Chapter 2

Island Locations and Classifications

Christian Depraetere
Arthur L. Dahl

Definitions

Defining an island, or the state of 'islandness', is never straightforward, though this is fundamentally a question of isolation, whether of land isolated by water, or of one entity being separated from others. This chapter adopts a positivist approach to explore the geographic realities behind our concept of islands. There is in fact a continuum of geographic entities that can fit the definition of "a piece of land surrounded by water": from the continent of Eurasia to the rock on a beach lapped by the waves that becomes a child's imaginary island. Drawing the line between something that is too large to be an island, or too small to be an island, ultimately remains an arbitrary decision.

If one concurs with Holm (2000) that "an island is whatever we call an island", we can select from the traditional uses, the convenient distinctions and arbitrary choices of the past, a terminology for islands that corresponds to scientific observations gleaned from geological, biological and human perspectives.

Fortunately, the new tools of remote sensing satellite imagery (such as WORLDWIND for global LANDSAT imagery by NASA: http: //worldwind.arc.nasa.gov/) provide data sets that make possible for the first time some globally consistent and homogenous measurements of that 'world archipelago' made up of all those pieces of land surrounded by water. At the same time, our understanding of geotectonic movements, sea level changes and island-building processes allows us to see the oceanic islands of today not as eternal entities but as one static image captured from ongoing processes of islands growing and shrinking, joining and being separated, appearing and disappearing through time. In looking across the spectrum of continents, islands and other bodies, we can start with a purely geographic definition of oceanic islands as any piece of land surrounded by water, whatever its size or its distance to the closest mainland. Using criteria from physical geography, the number of oceanic islands in any particular size range can be counted, and details concerning their distribution explored.

From this platform, one can explore more functional definitions of 'islandness', or various scales and forms of isolation, as expressed for instance in the processes underlying island biogeography and the amazing diversity of species for which many islands are famous (MacArthur & Wilson, 1967). Similar processes lie behind the human populations of islands, the history of their settlement and the unique island cultures they have generated. Today, islandness also finds economic, social and political expressions that are significant in addressing problems of sustainable development and integration into a rapidly globalizing world.

While the concept of an island may seem simple in theory, there are so many variations on the theme of islandness that we often face puzzling questions. What happens to an island if it is not surrounded by water all the time, or the channel that separates it fills in, or a causeway is constructed? Does a piece of land become an island if it is artificially cut off from surrounding land? The study of islands on their own terms has now been given its own name: Nissology (Depraetere, 1991a; 1991b; McCall, 1994; 1996). Understanding the deeper significance of islands means assembling a puzzle with many interlocking pieces; these would include the importance of isolation and the resulting creation of diversity, the effects of fragmentation, and the influence of marginality. Each of these would, in turn, affect various geographic, evolutionary and cultural processes in different ways.

The World Archipelago

The world during antiquity as illustrated in the work of Herodotus, Strabo and Ptolemy was presented as a big island; the Old World for many years was conceived as surrounded by a few islands such as Thule, Hibernia, Brittania, the Hesperides, Dioscoridis or Taprobane. In a way, this impression has been confirmed by science: one idea that is apparent when looking at a globe or world map is that the emerged lands of our blue planet constitute a sort of world archipelago (Map 1). The general description of this archipelago as it is today supposes no *a priori* definition of pieces and bits of the puzzle: continents, islands, islets, atolls, motus, reefs, keys and rocks are inherited from a rather imprecise usage in the past (*see Royle, this volume*). Nevertheless, they present an obvious hierarchy according to their size (Table 1). This leads to the notion of mainlands surrounded by smaller units, whatever the scale considered.

Map 1 - The evolution of the 'World Archipelago' between 15,000 BP and the present.

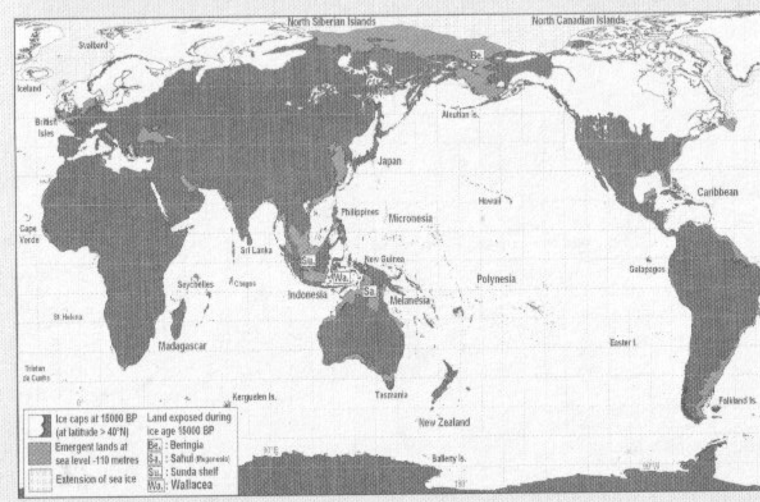
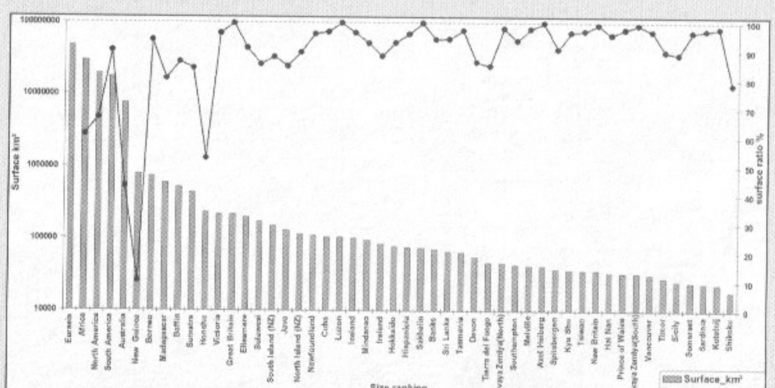


Table 1 - Size Ranking of Continents and Islands of the World Archipelago

Continents and islands	Size S_{km^2}	%Earth %	Rank R_i	Rank proportion $100*S(R_i)/S(R_{i-1})$	Comments or context
Ocean	454 204 533	76.1			*excluding Caspian and Aral seas*
Old World	77 355 469	13.0			
Eurasia	*48 032 081*	*8.0*	1		
Africa	*29 323 387*	*4.9*	2	61.0	
New World	37 255 401	6.2			
North America	*19 574 227*	*3.3*	3	66.8	
South America	*17 681 174*	*3.0*	4	90.3	
Antarctica	10 540 223	1.77			*mostly ice caps*
Australia	7 605 661	1.27	5	43.0	*the "continental island"*
Greenland	2 104 005	0.35			*mostly ice caps*
Islands>=0.1km²	7 733 461	1.30			*computed from GSHHS*
New Guinea	*783 408*		6	10.3	*part of the Sahul plate*
Borneo	*735 853*		7	93.9	*part of the Sunda Shelf*
Madagascar	*592 495*		8	80.5	*micro-plate*
Baffin	*477 549*		9	80.6	*northern Canadian shield*
Sumatra	*430 802*		10	90.2	*part of the Sunda Shelf*
Honshu	*227 899*		11	52.9	*part of the Pacific rim of fire*
Victoria	*219 135*		12	96.2	*northern Canadian shield*
Great Britain	*218 571*		13	99.7	*part of Western European shelf*
Ellesmere	*199 289*		14	91.2	*northern Canadian shield*
Sulawesi	*170 493*		15	85.6	*part of Wallacea*
South Island (NZ)	*149 955*		16	88.0	*micro-plate*
Java	*127 207*		17	84.8	*part of the Sunda Shelf*
North Island (NZ)	*113 886*		18	89.5	*Cut off from mainland by glacier*
Newfoundland	*109 315*		19	96.0	*Cut off from mainland by glacier*
Cuba	*105 797*		20	96.8	*Micro-plate*
Luzon	*105 548*		21	99.8	*part of Wallacea*
Iceland	*101 794*		22	96.4	*volcanic mid-Atlantic ridge*
Mindanao	*94 550*		23	92.9	*part of Wallacea*
Ireland	*83 577*		24	88.4	*part of Western European shelf*
Hokkaido	*77 661*		25	92.9	*part of the Pacific rim of fire*
etc.	...	...	...		
Islands<0.1km²	28 570	0.005			*estimated from power law of fractal surface*

The two mainlands of the world archipelago are the Old World (including Eurasia with its African peninsula) and the New World of North America (with its southern peninsula). Both Antarctica and Greenland should be considered with caution because they are mostly ice caps with most of their bedrock below sea level. They are not, strictly speaking, emergent land and will not be considered as mainlands, even though they form an emergent part of the Earth. The next ranked mainland is the 'continental island' of Australia, which has only 43% of the surface of South America but is 10 times larger than the next ranked land, New Guinea. This appears to be the major size gap between two land areas according to their surface proportion (Figure 1). This basic and robust relative surface proportion method provides an objective definition of what are the mainlands of the world archipelago compared to other land that usage tends to consider as islands *per se*. This method is also valuable for describing smaller archipelagos (like Japan, British Isles, and the Caribbean). Thus, the mega-archipelago of Indonesia, Philippines and Papua New Guinea shows 4 size gaps among islands larger than 100km² (Figure 2).

Figure 1 - Surface Proportion of Lands over 100.000 km² according to their Size Ranking



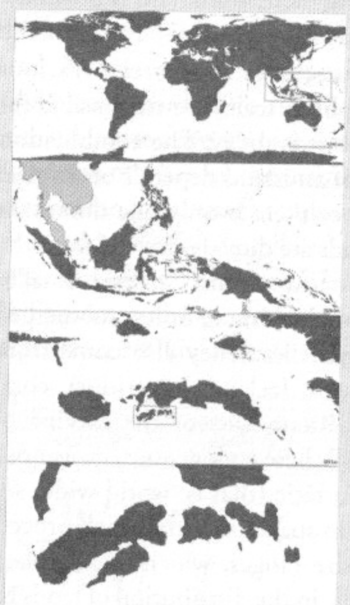
Are there any other size gaps among lands below 1 billion km²? The surface proportion of tenth-ranking Honshu (the main island of Japan, R_{10}=227,899km²) relative to ninth-ranking Sumatra (Indonesia,

R_9=430,802km²) is 53%. This threshold occurs just after a class of 5 islands: New Guinea (as part of the Sahul plate), Borneo and Sumatra (as parts of the Sunda Shelf), Baffin within the northern Canadian shield, and Madagascar as a micro-plate on its own. These reflect various tectonic and geomorphologic contexts (*see Nunn, this volume*). Another size gap occurs between 23rd-ranked Mindanao (Philippines, R_{23}=94,550km²) and 24th-ranked Ireland (R_{24}=83,577km²), though the proportion of 88% is not as sharp.

What is the significance of this pattern of land areas? Various processes with specific time and geographical scales are responsible for the structure of the world archipelago as it is today. The combination of processes involved in the formation of an island depends on its size: the smaller the size, the better the chance there is only one dominant process. Major mainlands and large islands are directly derived from the break-up of the ancient continents of Gondwana and Laurasia. Smaller islands may also be fragments of tectonic plates more or less submerged at the present sea level such as the Seychelles. They also come from processes related to volcanism (Galápagos, Iceland, Mauritius), coral reef formation (Micronesia, Bahamas, Tuamotus) or the carving of coastlines by glaciers (Norway, Chile). All these endogenous, exogenous and biological processes interact with eustatic (that is, world-wide) sea level changes to define the land pattern in space and time. Each process tends to produce islands of different size ranges, which may explain some of the size gaps and peaks observable in the distribution of lands by area at global, regional and local scales. Timing may also be important. Since small islands erode faster than large ones because of their higher coastline to area ratio, the large number of small islands created by the retreat of glaciers at the end of the last ice age has not yet been reduced significantly by erosion.

