Chapter 6

Herring-like fish - Clupeiformes

The order Clupeiformes includes the **herring** and **anchovy** families (Clupeidae and Engraulidae). The Clupeiformes are mostly plankton feeders that live pelagically and may form huge shoals. The order holds about 300 species, in six families. Here, we feature six species, one from the Engraulidae (anchovies) and five from the Clupeidae (herrings, sardines, shads, and menhadens). They are all fast swimming, silvery, open-water fish. It is possible to confuse a Pearlsides (Chapter 9) or a young Horse mackerel (Chapter 24) with a clupeid. This order holds many of our most important food fish, but they are also important prey fish for a variety of marine birds, marine mammals, and predatory fish.

As important prey species for numerous marine predators, the slowly digestible remains of Clupeiformes that hold important characteristics to allow us to identify the group (herring-like fish), the species, the size and sometimes even the age of the consumed fish, are given considerable attention. Otoliths of herring-like fish all have a similar gun shape, with the rostrum extending beyond the antirostrum. The otoliths are relatively large and therefore easy to find, but are unfortunately rather fragile and they rapidly wear down (plate, p. 68). The Clupeidae are further characterised by the presence of pro-otic and/or pterotic bullae in the skull, which may show up as little hollow balls in prey samples (not to be confused with eye-lenses). Pro-otic bullae are round, while pterotic bullae are potato-shaped. The bullae may be found with clupeid otoliths, and can then be matched with these to arrive at a minimum number of (specifically identified) fish for that sample. However, in more strongly-digested prey remains, bullae are more likely to be found than the more fragile otoliths. All vertebrae have a rectangular shape with defined rib and 'horns'. These horns are also fragile, but vertebrae are quite useful for species identification. Characteristic for the order are the thin neural and haemal spines positioned at the anterior end of the centrum (plate, p. 68). Vertebrae in this order may also be distinguished by their wide spinal foramen (in gadoids the spinal foramen is narrow) and prominent ribs. Prey samples are often packed with the prominent scales in herrings and shads, but species identification on the basis of scales only is hard. All clupeids are potentially high-quality prey (6 - 10 kJ g^{-1}), but show large seasonal variations in lipid contents and therefore in calorific value. The energy density of clupeids may vary three to four-fold over a year.

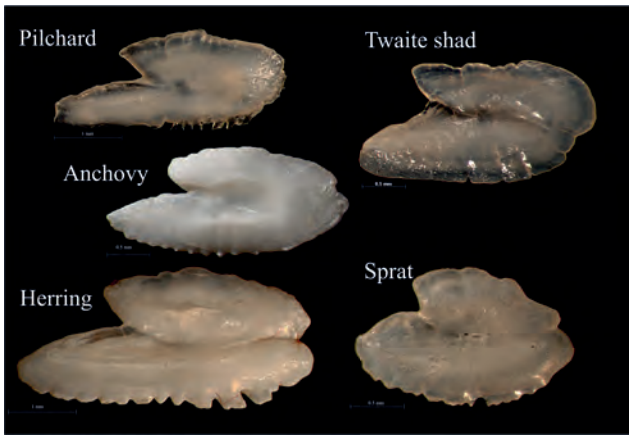
Key to species of herrings and anchovy

1 Snout prominent and jaws extending back well past the eye ..... **Anchovy**, *Engraulis encrasicolus* (p. 69)
or Snout not prominent and jaws never extended behind eye 2
2 Distinct notch in the centre of the upper jaw ..... **shads**, *Alosa* spp. - 5
or No notch on the upper jaw 3
3. Body oval in cross-section, gill cover with pronounced radiating ridge ..... **Pilchard**, *Sardina pilchardus* (p. 78)
or Body laterally flattened with distinct sharp keel, no pronounced ridges on gill covers 4
4 The belly formed into a sharp-toothed keel with backward pointed scales, the dorsal fin origin is behind the pelvic fin origin. Normally smaller than 13 cm (can exceed 16 cm) ..... **Sprat**, *Sprattus sprattus* (p. 80)
or The belly with a sharp, but smooth, keel, which does not obviously snag the finger when run forwards under the throat. The dorsal fin origin is in front of the pelvic fin origin. Can be much greater than 13 cm in length..... ..... **Herring**, *Clupea harengus* (p. 75)
5 With 40 to 60 gill rakers ..... **Twaite shad**, *Alosa fallax* (p. 72)
or With 80 to 130 gill rakers ..... **Allis shad**, *Alosa alosa* (p. 74)

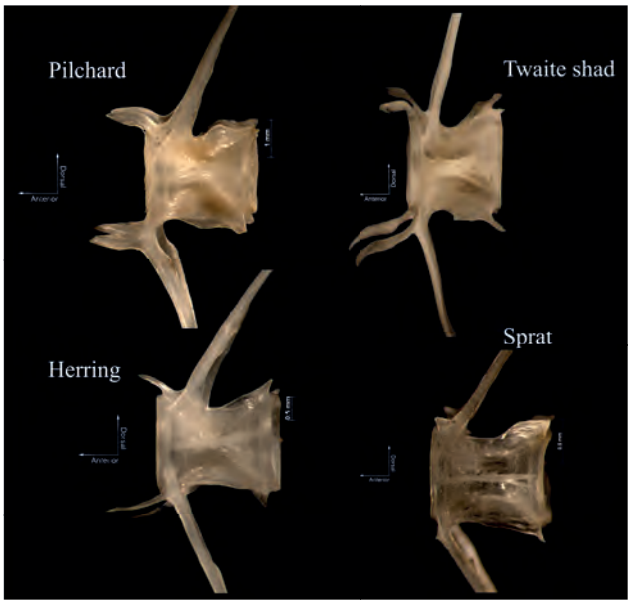
*A mixed catch of juvenile **Sprat** and **Herring** trawled in Southampton Water (UK). Juveniles of both species are sold as whitebait. Photo Robin Somes.*

*Netting for **Sprats**, Norway, 1912. Photo Anders Beer Wilse / Norwegian Museum of Cultural History (public domain).*

*Approximately one metric tonne of adult **Herrings**, caught in a power station cooling water intake. Photo Robin Somes.*



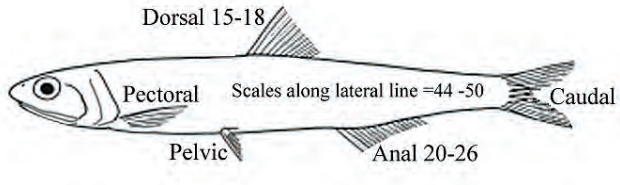
*Species comparison. The **otoliths** of the herrings and Anchovy compared. The 'gun shape' is typical for all species. The rostrum is rather long and blunt in Pilchards, wide and more triangular in Twaite shad. The otoliths are more oval-shaped overall in Sprat, and less fragile with a pointed rostrum in Anchovy. See species accounts for more detailed descriptions. Photos Estefania Velilla.*



*Species comparison. The **vertebrae** of four Clupeidae compared. The anterior 'horns' (DPrZ and VPrZ) are extremely fragile in Herring and Sprat. Photos Estefania Velilla.*

Anchovy, ***Engraulis encrasicolus*** (L., 1758)

Du: Ansjovis, Ge: Sardelle, No: Ansjos, Da: Ansjos



Diagnostic features The position of the mouth under the head, with an exceptionally long lower jaw and a snout extending forward of the mouth, is an unmistakeable feature of the Anchovy. This is the only member of the Engraulidae in the North Sea.

Size Can reach about 20 cm in length. Rod-caught record 49 g.

Colour The dorsal surface is dark green-brown, there is a silver band along the sides and the ventral surface is transparent or white.

Similar species The mouth and head of the Anchovy are unmistakeable.

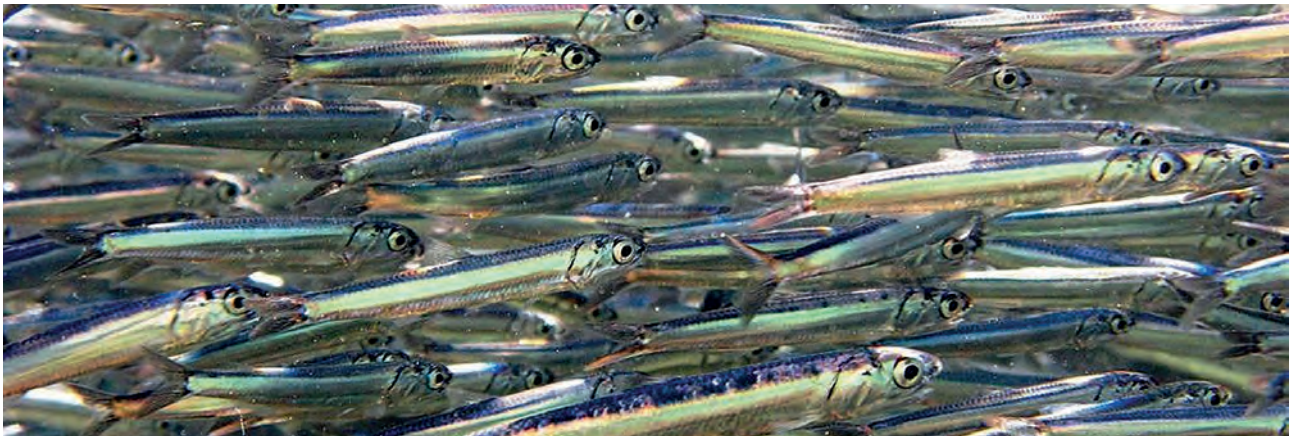
Distribution and seasonality Found throughout the North Sea, but abundant only in the English Channel, the southern North Sea and in the Skagerrak. The depth range observed in the North Sea ranges from 1 - 500 m. Other anchovy species occur worldwide in temperate waters, often in vast numbers, forming a significant food source for fish, marine mammals, birds, and humans. The mining of seabird dung, or guano, for fertiliser, in the world's large upwelling systems is largely founded on small forage fish such as Anchovy. Prior to the construction of the 'Afsluitdijk' in the Nederlands, the barrier that converted a shallow sea (the Zuiderzee) into a lake in the 1930s, Anchovies spawned there in great numbers (May - August), and larval fish developed in the SW part of the Zuiderzee before the young fish departed in autumn. Annual western Wadden Sea NIOZ fyke catches peak May - July, occasionally in September (1969). Notably abundant in 1964, 1969, 1979, and 1985. Very low numbers from 2001 - 2011, but higher catch rates again in 2012. Abundant in English East Anglian inshore waters April - August.

