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Growth, feeding and distribution of the solenette *Buglossidium luteum* with particular reference to its habitat preference

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Abstract

Growth, condition, diet and spatial distribution of the solenette *Buglossidium luteum* (Risso, 1810) were investigated along the coasts of the French Atlantic, eastern English Channel and Southern Bight of the North Sea. Distribution and habitat preferences of solenette were analysed in relation to physical and biological features presumed to influence fish distribution. *B. luteum* was patchily distributed and concentrated in shallow muddy and muddy-sand bottoms moderately influenced by estuarine waters (euhaline waters). In the studied area, solenette seemed to find habitats suitable for growth. Food availability was not assumed to be a limiting factor for solenette distribution in contrast to abiotic factors such as salinity.

Keywords: Growth; Feeding; Distribution; Habitat suitability; Solenette

1. Introduction

The solenette, *Buglossidium luteum* (Risso, 1810) is the smallest species of the Soleidae in European waters, the adult only reaching 10–13 cm in length (Wheeler, 1969). This species is most abundant at depths ranging between 5–20 m along the south coast of England (English Channel) (Rogers et al., 1998) and 10–50 m in the southern North Sea (Baltus and Van der Veer, 1995). It is rarely found inshore and does not make any pronounced migrations (Wheeler, 1969). Although flatfish have generally specific preferences for bottom substrate, Amezcua and Nash (2001) showed that the distribution and abundance of solenette are not related to sediment type. Unlike plaice (*Pleuronectes platessa*), sole (*Solea solea*) and dab (*Limanda limanda*), which are the most abundant and widespread flatfish species in the shallow waters of the northeast Atlantic, solenette is patchily distributed and more specific in its habitat requirements (Baltus and Van der Veer, 1995; Rogers et al., 1998). Since it is not a commercial fish, detailed information on its biology and ecology is lacking and factors influencing its distribution or habitat requirements are misunderstood.

The aim of this study was to investigate the habitat preference of solenette along the coasts of the French Atlantic, eastern English Channel and southern Bight

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of the North Sea. The spatial distribution of the species was examined in relation to physical and biological features presumed to influence its distribution. Growth, condition and diet were analysed and used to compare the suitability of the habitat in which solenette were found.

2. Material and methods

2.1. Study area and sampling

Fish were collected during autumn 1999 and 2000 in the eastern Channel and Southern Bight of the North Sea and during autumn 2000 and 2001 in the Bay of Biscay (Fig. 1). A total of 618 stations were sampled during daylight with a 3 m beam trawl (10 × 10 mm mesh codend) equipped with one tickler chain. Temperature and salinity were recorded at each station. All fish were identified and counted. No correction for net efficiency was applied. Numbers caught were converted into numbers of individuals per 1000 m^{-2}.

2.2. Analyses of spatial distribution

To study the distribution and habitat requirements of solenette, a Generalized Linear Model was performed. This model, previously developed by Le Pape et al. (2003) to study the spatial distribution

