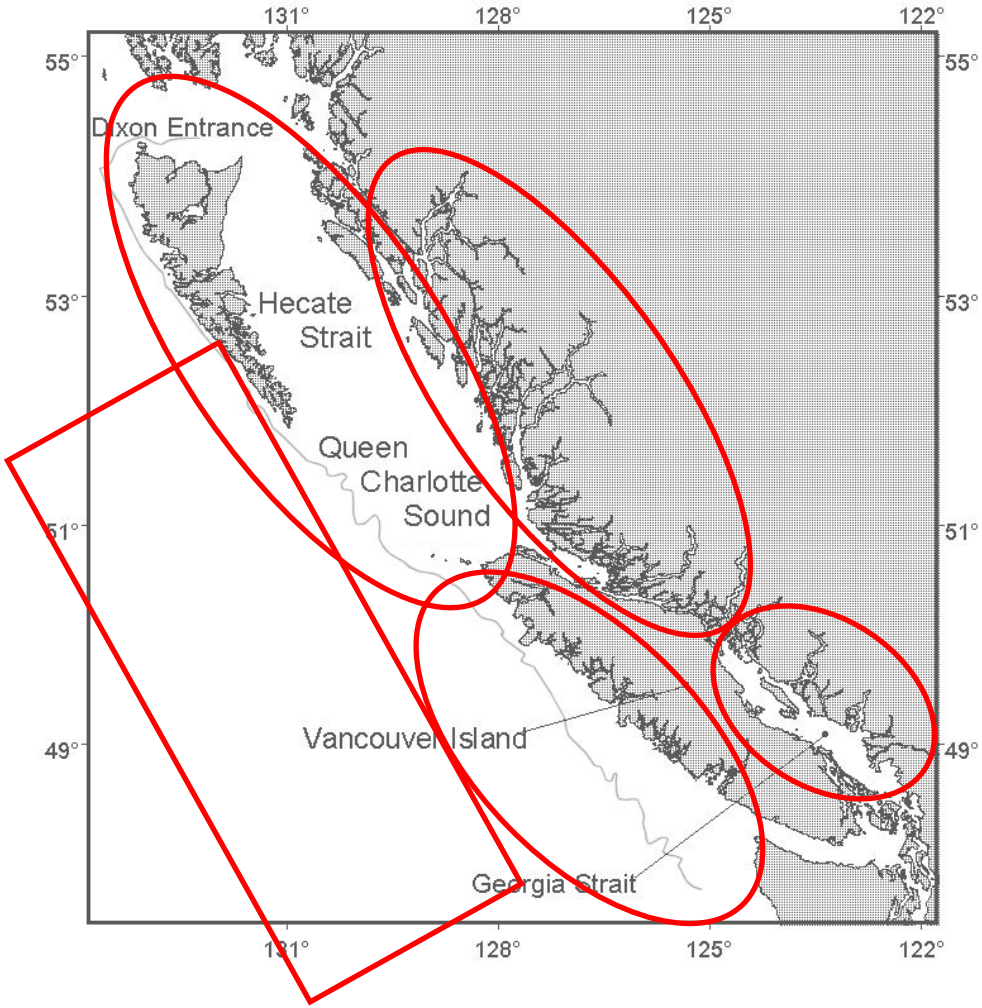
Identify distinct BC marine ecosystems

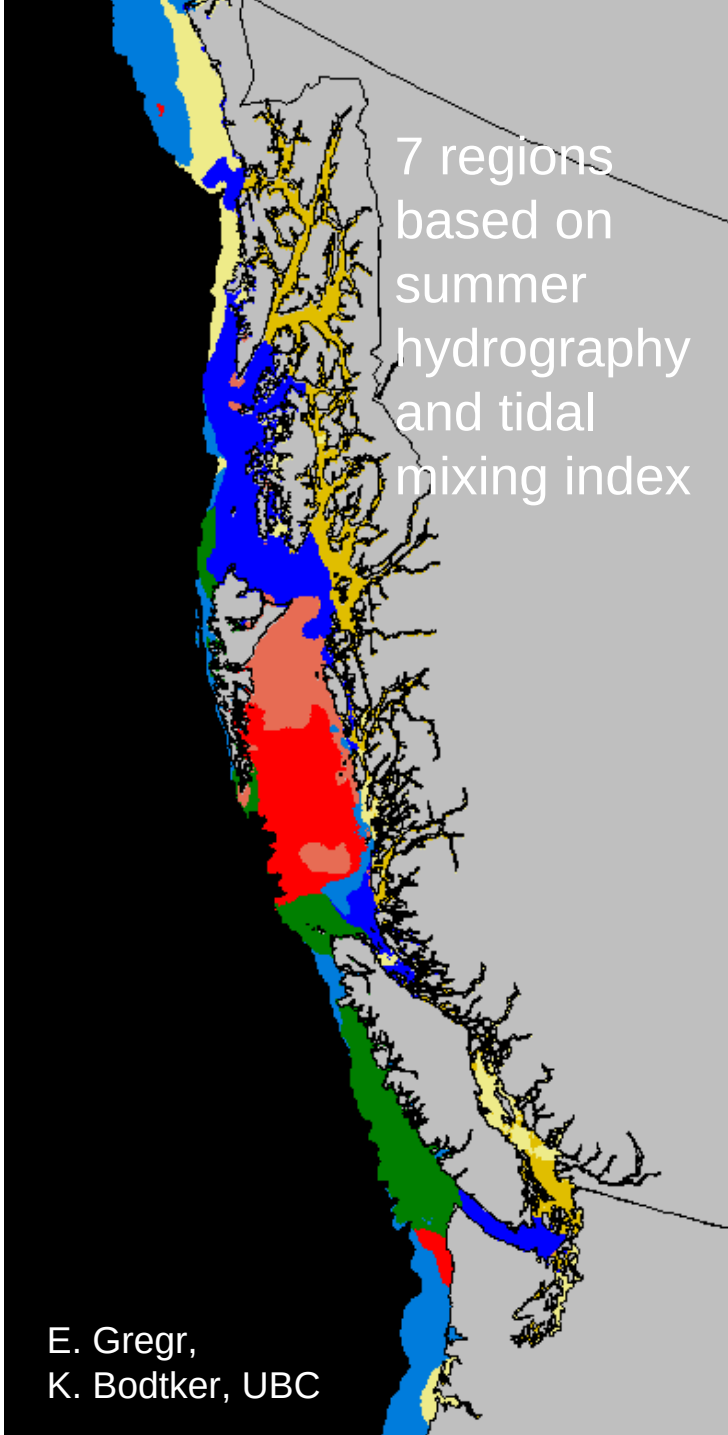


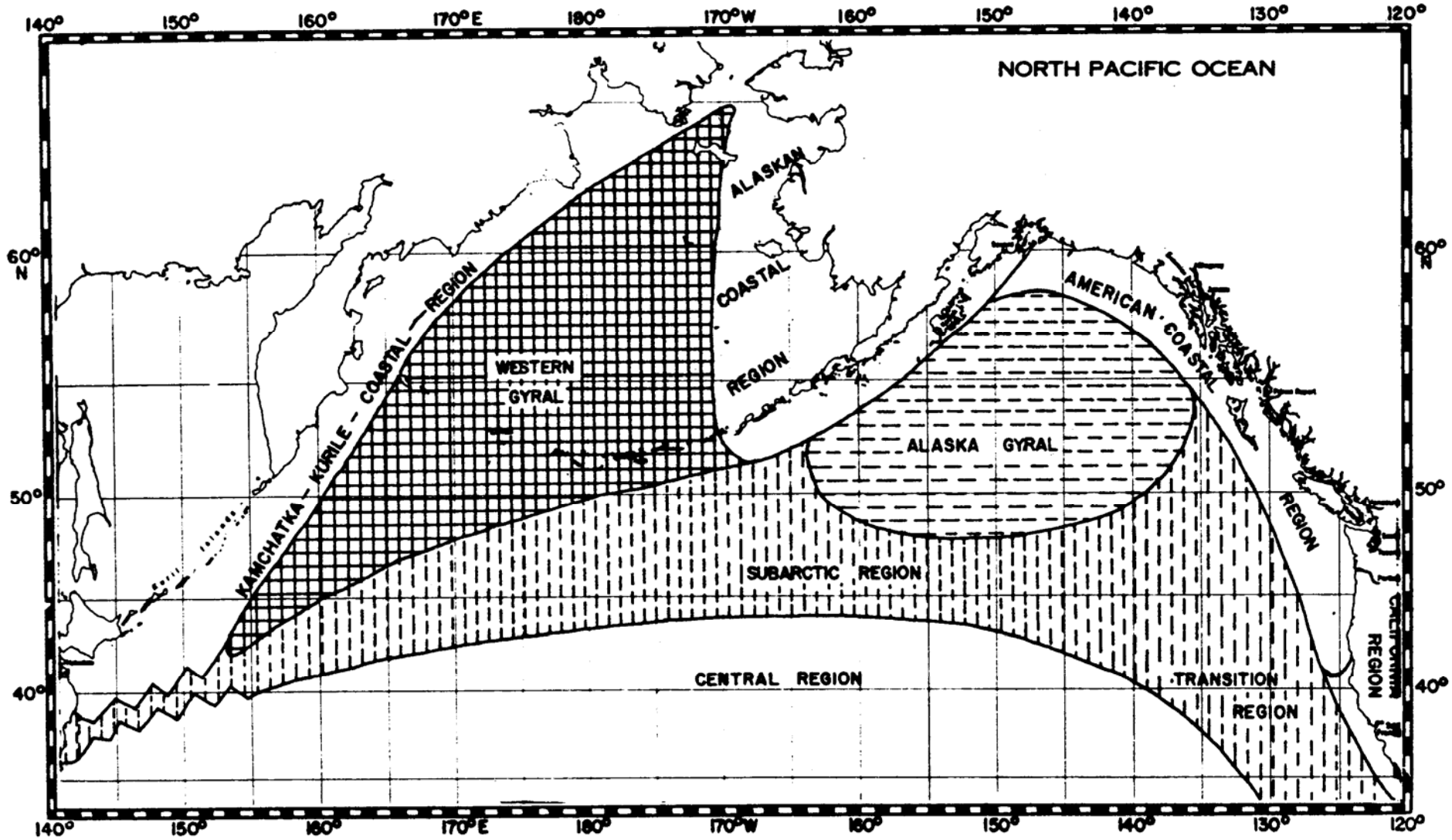
Identify distinct BC marine ecosystems



Identify distinct BC marine ecosystems



