

Reviews

THOMAS, D.N. 2004. *Frozen oceans: the floating world of pack ice*. London, Natural History Museum. 224 pp. ISBN 0 565 09188 3, hardback, £22.

An excellent book. Anybody who has been privileged to witness David Thomas lecture will be fully aware of his enthusiasm for polar regions in general and sea-ice research in particular, and his wonderful powers of communication. These same qualities pervade this book. Dr Thomas is an authority on biogeochemistry of polar oceans, and this book is built upon the foundations of his first-hand experience in the field and a large and ever-expanding corpus of writing on the subject of sea-ice biology and biochemistry. Aimed at a general audience, the book covers a great deal of ground (or ocean!) and is full of useful information on all aspects of the extraordinary world of sea ice. That the author has a deep love, understanding and appreciation of his subject matter comes across strongly throughout.

Covering fully 13% of the Earth's surface at its maximum extent and affecting a much greater area through its impact on global ocean and atmospheric circulation, sea ice plays a central role in global patterns of weather and climate. The inter-seasonal waxing and waning of sea-ice areal extent is indeed one of the greatest geophysical shows on the planet. Although thin, the ice veneer not only plays a dominant yet highly variable role in physical and biological processes in high-latitude oceans. It also represents a highly sensitive integrator and modulator of climate variability and change, and one which responds rapidly to changes in patterns of air temperature and atmospheric circulation, for example. Moreover, it is home to a richly diverse range of organisms, from microbes to great whales, all of which are specially adapted to its presence. Sea ice has also played a central role in the lifestyles of circum-Arctic native peoples for tens of millennia, and forms a major impediment to high-latitude navigation and marine operations over a vast region and for much of the year. Last but not least, sea ice leaves an indelible impression on those lucky enough to witness its beauty and ever-changing nature. Recent research shows, however, that changes in the distribution and characteristics of sea ice are taking place at an alarming rate in the Arctic and the West Antarctic Peninsula region in particular, with potentially dire consequences. In covering these issues, the book is not only highly informative but is also timely and topical. It also effectively places up-to-date information in an historical context, and gives the reader an excellent overview of our current state of knowledge. It is also not afraid of identifying important gaps in our understanding.

The book is logically and thoughtfully laid out, initially setting the scene with a short treatise on what distinguishes sea ice from its glacial counterparts. Although this may seem obvious to those deemed to be experts in the field, confusion often reigns in wider public circles as to the difference between frozen ocean and other forms of polar ice. To this reviewer, who all too often sees reference in the media to sea ice as 'the ice sheet', and confusion between ice floes and icebergs, this introduction is most welcome. Chapter 2 describes what happens when sea water freezes. This again is an excellent introduction, in this case to the processes of sea-ice formation, its subsequent evolution under different environmental conditions, its highly dynamic nature, and

its profound roles in the Earth's energy balance, global ocean circulation, and the transport of carbon dioxide, oxygen and nutrients. As such, the chapter combines with later discussion to become an effective primer on the possible effects of climate change and variability on sea ice, and the complex feedback mechanisms involved. Chapter 3 describes the large-scale characteristics of the sea-ice covers of both hemispheres. Interestingly, it includes information on the marginal Caspian, Baltic and White Seas – a rarity in books on sea ice – although the Sea of Okhotsk is missing. This chapter effectively describes seasonal patterns of ice movement (circulation) and extent, and longer-term trends and patterns of variability observed in time series derived from satellite and other data. The latter include proxy records obtained from new high-resolution analyses of biogeochemical signatures contained in ice-sheet core samples. It also discusses recent findings of an apparently thinning and diminishing perennial ice cover in the Arctic. I was pleased to see emphasis placed not only on regional variations in sea-ice processes and characteristics but also on hemispheric differences, which are substantial and result from the different environmental conditions occurring in the two polar regions.