Order does not come without underlying patterning; a theoretical approach is required to help one grasp or at least describe the puzzling and complex origin of the world archipelago. Several authors, including Mandelbrot (1982), suggest that the world looks like a fractal surface with inherently similar properties that are shared at various scales. Thus changing magnification will still result in typically large but few chunks of mainland plus smaller but more numerous islands, both set in a largely aquatic frame. If this hypothesis is true, it will help us answer a key question: *how many islands are there?*

Map 2 - Islands as a Fractal Property of the Land Surface



How many islands?

The exercise of looking at maps from global to local scales suggests some sort of constancy in the structure of emerged lands. As suggested on Map 2, it seems that the search for islands is an endless quest till we reach very small patches of land only visible at a large scale. This observation fits with the underlying concept of self-similarity implied by fractal theory.

The fractal dimension D of the world archipelago can be estimated from the relationship between island size and frequency, given a cumulative size-frequency distribution (Burrough, 1986). It has been calibrated on the GSHHS seashore data base (Wessel & Smith, 1996) which is homogenous and includes all pieces of land greater than 0.1 km² as shown on a Log(Frequency)/Log(Area) graph (Figure 3). Thus, we can expect only one island with an area of around 10,000,000km², but close to 100 islands with an area of 9,000 km². The frequency of lands with area a above the value A can be estimated from equation (1):

$$(1)\ F(a>A) = \alpha . A^{-\beta}$$

$$\text{Where: } \alpha = 26702$$

$$\beta = 0.6295$$

(Calibration on land between 0.1km² and 100,000km² from GSHHS data)

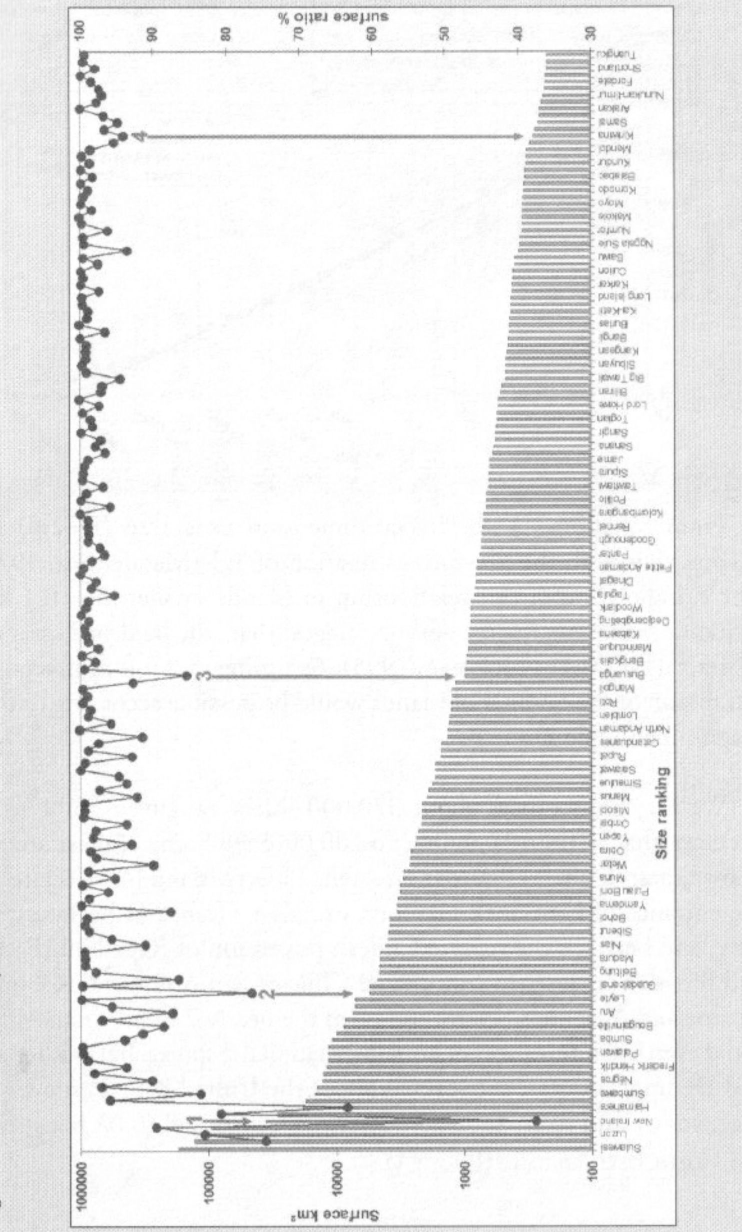


Figure 2 - Island Surface Proportion of Indonesia, Philippines and Papua New Guinea

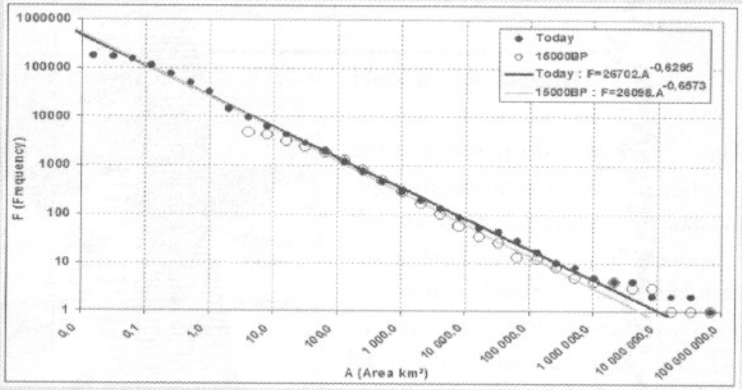


Figure 3 - The Distribution of Land Areas Today and 15000BP follows a Power Law as one might expect of the Contours of a Fractal Surface (Departure from regression lines for small areas are due to undersampling.)

From equation (1), the fractal dimension D is 1.26 (D=2.β) and is consistent with the previous estimation of 1.3 (Mandelbrot, 1975). The extrapolation of this relationship to islands smaller than 0.1 km² is questionable, since some authors suggest that "the land surface is not unifractal" (Evans & McClean, 1995). Assuming that it is unifractal, an estimation of the number of islands would be possible according to their magnitude (Table 2).

We may thus expect about 370,000 'islets' ranging from 1 to 10 hectares (that is, from 10,000m² to 100,000m²). Some of these are well known, despite their lilliputian size: take Liberty Island (4.9 hectares) at the entrance of New York Harbour, or Sala-y-Gomez (2 hectares), the only land between the remote Chilean possession of Rapa Nui (Easter) and the islands closer to continental Chile of San Ambrosio, Robinson Crusoe and Alejandro Selkirk. A few of the nearly 7 billion 'nano-islets' could even become sources of keen international disputes: Ireland, Iceland and Denmark contest the sovereignty of the United Kingdom over the bare, windy and misty bird-nesting refuge of Rockall (0.08 hectare) in the North East Atlantic (Photo 1).

Table 2: Classification of Lands according to Size Magnitude

Magnitude 10^m	class of area		Number (from GSHHS)	Fractal (from F=α.A^-β)	Surface km²	Example	prefix	+ term
7		A>= 10⁷ km²	3	*1*	125 151 092	America	*standard*	continent
6	10⁶ km²	< A < 10⁷ km²	2	*3*	9 709 666	Australia	micro	- continent
5	10⁵ km²	< A < 10⁶ km²	17	*15*	4 868 996	Madagascar	giga	- island
4	10⁴ km²	< A < 10⁵ km²	53	*62*	1 653 299	Iceland	mega	- island
3	10³ km²	< A < 10⁴ km²	219	*264*	674 559	Mauritius	*standard*	island
2	10² km²	< A < 10³ km²	1 135	*1 126*	337 947	Barbados	micro	- island
1	10 km²	< A < 10² km²	4 251	*4 796*	129 128	Nauru	nano	- island
0	1 km²	< A < 10 km²	16 359	*20 435*	49 959	Pitcairn	giga	- islet
-1	0.1 km²	< A < 1 km²	63 324	*87 072*	19 573	Heligoland	mega	- islet
-2	1 hectare	< A < 0.1 km²	90 446	*371 005*	16 060	Sala-y-Gomez	*standard*	islet
-3	1000 m²	< A < 1 hectare		1 580 809	7 100		micro	- islet
-4	100 m²	< A < 1000 m²		6 735 650	3 139	Rockall	nano	- islet
-5	10 m²	< A < 100 m²		28 699 843	1 388		mega	- rock
-6	1 m²	< A < 10 m²		122 286 783	613		*standard*	rock
-7	0.1 m²	< A < 1 m²		521 050 143	271		micro	- rock

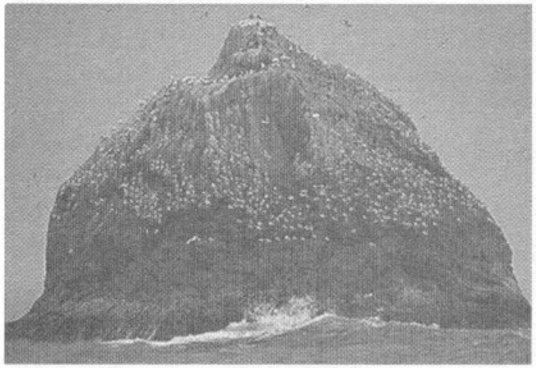


Photo 1 - The 0.2 acre "nano-islet" of Rockall. (Each white speck is a bird.)

To answer the question "how many islands?", we have to decide when to end the quest for smaller and even smaller pieces of land. Common sense clearly suggests that there is a physical limit: a half-submerged grain of sand cannot be an island. In our counting, we stop arbitrarily at 0.1 m^2 (1 square foot): just enough for a bird or a child to have a rest on one of the expected hundreds of billions of "micro-rocks". We can safely assume that there are some 680 billion such "islands". This number originates either from observations for lands greater than 0.1 km^2, or from extrapolation from the smaller ones as detailed in Table 2. This allows us to compute some statistics across a variety of sizes:

3 Continents (area greater than 1,000,000 km^2): Old World, New World and Australia. (Greenland and Antarctica are considered as ice caps and not continents.)

5,675 islands (with an area from 10 km^2 to 1,000,000 km^2): for a total area of 7,700,000 km^2.

8,800,000 islets (with an area from 10^{-4} km^2 to 10km^2): for a total area of 95,000 km^2.

672,000,000 rocks (with an area from 10^{-7} km^2 [one square foot] to 10^{-4} km^2): for a total area of 2,300 km^2.

At least, this formal statistical exercise of island counting and defining shows that it is anyway scale dependant and presupposes empirically defined limits. For instance, the official number of islands in Indonesia

is sharply defined as 18,108, but without any reference to a minimum size (DK Atlas, 2004). We can however compute that this limit is about 2.5 hectares from a size-frequency distribution of Indonesian islands.