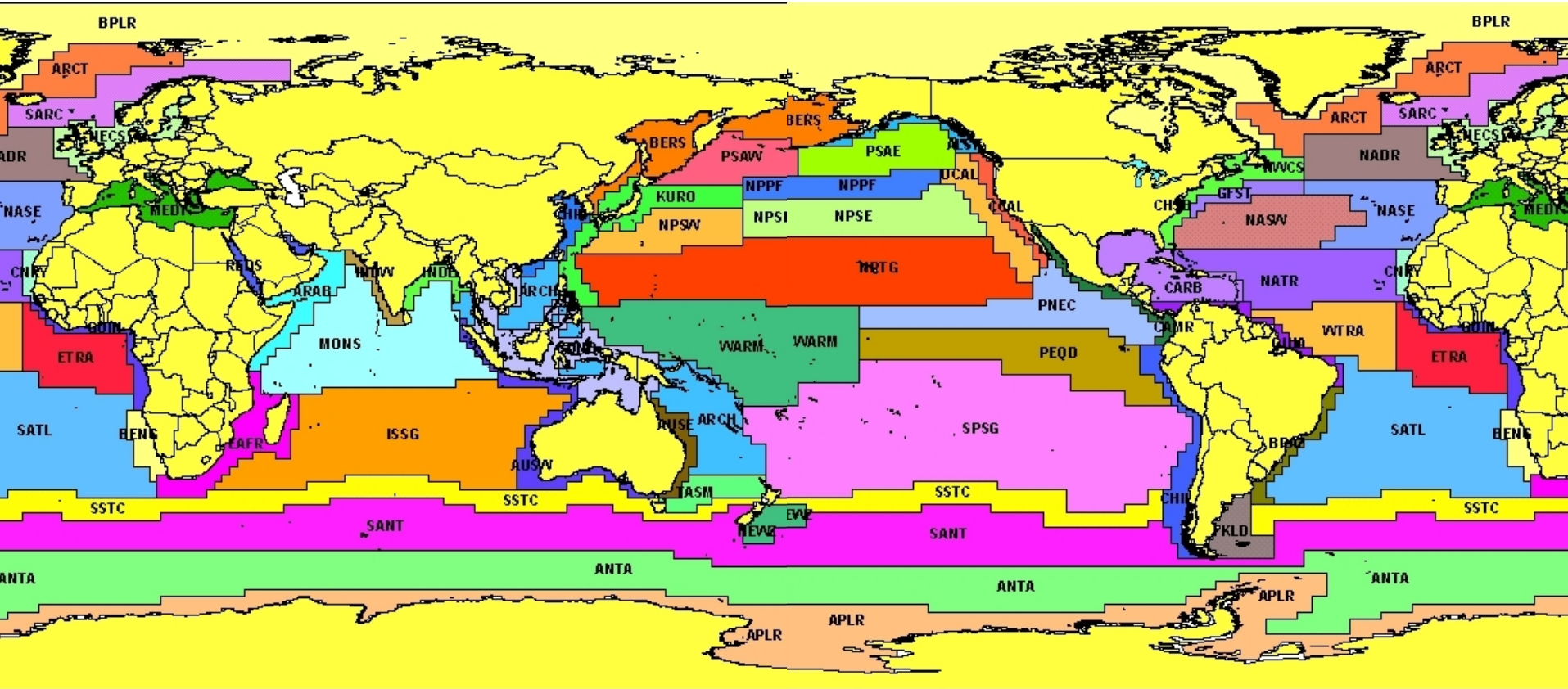


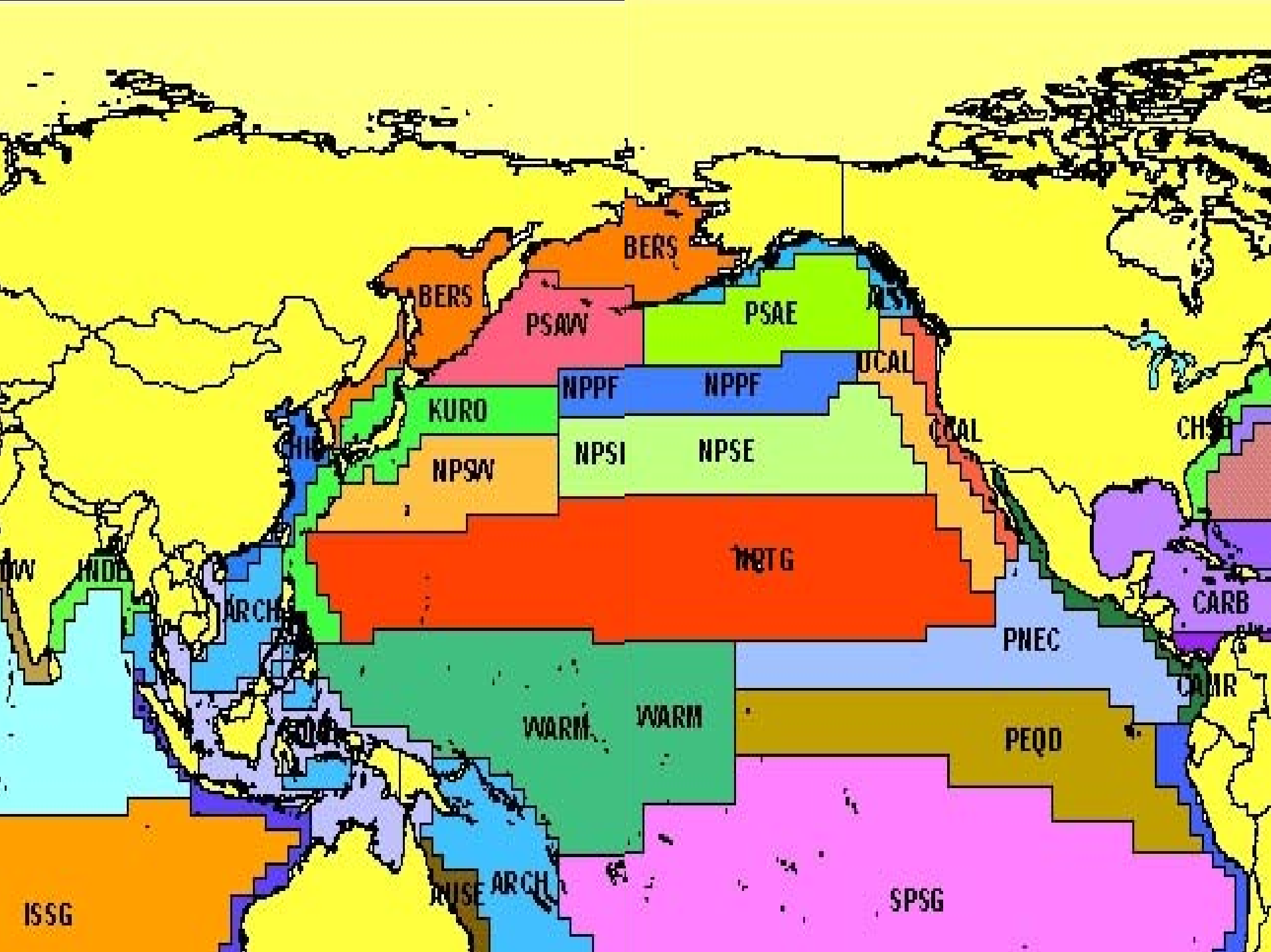


Source: Dodimead, Favorite, Hirano. 1963. INPFC Bull 13

At global scales, Longhurst has defined Biogeochemical Provinces (Longhurst. 2001. Ecological Geography of the Sea. Academic Press)

