Unusual shallow inshore records of Cornish blackfish
*Schedophilus medusophagus* (Stromateoidei: Centrolophidae)
from Galician waters (NW Spain)

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**Abstract:** Three shallow inshore records of Cornish blackfish *Schedophilus medusophagus* from Galician waters (NW Spain) are reported. *S. medusophagus* is a relatively rare mesopelagic species in the NE Atlantic. Adult specimens are mainly found in medium-depth waters (300-900 m). Their presence in shallower coastal waters is very unusual. An historical review of North Atlantic shallow inshore records was made. Reproductive and stomach content analyses were investigated and related to two proposed inshore migration hypotheses. Resulting from these investigations, the first description of gametogenesis and gonadal development organization of this species is presented. Ovary development was found to be group-synchronous, with a highly synchronous population of larger follicles. Testicular tissue was found to be lobular type. Since no conclusive evidence was found to support either of the two proposed hypotheses an additional hypothesis related to increasing sea water temperatures was proposed.


**Keywords:** Cornish blackfish ● Centrolophidae ● shallow water records ● reproduction ● stomach content ● Galicia
**Introduction**

The family Centrolophidae includes 27 species worldwide, 4 of which occur in Atlantic European waters (Quéro et al., 2003): *Centrolophus niger* (Gmelin, 1789), *Hyperoglyphe perciformis* (Mitchill, 1818), *Schedophilus medusophagus* Coco, 1839, and *Schedophilus ovalis* (Cuvier, 1833).

The Cornish blackfish *Schedophilus medusophagus* is a mesopelagic species found in temperate waters of the north Atlantic and western Mediterranean (Haedrich, 1986). There is little information available on the vertical distribution and behaviour of the Cornish blackfish. The study of vertical migrations of *S. medusophagus* is further complicated because they undertake it at night (Badcock, 1970). Juveniles of this species (up to 20 cm total length TL), tend to occur in shallower water than adults and often in association with jellyfishes or man-made fish aggregating devices (FADs) (Haedrich, 1986; Dulčić, 1998). However, adults live in deeper waters, mainly from 300 to 900 m depth (Quigley, 1984).

The characteristics of the vertical distribution of meso- and bathypelagic fishes are also poorly known. For example, in Stromateoid fishes, marked changes occur when maturity approaches, often associated with the migration from the surface layers to deeper layers where adults are more frequently encountered (Haedrich, 1969). In the case of Centrolophid fishes, larvae occur in the plankton, and juveniles and young adults are commonly associated with pelagic medusae or floating objects, whereas adults live in deep water at the edge of the continental shelf, in submarine canyons or associated with oceanic islands (Haedrich, 1986).

New and also unusual records of *S. medusophagus* have been reported by several authors (Onofri, 1986; Dulčić et al., 1999; Corsini-Foka & Frantzis, 2009; Milana et al., 2011). All these records have been justified in different ways, most of them connected to environmental factors. For the congeneric *S. ovalis*, Corsini-Foka & Frantzis (2009) suggested the colonization of vacant niches in a new area. Onofri (1986) noted the concurrence of juvenile stage *S. ovalis* and *S. medusophagus* in the Adriatic Sea during an invasion of the medusa *Pelagia noctiluca* (Forsskal, 1775). Dulčić et al. (1999) considered that the presence of *S. ovalis* and *S. medusophagus* in the Adriatic was due to water warming. Milana et al. (2011) also suggested that the presence of *S. medusophagus* in the Central Tyrrhenian Sea could be an indicator or example of the biological consequences of environmental and climatic change.

The presence of adult specimens of *S. medusophagus* in coastal shallow inshore waters is an unusual behaviour that has been poorly documented. The aim of this paper is to describe the unusual records of three specimens of *S. medusophagus* found in shallow inshore waters of Galicia (NW Spain) and to investigate the possible causes that might explain this rare phenomenon. Although the sample size analyzed was too small to draw a firm conclusion, the probable origin of these unusual records was investigated based mainly on feeding and reproductive analyses.

**Material and Methods**

Three specimens of *S. medusophagus* were caught in coastal shallow locations of Galician waters (NW Spain) by commercial (gillnets) and recreational fishers (rod and line) (Fig. 1). The first specimen (506 mm TL), was caught on 17th February 2009 in the Ría de Vigo at 4 m depth by gillnet. The second specimen, approximately 500 mm TL (assessed through calibrated image), was caught with rod and line on 16th March 2010 off Balieiros beach (Corrubedo) at approximately 5 m depth (specimen not preserved). The third specimen (444 mm TL), was caught on 28th April 2010 in the Ría de Cedeira at 4-5 m depth by gillnet. It was confirmed that the second specimen was captured at night, while no confirmation for the other two specimens was possible due to gillnet soak time (24h approximately). The first and third specimens were collected and initially preserved frozen and subsequently stored in 70% ethanol in the fish collections of the Museum Luis Iglesias de Ciencias Naturais of Santiago de Compostela (Galicia, Spain) with the reference numbers 6157 and 6158 respectively.

