

# **THE GLOBAL COASTAL OCEAN: INTERDISCIPLINARY MULTISCALE PROCESSES, REGIONAL DYNAMICS AND SYNTHESIS**

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## **THE GLOBAL COASTAL OCEAN**

- **Interesting and important interdisciplinary marine system**
- **Natural laboratory for fundamental coupled physical-biological-chemical sedimentation processes**
- **Contribution to global ocean dynamics generally?**

## **COASTAL OCEAN INTERACTIONS**

- **Link together the land, the open sea, the atmosphere and the underlying sediments**
- **Impact global processes disproportionately to relative volume**

## **COASTAL ZONE CHANGES**

- **Local and global forcings**
- **Natural and anthropogenic origins**
- **Sensitive to climate change**
- **Increasing human coastal populations and impact**

## **COASTAL OCEAN MANAGEMENT**

- **Scientific understanding essential input to advanced methods**

The effective management and protection of coastal ecosystems must be science-based. With this general purpose in mind, the **COASTS** Programme, sponsored by the Intergovernmental Oceanographic Commission of UNESCO and the Scientific Committee on Oceanic Research, was established *to promote and facilitate research and applications in interdisciplinary coastal and shelf ocean sciences and technology on a global basis to increase scientific understanding of coastal ocean processes.*

# **THE SEA**

## **Ideas and Observations on Progress in the Study of the Seas**

*Volume 13:* THE GLOBAL COASTAL OCEAN:  
MULTISCALE INTERDISCIPLINARY PROCESSES

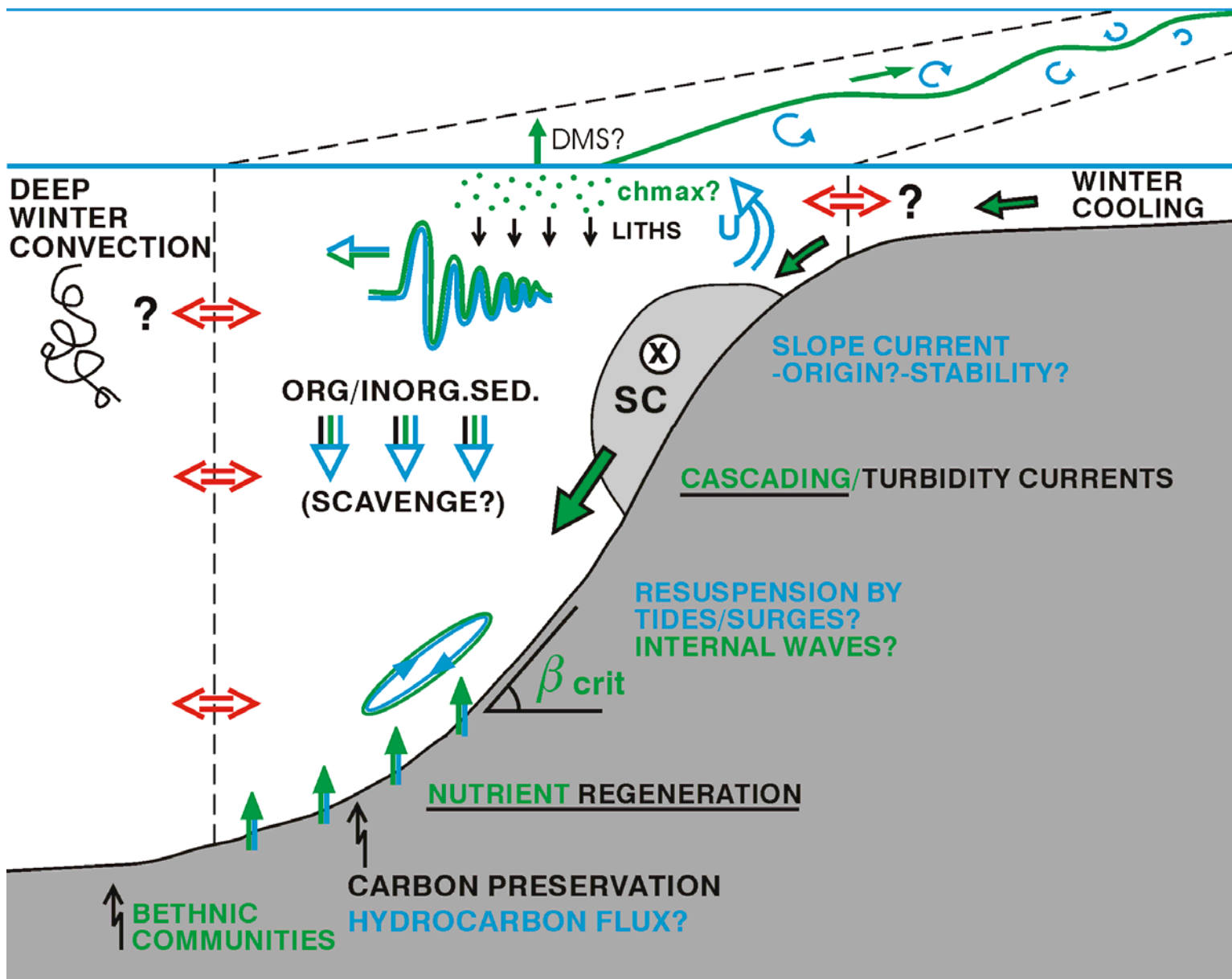
*Volume 14:* THE GLOBAL COASTAL OCEAN:  
INTERDISCIPLINARY REGIONAL STUDIES AND  
SYNTHESES

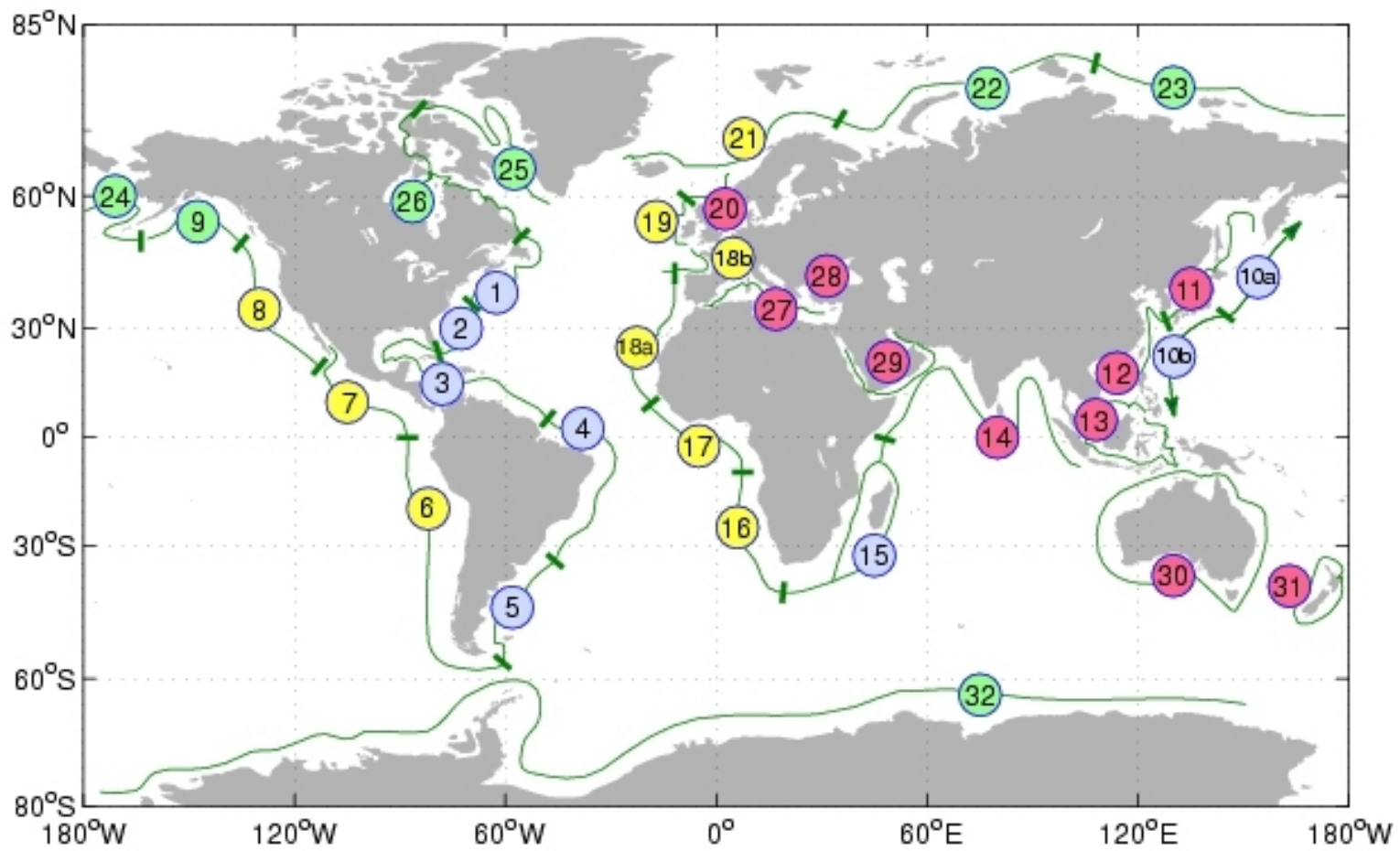
Part A – Pan-regional Syntheses and the Coasts of  
North America and South America and Asia  
Part B – The Coasts of Africa, Europe, Middle East,  
Oceania and Polar Regions.

