Nevertheless, it is an exceedingly valuable publication, and it is hard to imagine that it will not be the authoritative source on its subject for many years to come. (Beau Riffenburgh, Scott Polar Research Institute, University of Cambridge, Lensfield Road, Cambridge CB2 1ER.)

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CLIMATE AND SEA LEVEL CHANGE: OBSERVATIONS, PROJECTIONS AND IMPLICATIONS. R.A. Warrick, E.M. Barrow, and T.M.L. Wrigley (Editors). 1993. Cambridge: Cambridge University Press. xvi + 424 p, diagrams and charts, hard cover. ISBN 0-521-39516-X. £45.00.

Among the many books written on aspects of global change, few take issue with the real problems of measuring sea-level change and estimating the effects of greenhouse-gas-induced warming on sea level. This book is an outgrowth of a multi-national workshop on 'Climate change, sea level, severe tropical storms and associated impacts' (sponsored by the United Nations, the Directorate General XII of the European Commission, the US Environmental Protection Agency, and the UK Water Resources Centre) held in Norwich, UK, at the Climate Research Unit, University of East Anglia, in September 1987. The chapters therein attempt to summarize and synthesize what is known of historical and modern sea-level change and then forecast the amplitude and impacts of future sea-level change given the enormous uncertainties in the natural system. Topics are masterfully organized into four sections: records of sea-level change during various time scales; modeling and future projections of sea-level change; impacts and case studies of sea-level change; and summaries of workshop panel discussions.

Five years is a long time to wait for synthesis papers from a workshop on such a timely topic. However, publication of this volume was purposely delayed to allow many authors to update their contributions in light of new greenhouse-gas emissions scenarios first published in 1990 and later revised in 1992 by the Intergovernmental Panel on Climate Change. With few exceptions, all of the chapters are as up to date as one might expect in such a rapidly changing research field. For example, recent work on post-glacial sea-level change by Tushingham and Peltier is included in several chapters, but references to revised sea-level curves produced by Fairbanks and colleagues at Lamont-Doherty and new modeling insights into the stability of the West Antarctic Ice Sheet by MacAyeal are not included in critical summaries on long-term sea-level change and the melting of ice sheets. This criticism should not detract from the quality of the work. One will find thorough reviews that are nicely cross-referenced from one chapter to another, much to the credit of the authors.

The first section is a chapter by Warrick, who provides a much needed summary of the linkages addressed in subsequent sections between climate change (mainly temperature) and sea-level change. He concisely contrasts estimates made by various authors of sea-level rise from different sources (such as thermal expansion and melting ice), highlighting inherent uncertainties. Notably, most scenarios project that sea-level rise will amount to less than a meter by the year 2100, but the range of best estimates is wide (20 to 100 cm). The second section includes five chapters assessing the quality of tide-gauge data and processes that confound both the accuracy and precision of these data. Two chapters in this section focus on methods of sea-level measurement and programs to establish regional and global networks of monitoring tide-gauge stations with geodetic baselines tuned by satellite. One chapter by Tooley reviews the Quaternary record of eustasy and demonstrates why the term global eustasy has become obsolete in favor of regional eustasy (a la Mörner) reflecting glacial/interglacial cycles modified by hydroisostatic, geodetic, and steric processes.

The third section in the book includes six chapters on future projections of sea-level change based on modeling simulations and best estimates of contributions from steric effects, the melting (or growth?) of the Antarctic and Greenland ice sheets, and contributions from small glaciers. All of these projections are dependent on estimates of the magnitude of greenhouse-gas-induced warming, making it difficult to come up with anything but low, median, and high values. Given the inevitable rise of sea level predicted, the chapter by Wrigley and Raper, among others in this book, should be required reading by politicians and planners worldwide.

The fourth section includes 10 chapters that focus on impacts and case studies of sea-level rise. The global distribution of these studies is impressive. Moreover, all studies emphasize the need to understand local processes mitigating sea-level rise, as well as the socio-economic impacts of permanent land loss, temporary flooding, and salt-water intrusion.

The final section of the volume consists of three brief chapters that summarize panel discussions by scientists attending the 1987 workshop. The first panel summarized the complex record of sea-level and climate change, predicting that during the next 40 years total sea-level rise will be about 13±4 cm; during the next 100 years sea level will likely rise by about 61 cm, or four times the present rate. The second panel reviewed the linkage between increased sea surface temperatures associated with rising sea level and the severity of tropical storms and storm surges. Unfortunately, the relationship is not unidirectional, as model simulations suggest that positive and negative correlations vary from region to region. The third panel compiled a comprehensive list of sea-level issues, including physcial effects, environmental and social/economic impacts, and necessary responses, to be urgently addressed by scientists and politicians. Probably the most important

needs are for policy makers to become knowledgeable about the potential impacts of rising sea level, for high risk areas to be identified, and for information about sea-level change to be translated into various languages.

