British Antarctic Survey • Centre d'Etudes Biologiques de Chizé • Centro de Ciências do Mar

CEPHALOPOD BEAK GUIDE FOR THE SOUTHERN OCEAN

J. C. Xavier & Y. Cherel

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
High Cross, Madingley Road,
Cambridge, CB3 0ET , UK

CNRS
dépasser les frontières
Centre d'Etudes Biologiques de Chizé,
UPR 1934 du CNRS
79360 Villiers-en-Bois, France

Centro de Ciências do Mar
Universidade do Algarve
Campus das Gambelas, 8000-139
Faro, Portugal

Ciência.Inovação 2010

International Polar Year 2007-2008

APECS Association of Polar Early Career Scientists

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Integrating Climate and Ecosystem Dynamics • ICED •

Census of Antarctic Marine Life
www.caml.aq

“This book is dedicated to Malcolm Clarke”

CEPHALOPOD BEAK GUIDE FOR THE SOUTHERN OCEAN

Published by British Antarctic Survey
Authors: José Xavier & Yves Cherel

Original Edition: © 2009 British Antarctic Survey
Photography: José Xavier, Chris Gilbert & Peter Bucktrout
Design Agency: ouranja.com
Art Director: Bruno Cruz
3D Imaging(QVR): ETI BioInformatics, University of Amsterdam, The Netherlands

Cite book as following:
Xavier JC, Cherel Y (2009) Cephalopod Beak Guide
For The Southern Ocean. British Antarctic Survey, Cambridge, UK. 129pp.

ISBN 978-0-85665-146-5

Recycled paper

Cover: the gonatid squid *Gonatus antarcticus*

AUTHORS

Dr. José Xavier

is a marine ecologist. He has a doctorate from the University of Cambridge (United Kingdom) and presently works at the British Antarctic Survey (BAS, United Kingdom), the Centre d´Etudes Biologiques de Chizé (CNRS, France) and the Centre of Marine Sciences (CCMAR, Portugal). His current studies focus on understanding food web dynamics in relation to climate change and he has been working on Antarctic cephalopod beaks since 1997. José has extensive experience in interdisciplinary studies and international collaborations with more than 30 countries, is a member of the Portuguese Committee for the International Polar Year, Cephalopod International Advisory Council (CIAC), Cambridge Philosophical Society, Association of Polar Early Career Scientists (APECS) and member of the Scientific Steering Committee of ICED.

José Xavier
Institute of Marine Research (IMAR)
Department of Zoology
University of Coimbra
3004-517 Coimbra, Portugal
Email: jccx@cantab.net

Dr. Yves Cherel

is Directeur de Recherche at the Centre d´Etudes Biologiques de Chizé (CNRS, France). He works on trophic interactions and feeding strategies of top marine predators, and thus on the food web structure of the pelagic ecosystem, focusing on the Southern Ocean. Yves is a leader in his field and has been identifying cephalod beaks since 1994. He is member of the Cephalopod International Advisory Council (CIAC) and member of the editorial board of the international journals Antarctic Science and Marine Ecology Progress Series.

Yves Cherel
Email: yves.cherel@cebc.cnrs.fr

PREFACE

Cephalopods play a key role in global marine ecosystems. They occupy a wide range of habitats, are voracious predators and are important in the diet of numerous higher predators. To understand the feeding ecology of their predators, it is essential to identify the indigestible cephalopod beaks in the predator gut contents. Early research on beaks was based on material collected from whales during the industrial whaling era in the first half of the 20th century and the field was led by Malcolm Clarke at the National Institute of Oceanography, working largely with material from the Southern Ocean.

Clarke's book on identifying cephalopod beaks was published more than 25 years ago and since then much new knowledge has emerged. There is therefore a need for an updated catalogue for identification purposes, that includes all the new material. This book was written during the International Polar Year (IPY) 2007-08 and arose from two core projects: Integrating Climate and Ecosystem Dynamics (ICED) and the Census of Antarctic Marine Life (CAML), which included work on cephalopod beaks from the Southern Ocean. It's scope is comprehensive and circumpolar; it updates methods of identification and includes detailed 3-D images of the key species. Until now most research has focussed on the lower beak for identification purposes. This book includes data on both upper and lower beaks providing new and useful information. It also includes an up to date review of the role of cephalopods in the diet of Southern Ocean predators including seals, whales, penguins, albatrosses and fish.

This new guide will be an essential identification tool for ecologists working on the diets of higher predators. Nevertheless it is clear that there are still cephalopod beaks being found in predator diets that belong to species that are unknown to science. There is therefore a continuing need for shipboard scientific cruises using innovative methods to catch bigger and faster cephalopods to complement data obtained from predators. In recent years development of satellite tracking techniques for marine predators has made it possible to determine the distribution of cephalopods caught by these predators. This has advanced our knowledge, particularly of poorly known species. It is now necessary to develop integrated research projects, focused on inter-disciplinary science, to understand the response of ecosystems to global climate change. Shipboard research cruises combined with higher predator tracking studies and carefully executed dietary analyses will continue to make important contributions in this field.

This book will make an essential contribution to the development of knowledge about the role of cephalopods in the Southern Ocean ecosystem and will stimulate further research in this exciting field of marine ecology.

Prof. Paul Rodhouse
Head of Biosciences Division
British Antarctic Survey

ACKNOWLEDGEMENTS

We are grateful to Ben Phalan for his enthusiasm related to this book during his stay at Bird Island Research Station (Antarctic) of the British Antarctic Survey, Martin Collins for providing unpublished data and beaks, Peter Bucktrout and Chris Gilbert for all their expertise and advice for photographing beaks, Hubb Veldhuijzen for all the brilliant work on 3-D images, Bruno Cruz for the extraordinary work on the design and editing of the book, Linda Capper and Jamie Oliver (BAS Press, Public Relations and Education Office) for their publication expertise, and CC Lu, George Jackson, Uwe Piatkowski, Jenny Baeseman (APECS), Ewan Edwards, Rhian Salmon, Nicola Munro and Dave Carlson (IPY office), Eugene Murphy and Nadine Johnson (ICED), Vicky Wadley (CAML), Richard Phillips, Dick Young, Clyde Roper, Sasha Arkhipkin, John Croxall and Malcolm Clarke for following this project with interest.

INDEX

INTRODUCTION

Cephalopods play an important role in the Antarctic ecosystem, being consumed by a wide range of predators such as whales, fish, seals, albatrosses and penguins. To understand predator-prey interactions between top predators and cephalopods, effort has been put into the development of methods to determine the identity and size of world cephalopods using beaks since the 1950s (Clarke 1962a, b; Clarke 1966; Clarke 1977; Clarke 1980; Clarke 1986; Kubodera & Furuhashi 1987; Fiscus 1991; Smale *et al.* 1993; Xavier *et al.* 2007). The most used beak guide worldwide (Clarke 1986) is now out of print and is in need of urgent revision with additional material (Santos *et al.* 2001). Also, several new cephalopod species for the Southern Ocean have been recently described taxonomically, whose beaks need to be described and/or included in a guide (e.g. Collins & Henriques 2000; Lipinski 2001; Allcock & Piertney 2002).

New efforts in the Southern Hemisphere allowed a new cephalopod beak guide to be produced (Lu & Ickeringill 2002), covering 75 species of cephalopods in Australian waters. Also new internet technology has been used to create a website to aid beak identification (http://research.kahaku.go.jp/zoology/Beak-E/index.htm) for Japanese waters. However, a cephalopod beak guide for the entire Southern Ocean is nonexistent and urgently needed.

Here, we specifically aim to describe the main cephalopod beaks from species found in the diet of predators from the Southern Ocean (defined as south of the Subtropical Front) and adjacent waters in order to assist scientists and students interested in identifying cephalopods by the means of their beaks. Special attention was paid to providing photographs of typical beaks found in the diets of adults and juveniles when relevant. As a new tool applied to marine ecology, 3-D computer images of the most important lower beaks are also provided, where it is possible to rotate each beak 360 degrees and zoom in and out of particular key features of beaks in three dimensions. In addition, a review of the allometric regressions available is provided in order to relate cephalopod beak size to mantle length and mass as well as a review of the predators feeding on those cephalopod species.

PROCEDURE FOR SORTING AND IDENTIFYING BEAKS

Each cephalopod researcher has his own way to sort and identify beaks (for instructions for the collection and preservation of cephalopod beaks see Clarke (1986)). Identifying cephalopod beaks is an arduous task that requires spending a long time analyzing the morphological characteristics of beaks, comparing your beaks with others in reference collections and using guides. Identification keys can be used to help identify cephalopod beaks (Clarke 1986) but some researchers do not use them, and others, as they get more familiar with the species that they encounter in their region, prefer to use their beak collection, and beak guide photos, to confirm identification. Be aware, nevertheless, that even with this guide, it is extremely important to compare your beaks with beaks from reference collections and to get expert advice, before attributing a name to a beak.

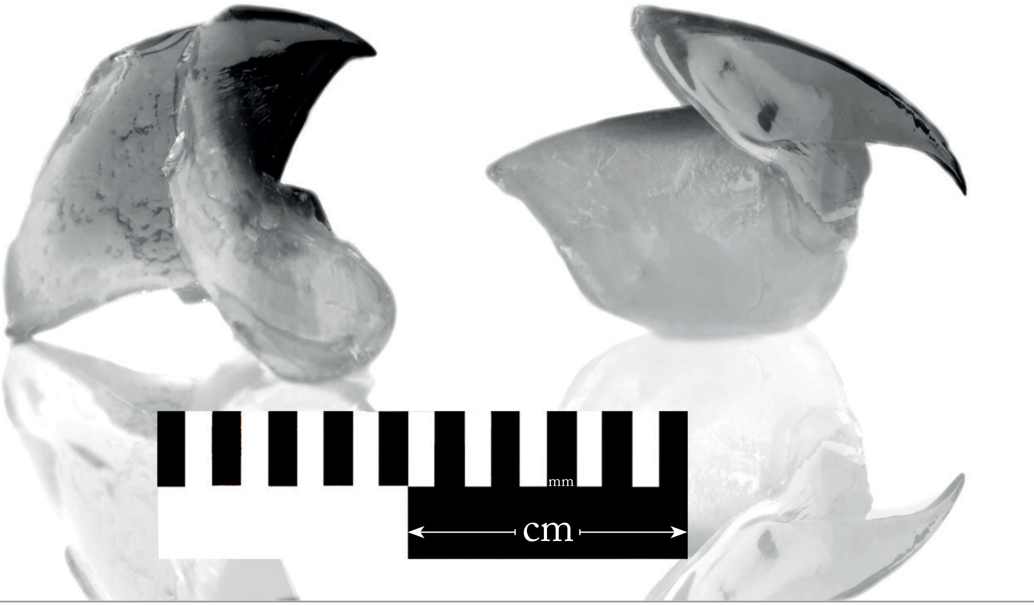
To become familiar in sorting and identifying beaks from your region, here are a few suggested steps to follow.

Firstly, have access to a large number of beaks, ideally from the diet of a single predator species that feeds on large cephalopods (larger beaks are easier to identify). It is advisable to register fresh beaks (e.g. beaks recently consumed by predators that still have flesh attached, beaks in buccal masses or from complete or partially completed specimens. See examples of fresh beaks in Figure 1 and of old, eroded beaks of *Histioteuthis macrohista* in Figure 13) in order to assess if those beaks were consumed recently or not.

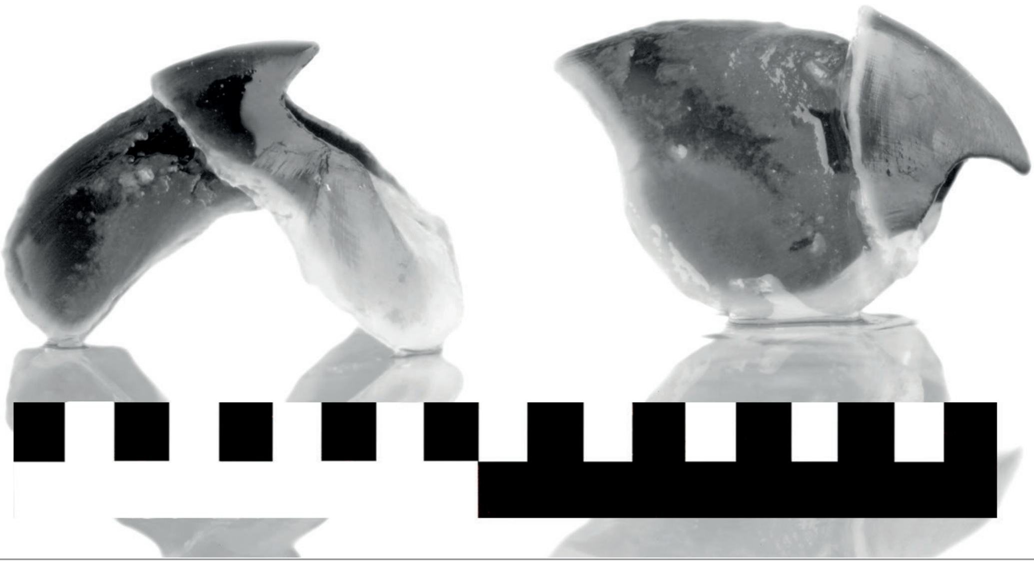
If possible, keep buccal masses because:

1. they have a radula, which may be useful in identifying the cephalopod species;
2. they can be used for genetic analysis (if frozen or fixed in ethanol; to confirm identification) or stable isotopic studies (for food web dynamics); and
3. they enable one to relate both upper and lower beaks (see more below), important for identification studies when beaks of cephalopod species can be found loose in the diet of predators;

When dealing with buccal masses or loose beaks, it is very important to spend considerable amount of time on separating the beaks according to their morphology, in order to get your eyes familiar with the features of the beaks. As a first step, separate upper and lower beaks (Figure 1). Then, within those, group beaks of similar morphology together. At present, most of the identification work is done on lower beaks due to their more obvious features (Clarke 1986) but upper beak identification can also be used.



Lower (on the left) and upper (on the right) squid beaks. *Todarodes* sp.



Lower (on the left) and upper (on the right) octopod beaks. *Pareledone turqueti*

Figure 1. Profiles of upper and lower beaks of cephalopods. Scale, which should be applied for all cephalopod photo images, is also shown. For fresh loose beaks, look at the outer parts of the beaks (i.e. edges of the wings, lateral wall and hood), which should be transparent.

Secondly, try to identify each group to a species level (where possible) using cephalopod beak guides, reference collections, biodiversity information of the cephalopod fauna and distribution atlases (e.g. Xavier *et al.* 1999) and information about the biology of the cephalopod species of the study region (Tables 1, 2). It is not unusual to be unable to give a name to a beak. Indeed, a great majority of studies (if not all!), include unidentifiable or immeasurable beaks. Getting beaks from

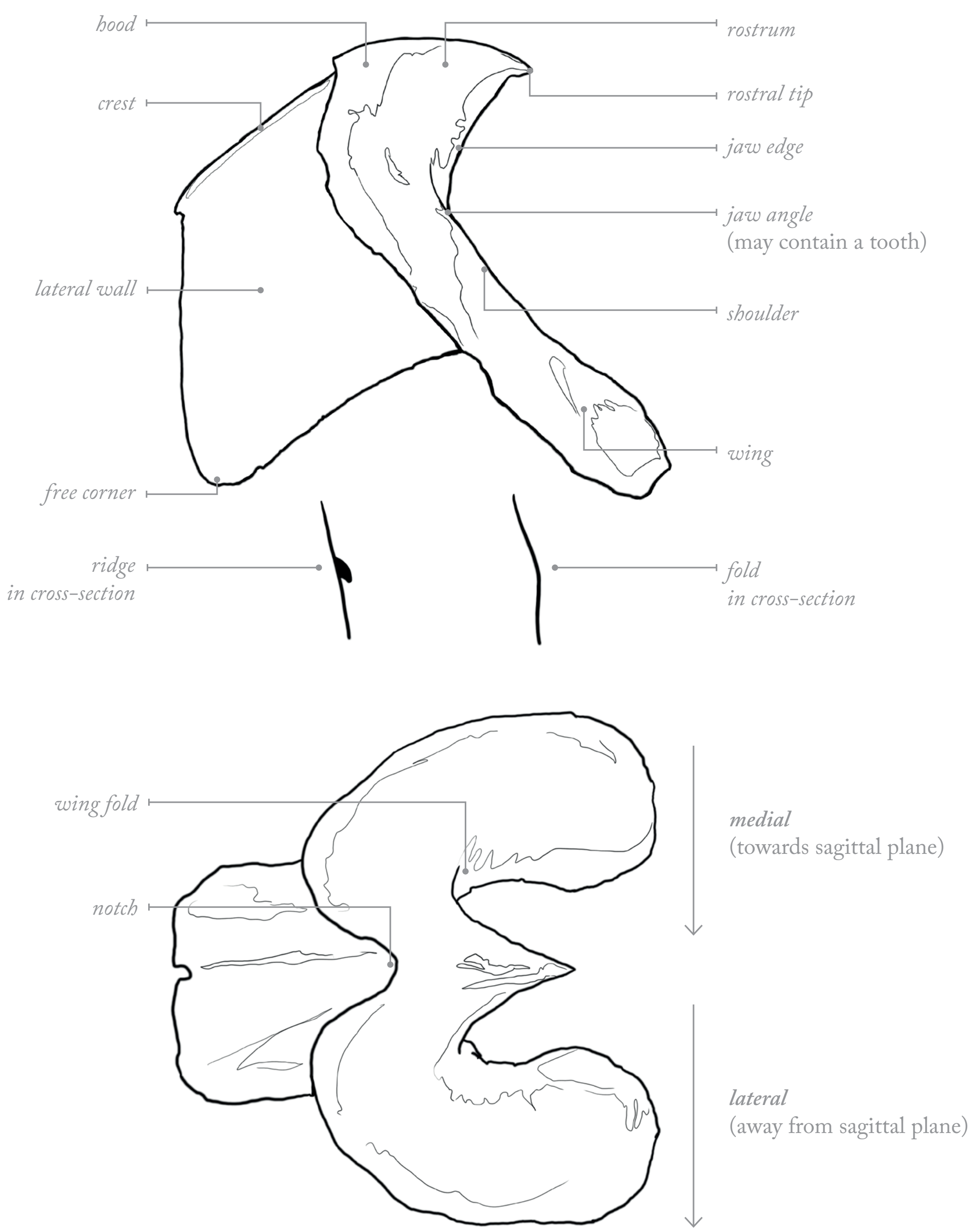
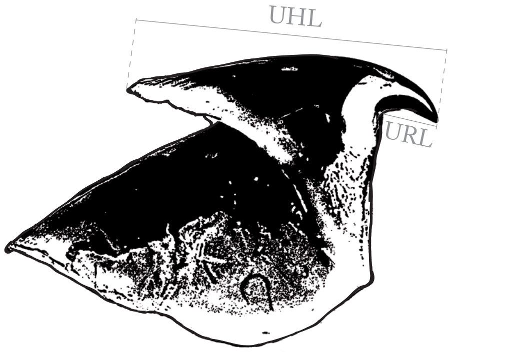
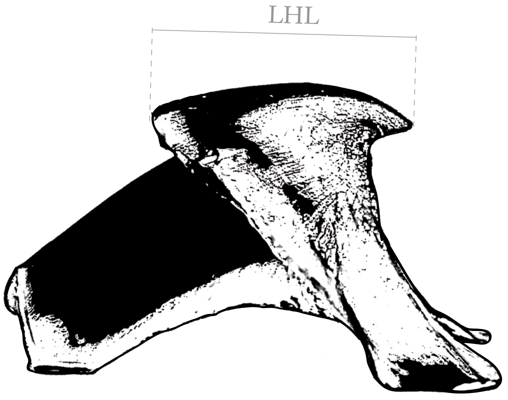


Figure 2. Principal terms used to characterize decapod beaks (following Clarke 1986).



Opisthoteuthis sp.



Opisthoteuthis sp.

Gonatus antarcticus

Figure 3. Key measurements of cephalopod beaks. Squid lower beaks are usually measured using the lower rostral length (LRL), from the rostral tip to the jaw angle. Octopod and sepiolid lower beaks are usually measured by the lower hood length (LHL), from the rostral tip to the edge of the hood. For upper beaks, the upper hood length (UHL) and upper rostral length (URL) are mostly used.

other cephalopod predators from the same study region can be useful as an unknown eroded beak in the diet of one predator can be a very common beak in the diet of another predator.

Thirdly, work with an experienced beak expert to confirm or correct your identifications. It is advisable not to publish data without it being double checked by an expert. It is also important to go back and review which features you should be aware of when looking at s specific species beak, using specific beak terminology (Figure 2), when new beaks from other collections are available. For further discussion on the terminology used to describe the characteristics of cephalopod beaks see Clarke (1986).

To facilitate the identification of beaks, it is valuable to assess first the general shape, rostrum shape, presence or absence of a fold or ridge on the lateral wall, shapes of the beak behind the hood/groove and the characteristics of the jaw and level of darkening of the beaks (to assess if it is from a juvenile/sub-adult or adult; useful to determine if that particular species reaches large sizes; Table 2), comparing beaks of the same size is useful if there is access to a reference collection. Checking maximum species sizes, and known geographical position, is also helpful to exclude species of the same family (e.g. within histioteuthids). The lower rostral length (LRL) of the lower beaks of squid and lower hood length (LHL) of octopods, and upper hood length (UHL) or upper rostral length (URL) from squids and octopods for upper beaks, are usually measured (Figure 3). Attention should be paid when measuring the LRL, as it should be measured from the inside of the lower beak rather than from the outside (Figure 3). When measuring beaks, it poses an excellent opportunity to double-check the identification of the cephalopods.

Fourthly, after confirming the identification of the cephalopod beaks with an expert, it is good to exchange beaks with colleagues to improve your own collection and double check identifications. Therefore it is essential to go back to the laboratory regularly to identify beaks so that you do not lose touch with identifying them (it is so easy to forget after being away for months!) even if you have really good notes. Also, do not discard them as they can be important for future studies (e.g. to double-check identifications, for new reference collections, and for stable isotopic studies).

Although upper beaks are less for identification, their overall shape and morphology can be species specific and very distinctive (e.g. *Architeuthis, Taonius* sp. B (Voss)), and can provide valuable biological information. In species that do not feed heavily on cephalopods, upper and lower beaks may come in pairs and can provide immediately provide good information for future identification studies on how the upper or lower beaks of a certain species looks (ideally when in buccal masses). Also, as the number of upper and lower beaks differ in the diets of predators (when they should be the same), it is relevant to understand which mechanisms are affecting the presence of beaks in the diets (Cherel *et al.* 2004; Xavier *et al.* 2005).

THE STRUCTURE OF THE BOOK

Families are ordered alphabetically. The general family beak identification characteristics are based on the lower beaks of the most important cephalopod species that are present in the diet of predators from the Southern Ocean only. The photos of lower and upper beaks are provided to further assist in identification of these type of beaks. In addition, 3-D images of beaks of key cephalopod species are also provided.

