Journal of Sea Research xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Sea Research

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

Trophic niche overlap of sprat and commercial small pelagic teleosts in the Gulf of Lions (NW Mediterranean Sea)

B. Le Bourg [a], D. Bănaru [a,*], C. Saraux [b], A. Nowaczyk [a,c], E. Le Luherne [a,d], A. Jadaud [b], J.L. Bigot [b], P. Richard [e]

[a] Aix Marseille Université, CNRS/INSU, IRD, Mediterranean Institute of Oceanography (MIO), UM 110, 13288 Marseille, France
[b] IFREMER (Institut Français de Recherche pour l'Exploitation de la MER), CRH, UMR MARBEC (IRD/IFREMER/UM/CNRS), Avenue Jean Monnet, BP171, 34203 Sète Cedex, France
[c] Université de Bordeaux, UMR CNRS 5805 EPOC – OASU, 2 Rue du Professeur Jolyet, 33120 Arcachon Cedex, France
[d] Agrocampus Ouest, UMR985 ESE Ecologie et santé des écosystèmes, F-35042 Rennes Cedex, France
[e] Université de La Rochelle, UMR CNRS 7266 LIENSs, 2 Rue Olympe de Gouges, 17000 La Rochelle, France

ARTICLE INFO

Article history:
Received 26 January 2015
Received in revised form 13 May 2015
Accepted 21 June 2015
Available online xxxx

Keywords:
Anchovies
Sardines
Sprats
North-western Mediterranean sea
Stomach contents
Stable isotopes

ABSTRACT

Increasing abundance of non-commercial sprats and decreasing biomass and landings of commercial anchovies and sardines justify the need to study the feeding ecology and trophic niche overlap of these planktivorous species in the Gulf of Lions. Their diet has been investigated on the basis of stomach content and stable isotope analyses in 2011 and 2012 according to different depths and regions in the study area. The main prey were Corycaeidae copepods, *Clauso/Paracalanus*, *Euterpina acutifrons* and *Microsetella*, for sprats and small copepods, such as *Microsetella*, *Oncaea* and Corycaeidae, for anchovies and sardines. This is the first time that the diet of sprats is described in the Gulf of Lions. Sprats fed on a larger size spectrum of prey and seem to be more generalist feeders compared to anchovies and sardines. Ontogenetic changes as well as spatial and temporal variations of the diet occurred in the three species. Stable isotope analysis revealed mobility of sardines and sprats among feeding areas while anchovies exhibited preferred feeding areas. Sprats showed a higher relative condition assessed by C/N ratios than sardines and anchovies. Our results showed an overlap of the trophic niches for the three species, indicating a potential trophic competition in the Gulf of Lions.

1. Introduction

Small pelagic teleosts are key species in ecological systems as they ensure the transfer of organic matter from zooplankton to higher trophic levels (Banaru et al., 2013). They may exert different types of control in marine systems such as bottom–up (Cury et al., 2011), top–down (Köster and Möllmann, 2000; Verheye and Richardson, 1998) or wasp-waist control (Cury et al., 2000).

Traditionally, anchovies (*Engraulis encrasicolus*; Linnaeus, 1758) and sardines (*Sardina pilchardus*; Walbaum, 1792) were the two main pelagic teleosts in the Gulf of Lions (North-west Mediterranean Sea) in terms of biomass and represent target and commercial species for the fishing industry (Banaru et al., 2013). However, anchovy and sardine landings have declined since 2005 and fishing activity has been reduced to an exploratory activity in 2010. Anchovies and sardines are still abundant but their biomasses and size have decreased, which lowers their commercial value. Furthermore, there has been an unusual increase of non-commercial sprat (*Sprattus sprattus*; Linnaeus, 1758) abundance since 2008 (Van Beveren et al., 2014). A recent decline was reported in body condition and growth of anchovies and sardines (Van Beveren et al., 2014) which might be linked to changes in their diet compared to past studies (Costalago and Palomera, 2014; Plounevez and Champalbert, 2000) and/or to trophic interactions with sprats. Indeed, the abundance of prey seems to be one of the main environmental drivers of body condition in these species (Brosset et al., 2015). The three species are zooplanktivorous and may be competitors for food in the study area. Moreover, there is significant overlap in their spatial distribution (Saraux et al., 2014) but no data are available concerning their trophic interactions in this area. No qualitative or quantitative data on the zooplankton community are available to show eventual changes in the availability of the resources during the last period. Consequently, studies on their feeding behaviour and interactions are necessary to understand the origin of the recent shifts in the pelagic ecosystem of the Gulf of Lions.

