Working Group 5
Marine Ecosystem Change

Introduction

-Marine Biosphere:

- 71% of the Earth's surface
- average water depth: 3.8 km;
- subsurface marine biosphere: > 1 km

-- (Microbial) diversity extremely high

-- 1 l Sea water:

10^9 bacteria; 10^9 Archaea; ca. 10^3 microbial eukaryotes

-- 20,000 bacterial "species" in 1 l. Sea water

--- Very much and very different ecosystems

--- Determines Biogeochemical cycles and climate

Working Group 5
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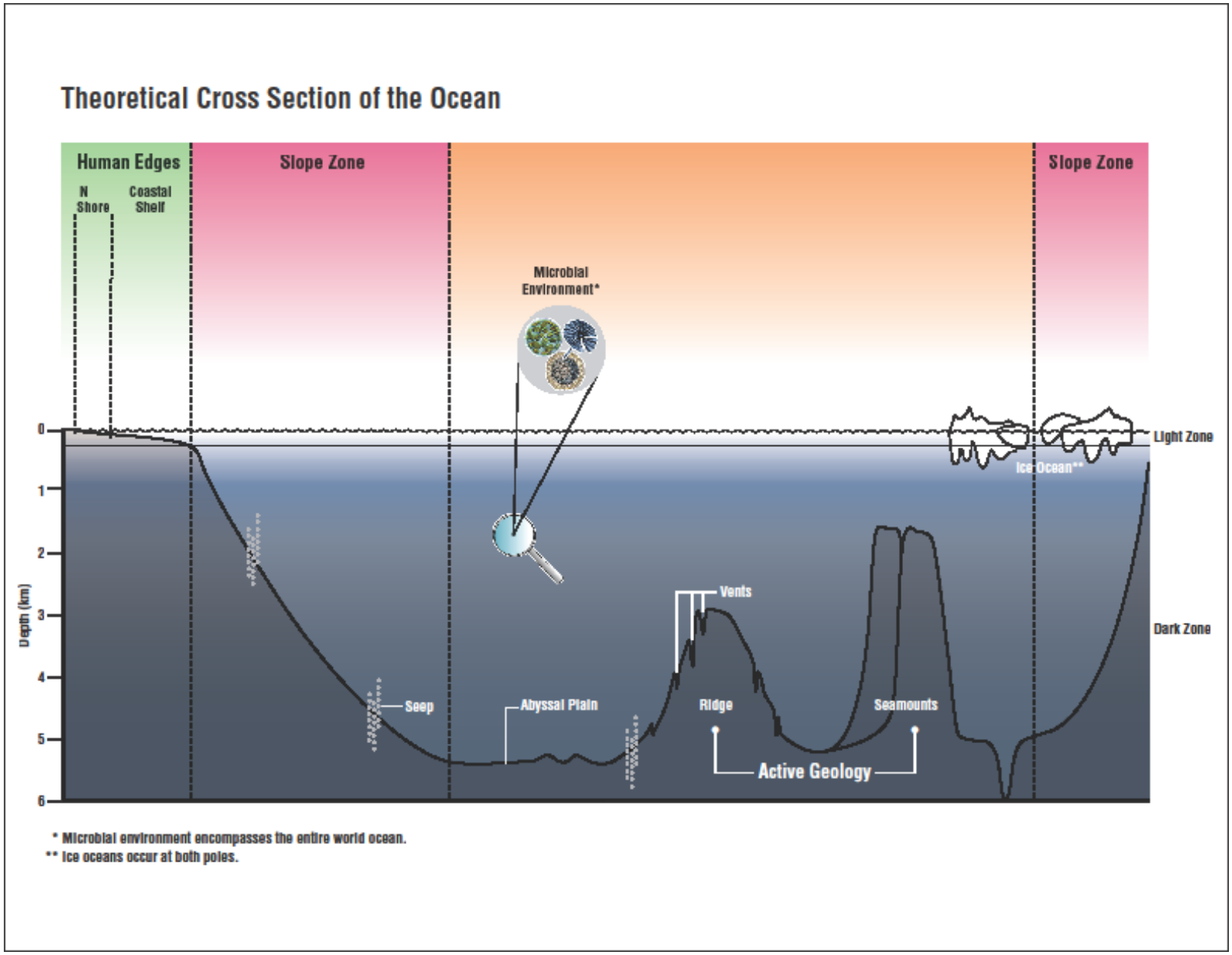
Activities

-Marine Realms and Associated Ecosystems (Ecosystem Classification)
-Historical, anecdotal ,archaeological and fossil biological data
-Actual data and data accessibility
-Observations and monitoring
-Invasive Species
-Models
-Periodic reports on Biodiversity Change
-Capacity Building

Ecosystem Classification a la CoML



-***Nearshore Zone.***

The region between the high tide line and 10 meters water depth
(NaGISA , CReefs, ICoMM CoML-projects, See appendix 1 for acronyms).

-***Coastal Zone.***

The continental shelf from ca. 10 meter to ca. 200 meter water depth
(GoMA , POST, ICoMM CoML-projects).

-Slope Zone.

The slope region of continental margins from the continental shelf to the abyssal plain.
(COMARGE, ICoMM CoML-projects).

-***Abyssal Plain Zone.***

The deep sea floor below the base of the continental slope covering ca. 30% of the Earth's surface.
(CeDAMar, ICoMM CoML-projects).

-***Open Ocean Photic Zone*.**

The water column between the coastal shelves and margins until ca. 200 meters depth
(CMarZ, TOPP, ICoMM CoML-projects).

-***Open Ocean Dark Zone.***

The water column between the coastal shelves and margins from ca. 200 meters depths to the sediment surface covering the mid- and bottom-waters of the oceans.
(MAR-ECO, ICoMM CoML-projects).

-***Surface Sediment Zone.***

Geologically-active regions below and directly above the seafloor, including seamount, hydrothermal vent, cold seep and mud volcano ecosystems.
(ChEss, CenSeam, ICoMM CoML-projects).

-***Deep Sediment Zone.***

The so called Deep Biosphere below the surface sediment till ca 1000 meters sediment depth.