CEPHALOPOD TAXONOMY

DECAPODA

» FAMILY ANCISTROCHEIRIDAE
» FAMILY ARCHITEUTHIDAE
» FAMILY BATHYTEUTHIDAE
» FAMILY BATOTEUTHIDAE
» FAMILY BRACHIOTEUTHIDAE
» FAMILY CHIROTEUTHIDAE
» FAMILY CRANCHIIDAE
» FAMILY CYCLOTEUTHIDAE
» FAMILY GONATIDAE
» FAMILY HISTIOTEUTHIDAE
» FAMILY LEPIDOTEUTHIDAE
» FAMILY LOLIGINIDAE
» FAMILY LYCOTEUTHIDAE
» FAMILY MASTIGOTEUTHIDAE
» FAMILY NEOTEUTHIDAE
» FAMILY OCTOPOTEUTHIDAE
» FAMILY OMMASTREPHIDAE
» FAMILY ONYCHOTEUTHIDAE
» FAMILY PHOLIDOTEUTHIDAE
» FAMILY PSYCHROTEUTHIDAE
» FAMILY SEPIOLIDAE
» FAMILY UNKNOWN

FAMILY ANCISTROCHEIRIDAE Figure 4 | pages 51 & 82

Family identification:

- » Obtuse jaw angle
- » Broadly rounded
- » Small rostrum which often has a protruding tip
- » Prominent fold in the lateral wall, running to about halfway between the crest and the free corner
- » Broad, and often curled-up, wings

The only species likely to be found is:

Ancistrocheirus lesueuri
ML=-41.3+40.75LRL ; ln M=-0.194+3.56ln LRL (n=23 for ML, n=21 for M) (Clarke 1986)

The subtropical squid species *A. lesueuri* is found in small numbers in the diet of sperm whales, albatrosses and petrels (Table 1).

Practical procedures to differentiate the lower beaks of this species:

Ancistrocheirus lesueuri. Easily identifiable by its medium-large size, long wings, very small hood and well defined fold in the lateral wall. Often large, potential for confusion with *K. longimana*, but its hood is much shorter than the crest, with a deep broad notch, very long broad wings, "pulled forward" so flat when seen from the front and has a fold on lateral walls running to posterior edge.

FAMILY ARCHITEUTHIDAE Figure 5 | pages 51 & 82

Family identification:

- » Smooth lateral wall with no ridge or marked fold
- » Very broad hood
- » Thickened crest
- » Long wings
- » Has a shoulder tooth
- » Short rostrum with often a slightly curved rostral tip
- » Beaks can reach large sizes
- » Beaks are soft, not very dark and generally flexible

The only species likely to be found is:

Architeuthis dux

ML=-55.6+59.31LRL ; ln M=-1.773+4.57ln LRL (n=11 for ML; n=9 for M) (Clarke 1986) For relationships between ML and LRL, $ML=10^{((LRL/11.2)+1.723214286)}$ (n=43) might be better (Roeleveld 2000) with ML= mantle length (in mm), M= mass (in g) and LRL= lower rostral length (in mm).

This subtropical/temperate species occurs in small numbers in the diet of predators from South Georgia and Kerguelen, including wandering albatrosses and sharks (Table 1) (Xavier *et al.* 2003b; Cherel & Duhamel 2004).

Practical procedures to differentiate the lower beaks of this species:

Architeuthis dux. Easily identifiable by its large size, darkens at a large size (Table 2), by the large shoulder tooth and by having a broad hood. It is not very dark when mature, unlike *Mesonychoteuthis hamiltoni*.

FAMILY BATHYTEUTHIDAE Figure 6 | pages 52 & 83

Family identification:

» Obtuse jaw angle
» Broad hood with no notch
» Lateral walls with no fold or ridge

The only species likely to be found is:

Bathyteuthis abyssicola
ML=1.68+51.59LRL; ln M=2.855+3.38ln LRL (n=17 for both ML and M) (Clarke 1986)

This deep-sea species is cosmopolitan in its distribution and is extremely rare in the diets of top predators (Sekiguchi *et al.* 1993; Clarke & Goodall 1994).

Practical procedures to differentiate the lower beaks of this species:

Bathyteuthis abyssicola lower beak is easily identifiable by having a broad hood and by being generally a small beak. Drawings of beaks of this species appear in Clarke (1986) and Lu & Ickeringill (2002).

FAMILY BATOTEUTHIDAE Figure 7 | pages 52 & 83

Family identification:

» Sharp slightly thickened fold at the lateral wall
» Narrow beak

The only species likely to be found is:

***Batoteuthis skolops* (no specific equations)**
May use formulas for close families
ML=11.4+24.46LRL; ln M=-0.241+2.7ln LRL (n=23 for ML, n=14 for M) (Clarke 1986), based on *Chiroteuthis* spp. formulas
ML=-1.8+29.08LRL ; ln M=0.184+2.88ln LRL (n=47 for ML, n=45 for M) (Clarke 1986), based on *Mastigoteuthis* spp. formulas

This Antarctic circumpolar species is present in the diet of Patagonian toothfish (Xavier *et al.* 1999; Cherel *et al.* 2004), black-browed, grey-headed and yellow-nosed albatrosses (Cherel *et al.* 2000, 2002c), but rarely in high numbers (Table 1).

Practical procedures to differentiate the lower beaks of this species:

Batoteuthis skolops. It has a short crest and a fold on the lateral wall, unlike *Mastigoteuthis psychrophila*, which has a very thickened fold (in certain cases looking like a ridge, mostly under the groove). Could be confused with *Chiroteuthis veranyi*, but the hood is much bigger in relation to the size of the crest (whereas in *C. veranyi*, the size of hood and crest is far more similar). It is characterized by having a unique jaw, which the “pseudo-tooth” never links to the shoulder of the beak, similar to a small channel. This does not occur in *M. psychrophila*.

FAMILY BRACHIOTEUTHIDAE Figure 8 | pages 53 & 84

This family is in need of revision world-wide. Beaks from brachioteuthid squids were identified under various names until the preliminary description of two species from the Southern Ocean (Lipinski 2001). Examination of beaks from the two species allowed us to clarify their identification (Cherel *et al.* 2004).

Family identification:

- » Beaks are usually small (LRL usually < 4.0 mm; *Slosarczykovia circumantarctica* is generally smaller than *Brachioteuthis linkovskyi*)
- » Narrow rostrum
- » Distinctly thickened crest
- » Small wings
- » Hood slightly longer than crest
- » Curved rostral edge protruding forwards in sharp tip

Two species may be found and are provisionally referred to as:

Brachioteuthis linkovskyi **(no specific equations)**

Slosarczykovia circumantarctica **(no specific equations)**
ML= 16.31+20.18LRL ; ln M=0.55+1.41ln LRL (n= 11 for both ML and M) (Clarke 1986) for the species of the family Brachioteuthidae

Both species are present in predators from the Indian and Atlantic sectors of the Southern Ocean, including in the diet of Patagonian toothfish, squids, Antarctic fur seals, gentoo and macaroni penguins, petrels and sharks (Cooper & Brown 1990; Ridoux 1994; Berrow & Croxall 1999; Daneri *et al.* 1999; Hoff 2001; Cherel & Duhamel 2003; Xavier *et al.* 2003b; Arata *et al.* 2004; Cherel & Duhamel 2004; Cherel *et al.* 2004; Lescroël *et al.* 2004 ; Xavier, unpublished data). *S. circumantarctica* is however commonly encountered in food samples from many predators, and from nets, around South Georgia (e.g. Rodhouse *et al.* 1996 ; Collins, Stowasser and Xavier, unpublished data), whereas *B. linkovskyi* has not been caught in nets and specimens are rarer in diets (e.g. occasionally in wandering albatrosses breeding at South Georgia, Xavier *et al.* 2003b), suggesting that the latter species is distributed further north.

Practical procedures to differentiate the lower beaks of these species:

Beak from *B. linkovskyi* has a distinct thickened ridge running towards free corner of lateral wall whereas the beak of *S. circumantarctica* has a fold on the lateral wall, relatively less distinct (Rodhouse *et al.* 1992; Cherel *et al*. 2004). Also, *B. linkovskyi* is a much darker beak than *S. circumantarctica*. *S. circumantarctica* can be confused with cranchiids such as small *Galiteuthis glacialis*.

FAMILY CHIROTEUTHIDAE Figure 9 | pages 54 & 85

Description of beaks from this family is in need of revision world-wide. Beaks from several species of chiroteuthids were described under various names (e.g. Imber 1992), but only one species was definitely identified in the Southern Ocean (Rodhouse & Lu 1998). Thus, great care is needed when giving a species name.

Family identification:

- Very short crest relative to its hood and beaks are thin in profile (e.g. *Chiroteuthis veranyi*)
- Distinct thickened fold running to middle of posterior edge of lateral wall
- Obtuse jaw angle hidden in profile
- No shoulder tooth or groove
- Hood broadly notched in midline
- Hood lies close to the crest

At least one species is likely to be found:

***Chiroteuthis veranyi* (no specific equations)**
ML=11.4+24.46LRL ; ln M=-0.241+2.7 ln LRL (n=23 for ML, n=14 for M) (Clarke 1986), based on *Chiroteuthis* spp. formulas

This sub-Antarctic circumpolar species is present in the diet of a wide range of predators, but generally in low numbers, with the exception of the Patagonian toothfish at Kerguelen (Cherel *et al.* 2004) (Table 1).

Practical procedures to differentiate the lower beaks of this species:

C. veranyi rostrum is thinner, straighter, and has smaller crest than ?*Mastigoteuthis* A (Clarke) which is bigger and has a larger, but blunter, rostrum.

FAMILY CRANCHIIDAE Figure 10 | pages 54 & 85

Family identification:

» Wide range of characteristics and most beaks can be confused with other families (Clarke 1986)

Several species can be found in Southern Ocean waters:

Galiteuthis glacialis
ML=6.676+83.785LRL; log M= 0.415+2.20 log LRL (n=25 for ML and M) (Lu & Williams 1994)

***Galiteuthis* stC sp. (Imber) (no specific equations)**

***Galiteuthis* sp. 3 (Imber) (no specific equations)**

***Taonius* sp. B (Voss) (no specific equations)**
ML=-12.3+61.43LRL ; ln M=0.786+2.19 ln LRL (n=72 for ML, n=74 for M) (Rodhouse *et al.* 1990) based on *Taonius* spp. formulas

***Taonius* sp. (Clarke) (no specific equations)**

Teuthowenia pellucida
ML=22.27+29.90LRL ; ln M=0.71+1.94 ln LRL (n=41 for ML and M) (Rodhouse *et al.* 1990)

Mesonychoteuthis hamiltoni
ML=-12.3+61.43LRL (n=72) (Rodhouse *et al.* 1990), although the relationship is weak and therefore evaluate carefully if it applies well to your data.

Although some species might have equations for M, in certain cases it might be better to apply the following allometric equation for all squids in this family: ln M=ln 3.24 + 2.80 ln LRL (Clarke 1962b).

The Antarctic circumpolar species *G. glacialis* is one of the most common squid species in the diet of Antarctic predators, particularly important in the diet of black-browed, grey-headed and light-mantled sooty albatrosses (Cherel & Klages 1998; Cherel *et al.* 2000, 2002c; Xavier *et al.* 2003a,c). The species *Taonius* sp. B (Voss) is one of the most important species in wandering albatrosses at South Georgia (Xavier *et al.* 2003b) and in Patagonian toothfish at Crozet (Cherel *et al.* 2004). Large sizes of the Antarctic circumpolar squid *M. hamiltoni* are found in sperm whales (Clarke 1980) and sleeper sharks (Cherel & Duhamel 2004) but rarely found in other predators (Table 1). *Taonius* sp. (Clarke), *Galiteuthis* stC sp. (Imber) and *Galiteuthis* sp. 3 (Imber) and *Teuthowenia pellucida* are not common prey species (Clarke 1986; Young *et al.* 1997; Tremblay *et al.* 2003; Cherel *et al.* 2004).

Practical procedures to differentiate the lower beaks of these species:

Galiteuthis glacialis is a rather plain beak, with few distinctive features (lacks a distinct fold on lateral wall, ridge or shoulder tooth), a broad rostrum, hood length roughly 1:1 with crest length. *Galiteuthis* stC sp. (Imber), typical of Subtropical Front region, have usually their lateral walls intact when found in predators stomachs, and is relatively bigger than *G. glacialis*. *Galiteuthis* sp. 3 (Imber) has a little notch in the hood (not characteristic of *G. glacialis* nor *Galiteuthis* stC sp. (Imber)) and is also considerably bigger than *G. glacialis*. *Taonius* sp. B (Voss) can be confused with *Gonatus antarcticus*. Similar in general shape, however the crest of the lower beak of *Taonius* sp. B (Voss) is straight (slightly curved in *G. antarcticus*), has a bigger, more "inflated" hood, has a fold in the lateral wall, the bottom edge of the lateral wall is quite straight and the free corner of lateral wall is more rounded and blunt. *Taonius* sp. (Clarke) is similar to *Taonius* sp. B (Voss) but it is considerably smaller, with wings darkened at a small size (i.e. wings are found darkened at less than 5 mm LRL). *T. pellucida* is similar to *G. glacialis* but the former species has a distinctive lateral wall fold and a smaller crest in comparison to the total length of the lateral wall. *M. hamiltoni* has a broad hood, is often large, darker and potentially confused with *K. longimana*. The key differences are the lack of a distinctive fold in the lateral wall and the more "inflated" hood in *M. hamiltoni*. The beak of *M. hamiltoni* is very dark when compared to most other squids and its lower beaks darken at large sizes (Table 2).

FAMILY CYCLOTEUTHIDAE Figure 11 | pages 57 & 89

Family identification:

» Narrow fold at lateral wall
» Often curved wings
» No step at jaw edge
» Narrow distinctive crest
» Distinctive rostrum tip

The only species likely to be found is:

Cycloteuthis akimushkini
ML= 31LRL ; ln M = 1.89+1.95 ln LRL (Clarke 1986)

The species is a regular prey of wandering albatrosses breeding in the Indian Ocean (Cherel & Weimerskirch 1999) (Table 1).

Practical procedures to differentiate the lower beaks of this species:

Similar to *K. longimana* but *C. akimushkini* has not step on the jaw edge, it has a typical tip of the rostrum and a lighter fold in the lateral wall.

FAMILY GONATIDAE Figure 12 | pages 58 & 89

Family identification:

- » Distinctively laterally compressed beak when found in diets: lateral walls are usually close together
- » A tall beak (LRL longer than hood)
- » Fold in lateral wall (sometimes this is not well developed)
- » Bottom edge of lateral wall strongly curved
- » Hood curved, follows crest, which is also slightly curved

The only species likely to be found is:

***Gonatus antarcticus* (no specific equations)**
ML=-43.4+42.87LRL ; ln M=-0.655+3.33ln LRL (n=17 for ML, n=20 for M) (Clarke 1986) based on *Gonatus* spp. formulas
The following equations is better for small beaks/specimens:
ML=12.82+19.02LRL ; ln M=0.086+2.13ln LRL (Clarke 1986)

The Antarctic/sub-Antarctic squid *G. antarcticus* is commonly found in predator diets of the Southern Ocean, particularly in the diet of Patagonian toothfish, rockhopper and king penguins, wandering albatrosses and southern right-whale dolphins (Goodall & Galeazzi 1985; Rodhouse *et al.* 1996; Cherel & Klages, 1998; Cherel & Kooyman 1998; Xavier *et al*. 1999; Cherel *et al*. 2002b,c; Xavier *et al*. 2003b; Cherel *et al*. 2004).

Practical procedures to differentiate the lower beaks of this species:

Gonatus antarcticus. Can be confused with *Taonius* sp. B (Voss). Free corner of lateral wall more pointed than in *Taonius* sp. B (Voss). Also tall, but rather different shape, *G. antarcticus* has a less "inflated" hood, the bottom edge of the lateral wall curved, free corner of lateral wall less rounded and the crest is longer and more curved than in *Taonius* sp. B (Voss). Note also that upper beaks of the two species are quite different, with the upper beak of *Taonius* sp. B (Voss) having a very typical long and curved rostrum.

FAMILY HISTIOTEUTHIDAE Figure 13 | pages 59 & 90

Family identification:

- Distinct, or shallow, notch in the posterior dorsal edge of hood
- Have a well developed ridge (*Histioteuthis* A) or weakly developed ridge (*Histioteuthis* B) along the lateral wall - Rostrum tip is typically curved
- Beaks are usually small - medium in size

This family comprises various species in the Southern Ocean that are divided into two types of beaks, A and B (see Clarke 1986):

» ***Histioteuthis*** **A**, which has a deep notch in back of hood and a well-developed ridge running to free corner of lateral wall:

H. arcturi **(no specific equations)**

H. bonnellii corpuscula
ML=17.1+8.99LRL (n=19) (Clarke 1986)
ML=1.82+15.24LRL; ln M= 1.16+2.70lnLRL (n=21 for ML and M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

H. macrohista
ML=2.36+14.46LRL; ln M= 1.16+2.72lnLRL (n=8 for ML and for M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

H. miranda
ML=-7.0+25.82LRL ; ln M=1.783+2.44ln LRL (n=27 for ML, n=14 for M) (Clarke 1986)
ML=-26.51+34.21LRL; ln M= 0.86+3.04lnLRL (n=31 for ML, n=22 for M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

» ***Histioteuthis*** **B** has a shallow notch in back of hood and a weakly-developed ridge under the hood (evident in *H. atlantica* juveniles) that becomes a slight fold running to free corner of lateral wall:

H. atlantica

ML=-10.42+25.66LRL; ln M= 1.49+2.45lnLRL (n=21 for ML, n=19 for M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

H. eltaninae

ML=-3.65+24.48LRL; ln M= 0.33+3.11lnLRL (n=6 for ML, n=5 for M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

Histioteuthis arcturi occurs in Atlantic sector of the Southern Ocean waters (also known as *Histioteuthis* A5 (Clarke, 1986)) and *Histioteuthis hoylei* might occur in Indian sector of the Southern Ocean waters. These species can be confused with *Histioteuthis bonnellii bonnellii*, which does not occur in the Southern Ocean (Voss *et al.* 1998).

Within the histioteuthids, the Antarctic/sub-Antarctic circumpolar squid *H. eltaninae* is far more common in predators, being important in the diet of wandering, grey-headed, sooty and light-mantled sooty albatrosses (Cherel & Klages 1998). The sub-Antarctic circumpolar *H. atlantica* is an important prey of porbeagle sharks at Kerguelen (Cherel & Duhamel 2004). The other species are less common in predators and mostly distributed north of the Antarctic Polar Front (APF) (Imber 1992; Xavier *et al.* 1999).

Practical procedures to differentiate the lower beaks of these species:

***Histioteuthis* A.**

Histioteuthis miranda is similar to *H. macrohista* but the former species has a distinct shoulder groove and a ridge of the lateral wall that goes continuously to the end of the free corner of the lateral wall. *H. miranda* reaches a larger size than *H. macrohista*. *H. bonnellii corpuscula* has a more curved rostral tip than *H. macrohista*. *H. arcturi* tends to be more deeper than longer, with a very obvious ridge (also called a keel) under the hood.

***Histioteuthis* B.**

Beaks of *Histioteuthis eltaninae* and *H. atlantica* are easily confused. *H. eltaninae* is rounded in profile whereas *H. atlantica* is taller, has a small ridge in the lateral wall beneath the hood, jaw edge is straighter and crest is generally longer. Although the lower beaks of both species overlap in size, *H. atlantica* is usually bigger (Clarke 1986; Rodhouse *et al.* 1987). Note that small beaks of *H. atlantica* have a distinct ridge on the lateral wall under the hood, thus looking like, from a first quick glance from inexperienced eyes, beaks of *Histioteuthis* A.

FAMILY LEPIDOTEUTHIDAE Figure 14 | page 61

Family identification:

- Very low wing (and thickened) fold
- Narrow rostrum
- Long jaw angle
- Hood deeply notched
- Shallow groove at hood's surface
- Lateral wall with a deep notch to the sides of the crest and a prominent, slightly thickened fold.

The only species likely to be found is:

Lepidoteuthis grimaldii
ML=36.2LRL ; ln M=-0.17+3.0ln LRL (British Antarctic Survey, unpublished data)
ML=-10.60+50.57LRL (n=2, using total weight of preserved specimens) (Lu & Ickeringill 2002) but this relationship is obviously not strong.

The tropical/subtropical squid *L. grimaldii* is rarely found in high numbers in the diet of Southern Ocean predators (Table 1).

Practical procedures to differentiate the lower beaks of this species:

Lepidoteuthis grimaldii. Can be confused with *K. longimana* and *T. danae*. It has a thickened fold (unlike *K. longimana*), has a large notch in posterior edge of lateral wall and a shallow groove in rostrum that mirrors the underlying thickened fold in lateral wall (unlike *T. danae*).

FAMILY LOLIGINIDAE Figure 15 | pages 62 & 92

Family identification:

- » Obtuse jaw angle
- » Broad rostrum
- » No distinct fold or ridge on lateral wall
- » Jaw edge with sometimes indentation, particularly in smaller sizes

The only species likely to be found is:

Loligo gahi
ln ML= 4.23+1.01lnLRL ; ln M=2.25+2.39lnLRL (n=446) (British Antarctic Survey, unpublished data)

This sub-Antarctic species is particularly important in predators foraging at the Patagonian shelf (South America) such as black-browed albatrosses, sea lions, penguins and Commerson´s dolphins (Thompson 1992; Clarke & Goodall 1994; Alonso *et al.* 2000; Clausen & Pütz 2003; Xavier *et al.* 2003b; Herling *et al.* 2005).

Practical procedures to differentiate the lower beaks of this species :

Loligo gahi is generally a very small beak, easily identifiable by the indentated jaw angle.

FAMILY LYCOTEUTHIDAE Figure 16 | pages 62 & 93

Family identification:

» Thick, well developed lateral wall ridge
» Beaks usually dark in adults
» Shoulder forming a slight tooth
» Short crest

The only species likely to be found is:

Lycoteuthis lorigera
ML=-13.04+34.56LRL; ln M= 0.32+3.00lnLRL (n=45 for ML and M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

This subtropical species is present in the diet of predators from the Indian, Pacific and Atlantic Oceans, including catsharks in South Africa, tuna in the Tasman sea, and elephant seals and whales in Brazil (Young *et al.* 1997, Richardson *et al.* 2000; Aguiar & Haimovici 2001).

Practical procedures to differentiate the lower beaks of this species:

Lycoteuthis lorigera. This species is distinguishable from other species by the dark aspect of the beak and by the well-developed ridge in the lateral wall.

FAMILY MASTIGOTEUTHIDAE Figure 17 | pages 63 & 93

Family identification:

- Very high, and very well defined, thick fold (in certain cases becoming a ridge mostly under the hood)
- Very broad wings
- Hood with broad notch

The species likely to be found are:

Mastigoteuthis psychrophila
ML=94.424+6.203LRL ; log M=0.701+1.779logLRL (n=19 for ML and M) (British Antarctic Survey, unpublished data)

***?Mastigoteuthis* A (Clarke) (no specific equations)**

Mastigoteuthis psychrophila is an Antarctic species that is common in a wide range of Southern Ocean predators, but only in high numbers in the diet of the Patagonian toothfish and occasionally in the diet of lanternsharks, southern elephant seals and toothed whales (Cherel *et al*. 2004; Cherel & Duhamel 2004). ?*Mastigoteuthis* A (Clarke) is known to occur in sperm whales and wandering albatrosses from South Georgia (Clarke 1980; Xavier *et al.* 2003b). ?*Mastigoteuthis* A (Clarke) is possibly a synonym of the recently described chiroteuthid squid *Asperoteuthis nesisi* (Arkhipkin & Laptikhovsky 2008).