**Figure 1.** *Schedophilus medusophagus*. Capture locations. **Figure 1.** *Schedophilus medusophagus*. Localisation des exemplaires capturés.
Historical Records

An historical review of specimens of *S. medusophagus* recorded from the North Atlantic based on published and grey literature was made in order to determine the best known depth distribution.

Reproductive analysis

After defrosting, gonads were removed and fixed in 3.6% buffered formalin. Central portions of the fixed gonads were extracted, dehydrated, embedded in paraffin, sectioned at 3 μm and stained with haematoxylin-eosin for microscopic analysis. Histological procedure details are available in Alonso-Fernández et al. (2008).

The ovarian follicles (oocytes and surrounding follicular layer) were classified into stages of development using histological criteria (Tyler & Sumpter, 1996; Murua & Saborido-Rey, 2003). Testicular germ cells were classified into the stages of development as proposed by Grier (1981). Since the fish were previously frozen, some ovarian and testicular structures were not clearly identifiable, such as atretic follicles and postovulatory follicles (POFs) or spermatogonia. Female and male maturity phase was based on Brown-Peterson et al. (2011).

The number of follicles in the ovary was estimated by separating follicles (Lowerre-Barbieri & Barbieri, 1993), combining the gravimetric method with a computer-aided image analysis system that enumerated and measured follicle diameters in a sub-sample of 0.050 g (± 0.002 g) approximately. Measurements (number of follicles > 1000) were performed using QWin software (Leica Imaging Systems) on a PC connected to a video camera on a stereo microscope. Three ovarian sub-samples from anterior, middle and posterior sections of the gonad were examined in order to investigate follicle distribution and homogeneity of follicle density within the ovary (Murua & Saborido-Rey, 2003). Sub-samples were preserved in 3.6% buffered formalin with rose Bengal dye to enhance features and increase the contrast. Fecundity (F) was then estimated using the equation:

\[
F = \frac{GW \times N}{SW}
\]

where SW is the sub-sample weight and N is the total number of follicles in the leading cohort of the sub-sample. Fecundity was calculated as the product of the mean number of follicles per unit of ovarian weight by the total ovarian weight (GW).

Stomachs contents

The stomach contents of the specimens were also analysed. Where possible, prey were separated and identified to species level.

Results

Historical Records

Out of a total of 92 compiled records since 1859 we selected 20 shallow inshore records (estimated capture depth < 20 m) (Table 1). Lagardère & Fourneau (2009) recently reported the capture of two specimens of *S. medusophagus* by gillnets in shallow inshore waters of the Bay of Biscay. Another shallow inshore specimen of *S. medusophagus* measuring 44 cm TL was caught by gillnets off Lihou Island (Guernsey) at 6 m depth in 2010 (Marine Wildlife News, Spring 2010). In both cases, the specimens were not analysed and no explanations for their capture were provided.

Reproductive analysis

Gonad development. The ovaries of *S. medusophagus* are oval-shaped, displaying two lobes which are fused posteriorly, each with a roughly hollow cylindrical form and a lamellar configuration. Histological examination of the ovary revealed that although some stages of development seemed to be present within the gonad, there was clearly a dominant population of bigger vitellogenic follicles greater than 650 μm (Fig. 2), which composed the leading cohort of follicles (potential fecundity). A smaller mode of reduced follicles was present within the follicle size frequency distribution.

Although no hydrated follicles were identified, there was evidence of follicle maturation such as the presence of Germinal Vesicle Migration (GVM). Despite the low

![Figure 2](image_url)
quality of the ovarian tissue sampled (due to initial frozen preservation), it was possible to confirm the maturity status of the female as Actively Spawning, due to the presence of GVM within the ovary (Fig. 3).

The morphology of the testes was lobular with spermatogonia development evident along the germinal epithelium. Spermatogenesis is cystic in this species, with developing germ cells enclosed within germinal cysts formed by enveloping Sertoli-cell processes. Within each cyst the maturation of germ cells is synchronous. The male maturity status was established as Actively Spawning since the testes exhibited spermatozoa in the lumen of the lobules (Fig. 4).

