

Preface

The ocean covers 71% of the surface of the earth and the deep sea (considered here to be at depths greater than the continental shelf at 200–300 m) comprises the vast majority of this area. Seafloor habitats in the deep sea are many and varied, and include extensive areas of lower continental slope incised with canyons, beyond which there are large numbers of seamounts among plateaux, ridges, rises, plains and trenches, as well as hydrothermal vents and cold seeps. Until the late nineteenth century the depths beyond the photic zone were thought to be largely devoid of life. However, this concept has been disproven as scientific expeditions have discovered, and continue to find, a specialist deep-sea fauna that is among the most diverse on the planet.

Scientific knowledge of the deep sea has increased rapidly, but there exist large gaps in sampling coverage. As researchers have collectively worked towards increasing spatial coverage, inconsistencies have become apparent in how different habitats and regions have been sampled. Ultimately the extent to which data can be integrated will constrain how much our understanding of deep-sea ecosystems can develop. Furthermore, the pace of human impacts and changes in the deep sea are outstripping knowledge growth. There is growing pressure on deep-sea researchers to obtain data to understand the effects of fisheries and other human impacts that is vital for effective management and conservation.

In the wider scientific literature and online there already exist a number of publications and 'grey literature' reports discussing deep-sea sampling. In particular there are several methodological books (e.g. Eleftheriou & McIntyre, 2005; Eleftheriou, 2013; Danavaro, 2010) and general deep-sea texts (e.g. Gage & Tyler, 1991; Tyler, 2003). However, this book represents the first comprehensive compilation of deep-sea sampling methodologies for a range of habitats, and by dedicating a book specifically to deep-sea methods we are recognizing that the field of deep-sea research now warrants its own volume. The book fills a niche in the scientific and management communities, reviewing the real-life applications of current (and in some instances developing) deep-sea sampling tools and techniques across a range of deep-sea habitats and under a variety of conditions. In creating this book we have been able to draw upon the experiences of those at the 'coal face' of deep-sea sampling, expanding on the existing methodological texts while encompassing a level of detail often omitted from journal publications.

Ultimately we hope that the book will promote international consistency in sampling approaches and data collection, advance the integration of information into global databases, and facilitate improved data analyses and consequently uptake of science results for management and conservation of the deep sea.

Origin and scope of the book

The concept of this book was initially discussed by a small group of researchers comprising a 'Standardization Working Group' of the Census of Marine Life field project on seamounts (CenSeam). However, it rapidly became apparent that we could not, and should not, sample seamounts in isolation and the scope of the book was widened to encompass all deep-sea habitats.

The majority of sampling methods covered in the book target the mega- and macrofaunal assemblages associated with the deep seafloor. However, any study of the deep sea cannot exclude the wider influence of the entire water column and we also consider pelagic and environmental sampling. The main focus of the book by its very nature is biological sampling, but deep-sea research is a truly multidisciplinary venture. However, to encompass oceanographic and geological sampling in any detail would call for additional volumes that were beyond the realistic scope of our efforts. Nevertheless we hope all biologists can engage with other disciplines and encourage ongoing collaboration to obtain a wider understanding of deep-sea ecosystems.

In gathering authors to contribute to this book we have tried to cover as wide a range habitats and sampling equipment as possible. However, the content reflects personal experience and inevitably there will be omissions, but hopefully the book manages to build a solid foundation for future discussions of how to develop and progress biological sampling in the deep sea.

We hope that this book will appeal to a range of readers. Early career researchers can benefit from the experiences shared by those who have been on the trawl deck for many years, wisdom that is often not recorded in scientific papers and is often learnt the hard way. We also hope that the book will provide a scholarly platform and a solid foundation for students, as well as a valuable resource for environmental and science managers and policy-makers in detailing not only what tools are available to address issues in deep-sea management and conservation, but also in explaining some of the inherent challenges. The content of this book is based on the collective experiences of many deep-sea scientists, but we anticipate that even the most seasoned researcher will find this book of use. By documenting even the seemingly simplest of steps we might better identify where differences in approach occur, thereby providing opportunities for discussion and standardization across the research community to facilitate more robust data comparisons and analyses. Finally, the role of every research ship's complement in making deep-sea research happen cannot be understated, and we hope that the book may find a place on board research vessels around the world as a reference to crews for the rationale behind some of the deployment strategies, and subsequent use of data.

The book cannot deal with every situation or gear type. Hence the chapters are cross-referenced and contain an extensive list of citations. The references included in the book are intended to give readers access to the main papers that can facilitate more detailed investigation of particular issues.

The book has been 5 years in the making, as the authors involved have tried to juggle the demands of their scientific work with the preparation of the various chapters. Research never stands still, and hence technological and sampling advances have occurred over that time period. We have tried to incorporate such changes wherever possible, and trust there are no major omissions that affect current 'best practice' advice or information.

Structure of Biological Sampling in the Deep Sea

The first part of the book sets the background scene with Chapters 1 and 2 considering general characteristics of deep-sea habitat and fauna, in the context of their influence on sampling methodologies. Chapter 3 moves towards the details of deep-sea sampling and discusses survey and sampling design. Recognizing that the motivations behind research surveys will vary, this book does not aim to be prescriptive, but rather to provide a toolbox of experience for users to utilize; with this in mind Chapter 3 draws heavily on case studies which bring to bear experiences from several research institutes.

Chapters 4–14 cover the major deep-sea sampling methods and equipment that are employed today. A 'hands on' description of the sampling operations includes information that is largely overlooked in the published literature. Each chapter encompasses a detailed description of the method, including information on gear specifications, modifications as well as notes on gear maintenance and handling; and also specific advice for application to different habitats and fauna. Treating sampling

on the basis of gear type means there is some duplication and repetition, but this approach enables researchers to learn quickly about a particular gear type available to them, and keeps all relevant information together in concise sections. This structure emphasizes the need for consistency and comparability in the set-up and use of particular equipment, which is one of the priority objectives of the book. Chapter authors also detail what information must be captured for future cross-comparisons and analyses, as well as offering guidance on quality assurance. Sample sorting and processing is considered in the context of each method, and Chapter 15 includes a detailed discussion on the preservation and curation of biological samples.

However, important as ocean-going research and shipboard sampling are, ultimately they are only the beginning of the sequence of scientific research. Chapter 16 tackles what happens when ashore, and outlines best practices for developing and implementing deep-sea data management. Chapter 17 builds on this discussion to consider the peculiarities of deep-sea data analysis, with the authors drawing heavily on their own experiences and lessons learnt about data-poor situations and what to do and what not to do.

Scientific curiosity drove much of the early exploratory deep-sea research, but the current-day motivation to better understand this environment is now driven by an increasing need to manage and conserve deep-sea habitats and communities given a wide suite of anthropogenic threats. The knowledge base needed to effectively manage and conserve the deep sea is underpinned by good sampling design and practice, as well as effective transfer of information. Chapter 18 considers management approaches and outlines a process for developing biological sampling programmes in the deep sea that deliver both what scientists desire and managers or policy-makers need.

Ongoing technological advances drive continued exploration of the deep, and just as early researchers might never have anticipated the wealth of life that we now know exists, the deep sea is so poorly sampled we know there is a lot more to discover. Therefore the book ends with Chapter 19 considering how advances in technology and capability might drive further exploration, and what the future of deep-sea sampling might hold.

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