Practical procedures to differentiate the lower beaks of this species:

Mastigoteuthis psychrophila. Similar to *Batoteuthis skolops*, but it as a distinct, and well defined, thickened fold in lateral wall (closer to the hood) and a shoulder tooth. ?*Mastigoteuthis* A (Clarke) can be confused with *Chiroteuthis veranyi*, but ?*Mastigoteuthis* A (Clarke) is bigger and has a larger, but blunter, rostrum.

FAMILY NEOTEUTHIDAE Figure 18 | pages 64 & 94

Family identification:

- Shoulder forms a distinct hook-like tooth
- Lateral wall lacks a ridge or distinct fold (though a slight infold may be present)
- Recessed jaw angle from the side
- A distinctively wide, squat, but attractively proportioned beak when viewed from the front
- Frequently encountered in small numbers in albatross diets

The species likely to be found are:

Alluroteuthis antarcticus
ML=-4.301+34.99LRL ; ln M=1.229+2.944ln LRL (n=22) (Piatkowski *et al.* 2001).

Nototeuthis dimegacotyle **(no specific equations)**

The Antarctic circumpolar species *A. antarcticus* can be found in the diet of a wide range of predators, but rarely in high numbers (Table 1). The poorly known subantarctic *N. dimegacotyle* is a regular prey of predators, but it has been previously misidentified (Cherel *et al.* 2004) (Table 1).

Practical procedures to differentiate the lower beaks of these species:

Alluroteuthis antarcticus. Easily identifiable for its broad shoulder groove. *N. dimegacotyle* has a shoulder that forms a distinct tooth, has a pale strip inside jaw angle, no true fold or ridge, but lateral walls "pinched" to form overhang/suggestion of fold, wings generally folds backwards and has a shallow notch in hood. The rostrum resembles *Loligo gahi*. But *Loligo gahi* is mostly distributed at the Patagonian shelf (South America, Hatfield & Rodhouse 1994) whereas *A. antarcticus* is distributed in the Southern Ocean (Xavier *et al.* 1999). Unlike *N. dimegacotyle, L. gahi* lacks an "overhang" in lateral wall, darkening of beak extends below jaw angle and jaw edge is slightly jagged or indentated. Drawings of beaks of *N. dimegacotyle* appear in Cherel *et al.* (2004).

FAMILY OCTOPOTEUTHIDAE Figure 19 | pages 65 & 95

Family identification:

» Very low wing fold
» Broad rostrum
» Little-thickened jaw edge
» No groove in hood´s surface

The species likely to be found are:

Taningia danae
ML=-556.9+75.22LRL; ln M=-0.874+3.42ln LRL (n=15 for ML and M) (Clarke 1986)

***Octopoteuthis* sp.**
ML=-0.4+17.33LRL; ln M=0.166+2.31ln LRL (n=30 for ML, n=22 M) (Clarke 1986)

The large *T. danae* is relatively rare in Southern Ocean predators, probably with the exception of sperm whales (Table 1) and sleeper sharks (Cherel & Duhamel 2004).

Practical procedures to differentiate the lower beaks of these species:

Taningia danae. Often large, potential for confusion with *K. longimana* and *Lepidoteuthis grimaldii*. *T. danae* has a well-defined low wing fold (unlike *K. longimana*) and has a notch in posterior edge of the lateral wall. The key feature to differentiate *T. danae* from *L. grimaldii* is the absence of groove in the rostrum of *T. danae*. The beaks of *Octopoteuthis* sp. has a sharper tip in the rostrum and darken at an earlier size (e.g. wings are found dark at less than 14 mm LRL) in comparison with *T. danae*. At 14 mm LRL the wings of *T. danae* are not dark, has no rostrum tip and, in most instances, has cartilage present at the jaw. The lower beaks of this species darken at large sizes (Table 2).

FAMILY OMMASTREPHIDAE Figure 20 | pages 66 & 96

Family identification:

- » Large shoulder tooth present
- » Transparent strip below jaw angle (not always present in older beaks)
- » Low wing fold or no wing fold
- » Broad hood with a notch
- » Rostrum curved and relatively long rostral edge
- » Rather "square" profile
- » Lateral wall fold runs to point above half way between crest and free corner of lateral wall, or no fold at all

The species likely to be found are:

Martialia hyadesi
ML= 102.0+29.47LRL ; ln M=2.405+2.012 ln LRL (n=67 for ML and M) (Rodhouse & Yeatman 1990)

Illex argentinus
ML=-12.228+55.187LRL ; M=2.2750 $LRL^{3.1210}$ (n=131for ML and M) (Santos & Haimovici 2000)

***Todarodes* sp. (no specific equations)**
ML=-11.3+41.36LRL ; ln M=0.783+2.83 ln LRL (Clarke 1986), based on *Todarodes* spp. formulas

The Antarctic/sub-Antarctic circumpolar squid *M. hyadesi* is commonly found in the diet of grey-headed, black-browed and yellow-nosed albatrosses and white-chinned petrels (Croxall *et al.* 1995; Cherel & Klages 1998; Waugh *et al.* 1999; Xavier *et al.* 2003a). It is also present in the diet of other albatrosses, petrels, penguins, fish, whales and sharks (Table 1). The sub-Antarctic squid *I. argentinus* occurs in a wide range of predators feeding at the Patagonian shelf (South America) such the albatrosses, penguins, whales, dolphins, fish, sea lions and white-chinned petrels (Thompson 1992; Garcia de la Rosa *et al.* 1997; Cherel

& Klages 1998; Berrow & Croxall 1999; Alonso *et al.* 2000; Santos & Haimovici 2000; Clausen & Pütz 2003; Piatkowski *et al.* 2001; Cherel *et al.* 2002b; Xavier *et al.* 2003a,b). This species can be found in the diet of large procellariiforms outside its geographical range because it is a common bait used by longliners (Catard *et al.* 2000). Finally, *Todarodes* sp. is common in Kerguelen waters only, where it is consumed by many predators (Cherel & Weimerskirch 1995; Cherel *et al.* 2000, 2002c; Cherel *et al.* 2004; Cherel & Duhamel 2004).

Practical procedures to differentiate the lower beaks of these species:

M. hyadesi has more acutely pointed rostrum than *I. argentinus*, with distinctive "pickaxe" shape even when missing wings. *Todarodes* sp. is narrow like *M. hyadesi*, less acutely pointed rostrum like *I. argentinus*, usually larger (LRL > 10 mm) and wings do not darken until LRL of 5-9 mm (darken at < 4 mm in *M. hyadesi* and *I. argentinus*). *Pholidoteuthis massyae*, which also possess a large shoulder tooth, is easily differentiable amongst ommastrephids by the very prominent, and curved, rostrum, and deep hood notch (see Figure 22).

FAMILY ONYCHOTEUTHIDAE Figure 21 | pages 68 & 98

Some species of this family are well known, but some beaks probably belong to undescribed species (e.g. *Moroteuthis* sp. B (Imber)).

Family identification:

- Distinct jaw angle ridge
- Fold or a ridge on lateral wall (*Moroteuthis ingens, Moroteuthis* sp. B (Imber), and *Onychoteuthis banksii*)
- Beaks are often large, particularly *Kondakovia longimana*

The species likely to be found are:

Kondakovia longimana
ML=-22.348+37.318LRL ; M=0.713LRL$^{3.152}$ (n=13 for ML; n=22 for M) (Brown & Klages 1987)

Moroteuthis ingens
It is provided the mean value between estimates obtained using equations for males and females (Jackson 1995):
Males: ML= 98.59+24.40LRL (n=82); females: ML=-27.84+44.63LRL (n=68)
Males: logM= 1.22+1.80logLRL (n=82); females: logM= 0.15+3.25logLRL (n=68)

Moroteuthis knipovitchi
ML=-105.707+62.369LRL; ln M=-0.881+3.798lnLRL (n=7 for ML, n=5 for M) (Cherel, unpublished data)

Moroteuthis robsoni
ML=-652.91+151.03LRL; ln M= -9.15+8.07lnLRL (n=8 for ML, n=6 for M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

***Moroteuthis* sp . B (Imber) (no specific equations)**

Onychoteuthis banksii

ML=2.31+32.75LRL; ln M= -0.04+2.80lnLRL (n=10 for ML and M, using total weight of preserved specimens) (Lu & Ickeringill 2002)

Other very rare species that might occur are *Onychoteuthis* sp. C (Imber), and *Onychoteuthis* sp. B (Imber) (Imber 1992), which is probably the subsequently described *Notonykia africanae* (Nesis *et al.* 1998). Most recently, another species of the genus *Kondakovia* has been described, *Kondakovia nigmatullini* (Laptikhovsky *et al.* 2008).

The Antarctic/sub-Antarctic circumpolar squid *K. longimana* is commonly found in the diet of albatrosses, penguins, bottlenose and sperm whales, and sleeper sharks (Clarke 1980; Brown & Klages 1987; Clarke & Goodall 1994; Cherel & Klages 1998; Green & Burton 1998; Cherel & Weimerskirch 1999; Arata & Xavier, 2003; Xavier, 2003a,b,c; Arata *et al.* 2004; Cherel & Duhamel 2004;). This species is also widely present in other Antarctic predators (Table 1), although it is relevant to re-assess possible mis-identifications with *K. nigmatullini*. The Antarctic circumpolar squid *M. knipovitchi* is common in the diet of sperm whales and grey-headed, black-browed and wandering albatrosses in some years (Clarke 1980; Cherel & Klages 1998; Xavier *et al.* 2003a). The sub-Antarctic circumpolar squid *M. ingens* is common in the diet of king penguins, wandering and royal albatrosses, pilot whales and the southern opah (Clarke & Goodall 1994; Cherel *et al.* 1996; Cherel & Klages 1998; Cherel & Weimerskirch 1999; Jackson *et al.* 2000), whereas the warm-water circumpolar species *M. robsoni* and *O. banksii* are generally not very common in predator diets. Finally, the poorly known *Moroteuthis* sp. B (Imber) is a regular prey of Patagonian toothfish and king penguins in the southern Indian Ocean (Cherel *et al.* 2004, unpublished data).

Practical procedures to differentiate the lower beaks of these species:

K. longimana beaks are usually big, with a large rostrum and jaw angle step well defined. It also has a hood shorter than the crest that flares up from line of crest, long jaw edge, with distinct jaw angle, whereas *M. knipovitchi* has a hood that curves to follow line of crest, shorter jaw edge, and less distinct curved jaw angle when viewed from the side. Hood length equal to (or slightly shorter than) crest length. *K. nigmatullini* has been described based on two immature specimens, whose beaks are small making comparisons with large beaks of *K. longimana* difficult. The lower beaks of *K. nigmatullini* have a well-developed ridge along the entire length and remaining distinct to posterior margin of lateral wall (Laptikhovsky *et al.* 2008) whereas *K. longimana* has a fold on the lateral wall of their lower beaks. However, from the photos of the lower beak of *K. nigmatullini* (Laptikhovsky *et al.* 2008*)* the ridge on the lateral wall is not apparent, and therefore more individuals, and beaks, from this newly described species are needed. *M. knipovitchi* can be also confused with *M. robsoni*, but the latter has very long wings and hood doesn't curve following the line of the crest (i.e. fairly straight) and it reaches larger size. *M. ingens* can be easily identified by having a concave shape and a curved ridge on the lateral wall (it becomes a fin close to the hood) in adults. Sexual dimorphism in the beaks of *M. ingens* has been recently described when they reach a large size (Bolstad 2006). The beaks of *M.* sp. B (Imber) darken at a smaller size, its ridge is straight and asperous (in comparison with *M. ingens*), with a coarse texture, that runs to the middle of posterior edge and extend much further than the hood in adults (unlike *M. ingens* and *O. banksii*). Drawings of beaks of this species appear in Cherel *et al.* (2004). *O. banksii* is a small species and therefore wings are already darkened at < 3 mm LRL, the lower beak has a very strong ridge all along the lateral wall. For juvenile squid, *K. longimana* and *M. ingens* have a long and narrow dark jaw, whereas *M. knipovitchi* and *M. robsoni* have a wide and broader dark jaw.

FAMILY PHOLIDOTEUTHIDAE Figure 22 | pages 72 & 101

Family identification:

» Curved rostral tip
» Shoulder tooth
» Unthickened lateral wall fold
» Crest narrow

The only species likely to be found is:

Pholidoteuthis massyae
ML=11.3+41.09LRL ; ln M=0.976+2.83ln LRL (n=12 for ML, n=15 for M) (Clarke 1986)

This subtropical/temperate species is present in a wide range of predator diets from the Atlantic, Indian and Pacific waters, including albatrosses, petrels, sperm whales and Patagonian toothfish, but always in low numbers (Clarke & MacLeod 1982b, Imber *et al.* 1995, Xavier *et al*. 2003b, Cherel *et al.* 2004). This species was previously named *Pholidoteuthis boschmai* (Table 3; O´Shea *et al*. 2007).

Practical procedures to differentiate the lower beaks of this species:

P. massyae can be confused with ommastrephids but it can be is easy differentiable by the short step below the jaw angle (as in onychoteuthids) and the very prominent, and curved, rostrum and deep hood notch.

FAMILY PSYCHROTEUTHIDAE Figure 23 | pages 72 & 101

Family identification:

» A distinctive square shoulder tooth
» Very distinct thick ridge running to near, or just below the middle of posterior edge of the lateral wall
» Hood length 1:1 with crest length
» Hood stands high above crest
» Obtuse jaw angle not (or possibly, in older specimens, just) hidden from the side by a low wing fold
» Clear strip below jaw angle in young beaks
» Beaks may be large or small (i.e. usually two almost distinct beak size groups)

The only species likely to be found is:

Psychroteuthis glacialis
$ML= 50.6895LRL-8.6008LRL^2+1.0823LRL^3-8.7019$ (n=211) ; $\ln M = 0.3422+2.1380 \ln LRL+0.2214 \ln LRL^3$ (Gröger *et al*. 2000)

This Antarctic circumpolar species occurs particularly in high numbers in the diet of emperor penguins, sperm whales and elephant seals (Offredo *et al.* 1985; Piatkowski *et al.* 2002; Clarke 1980).

Practical procedures to differentiate the lower beaks of this species:

Psychroteuthis glacialis. Easily identified by a shoulder tooth and ridge on the lateral wall. Can be confused with sub-adults of *M. ingens* and *M.* sp. B (Imber). The beaks of both the small and the large forms are usually dark. Note that the small form is rare in predator diets.

FAMILY SEPIOLIDAE Figure 24 | pages 73 & 102

Family identification:

» Jaw edge not S-shaped
» No lateral wall fold
» Deep groove or step in the sides of the hood
» Obtuse jaw angle
» Indefinite jaw angle

The only species likely to be found is:

cf. *Stoloteuthis leucoptera*

This species is present in the diet of Patagonian tootfish from the Indian Ocean, at Kerguelen Islands (Cherel *et al.* 2004).

Practical procedures to differentiate the lower beaks of this species:

cf. *Stoloteuthis leucoptera* is differentiable from other cephalopod species by its small size (i.e. they darken at small size), the lack of a well-defined angle point of the jaw.

FAMILY UNKNOWN Figure 25 | pages 74 & 102

Oegopsida sp. A (Cherel) (no allometric equations available)

From a single lower beak found in the diet of sooty albatrosses collected at Marion Island, Imber (1978) described a new species, *Gonatus phoebetriae*. We called this squid Oegopsida sp. A (Cherel) because, according to us, the beaks cannot be assigned with confidence to *Gonatus*. Drawings of beaks of this species appear in Cherel *et al*. (2004) (Figure 25).

Oegopsida sp. A (Cherel) is a rare prey of Patagonian toothfish at Crozet (Cherel *et al*. 2004) .

OCTOPODA

» FAMILY ALLOPOSIDAE
» FAMILY CIRROTEUTHIDAE
» FAMILY OCTOPODIDAE
» FAMILY OPISTHOTEUTHIDAE
» FAMILY STAUROTEUTHIDAE

FAMILY ALLOPOSIDAE Figure 26 | page 76

Family identification:

» Broad hood, fairly flat in profile
» Acute jaw angle
» Fold present

The only species likely to be found is:

Haliphron atlanticus
Ln M=2.5+1.45ln LHL (British Antarctic Survey, unpublished data)

This cosmopolitan species is regular in the diets of wandering albatrosses and great-winged petrels (Xavier *et al.* 2003b; Table 1).

Practical procedures to differentiate the lower beaks of this species:

Haliphron atlanticus. Different shape of lower beak cf. squid. No well-defined jaw angle, so measure lower hood length (LHL) instead of LRL. Definite large rostrum compared with other pelagic octopods but small compared with decapod (squid) beaks. Broad hood, fairly flat in profile, stands high above the crest posteriorly.

FAMILY CIRROTEUTHIDAE Figure 27 | pages 76 & 104

Family identification:

» Long crest in relation to the size of the hood
» Rostrum with small hook

The only species likely to be found is:

Cirrata sp. A (Cherel) (no allometric equations available)

This species is present in predators from the Indian Ocean, such as the Patagonian toothfish and sleeper sharks (Cherel *et al.* 2004; Cherel & Duhamel 2004).

Practical procedures to differentiate the lower beaks of this species:

Cirrata sp. A (Cherel). This large species has an identifiable rostrum with a small hook and a sharp rostrum.

FAMILY OCTOPODIDAE Figure 28 | pages 77 & 104

There are many species of endemic benthic octopods all around Antarctica and sub-Antarctic islands (review in Collins & Rodhouse, 2008), but they are usually reported in low numbers in predator diets. In terms of identifying beaks from Antarctic octopodids, numerous species have very similar beaks (e.g. *Thaumeledone* spp.; Allcock *et al*. 2004), making the identification to a species level difficult. Below are beaks of octopod species that have been found regularly in the diet of predators and have features that makes them identifiable.

Family identification:

» No fold or ridge on lateral wall
» No hood notch
» Shoulder tooth absent
» Angle point absent
» Free corners of lateral walls widely spread
» Rostrum tip blunt

The numerous species present in this family include:

Pareledone turqueti
ML=17.70487+ 13.32812LHL; LnM =0.689269+2.542938LnLHL (n=7 for ML, n=23 for M), where LHL= lower hood length (in mm) (Collins, unpublished data)

Adelieledone polymorpha
ML= -7,426229508+25,16393443LHL; Ln M =1,077552+3,200449LnLHL
(n=3 for ML, n= 39 for M) (Collins, unpublished data)

Benthoctopus thielei
ML = 7.398+12.569LHL; lnM= 0.471+2.706lnLHL (n=48 for ML and M) (Cherel, unpublished data)

Graneledone gonzalezi
ML = 5.047+13.004LHL; lnM= 0.288+2.967lnLHL (n=54 for ML and M) (Cherel, unpublished data)

The Antarctic species *P. turqueti* and *A. polymorpha*, mostly present in South Georgia waters, are common in the diet of the Patagonian toothfish, but also present in the diets of albatrosses and seals (Rodhouse & Prince 1993; Reid & Arnould 1996; Rodhouse *et al.* 1996; Croxall *et al*. 1997; Daneri *et al.* 2000; Rodhouse *et al*. 1992; Xavier *et al*. 2002). The Kerguelen endemic *B. thielei* is present in black-browed albatross diet and both *B. thielei* and *G. gonzalezi* in the food of Patagonian toothfish (Cherel *et al.* 2000, 2002c, 2004).

Practical procedures to differentiate the lower beaks of these species:

Octopods of the genus *Adelieledone* have a peculiar beak morphology, which contrasts with other genera of benthic octopods in the area in which the overall shape is similar, thus often precluding species identification. In South Georgia, *Pareledone turqueti* is easily differentiated from *A. polymorpha* by the latter species having a rostral tip sharp and pointed. On the other hand, there is no good way to differentiate the lower beaks of the two endemic species from the Kerguelen Plateau, *Benthoctopus thielei* and *Graneledone gonzalezi*.

FAMILY OPISTHOTEUTHIDAE Figure 29 | pages 78 & 106

Family identification:

» Jaw obtuse or absent

The identifiable species likely to be found is:

***Opisthoteuthis* sp.**
ML=-26.0047+12.4858CL; logM=0.5893+0.2413CL (n= 13 for ML, n=9 for M) (Smale *et al.* 1993) where CL = Crest length (in mm)

This species is present in predators from the Indian Ocean, such as the Patagonian toothfish (Cherel *et al.* 2004).

Practical procedures to differentiate the lower beaks of this species:

This species has a typical curved rostrum and a short jaw edge. Drawings of beaks of that species appear in Cherel *et al.* (2004).

FAMILY STAUROTEUTHIDAE Figure 30 | pages 79 & 107

Family identification:

» Sharp rostrum
» Large hook
» Straight crest

The identifiable species likely to be found is:

***Stauroteuthis gilchristi* (no allometric equations available)**

This species is present in predators from the Indian Ocean, such as the Patagonian toothfish (Cherel *et al.* 2004), although it is known to occur in southern Atlantic Ocean waters too (Collins & Henriques 2000).

Practical procedures to differentiate the lower beaks of this species:

Stauroteuthis gilchristi. Easily identifiable by the large hook at the tip of the rostrum. Drawings of beaks of this species appear in Cherel *et al.* (2004).

