North Sea fish

and their remains

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Introduction

Our aim was to produce a book to aid the identification of marine and estuarine fish in the **North Sea**. We have used a combination of identification keys, simple line drawings, sometimes annotated photographs of fresh fish, and concise descriptions. What is unusual about this book is that we have added detailed information on the identification of *fish remains* (i.e. various fish bones, otoliths, and scales). Fish remains may be encountered when the diets of marine predators (cetaceans, seals, seabirds and predatory fish) are studied, during archaeological excavations, or geological reconstructions (from deposits). The material presented in this book should be useful to identify fish based on small fragments of the skeleton, to reconstruct species composition, and sometimes even the size and age of fish found during these studies. It is the first time that such a comprehensive overview of fish bones of North Sea fish species has been put in to print.

Study area and selected fish species - The **North Sea** is a shallow semi-enclosed shelf sea in the north-east Atlantic that was formed as a consequence of sea level rise following the last Glacial Maximum, when seas began to flood the European Continental Shelf, over the past 15,000 years. The North Sea is located between Norway, Denmark, Germany, the Netherlands, Belgium, northern France and Great Britain (**Fig. 1**). The sea floor is sandy in most places, with scattered patches of gravel and silt. Fishing techniques most commonly deployed nowadays include otter trawls, pelagic trawls, purse seines, beam trawls (including shrimpers), Danish seine (snurrevad), and set-net fisheries.

Based on water depth, the area may be subdivided into the **southern North Sea** (to the south of the Dogger Bank where the water depth is mostly less than 50 m), the **central North Sea** (depths ranging mostly from 50 - 100 m), and the **northern North Sea** (depths ranging from 100 - 200 m). A fourth, and generally much deeper, region is the **Norwegian Deep** that connects to the **Skagerrak** (200 - 700 m) in the north-eastern part of the North Sea.

This book will focus on fish species that are commonly found in habitats ranging from the upper shore to depths of about 200 m. This includes the international **Wadden Sea**, a shallow coastal sea area along the northern and western coasts of the Netherlands, Germany, and Denmark. This ~10,000 km² area (500 km long, on average 20 km wide), is separated from the North Sea by a row of barrier islands and sand banks. Deep tidal channels connect the North Sea and the Wadden Sea, and these channels branch into numerous gullies and creeks within the Wadden Sea.

Not all North Sea fish species included in this book have been given a full species account. We simply listed most (rarer) species that could potentially occur within the North Sea at large, and this includes species that are more typically found in deeper waters, or that have a more southerly, northerly or oceanic distribution.

Readership - The book is intended for everyone with an interest in the identification of fish, including anglers, professional fishermen, fish merchants, naturalists, students, post-graduates and professional biologists. Some features, such as the more specific explanations, will probably only be used by professional biologists, bioarcheaologists or palaeontologists, but most of the text is kept as simple as possible and has been written for those without expert knowledge.

Sources of information - The natural world is constantly changing, and recent research has greatly expanded our knowledge. The information provided in this book on the identification of fish is based largely on experience gained by the Pisces team over nearly 40 years of regular monthly sampling of the inshore fish at a wide range of localities around the British Isles. Throughout this period we have used the excellent works of Alwyne Wheeler. His large book, *The Fishes of the British Isles and North West Europe*, was published in 1969, and the smaller field guide, *Key to the Fishes of Northern Europe*, in 1978. Both these books have been out of print for a long time, and the key has become expensive and difficult to obtain. It has been apparent for some time that there was a need for a new book on NW European fish that used both photographs and diagrams to aid identification. In this book, we have photographed most specimens out of water, as this is where most identification occurs, and when it is possible to arrange the fish to show and label diagnostic features. Photographs alone are often insufficient, as they cannot display all the fins and other diagnostic features, and so they are supported with line drawings showing the layout of the fins and body shape.

Kees Camphuysen and Estefania Velilla have reorganised the text, deleted parts that were more typical for the UK, and added information that was more relevant for the North Sea. In this edition, we did not include distribution maps or graphs presenting seasonal patterns in abundance. Instead, with regard to "Distribution and seasonality", we have chosen to rather concisely describe the overall distribution, largely with reference to the recently-published and highly comprehensive "*Fish atlas of the Celtic Sea, North Sea, and Baltic Sea*" (Heessen *et al.* 2015). This atlas presents a unique set of abundance data, based on quantitative information on some 200 fish taxa derived from 72,000 stations fished by fisheries research vessels during the period 1977 - 2013 to describe the spatial, depth, size, and temporal distribution of demersal and pelagic fish species over an extensive marine area, including the entire North Sea, together with accounts of

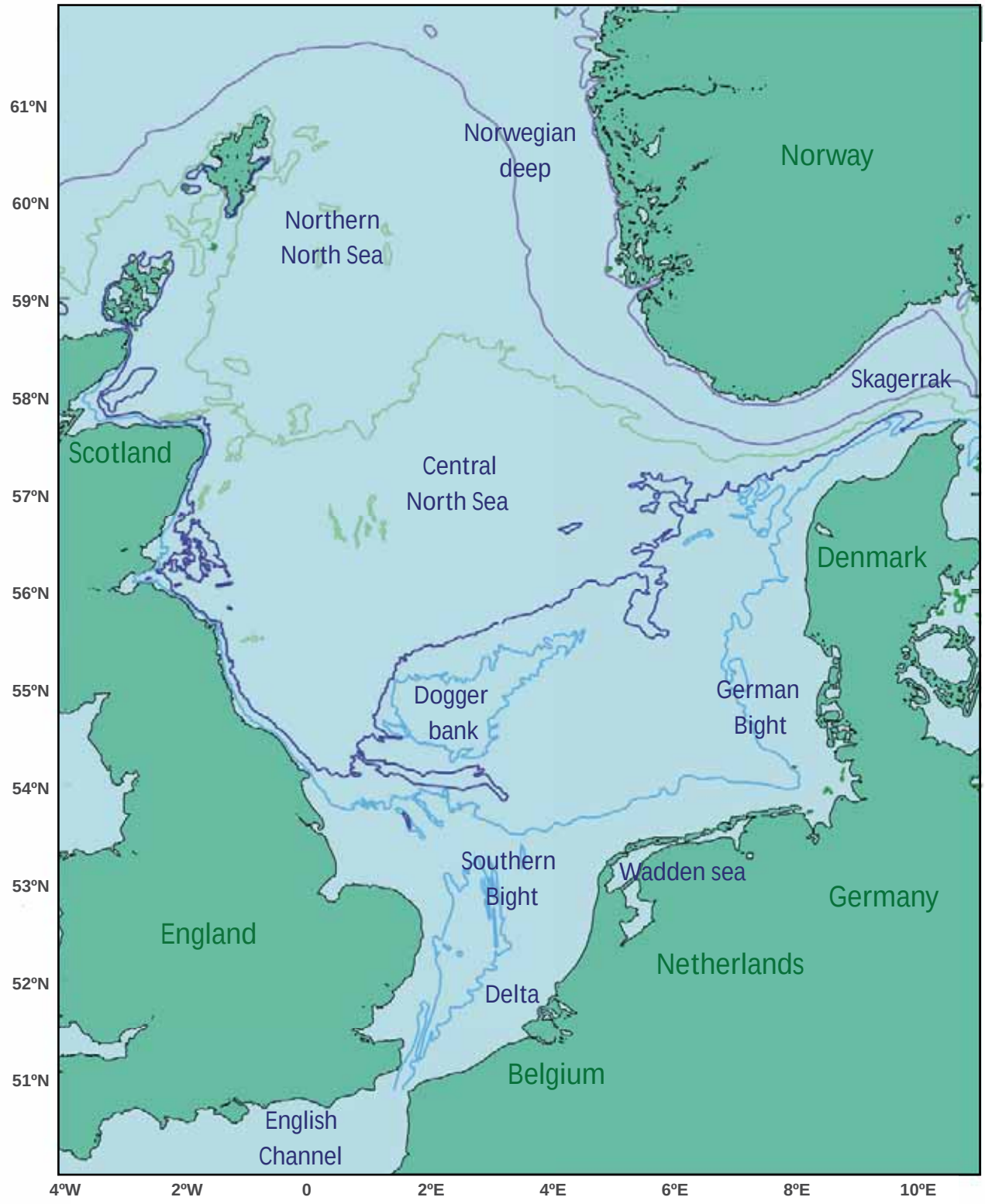


Figure 1. *Map of the North Sea with the 200 m depth contour in purple, and major regions referred to in this book.*

their biology. Because this atlas is based on quantitative information derived from bottom trawl and groundfish surveys, other sources were consulted where needed to describe the distribution patterns of, for example, pelagic and estuarine fish species (see References).

