

# **MARINE PRODUCTIVITY:**

*Explaining Geographic Patterns of Economic Development*

**Caleb McClennen  
Professor Perry  
Contemporary Oceanic Issues  
December 11, 2003**

***‘Geography determines all’***  
– Napoleon Bonaparte<sup>1</sup>

It is no revelation to oceanic scholars that we live in an academically *terracentric* society. We seek explanations to problems and phenomenon first and often exclusively through investigation limited to land-based circumstances. This makes sense for a creature that evolved in the jungle as opposed to the sea. However, the oceans have played a vast and important role in our human history. They may, as this paper suggests, have been one of the central drivers to human economic development.

“Why is it that you white people developed so much cargo and brought it to New Guinea, but we black people had little cargo of our own?” questions the Yali in the beginning of Jared Diamond’s *Guns, Germs and Steel*.<sup>2</sup> The partial answer, according to the author, includes a geographic alignment of continental landmasses and corresponding ecological zones that served as a catalyst for agricultural advantage, disease prevalence and cultural exchange. Gallup, Sachs and Mellinger expand on Diamond’s thesis by empirically proving the advantage of coastal economies in the northern temperate zone.<sup>3</sup> These economies are theorized to have a distinct economic advantage over all other competitors due to lower transport costs, agricultural production, and patterns of disease prevalence. While both Diamond and Sachs have built highly credible theses, based on geographic and climatic considerations, they have failed to incorporate the biological geography of the ocean into their theories. The northern, temperate and coastal economies also happen

---

<sup>1</sup> Wigan, Michael. *The Last of the Hunter Gatherers: Fisheries Crisis at Sea*. Swan Hill Press. Shrewsbury, England. 1998.

<sup>2</sup> Diamond, Jared. *Guns, Germs and Steel: The Fates of Human Societies*. W. W. Norton and Company. New York. 1997.

<sup>3</sup> Gallup, Sachs and Mellinger. *Geography and Economic Development*. CID Working Papers No. 1 Harvard University 2001

to be located within some of the most highly productive marine environments in the world. Thus, an additional geographic advantage, governed by thermodynamic and biochemical principles, is a nation's proximity and access to the most productive regions of the world's oceans. In developing England it was acknowledged that an acre of sea could yield as much food fit for human consumption as a *hundred* acres of adjacent grassland.<sup>4</sup> This paper demonstrates the role geographically varied coastal resources have played throughout the history of human settlement: building of civilization, then of empires, and now the diversified development of countries with few other natural resources. As Jared Diamond characterized land-based eco-regions of importance, here the focus is on the importance of patterns in oceanic productive systems for human economic development.

Proximity to natural resources has always been accepted as a driver and stimulus, perhaps even a necessity for economic growth. Somehow, for a people to increase their economic well-being, they historically needed natural resources of their own, or the ability to tap into the natural resources of others. Mark Kurlansky's *Cod* illustrates what fisheries production can mean to a developing country. In the 1600s, New England's productive waters contributed to the assured food security of the settlers. As time passed, the fortunes of many of the early colonialists were built on the natural abundance their marine environment offered. The Bostonian purses were fattened on the mercantilist triangle trade of cod to Britain for manufactured goods and to the Caribbean for sugar imports back into the New England economy. Only the North Atlantic was geographically situated to spurn the growth of America's northern colonies via a thousand year cod fishery. However, as with all primary economic activities, the

---

<sup>4</sup> Gallup, Sachs and Mellinger et al.

importance of marine productivity faded through time. Now, what was once a major element of the colonies is but a fading glimmer of subsidized and increasingly poor US fishers. In other economies however, marine resource extraction and export is still a major driver for growth.

### ***The Biological Geography of the Ocean***

Thus, an important question must be asked. What drives oceanic biological productivity? Off shore, marine productivity primarily relies on the availability of two main ingredients: nutrients and sunlight. Both are the crucial elements for photosynthetic organisms, the base of the food chain. Elevated levels of nutrients and light, increase plant matter, which in turn increases the supported ecosystem biomass. Sunlight is available around the world in the top ten to one hundred meters of the ocean, called the photic zone, for much of the day. Thus, the only geographically variable factor is nutrient availability. A survey of the world's oceans finds the most highly productive systems where there are nutrients, and the least productive systems where there are little to none.