Stomach content analysis is a well-known method to study the trophic ecology of teleosts and provides a qualitative and quantitative snapshot of the diet (Hyslop, 1980). Ratios of nitrogen and carbon isotopes (^{14}N:^{15}N, $\delta^{15}N$; ^{12}C:^{13}C, $\delta^{13}C$) are used to determine feeding areas and primary sources of carbon in food-web (Hobson, 1999; Michener and Kaufman, 2007). Stable isotope analyses allow longer-term study of the diet of organisms and identification of changes in

* Corresponding author at: Aix Marseille Université, CNRS/INSU, IRD, Mediterranean Institute of Oceanography (MIO), Campus de Luminy, Case 901, 13288 Marseille, France.
E-mail addresses: lebourg.bap@orange.fr (B. Le Bourg), daniela.banaru@univ-amu.fr (D. Bănaru), Claire.Saraux@ifremer.fr (C. Saraux), a.nowaczyk@epoc.u-bordeaux1.fr (A. Nowaczyk), emilie.leluherne@agrocampus-ouest.fr (E. Le Luherne), Angelique.Jadaud@ifremer.fr (A. Jadaud), Jean-Louis.Bigot@ifremer.fr (J.L. Bigot), pierre.richard01@univ-lr.fr (P. Richard).

http://dx.doi.org/10.1016/j.seares.2015.06.011
1385-1101/

feeding sources and areas. Carbon/nitrogen (C/N) ratios measured with stable isotope ratios are a proxy of the lipid content of organisms (Dempson et al., 2010; Logan et al., 2008; Post et al., 2007; Sweeting et al., 2006) and thus can be used as indicators of the relative condition.

Some studies on the trophic ecology of small pelagic teleosts of the European coasts have been previously conducted using stomach content analyses (e.g. Costalago and Palomera, 2014; Costalago et al., 2014; Garrido et al., 2008; Plounevez and Champalbert, 2000; Tičina et al., 2000) and stable isotopes (e.g. Bode et al., 2004; Chouvelon et al., 2014; Costalago et al., 2012), but few studies have combined the two approaches (Pasquaud et al., 2008) and none of them in the study area. Moreover, the last diet studies based on stomach content analysis of adult anchovies and sardines in the Gulf of Lions were performed in 1995–1996 by Plounevez and Champalbert (2000), and in 2007 by Costalago and Palomera (2014), when these species had higher condition values (Brosset et al., 2015; Van Beveren et al., 2014) and before the fall of their biomass. No data on the trophic ecology of *S. sprattus* is available for the North-western Mediterranean Sea.

The aim of this study was to combine the methods of stomach content analysis and stable isotopes to describe the trophic ecology, niche width and diet overlap of anchovies (*E. encrasicolus*), sardines (*S. pilchardus*) and sprats (*S. sprattus*) in the Gulf of Lions to infer the potential interactions between the three species. In addition, this is the first time that spatial variations in the diet of these species related to their stable isotope ratios were described in the North-western Mediterranean Sea.

2. Material and methods

2.1. Study area and sampling

The Gulf of Lions has a wide continental shelf. It is a mesotrophic area influenced by Rhône river inputs and the northern current flowing southwestwards along the continental slope (Espinasse et al., 2014a). Consequently, concentrations of nutrients in water and sediments decrease from east to west and from coast to continental shelf (Cruzado and Velasquez, 1990; Denis and Grenz, 2003; Van Den Broeck and Moutin, 2002). Furthermore, river inputs influence isotopic ratios of particulate organic matter and phytoplankton, with higher $\delta^{15}N$ and lower $\delta^{13}C$ in waters influenced by the Rhône plume (Harmelin-Vivien et al., 2008). Espinasse et al. (2014a) divided the gulf into three habitat types: the western part of the coast, most of the eastern area of the gulf influenced by the Rhône river (the coast and a part of the continental shelf), and the continental shelf (except in eastern areas where river inputs are high). In the present study, the gulf has been divided into two depth zones (coastal areas and continental shelf) separated by the 50 metre isobath and three regions (west, centre and east) according to the spatial changes of environmental conditions (Espinasse et al., 2014a; Harmelin-Vivien et al., 2008) (Fig. 1).