In addition, we provided seasonalities and trends in catch rates of fish entering the western (Dutch) Wadden Sea based on the constant effort site (the "NIOZ fish fyke") off Texel (see photo p. 9). Since 1960, this kom-fyke trap has been operating at the entrance of the Marsdiep basin (Van der Veer *et al.* 1992). The kom-fyke consists of a 200 m long and 2 m high leader which starts above the high water mark and ends in two chambers in the subtidal region with a mesh size of 10 x 10 mm. Fishing normally started in March - April and lasted until October. In winter, the trap was usually removed

Sieme Gieles operating the NIOZ fish fyke. Photo: Threes Anna.

because of possible damage by ice floes and, from 1971 onwards, no fishing took place during part of the summer because of clogging of the net by macroalgae. Normally, the kom-fyke was emptied every morning, except when bad weather prevented this. Overall, these fyke catches show that fish stocks in the western Wadden Sea have declined: a 95% drop in biomass over the past 50 years.

The information on the identification of fish remains is based largely on experienced gained by Kees Camphuysen (NIOZ) and Mardik Leopold (WMR), together with numerous students at both institutes and colleagues, over 30 years of diet studies of North Sea seabirds and marine mammals. Throughout this period we have used the excellent work of Härkonen (1986) *Guide to the Otoliths of the Bony Fishes of the Northeast Atlantic*, the ICES report of Watt and co-workers (1997) *Guide to the identification of North Sea fish using premaxillae and vertebrae*, Leopold's (2001) digital publication on *Otoliths of North Sea fish*, and several more obscure publications. These books or reports have long been out of print, and the software used on the CD does not work on modern computers.

Taxonomy and Latin names - The system of Latin names was originated by the Swedish natural scientist Carl Linnaeus in 1753. As well as having common names, such as Cod or Whiting, all species have a Latin or 'scientific' name, a two-part name which indicates the species and the genus (the next taxonomic level up) to which it belongs. A genus can contain a single species, or many. By convention, Latin names are written in italic script, with the generic name capitalised. When a name is given for the second and subsequent times in a text, the generic name may be abbreviated to the initial letter. As an example, the Latin name of the Cod is *Gadus morhua*. The first part, *Gadus*, is the name of the genus, *morhua* indicates the individual species. The genus *Gadus* contains four species, Atlantic cod, *G. morhua*, Pacific cod, *G. microcephalus*, Greenland cod, *G. ogac*, and Alaska pollock, *G. chalcogrammus*. The genus Gadus, in turn, is a member of the family Gadidae, which contains a total of 13 genera. Those genera include many other familiar fish, such as the Haddock, Whiting, Hake, Pollack, Saithe, Norway pout, Pout and Poor cod.

When Latin names are used, the authority and the date of publication are often given. The authority is the name of the person who first described and gave a Latin name to the species, and the date is of the first publication of that description. For instance the full Latin name of the Sea lamprey is *Petromyzon marinus* L., 1758. L. stands for Linnaeus, and 1758 was the date of publication of Linnaeus's description of the fish. Species may be moved from one genus to another, and hence their Latin names changed, for instance when new research challenges the accepted knowledge on the familial relationships between different species. Usually, the specific name (*morhua*, in the case of Cod) remains the same, while the generic name is changed. When the Latin name of a species has been changed, this is indicated by placing the authority in brackets. For instance, the full Latin name of the Corkwing wrasse is *Symphodus melops* (L., 1758). Linnaeus first named the species *Labrus melops* in 1758; since then it has been moved to several other genera, including *Crenilabrus*, *Lutjanus*, and most recently, *Symphodus*, by other scientists. Linnaeus, however, remains as the authority, the first describer of the species.

Language abbreviations - We have used the following abbreviations for the regional common names of fish: Du: Dutch, Ge: German, No: Norwegian, and Da: Danish.

Online resources - There are many online resources on fish, commercial fisheries and angling. We have generally found the following pages interesting and useful:
+ Food and Agriculture Organization of the United Nations (FAO) - Fisheries and Aquaculture Department: www.fao.org/fishery/en
+ FishBase: www.fishbase.org/search.php
+ Marine Life Information Network (MarLIN): www.marlin.ac.uk
+ Marine Species Identification Portal: http://species-identification.org/
+ Marine Biodiversity and Ecosystem Functioning: http://marbef.org/

Acknowledgements - A book of this scope requires the support of a team of ichthyologists as well as marine ecologists. Everyone at Pisces Conservation Ltd was involved in collecting and photographing specimens. At the Royal NIOZ, a reference collection of fish bones became established and numerous new additions were included during the preparations of this book, notably as a result of dissections, careful identification, storage and digital photography by Estefania Velilla (NIOZ) and Suse Kühn (WMR). The Pisces team, Mardik Leopold (WMR) and Hans Witte (NIOZ), have all helped to collect and identify the fish. Numerous people have helped to collect fresh fish to support us build the reference collection and too many people were involved to even …. just name them all. We are particularly grateful to Hans Witte (NIOZ) and the fishermen of the NIOZ fish fyke: Sieme Gieles, Wim Jongejan, and Marco Kortenhoeven to keep an eye open for 'unusual fish' for us to dissect and study. Tycho Anker Nilssen (NINA, Norway) and Henrik Skov (DHI, Danmark/Sweden) kindly corrected the Norwegian and Danish names of the fish species, Suse Kühn commented on the German names. Nelleke Krijgsman and Kees Camphuysen designed the lay-out of this book. The text was subsequently corrected, checked, and improved by the authors with an additional reviewing and corrections by Suse Kühn (WMR). Henk van der Veer (NIOZ) was the initiator of the project and kept the financial oversight.

Chapter 11

Codfish - Gadiformes

The **codfish** order Gadiformes (Anacanthini) holds 9 families and 75 genera of fish, including several species that are important for human consumption, such as **Cod,** *Gadus morhua,* **Haddock,** *Melanogrammes aeglefinus,* **Hake,** *Merluccius merluccius* and **Pollack,** *Pollachius pollachius*. They have soft-rayed fins and no spines; some species can grow large if given the chance (greater than 1 m long). They are mostly cold-water fish. The **grenadiers** or **rat-tails** (Macrouridae) are deep-water species and are not included in this book. The families represented in this chapter are the **hakes** (Merlucciidae) (1 species), and the **Codfishes**, Gadidae. They are all demersal species, found throughout the North Sea, including shallow waters where they occur mostly as juveniles. Smaller **rocklings**, a subfamily of the Gadidae, may also be found in numbers in rockpools along rocky shorelines. Another subfamily, the **phycid hakes** (represented by the Greater fork-beard) is also not included given their primarily deep-water distribution.

We provide considerable material of the remains of codfish, including a multi-species composite (p. 99), because small gadoids are important prey fish for numerous marine predators, including larger gadoids. The codfish have relatively low lipid contents (0.7 - 2.8%) and moderate calorific values (3.9 - 5.5 kJ g^{-1}). The **otoliths** are large in relation to fish length (except in the case of rocklings) and the outside of the otoliths is often strongly lobed, in contrast to the otoliths of most other fish species. Gadoid **vertebrae** have a distinct waist in most species, one or more prominent ridges or a network of lines of ossification, and have a very narrow spinal foramen. Vertebrae are generally robust and strongly ossified. Both the neural and haemal spines depart from the anterior side of the centrum, and are thick at the base. The **premaxillae** are distinct, often easy to find, and hold important characteristics, but break easily as part of the digestive process. The **cleithra** are distinct for the group, but species are more difficult to separate on the basis of these bones alone.

