Estuarine, Coastal and Shelf Science 79 (2008) 507–517

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Environmental factors structuring fish composition and assemblages in a small macrotidal estuary (eastern English Channel)

Jonathan Selleslagh*, Rachid Amara

Laboratoire d'Océanologie et de Géosciences, UMR 8187 LOG CNRS, Université du Littoral Côte d'Opale, 32 avenue Foch, 62930 Wimereux, France

ARTICLE INFO

Article history:
Received 25 February 2008
Accepted 9 May 2008
Available online 21 May 2008

Keywords:
fish assemblage
estuarine use
ecological guilds
environmental factors
eastern English Channel

ABSTRACT

The fish assemblage structure was analyzed along an estuarine gradient of a small macrotidal estuary (the Canche, France). Fishes were collected every two months between May 2006 and July 2007 from 12 sampling stations using a 1.5-m beam trawl with a 5 mm mesh size in the cod end. To complement this information, sampling was also performed using 15-m fyke nets (8 mm mesh size in the cod end). For each sample, abiotic (temperature, salinity, pH, oxygen, turbidity, river flow, wind speed and depth) and biotic (macro crustacean species abundances) were recorded. Throughout the study, 28 fish species belonging to 20 families were collected. Fish catches were dominated by juveniles, especially Young-Of-the-Year (YOY) for the majority of the species. According to the Index of Relative Importance (IRI), common goby *Pomatoschistus microps*, flounder *Platichtys flesus*, sprat *Sprattus sprattus*, sea-bass *Dicentrarchus labrax* and plaice *Pleuronectes platessa* were the most abundant species, together accounting for 99.2% of the total IRI. Estuarine residents (ER = 66.2%) and marine juvenile migrants species (MJ = 31.4%) were the most important ecological guilds. The structure of the fish assemblage and its relationship to environmental variables was examined using multivariate techniques. Cluster and non-metric multidimensional scaling (nMDS) analysis defined six distinct groups in the Canche estuary, which are discriminated by specific species (SIMPER). Spatio-temporal variations in fish assemblage structure reflect the density peaks of the most abundant species. Spearman rank correlations and canonical correspondence analysis (CCA) showed that among the ten environmental variables examined, temperature, salinity and *Crangon crangon* (a potential predator for YOY fish or prey for older ones) are the three most important factors influencing fish species richness and abundances. Our observations reinforce the idea that certain fish species may have different life history styles in different geographic areas. The present study highlights the necessity of a better knowledge of the connectivity between estuaries and adjacent marine areas. The Canche constitutes an important ecosystem for fishes and as it is subject to little anthropogenic disturbance; its ichthyofauna can be viewed as a reference or normal assemblage for small temperate macrotidal estuaries.

1. Introduction

Estuaries are important to humans and marine life. They are widely regarded as among the most productive aquatic systems in the world (McHugh, 1967) and perform a crucial role in the population dynamic of many invertebrate and fish species. They provide a migratory route for anadromous and catadromous fish species, an environment for truly estuarine species and nursery areas for many marine species (McLusky and Elliott, 2004). Several authors have emphasized the importance of estuaries for marine fisheries by demonstrating that a large part of the landings around the world is made up of species that spend part of their life in estuarine waters (Pauly, 1988; Lamberth and Turpie, 2003). Since the adults of many estuarine-dependent species are exploited commercially, the preservation of estuarine habitats is clearly important for maintenance of many marine fisheries (Chambers, 1992).

Estuaries are transition zones between seas and freshwater that are occupied by a combination of freshwater and marine species, including many juveniles (Claridge et al., 1986). Compared to marine or freshwater systems, estuaries are abiotically variable and therefore may be rigorous and stressful habitats. Species that inhabit estuaries must be able to tolerate or avoid wide range of salinity, temperature, dissolved oxygen and high level of turbidity. For example, relatively few species are adapted to thrive in conditions such as fluctuating salinity and their resultant physiological demands (Haedrich, 1983). The relationship between environmental factors and the distribution of organisms within estuaries has

* Corresponding author.
E-mail address: jonathan.selleslagh@univ-littoral.fr (J. Selleslagh).

0272-7714/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ecss.2008.05.006

received considerable attention. Because fish are one of the dominant macrofaunal components of estuarine biota, many studies have focused on their distribution patterns (Blaber and Blaber, 1980; Marshall and Elliott, 1998; Whitfield, 1999; Akin et al., 2005). Most of these studies were, however, conducted in large estuaries exposed to important human pressures. Consequently, we currently lack information on both small and less-impacted or non-impacted estuaries.

Estuaries, like many other types of wetland worldwide, are under long-term threat of damage and destruction. While the role of estuarine nursery areas is well known on a qualitative basis (Elliott et al., 1990), the consequences of temporal fluctuations in estuarine environmental variables on the fish populations utilizing estuaries are less well understood. The knowledge of the response of estuarine fishes to changes in environmental conditions will not only enhance our biological understanding of estuarine fish, but will contribute to our understanding of the potential effects of anthropogenic impacts on estuarine fish species. Indeed, there is a growing interest in the use of fish communities in estuarine water quality evaluation and assessments of human impacts (Whitfield and Elliott, 2002; Harrison and Whitfield, 2004). As part of the European Water Framework Directive (WFD; EC, 2000) there is for example a need to determine what is a normal fish assemblage of transitional waters and to assess what deviation there has been from that normality due to human impacts. The study of the structure and functioning of biological communities of least impacted estuaries can be used to generate reference conditions (Harrison and Whitfield, 2004; McLusky and Elliott, 2004).