-***Ice Zones.***

The Arctic and Antarctic Oceans with seasonal or permanent ice coverage.
(ArcOD, CAML, ICoMM, CoML-projects)

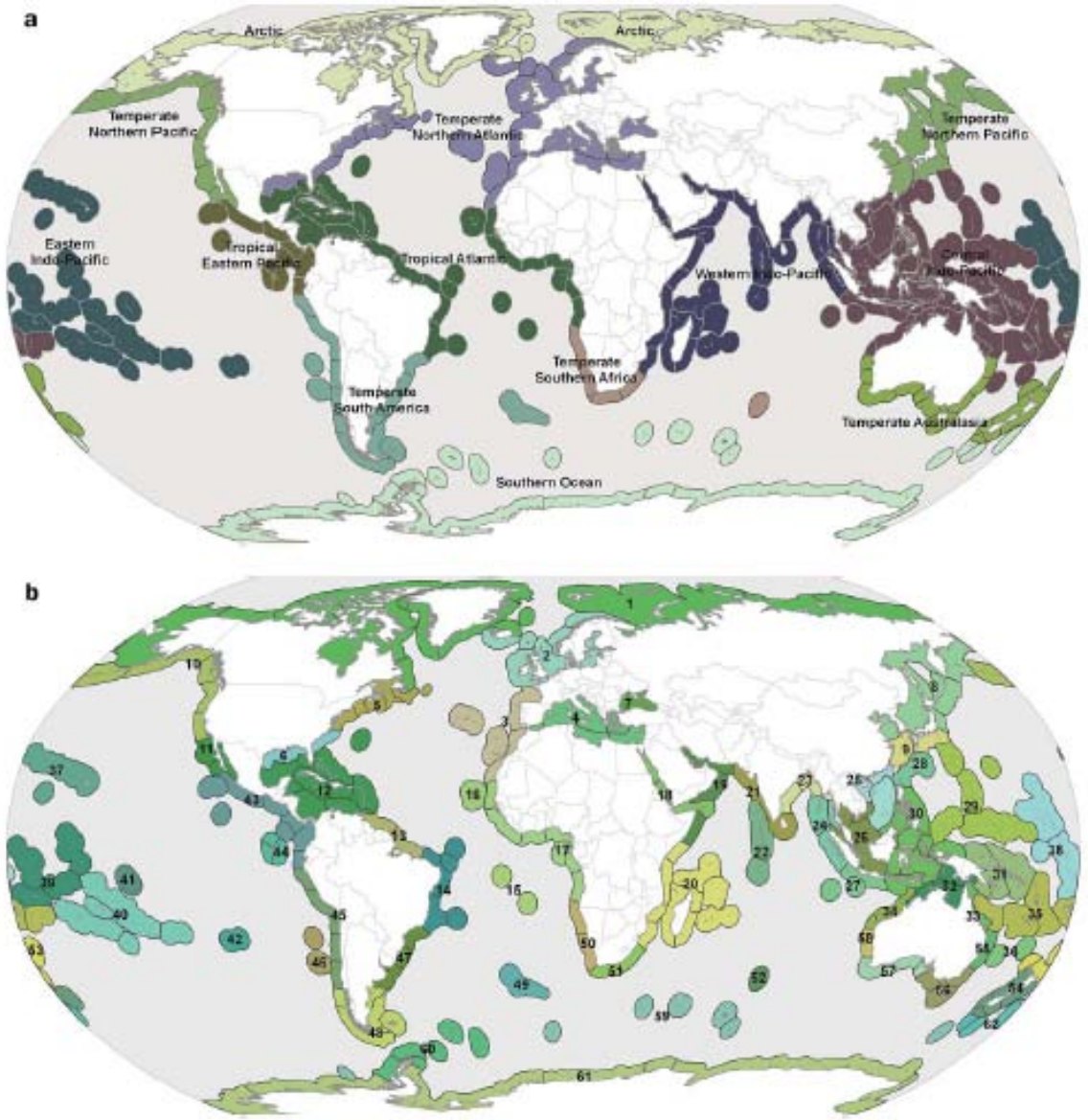
Who are the local, regional experts doing the job??

NRIC's/CoML

Australia
Canada
Caribbean
China
Europe
Japan
Indian Ocean
Indonesia
Republic of Korea
South America
Sub-Saharan Africa
USA
Arabian Sea (information coming)

Countries, ministries, regional bodies, individuals, institutes, universities, programs, NAML, MARS, BATS, HOTS, PAP, SAHFOS, FerryBox, etc. etc.

Coastal and shelf areas; Marine Ecoregions Of the World (MEOW):
12 realms, 62 provinces, 232 ecoregions



Spalding et al., BioScience 57, 573-583 (2007)

Realms: **bold**
Provinces**:** *italics*
Ecoregions: roman

Example:
North Sea Ecoregion can be subdivided:

- Channel
- southern North Sea (non-stratified)
- northern North Sea (seasonally stratified)
- very different estuaries
- Wadden Sea (tidal flat system)
 [Unesco cultural heritage; pilot study??!]

Box 1. Marine Ecoregions of the World.

Numbers for the provinces and ecoregions match those shown on the maps in figures 2b and 3. Realms are indicated in boldface, provinces (1–62) in italics, and ecoregions (1–232) in roman type.

Arctic

1. Arctic (no provinces identified)
1. North Greenland
2. North and East Iceland
3. East Greenland Shelf
4. West Greenland Shelf
5. Northern Grand Banks–Southern Labrador
6. Northern Labrador
7. Baffin Bay–Davis Strait
8. Hudson Complex
9. Lancaster Sound
10. High Arctic Archipelago
11. Beaufort–Amundsen–Viscount Melville–Queen Maud
12. Beaufort Sea—continental coast and shelf
13. Chukchi Sea
14. Eastern Bering Sea
15. East Siberian Sea
16. Laptev Sea
17. Kara Sea
18. North and East Barents Sea
19. White Sea

Temperate Northern Atlantic

2. Northern European Seas
20. South and West Iceland
21. Faroe Plateau
22. Southern Norway
23. Northern Norway and Finnmark
24. Baltic Sea
25. North Sea
26. Celtic Seas

3. Lusitanian
27. South European Atlantic Shelf
28. Saharan Upwelling
29. Azores Canaries Madeira

4. Mediterranean Sea
30. Adriatic Sea
31. Aegean Sea
32. Levantine Sea
33. Tunisian Plateau/Gulf of Sidra
34. Ionian Sea
35. Western Mediterranean
36. Alboran Sea

5. Cold Temperate Northwest Atlantic
37. Gulf of St. Lawrence–Eastern Scotian Shelf
38. Southern Grand Banks–South Newfoundland
39. Scotian Shelf
40. Gulf of Maine/Bay of Fundy
41. Virginian

6. Warm Temperate Northwest Atlantic
42. Carolinian
43. Northern Gulf of Mexico

7. Black Sea
44. Black Sea

Temperate Northern Pacific

8. Cold Temperate Northwest Pacific
45. Sea of Okhotsk
46. Kamchatka Shelf and Coast
47. Oyashio Current
48. Northeastern Honshu
49. Sea of Japan
50. Yellow Sea

9. Warm Temperate Northwest Pacific
51. Central Kuroshio Current
52. East China Sea

10. Cold Temperate Northeast Pacific
53. Aleutian Islands
54. Gulf of Alaska
55. North American Pacific Fjordland
56. Puget Trough/Georgia Basin
57. Oregon, Washington, Vancouver Coast and Shelf
58. Northern California