This pattern of land and sea has changed over time, since it is known that during the last glacial maximum 15,000 BP [Before Present], the sea level was 110 meters lower than today and ice shelves covered large parts of Europe and Northern America (Map 1). The same method of size-frequency distribution can be applied to land above that depth (Figure 3). The NOAA/NGDC ETOPO2 bathymetry data set used for that purpose – with digital databases of seafloor and land elevations on a 2-minute latitude/longitude grid: www.ngdc.noaa.gov/mgg/image/2minrelief.html - is not as accurate as the GSHHS used to define the seashore as it is today. Therefore, it is only relevant for paleo-emerged lands with an area greater than 50 km^2. This lowering of sea level has had drastic consequences on the mainlands of the world archipelago (Map 1):

- Connection of Eurasia and America via the Bering Strait ('Beringia').
- Emergence of the Sunda Shelf including Borneo, Sumatra, Java and Bali.
- Merging of New Guinea, Australia and Tasmania ('Sahul' paleo-continent).
- Disappearance of the English Channel and North Sea making the British Isles a part of Eurasia.

One major change in the oceanic domain was the emergence of large land areas where today only tiny sparse islands can be found. This phenomenon is exemplified in the Indian Ocean by the Seychelles, Maldives and Chagos archipelagos where several islands of more than 10,000 km^2 existed at that time. Another stunning case is the Grand Banks at south-east of Newfoundland which formed a large island of 150,000 km^2 and which presents no more emergent lands today.

At that time, there was a less overwhelming predominance of the largest islands. This is due to the merging of many of them (Borneo, Sumatra, Great Britain, North Canada, North Siberia) into the main continent formed by Eurasia, Africa and America; new mainlands such as Sahul (New Guinea and Tasmania); and the merging of archipelagos into unique land masses (New Zealand, Philippines).

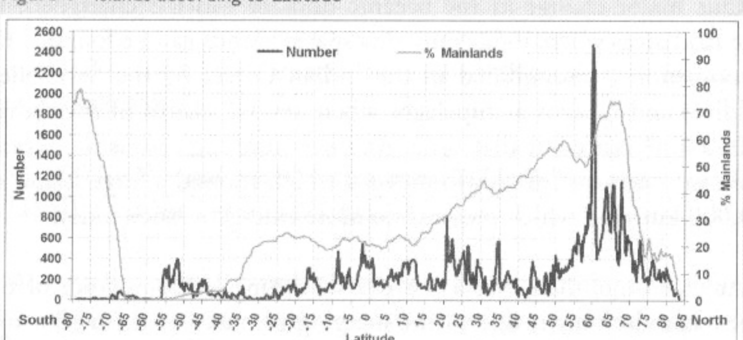
Islands in space and time

The statistical distribution of land *masses* within the world archipelago is consistent with the fractal hypothesis. This not true for island *locations* however, which are not evenly distributed around the Earth and do not follow a simple spatial distribution law. Islands tend to be aggregated in specific regions or to form large archipelagos where most of them are concentrated.

The distribution of islands according to latitude shows that most of them are located in the northern hemisphere, despite the fact that this has a lower proportion of ocean (Figure 4). The most striking result is the high occurrence of islands between latitude 50°N and 80°N with a sharp peak between 58°N and 66°N. At those latitudes lies the lowest ratio of ocean to land.

The density of islands of about 30 per 10,000 km² is ten times higher than anywhere else. Most of them are located along the coast of mainlands, creating a patchy landscape made of tiny islands separated by narrow channels. They are typical of the fjordlands of Norway, Greenland, Baffin, Labrador and western Canada where they have been carved from

Figure 4 - Islands according to Latitude



the continent during the last glaciation on the rims of the ice cap (*see Nunn, this volume*). The same type of island structure occurs in the southern hemisphere in Chile, the Kerguelen and Falkland Islands, and on the west coast of the Antarctic Peninsula. Another consequence of reduced glaciation is the steady uplift of the Scandinavian shield at 1 cm/year in the northern part of the Baltic Sea. One result is the progressive rise of numerous low lying islands along the coast, as beautifully examplified with the Åland Archipelago: a puzzle of 3,000 patches of land over a surface of 15,000 km² creates the world's highest density of islands (see Map 5 below).

The frequency of islands by latitude in the tropical zone is quite erratic, depending mostly on the location of the main clusters of islands such as the Caribbean (10°N to 25°N), Insulindia, from Indonesia to the Solomon Islands (15°N to 10°S) and the numerous archipelagos of the South Pacific (5°S to 25°S). The reef-building activity of living coral from northernmost Bermuda (32°N) to southernmost Lord Howe (32°S) also has a noticeable effect by constructing or preserving many islands with volcanic basement. The absence of coral reefs may partly explain the minimum frequencies observed at subtropical latitudes in both hemispheres.

The proximity of islands to continental landmasses is another significant geographic detail. For that purpose, a useful criterion is the coastal maritime zone legally defined as the territorial sea (12 nautical miles ≈ 22.2 km), which also corresponds to the distance from which the coast is visible at sea level. Since an island within this zone also has a territorial sea, such islands may extend this continental coastal zone beyond 12 miles, and so on until there are no more islands within the zone. This criterion defines two classes: the 'pericontinental' islands located within this continental coastal zone and subject to strong continental influences, and 'open ocean' islands distant from immediate continental areas.

Most islands are located near continents, while 'open ocean' islands are less numerous but include a much larger total island area (Table 3).

Table 3: Islands according to their Distance to the Nearest Mainland

Type of islands according to distance to mainland	Number Islands (NI)	12 nautical mile Coastal Zone (CZ km²)	Island Area (IA km²)	(NI %)	(CZ %)	(IA %)	Island Density ID=10000.NI/(CZ-IA)
World archipelago	86 732	22 415 363	7 738 683	100.0	100.0	100.0	59
'Pericontinental' islands	58 913	7 580 845	647 009	67.9	33.8	8.4	85
Europe	15 422	1 000 058	102 633	17.8	4.5	1.3	172
Greenland	4 392	383 602	51 061	5.1	1.7	0.7	132
North America	16 872	1 612 737	204 968	19.5	7.2	2.6	120
South America	6 902	898 321	155 525	8.0	4.0	2.0	93
Asia	10 247	1 661 328	72 179	11.8	7.4	0.9	64
Australia	2 556	603 872	28 187	2.9	2.7	0.4	44
Africa	1 940	747 398	9 488	2.2	3.3	0.1	26
Antarctica	544	631 733	22 518	0.6	2.8	0.3	9
'Open ocean' islands	27 819	14 834 518	7 091 675	32.1	66.2	91.6	36
North Canada	4 942	2 069 373	1 346 028	5.7	9.2	17.4	68
Caribbean	1 877	516 595	213 763	2.2	2.3	2.8	62
Indo., Phil., PNG, Solomons	7 387	5 134 339	2 908 367	8.5	22.9	37.6	33

This contrast between the two main island classes can be summarized by calculating a coastal/archipelagic island density (ID) using equation (2):

(2) ID = 10,000 x NI/(CZ-IA)

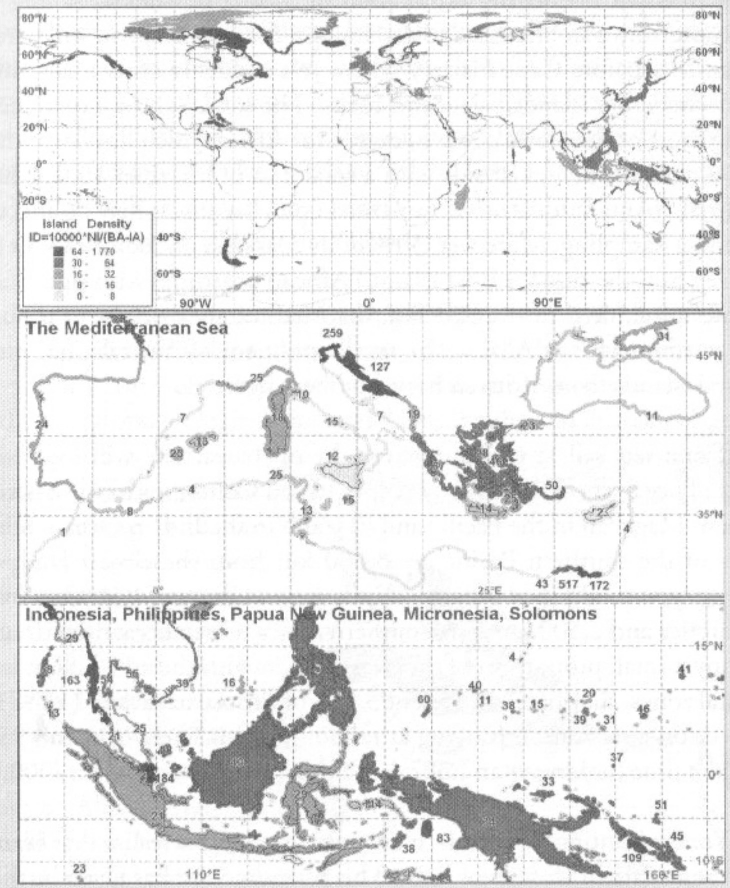
Where:

NI: number of islands in a given area

CZ: area in km² of the 12 nautical mile coastal zone including the area of the islands themselves

IA: area in km² of the islands

Map 3 - Islands Density along the Continental Coast and within Archipelagos



The reference surface is 10,000 km^2, which approximates a square degree at the equator.

The density along continental coasts (ID=85 islands/10000km^2) is more than twice that of archipelagos (ID=36).

The result of all these island-forming processes is sharp contrasts in the distribution and density of islands. Put yourself in the place of a navigator criss-crossing the oceans and sailing along all the coasts of the continents, whether a long monotonous coastline without islands or a dangerous but fascinating exploration of a maze of islands. Sailing up the coast from San Francisco to Anchorage, for instance, you will hardly see an islet before Cape Flattery where you suddenly enter a labyrinth of innumerable islands, islets and rocks. The same can be experienced along most of the world's coasts, except for Africa which has fewer than 2,000 pericontinental islands with a total area of less than 10,000 km^2 (Map 3). (Antarctica is not commented upon because it may be affected by under-sampling. Moreover, 30% of its coast lies under ice caps or ice shelves, as is the case for Ross Island.) African coastlines with significant islands are limited to the Red Sea, the Mediterranean coast near Suez, and portions of East Africa. The small continent of Australia has more coastal islands than Africa in both numbers and area.

If one sets sail at random across the open sea, one will find large parts of ocean space desperately empty, as did Columbus in the Atlantic Ocean, Magellan in the Pacific and El Cano in the Indian Ocean. Some parts of the southern Pacific are 3,000 km from the closest land. By chance, you might spot isolated islands such as Bouvet, 1,600 km from Antarctica and 2,500 km from southern Africa. Open ocean islands only occupy a small proportion of the oceans; even with their 15 billion km^2 coastal zones, they barely represent 3.3 % of the ocean surface (1.7% for pericontinental zones). Moving at random, one is likely to spend 95% of one's time looking at an unbroken horizon.

If one is hunting for islands, it does not take long to realize that islands tend aggregate in clusters or lines. This phenomenon has given birth to

the fuzzy term "archipelago". On occasion, it reflects the tangible reality of a group of islands isolated from others, as in the case of Cape Verde or Hawaii. There are other examples where this term is used more loosely, such as the Dodecanese Archipelago in Greece.

By the end of this island voyage, one would conclude that there are three main mega-archipelagos (archipelago of archipelagos) in the world: the group bounded by Sumatra, Timor, the Solomons and Philippines; the archipelagos of northern Canada; and the Caribbean. Together they contain more islands, and cover a larger area, than all other open ocean archipelagos, and include most of the large islands. Their average island densities range from 33 to 68 islands/10,000km^2, but with drastic differences among their component archipelagos. In the Caribbean (Map 4), Cuba and part of the patchy coral keys of Bahamas reach a density of 100 islands/10,000km^2 compared to 15 for the massive Hispaniola and Jamaica groups, while the spotty line of mostly volcanic islands in the Lesser Antilles has a density of 28. Puerto Rico and its tiny western neighbours in the Virgin Islands are in between at 56 islands/10,000km^2.

