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Octopus life history relative to age, in a multi-geared developmental fishery

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ABSTRACT

The ability to obtain broad-scale age information for an exploited octopus population enables the identification of essential life history information, such as age at maturity, recruitment pulses and seasonal effects on growth. This study uses stylet weight (reduced internal shell) as a proxy to age 3494 *Octopus* (cf) *tetricus*, the target species of a rapidly developing octopus fishery in Western Australia. Samples were collected during 2008–2012 using passive shelter pots and active trigger traps. Both males and females were found to have similar maximum ages at 1.5 years, with males reaching maturity at 243 days compared to 379 days for females. The two gear types selected for different parts of the population, with shelter pots catching mostly octopus <1 kg total weight, who were a mixture of immature females and immature/mature males, whereas trigger traps caught octopus >1 kg total weight, of which 75% of the total catch were mature males. This variation in catch composition coupled with the inshore (shelter pot) and offshore (trigger trap) depth profiles of the gear types suggests offshore migration may be occurring. Back-calculated hatch months revealed six-monthly recruitment pulses and a positive relationship with ascending sea surface temperature and growth up to 22 °C.

1. Introduction

Octopus populations typically demonstrate fast growth rates, short semelparous life cycles and high fecundity (Hanlon and Messenger, 1996; Mangold, 1983). Factors which make them seem relatively resilient to fishing pressure and environmental perturbations, compared to many teleost species (Faure et al., 2000). However, as a consequence of these attributes, octopus populations have minimal overlap between generations, a predicament that can leave them without a buffer from poor recruitment (Boyle, 1990; Rocha et al., 2001). This mixture of adaptability and susceptibility, can lead to sharp and sporadic fluctuations in the distribution and abundance of octopus populations (Sobrino et al., 2002). To determine the causes of or to forecast for such fluctuations, it is essential to have a sound knowledge of the life history of the species targeted and the potential impacts fishing practices may have on recruitment dynamics. This is particularly relevant for developmental fisheries, which are generally data poor due to their short time series and typically lack research attention commensurate with their unidentified economic potential (Perry et al., 1999).

The developmental octopus fishery (DOF) in Western Australia was established in 2001 and is currently going through a period of rapid expansion. In 2010, the introduction of an active trigger trap, led to a 400% catch increase during its first year of deployment (33 t in 1999 to 170 t in 2010) (Hart et al., 2012). Trigger traps consist of a rectangular pot baited with a plastic crab connected to a trip wire that triggers a trap door when grasped by an octopus (Fig. 1a). Prior to the introduction of the trigger trap, the primary gear used in the fishery was open-ended passive shelter pots set on demersal longlines (Fig. 1b). The light-weight (3.5 kg) shelter pot's susceptibility to burying and displacement, led to the development of the trigger trap, for the exploration of more exposed waters (deeper than 20 m). Configured in cradles of three trigger traps (weighing 45 kg), the fishing power (i.e. catch per unit of effort relative to soak period) of a single cradle is ~30 times that of a single shelter pot per annum (unpublished data). The increased fishing efficiency of the trigger traps and the ability to explore deeper waters has prompted the exploration of 780 km of the western coastline of Western Australia, with the 1600 km southern coastline only beginning to be considered. Management instruments in the DOF currently consist of limited entry (number of exemption holders), prescribed gear

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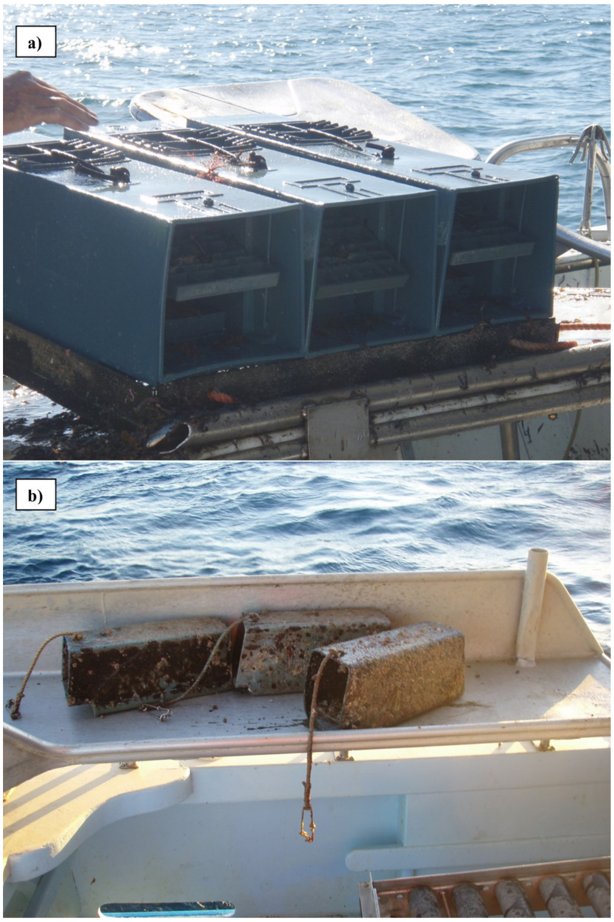

Fig. 1. Octopus traps used in the developmental octopus fishery: (a) cradle of trigger traps and (b) shelter pots.

