DEVELOPMENT OF COASTAL SCIENCE AND ENGINEERING: PART 1 - FROM CHAOS TO ORDER

J.W. Kamphuis
Civil Engineering, Queen's University
Kingston, Ontario, Canada L7R 4A6

ABSTRACT/RESUME

This paper traces the development of coastal science and engineering through the modern era. It is followed by a companion paper, "From Order to Chaos", that traces their development in postmodern times.

Cette présentation documente l'évolution de la science et du génie côtier durant l'ère moderne. Elle est suivie d'une communication intitulée "From Order to Chaos", qui documente leur évolution durant l'époque postmoderne.

INTRODUCTION

The history of Coastal Science and Engineering is of course related to the history of civilization and development of technology. To understand the one means we must understand the other. Hence, we will first recall general historical development. This we think (or like to think) is a journey from original chaos to one of order.

Table 1: Simplistic view of societal development

Phase	**1**	**2**	**3**
Keyword	**Providence**	**Progress**	**Nihilism**
Time	400 - 1600	1600 - 1800	1800 +
Philosophy (ers)	Hippo	Enlightenment	Nietzsche, Heidegger
Laws	Laws of God(s)	Laws of Nature	None
Crux	History is linear (not cyclical as believed earlier). Hope is future-oriented (other-worldly)	Secular version of providence. Hope is in a future here on earth.	Futility of any system. Progress is an aberration.

It is simplistic, but realistic to divide societal development over the past two millennia into three phases, as summarized in Table 1. I am indebted to Lyon (1999) for the basic ideas. In this paper we will use some sociological jargon – terms such as modern[1],

[1] *Modern*: Belonging to the era when we thought everything was possible, the era when society thought it made progress.

postmodern[2], paradigm shift[3] – because they are flags that identify rather complex societal developments and have now become generally adopted into our lexicon.

In the first phase of development, a very short time ago (on a geological time scale) or a long time ago (on our time scale), the operative word was providence. Every civilization believed in God (or in gods) and his (her) laws were the rule of life. Life was simple – please the gods and they will provide for you[4]. But a few hundred years ago this became too simple for some. They thought that thinking human beings should be less dependent on fickle gods. They proposed that we take our lives into our own hands. We should be responsible for our own fate. The inscrutable laws of the gods should be replaced by the one aspect of life that appeared constant – the laws of nature. These laws are not inscrutable; they can be subjected to study. Thus we should in time be able to understand these laws and then steer our own course into the future. We should be able to chart progress from Chaos to Order[5].

Quickly the "scientific" work began to understand the laws of nature. They were unraveled and it appeared to the scientists involved that our understanding of these laws would ever increase, until we clearly knew what they were, how we had to deal with them and how we could even make improvements. The *modern* era had begun. Scientific method and discovery were seen as new paradigms. But two to three hundred years later, we began to discover that perhaps life is still inscrutable. Why in the light of the enlightenment and all that rigorous scientific follow-up are there still violence, war and cancer, and why do we not understand the common cold?

Thus the *postmodern* era began with thinkers such as Nietzsche (1844-1900) followed by others like Heidegger (1889-1976). Although the ideas took quite some time to take hold, it is generally perceived that mainstream thinking today is postmodern. Some individuals and whole areas of life still subscribe to modernity (Yes, we can! - given enough funding, effort, education and research). Much of such antiquated thinking is actually still found the areas of science and technology.

In this paper, **From Chaos to Order**, we will trace the development of modern science and technology. We leave the disillusionment and steps into postmodernity to a companion paper **From Order to Chaos**. The journey from Chaos to Order will be

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[2] *Postmodern*: Belonging to the era after we woke up to the fact the concepts of the modern era do not work.

[3] *Paradigm Shift*: A genuine shift from one model or standard to another – a profound change in thinking.

[4] A notable exception was the Sumerians (4000 BPE). Their civilization was the first to escape the clutches of simple agrarian survival routine and to think independently of their gods. They invented writing to record their thoughts. The Gilgamesh epic (2700 BPE) describes their relationships to their gods. They also invented ownership of property, the wheel (3700 BPE), the plow, and a math system (base 60, which is still in use in our time keeping). Hammurabi (1700BPE) re-united the Sumerian civilization (as Babylonians) and is known for his vast irrigation and construction projects as well as his codification of the Babylonian laws (from which many of our legal tenets are derived). Greek thinkers formed the next exception (400 BPE).

