# Sprraint Reference Manual Cornwall Coastal Otter Project


Dave Groves

Cornwall Mammal Group


2020

www.cornwallmammalgroup.org

River Camel otter - Adrian Langdon

# Spraint Reference Manual – Cornwall Coastal Otter Project – CMG 2020

## Introduction

This manual is intended to support analysis of otter spraint to determine diet of otters in Cornwall and the South West. The manual includes reference samples collated from a number of sources and images collected during the project. The bibliography includes texts, research papers and websites which we have found to be useful. Ideally spraint remains should be compared with known reference samples but this is difficult for many reasons, both practical and ethical. The definitive guides for the analysis of otter spraint remain the booklets produced by the Mammal Society, the most recent of which is Conroy et al. (2005). The Suffolk Otter Group has produced a useful web-based resource and other more specialised research papers and reports are listed in the bibliography. Analysis of fish remains is also widely used in dietary studies for birds, marine mammals and other fish species. Archaeological resources are also often useful. Two websites in particular include extensive images of fish remains: Nottingham University's **Fish Bone** database and the **Bonebase** website which includes many fish from the North Sea, usefully including smaller species. The book **North Sea fish and their remains** (Camphuysen & Henderson 2017) is an excellent reference with useful photographs and comparisons.

There are many books and research papers which discuss otters and diet, Chanin (2013) is an excellent place to start, but it is clear that otters are opportunistic – they hunt what is available and what they can catch. Their diet varies with habitat, season and age – young cubs often taking easy, but less nutritious prey. Spraint collected in the late winter from moorland streams may contain mainly frog bones, summer spraint from a large estuary may include a range of fish and crustacean remains. Some remains are easily recognised and categorised to species level others may have to be recorded at family level or even higher.

The rigour of the analysis will depend on the objectives of the study. The Cornwall Coastal Otter Project (CCOP) was looking for evidence of the use of marine prey by otters to better understand the importance or marine habitats. Identification of prey species was important in this case but no attempt was made to quantify prey numbers or to consider the relative biomass. Many studies have looked at ways of comparing the contribution of different prey but this is beyond the scope of this manual.

## Indexing and classification

The extensive coastline of Cornwall with its frequent river valleys and estuaries means that many prey species within the grasp of hunting otters are neither entirely marine nor entirely freshwater. Some primarily marine species such as flounder are found in water of  very low salinity, other species considered freshwater such minnow are found in brackish water and some including salmon, European eel and stickleback move between marine and freshwater environments.

## Prey Categories:

Fish have been divided into freshwater and marine for the purpose of indexing according to the convention of Wheeler (1969).

## Key component comparison



## Manual design

For each prey category there is a brief background followed by reference images collated from a variety of sources which are identified and included in the bibliography. Images taken from the Nottingham University Fish Bone website and Baltic Sea BoneBase website (with permission) are identified FB and BB respectively. Images from CCOP reference samples are identified as DG.

Following this are one or more pages of images of identified category remains from CCOP samples for comparison.

The final section of the manual is comprised of similar structures from a range of prey categories which may help to narrow down the search for the source of any remains.

The bibliography includes references from the text and other useful resources.

## Suggested approach -

Once spraint samples have been cleaned it is helpful to use a low-power dissection microscope or digital microscope to separate any identifiable material. This can be glued (using entomological adhesive) to piece of black card and/or photographed if records are required. Taking into account the environment where the samples were collected, use the Key component comparison to try and identify more obvious remains. Once a species or group has been identified, perhaps from vertebrae, use the species/groups account to identify other remains from this category. Return to the species/groups accounts to compare with unidentified material. Bear in mind that remains may be damaged or untypical and therefore not easily identifiable. It is always worth confirming important identifications from other source material.

## Salmonids

Two salmonid species are present in Cornish waters - the Atlantic salmon (*Salmo salar)* and the brown trout/sea trout (*Salmo trutta*). Both species breed in freshwater rivers and streams but salmon and sea trout migrate to the sea and so can be found in freshwater, estuarine and marine environments. Although otters do take larger salmon and sea trout typically most remains collected from spraint are smaller fish most likely to be the freshwater stage of both species. Most marine species found in otter diet are bottom-dwelling and relatively slow-moving and it seems unlikely that active mid-water fish such as salmonids would feature prominently in otter diets in open water environments. Presence of salmonid remains are considered as evidence of otters feeding in freshwater habitats.

Although it is possible to discriminate between the two species if suitable remains are found for the purposes of this study they are grouped together.

Key identifiable remains are vertebrae which are characterised by a spongy appearance to the centrum, thin and curved spines which arise centrally with a narrow base and small zygaphophyses, Thoracic vertebrae have no spines but are also spongy in appearance. Jaw elements are commonly found. Otoliths are also characteristic and often found.

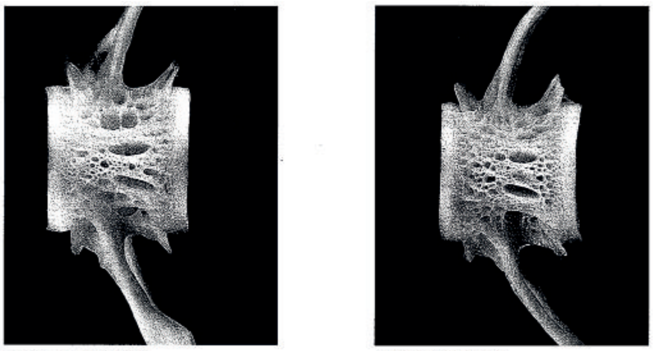
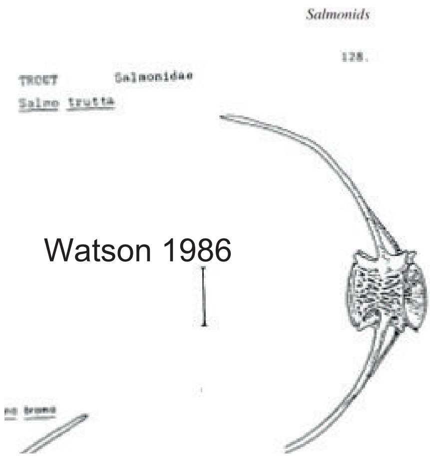


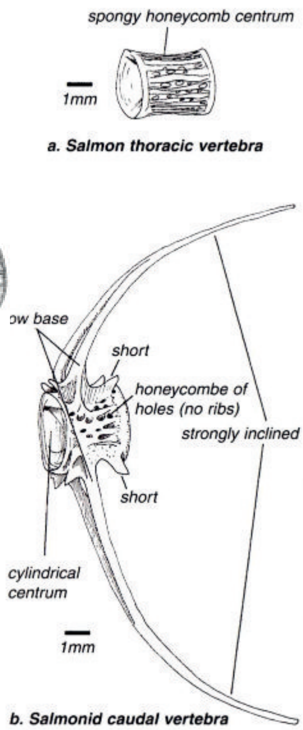
plate 1 anterior caudal    plate 2 mid caudal

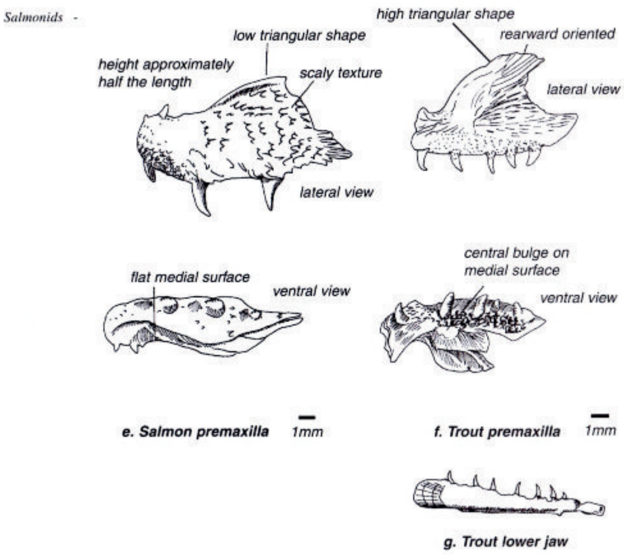
Watt et al.1997

Salmonid
(Salmon, trout family)
Honeycombed centrum - contrasts with smooth front and rear margin.
**Suffolk Otter Group**

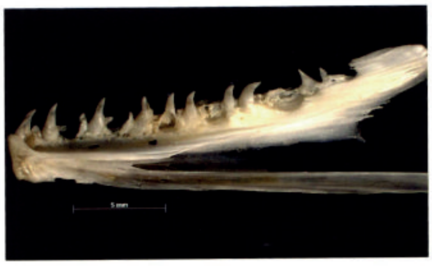



Watson 1986



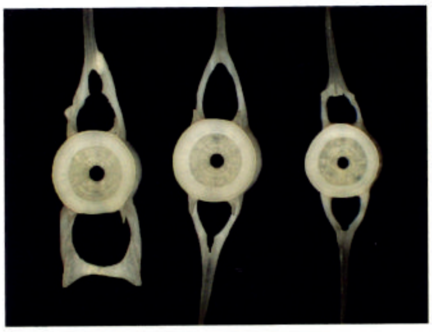




Conroy et al.

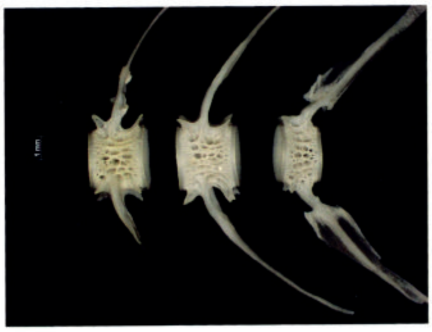


***Dentary*** *of Sea trout, with sharp, hooked teeth. Photo Estefania Velilla.*

***Otolith*** *of Sea trout, inside view, showing the clear and open sulcus. Photo Estefania Velilla.*



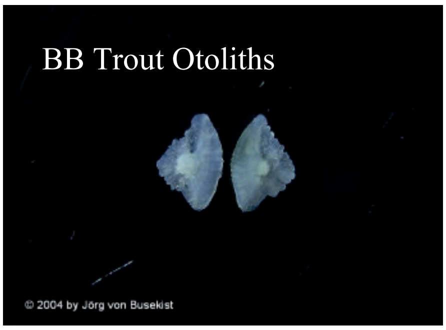
*Frontal view of* ***caudal vertebrae*** *of Sea trout. Photo Suse Kühn.*

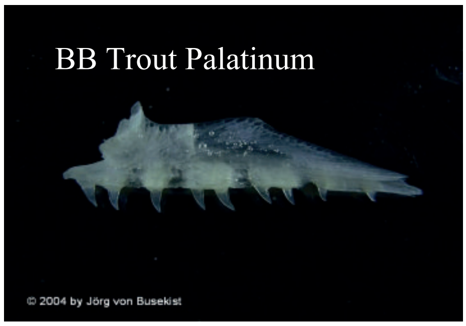


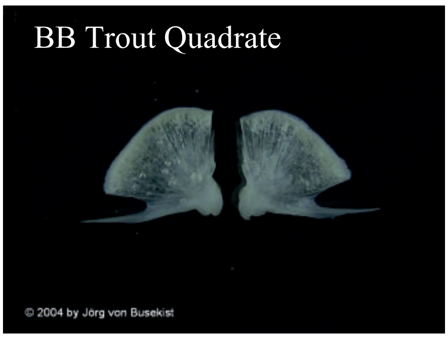
*Lateral view of* ***caudal vertebrae*** *of Sea trout. Photo Suse Kühn.*

Camphuysen & Henderson 2017








BB Salmon articular
© 2004 by Jörg von Busekist


BB Salmon Dentary
© 2004 by Jörg von Busekist


BB Salmon Epihyale
© 2004 by Jörg von Busekist


BB Salmon Maxilla
© 2004 by Jörg von Busekist


BB Salmon Otolith
© 2004 by Jörg von Busekist

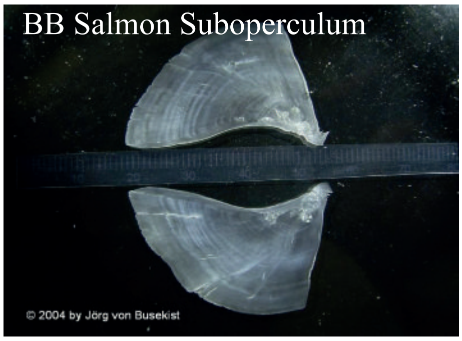

BB Salmon Parasphenoid
© 2004 by Jörg von Busekist


FB Salmon articular


BB Salmon Premaxilla
© 2004 by Jörg von Busekist

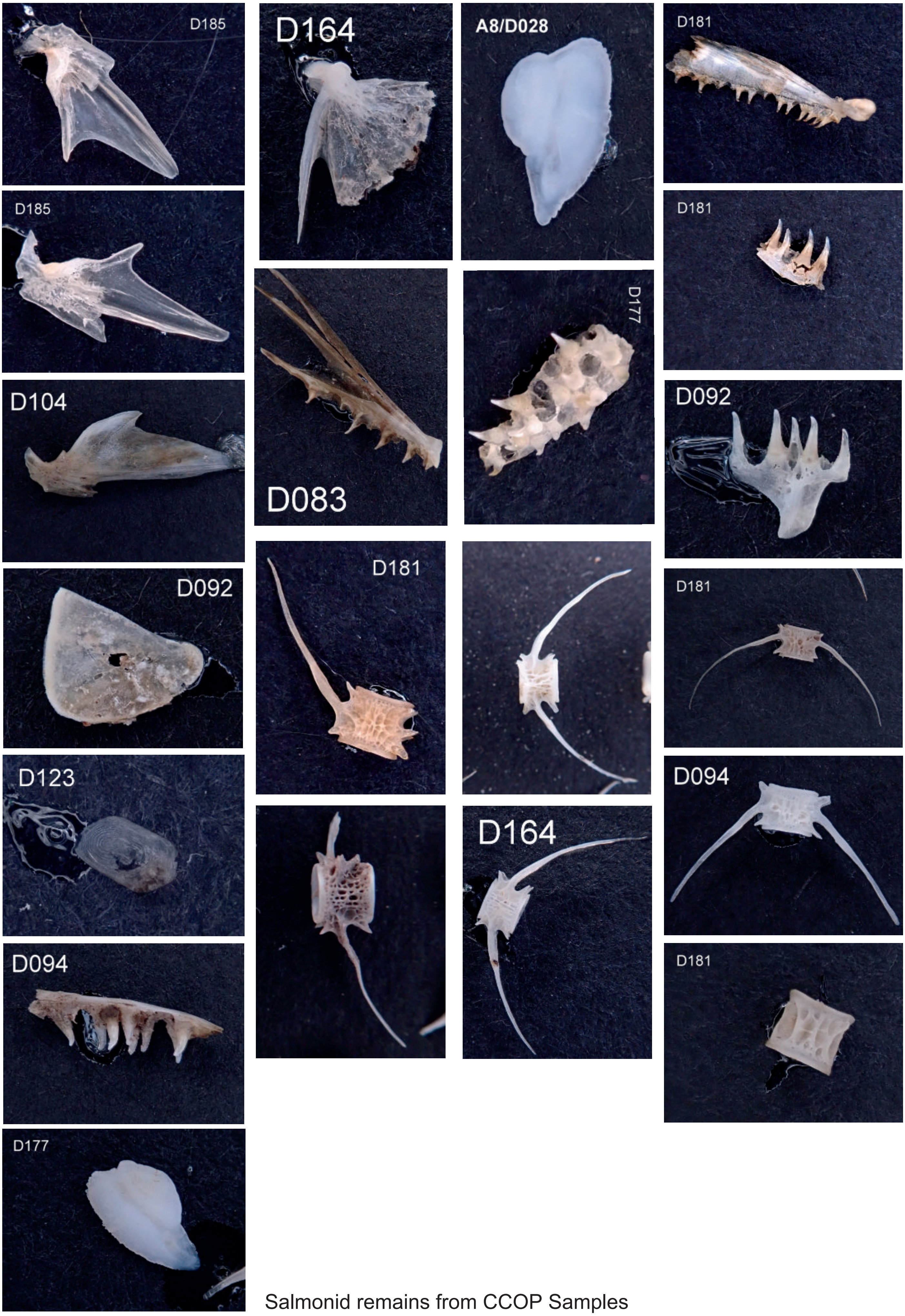

BB Salmon Quadrate
© 2004 by Jörg von Busekist


BB Salmon Scales
© 2004 by Jörg von Busekist


BB Salmon Suboperculum
© 2004 by Jörg von Busekist


BB Salmon Thoracic vertebrae
© 2004 by Jörg von Busekist


BB Salmon Glossohyale
© 2004 by Jörg von Busekist



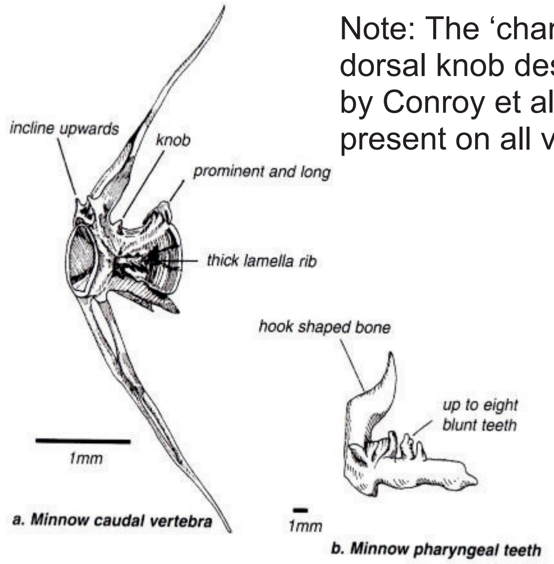

Salmonid remains from CCOP Samples

## Cyprinids

A number of cyprinids are found in Cornish freshwaters include roach, rudd, minnow, gudgeon and stone loach (covered separately). In addition several species are stocked in angling or fish-keeping waters and may appear in otter diet - these may include various carp species, bream, tench, dace and grayling (EA).

Minnow reference samples have been prepared. It is not possible to discriminate roach and rudd from spraint samples and elements from larger cyprinids may be damaged or not ingested. Cyprinids are grouped together although there is an obvious difference between a large common carp and a minnow in terms of diet. For this project the importance lies in that cyprinids are freshwater species.

Figure 9: Minnow




From Conroy et al. 2005

Note: The 'characteristic' dorsal knob described by Conroy et al is NOT present on all vertebrae.

Cyprinid vertebrae are narrow-waisted with both neural and haemal spines arising from the anterior and with prominent zygapophyses. Scales are freqently found but they may be fragmentary, breaking into triangular segments. The pharyngeal (throat) teeth of cyprinids are also characteristic.

**4.9 Gudgeon**

Table 15 Determination material for the Gudgeon (*Gobio gobio gobio*)

| | |
|---|---|
| Scientific name | *Gobio gobio gobio* |
| Exterior | Figure 43 (Sportvisserij Nederland, 2012) |
| Scale | Figure 44 |
| Otolith | Figure 45 |

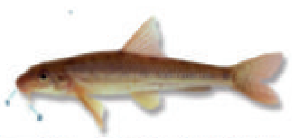
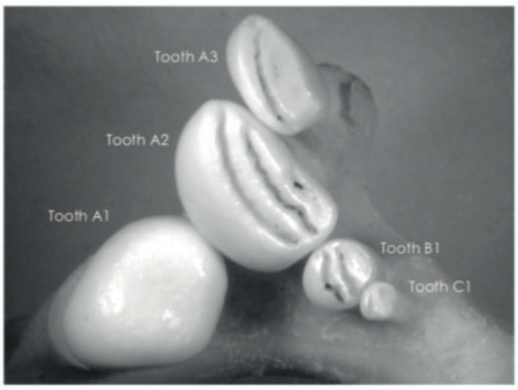


Figure 43 *Gobio gobio gobio* (Sportvisserij Nederland, 2012); 1; The mouth is pointing downwards. 2; There are two mouth-wires present, one in each corner of the mouth.

Figure 44 *Gobio gobio gobio* scale, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

Figure 45 *Gobio gobio gobio* otolith, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

From: Hermsen & Maarseveen 2011




**Supplementary Figure 2. Left pharyngeal bone and pharyngeal teeth of common carp, *Cyprinus carpio*.** There are three teeth in row A, one tooth in row B, and one tooth in row C.

Also see: Schofield et al. 2005

### 4.2 Bream

Table 8 Determination material for the Bream (*Abramis brama*)

| | |
|---|---|
| Scientific name | *Abramis brama* |
| Exterior | Figure 13 (Sportvisserij Nederland, 2012) |
| Scale | Figure 14 |
| Otolith | Figure 15 |
| Jaw | Figure 16 |
| Spine | Figure 17 |

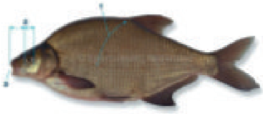


Figure 13 *Abramis brama* (Sportvisserij, 2012); 1; Number of rows of scales above the side-line, counted from diagonal pointing arrow to the dorsal fin, contains 12-14 scales (excluded the one from the side-line itself). 2; The eye-diameter is smaller than the distance from the eye till the point of its mouth. 3; The mouth is pointing downwards and is far bulging.

Figure 14 *Abramis brama* scale, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

Figure 15 *Abramis brama* otolith, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

Figure 16 *Abramis brama*, jaw, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 0.67.

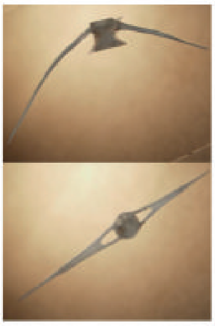


Figure 17 *Abramis brama* spine, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 0.67. Upper photo; side view, bottom photo; front view.

70

### 4.5 Tench

Table 11 Determination material for the Tench (*Tinca tinca*)

| | |
|---|---|
| Scientific name | *Tinca tinca* |
| Exterior | Figure 28 (Sportvisserij Nederland, 2012) |
| Scale | Figure 29 |
| Otolith | Figure 30 |
| Spine | Figure 31 |

Figure 28 *Tinca tinca* (Sportvisserij Nederland, 2012); 1; The iris is orange-colored. 2; The fins (point out is the dorsal fin) have a convex-shape. 3; There are two little mouth-wires present.

Figure 29 *Tinca tinca* scale, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

Figure 30 *Tinca tinca* otolith, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

Figure 31 *Tinca tinca* spine, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 0.67.

### 4.6 Rudd

Table 12 Determination material for the Rudd (*Scardinius erythrophthalmus*)

| | |
|---|---|
| Scientific name | *Scardinius erythrophthalmus* |
| Exterior | Figure 32 (Sportvisserij Nederland, 2012) |
| Scale | Figure 33 |
| Otolith | Figure 34 |
| Spine | Figure 35 |
| Jaw | Figure 36 |

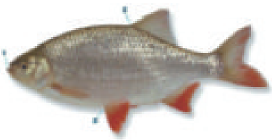


Figure 32 *Scardinius erythrophthalmus* (Sportvisserij Nederland, 2012); 1; The mouth is pointing upwards. 2; The front-side of the dorsal fin is clearly further to the tail of the fish than the pelvic fins.

Figure 33 *Scardinius erythrophthalmus* scale, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

Figure 34 *Scardinius erythrophthalmus* otolith, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

Figure 35 *Scardinius erythrophthalmus* spine, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 0.67.

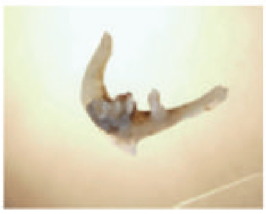


Figure 36 *Scardinius erythrophthalmus* photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 0.67.

74

### 4.8 Common carp

Table 14 Determination material for the Common carp (*Cyprinus carpio*)

| | |
|---|---|
| Scientific name | *Cyprinus carpio* |
| Exterior | Figure 40 (Sportvisserij Nederland, 2012) |
| Scale | Figure 41 |
| Otolith | Figure 42 |

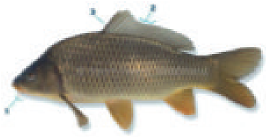


Figure 40 *Cyprinus carpio* (Sportvisserij Nederland, 2012); 1; There are four mouth-wires present, from which two in de corners of the mouth and two shorter ones on top of the upper lip. 2; The edge of the large dorsal fin is hollow inched. 3; The first fin rays of the dorsal fin is firm serrated.

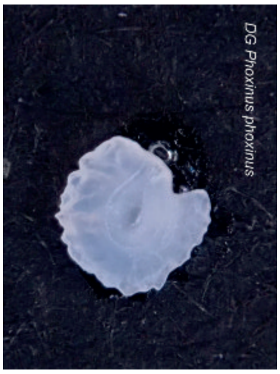
Figure 41 *Cyprinus carpio* scale, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

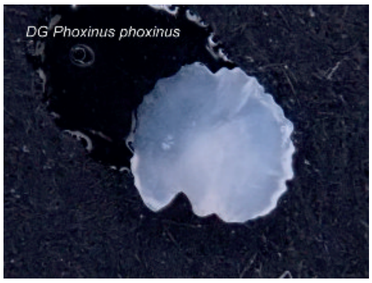
Figure 42 *Cyprinus carpio* otolith, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4.

From: Hermsen & Maarseveen 2011

Minnow (*Phoxinus phoxinus*) Reference samples prepared from WRT material DG Jan. 2020

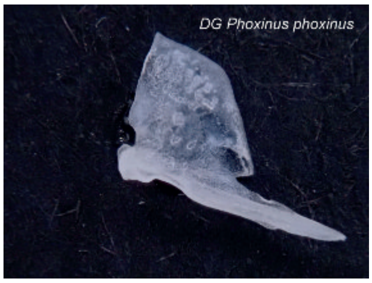




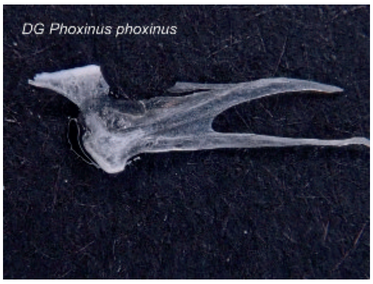







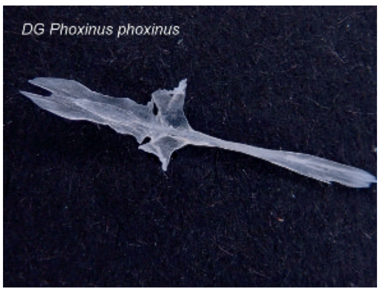





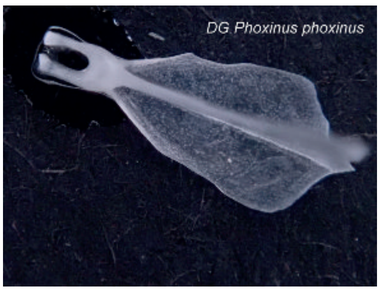




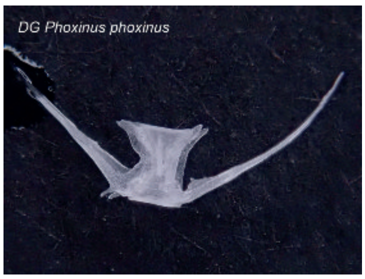


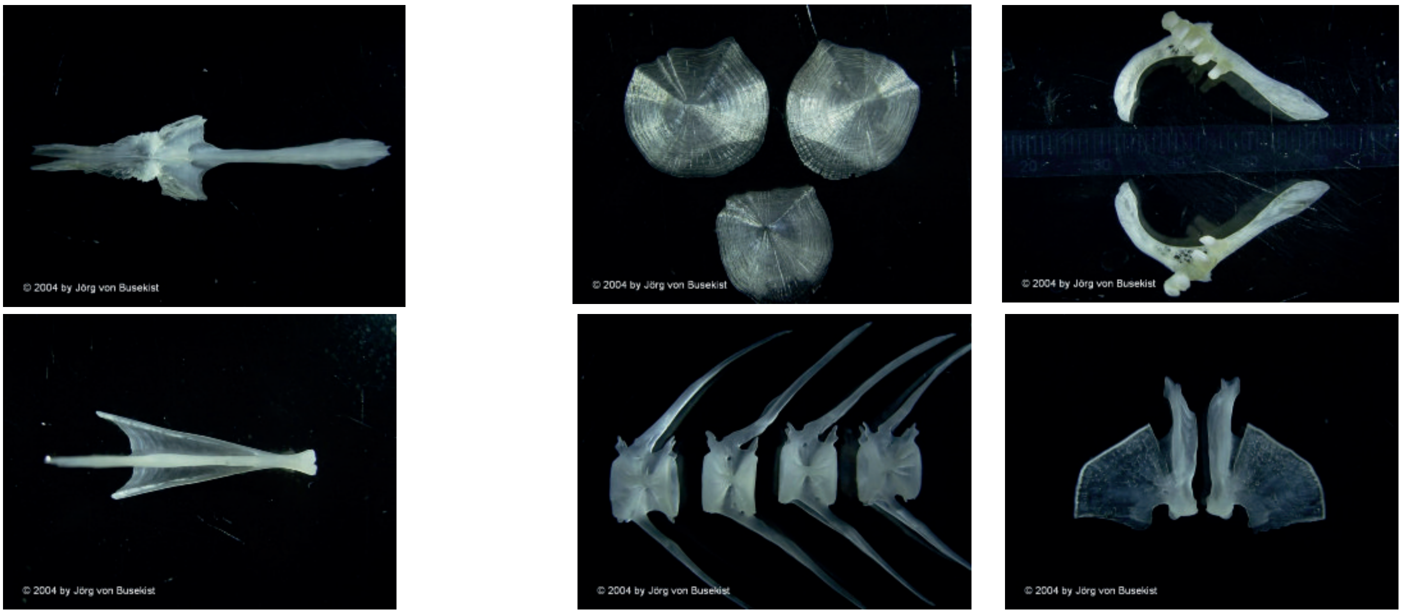





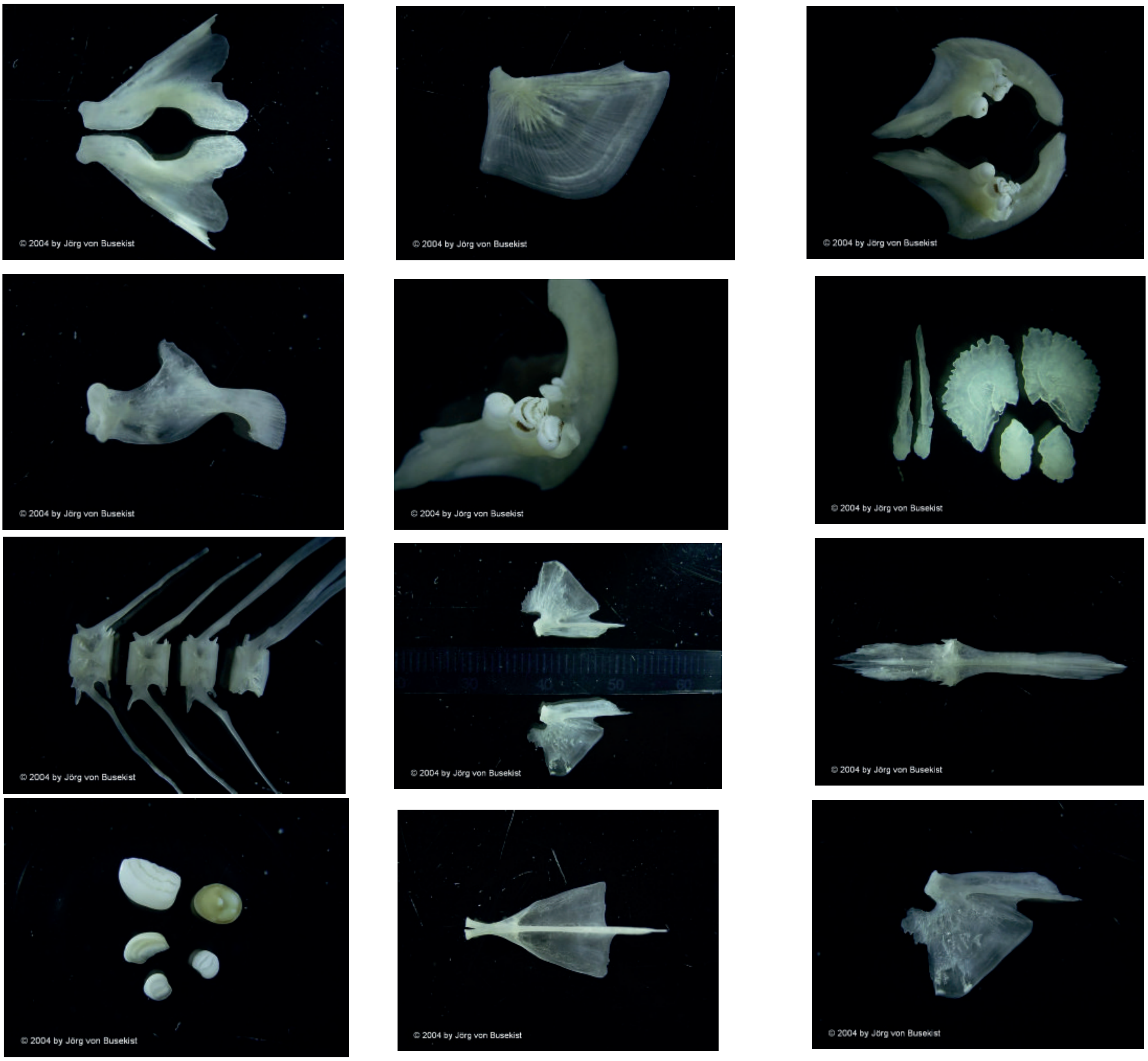





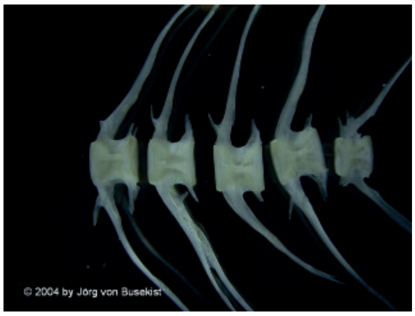




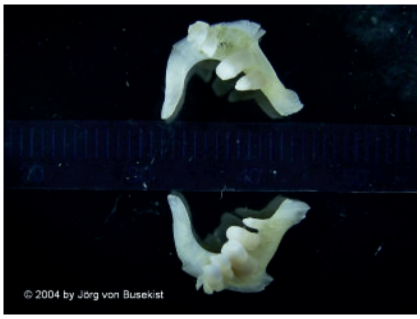

BB Bream *Abramis brama*

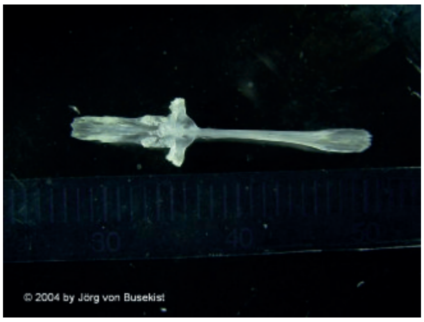


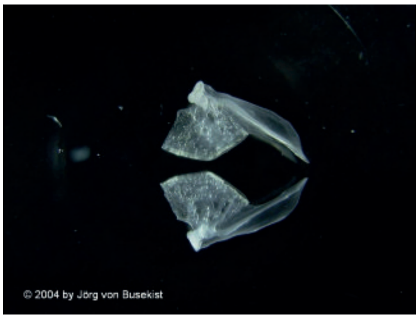

BB Common Carp (*Cyprinus carpio*)