*Allan R. Robinson and Kenneth H. Brink, Editors*

**THE VOLUMES COMPRISE 60 CHAPTERS, 2550 PAGES,  
AUTHORED BY 170 INTERNATIONAL SCIENTISTS.**

↓↑ **HEATING** (PREC)  
↑↓ **COOLING** (EVAP)





# Global Coastal Ocean and its Subregions - 1

## PRESENTLY NON-UNIFORM TERMINOLOGY

- the coastal ocean, coastal zone, coastal margin, continental shelf, continental margin, shelf sea
- terms used (often without definition) interchangeably by different scientists
- Obfuscates the inter-comparison of quantitative estimates of processes

**PROPOSED DEFINITION:** the coastal ocean - that area, extending offshore from the surf zone and from estuarine mouths, that includes at least the continental shelf and slope, and that also includes waters extending uninterruptedly farther offshore that are (based on temperature or salinity properties only) of shelf or inshore origin

# **Global Coastal Ocean and its Subregions - 2**

## **THE CLASSIFICATION OF SUB-REGIONS VIA GEOGRAPHY, GEOMORPHOLOGY AND DYNAMICAL PROCESSES**

- 4 panregions - eastern and western boundaries, polar, semi-enclosed seas/islands;
- 5 physical processes - boundary layers, tides, wind and buoyancy forcing, boundary currents;
- 6 offshore zones - near shore, freshwater influence, well mixed, tidal fronts, thermally stratified, shelf-edge;
- 7 biogeochemical processes - subtropical shelf pumps, temperate shelf: biology or physics dominant, upwelling: biology or physics dominant, coral reefs, polar ice pump;
- 7 ecosystem types (permanent and intermittent polar ice, mid-latitude and topographically forced coastal, upwelling, wet and dry tropical.

## **COMMON SCIENTIFIC VERNACULAR NECESSARY FOR COLLABORATIVE INTERDISCIPLINARY RESEARCH AND INTERNATIONAL COOPERATION**



# Status of Knowledge

## *The coastal ocean's role in the global carbon cycle*

- Is coastal ocean net source or sink of CO<sub>2</sub> to atmosphere?
- Conclusions controversial at this time
  - Varying definitions
  - Balances difficult to work out

## *High coastal ocean biological production*

- Most biologically productive part of world's oceans
- Processes which drive productivity not globally well known

## *Natural ecosystem variability*

- Shifts pre-date human activity
- Physical-biological couplings under investigation

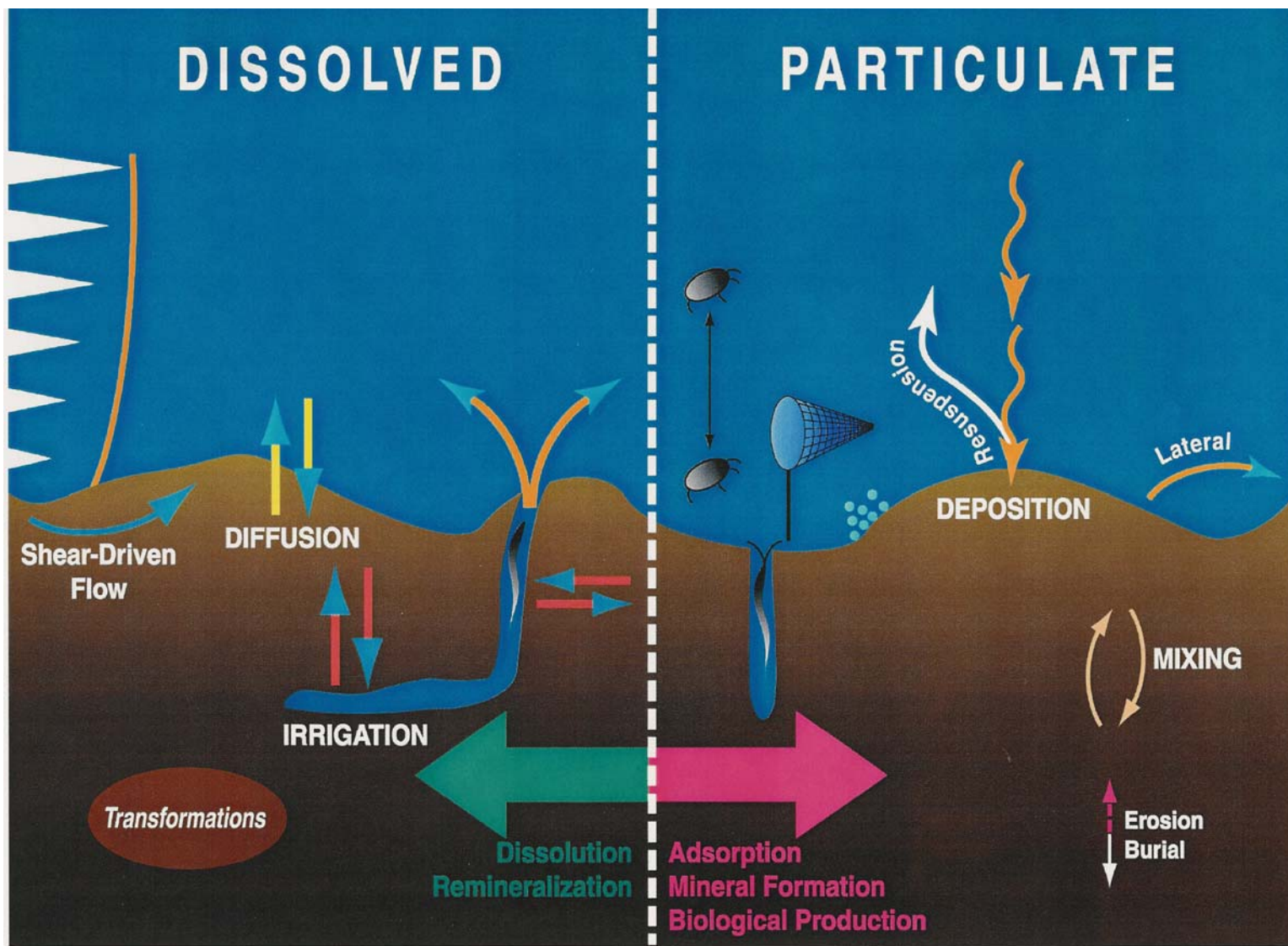
## *The role of the bottom*

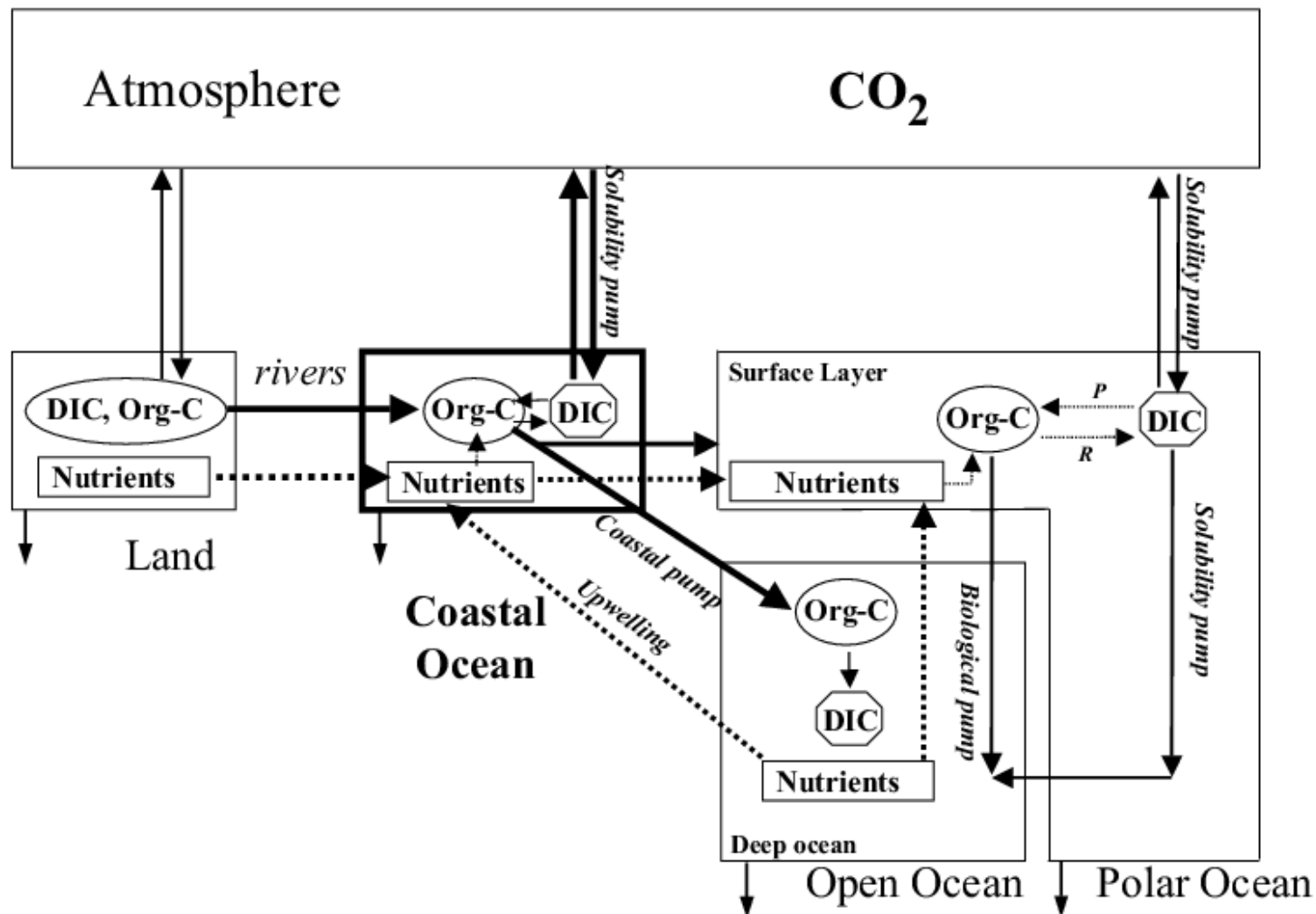
- Coupling of bottom to water column generally poorly quantified on a global basis