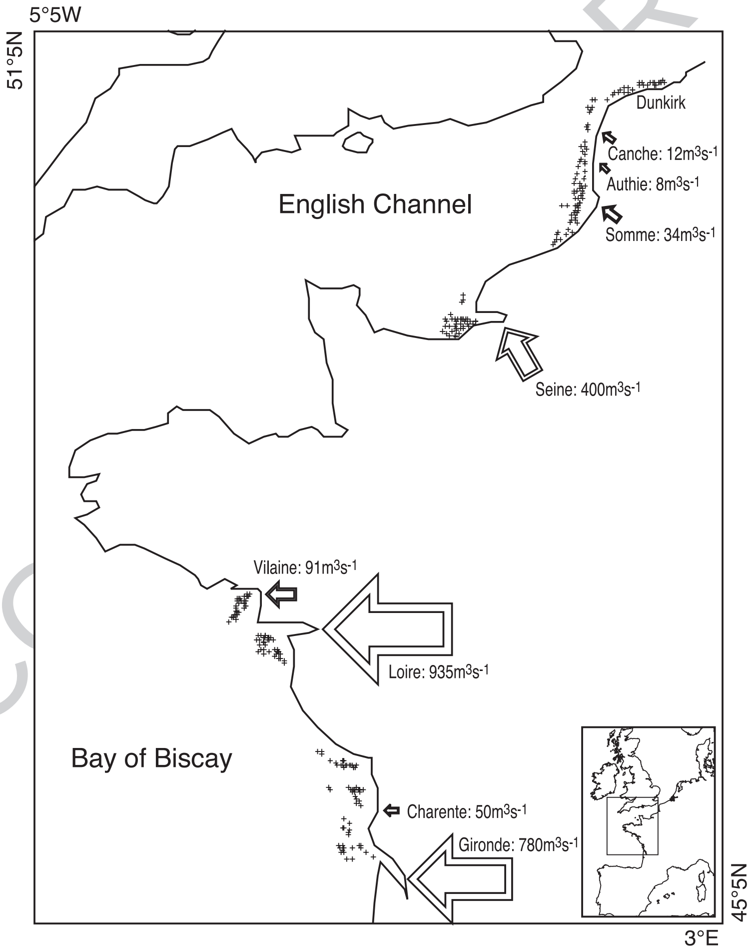

Fig. 1. Map of the studied area showing the sampling stations and the location of the main rivers.

of sole nursery grounds, was built assuming a delta distribution. A binomial distribution for the presence of solenette was coupled with a log-normal distribution for density when solenette were present (Le Pape et al., 2003). The maximum likelihood estimation for this model amounted to fitting one GLM to 0/1 values and another to positive abundance values (Stefanson, 1996). Physical parameters known to influence spatial distribution of flatfish (bathymetry, sediment structure, salinity, temperature, interannual variability and geographical area) were taken into account.