11. Warm Temperate Northeast Pacific
59. Southern California Bight
60. Cortezian
61. Magdalena Transition

Tropical Atlantic

12. Tropical Northwestern Atlantic
62. Bermuda
63. Bahamian
64. Eastern Caribbean
65. Greater Antilles
66. Southern Caribbean
67. Southwestern Caribbean
68. Western Caribbean
69. Southern Gulf of Mexico
70. Floridian

13. North Brazil Shelf
71. Guianan
72. Amazonia

14. Tropical Southwestern Atlantic
73. Sao Pedro and Sao Paulo Islands
74. Fernando de Naronha and Atoll das Rocas
75. Northeastern Brazil
76. Eastern Brazil
77. Trindade and Martin Vaz Islands

15. St. Helena and Ascension Islands
78. St. Helena and Ascension Islands

16. West African Transition
79. Cape Verde
80. Sahelian Upwelling

17. Gulf of Guinea
81. Gulf of Guinea West
82. Gulf of Guinea Upwelling
83. Gulf of Guinea Central
84. Gulf of Guinea Islands
85. Gulf of Guinea South
86. Angolan

Western Indo-Pacific

18. Red Sea and Gulf of Aden
87. Northern and Central Red Sea
88. Southern Red Sea
89. Gulf of Aden

19. Somali/Arabian
90. Arabian (Persian) Gulf
91. Gulf of Oman
92. Western Arabian Sea
93. Central Somali Coast

20. Western Indian Ocean
94. Northern Monsoon Current Coast
95. East African Coral Coast
96. Seychelles
97. Cargados Carajos/Tromelin Island
98. Mascarene Islands
99. Southeast Madagascar
100. Western and Northern Madagascar
101. Bight of Sofala/Swamp Coast
102. Delagoa

21. West and South Indian Shelf
103. Western India
104. South India and Sri Lanka

22. Central Indian Ocean Islands
105. Maldives
106. Chagos

23. Bay of Bengal
107. Eastern India
108. Northern Bay of Bengal

24. Andaman
109. Andaman and Nicobar Islands
110. Andaman Sea Coral Coast
111. Western Sumatra

Central Indo-Pacific

25. South China Sea
112. Gulf of Tonkin
113. Southern China
114. South China Sea Oceanic Islands

26. Sunda Shelf
115. Gulf of Thailand
116. Southern Vietnam
117. Sunda Shelf/Java Sea
118. Malacca Strait

27. Java Transitional
119. Southern Java
120. Cocos-Keeling/Christmas Island

28. South Kuroshio
121. South Kuroshio

29. Tropical Northwestern Pacific
122. Ogasawara Islands
123. Mariana Islands
124. East Caroline Islands
125. West Caroline Islands

30. Western Coral Triangle
126. Palawan/North Borneo
127. Eastern Philippines
128. Sulawesi Sea/Makassar Strait
129. Halmahera
130. Papua
131. Banda Sea
132. Lesser Sunda
133. Northeast Sulawesi

31. Eastern Coral Triangle
134. Bismarck Sea
135. Solomon Archipelago
136. Solomon Sea
137. Southeast Papua New Guinea

32. Sahul Shelf
138. Gulf of Papua
139. Arafura Sea
140. Arnhem Coast to Gulf of Carpenteria
141. Bonaparte Coast

33. Northeast Australian Shelf
142. Torres Strait Northern Great Barrier Reef
143. Central and Southern Great Barrier Reef

34. Northwest Australian Shelf
144. Exmouth to Broome
145. Ningaloo

35. Tropical Southwestern Pacific
146. Tonga Islands
147. Fiji Islands
148. Vanuatu
149. New Caledonia
150. Coral Sea

36. Lord Howe and Norfolk Islands
151. Lord Howe and Norfolk Islands

Eastern Indo-Pacific

37. Hawaii
152. Hawaii

38. Marshall, Gilbert, and Ellis Islands
153. Marshall Islands
154. Gilbert/Ellis Island

Box 1. *(continued)*

Numbers for the provinces and ecoregions match those shown on the maps in figures 2b and 3. Realms are indicated in boldface, provinces (1–62) in italics, and ecoregions (1–232) in roman type.

39. Central Polynesia
- 155. Line Islands
- 156. Phoenix/Tokelau/Northern Cook Islands
- 157. Samoa Islands

40. Southeast Polynesia
- 158. Tuamotus
- 159. Rapa-Pitcairn
- 160. Southern Cook/Austral Islands
- 161. Society Islands

41. Marquesas
- 162. Marquesas

42. Easter Island
- 163. Easter Island

Tropical Eastern Pacific

43. Tropical East Pacific
- 164. Revillagigedos
- 165. Clipperton
- 166. Mexican Tropical Pacific
- 167. Chiapas–Nicaragua
- 168. Nicoya
- 169. Cocos Islands
- 170. Panama Bight
- 171. Guayaquil

44. Galapagos
- 172. Northern Galapagos Islands
- 173. Eastern Galapagos Islands
- 174. Western Galapagos Islands

Temperate South America

45. Warm Temperate Southeastern Pacific
- 175. Central Peru
- 176. Humboldtian
- 177. Central Chile
- 178. Araucanian

46. Juan Fernández and Desventuradas
- 179. Juan Fernández and Desventuradas

47. Warm Temperate Southwestern Atlantic
- 180. Southeastern Brazil
- 181. Rio Grande
- 182. Rio de la Plata
- 183. Uruguay–Buenos Aires Shelf

48. Magellanic
- 184. North Patagonian Gulfs
- 185. Patagonian Shelf
- 186. Malvinas/Falklands
- 187. Channels and Fjords of Southern Chile
- 188. Chiloense

49. Tristan Gough
- 189. Tristan Gough

Temperate Southern Africa

50. Benguela
- 190. Namib
- 191. Namaqua

51. Agulhas
- 192. Agulhas Bank
- 193. Natal

52. Amsterdam–St Paul
- 194. Amsterdam–St Paul

Temperate Australasia

53. Northern New Zealand
- 195. Kermadec Island
- 196. Northeastern New Zealand
- 197. Three Kings–North Cape

54. Southern New Zealand
- 198. Chatham Island
- 199. Central New Zealand
- 200. South New Zealand
- 201. Snares Island

55. East Central Australian Shelf
- 202. Tweed-Moreton
- 203. Manning-Hawkesbury

56. Southeast Australian Shelf
- 204. Cape Howe
- 205. Bassian
- 206. Western Bassian

57. Southwest Australian Shelf
- 207. South Australian Gulfs
- 208. Great Australian Bight
- 209. Leeuwin

58. West Central Australian Shelf
- 210. Shark Bay
- 211. Houtman

Southern Ocean

59. Subantarctic Islands
- 212. Macquarie Island
- 213. Heard and Macdonald Islands
- 214. Kerguelen Islands
- 215. Crozet Islands
- 216. Prince Edward Islands
- 217. Bouvet Island
- 218. Peter the First Island

60. Scotia Sea
- 219. South Sandwich Islands
- 220. South Georgia
- 221. South Orkney Islands
- 222. South Shetland Islands
- 223. Antarctic Peninsula

61. Continental High Antarctic
- 224. East Antarctic Wilkes Land
- 225. East Antarctic Enderby Land
- 226. East Antarctic Dronning Maud Land
- 227. Weddell Sea
- 228. Amundsen/Bellingshausen Sea
- 229. Ross Sea

62. Subantarctic New Zealand
- 230. Bounty and Antipodes Islands
- 231. Campbell Island
- 232. Auckland Island

(draft)Global Open Oceans and Deep Sea-habitats (GOODS):
29 pelagic bioregions,
9 bathyl provinces (800-3500 m),
10 abyssal provinces (3500-6500 m.),
10 hadal provinces (> 6500 m.),
10 hydrothermal bioregions.