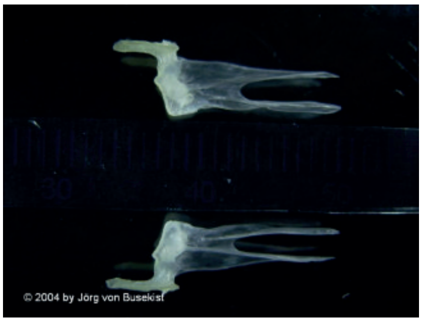


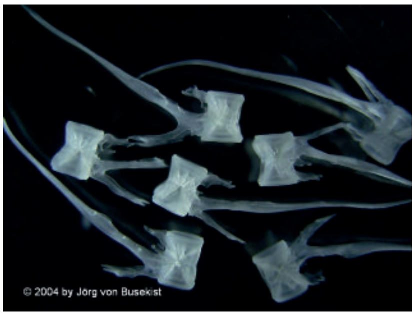

BB Common Carp (*Cyprinus carpio*)

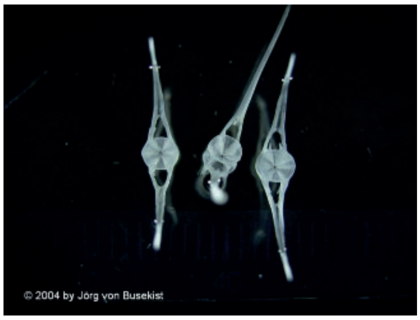


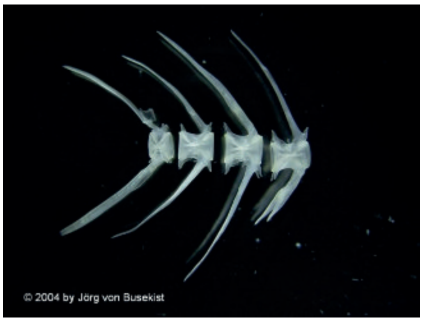




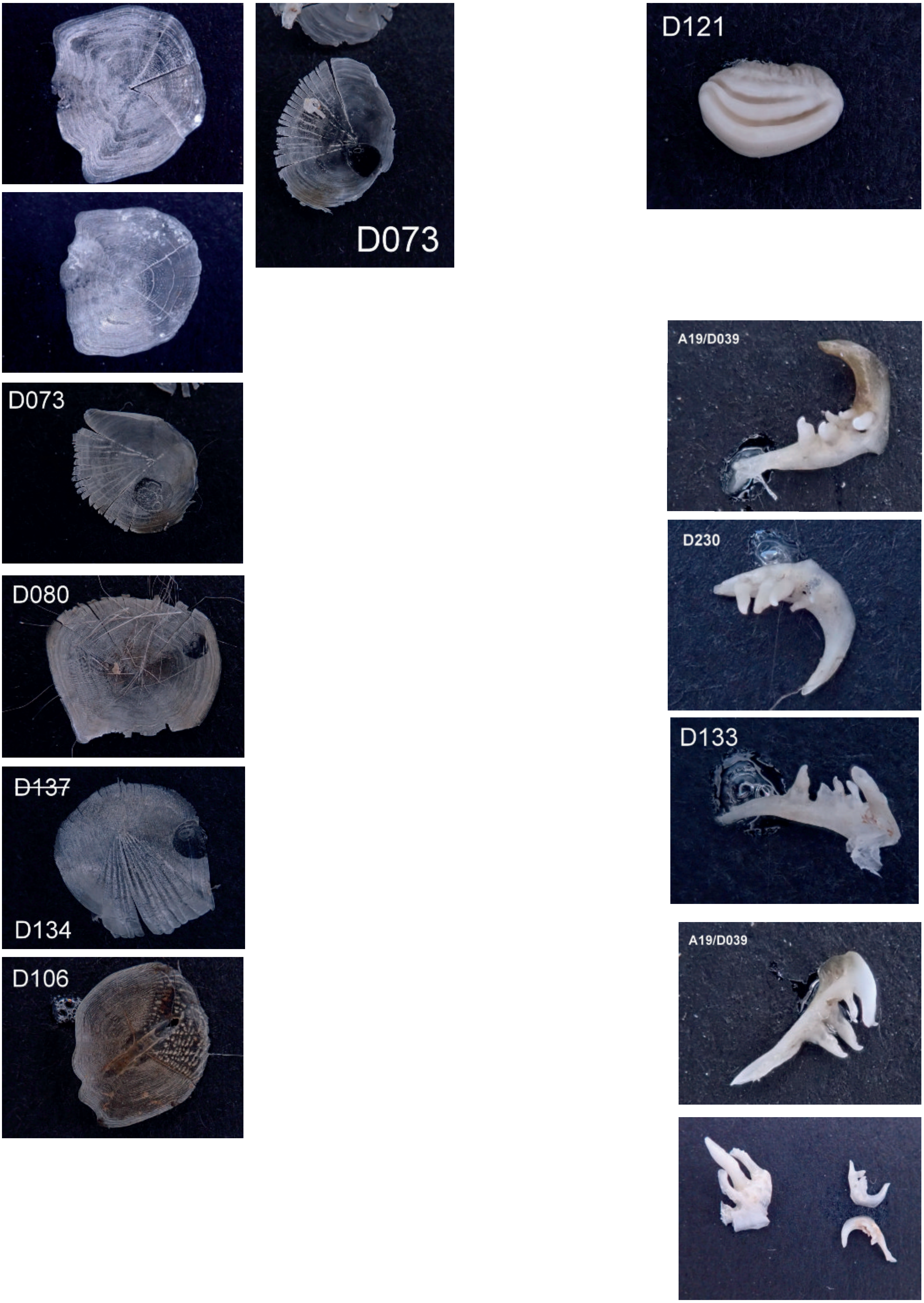




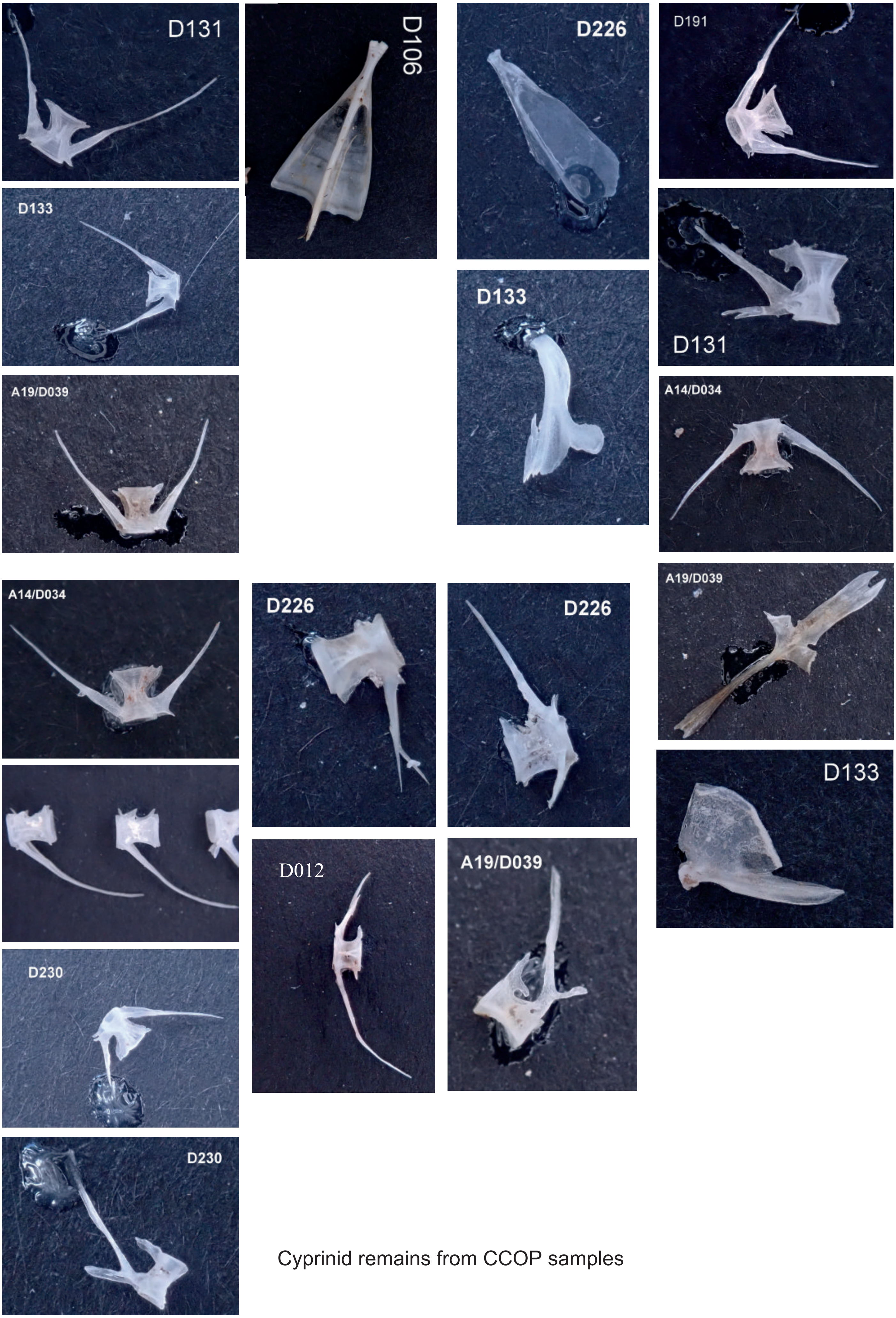





BB Rudd (*Rutilus rutilus*)




Cyprinid remains from CCOP samples




Cyprinid remains from CCOP samples

## Stone loach

Stone loach (*Barbatula barbatula*) are present in the Tamar catchment (EA) with some scattered records to the East (NBN Atlas).

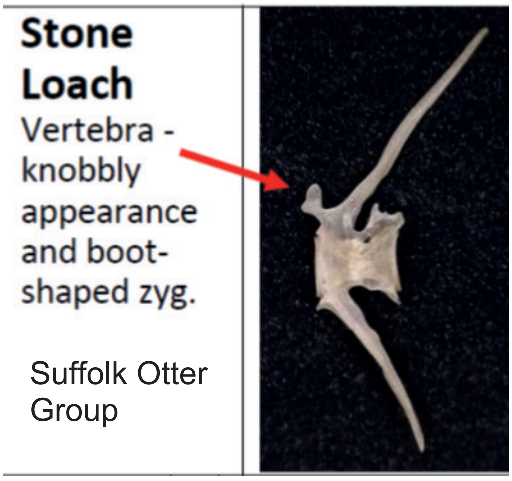
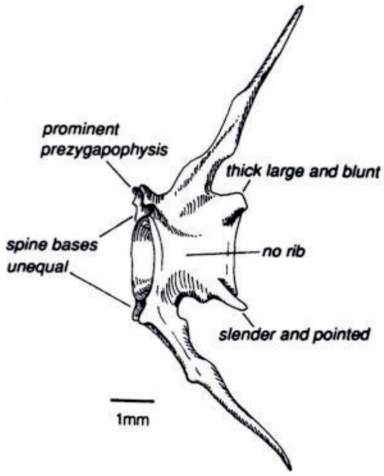
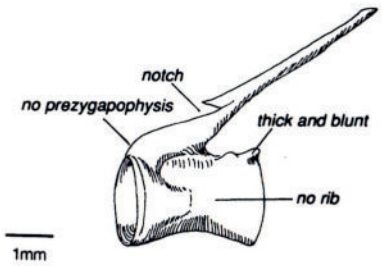



Fig. 9. Stone loach

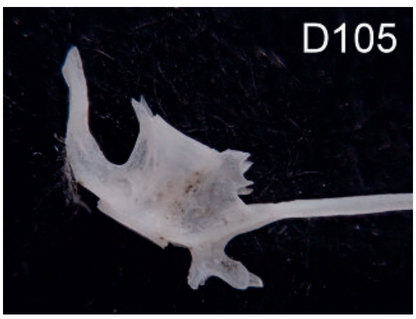



a. Stone loach caudal vertebra

Conroy et al. 2005




b. Stone loach thoracic vertebra

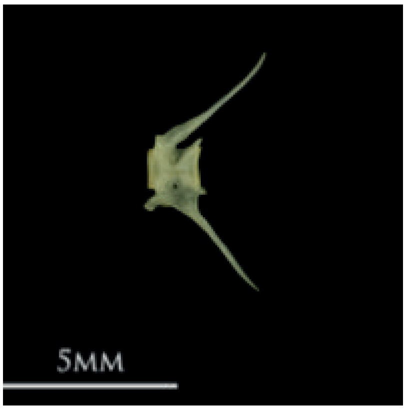


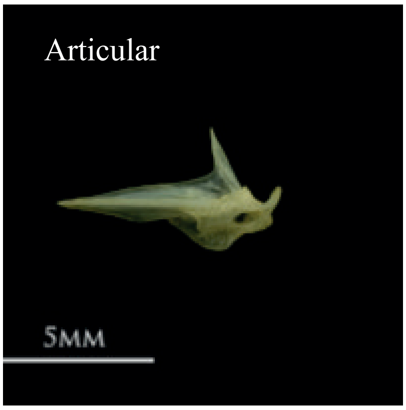

## Bullhead

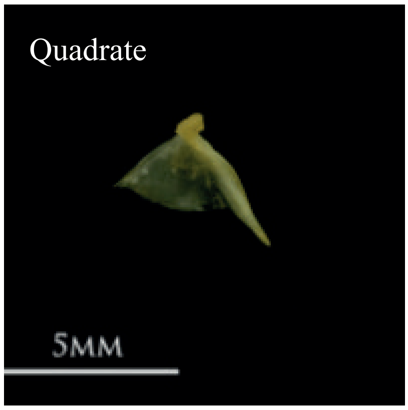
Bullhead (*Cottus gobio*) live in fast flowing stony streams and rivers and hide under rocks during the day. An RDB species they feature prominently in otter diet.

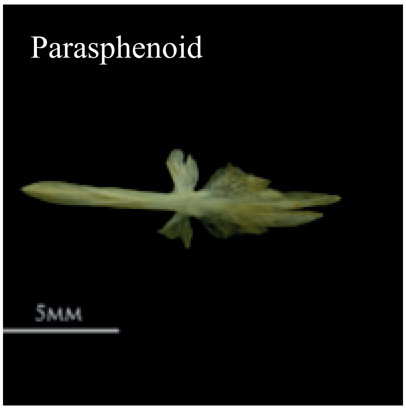
Vertebrae have a short stout neural spine rising centrally from a broad base which has a neural foramen. The dorsal prezygapophyses are large and there is a single lamellar rib.

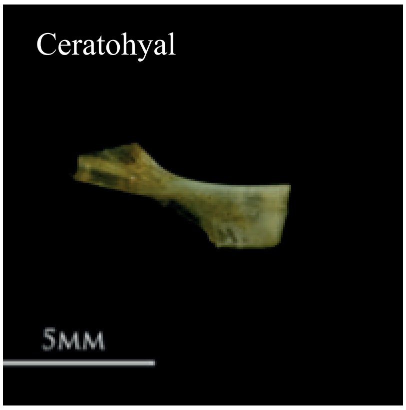
Bullhead jaw structures are frequently found and although they may be similar to other marine Cottidae including bullrout and sea scorpion they are clearly associated with river habitat. As well as the vertebrae there are distinctive pasty-shaped otoliths and operculum with a single hooked spine.

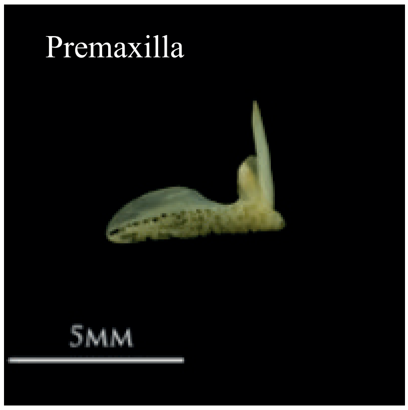


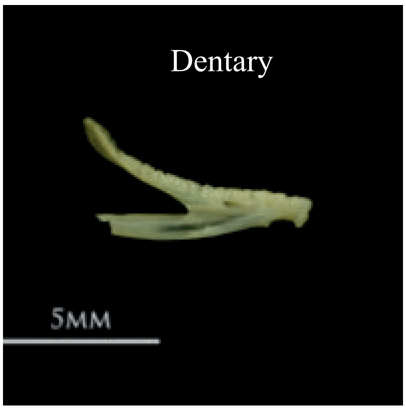



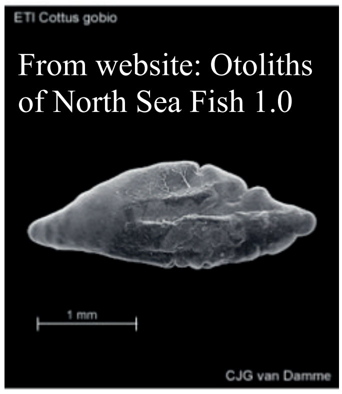




Images from Nottingham Fish Bone

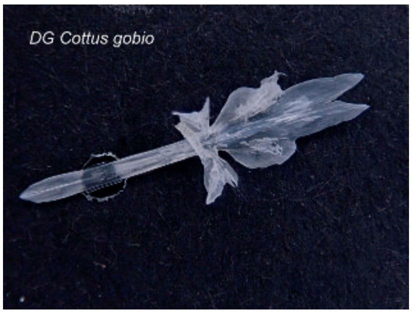






Reference samples prepared from WRT material by DG Jan. 2020.

Reference samples prepared from WRT material by DG Jan. 2020.





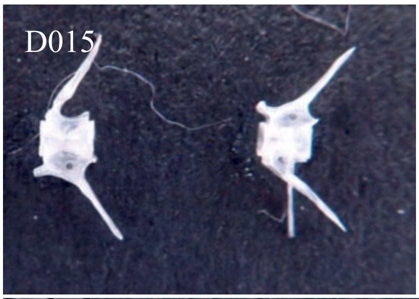






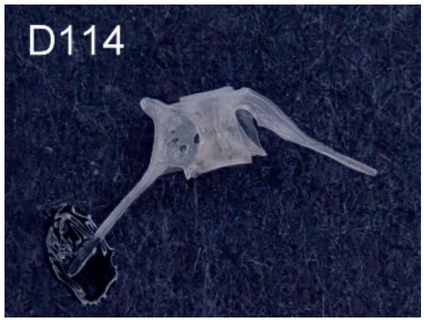




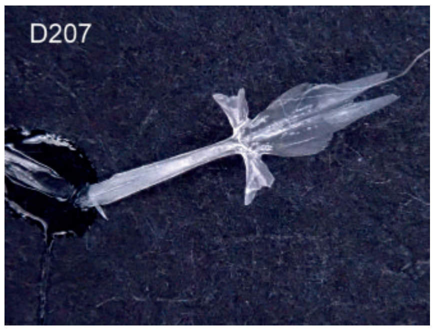


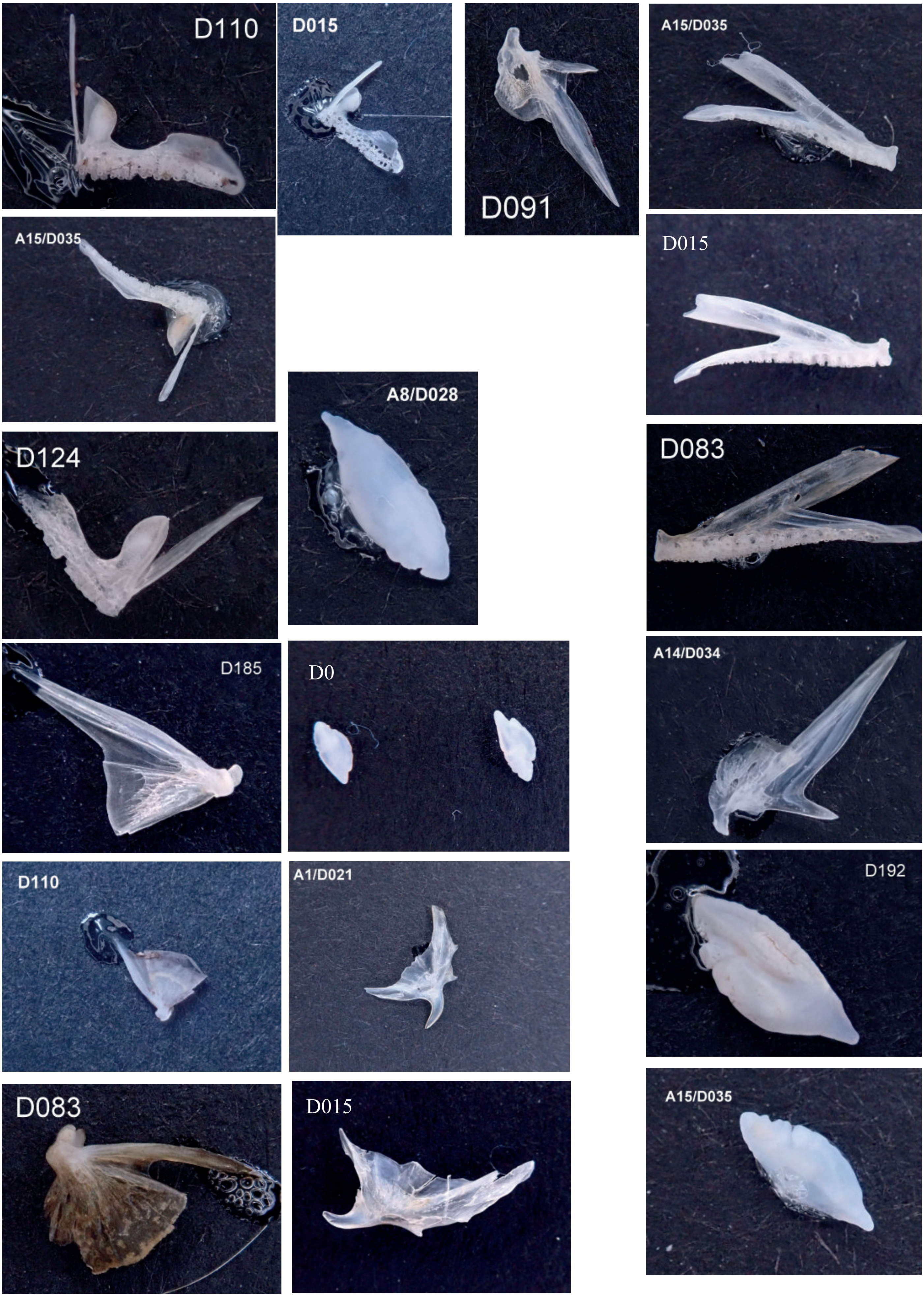



Bullhead remains from CCOP samples






Bullhead remains from CCOP samples

## *3-Spined Stickleback*

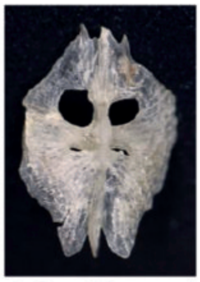
The 3-spined stickleback *(Gasterosteus aculeatus)* is widely distributed in Cornwall - recorded from North and South coast catchments as well as Tamar and Fowey estuarine catchments (EA, NBN and CC). This is the only freshwater stickleback in Cornwall. Remains are widely recorded in spraint and easy to identify using vertebrae, jaw structures, the spines themselves and other bones which have a characteristic ‘bubbly’ translucence. Remains in spraints are often of multiple and tiny individuals.

**Freshwater fish species – basic info for a start**

**Stickleback** - One of our commonest fish species. They do not have scales. We get 3- and 10- spined and, as we cannot always be sure which is which, we record them on our database as 'stickleback.' You will find details later for how to tell the difference - at this stage do not bother.
Most of the vertebrae have a large hole.

