tested—regardless of an obvious economic advantage. They prefer "yesterday's technology"—and perhaps "just formulas"!! Consequently, it has proven to be difficult to "sell" the berm breakwater. The "from the beginning of stable" S-breakwater is more receptive to them. Its advantages include developed theories (Bruun and Johannesson, 1974, 1976, Kobayashi and Jacobs, 1985) and the same economic advantages as the berm-breakwater (which is its "younger brother"). Its design meets the criticism by the PIANC-1976 report and other oppositions better by its compromising features. An example of an S-breakwater compared to a straight slope breakwater is shown in Brunn *et al.* (1985) for Nome, Alaska. It eliminated the need for large expensive rods.

The stable S-berm breakwater was not the topic of the Ottawa workshop which only has 3 references to it in its literature lists and no reference to PIANC-1976.

The proceedings include much good and useful information and "enthusiasm," without any fully rational handling, but an excellent paper by Dr. Mansard on wave criteria in shoaling waters, and a paper by Ahrens on reef breakwaters. The authors were not concerned with "inertia of human nature." The proceedings have no general conclusion—but just a little step "towards the right" (the stable S) may solve the problem with the unstable berm.

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Tides, Surges, and Mean Sea Level: A Handbook for Engineers and Scientists, by D. T. Pugh, 1987: Wiley, London, 472 pp. $115 plus postage and handling.

The author has a background in geophysics and physical oceanography, but has shown practical aspects of engineering nature including recording and analysis of data of considerable interest. As mentioned in the preface, some of the material in the book was used for education of students with an academic background varying from mathematics to field geology. It is stated by the author in the preface that:

> This range of previous scientific experience inevitably causes difficulties in determining the level of mathematical treatment which should be adopted. In this book, I have tried to keep the mathematics as simple as is consistent with a proper physical explanation, while developing the non-mathematical discussions in an essentially independent yet parallel way. Sections which may be omitted by the non-mathematical reader are marked with an asterisk.

As such, the book is "service-minded" and it does serve a good purpose of bridgebuilding between basics and applied subjects. No similar book on the combined topics exists.

Chapter 1 gives basic overviews ranging from "history" to "basic statistics of tides as time serves." It is followed by Chapter 2 on observations and data reduction covering of tide instrumentation. Satellite altimetry is a new, very important and promising development for defining the sea surface offshore. The same chapter reviews current measurements and the corresponding data reductions.

Chapter 3 on "forces" gives a detailed, but easily understandable, account on tidal forces on the seas by the moon and the sun as well as on the solid earth. Spring and leap tides, diurnal and semi-diurnal tides are explained. Section 3.22 on "the equilibrium tide" explains the equilibrium theory of tides which assumes the free surface to be level under the combined action of earth's gravity and the tidal disturbing forces. A subsection on "the geoid" says:

If there were no tidal forcing, no differences in water density, no currents and no atmospheric forcing, the sea surface would adjust to take the form of an equipotential surface. In this condition, because the force of gravity is always perpendicular to this surface, there are no horizontal forces to disturb the water. There are many reasons, discussed in Chapter 9, why this is not the case, and why the mean sea-level surface deviates from an equipotential surface by as much as a metre. Nevertheless, an equipotential surface is still an important reference for mean sea-level studies and it is appropriate to discuss the concept further here.

Basic hydrodynamic equations are given clearly and concisely. "Analysis and Prediction" is the subject of Chapter 4 which explains harmonic analysis including all the L/M/N, semi-diurnal and diurnal components as well as the various long period, 2 week, 4 week, semi-annual, 8.85 year and 18.6 year, and seasonal tides. It is explained how in shallow water the progression of a tidal wave is modified by bottom friction and other physical processes which depend on the square or higher powers of the tidal amplitude itself.

Some of the more important shallow water harmonic constituents are summarized in Table 4.4. Fitting procedures, choice of constituents in the tidal function, and harmonic equivalents of some non-harmonic terms are dealt with in separate subsections.