Food and bait, predators A plankton feeder, which eats copepods, barnacle and mollusc larvae, plus the eggs and larvae of other fish. An important food fish for marine wildlife and predatory fish around the world, but only fairly recently of significance within the North Sea. A slightly lower-quality food fish than the Clupeidae, but up to 5.6 kJ g^{-1} has been reported.

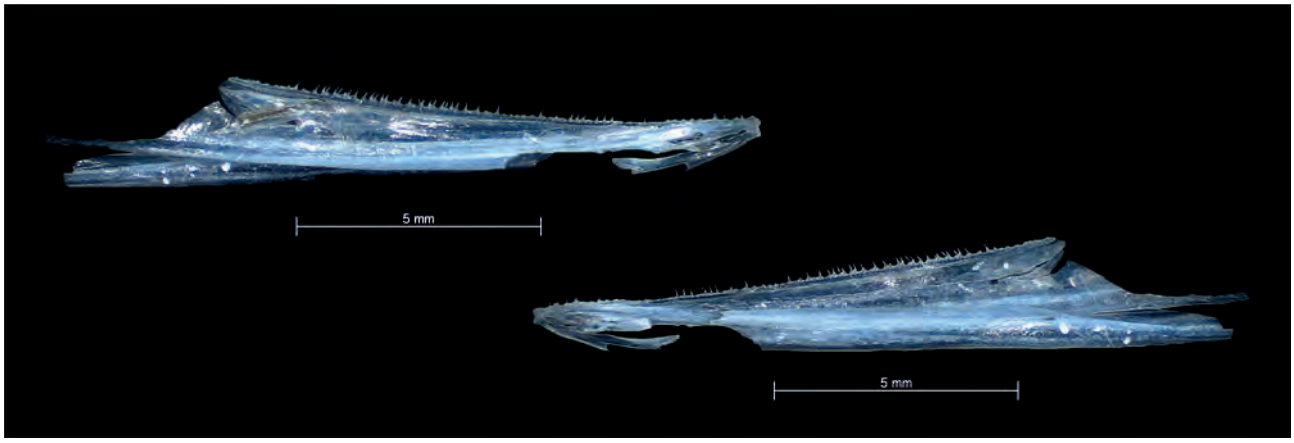
Life history Anchovy spawn inshore from April to October, depending on locality. They grow rapidly, spawn at the end of their first year of life, and rarely survive for a second year. The eggs and larvae are pelagic. They form large shoals inshore during the summer, and move deeper and offshore for the winter. European Anchovy are a warm-water species, preferring temperatures warmer than those normally found in boreal waters. In the 1990s increasing quantities were observed in the North Sea and Baltic. Whereas global warming probably played a role in these northward distribution shifts, other influences have been identified, such as the North Atlantic Oscillation (NAO), the Atlantic Multi-decadal Oscillation (AMO) and a contraction of the subpolar gyre. Increasing numbers of Anchovy eggs, larvae, juveniles and adults have been recorded only since the mid-1990s, when, particularly, summer temperatures started to increase. Apparently, climate variability drove Anchovies (and Sardines) into the North and Baltic Seas.

Unusually large (approx. 180 mm) ***Anchovy*** *caught on the Suffolk coast (UK). Photo Peter Henderson.*

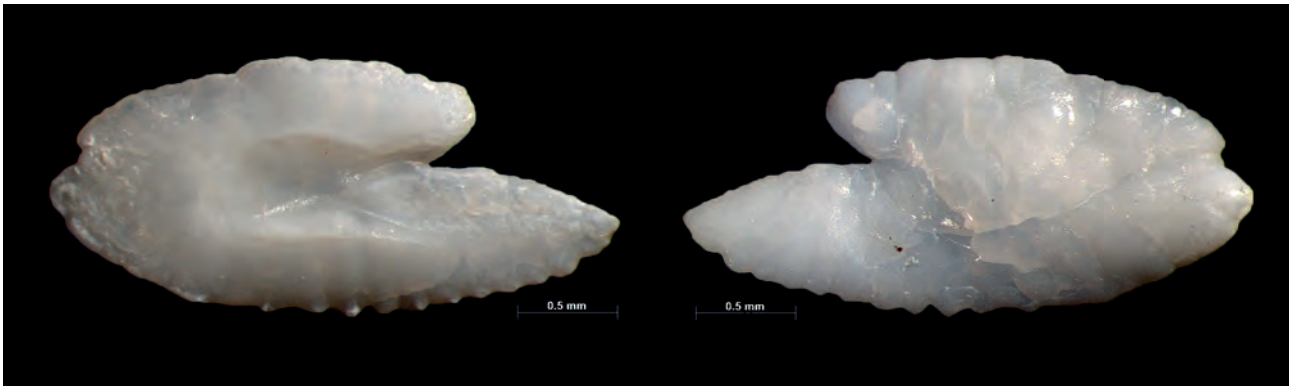
*The mouth of an **Anchovy** showing the very distinctive jaw and snout. Photo Peter Henderson.*



*A shoal of **Anchovies**, Liguria, Italy. Photo Etrusko25 (CC).*



*Anchovy **dentary** (inside view on top, outside view below), showing fine teeth. Photos Suse Kühn.*

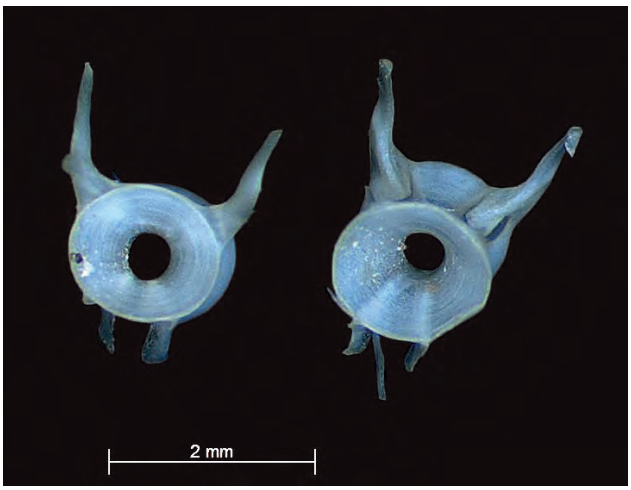


*Anchovy **otoliths**, inside (left) and outside (right) with fairly smooth surface, more pointed rostrum than in most other clupeids. Photos Estefania Velilla.*

Commercial fishing and human consumption Anchovy are a popular consumption fish usually eaten salted and canned or in a paste; also used extensively for fishmeal. They have supported large coastal fisheries in Europe since Roman times.

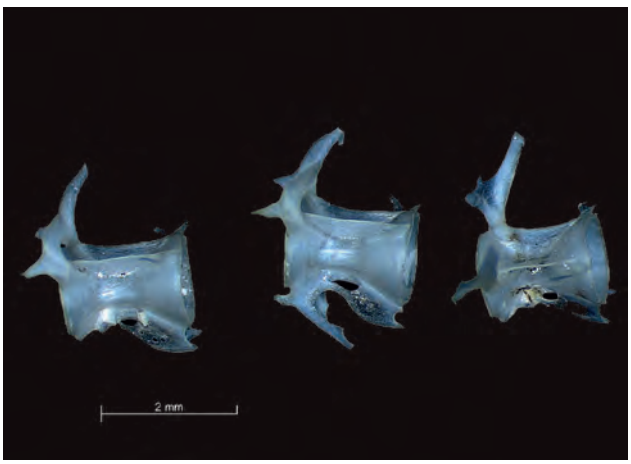
Fishing methods Midwater trawl, seine netting. Not targeted by recreational anglers; sometimes taken by accident.

Remains The **dentaries** are long and straight with numerous fine teeth attached. Anchovy **otoliths** are fairly bold and thick in comparison with the other clupeids. General shape is ovally pointed. The straight sulcus runs to the centre of the otolith, is not well-developed and open at the ostium. The rostrum of the otolith is well-developed and pointed as is the anti-rostrum. Otoliths can be difficult to distinguish from those in other clupeids. When eroded, the spikes at the ventral margin disappear, the sulcus becomes less distinct and the ventral margin is smoothed. To calculate fish length (FL) from otolith length (OL) use $FL^{(cm)} = -0.00+4.61OL^{(mm)}$. The **cleithrum** is much less complex than in the herring-like fish. The **abdominal vertebrae** are rectangular, VL>VH, with a smooth centrum or a fine central rib. Ventral and dorsal appendices are usually broken, but if pristine, the overall appearance is that of a leafy seahorse. The **caudal vertebrae**, however, are strongly waisted with a smooth rounded centrum and with a prominent triangular anterior ventral horn (VPrZ) departing from the base of the haemal spine.