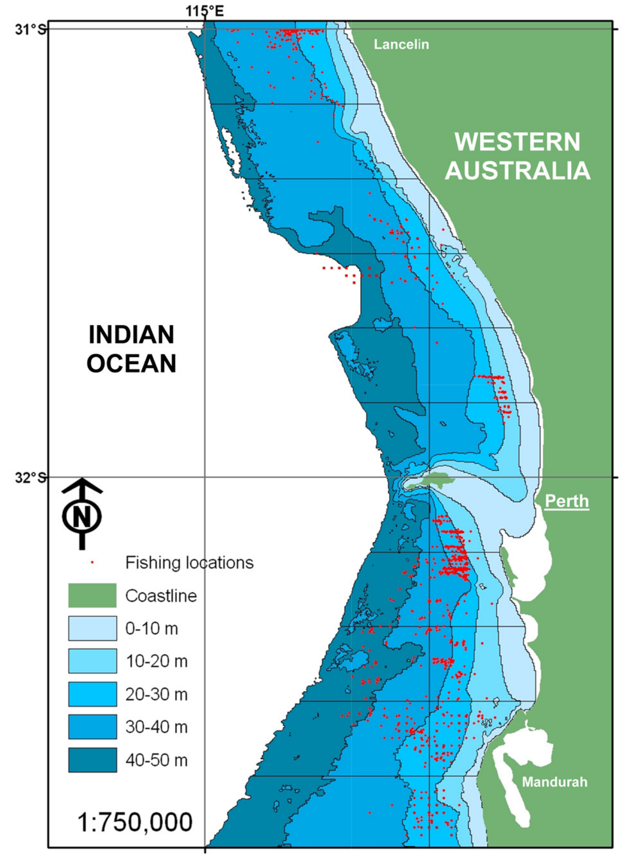

Fig. 2. Location of the main fishing grounds for the developmental octopus fishery, with trigger trap fishing locations during 2011 (dots).

entitlements per vessel (shelter pot and trigger trap) and spatial zonation of fishing effort (Hart et al., 2012).

The target species of the DOF is *Octopus* (cf) *tetricus*, it was recently identified as separate to *O. tetricus* on the east coast of Australia and New Zealand, with both species believed to be closely related to the cosmopolitan *Octopus vulgaris* species complex (Amor, 2011; Guerra et al., 2010; Acosta-Jofré et al., 2012). Being a merobenthic species, *O.* (cf) *tetricus* produces hundreds of thousands of eggs and planktonic paralarvae (Joll, 1983). Captivity experiments have revealed that females brood their eggs for ∼1 month (Joll, 1976) and paralarvae spend ∼50 days in the water column before settling on the benthos (S. Kolkovski pers. comm.). *O.* (cf) *tetricus* is distributed in temperate waters from Shark Bay in the north to the South Australian border in the south east, it inhabits rocky reefs, seagrass meadows and sandy substrates at depths of 5–70 m (Edgar, 1997).

Published research on the biology of *O.* (cf) *tetricus* has primarily focused on captivity studies of reproduction, growth and food intake (Joll, 1976, 1977a, 1978, 1983). The potential of commercial octopus fishing in Western Australia was investigated by Japanese and Australian researchers during 1978–1981, in response to the high levels of octopus predation in the lucrative rock lobster (*Panulirus cygnus*) fishery (Joll, 1977b; Kimura and Isomae, 1981). A major finding of this research was the need to find an appropriate gear type to harvest the stock (Kimura and Isomae, 1981). The introduction of the trigger trap has met this need and catches have escalated accordingly. These changes have heightened the necessity to acquire detailed information on the life history of *O.* (cf) *tetricus* at the population level, to help ensure the sustainable development of the fishery.

Until recently, the most evasive life history parameter for wild exploited octopus populations has been age information (Cuccu et al., 2013; Vaz-Pires et al., 2004). Without age data, all estimations controversially reside on assumptions made on the age/size relationship of octopuses (Semmens et al., 2004). This has been particularly pressing for merobenthic species (e.g. *O. vulgaris*, *Octopus mimus*, *Enteroctopus dofleini*), where the ability to verify ageing techniques has been hindered by the complexities of raising paralarvae in captivity.

Stylets are reduced internal structures found in the mantle musculature, which contain concentric rings in their internal microstructure that can be used to age octopus in a similar manner to otolith in fish and statoliths in squid (Bizikov, 2004; Sousa Reis and Fernandes, 2002). Leporati and Hart (2015) confirmed daily stylet increment periodicity in *O. (cf) tetricus*, by injecting captive octopus with calcine. Using stylet increment analysis (SIA) as described by Doubleday et al. (2006), a strong relationship between

Table 1
Maturation stages of *Octopus* (cf) *tetricus*.

Gonad stage	Male	Female
(I)	Spermatophoric organ transparent and whitish.	Ovary whitish, very small no signs of granulation.
(II)	Spermatophoric organ with white streaks of sperm.	Ovary yellowish with signs of granulation.
(III)	Needhams sack full of spermatophores.	Ovary very large, yellow/orange to a clear colour if in the process of laying eggs. Oviducts and oviducal glands enlarged.
(IV)	N/A	Ovary flaccid, purple in colour with few to no eggs.