LOWER CEPHALOPOD BEAKS

DECAPODA

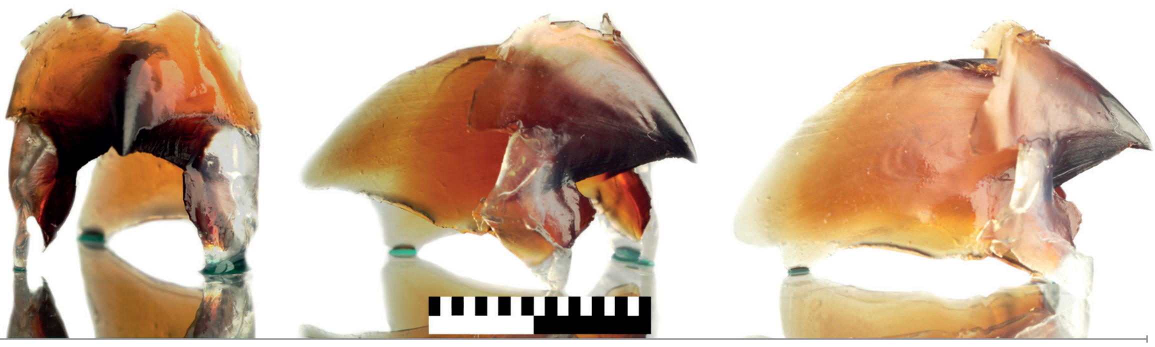
» FAMILY ANCISTROCHEIRIDAE
» FAMILY ARCHITEUTHIDAE
» FAMILY BATHYTEUTHIDAE
» FAMILY BATOTEUTHIDAE
» FAMILY BRACHIOTEUTHIDAE
» FAMILY CHIROTEUTHIDAE
» FAMILY CRANCHIIDAE
» FAMILY CYCLOTEUTHIDAE
» FAMILY GONATIDAE
» FAMILY HISTIOTEUTHIDAE
» FAMILY LEPIDOTEUTHIDAE
» FAMILY LOLIGINIDAE
» FAMILY LYCOTEUTHIDAE
» FAMILY MASTIGOTEUTHIDAE
» FAMILY NEOTEUTHIDAE
» FAMILY OCTOPOTEUTHIDAE
» FAMILY OMMASTREPHIDAE
» FAMILY ONYCHOTEUTHIDAE
» FAMILY PHOLIDOTEUTHIDAE
» FAMILY PSYCHROTEUTHIDAE
» FAMILY SEPIOLIDAE
» FAMILY UNKNOWN

FAMILY ANCISTROCHEIRIDAE Figure 4 | pages 13 & 82

Ancistrocheirus lesueuri | from the diet of a Wandering albatross, South Georgia, 4.4 mm LRL

FAMILY ARCHITEUTHIDAE Figure 5 | pages 14 & 82

Architeuthis dux | adult | Sleeper shark, Kerguelen, 16.2 mm LRL

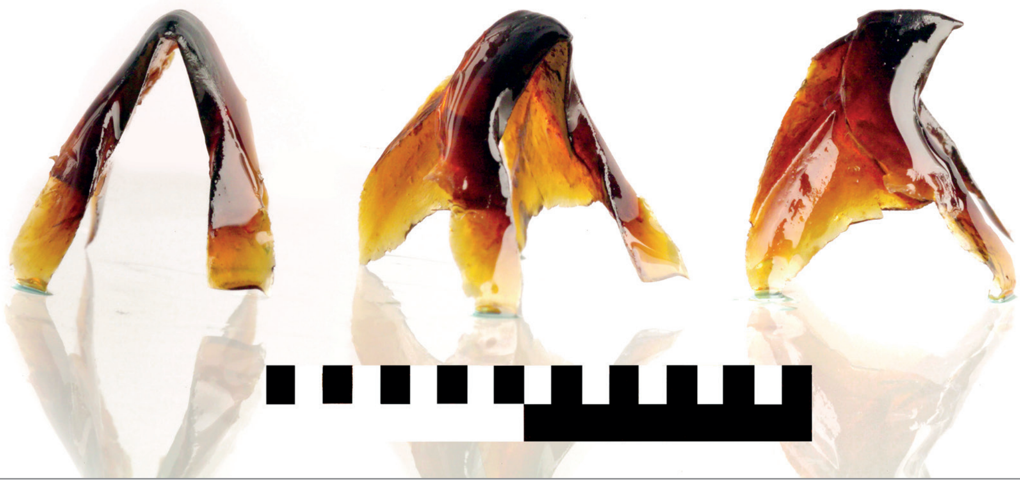


Architeuthis dux | juvenile | Sleeper shark, Kerguelen, 10.1 mm LRL

FAMILY BATHYTEUTHIDAE Figure 6 | pages 15 & 83

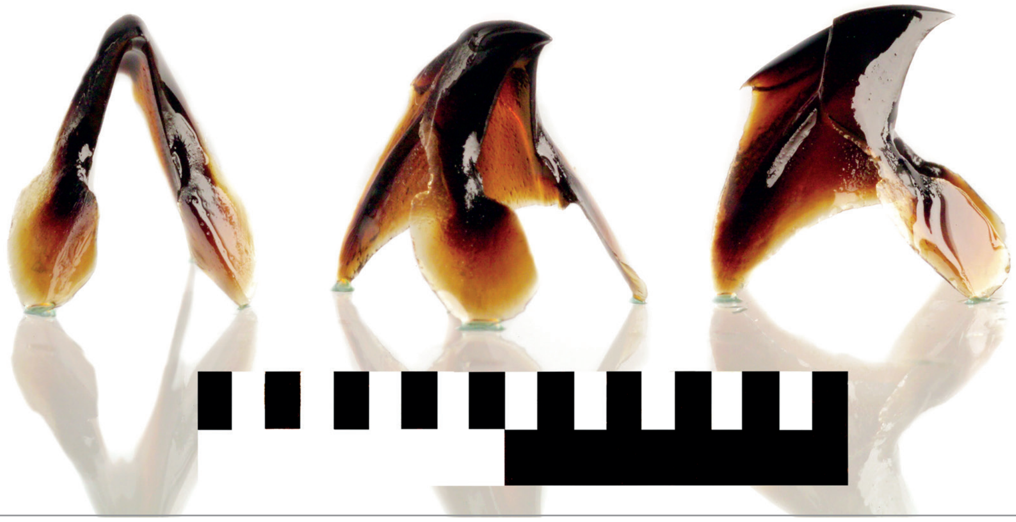
Bathyteuthis abyssicola | from fresh specimen, South Georgia, 0.8 mm LRL

FAMILY BATOTEUTHIDAE Figure 7 | pages 16 & 83



Batoteuthis skolops | Wandering albatross, South Georgia, 4.6 mm LRL

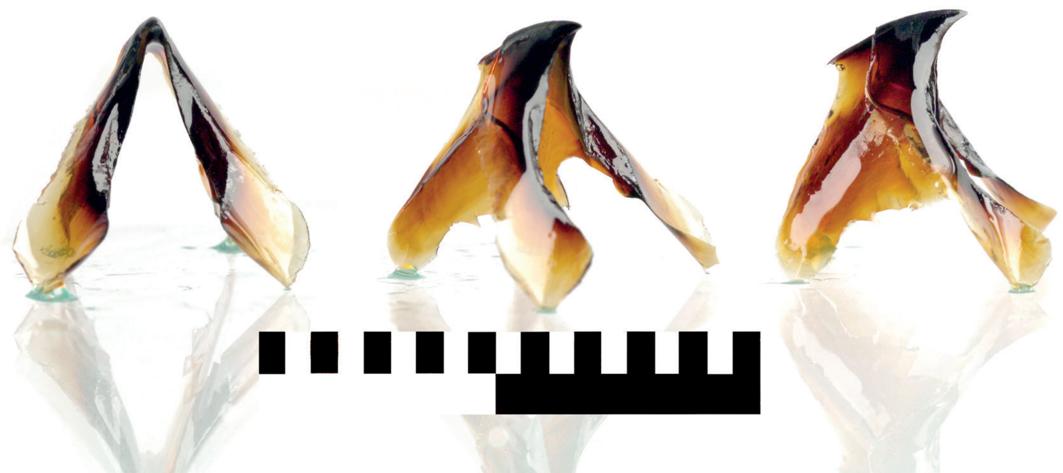
FAMILY BRACHIOTEUTHIDAE Figure 8 | pages 17 & 84



Brachioteuthis linkovskyi | Grey-headed albatross, South Georgia, 4.8 mm LRL

Slosarczykovia circumantarctica | Black-browed albatross, South Georgia, 2.0 mm LRL

FAMILY CHIROTEUTHIDAE Figure 9 | pages 19 & 85

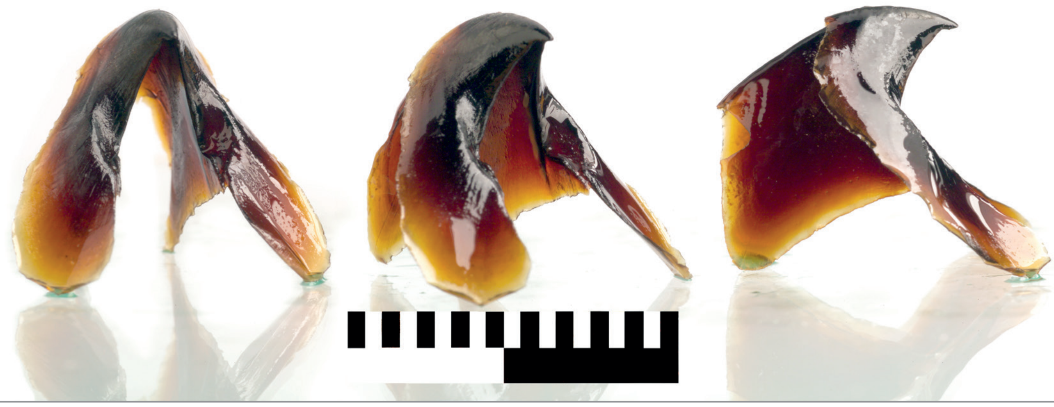


Chiroteuthis veranyi | Wandering albatross, South Georgia, 5.2 mm LRL

FAMILY CRANCHIIDAE Figure 10 | pages 20 & 85

Galiteuthis glacialis | Wandering albatross, South Georgia, 5.3 mm LRL

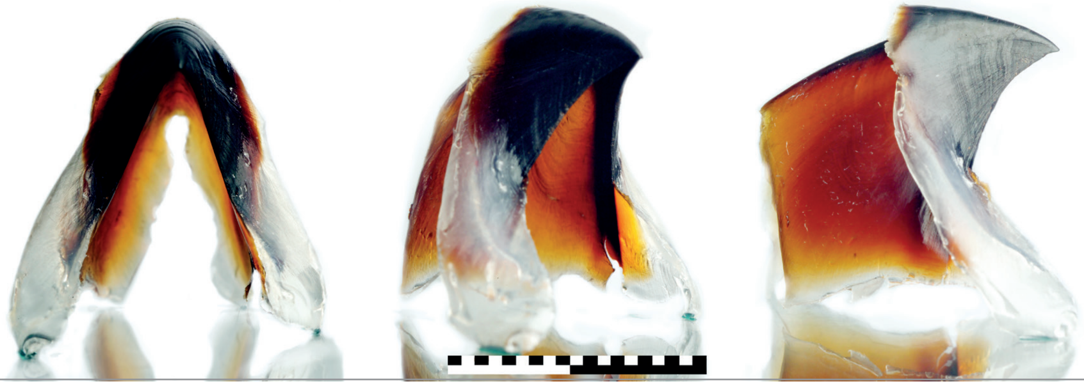
Galiteuthis stC sp. (Imber) | Wandering albatross, Crozet, 6.3 mm LRL



Galiteuthis sp. 3 (Imber) | Wandering albatross, Crozet, 8.3 mm LRL

Mesonychoteuthis hamiltoni | adult | Sleeper shark, Kerguelen, 23.6 mm LRL

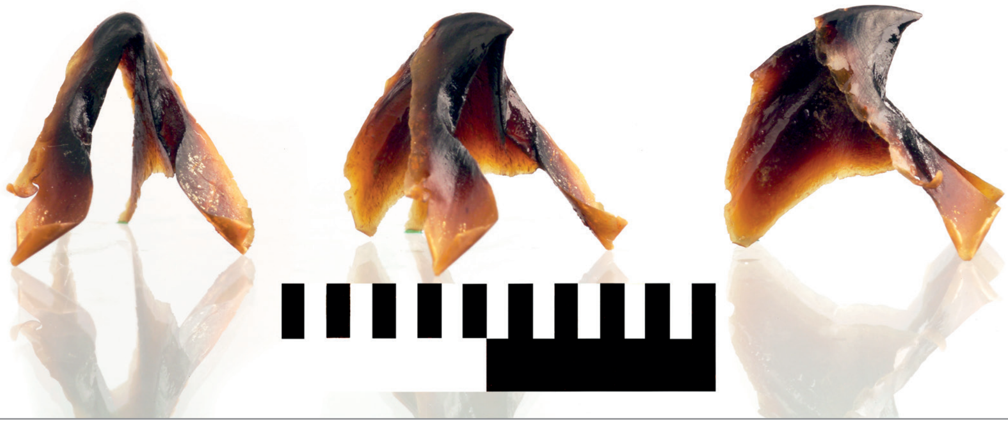
continue...



Mesonychoteuthis hamiltoni | juvenile | Sleeper shark, Kerguelen, 10.4 mm LRL

Taonius sp. (Clarke) | Wandering albatross, Crozet, 5.0 mm LRL

Taonius sp. B (Voss) | Wandering albatross, South Georgia, 8.9 mm LRL



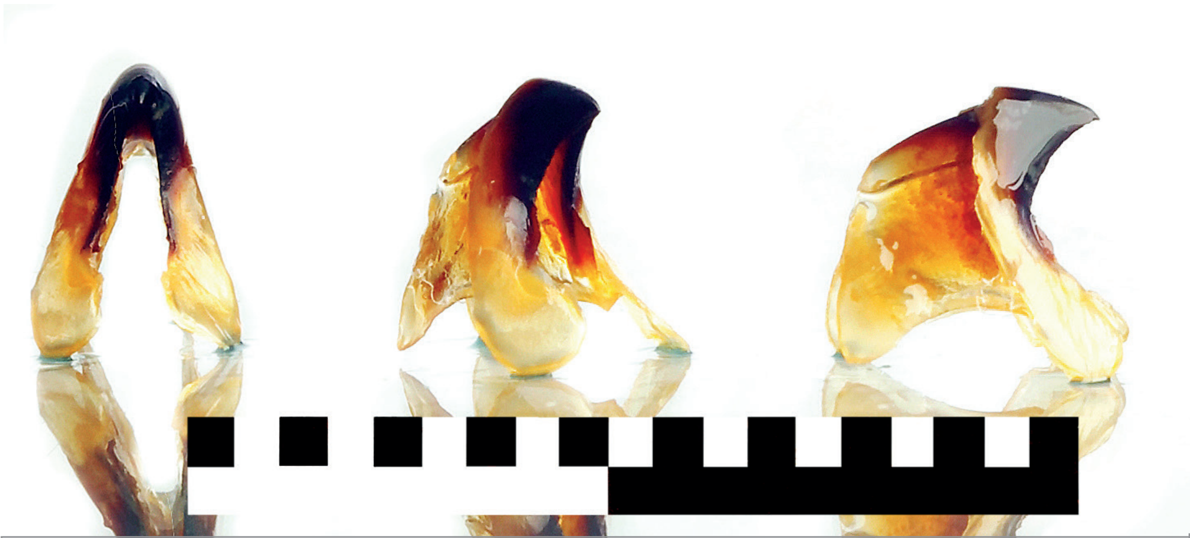
Teuthowenia pellucida | Yellow-nosed albatross, Amsterdam, 5.0 mm LRL

FAMILY CYCLOTEUTHIDAE Figure 11 | pages 22 & 89

Cycloteuthis akimushkini | Wandering albatross, Crozet, 14.9 mm LRL

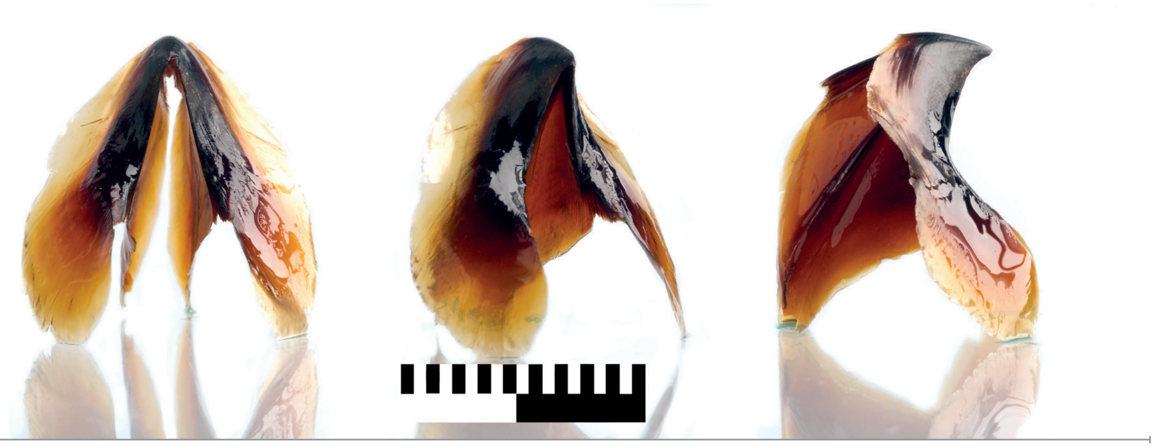
FAMILY GONATIDAE Figure 12 | pages 23 & 89

Gonatus antarcticus | adult |Grey-headed albatross, South Georgia, 7.3 mm LRL



Gonatus antarcticus | juvenile | King penguin, Falkand Islands, 2.5 mm LRL

FAMILY HISTIOTEUTHIDAE Figure 13 | pages 24 & 90

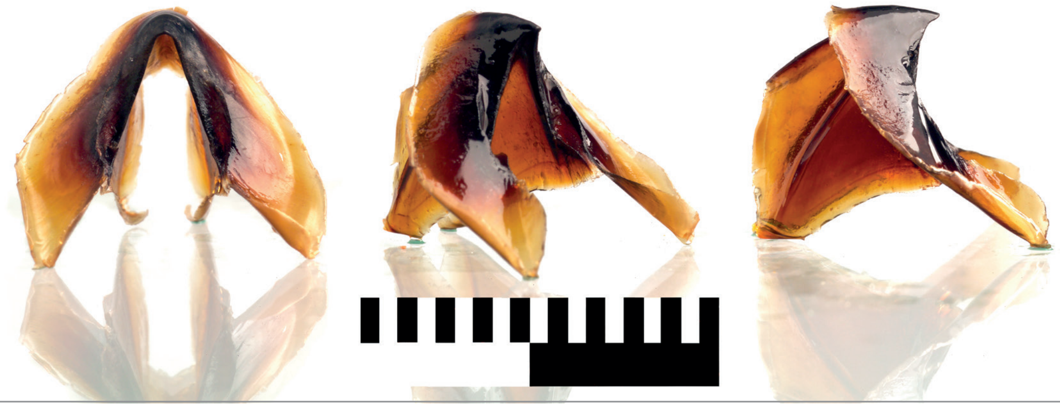


Histioteuthis arcturi | =H. A5 in Clarke (1986); Wandering albatross, South Georgia, 10.3 mm LRL

Histioteuthis bonnellii corpuscula | Wandering albatross, Crozet, 4.9 mm LRL

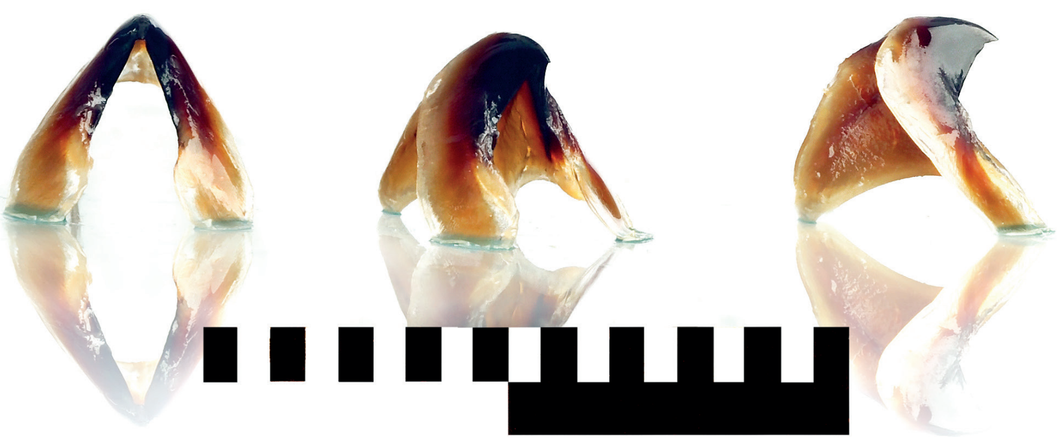
Histioteuthis macrohista | Wandering albatross, South Georgia, 3.5 mm LRL

continue...