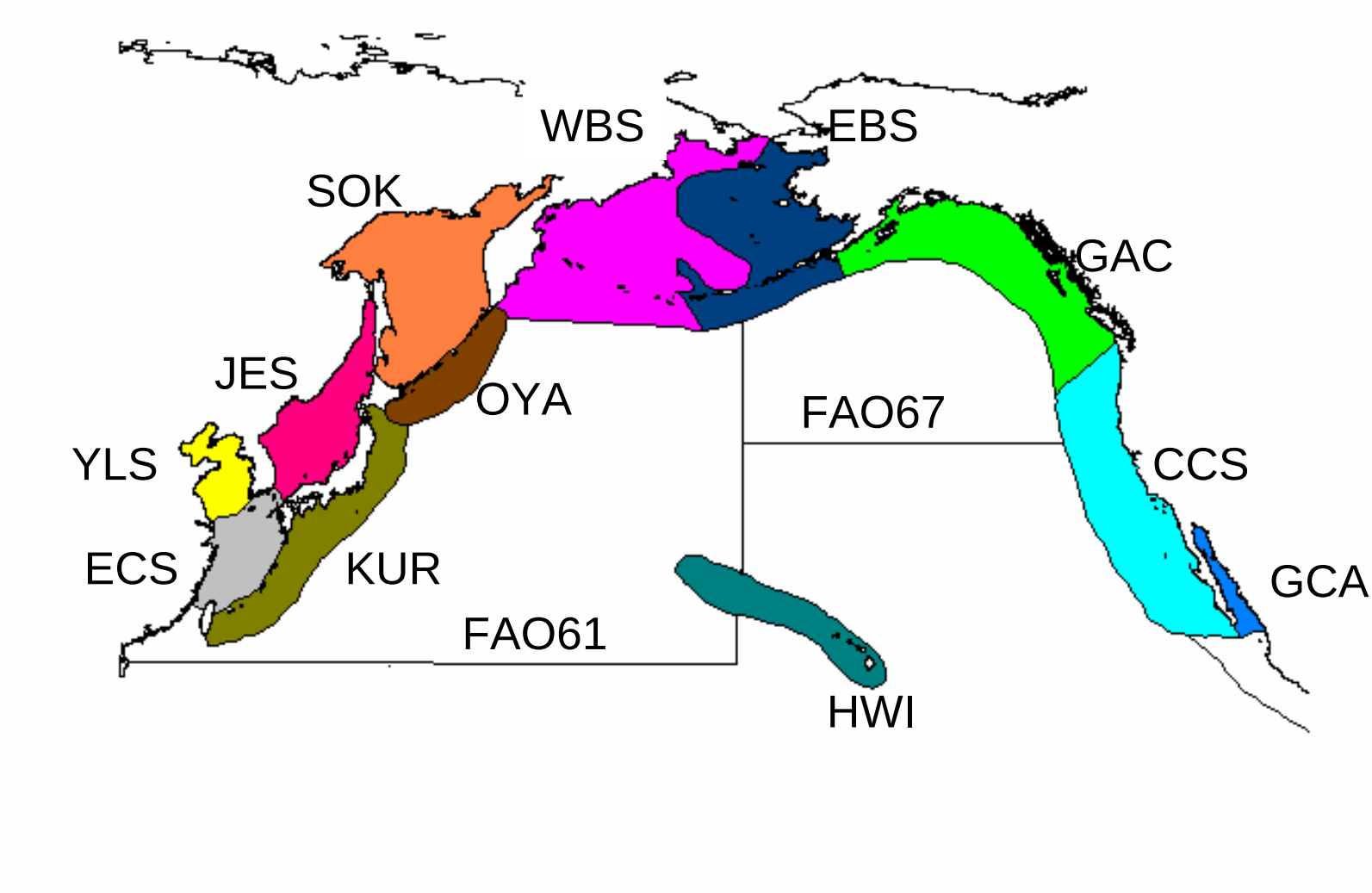
- based on properties including mixed layer depth, mixed layer temperature, phytoplankton production characteristics
- largely derived from satellite remote sensing




BERS
BERS
PSAW
PSAE
UCAL
NPPF
NPPF
KURO
CCAL
NPSI
NPSE
NPSW
NATG
CARB
PNEC
WARM
WARM
PEQD
SPSG
ISSG

At Basin scales, “Large Marine Ecosystems” (LME’s) are defined

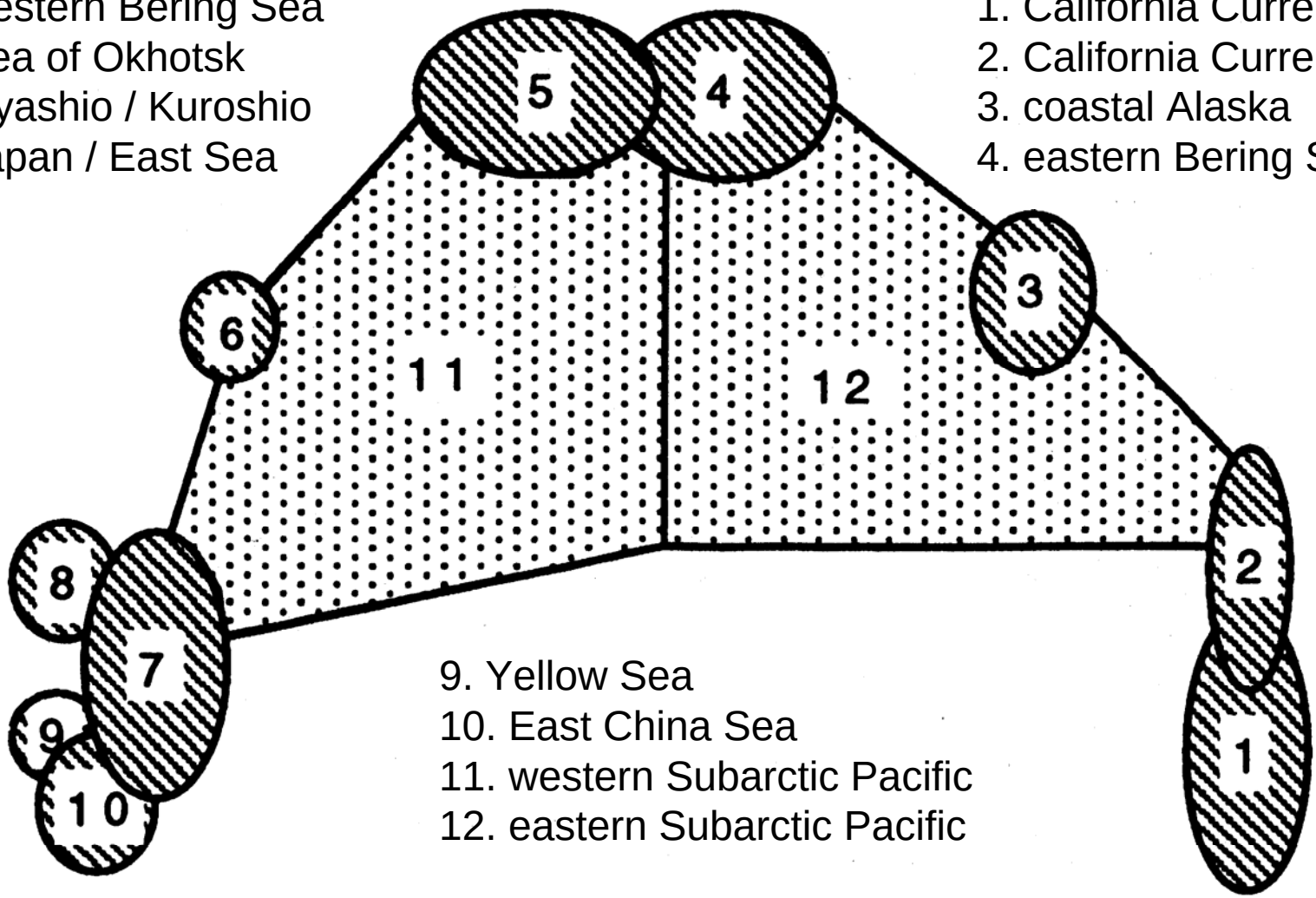
- boundaries based mostly on oceanographic and topographic features



