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Stock structure of the blue threadfin (*Eleutheronema tetradactylum*) across northern Australia derived from life-history characteristics

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ABSTRACT

Life history characteristics were used to determine the stock structure of the polynemid *Eleutheronema tetradactylum* across northern Australia. Growth, estimated from back-calculated length-at-age from sagittal otoliths, and length at sex change were estimated from samples collected from 12 different locations across western, northern and eastern Australia between 2007 and 2009. Comparison of back-calculated length-at-age, growth and length at sex change between locations revealed significant variation in the life-history characteristics of *E. tetradactylum* across northern Australia, with significant differences detected in 43 of 45 location comparisons. Differences in otolith size relative to fish length also existed amongst locations. No differences in other morphometric relationships were detected. The results of this study provide evidence for a high degree of spatial population subdivision for *E. tetradactylum* across northern Australia, the finding of which has implications for *E. tetradactylum* fisheries throughout its range, and provides a biological basis for spatial management of the species in Australia.

1. Introduction

Understanding of the life-history characteristics of exploited fish species is fundamental to the premise of sustainable fisheries management (Beverton and Holt, 1957). The life-history characteristics of fish populations determine important biological attributes such as productivity, which significantly affect vulnerability to exploitation and responses to fishing (Bianchi et al., 2000; Jennings et al., 1998). Estimates of age and growth rate are two of the most influential life-history characteristics controlling the productivity of fish populations (Campana and Thorrold, 2001), and a recent estimate of growth rate coupled with age at first maturity are minimum requirements for effective single-species fisheries management (Sale, 1982). It has also been shown that life histories of fish can be plastic and can change in response to fishing pressure (Rochet, 1998). It is therefore imperative that management strategies be based on the best available life-history parameter estimates that are relevant to the population being managed.

A major goal of modern fisheries research is to acquire knowledge on spatial and temporal variation in demographics, to provide information on stock subdivision, genetic depletion, and the capacity of populations to cope with environmental changes (Chopelet et al., 2009; Palsbøll et al., 2007; Schwartz et al., 2007). As well as the life-history characteristics, the identification of the stock structure of exploited fish species is fundamental to fisheries management and provides the basis for the determination of appropriate spatial management units (Begg and Waldman, 1999). Hilborn and Walters (1992) define stocks as self-reproducing groups of fish having similar life-history characteristics. However, many definitions have been postulated in the literature and the term 'stock' is often used inter-changeably with the term 'population'. Geographical differences in life-history characteristics, such as growth, have been used as evidence of separate stocks and suggest the need to consider the spatial scale of assessment and management (Begg, 2005; Begg et al., 1999a; Rahikainen and Stephenson, 2004). As such, estimates of life-history parameters cannot only help elucidate different fish stocks; an understanding of life-history characteristics is also essential for determining the biological attributes of each stock and is the basis for effective management (Abaunza et al., 2008a; Begg et al., 1999b).

Several methods are used to discriminate different fish stocks including genetic techniques, parasites, morphology, otolith chemistry, mark-recapture and life-history characteristics (Begg and Waldman, 1999; Cadrin et al., 2005; Waldman, 1999). There has been a recent shift in fisheries research towards using

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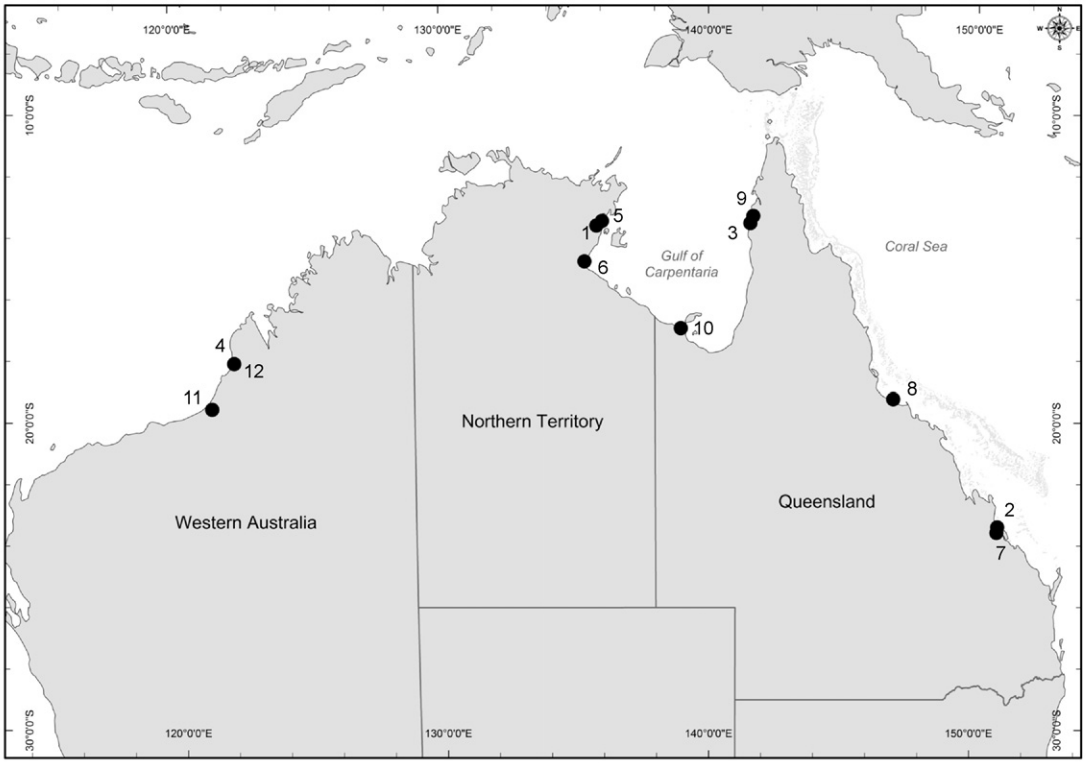