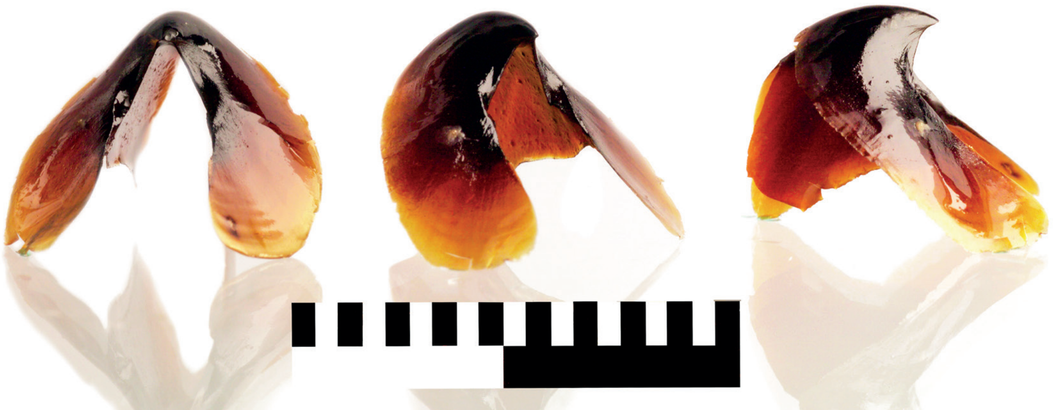


Histioteuthis miranda | Wandering albatross, Crozet, 6.7 mm LRL

Histioteuthis atlantica | adult | Wandering albatross, South Georgia, 5.3 mm LRL

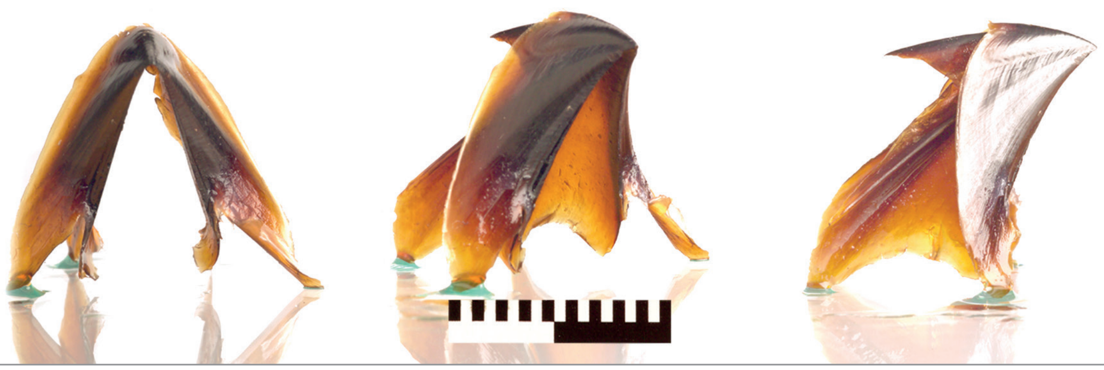


Histioteuthis atlantica | juvenile | Patagonian toothfish, Kerguelen, 2.2 mm LRL



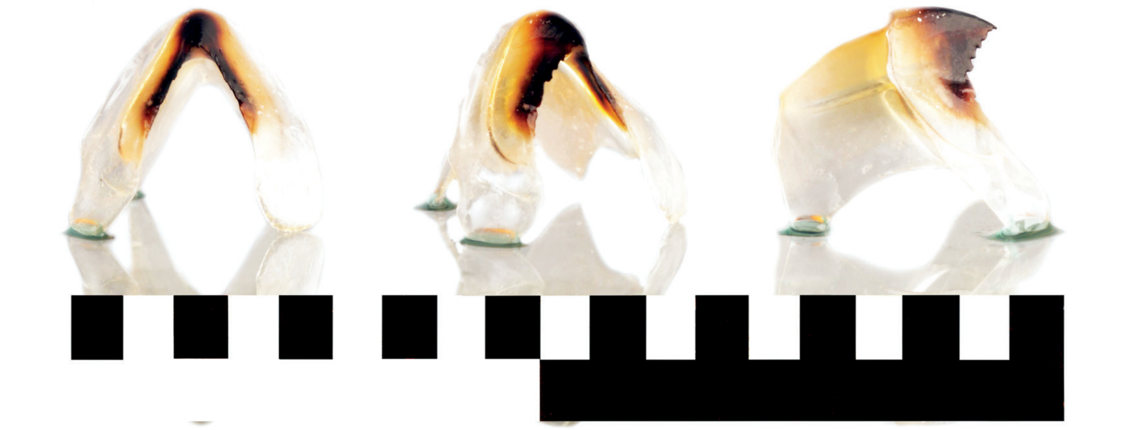
Histioteuthis eltaninae | Wandering albatross, South Georgia, 3.6 mm LRL

FAMILY LEPIDOTEUTHIDAE Figure 14 | page 27



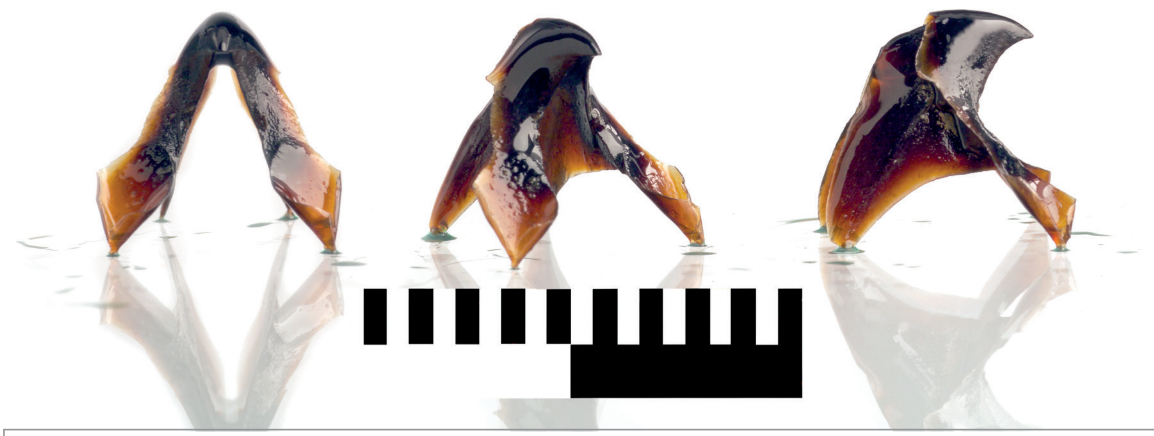
Lepidoteuthis grimaldii | Wandering albatross, South Georgia, 15.9 mm LRL

FAMILY LOLIGINIDAE Figure 15 | pages 28 & 92



Loligo gahi | Wandering albatross, South Georgia, 1.6 mm LRL

FAMILY LYCOTEUTHIDAE Figure 16 | pages 29 & 92



Lycoteuthis lorigera | Yellow-nosed albatross, Amsterdam, 4.3 mm LRL

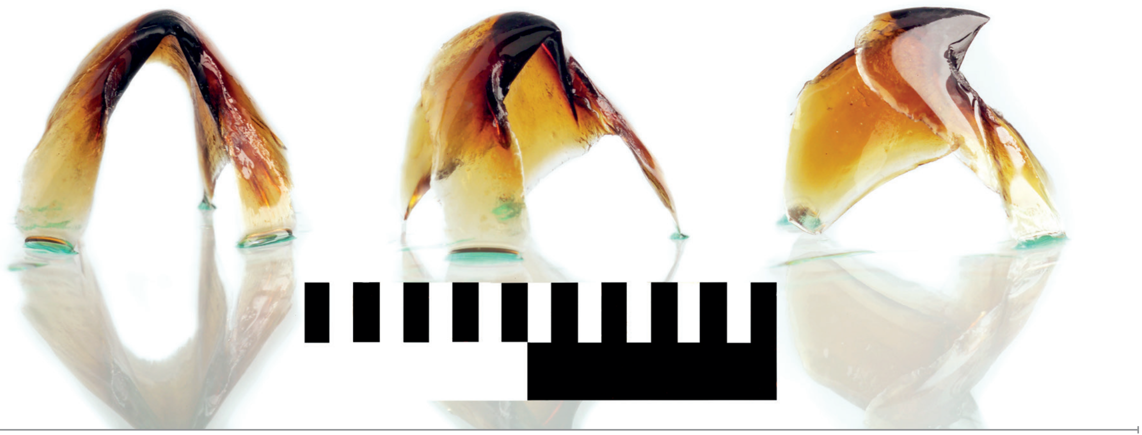
FAMILY MASTIGOTEUTHIDAE Figure 17 | pages 30 & 93

Mastigoteuthis psychrophila | Wandering albatross, South Georgia, 3.7 mm LRL

?Mastigoteuthis A (Clarke) | Wandering albatross, South Georgia, 6.7 mm LRL

FAMILY NEOTEUTHIDAE Figure 18 | pages 31 & 94

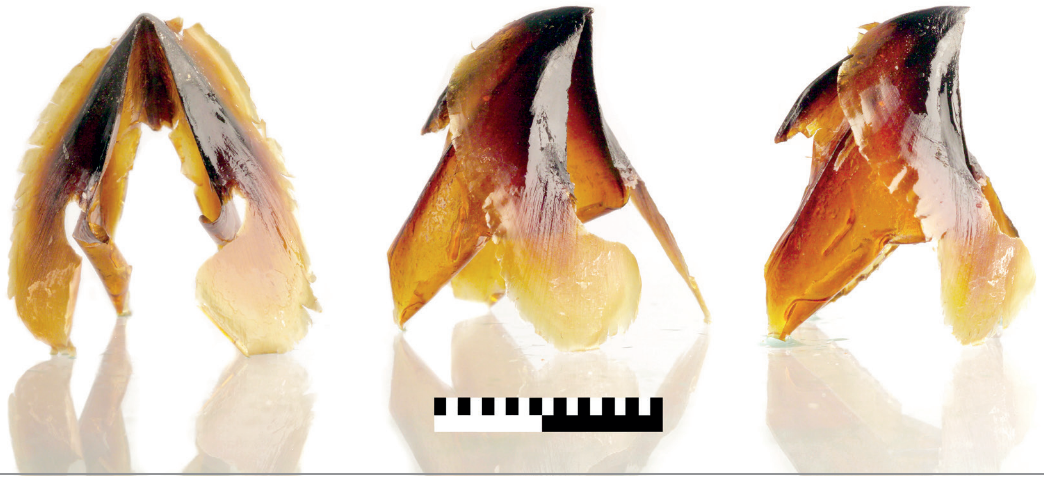
Alluroteuthis antarcticus | Wandering albatross, South Georgia, 5.4 mm LRL



Nototeuthis dimegacotyle | Patagonian toothfish, Crozet, 3.1 mm LRL

FAMILY OCTOPOTEUTHIDAE Figure 19 | pages 32 & 95

Taningia danae | Sleeper shark, Kerguelen, 16.6 mm LRL

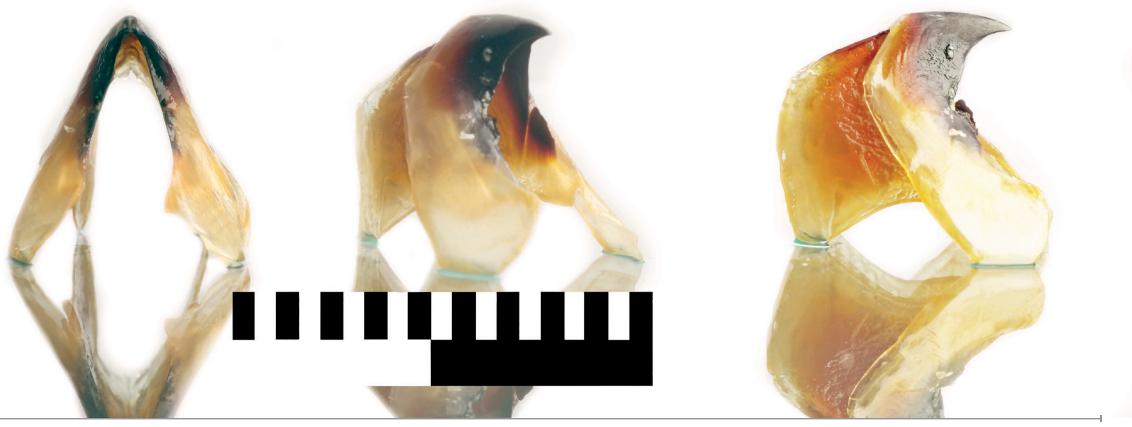


Octopoteuthis sp. | Wandering albatross, South Georgia, 14.5 mm LRL

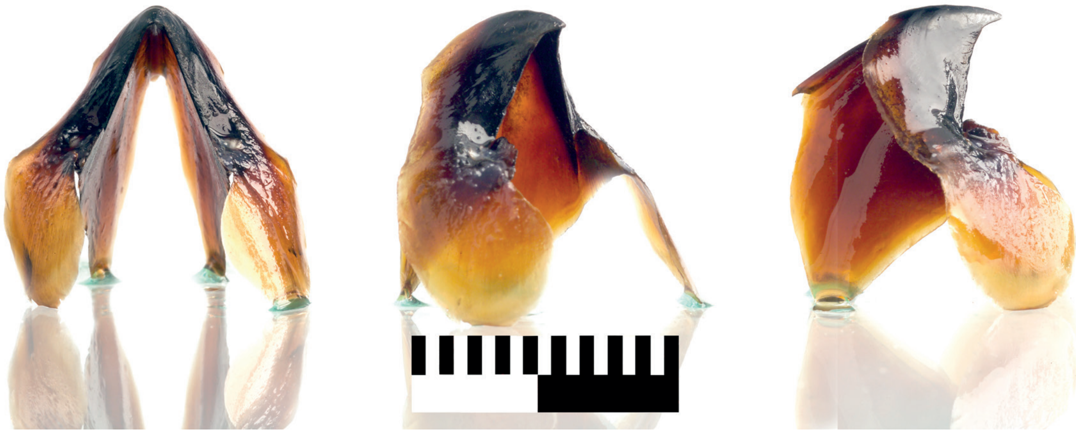
FAMILY OMMASTREPHIDAE Figure 20 | pages 33 & 96

Illex argentinus | Wandering albatross, South Georgia, 6.9 mm LRL

Martialia hyadesi | adult | Wandering albatross, Crozet, 8.4 mm LRL



Martialia hyadesi | juvenile | Black-browed albatross, Crozet, 4.7 mm LRL



Todarodes sp. | adult | Black-browed albatross, Kerguelen, 10.1 mm LRL

Todarodes sp. | juvenile | Grey-headed albatross, Kerguelen, 5.4 mm LRL

FAMILY ONYCHOTEUTHIDAE Figure 21 | pages 35 & 98

Kondakovia longimana | adult | Wandering albatross, South Georgia, 11.3 mm LRL

Kondakovia longimana | juvenile | Patagonian toothfish, Kerguelen, 3.7 mm LRL

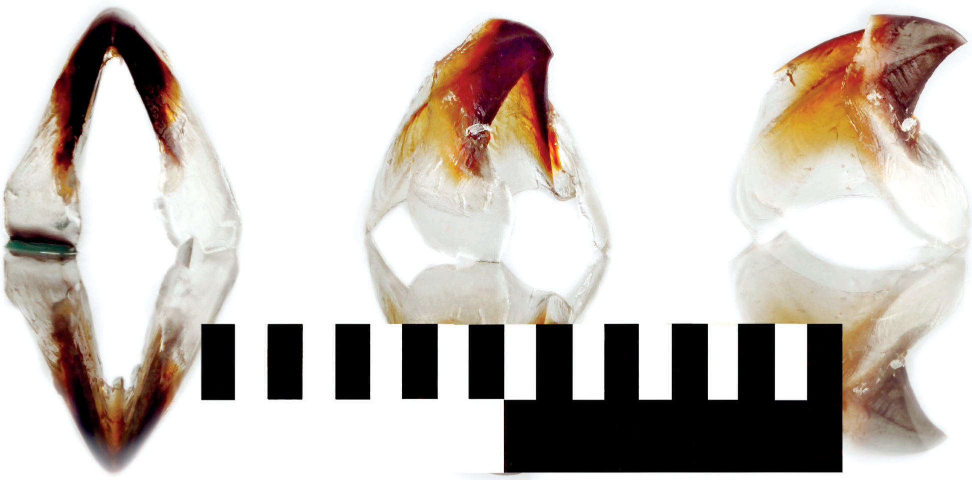
Moroteuthis knipovitchi | adult | Wandering albatross, South Georgia, 6.3 mm LRL

Moroteuthis knipovitchi | juvenile | King penguin, Crozet, 2.9 mm LRL

continue...

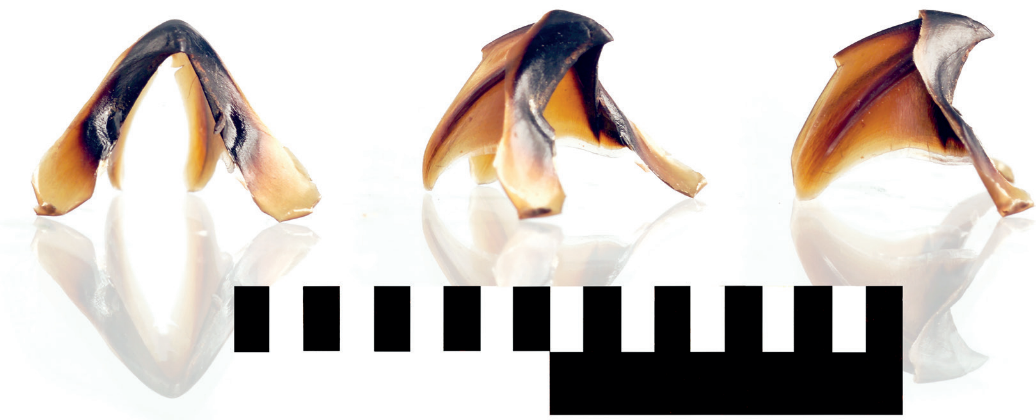
Moroteuthis ingens | female adult | Wandering albatross, South Georgia, 10.2 mm LRL

Moroteuthis ingens | male adult | Patagonian toothfish, Crozet, 8.7 mm LRL

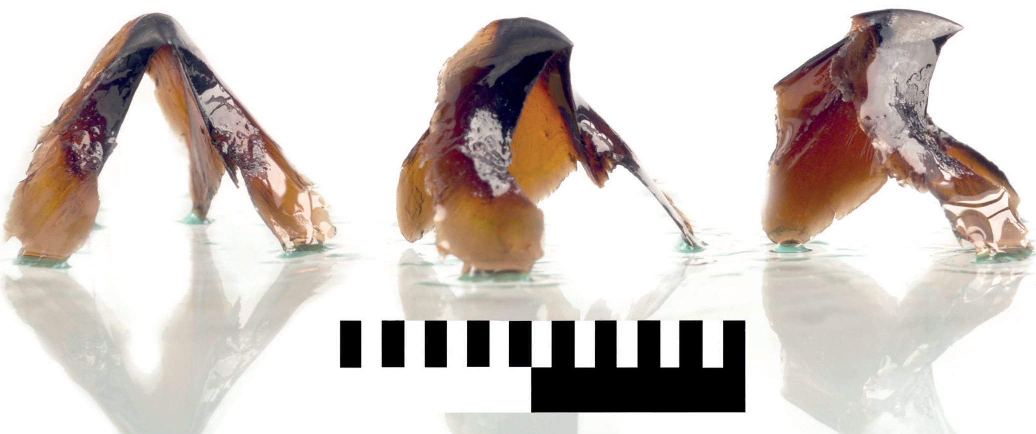


Moroteuthis ingens | juvenile | Patagonian toothfish, Crozet, 3.0 mm LRL

Moroteuthis robsoni | Wandering albatross, South Georgia, 8.3 mm LRL

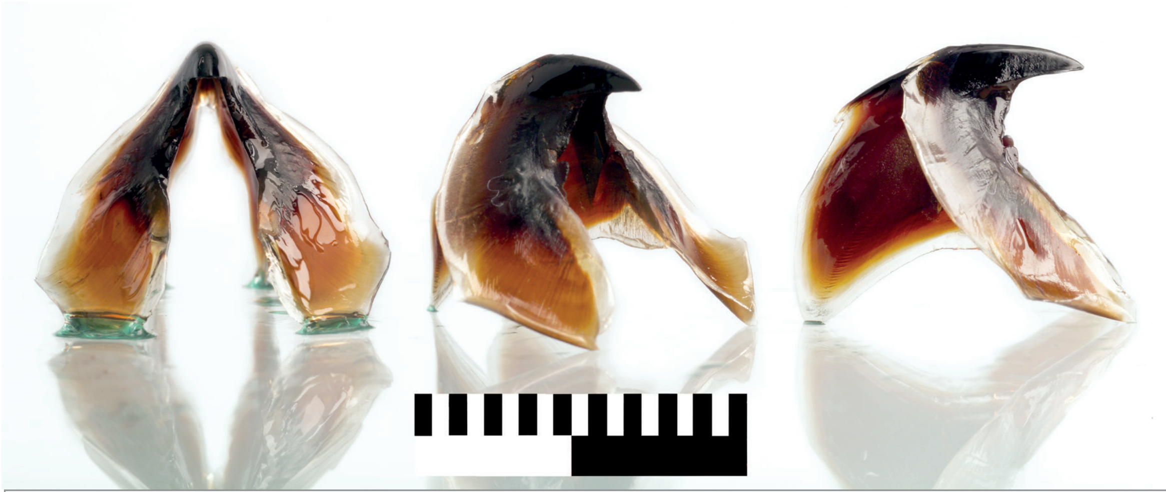


Onychoteuthis banksii | Subantarctic fur seal, Amsterdam, 2.9 mm LRL



Moroteuthis sp. B (Imber) | Patagonian toothfish, Kerguelen, 5.4 mm LRL

FAMILY PHOLIDOTEUTHIDAE Figure 22 | pages 38 & 101



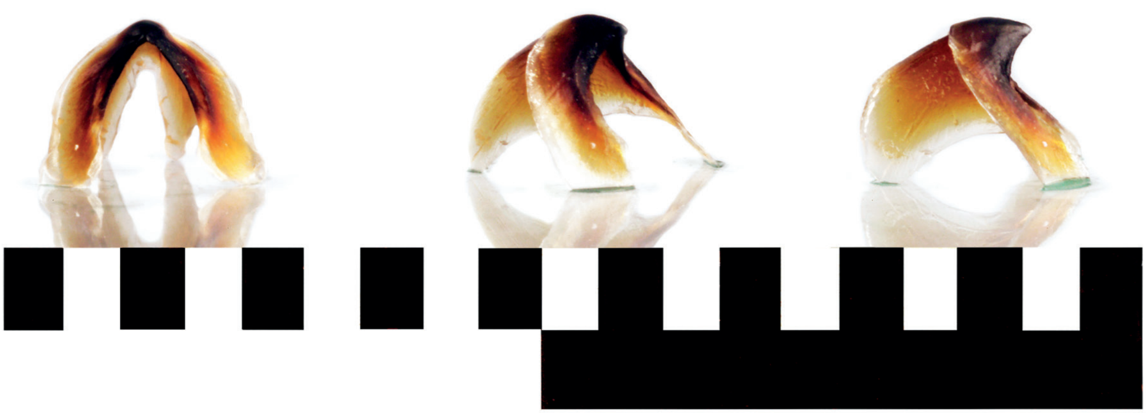
Pholidoteuthis massyae | Patagonian toothfish, Kerguelen, 6.5 mm LRL

FAMILY PSYCHROTEUTHIDAE Figure 23 | pages 39 & 101

Psychroteuthis glacialis | adult | Wandering albatross, South Georgia, 7.7 mm LRL

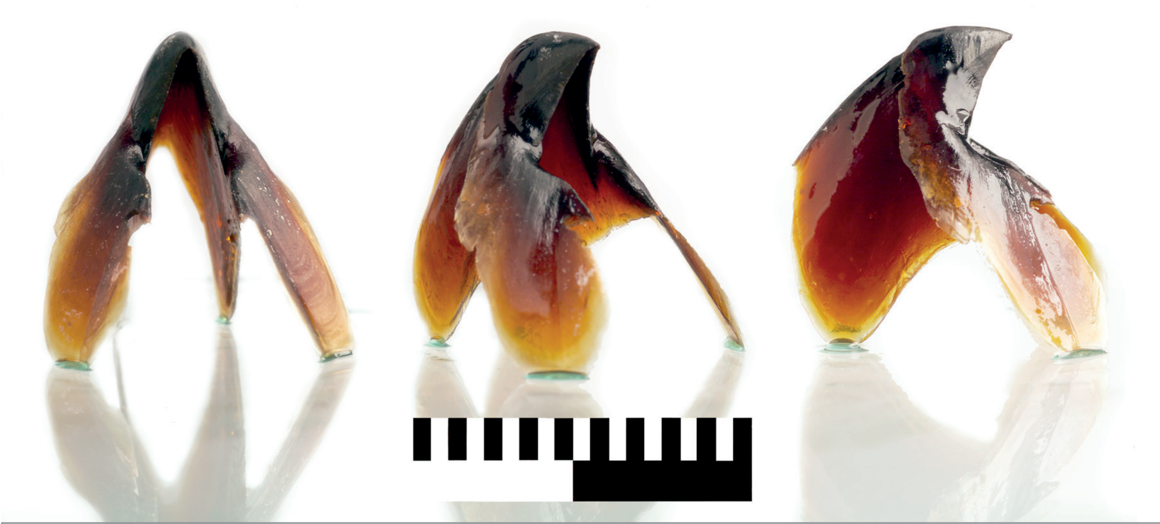
Psychroteuthis glacialis | juvenile | Emperor penguin, Adélie Land, Antarctica, 1.8 mm LRL

FAMILY SEPIOLIDAE Figure 24 | pages 40 & 102



cf. *Stoloteuthis leucoptera* | from fresh specimen, Kerguelen, 1.3 mm LRL

FAMILY UNKNOWN Figure 25 | pages 41 & 102



Oegopsida sp. A (Cherel) | = *Gonatus phoebetriae* (Imber); Patagonian toothfish, Crozet, 7.0 mm LRL

OCTOPODA

» FAMILY ALLOPOSIDAE
» FAMILY CIRROTEUTHIDAE
» FAMILY OCTOPODIDAE
» FAMILY OPISTHOTEUTHIDAE
» FAMILY STAUROTEUTHIDAE

FAMILY ALLOPOSIDAE Figure 26 | page 43

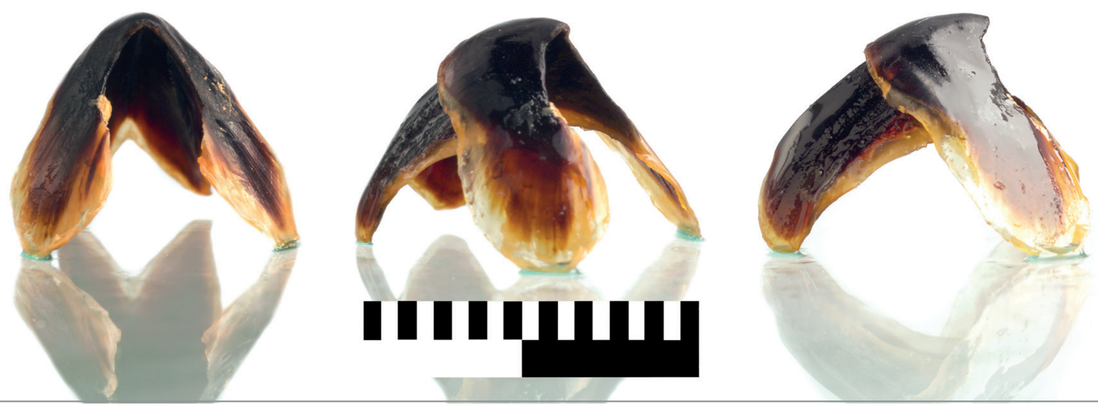
Haliphron atlanticus | Wandering albatross, South Georgia, 15.9 LHL

FAMILY CIRROTEUTHIDAE Figure 27 | pages 44 & 104

Cirrata sp. A (Cherel) | Patagonian toothfish, Crozet, 6.6 mm LHL

FAMILY OCTOPODIDAE Figure 28 | pages 45 & 104

Adelieledone polymorpha | from fresh specimen, South Georgia, 2.3 mm LHL



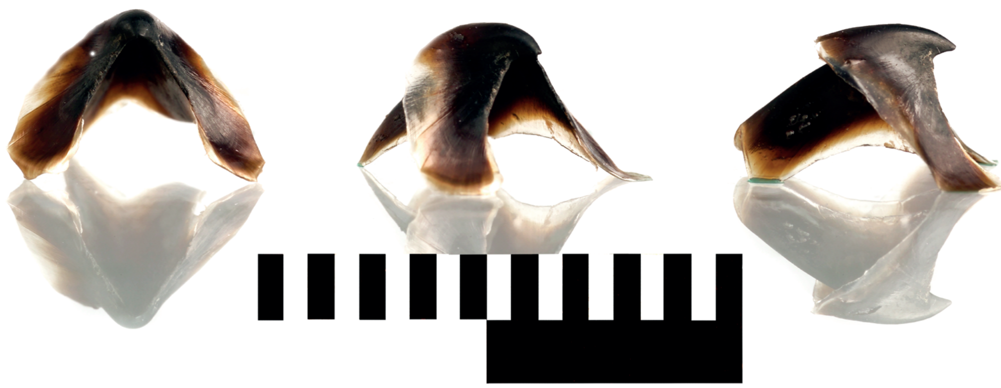
Benthoctopus thielei | Black-browed albatross, Kerguelen, 6.8 mm LHL

Graneledone gonzalezi | from fresh specimen, Kerguelen, 5.7 mm LHL

continue...

