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Rapid and cost-effective assessment of connectivity among assemblages of *Choerodon rubescens* (Labridae), using laser ablation ICP-MS of sagittal otoliths

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ABSTRACT

A rapid and cost-effective assessment was required to provide advice to management on the connectivity between juvenile and adult life cycle stages of Baldchin Groper *Choerodon rubescens*, a labrid endemic to the west coast of Australia, which has high social value, but relatively low commercial fishery importance. To minimise costs we used laser ablation ICP-MS to analyse levels of a small suite of elements (Ca, Mg, Mn, Cu, Zn, Sr, Rb, Ba and Pb) at the margin (adult phase) and core (juvenile phase) of the same otoliths of adult *C. rubescens*, collected at ten locations in five management zones. The elemental composition of both otolith margins and cores differed significantly among management zones and in some cases among locations within zones. Similarity of the pattern of among-zone elemental composition in otolith margins and cores indicated that, when cores are laid down, individuals have already recruited to the zones they will occupy as adults and there is no evidence of discrete juvenile nurseries. Thus, movement of juvenile or adult *C. rubescens* is likely to occur at relatively small spatial scales. Monitoring and management of adult stocks at the management zone level may be appropriate to sustain stocks broadly, but may not detect more localised depletion. Methods of elemental analyses are discussed and costs and benefits of this study vs an equivalent tagging study were compared.

1. Introduction

Understanding the connectivity between the post-settlement juvenile and adult stages of the life cycle of an exploited fish species is an important prerequisite for effective management of its stocks (Gillanders, 2002a; Gillanders et al., 2003; Hamer et al., 2003). Early stage juveniles (0+ recruits) may occupy habitats that function as nurseries, which are either discrete from or which partly or completely overlap habitats or locations occupied by adults of the same species (see Beck et al., 2001). Such nurseries, or sources of recruits to adult populations, may be restricted to specific habitats or locations and thus may be few in number and/or may also be at risk of perturbation from anthropogenic effects, which needs to be taken into account when developing management plans for a species (e.g. Fowler et al., 2005; Hamer et al., 2011; Wakefield et al., 2011).

Elucidation of the connectivity between source of new recruits and the adult population(s) is often conducted using analysis of the elemental composition of otoliths (Campana, 2005; Elsdon et al., 2008; Thorisson et al., 2011). This approach can provide a cost-effective way to delineate non-mixing populations of fish within the overall distribution of a species (Campana, 2005). The method is based on the premise that the concentrations of some minor elements, e.g. stable isotopes of oxygen and carbon, and trace elements, e.g. Mg, Ba and Sr, in otolith carbonate are determined by environmental factors that are location-specific. As the carbonate in otoliths is metabolically inert, i.e. not reworked or resorbed as are bone and scales (Simkiss, 1974; Campana and Thorrold, 2001), a location-specific signature is continually laid down. Suitable analyses will reveal these signatures and geographic separation or continuity of the fish populations under investigation can be implied (Campana, 1999). Such information is particularly useful, as the period of growth of the otolith and deposition of such elements, i.e. the complete lifetime of an individual fish, often approximates the time scale within which fisheries are managed.

Fisheries scientists often are required to provide information to managers on the stock structure of a species in a cost-effective manner. This is particularly important if commercial catches of that species are low and it is of marginal economic importance, but is highly valued for other reasons, e.g. as a sport fish by recreational and spear fishers. The Baldchin Groper *Choerodon rubescens* (Günther 1862), a large labrid endemic to ca 1200 km of the west coast of Australia, is such a species (Hutchins and Swainston, 1986; Fairclough et al., 2010; Fig. 1). Its population status was assessed as “least concern” by the IUCN in 2004 (Fairclough and Cornish, 2004). However, since that time, a stock assessment demonstrated that overfishing of *C. rubescens* had been occurring at the Houtman-Abrolhos Islands (referred to hereafter