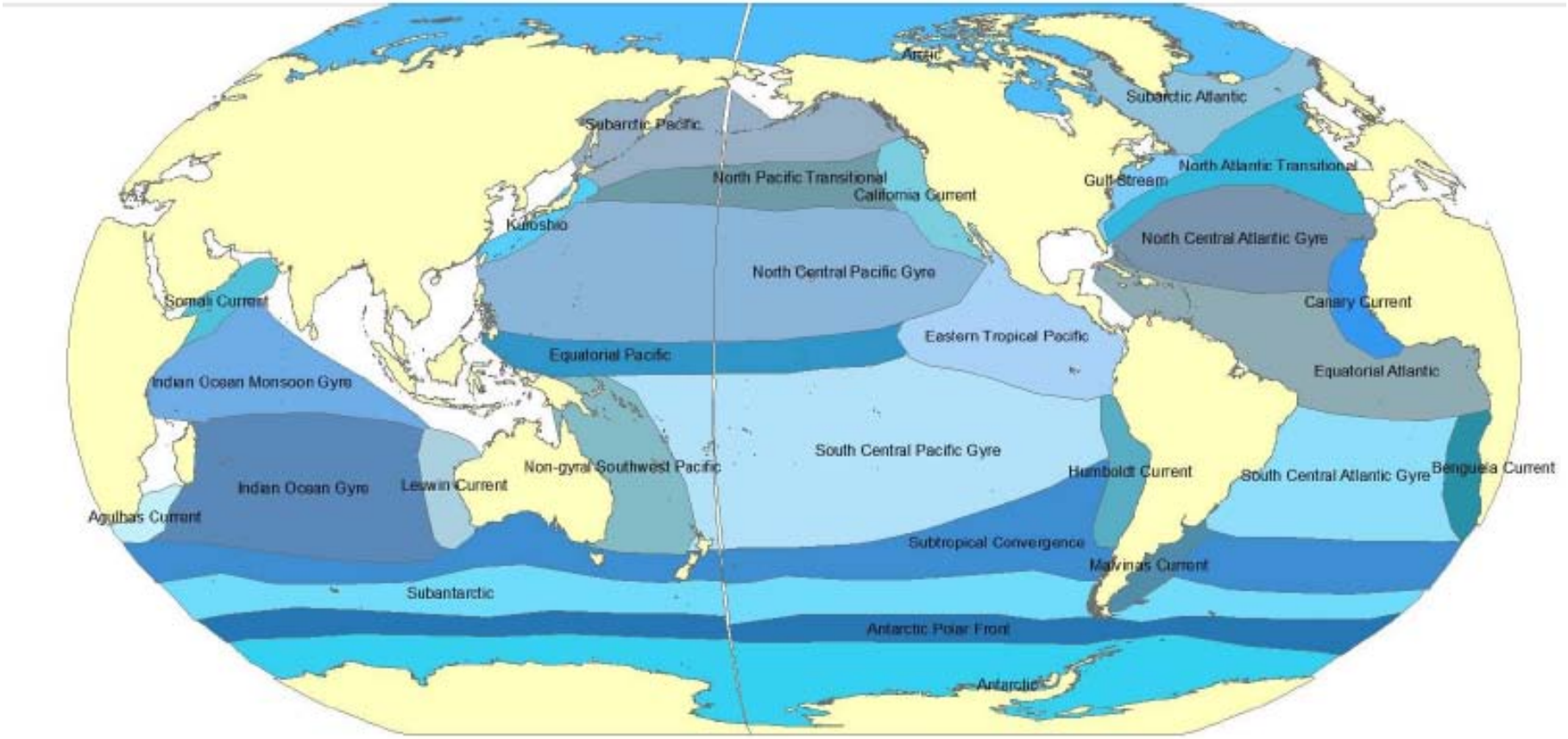


Figure 1: Map of pelagic bioregion

Agnostini et al., white paper 2007
http://www.ias.unu.edu

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Activities

-Marine Realms and Associated Ecosystems (Ecosystem Classification)
-Historical, anecdotal ,archaeological and fossil biological data
-Actual data and data accessibility
-Observations and monitoring
-Invasive Species
-Models
-Periodic reports on Biodiversity Change
-Capacity Building

Deliverables

- “IPPC” type report every 3 years
- Brochure/ppt regarding challenges and benefits of marine biodiversity observation
- Detailed Inventory of past and present biodiversity observations

Partners

- NRICs/CoML, MARS, NAML, POGO, SCOR, IODE, IOC, IUCN, WWF, UNEP-WCPC, etc.

Schedule

- Agreement Implementation Plan (Feb. 2010)
- Creating partnerships with MARS, NAML, CHONE, POGO, etc. (2010)
- Discuss implementation plan with IOC (April 2010)
- Discuss implementation plan with CoML (July 2010)
- Creation of int. network on marine biodiversity observation (2010-2011)

Financials

- Coordination WG 5: Royal NIOZ
- Others TBD

Barriers

- Reach and convince Partners
- Find money
- Governance barriers and management: who joins, who takes responsibility
- Data: where, which, access
- Definition of what constitutes an observation network and its components

Contributors so far:

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Comments, additions, suggestions, etc. very welcome