What has caused such contrasts in island locations and density? While plate tectonics provides a global explanation, the location, density and spatial structure of islands depend on climatic, geological, oceanic, hydrological and biological processes. Consider the case of archipelagos or sets of islands well defined by origin (Table 4). The bulky ice caps and the post glacial uplift resulting from their melting created most of the numerous pericontinental islands at high latitudes, with densities of 300 islands/10,000km^2 or even more (case of Åland, Map 5). Coral reef formation only in tropical waters of

Map 4 - Islands Density in the Caribbean

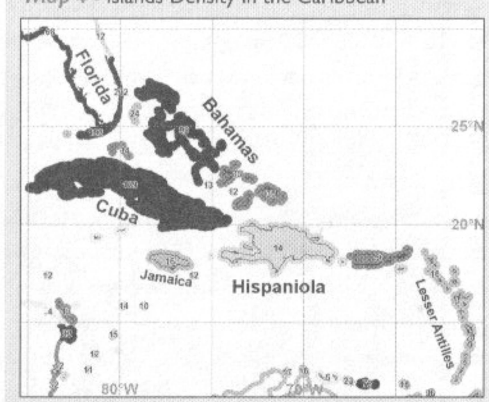
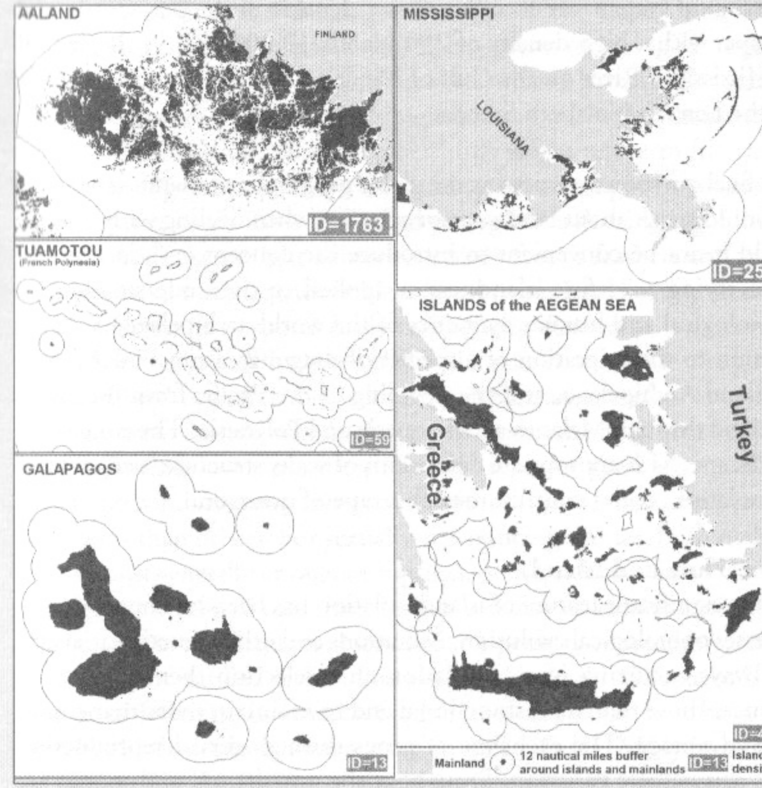


Table 4: Examples of Islands according to their Dominant Geological Origin

Type of islands according to processes	Example	NI	CZ km²	IA km²	Largest km²	Island density	Mean ID
Glacial processes including post glacial isostatic uplift	Åland (Finland)	2874	20,412	4,112	879	1763	300
	Norway	4236	124,400	22,229	2,239	415	
	Chile	4511	289,916	127,630	47,107	278	
	West Canada	3107	222,158	97,943	31,947	250	
Coral processes including uplifted coral	Bahamas	1099	157,711	14,390	3,618	77	70
	Maldives	489	66,045	215	9	74	
	Tuamotu (F.P.)	566	99,008	562	56	57	
Volcanic processes	Lesser Antilles	129	61,597	6,049	1,469	23	15
	Galápagos	41	44,295	8,087	4,739	11	
	Cape Verde	17	33,872	4,139	1,006	6	
Alluvial processes at the mouth of main rivers	Mississippi	505	20,382	796	41	258	250
	Lena (Russia)	476	21,377	1,394	71	238	
	Orinoco	65	3,034	542	81	261	

Map 5 - Islands Density (ID) in Coastal Zones and Archipelagos according to Dominant Processes



over 20°C generates archipelagos with an average density of 70 islands/10,000km² in at least three cases: generally small atolls as in the Maldives; uplifted coral islands reaching up to 50 km² as in the Tuamotus; or even islands of more than 1000 km² in the Bahamas. Compared to these two types, volcanic islands can be found at any latitude. They are mostly located far from the mainland in isolated archipelagos or islands in areas of subduction at the borders of continental plates ('the rim of fire', in the Pacific), along oceanic ridges, or at hot spots within oceanic plates. They give birth to islands of a few thousand square kilometres, like Big Island in Hawaii, or more if they merge as Isabella, the largest of the Galápagos. For that reason, the density of their archipelagos is only 15 islands/10,000 km^2. The alluvial islands formed at the front shore of main continental river deltas, while they may result from a terrestrial hydrological system, are locally a major element of the pericontinental seascape, with a high density of 250 islands/10,000 km^2 in the case of the Mississippi River on the Gulf of Mexico, the Orinoco in Venezuela and the Lena in Northern Siberia.

A final question in reviewing the global geography of islands is whether we should speak about landscape or seascape when dealing with islands. Would it not be convenient to introduce the concept of "islandscape" before trying to define islandness as applied to the understanding of the biological and human dynamics of the world archipelago? What is common to the migration of a species of dragonfly from Finland over the Åland Archipelago, and the peopling of the Pacific from the Asian mainland through Melanesia, Micronesia and Polynesia? The concept of islandscape, with appropriate definitions of scale, structure, size, density and isolation, could contribute to this type of question.

Fauna, Flora and Islands

One significant feature of island isolation has been its impact on the processes of biological evolution. Mutations and other genetic variations are always occurring in a population, and selection then operates to eliminate those that are disfunctional and to maintain those that confer some advantage. The exchange of genes through sexual reproduction mixes this genetic variation throughout the population, and species are defined as organisms whose similarity demonstrates that they share a single gene pool. When a population is separated and reproductively isolated, it will diverge over time and eventually become a separate species. Isolation is therefore a significant part of the evolutionary process creating species diversity. Population size is also important. A large population spread over a considerable area is less vulnerable to a extreme event causing high mortality, whereas a small localized population can easily be exterminated by a severe storm, drought, tsunami or epidemic.

The size and isolation of islands thus play an important role in biological evolution, so much so that island biogeography has become a

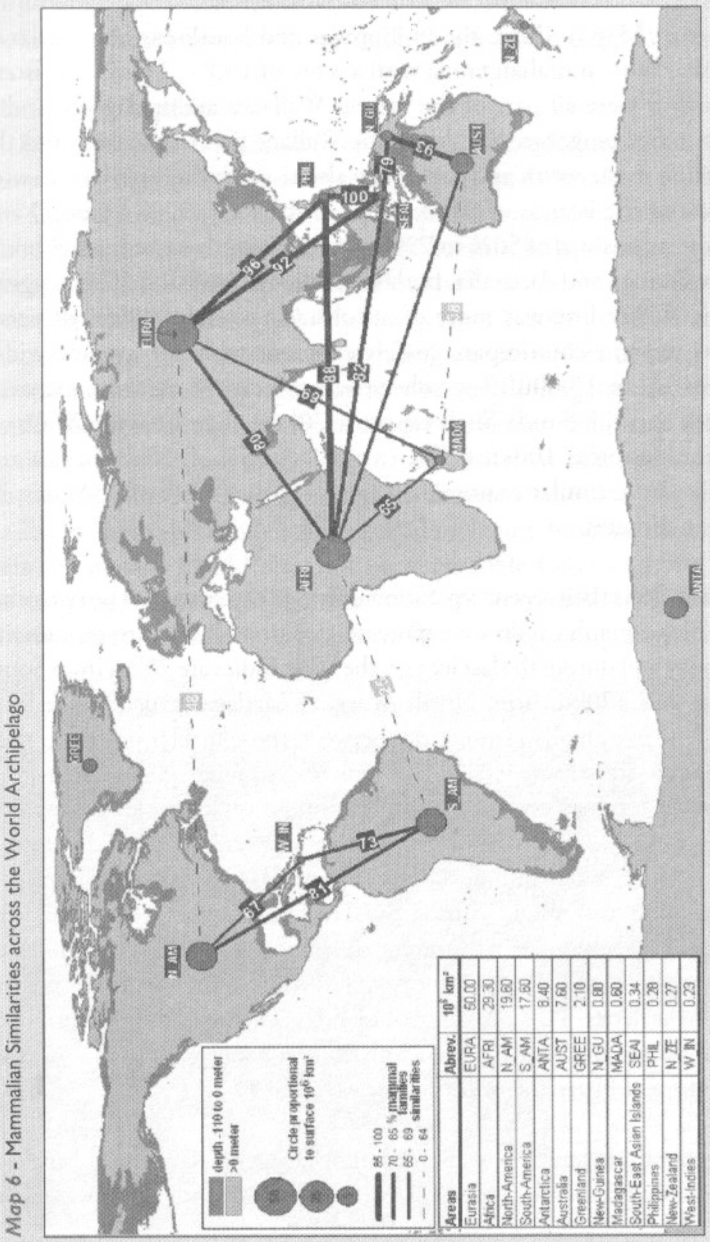
distinct field for which MacArthur and Wilson (1967) are the defining figures but of which Darwin was the precursor. (Darwin had visited several islands, apart from the Galápagos: San Iago in the Cape Verde Islands, St Paul Rocks, Chiloé and Tahiti.) Each species of biological organism has its own capacity to cross gaps between suitable habitats. For seabirds, the space between islands is only significant if it is wider than they can fly before exhaustion, whereas other birds might refuse to fly over the tiniest water gap. Amphibians might die from any exposure to seawater, while reptiles could more easily find passage on a floating log. However algae or frogs' eggs might adhere to a bird's feet or feathers and thus be transported to a new aquatic habitat. Some plants have floating seeds, and others light seeds or spores easily carried long distances on air currents, and others again may have seeds in fruits that can travel in the gut of a bird and be dropped in a new location. There are therefore always new immigrants to islands, with higher numbers on islands closer to adjacent land areas and lower numbers of fewer types at great distances. The prevailing winds and currents also transport migrants more easily in some directions than others. For sexually-reproducing species, both male and female must generally immigrate together, or in quick succession. The very small genetic base of most immigrants can also accelerate evolutionary change, as can the frequent absence of competitors or predators, and the availability of unfilled niches. Darwin's finches in the Galapagos Islands evolved different beaks to access food sources that would have been taken by other birds in places with a more complete fauna. Many immigrants do not survive the rigours of a new environment. A larger area, better living conditions, more diverse habitats and stable environment can all increase the chances of survival. The final biological population of an island is thus a balance between the rate of immigration and the rate of extinction as determined by the island's isolation and size, with the total number of species at equilibrium rising with size and decreasing with isolation. The distinctive island environments also accelerate evolutionary processes, producing their unique faunas and floras, with many endemic species found nowhere else (*see Anderson, this volume*).