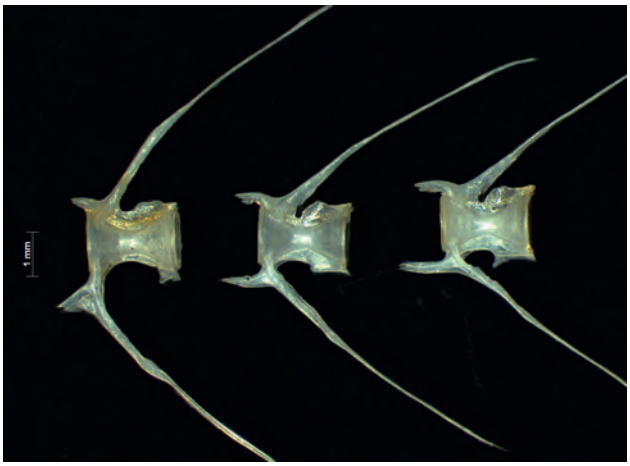


*Anchovy **abdominal vertebrae** in frontal views. Photo Suse Kühn.*

*Anchovy **cleithrum**, outside view. Photo Suse Kühn.*



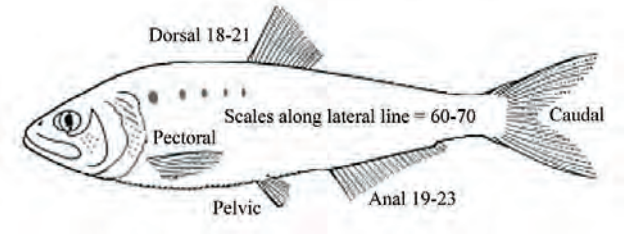
*Anchovy **abdominal vertebrae** in lateral views. Photo Suse Kühn.*



*Anchovy **caudal vertebrae** in lateral view. Photo Suse Kühn.*

Twaite shad, ***Alosa fallax*** Lacépède, 1800

Du: Fint, Ge: Finte, No: Stamsild, Da: Stavsild



Diagnostic features A deep-bodied herring-like fish with radiating lines on the operculum, a sharp keel and a prominent notch on the upper jaw (p. 75). There are 40 to 60 gill rakers on the first gill arch (photo, p. 73).

Size Can reach about 50 cm in length. Fish of 35 cm are commonly observed. Shore-caught record 1.25 kg.

Colour The dorsal surface is dark blue, shading to gold and silver; along the sides there may be 6 to 8 black spots. 0-group fish have only a single, often comma-shaped, black spot behind the operculum.

Similar species Allis shad, which is much rarer and has 80 - 130 gill rakers on the first gill arch (photos, p. 74 & p. 75). The two species can hybridise, so are not always distinguishable. The young can be mistaken for Sprat or Herring. Look for the small black mark behind the gills and row of spots along the flanks, and remember that Shad are notably deeper in the body than Herring or Sprat. To distinguish Twaite and Allis shad, count the gill rakers.

Distribution and seasonality Occasionally caught in coastal waters. Adults are frequently caught in the southern North Sea and along the Channel coast. These were probably raised in European rivers. Near-resident in the Wadden Sea, spawning in rivers. Western Wadden Sea NIOZ fyke catches year-round (1960 - 2015), with a distinct peak July - October. Higher catches in the 1970s than in the most recent decades, suggesting a gradual decline.

Food and bait, predators A water column feeder, eating crustaceans such as mysids and the young of other fish. Food fish mostly for marine predators foraging nearshore, including seabirds and seals.

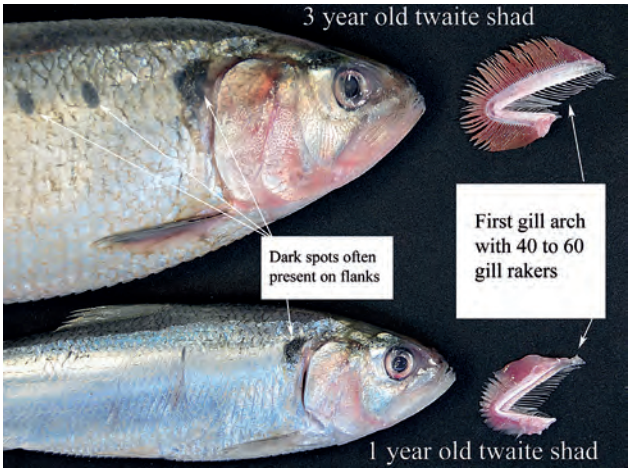
Life history Mature Twaite shad enter rivers to spawn from mid-May to mid-July. Spawning takes place in flowing water over stones and gravel. The young fish drop quickly downstream to the quieter waters of the upper estuary. Growth is rapid and juveniles can reach 50 mm in 6 months and 100 - 150 mm after 1 year. The males start to mature at 3 years of age and the females at 5.

Commercial fishing and human consumption A rare and protected species no longer legally fished. In many parts of the world migratory shad of other species are important food fish.

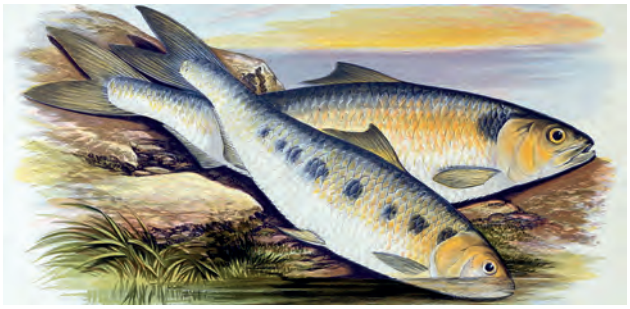
Fishing methods Caught in seine nets and traps. Not targeted by recreational anglers, but occasionally caught when feathering for Mackerel. They should be returned alive.

Remains The **otoliths** are fragile and relatively small for the size of fish (OL:FL ~1:110). They are gun-shaped, with an irregular outline, pointed anterior and deep indentations in older fish. The sulcus is straight, runs over the whole length and is open at both sides, but is poorly developed. The inside of the otoliths is smooth. $FL^{(cm)}$= -12.11+13.74$OL^{(mm)}$. May be difficult to separate from other clupeids. The posterior end of Herring otoliths is indented and at 90° with the ventral side, whereas the Twaite shad otolith is rounded and at a wider angle with the ventral side. Centrum length of **vertebra** equal to the height. A single, prominent broad rib (VL:FL ~1:90).

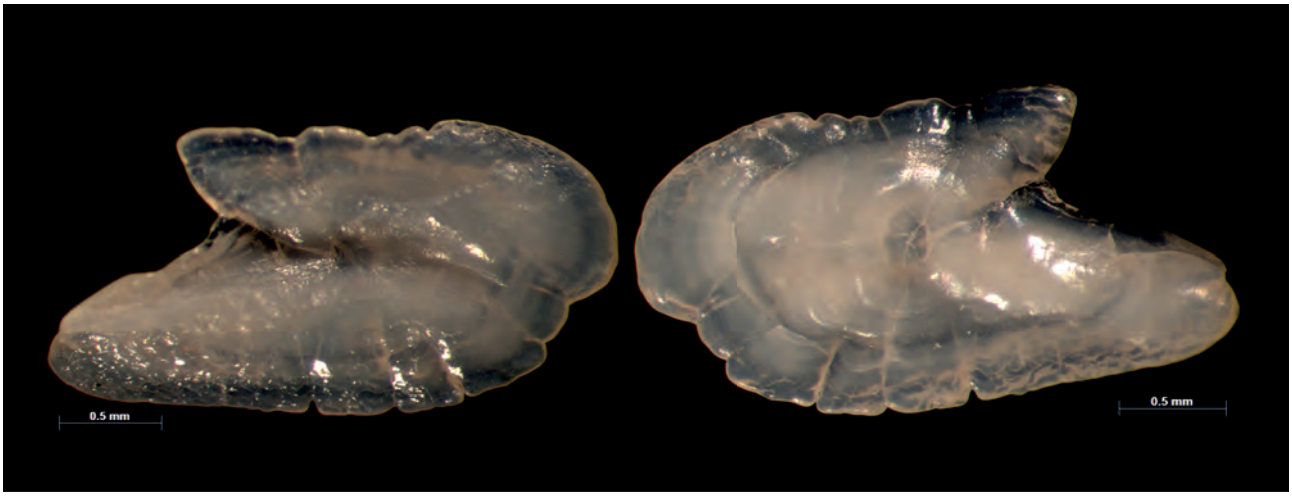
*Mature **Twaite shad** caught inshore on the Suffolk coast. Photo Peter Henderson.*