Original view of CCCC Regions

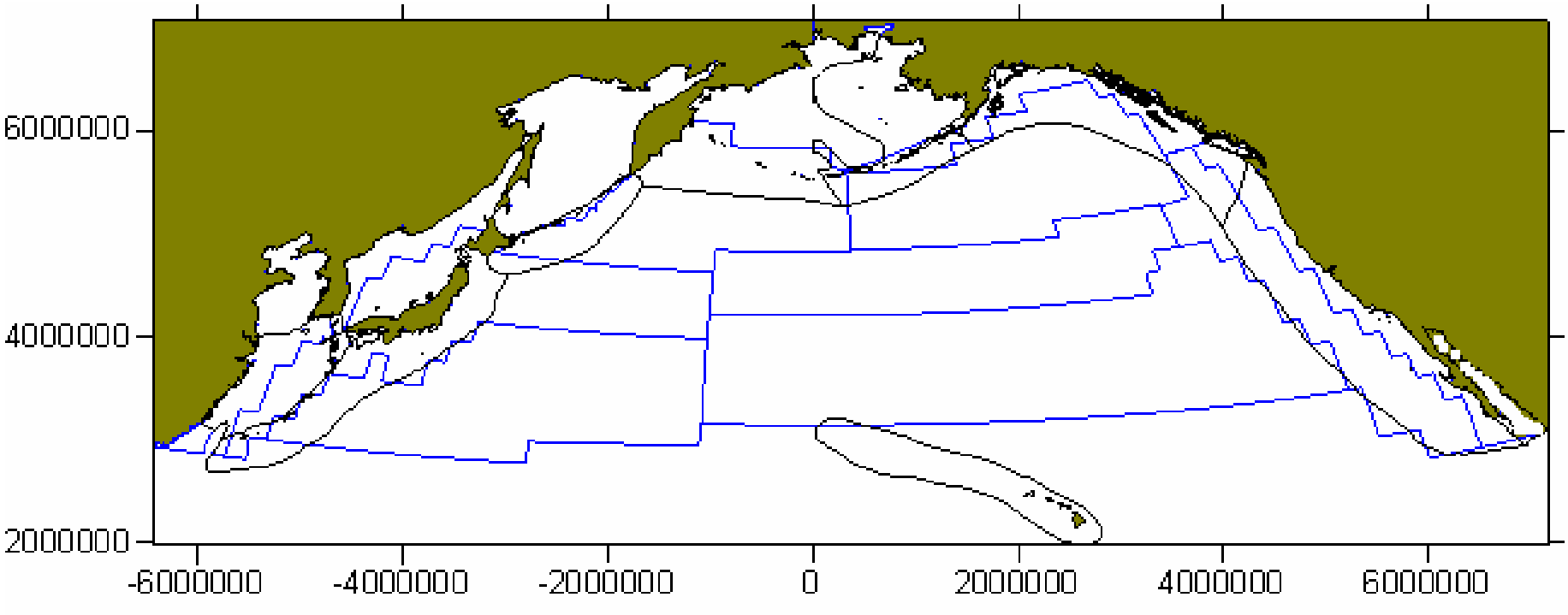
5. western Bering Sea
6. Sea of Okhotsk
7. Oyashio / Kuroshio
8. Japan / East Sea

1. California Current – south
2. California Current – north
3. coastal Alaska
4. eastern Bering Sea



9. Yellow Sea
10. East China Sea
11. western Subarctic Pacific
12. eastern Subarctic Pacific

Overlay of Longhurst Biogeochemical Provinces (blue) and Large Marine Ecosystems (LME's – black)



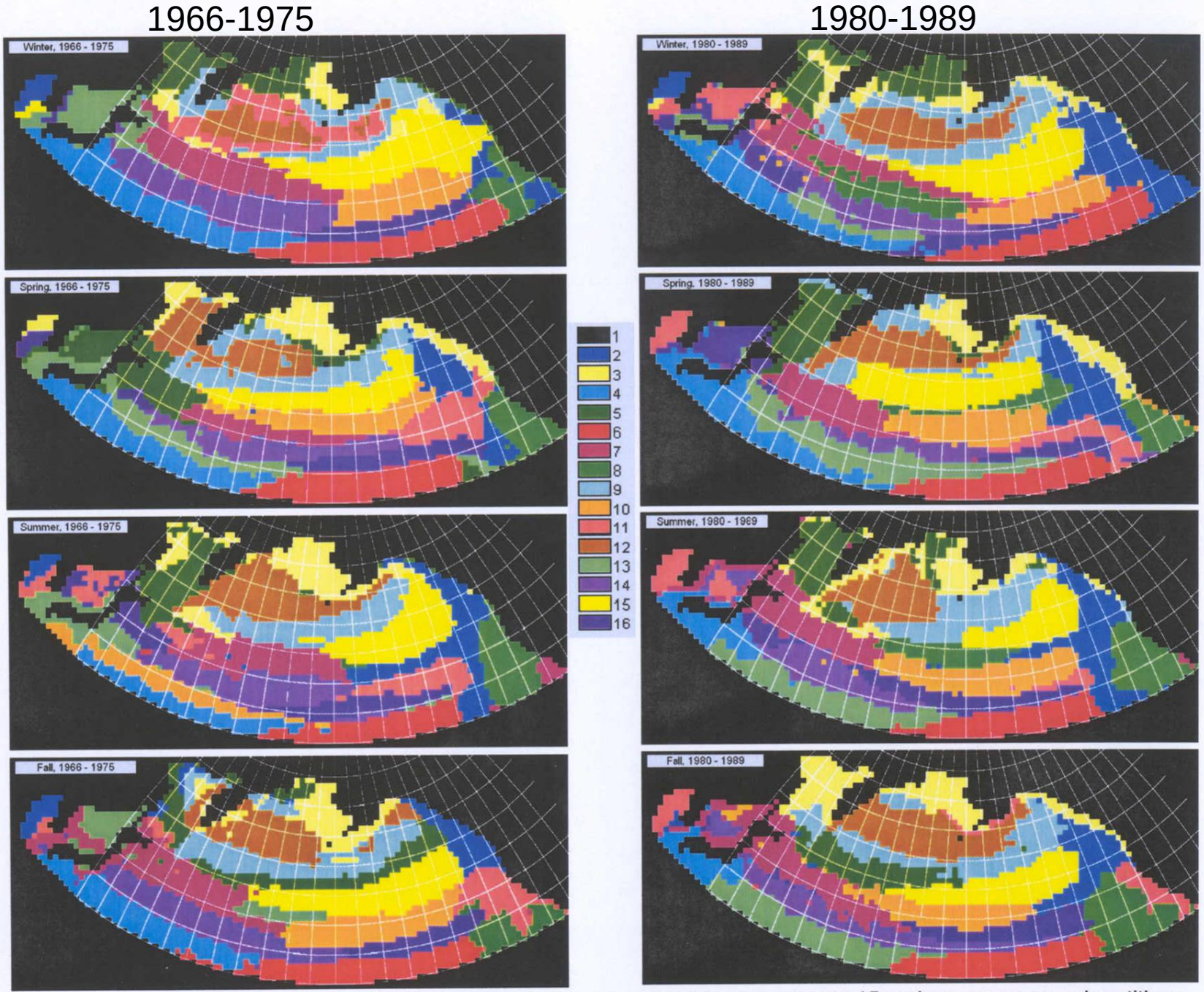
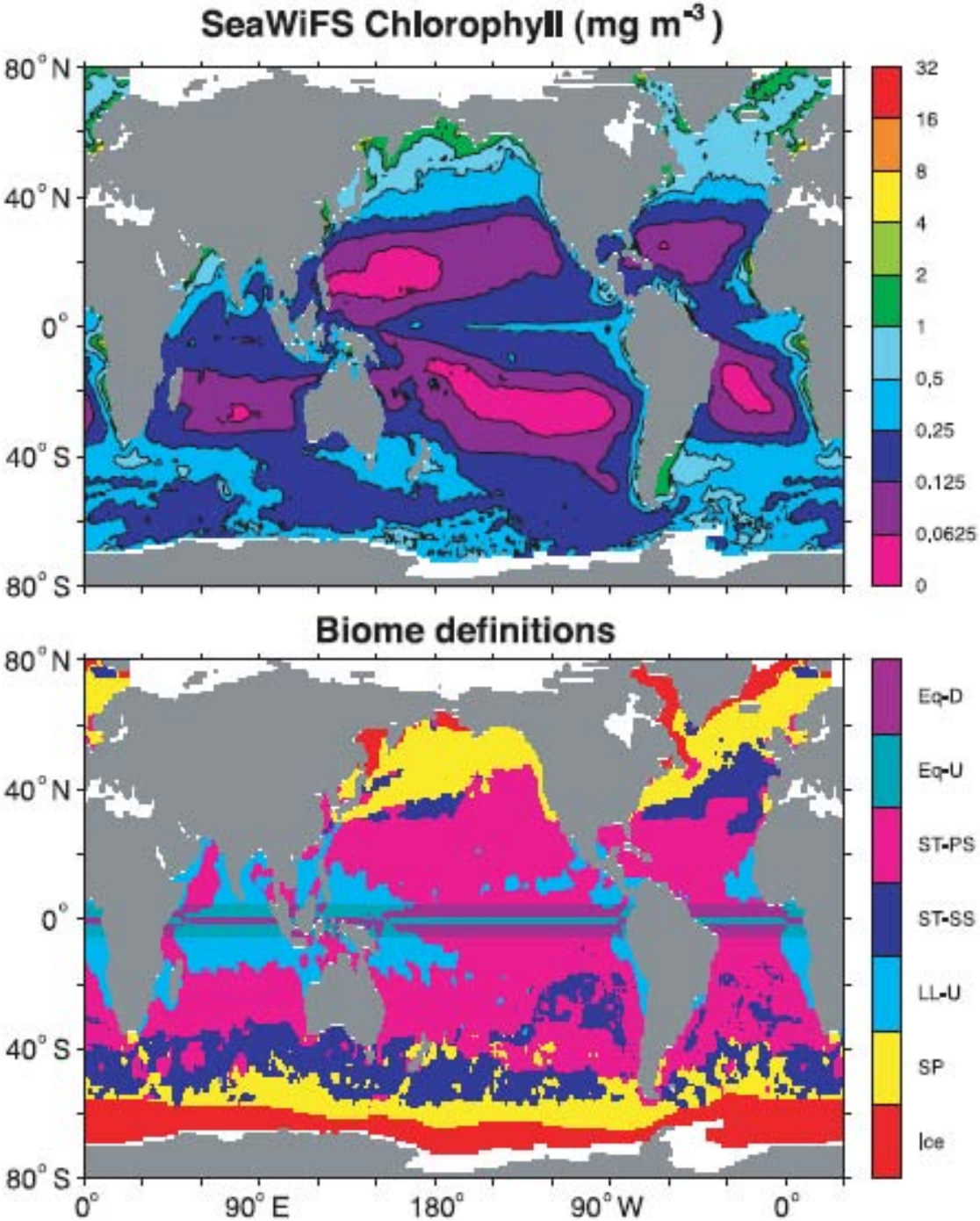


Figure 3: Results of the image classification applied to five input variables to generate 15 regions per seasonal partition.