Fecundity estimation. Homogeneity of follicle size distribution was checked in order to avoid bias in diameter estimation in relation to tissue sampling location within the ovary. No significant differences were found in follicle diameter between ovary sub-sample locations (ANOVA, $F = 2.31$, $df = 2$, $n = 8$, $p$-value = 0.14). For fecundity estimation it was assumed that the leading cohort of follicles ($> 650 \mu m$) corresponded with the potential fecundity. Since the identification of Post Ovulatory Follicles (POFs) in the ovary was not confirmed, the potential fecundity estimations could be underestimated if the female had already spawned at least once during the spawning season. However, no evidence of batch fecundity was observed. Taking these factors into consideration, the estimated potential fecundity was 355,004 eggs and the estimated relative potential fecundity ($N_{follicles.g^{-1}}$ of female) was 409 eggs.g$^{-1}$.

Stomachs contents

There was little content in both of the stomachs analysed. The first stomach contained two copepod remains (probably calanoids), eggs, an unidentifiable tissue and different types of pigmented scales. The second stomach contained scales, an unidentifiable tissue (cephalopoda?) and one digested siphonophore.

Discussion

The presence of adults and mature specimens of $S. medusophagus$ in shallow coastal waters is unusual. The current inshore records represent a vertical, but also a horizontal displacement from the previously described mesopelagic natural

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### Table 1. *Schedophilus medusophagus*. Historical compilation of shallow inshore records in Atlantic waters.

<table>
<thead>
<tr>
<th>Date</th>
<th>Method &amp; Depth</th>
<th>TL (cm)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 1859</td>
<td>stranded after storm</td>
<td>45.3</td>
<td>Polperro, near Looe (UK)</td>
</tr>
<tr>
<td>August 1878</td>
<td>by hand at surface</td>
<td>42.0</td>
<td>Cornwall (SW England)</td>
</tr>
<tr>
<td>May 1903</td>
<td>set net</td>
<td>40.0</td>
<td>Portrush, Co Antrim (N Ireland)</td>
</tr>
<tr>
<td>March 1908</td>
<td>washed, ashore</td>
<td>43.0</td>
<td>Arcachon, SW France</td>
</tr>
<tr>
<td>March 1903</td>
<td>in shallow water</td>
<td>42.0</td>
<td>Westward Ho, Devon (UK)</td>
</tr>
<tr>
<td>March 1908</td>
<td>stranded alive</td>
<td>42.0</td>
<td>Portrush, Co Antrim (N Ireland)</td>
</tr>
<tr>
<td>March 1908</td>
<td>red &amp; line from shore</td>
<td>42.0</td>
<td>W shore of Ballyliss, Co Mayo (W Ireland)</td>
</tr>
<tr>
<td>March 1909</td>
<td>caught from shoreline</td>
<td>42.0</td>
<td>Cefn Siddan Beach, Swansea, S Wales (UK)</td>
</tr>
<tr>
<td>01.05.1954</td>
<td>gill-net</td>
<td>47</td>
<td>Steven (1955)</td>
</tr>
<tr>
<td>03.06.1954</td>
<td>gill-net</td>
<td>44</td>
<td>Steven (1955)</td>
</tr>
<tr>
<td>17.02.2009</td>
<td>gill-net</td>
<td>44.6</td>
<td>This paper</td>
</tr>
<tr>
<td>19.06.2010</td>
<td>gill-net</td>
<td>44.6</td>
<td>This paper</td>
</tr>
<tr>
<td>02.07.2010</td>
<td>shrimp trawl (3 m)</td>
<td>44.6</td>
<td>This paper</td>
</tr>
</tbody>
</table>

*Table 1. Schedophilus medusophagus*. Historical compilation of shallow inshore records in Atlantic waters.
habitat of the species. Although the current phenomenon is difficult to explain, infrequent and exceptional behaviours can provide insights into the ecology and physiology of a particular species (Houghton et al., 2008).

The historical data indicated a diverse origin for these shallow inshore records, including some strandings. Inshore specimens were reported during most months of the year except January, July, November and December. Although no seasonal trend was found in the historical data set, most of the specimens were recorded during the first half of the year, which may also indicate some type of periodicity. No latitudinal trend was found either.

Our first tested hypothesis suggests spawning migration as a possible cause for the capture of specimens in shallow waters. Reproductive analyses showed typical oogenesis and spermatogenesis development as in most teleosts (West, 1990; Tyler & Sumpter, 1996; Murua & Saborido-Rey, 2003). Although the follicle size-frequency distribution was continuous within the ovary, females exhibited a dominant population of bigger vitellogenic follicles. This leading cohort of follicles may represent the potential fecundity for the subsequent spawning season. Moreover, the existence of a smaller cohort of follicles would indicate the presence of the upcoming stock of follicles that will be released in the next spawning season. Taking all these facts into account, S. medusophagus may be considered group-synchronous, with a highly synchronous population of larger follicles (Murua & Saborido-Rey, 2003). Other centrolophid species such as Hyperoglyphe antarctica (Carmichael, 1819) clearly showed a determinate fecundity strategy and a group-synchronous ovarian development (Baelde, 1996).