The analysis of the geographic features of islands, their size, form and composition, their proximity to or isolation from other islands or continents, and their situation in terms of winds, currents, climate and migratory pathways, all help to explain their biological populations. Again, the dynamic processes involved have to be understood in the context not only of islands as they are at present, but also as they have changed over time. Islands that were once part of a continent until they were cut off by rising sea level will be much richer biologically for having started with a continental fauna and flora. Those that are actually ancient continental fragments that have drifted away from adjacent land masses may even preserve primitive life forms that became extinct or were replaced as evolution proceeded elsewhere. Volcanic islands and atolls, in contrast, start with nothing and accumulate biota with the passage of time. Moreover, some islands may be repeatedly submerged and exposed as sea levels have risen and fallen during the ice ages, and with each exposure the process of terrestrial colonization must start over again. With all these processes operating, it is difficult to find any two islands that are completely identical. Each one represents variations on a theme or a series of themes, and the result is an endless diversity of island life forms and ecosystems with many surprises.

The principles of island biogeography also apply to some extent to the marine biology of islands. Many coastal species are limited to shallow water areas or require a hard substrate to attach themselves, while others are dependent on coastal habitats for food or shelter. For such species, islands may be just as isolated as for terrestrial species, with immigration perhaps dependent on how long their larvae can drift in ocean currents before they either settle or die. One difference is that there may be seamounts or reefs that do not qualify as islands because they fail to emerge above the ocean surface (best examples of these lie in the North-west Pacific) but which can still serve as stepping stones for marine migrants, so the geographical relationships at a regional scale may be distinct from those of terrestrial forms.

The same principles operate at all the geographic scales of the world archipelago, whether for the flora of islets and rocks or the distribution of mammalian species among the continents and largest islands. The map of mammalian similarities across the world archipelago includes 5

Map 6 - Mammalian Similarities across the World Archipelago



groups of islands that illustrate their relationships with the neighbouring continents (Map 6). First, the Philippines and South-east Asian islands are similar in mammalian fauna with a score of 100%. This is consistent in that they were all part of the former Wallacea archipelago bounded by two major biogeographic lines: the Wallace line to the west and the Weber line to the south and east. They also show strong similarities with Eurasia and the islands of Sunda Shelf to the west (92% or more) and weaker relationships of 50% to 79% with their south-eastern neighbours of New Guinea and Australia, both split apart from Sahul. This suggests that the Weber line was more of an obstacle to mammalian dispersal than its western counterpart, and is coherent with the average width of straits up to 15,000BP, which were significantly narrower between Wallacea and the Sunda Shelf (approx. 20km) than between Wallacea and Sahul (approx. 100km). The two parts of Sahul, New Guinea and Australia, have similar mammalian faunas with a score of 93% despite different climates.

This reflects their recent separation only 8,000 years ago. The two other insular biogeographic units were more isolated from their nearest continents both today and during the last ice age: the West Indies are 70km from South America and 120km from North America; Madagascar is 350km from Africa. The mammalian similarities between those insular units and their continents are respectively 73%, 67% and 65%. These figures demonstrate the relationship between species similarities and such simple geographical features as the width of straits during the late Quaternary era. Other factors should also be taken into account, in particular the paleogeography of plate tectonic movements during the Tertiary era when mammals were evolving. If geographical constraints are obvious for a class of animals at the global scale, they are even more significant at other scales for genera, species or varieties. The specificity of islands compare to the vast terrestrial continuum of continents is their isolation by water gaps that constitute drastic dispersal barriers for most species.

A geographic analysis of the different facets of 'islandness' can have considerable predictive and explanatory value in understanding island

biogeography. Islands in turn have been important laboratories of evolution whose study has done much to advance biological science.

Islands and Models

Islands also provide excellent conditions for modelling, an important scientific tool and a "rehearsal for reality" (Judson, 1980). Such models can explore everything from evolutionary equilibria to the water movements around islands that transport larvae or pollutants. Judson cites a hydraulic model built in the 1970s to solve a serious pollution problem in the inland sea of Japan. This analogical model at a scale 1:2000 filled an airplane hangar (Figure 5). The scientist standing on the replica of Iwaji Shima (*Shima* means 'island' in Japanese) may be questioning the validity of the model. Is the scale right to represent the small bits and pieces that may significantly affect the modelling of the whole? At that scale, a mega-islet ($A \geq 0.1$ km^2) has an approximate diameter of 0.2m, the smallest feasible scale in this model. But what about more tenuous islets, rocks, reefs and shoals? Could they not be responsible for a 'butterfly effect' on the processes and changes that need to be modelled? What about external forces – such as atmospheric forces - impacting on the naively

Figure 5 - An Analogic Model of the Inland Sea of Japan (*after* Judson, 1980)

self-contained system? The island as a microcosm can certainly help to simplify understanding, but it still needs to be related to larger and more complex system dynamics (Von Bertallanfy, 1968).

Stages of Human Discovery and Settlement

The same tools of geographic analysis that shed light on island biogeography can also help to explain the interaction of geographic, technological and cultural factors behind the migrations of people into island regions, migrations that have been the subject of many analyses not only by historians but by anthropologists, archaeologists, linguists and geneticists, especially in the Pacific (Gibbons, 1994). For people to settle on an island, they have to get there. Beyond the distance that people can swim, this requires some technology in raft, canoe or boat-building, propulsion by paddle or sail, and skills in navigation or orientation. Even with the technology, there is the psychological and cultural capacity to overcome the fear of the unknown and to want to explore new opportunities, and particularly to venture out of sight of land. There are enormous gaps in time between the migrations that were possible overland, those that could take place by navigating within sight of land, and those courageous adventurers who were ready to set out over the horizon in the hope of finding a new home.

With new, 3-dimensional, geographic data sets of islands - such as the Digital Elevation Model from Shuttle Radar Topography Mission (DEM/SRTM) from NASA available from 61°N to 60°S: www2.jpl.nasa.gov/srtm/ - and information on the sea level at the time of human migrations that has been documented with archaeological evidence, it is possible to calculate where there were land bridges between areas that today are islands, and where someone on the highest point of an island or coast could see the next piece of land across the water, and thus know that in setting out from the shore in a particular direction, a landfall was certain, a process that we can call *island hopping*.

According to paleo-anthropolgy, it seems that the pre-*homo sapiens* was trapped on the mainland of the world archipelago, and it took quite

some time before mastering the ability to get out of the African peninsula cradle via the isthmus of Sinaï or the Bab el Mandeb narrow strait.

Before considering the stages of human saga over the marginal isolated lands, as we may called islands, one needs to know the equation (3) which gives the 'visibility range' (Lewis, 1994) on our spherical planet:

$$(3)\ V_{km} = 3.57 \times Z_m^{0.5}$$

Where:

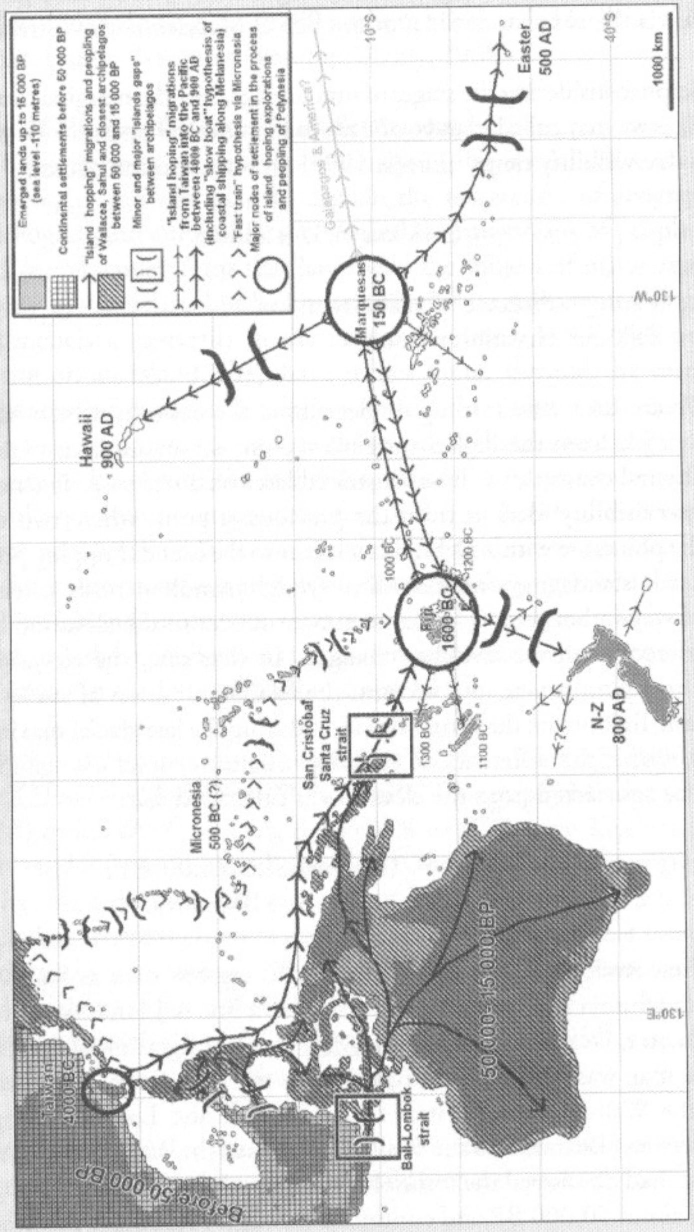
V_{km}: distance of visibility in km
$Z_m^{0.5}$: elevation in metres.

We are then able to roughly determine theoretically which islands were visible from the highest or closest point on an adjacent island or continental coast; this will be illustrated later on a real case. The notion of 'intervisibility' derives from the previous: a point where two other specific points are within sight. It is relevant to the islands hopping process since two islands may only be within eyesight simultaneously when one is half-way in between. The last comment relates to the elevation to be considered when sea level has changed. In that case, the elevation as given today must take into account the relative variation of sea level in the past. To estimate the actual elevation during the last glacial maximum at 15,000BP, the difference of elevation due to see level change (SLC) must be subtracted from the elevation as calculated today:

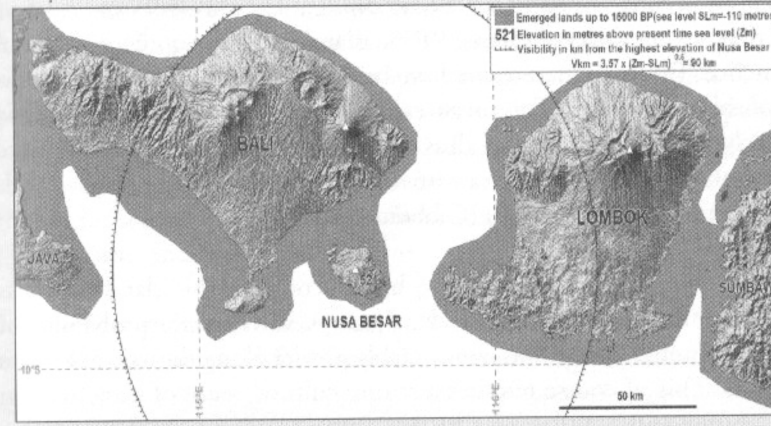
$$Z(15{,}000BP) = Z(Present) - SLC(15{,}000BP)$$
$$\text{with } SLC(15{,}000BP) = -110 \text{ metres.}$$

These notions can be applied to specific regions such as South-east Asia and Sunda Shelf, including the southern line of islands constituted by Sumatra, Java, Bali and Borneo (Map 7). The migration of *Pre-Homo sapiens* man was blocked there by critical water gaps along what is called now the Wallace line: the straits between Bali and Lombok (Map 8) and between Borneo and the Philippines. Once the *Homo sapiens* Asian peoples had developed the technology to cross the water, island hopping began about 50,000 BP and continued through 15,000 BP, covering all

Map7 - From 'Island Hopping' to 'Island Hoping' in the Pacific



Map8 - The Strait between Bali and Lombok Islands up to 15,000 BP



of the South and East lands of Wallacea, Sahul and as far as the Solomon Islands, involving the ancestors of the dark-skinned Aborigines, Papuans and Melanesians. This migration reached its limit beyond the Solomon Islands where there was a major 'island gap' before the Santa Cruz Archipelago. Island hopping stopped there because there was no more land visible on the horizon to encourage another step. The statement that only *homo sapiens* was able to 'island hop' has however been recently shaken. *Homo floresiensis*, a dwarf form of *Homo erectus* dated from 12,000BP, was discovered on the island of Flores (Brown *et al.*, 2004) beyond the Bali-Lombok water gap. Scientists are thus considering various hypotheses that would explain how the Flores exemplar was possibly a side effect of *homo sapiens* migrations.