Response analysis techniques are mentioned in considerable detail in section 4.3 In *cit.:*

The basic ideas involved in Response Analysis are common to many activities. A system, sometimes called a 'black box' is subjected to an external stimulus or input. The output from the system depends on the input and the system's response to that input. The response of the system may be evaluated by comparing the input and output functions. These ideas are common in many different contexts. Financially one might ask how the economy responds to an increase in interest rates, and measure this response in terms of industrial production. In engineering the response of a bridge to various wind speeds and directions may be monitored in terms of its displacement or its vibration. Mathematical techniques for describing system responses have been developed and applied extensively in the fields of electrical and communication engineering.

Later,

A criterion of a good analysis is one which represents the data with the smallest possible number of parameters, the response procedure is superior to the harmonic approach: typically the response technique can account for slightly more of the total variance than the harmonic method can accommodate, using less than half the number of harmonic parameters. Its advantages as a research tool include the identification of additional forcing inputs, and the opportunity of making subtle choices of factors for inclusion. A typical response analysis will have the gravitational input, the solar radiation input and a series of shallow-water interactive inputs. By comparison, the harmonic analysis approach offers few alternatives, apart from the addition of extra constituents, and little scope for development. The laborious adjustments for nodal variations illustrate this restriction. These variations are automatically taken care of in response analysis. In harmonic analyses the shallow-water effects and the radiation effects are automatically absorbed together into the estimates of the constituents.

Section 4.4 gives detailed information on the analysis of currents in the ocean.

The very important practical problem of the accuracy of tidal parameters is dealt with in Section 4.6 which also discusses the reasons for variances. Tidal prediction is explained in Section 4.7. The standard practice is to publish high and low water times and heights in official tables, for a selected list of Standard or Reference Stations. The tables also include sets of constants for adjusting the times and heights for intermediate places, called Secondary or Subordinate Stations. Tables refer predicted levels to the local Chart Datum of soundings. The easily read subsection 4.72 gives interesting historical information on tide prediction.

From an engineering point of view, Chapter 5 on "Tidal Dynamics" is probably the most interesting chapter of the book. The Equilibrium Tide developed from Newton's theory of gravitation consists of two symmetrical tidal bulges, directly under and directly opposite the moon or sun. Semi-diurnal tidal ranges would reach their maximum value of about 0.5 m at equatorial latitudes. The individual high water bulges would track around the earth, moving from east to west in steady progression. These characteristics are clearly not those of the observed tides.

The deviations of the real world from Newton's have many causes related to the propagation of water under a variety of geometrical conditions subjected to earth's rotation as well as to its elastic deformations. Long wave propagation, standing waves and resonance is explained. The subsection on "tidal charts" gives overall information on tidal behavior in world oceans. The co-tidal and co-amplitude charts, including amphidromic systems, are particularly interesting. Tides in enclosed seas and shelf tides and currents of particular interest to engineering are explained and well illustrated by figures.

The terminology "tide" does however, not only refer "to the moon," but to storm tides as well. Storm surges (Chapter 6) occur everywhere in the world, associated with deep low pressures, hurricanes, typhoons, *etc.* The reaction of the sea level to barometric pressures and winds including seasonal modes and Ekman transports are described briefly including numerical modelling of surges, with examples of *slosh-basins,* that means defined sea territories for which numerical modelling is applied. Seiches and tsunamis are explained in separate sections. Wave set-up, surf beats (and edge waves) are defined without hydrodynamic details.

Shallow-water Dynamics dealt with in Chapter 7, is a very complex field which cannot be fully explained in just 33 pages. Yet these pages still give a simplified and easily understandable account of essential aspects including nonlinear interactions, friction aspects, behavior of wind waves travelling over finite water depths and currents over a friction bottom (along headlands) and in channels. These sections are abstracts only with a few references to more detailed literature. Tides in rivers and tidal bores are mentioned briefly by simple hydrodynamics. Tide surge interactions (Section 7.8) are very important for shallow-water areas where large surges may be generated. Examples are given of the surge-infested lower North Sea. Energy budgets (Section 7.9) are explained including losses by friction.