*Rowena Henderson with a large **Cod** caught at Sizewell on the Suffolk coast. Photo Robin Somes.*

Key to species

1 With a long tapering tail ..... **Rat-tails** – deep-water species (not in this book)
or Possessing a normal caudal fin 2
2 Possessing 3 dorsal & 2 anal fins 3
or Possessing 1 or 2 dorsal fins & 1 anal fin 11
3. Anal fin long beginning in front of or under the 1st dorsal 5
or Anal fin short, beginning behind the 1st dorsal fin 17
5 Anal fin begins in front of 1st dorsal fin origin ..... **Blue whiting**, *Micromesistius poutassou* (p. 109)
or Anal fin begins under or behind dorsal fin origin 6
6 Dark spot at base of pectoral fin 7
or No dark spot 10
7 Barbel missing or minute ..... **Whiting**, *Merlangius merlangus* (p. 106)
or Barbel conspicuous 8
8 Body deeper than head length, anal fin begins near middle of 1st dorsal fin base **Pout**, *Trisopterus luscus* (p. 115)
or Body depth less than head length, anal fin begins in space between 1st & 2nd dorsal fins 9
9 Lower jaw projects beyond upper jaw ..... **Norway pout**, *Trisopterus esmarkii* (p. 113)
or Upper jaw projects beyond lower jaw ..... **Poor cod**, *Trisopterus minutus* (p. 117)
10 Lower jaw projects strongly beyond upper jaw, lateral line curved and dark ..... **Pollack**, *Pollachius pollachius* ..... (p. 110)
or Jaws equal, lateral line straight and white ..... **Saithe**, *Pollachius virens* (p. 112)
11 1st dorsal fin well-developed 18
or 1st dorsal fin reduced to 1 long ray or minute 12
12 At least 3 barbels, 1st dorsal fin reduced to 1 ray and a row of hair-like rays 13
or No barbels, 1st dorsal fin minute, head large and body tadpole-shaped ..... **Tadpole fish**, *Raniceps raninus* (p. 119)
13 3 barbels, 1 on chin, 1 on each anterior nostril 14
or 4 or 5 barbels 15
14 Dark uniform colouration, pectoral fin 15 - 17 rays ..... **Shore rockling**, *Gaidropsarus mediterraneus* (not in this book)
or Brown blobs on a pink background, pectoral fin 20 - 21 rays ..... **Three-bearded rockling**, *Gaidropsarus vulgaris* (p. 127)
15 4 barbels ..... **Four-bearded rockling**, *Enchelyopus cimbrius* (p. 125)
or 5 barbels 16
16 Fringe of papillae along upper lip, body colour pink-brown ..... **Northern rockling**, *Ciliata septentrionalis* (p. 124)
or No fringe of papillae, body colour golden-brown ..... **Five-bearded rockling**, *Ciliata mustela* (p. 122)
17 Barbel long, no black blotch on sides ..... **Cod**, *Gadus morhua* (p. 102)
or Barbel minute, black blotch on sides ..... **Haddock**, *Melanogrammus aeglefinus* (p. 104)
18 Lower jaw without barbel ..... **European hake**, *Merluccius merluccius* (p. 100)
or Lower jaw with large barbel ..... **Ling**, *Molva molva* (p. 128)

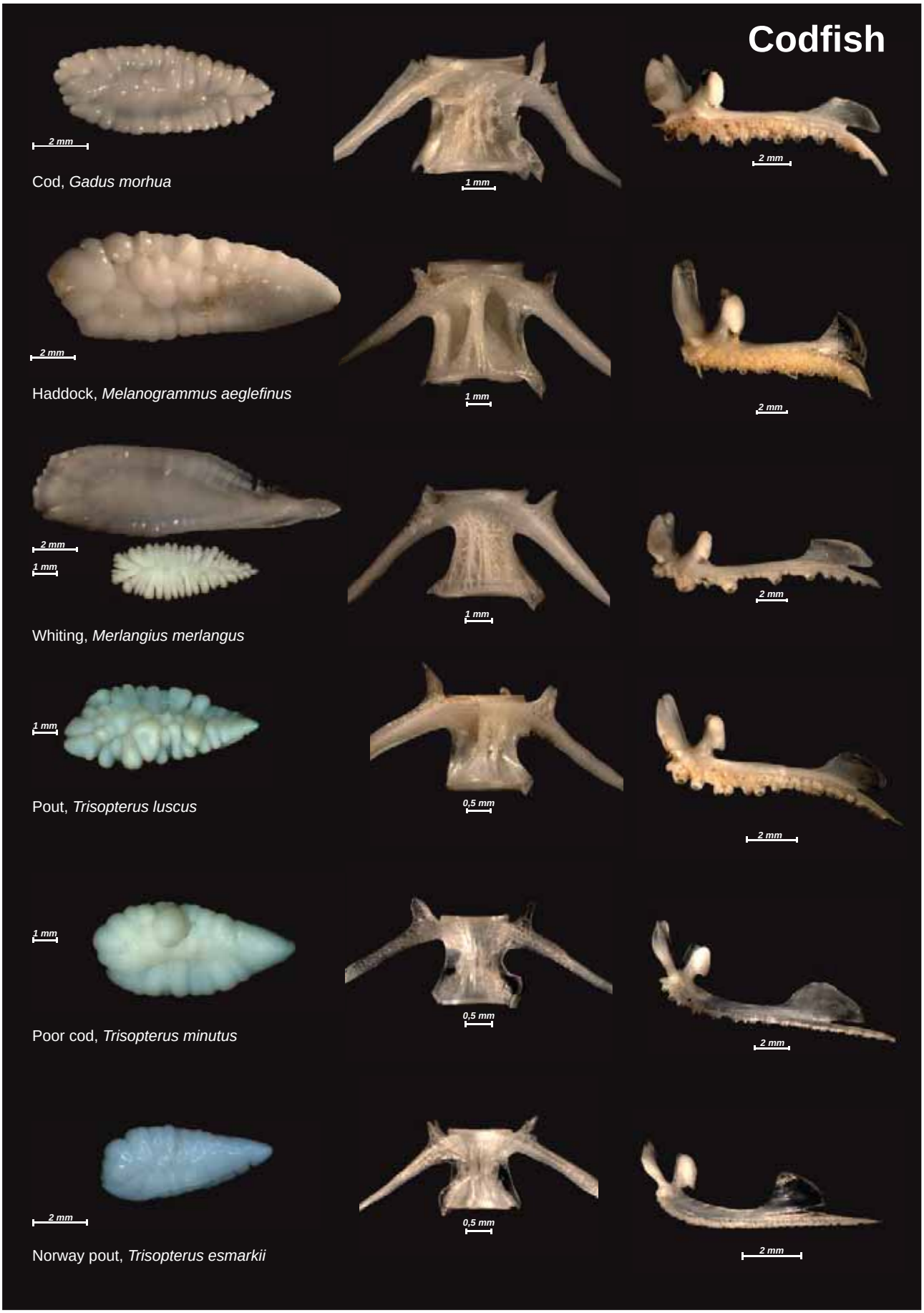
Not included in this book:

Grenadiers or **rat-tails** Macrouridae

Roundnose grenadier, *Coryphaenoides rupestris* – a deep-water species common in the Norwegian Deep.
Hollowsnout grenadier, *Coelorinchus caelorhincus* – an Atlantic deep-water species.
Softhead grenadier, *Malacocephalus laevis* – an Atlantic deep-water species

Codfishes Gadidae

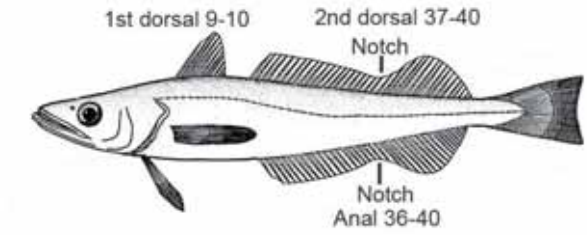
Silvery pout, *Gadiculus argenteus* – deep-water species, edge of the Continental shelf.
Tusk, *Brosme brosme* - non-shoaling, deep-water species, rocky bottoms northern North Sea.
Bigeye rockling, *Gaidropsarus macrophthalmus* – probably rare, from more southerly waters.
Shore rockling, *Gaidropsarus mediterraneus* – probably rare, from more southerly waters.
Blue ling, *Molva dypterygia* – a deep-water species found in the Norwegian Deep.
Greater fork-beard, *Phycis blennoides* – a deep-water species from the Continental slope.