The distribution of nutrients is slightly complex and ever changing. However, there are global patterns that can be recognized. Nutrients tend to sink into the colder, darker, denser layers of water, away from the light. This fact is coupled with solar heating of the sea-surface, making it less dense; thus preventing the deep, cold, nutrient rich water from breaking to the surface in normal conditions. Only through upwelling or vertical mixing can the deep nutrient-rich water make it to the surface. Vertical mixing occurs most

frequently with temperature-driven density changes, while upwelling tends to result from strong surface winds. The geography of the ocean is thus primarily determined by where this upwelling and vertical mixing, exists, dependant on prevailing winds and seasonal temperature changes.

Satellite data has been processed to reveal the areas of the earth that are most and least productive. Figure 1 shows a global distribution of primary productivity. There are three geographic regions that specifically benefit from these processes. First, the most significant productivity is due to seasonal mixing every fall and winter, as ocean water cools at the surface in the northern and southern temperate zones. The cooler surface water becomes dense enough to vertically mix with the previously denser, nutrient rich water. Hence, Fig 1. reveals at about thirty-five degrees north and south of the equator, there is much higher productivity. Second, along the western edge of continental landmasses, just north and south of the equator, coastal upwelling is apparent. This is due to prevailing northeasterly and southeasterly trade winds that effectively push surface waters away from the coastline, necessitating their replacement by upwelled nutrient rich waters. Finally, though the trade winds effectively blow latitudinally westwards near the equator, a phenomenon called Ekman transport, resulting from the rotation of the earth, divergently pushes net surface currents north and south. This net movement of water, creates a vacuum that is simultaneously filled by upwelled deeper water. Additionally, along the coasts, production tends to be greater, because the continental shelf keeps sinking nutrients close to the photic zone, and river run-off brings with it land-based nutrients. This effect is enhanced in regions, such as the Grand Banks in the North Atlantic, where oceanic conditions already provide elevated levels of productivity. Thus,

the combination of these three oceanic trends, plus a few river plumes and coastal intensification, help realize the global map of marine productivity witnessed in Figure 1. It must be recognized that the most dominant and extensive of these patterns is the vast productivity in northern and southern waters. Additionally, because the vast majority of the landmass on earth is in the northern hemisphere, it is this northern primary production that is of most interest for the historic development of human economies.

### ***The Nexus between Biological and Human Productivity***

This strong latitudinal determination of marine productivity directly correlates to the latitudinal trends in development. Gallup et al. point out very clearly the advantage of a northern coastal economy with regards to lower transport cost and agricultural potential. However, a view of the world at night shows a strong correlation between energized (hence economically active) population centers and the regions of the ocean's most productive waters. Figure 2 combines marine production with human economic geography. The map clearly demonstrates, on a continent by continent basis, the concentration of people and wealth firstly in the northern temperate zone and secondly along the coasts. Beyond this trend, a bias towards the world's most productive waters is clear, especially in the northern hemisphere. In North America, the greatest concentrations of wealth are on the northeast, Great Lakes and west coasts. In Eurasia, the largest concentrations of populations and wealth are on the western, European, and eastern—Japan, South Korea and China—coasts. In Australia, the greatest city centers—Perth, Melbourne, Brisbane and Sydney—all built themselves on the southern coasts. Africa, again, reveals its greatest wealth in South Africa, especially coastal Cape Town.

The apparent exception in this case is the Indian concentration of economic productivity that is evenly balanced throughout the subcontinent, perhaps even with a bias towards the center. Additionally, South America stands as a partial anomaly, although the wealthiest southern countries, Chile and Argentina, are adjacent to some of the world's most productive fishing grounds. The Andean concentration of wealth is partially due to its proximity to the Pacific equatorial upwelling zone, in the case of Peru and Ecuador. The Brazilian center, near Sao Paulo and Rio, though coastal, is significantly further north from the thriving southern oceans. In total, the geographic distribution of coastal wealth is variable, but demonstrates a relatively greater concentration on nutrient rich fishing grounds.