[5] This age of enlightenment was a general change in thinking, which brought us into the modern world. This was not the first such paradigm shift. We already noted the Sumerians and Greeks (Footnote 4).

traced through examples of societal changes and will focus increasingly on science, technology, hydraulics, fluid mechanics, and finally coastal engineering and science.

MODERNITY

The rise of modernity can be traced through the societal benchmarks in Table 2. Also included in Table 2 are names and benchmarks from the fields of hydraulics, fluid mechanics. Coastal science and engineering[6] prior to 1950 was mainly concerned with large issues of national interest, such as national defence, transportation and safety from flooding. The keyword for the modern era was *progress* and the tools to achieve this may be characterized by *systems* and *organization*. The rise of the great research institutions began in this modern era - every country needed (a) national research organization(s).

Table 2: Modernity

"Modern" is defined by its systems, organization and progress	
Societal benchmarks	**Fluids parallels**
Age of enlightenment (1600-1800)	Galileo, Descartes, Pascal, Hooke, Newton, Leibnitz,
Era of colonialism (1600 – 1950)	
Industrial, French and American revolutions (1750-1850)	Bernoulli, Euler, d'Alembert, Lagrange, Laplace, Gerstner, Chezy, Navier, Coriolis
Victorian optimism (1850-1910)	Saint-Venant, Airy, Russell, Froude, Francis, Stokes, Helmholz, Kelvin, Dupuis, Vernon-Harcourt, Pelton, Boussinesq, Reynolds, Rayleigh, Lamb. Work on waves and wave theory. Some coastal modelling
"Great" war (1914-1918)	
Chicago world's fair "A century of progress" (1933)	Physical modelling – The large laboratories start. Much of the work concentrated on transportation and national safety. Engels, Rehbock, Freeman
Rise of National Socialism (1933-1945), and WW II.	Waves and coastal research takes place in support of the war effort (Sverdrup, Munk).
Post-war optimism (1948-1968)	Prandtl, Blasius, von Karman, Taylor, Bakhmetev. Large research institutions flourish.
Science and technology boom (1948 -)	Explosion of hydraulics facilities and papers in all areas of hydraulics and fluid mechanics.
Rise of consumer society (1948 -) Demand for industrial products (houses, automobiles, infrastructure) increased rapidly.	Real beginning of Coastal Engineering and science in support of transportation (shipping and ports), safety against flooding and erosion, and tourism.

It is in this buoyant atmosphere of modernity that coastal science and engineering grew up. The pioneering work of wave forecasting and maritime construction to support the effort in World War II from 1940 to 1945 was followed by a large expansion of funding

[6] Coastal management is a very recent discipline. Historically it was synonymous with coastal engineering. Managing the coasts (essentially to maximize its economic value) was expressed completely in design and construction related to personal safety, military defense and transportation (Kamphuis, 2000, Ch 10).

and facilities related to coastal science and engineering. Fishing ports needed to be built and improved to accommodate larger vessels, new transportation systems needed to be developed, shorelines were improved and shore protection was built to provide safety against flooding and shore erosion. The International Conferences on Coastal Engineering started in 1950.

MODERN COASTAL SCIENCE AND ENGINEERING IN CANADA

Focusing on Canada, fishing ports were built and improved. Marine transportation corridors, such as the St. Lawrence Seaway and the Fraser River, were developed and improved. The National Research Council of Canada (NRCC) was established in 1916 and owned a large towing tank in the 1930s. By 1945 the NRCC hydraulics laboratory and ship laboratory had been formed. The NRCC hydraulics facility became essentially a coastal engineering laboratory in the early 1960s, studying for example, tides and tidal currents on the Fraser and St. Lawrence River and Estuary, and waves in the Great Lakes and along the Gulf of St. Lawrence. Queen's University's Coastal Research Laboratory was begun in 1959 with an NRCC grant. Its initial studies concerned shore erosion on the Great Lakes, the development of alternative, inexpensive solutions to breakwater construction, damage caused by landslide and ship-generated waves.

