The Fractal Geometry of Estuaries

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An example of the kind of new studies which can be undertaken at South Slough are exemplified in the new field of fractals. Benoit Mandelbrot has gained worldwide attention with his development of this new science. Mr. Mandelbrot developed this field in part to provide a method for studying the geometry of natural objects. Thus, in the introduction to his classic book The Fractal Geometry of Nature, Mandelbrot asks:

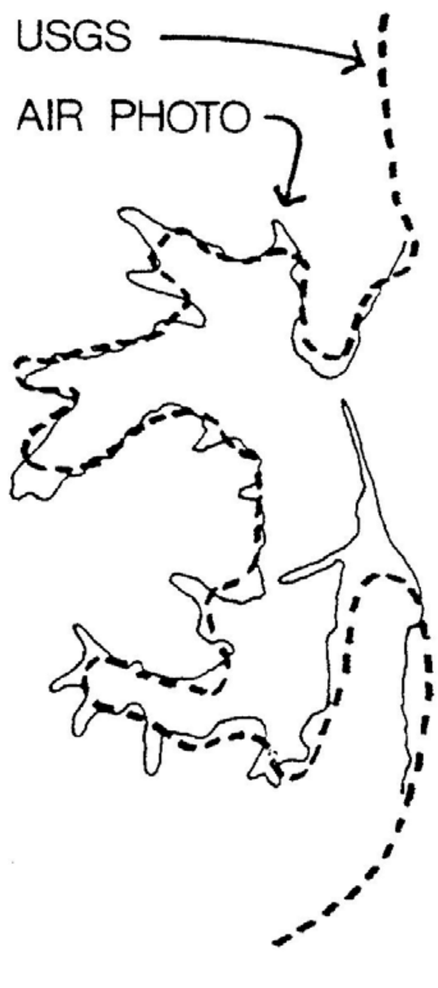
"Why is geometry often described as 'cold' and 'dry'? One reason lies in its inability to describe the shape of a cloud, a mountain, a coastline, or a tree."

In examining this contradiction, Mandelbrot identified a family of shapes called fractals which do prove useful in describing the geometry of nature, and are leading science into a mode of being able to better understand what heretofore could only be described as "chaos".

A fundamental problem within the study of fractals is to determine the length of a shoreline. In the case of South Slough we can phrase the problem as:

"How long is the shoreline at South Slough?"

Although it sounds like a simple problem, if a portion of shoreline is first measured on a USGS topographic map and then measured on a more detailed air photo, it will be found that the shoreline length increases.



The distance increases because the more detailed in's and out's of the shoreline can be measured in greater detail on an air photo than on the USGS map. Common sense tells us that as we increase the fine detail of our measurements, the distance of the shoreline will forever continue to increase. What sense can we make of a continuously increasing shoreline length?

Mandelbrot developed a method whereby a "fractal dimension" of a shoreline can be determined. Unlike the ever changing distance of the shoreline, the fractal dimension for a specific type of shoreline may be found to be constant, and more importantly--highly descriptive of the shoreline's geometry.

Using Mandelbrot's methodology we find that a sample estuary shoreline length determined alternately from a

USGS map and then an air photo, suggests a fractal dimension of D=1.2 for the South Slough estuary high tide shoreline.

When one adds to this analysis the extreme changes in estuary shoreline length that occur as the tide comes in and out we recognize that estuary shorelines are unusually complex. For example, performing similar measurements to those described above, but for low tide conditions, suggests a fractal dimension of D=1.5, somewhat greater than that of the high tide.

Application of the science of fractals to the study of South Slough may provide a descriptive methodology for classifying estuary types and for relating estuaries to the continuum of other shoreline types, which could provide a basic organization and methodology to the science of estuaries as a whole.

Fractals represent a distinctly new way of scientifically describing natural systems. The watershed walkway and trail system can function as an armature for introducing these concepts to students and the public, as well as for the undertaking of original research.