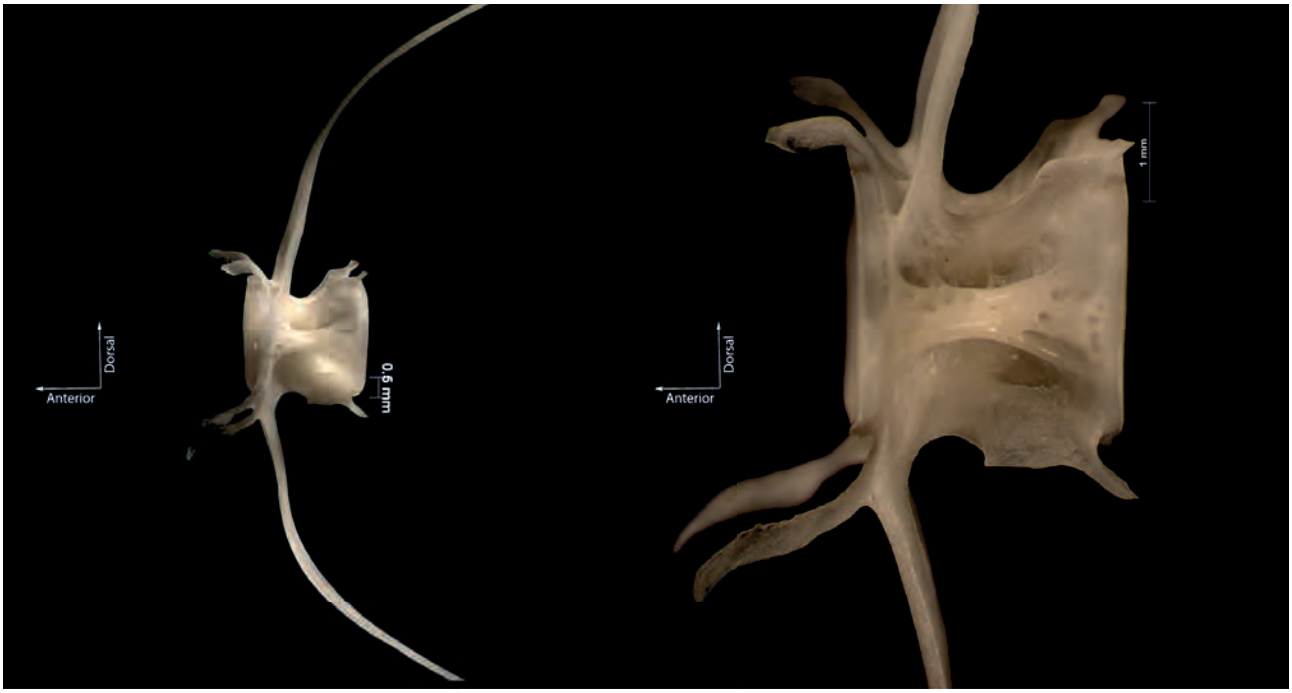
*Adult and young **Twaite shad**. The 40 - 60 gill rakers on the first gill arch appear quite coarse, in comparison to those of the Allis shad (photo, p. 75). Photo Peter Henderson.*



*Detail from a watercolour painting of **Twaite shad** by Alexander Francis Lydon (1836 - 1917), from British Freshwater Fishes, by the Rev. W. Houghton (public domain).*



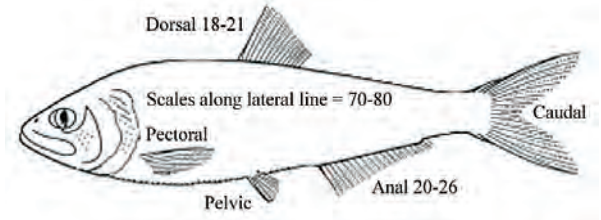
***Otoliths** (left inside, right outside) of **Twaite shad**. Photos Estefania Velilla.*



***Vertebrae** of **Twaite shad** in a pristine state: overall outline left, zoom in on centrum right. Photos Estefania Velilla.*

Allis shad, ***Alosa alosa*** L., 1758

Du: Elft, Ge: Alse, No: Maisild, Da: Majsild



Diagnostic features A deep-bodied herring-like fish with radiating lines on the operculum, a sharp keel and a prominent notch on the upper jaw (photo, p. 75). There are 80 to 130 gill rakers on the first gill arch (p. 75).

Size Can reach about 60 cm in length. Shore-caught record 2.2 kg.

Colour Dorsal surface dark blue, shading to gold and silver along the sides. Unlike the Twaite shad, there is usually only a single dark blotch on the side, behind the gill covers.

Similar species Twaite shad, which has 40 - 60 gill rakers on the first gill arch and is much commoner in British waters. Juveniles may be mistaken for Sprat or Herring. Look for black spots along the sides and count the gill rakers. The young are deeper-bodied than Herring or Sprat and have a small black dot behind the gill cover. No NIOZ fyke Wadden Sea catches known.

Distribution and seasonality Occasionally caught in coastal waters. Allis shad have been reported in the south-eastern North Sea. They have been reported elsewhere in the North Sea, but less frequently. Found at depths of 0 - 5 m (Wadden Sea and Scheldt estuaries) and are seldom reported at >40 m depth.

Food and bait, predators A water-column feeder, eating crustaceans such as mysids and the young of other fish. Young fish feed on benthic river invertebrates. Not often a reported food fish for nearshore predators.

Life history Anadromous. Allis shad enter rivers to breed in late spring. Spawning takes place at night in flowing water over clean gravel. After spawning the adults return to sea, but most die before reaching it; only 5 - 6% of adults survive to spawn more than once. After hatching, the young live initially in the slow-flowing reaches of the lower parts of rivers; they then move into estuaries and coastal waters. Allis shad mature at between 3 and 8 years of age, the majority of females at 5 or 6, and males at 4 or 5.

Commercial fishing and human consumption This is a protected species no longer legally fished in the North Sea. In many parts of the world, migratory shad of various species are an important food fish, and minor commercial fisheries for Allis shad exist in France and Portugal.

Recreational fishing Not targeted by anglers, although occasionally caught on mackerel feathers. This is a rare and protected fish and should be returned alive.

Remains **Otoliths** similar as in Twaite shad, gun-shaped, with irregular outline and deep indentations in oldest fish. Ostium longer than cauda, with pointed anterior. No further bone material available.

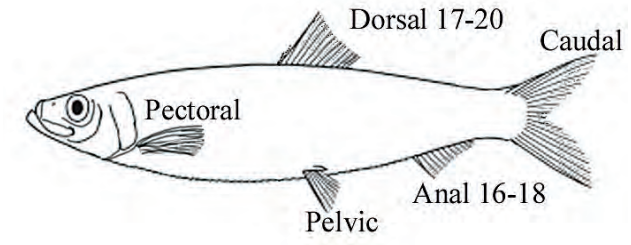
Mature ***Allis shad*** *caught inshore on the Suffolk coast. Photo Peter Henderson.*

*The mouth of an **Allis shad** showing the notch in the upper jaw. Photo Peter Henderson.*

*The **gill rakers** of an **Allis shad**; between 80 and 130 rakers, appearing finer and more delicate than those of the Twaite shad. Photo Peter Henderson.*

Herring, *Clupea harengus* L., 1758

Du: Haring, Ge: Hering, No: Sild, Da: Sild



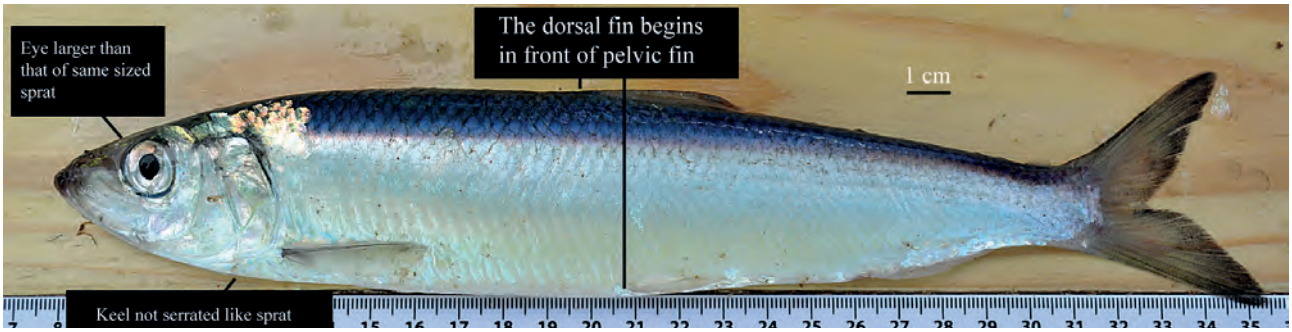
Diagnostic features A laterally-flattened fish that has large, easily-dislodged, scales, and no lateral line. The lower jaw and eyes are prominent. The single dorsal fin is set in front of the pelvic fin.

Size To about 40 cm in length and 500 grams in weight.

Colour Typically with a dark blue back with silvery-white sides and belly.

Similar species The young can be confused with Sprat and shad, the adults with Pilchards. The main problem lies in telling a young Herring from a Sprat (see Sprat and Herring comparison, p. 81). The eye of the Herring is proportionally larger than that of the Sprat. Run your finger along the keel of the fish, from about the pectoral fin forward towards the head; the Herring is smooth, but the sharp edges of the scales on a Sprat feel jagged. Look at the relative position of the dorsal and pelvic fins – in Herring the origin of the pelvic fin is set back a little from the origin of the dorsal fin, whereas in Sprat the two fins are aligned – or the pelvic fin can be slightly in front. The Herring is typically not as deep-bodied as a Sprat or shad of similar size. Juvenile shad have a characteristic black comma-like mark on their sides.