Gregr and Bodkin 2006



Predicted response of Integrated Primary Production (Pg carbon yr^{-1}) to global warming for 2040-2060:

N. Pacific Ocean

Marginal ice zone	-38.6%
Subpolar	34.0%
Subtropical seasonal	-10.8%

Sarmiento et al. 2004. Global Biogeochemical Cycles 18.

Management (statistical) areas

Function:

- collection of catch information
- stock management

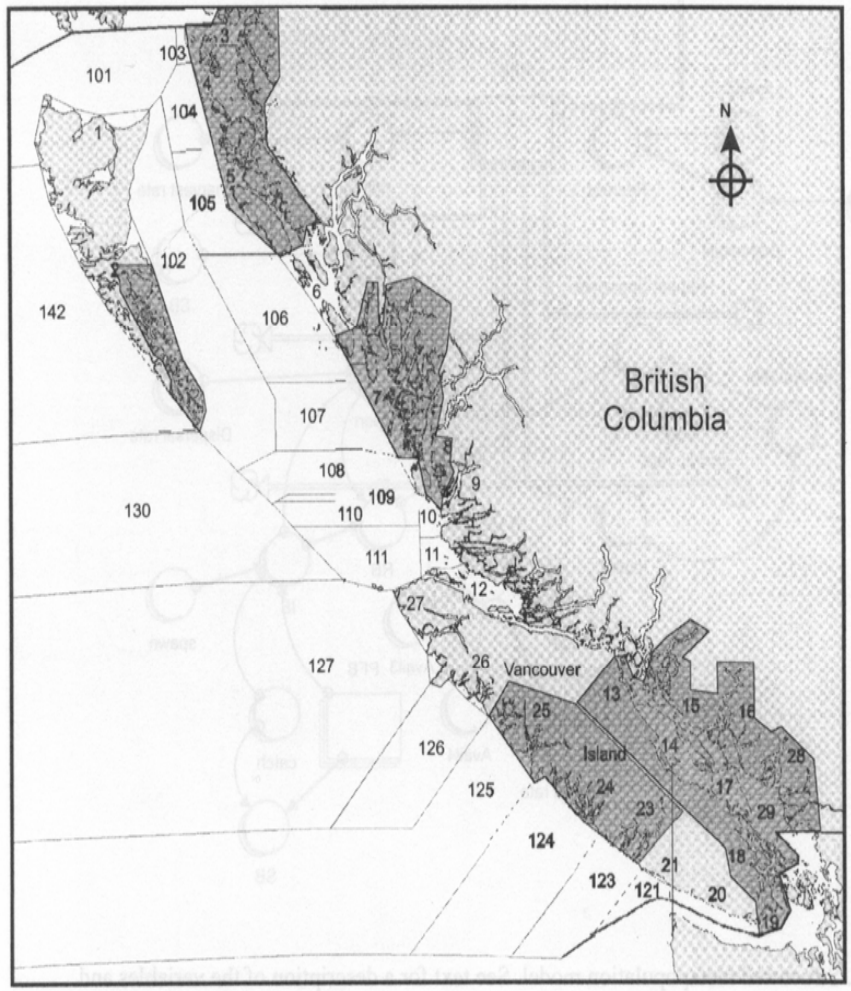
Management Issue:

- Stock Identification - identifying the appropriate size of the management unit so that the population will be self-sustaining in the presence of fishing – "Unit Stock" concept
- Problems:
  - often established for one or several "key" species
  - may not be appropriate for all managed fisheries

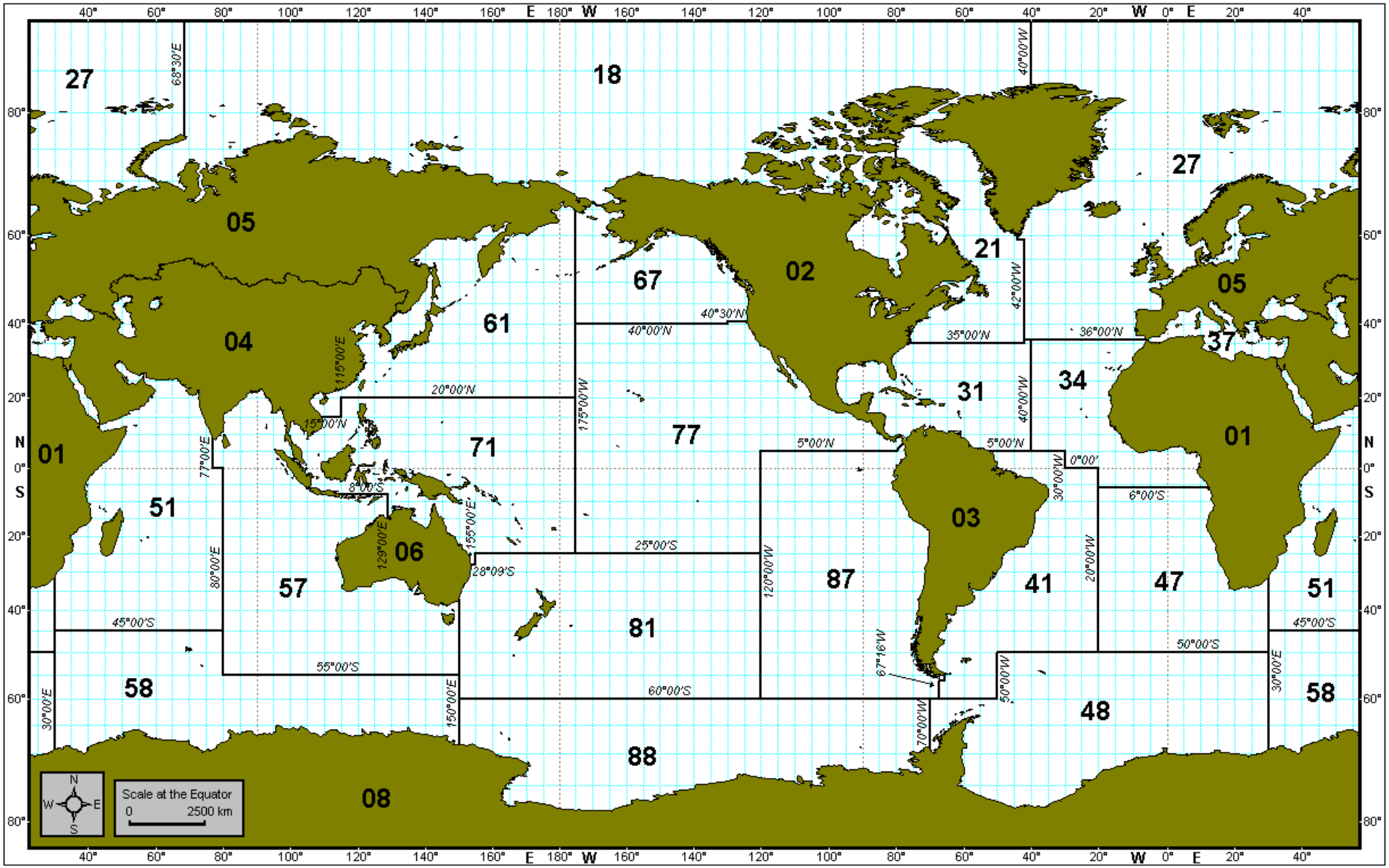
What is the size of the management unit so that the population can (potentially) be self-sustaining (in the presence of fishing)?