Testicular tissue was found to be lobular type (Takashima & Hibiya, 1995), i.e. spermatogonia were randomly distributed along the entire length of the tubule in reproductively active fish, equivalent to the unrestricted spermatogonial type proposed by Grier (1981). This type of testis organization does not differ from the organization found in the centrolophid H. perciformis (Filer & Sedberry, 2008). However, in the latter species, a small proportion of intersexual individuals have been found. Although more specimens of S. medusophagus are required to clearly state ovarian and testes development organization, this is the first histological analysis of the reproductive traits in this species.

The obtained potential fecundity estimation could have been underestimated since it was not possible to identify postovulatory follicles due to the low quality of the samples.
preserved. However, in spite of these limitations, the result of the relative fecundity, 409 eggs.g⁻¹, does not differ much from the average counts found in *H. antarctica* of 480 ± 125 eggs.g⁻¹ (Baelde, 1996).

The most important result obtained from the reproductive analyses in the present study was that the two specimens examined were sexually mature and in an Actively Spawning phase, suggesting a possible spawning migration. Their occurrence, mainly during the first half of the year, could support a possible inshore migration related to a spawning season. In Galician waters, this kind of reproductive offshore-inshore migratory behavior has only been noted in the lump sucker *Cyclopterus lumpus* Linnaeus 1758, a species in which this reproductive pattern is well documented. Mature or spawning specimens of *C. lumpus* are occasionally found in coastal inshore waters of Galicia albeit only during the reproductive season, in the first half of year (Bañón et al., 2008). However, in order to support the case for a potential offshore-inshore reproductive migration in *S. medusophagus*, one would expect a higher number of records of mature specimens in shallow coastal waters among the historical data set. Since no previous information regarding the sexual cycle of *S. medusophagus* is currently available and there are relatively few records of coastal shallow-water specimens, it is not possible to definitively confirm the connection of such shallow coastal records with a spawning season. Spawning migrations are designed to maximize reproductive success fitting spawning with optimal environmental conditions for eggs and larvae (Leggett, 1977). Unfortunately such optimal conditions for *S. medusophagus* eggs and larvae remain unknown.

Feeding migrations could also be another possible explanation for this phenomenon. A temporary lack or shortage of their usual offshore prey may explain the migration and/or occasional occurrence of this species in coastal waters. *S. medusophagus* feeds mainly on gelatinous plankton and small crustaceans (Haedrich, 1986).

Most mesopelagic species show extensive vertical migrations into the epipelagic zone at night, where they prey on plankton and on other mesopelagic species, and thereafter they migrate down several hundred meters to their daytime depths (Salvanes & Kristoffersen, 2001). If we assume that all of our specimens were taken at night, we could possibly relate these anomalous occurrences to a potential nocturnal coastal feeding migration analogous to a diel vertical migration (DVM). It is interesting to note that both of the specimens recently recorded from the Bay of Biscay as well as the recent Guernsey Island specimen were captured at night. Likewise, pelagic juvenile specimens of *S. medusophagus* have been captured at the surface mainly at night (Bone & Brook, 1973).

The stomach content analysis did not reveal sufficient evidence to support the hypothesis of an inshore feeding migration, because relatively few prey items were recorded. The presence of efficient food-shredding toothed saccular outgrowths in the alimentary tract of centrolophid species may explain why stomach contents are generally unidentifiable (Haedrich, 1967) as well as the paucity of prey items. Although catches at night could support the hypothesis of a nocturnal coastal feeding migration, they do not rule out the alternative hypothesis of an inshore reproductive migration.

Since the current study did not find any conclusive evidence to support either of the two proposed hypotheses, other possible explanations need to be explored. For example, Blanchard & Vandermeirsch (2005) suggested that increasing water temperatures may lead to the translocation of deep-water species into shelf seas. In Galician waters, the sea surface temperature increased by 0.8°C during the period 1960-2006 (Bañón, 2009). The recorded data do not clarify if it is an emerging phenomenon that could be due to either recent ecological or physiological changes. Further investigations of shallow inshore records of *S. medusophagus* are required in order to clarify whether or not it is a consequence of real changes or just the occasional arrival of vagrant specimens.

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**References**


Bañón R., Garazo A. & Fernández A. 2008. Note about the presence of the lump sucker *Cyclopterus lumpus* (Teleostei,


British Record (Rod-Caught) Fish Committee (BRFC) www.anglingtrust.net