Comparison of remains of typical codfish species (Gadidae) that are common within the North Sea, showing the lobed outside of ***otoliths****, anterior caudal* ***vertebrae*** *and* ***premaxillae*** *of* ***Cod****,* ***Haddock****,* ***Whiting****,* ***Pout****,* ***Poor cod****, and* ***Norway pout****. Note difference between small and larger Whiting otoliths. Photos Suse Kühn & Estefania Velilla.*

European hake or Hake, ***Merluccius merluccius*** L., 1758

Du: Heek, Ge: Seehecht, No: Lysing, Da: Kulmule



Diagnostic features A slender and round-bodied fish with large mouth and sharp, long teeth. There are 2 dorsal fins, the first triangular, the second long-based. One long-based anal fin. No chin barbel present.

Size To about 140 cm in length. In shallow inshore waters they are often 15 to 30 cm in length. A weight in excess of 5 kg is rare, but a fairly recent (1997) boat record of 11.7 kg is known.

Colour The back is grey or blue-grey, shading to silver along the sides and silver-white on the ventral.

Similar species Not readily confused with any other inshore species. Look for the elongate and rounded body form, a large mouth with long, needle-sharp teeth, and the characteristic arrangement of fins.

Food and bait, predators Active open water predator of fish (including their own species, other gadoids, Herrings Sprats and Pilchards) and squid. Young feed on krill and other crustaceans. Preyed upon by piscivorous cetaceans such as Common dolphin and Harbour porpoise, occasionally by Harbour seals. Hake have the lowest calorific value of all codfish described in this book (~3.7 kJ g^{-1}).

Distribution and seasonality Essentially an offshore fish, demersal as well as bentho-pelagic, favouring depths of 165 to 550 m. Distributed mainly in deeper waters, so rarely encountered in the southern North Sea. The European hake is most abundant in the northern North Sea and Skagerrak. Catch rates have been found to be highest on the outer shelf and upper part of the slope. May come further inshore during cool climatic conditions. A single catch in the western Wadden Sea in the NIOZ fish fyke (April 2011).

Life history Hake spawn off the south west and west coasts of the British Isles in waters with depths of around 200 m. The eggs are pelagic. Males are mature in their 3rd or 4th year, while females mature at a larger size in their 8th year. The larger females can reach a length of 1 m and a weight of 5 kg.

Commercial fishing and human consumption Hake is an important commercial species which has been heavily exploited; as a result, the size of fish landed has greatly declined.

*Typical immature **Hake** caught inshore in the Bristol Channel (UK). Photo Peter Henderson.*

Fishing methods

It is caught with trawls, gill nets and longlines. Only occasionally caught by shore anglers. Boat fishing in midwater at night in waters 200 m or more deep is required to catch large specimens. Hake move from the sea bed to midwater at night to feed.

Remains

Not commonly encountered as a prey fish in most studies, but the **otoliths** are ovally to nearly kite-shaped, with a well-developed and wide sulcus, closed at the cauda, running over almost the whole length. $FL^{(cm)} = -4.35 + 2.66OL^{(mm)}$. In contrast to the other Gadiformes included in this book, **vertebrae** of European hake are poorly ossified, very light in weight, and have an almost spongy texture with deep oval depressions on either side of a distinct central rib. $lnFL^{(mm)} = 4.4327 + 0.9916\ lnVL^{(mm)}$.

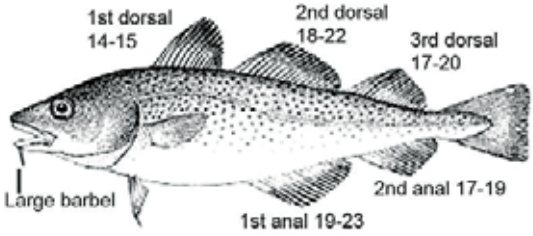
*The **Hake's mouth**, showing its sharp teeth. Photo Peter Henderson.*

***Hake**, Aquarium Finisterrae, Corunna, Spain. Photo Drow Male (CC).*

*Hake **otoliths**, inside (left), outside (right), showing overall shape, distinct sulcus and lobed margins. Photos Estefania Velilla.*

Cod, ***Gadus morhua*** (L., 1758)

Du: Kabeljauw, Ge: Kabeljau, No: Torsk, Da: Torsk



Diagnostic features A heavy-bodied fish with 3 dorsal and 2 anal fins. There is a large barbel on the chin. The upper jaw extends beyond the lower jaw.

Size Usually to about 70 cm in length. Cod can get considerably larger, up to at least twice that length, but as a result of overfishing, the larger fish have become much less common in the North Sea in recent decades. Recent record catches included individual Cod of 20 and 26.5 kg in weight.

Colour A pale olive-brown background colour, which shades to silver-cream on the lower surface of the belly. The upper surface has a characteristic mottled brown-yellow camouflage.

Similar species Young fish might be confused with other gadoids with a chin barbel. Note the mottled colouration, heavy build, white lateral line and the presence of the large chin barbel.

Food and bait, predators A major predator in marine ecosystems (certainly prior to overfishing) eating a wide range of invertebrates, becoming more piscivorous with increasing size. Important fish prey for mature Cod include other gadoids including young Cod, herring-like fish, sandeels, flatfish and Mackerel. In turn, young Cod are an important prey fish for numerous seabirds and marine mammals throughout the North Sea. A fish low in lipid contents, of moderate quality as a prey species (~4 kJ g^{-1}).

Distribution and seasonality Listed as 'Vulnerable' on the 2016 - 1 version of the IUCN Red List of Threatened Species. A widely-distributed fish occurring throughout the North Sea and Skagerrak. Adult Cod can reach depths of 600 m, but, the majority of catches occur within depths of <200 m. Shallow upper estuarine waters are used mostly by juveniles. In the southern North Sea it is found inshore during the winter. The juveniles enter estuaries in June and may remain within the estuary over the following winter. Year-round catches in the western Wadden Sea NIOZ fish fyke, with no distinct seasonal pattern (about 1 - 3 fish day^{-1} year-round), but with rather higher catch rates in 1979 (8.6), 1985 (29.3), and 2006 (10.0 fish day^{-1}) in all other years (remainder 1960 - 2015 mean = 1.38 , standard deviation = 1.23, n= 52).

Life history Primarily a demersal species, with loose schools hunting over the sea bed and in mid water. Cod are migratory fish moving between nursery, feeding and spawning grounds. Spawning occurs on the European continental shelf to a depth of 200 m between February and April. The eggs are pelagic and widely dispersed. The larvae initially feed on copepods, and gradually switch to larger crustaceans as they grow. Cod grow rapidly, and have the potential to live over 15 years and reach 150 cm in length. Growth rates differ per region and between years. Cod in the southern North Sea grow faster initially, but to a smaller

*A young **Cod** caught inshore on the Suffolk coast. Photo Peter Henderson.*

ultimate size than those in the north. The proportion reaching sexual maturity at 2 years old has increased between the 1970s and the 2000s.