- defining too large a management unit may include several discrete populations
  - complicates interpretation of aggregate abundance data and “population” dynamics
  - integrates independent and possibly spatially varying birth and mortality processes
  - populations may compensate each other
    - i.e. declines in one populations are offset by increases in another population, so total does not vary
- defining too small a management area risks collapsing sub-populations that may depend on recruits from other, separately managed, populations

(in Canada) Statistical areas are often grouped into larger management areas for particular species



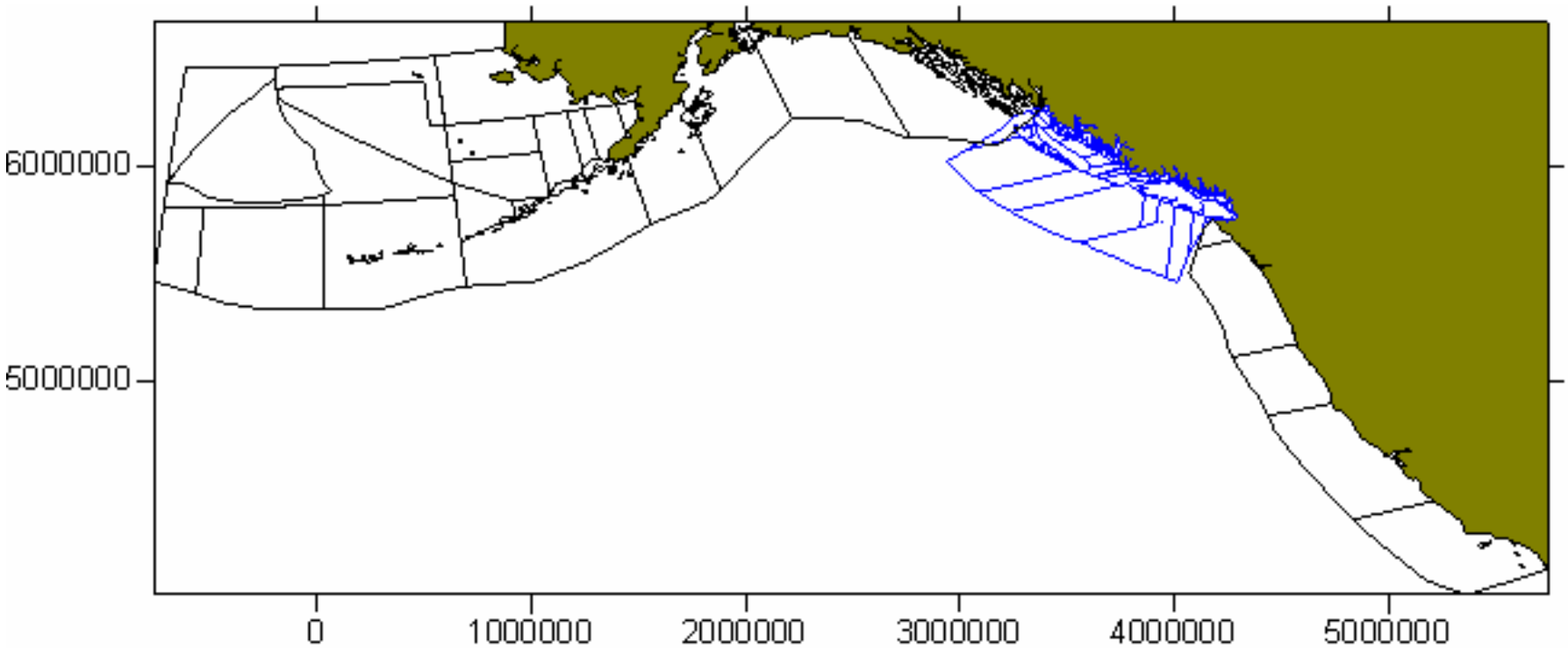
Global Fisheries Statistical Areas - FAO



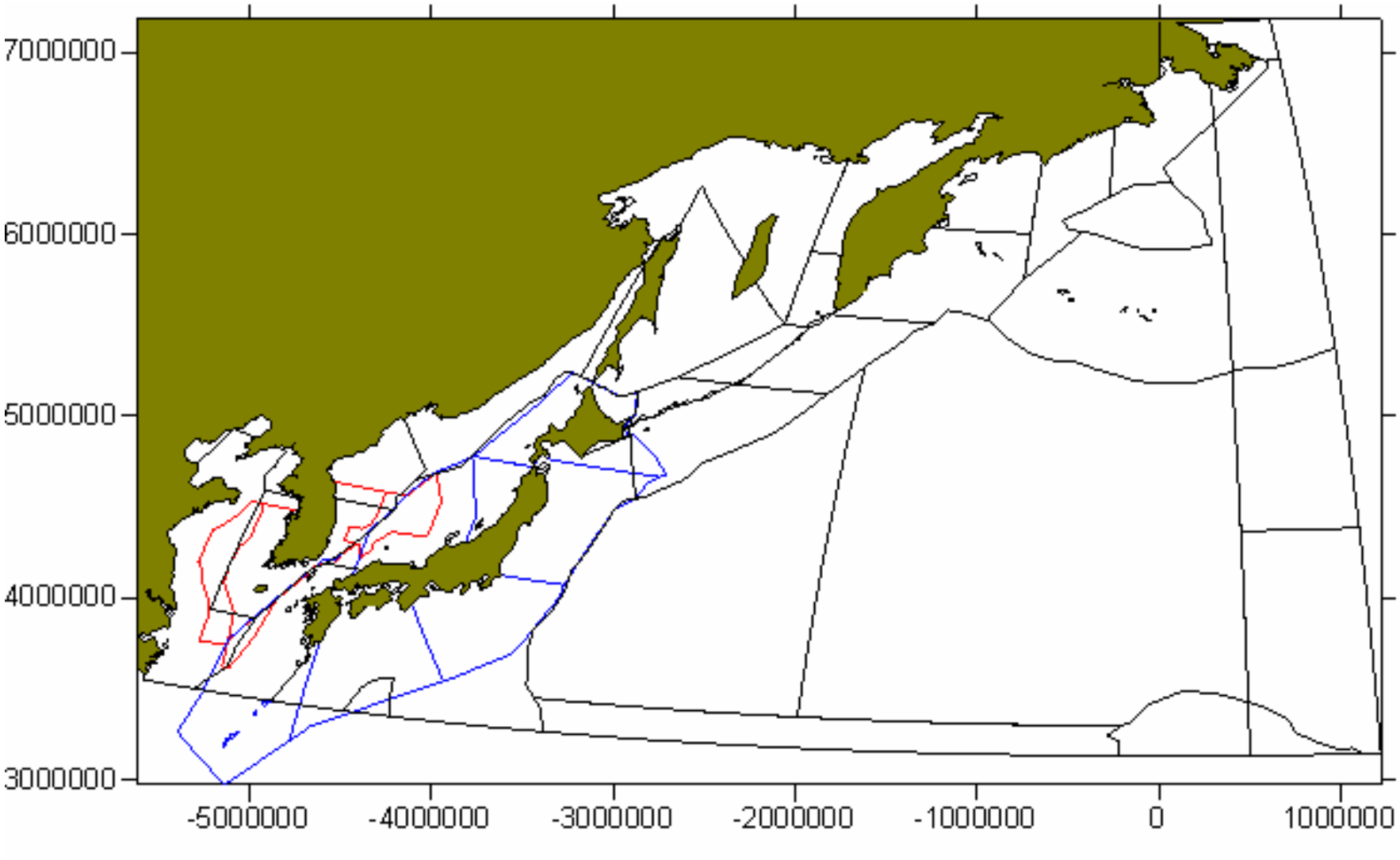
© FAO 2003

Miller cylindrical projection

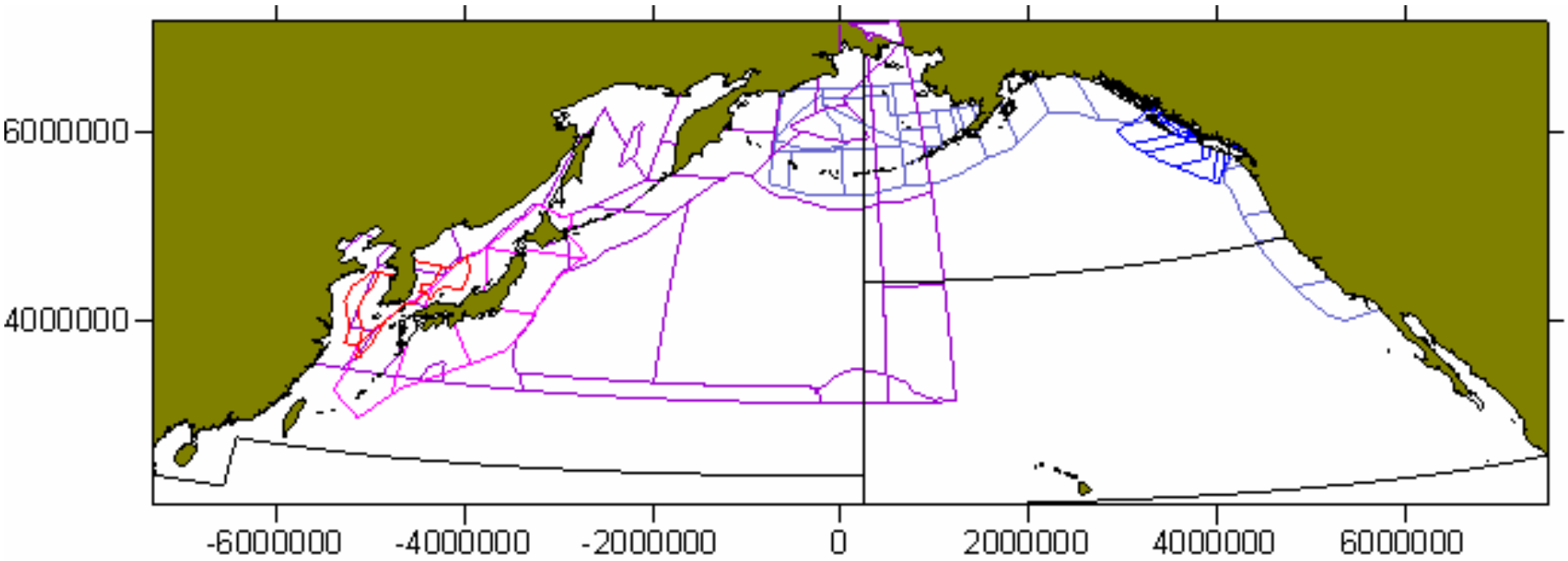
National Statistical areas for eastern North Pacific