One of the most significant evidentiary problems with this thesis is not the location of wealth independent of marine productivity, but rather the location of marine productivity without adjacent wealth. There are three geographically distinct tropical regions where this occurs, which deserve further explanation. First, along the west coast of Africa in the northern and southern upwelling zones, one would expect higher levels of economic productivity. Of course, relative to the east African coast, the trend is evident in the *world at night* data. However, due to the unfortunate incongruent pattern of oceanic and terrestrial eco-regions, the same regions that yield the greatest marine productivity along the northern and southern African coasts are also home to the Sahara and Namib deserts. Similarly on the west coast of Peru, a substantial upwelling zone exists, supporting today's fisheries; however, the adjacent land is again a desert, yielding little or no agricultural production. The second tropical region of relative productivity is along the equatorial upwelling regions, off Gabon in Africa and Ecuador in South America. Here,

lush rainforests cover the land and the coastal waters are extremely rich. Historically Gabon has been an exporter of fish, but relatively recent exploitation of oil has overshadowed any impact fisheries have on the local economy. Similarly in Ecuador, though shrimp was recently its second largest export, petroleum now dwarfs any fishery export. Thus, while tropical countries have been able to capitalize a great deal from their equatorial fisheries, their productive potential is significantly less than that of the northern and southern oceans. Finally, the third anomaly is river outflows, such as the Amazon and Orinoco on the northeast coast of South America and the Congo River on the West African coast. These do not appear to provide for significant fisheries production, perhaps due to heavy loads of particulate matter and the extreme seasonality of their nutrient flows. These three anomalies aside, the dominance of the great Northern Fisheries and resulting human settlement and growth cannot be ignored.

Regression analyses of current fisheries productivity vs. GDP per capita was attempted with current production figures, but only a slight and insignificant positive correlation was determined (Fig 3). This is mostly due to the limited growth potential available in fisheries production, because of biological constraints. Fisheries, unlike agriculture and industry, have a natural limit as to how much product can be sustainably harvested. This, unfortunately, is a recent understanding, such that what once were great fisheries of the past have now faded into near non-existence. Thus, while on land a suitable agro-ecological zone can create an environment for productivity that can constantly be improved and provide increasing yields through technological change, fisheries have a cap. Technical change can improve coastal welfare for a few decades, but in case after case the increased production always results in an inevitable decline or crash in target

population. Moreover, the importance of fisheries and natural resource extraction portion of GDP tends to diminish through development such that past drivers have declined in importance. Without current evidence of substantial fisheries in modern day developed countries, with the partial exceptions of New Zealand and Iceland, we are forced to look back at the historical evidence to explain today's trends.

### *Historical Evidence*

While it is often cited that the cradle of civilization began with the Mesopotamians between the Tigris and Euphrates rivers; the first evidenced semi-sedentary human populations settled on the shores of the Baltic even earlier. Called the Maglemosiands, meaning 'big bog' in Danish, they made camp and began fishing for shellfish in some of the world's most productive coastal waters. Further data shows that these cultures were able to produce a surplus and trade with neighboring communities, furthering their development. Evidence of their early existence is witnessed in massive piles of oyster and other shellfish mounds, common throughout the world's coastal archeological record. Similar evidence remains from populations of the Nile River, Lake Rudolph in Kenya, Japan, Baja California and Peru, all between five and eight thousand years old. Certain historians credit the birth of some of the world's greatest civilizations to their proximity to coastal resources. There is archeological evidence that early Andean civilization first began exploiting the nutrient rich coasts before moving inland. Additionally, Mexico's first advanced civilization was situated along the coast. While these bits of archaeological evidence do little to explain today's distribution of wealth, they do

demonstrate the importance of marine resources in creating the first agglomerations of people, wealth and organized economic activity.<sup>5</sup>