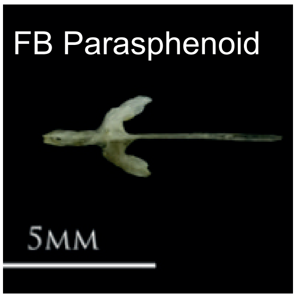
Vertebra

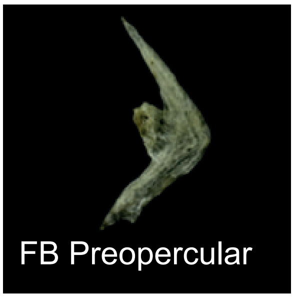
Spines

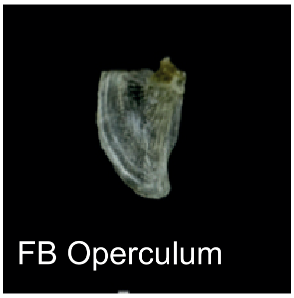


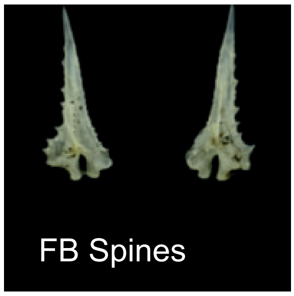
Spines’ base plate – like a face mask

Suffolk Otter Group

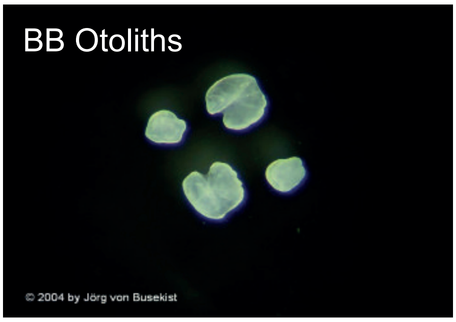


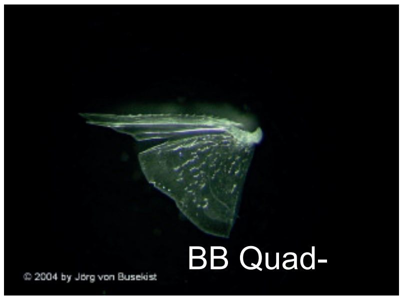



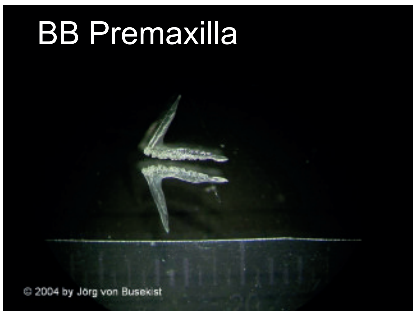



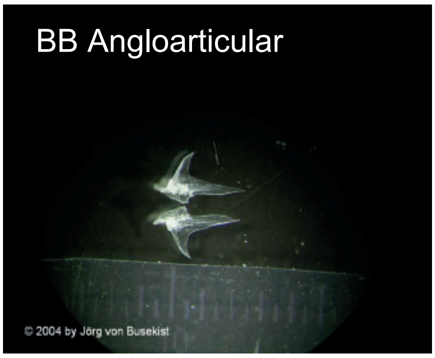




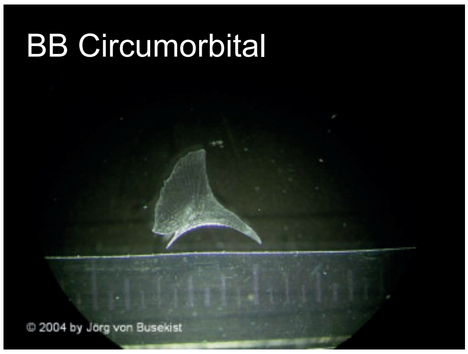





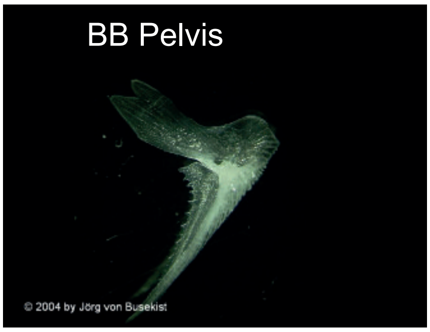







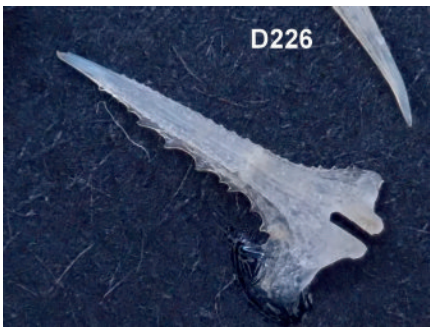




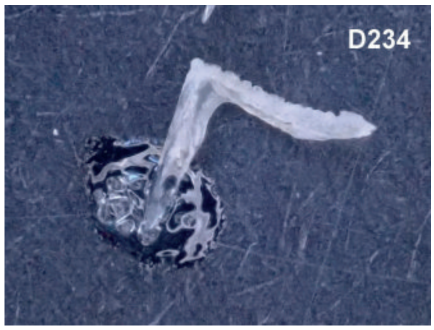





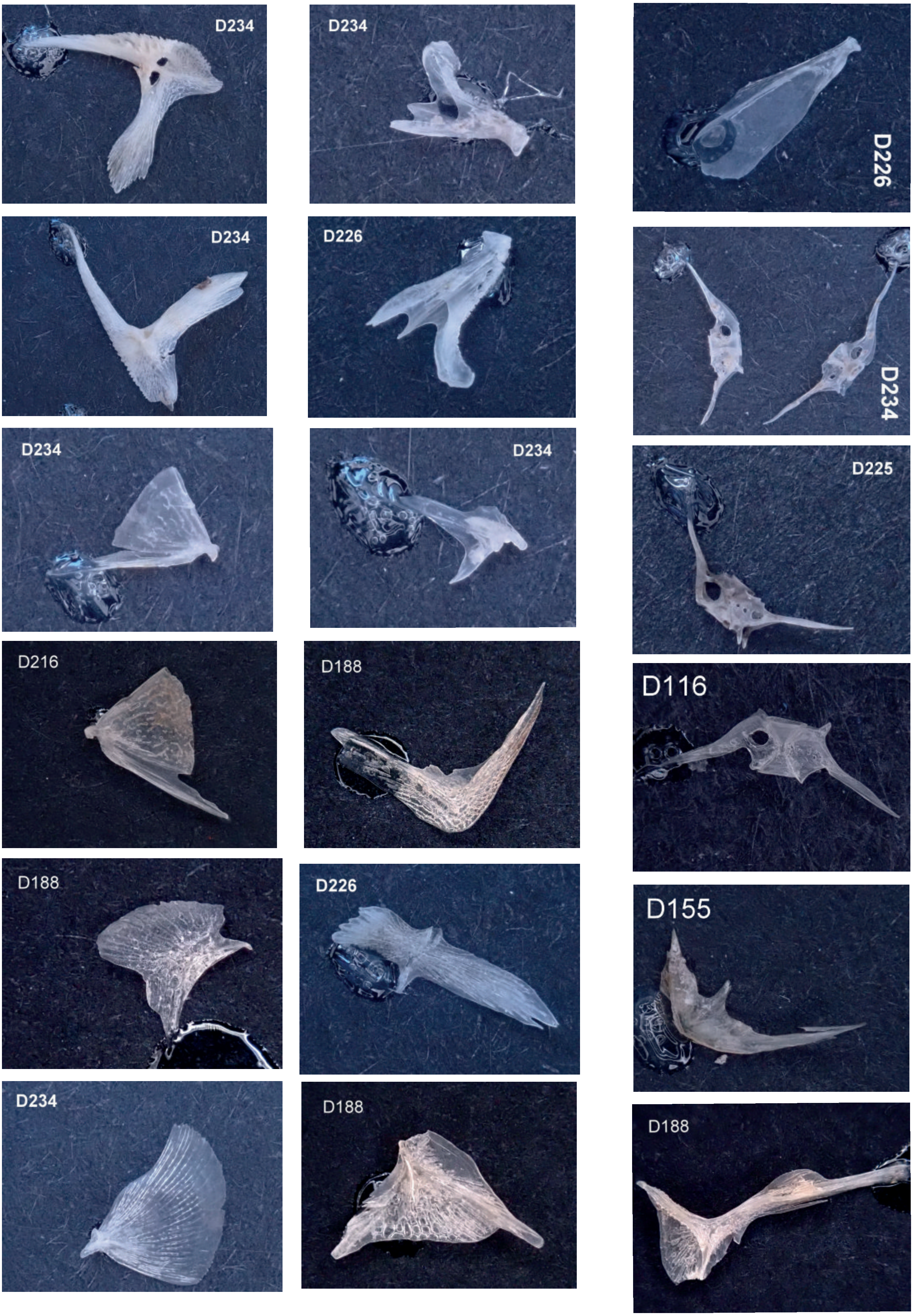
Stickleback remains from CCOP samples









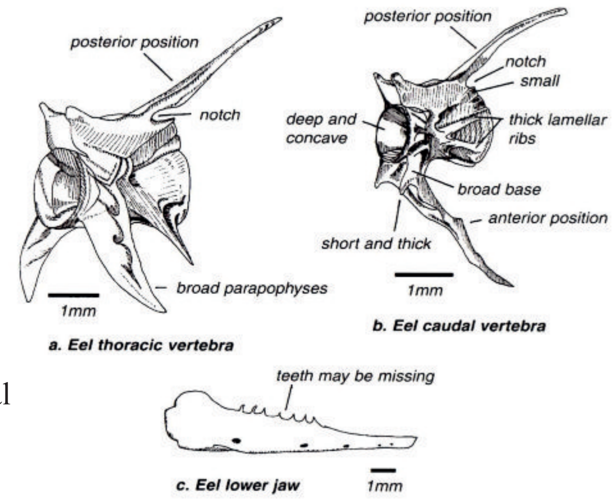

Stickleback remains from CCOP samples

## Eel

The European eel (*Anguilla anguilla)* is found throughout Cornwall in freshwater rivers and ponds as well as estuarine habitats and coastal environments. Mature eels (silver eels) migrate downstream in early autumn heading for the Sargasso sea to breed and the returning elvers enter estuariesin spring and early summer but the majority of the eel's lifecycle takes place in fresh or brackish water.

Eel vertebrae are easily identified when intact - the neuralspine is posterior and the haemal spine anterior from a rectangular centrum. Remains from larger specimens may be more fragmentary. Thoracic vertebrae have broad pointed transverse processes. Other elements can often be identified including jaw structures, opercula, parasphenoids and otoliths. Many smaller specimens are eaten and there may be very large numbers of vertebrae present in spraints.

*Figure 6: Eel*

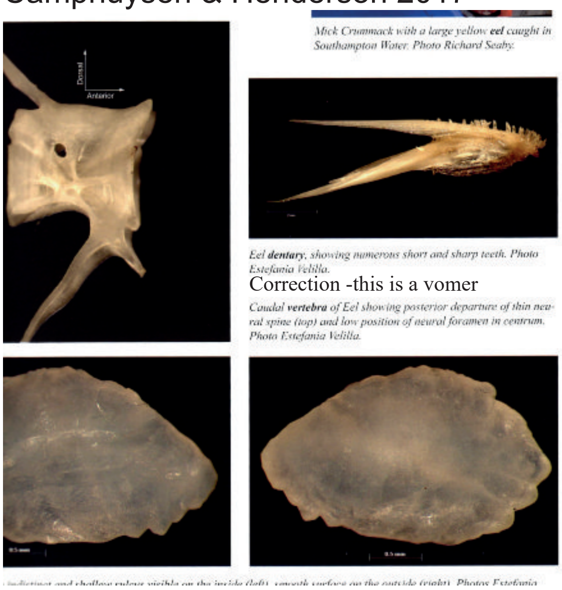



Conroy et al 2005

**Eel** - No scales but very distinctive vertebrae with top and bottom spines coming from different ends of centrum

Suffolk Otter Group

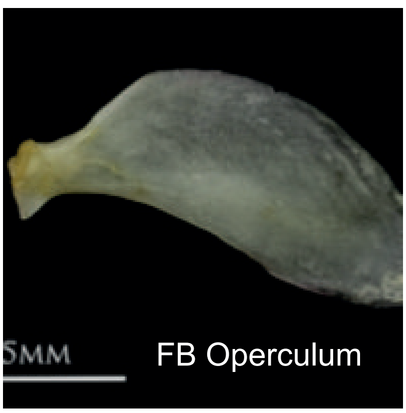
Camphuysen & Henderson 2017

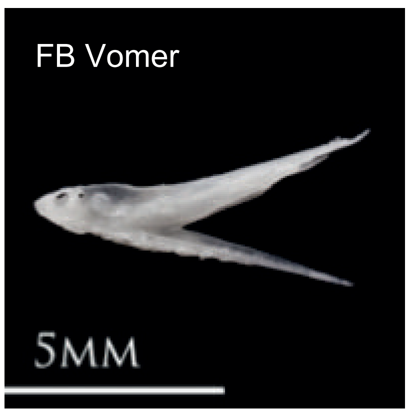


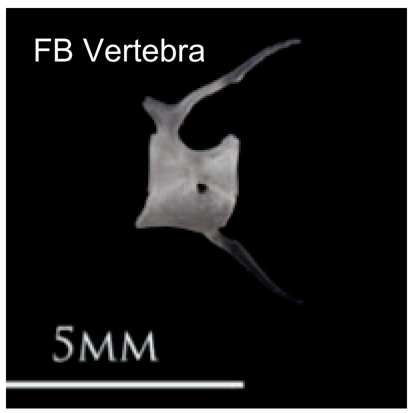

COMMON EEL Anguillidae

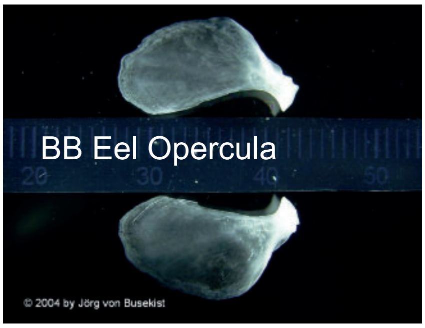
Anguilla anguilla

Watson 1986



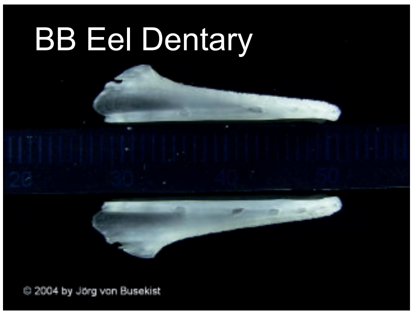



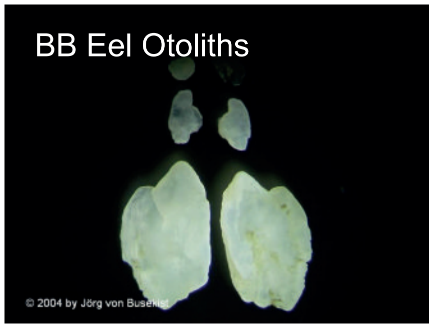







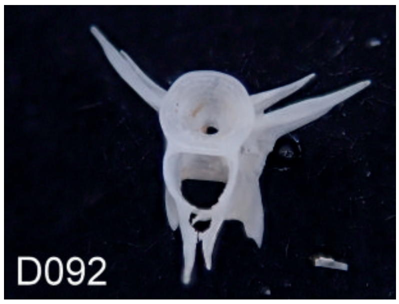


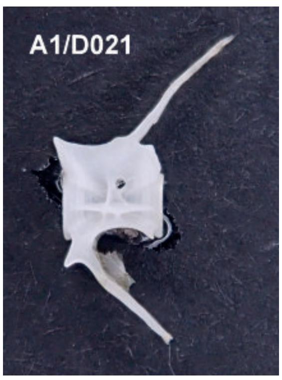





Eel remains from CCOP samples

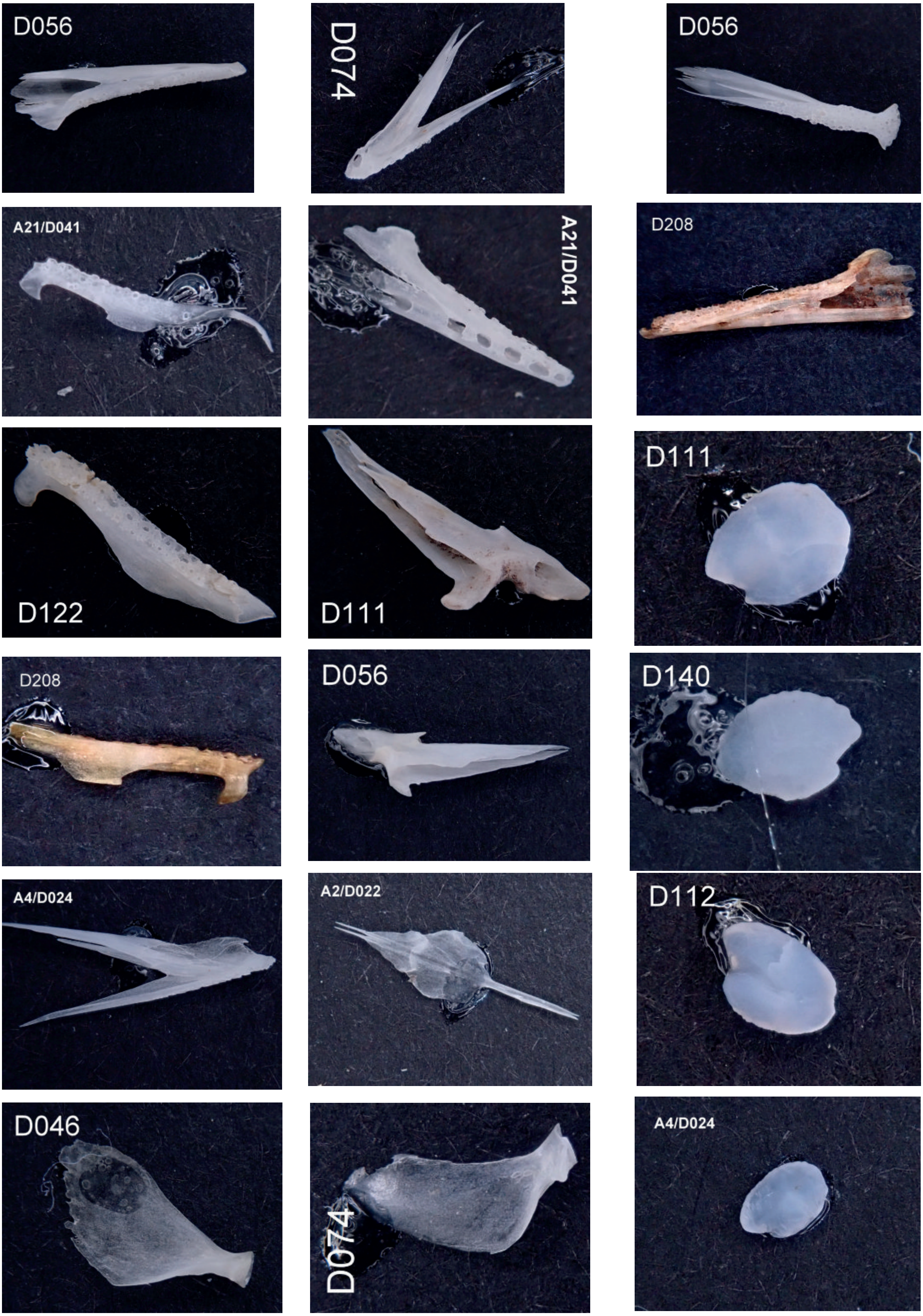




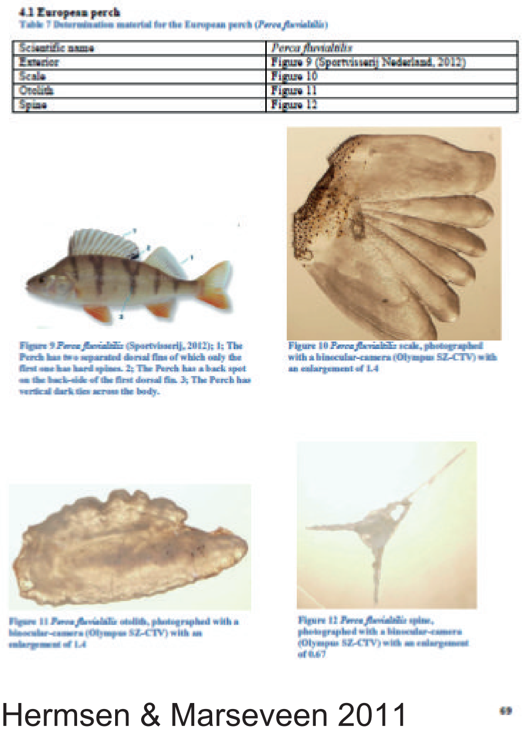



Eel remains from CCOP samples



## Other freshwater species

A number of freshwater species not dealt with separately which may feature in Cornish otter diet include perch and pike.



**4.1 European perch**

Table 7 Determination material for the European perch (*Perca fluviatilis*)

| | |
|---|---|
| Scientific name | *Perca fluviatilis* |
| Exterior | Figure 9 (Sportvisserij Nederland, 2012) |
| Scale | Figure 10 |
| Otolith | Figure 11 |
| Spine | Figure 12 |

Figure 9 *Perca fluviatilis* (Sportvisserij, 2012); 1: The Perch has two separated dorsal fins of which only the first one has hard spines. 2: The Perch has a back spot on the back-side of the first dorsal fin. 3: The Perch has vertical dark ties across the body.

Figure 10 *Perca fluviatilis* scale, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4

Figure 11 *Perca fluviatilis* otolith, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 1.4

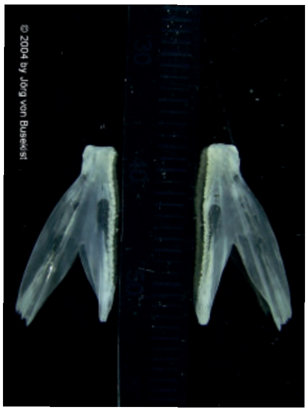
Figure 12 *Perca fluviatilis* spine, photographed with a binocular-camera (Olympus SZ-CTV) with an enlargement of 0.67

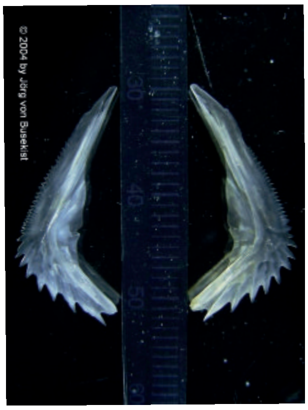
69

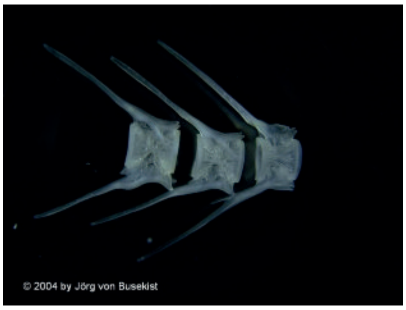
Hermsen & Marseveen 2011

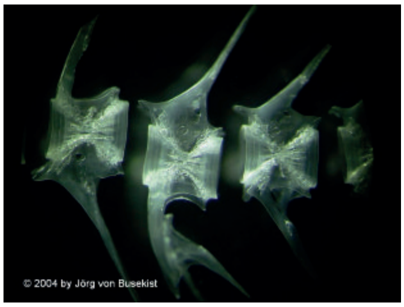
**Perch** - The scales are very distinctive. The vertebrae are difficult - especially if you also get bullhead.

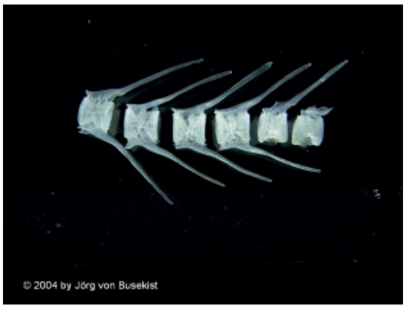
Suffolk Otter Group

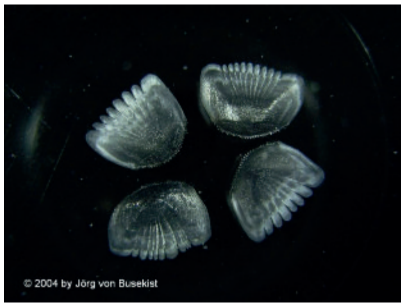


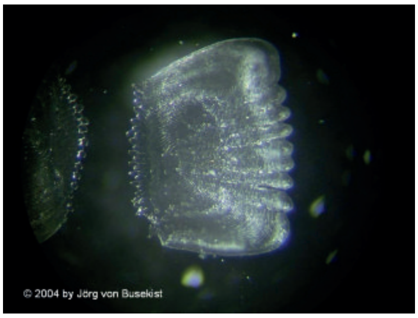



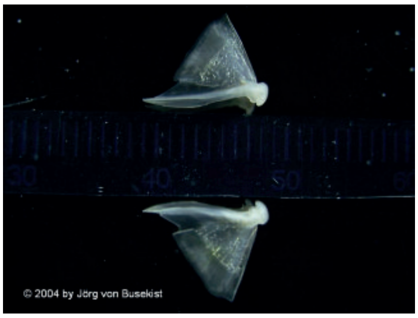



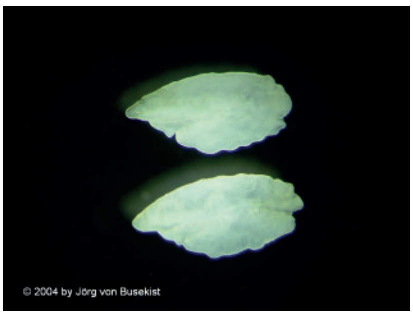



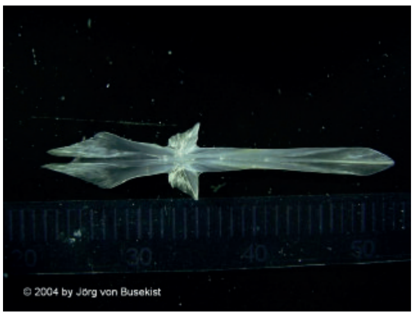

BB Perch (*Perca fluviatilis*)

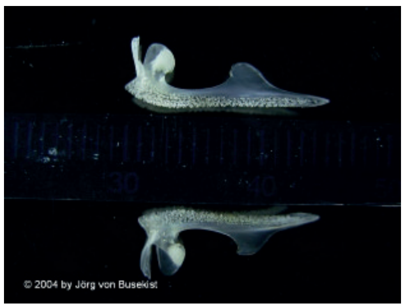


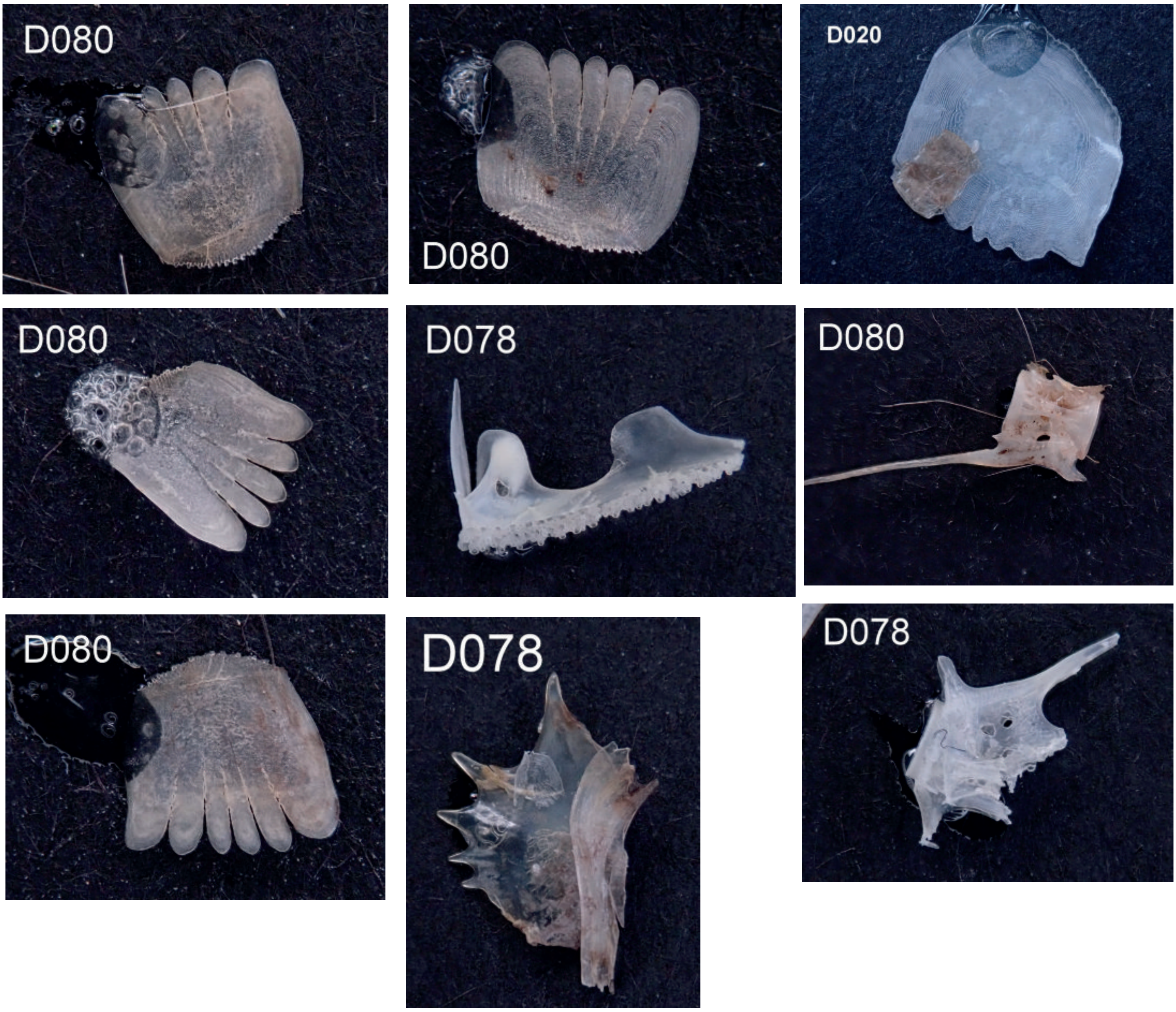







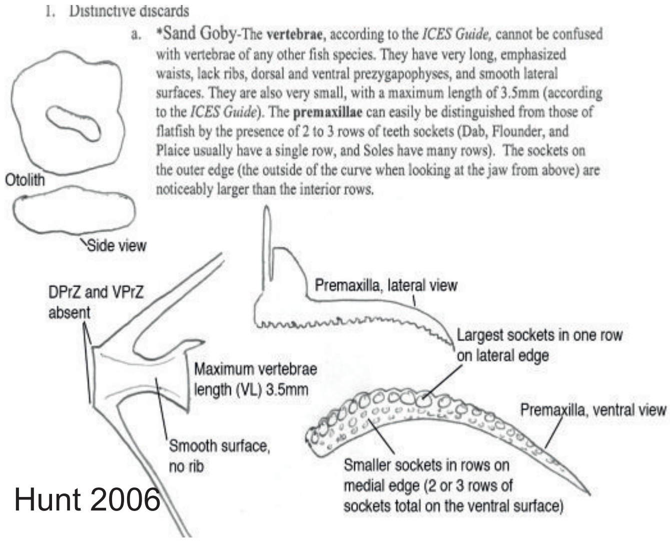






Perch remains from CCOP samples

# Gobies

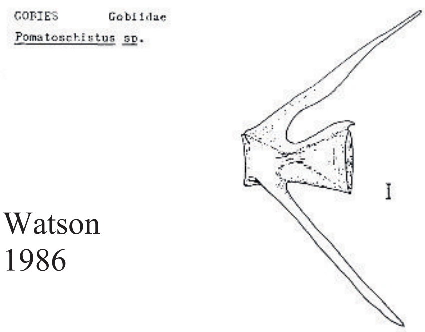
At least 10 goby species are found around the Cornish coast including common goby, sand goby and black goby. It is unrealistic to discriminate between the species based on spraint remains but the tiny, translucent, hourglass-shaped vertebrae are distinctive as are scales and various mouth parts and the spade-shaped parasphenoid. Otoliths are relatively plain rounded squares but often occur in very large numbers. Quadrates are elongated.


1. Distinctive discards

a. *Sand Goby-The **vertebrae**, according to the *ICES Guide*, cannot be confused with vertebrae of any other fish species. They have very long, emphasized waists, lack ribs, dorsal and ventral prezygapophyses, and smooth lateral surfaces. They are also very small, with a maximum length of 3.5mm (according to the *ICES Guide*). The **premaxillae** can easily be distinguished from those of flatfish by the presence of 2 to 3 rows of teeth sockets (Dab, Flounder, and Plaice usually have a single row, and Soles have many rows). The sockets on the outer edge (the outside of the curve when looking at the jaw from above) are noticeably larger than the interior rows.



Hunt 2006

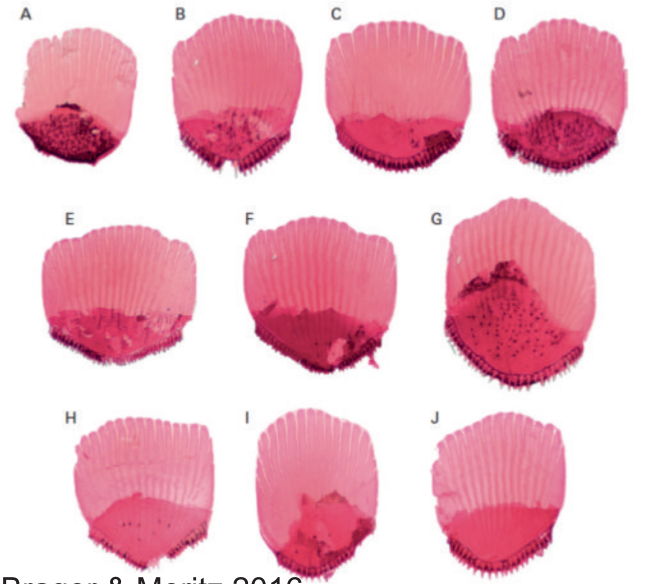



Watson 1986

**Goby**
Vertebrae very small. Scales - (not commonly found) can be confused with perch. Goby scales have more 'fingers' and they are more deeply cut.

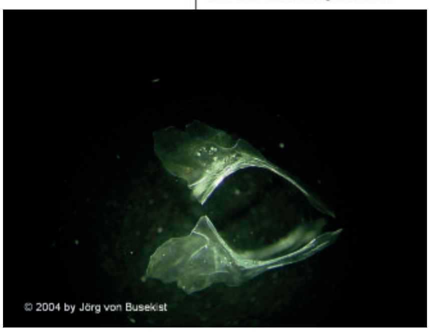
Suffolk Otter Group


Warning - do not confuse this scale with perch

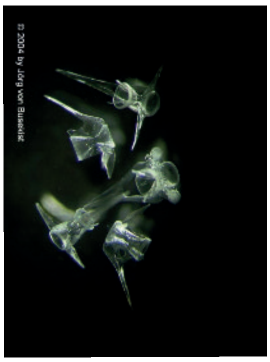


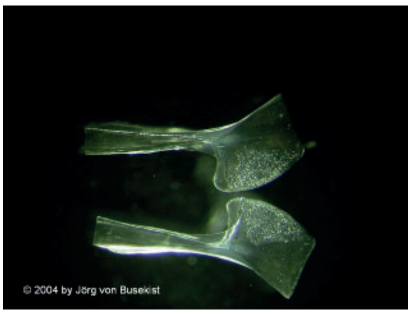

Brager & Moritz 2016

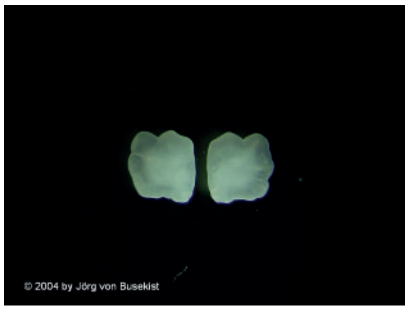
**Fig. 78.** *Gobius paganellus*; 61 mm SL, Costa Brava, Spain, DMM IE/5870. Scale bar = 500 µm.