Pareledone turqueti | from fresh specimen, South Georgia, 3.8 mm LHL

FAMILY OPISTHOTEUTHIDAE Figure 29 | pages 47 & 106



Opisthoteuthis sp. | Patagonian toothfish, Crozet, 5.8 mm LHL

FAMILY STAUROTEUTHIDAE Figure 30 | pages 48 & 107

Stauroteuthis gilchristi | Patagonian toothfish, Crozet, 3.5 mm LHL

UPPER CEPHALOPOD BEAKS

DECAPODA

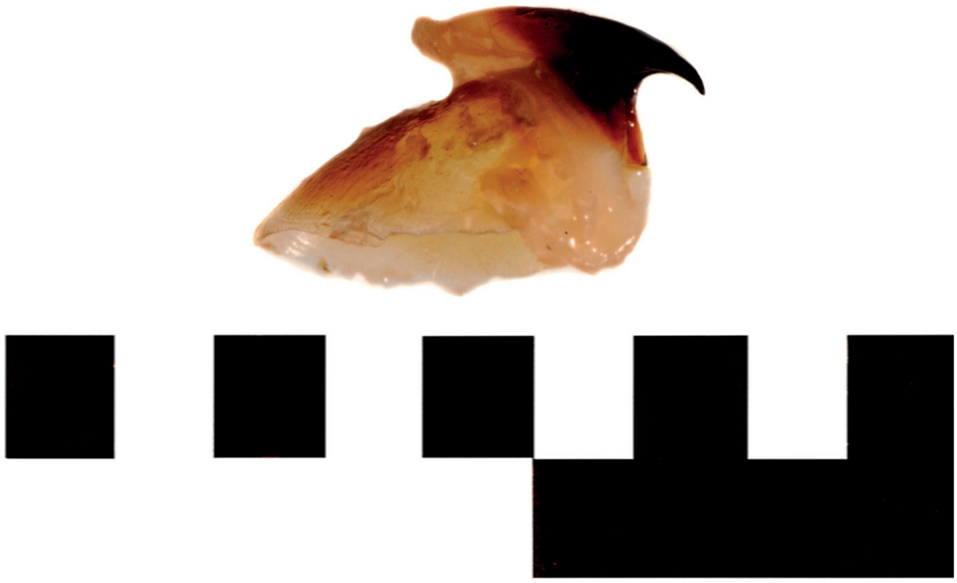
FAMILY ANCISTROCHEIRIDAE Figure 4 | pages 13 & 51

Ancistrocheirus lesueuri | Swordfish, Tropical Indian Ocean, 4.7 mm URL

FAMILY ARCHITEUTHIDAE Figure 5 | pages 14 & 51

Architeuthis dux | from the diet of Sleeper shark, Kerguelen, 18.1 mm URL

FAMILY BATHYTEUTHIDAE Figure 6 | pages 15 & 52



Bathyteuthis abyssicola | from fresh specimen, Falkland Islands, 1.8 mm URL

FAMILY BATOTEUTHIDAE Figure 7 | pages 16 & 52

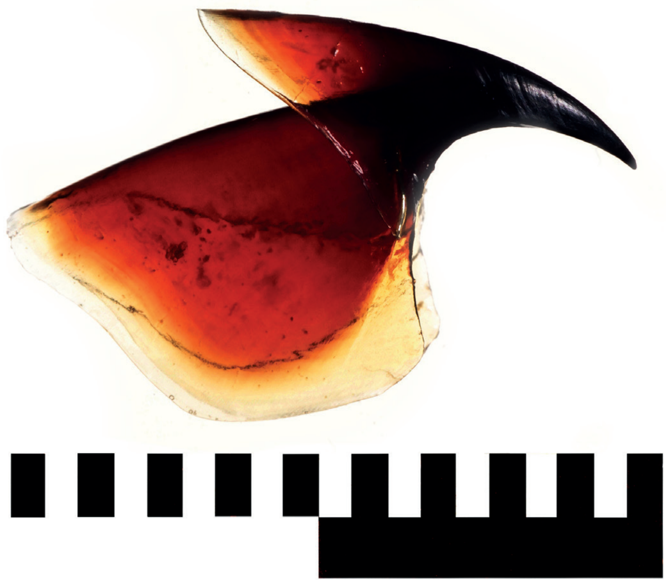
Batoteuthis skolops | Patagonian toothfish, Kerguelen, 3.3 mm URL

FAMILY BRACHIOTEUTHIDAE Figure 8 | pages 17 & 53

Brachioteuthis linkovskyi | Patagonian toothfish, Kerguelen, 3.9 mm URL

Slosarczykovia circumantarctica | Patagonian toothfish, Kerguelen, 2.6 mm URL

FAMILY CHIROTEUTHIDAE Figure 9 | pages 19 & 54

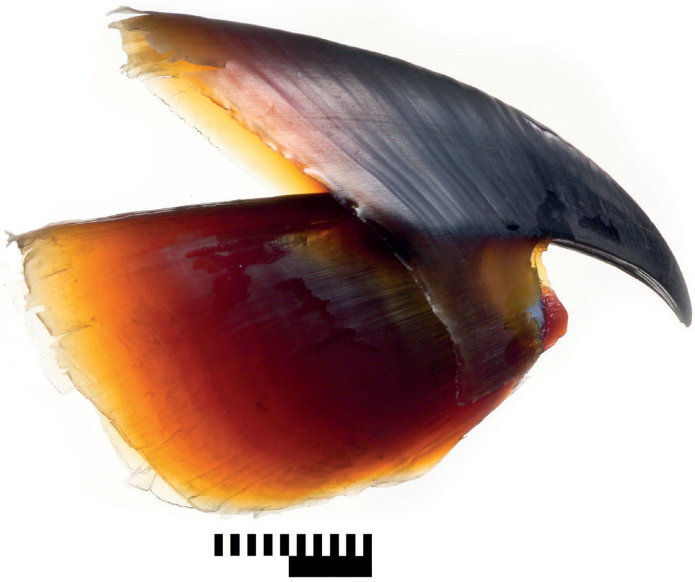


Chiroteuthis veranyi | Patagonian toothfish, Kerguelen, 5.3 mm URL

FAMILY CRANCHIIDAE Figure 10 | pages 20 & 54

Galiteuthis glacialis | Black-browed albatross, Crozet, 5.3 mm URL

continue...



Mesonychoteuthis hamiltoni | Sleeper shark, Kerguelen, 27.7 mm URL

Galiteuthis stC sp. (Imber) | Yellow-nosed albatross, Amsterdam island, 5.5 mm URL

Galiteuthis sp. 3 (Imber) | Yellow-nosed albatross, Amsterdam island, 6.5 mm URL

Taonius sp. B (Voss) | Patagonian toothfish, Crozet, 8.0 mm URL

continue...

Taonius sp. (Clarke) | Yellow-nosed albatross, Amsterdam island, 4.2 mm URL

Teuthowenia pellucida | Yellow-nosed albatross, Amsterdam island, 1.2 mm URL

FAMILY CYCLOTEUTHIDAE Figure 11 | pages 22 & 57

Cycloteuthis akimushkini | Sleeper shark, Kerguelen, 13.7 mm URL

FAMILY GONATIDAE Figure 12 | pages 23 & 58

Gonatus antarcticus | King penguin, Falkland Islands, 4.6 mm URL

FAMILY HISTIOTEUTHIDAE Figure 13 | pages 24 & 59

Histioteuthis miranda | Yellow-nosed albatross, Amsterdam island, 6.4 mm URL

Histioteuthis bonnellii corpuscula | Yellow-nosed albatross, Amsterdam Island, 4.6 mm URL

Histioteuthis macrohista | Yellow-nosed albatross, Amsterdam Island, 2.5 mm URL

Histioteuthis atlantica | Yellow-nosed albatross, Amsterdam Island, 6.1 mm URL

continue...

Histioteuthis eltaninae | Patagonian toothfish, Kerguelen, 2.5 mm URL

FAMILY LOLIGINIDAE Figure 15 | pages 28 & 62

Loligo gahi | from fresh specimen, Falkland Islands, 11.7 mm UHL

FAMILY LYCOTEUTHIDAE Figure 16 | pages 29 & 62

Lycoteuthis lorigera | Yellow-nosed albatross, Amsterdam, 4.5 mm URL

FAMILY MASTIGOTEUTHIDAE Figure 17 | pages 30 & 63

Mastigoteuthis psychrophila | Patagonian toothfish, Kerguelen, 3.7 mm URL

continue...

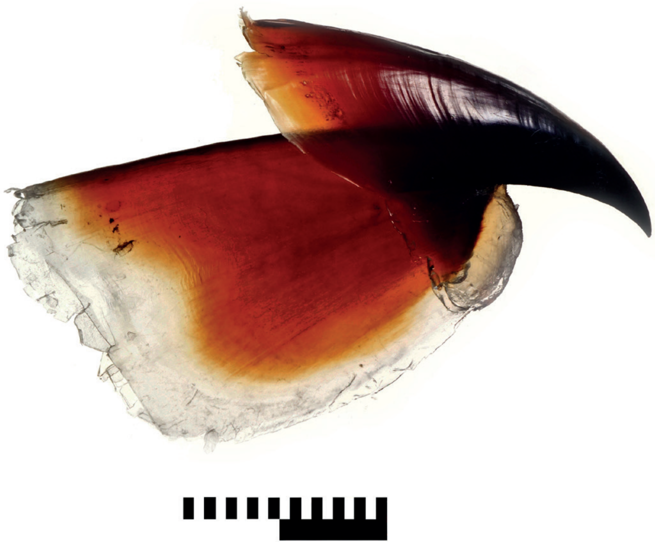
? Mastigoteuthis A (Clarke) | from specimen, Kerguelen, 5.3 mm URL

FAMILY NEOTEUTHIDAE Figure 18 | pages 31 & 64

Alluroteuthis antarcticus | Patagonian toothfish, Crozet, 3.8 mm URL

Nototeuthis dimegacotyle | Patagonian toothfish, Kerguelen, 2.7 mm URL

FAMILY OCTOPOTEUTHIDAE Figure 19 | pages 32 & 65



Taningia danae | Sleeper shark, Kerguelen, 14.6 mm URL

continue...

Octopoteuthis sp. | Sooty albatross, Amsterdam, 30.0 mm UHL

FAMILY OMMASTREPHIDAE Figure 20 | pages 33 & 66

Illex argentinus | from fresh specimen, Falkand Islands, 18.0 mm UHL

Martialia hyadesi | Patagonian toothfish, Crozet, 7.0 mm URL

Todarodes sp. | Patagonian toothfish, Kerguelen, 11.4 mm URL

FAMILY ONYCHOTEUTHIDAE Figure 21 | pages 35 & 68

Kondakovia longimana | Patagonian toothfish, Kerguelen, 12.8 mm URL

Moroteuthis knipovitchi | King penguin, Crozet, 6.2 mm URL

Moroteuthis ingens | Patagonian toothfish, Crozet, 7.6 mm URL

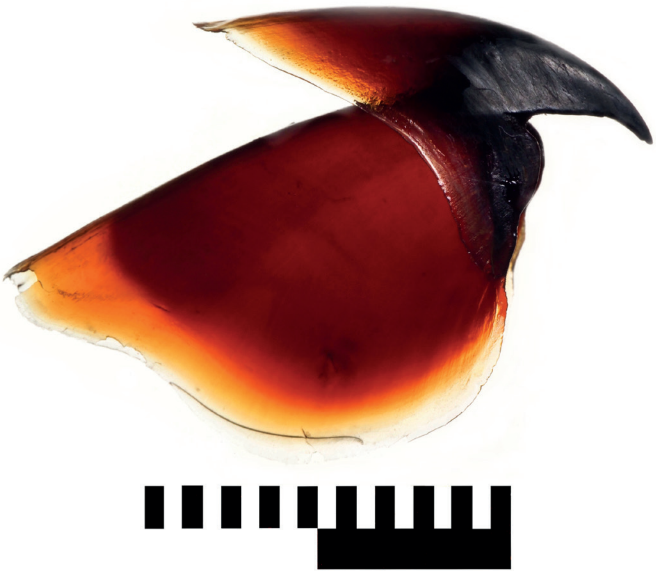
Moroteuthis robsoni | Patagonian toothfish, Kerguelen, 7.8 mm URL

continue...

Moroteuthis sp. B (Imber) | Patagonian toothfish, Kerguelen, 5.0 mm URL

Onychoteuthis banksii | Subtropical fur seal, Amsterdam, 2.9 mm URL

FAMILY PHOLIDOTEUTHIDAE Figure 22 | pages 38 & 72



Pholidoteuthis massyae | Patagonian toothfish, Kerguelen, 7.0 mm URL

FAMILY PSYCHROTEUTHIDAE Figure 23 | pages 39 & 72

Psychroteuthis glacialis | Emperor penguin, Adelie Land, Antarctica, 6.9 mm URL

FAMILY SEPIOLIDAE Figure 24 | pages 40 & 73

cf. *Stoloteuthis leucoptera* | from fresh specimen, Kerguelen, 1.3 mm UHL

FAMILY UNKNOWN Figure 25 | pages 41 & 74

Oegopsida sp. A (Cherel) | Patagonian toothfish, Crozet, 5.8 mm URL

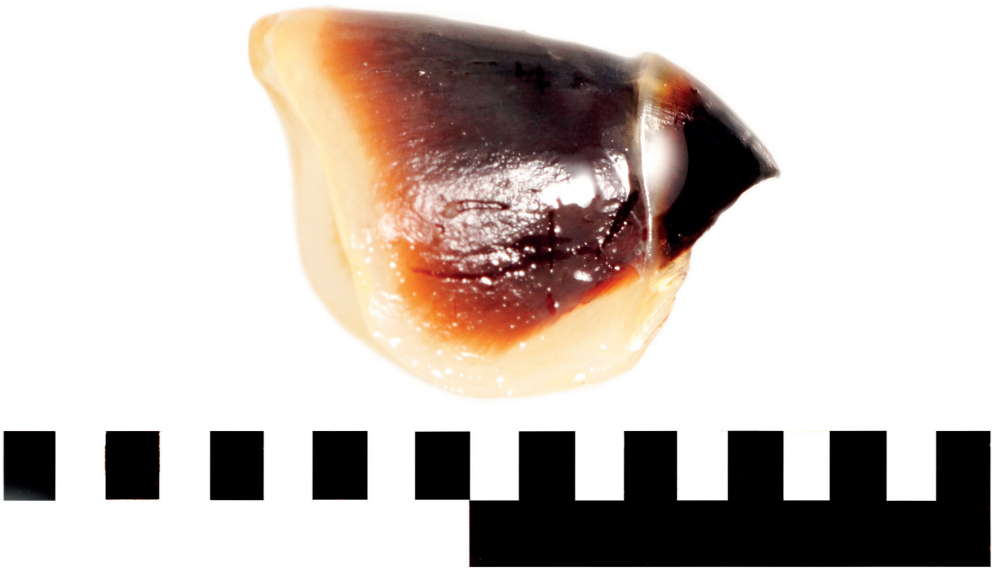
OCTOPODA

- » FAMILY CIRROTEUTHIDAE
- » FAMILY OCTOPODIDAE
- » FAMILY OPISTHOTEUTHIDAE
- » FAMILY STAUROTEUTHIDAE

FAMILY CIRROTEUTHIDAE Figure 27 | pages 44 & 76

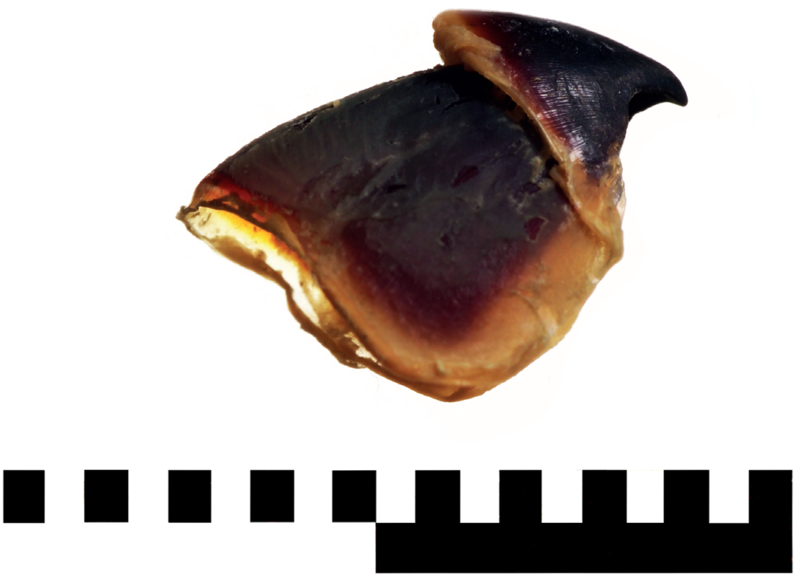
Cirrata sp. A (Cherel) | Patagonian toothfish, Crozet, 13.1 mm UHL

FAMILY OCTOPODIDAE Figure 28 | pages 45 & 77



Adelieledone polymorpha | from fresh specimen, South Georgia, 3.6 mm UHL

Benthoctopus thielei | from fresh specimen, Kerguelen, 7.5 mm UHL



Graneledone gonzalezi | from fresh specimen, Kerguelen, 6.5 mm UHL

continue...

Pareledone turqueti | from fresh specimen, South Georgia, 5.2 mm UHL

FAMILY OPISTHOTEUTHIDAE Figure 29 | pages 47 & 78

Opisthoteuthis sp. | Patagonian toothfish, Crozet, 9.8 mm UHL

FAMILY STAUROTEUTHIDAE Figure 30 | pages 48 & 79

Stauroteuthis gilchristi | Patagonian toothfish, Crozet, 7.5 mm UHL

TABLES

TABLE 1a. Main cephalopod taxa in the diet of albatrosses.