### *The West European Coast*

Marine Productivity was a crucial element and a catalyst for early economic productivity in all four of today's oceanic cores—The western European coast, the east and west coasts of the US and the east Asian coast. The early English economic system, said to be based on wool and herring, grew to the credit of this the first large scale commercialized seafood. By the ninth century the first herring were being exported from the British Isles to the European mainland. Further east, by the fourteenth century, thousands of boats were fishing and processing herring between the various Northern European towns that made up the Hanseatic League in the Baltic. “Herring had become the very currency of trade.”<sup>6</sup> Then, perhaps due to what has now been called the ‘Little Ice Age’; the herring shifted out of the Baltic and reappeared off the coast of Holland. As thousands of Dutch boats began to exploit the fishery, the Dutch Empire began to expand around the world. Various disputes between the British and the Dutch erupted throughout the years. In 1651, an Act, similar to the modern day US Cabotage Act, prohibited any trade in herring in or out of England except on English ships. Meanwhile, Scotland was rising to international prominence as the world's leading exporter of herring. By 1808, the British again declared that ‘The improvement of the British herring fishery is an object of the most essential importance to the wealth and commercial prosperity, as well as to the

---

<sup>5</sup> McGoodwin, James R. *Crisis in the World's Fisheries: People, Problems and Policies*. Stanford University Press. Stanford. 1990.

<sup>6</sup> Wigan et. al.

naval strength, of this kingdom.”<sup>7</sup> Soon, more than eleven thousand British boats would be plying the North Sea and adjacent waters for herring.<sup>8</sup> Accordingly, the phrase ‘over fishing’ was first coined by fishery investigator John Cleghorn in 1854 with regards to the British fishery.<sup>9</sup> By the turn of the century the fisheries would be in steep decline.

At the same time as the herring trade was developing, the Basques, then the British and French amongst other European fishers, successfully exploited massive volumes of cod from the distant water fishery of the Grand Banks, east of Newfoundland. The Banks provided for perfect fishing grounds for cod and soon became a commodity throughout Europe. Again, thousands of boats ventured out, furthering European food security, providing a tradable commodity and enabling the region’s continued development.<sup>10</sup> Just as herring can be credited for aiding the rise of several European empires, cod has been crucial to the American economic rise.

### ***The East Coast of North America***

An recent analysis of the divergent development paths taken by the US colonies in contrast to those in Brazil attributes abundant maritime production as a key variable. Fisheries boosted the Northeastern colonies’ politics and economy in a direction that spurned growth and trade.

The North Atlantic system of trade and commerce included Europe, the Wine Islands, the West Indies and the Great Fishery. These components of the northern circulation system enabled the New England and Middle Atlantic colonies to create a prosperous, diversified and balanced

---

<sup>7</sup> Ibid.

<sup>8</sup> Ibid.

<sup>9</sup> Taylor, Joseph E. *Making Salmon: an environmental history of the Northwest fisheries crisis*. University of Washington Press. USA 1999

<sup>10</sup> Kurlansky, Mark. *Cod: A Biography of the Fish that Changed the World*. Penguin Press. USA. 1997.

economy... by exporting fish and agricultural staples on their own ships to North Atlantic Markets...<sup>11</sup>

In contrast, the same author describes Brazil's lack of southern trading partners, and 'meager' fishery resources. "The greatest and most productive fishing region in the world lay off the northeast coast of North America. One of the poorest was off the northeast coast of Brazil"<sup>12</sup> By 1650, six hundred New England fishing vessels and over four thousand men plied the Grand Banks. The New England colonies increasingly exploited their coastal fisheries and the Grand Banks for cod, haddock, mackerel and herring; in contrast, Brazilian fishers had hundreds of available species in their diverse waters, but none in such an abundance as to support anything but a subsistence fishery. As the North Atlantic mercantilist economy rose, salted cod became the New England economies' primary export, providing one of the few protein sources for distant trading and exploratory voyages. By 1784, the Massachusetts legislature recognized the importance of cod in their economy, and placed the fish as a symbol as a symbol representing the wealth upon which this region was first based.<sup>13</sup>

Along with fish, New Englanders became adept whalers and began to exploit the seas, first close to home, then abroad for whale oil and bone. Although the profits from whaling never significantly influenced the national economy, comprising only a third of a percent at its peak,<sup>14</sup> the industry, like the fisheries, had strong forward linkages. Investors in whaling and fish began to place their earnings in textiles and manufacturing as the industrial revolution took hold on the American continent. In contrast, Brazil

---

<sup>11</sup> DeWitt, John. *Early Globalization and the Economic Development of the United States and Brazil*. Praeger Publishers. Westport, CT. 2002. pg 22.

