Journal of Sea Research 90 (2014) 23–32

Contents lists available at ScienceDirect

Journal of Sea Research

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

Synchrony and variation across latitudinal gradients: The role of climate and oceanographic processes in the growth of a herbivorous fish

Jerom R. Stocks [a,b,*], Charles A. Gray [a,d], Matthew D. Taylor [a,c]

[a] School of Biological Earth and Environmental Sciences, University of New South Wales, Sydney, NSW 2052, Australia
[b] Batemans Bay Fisheries Centre, PO Box 17, Batemans Bay, NSW 2536, Australia
[c] Wild Fisheries Research, Port Stephens Fisheries Institute, Locked Bag 1, Nelson Bay, NSW 2316, Australia
[d] WildFish Research, Sydney, NSW 2232, Australia

ARTICLE INFO

Article history:
Received 17 April 2013
Received in revised form 8 January 2014
Accepted 3 March 2014
Available online 12 March 2014

Keywords:
Climate
Girella elevata
Growth
Otolith Increments
Sclerochronology

ABSTRACT

Spatial and temporal variation in the growth of a widely distributed temperate marine herbivore, *Girella elevata*, was examined using length-at-age data and multi-decadal otolith increment growth chronologies. In total 927 *G. elevata* were collected from three regions of the Australian south-east coast, extending 780 km and covering the majority of the East Australian Current, a poleward-flowing western boundary current of the Southern Pacific Gyre and climate change hotspot. A validated ageing method using sectioned sagittal otoliths was developed to enumerate both daily (juvenile fish) and annual otolith increments. *G. elevata* exhibited great longevity with a maximum recorded age of 45 + yrs. Spatial variation in growth from length-at-age data was observed with the highest growth rates within the centre of the species distribution. Analysis of otolith growth chronologies of 33 yrs showed a positive relationship with the Southern Oscillation Index. Identifying links between life-history characteristics and variation in oceanographic conditions across latitudinal gradients may shed light on potential impacts of expected climate shifts on fish productivity.

1. Introduction

Exploring latitudinal gradients of age and growth rates can provide insight into the relationship between the biological attributes of a species and variability in the environment in which it lives. Growth variation may be a result of trade-offs among other life-history traits such as fitness and reproduction, including onset of maturity and fecundity (Vila-Gispert et al., 2002), or restrictions imposed by latitudinal gradients in environmental conditions such as temperature (Lappalainen et al., 2008) and productivity (Sogard, 2011). For coastal and marine species, identifying links between oceanographic variability and latitudinal gradients in life history characteristics may shed light on expected changes associated with both basin- and decadal-scale climate shifts. In addition, such climate shifts may result in altered species distributions and community structures, which have already been observed in a number of fishes of south-eastern Australia (Last et al., 2011) and elsewhere throughout the world (Booth et al., 2011; Hiddink and Ter Hofstede, 2008; Perry et al., 2005).

Sclerochronological approaches, primarily employing fish otoliths (earstones), are being increasingly used to examine long-term temporal trends in fish growth (Black, 2009; Godiksen et al., 2012; Morrongiello et al., 2010; Neuheimer et al., 2011; Thresher et al., 2007). Due to the indeterminate nature of otolith deposition, long-term otolith growth chronologies can be constructed to deduce life-history traits (Stocks et al., 2011) and reflect environmental conditions and climate change (Thresher et al., 2007). Multiple climate and oceanographic processes have been correlated to otolith increment chronologies, such as sea-surface temperature (SST) (Black et al., 2008), El Niño Southern Oscillation (ENSO) (Black et al., 2008), and localised upwelling (Boehlert et al., 1989).

Girella elevata occur on shallow near-shore rocky reefs along the south-east coast of mainland Australia and north-eastern Tasmania, with their geographic distribution stretching across approximately 13° of latitude (Kuiter, 1993). The species is often found during the day in caves and under rocky ledges or in surge regions, although post-settlement fish use rockpools as nurseries before moving to shallow rocky reefs as they grow (Bell et al., 1980; Burchmore et al., 1985; Griffiths, 2003). The species experiences considerable pressure from recreational fishing, particularly spearfishing and anglers from rock platforms (Kingsford et al., 1991; Lincoln Smith et al., 1989).

The broad latitudinal distribution of *G. elevata* spans a large proportion of the East Australian Current (EAC). The EAC is the poleward-flowing western boundary current of the Southern Pacific Gyre, extending from the Coral Sea into Tasmanian waters. The EAC is primarily composed as a current of eddies (Mata et al., 2006), and thus displays high oceanographic variability. The EAC is considered among the fastest changing

* Corresponding author at: School of Biological Earth and Environmental Sciences, University of New South Wales, Sydney, NSW 2052, Australia.
E-mail address: jerom.stocks@dpi.nsw.gov.au (J.R. Stocks).

http://dx.doi.org/10.1016/j.seares.2014.03.002
1385-1101/

oceanic water bodies in the world (Matear et al., 2013), displaying a poleward advancement of ~350 km over a 60 year period that consequently warms the Tasman Sea at >2 °C century^{-1} (Ridgway, 2007). Modelling indicates that the poleward migration of the EAC is expected to further strengthen, and this will produce greater mesoscale variability (Cai et al., 2005). The spatial variation in the EAC is categorised by three distinct water bodies, which are delineated by a highly variable region of water where the EAC separates from the coast (at approximately 31.5°S) to form an eastward flowing frontal region off Sydney (Fig. 1). The resulting three regions thus represent a strong southward flowing northern section dominated by warm Coral Sea water, a highly variable separation zone dominated by a persistent eddy field, and a cooler southern zone which is seasonally dominated by either EAC flow-through water from the north or the cooler waters of the Tasman Sea.

