

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

Top Predators in Marine Ecosystems

Their Role in Monitoring and Management

The sustainable exploitation of the marine environment depends upon our capacity to develop systems of management with predictable outcomes. Unfortunately, marine ecosystems are highly dynamic and this property could conflict with the objective of sustainable exploitation. This book investigates the theory that the population and behavioural dynamics of predators at the upper end of marine food chains can be used to assist with management. Since these species integrate the dynamics of marine ecosystems across a wide range of spatial and temporal scales, they offer new sources of information that can be formally used in setting management objectives. This book examines the current advances in the understanding of the ecology of marine predators and will investigate how information from these species could be used in management.

IAN BOYD is Director of the Sea Mammal Research Unit at the University of St Andrews. He is a Fellow of the Royal Society of Edinburgh and a recipient of the Bruce Medal and the Scientific Medal of the Zoological Society of London for his scientific studies in Antarctica.

SARAH WANLESS, of the NERC Centre for Ecology and Hydrology, works on long-term studies of bird populations.

C. J. CAMPHUYSEN'S current research interests include: foraging ecology, mortality and distribution patterns of seabirds in the Atlantic Ocean and in the North Sea; the impacts of fishing on marine birds, and the spatial distribution and temporal trends in abundance of cetaceans in the North Sea.

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

Top Predators in Marine
Ecosystems
Their Role in Monitoring and Management

Edited by

I. L. BOYD, S. WANLESS AND C. J. CAMPHUYSEN



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press

The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org

Information on this title: www.cambridge.org/9780521847735

© The Zoological Society of London 2006

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2006

Printed in the United Kingdom at the University Press, Cambridge

A catalogue record for this publication is available from the British Library

ISBN-13 978-0-521-84773-5 hardback

ISBN-10 0-521-84773-7 hardback

ISBN-13 978-0-521-61256-2 paperback

ISBN-10 0-521-61256-X paperback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

Contents

List of contributors page [viii]

Preface [xiii]

- 1 Introduction [I]
I. L. BOYD, S. WANLESS AND C. J. CAMPHUYSEN
- 2 Effects of fisheries on ecosystems: just another top predator? [II]
A. W. TRITES, V. CHRISTENSEN AND D. PAULY
- 3 Physical forcing in the southwest Atlantic: ecosystem control [28]
P. N. TRATHAN, E. J. MURPHY, J. FORCADA,
J. P. CROXALL, K. REID AND S. E. THORPE
- 4 The use of biologically meaningful oceanographic indices to separate the effects of climate and fisheries on seabird breeding success [46]
B. E. SCOTT, J. SHARPLES, S. WANLESS, O. N. ROSS,
M. FREDERIKSEN AND F. DAUNT
- 5 Linking predator foraging behaviour and diet with variability in continental shelf ecosystems: grey seals of eastern Canada [63]
W. D. BOWEN, C. A. BECK, S. J. IVERSON,
D. AUSTIN AND J. I. McMILLAN
- 6 Distribution and foraging interactions of seabirds and marine mammals in the North Sea: multispecies foraging assemblages and habitat-specific feeding strategies [82]
C. J. CAMPHUYSEN, B. E. SCOTT AND S. WANLESS

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

vi Contents

- 7 Spatial and temporal variation in the diets of polar bears across the Canadian Arctic: indicators of changes in prey populations and environment [98]
S. J. IVERSON, I. STIRLING AND S. L. C. LANG
- 8 Biophysical influences on seabird trophic assessments [118]
W. A. MONTEVECCHI, S. GARTHE AND
G. K. DAVOREN
- 9 Consequences of prey distribution for the foraging behaviour of top predators [131]
I. J. STANILAND, P. TRATHAN AND A. R. MARTIN
- 10 Identifying drivers of change: did fisheries play a role in the spread of North Atlantic fulmars? [143]
P. M. THOMPSON
- 11 Monitoring predator–prey interactions using multiple predator species: the South Georgia experience [157]
J. P. CROXALL
- 12 Impacts of oceanography on the foraging dynamics of seabirds in the North Sea [177]
F. DAUNT, S. WANLESS, G. PETERS, S. BENVENUTI,
J. SHARPLES, D. GRÉMILLET AND B. SCOTT
- 13 Foraging energetics of North Sea birds confronted with fluctuating prey availability [191]
M. R. ENSTIPP, F. DAUNT, S. WANLESS, E. M. HUMPHREYS,
K. C. HAMER, S. BENVENUTI AND D. GRÉMILLET
- 14 How many fish should we leave in the sea for seabirds and marine mammals? [211]
R. W. FURNESS
- 15 Does the prohibition of industrial fishing for sandeels have any impact on local gadoid populations? [223]
S. P. R. GREENSTREET