Distribution and seasonality Found everywhere in the North Sea, Herring is locally highly abundant, particularly near spawning and nursery grounds. They have a wide depth range, but high catch rates are limited to depths between 20 - 100 m in the North Sea. Juveniles may enter estuaries in



*Mature **Herring** caught on the Suffolk coast. Photo Peter Henderson.*

large numbers during autumn. Adults aggregate in late winter - early spring in coastal waters prior to spawning. Overfishing over the 20th century has reduced the abundance of this fish. Annual western Wadden Sea NIOZ fyke catches are predominantly in June - December, peaking October - November. Particularly low numbers were observed 1960 - 1977 (Oct - Nov mean = 103 day^{-1}, Standard deviation= 127.2, n= 18), much higher but fluctuating catch rates 1978 - 2007 (1191 day^{-1}, SD= 1034.9, n= 30), lower catches again recorded post-2007 (241 day^{-1}, SD= 358.0, n= 8).

Food and bait, predators A plankton feeder specialising in crustaceans including copepods, amphipods and mysids. It is occasionally caught on baited hooks and mackerel feathers. It is a (locally) important and high-quality prey fish for a range of predators, including pelagic seabirds such as Northern gannets, Atlantic puffins, and Common guillemots, but also inshore species such as Red-throated divers, Great cormorants, Red-breasted mergansers, and Smew, Gulls and Terns, and various species of marine mammals including seals, Killer whales, Minke whales, Harbour porpoises and various dolphins. Calorific values of over 10 kJ g^{-1} have been reported.

Life history Herring in the North Sea are divided into a number of different stocks. Populations may spawn in spring or late summer - autumn. The smaller inshore populations tend to be spring-spawning. The once highly-abundant North Sea autumn spawners comprised a complex of three separate spawning stocks which mix during their migrations. These are the Buchan group which spawn in the Orkney and Shetland area and off the Scottish east coast (July to September); the Banks or central North Sea group which spawn off the north-east coast of England (August to October); and the Downs group which spawn in the Southern Bight and eastern English Channel (November to February). Most Herring first spawn at 3 or 4 years old. The eggs are released close to gravel or shell seabed and become attached to the substrate, often forming a mass several eggs deep. The eggs hatch in about 3 weeks, depending on temperature. The planktonic larvae are slender and about 6 mm in length on hatching. The young fish form large schools and are particularly common inshore during their first year. They move into deeper water with age (size) and may undertake extensive migrations between feeding grounds. The life expectancy, age at maturity and the maximum size of Herring in British waters have all declined with over-fishing. In the past, Herring lived for 15 or even 20 years. Few Herring in the North Sea now exceed 8 years old.

Commercial fishing and human consumption Herring have long been commercially-fished throughout their range, and at one time supported one of the most important fisheries in northern Europe. Overfishing has resulted in the closure of certain fisheries and fishing is now strictly regulated. A popular eating fish which can be preserved by salting, pickling and smoking (e.g. kippers). Preservation of fish has been known since the Viking era, and salt and vinegar were, and still are, the basic ingredients to preserve fish. (e.g. rollmops, the famous Dutch “maatjesharing” and the Scandinavian marinated Herring). More modern techniques of conservation include deep freezing and canning.

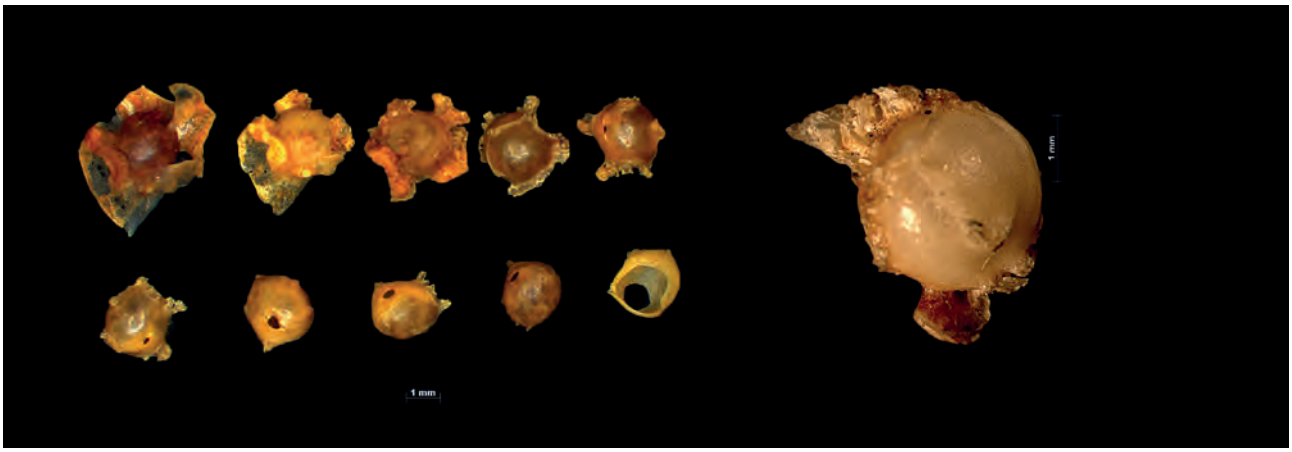
Fishing methods Midwater trawl, gill nets. Only occasionally caught by rod anglers, normally accidentally when feathering for Mackerel.

Remains The significance of Herring as a prey species in the North Sea ecosystem is such that the remains received extra attention in this book. The **otoliths** are fragile and fairly small relative to the size of the fish (OL:FL 1:50 - 1:70). Rostrum much longer than antirostrum, leading to characteristic gun shape. Pronounced ostium and notch, the ventral edge is denticulate. Straight sulcus over the whole length, open on both sides. Inner surface smooth.

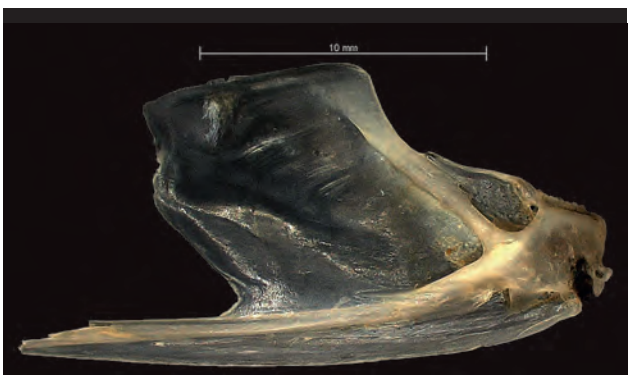
*Fresh-caught **Herring**. Photo Brent Wilson (CC).*

To calculate fish length (FL) from otolith length (OL) use $FL^{(cm)} = -1.93+6.92OL^{(mm)}$. **Pro-otic bullae** are difficult to digest and are more likely to be found in prey samples than most other bones. Pro-otic bullae (round) may come from either Herring or Sprat; **pterotic bullae** (potato-shaped) are lacking in Sprat. The **vertebrae** are highly distinctive but fragile, with long straight anterior horns (DPrZ and VPrZ) in the mid caudal section, but these are much shorter in other vertebrae. A distinct waist in lateral view (CL>CH), a wide spinal foramen visible when seen up front. To calculate fish length (FL) from vertebra length (VL) use $\ln(FL)^{(mm)} = 4.455+1.020 \ln(VL)^{(mm)}$. Most bones (shown are **dentary**, **cleithrum**, and **urostyle**) are fragile and break easily. For identification purposes, even if their morphology may be characteristic, they are of limited use. As in most clupeids, Herring **scales** often feature in prey samples, sometimes packed together in scale stacks. The cracks in the scales are reminiscent of car tracks in wet sand.

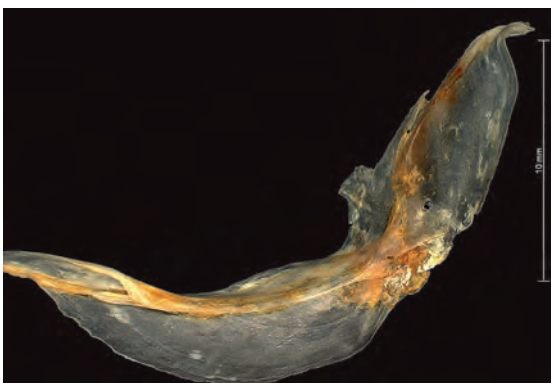
*Herring **otoliths**, inside (left) with straight sulcus and outside (right) with smooth surface. Photos Estefania Velilla.*



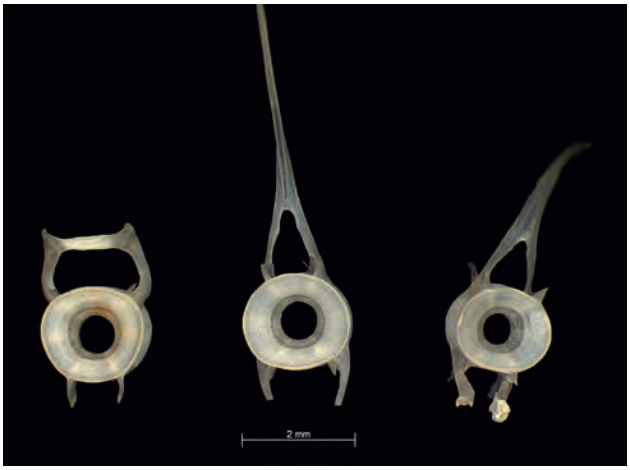
***Pro-otic bullae** of Herring, left in various stages of digestion (from prey samples), largely embedded in bone to almost completely circular, right almost free and circular zoomed in. Photos Suse Kühn and Estefania Velilla.*