Chapter 4 introduces the reader to the fascinating world of life within sea ice. This is an area in which the author excels, and the chapter represents an excellent overview of the extraordinary diversity of organisms that make up brown or stained sea ice. Far from being a barren slab, sea ice supports a rich community of micro-organisms that have a pivotal role in structuring and maintaining polar ecosystems. Rather than simply describing what organisms are found and where, the author again provides a good deal of fascinating background information on why and how. For instance, there are excellent sections on how biology survives under such seemingly harsh conditions, and what biological adaptations enable this. As is the case throughout the book, current knowledge is described in the context of historical findings in an entertaining and illuminating fashion. Chapter 5 builds upon the previous chapter to cover microbiology inside the ice. Here, we are given excellent information on the ecology of ice algae, their central importance in the polar marine food web, adaptations, and physical limitations on primary production both within the ice and in the underlying/adjacent ocean. Other topics covered here include species diversity, the effects of ultraviolet radiation (with reference to the ozone hole), nutrients and iron fertilization. The chapter concludes with a first-rate description of our current and only recently emergent knowledge of protozoa, bacteria and viruses in sea ice. Once again, this complex field is described in a clear, authoritative and highly readable manner.

Chapter 6 is devoted to larger grazers, the crustaceans, which inhabit the ice and its vicinity. Although krill is the best known of these (and is covered in an excellent manner here), there are many other weird and wonderful critters present in and around sea ice that are brought to light here. This chapter winds up with a description of ice-loving fish. The excitement of the hunt for new organisms comes across strongly. Life under the ice, both in the water column and on the ocean floor, comes to prominence in Chapter 7. In this, as in the other chapters, the reader is given insight into how modern research is conducted, and the new discoveries that

are emerging. These discoveries are also of practical significance, as described in a section in a later chapter on sea ice and biotechnology.

Chapter 8 takes us on a journey into the realm of the 'charismatic megafauna' – the birds and mammals inhabiting ice-covered oceans. It is hard to imagine a better overview of this topic. It even includes discussion on the use of sophisticated new instrument packages to not only monitor the foraging and diving behaviour of seals and whales but also acquire unique profiles of important oceanographic data. Potential impacts of changing ice conditions are also evaluated. Chapter 9 gives invaluable insight into the special logistical and other factors involved in carrying out research in ice-infested waters. The writing is again based upon the first-hand experience of the author, and gives the reader the feeling of being actually present on the ice. The comparative luxury of modern sea-ice research is in stark contrast to the heroic age of polar exploration (a brief history of which is also given). This rewarding journey comes to an end with a chapter reminding us of the modern threats to sea ice posed by Man and our facility to pollute and degrade. Ending on an upbeat note, we are shown ice on the surface of Europa, a moon of Jupiter, accompanying a short discussion on astrobiology.

The book comes with a useful glossary and is well indexed. Examples of its general topicality include up-to-date discussions on the role of newly described modes of atmospheric circulation on sea-ice distribution (including the Arctic Oscillation), the emerging role of remotely operated and autonomous underwater vehicles, the key role played by satellite remote sensing, and actual and potential threats to polar oceans.

The illustrations are well chosen, are invariably highly effective at illustrating a given point and are beautifully

reproduced. If I have a minor quibble, it is that none of the illustrations, be they photomicrographs or satellite images, come with a scale. Consequently, the reader has no feel for the dimension of the object or phenomenon being illustrated. A few minor errors have also evaded the proof reading, including referral to rates of change in Arctic sea-ice extent in per cent per year rather than the correct per cent per decade (p. 51–52).

In summary, this is a very timely, readable and informative book that has the potential to play a key role in educating the public on this important topic. I for one am extremely grateful to the author for creating a book that I can show to family members and friends alike to help explain 'what I do'. I have also heard favourable independent comments from students starting up in the field and with little prior knowledge of the key importance and complexities of sea ice. The book is written in layman's terms, but in no way talks down to the reader. Rather, it explains the complex nature of sea-ice related processes, phenomena and mechanisms in a concise and clear manner throughout. While it is not replete with references, it never aims to be. The writing is personable, and not without humour. As such, I have no hesitation in recommending this excellent book to anyone with a passion for, or even a passing interest in, polar regions. Indeed, this is a book that I would heartily recommend to my colleagues and grandmother alike. It certainly fills a niche, and is deserving of wide circulation.

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