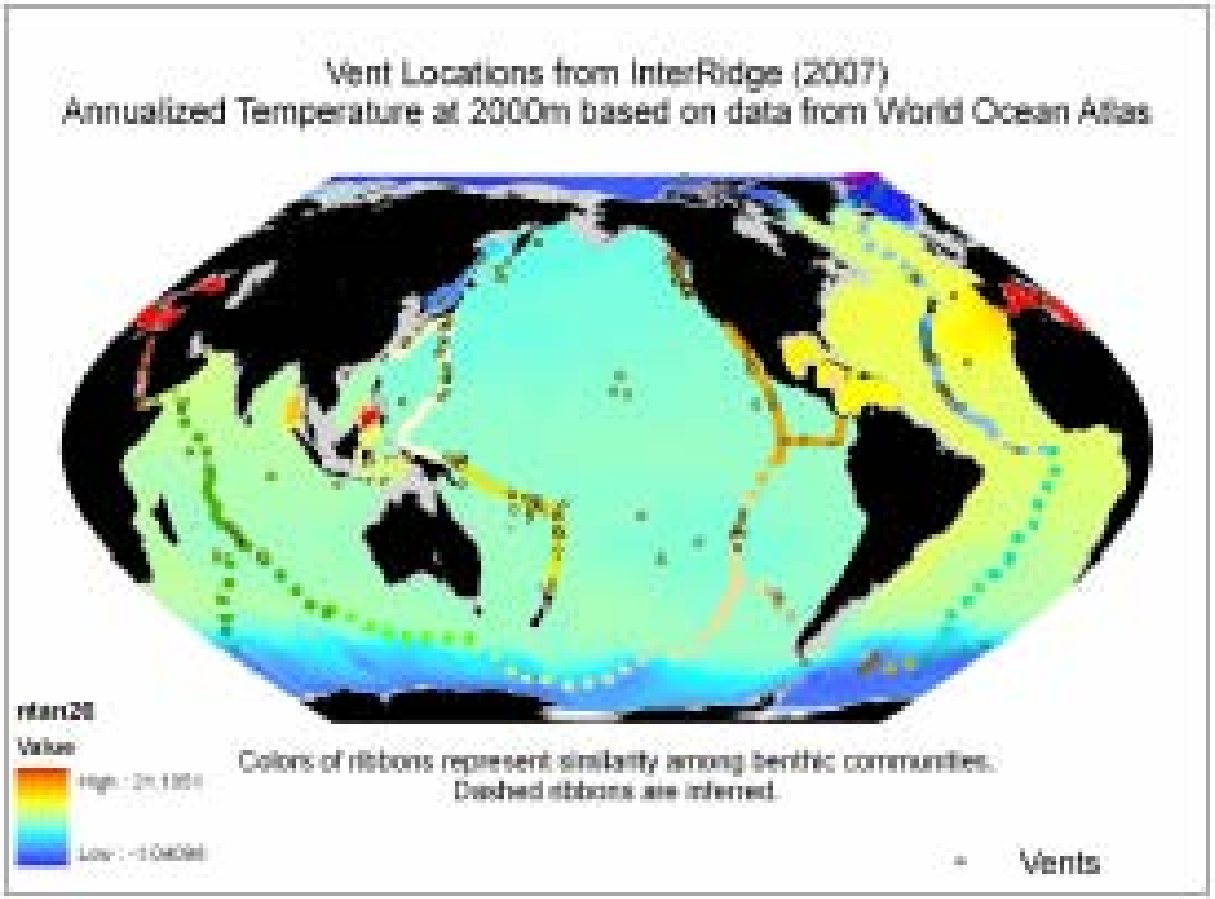

Figure 16 Hydrothermal vent bioregions. The hypothesized provinces and their relationships are indicated by dashed lines in the figure according to the ridge system on which they occur.

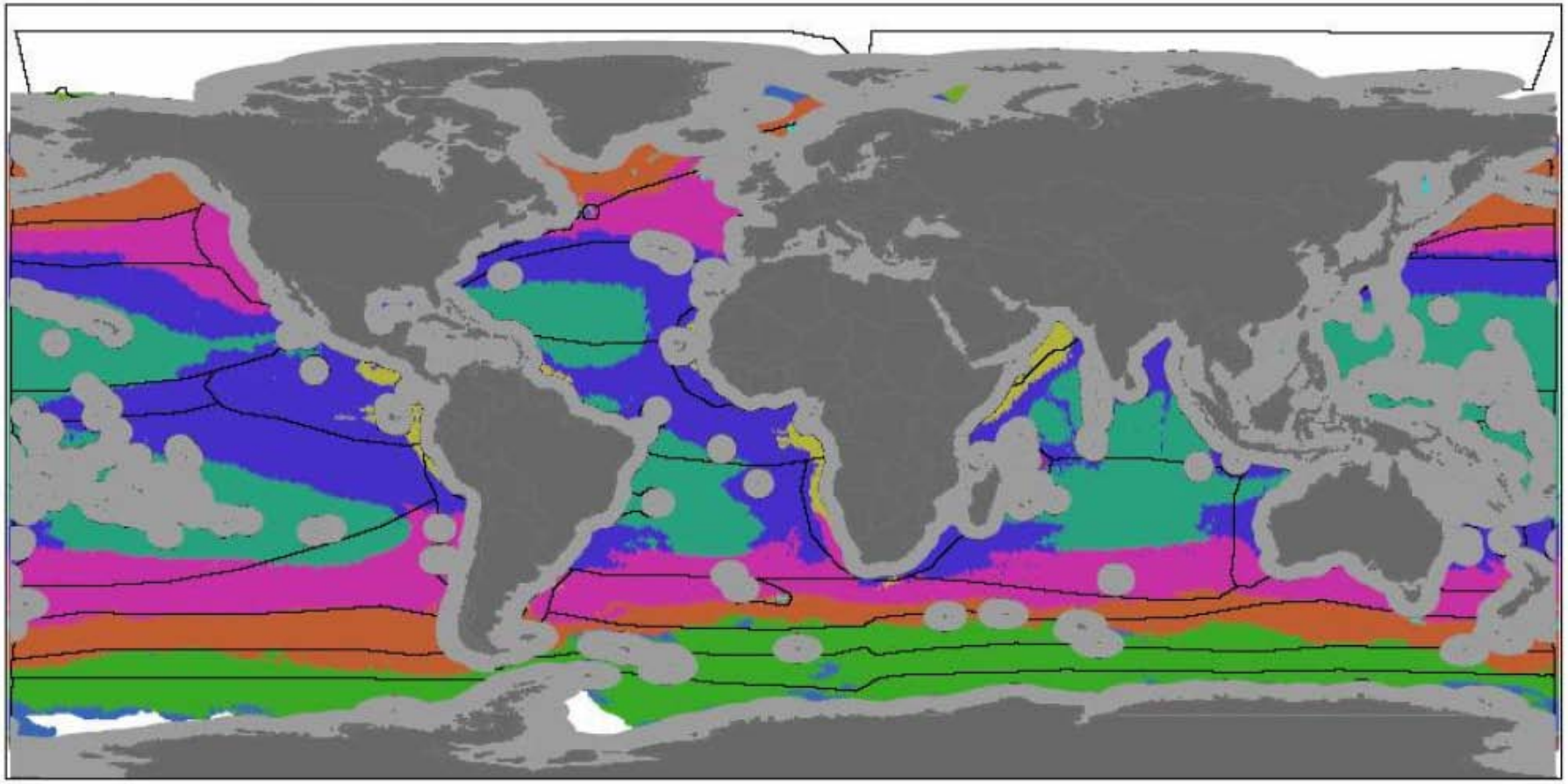

Figure 2: Proposed pelagic provinces overlaid on top of a cluster analysis of created using bathymetry, sea surface temperature and primary productivity.