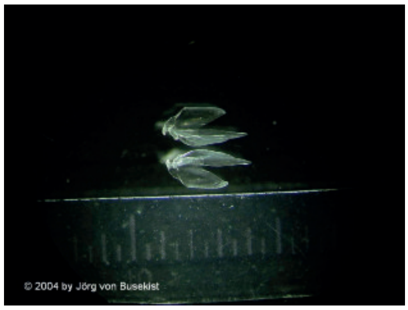




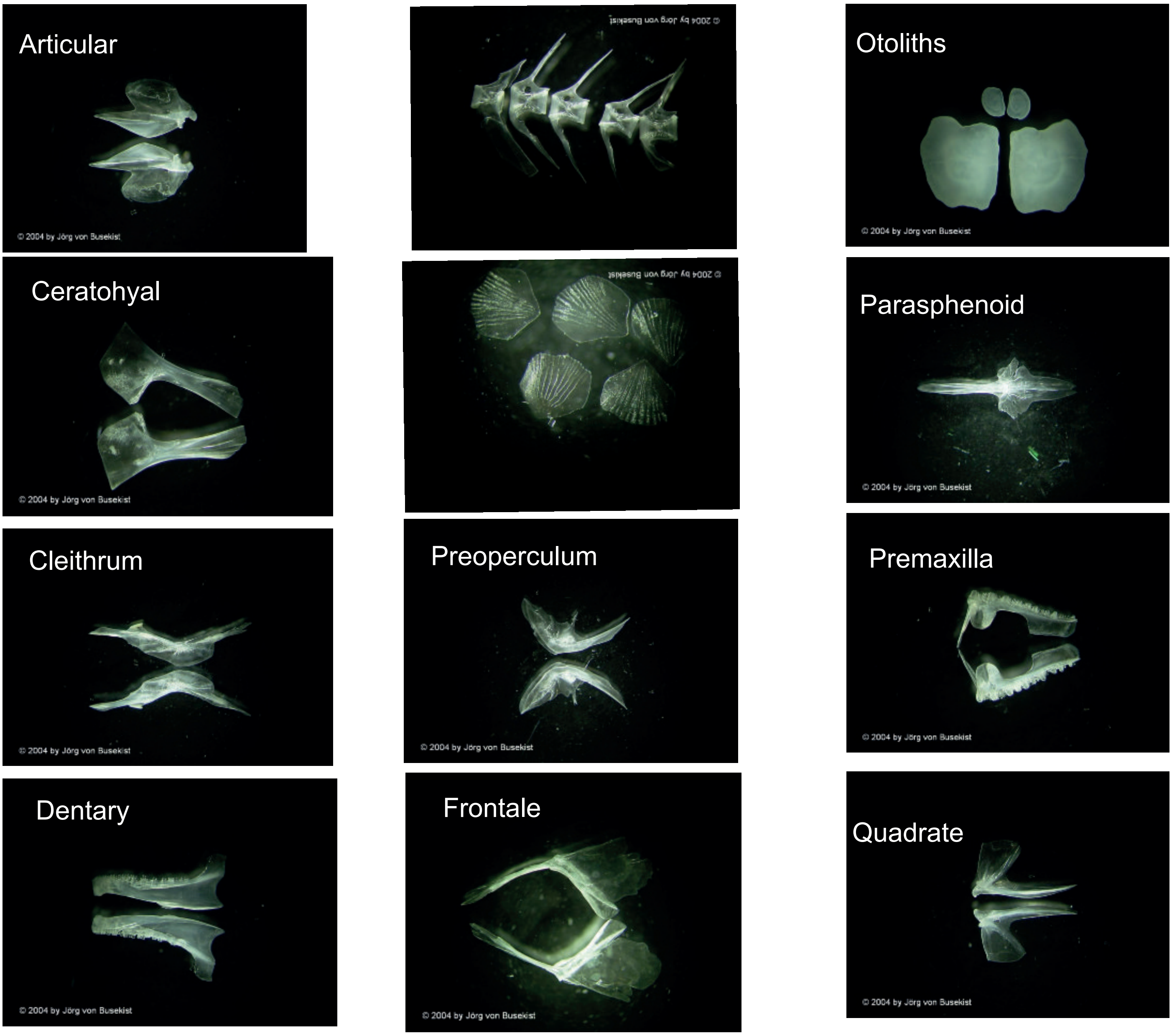



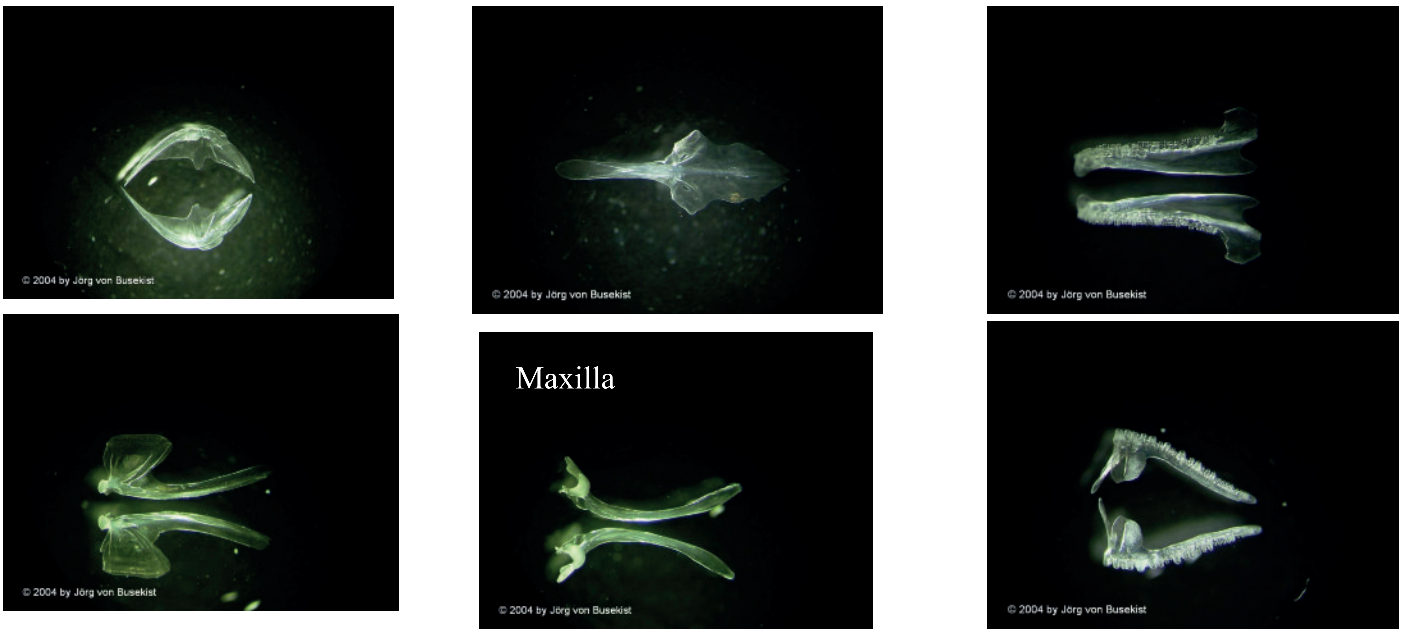





BB Sand Goby (*Pomatoschistus minutus*)

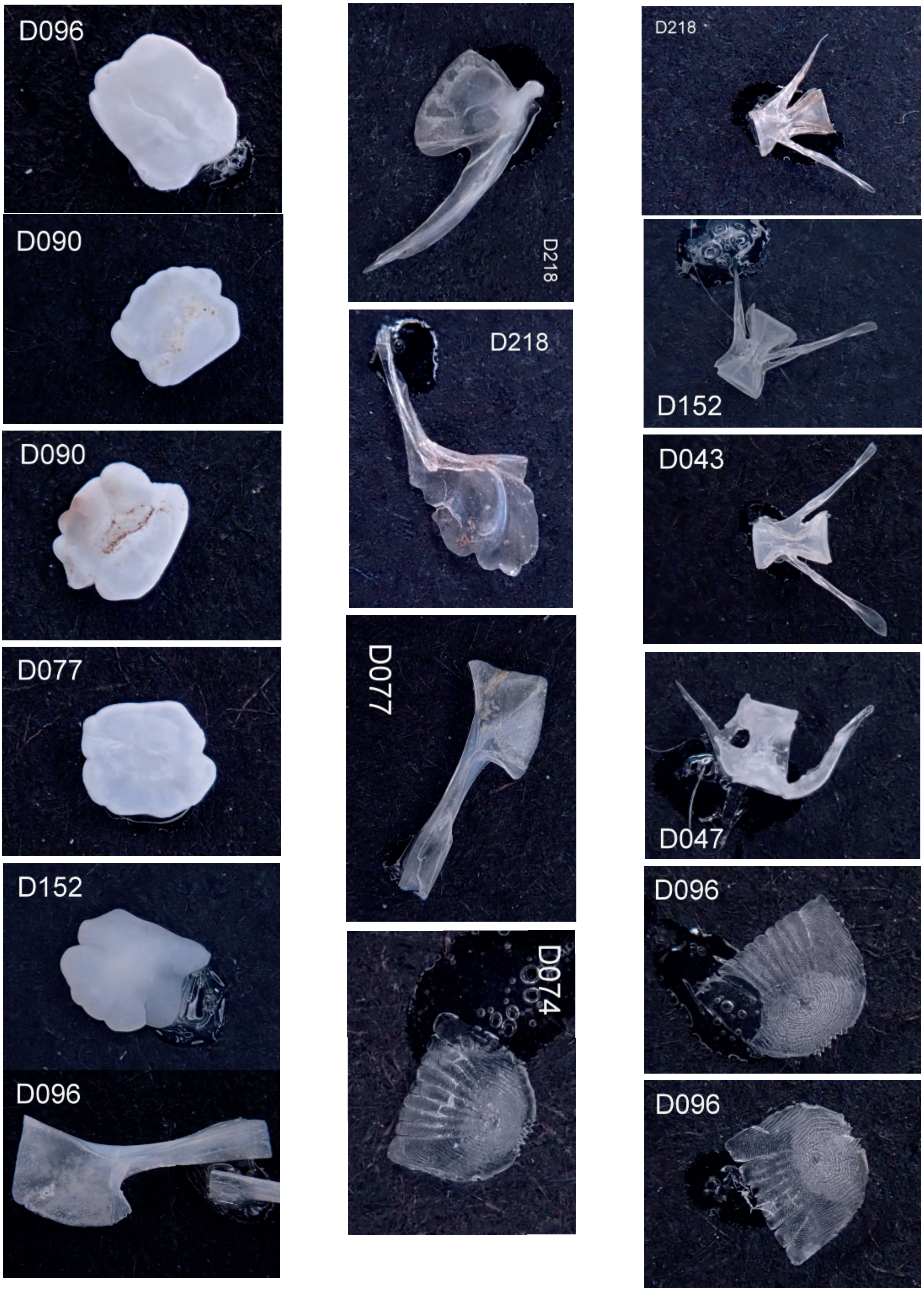



BB Black Goby (*Gobius niger*)




BB Sand Goby (*Pomatoschistus minutus*)


Goby remains from CCOP samples




Goby remains from CCOP samples

## Blennies

Although there are many blenny species found in British coastal waters only four are likely to feature in otter diet - all occurring in the intertidal zone and shallower water - three of these are members of the family Blennidae - the shanny or common blenny (*Lipophrys pholis*), tompot blenny (*Parablennius gattorugine*) and Montagu's blenny (*Coryphoblennius galerita*). The viviparous blenny or eelpout (*Zoarces viviparus*) is a member of the family zoarcides and not part of the order Blenniiformes. Conroy et al. (1993) include Yarrel's blenny but this species is typically found at 20 m and deeper.

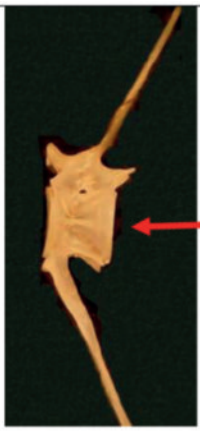
There is little information on Blennidae remains available but eelpout bones are recorded as having a green or turquoise tinge and vertebrae are similar to bullhead with a prominent dorsal prezygapophysis. No definite eelpout bones were identified from the CCOP samples.

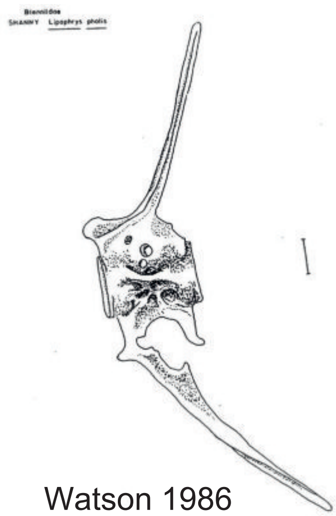
Blennies do not have scales but the Tompot blenny has a characteristic premaxilla

Most definitive remains are vertebrae with large dorsal prezygapophyses as well as ventral pre- and post-zygapophyses. The neural spine rises from mid-point of squarish base and is straight. Distinctive curved teeth are also associated with shanny remains.

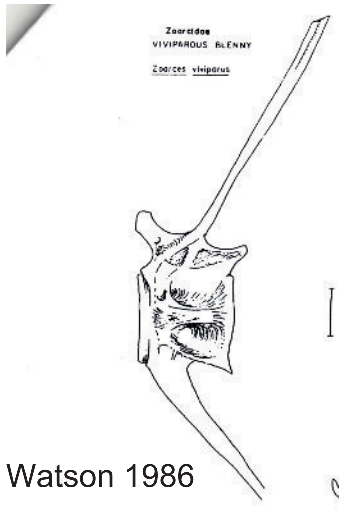
**Blenny/ Eelpout (same thing)** Bones sometimes greenish. The vertebrae have a prominent ridge along the sides of the centrum.

Suffolk Otter Group

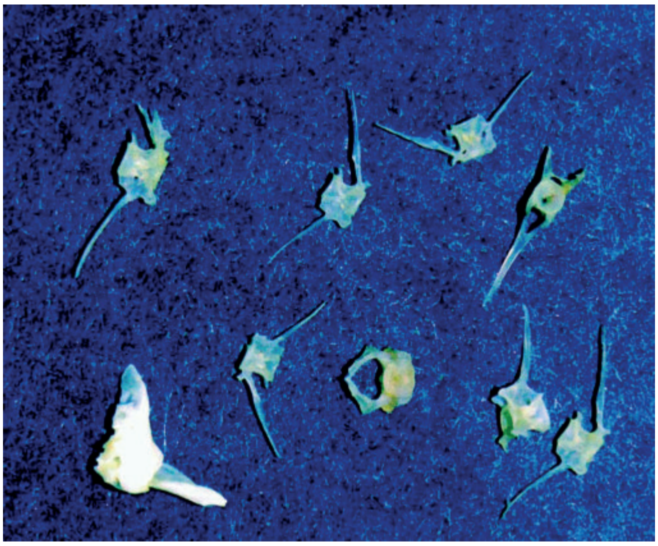




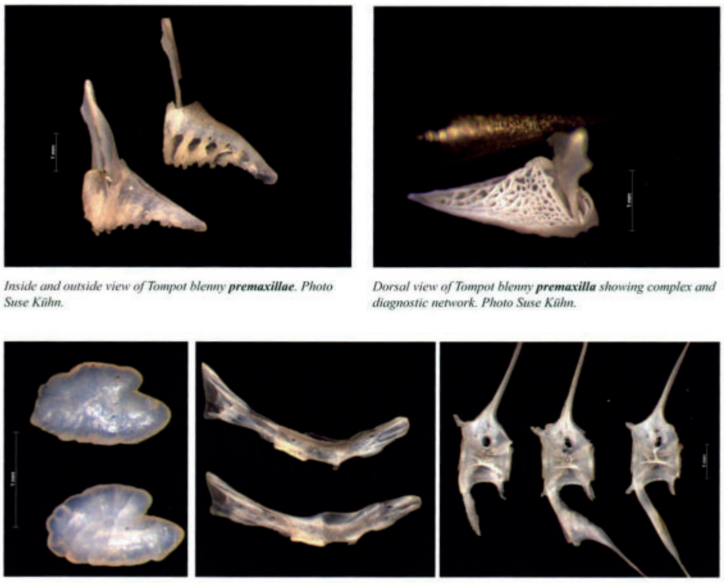

Watson 1986




Watson 1986



Common Blenny remains - Sheila Hamilton-Dyer



*Inside and outside view of Tompot blenny* ***premaxillae****. Photo Suse Kühn.*

*Dorsal view of Tompot blenny* ***premaxilla*** *showing complex and diagnostic network. Photo Suse Kühn.*

*Inside (below) and outside (top) view of Tompot blenny* ***otoliths****. Photo Suse Kühn.*

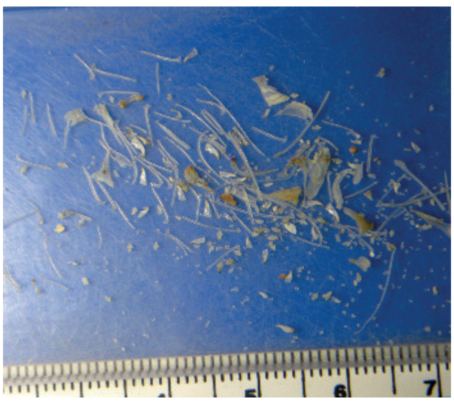
*Tompot blenny* ***cleithra****. Photo Suse Kühn.*

*Lateral view of a short series of Tompot blenny* ***caudal vertebrae****. Photo Suse Kühn.*

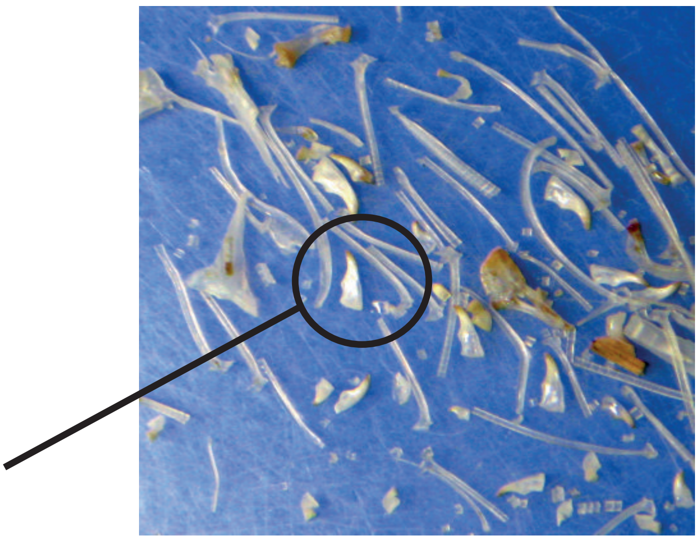
Camphuysen & Henderson 2017


Eelpout remains - Fish Bone

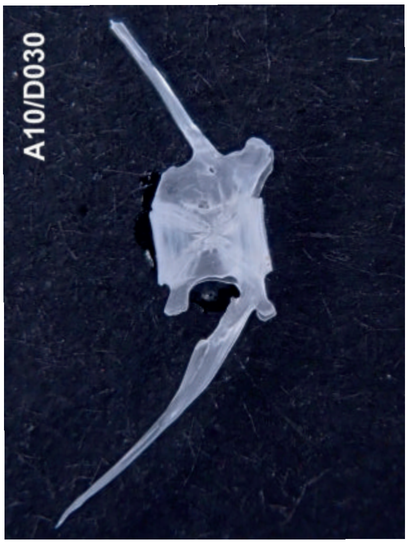

Eelpout from BoneBase



Shanny teeth - Sheila Hamilton-Dyer





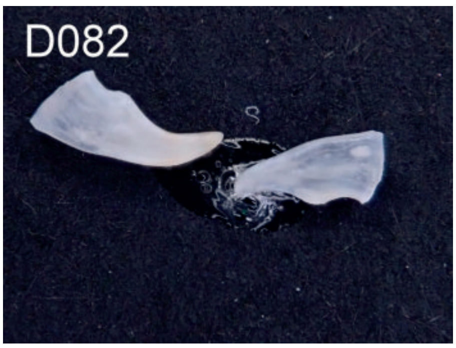





Blenny remains from CCOP samples



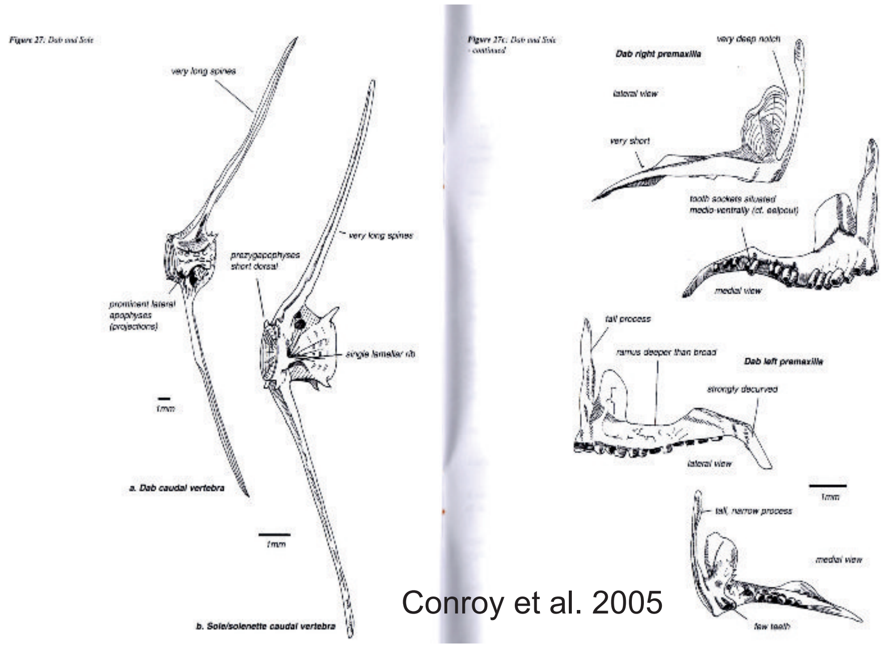




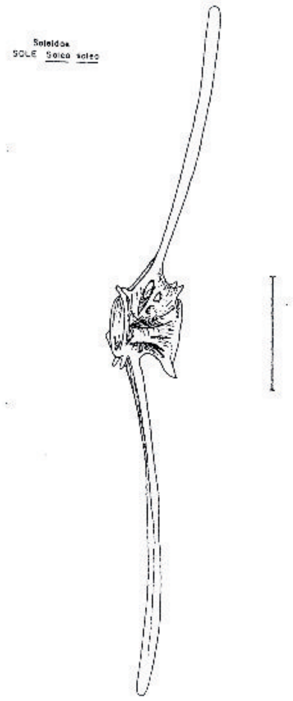

## Flatfish

A number of flatfish are known to occur around the Cornish coast and running up estuaries, sometimes into lower reaches of river. Plaice and flounder (Cornish Rockpools), Flounder (EA), Plaice, flounder and topknot (CWT), Other flatfish occurring in shallower waters include dab, sole and solenette (NBN Atlas). Surveys of the Helford estuary in 1990s recorded dab, plaice, flounder, turbot, solenette, common sole and brill (HVMCA Gainey 1999).

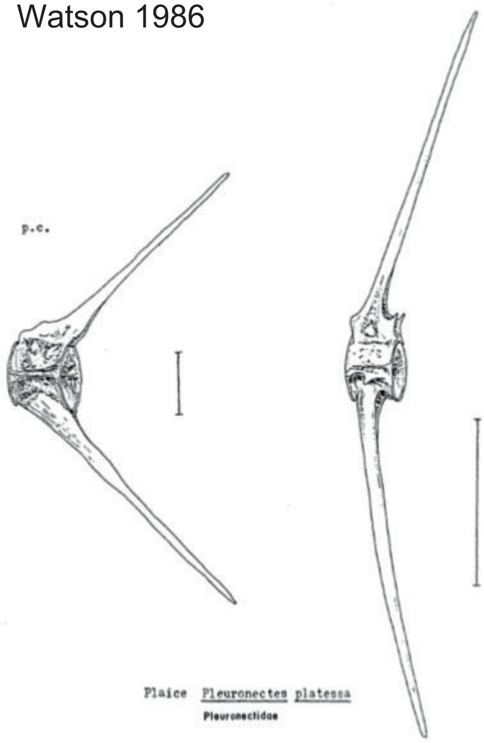
Generally it is not realistic to identify flatfish remains to species level but vertebrae are distinctive with long straight neural and haemal spines rising almost perpendicular to the centrum along with short lateral processes from the midline of the centrum. Other evidence of flatfish are premaxillae which are strongly asymetric and curved. Otoliths are occasionally found which are teardrop shaped with marked sulcus. Urohyals are ‘C’ shaped. As far as can be determined without reference samples scales from soles in particular are small and markedly ctenoid and have been found in several samples (Spinner et al, 2016).




Conroy et al. 2005




Watson 1986



**PLAICE**

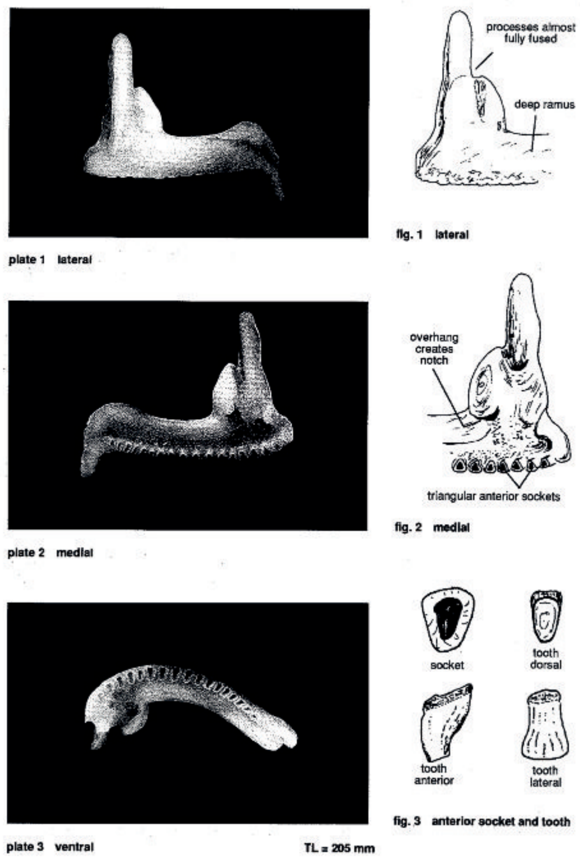



plate 1 lateral

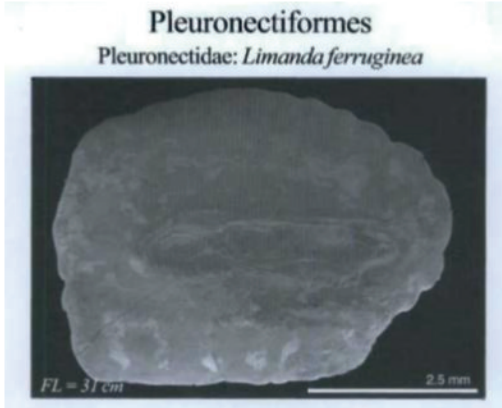
fig. 1 lateral

plate 2 medial

fig. 2 medial

plate 3 ventral TL = 205 mm

fig. 3 anterior socket and tooth




Otolith - Campana 2004

Watt et al. 1997

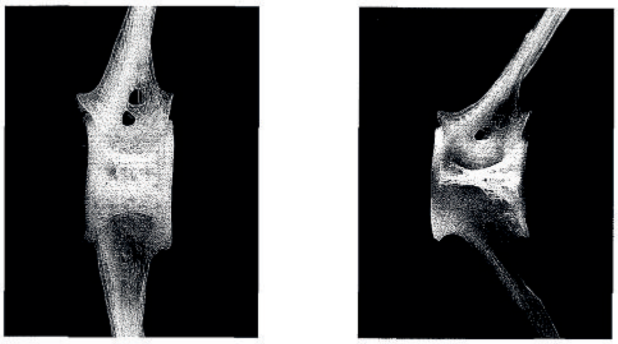
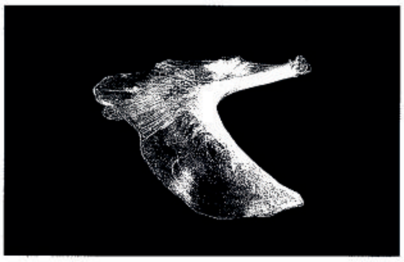


plate 1 anterior caudal

plate 2 mid caudal

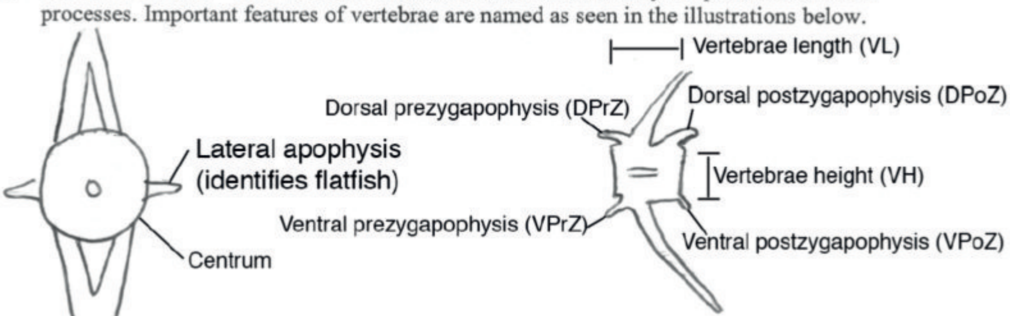
1.0 cm



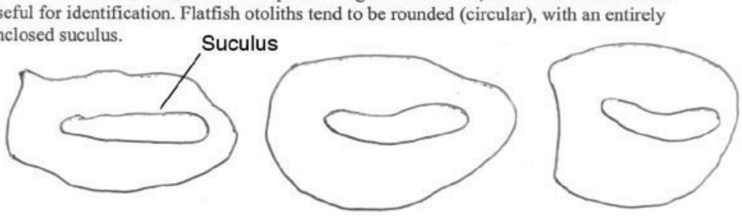
1.0 cm

Plaice (*Pleuronectes platessa*)

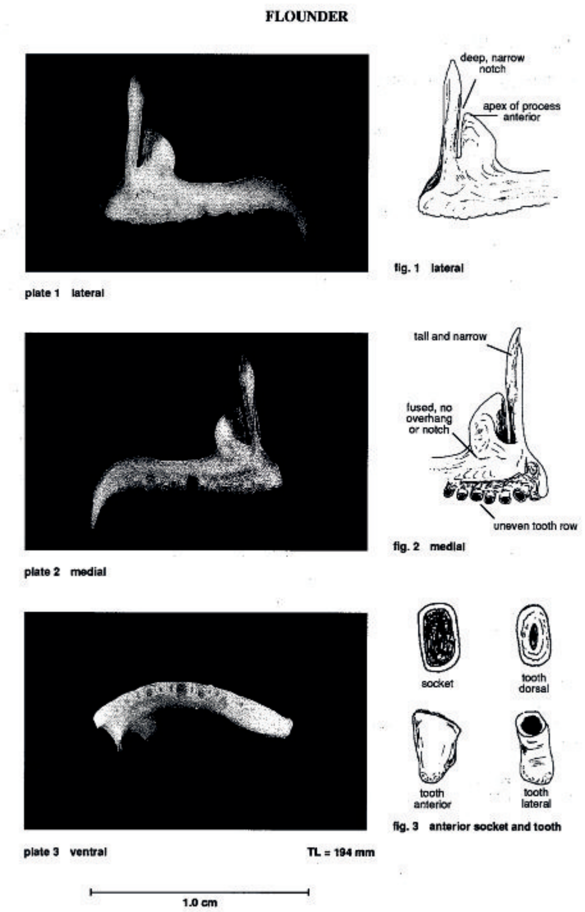
2. Flatfish Vertebrae – The vertebrae of flatfish can be identified by the presence of lateral processes. Important features of vertebrae are named as seen in the illustrations below.