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

Contents vii

- 16 Use of gannets to monitor prey availability in the northeast Atlantic Ocean: colony size, diet and foraging behaviour [236]
K. C. HAMER, S. LEWIS, S. WANLESS, R. A. PHILLIPS,
T. N. SHERRATT, E. M. HUMPHREYS, J. HENNICKE AND
S. GARTHE
- 17 Population dynamics of Antarctic krill *Euphausia superba* at South Georgia: sampling with predators provides new insights [249]
K. REID, E. J. MURPHY, J. P. CROXALL AND P. N. TRATHAN
- 18 The functional response of generalist predators and its implications for the monitoring of marine ecosystems [262]
C. ASSEBURG, J. HARWOOD, J. MATTHIOPOULOS AND
S. SMOUT
- 19 The method of multiple hypotheses and the decline of Steller sea lions in western Alaska [275]
N. WOLF, J. MELBOURNE AND M. MANGEL
- 20 Modelling the behaviour of individuals and groups of animals foraging in heterogeneous environments [294]
J. G. OLLASON, J. M. YEARSLEY, K. LIU AND N. REN
- 21 The Scenario Barents Sea study: a case of minimal realistic modelling to compare management strategies for marine ecosystems [310]
T. SCHWEDER
- 22 Setting management goals using information from predators [324]
A. J. CONSTABLE
- 23 Marine reserves and higher predators [347]
S. K. HOOKER
- 24 Marine management: can objectives be set for marine top predators? [361]
M. L. TASKER
- Index* [370]

Cambridge University Press
052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and
Management
Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen
Frontmatter
[More information](#)

Contributors

C. Asseburg
Centre for Conservation Science
University of St Andrews
St Andrews
Fife KY16 9LZ, UK

D. Austin
Dalhousie University
Halifax, Nova Scotia
Canada B3H 4J1

C. A. Beck
Alaska Department of Fish and Game
Division of Wildlife Conservation
Marine Mammals Section
Anchorage
Alaska 99518

W. D. Bowen
Marine Fish Division
Bedford Institute of Oceanography
Department of Fisheries and Oceans
Dartmouth, Nova Scotia
Canada B2Y 1A
Dalhousie University
Halifax, Nova Scotia
Canada B3H 4J1

I. L. Boyd
Sea Mammal Research Unit
Gatty Marine Laboratory
University of St Andrews
St Andrews
Fife KY16 8LB, UK

S. Benvenuti
Dipartimento di Etologia
Ecologia ed Evoluzione
Università di Pisa, Via Volta 6
I-56126 Pisa, Italy

C. J. Camphuysen
Royal Netherlands Institute for Sea
Research
PO Box 59
1790 AB Den Burg, Texel, the Netherlands

V. Christensen
Fisheries Centre
University of British Columbia
Vancouver, British Columbia
Canada V6T 1Z4

A. J. Constable
Australian Antarctic Division
Australian Department of Environment and
Heritage
203 Channel Highway, Kingston
Tasmania 7050, Australia

J. P. Croxall
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

F. Daunt
NERC Centre for Ecology and Hydrology
Banchory Research Station
Hill of Brathens
Banchory AB31 4BW, UK

G. K. Davoren
Zoology Department
University of Manitoba, Winnipeg
Manitoba
Canada R3T 2N2

M. R. Enstipp
Centre d'Ecologie et Physiologie
Énergétiques
Centre National de la Recherche
Scientifique

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

Contributors ix

23 rue Becquerel
F-67087 Strasbourg Cedex 2, France

J. Forcada
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

M. Frederiksen
NERC Centre for Ecology and Hydrology
Banchory Research Station
Hill of Brathens
Banchory AB31 4BW, UK

R. W. Furness
Institute of Biomedical and Life Sciences
Graham Kerr Building
University of Glasgow
Glasgow C12 8QQ, UK

S. Garthe
Centre for Research and Technology
Westkuste
University of Kiel Hafentörn

D-25761 Büsum, Germany

S. P. R. Greenstreet
Fisheries Research Services
Marine Laboratory, PO Box 101
Victoria Road
Aberdeen AB11 9DB, UK

D. Grémillet
Centre d'Ecologie et Physiologie
Énergétiques
Centre National de la Recherche
Scientifique

23 rue Becquerel
F-67087 Strasbourg Cedex 2, France

K. C. Hamer
Earth Biosphere Institute and School of
Biology, Ecology and Evolution Group
University of Leeds
Leeds LS2 9JT, UK