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http://www.earthobservations.org/geobon_par.shtml

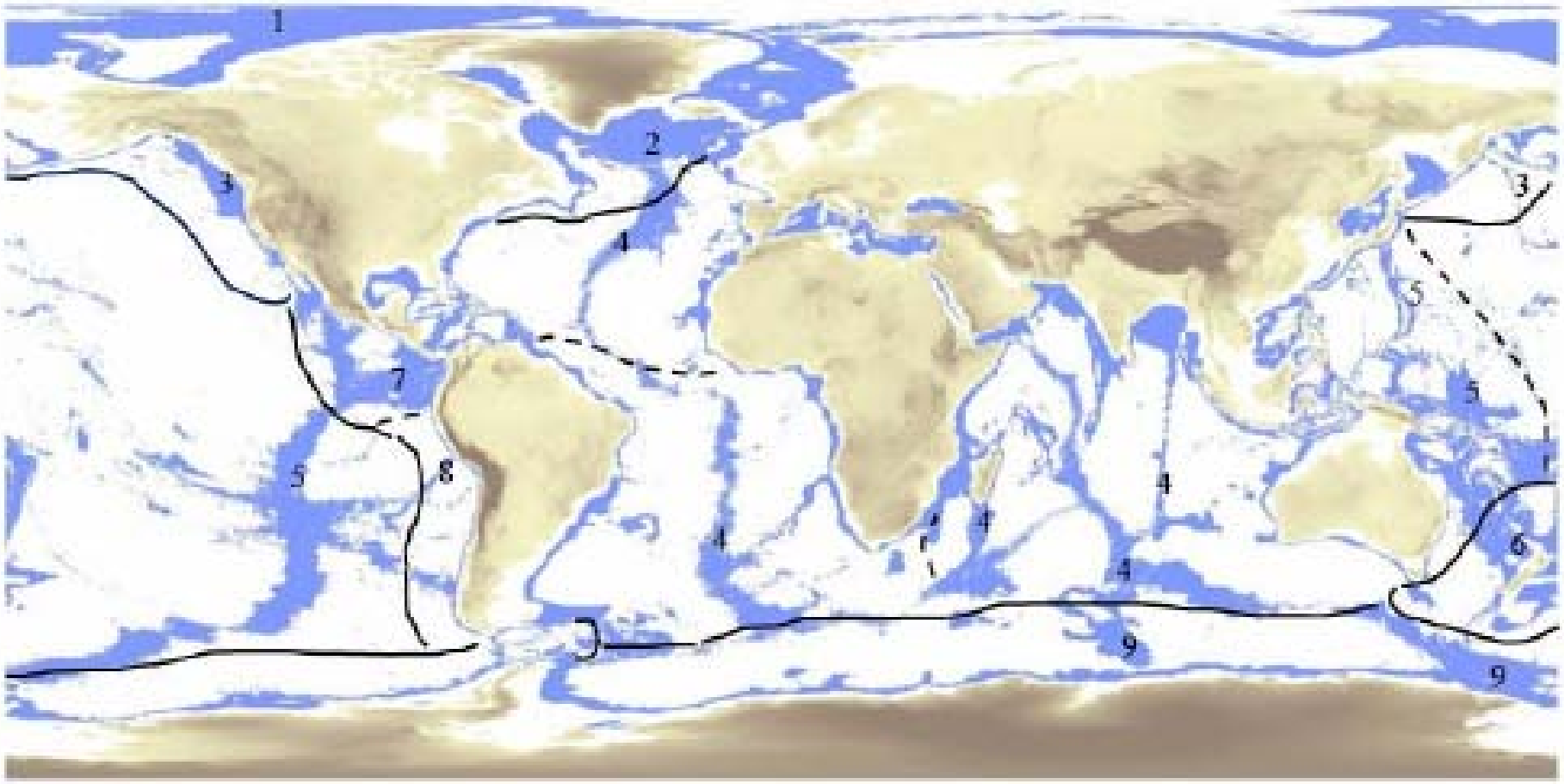

Figure 13: Lower bathyal provinces. 1 – Arctic; 2 - North Atlantic Boreal; 3 - North Pacific Boreal; 4 - Central Atlantic-Indian-South Australian; 5 - Western Pacific; 6 - New Zealand-Kermadec; 7 - Cocoplatensis; 8 – Nazcaplatensis; and 9 - Antarctic