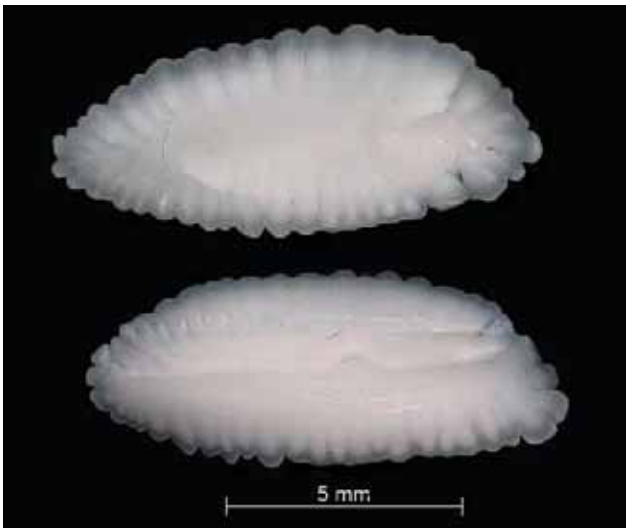
Commercial fishing and human consumption Cod are one of the most important commercial fishes in the world, and have been an important food resource to Europeans for thousands of years. They are mostly caught in trawls, although longlining for larger fish is also practiced. There has been a great reduction in Cod abundance over the last 30 years, almost entirely due to over-fishing and incompetent fisheries management.

Fishing methods Beach & boat fishing, bottom-trawling, gill netting, seine netting, longlining. Regularly targeted by both shore and boat anglers for recreational fishing.

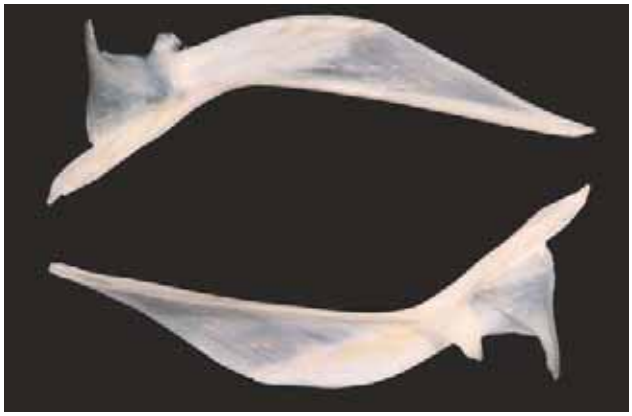
Remains Both the **dentary** and the **premaxillae** have distinct, sharp teeth, but the connections with the sockets is loose and teeth are usually missing in prey samples. The inside of the thick and oval **otolith** is convex and the outside strongly concave and heavily lobed, certainly in older specimens, so that viewed from the side, the otoliths are curved. The sulcus is closed, but runs over almost the whole length of the otolith. $FL^{(cm)}$= -6.64+3.49 $OL^{(mm)}$. The otoliths of Cod are difficult to distinguish from those of Haddock, but they are wider overall (length/width ratio 2.0-2.4). The **cleithrum** of Cod, as in the other gadoids, is a distinct and characteristic bone, but is of limited use to distinguish between related species. In the **vertebrae**, the centra are fairly short (VL~VH) with 2 - 4 distinct horizontal lines of ossification forming ridges but with a network of interconnecting structures. The anterior horns (DPrZ and VPrZ) are relatively short. Easily confused with Whiting vertebrae, but these have relatively longer centra. $lnFL^{(mm)}$= 4.3513+0.9202 $lnVL^{(mm)}$.

*Head of **Cod**. Photo Peter Henderson.*

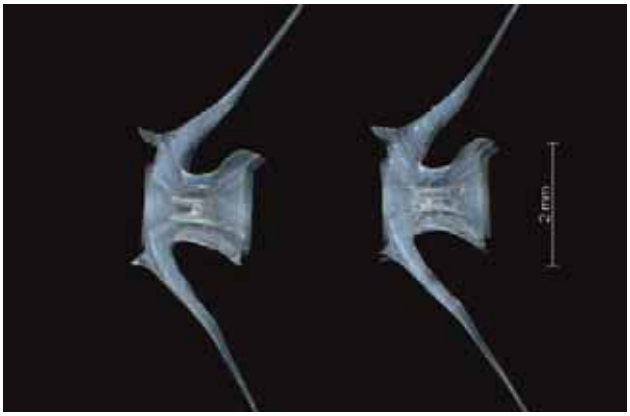
*Cod **premaxillae**, inside (top) and outside (bottom), with some loose teeth remaining. Photo Suse Kühn.*



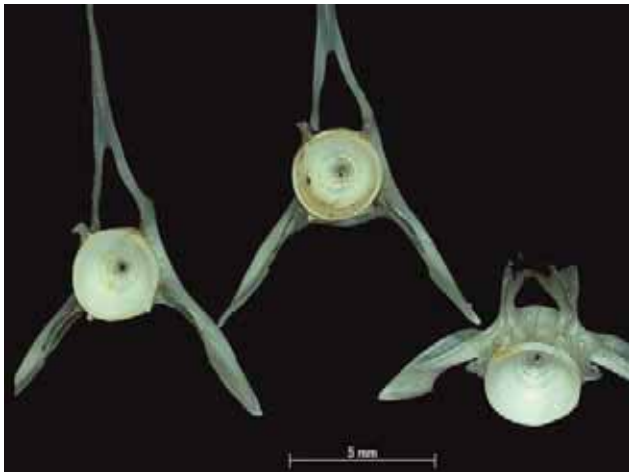
*Cod **otoliths**, showing lobed outside (top) and distinct sulcus on the inside (bottom). Photo Suse Kühn.*



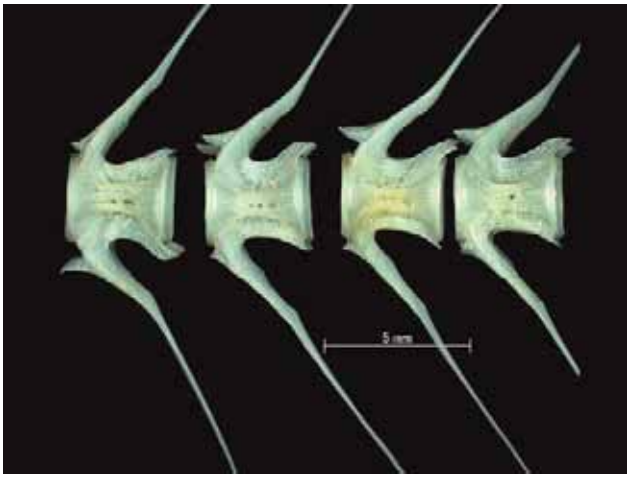
*Cod **cleithra**, with a shape highly characteristic for the gadoid group, but, certainly if not pristine, hard to separate from cleithra in related species such as Whiting, Haddock and Pouts. Photo Anne Ausems & Suse Kühn.*



*Lateral view of **caudal vertebrae** of a very young Cod (FL 110 mm). Photo Suse Kühn.*



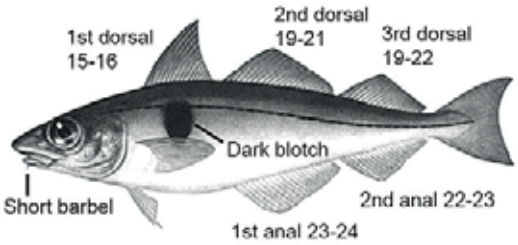
*Rear view of **abdominal vertebrae** in Cod, showing pinhole spinal foramen. Photo Suse Kühn.*