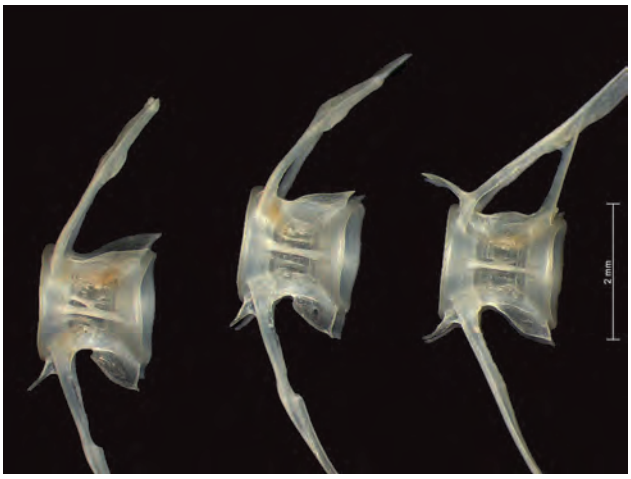
*Herring **dentary**. Photo Suse Kühn.*



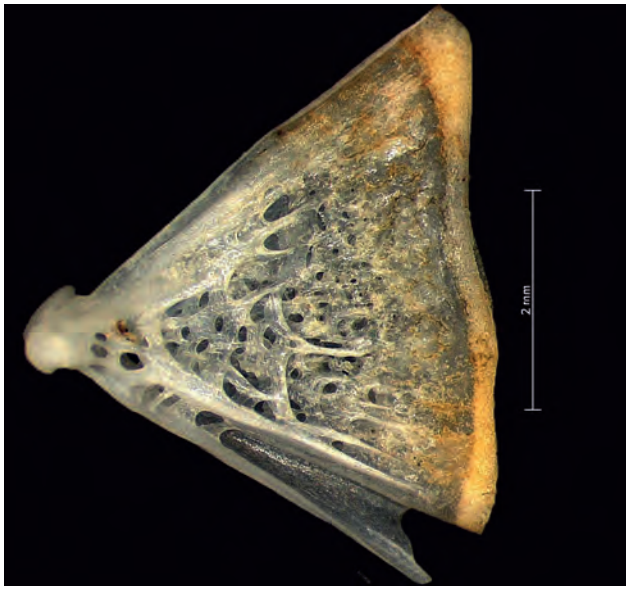
*Herring **cleithrum**. Photo Suse Kühn.*



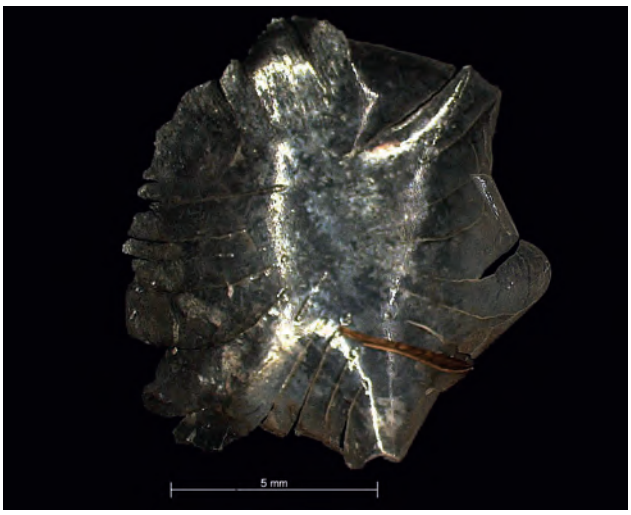
*Frontal view of abdominal **vertebrae** showing wide spinal foraman (circular hole), typical for clupeids. Photo Suse Kühn.*



*Mid-caudal **vertebrae** of Herring, showing distinctive long anterior horns in one example, and prominent rib in all. Photo Suse Kühn.*



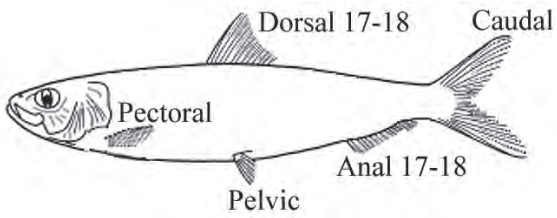
Herring **urostyle**. *Photo Suse Kühn.*



Herring **scale** *from a prey sample, showing irregular outline and characteristic lines or cracks. Photo Suse Kühn.*

Pilchard or Sardine, *Sardina pilchardus* Risso, 1827

Du: Sardien, Ge: Sardine, No: Sardin, Da: Sardin



Diagnostic features A herring-like fish, with easily-detached scales, notably larger than those of Herring or Sprat. The gill covers show a radiating pattern of ridges (see photo below). The scales along the keel of the belly are large and sharp, with a distinctive saw-tooth appearance.

Size Up to 25 cm in length and a weight of about 200 g.

Colour The dorsal surface is green-blue, shading to a golden-silver along the sides.

Similar species They are often caught with other clupeids, particularly Herring. The occasional Pilchard of the same size is easily overlooked, although the experienced eye can sometimes spot the rather different steel-blue colour of the Pilchard's back among the dark blue Herring. Otherwise it is easily identified because of the large scales, forming a saw-toothed edge to the keel of the belly, and characteristic radiating ridges on the gill covers.

*Mature **Pilchard** or **Sardine** caught inshore on the Suffolk coast (UK). Photo Peter Henderson.*

Distribution and seasonality Found around the North Sea, with highest abundance in the English Channel and the southern North Sea at 15 - 50 m depth. In the North Sea it is most abundant inshore in the spring. Annual western Wadden Sea NIOZ fyke catches are predominantly April - October. Notably abundant in April 2007. Very low numbers in most other years. It is one of the commonest fish in British inshore North Sea waters where it undertakes regular seasonal migrations between spawning grounds and inshore, frequently estuarine, nursery areas. In some sheltered inshore localities, huge over-wintering shoals form annually.

Food and bait, predators A plankton feeder specialising in crustaceans, including copepods, amphipods and mysids. As a prey species with a more southerly distribution, there are far fewer predators known within the North Sea than for Herring or Sprat. Further to the south in Europe, key predators include species such as Great cormorant, Sandwich tern, Razorbill and Common dolphin. Seasonal variation in lipid contents, but generally a high-quality food fish (4 - 8 kJ^{g-1}).

Life history May live as long as 15 years. Pilchards spawn offshore during spring and summer. Eggs and early larvae are pelagic. There is often a summer migration into more northerly waters. Pilchards are southern, warm-water species that prefer temperatures warmer than those in boreal waters. After ~40 years of absence, they were observed in increasing quantities in the 1990s in the North Sea and the Baltic Sea, probably mainly as a response to warmer temperatures associated with the strengthening of the North Atlantic Oscillation in the late 1980s.

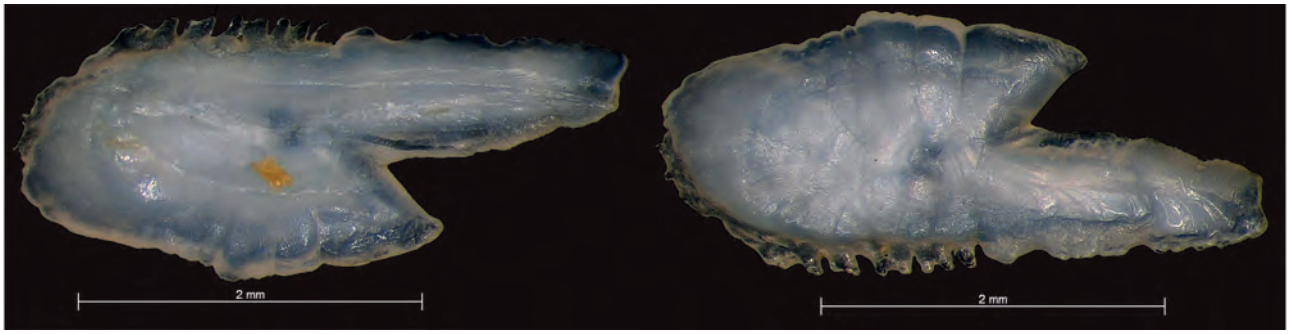
Commercial fishing and human consumption Pilchards or Sardines have long been commercially-fished throughout their range, and support an important fishery in northern Europe. In parts of Europe, much valued as a summer fish for grilling and barbecueing; the species has regained popularity in recent years.

Fishing methods Midwater trawl, gill nets. Never targeted by recreational anglers and almost never caught on rod and line.