The next stage in the island quest of humankind remains undoubtedly the giant advance that led to the Polynesian migration across the Pacific. This came about because these people had the technology to master long sea voyages with everything necessary to colonize a new island (Dening, 2004). What remains outstanding is their courage and cultural framework that enabled these peoples to hope that there would be another island beyond the one they were leaving behind, and possibly also the confidence that they could sail back if they did not find land in time. This great migration from 4,000BC to 1,200AD, can be understood as being fuelled by the hope of finding an island, or *'island hoping'*. These Polynesians reached all over, except the easternmost Pacific islands close to South and Central America. Two migration routes have been proposed for these people who probably originated in Taiwan: an 'express' route down through Micronesia to Polynesia from near Japan, thus bypassing Melanesia; and a 'slow' route along the fringes of Melanesia with some interchange along the way with Melanesian peoples (Map 7) (Gibbons, 1994).

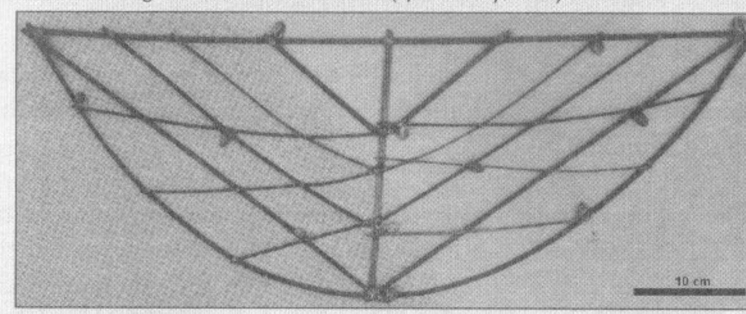
One geographic factor that may have encouraged this island hoping is the linear arrangement of most island groups, such that the probability of finding another island was considerably greater along the axis of known islands. This of course requires a strong cultural sense of geography as well as orientation and navigation, which the Polynesian and Micronesian people acquired and maintained (Lewis, 1994). The stick-charts of Micronesia illustrate the ability of their navigators to synthesize their knowledge into a reticular structure made of points and lines (Figure 6). The knowledge of seas, winds, stars and other signs acquired during their oceanic migrations, whether voluntary or not (Map 9), gave them an empirical knowledge as useful as that of the quantitative skills of chart-making with graphic theory applied to islands (Map 10).

In general, Melanesian peoples were culturally more land oriented, developing many different local cultural and linguistic forms corresponding to the fragmented terrain of their high islands. Their island hoping, when they finally reached Fiji, Vanuatu and New Caledonia (1600BC - 1100BC), was contemporaneous with the eastward Polynesian migration and may well have been inspired and enabled by transfers of Polynesian technologies and cultural elements. Significantly, the Melanesian legends and myths of those archipelagos retain no trace of their island migrations (Bonnemaison, 1986). The Melanesians became totally rooted in there new lands without looking back and with no expectation of discovering new islands beyond the horizon. New Zealand was only about 1,400 km from New Caledonia with Norfolk Island half way in between; but it was only discovered by the Maori around 800AD.

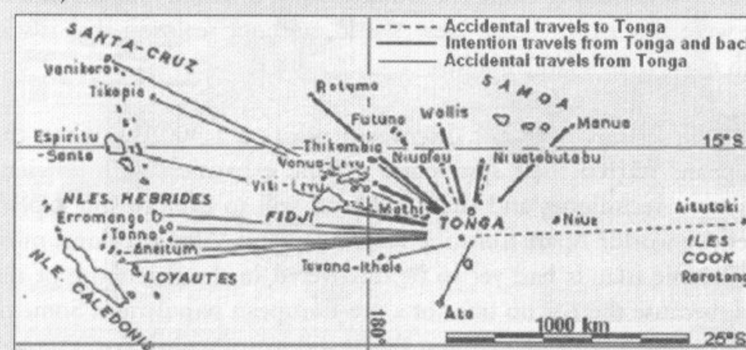
Apart from the Pacific, there are other examples of both island hopping and hoping. One of the most dramatic examples is the settlement of Madagascar by people coming from Borneo after a long sea migration along the southern coast of Asia and the east coast of Africa. They probably crossed the Mozambique Strait via the Comoros Archipelago by island hoping before landing on Madagascar some 1,800BP. Today, the Malagasy language is part of the Nusantarian (or Austronesian) family that includes Malay and Polynesian, but with significant lexical influences from African and even Indian origins.

The Mediterranean islands were only settled relatively recently, despite most of them being visible from the surrounding mainland. Cyprus

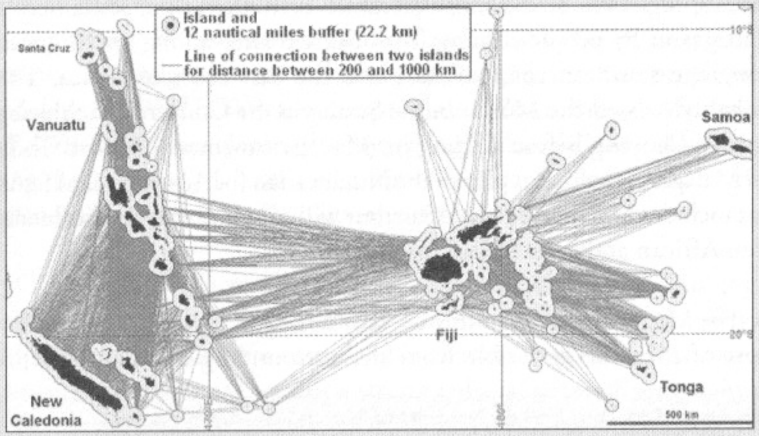
Figure 6 - Stick-chart from the Marshall Islands made of shells representing islands and sticks indicating currents and lines of swell (*after* Harvey, 1980)



Map 9 - Example of Polynesian Voyages in Pre-European Times (*after* Doumenge, 1966)



Map 10 - The Reticular Structure of Connections between Islands

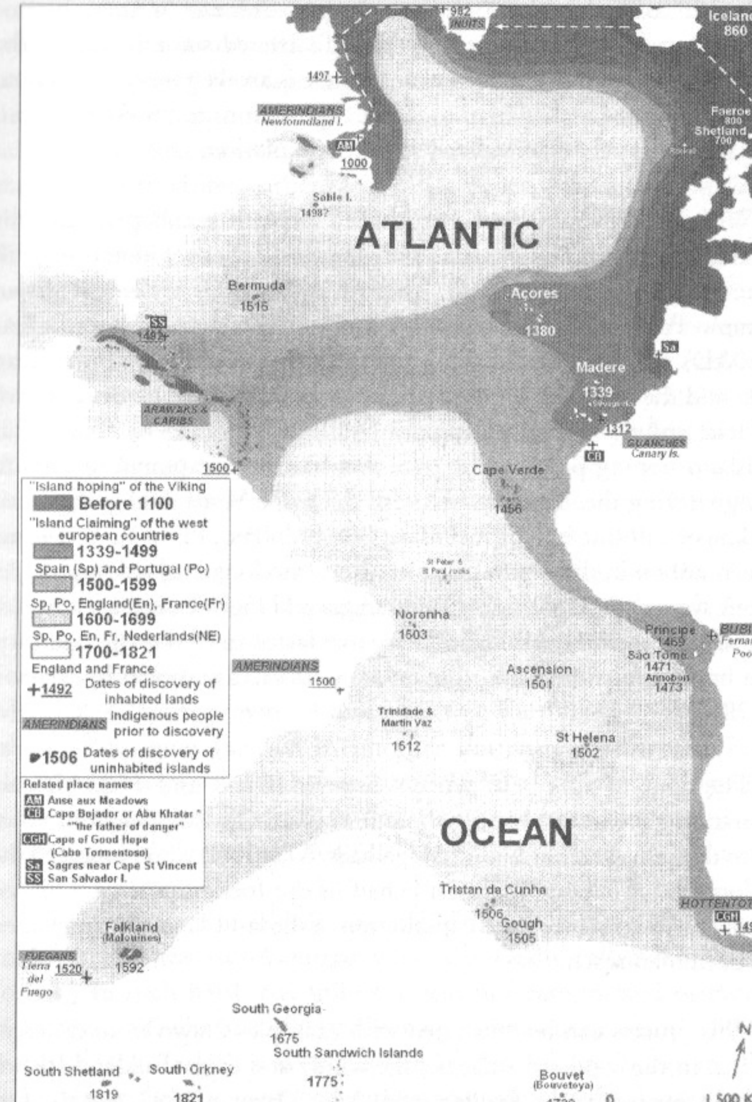


was the first to be colonized about 6,000 BC, probably by Neolithic populations coming from Anatolia. Since it cannot be seen by coastal shipping from the continent, the Balearic archipelago was the last to be inhabited, around 3,000 BC.

The Vikings heading westward from their native peninsula of Scandinavia initiated island hoping in the North Atlantic, and their descendants are proud to recall these voyages in their famous sagas: Faroes in 800AD, Iceland in 860AD and Greenland in 982AD. Their ultimate landing at the L'Anse aux Meadows site in Newfoundland around 1,000AD after sailing along the wooded coast of Labrador proved that they were able to reach the New World, without realizing that it was much more than a large island.

Which islands were not discovered prior to 1,300AD, when the Europeans started their systematic marine expansion with efficient navigation techniques and their stubborn will to explore and exploit the entire world? Apart from the Polynesian and Viking regions, most mid-oceanic islands had yet to be discovered in the true sense of the word, because there is no trace of a pre-European population. Some of them may have been sighted, but this is still hypothetical. For instance,

Map 11 - European Explorations and Discoveries in the Atlantic Ocean (*after* Marrou, 1998)



Thor Heyerdahl tried to prove that there was archeological evidence and the technical possibility of Inca voyages as far as the Galápagos or Easter Island, but his work has not been confirmed (Heyerdahl, 1952; Heyerdahl & Skjolsvold, 1956). Some tenuous elements in Arabic marine traditions suggest that Arabs may have discovered some islands in the Indian Ocean prior to the Europeans. There is an even more conjectural literature about Carthaginian or Celtic explorations in the Atlantic; but they should as yet be considered as pure speculation.