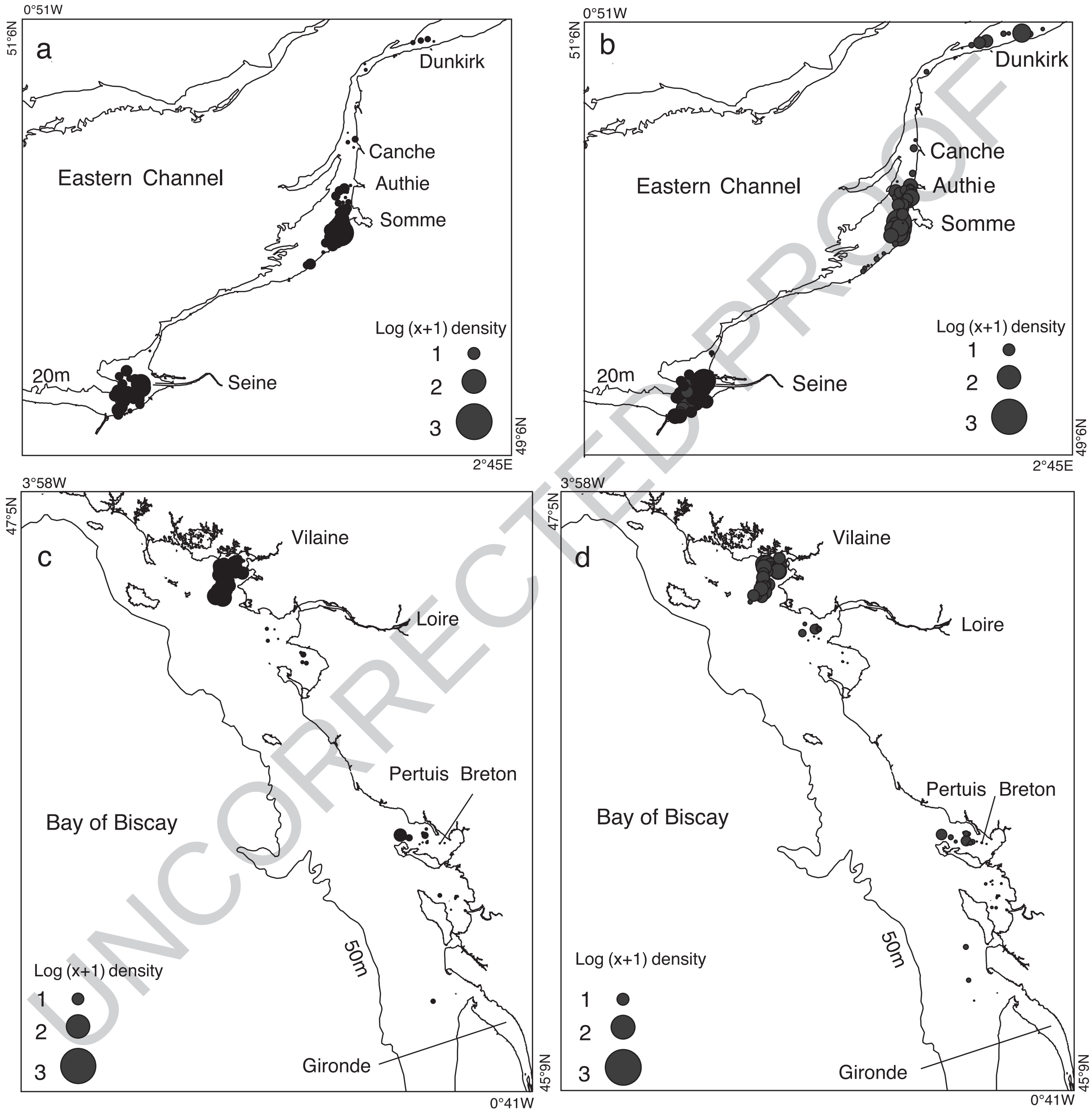

Fig. 2. Distribution of solenette (a) during autumn 1999 and (b) 2000 in the eastern Channel and southern North Sea, and (c) during autumn 2000 and (d) 2001 in the Bay of Biscay. Densities were log-transformed, y = Log (x + 1).

2.3. Growth, condition and diet composition

The solenette were measured for total length and weighed. At each site, a sub-sample of 4 fish per 5 mm size class was analysed for age and growth estimates. Age was estimated for 228 fish. The condition factor K (Fulton, 1911) of juvenile solenette ($Lt \leq 8$ cm) was calculated for each fish with the formula $K=(W/L^3) \times 100$, where W is the fresh weight (mg) and L is the total length (mm). This morphometric index assumes that heavier fish of a given length are in better condition.

A total of 215 individuals were examined for their stomach contents. Fish were divided into six size classes (<40; 41–60; 61–80; 81–100; 101–120; >120 mm) to study their diet during growth. Individuals analysed were randomly selected in each size class. All prey in the stomach contents were sorted under a binocular microscope, identified to the nearest taxon or species and counted.

3. Results

3.1. Distribution and habitat suitability

Solenette were essentially located in shallow waters near riverine outflows of the Somme, Seine and Vilaine estuaries. However, they were almost absent from the river mouths of the largest estuaries studied (the Loire and Gironde) (Fig. 2). In all the years considered, abundances were higher in the eastern Channel than in the Bay of Biscay. The results of the model confirmed the estuarine influence on solenette distribution (Fig. 3). This species was located in waters moderately influenced by estuaries, in