Energy losses in shallow seas result in a systematic adjustment of the tidal patterns. Consider the case of a standing wave on a rotating earth which produces an amphidromic system as illustrated in Figure 5.6. If the wave is not totally reflected at the head of a channel, the returning wave will have a smaller amplitude. As a result, in the northern hemisphere the amphidromic point will be displaced from the center line of the channel towards the left of the direction of the in going wave. A very good example of this displacement is shown by the distribution of M_2 amphidromes in the North Sea.

The author, as expressed in the preface, has several years of experience in engineering applications as advisor to consultants and to government departments on engineering aspects. Chapter 8 on "Tidal Engineering" bears witness hereof in its sections on operating and extreme conditions including analysis of extreme values, joint tide-surge probabilities, and modelling from extreme winds and extreme currents. Section 8.4 on wind, waves, currents and levels is a brief abstract with references to more comprehensive literature. Sections on aspects of coastal and offshore engineering as well as power generation just touch the respective subjects, putting them "on record."

Coastal engineers and scientists will find Chapter 9 on "Mean Sea Level" extremely interesting, not least due to the somewhat contraversal subject of "rising sea level." A great deal of useful information on definitions, datrum determination and stability, seasonal as well as long term changes of M.S.L. in relation to geographical locations are given. Of particular interest to those involved in the environmental effects of a rising sea level is subsection 9.53 on "secular trends and eustatic changes." Table 9.2 gives "fits of linear trends to long series of annual mean sea levels and the estimated rates of sea-level rise," all in mm with standard errors.

Chapter 10 on "Geological Processes" is an abstract giving a few essential facts and some reference literature. Of particular interest to the coastal geomorphologist or geophysicist is section 10.4 on "offshore tidal sediments," section 10.5 on "tides past" (tide history), and section 10.6 on "mean sea level: the geological record," including Figure 10:4 which is an excellent overview of the apparent sea level rise since 10,000 BP from records in Argentina, Australia, Ceylon, Florida, Holland and Mexico. Figure 10:15 gives sea level rise/isostatic uplifts for North Europe revealing that the O-line (equilibrium) now passes through the middle of the Baltic Sea and the northern part of

Denmark up through Western Norway. From section 10.7:

> To summarize, the best recent analyses of eustatic sea-level trends (Barnett, 1984. See also Etkins and Epstein, 1982; Gornitz et al., 1982; Barnett, 1983a) based on a global average, and assuming positive and negative eperiogenic movements are randomly distributed, give increases from 120 to 150 mm per century. There are not enough observations to determine the source of the present sea-level increase, but observations of astronomical and climate change are compatible with this upward trend being due to the melting of ice from Antarctica and Greenland. However, only the average trends over a century in the several related observations are mutually consistent. Uncorrected variations over several decades are found in all the series. In addition to ice melting, some contribution to the observed increase of levels from warming of the surface layers of the ocean is also likely.

Chapter 11 is on "Biology: Some Tidal Influences," but has some physical sections of importance to biology.

The book has 4 appendixes: *Appendix 1,* "Filters for Tidal Time Series," *Appendix 2,* "Response Analysis Inputs and Theory," *Appendix 3* "Analysis of Currents," and *Appendix 4* "Theoretical Tidal Dynamics." In addition, a comprehensive "list of references" and finally a "glossary" which is very useful (should be read first!).

Each chapter has, as introduction, a small (1-2 lines) "piece of poetry." Chapter 7 starts as follows: "God does not care about our mathematical difficulties. He integrates empirically" (Albert Einstein. *In:* L. Infield, *Quest.*)

The book serves a very useful purpose as a handbook for the practical scientist and the scientific practitioner. Its strength lies in tides and tidal behavior but in addition it gives some good practical overall advice on related technical subjects of interest for coastal, offshore and port engineers.

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