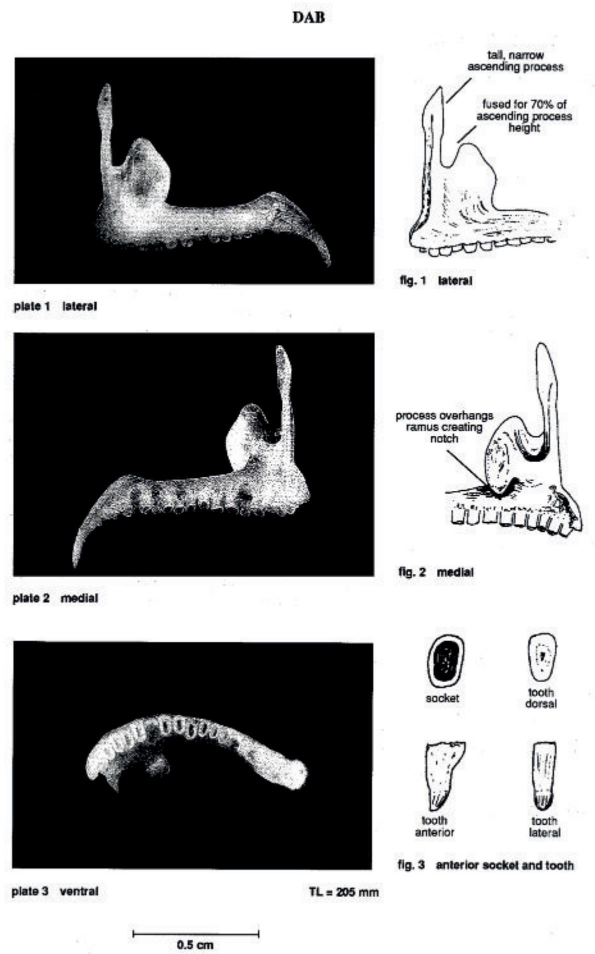

suculus (interior channel) is in the otolith, and in showing side views. There is a lot of variation within a given species in the patterns on the edges of otoliths, especially in flatfish. Interior features, such as the positioning of the suculus, seem to be reliable and useful for identification. Flatfish otoliths tend to be rounded (circular), with an entirely enclosed suculus.

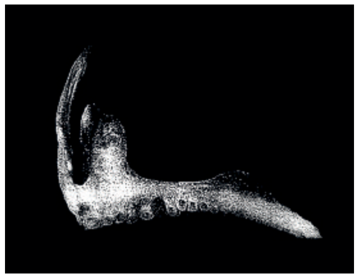



Hunt 2006




Watt et al. 1997

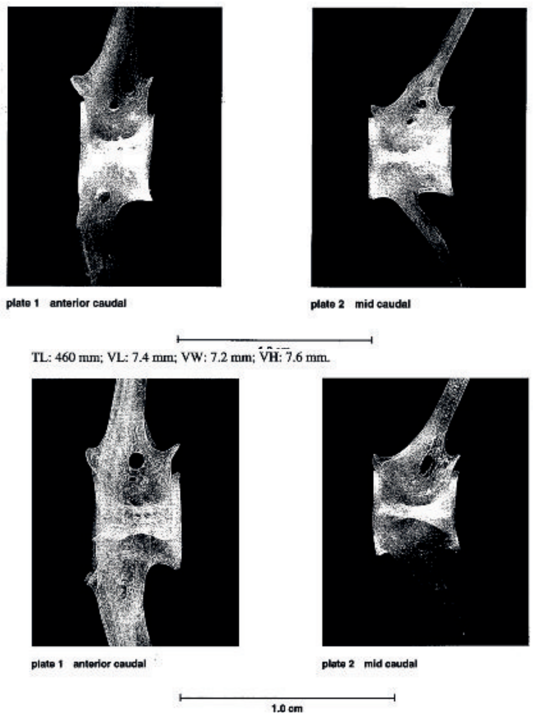


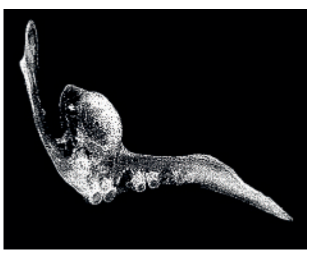



1.0 cm

**Flounder (*Platichthys flesus*)**

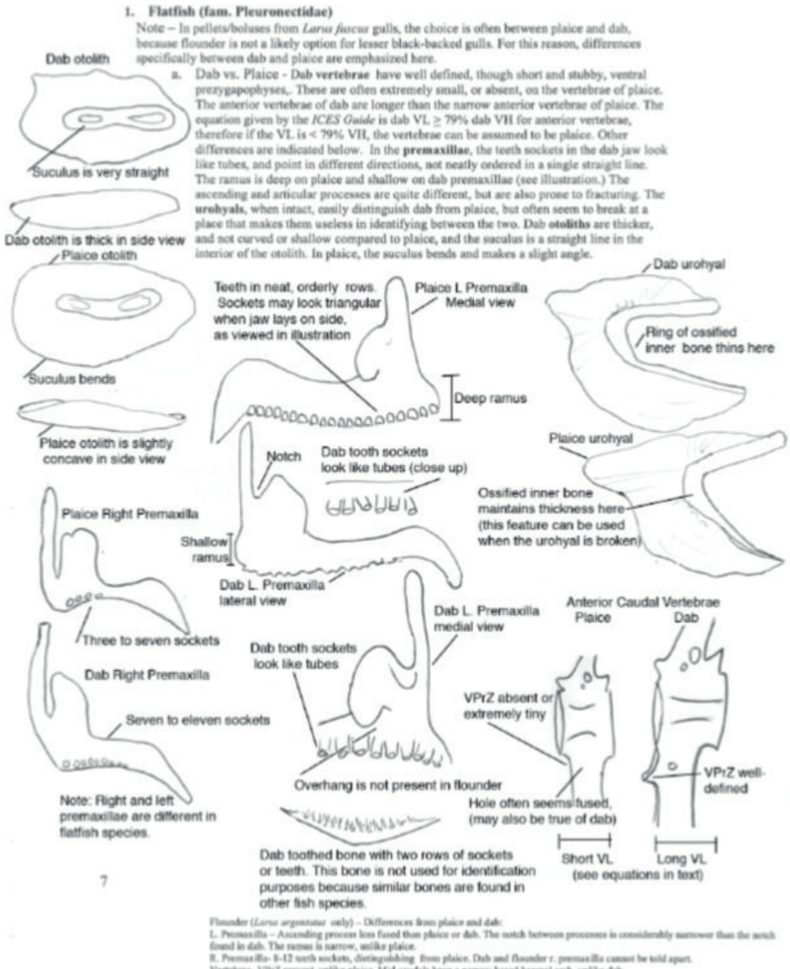
TL: 600 mm; VL: 10.1 mm; VW: 10.1 mm; VH: 11.5 mm.



1.0 cm

**Dab (*Limanda limanda*)**



1. **Flatfish (fam. Pleuronectidae)**

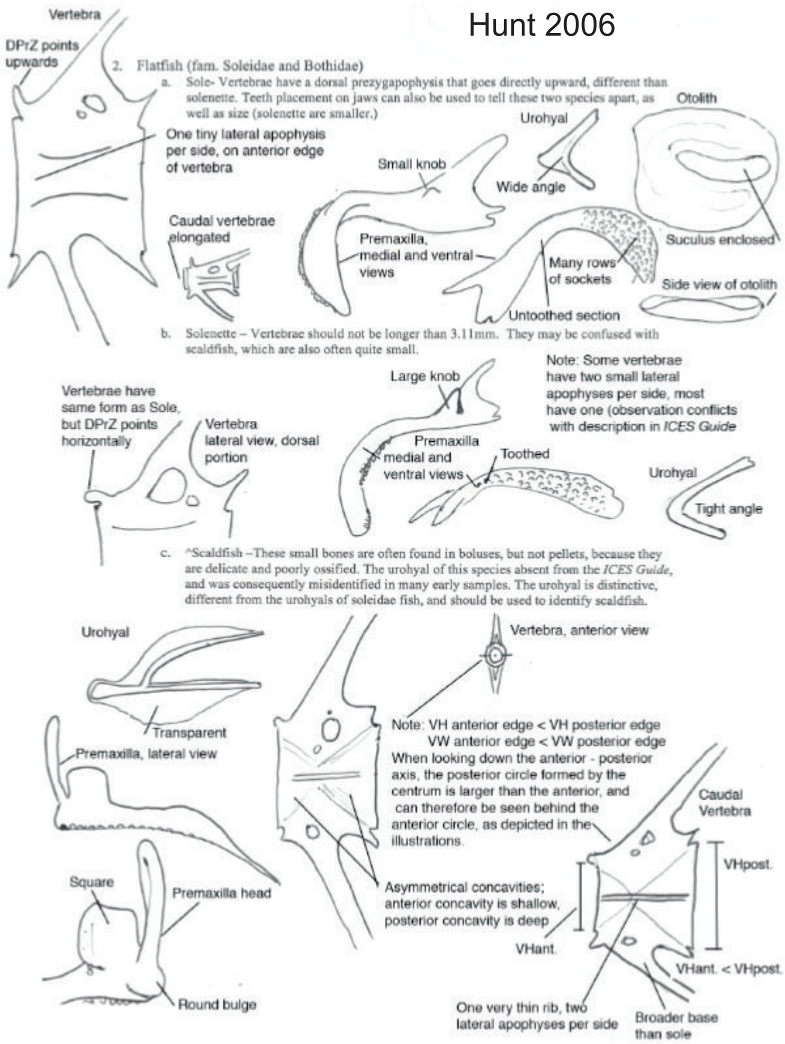
Note – In pellets/boluses from *Larus fuscus* gulls, the choice is often between plaice and dab, because flounder is not a likely option for lesser black-backed gulls. For this reason, differences specifically between dab and plaice are emphasized here.

a. Dab vs. Plaice - **Dab vertebrae** have well defined, though short and stubby, ventral prezygapophyses,. These are often extremely small, or absent, on the vertebrae of plaice. The anterior vertebrae of dab are longer than the narrow anterior vertebrae of plaice. The equation given by the *ICES Guide* is dab VL ≥ 79% dab VH for anterior vertebrae, therefore if the VL is < 79% VH, the vertebrae can be assumed to be plaice. Other differences are indicated below. In the **premaxillae**, the teeth sockets in the dab jaw look like tubes, and point in different directions, not neatly ordered in a single straight line. The ramus is deep on plaice and shallow on dab premaxillae (see illustration.) The ascending and articular processes are quite different, but are also prone to fracturing. The **urohyals**, when intact, easily distinguish dab from plaice, but often seem to break at a place that makes them useless in identifying between the two. Dab **otoliths** are thicker, and not curved or shallow compared to plaice, and the suculus is a straight line in the interior of the otolith. In plaice, the suculus bends and makes a slight angle.



Flounder (*Larus argentatus* only) – Differences from plaice and dab:
L. Premaxilla – Ascending process less fused than plaice or dab. The notch between processes is considerably narrower than the notch found in dab. The ramus is narrow, unlike plaice.
R. Premaxilla- 8-12 teeth sockets, distinguishing from plaice. Dab and flounder r. premaxilla cannot be told apart.
Vertebrae- VPrZ present, unlike plaice. Mid caudals have a narrow based haemal arch, unlike dab.

Hunt 2006



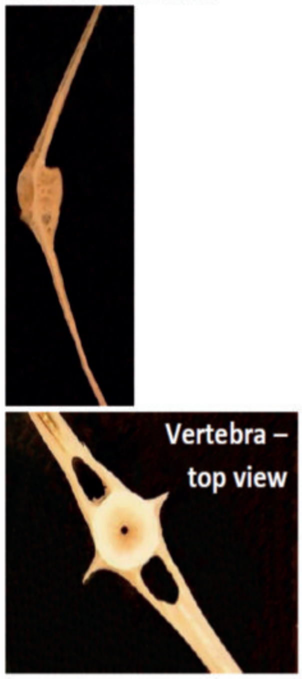
2. Flatfish (fam. Soleidae and Bothidae)

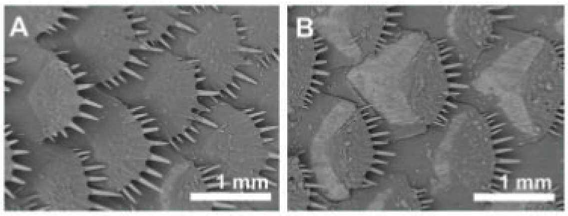
a. Sole- Vertebrae have a dorsal prezygapophysis that goes directly upward, different than solenette. Teeth placement on jaws can also be used to tell these two species apart, as well as size (solenette are smaller.)

b. Solenette – Vertebrae should not be longer than 3.11mm. They may be confused with scaldfish, which are also often quite small.

c. ^Scaldfish –These small bones are often found in boluses, but not pellets, because they are delicate and poorly ossified. The urohyal of this species absent from the *ICES Guide*, and was consequently misidentified in many early samples. The urohyal is distinctive, different from the urohyals of soleidae fish, and should be used to identify scaldfish.



| **Flatfish** | Vertebra side view |
|---|---|
| Centrum looks rectangular, vertically, and has long spines, often broken. The most distinctive feature - little projections on sides - like tiny stabilisers. (Turn it on end to see)<br><br>Suffolk Otter Group |   |




*Solea solea* scales (Spinner et al. 2016)


Flounder BB Articular
© 2004 by Jörg von Busekist

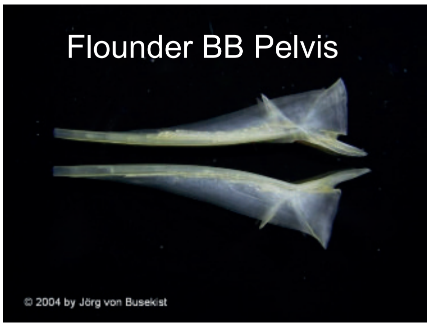

Flounder BB Dentary
© 2004 by Jörg von Busekist

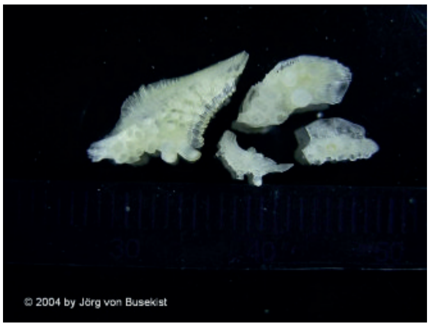

Flounder BB Premaxilla
© 2004 by Jörg von Busekist

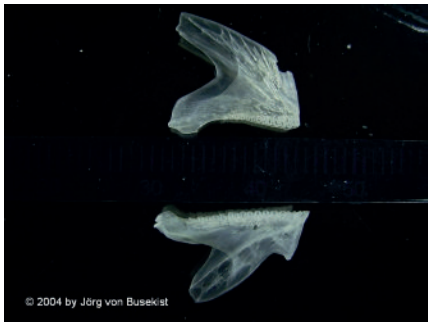

Flounder BB Otoliths
© 2004 by Jörg von Busekist


Flounder BB Urohyal
© 2004 by Jörg von Busekist

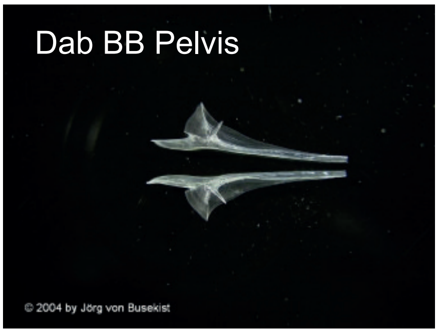

Flounder BB Quadrate
© 2004 by Jörg von Busekist


Flounder BB Pelvis
© 2004 by Jörg von Busekist

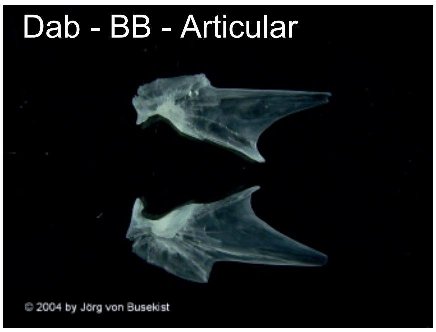

© 2004 by Jörg von Busekist

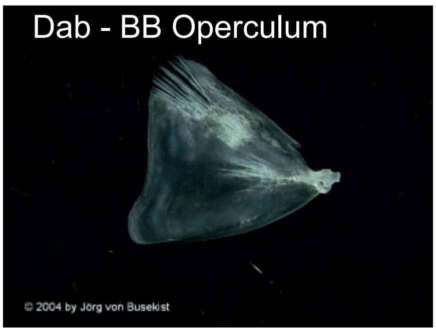

© 2004 by Jörg von Busekist


© 2004 by Jörg von Busekist

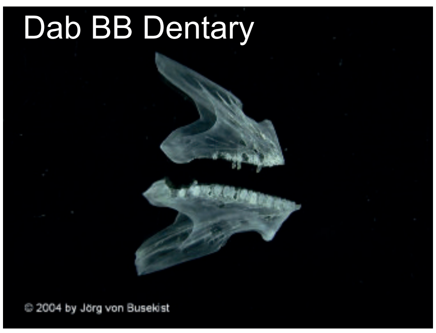

Dab BB Pelvis
© 2004 by Jörg von Busekist


Dab BB Urohyal
© 2004 by Jörg von Busekist


Dab - BB - Articular
© 2004 by Jörg von Busekist

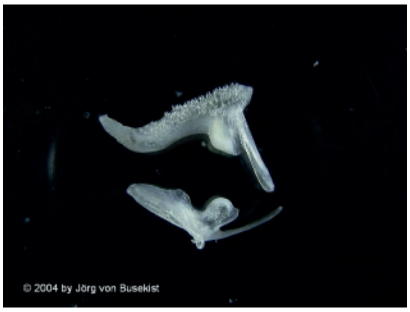

Dab - BB Operculum
© 2004 by Jörg von Busekist

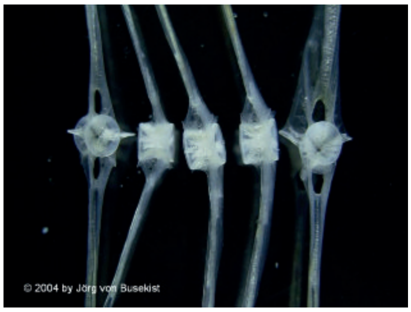

Dab BB Otoliths
© 2004 by Jörg von Busekist


Dab BB Dentary
© 2004 by Jörg von Busekist


Dab BB Premaxilla
© 2004 by Jörg von Busekist

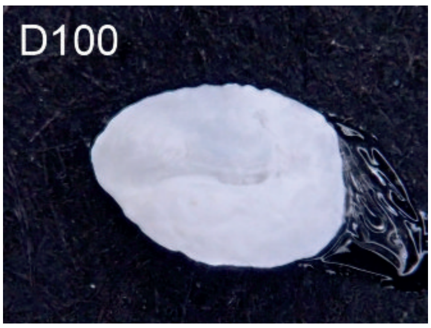

Dab BB Quadrate
© 2004 by Jörg von Busekist

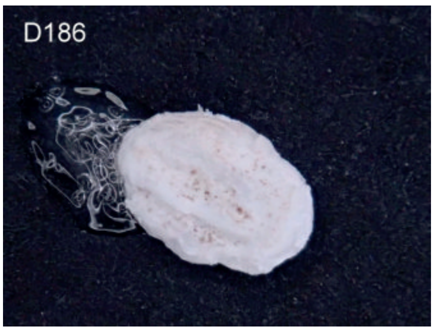


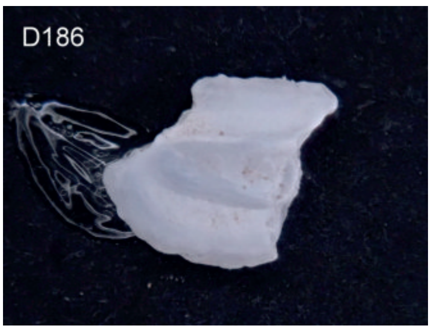


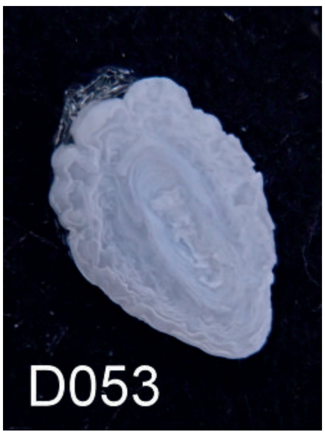

BB Plaice

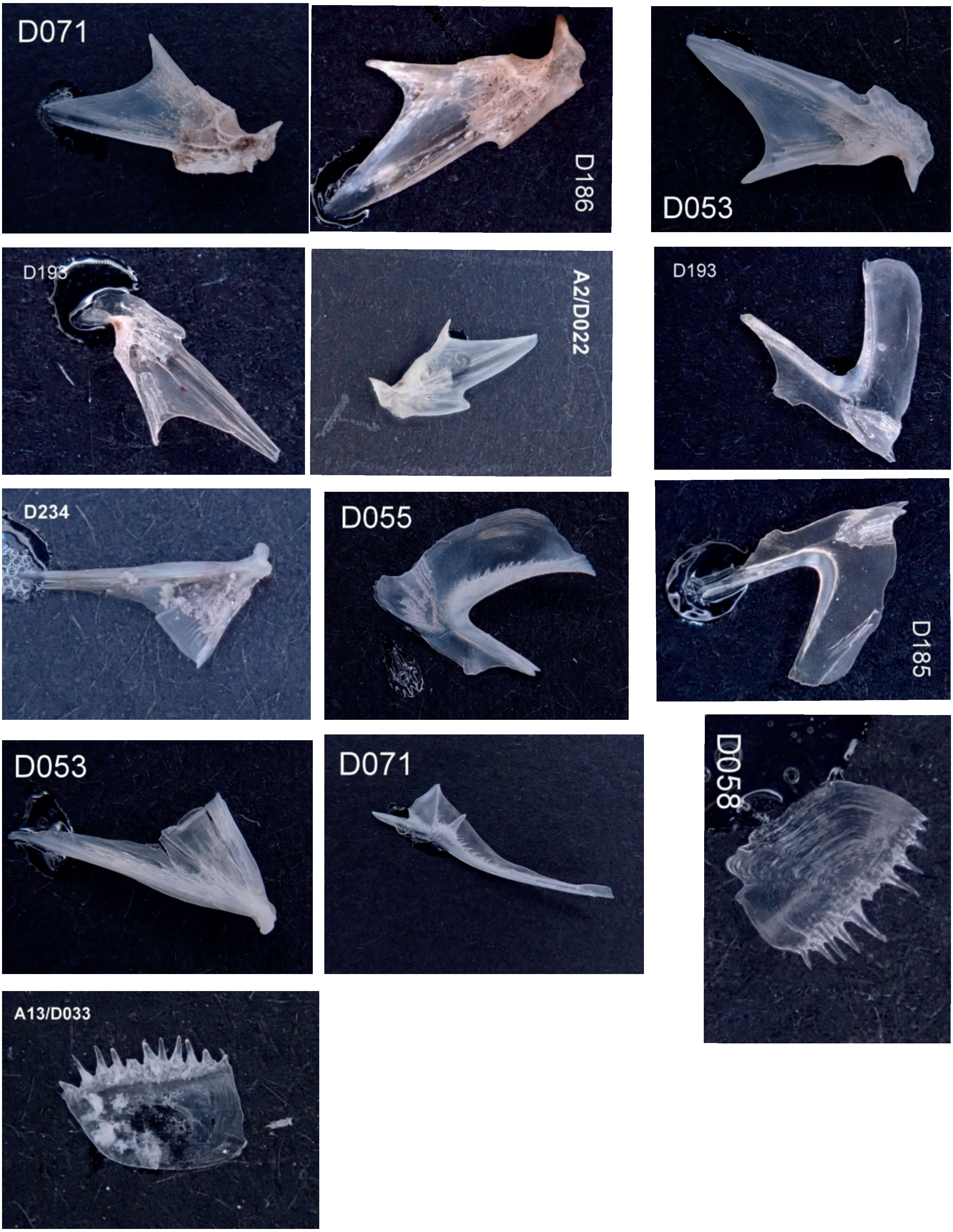
Flatfish remains from CCOP samples



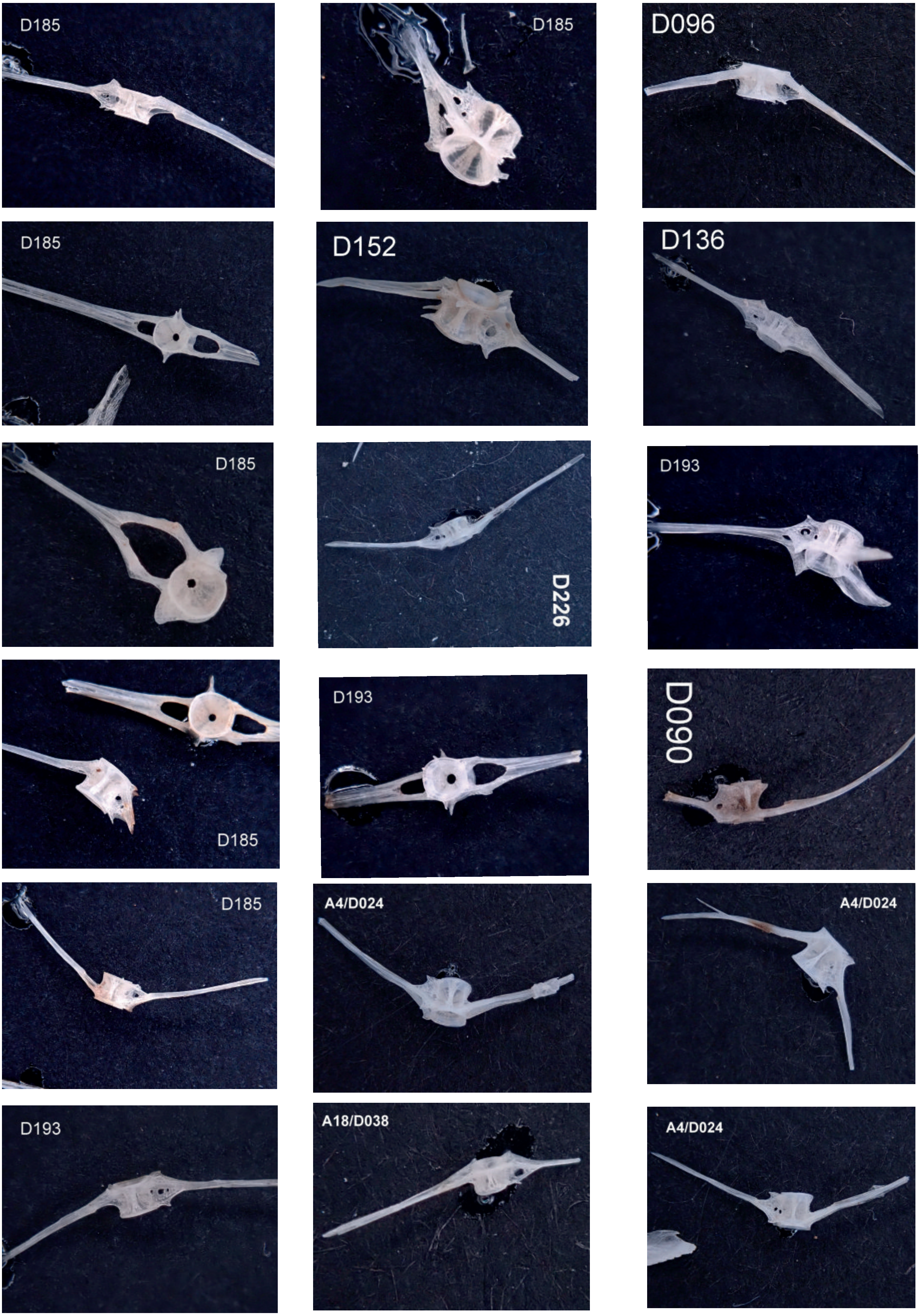









Flatfish remains from CCOP samples

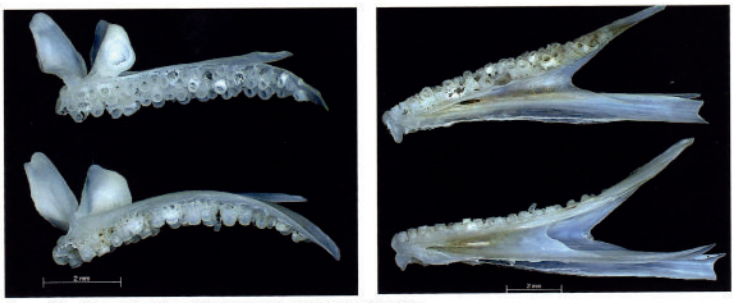



Flatfish remains from CCOP samples

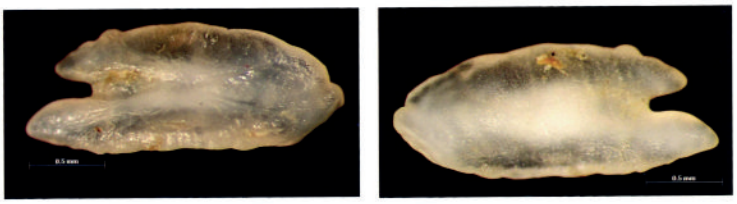

Flatfish remains from CCOP samples

## Rocklings

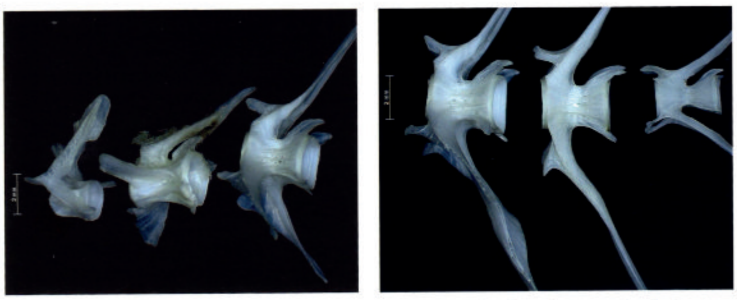
There are three inshore rockling species found around the South West coast - five-bearded (*Ciliata mustela*), three-bearded (*Gaidropsarus vulgaris*) and shore rockling (*Gaidropsarus mediterraneus*). These members of the cod family have distinctive robust and well calcified vertebrae and characteristic premaxillae. The vertebrae have large ventral and dorsal prezygapophyses and the dorsal postzygapophyses are particularly obvious.



**Premaxillae** (left) and **dentaries** of Five-bearded rockling. Photos Suse Kühn

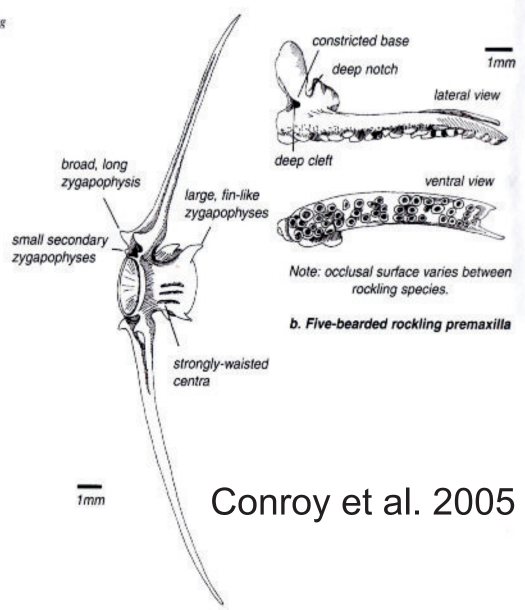


Inner (left) and outer (right) face of **otoliths** of Five-bearded rockling. Photos Estefania Velilla.