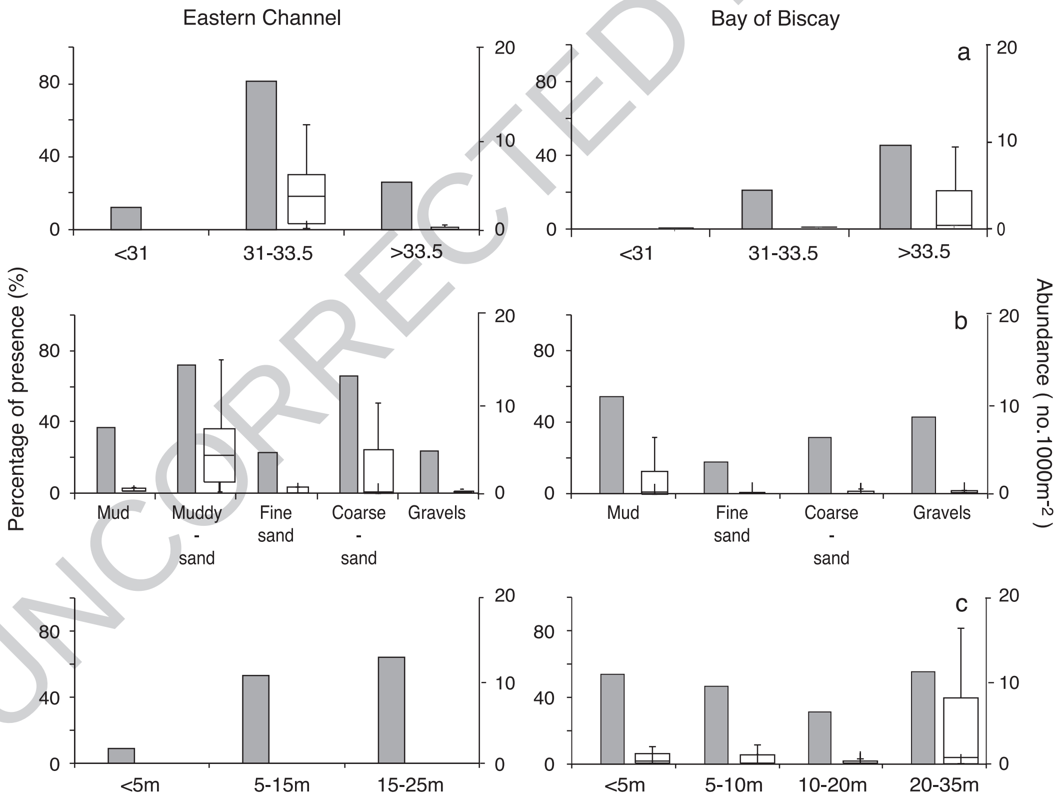

Fig. 3. Mean percentage of presence (solid bar) and abundance (white bar, with median value, upper and lower quartiles(box) and extreme values (line)) of solenette in the eastern Channel and the Bay of Biscay according to (a) salinity, (b) sediment and (c) depth classes.

front of small estuarine systems, but was rare in more estuarine waters (i.e. the largest estuaries). The model also emphasised that solenette were rare in very shallow waters, maximum densities being found from 5 to 15 m in the eastern Channel and from 20 to 35 m in the Bay of Biscay on muddy and sandy-muddy bottom sediments. Seawater temperature did not influence solenette distribution.

3.2. Growth, condition and feeding

The size of the sampled fish varied between 2.3 and 12.5 cm. The shape of the growth curve for the same sex was similar whatever the studied area considered (Fig. 4). Most growth occurred in the first year of life and continued at a relatively low and constant rate. The growth coefficient (K), which determined the rate to which the fish reaches its maximum size, was higher for males ($K = 0.64$) than for females ($K = 0.49$) (Fig. 4). Except at Dunkirk where the majority (95%) of the solenette caught were O-group juveniles, there were no significant differences in the length/weight relationship between the three main areas (Bays of Somme, Seine and Vilaine) (ANCOVA, $p > 0.05$). However, there were significant differences (ANOVA, $P < 0.05$) in the condition factor (K) of juvenile solenette, the lower values being recorded at Dunkirk and the highest in the Bay of Somme. The condition factor did not differ significantly between juveniles of the Bays of Seine and Vilaine.

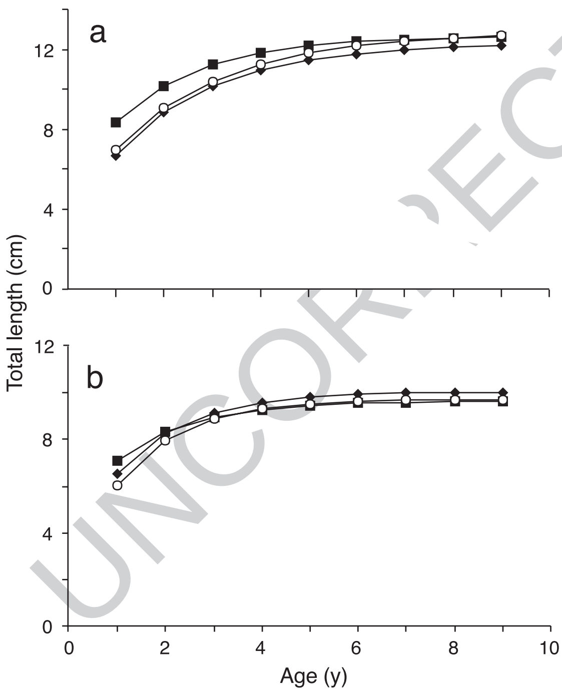

Fig. 4. Growth curve of (a) female and (b) male solenette in the Bay of Somme (♦), Seine (■) and Vilaine (○).

