

**First record of brown  
colouration of Atlantic  
cod (*Gadus morhua*, L.)  
from the North Sea**

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**Abstract**

This paper reports the biological characterisation of a specimen of Atlantic cod (*Gadus morhua* L.) with a unique brown colour, which is the first fish of this species with such a colouration recorded from European waters. It was caught in the coastal zone of the North Sea in June 2011. This ‘brown’ cod fish weighed 1074.3 g and had an overall length of 422 mm.

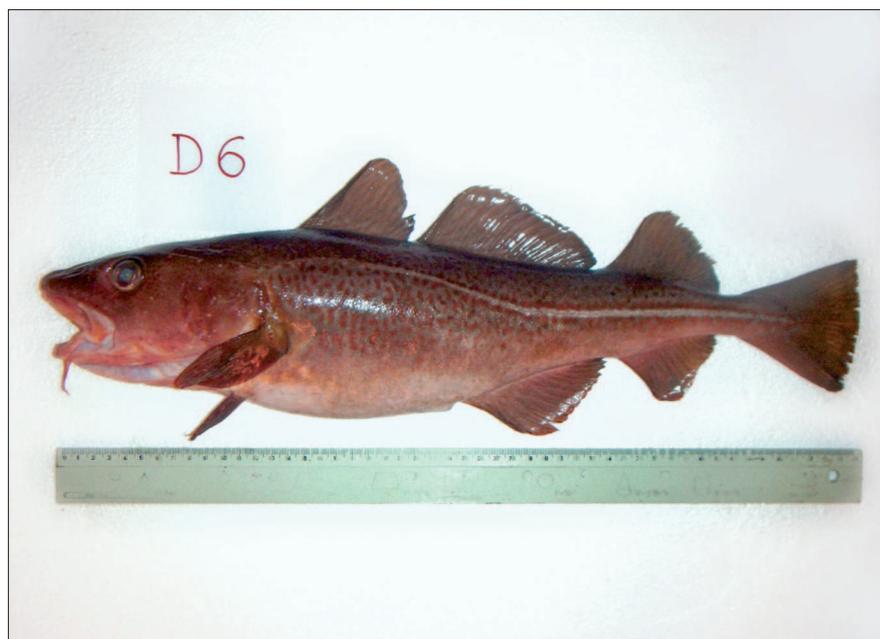
Although brown-coloured cod have been known to occur sporadically in the North Sea and anecdotally referred to by local fishermen, the authors were unable to find any scientific publications relating to it. This lack of publications on this unique colouration in the cod prompted the authors to communicate this finding.

On 22 June 2011, one specimen of cod with a unique brown coloration was caught in the North Sea at a depth of 18 m (GPS: 56°45,00'N; 007°24,50'E). This specimen was a female with a total length of 442 mm and a mass of 1074.3 g. To estimate its age, sagittal otoliths were prepared according to the procedure described by Secor et al. (1992). Samples were examined under a light microscope by two researchers independently, who were unaware of the fish's size at the time of the examinations. The fish was aged as 2 years old. According to Ursin (1984) and Thorsen et al. (2010) cod fish from the North Sea reach a length between 356 and 412 mm at the age of 2 years, whereas in the first year of life they reach a length of 150 mm. This brown cod was longer at the same age than normally coloured cod fish from this location. The differences in the growth rates of cod have been found to be affected by differences in water temperature among the various catching areas, food quality and availability, and other factors that have been difficult to quantify in population studies of this species (Brander 1995).

Macroscopic and histological analysis of the gonads (after the method described by Vitale et al. 2006) showed that this female brown cod was sexually immature with small oocytes containing a dense basophilic cytoplasm, a central nucleus with a few large nucleoli around its edge. In the North Sea, cod fish usually reach sexual maturity at the age of 5–6 years (Oosthuizen & Daan 1974, Rijnsdorp et al. 1991). According to Vitale et al. (2006) only 24 to 39% fish in age class 2 are mature.

This 'brown' fish had its dorsal surface coloured dark brown to red with sides slightly brighter but still of an intensive brown colour; the ventral surface was bright but not white. The dorsal surface, top of the head and sides of the body were covered with many dark spots. The fins were dark brownish-red in colour and the first rays of the pectoral fins were intensively red. The iris was gold-coloured (see Figure 1).

The body of this fish was elongated, strongly humped at the first dorsal fin, and the head was large and wide with an elongated snout. At the tip of the chin there was one well-developed barbel. The caudal fin was vertically straight. The fish had three well-separated dorsal fins and two well-separated anal fins. There were no hard rays in these fins. The readily visible pale lateral line arched over the pectoral fins and extended well onto the head. The body was covered with fine, deeply rooted cycloidal scales.



**Figure 1.** Atlantic cod (*Gadus morhua*) with brown colouration caught in the North Sea (female, TL = 422 mm, age = 2 years)

The terminal mouth was relatively large with the lower jaw (mandible) shorter than the upper one (maxilla). The eyes were of medium size.

The stomach of this fish was about 60% full, and the content comprised mostly benthic organisms. About 50% of the stomach content consisted of brittle stars – echinoderms from the class Ophiuroidea. The next most important components were opossum shrimps of the genus *Neomysis*, (Gammaridae, Mysidacea). Other, less important components of the diet were edible or brown crabs (*Cancer pagurus*), vascular plants, algae and detritus. This is not the typical diet of normally coloured cod in this region. Generally, the North Sea cod consumes a variety of fish prey (up to 59% of the stomach content weight) and only occasionally eats other food. For example, echinoderms were found only in 10.4% of stomachs, making up 2.6% by weight of the diet (Kikkert 1993, Magnussen 2011). The colour of this ‘brown’ cod could be related to the atypical diet, 50% of which consisted of brittle stars and other benthic invertebrates. Morris & Green (2002) suggested that the similar brown colour of the north-west Atlantic cod from Gilbert Bay was related to their diet, which was composed mainly of benthic invertebrates such as Mysidacea, Amphipoda and some crab species. According to Gosse & Wroblewski (2004) and Sherwood & Grabowski (2012) the brown colour of the cod’s skin that is characteristic

of the North American coastal zone populations is related to the diet rich in carotenoids, found in marine benthic invertebrates. The carotenoids leutin and taraxanthin were found to be present in the skin of the fish specimen under scrutiny here (Goodwin 1950). It has been found that the combination of carotenoids and proteins can impart a brown colour to the skin of fish (Fox 1976, Ahilan & Prince Jeyaseelan 2001). Also, the colour of fish skin may change following the consumption of plant-synthesised carotenoids (Bagnara & Hadley 1973).

The fact that a cod with this unique brownish-red colouration was caught in the North Sea suggests that, as in the case of the north-west Atlantic cod, fish of such a colour may become more common in the near future. It would be interesting to investigate the reasons for the appearance of this unique colouration in cod fish and to analyse in detail their growth, condition and population structure on a larger number of individuals.

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