Lateral view of **abdominal vertebrae** (left) and **caudal vertebrae** (right) of Five-bearded rockling, showing strongly-waisted centra and promient anterior and posterior horns. Photos Suse Kühn.

Figure 13: Rockling




a. Five-bearded rockling caudal vertebra

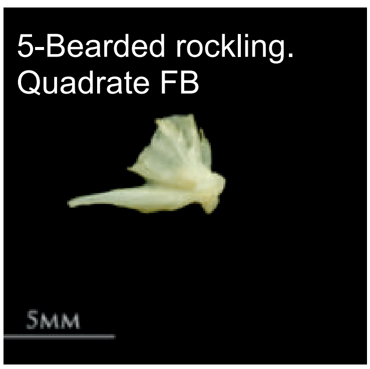
26

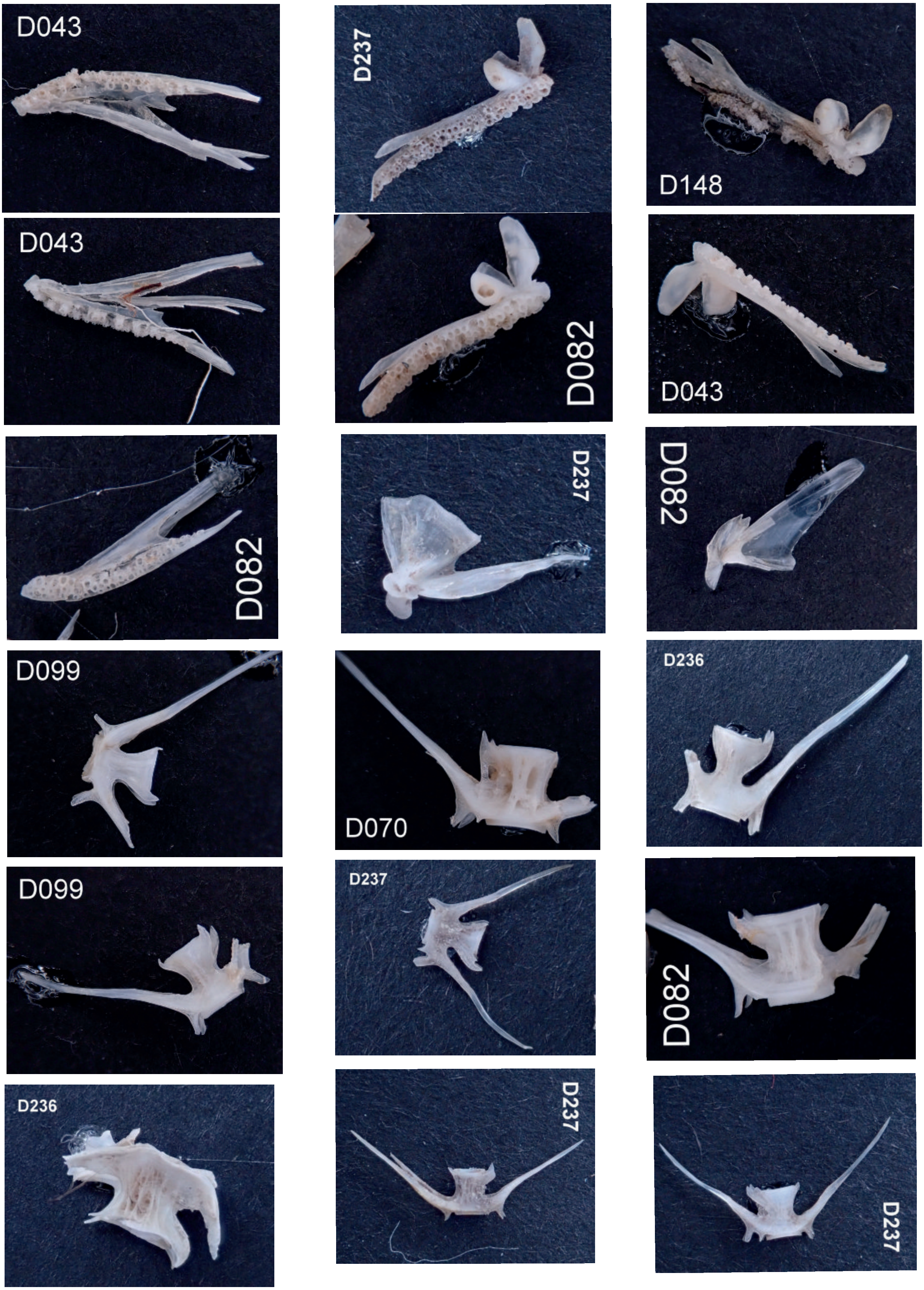
**Premaxillae** of Three-bearded rockling (inside top, outside bottom). Photos Estefania Velilla.

Anterior **caudal vertebra** of Three-bearded rockling. Photo Estefania Velilla.


Camphuysen & Henderson 2017





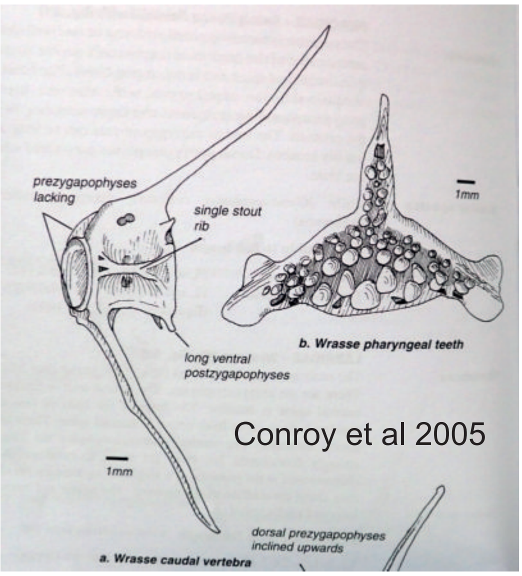



Rockling remains from CCOP samples

## Wrasse species

CWT advise that 3 wrasse species are found in Cornwall: ballan (*Labrus bergylta*), corkwing (*Symphodus melops*) and goldsinney (*Ctenolabrus rupestris*) wrasse. Additionally cuckoo wrasse (*Labrus mixtus*) and rock cook (*Centrolabrus exoletus*) are recorded in IFCA reports. Cuckoo wrasse is mainly found in deeper water. Corkwing wrasse and rock cook are most likely to be found in shallow water and rock pools. Corkwing move to deeper water in the winter. There is concern around the impact of live fish collection on wrasse populations around the Southwest.

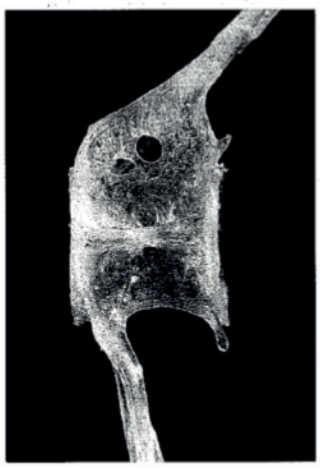
Otoliths change shape as fish age with more irregular outline, younger fish arrow shaped. Vertebrae similar in all species - broad-based neural spine with neural foramen and up to 3 distinct apertures no anterior zygopophyses but but pointed post-zygopophyses dorsal and ventral. There is a strong lamellar rib. Available scale information indicate long scales with a triangular anterior and a flat posterior with many horizontal creases which may separate into and extended 'frill' in damaged examples. Clearest remains are pharyngeal teeth (both in situ and detached) and premaxillae and dentary. Few intact vertebrae were recovered from CCOP samples




Conroy et al 2005

**Labrus mixtus**

1.0 cm



**Labrus mixtus**

0.5 cm

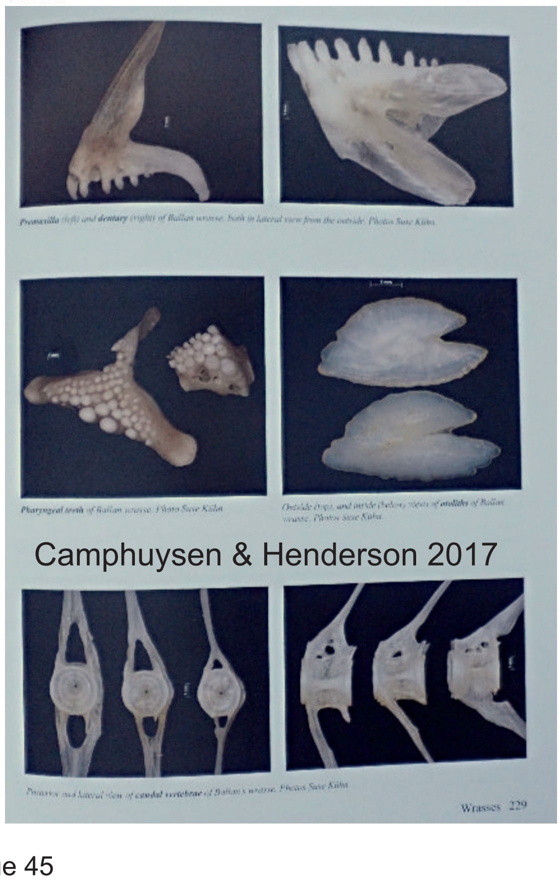
Watt et al. 1997

1.0 cm

**Cuckoo wrasse (*Labrus mixtus*) pharyngeal teeth**

1.0 cm

**Cuckoo wrasse (*Labrus mixtus*) left premaxilla and dentary**



Camphuysen & Henderson 2017

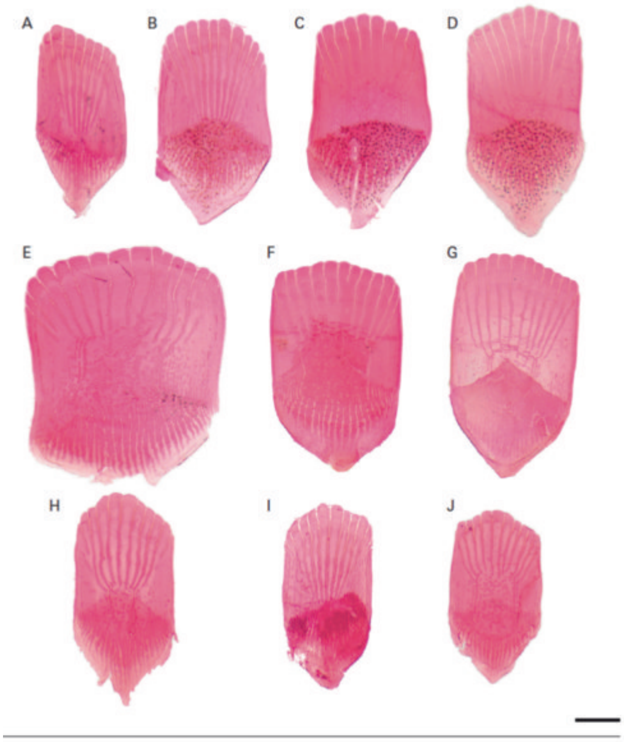



**Fig. 68.** *Coris julis*; 96 mm SL, Costa Brava, Spain, DMM IE/5020. Scale bar = 500 µm.

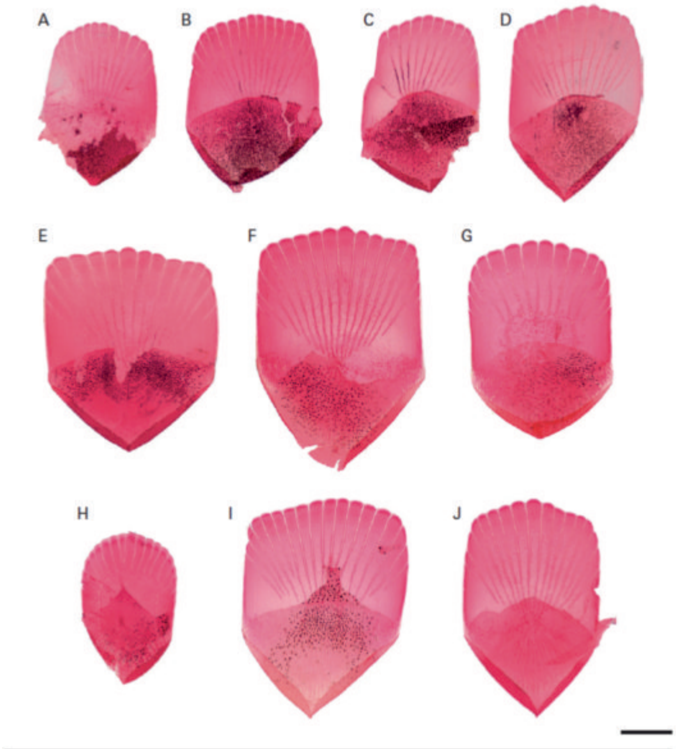
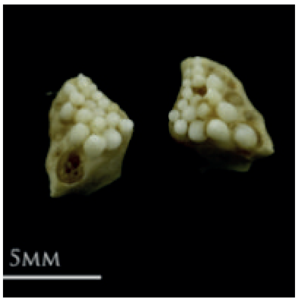
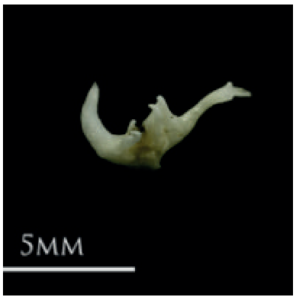



**Fig. 69.** *Labrus viridis*; 106 mm SL, Costa Brava, Spain, DMM IE/5886. Scale bar = 1 mm.

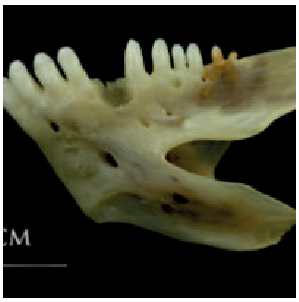
Brager and Moritz 2016 - Mediterranean fish scale atlas - these are two wrasse species for comparison

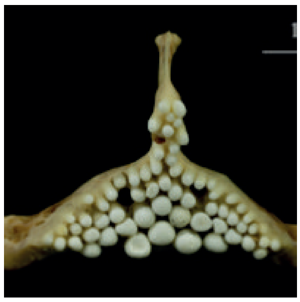



Corkwing Wrasse FB

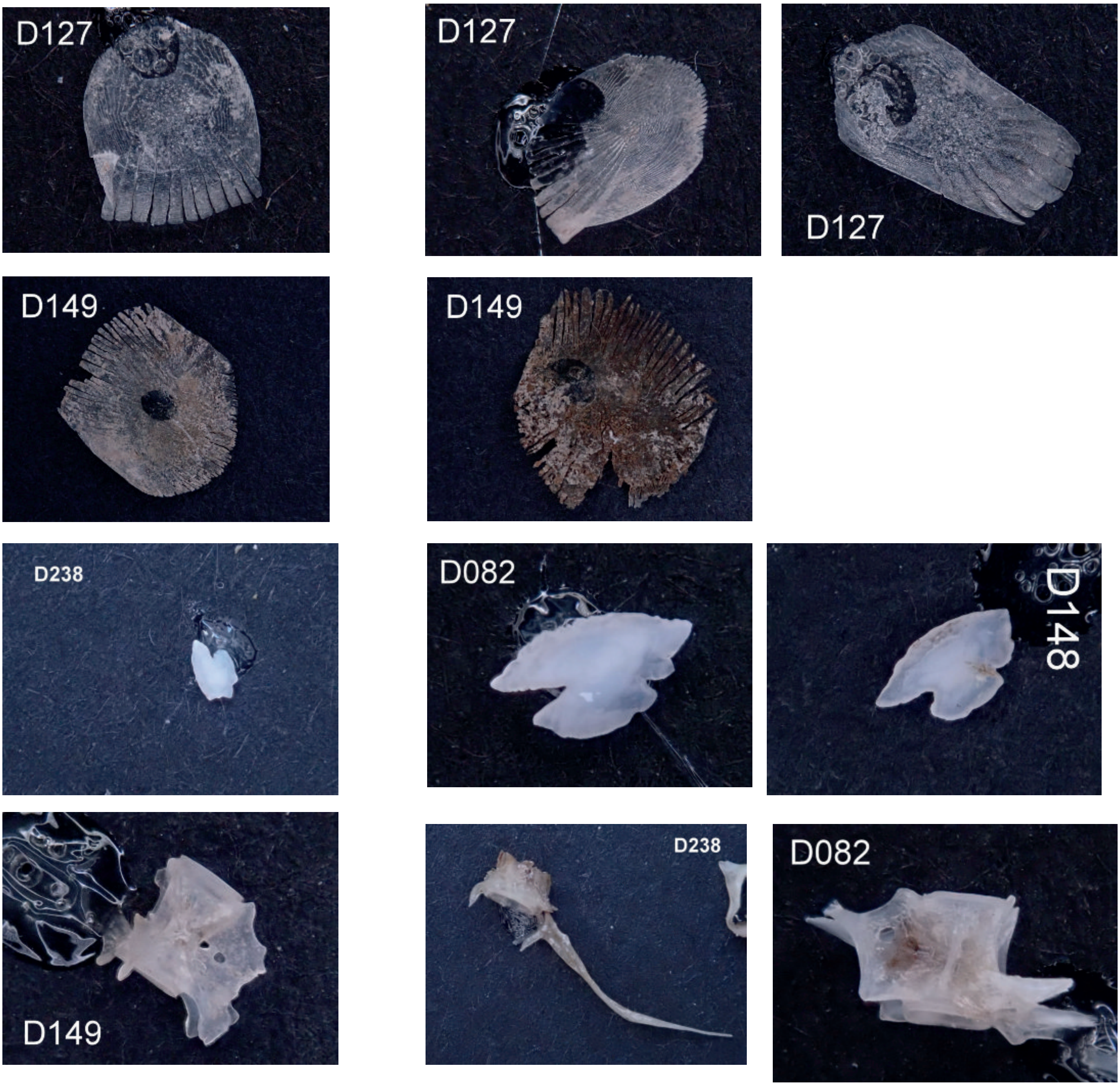
Cuckoo Wrasse FB



Ballan Wrasse FB


Wrasse remains from CCOP samples




Wrasse remains from CCOP samples

## Mullet species

Mullet species known to occur around the South West include thick-lipped (*Chelon labrosus*) and thin-lipped (*Chelon ramada*) grey mullet and golden grey mullet (*Chelon aurata*). Although not bottom-dwelling fish they do occur in shallow water and are recorded in otter diets elsewhere.

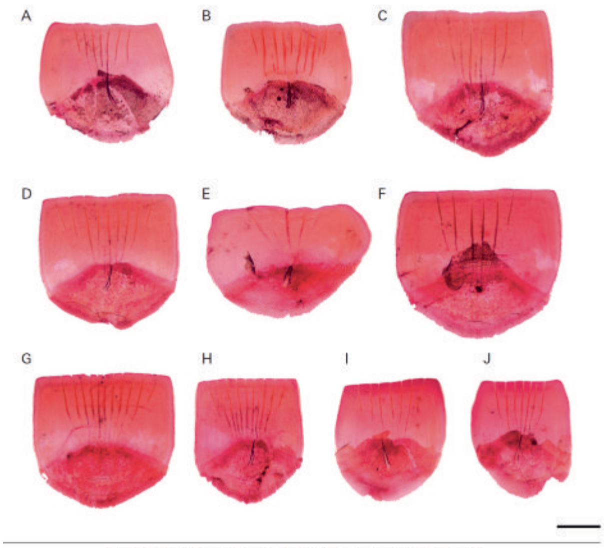
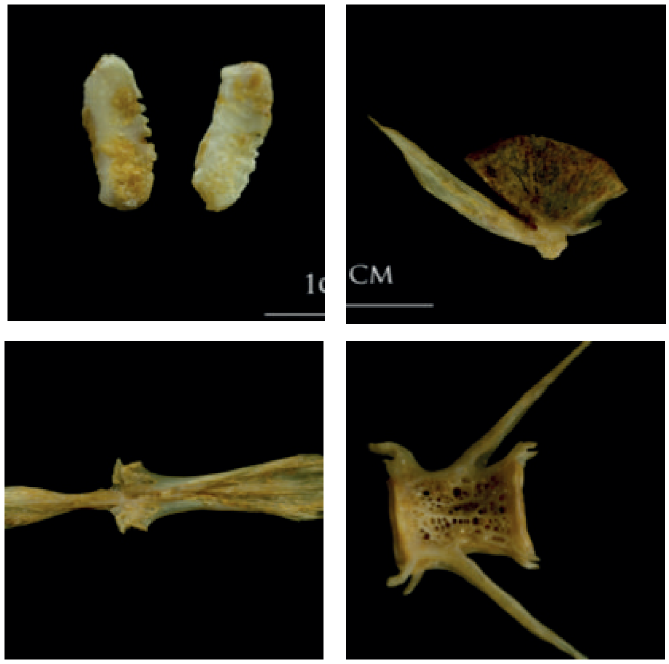
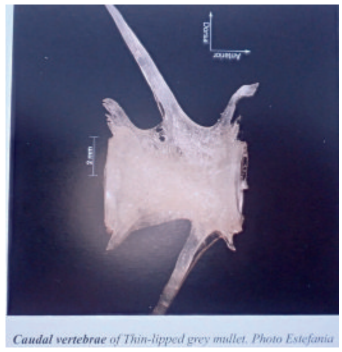



Fig. 28. *Chelon labrosus*: 181 mm SL, Elba, Italy, DMM IE/6188. Scale bar = 2 mm.

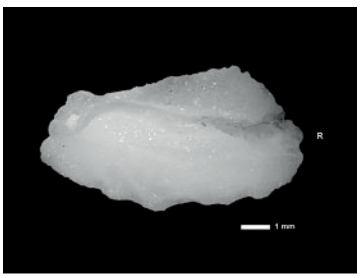
Brager & Moritz 2016



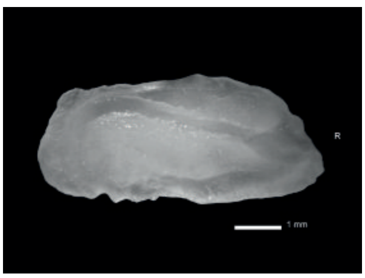

Thin-lipped grey mullet FB



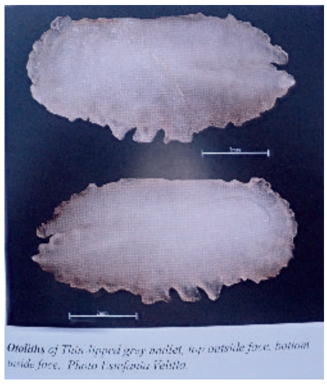

Thin-lipped grey mullet - Camphuysen & Henderson 2017



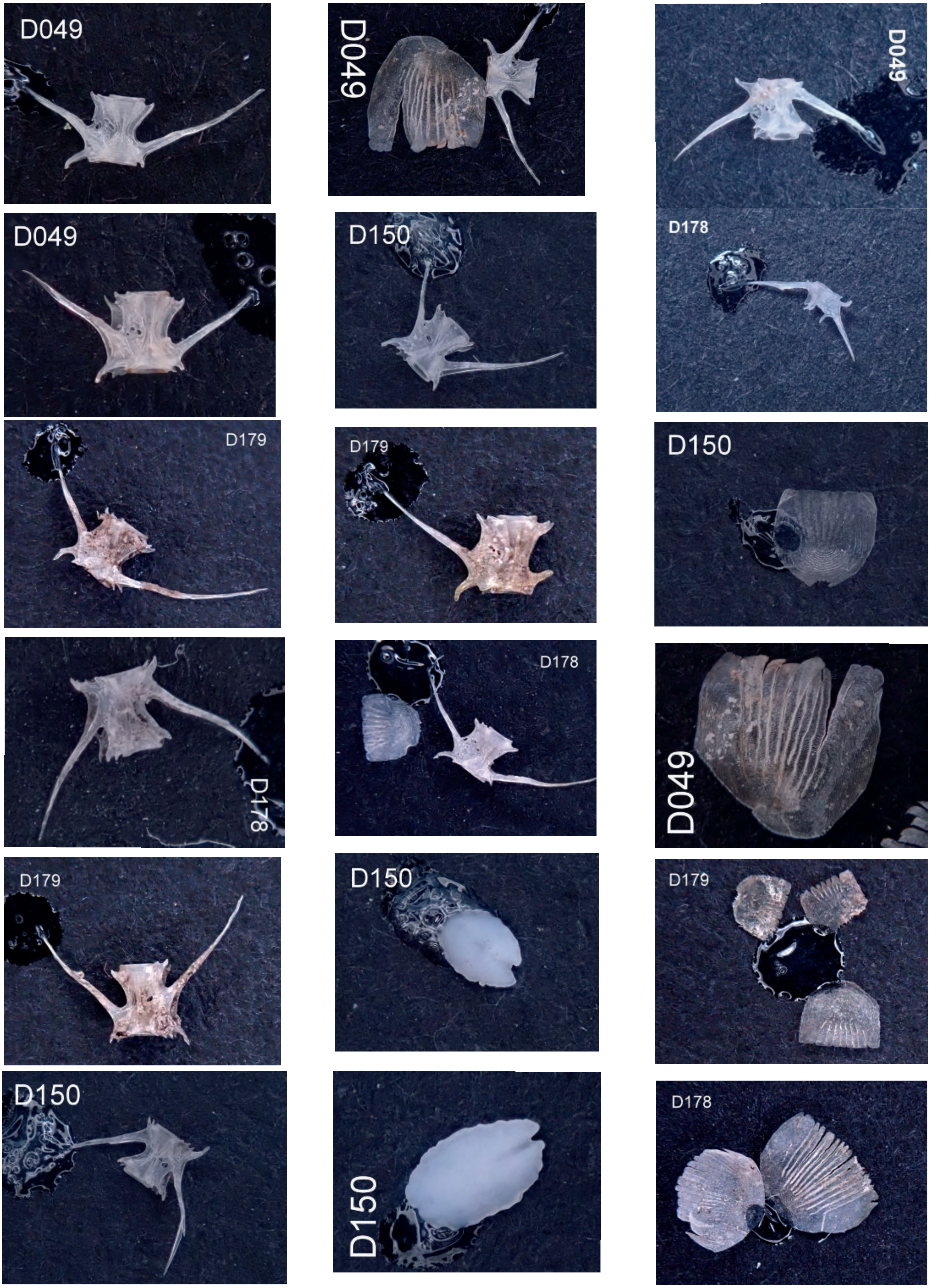

Thick-lipped grey mullet - AFORO website




Thin-lipped grey mullet - AFORO website



Thin-lipped grey mullet - Camphuysen & Henderson 2017

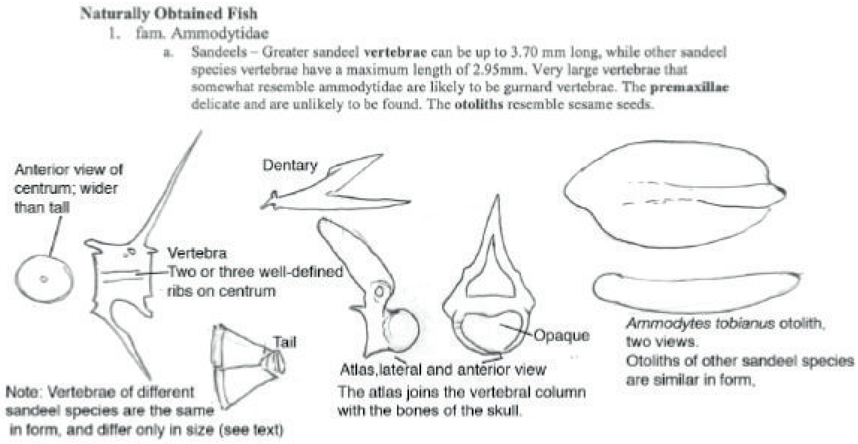



Mullet remains from CCOP samples

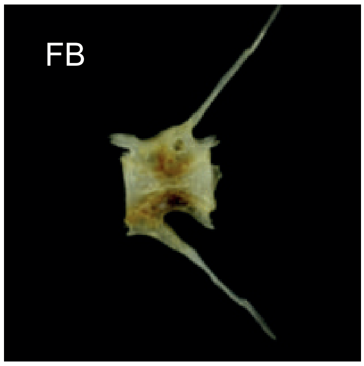
## Sand Eels

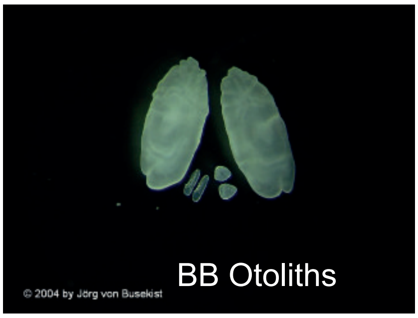
Sand eels are one of the keystones of marine food chains and large shoals occur around the coast and in deeper water. Although an unlikely prey item for otters when shoaling sand eels spend a considerable amount of time buried in the sand and this may be when they are vulnerable to otter searching and predation. Six species occur around the UK but the most likely to occur in the otter's diet are greater (*Hyperoplus lanceolatus*), and lesser (*Ammodytes tobianus*) sand eels and the sand lance (*Ammodytes dubius*). All remains are delicate and vertebrae were the only bones identified alongside a possible otolith. Key identifiers are the prominent pre- and post-zygaphopheses, the broad-based neural arch with both a neural foramen and a second larger aperture. The vertebrae are stongly waisted and have several lamellar ribs.

