

Seasonal and spatial dynamics of *Centropages typicus* and *C. hamatus* in the western North Atlantic

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Available online 19 January 2007

Abstract

Centropages typicus and *Centropages hamatus* are two of the most abundant copepods on the continental shelf in the mid-Atlantic region of the western North Atlantic. Their range extends from the Scotian Shelf (*C. typicus*) and the Grand Banks (*C. hamatus*) in the north to Cape Hatteras in the south. South of Cape Hatteras they have only been observed in inshore waters of North and South Carolina and not offshore on the continental shelf or in coastal waters of eastern Florida. However, *C. hamatus* has been observed in western Florida. Abundances of both species are greatest in inshore regions in the mid-Atlantic Bight with *C. hamatus* tending to have a more coastal distribution. In this region seasonal variability is low with high abundances from late fall through mid-summer. In the north year-round presence of both species is confined to inshore areas and offshore banks such as Georges Bank, and Browns Bank, Emerald Bank and Western Bank on the Scotian Shelf. In this northern region there is a pronounced seasonal cycle in abundance with high abundances during late summer and fall. Periods of high reproductive rates are closely linked to blooms of large phytoplankton and food availability rather than temperature appears to be controlling population abundances.

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Keywords: *Centropages typicus*; *Centropages hamatus*; Abundance; Seasonal cycle; Mid-Atlantic Bight; Georges Bank; Gulf of Maine

1. Introduction

Centropages typicus and *Centropages hamatus* are two of the most abundant copepods on the continental shelf in the mid-Atlantic region of the western North Atlantic. Other *Centropages* species present in the western North Atlantic include *Centropages bradyi* and *Centropages velificatus* (= *furcatus*) but these are both much less abundant. Here we briefly review spatial and temporal patterns of abundance of *C. typicus* and *C. hamatus* in this region and discuss aspects of their biology.

Information presented here comes from small-scale or single-station surveys (e.g. Deevey, 1952; Judkins et al., 1980; Grant, 1988), as well as several large-scale studies including MARMAP (Sherman, 1980), and

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the US GLOBEC Georges Bank study (see Durbin et al., 2000 for methods) that provide more extensive spatial and temporal coverage. The MARMAP surveys extended from Cape Hatteras in the south to the southern edge of the Scotian Shelf in the north. Approximately 184 stations were sampled monthly or bimonthly from 1977 to 1987 with a 60 cm 0.333 mm bongo net deployed to the bottom or 200 m. This probably only effectively captured the adults of *Centropages*. Subsequent to 1987 the surveys have continued at a reduced level with bimonthly sampling. The US GLOBEC Georges Bank study took place between 1995 and 1999. Sampling was carried out at approximately 41 stations on Georges Bank (GB) and in adjacent Slope waters to the south and Gulf of Maine (GoM) to the north at monthly intervals between January and June of each year. Zooplankton were collected with a zooplankton pump (0.035 mm mesh nets) and a 1 m² MOCNESS (0.15 mm mesh nets) so all stages were sampled. Only adults of *C. typicus* and *C. hamatus* were identified to species while younger stages were identified to genus and grouped as nauplii and copepods.

2. Spatial distribution

Centropages typicus ranges from the Scotian Shelf in the north to Cape Hatteras in the south (Bigelow, 1926; Deevey, 1952; Judkins et al., 1980; Davis, 1987; Grant, 1988; Kane, 1999). South of Cape Hatteras it has only been observed inshore in inlets such as at Beaufort, North Carolina (Sutcliffe, 1948), and in South Carolina (Lonsdale and Coull, 1977), and not offshore on the continental shelf in this region (Paffenhöfer, 1980), or in coastal waters of Florida such as Biscayne Bay (Reeve, 1970; Roman et al., 1983). To the north it is reported as among the dominants on the Scotian shelf and is present year round (Tremblay and Roff, 1983a,b; McLaren et al., 1989; McLaren and Avendano, 1995). It has not been reported from the Gulf of St Lawrence (de Lafontaine et al., 1991; S. Plourde pers comm.) or on the Grand Banks (Anderson and Gardner, 1986). It is absent or very low in abundance in shallow estuaries and embayments such as Westport River, Massachusetts (Conley and Turner, 1991), Narragansett Bay, Rhode Island (Martin, 1965; Hulsizer, 1976; Durbin and Durbin, 1981), Peconic Bay, Long Island (Turner, 1982; Turner et al., 1983), Navesink River estuary, New Jersey (Knatz, 1978), and Delaware Bay (Deevey, 1960).

Centropages typicus is present year round in the mid-Atlantic Bight in the southern and middle part of its range (Deevey, 1952; Judkins et al., 1980; Grant, 1988; Davis, 1987; Kane, 1999), while in the northern part of its range year-round presence is confined to inshore areas and offshore banks such as Georges Bank and Browns Bank, Emerald Bank and Western Bank on the Scotian Shelf (Tremblay and Roff, 1983a,b; Davis, 1987; McLaren et al., 1989; McLaren and Avendano, 1995; Kane, 1999; Reiss et al., 2002). In the deeper shelf regions in the north such as the Gulf of Maine or the Scotian Shelf it may be absent during winter (Kane, 1999; see Fig. 1).

There is an onshore–offshore trend in abundance of *C. typicus* with highest abundances observed in water depths of <59 m in inshore shelf regions and decreased abundances towards their outer edges (Kane, 1999; Fig. 1). There is also a north–south trend in abundance of *C. typicus* with highest abundances observed in the southern part of its range in the mid-Atlantic Bight (Kane, 1999). In this region highest abundances have been observed inshore at the mouth of large estuaries (Chesapeake Bay, Delaware Bay, Hudson River). In the northern part of its range abundances were lower with population centers present in Southern New England, the inshore western Gulf of Maine, and on Georges Bank (Fig. 1).

Centropages hamatus is somewhat more widely distributed and has been observed from the Grand Banks of Newfoundland (Anderson and Gardner, 1986), the Straits of Belle Isle (Pinhey, 1926) and the Gulf of St Lawrence (S. Plourde, pers comm.) in the north, to Alligator Harbor in the Gulf of Mexico to the south (Grice, 1956; Marcus, 1989). Similarly to *C. typicus*, it has not been reported from waters of southern Florida (Reeve, 1970; Roman et al., 1983). In contrast to *C. typicus*, it has a more coastal distribution and is confined to inner regions of the shelf or to shallow banks such as Georges Bank (Kane, 1997). While it is present in shallow estuaries and embayments, it is not a dominant in these sites (Conley and Turner, 1991; Deevey, 1956, 1960; Durbin and Durbin, 1981; Hulsizer, 1976; Turner, 1982, 1994; Turner et al., 1983).

Centropages bradyi is present on the outer shelf regions of the mid-Atlantic Bight and is most frequent during the summer and fall (Grant, 1988). *Centropages velificatus* is present on the southeastern shelf down to southern Florida (Paffenhöfer, 1980; Reeve, 1970).

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