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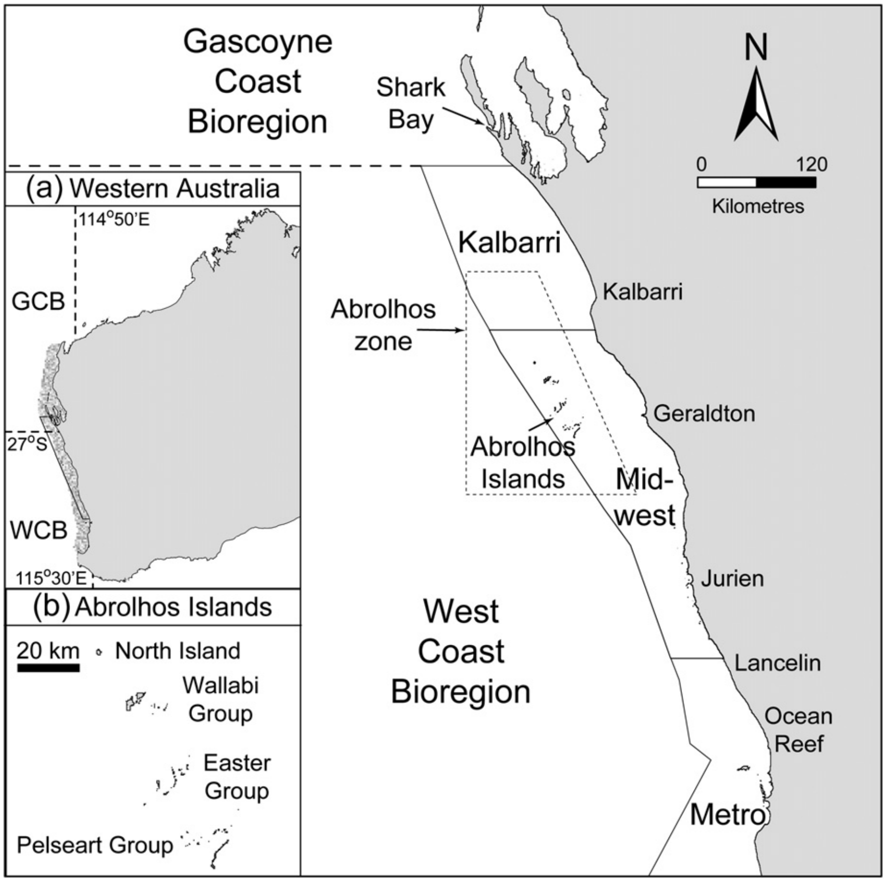

Fig. 1. Map of (a) the distribution of *Choerodon rubescens* in Western Australia (stippling), the boundaries (dashes) of the Gascoyne Coast (GCB) and West Coast Bioregions (WCB) and the area of sampling (box) and, in the main map, the coastal and offshore locations and zones (boundaries as solid lines) of the WCB where *C. rubescens* were collected, and in inset (b) the four groups of the Abrolhos Islands.

as the Abrolhos Islands; Wise et al., 2007; Sumner, 2008; Fig. 1). *C. rubescens* is protogynous and its individuals can live for over 20 years, maturing first as females at approximately 3–4 years of age and changing sex at 10–12 years. It spawns during austral spring/early summer, producing buoyant eggs and pelagic larvae. However, the length of the larval phase is unknown. Spawning occurs throughout its range, including at the Abrolhos Islands, which is the mid-point of its geographic range and an area where this species is abundant (Fig. 1; Hutchins, 2001; Fairclough, 2005; Nardi et al., 2006). Thus, the contribution of stocks at the Abrolhos Islands to those in its broader range and *vice versa* needs to be resolved for informing future fishery management decisions. Its overall stock structure may also be indicative of other demersal species that occupy the same environments.

The objectives of this study were to investigate, among five different fishery management zones encompassing a large part of the range of *C. rubescens* and including the Abrolhos Islands (Fig. 1), (1) whether adult *C. rubescens* have remained separate during their recent life history and (2) the connectivity between early stage juveniles and adults of this species. Concentrations of a suite of trace elements were measured using laser ablation inductively coupled plasma mass spectrometry, a technique that is widely used in studies seeking to discern population structure and which provided a rapid, convenient and cost-effective approach to obtaining such previously unavailable information for this species (see Campana, 2005; Hamer et al., 2003; Schuchert et al., 2010; Thorisson et al., 2011). Analysis was conducted at the margins (representing the environment occupied during a period of recent adult life history) and cores (representing part of the early juvenile stage) of the sectioned sagittal otoliths of adult *C. rubescens* collected at ten locations among the five zones. The data were used to test the null hypothesis of no difference among management zones of the elemental composition of both the otolith margins and cores and to determine the classification success of each margin and core sample from each fish to the zone in which it was caught.

We did not adhere to the proviso of Gillanders (2002b) and Hamer et al. (2003) that in order to assign individual adults, from one or more stocks, to their nursery location requires the previous collection of juveniles of the same year class from known nurseries. Elemental fingerprints of the cores of the otoliths of adults and juveniles of the same year class can then be compared and the assignment conducted. Such a study can take several years to complete, depending on the growth and demographic characteristics of the species (e.g. Thorisson et al., 2011). *C. rubescens* is a marine species and therefore the stability of the open marine environment compared with the greater year-to-year variability in, for example, estuarine or embayment conditions, would render the conditional stipulation of Gillanders (2002b) and Hamer et al. (2003) of accounting for temporal variation less critical.

Comparisons are also provided of different methods of elemental analysis of otoliths and of the cost and benefits of this study with that of an equivalent mark–recapture program to elucidate connectivity of such a species.

2. Materials and methods

2.1. Sample collection and otolith preparation

Adult *C. rubescens* caught by line fishing by commercial and recreational fishers and by the Department of Fisheries Western Australia research staff between February 2008 and March 2009 were used in this study. Fish collected by research staff were immediately