The otoliths are long and pointed - the example from D145 appears quite worn. This sample also contained remains of goby and flatfish




Hunt 2006





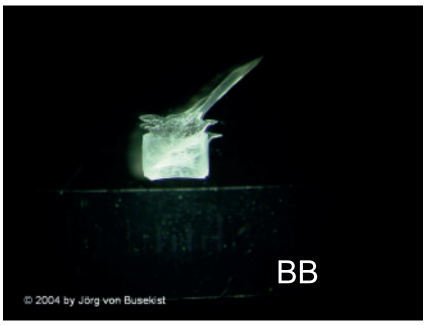
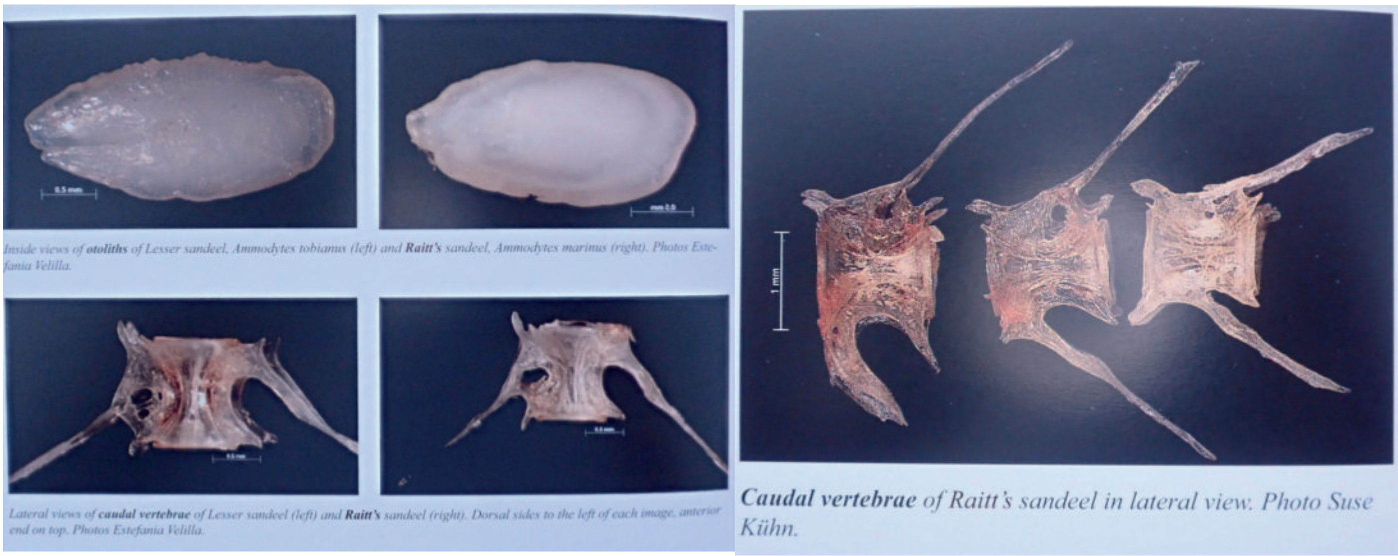



plate 1 anterior caudal

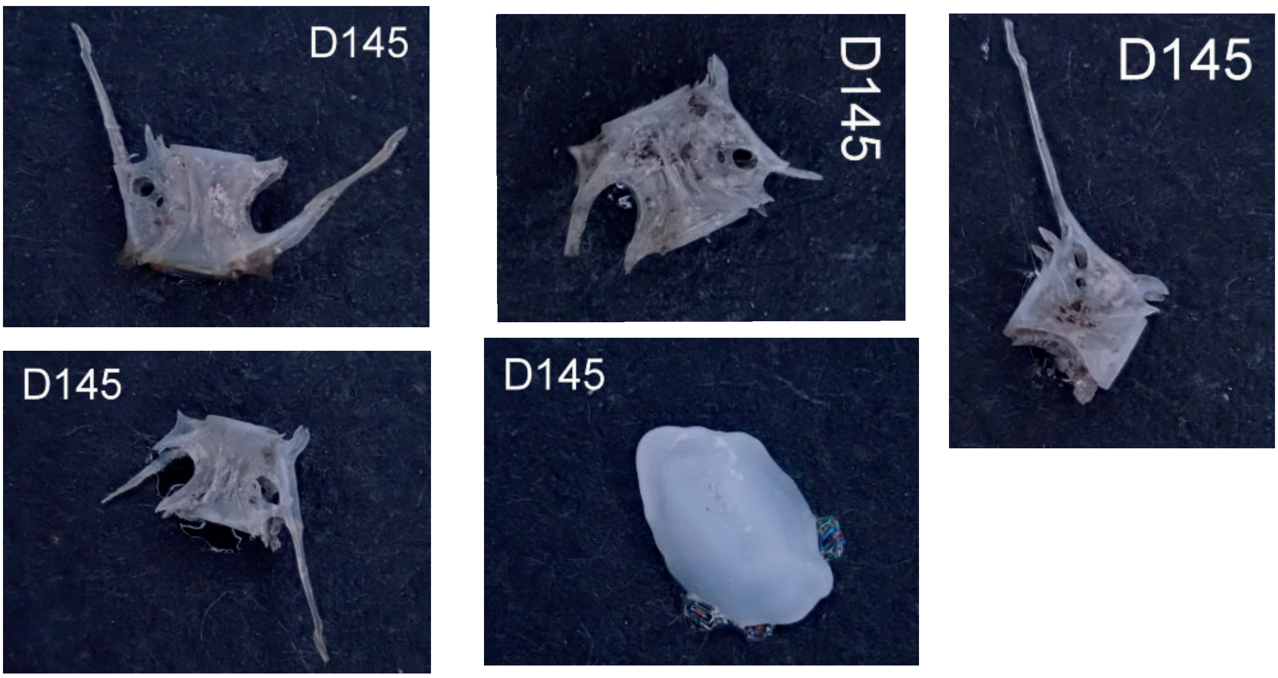
plate 2 mid caudal

0.25 cm

Watt et al. 1997




Camphuysen & Henderson 2017

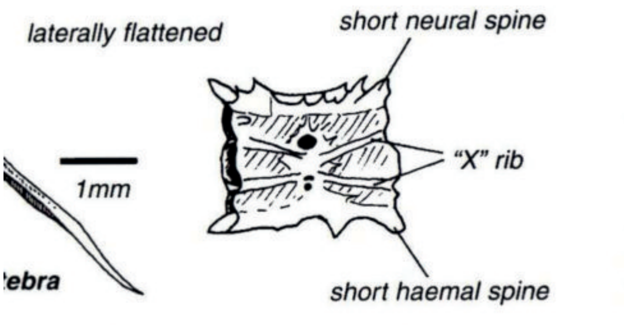



Sand eel remains from CCOP samples

## 15-Spined stickleback

15-Spined stickleback (*Spinachia spinachia*) is a completely marine fish not listed in either the marine fish or rock pool fish from CWT sources although there are records as unusual on the Cornish Rockpooling site and Aphotomarine. Also recorded from Helford marine survey of 1999. And the NBN atlas has records from around the coast of Cornwall.

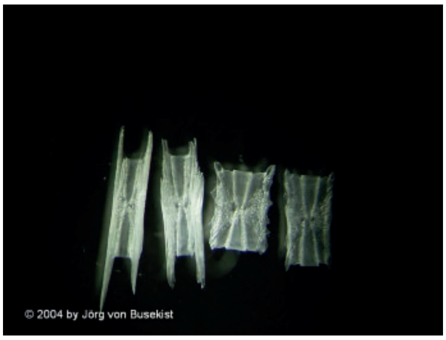
Key identifiable elements are the flattened rectangular vertebrae and the dermal scutes which appear heart-shaped in two dimensions although they have a clear central ridge



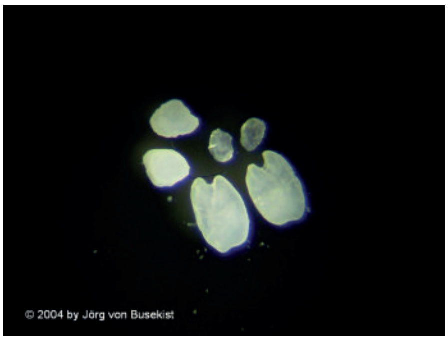

c. 15-spined Stickleback caudal vertebra

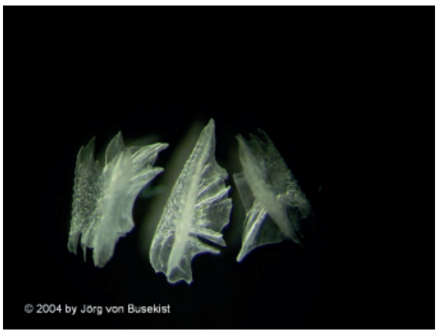
Conroy et al. 2005

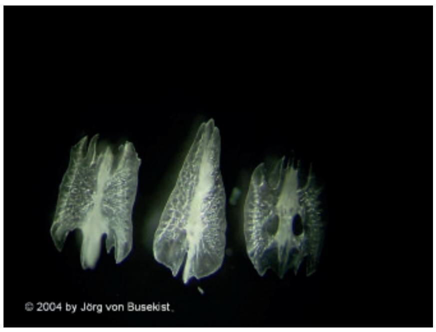
Elements from Bone Base

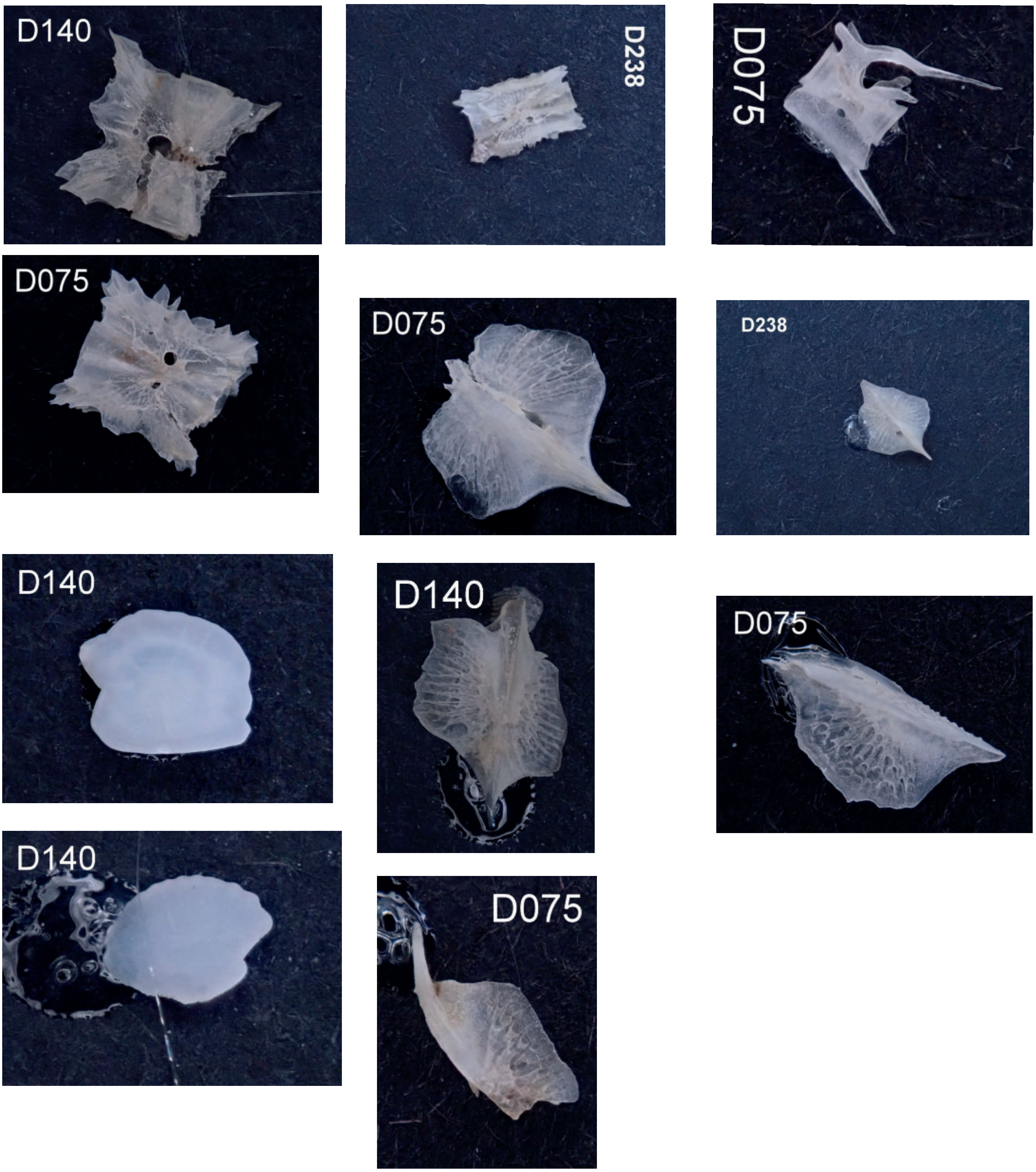







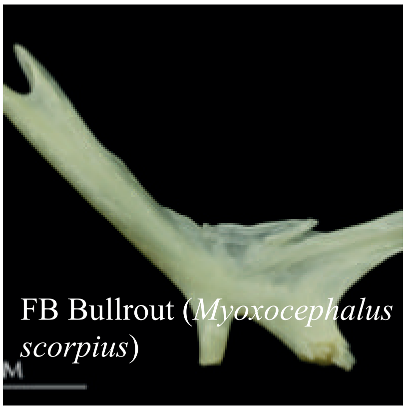



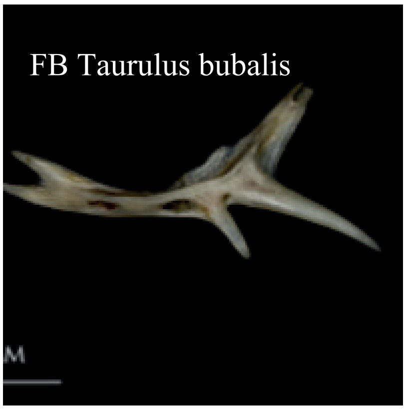



15-Spined stickleback remains from CCOP samples

## Other marine species

A large number of other marine species are present around the coast of Cornwall which were not identified in this project. This may be that the species were not present at the surveyssites, or at the time when collections were made. It may be that they are found in habitat inaccessible to otters through depth or exposure. It may also be evidence was not identified. Reference samples of many of the smaller benthic species are lacking and this is one area which requires attention. Naming of species can vary so stick with scientific nomenclature.



Marine Cottidae remains from CCOP samples

## Amphibians

Amphibians feature prominently in otter diet studies with strong seasonal bias towards late winter and early spring. Common frog (*Rana temporaria*), common toad (*Bufo bufo*) and palmate newt (*Lissotriton helveticus*) occur widely across Cornwall. It is not possible to differentiate between frog and toad without further study. Amphibian bones are generally denser and more heavily calcified than fish bones of an equivalent size - they appear less translucent and more yellow. Frog bones from larger animals are often fragmentary. When frog remains are present there are often many smaller bones from the feet. Key indicators are the rounded ends of leg bones and the fused ends of the ankle bones. The vertebral column is short and the vertebrae have long transverse processes that project perpendicularly to the column and the neural canal is large. Fragments of anuran upper jaw are characterised by small peg-like teeth and a longitudinal ridge.

Newt bones are generally less substantial than those of anurans. The vertebrae are rectangular with short, rearward swept transverse processes and disc-like articulating surfaces. Newt lower jaws (dentaries) are often found intact as are the radioulna (forearm) with a characteristic articulating socket.

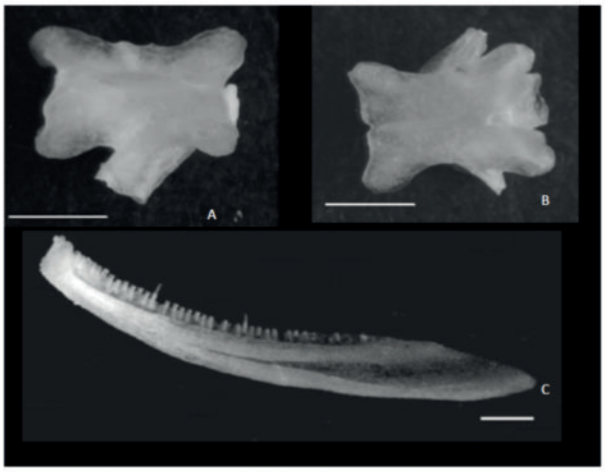
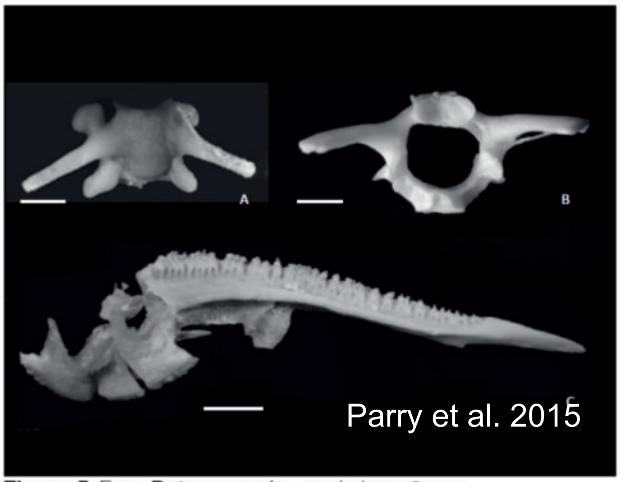


**Figure 2** Palmate newt *L. helveticus* - scale bars 1 mm.



Parry et al. 2015

**Figure 5** Frog *R. temporaria* - scale bars 2 mm.

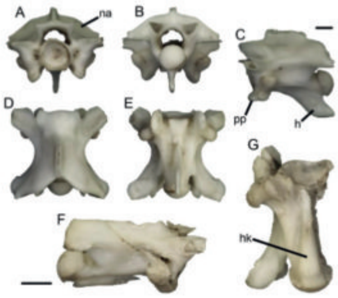


Figure S1. Trunk vertebra of *Natrix natrix* in anterior (A), posterior (B), left lateral (C), dorsal (D) and ventral (E) views; trunk vertebra of *Hierophis carbonarius* in right lateral (F) and ventral (G) views. Abbreviations: h, hypapophysis; hk, hemal keel; na, neural arch; pp, parapophyseal process. Scale bars equal 1 mm.

**Figure 1**. Trunk vertebra of *Lissotriton italicus* in dorsal (A), ventral (B) and left lateral (C) views; left humerus of *Rana dalmatina/italica* in ventral (D) and dorsal (E) views; right ilium of a juvenile *R. dalmatina/italica* in lateral (F) and medial (G) views; sphenetmoid of *Pelophylax* spp. in dorsal (H) and ventral (I) views; left ilium of *Pelophylax* spp. in lateral (J) and medial (K) views; left ilium of *Hyla intermedia* in lateral (L) and medial (M) views; right ilium of *Bufo bufo* in lateral view (N); left ilium of *B. bufo* in lateral view (O); left ilium of *Bufotes* sp. in lateral view (P). Abbreviations: ac, anterior condyle; ap, anterior process; c, centrum; d, diaphysis; dc, dorsal crest; ip, ischiadic process; is, incisura semielliptica; lp, lateral process; mc, medial crest; mn, median notch; n, neurapophysis; na, neural arch; pf, preacetabular fossa; pp, pubic process; sf, subcentral foramina; ts, tuber superior; vc, ventral crest; zc, zygapophyseal crest. Scale bars equal 1 mm.

Smirolodo et al. 2019

**Amphibian**

**Frog** - Vertebrae a distinctive shape. Bones look more solid than fish bones. (Not sure we can tell toads and frogs apart)

Suffolk Otter Group

**Teeth**

**Vertebra**

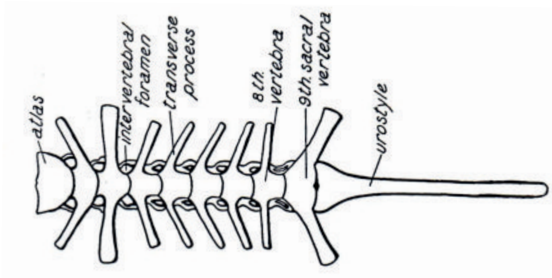
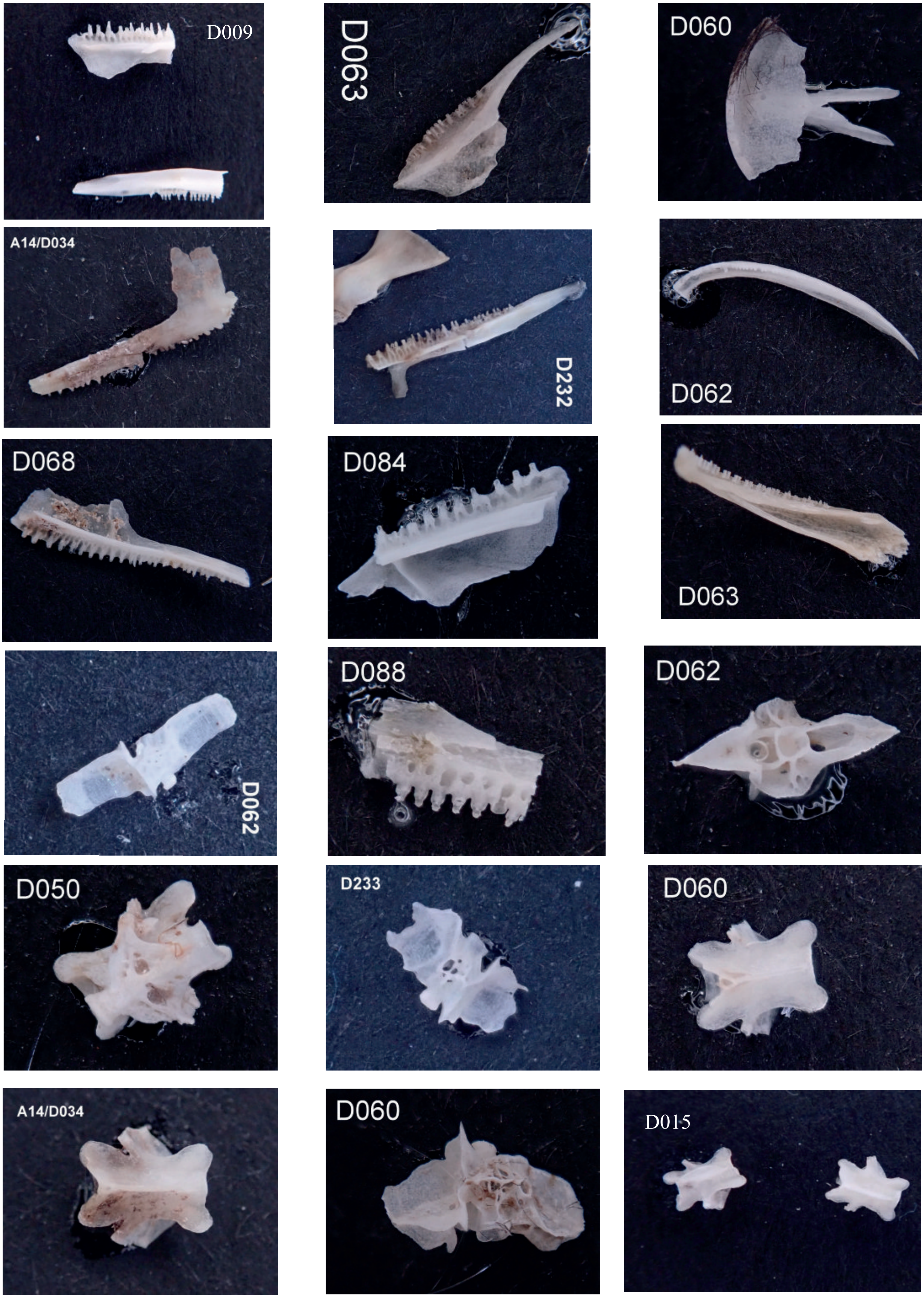



**Fig. 27.12.** Ventral view of vertebral column of frog.




Amphibian remains from CCOP samples

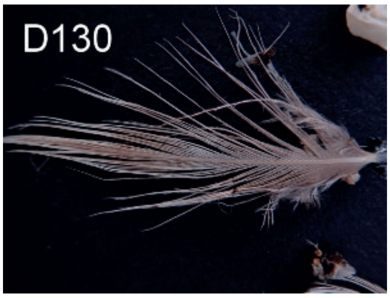

Amphibian remains from CCOP samples

## Birds and mammals

Birds and mammals have been widely recorded in otter diet. In the current study bird remains were much more common. Bird remains are readily identified if feathers are present in the spraint, other characteristic elements are beak and claw/leg remains. Mammals can be identified from teeth and fur. Bone fragments are often found but are small and difficult to separate unless the elements can be identified or if they are from a mature animal where bird trabeculae separate the internal spaces of the bones. Spongy bone occurs in both classes. Both bird and mammal bone is generally more calcified than fish bones and appears heavier and denser. Vegetation fragments can also be confused with mammal fur.

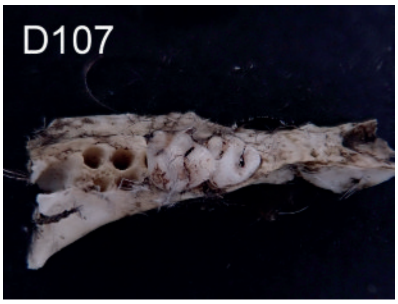

Feather remains - note downy material and quills





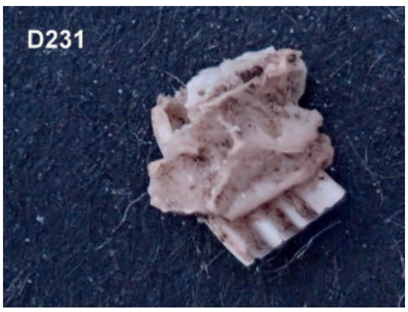


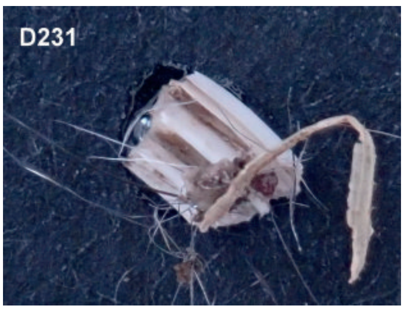




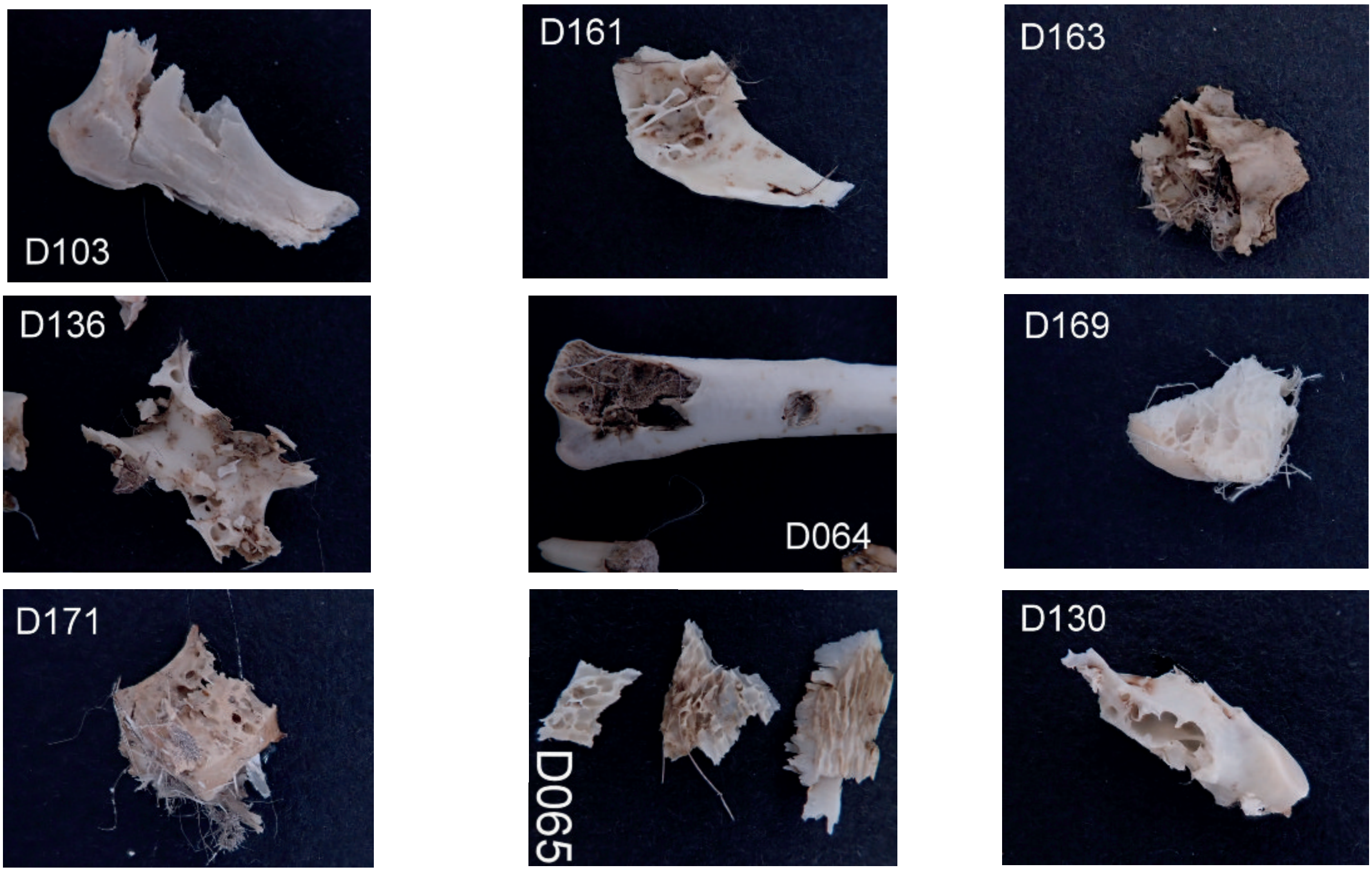

Wood mouse jaw and teeth




Vole teeth

Bird and mammal remains from CCOP samples




Bird and mammal bone fragments


Rodent limb bones


Mammal fur

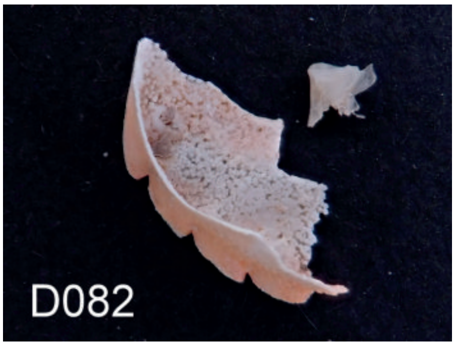

Bird claw sheathes and claws


Bird (moorhen) beak sheath

Bird and mammal remains from CCOP samples

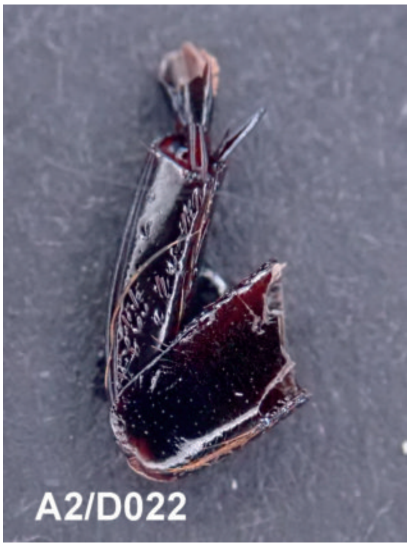
## Invertebrates

A wide range of invertebrate remains are found associated with otter spraint. These fall into three categories: firstly material from animals that have been directly consumed by the otter; secondly material that has been indirectly consumed - either eaten by the otter's prey or swept up alongside it; and thirdly animals that were present on the substrate when the spraint was deposited or which arrived afterwards. The first category typically includes water beetles in freshwater habitats (and crayfish where they are present) and crabs and larger crustacea in marine habitats. Some larger molluscs may also appear. The second category may include smaller crustacea and molluscs - both barnacles and tiny limpets and mussels have been found along with small shrimp and caddis larvae which seem too small to be targeted by an otter. The final category may include fly larvae and terrestrial beetles as well as plant material inadvertently collected with the sample. Where crabs have been eaten the spraint may be predominantly crab shell fragments.






Crab carapace and remains





Diving beetle remains


Grasshopper leg

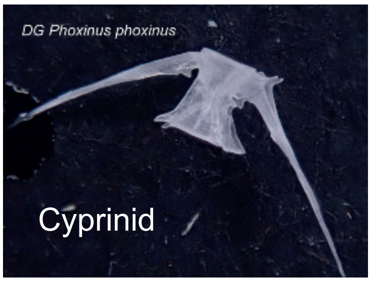

Small shrimp


Chiton shell fragment

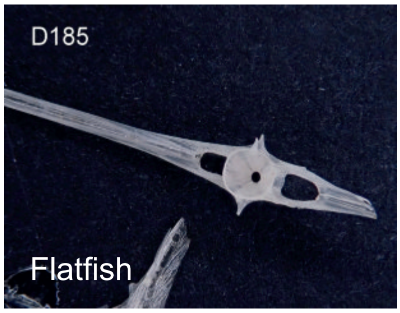

Caddis larva case

## Key component comparisons - Vertebrae

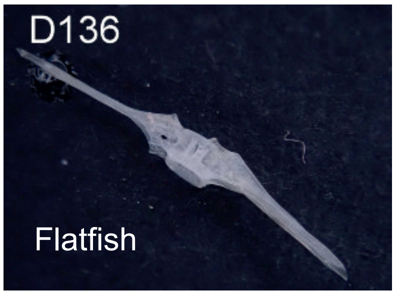
Small vertebrae are often poorly calcified and semi-transparent. Mammalian and amphibian veterbrae are denser and more yellow. Vertebrae from larger fish are often mangled. Look for where the spines leave the centrum (body) and the angle, also the presence and shapes of the zygopophyses (small projections at the front and rear of the centrum). Flatfish vertebrae have small lateral projections, salmonid vertebrae have a spongy appearance.