The solenette fed on a wide range of bottom-living organism. Its diet comprised 33 prey species belonging essentially to the three groups of benthic invertebrates: crustaceans (44.18%O: % of occurrence, 77.20%N: % by number), polychaetes (38.61%O, 5.84%N) and molluscs (21.01%O, 14.78%N). Whatever the area and the solenette size considered, crustaceans were numerically the most common prey. Among them, the Cumacea, Ostracoda and harpacticoid copepods, characterised by their small size, were the main components of the diet of individuals < 6 cm. For larger fish, the crustacean prey belonged essentially to the Malacostraca. The polychaetes, mainly *Nephtys* sp., although often found in the stomach of small individuals, were more important in the diet of fish >8 cm. For all size classes, the diet was completed by molluscs, mainly *Abra alba* and *Macoma balthica*. Some geographical differences in the diet were observed. Solenette fed on a wider range of prey species in the Bay of Biscay (27 species or taxa) than in the eastern Channel (22 taxa or species). Polychaetes were more important in the diet of specimens from the eastern Channel, whereas in the Bay of Biscay crustaceans and molluscs dominated the diet.

4. Discussion

Many environmental variables are assumed to be responsible for the distribution of fish populations (e.g. Riley et al., 1981; Gibson, 1994). Several studies have examined environmental variables that affect flatfish distribution in shallow coastal areas and found salinity, temperature, depth and sediment type to be the dominant factors influencing distribution (Rogers, 1992; Norcross et al., 1999; Le Pape et al., 2003). In the studied area, solenette is concentrated near riverine outflows, in shallow muddy and muddy-sand bottoms moderately influenced by estuarine waters (in water salinities between 29–33). The dependence of flatfish on sediments is generally related both to the ability to bury themselves and to the distribution of suitable prey (Gibson and Robb, 1992; Gibson, 1994). As in other areas, the solenette feeds on a wide range of bottom-living organisms (Nottage and Perkins, 1983; Darnaude et al., 2001). Geographical differences in diet, as observed in the present study, are common among flatfish (De Groot, 1971) and can reflect the high trophic adaptability of solenette to the available prey. The uniformity of the seabed environment along the French coast of the eastern Channel and Southern Bight of the North Sea supports a uniform distribution of benthic fauna (i.e. potential prey) (Desroy et al., 2003). Solenette feeds on the same prey as other flatfish species of the studied area (Amara et al., 2001). The absence or scarcity of solenette in areas (e.g. the Bay of Canche or the Southern Bight of the North Sea) where growth and feeding conditions are suitable for sole, plaice and dab (Amara et al., 2001; Amara and Paul, 2003) suggests that food availability is not a limiting factor of solenette distribution. The length at age and the growth parameters obtained in the present study are similar to those described in other areas (Nottage and Perkins, 1983; Deniel, 1990; Baltus and Van der Veer, 1995). The fact that no geographical patterns in solenette growth and condition were observed also suggests that solenette find habitats suitable for growth in the studied areas and that other factors may be responsible for their patchy distribution.

Although solenette are concentrated near riverine outflows, they are almost absent from the mouths of the largest estuaries. Along the coasts of England and Wales, the O-group solenette occur mainly in salinities between 30 and 35 and are absent in salinities <20 (Riley et al., 1981). As a consequence, they are abundant on the south coast of England and absent on the east coast, notably near the Thames estuary, where the salinity is low, and where other flatfish species (e.g. sole, plaice and dab) are highly abundant (Rogers et al., 1998). In the southern North Sea, neither the estuarine Dutch Wadden Sea nor the very shallow coastal zone is used as a nursery area by this species. The distribution and movements of several flatfish species have been correlated with salinity (Riley et al., 1981; Marchand, 1993). The present study confirms that the solenette avoids low-salinity waters. It never penetrates into estuaries (Wheeler, 1969) and intertidal areas (Amara and Paul, 2003) and can be defined as a 'peri-estuarine species' (Lagardère, 1982). Temperate estuaries are known to provide important nursery habitats for euryhaline fishes, which find large food resources there. In the studied area, the distribution of solenette clearly differs from that of sole and plaice, which show a euryhaline tendency and use very shallow coastal and estuarine areas as nursery grounds (Zijlstra, 1972; Marchand, 1993; Van der Veer et al., 1990). Although nothing is known about the physiology of the solenette, it may be intolerant of the often harsh physical conditions encountered in the very shallow zone and near large riverine outflows because it is not capable of the rapid physiological adjustments needed to maintain a functional homeostasis. Many questions remain to be answered concerning the physiological and behavioural mechanisms by which fish select preferred habitats. Experimental studies are needed to evaluate the tolerance of solenette to several abiotic factors such as salinity.

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