In the present study we analyzed for the first time the fish assemblage of a small macrotidal estuary (the Canche) which is, in contrast to numerous estuaries, less subject to anthropogenic disturbance (Amara et al., 2007). The composition and assemblage of its ichthyofauna can be viewed as a reference or normal assemblage for small temperate estuaries. No information is available about fish assemblages of the English Channel estuaries (Franco et al., 2008). The objectives of the present study were to address this lack of knowledge by describing the fish composition and analyzing the seasonal and spatial patterns in the structure of the fish assemblages of the Canche estuary in relation with various abiotic and biotic factors.

2. Materials and methods

2.1. Study area

The study area was the Canche (50°50′ 50°56′ N, 1°57′ 1°67′ E; Fig. 1), a small estuary, located in northern France along the coast of the eastern English Channel. The Canche estuary is 12 km in length, 1 km maximum in width and is characterized by a sandy-mud substratum (Selleslagh, unpublished data). The estuary is characterized by semi-diurnal tide with an average tidal range of about 1 m at neap tides and 6 m at spring tides and can be considered as a macro/hyper-tidal estuary according to the McLusky and Elliott (2004) classification. The water circulation is mainly dependant on the tides and on a small freshwater input of about 13 $m^3 s^{-1}$. The Canche estuary can be considered as a little impacted system (Amara et al., 2007) and is classified site under "Natura 2000".

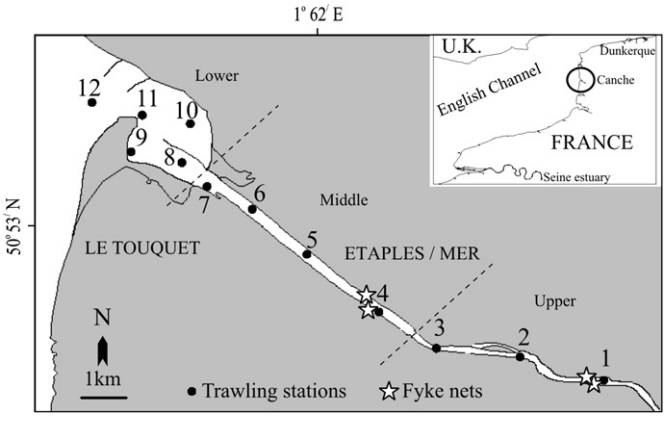

Fig. 1. Map of the Canche estuary with location of the beam trawl and fyke net sampling stations.

2.2. Sampling and environmental data

Fish were collected every two months from May 2006 to July 2007 (except in July 2006) in 12 sampling stations distributed along the estuarine gradient where salinity ranged from 0 in upper reaches to 35 in lower reaches (Fig. 1). Sampling was performed during daytime using a 1.5 m beam trawl, with one tickler chain and 5 mm mesh size in the cod end, towed by a zodiac against the current at 2 knots for 15 min, covering an area of about 1000 m^2. All stations were sampled at each survey, except two (stations 7 and 12) in November 2006 due to technical problems.

In order to minimize the confounding effects of variations in tidal stage and environmental conditions between each sampling period and to standardize the sampling regime, all sites were sampled at high tide $\pm$ 2 h and with similar tide coefficients for each survey. To complement information on species richness, sampling was also performed using four 15-m fyke nets (8 mm mesh size in the cod end). Two fyke nets were displayed in the middle and upper estuary (Fig. 1) at low tide for a 48 h period at each sampling survey.

Prior to trawling, water physico-chemical factors (temperature, salinity, pH, % saturation in dissolved oxygen and turbidity) were recorded using a Tetracon 325 and Cyberscan multiprobes in each sampling station. Depth was recorded at each station and Canche river flow and wind speed data were obtained from the water agency (www.hydro.eaufrance.fr) and "Météo France Boulogne" respectively. The abundance of the brown shrimp *Crangon crangon* and the green crab *Carcinus maenas* captured during trawling were also taken into account in the analyses as biotic factors. These two species are considered as potential predator for Young-Of-the-Year (YOY) fish or prey for older ones, and accounted for more than 90% of the total abundance of macro crustaceans.

2.3. Data analysis

After each trawl, fishes were identified to species level, weighed (total weight) and measured to the nearest millimeter (total length). If the number of individuals of a species exceeded 30, a representative sub-sample of 30 individuals was measured and weighed and the rest was counted. In order to standardize captures between each trawl and to allow comparisons, fish and macro crustacean abundances were expressed as number of individuals per 1000 m^2. The dominant fish species throughout the study period (together contributing >90% of the total Index of Relative Importance (IRI) for each sampling month) were determined using the IRI developed by Pinkas et al. (1971). The IRI aggregate the main evaluation methods (abundance, biomass and frequency of occurrence) within a single index: IRI = (N% + W%) FO%, where N%, W% and FO% are the relative abundances, biomass and frequency of occurrence, respectively. These indices were calculated on the total 82 samples.