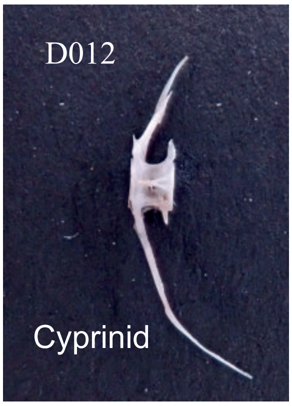








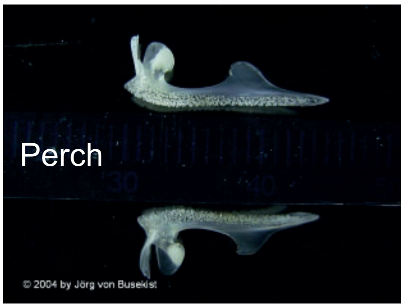





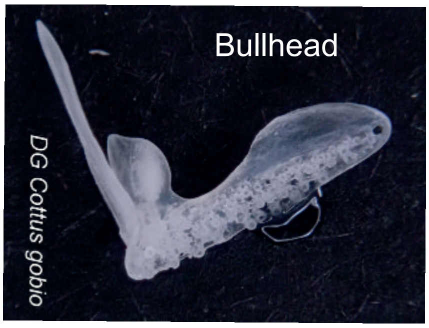




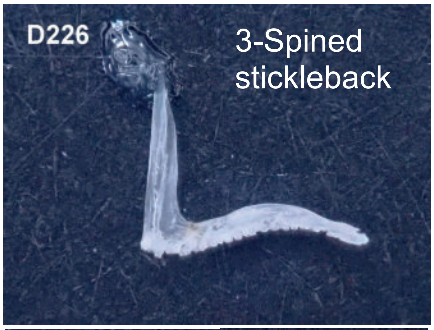
## Jaw structures and teeth

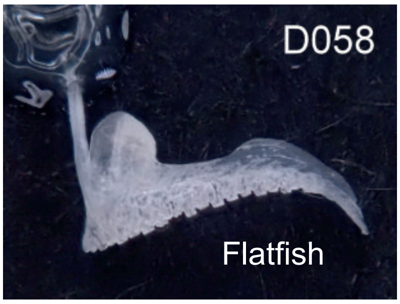







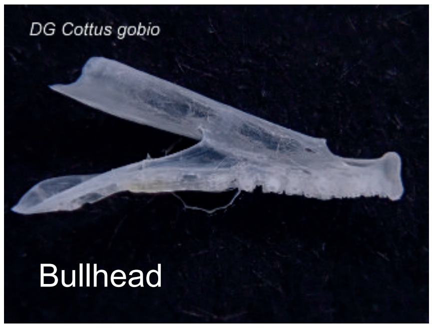


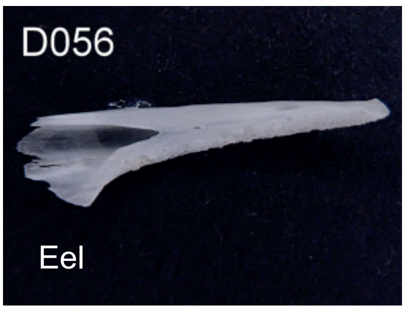



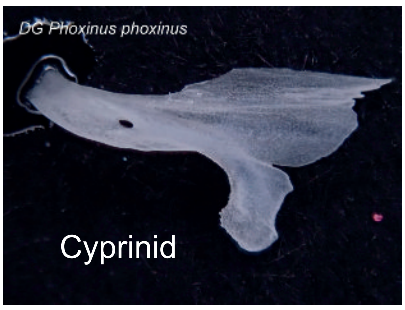


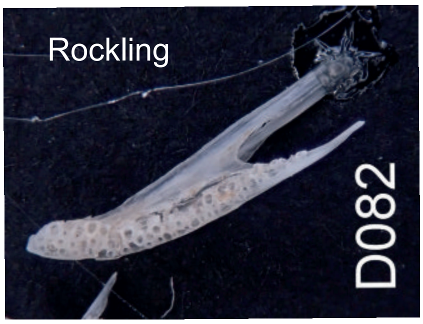






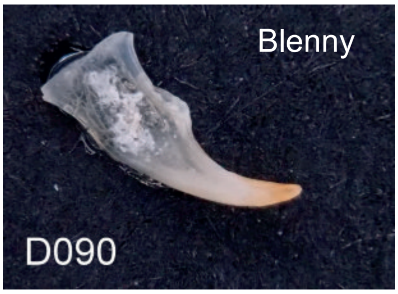
## Jaw structures and teeth (continued)

Pharyngeal (throat) teeth of cyprinids and wrasse are useful as they often survive intact and can be used to species level ID if necessary. Detached wrasse teeth are short, rounded blunt cylinders. Carp teeth from larger specimens are bean-shaped and distinctive. The hooked flat claw-like teeth of blenny are often the only clearly identifiable remains. Salmonid teeth are conical and pointed. Frog (and toad) jaws are often fragmentary but have a marked internal ridge below the peg-like teeth.

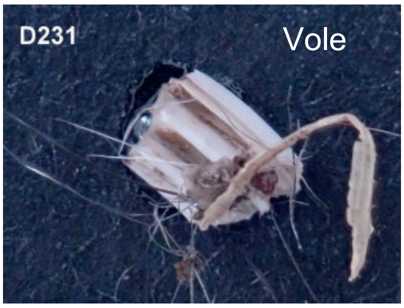




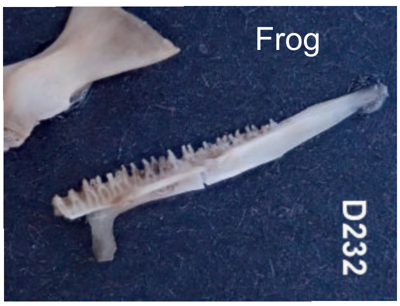




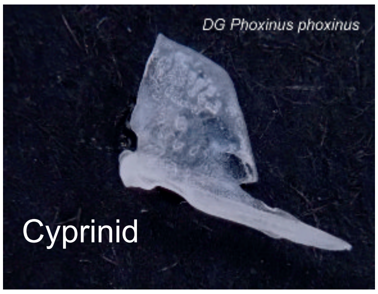


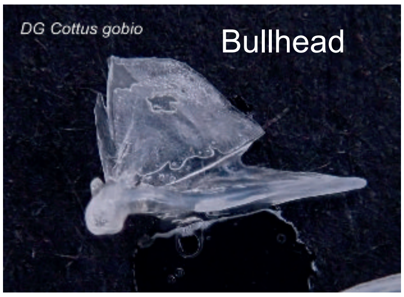


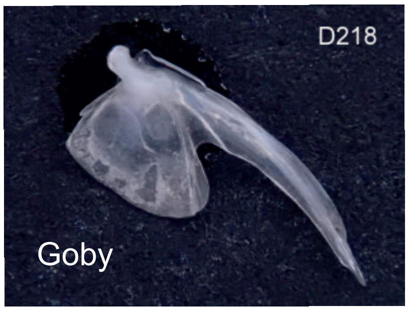
## Quadrate





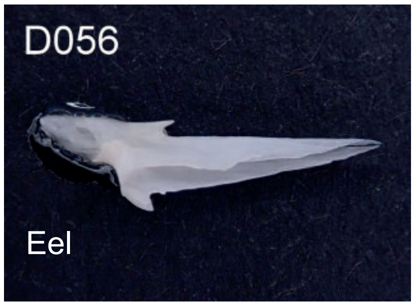






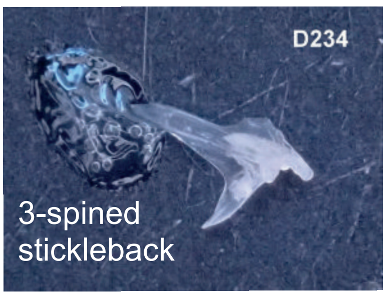
## Articular

Eel, bullhead and goby are particularly distinctive.









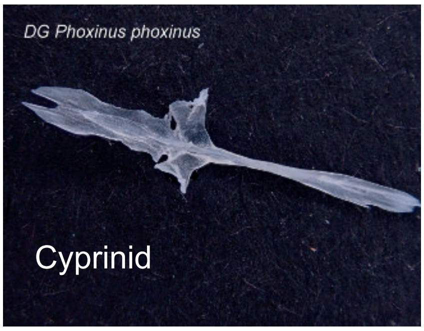


## Parasphenoid

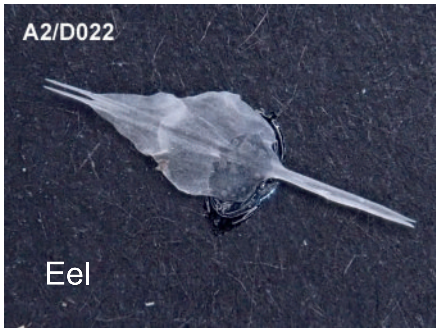
Parasphenoid bones from the skull are very useful for identifying smaller specimens where they are often intact.


Goby

Bullhead



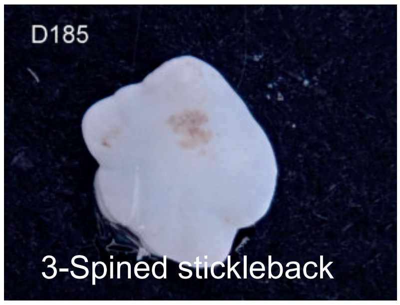
Cyprinid



Eel

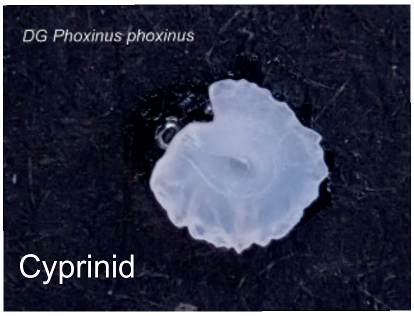
## Otoliths

Otoliths, especially from smaller specimens, often survive intact in spraint and may give indications of prey numbers as well as identity. The small (sub 2 mm) bones are noticeably white. They may be somewhat smoothed off but well preserved examples may be used for both species-level identification and aging of prey. For larger prey the head may not be eaten so otoliths will not occur in the spraint. Some of the less distinctive otoliths (e.g goby and 3-spined stickleback) are not suitable as the sole indicator of a species' presence.

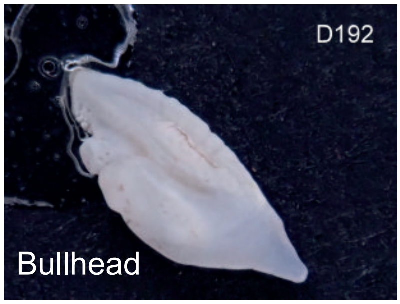


3-Spined stickleback

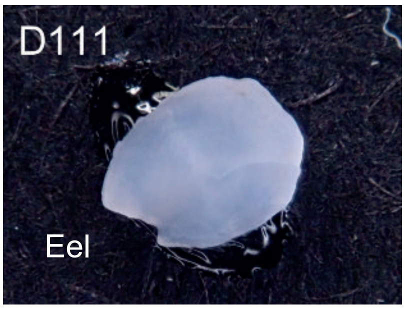
Salmonid



Cyprinid



Bullhead

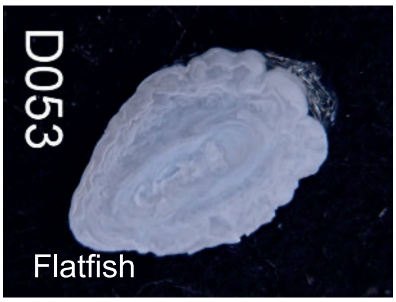


Eel

Goby

Mullet

Sand eel

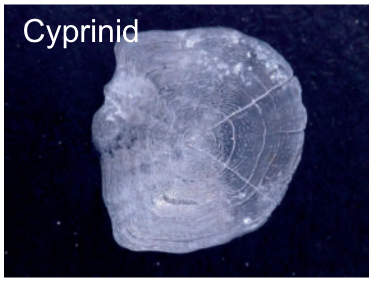


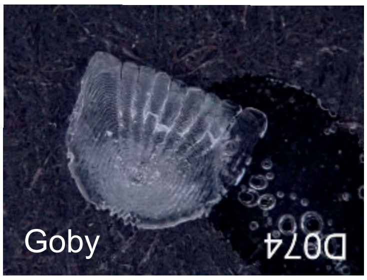
Flatfish

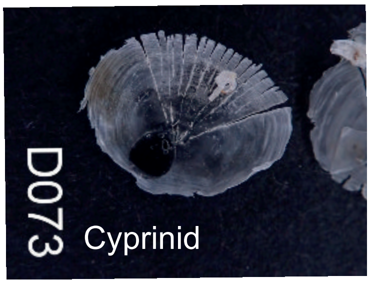
Wrasse

## Scales

Scales appear in relatively few spraints from estuarine and marine sites - possibly because many prey species do not have scales, or at least they are miniscule, as in the eel. It is also possible that either the otters avoid eating scales of larger prey or they are digested. Most recovered scales were from freshwater sites - cyprinid scales break up into triangular segments, salmonid scales are round or ovoid with no clear segmentation. Perch scales with their lobed posterior edge are characteristic and not to be confused with the much smaller goby scales with the squared off edge. Small oval scales with noticeable ctenii (comb) are from flatfish.

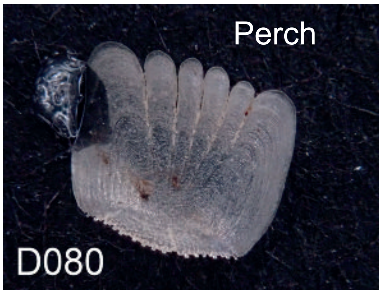




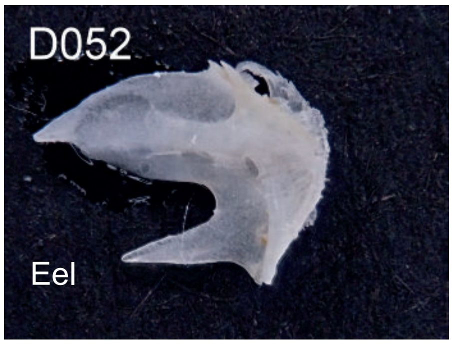




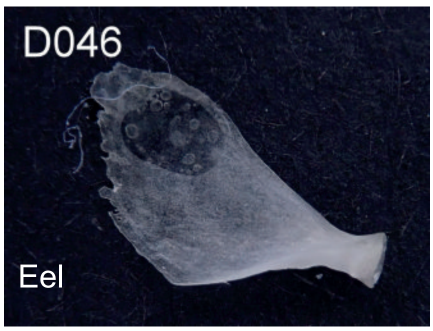

## Other distinctive remains

3-Spined stickleback produce a number of distinctive remains from the dorsal spines and the mask-like plate with which they articulate. Long cross-shaped bony plates also occur. Thoracic vertebrae from larger eels are often broken to produce a C-shaped fragment.



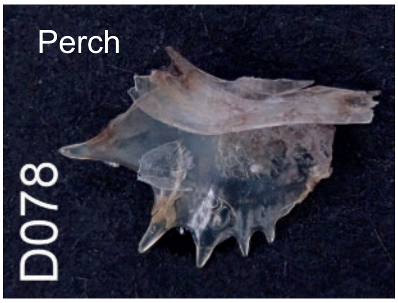




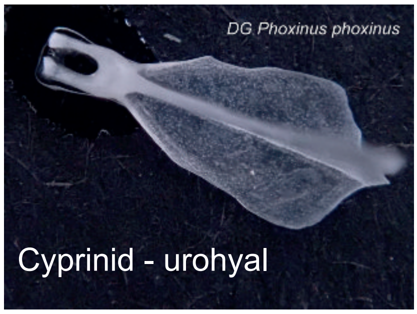
## Other distinctive remains (continued)

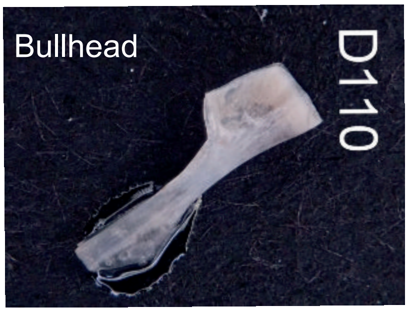
Flatfish urostyles are C-shaped with a thickened internal rim. Bullhead opercula have a distinctive curved spine and perch opercula have a curved spiney border (although this can be similar to some marine members of the perch family such as sea bass). Although vertebrae from the 15-spined stickleback are distinctive they are not commonly found but the heart-shaped dermal scutes (bony plates) are characteristic. The small axe-shaped ceratohyal bone of gobies is similar to that of the bullhead apart from the triangular raised area on the ‘handle’.

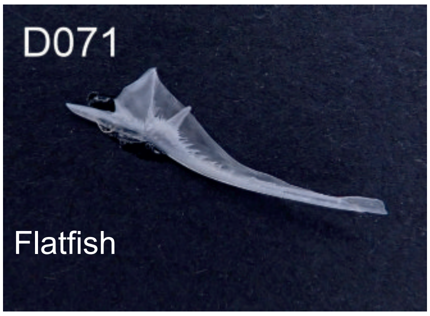









## Appendix 1. Structure of fish skull and vertebrae

Watt et al. 1997

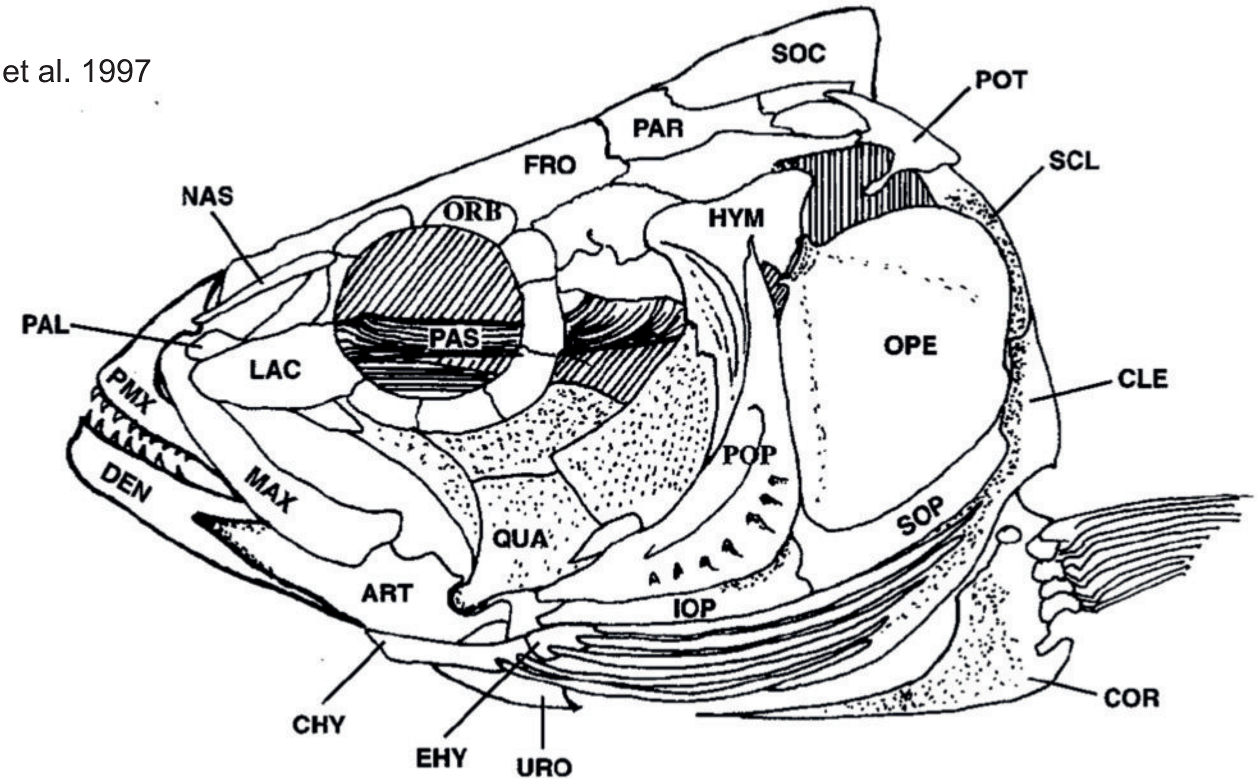
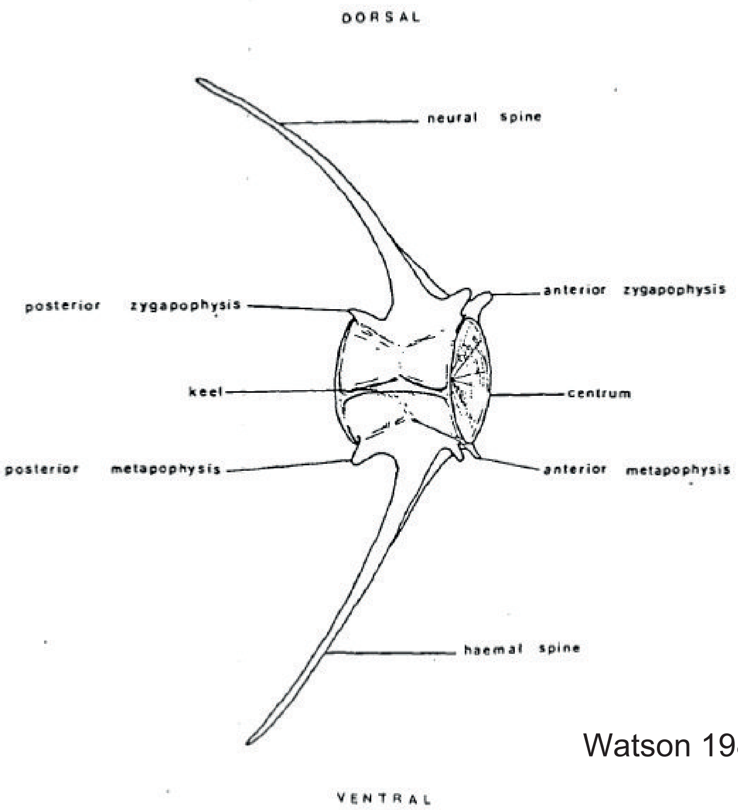



Figure 1. Skull of a generalized teleost fish (after Gregory, 1933). ART, articular; CHY, ceratohyal; CLE, cleithrum; COR, coracoid; DEN, dentary; EHY, epihyal; FRO, frontal; HYM, hyomandibular; IOP, interopercular; LAC, lachrymal; MAX, maxilla; NAS, nasal; OPE, opercular; ORB, orbitals; PAL, palatine; PAR, parietal; PAS, parasphenoid; PMX, premaxilla; POP, preopercular; POT, posttemporal; QUA, quadrate; SCL, supracleithrum; SOC, supraoccipital; SOP, subopercular; URO, urohyal.

The Caudal Vertebra of a Fish.




Watson 1986

## Appendix 2. Notes on spraint preparation and interpretation.

Collection and preparation of spraint samples is dealt with in detail in a number of the references, particularly Conroy et al. (2005). The aims of the CCOP did not require rigorous separation or ageing of spraints but if this is necessary known spraint sites can be cleared of older spraints and monitored regularly for fresh activity. CCOP samples were frozen after collection for convenience but they can also be dried prior to processing if DNA analysis is not required. Spraints were soaked in either dental cleaner (Steradent) or a saturated solution of biological washing powder (Biotex) for 1 or 2 hours before agitation and rinsing under running water in a cheap tea strainer. Some particularly dirty samples were re-treated and/or placed in an ultrasonic bath for 2 minutes before sieving. Samples were air-dried on clean paper before analysis under a x10 dissecting microscope on a black card background. Identifiable components were glued to black card using entomological cement (Insect body cement, Watdon Ltd.) Before photography using a Sony T5 digital camera.

No attempt was made to assess the relative importance of the prey items in individual samples. Firstly, no efforts were made to ensure each sample was a single spraint, secondly it is difficult if not impossible to identify every prey item in a spraint or to be sure how many individuals are represented, especially for larger prey which may be incompletely eaten and heavily damaged. It is possible to extrapolate prey sizes from suitable remains but these may not be present in every sample. Smaller prey may be quantified to some extent by counting jaw structures or otoliths (and dividing by 2) to come up with a minimum number of individuals.

Otters use spraint to mark territory and, as such, often deposit a series of small spraints at frequent intervals. The gut transit time is rapid but variable (Ruff 2007). They also move over large areas. Therefore it is not possible to be sure that a sample represents a particular meal or even feeding area. For the purposes of the CCOP this was not important but it needs to be considered if spraint analysis is being used to address more detailed dietary questions.

## Appendix 3: Abbreviations used in the text.

| | |
|---|---|
| AFORO | Analisi de Formes d'Otolits website. |
| BB | Bonebase website |
| CC | Cornwall Council |
| CWT | Cornwall Wildlife Trust |
| EA | Environment Agency |
| FB | Fishbone website |
| IFCA | Inshore Fisheries and Conservation Authority |
| NBN | National Biodiversity Network |
| RDB | Red Data Book |
| WRT | West Country Rivers Trust |

## Bibliography and references

AFORO Analisi de Formes d'Otolits website. Available at: http://aforo.cmima.csic.es/ [Accessed 24th August 2020]

Brager, Z. & Moritz, T. (2016) A scale atlas for common Mediterranean teleost fishes. Vertebrate Zoology 66(3): 275-386

Busekist, J. von (2008) Bone base Baltic Sea. Available at: http://www.bioarchiv.de/bonebase/boneba1.html [Accessed 5th August 2020]

Campana, S.E. (2004) Photographic atlas of fish otoliths of the Northwest Atlantic ocean. NRC Research Press, Ottowa, Ontario.

Camphuysen, C.J. & Henderson, P.A. (2017) North Sea fish and their remains. Royal Netherlands Institute for Sea Research & Pisces Conservation Ltd.

Gainey, P.A. (1999) A survey of the Pisces (fish) of the Helford estuary. HVCMA report for WWF and English Nature.

Gainey, P.A. (2009) Freshwater fish. In CISFBR, Red data book for Cornwall and the Isles of Scilly, 2nd Edition. Croceago Press, Praze-an-Beeble

Conroy, J.W.H., Watt, J., Webb, J.B. & Jones, A. (2005) A guide to the introduction of prey remains in otter spraint. The Mammal Society.

Day, M.G. (1966) Identification of hair and feather remains in the gut and faeces of stoats and weasels. J. Zool. 148: 201-217.

Hermsen, J. & Maarseveen, A. van (2011) A diet study of the Eurasian otter (Lutra lutra) based on spraint analysis. Niewold Wildlife Infocentre, The Netherlands.

Hunt, V. (2006) Larus fuscus and Larus argentatus pellet and bolus analysis guide. Unpublished report NIOZ available at: http://gull-research.org/papers/papers3/Larus%20fuscus%20and%20Larus%20argentatus%20Pellet%20and%20Bolus%20Analysis%20Guide.pdf [accessed 10th August 2020]

Knollseisen, M. (1996) Fischbestimmungsatlas: als Grundlage fur nahrungsokologische Untersuchungen. BOKU Reports on wildlife research and game management

Leopold, M.F., van Damme, C.J.G., Philippart, C.J.M., Winter, C.J.N. (2001) Otoliths of North Sea Fish. Available at: https://otoliths-northsea.linnaeus.naturalis.nl/ [Accessed 24th August 2020]

Nottingham University Archaeological Fish Resource. Available at: http://fishbone.nottingham.ac.uk/collections/browse [Accessed 5th August 2020]

Parry, G.S., Yonow, N. & Forman D. (2015) Predation of newts (Salamandridae, Pleurodelinae) by Eurasian otters Lutra lutra (Linnaeus). Herpetological Bulletin 132: 9-14.

Ruff. K. (2007) Optimising the nutrition of captive Eurasian otters (Lutra lutra). PhD. Thesis, University of Hanover

Schofield, P.J., Williams, J.D., Nico, L.G., Fuller, P. and Thomas, M.R. (2005) Foreign nonindigenous carps and minnows (Cyprinidae) in the United States – A guide to their identification, Distribution and Biology. USGS Scientific Investigations Report 2005-5041

Smiroldo G, Villa A, Tremolada P, Gariano P, Balestrieri A, Delfino M (2019) Amphibians in Eurasian otter Lutra lutra diet: osteological identification unveils hidden prey richness and male-biased predation on anurans. Mammal Review 49: 1162 240–255

Spinner, M. et al (2016) Key role of scale morphology in flatfishes (Pleuronectiformes) in the ability to keep sand. Sci. Rep. 6, 26308; doi: 10.1038/srep26308)

Suffolk Otter Group (2016) An introduction to otter spraint analysis. Available at: https://suffolkotters.files.wordpress.com/2016/06/intro-to-spraint-analysis-for-web-13-3-17.pdf [Accessed 5th August 2020]

Watson, H.C. (1986) The feeding ecology of the European otter (lutra lutra l.) in a marine environment. Durham theses, Durham University. Available at: http://etheses.dur.ac.uk/6777/ [Accessed 5th August 2020]

Watt, J., Pierce, G.J. & Boyle, P.R. (1997) Guide to the identification of North Sea fish using premaxillae and vertebrae. ICES Cooperative research report No. 220. International Council for the Exploration of the Sea, Denmark.

Webb, J.B. (1980) Otter spraint analysis. The Mammal Society.
Wheeler, A. (1969) The fishes of the British isles and North-West Europe. Macmillan, London

## Acknowledgements:

This manual was produced during the Cornwall Coastal Otter Project and would not have been possible without the inspiration and support of a wide range of people. It would be difficult to name-check everyone involved but many of the images were taken from samples collected by an enthusiastic bunch of volunteer surveyors including Hilary Marshall, Teagen Hill, Adrian Langdon, Matt de Villiers, Jenny Heskett, Rob Wells, Becky Prudden, Ian McCarthy, Keith Brisland, P.McMurdie and the RSPB volunteers. Rebecca Smith helped develop and co-ordinate the Project as part of her final year dissertation.

Guidance from Paul Chanin, Kate Hills, Rob Williams, Dan Forman, Ellie Knott, Johnny Birks, Ken Hutchinson, Mary-Rose Lane and Richard Woolnough got us pointed in the right direction. Support from Sheila Hamilton-Dyer, Naomi Sykes, Andrew Jones, Hannah Russ, Rebecca Nicholson, Rebecca Reynolds and all the archaeologists gave us a different spin on bone analysis and a huge number of connections and resources. Giles Rickard and his team at Westcountry Rivers Trust helped us source reference samples, Jorge von Busekist was kind enough to allow use of his amazing images from Bonebase Baltic Sea. Gavin Parry, Douglas Herdson, Matt Slater, Enid Alison, Heather Buttivant and Tony Atkinson all helped with identification of those tricky bits and pieces. I would also like to thank the Environmental Records Centre for Cornwall and the Isles of Scilly, Cornwall Wildlife Trust, The University of Exeter, The Lost Gardens of Heligan, Cornwall Mammal Group and the Alexanda Fund for providing data, facilities and financial support during the Project. Most of all I would like to thank Mary Groves for her understanding, and support during the hours I have spent staring down a microscope or tapping on a computer.

Dave Groves

August 2020

Copies of this manual are available at cost from Cornwall Mammal Group or can be downloaded from our website **cornwallmammalgroup.org**