J. Harwood
Centre for Conservation Science and Sea
Mammal Research Unit
University of St Andrews
St Andrews
Fife KY16 8LB, UK

J. Hennicke
Zoological Institute and Museum
University of Hamburg
Hamburg, D-20146 Germany

S. K. Hooker
Sea Mammal Research Unit
Gatty Marine Laboratory
University of St Andrews
St Andrews
Fife KY16 8LB, UK

E. M. Humphreys
Earth Biosphere Institute and School of
Biology, Ecology and Evolution Group
University of Leeds
Leeds LS2 9JT, UK

S. J. Iverson
Dalhousie University
Halifax, Nova Scotia
Canada B3H 4J1

S. L. C. Lang
Dalhousie University
Halifax, Nova Scotia
Canada B3H 4J1

S. Lewis
NERC Centre for Ecology and Hydrology
Banchory Research Station
Hill of Brathens
Banchory AB31 4BW, UK

K. Liu
Culterty Field Station
The School of Biological Sciences
The College of Life Sciences and Medicine
University of Aberdeen
Newburgh
Ellon AB41 6AA, UK

J. I. McMillan
Marine Fish Division
Bedford Institute of Oceanography
Department of Fisheries and Oceans
Dartmouth, Nova Scotia
Canada B2Y 1A

M. Mangel
Center for Stock Assessment Research
University of California Santa Cruz
1156 High Street
California 95064, USA

A. R. Martin
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

x Contributors

J. Matthiopoulos
Sea Mammal Research Unit and Centre for
Research into Ecological and
Environmental Modelling
University of St Andrews
St Andrews
Fife KY16 8LB, UK

J. Melbourne
Department of Astronomy and
Astrophysics
University of California Santa Cruz
1156 High Street
California 95064, USA

W. A. Montevecchi
Cognitive and Behavioural Ecology
Program
Memorial University St John's
Newfoundland
Canada A1B 3X9

E. J. Murphy
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

J. G. Ollason
Oceanlab
School of Biological Sciences
The College of Life Sciences and Medicine
University of Aberdeen
Newburgh
Ellon AB41 6AA, UK

D. Pauly
Fisheries Centre
University of British Columbia
Vancouver, British Columbia
Canada V6T 1Z4

G. Peters
Centre d'Ecologie et Physiologie
Énergétiques
Centre National de la Recherche
Scientifique
23 rue Becquerel
67087 Strasbourg Cedex 2, France
Earth and Ocean Technologies
Hasseer Str 75
24113 Kiel, Germany

R. A. Phillips
British Antarctic Survey, Natural
Environment Research Council

High Cross, Madingley Road
Cambridge CB3 0ET, UK

K. Reid
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

N. Ren
Oceanlab
The School of Biological Sciences
The College of Life Sciences and Medicine
University of Aberdeen
Newburgh
Ellon AB41 6AA, UK

O. N. Ross
University of Southampton
School of Ocean and Earth Sciences
Southampton Oceanography Centre
Empress Dock
Southampton S14 3ZH, UK

T. Schweder
Norwegian Computing Center
Box 114 Blindern
0314 Oslo, Norway
Department of Economics
University of Oslo
Box 1095 Blindern
0317 Oslo, Norway

B. E. Scott
Department of Zoology
School of Biological Sciences
University of Aberdeen
Tillydrone Avenue
Aberdeen AB24 2TZ, UK