In this modern era, every bit of research was indeed considered to add to the general body of knowledge and given time and funding, we could improve the solution of coastal problems, providing accurate answers for questions that had been there since antiquity. These were halcyon times and in the midst of all this optimism, the computer arrived, spurring even greater euphoria. These exciting times continued into the 1980s. More on the history of Canadian coastal engineering may be found in Kamphuis (1996).

TOWARDS END OF COASTAL MODERNITY IN CANADA

However, clouds appeared on the horizon of this bright future as early as 1970. At the International Conference on Coastal Engineering in Washington a discussion took place about the value of hydraulic model studies – the backbone of coastal research and design. Although the clients trusted the model results, the modelers themselves had difficulty believing them. They saw that physical modelling, upon which much of coastal engineering knowledge was based, had reached practical limits. Because of limitations such as scale and laboratory effects, models could only provide answers up to a certain level of accuracy. If to improve the results larger models were used, the costs of such models was so large that clients were no longer willing to pay for them. The *malaise* increased as time progressed. This was essentially just one of *our* manifestations of the coming to an end of the modern era. Table 3 describes some of the symptoms in more detail.

Table 3: The End of Modernity

The Modern "systems" do (did) not work	
Societal benchmarks	**Technical parallels**
There seems to be an end (limit) to "Progress"	Theoretical frameworks, physical and numerical models cannot describe what happens in practice.
Extrapolation of existing political and societal systems no longer works.	Larger groins and higher seawalls, larger models and higher order equations are not the answer. (What good is a higher order equation when the coefficients that need to be introduced can vary over two orders of magnitude, without adequate explanation?)
Existing political systems such as colonialism and finally communism disintegrated.	Position of leadership and authority of some universities and national laboratories gradually eroded.
Large agglomerations (e.g. "Africa", USSR, Canada?) were replaced by many small nation states.	The few recognized centres of presumed excellence were replaced by many small centres of excellent thought and application
At the same time a few super states arose (e.g. US and EU)	Some of the large research and engineering centres re-emerged as (physical and numerical) superpowers.
Some participants continue the "modern" course of development and progress.	Most technical research and publication continues unabatedly along "modern" lines – systematic research is presumed to lead to progress.
Negative impacts of modernity such as environmental degradation and depletion of natural resources lead to a questioning of status quo.	Negative impacts of modern engineering such as environmental degradation and depletion of natural resources lead to a questioning of status quo.
There seems to be too much emphasis on specialization and too little integration of the various disciplines	Communication between theory and academe on the one hand, and design and practice on the other has broken down.

The *malaise* appeared at different times in different disciplines. Whereas some philosophers began to feel uneasy about progress and the directions of modernity as early in the 19th century, some scientists and engineers are still not aware of the limitations of modern science and technology in the 21st century. The recognition of the limitations in a field is also related to where on the learning and development curves a discipline finds itself. While electronics, communications and data transmission, for example, are on the steep parts of their learning curves, coastal engineering's curves have flattened considerably since the halcyon days of the 1950s to 1970s. Thus in the electronics field, there is still great optimism that the word's problems will eventually be solved by larger, faster computers and more sophisticated software.

In our field there may still be some who believe that more sophisticated numerical modelling will provide ever better answers, but most scientists and engineers now recognize the uncertainties of our methods and results. They also recognise that it is unlikely that we will be able to produce much better answers in the future. Many of us do not believe that our knowledge will improve rapidly and indefinitely. At the same

time, clients are beginning to ask the same questions about our numerical modelling, as they did in the 1970s about our physical modelling.

As we approached the end of the modern era, two new words gradually crept into the daily lexicon of the coastal engineers and scientists. These were "sustainability" and "uncertainty". They reflect the realization that solutions need to be found with the future (of the world) in mind and that these solutions have limitations at present and will probably not become much more certain in the future.

This brings us to *Postmodernity*, a journey that will be further described in the next act, titled **"From Order to Chaos"**.

REFERENCES

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