Teleosts were sampled in June and July 2011 and 2012 during the IFREMER MEDITS and PELMED campaigns aboard the IFREMER R.V. 'l'Europe'. In addition, small juvenile sardines were sampled in May 2011 by beach seining near the Rhône estuary. Sampled teleosts were immediately frozen to avoid digestion. In the laboratory, the following measurements were taken on each teleost: total length (TL) to the nearest 1 mm and total body weight (TW). Stomachs were extracted and preserved in 95% alcohol. Eviscerated body weight (EW) was measured. Anterior dorsal muscles of teleosts were sampled and freeze-dried for subsequent stable isotope analyses.

2.2. Stomach content analysis

We chose individuals of the different available size classes (1 cm interval) for each depth and region. Selected stomach contents (117 anchovies, 145 sardines, 166 sprats) (Fig. 1; Table 1.a) were weighed. In each stomach, ingested organisms were identified to genus level (if possible) and counted. Dry weight (DW) of ingested organisms was obtained from the literature (Table A.1). Food composition was expressed by frequency of occurrence (%O; percentage of non-empty stomachs containing a given prey item), numerical percentage (%N; mean percentage per stomach of the number of a given prey item as a proportion of the total number of all prey in each stomach), weight percentage (%W; mean percentage per stomach of the weight of a given prey item as a proportion of the total weight of all prey in each stomach). The index of relative importance (IRI) (Pinkas et al., 1971) was then calculated according to the formula:

$$IRI = \%O \times (\%N + \%W).$$

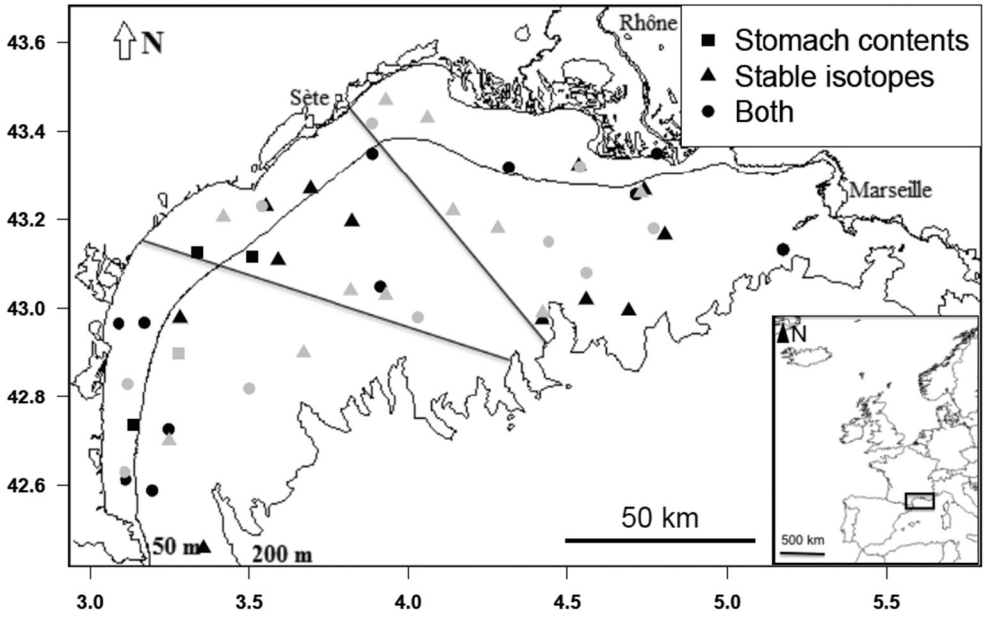

Fig. 1. Location of sampling stations in the Gulf of Lions selected for stomach content analysis and/or stable isotope analysis in 2011 (black) and 2012 (grey). The 50 metre isobath separates coastal areas and the continental shelf. The lines separate the regions west, centre and east.

Please cite this article as: Le Bourg, B., et al., Trophic niche overlap of sprat and commercial small pelagic teleosts in the Gulf of Lions (NW Mediterranean Sea), J. Sea Res. (2015), http://dx.doi.org/10.1016/j.seares.2015.06.011