National Statistical areas for western North Pacific



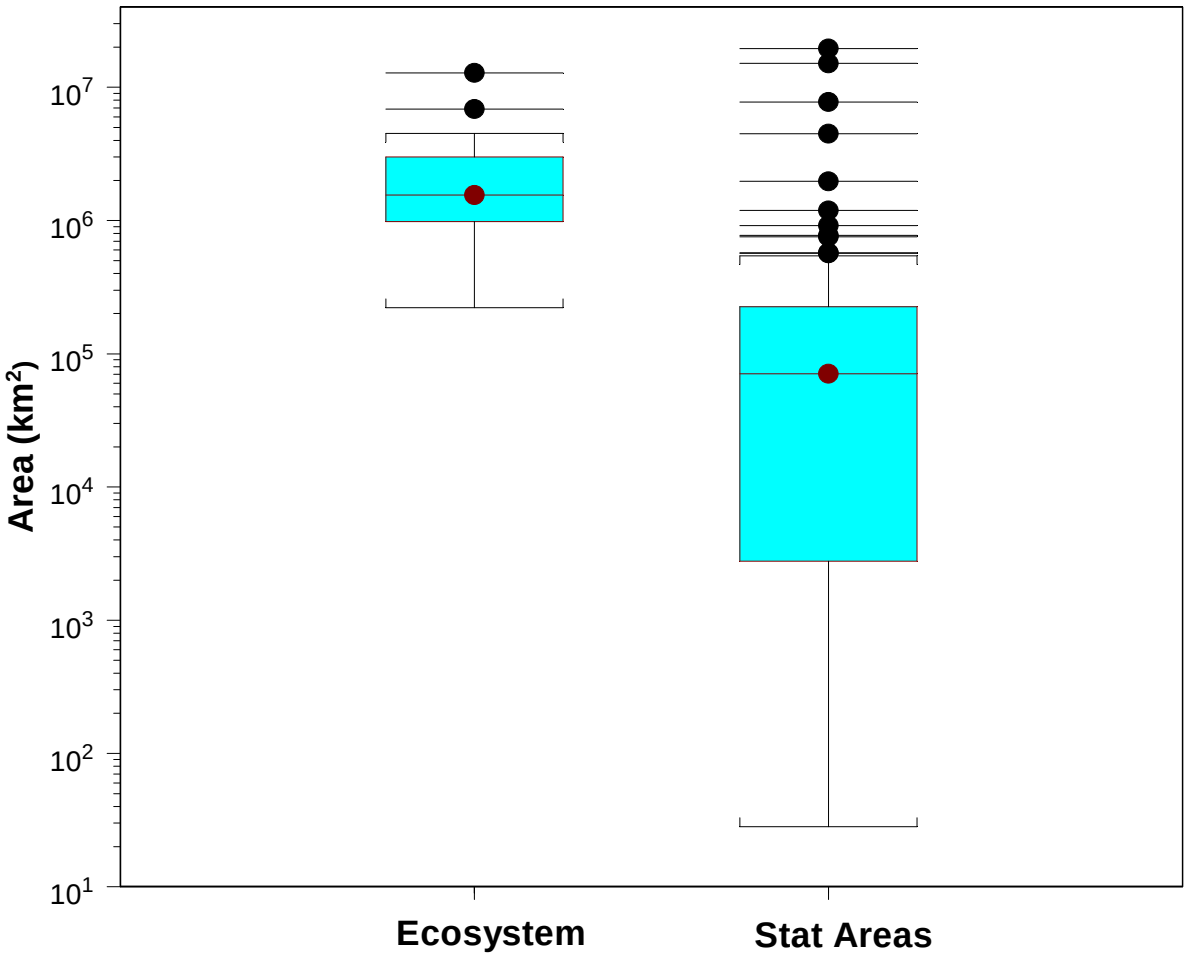
North Pacific national statistical areas



Comparison of EcoRegions and Management Areas

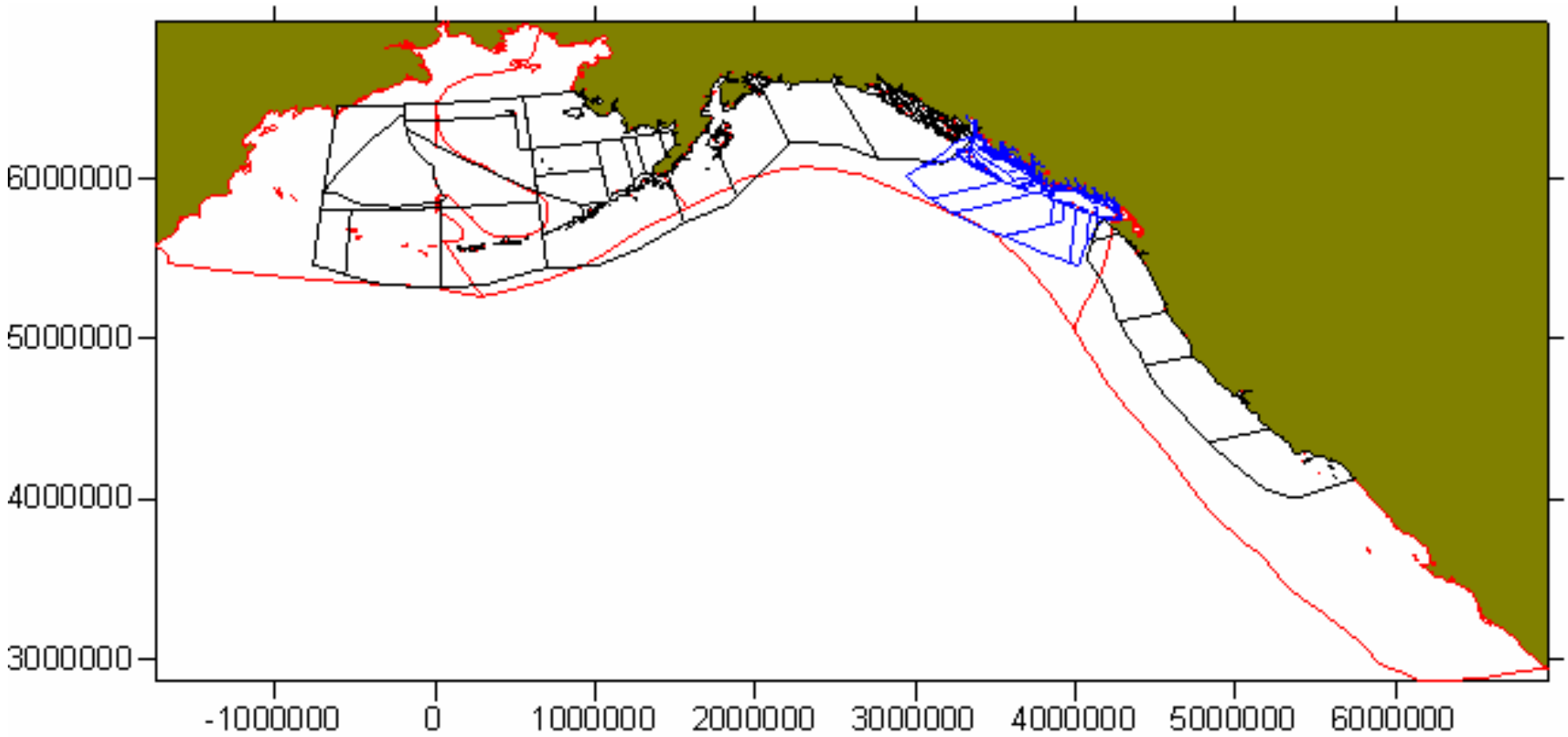
Areas of “EcoRegions” (Longhurst Provinces, LME’s)