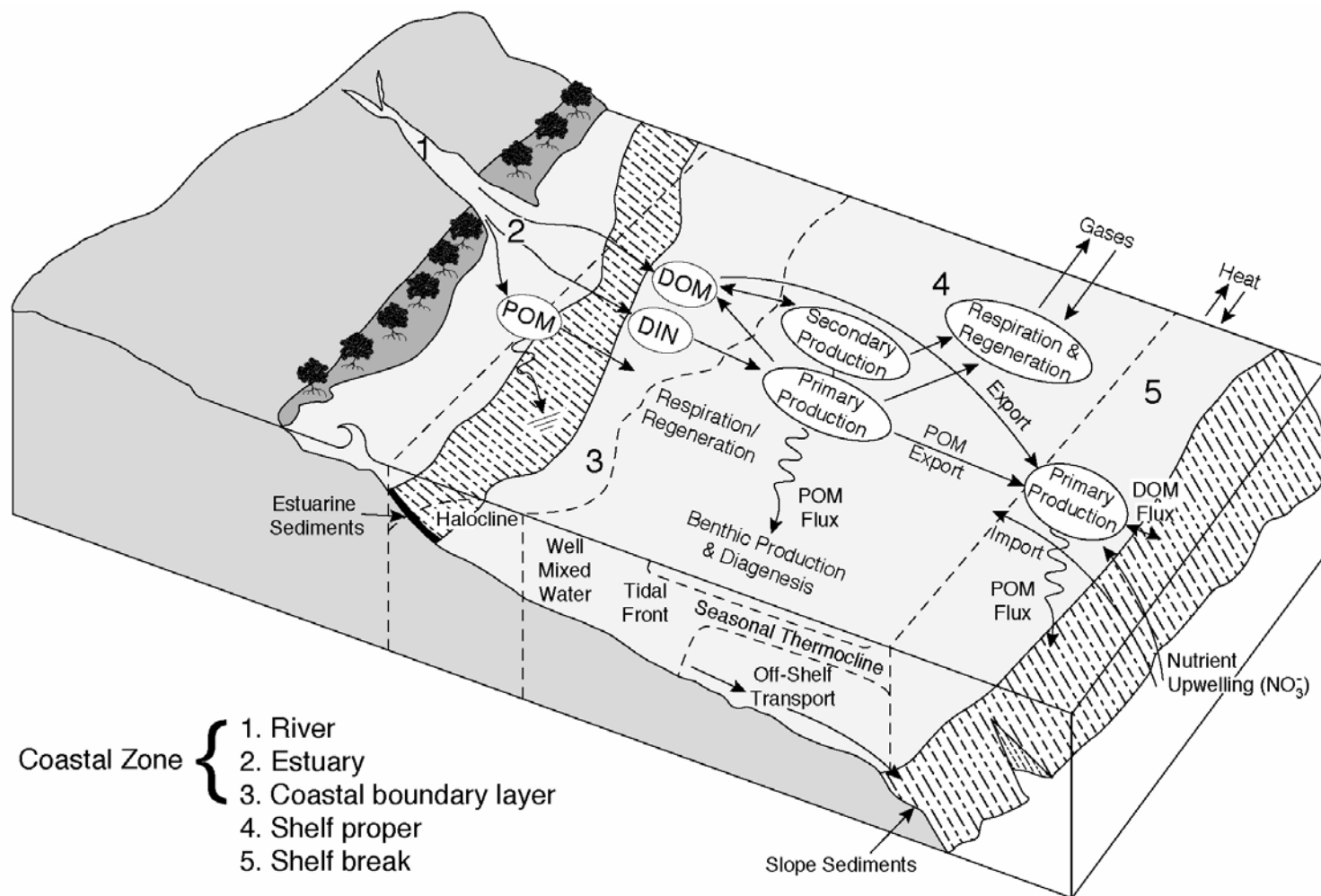
## *Understanding human impacts on the coastal ocean*

- Anthropogenic influences increasingly obvious and diverse
  - Nutrient release can cause harmful algal blooms
  - Fishing practices can change ecosystems

## *Need for more data*







# Measurements and Observations

## *Critical reasons for coastal measurements:*

- Establishing a global baseline of coastal information,
- Discovering ocean processes, understanding how they work, and developing parameterizations,
- Testing hypotheses,
- Driving and evaluating numerical models,
- Observing change, either secular (as in the atmospheric increase of CO<sub>2</sub>), or low frequency (such as ENSO phenomenology), and
- Essential for monitoring and input to management

## *Ability to measure improved radically*

- New sensors (optical techniques, Video Plankton Recorders, etc.)