This comprehensive volume should be of interest to researchers and policy-makers from a variety of disciplines, including climate modelers, coastal geomorphologists and sedimentologists, governmental environmental agencies, and federal emergency management agencies. It is a valuable reference for both professional and graduate level researchers and provides chapters adaptable as reading or lecture material for graduate and undergraduate courses in global change. (Julie Brigham-Grette, Quaternary Studies Program, University of Massachusetts, Amherst, MA 01003, USA.)

THE CANADIAN HABBAKUK PROJECT. Lorne W. Gold. 1993. Cambridge: International Glaciological Society. 323 p, illustrated, soft cover. ISBN 0-946417-16-4. £33.00; US$60.00.

At a cursory glance, the casual reader might be excused for thinking that on picking up Lorne Gold's *The Canadian Habbakuk Project* he has in his hands a work of science fiction. To the uninitiated the very 'possibility of building ships of ice' (page 9), which comprises the subject of this work, might seem to be more appropriate to the pages of a Jules Verne novel than to those of a meticulously written account of one of the Second World War's more unusual scientific projects. Throughout, the author is concerned to dispel the 'science-fiction nature of the project' (page 58), and as a social history of technology the text does its utmost to allay any residual temptation to judge the wisdom of the project by modern-day standards.

The inspiration of ice as a construction material of war was that of Geoffrey Pyke, an 'eccentric individual' (page 19) as richly complex and unpredictable as the project that was to develop out of the 35,000-word proposal that he delivered to Mountbatten in October 1942. A man with a 'natural ability to do the unexpected and unorthodox' and whose 'ideas often bordered on the bizarre' (page 19), Pyke had nevertheless already successfully provided the imaginative impetus for 'Project Plough,' from which 'evolved the versatile all-terrain tracked vehicle' (page 19).

Pyke's proposition to Mountbatten was deceptively simple. He reasoned that winning the war required total mastery of the oceans and the provision of floating airfields. To achieve this required the construction of a radically new vessel built from an unusual but common material — ice. Ice, he argued, was cheap, easily produced, and could be used to construct 'bergships' that could be formed in any size, insulated and cooled to prevent melting, and made practically invulnerable to attack. In a context when Britain was suffering heavy losses at sea, Mountbatten was 'intrigued' (page 9) and Churchill 'impressed' (page 10). The former commented: 'Someone in Canada is alleged to have said "this scheme is so damned crazy that one has to take it seriously" ' (page 38).

Despite the project's British origins, it was immediately evident that substantial research would have to be undertaken on a large scale and in cold conditions. Canada was thus quickly involved. Contrary to Pyke's original assertions, this research revealed that ice alone was too brittle and uncertain in its properties as a construction material, precipitating a search for a reliable means of reinforcement. Extensive experimentation revealed that a combination of wood chips and ice formed a material sufficiently durable for the purpose of the project. It was named 'pykrete' in honour of the man who conceived the project. This new substance was repeatedly tested to destruction and on two separate occasions during high level meetings repelled revolver bullets with dramatic consequences. Once the bullet 'glanced off one of the senior officers' (page 55) and on another occasion 'the bullet that bounced off the block of pykrete struck the shoulder of the Chief of the Imperial Staff' (page 58).

The great potential and strategic significance of 'bergships,' coupled with the sketchy knowledge of the properties of ice and of experience in using it as a structural material, effectively neutralised opposition to the scheme. In combination, though, these factors were to prove its undoing. The move away from the initial concept of building 'bergships' from ice to the use of artificial pykrete compromised the simplicity of Pyke's original plan. Further complications arose as natural freezing was too slow for the size of the vessel envisaged and artificial refrigeration was required to produce sufficient quantities of reinforced ice. In addition, the projected size of the construction site; the amount of steel, timber, and machinery required; and a necessary workforce of 35,000 were sufficient to cause R.E. Chadwick, leader of the senior construction men in Canada, to comment that '[Habbakuk] is so far removed from the simple structure originally conceived that the project has lost all prospect of being either cheap or easy to construct' (page 52).

The radical new technology necessary for 'bergship' construction, although theoretically feasible, could neither be developed rapidly nor cheaply to be practical in a time of war. The project was consequently terminated on 14 December 1945. Perhaps the most fitting epitaph for the Habbakuk Project is embodied in a 1946 press release: 'A scheme of this magnitude undertaken in wartime is necessarily a gamble....Its failure, therefore, only serves to demonstrate the inevitable cost of pursuing a policy involving the backing of new and ingenious ideas. Such a policy appears fully justifiable in war' (page 314).

In many respects the structure of Gold's book reflects the meticulousness of the Habbakuk experiments that he details in the book's latter half. The work is clear, concise, well indexed, illustrated, and devoid of retrospective sentiment. The book is divided into two halves: the first a seven-chapter history of the project and the second comprising 13 appendices that constitute the bulk of the original scientific research carried out, complete with tables,