	Albatrosses								
Cephalopod taxa	**Grey-headed**	**Black-browed**	**Wandering**	**Light-mantled**	**Sooty**	**Northern Royal**	**Southern Royal**	**Yellow-nosed**	**Buller´s**
Alluroteuthis antarcticus	Cr, DR, PE, SG	K, SG	An, Au, Cr, G, Mac, PE, SG	C, Cr, H, Mac, PE, SG	Cr, PE	Cht			
Ancistrocheirus lesueuri	An, Au, Cr, G, Mac, PE, SG	SG		PE	Cr, PE	Cht	C	K	Ch, Sn
Batoteuthis skolops	DR, K, SG	DR, K, SG	An, Au, Mac, PE, SG		PE	Cht	C	K	
Chiroteuthis veranyi	DR, K, SG	K, SG	SG		PE				
Galiteuthis glacialis	C, Cr, DR, K, PE, SG	C, DR, K, SG	An, Au, Cr, G, Mac, PE, SG	C, Cr, K, Mac, PE, SG	Cr, PE	Cht		K	
Gonatus antarcticus	Cr, DR, K, PE, SG	FI, K, SG	An, Au, Cr, G, Mac, PE, SG	Cr, H, Mac, PE, SG	Cr, PE	Cht	C	K	
Haliphron atlanticus	K	K	An, Au, G, Mac, PE, SG	PE	PE	Cht	C	K	Ch, Sn
Histioteuthis atlantica	K	K	An, Au, G, Mac, PE, SG	PE	PE	Cht	C	K	Ch, Sn
Histioteuthis bonnellii corpuscula	SG	SG	An, Au, G, PE, SG	PE	PE	Cht			
Histioteuthis eltaninae	Cr, K, PE, SG	K, SG	An, Au, Cr, Mac, PE, SG	Cr, H, Mac, PE, SG	Cr, PE	Cht	C	PE	
Histioteuthis macrohista	SG		An, Au, G, PE, SG			Cht			Ch, Sn
Histioteuthis miranda			An, Au, G, PE, SG	PE	PE	Cht	C		Ch, Sn
Kondakovia longimana	Cr, DR, K, PE, SG	DR, K, SG	An, Au, Cr, G, Mac, PE, SG	H, Mac, PE, SG	Cr, PE	Cht	C	Cr, PE	
Lepidoteuthis grimaldii		SG	An, Cr, G, PE, SG	SG	Cr	Cht			
Martialia hyadesi	C, Cr, DR, PE, SG	C, Cr, DR, FI, K, SG	An, Mac, PE, SG	H, Mac, PE, SG	PE	Cht	C	Cr	
Mastigoteuthis psychrophila	DR, K, PE, SG	K, SG	An, Mac, SG						
Mesonychoteuthis hamiltoni	DR, SG	SG	An, Cr, Mac, PE, SG	Cr, Mac, PE	Cr, PE				
Moroteuthis ingens	DR, K, PE	K	An, Au, Cr, G, Mac, PE, SG	Cr, Mac	PE	Cht	C		Ch, Sn
Moroteuthis knipovitchi	DR, PE, SG	K, SG	An, Au, Cr, G, Mac, PE, SG	Cr, Mac, PE	Cr, PE	Cht	C	PE	
Moroteuthis robsoni	PE, SG	SG	An, Au, Cr, G, Mac, PE, SG	PE	Cr, PE	Cht	C	K, PE	Ch, Sn
Nototeuthis dimegacotyle	DR, K	K	An, Au, G, Mac, PE, SG		PE	Cht	C		
Psychroteuthis glacialis	Cr, DR, K, PE, SG	Cr, SG	An, Cr, Mac, PE, SG	C, Cr, Mac, PE, SG	PE				
Taningia danae	K, PE	K	An, Au, Cr, G, Mac, PE, SG	PE	Cr, PE		C	K	
Taonius sp.	Cr, DR, SG	SAf, SG	An, Au, Cr, G, Mac, PE, SG	H, Mac, PE, SG	Cr, PE				Ch, Sn

(Legend: C-Campbell, K- Kerguelen, SG-South Georgia, DR-Diego Ramirez, Cr-Crozet, SA-South America, FI-Falkland Islands, Mac-Macquarie Island, PE-Prince Edward and Marion Islands, H- Heard Island, Ch-Chatham Island, G-Gough Island, An-Antipodes, A-Antarctica (waters close to continent), SS-South Shetland Islands, T-Tasman Sea, Au-Auckland Islands, Sn-Snares Islands, NZ-New Zealand waters, Cht-Chatham Islands and Taiaroa Head, SAf-South African waters)

TABLE 1b. Main cephalopod taxa in the diet of petrels and prions.

	Petrels										Prions	
Cephalopod taxa	**White-chinned**	**Northern Giant**	**Southern Giant**	**Great-winged**	**Grey**	**Westland black**	**Black**	**Kerguelen**	**Blue**	**Soft-plumaged**	**Antarctic**	**thin-billed**
Alluroteuthis antarcticus	SAf, SG										SG	
Ancistrocheirus lesueuri				PE		NZ	NZ					
Chiroteuthis veranyi				PE			NZ					
Galiteuthis glacialis	Cr, SG	SG		PE								
Gonatus antarcticus	Cr, SG	Cr, Mac, PE, SG	PE	PE	Cr	NZ		PE		PE	SG	K
Haliphron atlanticus		PE		PE			NZ					
Histioteuthis atlantica		PE		PE			NZ					
Histioteuthis eltaninae	SG	PE			Cr	NZ	NZ	SAf	PE			
Histioteuthis macrohista				PE		NZ	NZ	PE				
Histioteuthis miranda				PE		NZ	NZ					
Kondakovia longimana	Cr, SG	Cr, K, SG	Cr, Mac, PE, SG								SG	
Lepidoteuthis grimaldii									SAf			
Martialia hyadesi	SG	SG										
Mastigoteuthis psychrophila	SG											
Mesonychoteuthis hamiltoni	SAf											
Moroteuthis ingens		Cr, PE	Cr, PE		Cr	NZ						
Moroteuthis knipovitchi	Cr	Cr		PE							SG	K
Moroteuthis robsoni			PE	PE								
Psychroteuthis glacialis	SG	SG		SAf								
Taonius sp.	Cr	PE		PE		NZ		PE				

TABLE 1c. Main cephalopod taxa in the diet of penguins.

	Penguins						
Cephalopod taxa	**Gentoo**	**King**	**Adelie**	**Rockhopper**	**Royal**	**Macaroni**	**Emperor**
Alluroteuthis antarcticus	Cr	Cr, FI, PE, SG		Cr		Cr	A
Galiteuthis glacialis	Cr	Cr, PE					A
Gonatus antarcticus	Cr, FI, K	Cr, FI, PE, SG		FI		Cr	A
Haliphron atlanticus		Cr					
Histioteuthis atlantica		Cr					
Histioteuthis eltaninae		FI		Mac	Mac		
Histioteuthis macrobista		Cr					
Kondakovia longimana	Cr, H, K, PE	Cr, FI, PE, SG		Cr, Mac, PE	Mac	Cr, PE, SG	A
Martialia hyadesi	Mac	Cr, FI, Mac, PE, SG		G, Mac,	Mac	SG	
Mesonychoteuthis hamiltoni		Cr	A				A
Moroteuthis ingens	FI	Cr, FI		Mac	Mac		A
Moroteuthis knipovitchi	Cr	Cr, FI, SG		Mac, PE	Mac	Cr, PE	
Psychroteuthis glacialis		SG	A				A

TABLE 1d. Main cephalopod taxa in the diet of sharks, other fish, dolphins and whales.

	Fish		Sharks		Dolphins			Whales	
Cephalopod taxa	Patagonian toothfish	Porbeagle	Sleeper	Lantern	Southern right-whale	Long-finned pilot whale	Bottlenose	Pilot	Sperm
Alluroteuthis antarcticus	Cr, K, SG	K					SA	SA	
Ancistrocheirus lesueuri						SA			A, SA, SG, T
Batoteuthis skolops	Cr, K, SG			K			SA		
Chiroteuthis veranyi	Cr, K, SG	K					SA	SA	
Galiteuthis glacialis	Cr, K, Mac, SG	K	K						A, SG
Gonatus antarcticus	Cr, K, Mac, SG	K	K		A		SA	SA	A, SA, SG
Haliphron atlanticus	C, K	K	K	K					A, SA, SG
Histioteuthis atlantica	Cr, K	K	K	K					A, SA, SG
Histioteuthis bonnellii corpuscula									A, SA, SG
Histioteuthis eltaninae	Cr, K, Mac	K					SA	SA	A, SA, SG
Histioteuthis macrohista	C								
Histioteuthis miranda									A, SA, SG
Kondakovia longimana	Cr, K, Mac, SG	K	K				SA		A, SG, T
Lepidoteuthis grimaldii									A, SA, SG, T
Martialia hyadesi	Cr, K, SG	K					SA		A, SG
Mastigoteuthis psychrophila	C, K	K		K					A, SA, SG
Mesonychoteuthis hamiltoni	Cr, SG		K				SA	SA	A, SA, SG, T
Moroteuthis ingens	Cr, K, Mac	K	K				SA	SA	A, SA, SG
Moroteuthis knipovitchi	Cr, K, Mac, SG	K	K				SA		A, SG
Moroteuthis robsoni	K		K						A, SA, SG,T
Nototeuthis dimegacotyle	Cr, K	K							
Psychroteuthis glacialis	Cr, K, SG								A, SG
Taningia danae	Cr, K		K				SA		A,SA,SG, T
Taonius sp.	SG						SA		A, SA, SG, T

TABLE 1e. Main cephalopod taxa in the diet of seals.

	Seals				
Cephalopod taxa	**Antarctic fur**	**Sub-Antarctic fur**	**Elephant**	**Weddell**	**Sea lion**
Alluroteuthis antarcticus	SG, SA		A, SG, SS		SA
Batoteuthis skolops			SG		
Chiroteuthis veranyi			SS		
Galiteuthis glacialis	SG		A, SG		
Gonatus antarcticus	K		A, Mac, SG, SS	SS	
Kondakovia longimana	SG		Mac, SG, SS, A	SS	
Martialia hyadesi	SG, K		SG		
Mastigoteuthis psychrophila	SG				
Mesonychoteuthis hamiltoni			SG		
Moroteuthis ingens	K				
Moroteuthis knipovitchi	K, SG	G	A, SG, SS	SS	
Psychroteuthis glacialis			A, SS, SG	A, SS	

References: Adams & Klages (1987), Aguiar dos Santos & Haimovici (2001), Alonso *et al.* (1998), Arata & Xavier (2003), Arata *et al.* (2004), Berrow & Croxall (1999), Bester & Laycock (1985), Brooke & Klages (1986), Brown & Klages (1987), Casaux *et al.* (1997), Casaux *et al.* (2003), Cherel & Duhamel (2003), Cherel & Duhamel (2004), Cherel & Klages (1998), Cherel & Kooyman (1998), Cherel & Weimerskirch (1995), Cherel & Weimerskirch (1999), Cherel *et al.* (2004), Cherel *et al.* (2002a,b,c), Cherel *et al.* (1996), Cherel *et al.* (2000), Clarke & Prince (1981), Clarke & MacLeod (1982a,b), Clarke & Goodall (1994), Clarke *et al.* (1976), Clarke *et al.* (1981), Clarke (1996), Clausen & Pütz (2003), Cooper & Brown (1990), Cooper & Klages (1995), Cooper *et al.* (1992), Croxall & Lishman (1987), Croxall *et al.* (1997), Croxall *et al.* (1995), Croxall *et al.* (1985), Croxall *et al.* (1999), Daneri *et al.* (2000), Daneri *et al.* (1999), Doidge & Croxall (1985), Garcia de la Rosa *et al.* (1997), Goldsworthy *et al.* (2001), Goldworthy *et al.* (2002), Goodall & Galeazzi (1985), Green & Burton (1987), Green *et al.* (1998), Green & Wong (1992), Herling *et al.* (2005), Hoff (2001), Hoff *et al.* (2003), Hull (1999), Hunter (1983), Hunter & Klages (1989), Imber (1976), Imber (1992), Imber (1999), Imber & Russ (1975), Imber & Berruti (1981), Imber *et al.* (1995), Kent *et al.* (1998), Klages *et al.* (1988), Lea *et al.* (2002), Lescroël *et al.* (2004), Lipinski (2001), Lipinski & Jackson (1989), Lorentsen *et al.* (1998), Nel *et al.* (2000), Nel *et al.* (2001), North (1996), Offredo *et al.* (1985), Piatkowski *et al.* (2001), Piatkowski *et al.* (2002), Plötz (1986), Plötz *et al.* (1991), Prince (1980), Reid & Arnould (1996), Reid *et al.* (1997), Richardson *et al.* (2000), Ridoux (1994), Robertson *et al.* (1994), Rodhouse & Prince (1993), Rodhouse *et al.* (1987), Rodhouse *et al.* (1990), Rodhouse *et al.* (1992), Rodhouse *et al.* (1996), Rodhouse *et al.* (1998), Thomas (1992), Thompson (1992), Young *et al.* (1997), Waugh *et al.* (1999), Xavier *et al.* (2003a,b,c), Xavier *et al.* (2002), Xavier *et al.* (2004).

TABLE 2. Darkening of lower beaks (from the wings) of cephalopod species from the Southern Ocean and adjacent areas.

	Wings start darken (mm)		
Species	**Minimum**	**Maximum**	**Reference**
Ancistrocheirus lesueuri	<3.78	6.00	Clarke (1986), Lu & Ickeringill (2002)
Architeuthis dux	7.00	11.00	Clarke (1986)
Bathyteuthis abyssicola	0.55		Lu & Ickeringill (2002)
Chiroteuthis veranyi	3.00	4.00	Clarke (1986)
Cycloteuthis akimushkini	8.00	12.00	Clarke (1986)
Gonatus antarcticus	<5.50		Clarke (1986)
Histioteuthis atlantica	2.54	3.50	Clarke (1986), Lu & Ickeringill (2002)
Histioteuthis bonnellii corpuscula	3.04		Clarke (1986), Lu & Ickeringill (2002)
Histioteuthis eltaninae	2.20		Clarke (1986), Lu & Ickeringill (2002)
Histioteuthis macrohista	1.50	3.20	Clarke (1986)
Histioteuthis miranda	>2.41	<5.40	Clarke (1986), Lu & Ickeringill (2002)
Illex argentinus		<4.00	Clarke (1986)
Lepidoteuthis grimaldii	7.50	17.00	Clarke (1986)
Lycoteuthis lorigera	> 2.56		Lu & Ickeringill (2002)
Martialia hyadesi	3.70		Clarke (1986)
Mesonychoteuthis hamiltoni	17.00	27.00	Clarke (1986)
Moroteuthis ingens	8.20	10.50	Clarke (1986)
Moroteuthis knipovitchi	9.00	12.00	Clarke (1986)
Moroteuthis robsoni	5.00	10.50	Clarke (1986)
Onychoteuthis banksii	2.02	2.36	Lu & Ickeringill (2002)
Pholidoteuthis massyae	5.00	6.00	Clarke (1986)
Taningia danae	9.00	16.00	Clarke (1986)
Taonius sp. B (Voss)	5.00	6.00	Clarke (1986)
Teuthowenia pellucida	2.66	3.14	Lu & Ickeringill (2002)

TABLE 3. Latest nomenclature of some Southern Ocean species.

Before	BAS collection	CEBC collection	Overall	Reference
Alloposus mollis (Clarke 1980)	*Haliphron atlanticus*	*Haliphron atlanticus*	*Haliphron atlanticus*	Clarke (1980), Xavier *et al.* (2003b)
	Brachioteuthis ?picta (Clarke 1986)	*Brachioteuthis linkovskyi*	*Brachioteuthis linkovskyi*	Clarke (1986), Lipinski (2001)
	Brachioteuthis ?picta (Rodhouse *et al.* 1992)	*Slosarczykovia circumantarctica*	*Slosarczykovia circumantarctica*	Rodhouse *et al.* (1992), Lipinski (2001)
Chiroteuthis sp. C (Clarke 1980)	*Chiroteuthis veranyi*	*Chiroteuthis veranyi*	*Chiroteuthis veranyi*	Clarke (1980), Xavier *et al.* (2003b)
	Chiroteuthis sp.	*Asperoteuthis* sp. B	*? Mastigoteuthis* A (Clarke)	Clarke (1986)
?Crystalloteuthis glacialis (Clarke 1980)	*Alluroteuthis antarcticus*	*Alluroteuthis antarcticus*	*Alluroteuthis antarcticus*	Clarke (1980), Xavier *et al.* (2003b)
	Histioteuthis corpuscula	*H. bonnellii corpuscula*	*H. bonnellii corpuscula*	
Histiotetuhis A5 (Clarke, 1986)			*H. arcturi*	Clarke (1986)
Histioteuthis A1 (Clarke 1986)	*Histioteuthis macrohista*	*H. macrohista*	*H. macrohista*	Clarke (1986), Cherel *et al.* (2004)
Histioteuthis A3 (Clarke 1986)	*Histioteuthis miranda*	*H. miranda*	*H. miranda*	Clarke (1986), Xavier *et al.* (2003b)
Histioteuthis B1 (Clarke 1986)	*Histioteuthis eltaninae*	*H. eltaninae*	*H. eltaninae*	Clarke (1986)
Histioteuthis B3 (Clarke 1986)	*Histioteuthis atlantica*	*H. atlantica*	*H. atlantica*	Clarke (1986)
Lycoteuthis diadema		*Lycoteuthis lorigera*	*L. lorigera*	
Moroteuthis A (Clarke 1980)		*Moroteuthis ingens*	*M. ingens*	Clarke (1980), Clarke (1986)
	Taonius sp. (cf pavo)	*Taonius* sp. B (Voss)	*Taonius* sp. B (Voss)	
		Taonius sp. (Clarke)	*Taonius* sp. (Clarke)	Cherel *et al.* (2004)
Pholidoteuthis massyae (Pfeffer1912)	*Pholidoteuthis boschmai*	*Pholidoteuthis boschmai*	*Pholidoteuthis massyae*	O´Shea *et al.* (2007)

Legend: British Antarctic Survey – BAS, Centre d'Etudes Biologiques de Chizé – CEBC.

REFERENCES

A

Adams NJ, Klages NT (1987) Seasonal variation in the diet of king penguin *Aptenodytes patagonicus* at Sub-Antarctic Marion Island. Journal Zoology, London 212: 303-324

Aguiar dos Santos R, Haimovici M (2001) Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21–34°S). Fisheries Research 52: 99-112

Allcock, AL, Piertney, SB (2002) Evolutionary relationships of Southern Ocean Octopodidade (Cephalopoda: Octopoda) and a new diagnosis of *Pareledone*. Marine Biology 140: 129-135

Allcock AL, Collins MA, Piatkowski U, Vecchione M (2004) *Thaumeledone* and other deep water octopodids from the Southern Ocean. Deep-Sea Research II 51: 1883-1901

Alonso MK, Crespo EA, García NA, Pedraza SN, Coscarella MA (1998) Diet of dusky dolphins, *Lagenorhynchus obscurus*, in waters off Patagonia, Argentina. Fishery Bulletin 96: 366-374

Alonso MK, Crespo EA, Pedraza SN, García NA, Coscarella M (2000). Food habits of the South American sea lion, *Otaria flavescens*, off Patagonia, Argentina. Fishery Bulletin 98: 250-263

Arata J, Xavier JC (2003) The diet of black-browed albatrosses at the Diego Ramirez Islands, Chile. Polar Biology 26: 638-647

Arata J, Robertson G, Valencia J, Xavier JC, Moreno CA (2004) Diet of grey-headed albatrosses at the Diego Ramirez Islands, Chile: ecological implications. Antarctic Science 16: 263-275

Arkhipkin AI, Laptikhovsky VV (2008) Discovery of the fourth species of the enigmatic chiroteuthid squid *Asperoteuthis* (Cephalopoda: Oegopsida) and extension of the range of the Genus to the South Atlantic. Journal of Molluscan Studies 74: 203-207

B

Berrow SD, Croxall JP (1999) The diet of white-chinned petrels *Procellaria aequinoctialis*, Linnaeus 1758, in years of contrasting prey availability at South Georgia. Antarctic Science 11: 283-292

Bester MN, Laycock PA (1985) Cephalopod prey of the sub-Antarctic Fur Seal, *Arctocephalus tropicalis*, at Gough Island. In: Siegfried WR, Condy PR, Laws RM (eds) Antarctic Nutrient Cycles and Food Webs. Springer-Verlag, Berlin, pp 551-554

Bolstad KS (2006) Sexual dimorphism in the beaks of *Moroteuthis ingens* Smith, 1881 (Cephalopoda: Oegopsida: Onychoteuthidae). New Zealand Journal of Zoology 33: 317-327

Brooke ML, Klages N (1986) Squid beaks regurgitated by greyheaded and yellownosed albatrosses, *Diomedea chrysostoma* and *D. chlororhynchos* at the Prince Edward islands. Ostrich 57: 203-206

Brown CR, Klages NT (1987) Seasonal and annual variation in diets of macaroni (*Eudyptes chrysolophus chrysolophus*) and southern rockhopper (*E. chrysocome chrysocome*) penguins at sub-Antarctic Marion Island. Journal of Zoology, London 212: 7-28

C

Casaux R, Baroni A, Carlini A (1997) The diet of the weddell seal *Leptonychotes weddelli* at Harmony Point, South Shetland Islands. Polar Biology 18: 371-375

Casaux R, Baroni A, Ramón A (2003) Diet of Antarctic fur seals *Arctocephalus gazella* at the Danco Coast, Antarctic Peninsula. Polar Biology 26: 49-54

Catard A, Weimerskirch H, Cherel Y (2000) Exploitation of distant Antarctic waters and close shelf-break waters by white-chinned petrels rearing chicks. Marine Ecology Progress Series 194: 249-261

Cherel Y, Duhamel G (2003) Diet of the squid *Moroteuthis ingens* (Teuthoidea: Onychoteuthidae) in the upper slope waters of the Kerguelen Islands. Marine Ecology Progress Series 2003 250:197–203

Cherel Y, Duhamel G (2004) Antarctic jaws: cephalopod prey of sharks in Kerguelen waters. Deep Sea Research I 51: 17-31

Cherel Y, Klages N (1998) A review of the food of albatrosses. In: Robertson G, Gales R (eds) Albatross Biology and Conservation. Surrey Beatty & Sons, Chipping Norton, Australia, pp 113-136

Cherel Y, Kooyman GL (1998) Food of emperor penguins (*Aptenodytes forsteri*) in the western Ross Sea, Antarctica. Marine Biology 130: 335-344

Cherel Y, Weimerskirch H (1995) Seabirds as indicators of marine resources: black-browed albatrosses feeding on ommastrephid squids in Kerguelen waters. Marine Ecology Progress Series 129: 295-300

Cherel Y, Weimerskirch H (1999) Spawning cycle of onychoteuthid squids in the southern Indian Ocean: new information from seabird predators. Marine Ecology Progress Series 188: 93-104

Cherel Y, Bocher P, De Broyer C, Hobson KA (2002a) Food and feeding ecology of the sympatric thin-billed *Pachyptila belcheri* and Antarctic *P. desolata* prions at Iles Kerguelen, Southern Indian Ocean. Marine Ecology Progress Series 228: 263-281

Cherel Y, Duhamel G, Gasco N (2004) Cephalopod fauna of subantarctic islands: new information from predators. Marine Ecology Progress Series 266: 143-156

Cherel Y, Pütz K, Hobson KA (2002b) Summer diet of king penguins (*Aptenodytes patagonicus*) at the Fakland Islands, southern Atlantic ocean. Polar Biology 25: 898-906

Cherel Y, Ridoux V, Rodhouse PG (1996) Fish and squid in the diet of king penguin chicks *Aptenodytes patagonicus* during winter at sub-Antarctic Crozet Islands. Marine Biology 126: 559-570

Cherel Y, Weimerskirch H, Trouvé C (2000) Food and feeding ecology of the neritic-slope forager black-browed albatross and its relationships with commercial fisheries in Kerguelen waters. Marine Ecology Progress Series 207: 183-199

Cherel Y, Weimerskirch H, Trouvé C (2002c) Dietary evidence for spatial foraging segregation in sympatric albatrosses [*Diomedea* spp.] rearing chicks at Iles Nuageuses, Kerguelen. Marine Biology 141: 1117-1129

Clarke M (1962a) Significance of cephalopod beaks. Nature, 193,560-1

Clarke M (1962b) The identification of cephalopod “beaks” and the relationship between beak size and total body weight. Bulletin of the British Museum of Natural History B 8(10), 421-480

Clarke M (1966) A review of the systematics and ecology of oceanic squids. Advances in Marine Biology 4: 91-300

Clarke M. (1977) Beaks, nets and numbers. Symposium of the Zoological Society London 38: 89-126

Clarke M (1980) Cephalopoda in the diet of sperm whales of the southern hemisphere and their bearing on sperm whale biology. Discovery Reports, pp 324