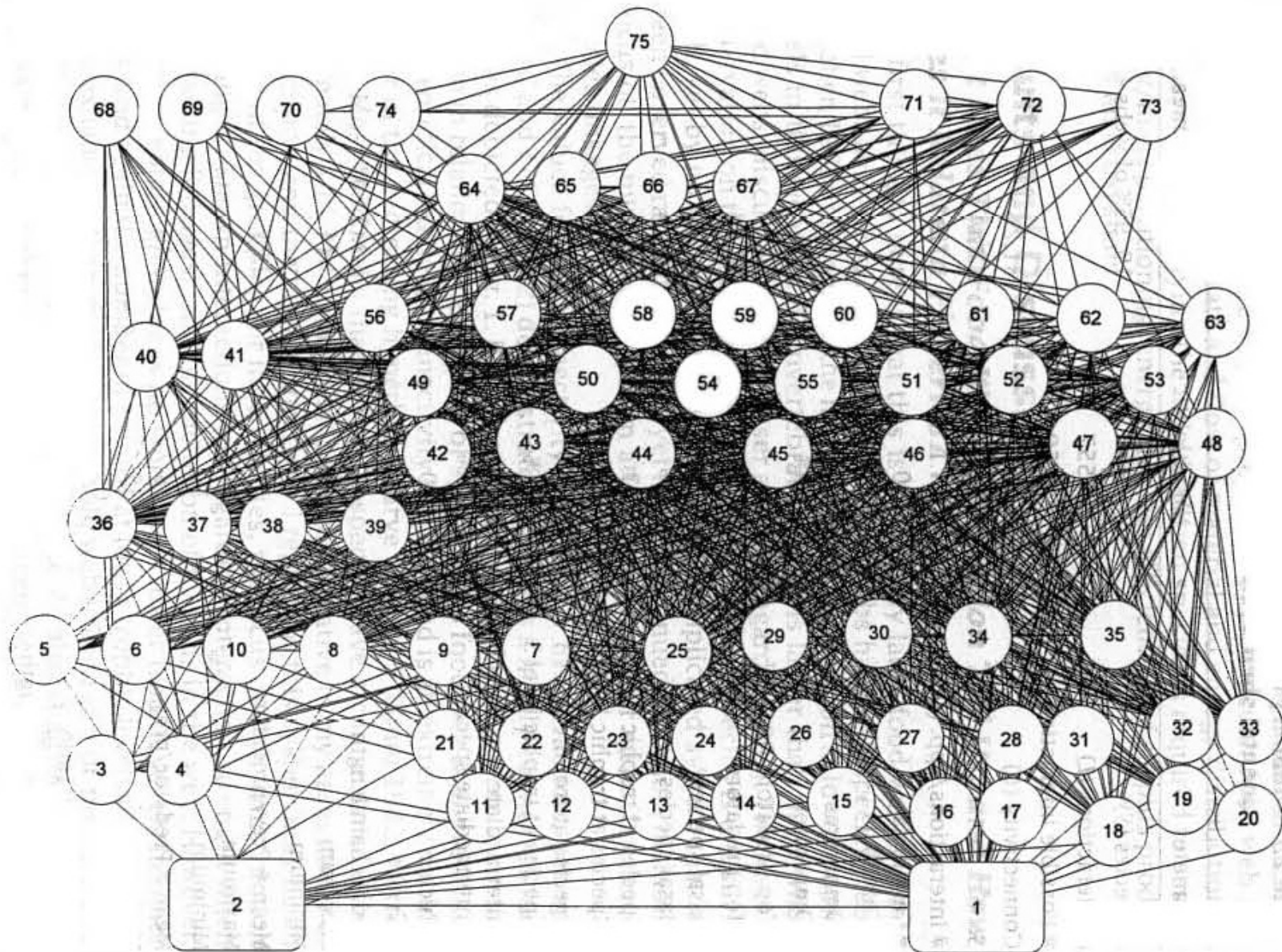
## *How to deploy sensors evolving*

- Remote sensing, AUVs, Ocean Observatories

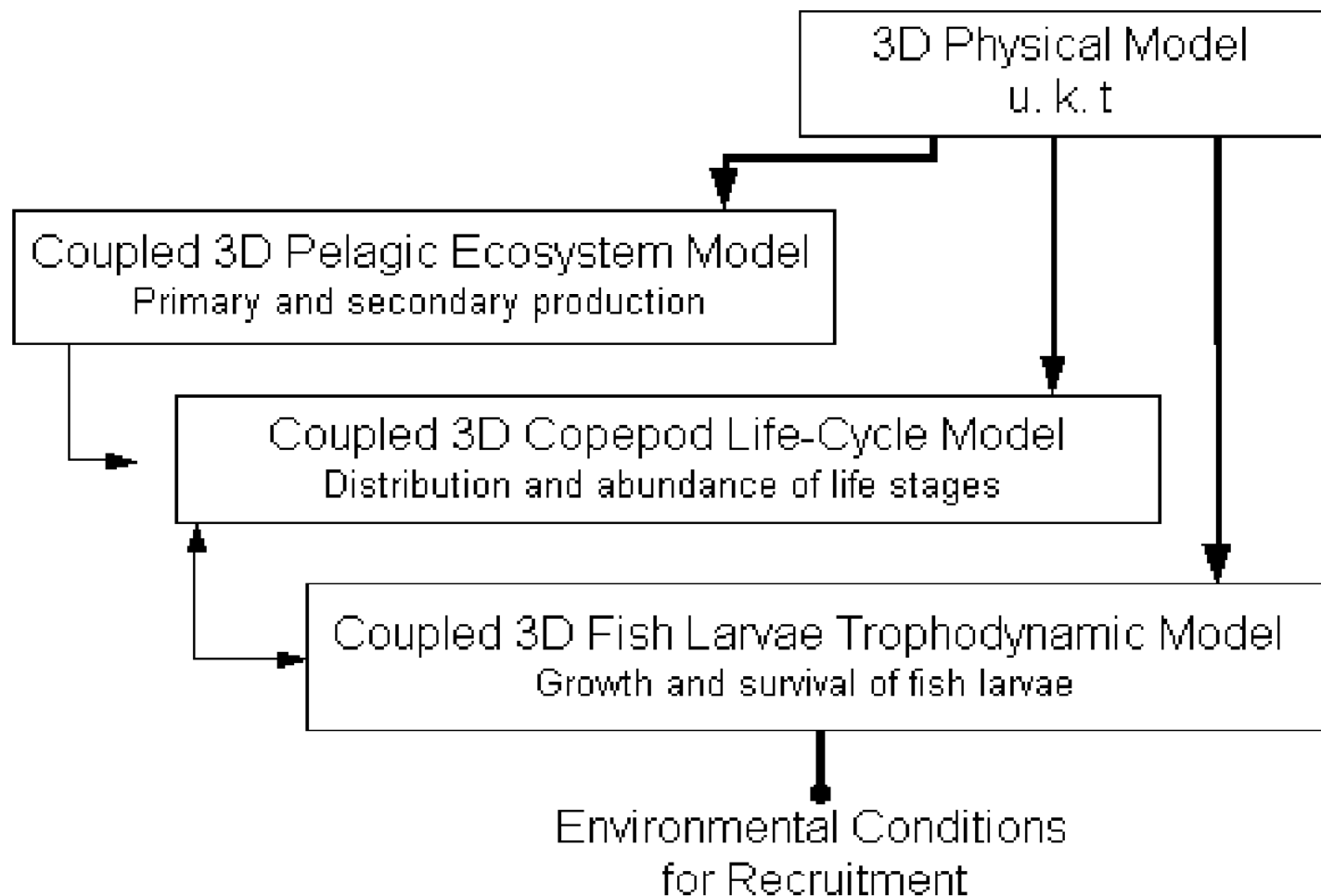
## *Knowledge of space/time scales is critical*