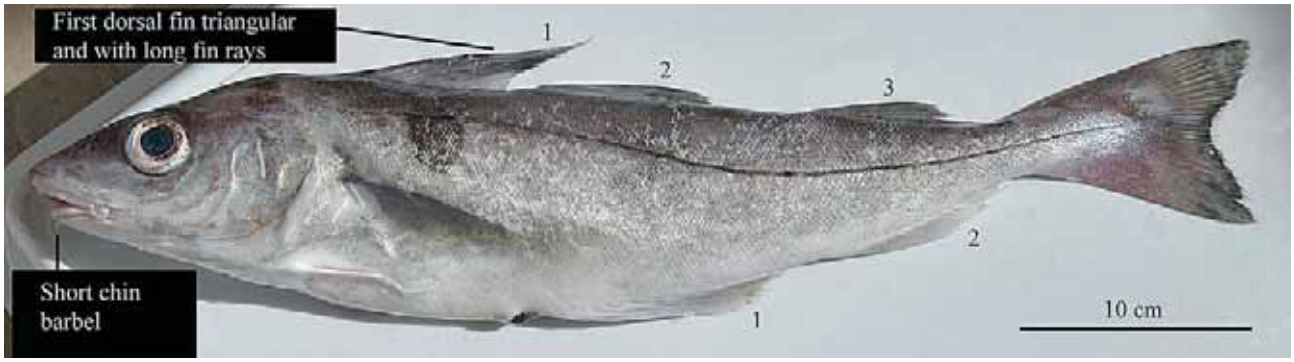
*Lateral view of **caudal vertebrae** in Cod, showing complex rib structures and absence of neural foramen. Photo Suse Kühn.*

Haddock, *Melanogrammus aeglefinus* (L., 1758)

Du: Schelvis, Ge: Schellfisch, No: Hyse, Da: Kuller



Diagnostic features	A codfish with 3 dorsal and 2 anal fins. First dorsal fin triangular with notably long fin rays. Short but visible chin barbel. Lower jaw clearly shorter than the upper jaw. Lateral line clearly visible and black.
Size	Can reach about 75 cm in length. Recent record catches included Haddock of 3 (shore) to over 6 kg (boat).
Colour	Dark green-brown dorsal and cream belly. Characteristic dark blotch above the pectoral fins.
Similar species	Young Haddock can be confused with other gadoids such as Whiting and Cod, but the dark blotches and the dark lateral line are distinctive. The lateral line of Cod is white.
Food and bait, predators	A demersal species that feeds primarily on benthic invertebrates. It will take a wide range of baits, including mussels, ragworm, lugworm and fish strips. As a food fish primarily known from diet studies of scavenging seabirds (discards), but also taken by auks and marine mammals (mostly seals). Low in fat and moderate in calorific value (~4 kJ g^{-1}).



***Haddock** caught off the north-east English coast. Photo Peter Henderson.*

Distribution and seasonality Listed as 'Vulnerable' on the 2016-1 version of the IUCN Red List of Threatened Species. Found nowadays primarily in the northern North Sea, from 40 to 300 m. Archaeological records and historical commercial fisheries statistics suggest that Haddock were once common in the southern North Sea prior to the mid-1960s. Rarely caught in the English Channel. Haddock live close to the sea bed, where they feed. They enter shallow coastal waters in summer and retreat deeper in winter. Unrecorded since 1960 from the western Wadden Sea NIOZ fish fyke.

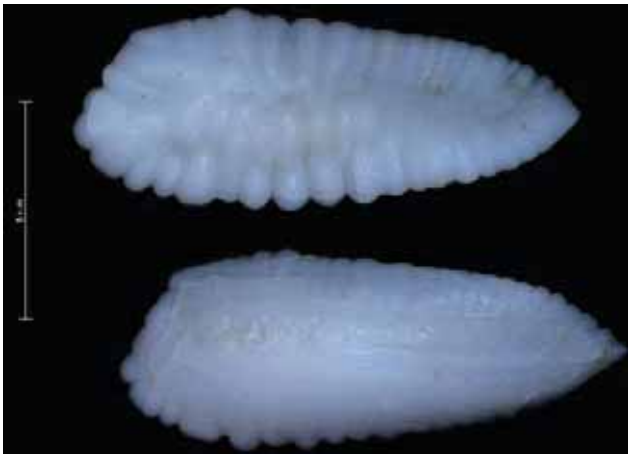
Life history Spawning February to June, but mostly in March and April. The eggs float; the larvae are pelagic, and have been found in association with jellyfish. Haddock may live for 14 years and reach sexual maturity at 4 - 5 years (at 41 cm for males, 46 cm for females). One year-old Haddock in the North Sea is 16 - 18 cm, 2 year-old Haddock reach 25 - 30 cm, so that the youngest fish appearing in commercial landings are usually 2 - 3 years old. The main spawning grounds are in the northern North Sea and in the Atlantic, off Rockall, Faroe, and Iceland.

Commercial fishing and human consumption An important commercial species particularly favoured in the north of Britain. Haddock are often sold smoked.

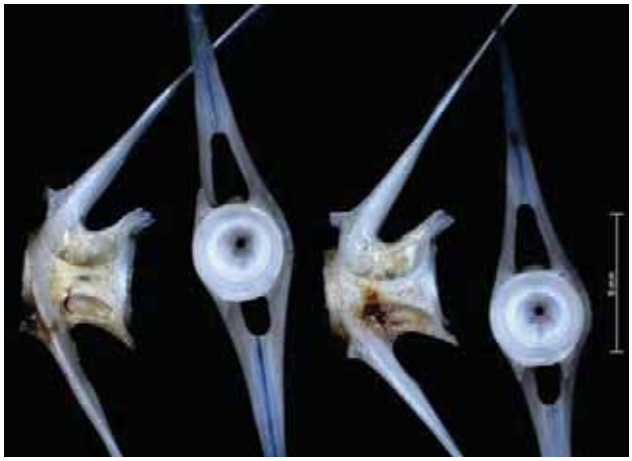
Fishing methods It is captured by trawling and also longlining. Targeted by boat recreational anglers in the north of Britain.

Remains Intact **premaxillae** would give an easy clue, given that the most anterior process, or 'ear' (ASP) is considerably larger than that in Cod, while the ramus is relatively shorter. The **otoliths** are difficult to distinguish from those of Cod, but are narrower (length/width ratio 2.35 - 3.50) and more strongly curved in lateral view. The sulcus is well-developed, closed, and runs over almost the whole length of the otolith. $FL^{(cm)}$= -3.27+2.53$OL^{(mm)}$. Ribs on the centra of all **vertebrae** are more pronounced and more strongly ossified than in those of the other gadoids. Both anterior and posterior caudal vertebrae are fairly short, but the mid-section has relatively long centra. $lnFL^{(mm)}$= 4.3571+0.9701 $lnVL^{(mm)}$. Haddock **cleithra** are shown on p.17.

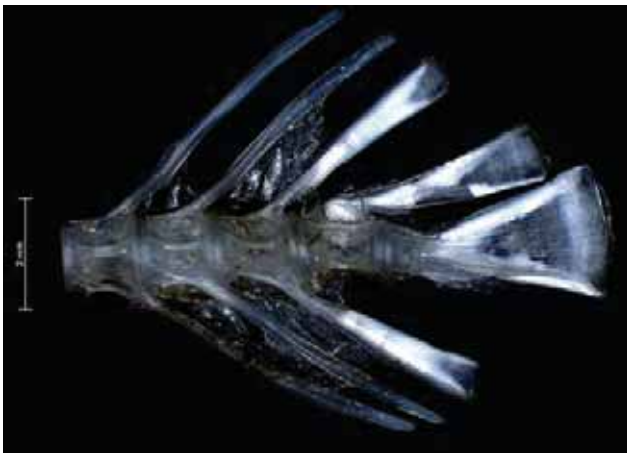
*Haddock **premaxillae**, outside view (for inside view see p. 99). Photo Suse Kühn.*



*Haddock **otoliths** (lobed outside upper, inside lower image) showing typical outline, lobed margins and distinct sulcus. Photo Suse Kühn.*