Clarke MR (1986) A handbook for the identification of cephalopod beaks. Clarendon Press, Oxford

Clarke MR (1996) Cephalopods as prey. The role of cephalopods in the World’s oceans (ed. MR Clarke). Philosophical Transactions of the Royal Society of London, B. Special Volume, 351: 1053-1065

Clarke MR, Prince PA (1981) Cephalopod remains in regurgitations of black-browed and grey-headed albatrosses at South Georgia. British Antarctic Survey Bulletin, No. 54: 1-8

Clarke MR, MacLeod N (1982a) Cephalopod remains from the stomachs of sperm whales caught in the Tasman sea. Memoirs of the National Museum Victoria 43: 25-42

Clarke MR, MacLeod N (1982b) Cephalopod remains in the stomachs of eight Weddell Seals. British Antarctic Survey Bulletin 57: 33-40

Clarke MR, Goodall N (1994) Cephalopods in the diets of three Odontoceti cetacean species stranded at Tierra del Fuego, *Globicephala melaena* (Traill, 1809), *Hyperoodon planifrons* Flower, 1882 and *Cephalorhynchus commersonii* (Lacepede, 1804). Antarctic Science 6: 149-154

Clarke MR, MacLeod N, Paliza O (1976) Cephalopod remains from the stomachs of Sperm whales caught off Peru and Chile. Journal of Zoology, London 180: 477-493

Clarke MR, Croxall JP, Prince PA (1981) Cephalopod remains in regurgitations of the wandering albatross at South Georgia. British Antarctic Survey Bulletin 54: 9-22

Clausen AP, Pütz K (2003) Winter diet and foraging range of gentoo penguins (*Pygoscelis papua*) from Kidney Cove, Falkland Islands. Polar Biology 26: 32-40

Collins, MA, Henriques, C (2000) A revision of the family Stauroteuthidae (Octopoda: Cirrata) with redescriptions of Stauroteuthis syrtensis and S. gilchristi. Journal of the Marine Biological Association of the UK 80: 685-697

Collins, MA, Rodhouse, PGK (2006) Southern Ocean cephalopods. Advances in Marine Biology 50: 191-265

Cooper J, Brown CR (1990) Ornithological research at the sub-Antarctic Prince Edward Islands: a review of achievements. South Africa Trans. Nav. Antarkt. 20: 40-57

Cooper J, Klages NW (1995) The diets and dietary segregation of sooty albatrosses (*Phoebetria* spp.) at subantarctic Marion Island. Antarctic Science 7: 15-23

Cooper J, Henley S, Klages N (1992) The diet of the wandering albatross Diomedea exulans at subantarctic Marion Island. Polar Biology 12: 477-484

Croxall JP, Lishman GS (1987) The food and feeding ecology of penguins. In: Croxall JP (ed) Seabirds: Feeding Ecology and Role in Marine Ecosystems. Cambridge University Press, Cambridge, pp 101-133

Croxall JP, Prince PA, Reid K (1997) Dietary segregation in South Georgia seabirds. Journal of Zoology, London 242: 531-556

Croxall JP, Hall AJ, Hill HJ, North AW, Rodhouse PG (1995) The food and feeding ecology of the white-chinned petrel *Procellaria aequinoctialis* at South Georgia. Journal of Zoology 237: 133-150

Croxall JP, Prince PA, Baird A, Ward P (1985) The diet of the southern rockhopper penguin *Eudyptes chrysocome chrysocome* at Beauchêne Island, Falkland Islands. Journal of Zoology 206: 485-496

Croxall JP, Reid K, Prince PA (1999) Diet, provisioning and productivity responses of marine predators to differences in availability of Antarctic krill. Marine Ecology Progress Series 177: 115-131

D

Daneri GA, Carlini AR, Rodhouse PGK (2000) Cephalopod diet of the southern elephant seal, *Mirounga leonina*, at King George Island, South Shetland Islands. Antarctic Science 12: 16-19

Daneri GA, Piatkowski U, Coria NR, Carlini AR (1999) Predation on cephalopods by Antarctic fur seals, *Arctocephalus gazella* at two localities of the Scotia Arc, Antarctica. Polar Biology 21: 59-63

Doidge DW, Croxall JP (1985) Diet and Energy Budget of the Antarctic fur seal, *Arctocephalus gazella*, at South Georgia. In: Siegfried WR, Condy PR, Laws RM (eds) Antarctic Nutrient Cycles and Food Webs. Springer-Verlag, Berlin, pp 542-550

F

Fiscus, CH (1991) Notes on North Pacific gonatids: identification of body fragments and beaks from marine mammal stomachs. The Western Society of the Malacologist Annual Report 23:2-6

G

Garcia de la Rosa SB, Sanchez F, Figueroa D (1997) Comparative feeding ecology of Patagonian toothfish (*Dissostichus eleginoides*) in the Southwestern Atlantic. CCAMLR Science 4:105–124

Goldsworthy SD, He X, Tuck GN, Lewis M, Williams R (2001) Trophic interactions between the Patagonian toothfish, its fishery, and seals and seabirds around Macquarie Island. Marine Ecology Progress Series 218: 283-302

Goldsworthy SD, Lewis M, Williams R, He X, Young JW, Hoff Jvd (2002) Diet of Patagonian tootfish (*Dis-*

sostichus eleginoides) around Macquarie Island, South Pacific Ocean. Marine and Freshwater Research 53: 49-57

Goodall RNP, Galeazzi AR (1985) A review of the food habits of the small cetaceans of the Antarctic and Sub-Antarctic. In: Siegfried W, Condy PR, Laws RM (ed) Antarctic Nutrient Cycles and Food Webs. Springer-Verlag, Berlin, pp 566-572

Green K, Burton HR (1987) Seasonal and geographical variation in the food of Weddell seals, *Leptonychotes weddelli*, in Antarctica. Australian Wildlife Research 14: 475-489

Green K, Kerry KR, Disney T, Clarke MR (1998) Dietary studies of light-mantled sooty albatrosses *Phoebetria palpebrata* from Macquarie and Heard Islands. Marine Ornithology 26: 19-26

Green K, Wong V (1992) The diet of gentoo penguins *Pygoscelis papua* in early winter at Heard Island. Corella 16: 129-132

Gröger J, Piatkowski U, Heinemann H (2000) Beak length analysis of the Southern Ocean squid *Psychroteuthis glacialis* (Cephalopoda: Psychroteuthidae) and its use for size and biomass estimation. Polar Biology 23: 70-74

H

Hatfield EMC, Rodhouse PG (1994). Distribution and abundance of juvenile *Loligo gahi* in Falkland Island waters. Marine Biology 121: 267-272

Herling C, Culik BM, Hennicke JC (2005) Diet of the Humboldt penguin (*Spheniscus humboldti*) in northern and southern Chile. Marine Biology 147: 13-25

Hoff Jvd (2001) Further observations on the cephalopod diet of wandering albatrosses (*Diomedea exulans* L.) at Macquarie Island. EMU 101: 169-172

Hoff Jvd, Burton HR, Davies R (2003) Diet of male southern elephant seals (*Mirounga leonina* L.) hauled out at Vincennes Bay, East Antarctica. Polar Biology 26: 27-31

Hull CL (1999) Comparison of the diets of breeding royal (*Eudyptes schlegeli*) and rockhopper (*Eudyptes chrysocome*) penguins on Macquarie Island over three years. Journal of Zoology 247: 507-529

Hunter S (1983) The food and feeding ecology of the giant petrels *Macronectes halli* and *M. giganteus* at South Georgia. Journal of Zoology 200: 521-538

Hunter S, Klages NTW (1989) The diet of grey-headed albatrosses *Diomedea chrysostoma* at the Prince Edward Islands. South African Journal of Antarctic Research 19: 31-33

I

Imber M (1976) Comparison of prey of the black *Procellaria* petrels of New Zealand. New Zealand Journal Marine and Freshwater Research 10: 119-130

Imber MJ (1978) The squid families Cranchiidae and Gonatidae (Cephalopoda: Teuthoidea) in the New Zealand region. New Zealand Journal of Zoology 5: 445-484

Imber MJ (1992) Cephalopods eaten by wandering albatrosses *Diomedea exulans* L. breeding at six circumpolar localities. Journal of the Royal Society of New Zealand 22: 243-263

Imber MJ (1999) Diet and feeding ecology of the Royal albatross *Diomedea epomophora* - King of the shelf break and inner slope. EMU 99: 200-211

Imber MJ, Russ R (1975) Some foods of the wandering albatross (*Diomedea exulans*). Notornis 22: 27-36

Imber MJ, Berruti A (1981) Proccellariiform seabirds as squid predators. In: Cooper J (ed) Proceedings of the Symposium on Birds of the Sea and Shore. African Seabird Group, Cape Town: 43-61

Imber MJ, Jolly JN, Brooke ML (1995) Pelagic food of three sympatric gadfly petrels (*Pterodroma* spp.) breeding on the Pitcairn Islands. Biological Journal of the Linnean Society 56: 233-240

J

Jackson GD (1995) The use of beaks as tools for biomass estimation in the deepwater squid *Moroteuthis ingens* (Cephalopoda: Onychoteuthidae) in New Zealand waters. Polar Biology 15: 9-14

Jackson GD, Buxton NG, George MJA (2000) Diet of the southern opah *Lampris immaculatus* on the Patagonian Shelf, the significance of the squid *Moroteuthis ingens* and anthropogenic plastic. Marine Ecology Progress Series 206:261-271

K

Kent S, Seddon J, Roberston G, Wienecke BC (1998) Diet of Adélie penguins *Pygoscelis adeliae* at Shirley Island, East Antarctica, January 1992. Marine Ornithology 26: 7-10

Klages NT, Brooke ML, Watkins BP (1988) Prey of Northern rockhopper penguins at Gough Island, south Atlantic Ocean. Ostrich 59: 162-165

Kubodera T, Furuhashi M (1987) Manual for the identification of cephalopods and myctophids in the stomach contents. The fisheries Agency of Japan. 65pp (in Japanese)

L

Laptikhovsky V, Arkhipkin A, Bolstad KS (2008) A second species of the squid genus *Kondakovia* (Cephalopoda: Onychoteuthidae) from the sub-Antarctic. Polar Biology 32: 21-26

Lea MA, Cherel Y, Guinet C, Nichols PD (2002) Antarctic fur seals foraging in the Polar Frontal Zone: inter-annual shifts in diet as shown from faecal and fatty acid analyses. Marine Ecology Progress Series 245: 281-297

Lescroël A, Ridoux V, Bost CA (2004) Spatial and temporal variation in the diet of gentoo penguin (*Pygoscelis papua*) at Kerguelen Islands. Polar Biology 27: 206-216

Lipinski MR (2001) Preliminary description of two new species of cephalopods (Cephalopoda: Brachioteuthidae) from South Atlantic and Antarctic waters. Bulletin of the Sea Fisheries Institute 1:3-14

Lipinski MR, Jackson S (1989) Surface-feeding on cephalopods by procellariiform seabirds in the southern Benguela region, South Africa. Journal of Zoology, London 218: 549-563

Lorentsen S-H, Klages N, Røv N (1998) Diet and prey consumption of Antarctic petrels *Thalassoica antarctica* at Svarthamaren, Dronning Maud Land, and at sea outside the colony. Polar Biology 19: 414-420

Lu CC, Williams R (1994) Contribution to the biology of squid in the Prydz Bay region, Antarctica. Antarctic Science 6: 223–229

Lu CC, Ickeringill R (2002) Cephalopod beak identification and biomass estimation techniques: tools for dietary studies of southern Australian finfishes. Museum Victoria Science Reports 6:1-65

N

Nel DC, Nel JL, Ryan PG, Klages NTW, Wilson RP, Robertson G (2000) Foraging ecology of grey-headed mollymawks at Marion Island, southern Indian Ocean, in relation to longline fishing activity. Biological Conservation 96: 219-231

Nel DC, Lutjeharms JRE, Pakhomov EA, Ansorge IJ, Ryan PG, Klages NTW (2001) Exploitation of mesoscale oceanographic features by grey-headed albatross *Thalassarche chrysostoma* in the southern Indian Ocean. Marine Ecology Progress Series 217: 15-26

Nesis KN, Roeleveld MAC, Nikitina IV (1998) A new genus and species of onychoteuthid squid (Cephalopoda, Oegopsida) from the Southern Ocean. Ruthenica 8: 153-168

North AW (1996) Fish in the diet of Antarctic fur seals (*Arctocephalus gazella*) at South Georgia during winter and spring. Antarctic Science 8: 155-160

O

Offredo C, Ridoux V, Clarke MR (1985) Cephalopods in the diets of Emperor and Adélie penguins in Adélie Land, Antarctica. Marine Biology 86: 199-202

O'Shea S, Jackson G, Bolstad KS (2007) The nomenclatural status, ontogeny and morphology of *Pholidoteuthis massyae* (Pfeffer, 1912) new comb (Cephalopoda: Pholidoteuthidae). Reviews in Fish Biology & Fisheries 17: 425-435

P

Piatkowski U, Pütz K, Heinemann H (2001) Cephalopod prey of king penguins (*Aptenodytes patagonicus*) breeding at Volunteer Beach, Falkland Islands, during austral winter 1996. Fisheries Research 52: 79-90

Piatkowski U, Vergani DF, Stanganelli ZB (2002) Changes in the cephalopod diet of southern elephant seal females at King George Island, during El Niño-La Niña events. Journal of the Marine Biological Association of the UK 82: 913-916

Plötz J (1986) Summer diet of weddell seals (*Leptonychotes weddelli*) in the Eastern and southern Weddell sea, Antarctica. Polar Biology 6: 97-102

Plötz J, Ekau W, Reijnders PJH (1991) Diet of weddel seals *Leptonychotes weddelli* at Vestkapp, Eastern Weddel sea (Antarctica), in relation to local food supply. Marine Mammal Science 7: 136-144

Prince PA (1980) The food and feeding ecology of blue petrel (*Halobaena caerulea*) and dove prion (*Pachyptila desolata*). Journal of the Zoological Society of London 190: 59-76

R

Reid K, Arnould JPY (1996) The diet of Antarctic fur seals *Arctocephalus gazella* during the breeding season at South Georgia. Polar Biology 16: 105-114

Reid K, Croxall JP, Edwards TM (1997) Interannual variation in the diet of the Antarctic prion *Pachyptila desolata* at South Georgia. EMU 97: 126-132

Richardson AJ, Maharaj G, Compagno LJV, Leslie RW, Ebert DA, Gibbons MJ (2000) The abundance, distribution, morphometrics, reproduction, and diet of the Izak catshark, *Holohalaelurus regani*. Journal of Fish Biology 56: 552-576

Ridoux V (1994) The diets and dietary segregation of seabirds at the Subantarctic Crozet Islands. Marine Ornithology 22: 1-192

Robertson G, Williams R, Green K, Robertson L (1994) Diet composition of emperor penguin chicks *Aptenodytes forsteri* at two Mawson Coast colonies, Antarctica. Ibis 136: 19-31

Rodhouse PG, Yeatman J (1990) Redescription of Martialia hyadesi Rochbrune and Mabille, 1889 (Mollusca: Cephalopoda) from the Southern Ocean. Bulletin of the British Museum of Natural History (Zoology) 56: 135-143

Rodhouse PG, Prince PA (1993) Cephalopod prey of the black-browed albatross *Diomedea melanophrys* at South-Georgia. Polar Biology 13: 373-376

Rodhouse PG, Lu CC (1998) Chiroteuthis veranyi from the Atlantic sector of the Southern Ocean (Cephalopoda: Chiroteuthidae). South African Journal of Marine Science 20: 311-322

Rodhouse PG, Clarke MR, Murray AWA (1987) Cephalopod prey of the wandering albatross *Diomedea exulans*. Marine Biology 96: 1-10

Rodhouse PG, Prince PA, Clarke MR, Murray AWA (1990) Cephalopod prey of the grey-headed albatross *Diomedea chrysostoma*. Marine Biology 104: 353-362

Rodhouse PG, Olsson O, Ankernilssen P, Murray AWA (1998) Cephalopod predation by the king penguin *Aptenodytes patagonicus* from South Georgia. Marine Ecology Progress Series 168: 13-19

Rodhouse PG, Arnbom T, Fedak MA, Yeatman J, Murray AWA (1992) Cephalopod prey of the southern elephant seal, *Mirounga leonina* L. Canadian Journal of Zoology 70: 1007-1015

Rodhouse PG, Prince PA, Trathan PN, Hatfield EMC, Watkins JL, Bone DG, Murphy EJ, White MG (1996) Cephalopods and mesoscale oceanography at the Antarctic Polar Front: satellite tracked predators locate pelagic trophic interactions. Marine Ecology Progress Series 136: 37-50

Roeleveld MAC (2000) Giant squid beaks: implications for systematics. Journal of the Marine Biological Association of the UK 80: 185-187

S

Santos MB, Clarke MR, Pierce GJ (2001). Assessing the importance of cephalopods in the diets of marine mammals and other top predators: problems and solutions. Fisheries Research 52: 121-139

Santos RA, Haimovici M (2000) The Argentine short-finned squid *Illex argentinus* in the food webs of southern Brazil. Sarsia 85: 49-60

Sekiguchi K, Klages N, Findlay K, Best PB (1993). Feeding habits and possible movements of Southern . Proceedings of the NIPR Symposium of Polar Biology 6: 84-97

Smale MJ, Clarke MR, Klages TW, Roeleveld MA (1993) Octopod beak identification: resolution at a regional level (Cephalopoda, Octopoda: Southern Africa). South African Journal of Marine Sciences 13: 269-293

T

Thomas G (1982) The food and feeding ecology of the light-mantled sooty albatross at South Georgia. EMU 82: 92-100

Thompson KR (1992) Quantitative analysis of the use of discards from squid trawlers by black-browed albatrosses *Diomedea melanophrys* in the vicinity of the Falkland Islands. Ibis 134: 11-21

Tremblay Y, Cherel Y (2003) Geographic variation in the foraging behaviour, diet and chick growth of rockhopper penguins. Marine Ecology Progress Series 251: 279-297

Y

Young JW, Lamb TD, Duyet Le R, Bradford RW, Whitelaw AW (1997) Feeding ecology and interannual variations in diet of southern bluefin tuna, *Thunnus maccoyii*, in relation to coastal and oceanic waters of eastern Tasmanian, Australia. Environmental Biology of Fishes 50:275-291

V

Voss NA, Nesis KN, Rodhouse PG (1998) Systematics, biology and biogeography of the family Histioteuthidae (Oegopsida). In: Voss NA, Veechione, M., Toll, RO, & Sweeney, MJ (ed) Systematics and Biogeography of Cephalopods. Smithsonian contribution to Zoology, pp 293-373

W

Waugh SM, Weimerskirch H, Cherel Y, Shankar U, Prince PA, Sagar PM (1999) Exploitation of the marine environment by two sympatric albatrosses in the Pacific Southern Ocean. Marine Ecology Progress Series 177: 243-254

X

Xavier J C, Rodhouse PG, Trathan PN, Wood AG (1999) A Geographical Information System (GIS) atlas of cephalopod distribution in the Southern Ocean. Antarctic Science 11: 61-62

Xavier JC, Croxall JP, Reid K (2003a) Inter-annual variation in the diet of two albatross species breeding at South Georgia: implications for breeding performance. Ibis 145: 593-610

Xavier JC, Croxall JP, Trathan PN, Rodhouse PG (2003b) Inter-annual variation in the cephalopod component of the diet of wandering albatrosses *Diomedea exulans* breeding at Bird Island, South Georgia. Marine Biology 142: 611-622

Xavier JC, Croxall JP, Trathan PN, Wood AG (2003c) Feeding strategies and diets of breeding grey-headed and wandering albatrosses at South Georgia. Marine Biology 143: 221-232

Xavier, J C, Croxall, JP, Cresswell, KA (2005) Boluses: an effective method to assess the proportions of cephalopods in the diet of albatrosses. Auk 122: 1182-1190

Xavier JC, Rodhouse PG, Purves MG, Daw TM, Arata J, Pilling GM (2002) Distribution of cephalopods recorded in the diet of Patagonian toothfish (*Dissostichus eleginoides*) around South Georgia. Polar Biology 25: 323-330

Xavier JC, Trathan PN, Croxall JP, Wood AG, Podestá GP, Rodhouse PG (2004) Foraging ecology and interactions with fisheries of wandering albatrosses at South Georgia. Fisheries Oceanography 13: 324-344

Xavier JC, Clarke MR, Magalhães MC, Stowasser G, Blanco C, Cherel Y (2007). Current status of using beaks to identify cephalopods: III International Workshop and training course on Cephalopod beaks, Azores Islands, April 2007. Arquipélago - Life and Marine Sciences 24:41-48

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
High Cross, Madingley Road,
Cambridge, CB3 0ET , UK

cnrs dépasser les frontières
Centre d'Etudes Biologiques de Chizé,
UPR 1934 du CNRS
79360 Villiers-en-Bois, France

Centro de Ciências do Mar
Universidade do Algarve
Campus das Gambelas, 8000-139
Faro, Portugal

Ciência.Inovação 2010

International Polar Year 2007-2008

APECS Association of Polar Early Career Scientists

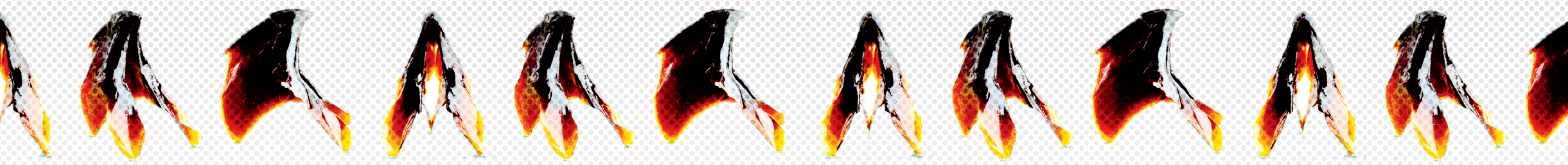
FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

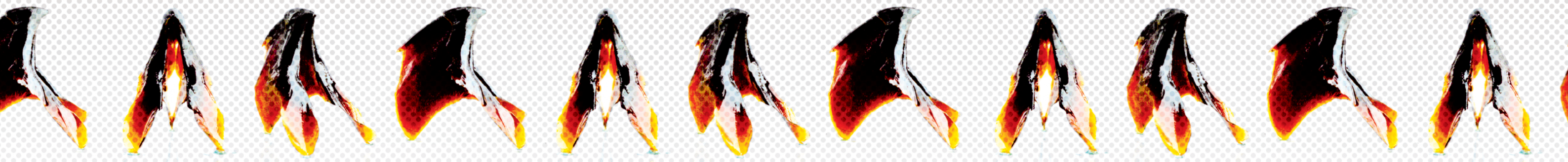
Integrating Climate and Ecosystem Dynamics • ICED •

Census of Antarctic Marine Life
www.caml.aq

CEPHALOPOD BEAK GUIDE FOR THE SOUTHERN OCEAN

J. C. Xavier & Y. Cherel





CEPHALOPOD BEAK GUIDE
FOR THE SOUTHERN OCEAN

J. C. Xavier & Y. Cherel