J. Sharples
Proudman Oceanographic Laboratory
Bidston Observatory
Birkenhead CH43 7RA, UK

T. N. Sherratt
Department of Biology
Carleton University
1125 Colonel By Drive, Ottawa
Ontario K1S 5B6, Canada

S. Smout
Centre for Conservation Science and Sea
Mammal Research Unit
University of St Andrews

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

Contributors xi

St Andrews
Fife KY16 8LB, UK

I. J. Staniland
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

I. Stirling
Canadian Wildlife Service
Edmonton, Alberta
Canada T6H 3S5

P. M. Thompson
Lighthouse Field Station
School of Biological Sciences
University of Aberdeen
Cromarty IV11 8YJ, UK

S. E. Thorpe
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

P. N. Trathan
British Antarctic Survey, Natural
Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET, UK

A. W. Trites
Fisheries Centre
University of British Columbia
Vancouver, British Columbia
Canada V6T 1Z4

S. Wanless
NERC Centre for Ecology and Hydrology
Banchory Research Station
Hill of Brathens
Banchory AB31 4BW, UK

N. Wolf
MRAG Americas
110 South Hoover Boulevard, Suite 212
Tampa, Florida 33609, USA
Center for Stock Assessment Research
University of California Santa Cruz
1156 High Street
California 95064, USA

J. M. Yearsley
Culterty Field Station
The School of Biological Sciences
The College of Life Sciences and
Medicine
University of Aberdeen
Newburgh
Ellon AB41 6AA, UK

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

Preface

This book began its evolution in 1999 when the British Antarctic Survey, where I worked at the time, began a new research programme on the management of marine ecosystems. This programme concentrated upon the krill-based ecosystem at South Georgia which has been the subject of almost continuous study since the Discovery Expeditions in the 1920s. Latterly, international efforts to understand the dynamics of this ecosystem and the wider Southern Ocean have been coordinated by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The daunting task of describing ecosystem dynamics over such a large oceanic area with relatively limited resources led to the establishment of the CCAMLR Ecosystem Monitoring Programme, an internationally coordinated effort at data collection. Among other things, this contained a major component of monitoring the seal and seabird populations in the region. The logic for their inclusion was that they foraged over most of the regions of interest but returned to breed at very well defined locations. By undertaking a series of measurements of these predators at these locations, it was then argued that aspects of the ecosystem dynamics should be reflected by variability in the measurements of the predators. It was hoped that appropriate choices of the predators and measurement variables would provide indicators of the dynamics of their prey at different spatial and temporal scales.

The same concept has been developed in parallel within other ecosystems during the past 20 years. The North Sea, California Current, northwest Atlantic, Bering Sea, Gulf of Alaska and Barents Sea are regions in which long-term monitoring studies of seabirds and seals are recognized as providing insights into ecosystem processes that can then be fed into the process of management. Even though the implementation and use of measurements has differed between regions, there has been a strong recognition that the interpretation of data about predator dynamics in the context of ecosystem dynamics can only be achieved on the back of basic research into the ecology of the species concerned. This book is, therefore, an effort

Cambridge University Press

052161256X - Top Predators in Marine Ecosystems: Their Role in Monitoring and Management

Edited by I. L. Boyd, S. Wanless and C. J. Camphuysen

Frontmatter

[More information](#)

xiv Preface

to synthesize across a range of studies that have examined the ecology of predators within the context of ecosystem approaches to management.

It is well recognised that people cannot manage ecosystems but can only manage their own activities within ecosystems. The concerns about the impacts of human activities upon ecosystems made this an appropriate subject for a symposium sponsored and hosted by the Zoological Society of London, and this took place in April 2004. At the same time, there was an opportunity to build upon two major programmes of research: one involving the Southern Ocean predators, mainly of krill, and being led by researchers at the British Antarctic Survey, and one on North Sea predators, mainly of sandeels, being undertaken by a consortium of researchers under the IMPRESS programme. The content of the book therefore reflects the interest in these two contrasting ecosystems but also includes representations from other ecosystems.

Production of this book would not have been possible without the interest and willing participation of the authors of each of the chapters and I am grateful to them for their efforts to share their research results and ideas and for delivering their manuscripts within the time and word limits. Since my background is in Antarctic research, it was essential also to include leadership in the project from the North Sea research community and I was fortunate to have the support of Sarah Wanless and Kees Camphuysen as co-editors of the book. I am grateful to Georgina Mace, Director of the Zoological Society of London, for supporting the proposal that developed into the symposium and this book, and to Deborah Body from the Zoological Society of London for all the assistance she provided in organizing the symposium and in the early stages of the production of the book. I am also grateful to Alan Crowden and others at Cambridge University Press for their encouragement and diligence during the production of the book.

I. L. Boyd