- Frequency, repetition, resolution

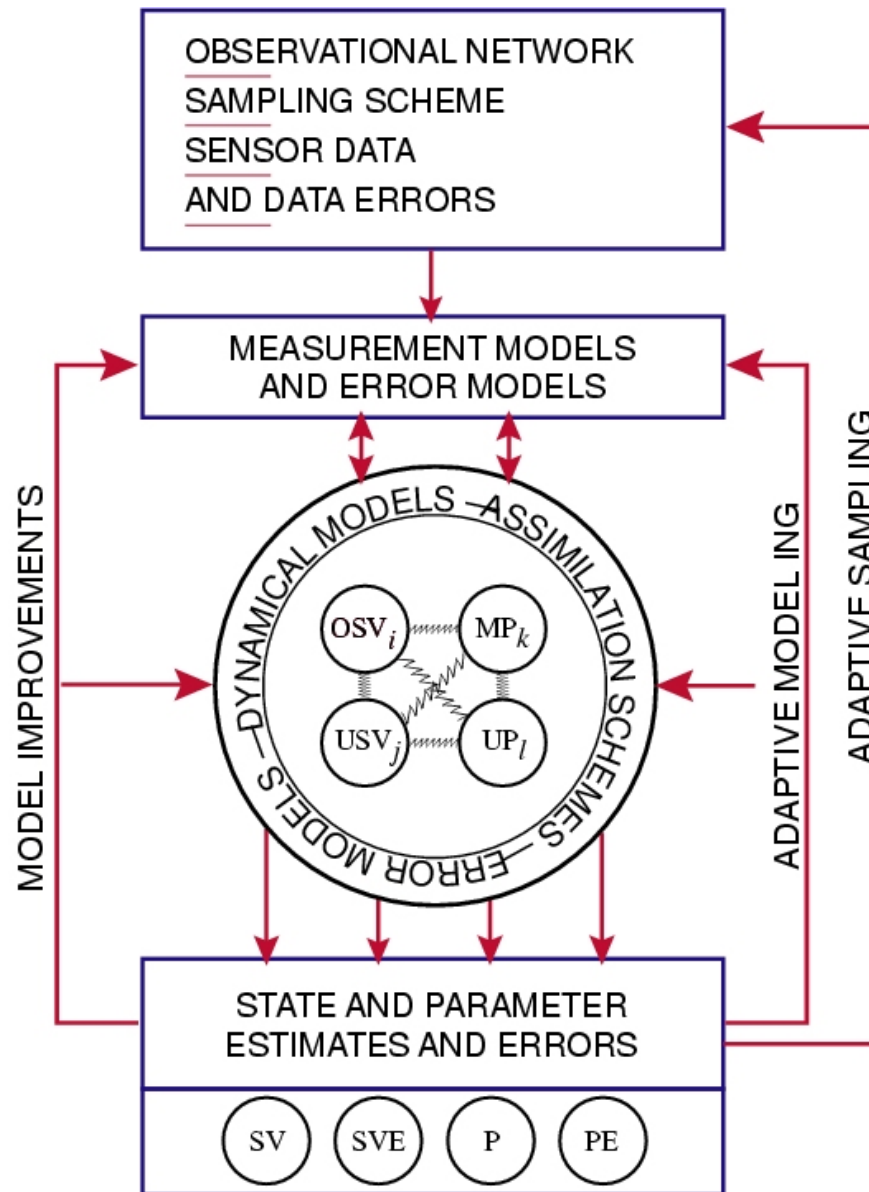
# Models



# Linked, Coupled Models

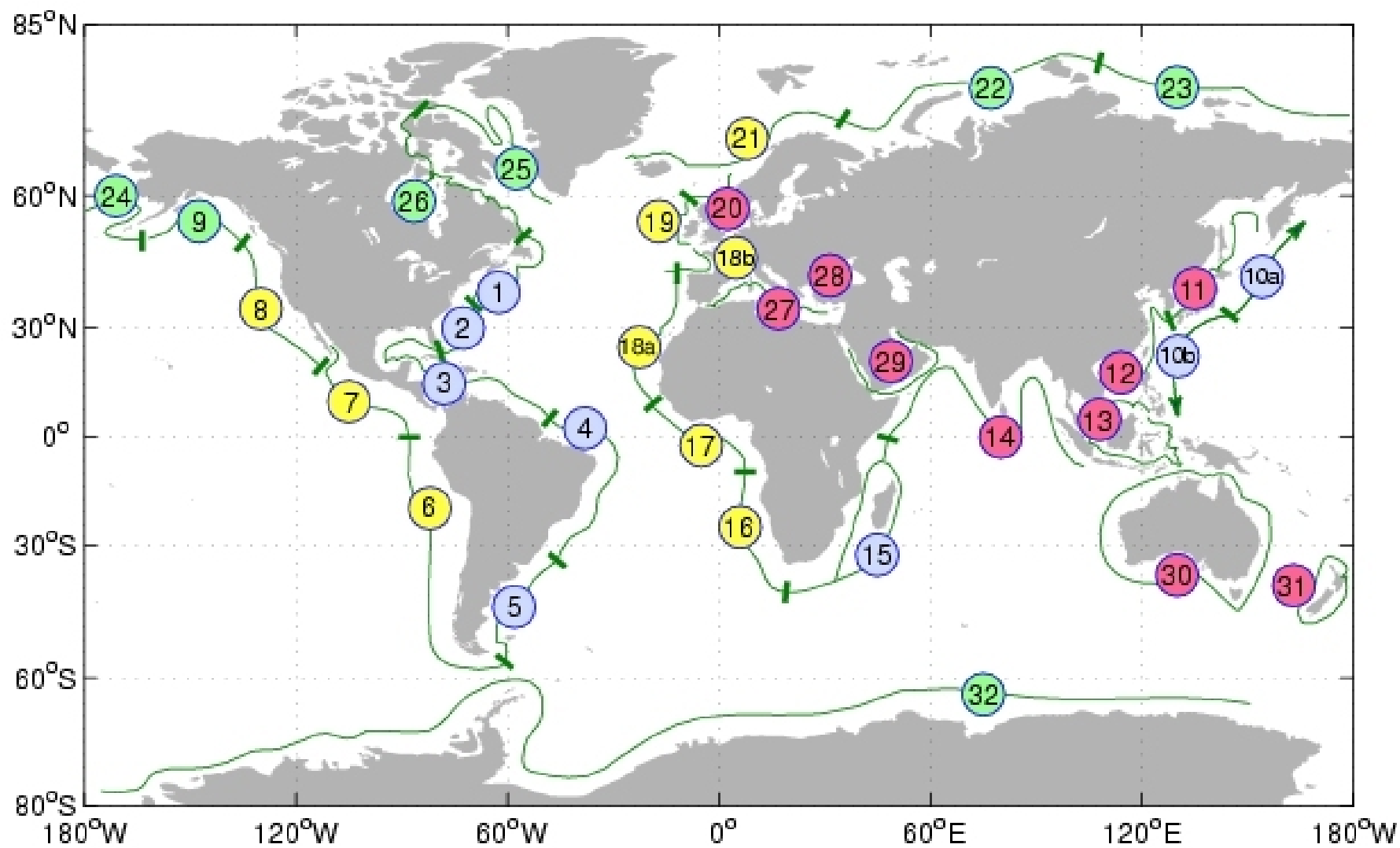


# Measurements and Models: Data Assimilation

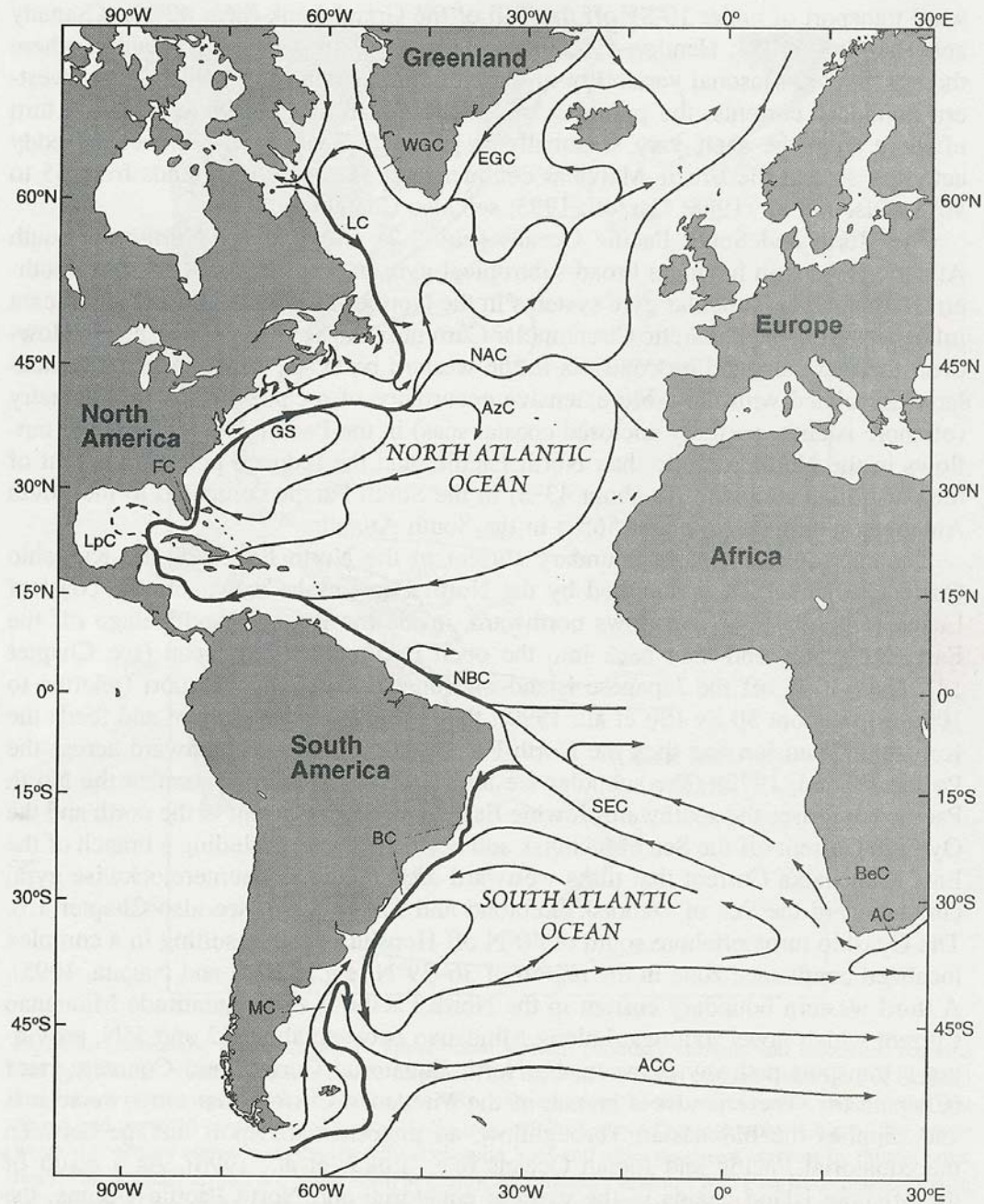


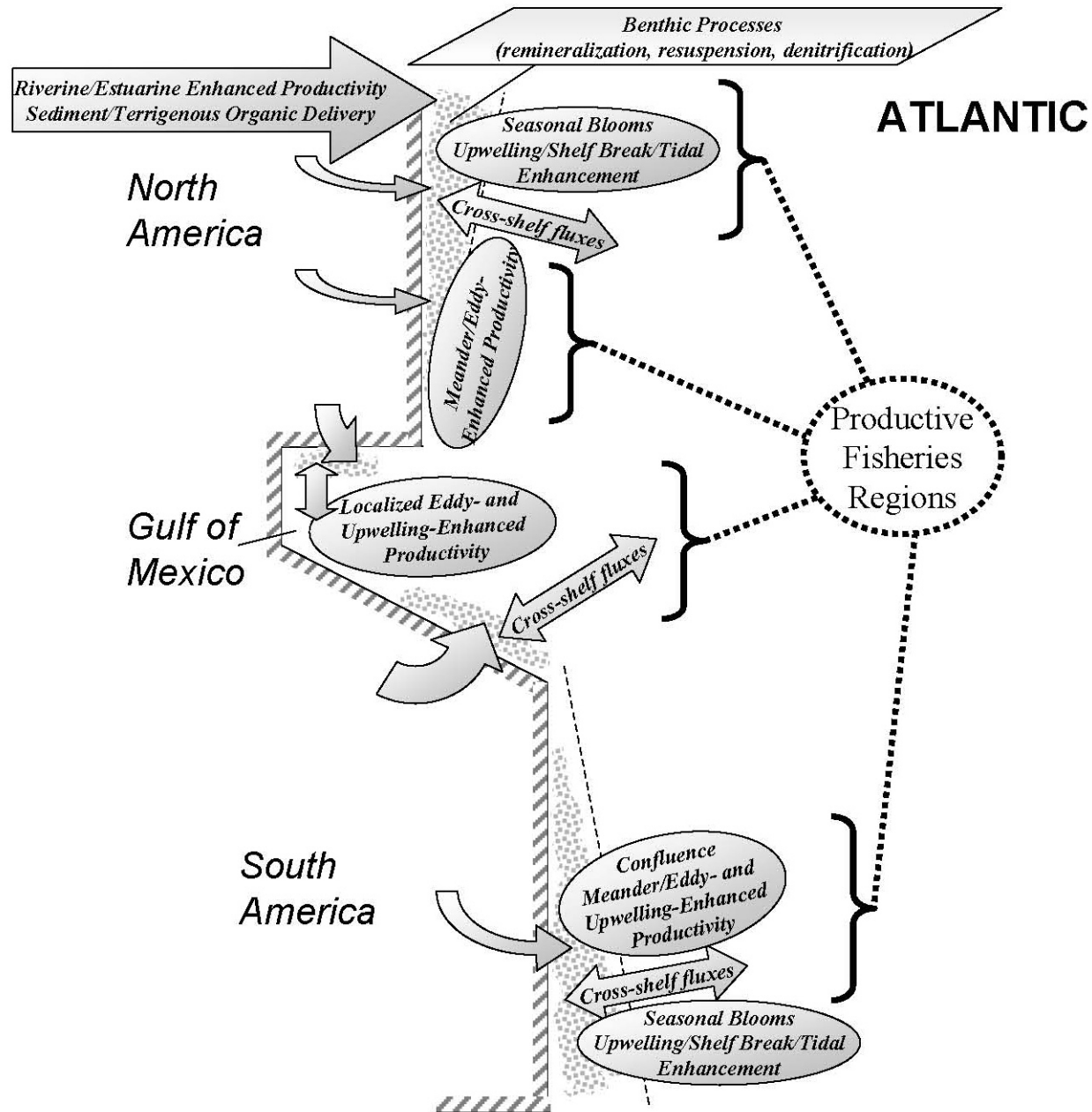
SV: STATE VARIABLE  
P: PARAMETER  
O: OBSERVED  
M: MEASURED  
U: UNOBSERVED OR UNMEASURED  
E: ERROR  
~~~~~: DYNAMICAL LINKAGES



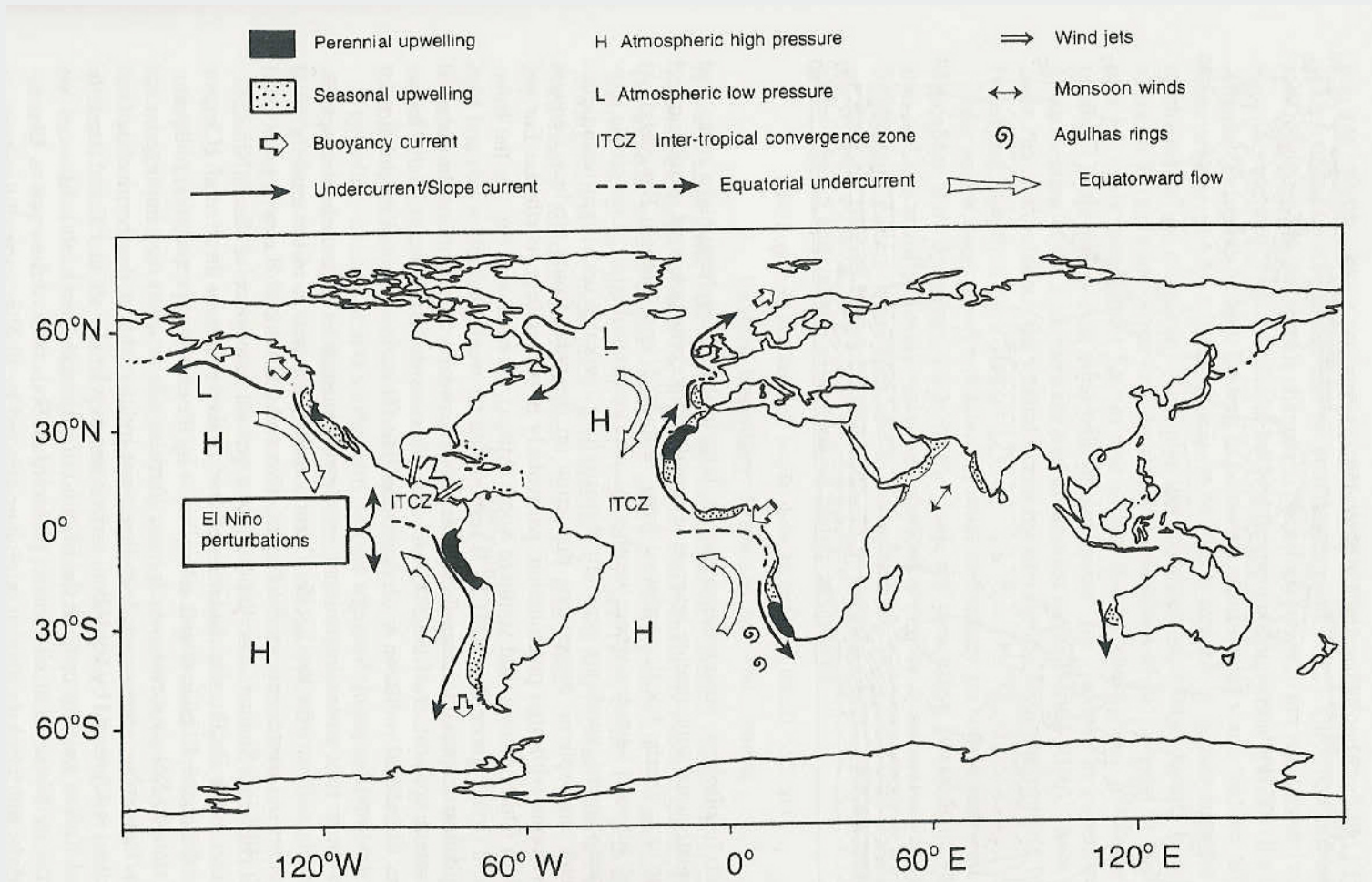


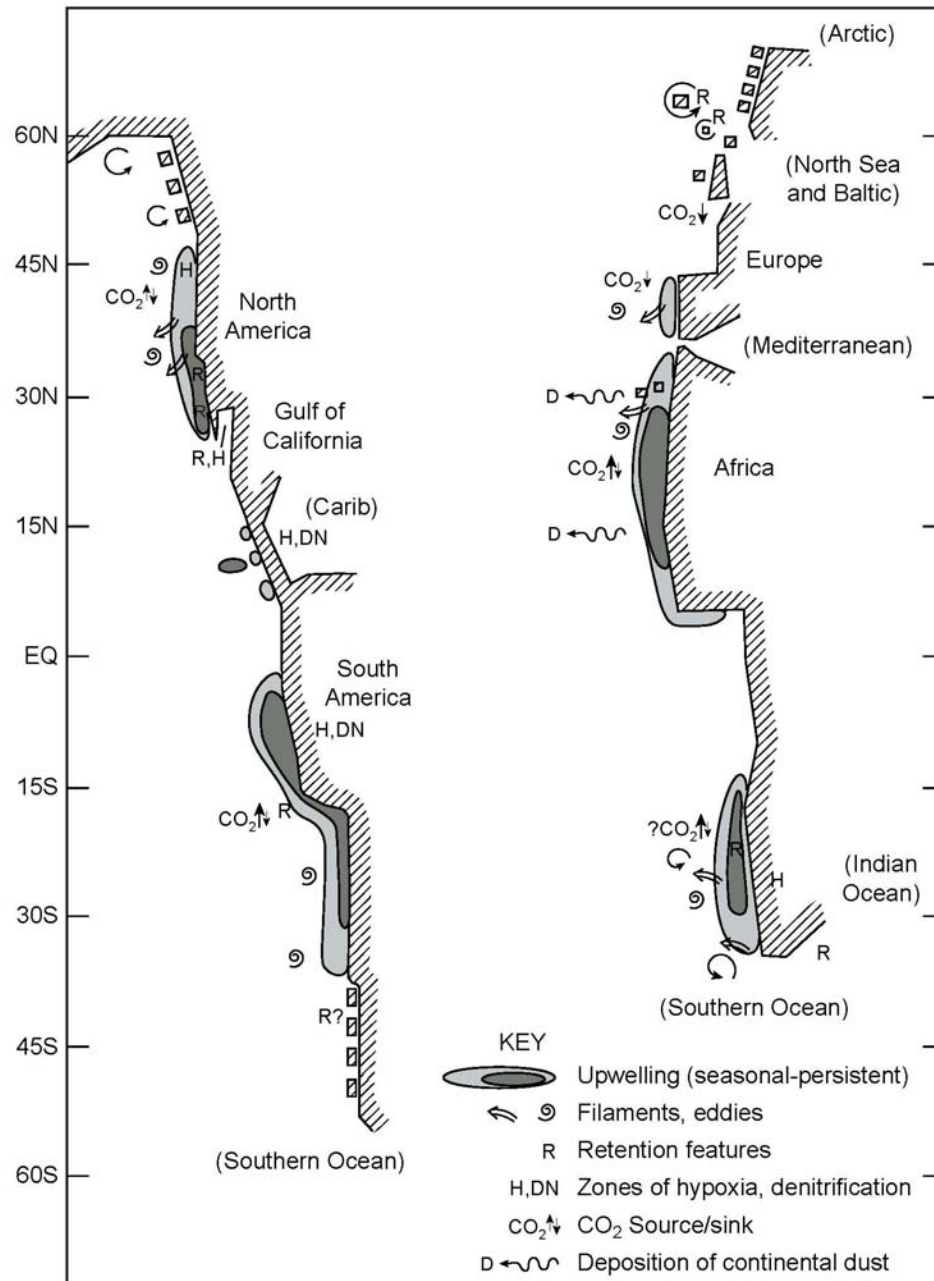
# Western Boundaries





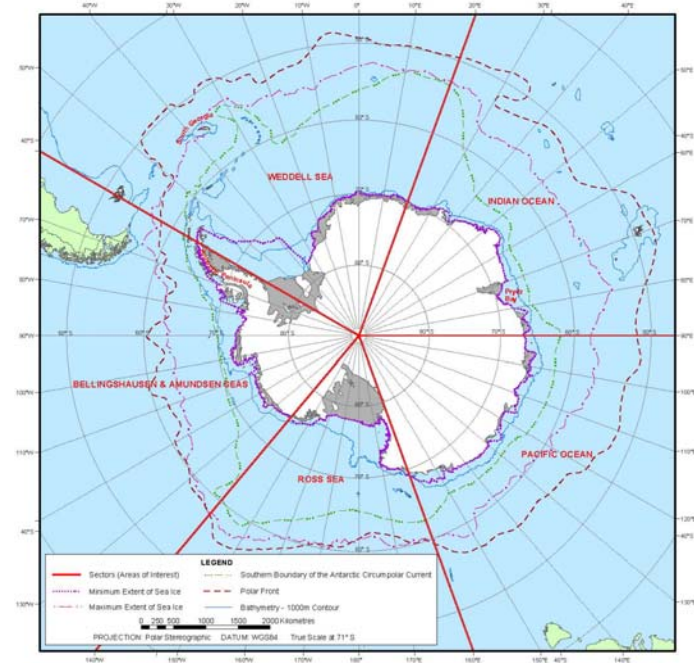
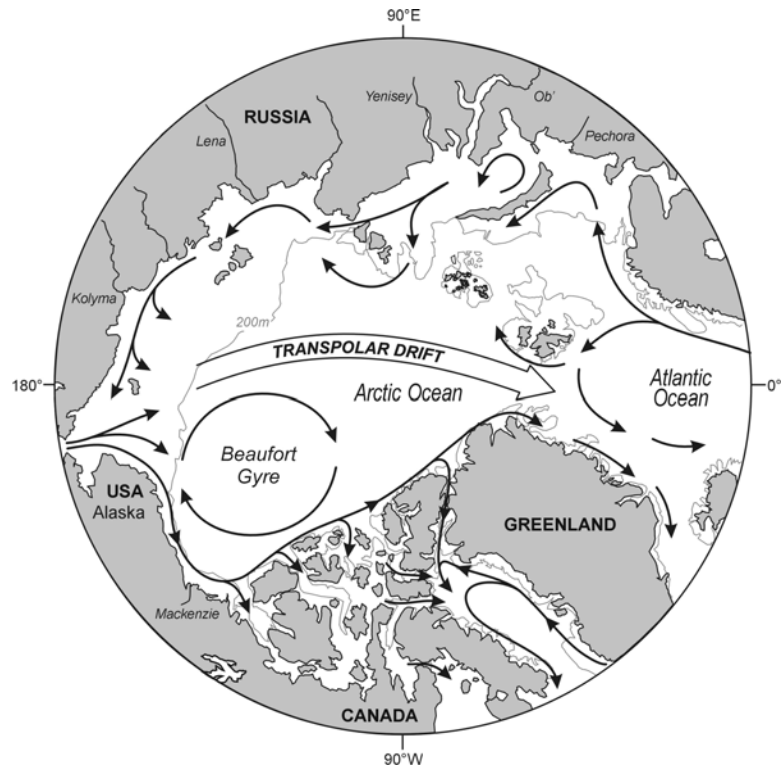
# Eastern Boundaries

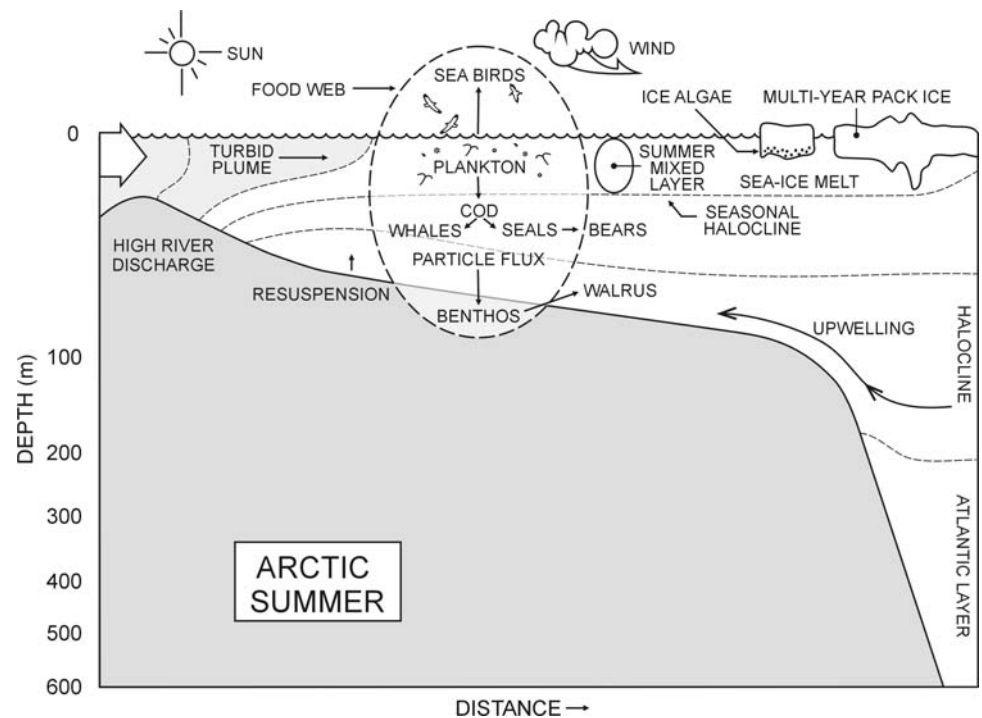
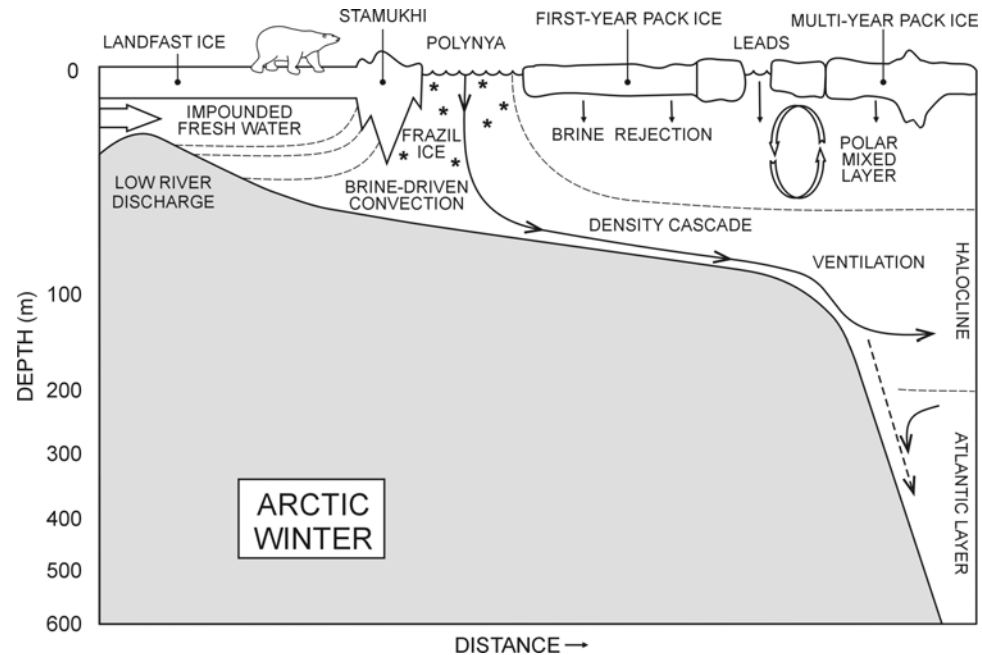


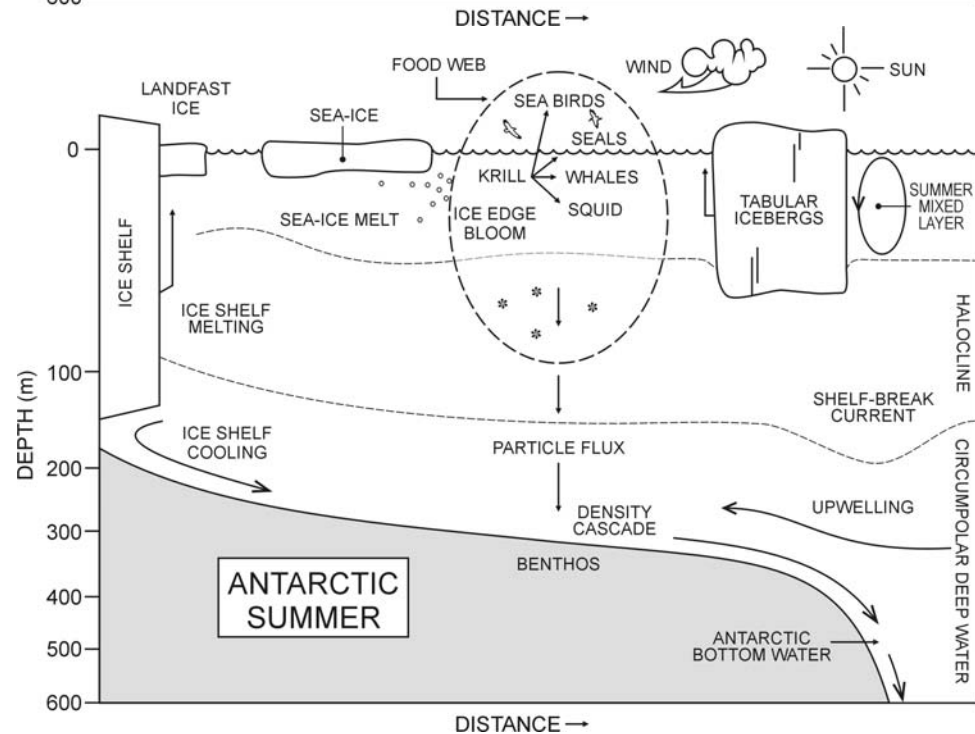
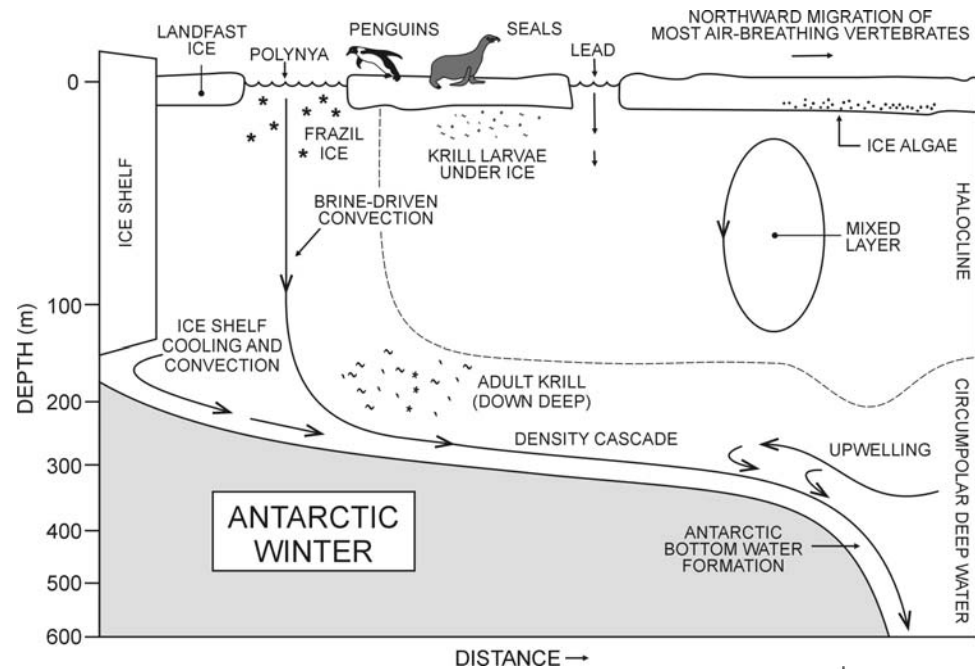




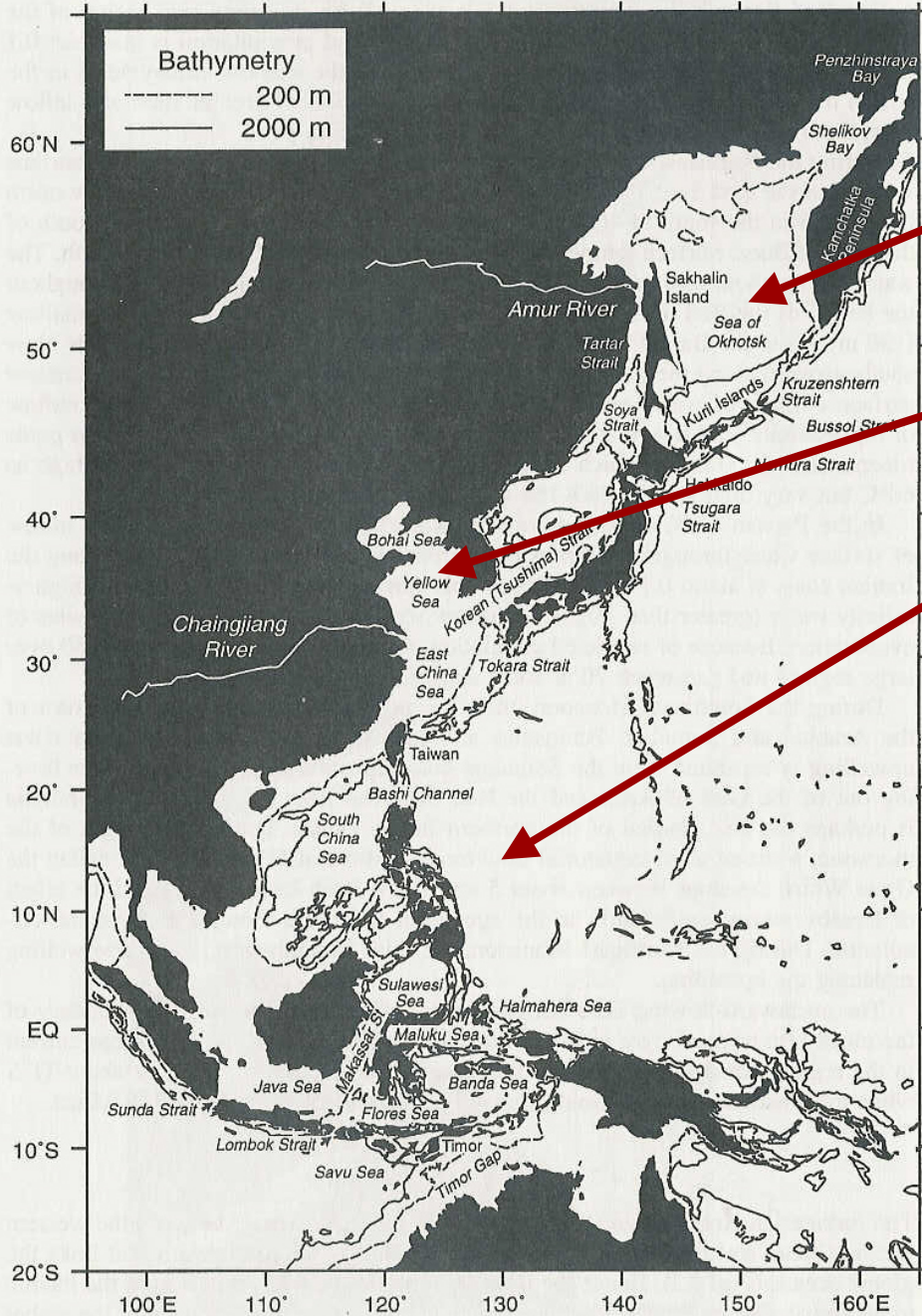
# Polar Boundaries







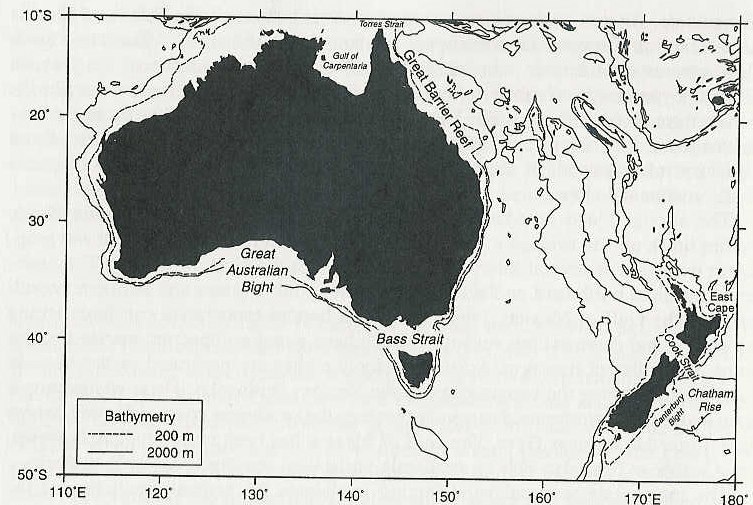




# Semi-Enclosed Seas and Islands

## Three types:

- i) **nearly-enclosed with limited exchanges with the open ocean (e.g. Sea of Okhotsk, Bohai Sea, Japan Sea)**
- ii) **Partially-enclosed with moderate exchanges along 1 or 2 boundaries (e.g. Yellow Sea)**