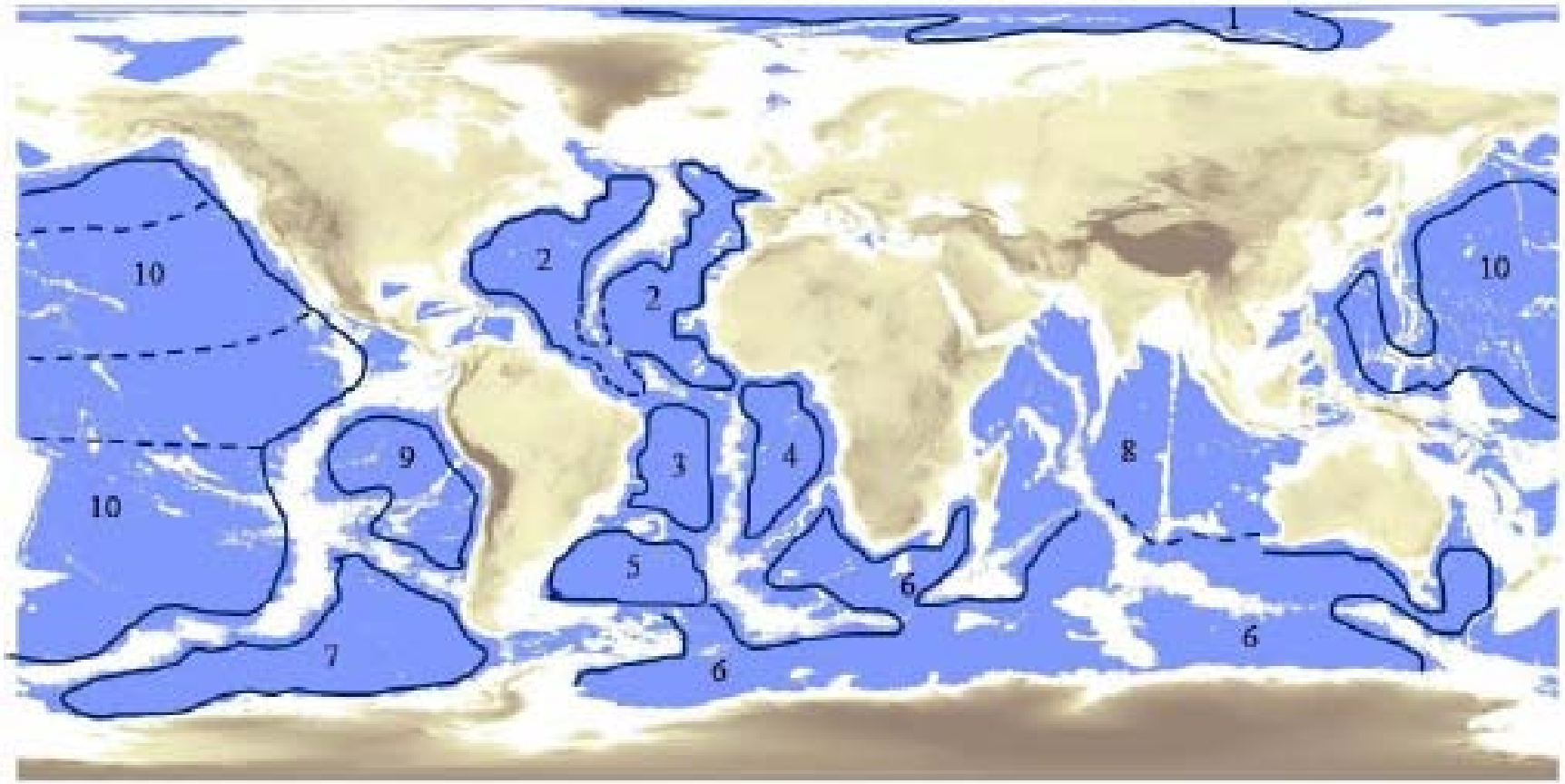

Figure 14: Abyssal provinces. 1 - Arctic basin; 2 - North Atlantic; 3 - Brazil Basin; 4 - Angola and Sierra Leone Basins; 5 - Argentine Basin; 6 - Antarctic East; 7 - Antarctic West; 8 - Indian Ocean; 9 – Nascapi stensis; and 10 - Pacific Ocean

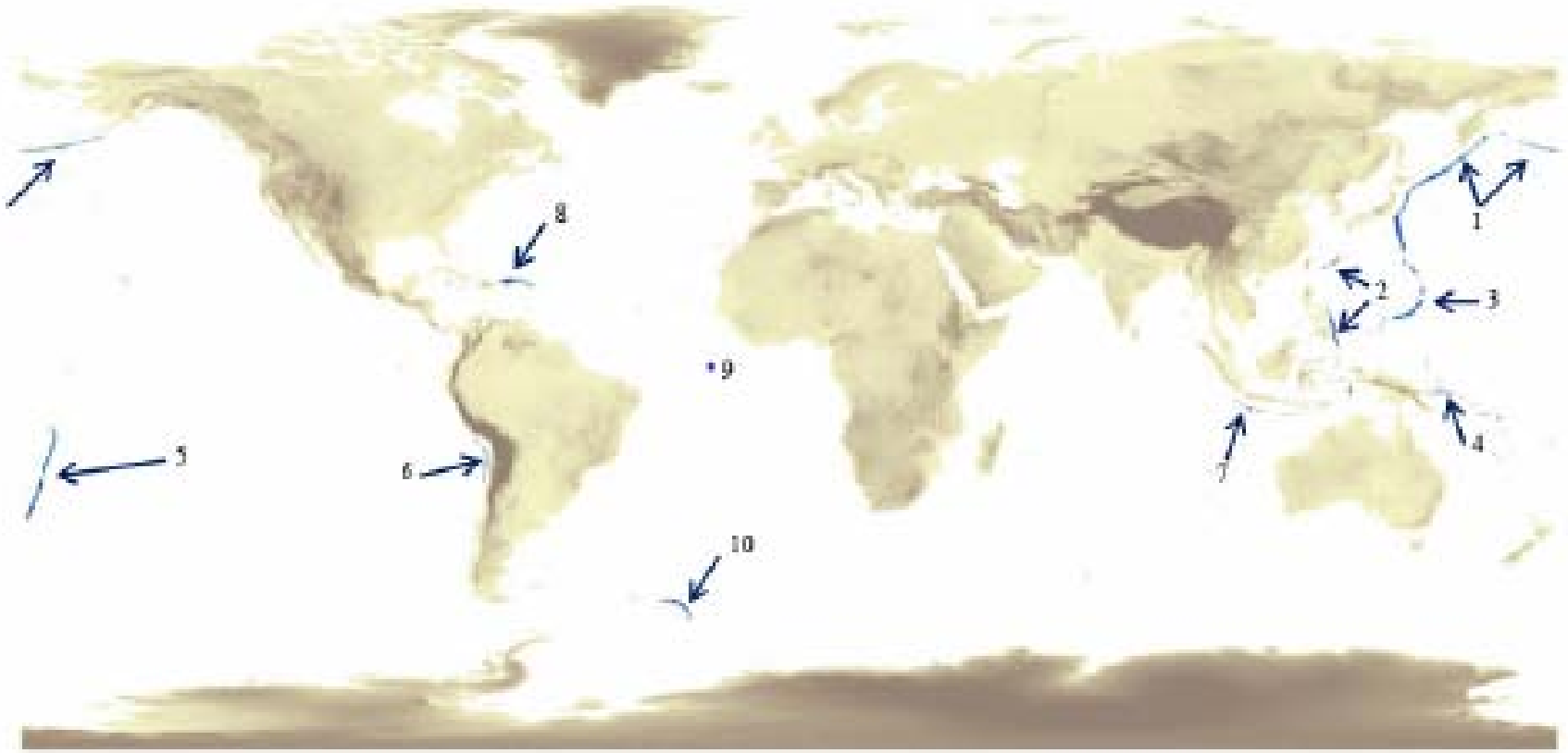

Figure 15: Hadal provinces. 1 - Aleutian-Japan Province (Aleutian, Kuril-Kamchatka, Japan, Izu-Bonin Trenches); 2 - Philippine Province (Philippine and Ryuku Trenches); 3 - Mariana Province (Volcano, Mariana, Yap and Palau Trenches); 4 - Bougainville-New Hebrides Province (New Britain, Bougainville, Santa Cruz, and New Hebrides Trenches); 5 - Tonga-Kermadec Province; 6 - Peru-Chile Province; 7 - Yavan Province; 8 - Puerto Rico Province; 9 - Romanche Province; and 10 - Southern Antilles Province

The proposed abyssal provinces are presented in the box below. A map of the abyssal provinces can be seen in figure 14.

Abyssal Provinces

The abyssal provinces have been designated based on the deep basin(s) in which they occur. The scheme heavily modifies that of Menzies et al. (1973) and Vinogradova (1997) based on some newer data.