<sup>12</sup> Ibid. pg 60.

<sup>13</sup> Kurlansky et. Al.

<sup>14</sup> Davis, Gallman and Hutchins. *Call Me Ishmael-Not Domingo Floresta: The Rise and Fall of the American Whaling Industry*. in *Research in Economic History: Supplement 6 – 1991*. Jai Press Inc. Greenwich, Connecticut. 1991.

never had a choice to diversify its economy into the products of the sea, with whales or fish, and was for many years left behind by the industrial revolution.<sup>15</sup>

### *The Pacific Northwest*

The emergence of the northwest coast of the United States into the realm of international power was much later, but initially was settled for the exploitation of marine resources. The original fishery on the west coast is salmon. Although salmon are caught in freshwater and hence independent of the laws governing the oceans, the entire life cycle of the salmon are dependent on the rich northern and southern waters, greater than forty degrees latitude. These waters provide the sustenance of herring, mackerel and other small fish that are so abundant in these northern waters. Indigenous human populations survived for thousand of years fishing the salmon resource and were settled much denser along the rivers of the Pacific west for that reason. However, the first commercial expansion of the West was to exploit sea-otters and seals for the fur trade. The abundance of these creatures, with their thick fur coats, is due to the corollary abundance of their foodstuffs—clams, shellfish and other marine invertebrates—that thrive in the rich coastal waters. This group of settlers spread disease and essentially wiped out the majority of the indigenous fishers. Thus, a second wave of settlers, ironically from the exhausted east coast salmon fishery, began to fish the streams and adjacent coastal waters for salmon soon thereafter. By 1865 the first industrial salmon canneries appeared. Less than twenty years later, there were 37 canneries on the Colombia River alone, producing 42 million pounds of canned salmon a year for export to the east coast, England and

---

<sup>15</sup> DeWitt et. al.

Europe.<sup>16</sup> Again, relative to the national US economy this had minimal impact, but provided food security and the springboard for further economic development on the west coast in the 20<sup>th</sup> century.

### ***Japan***

Thus far, we have traced the western experience of economic development and regularly established that fisheries production has been a core supplier and determinant of economic development and growth at least in the initial stages of settlement and resource extraction. The final northern example is best made in the western Pacific around the archipelagic chain of Japanese islands. The importance of the sea to Japanese cuisine is common knowledge, but how much of this actually helped the nation grow? Again, the economic record is difficult to assess. The original tributes paid to the first Japanese emperors were paid in the form of various marine edibles. In a country with little grazing grounds, throughout history, fish has played an important role as the main source of protein and resulting food security for a rising power.<sup>17</sup> Additionally as agriculture became more and more developed on the island, sardine and herring were used as fertilizer to improve agricultural yields for other crops well before the Green Revolution. In the nineteenth century, the Northern Island of Hokkaido became the largest producer of herring meal for fertilizer and dried herring for food in Japan.<sup>18</sup> In 1939, a treatise was written about the importance of the 'North Ocean Fishery' to Japan's economic rise.<sup>19</sup>

The fishery, located north of modern day Japan in the Sea of Okhotsk, accounted for over

---

<sup>16</sup> Taylor et. al.

<sup>17</sup> Wigan et. al.

<sup>18</sup> Howell, David L. *Capitalism from Within: Economy, Society and the State in a Japanese Fishery*. University of California Press. Berkely. 1995

<sup>19</sup> Yasuo, Nagaharu. *The North Ocean Fishery in Japan's Economic Life*. Far Eastern Survey. Vol 8. No 9. April 1939. 106-108

a quarter of Japanese production at the time and resulted in several military and political disputes with the Russians. The fishery mostly supplied Blue Crab and Salmon to the Japanese markets. Overall, at that time, the author attributes fisheries as one of the most important economic activities in Japan, employing over a half million people and making Japan the number one producer of marine products in the world. The fisheries produced four million yen, or roughly two and a half percent of the entire Japanese economy at the time.