- iii) **Peripheral seas extending along continental margins and having strong interactions (e.g. Outer SE China Sea, shelf seas around Australia)**



# **Semi-Enclosed Seas, Islands and Australia**

- Overview on 4 regions: (1) European semi-enclosed seas, (2) Arabian Peninsula and Northern Indian Ocean marginal seas, (3) East Asian (or Western North Pacific) marginal seas, (4) Australia-New Zealand shelf seas
- Contain complex and diverse ecosystems involving rich natural resources and concentrated human activities – provide vital habitat for many commercial and endangered species
- Food web structures, affected by internal and external factors associated with natural and anthropogenic changes, may undergo strong nonlinear changes within existing state or abruptly switch to another state with almost no warning of impending changes
- Must assess types of structural changes possibly introduced by human-induced interventions in the next decades, to what extent they might be controlled, and implementation of possible strategies for sustainable use of their resources through process-oriented model explorations and data assimilation

# **Progress in interdisciplinary research on the multi-scale dynamics of the global coastal ocean**

## **Three emerging concepts**

- coupled pelagic-benthic dynamical processes interactive between the water column and the sediments
- significant contribution arising from coastal ocean biogeochemical cycles to global cycles and budgets
- large variety of dominant structures, trophic interactions and variabilities (robust-rapid change-robust) that occur in the highly productive coastal ocean ecosystems

**These three concepts and their linkages provide now a powerful potential framework for research directions**

- specific research issues and next step problems essential

***Challenging from intellectual, scientific, technical and methodological viewpoints***

## Progress 2: Critical Processes

To advance understanding of the dynamics of the complex global coastal ocean, *critical processes* must be identified and quantified by critical experiments and concomitant advanced theoretical/numerical models.

- coastal deep sea exchanges, benthic productivity, CO<sub>2</sub> uptake/release, recruitment, etc.
- issues of measurability and modelability

Efficient progress can be made by using processes to identify *dynamically analogous regions* of the global coastal ocean and sharing scientific information, technologies and methodologies among them

- Many types of interactions among relatively well studied and less well understood regions can be fruitful

# **From a technical and methodological viewpoint we are at the threshold of a new management era.**

The material presented indicates the great complexity of the requisite scientific input *and* the unique opportunity for advanced management now provided by ongoing scientific and methodological progress.

Efficient and holistic management of the global coastal ocean and its interconnected natural and national subregions is essential to ensure the health of the coastal seas and their ecosystems, and the well being of the ever increasing human coastal populations.

Achievable only via effective and well-motivated collaboration and cooperation among the scientific, technical, governmental, commercial, economic and environmental communities.