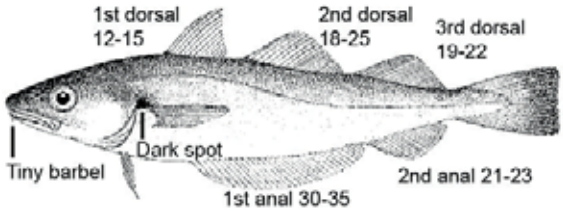
*Central **caudal vertebrae** of Haddock in lateral and posterior view showing small spinal foramen and characteristic rib structure. Photo Suse Kühn.*



*Posterior **caudal vertebrae** and **urostyle** of Haddock. Photo Suse Kühn.*

Whiting, *Merlangius merlangus* (L., 1758)

Du: Wijting, Ge: Wittling, No: Hvitting, Da: Hvilling



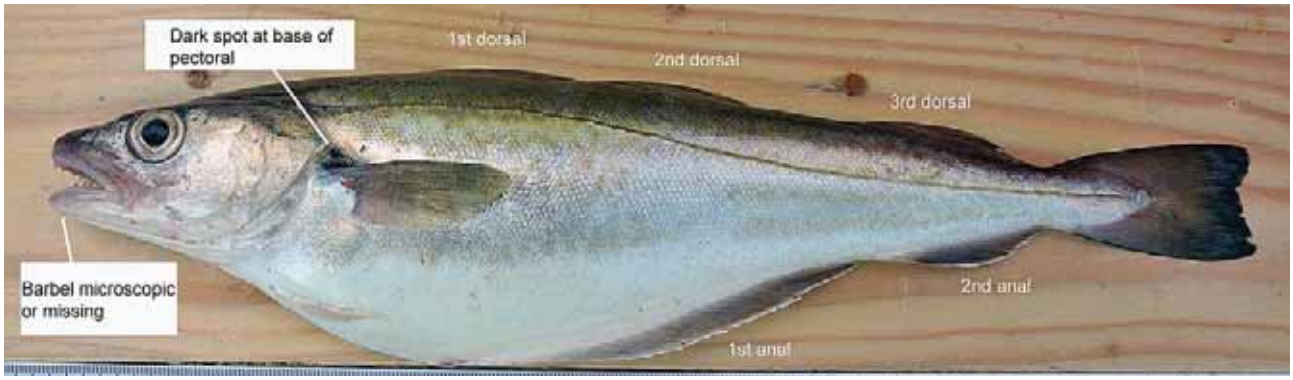
Diagnostic features 3 dorsal and 2 anal fins and a slender head. Only small fish possess a chin barbel, even in these it is minute. The upper jaw extends beyond the lower.

Size Length to 70 cm; usually smaller, especially males. Recent record catches were fish ranging from 1.8 (shore-based) to 3.3 kg (boat) in weight.

Colour A pale olive brown-yellow back and cream belly. The bright colouration of live fish quickly fades. A characteristic dark spot at the base of the pectoral fin.

Similar species The young can be confused with other gadoids such as Norway pout, Blue whiting and Poor cod. Note the dark spot at the base of the pectoral fin, the lack of chin barbel, and the 3 dorsal fins with little or no gap between their bases. Adults can look similar to Pollack; the jaw alignment easily distinguishes the two (p. 107).

Food and bait, predators A general predator on shrimps, crabs, molluscs, small fish, polychaetes and cephalopods. The young feed on crustaceans, moving on to fish such as Sprats and sandeel as they grow. They will take a range of baits including lugworm, ragworm, Mackerel strip and squid. As a food fish, primarily known from diet studies of scavenging seabirds, particularly in the south-eastern North Sea, where beamtrawlers and shrimpers dump large quantities as discards. Also frequently taken by auks and marine mammals (notably by seals and porpoises). A lean fish (lipids 0.7% wet weight), 3.9 - 4.3 kJ g^{-1}.



*Mature **Whiting** caught inshore on the Suffolk coast. Photo Peter Henderson.*

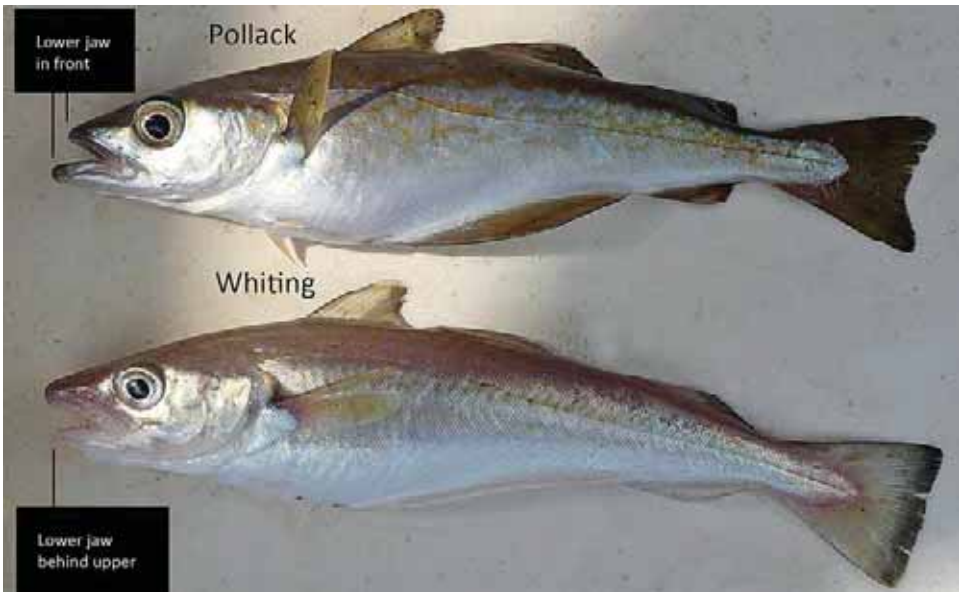
Distribution and seasonality Whiting is one of the most widely-distributed species and the commonest member of the cod family in many inshore waters. Found in large numbers throughout the North Sea and Skagerrak. The juveniles are highly abundant in estuarine habitats. Listed as 'Least concern' on the 2016 - 1 version of the IUCN Red List of Threatened Species, but concerns were raised suggesting that 'Vulnerable' would be more appropriate for the southern North Sea. Although it occurs to a maximum of 550 m, the majority are caught between 30 - 150 m. Adults most commonly found from 30 to 100 m over mud or gravel bottoms, occasionally sand and rock; most abundant inshore during winter. Juveniles penetrate far up estuaries, migrating to the open sea only after the first year of life. Year-round catches in the western Wadden Sea NIOZ fish fyke, but with low catch rates in spring (<1 fish day^{-1}), higher catches during June - December, notably in October - November (6 - 8 fish day^{-1}). Autumn catches rather higher October - November 1974 - 90 (average 13.8 day^{-1}, Standard deviation = 14.47, range 3.2 - 63.8 fish day^{-1}, n= 17) in comparison with earlier and later years.

Life history Larvae and juveniles are known to associate with jellyfish, using the tentacles as protection from predators, apparently unharmed by their sting. Spawning begins in the south in January and in the north may occur as late as July. The main spawning period is April/ May; spawning takes place in open water and the eggs are pelagic. Females may live for 7 or 8 years.

Commercial fishing and human consumption An important food fish, though not widely favoured because it lacks the firm flesh of Cod or Haddock.

Fishing methods Caught by bottom-trawling and longlining. Taken by recreational fishermen both from boats and from the shore.