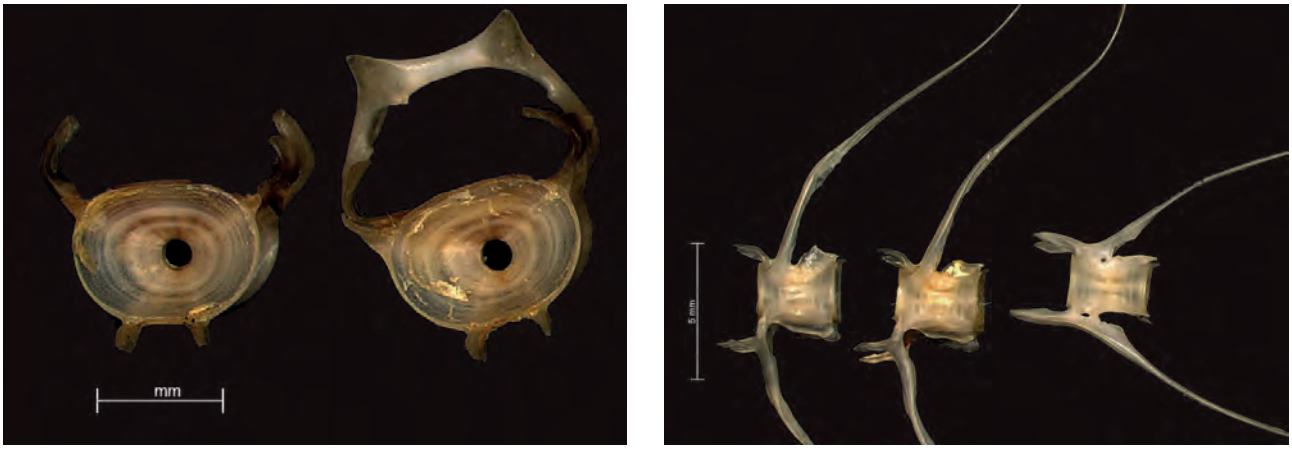
Remains The **otoliths** are difficult to distinguish from those of Herring, that also have a long rostrum. The sulcus (straight and open on both ends) is not as clearly developed as in Herring, and the tip of the rostrum is more rounded in Herring. Pilchard otoliths are thin and flat and do not exceed 4.5 mm. To calculate fish length (FL) from otolith length (OL) use $FL^{(cm)} = -6.09+8.13OL^{(mm)}$. In comparison with those of Herrings, the **vertebrae** have stronger anterior horns (DPrZ and VPrZ) and distinctly narrower spinal foramen. Vertebra length (VL) usually provides the best predictor of fish size (FL), but in Pilchards vertebrae width (VW) yields better results: $FL^{(mm)} = 50.06VW^{(mm)}+23.31$.

***Pilchards** for sale in a Turkish market. Photo Citrat / Wikimedia Commons (CC).*

*Head of a **Pilchard** showing the characteristic pattern on the **operculum**. Photo Peter Henderson.*

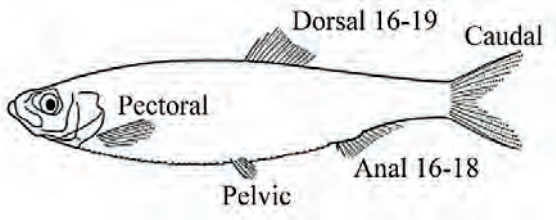


*Pilchard **otoliths**, inside (left) with straight but poorly developed sulcus and outside (right) with smooth surface. Photos Suse Kühn.*



*Pilchard **caudal vertebrae** in lateral view (right) with prominent anterior horns and **abdominal vertebrae** in frontal view (left) showing relatively narrow spinal foramen (pinholes). Photos Suse Kühn.*

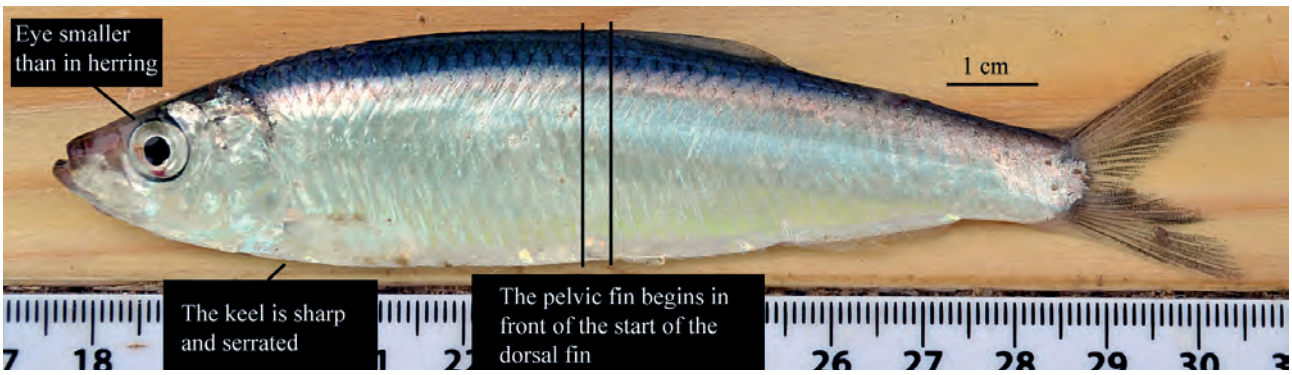
Sprat, *Sprattus sprattus* L., 1758



Du: Sprot, Ge: Sprotte, No: Brisling, Da: Brisling

Diagnostic features A laterally-flattened fish with a sharp, toothed, keel. The scales on the keel point backwards so it feels sharp and rough if a finger is stroked along the keel towards the head. A Sprat has the origin of the dorsal fin in line with or behind the origin of the pelvic fin. Sprat have a smaller eye than a Herring of the same size.

Size Typically reaches about 13 cm in length; exceptionally large fish may exceed 16 cm. A healthy 2-year old Sprat 125 mm in length weighs about 13 g.



*Mature **Sprat** caught inshore on the Suffolk coast (UK). Photo Peter Henderson.*

Colour Dark green-blue back with silver sides and belly.

Similar species Sprats are easily confused with young Herring and other juvenile clupeids such as Pilchards and Shad. For a comparison between Sprat and Herring, see the photo below. Shad have a dark mark on the side behind the operculum (see p. 74). Above 150 mm length it is likely to be a Herring or Shad; if it is more than 200 mm long it will always be so.

Food and bait, predators A plankton feeder specialising in crustaceans, including copepods, amphipods and mysids. Sprat are just another key prey species for a large number of marine predators within the North Sea and, because of their smaller overall size, this particularly includes smaller (seabird) taxa such as the small Little auk and Sandwich, Common and Arctic terns. Their large schools also attract marine mammals and predatory fish such as Cod and Whiting. Given the overall importance as a food fish, their remains have been given considerable attention in this book. Seasonal fluctuations aside, generally a high-quality food fish (7 - 8 $kJ\ g^{-1}$).

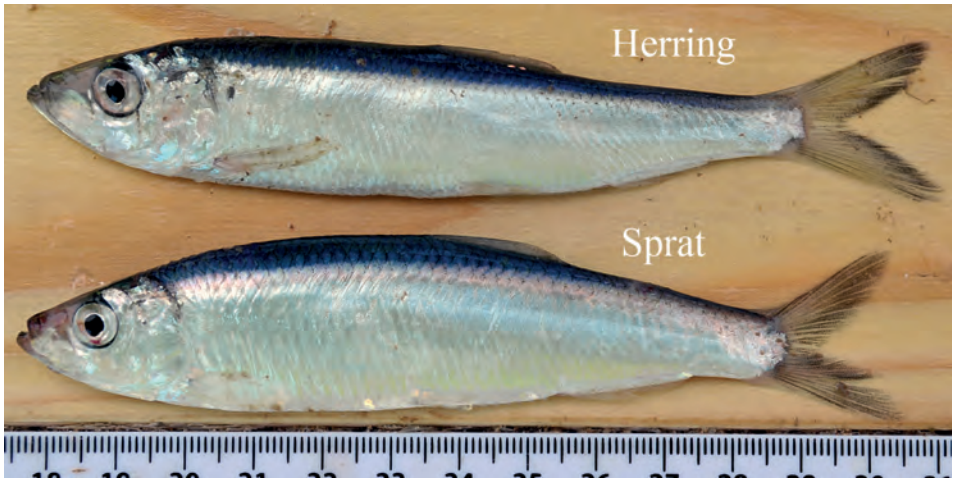
Distribution and seasonality Sprat can be found throughout most of the North Sea, but, catches are highest in the south-eastern North Sea. In the North Sea, Sprat can be found at 30 - 50 m depth. Adult Sprat enter estuaries in large numbers during winter. New recruits are usually first observed inshore during the summer. Annual western Wadden Sea NIOZ fyke catches peak June - July followed by a second but lower peak Oct - Nov. Particularly low numbers in recent years, but mid-summer catch rates fluctuated widely throughout the census period.

Life history Sprats are one of the most abundant pelagic fish in inshore waters in the North Sea, where they may form huge shoals. They batch spawn up to 10 times in spring and summer, producing pelagic eggs and larvae; following metamorphosis the juveniles often enter estuaries, marshes and other shallow waters to feed. Sprats live for a maximum of about 6 years and can reach maturity in about 1 year or less. Because Sprat form large shoals, temporal and spatial variation in abundance can be great. Their life-history characteristics indicate an opportunistic reproductive strategy which further increases temporal variability. This may result, if conditions dictate, in large between-year changes in population density. Large-scale and long-term ecosystem changes resulting mainly from overfishing and recruitment failure of predatory fish such as Cod, the main fish predator of Sprat, affected natural-history patterns in piscivorous seabirds in a complex way. When the Sprat stocks increased, the energy contents of the fish declined, affecting the fledging rates of avian predators. This has recovered locally in recent years as the Sprat stock diminished again, which led to increases in Sprat quality (weight-at-age and energy content).