Fig. 1. Map of northern Australia showing the locations sampled during the study. See Table 1 for location names.

combinations of these stock identification techniques (Begg and Waldman, 1999), with attempts to integrate the results from different methods (Abaunza et al., 2008b; Bradbury et al., 2008; Buckworth et al., 2007; Welch et al., 2009, 2010). Life-history parameters have been used in stock identification studies because they reflect both the genotypic and environmental influences on a stock, and therefore differences in life-history parameters are likely to reflect geographically and/or reproductively isolated populations (Begg et al., 1999b; Begg and Sellin, 1998).

The blue threadfin, *Eleutheronema tetradactylum*, is an important inshore fish species that provides an important source of food for local markets and forms the basis of substantial subsistence, commercial and recreational fisheries throughout its Indo-Pacific distribution (Motomura, 2004; Motomura et al., 2002). In Australian waters, *E. tetradactylum* occurs right around the northern coastline from the Ashburton River (21°42′S) in Western Australia, to the Mary River (25°26′S) in Queensland (Motomura et al., 2002). *E. tetradactylum* forms a large component of the multi-species inshore finfish fisheries across northern Australia and are harvested primarily in the inshore net fisheries that target barramundi, *Lates calcarifer* (Anon., 2007). *E. tetradactylum* are protandrous hermaphrodites maturing first as males and later changing to females (Pember et al., 2005). In Western Australia, the species typically reaches sexual maturity as males at the end of their first year of life when their lengths are *ca* 200 mm, and change from male to female at *ca* 400 mm when they are *ca* 2 years old (Pember et al., 2005).

Previous biological data for the species suggests that life-history characteristics vary geographically. In the Gulf of Carpentaria they can reach a maximum size of at least 1000 mm and 10 kg (Garrett, 1997), whilst in Western Australian they reach a maximum size of at least 800 mm and 5 kg (Pember et al., 2005). Further, recent research using several different techniques including genetics, parasites, otolith stable isotopes and tag-recapture, has demonstrated the existence of a fine spatial scale stock structure for *E. tetradactylum* across northern Australia (Horne et al., 2011; Moore et al., 2011; Newman et al., 2011; Welch et al., 2010; Zischke et al., 2009).

In this study, the stock structure of *E. tetradactylum* across northern Australian was inferred by comparing life-history parameter estimates from different locations. Fish collected from several locations around Australia were used to estimate life-history parameters, which are presented as the basis for understanding the species' biology on a regional scale. Morphology was also investigated as an indicator of stock structure by comparing morphometric relationships between locations.

2. Materials and methods

2.1. Sample collection

E. tetradactylum samples were collected by commercial fishing operations from several locations around the northern coast of Australia from July 2007 to August 2009 (Fig. 1 and Table 1). Samples were collected in two phases to provide for temporal comparisons, with Phase I samples collected in 2007–2008 and Phase II samples collected in 2008–2009.

Morphometric measurements (mm), taken with a measuring board and Perspex rule, included fork length (FL), total length (TL), head length (HL) – measured from the tip of the nose to the furthest edge of the pre-operculum, and upper jaw length (UJL) – measured from the front edge of the upper jaw to the rear edge (Fig. 2), and total weight where possible (g). Each fish was macroscopically sexed and staged using the staging system of Pember et al. (2005). Sagittal otoliths were removed, cleaned and stored dry in vials or envelopes.

2.2. Age estimation

Whole sagittal otoliths were immersed in mineral oil and viewed against a black background through a stereo-dissection microscope (10×–40× magnification). Otoliths were aged whole