In this study we aimed to address fish growth in the context of climate variation, through the unique combination of a long-lived (45+ yrs) marine herbivore with a wide distribution across a highly variable oceanographic region. This combination was selected to provide a dataset of sufficient spatial and temporal variation, and our broad aim was addressed through a sequential series of objectives: (1) develop a validated ageing method for *G. elevata* using sectioned sagittal otoliths; (2) analyse spatial and intersexual variation in the growth of *G. elevata* across a broad-latitudinal range using size-at-age information, and; (3) reconstruct multi-decadal otolith growth chronologies to examine climatic/oceanographic processes correlated with temporal trends in fish growth.

2. Methods

2.1. Study area

The dominant oceanographic features of this region include the poleward flowing East Australian Current (EAC) and its associated

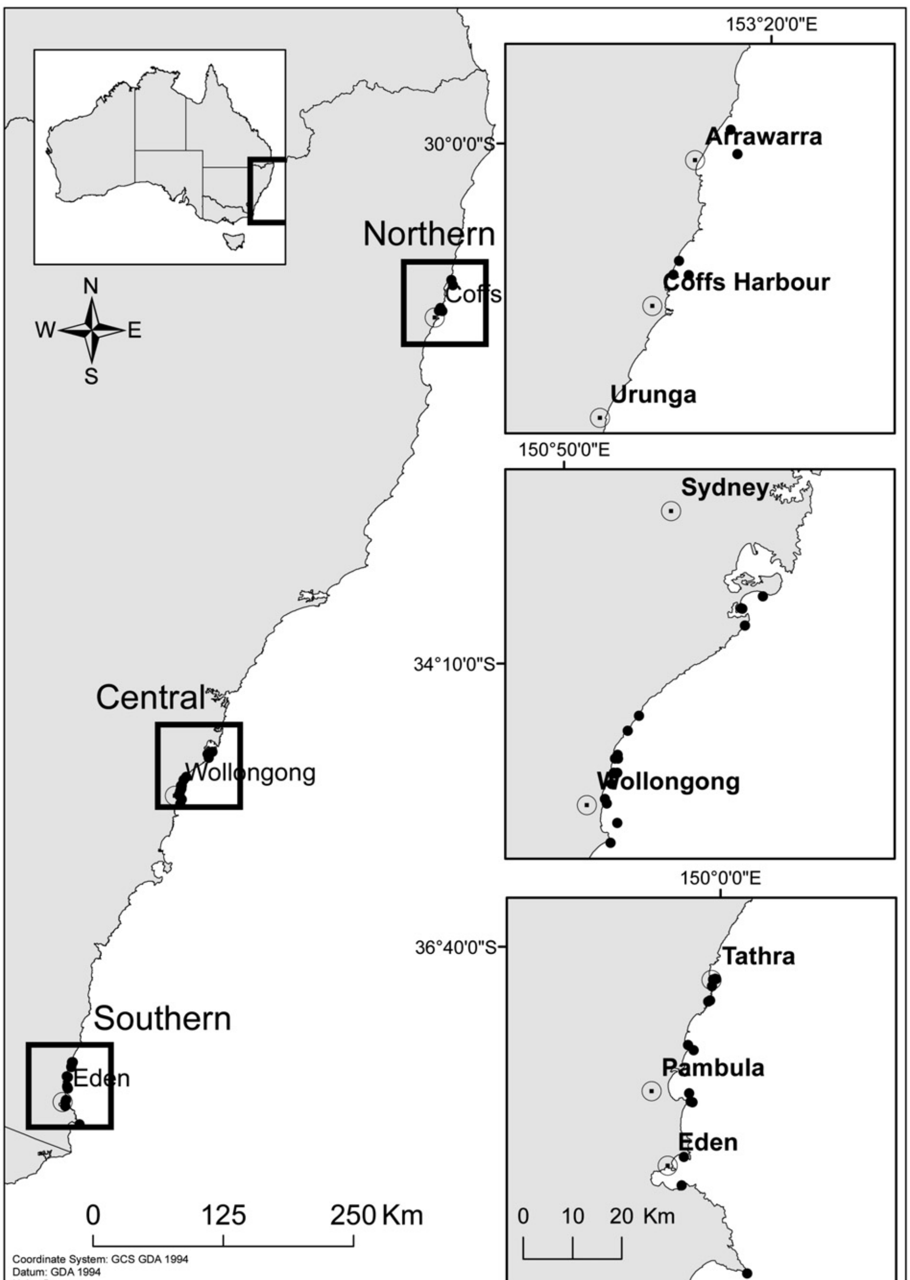

Fig. 1. Spatial distribution of the Northern, Central and Southern sampling regions. Filled circles indicate the locations where *Girella elevata* were collected by free-dive spearfishing.