### *Conclusions*

We have examined the four central oceanic cores—Western Europe, Eastern and Western North America and East Asia. A dominant historical trend in the relative importance of marine productivity to the development of all of these economies can be witnessed.

What are the implications of these findings for the developing world today? There is no way currently to alter the oceans and make them more productive, at least thus far.<sup>20</sup> Are tropical countries doomed to a land-based path to development? It depends. Some countries have very effectively exploited their equatorial marine resources, such as Peru and Ecuador. Additionally, the recent trend of aquaculture development, has tried to enhance the marine segment of primary production. Although the tropical waters cannot be controlled to produce more nutrients, small scale pens or ponds of fed fish can grow anywhere. The promise of aquaculture is to bring food security to areas without other sources of protein. Thus far, aquaculture development has been very balanced between the tropics and the temperate latitudes. Some of the top aquaculture producers in the

---

<sup>20</sup> Though projects such as the Iron-X experiment in the Tropical Pacific has made attempts to do such an endeavor by adding particulate iron to nutrient depleted waters. The hope is that production would begin positive feedback cycle, unfortunately the iron sank and costs were extremely high.

world are tropical developing countries such as India, China, Philippines, Indonesia, Thailand and Bangladesh.<sup>21</sup> However, the geography of aquaculture production is outside the scope of this paper.

In conclusion, this paper has established a strong correlation between the macro-geographic patterns and levels of both human and marine productivity. The tendency for the most developed northern coastal economies to be located proximate to the world's greatest fisheries is not inconsequential. Though the ocean's resources are surely not the only catalyst for human development, it is evident that throughout history they have played, and will continue to play, a crucial role in diversifying the economies of coastal populations. Due to the human tendency for over exploitation of fishery resources, what was once abundant is now in slow recovery. Thus, global fishery production figures do not reveal the importance of this resource for development. In combination with favorable conditions for agricultural production in temperate latitudes, patterns of global disease and the low cost of marine transport, the geographic distribution of marine productivity must be added to a list of crucial factors determining the spatial disparities in human economic development.

---

<sup>21</sup> FAO. *State of World Fisheries and Aquaculture*. [http://www.fao.org/sof/sofia/index\\_en.htm](http://www.fao.org/sof/sofia/index_en.htm)

## **Bibliography**

**Davis, Gallman and Hutchins. *CallMe Ishmael-Not Domingo Floresta: The Rise and Fall of the American Whaling Industry.* in *Research in Economic History: Supplement 6 – 1991.* Jai Press Inc. Greenwich, Connecticut. 1991.**

**DeWitt, John. *Early Globalization and the Economic Development of the United States and Brazil.* Praeger Publishers. Westport, CT. 2002.**

**Diamond, Jared. *Guns, Germs and Steel: The Fates of Human Societies.* W. W. Norton and Company. New York. 1997.**

**Gallup, Sachs and Mellinger. *Geography and Economic Development.* CID Working Papers No. 1 Harvard University 2001**

**Howell, David L. *Capitalism from Within: Economy, Society and the State in a Japanese Fishery.* University of California Press. Berkely. 1995**

**Kurlansky, Mark. *Cod: A Biography of the Fish that Changed the World.* Penguin Press. USA. 1997.**

**McGoodwin, James R. *Crisis in the World's Fisheries: People, Problems and Policies.* Stanford University Press. Stanford. 1990.**

**Taylor, Joseph E. *Making Salmon: an environmental history of the Northwest fisheries crisis.* University of Washington Press. USA 1999**

**Wigan, Michael. *The Last of the Hunter Gatherers: Fisheries Crisis at Sea.* Swan Hill Press. Shrewsbury, England. 1998.**

**Yasuo, Nagaharu. *The North Ocean Fishery in Japan's Economic Life.* Far Eastern Survey. Vol 8. No 9. April 1939.**

**FAO. *State of World Fisheries and Aquaculture.*  
Accessed from [http://www.fao.org/sof/sofia/index\\_en.htm](http://www.fao.org/sof/sofia/index_en.htm)**