With the Europeans, the process of exploring and peopling the uninhabited island margins of the known world changes in nature, with more mercantile and political objectives rather than settlement. As an example, Portugal with such protagonists as Henry the Navigator (1394-1460AD), had a deliberate policy to explore in priority both the African coast and the country's oceanic neighbourhood. While the discovery of Madeira and the Azores during the 14th century could be classified as an island hoping process, the pace and nature of exploration start to change during the 15th century with the Cape Verde Archipelago and the line of volcanic islands including Fernando Poo, Principe, São Tomé and Annobon in the Gulf of Guinea. It was no longer island hoping *per se*, but systematic exploration for strategic and logistic reasons, a sort of 'island claiming and naming' exercise that lasted until the 19th century. The implications of this for the Atlantic Ocean are shown by Marrou (1998) (Map 11).

The apex of this new process between 1488 and 1522AD saw outstanding navigators like Bartholomew Diaz, Christopher Columbus, Vasco de Gama and Ferdinand Magalhaes (Magellan) who pioneered the exploration of oceanic space on behalf of the Iberian powers. This led steadily to the discovery and exploitation of the last islands that remained out of human reach.

This process can be illustrated with examples drawn from different oceans. In the southern Atlantic, the windy and foggy Falkland Islands were discovered by the English sailor John Davis in 1592, but the first settlement was by Frenchmen from Saint-Malo in 1794. This is why

this archipelago, a part of the Argentine continental plateau, is also called Malouines in French and Malvinas in Spanish. The first person to set foot on the northernmost coral island of Bermuda in the North Atlantic was the Spanish navigator Juan de Bermúdez. The archipelago remained uninhabited until a group of colonists were shipwrecked there in 1609, inspiring Shakespeare to set and write *The Tempest* soon after. The Galápagos were discovered by chance in 1535 by Spanish navigators sailing from Panama to Peru, although some legends suggest that they may have been visited earlier by the Inca Tupac Yupanqui. Conversely, there is no evidence that the Polynesian outriggers ever reached them. When Captain George Vancouver landed on the Galápagos in 1795, his conclusion was they were "the most dreary, barren and desolate country I ever beheld" (Lamb, 1984). Yet, John Hickman, one of the first settlers at the beginning of 19th century, wrote a book entitled *The Enchanted Islands* about his experience in those same islands (Hickman, 1985). This difference in perception illustrates how judgment is largely subjective. The discovery of the Mascarene Islands - including Réunion, Mauritius and Rodrigues in the Indian Ocean - is attributed to one of two Portuguese navigators, Domingos Fernandez in 1511 or Pedro Mascarenhas in 1512, the later giving his name to the archipelago. However, the map of Alberto Cantino (1502) shows the location of the islands with Arabic names, suggesting pre-European exploration (Nebenzahl, 1991). The Dutch were the first to settle permanently on Mauritius (named after Maurits, a Dutch provincial leader) before the French took over the island. Rodrigues (named by another Portuguese navigator, Pedro Rodrigues) remained uninhabited until 1691 when French Huguenots led by François Leguat settled in their 'promised land'; yet left it 2 years later (Leguat de la Fougere, 1708).

The last chapter of mid-oceanic island discovery in the 19th century took place in the sub-Antarctic zone, deservedly called the "roaring forties". In such harsh conditions, it was not easy to land or even to sight new land. The first official discovery of Macquarie Island 1,500km south of New Zealand was by Captain Frederick Hasselburgh in 1810. In his report, he described the wreck of an unidentified old sailing vessel which remains a mystery (Cumpston, 1968). There are tenuous chances that the Polynesians went as far as Macquarie Island (55°S), since recent archaeological findings suggest that they landed in the Snares (48°S) and Auckland Islands (51°S) (Anderson & O'Regan, 2000). In the same region, other intrepid captains tried to find the Royal Company, Emerald and Aurora Islands, mentioned on nautical charts up to 1842. (The latter have now been identified as Shag Rocks (53° 33'S, 42° 02'W), some 115 miles WNW of South Georgia.) Most were never found: for the good reason that they don't exist.

The combination in the long term of all these processes of island hopping, hoping, claiming and naming is responsible for the present intricate geopolitical situation that many islands find themselves in today.

The current island puzzle

The same geographic processes that have operated in the past on the evolution of island biodiversity and the mosaic of island cultures are now influencing island societies in new ways as they integrate into a globalizing world. Air travel, radio, telephone, satellite connections, the internet and other new technologies of transportation and communications have reduced island isolation in some cases and increased it in others.

For example, considerable work has been done on island economies which, because of their small size, openness, limited diversity and lack of economies of scale, have been considered to be vulnerable to outside perturbations, and arguably cannot be competitive in world markets, except in specialized niches like tourism (Briguglio, 1995).

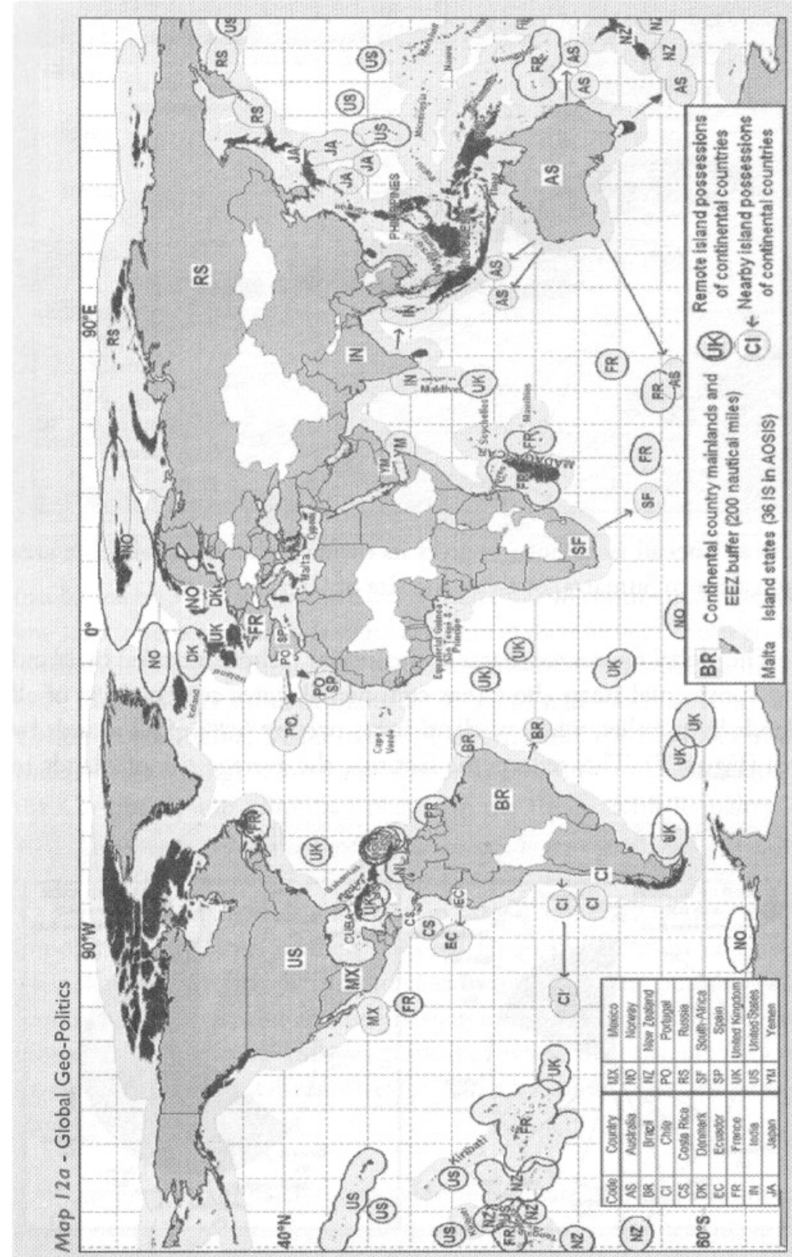
Culturally, the picture is more mixed. On the one hand, the wave of global culture in popular music, dress, films and television, and now the internet has swept over islands as it has the rest of the inhabited world. Yet islands are as subject to the digital gap as other remote areas, and the cost of these services where there are no economies of scale is very high. Emigration to find work or wider opportunities has led to many island countries having larger populations overseas than at home (*see Connell, this volume*). Yet the special conditions that created island cultures remain, and many island cultural characteristics have demonstrated surprising resilience. Island peoples continue to make a significant contribution towards global cultural diversity.

Politically, how do you weigh the influence of a nation of ten thousand or a hundred thousand people against one of a hundred million or a billion? Yet, population is not everything, as will be evident in the analysis below. Even politically, small island developing states (SIDS) have learned that there is power in numbers, and in fora where each nation has one vote, SIDS can represent a significant voting block of more than 40 countries. Starting from regional groupings of island countries and territories in the Pacific and Caribbean, SIDS have built a range of global political processes to define their particular situation and identify policy responses. Islands were included as a program area in Agenda 21, the action plan for environment and development adopted at the Rio Earth Summit in 1992 (UN, 1992). This led to the Conference on Sustainable Development of Small Island Developing States in Barbados in 1994, which adopted the Barbados Programme of Action (UN, 1994), assured the regular inclusion of SIDS issues in subsequent international negotiations, and ushered a follow-up international meeting in Mauritius ten years later, in January 2005 (UN, 2005).

Moreover, clearly aware of their limitations on the world stage, island states joined forces in 1991 to set up the Alliance of Small Island States (AOSIS) to give them a stronger and unified international voice. Adding the statistics for the 39 member countries (and even excluding the 4 overseas possessions of American Samoa, Guam, US Virgin Islands and Netherlands Antilles which are observers) makes AOSIS the third ranking insular power in the world, after Russia and USA, at least geographically speaking. It is worth noting that the Alliance also includes 4 low-lying coastal countries which are mostly continental (Belize, Guinea Bissau, Guyana and Surinam) and that Cuba and Papua New Guinea account for more than three quarters of the collective land area. AOSIS adopts common positions on key international issues such as climate change and is able to defend them with their votes at the United Nations, demonstrating strength in numbers that can help to counter-balance the power of major countries at both global and regional scales.

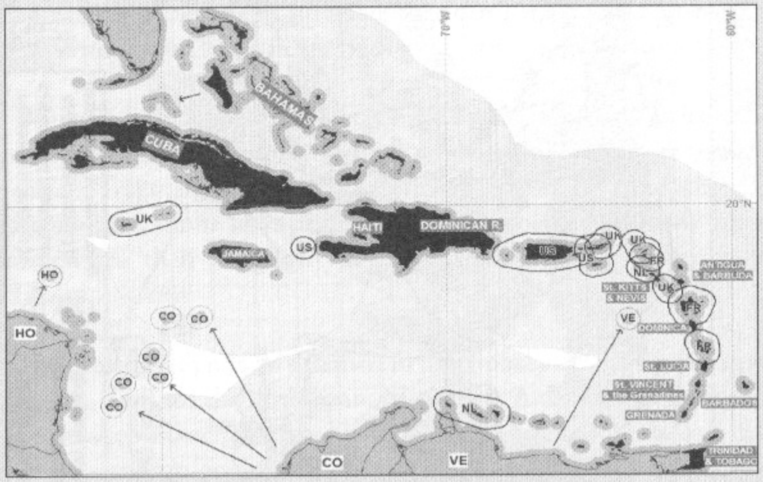
While independent island states have found a political voice at an international level, other islands have remained part of larger nations, or distant fragments of former empires. Thus, while transportation and communications links have reduced the isolation of many island communities, their marginality is expressed today more in economic and political terms.