1. **Arctic basin**;
2. **North Atlantic**, including all areas north of the equator under the influence of North Atlantic Deep water;
3. **Brazil Basin**;
4. **Angola and Sierra Leone Basins**;
5. **Argentine Basin**;
6. **Antarctic East**, which includes the areas where very cold bottom water flows into Cape, Agulhas, Natal, and Crozet and South Indian Basin and perhaps the Tasman Sea to about 170 E;
7. **Antarctic West**, includes the Amundsen Plain in the region from the Ross Sea to the Antarctic Peninsula and north to the Antarctic-Pacific Ridge and the Southeast Pacific Basin;
8. **Indian Ocean**, including all the basins north of approximately 30 S (this region is not well studied and some parts of this province may have species following the Antarctic Bottom Water northward);
9. **Nazcaplatensis**, includes the Peru and Chile Basins;
10. **Pacific Ocean**, encompassing the entire Pacific from the Antarctic and East Pacific Ridges in the south-east to the Aleutian ridge in the north and all of the abyssal depths in the western Pacific (divided into sub-units from north to south based on projections of food delivery from the photic zone as well as general decline in dissolved oxygen from south to north).

The proposed hadal provinces are presented in the box below. A map of the hadal provinces can be found in figure 15.

Hadal Provinces:

No changes are made to the scheme presented by Belyaev (1989).

Pacific Ocean Subregion:

1. Aleutian-Japan Province (Aleutian, Kuril-Kamchatka, Japan, Izu-Bonin Trenches),
2. Philippine Province (Philippine and Ryuku Trenches),
3. Mariana Province (Volcano, Mariana, Yap and Palau Trenches),
4. Bougainville-New Hebrides Province (New Britain, Bougainville, Santa Cruz, and New Hebrides Trenches),
5. Tonga-Kermadec Province,
6. Peru-Chile Province.

North Indian Subregion:

7. Yavan Province.

Atlantic Subregion:

8. Puerto Rico Province
9. Romanche Province.

Antarctic-Atlantic Subregion:

10. Southern Antilles Province

Results

The experts produced a map of benthic bioregions, which is presented in figure 1. The bioregional classification included 29 provinces as follows:

1. Agulhas Current
2. Antarctic
3. Antarctic Polar Front
4. Arctic
5. Benguela Current
6. California Current
7. Canary Current
8. Eastern Tropical Pacific
9. Equatorial Atlantic
10. Equatorial Pacific
11. Gulf Stream
12. Humboldt Current
13. Indian Ocean Gyre
14. Indian Ocean Monsoon Gyre
15. Kuroshio
16. Leuwin Current
17. Malvinas Current
18. Non-gyral Southwest Pacific
19. North Atlantic Transitional
20. North Central Atlantic Gyre
21. North Central Pacific Gyre
22. North Pacific Transitional
23. Somali Current
24. South Central Atlantic Gyre
25. South Central Pacific Gyre
26. Subantarctic
27. Subarctic Atlantic
28. Subarctic Pacific
29. Subtropical Convergence

These provinces have unique environmental characteristics in regards to variables such as temperature, depth and primary productivity, as documented in the statistic related to each bioregion available in Annex A.

Separate hydrothermal vent provinces were also delineated, and a map of them can also be found in figure 16. The vent provinces are unique in that they are based on biological data from field sampling. The hydrothermal vent classification scheme in the box below follows that of Van Dover et al. (2002), updated by Van Dover (unpublished).

Hydrothermal vent bioregions:

Pacific Ocean:

1. **East Pacific Rise**, encompassing all of the East Pacific Ridge from about the challenger Fracture Zone to the ridges surrounding the Cocos Plate.
2. **Southern East Pacific**, including southern section of the East Pacific rise, the Chile rise and the Pacific-Antarctic Ridge.
3. **Western Pacific Back-Arc Spreading Centers**, including all of the ridges on the western edge of the Pacific Plate as well as around the small plates in the region.
4. **Northeast Pacific Ridges**, encompassing the ridges of the Juan de Fuca Plate.

Atlantic Ocean:

5. **Mid-Atlantic Ridge North**, in the region from 15 to 30° N, could be extrapolated to include the MAR south to the equator.
6. **Azores**, includes the part of the MAR in the region of the Azores; not know whether this province extends north to Iceland because of the deepening of the ridge or whether the Mid-Atlantic Ridge Province exists in this deeper area north of the shallower Azores Province.
7. **Mid-Atlantic Ridge South**, hypothesized province, but no data currently exist.

Arctic Ocean:

8. **Arctic**, including the Mohns Ridge north of Iceland and the various vent sites in the Arctic Basin.

Southern Ocean:

9. **East Scotia Ridge**, hypothesized province, no data

Indian Ocean:

10. **Central Indian Ridge**, encompasses the region where the Mid-Indian, Southwest Indian, and Southeast Indian Ridges meet. It is likely the fauna of this province extends to varying degrees along each of the two southward trending ridges, and that some part of each ridge may belong to its own province.

Bathyal Provinces

As has been noted, the bathyal is not that well known even today. Proposed biogeographic units (provinces?) and their approximate coverage include:

1. Arctic, including entire Arctic Ocean Basin and Norwegian-Greenland Sea in the east and to the Bering Strait in the west;

2. North Atlantic Boreal, from the Iceland-Faroe Ridge in the north south along the Reykjanes Ridge, over the Newfoundland Seamounts and following the Western Boundary Undercurrent southward along the eastern slope of North America to off Cape Hatteras;

3. North Pacific Boreal, Aleutian Ridge in the North through the Gulf of Alaska to approximately the Mathematicians Seamounts in the eastern Pacific and including the Emperor Seamounts and the area off Hokkaido in the west;

4. Central Atlantic-Indian-South Australian perhaps divided into North and South Central Atlantic and Indian sub-units, includes all of the Mid-Atlantic Ridge from the southern extension of the Reykjanes Ridge to the junction with the Walvis Ridge in the south, all of the Indian Ocean from about 40 S northwards and easterly to encompass the Antarctic Intermediate Water south of Australia, including seamounts off Tasmania;

5. Western Pacific, from Hokkaido southward to seamounts along the Mariana Ridge to the Solomon Islands and Fiji, probably extending eastward beyond the East Pacific Ridge to about 83° W off Chile and Peru;

6. New Zealand-Kermadec, plateaus around New Zealand and extending northward along the Kermadec and Lau Ridges almost to Tonga;

7. Cocoplatensis, encompassing all the ridges and seamounts of the Cocos Plate;

8. Nazcaplatensis, suggested by Parin et al. (1997) to encompass the ridges of the Nazca Plate;

9. Antarctic, both east and west, with subdivisions centered on the Weddell Sea eastward to the Macquarie Ridge and from Ross Sea to the Antarctic Peninsula.