are significantly larger than areas of Statistical regions

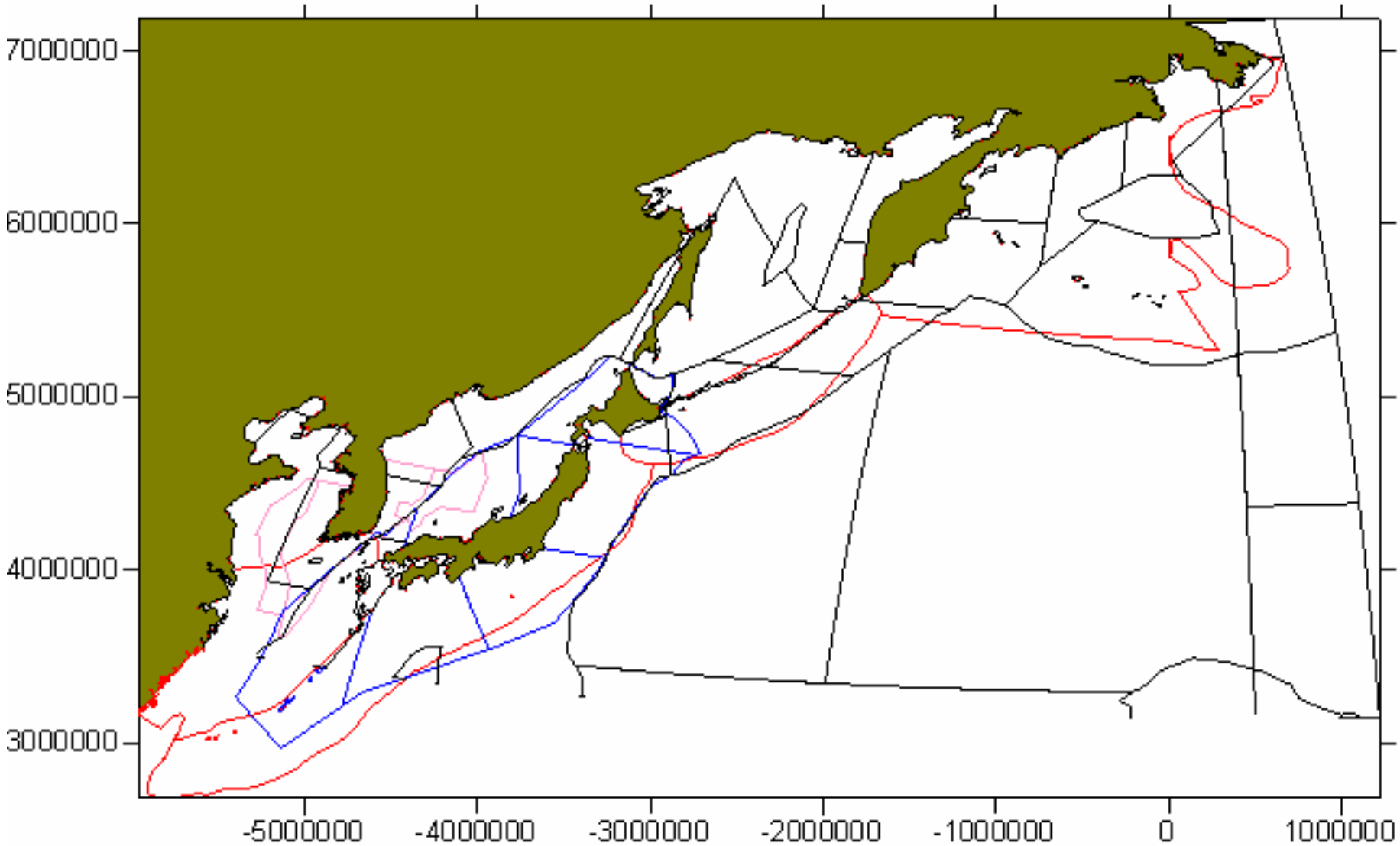


t-test, probability that true difference in means equals 0 is < 0.001

Overlay of EcoRegions (red) and Statistical areas (black – U.S. and blue - Canada)



Overlay of EcoRegions (red) and statistical areas (pink - Korea, blue – Japan, black – Russia)



Conclusions:

Ecosystem typologies / EcoRegions / Biogeochemical Provinces:

- exact boundaries difficult to define relative to fixed geography
- exact boundaries may be impractical considering temporal variability on short and long scales

LME's match Biogeochemical Provinces better in eastern North Pacific than western North Pacific

- significant differences in the western North Pacific appear related to finer shelf-deep ocean separation in the Biogeochem Provinces

Most useful for PICES Nations appears to be the system of LME's designated for the North Pacific

- boundaries of some of these LME's could be refined to better reflect present understanding

Conclusions (cont):

Management / Statistical Areas:

Network of national fishery management / statistical areas in the North Pacific are generally consistent and complementary among Nations

Need to recognise historical and political contexts of management and statistical areas, and build on these rather than trying to change or create new systems

Management areas are smaller than recognised EcoRegions

- in eastern North Pacific
  - management areas reasonably matched with LME's
  - could be easily aggregated to the scale of these LME's
- in western North Pacific
  - management areas less well matched with LME's
  - but also could be aggregated to the scale of these LME's

Move towards an “ocean zoning” concept, with perhaps a network of fixed geographic zones that can be aggregated to match the ecoregion or issue of concern

POLICYFORUM

SUSTAINABILITY

Resolving Mismatches in U.S. Ocean Governance

Problems in ocean resource management derive from governance, not science. Ocean zoning would replace mismatched and fragmented approaches with integrated regulatory domains.

L. B. Crowder,[1*] G. Osherenko,[2] O. R. Young,[3] S. Airamé,[2] E. A. Norse,[4] N. Baron,[5] J. C. Day,[6] F. Douvere,[7] C. N. Ehler,[7] B. S. Halpern,[8] S. J. Langdon,[8] K. L. McLeod,[9] J. C. Ogden,[10] R. E. Peach,[11] A. A. Rosenberg,[12] J. A. Wilson[13]

That the oceans are in serious trouble is no longer news. Fisheries are declining, formerly abundant species are now rare, food webs are altered, and coastal ecosystems are polluted and degraded. Invasive species and diseases are proliferating and the oceans are warming (*1*). Because these changes are largely due to failures of governance, reversing them will require new, more effective governance systems.

Historically, ocean management has focused on individual sectors. In the United States, at least 20 federal agencies implement over 140 federal ocean-related statutes. This is like a scenario in which a number of specialist physicians, who are not communicating well, treat a patient with multiple medical problems. The combined treatment can exacerbate rather than solve problems. Separate regimes for fisheries, aquaculture, marine mammal conservation, shipping, oil and gas, and mining are designed to resolve conflicts within sectors, but not across sectors. Decision-making is often ad hoc, and no one has clear authority to resolve conflicts across sectors or to deal with cumulative effects. Many scientists are now convinced that the solution can be found in ecosystem-based management (*2*). Ecosystem-based management focuses on managing the suite of human activities that affect particular places. This is a marked departure from the current approach. The time has come to consider a more holistic approach to place-based management of marine ecosystems, comprehensive ocean zoning (*3*).

Management regimes for individual sectors operate under different legal mandates and reflect the interests of different stakeholders, so governance is riddled with gaps and overlaps (*4*). Fishing has a larger impact on biological diversity than any other human activity (*5*), but the Magnuson-Stevens Act, which governs fisheries, contains no mandate to maintain biodiversity. Ecosystem-based fisheries management (*6*) is only a partial solution—it does not account for impacts on nontarget species or manage other activities that degrade fisheries, such as pollution or wetlands loss (*7*). The problem of fragmented governance is growing, as new place-based activities in the sea [e.g., aquaculture, wind farms, liquefied natural gas (LNG) terminals] are increasing the potential range and severity of conflicts across sectors.

California's Channel Islands illustrate the potential for conflict and fragmentation of management authority (see figure, above).

Fragmentation of management for human uses of marine areas in southern California.

[1]Center for Marine Conservation, Nicholas School of the Environment and Earth Sciences, Duke University Marine Laboratory, Beaufort, NC 28516, USA. [2]Marine Science Institute, University of California, Santa Barbara, CA 93106–6150, USA. [3]Donald Bren School of Environmental Science and Management, University of California, Santa Barbara, CA 93106–5131, USA. [4]Marine Conservation Biology Institute, Bellevue, WA 98004, USA. [5]National Center for Ecological Analysis and Synthesis, Santa Barbara, CA 93101, USA. [6]Great Barrier Reef Marine Park Authority, Townsville, QLD 4810, Australia. [7]Man and the Biosphere Program, UNESCO, 75732 Paris Cedex 15, France. [8]Department of Anthropology, University of Alaska, Anchorage, AK 99508, USA. [9]Department of Zoology, Oregon State University, Corvallis, OR 97331, USA. [10]Florida Institute of Oceanography, St. Petersburg, FL 33701, USA. [11]Kennedy School of Government, Harvard University, Cambridge, MA 02138, USA. [12]Institute for the Study of the Earth, Oceans, and Space, University of New Hampshire, Durham, NH 03824, USA. [13]School of Marine Sciences, University of Maine, Orono, ME 04469, USA.

*Author for correspondence. E-mail: lcrowder@duke.edu

CREDIT: MONICA PESSINO

e.g. Crowder et al. (2006. Science 313: 617-618)

“Problems in ocean resource management derive from governance, not science. Ocean zoning would replace mismatched and fragmented approaches with integrated regulatory domains”

- spatial mismatches between scales of ecosystems and scales of governance

e.g. mismatches occur when jurisdictional boundaries are too large or too small for effective management of the particular system

Ecosystem typologies (“EcoRegions”) are a useful concept within which to apply ecosystem-based management

- especially if they use, build on, and aggregate existing management and statistical areas

Need to be aware of temporal variability in EcoRegions

- will require monitoring and occasional adjustments to account for variations in EcoRegion distributions