Commercial fishing and human consumption Sprat have long been commercially-fished throughout their range and support an important fishery in northern Europe. It is not a common eating fish, probably because of its small size coupled with the presence of many small bones. However, in particular when available smoked, Sprat are both popular and delicious.

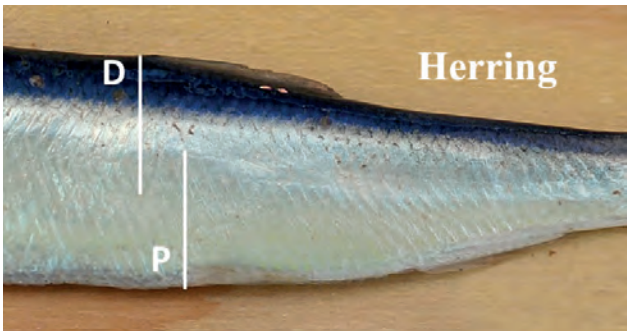
Fishing methods Midwater trawl, seine netting. Never targeted by recreational anglers and almost never caught on rod and line.

Remains The **otoliths** are irregular elliptical or ovally pointed in outline with a crenate ventral margin. They are the least 'gun-shaped' of the entire family of fish, especially in younger fish. The sulcus is not well-developed and ostium and cauda cannot or can only barely be distinguished. Otoliths are fairly large relative to the size of the fish (OL:FL = 1:60) and can easily be found. Unfortunately, they are very fragile. Otoliths can be hard to distinguish from those in young Herrings, but the posterior end of those in Sprat are more rounded and

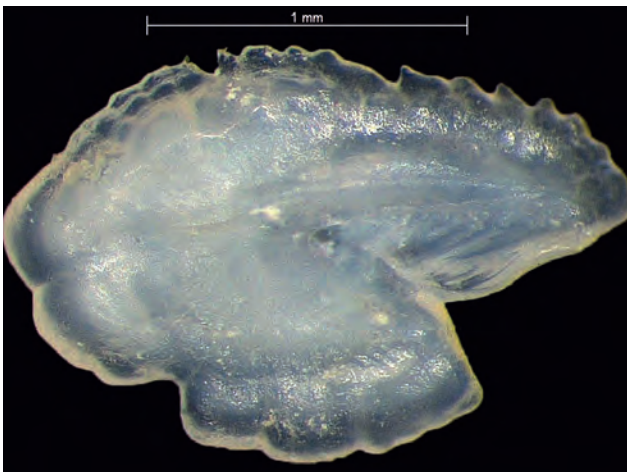


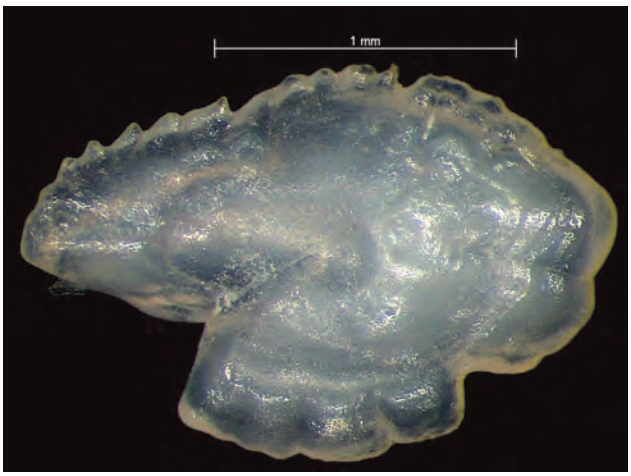
*Comparison of an immature **Herring** and mature **Sprat**. Note the differences in eye size, body depth and outline, and position of dorsal and pelvic fins. Photo Peter Henderson.*

the length-width ratio is smaller than in Herrings and Pilchards. To calculate fish length (FL) from otolith length (OL) use $FL^{(cm)} = -0.00+6.87OL^{(mm)}$. **Pro-otic bullae** may come from either Herring or Sprat but **pterotic bullae** are lacking in the latter. Sprat **vertebrae** are very fine, usually translucent, and rarely exceed 2.0 mm in length. As in all clupeids, the neural and haemal spines are thin and curved backwards. Any anterior horns (DPrZ and VPrZ) are much smaller than in the other species of this family, and the spinal foramen are comparatively wide. To calculate fish length (FL) from vertebra length (VL) use $\ln(FL)^{(mm)} = 4.252+0.962 \ln(VL)^{(mm)}$. Most other bones (shown are **dentary**, **cleithrum**, and **urostyle**) are fragile and break easily. For identification purposes, even if their morphology may be characteristic, they are of limited use. Sprat **scales**, in contrast to other clupeids, rarely feature in prey samples.

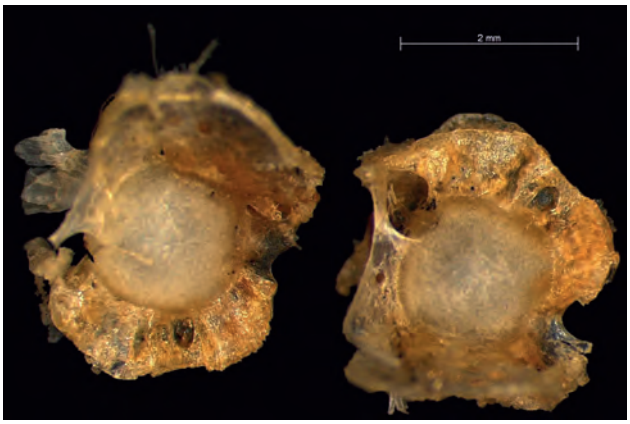


Detail of the comparison clearly shows the difference in the position of the dorsal and pelvic fins, between (adult) ***Sprats*** *and immature* ***Herrings.***

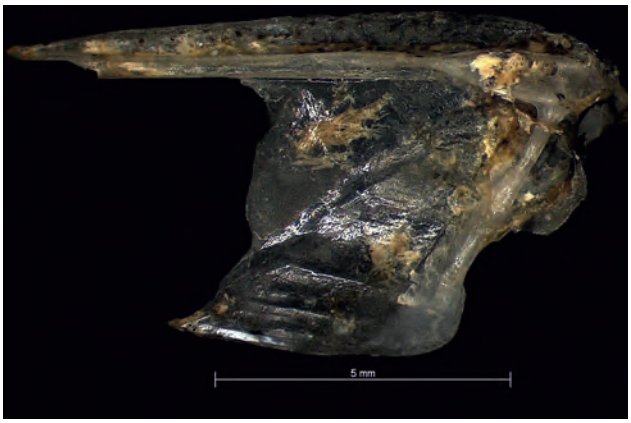




Sprat ***otoliths****, inside (left) and outside (right) with smooth surface, poorly developed sulcus and more oval overall shape than in the other clupeids. Photos Suse Kühn.*

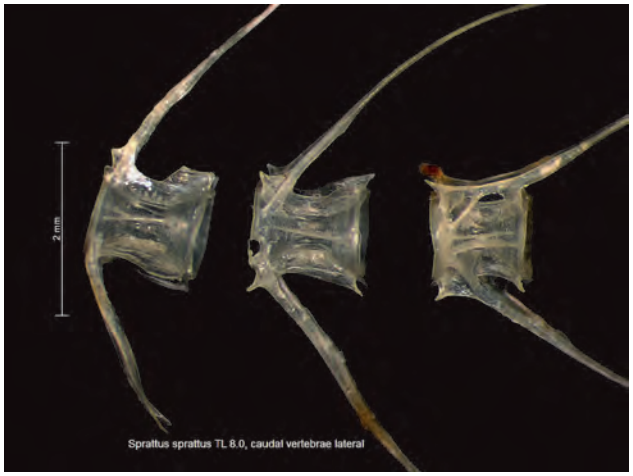


Sprat ***pro-otic bullae****. Photo Suse Kühn.*

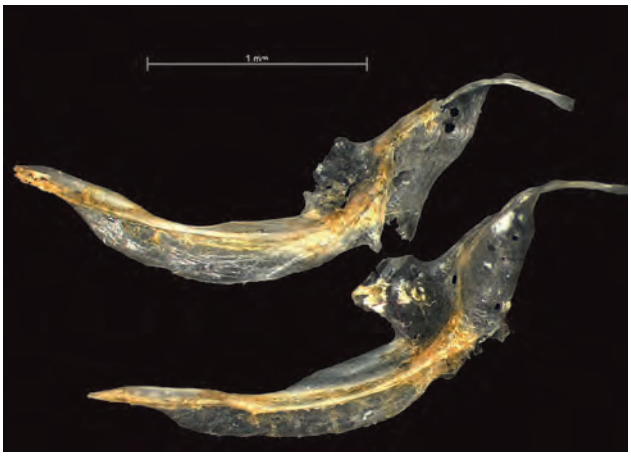


Sprat ***dentary*** *(outside). Photo Suse Kühn.*

*Sprat **abdominal vertebrae**, frontal view, very delicate structures with relatively wide spinal foramen. Photos Suse Kühn.*



*Sprat **caudal vertebrae**, lateral view, very delicate structures with fine ribs and fragile neural and haemal spines. Photos Suse Kühn.*



*Sprat **cleithra**. Photo Suse Kühn.*

*Sprat **urostyle** and last **caudal vertebra**. Photo Suse Kühn.*

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