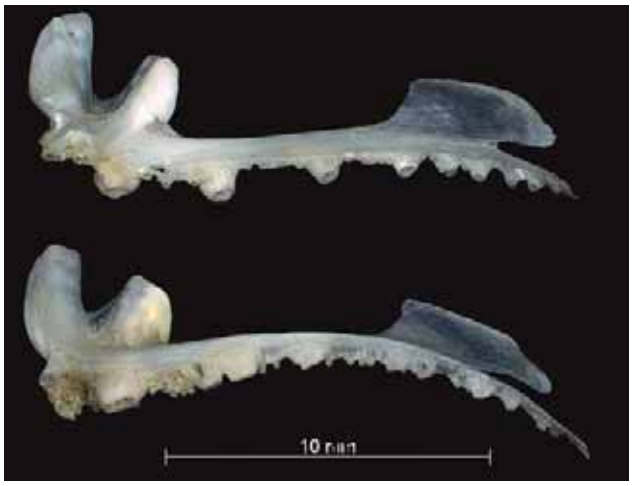
Remains The **premaxillae** are more fragile than in Cod or Haddock, and with the anterior processes, or 'ears' set rather wider apart. The **otoliths** are in fact unmistakable, sharp and pointed as they are, but unfortunately, the tips break rather easily. Otoliths from small fish, FL 8 - 15cm, tend to have more strongly-lobed ventral and dorsal margins (as well as on the



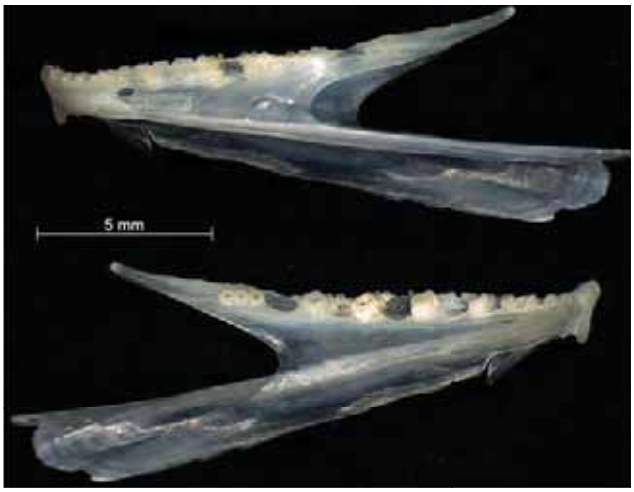
*A comparison of **Pollack** and **Whiting** of similar size. Photo Peter Henderson.*

*Comparison of **Whiting** and **Blue whiting**. Photo Peter Henderson.*

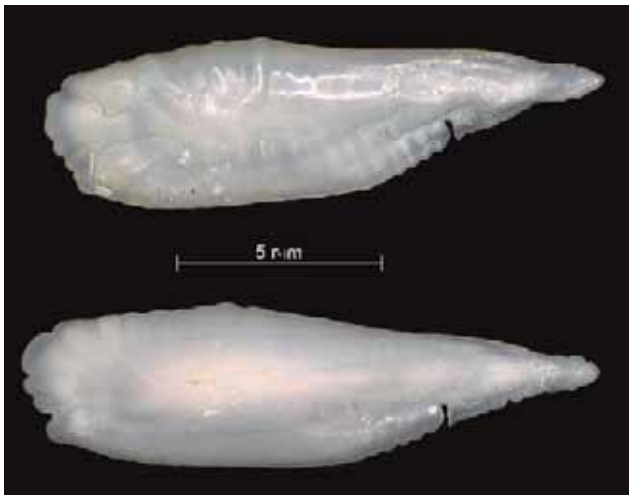
anterior round tips) than larger fish. To calculate fish length from otolith size, use $FL^{(cm)}$= 0.81 + 1.73$OL^{(mm)}$, but because the slender tip of these otoliths is almost invariably broken, using otolith width can be more practical: $FL^{(cm)}$= -2.97+6.74$OW^{(mm)}$. The surface of the strongly-waisted centrum of the **vertebrae** has a fine network, a gross-grained appearance of fine ribs with many tiny interconnecting septa. The vertebrae are relatively longer (VL/VW ratio) than the otherwise rather similar vertebrae of Cod and Pollack. The ventral anterior horns (VPrZ) are shorter than in Blue whiting. $FL^{(mm)}$= 1.906+73.108$VL^{(mm)}$



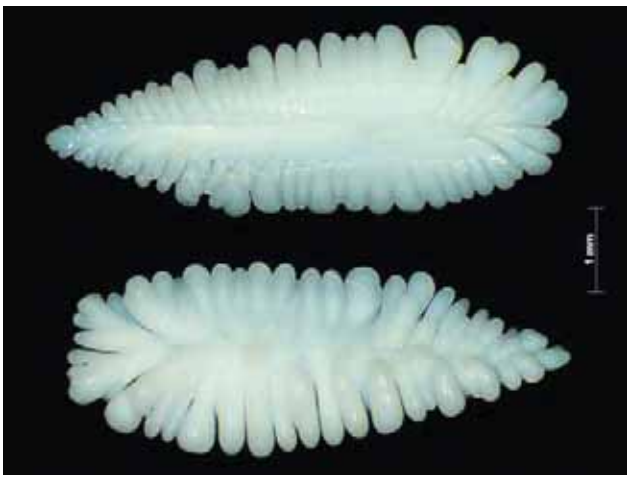
*Whiting **premaxillae**, outside view below, inside view above, showing relatively short 'ears' and longer ramus in comparison with those of Haddock. Photo Suse Kühn.*



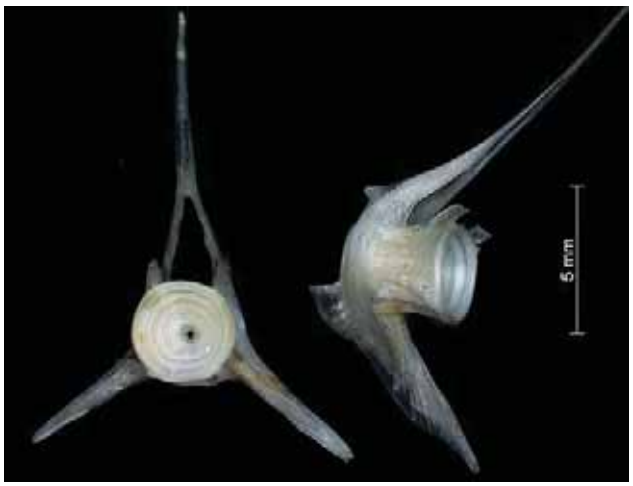
*Outside (top) and inside (bottom) view of Whiting **dentaries**. Photos Suse Kühn.*



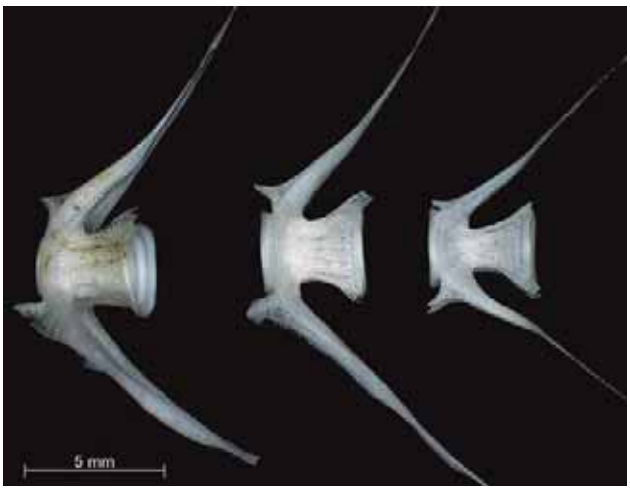
*Whiting **otoliths**, inside view below, outside view on top, showing typical outline and sharp, pointed posterior end of a fairly large animal (FL 265 mm). Photo Suse Kühn.*



*Whiting **otoliths**, inside view on top, outside view below, typical lobed margin of a small specimen (FL 125 mm). Photo Suse Kühn.*



*Abdominal **vertebrae** of Whiting showing typical network structure on centra and tiny spinal foramen. Photo Suse Kühn.*



*Caudal **vertebrae** of Whiting, showing diabolo shape, prominent horns, and fine network structure on centra. Photo Suse Kühn.*

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