The present geopolitical situation in this global puzzle can be mapped (Map 12a, and, for the Caribbean, Map 12b). A distinction should be made between island states and continental states, as they do not have the same views on oceanic issues both in terms of scale and necessity. The United Kingdom is an exception, because it is an island state yet often acts like a continental power. The fact that many islands are the dependent possessions in one way or another of continental countries is a major reality of ocean geopolitics. In some cases this is a simple extension of their coastal waters to nearby islands, as in Australia, India, Chile and Portugal. In other cases, these are remote island territories far away and without geographic continuity, often the heritage of the colonial past of island claiming. A few countries control overseas island territories in many oceans, such as the United Kingdom, France and USA. Some islands in the Caribbean are still attached to the Netherlands, and Norway has Bouvet and Peter Islands near Antarctica. One consequence of this is that the truly island states have many island neighbours that are to some degree controlled by global or local continental countries. This mix of small island developing states and world powers makes regional policy-making difficult, as exemplified in the Caribbean, Pacific and Indian oceans. All the near-Antarctic islands below 35°S are under the control of European countries or former dominions of the UK (Australia, New Zealand and South Africa). This overwhelming extension of continental national sovereignty over islands at the world scale has direct consequences for access to oceanic economic resources as they are defined by the 200 nautical mile (370 km) exclusive economic zone. An isolated nano-islet



Map 12a - Global Geo-Politics

Map 12b - Geopolitics of the Caribbean



such as Rockall (*see* Photo 1) gives its owner rights to an offshore area equivalent to Sumatra, or twice the size of Great Britain.

The global figures for shares of the insular realm controlled by island and continental states show that continental states control 81% of all islands by number, whereas island states occupy 64% of all islands by area (Figure 7). This reflects the fact that the average size of islands in

Figure 7 - Island States versus Continental States: Number and Area of Islands

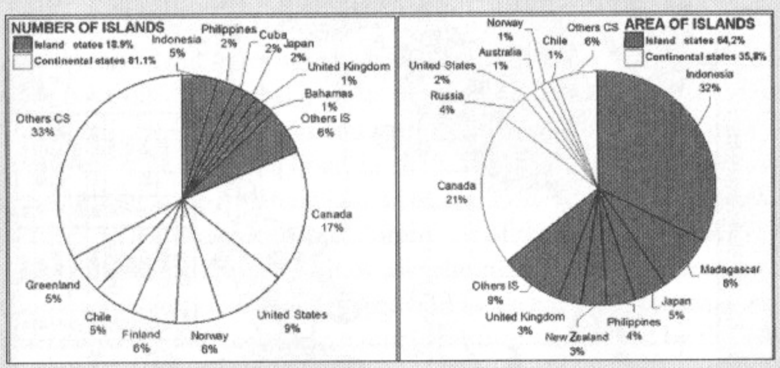
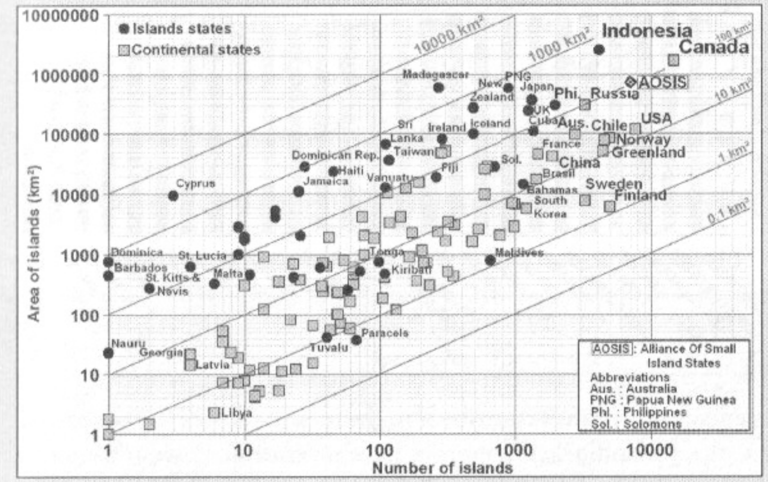


Figure 8 - Number and Area of Islands according to Countries

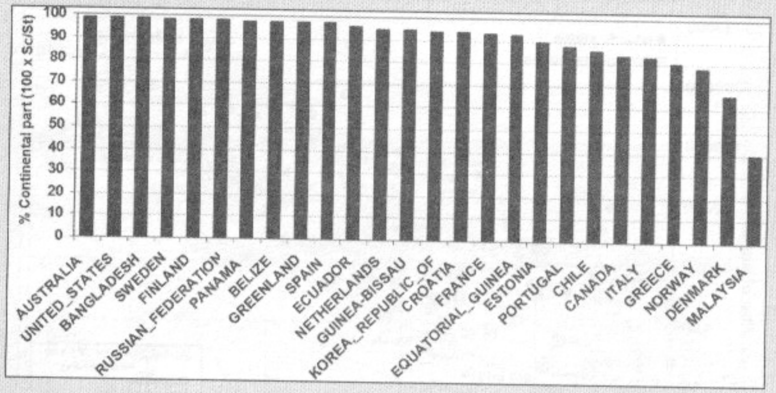


insular states (304 km²) is much larger than those in continental states (40 km²). Indonesia and Canada stand as giants in their respective categories. With each boasting thousands of islands covering more than a billion km², they rank far ahead of many small island states such as Tonga and Tuvalu in the Pacific, Malta in the Mediterranean, the Maldives in the Indian Ocean, single island states such as Dominica and Barbados in the Caribbean, and lilliputian Nauru in the Pacific with its paltry 20 km² (Figure 8).

The political interest of states in island issues is related to the importance of islands in their national territory. For most countries, their islands are relatively insignificant in terms of area, population or economic activities, and are usually marginalized in political processes. However they take on added significance when they extend national sovereignty over coastal resources or undersea oil and gas reserves, or serve as strategic outposts.

A geographic approach can provide an estimate of the island interest and concern of states. For continental states, a simple measure is the

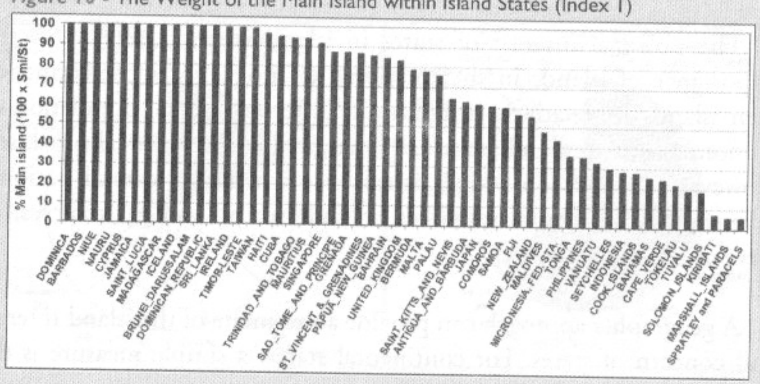
Figure 9 - The Weight of Islands within Continental States (Index I)



percentage that islands contribute to the total surface of the country (Is). First, the 36 landlocked countries have no oceanic coast and no direct link with oceanic islands, although they sometimes group themselves with island states as a geographically disadvantaged group. Most continental states with a coastline have only marginal interest in islands because they are small and located within the continental coastal zone. Some have only a narrow access to the sea, or have no coastal islands, such as Surinam, Benin, Jordan or Slovenia (Figures 9 & 10).

There are 73 countries with less than 1% of the territory on islands (Is<1%). The 26 other continental states with Is>1% have at least a

Figure 10 - The Weight of the Main Island within Island States (Index I)



significant island interest (Table 5). These include Australia (Is=3%, Tasmania), Russia (Is=1.8%, north Siberia, Sakhalin and Kuril Islands), Ecuador (4%, Galápagos), Equatorial Guinea (7.2%, Bioko and Annobon) and Italy (16.8%, mainly Sicily and Sardinia). Two states have large proportion of insular territory: Denmark with 33.9% including the Faroe Islands and isolated Bornholm, but excluding Greenland; and Malaysia, a case on its own with 60.5% insular territory, mainly the northern part of Borneo which is shared with Indonesia and Brunei.

Table 5: Type of States according to their Island Concern (Index I_s)

Classes of states	Index I_s	Number of states	States and votes	States in AOSIS
Landlocked states	0%	37	19.8%	
Marginal concern	<1%	73	39.0%	Surinam
Significant concern	>1%	26	13.9%	2 states*
Island states	100%	51	27.3%	37 states

**Guinea Bissau & Guyana*

Insularity also has political influence *within* states, where the relative size of the main island can influence its relationship with satellite islands and therefore impact on the archipelago's internal stability. There are cases where the main island of an archipelago behaves like a continental nation in its perspective on its marginal outlying islands. This can be measured with an index of "mono-insularity" I_{mi}: the proportion of the country area constituted by the main island. On this index, island states can be classified from mono-insular states to archipelagic states (Table 6).

Prospects

The international community raised the problem of the multiplication and viability of island micro-states in the 1980s. AOSIS has shown that the principle of "one country one vote" in international or even regional institutions gives small states an opportunity to become more powerful in the political sphere. Where might this lead in the future?

Table 6: Types of Island States according to the Relative Main Island Area (Index I_{mi})

Classification of island states	Index I_{mi}	Number of states	Example	States in AOSIS
Mono insular	100%	4	Nauru, Barbados	4
Quasi mono insular	>90%	16	Cyprus*, Timor-Leste**	9
Multi insular	>50%	16	Comoros, Malta*	11
Archipelagic	<50%	15	Vanuatu, Marshall	13

** Leave AOSIS to join EU in 2004*   *** In AOSIS since 2003*

The last few decades have seen secessionist tendencies within archipelagic or multi-insular states: Papua New Guinea with Bougainville, Vanuatu with Tanna and Santo, St Kitts and Nevis, Trinidad and Tobago, and the ongoing Comoros and Mayotte. The reasons range from political and island clientelism to cultural or historical factors. Official, potential or *de facto* partitioning of islands can also occur, as in the cases of Timor Leste, Sri Lanka, Ireland, St Martin, Hispaniola, New Guinea, Tierra del Fuego and Cyprus.

There is finally the potential proliferation of island micro-states due to overseas possessions becoming fully independent. This does not appear likely at present – many sub-national island jurisdictions are very pleased with their current autonomy and assurances of largesse from their metropolitan powers – yet, if this occurs, then some 25 new island states could easily join the international community. Their populations would range from a few thousand (Tokelau), to nearly one million (Réunion) or even more (Puerto Rico). All together, a collection of 60 to 80 island micro-states could be upon us in due course. This could strengthen island lobbying in international and regional politics, and bolster further island concerns on such global issues as climate change and biodiversity. Indeed, a specific programme of work on island biodiversity has been adopted at the March 2006 Conference of the Parties (COP) to the Convention on Biological Diversity (CBD), held in Curitiba, Brazil.

This outcome is one other example of the efficency of the 'island lobby' within international fora.

While islands may be at the small end of those geographic entities on our planet of human significance, they do help us to understand our problems and challenges at many other scales. Islands do symbolize that balance of isolated independence and integration into larger systems that are essential characteristics of all physical existence, whether geographically or metaphorically. Our planet too is an island in space, and we may have yet to learn to live within its limits.

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